Designation: E290 – 22

Standard Test Methods for Bend Testing of Material for Ductility[1]

This standard is issued under the fixed designation E290; 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 bend testing for ductility of materials. Included in the procedures are four conditions of constraint on the bent portion of the specimen; a guided-bend test using a mandrel or plunger of defined dimensions to force the mid-length of the specimen between two supports separated by a defined space; a semi-guided bend test in which the specimen is bent, while in contact with a mandrel, through a specified angle of bend or to a specified inside radius of bend (*r*) measured while under the bending force; a free-bend test in which the ends of the specimen are brought toward each other, but in which no transverse force is applied to the bend itself and there is no contact of the concave inside surface of the bend with other material; a bend-and-flatten test, in which a transverse force is applied to the bend such that the legs make contact with each other over the length of the specimen.

1.2 After bending, the convex surface of the bend is examined for evidence of a crack or surface irregularities. If the specimen fractures, the material has failed the test. When complete fracture does not occur, the criterion for failure is the number and size of cracks or surface irregularities visible to the unaided eye occurring on the convex surface of the specimen after bending, as specified by the product specification. Any cracks within one thickness of the edge of the specimen are not considered a bend test failure. Cracks occurring in the corners of the bent portion shall not be considered significant unless they exceed the size specified for corner cracks in the product specification.

1.3 The values stated in SI units are to be regarded as standard. Inch-pound values given in parentheses were used in establishing test parameters and 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.*

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]

E6 Terminology Relating to Methods of Mechanical Testing

E8/E8M Test Methods for Tension Testing of Metallic Materials

E190 Test Method for Guided Bend Test for Ductility of Welds

3. Terminology

3.1 *Definitions*—Refer to Terminology E6 for the definitions of bend test, ductility and springback.

3.1.1 *guided bend, n*—the bend obtained by using a mandrel to guide and force the portion of the specimen being bent between two faces of a die.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *angle of bend, n*—the change in the angle between the two legs of the specimen during a bend test, measured before release of the bending forces, unless otherwise specified.

3.2.2 *bend-and-flatten bend, n*—the bend obtained by compressing the legs of a 180° bend between platens until the legs of the bend contact.

3.2.3 *crack, n*—a nominally two-dimensional defect caused by the bend test that extends primarily from the surface of the test specimen to its interior.

3.2.3.1 *Discussion*—Different disciplines characterize and describe cracks using different, specific terminology. The terminology of a specification that cites E290 shall always be followed instead of any crack terminology defined here.

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

Current edition approved June 15, 2022. Published September 2022. Originally approved in 1966. Last previous edition approved in 2014 as E290 – 14. DOI: 10.1520/E0290-22.

[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.

***A Summary of Changes section appears at the end of this standard**

3.2.4 *free bend*—the bend obtained by applying forces to the ends of a specimen without the application of force at the point of maximum bending.

3.2.4.1 *Discussion*—In making a free bend, lateral forces first are applied to produce a small amount of bending at two points. The two bends, each a suitable distance from the center, are both in the same direction.

3.2.5 *mandrel, n*—In bend testing, the tool used to control the strain on the concave side of a bend in a wrap-around bend test and also to apply the bending force in a semi-guided or guided-bend test.

3.2.5.1 *Discussion*—The terms pin, plunger, and male die have been used in place of mandrel.

3.2.5.2 *Discussion*—In free bends or semi-guided bends to an angle of 180° a shim or block of the proper thickness is sometimes placed between the legs of the specimen as bending is completed. This shim or block is also referred to as a pin or mandrel.

3.2.6 *radius of bend* [L], *n*—the radius of the cylindrical surface of the pin, mandrel, plunger, roller, support, or male die that comes in contact with the inside surface of the bend during a guided or semi-guided bend test.

3.2.6.1 *Discussion*—In the case of free or semi-guided bends to 180° in which a shim or block is used, the radius of bend is one half the thickness of the shim or block.

3.2.6.2 *Discussion*—radius of bend is typically not measured in free-bend tests and bend-and-flatten bend tests.

3.2.7 *semi-guided bend, n*—the bend obtained by applying a force directly to the specimen in the portion that is to be bent.

