



Designation: E 812 – 91 (Reapproved 1997)

Standard Test Method for Crack Strength of Slow-Bend Precracked Charpy Specimens of High-Strength Metallic Materials¹

This standard is issued under the fixed designation E 812; 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.

1. Scope

1.1 This test method covers the determination of the crack strength σ_c of a Charpy-type specimen (see Fig. 1) containing a fatigue crack tested in slow bending. The nominal cross-sectional dimensions of this specimen are identical to those given in Test Methods E 23 (Fig. 4A) for the standard Charpy test specimen. The crack strength will be sensitive to changes in the plane-strain fracture toughness providing the strength of the specimen is determined primarily by crack propagation and not by plastic instability.

1.2 *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:

- E 4 Practices for Force Verification of Testing Machines²
- E 8 Test Methods for Tension Testing of Metallic Materials²
- E 23 Test Methods for Notched Bar Impact Testing of Metallic Materials²
- E 139 Practice for Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials²
- E 399 Test Method for Plane-Strain Fracture Toughness of Metallic Materials²
- E 616 Terminology Relating to Fracture Testing³

3. Terminology

3.1 Definition:

3.1.1 *crack strength*, σ_c [FL²]—the maximum value of the nominal (net-section) stress that a cracked specimen is capable of sustaining.

3.1.1.1 *Discussion*—See definition of nominal stress in Terminology E 616.

3.1.1.2 *Discussion*—Crack strength is calculated on the basis of the maximum load and the original cross-sectional area (net cross-section or ligament). Thus, it takes into account the original size of the crack but ignores any crack extension that may occur during the test.

3.1.1.3 *Discussion*—Crack strength is analogous to the ultimate tensile strength, as it is based on the ratio of the maximum load to the minimum cross-sectional area of the specimen at the start of the test.

4. Summary of Test Method

4.1 This test method employs a Charpy specimen provided with a sharp notch terminating in a fatigue crack tested in three-point bending using fixtures that minimize the contribution of friction forces to the measured applied load. The maximum load in the test is recorded and the crack strength is determined from this value and the original dimensions of the specimen using the simple-beam equation.

5. Significance and Use

5.1 The crack strength does not provide a quantitative measure of fracture resistance that could be used in the design of structures. However, experience with a number of high-strength alloys² has shown that the ratio of the crack strength to the 0.2 % tensile yield strength $\sigma_c / \sigma_{Y S}$ or to the tensile ultimate strength, $\sigma_c / \sigma_{U T}$, can be correlated with $K_{I c} / \sigma_{Y S}$ or with $K_{I c} / \sigma_{U T}$, respectively, where $K_{I c}$ is the plane-strain fracture toughness in accordance with Test Method E 399^{4, 5}. The lower-strength limits of useful correlations established by the presently available data are: for steel $\sigma_{Y S} = 1378$ MPa (200 ksi), for aluminum alloys $\sigma_{Y S} = 275.6$ MPa (40 ksi), and for titanium alloys $\sigma_{Y S} = 826$ MPa (120 ksi). Correlations of this type can be useful for the following purposes:

5.1.1 In research and development of materials, to study the effects of such variables as composition, heat treatment,

¹ This test method is under the jurisdiction of ASTM Committee E-8 on Fracture Testing and is the direct responsibility of Subcommittee E08.02 on Standards and Terminology.

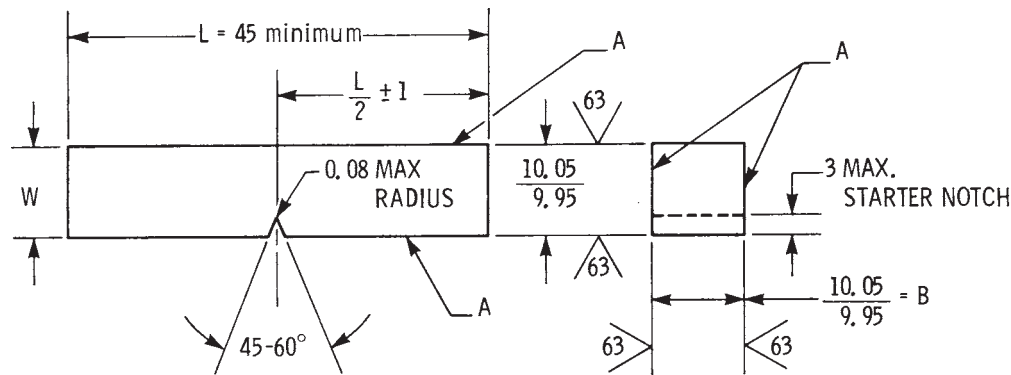
Current edition approved Sept. 15, 1991. Published November 1991. Originally published as E 812 – 81. Last previous edition E 812 – 81 (1986).