3.2.7.1 *Discussion*—The specimen is either held at one end or forced around a pin, mandrel, roller, or support, or is supported near the ends and bent by a force applied on the side of the specimen opposite the supports and midway between them. In some instances, the bend is started in this manner and finished in the manner of the free bend.

3.2.8 *surface irregularity, n*—a nominally two-dimensional type of damage caused by the bend test that encompasses an area of the surface of a test specimen, but does not extend into its interior.

3.2.8.1 *Discussion*—Surface disturbances such as loss of coating adherence or surface roughening such as orange peel are examples of surface irregularity.

3.2.8.2 *Discussion*—Different codes and product specifications characterize surface irregularities using different, specific terminology. The terminology of a code or product specification that cites E290 shall always be followed instead of any terminology defined or used here.

4. Summary of Test Methods

4.1 Four methods for ductility testing employing bending are included in these test methods. Three methods have subgroups with specific procedures.

4.1.1 *Guided-bend Tests:*

4.1.1.1 Guided-bend, No-die Test,

4.1.1.2 Guided-bend, U-bend Test,

4.1.1.3 Guided-Bend, V-bend Test,

4.1.1.4 Guided-Bend, V-bend test for cold-rolled sheet,

4.1.2 *Semi-guided Bend Tests:*

4.1.2.1 *Arrangement A,* one-end-held semi-guided bend test.

4.1.2.2 *Arrangement B,* thin-material semi-guided bend test.

4.1.2.3 *Arrangement C,* mandrel-guided semi-guided bend test.

4.1.3 *Free-bend Tests:*

4.1.3.1 *Type 1,* 180° free-bend test.

4.1.3.2 *Type 2,* flat-on-itself free-bend test.

4.1.4 *Bend-and-flatten Test*

4.2 A guided-bend test for ductility of welds is described in Method E190 and may be used for flat-rolled materials when specified by the product specification. The essential features of this bending method are employed in 4.1.1.2, guided-bend, U-bend test.

4.3 Bend tests are made in one of two directions relative to the principal working direction employed in production processing of the material.

4.3.1 Longitudinal tests use a specimen with its long dimension aligned with the processing direction such that the bend is formed across the processing direction, as shown in Fig. 1.

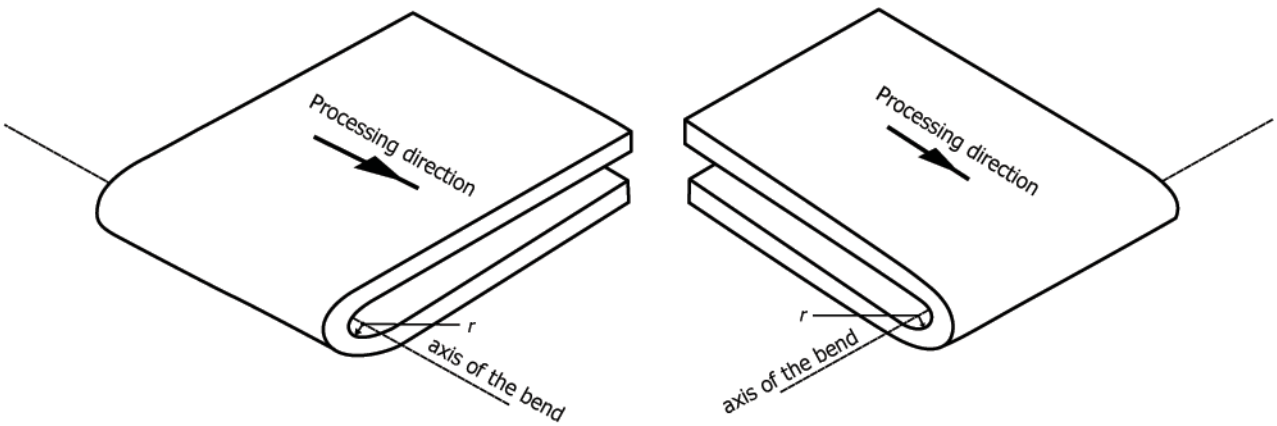

FIG. 1 Relationship Between Specimen Long Dimension and Processing Direction in Bend Tests