² *Annual Book of ASTM Standards*, Vol 03.01.

³ Discontinued 1996; see 1995 *Annual Book of ASTM Standards*, Vol 03.01.

⁴ Succop, G., and Brown, W. F., Jr., "Estimation of $K_{I c}$ from Slow Bend Precracked Charpy Specimen Strength Ratios," *Developments in Fracture Mechanics Test Method Standardization*, ASTM-STP 632, 1977.

⁵ "Rapid Inexpensive Tests for Determining Fracture Toughness," National Materials Advisory Board, National Academy of Sciences, NMAB 328, Washington, DC, 1976.

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NOTE 1—All dimensions are in millimetres.

NOTE 2—A surfaces shall be perpendicular or parallel as applicable to within 0.025 mm TIR.

NOTE 3—Crack starter shall be perpendicular to specimen length and thickness to within $\pm 2^\circ$.

FIG. 1 Dimensions of Precracked Charpy Specimen

mechanical processing, etc., where a ranking of materials in terms of their plane-strain fracture toughness K_{Ic} may be useful.

5.1.2 For specifications of acceptance and manufacturing quality control and for service evaluation to compare the resistance to plane-strain fracture of a number of materials that are otherwise suitable for an application; provided that a “calibration relation” can be established between σ_c and K_{Ic} over a range of toughness of interest.³

5.1.3 The variation of crack strength with testing temperature may be useful in establishing transition temperatures.

5.2 When using the crack strength of any of the preceding purposes, it is important that certain precautions be kept in mind.

5.2.1 The sensitivity of the crack strength to changes in the plane-strain fracture toughness will decrease as the toughness approaches a value sufficient to cause the crack strength to be determined by the plastic limit load. Available data obtained at room temperature for various materials³ indicate that useful sensitivity of σ_c / σ_{YS} to changes in K_{Ic} / σ_{YS} is maintained up to values of σ_c / σ_{YS} of about 2.0. On the average, for high-strength metallic materials, this limitation will correspond to a value of K_{Ic} / σ_{YS} of approximately $0.12 \text{ m}^{1/2}$ ($0.6 \text{ in.}^{1/2}$).

5.2.2 There is no assurance that a calibration relation established for one class of materials will be equally useful for another class of materials or that changes in the processing of a given material will not alter the calibration relation. Therefore, when it is desired to closely estimate K_{Ic} from such a relation, this relation should be carefully established over the range of plane-strain fracture toughness of interest for a particular alloy condition.

5.2.3 Calibration relations should not be extrapolated.

5.2.4 The crack strength of some materials will be sensitive to the rate of loading and loading rates should be confined to the range given in 8.3.2.

5.2.5 The crack strength will be influenced by the testing temperature and calibration relations may change with testing temperature.

6. Apparatus

6.1 *Tension-Testing Machine*, conforming to the requirements of Practices E 4.

6.2 *Bend-Test Fixture*—The procedure involves testing of the specimen in three-point bending. The bend test fixture should provide support rollers that are free to rotate and move apart slightly during loading (for example, see the Test Method E 399 bend test fixture for general principles of design). The nominal span between support rollers shall be 40 mm (1.57 in.). If the diameter of the support rollers is between 7.5 mm (0.30 in.) and 10 mm (0.39 in.) there will be negligible change in span during deformation of the specimen.

6.3 *Temperature Control and Measurement*—For tests at temperatures other than ambient, any suitable means may be used to cool or heat the specimen providing the region including the notched and cracked section can be maintained within $\pm 2^\circ\text{C}$ ($\pm 3.6^\circ\text{F}$) of the desired temperature during the course of the test.

6.3.1 Temperatures shall be measured with calibrated thermocouples used in conjunction with potentiometers or millivoltmeters. Such measurements are subject to various errors particularly at elevated temperatures and reference should be made to Practice E 139 for a discussion of errors encountered in elevated temperature testing.

6.3.2 The temperature-measuring apparatus should be calibrated periodically against standards traceable to the National Bureau of Standards in order to ensure the accuracy specified in 6.3 can be achieved.

6.3.3 The temperature of the specimen during any test other than one at room temperature shall be measured by means of a thermocouple attached near the notched and cracked section. This thermocouple may be spot welded in place, however, the spot weld location should avoid the crack path. Requirements for cooling or heating the specimens prior to testing are discussed in Test Methods E 23 and should be followed in this method. In the case where the specimen and the test fixture is immersed in a liquefied gas maintained at its boiling point, no temperature measurement is required provided exposure