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Standard Practice for Fracture Testing with Surface-Crack Tension Specimens[1]

This standard is issued under the fixed designation E740/E740M; 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 the design, preparation, and testing of surface-crack tension (SCT) specimens. It relates specifically to testing under continuously increasing force and excludes cyclic and sustained loadings. The quantity determined is the residual strength of a specimen having a semielliptical or circular-segment fatigue crack in one surface. This value depends on the crack dimensions and the specimen thickness as well as the characteristics of the material.

1.2 Metallic materials that can be tested are not limited by strength, thickness, or toughness. However, tests of thick specimens of tough materials may require a tension test machine of extremely high capacity. The applicability of this practice to nonmetallic materials has not been determined.

1.3 This practice is limited to specimens having a uniform rectangular cross section in the test section. The test section width and length must be large with respect to the crack length. Crack depth and length should be chosen to suit the ultimate purpose of the test.

1.4 Residual strength may depend strongly upon temperature within a certain range depending upon the characteristics of the material. This practice is suitable for tests at any appropriate temperature.

1.5 Residual strength is believed to be relatively insensitive to loading rate within the range normally used in conventional tension tests. When very low or very high rates of loading are expected in service, the effect of loading rate should be investigated using special procedures that are beyond the scope of this practice.

NOTE 1—Further information on background and need for this type of test is given in the report of ASTM Task Group E24.01.05 on Part-Through-Crack Testing (**1**).[2]

1.6 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.7 *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.*

1.8 *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:*[3]

E4 Practices for Force Calibration and Verification of Testing Machines

E8/E8M Test Methods for Tension Testing of Metallic Materials

E338 Test Method of Sharp-Notch Tension Testing of High-Strength Sheet Materials (Withdrawn 2010)[4]

E399 Test Method for Linear-Elastic Plane-Strain Fracture Toughness of Metallic Materials

E466 Practice for Conducting Force Controlled Constant Amplitude Axial Fatigue Tests of Metallic Materials

E561 Test Method for K_R Curve Determination

E1823 Terminology Relating to Fatigue and Fracture Testing

3. Terminology

3.1 *Definitions:*

3.1.1 Definitions given in Terminology E1823 are applicable to this practice.

3.1.2 *crack mouth opening displacement (CMOD), $2v_m$ (L)*—crack—opening displacement resulting from the total

[1] This practice is under the jurisdiction of ASTM Committee E08 on Fatigue and Fracture and is the direct responsibility of Subcommittee E08.07 on Fracture Mechanics.

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[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

[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.

[4] The last approved version of this historical standard is referenced on www.astm.org.

deformation (elastic plus plastic) measured under force at the location on the crack surface that has the largest displacement per unit force.

NOTE 2—In surface-crack tension (SCT) specimens, CMOD is measured on the specimen surface along the normal bisector of the crack length.

3.1.3 *fracture toughness*—a generic term for measures of resistance to extension of a crack.

3.1.4 *original crack size, a_o [L]*—the physical crack size at the start of testing.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *crack depth, a [L]*—in surface-crack tension (SCT) specimens, the normal distance from the cracked plate surface to the point of maximum penetration of the crack front into the material. Crack depth is a fraction of the specimen thickness.

3.2.1.1 *Discussion*—In this practice, crack depth is the original depth a_o and the subscript *o* is everywhere implied.

3.2.2 *crack length, 2c [L]*—in surface-crack tension specimens, a distance measured on the specimen surface between the two points at which the crack front intersects the specimen surface. Crack length is a fraction of specimen width.

3.2.2.1 *Discussion*—In this practice, crack length is the original length $2c_o$ and the subscript *o* is everywhere implied.

3.2.3 *residual strength, σ_r (FL^{-2})*—the maximum value of the nominal stress, neglecting the area of the crack, that a cracked specimen is capable of sustaining.

NOTE 3—In surface-crack tension (SCT) specimens, residual strength is the ratio of the maximum load (P_{max}) to the product of test section width (W) times thickness (B), $P_{max}/(BW)$. It represents the stress at fracture normal to and remote from the plane of the crack.

4. Significance and Use

4.1 The surface-crack tension (SCT) test is used to estimate the load-carrying capacity of simple sheet- or plate-like structural components having a type of flaw likely to occur in service. The test is also used for research purposes to investigate failure mechanisms of cracks under service conditions.

4.2 The residual strength of an SCT specimen is a function of the crack depth and length and the specimen thickness as well as the characteristics of the material. This relationship is extremely complex and cannot be completely described or characterized at present.

4.2.1 The results of the SCT test are suitable for direct application to design only when the service conditions exactly parallel the test conditions. Some methods for further analysis are suggested in Appendix X1.

4.3 In order that SCT test data can be comparable and reproducible and can be correlated among laboratories, it is essential that uniform SCT testing practices be established.

4.4 The specimen configuration, preparation, and instrumentation described in this practice are generally suitable for cyclic- or sustained-force testing as well. However, certain constraints are peculiar to each of these tests. These are beyond the scope of this practice but are discussed in Ref. (**1**).

5. Apparatus

5.1 The procedure involves testing of specimens that have been precracked in fatigue. force versus CMOD, if CMOD is measured, is recorded autographically or digitally.

5.2 *Fatigue Precracking Apparatus*—Axial tension or three-point, four-point, or cantilever bending are all acceptable modes for fatigue precracking. Fixture design is not critical as long as the crack growth is symmetrical and the plane of the crack remains perpendicular to the specimen face and the tensile force vector. The effect of cyclic frequency is thought to be negligible below 100 Hz in a nonaggressive environment.

NOTE 4—Certain crack shapes are more readily produced in axial tension, others in bending (see Annex A1).

5.2.1 Devices and fixtures for cantilever bending of sheet and plate specimens are described in Refs. (**2**) and (**3**), respectively. Others may be equally suitable. The axial fatigue machines described in Practice E466 are suitable for precracking in tension; however, since the precracking operation is terminated prior to specimen failure, one should ensure that load variations during slowdown or shutdown do not exceed those desired.

5.2.2 A magnifier of about 20 power should be used to monitor the fatigue precracking process. Ease of observation will be enhanced if the cyclic rate can be reduced to about 1 Hz when desired. Alternatively, a stroboscopic light synchronized with the maximum application of tensile force may serve as well.

5.3 *Testing Machine*—The test should be conducted with a tension testing machine that conforms to the requirements of Practices E4.

5.3.1 The devices for transmitting force to the specimen shall be such that the major axis of the specimen coincides with the load axis. The pin-and-clevis arrangement described in Test Method E338 should be suitable for specimens whose width is less than about 4 in. [100 mm]. An arrangement such as that shown in Fig. 2 of Practice E561 should be suitable for wider specimens.

5.3.2 For tests at other than room temperature, the temperature control and temperature measurement requirements of Test Method E338 are appropriate.

5.4 *Displacement Gage (Optional)*—If used to measure CMOD, the displacement gage output should accurately indicate the relative displacement of two gage points on the cracked surface, spanning the crack at the midpoint of its length. Further information on displacement gages appears in Appendix X2.

5.5 For some combinations of material and crack geometry, the crack may propagate entirely through the thickness prior to total failure. Methods of detecting this occurrence, should it be of interest, are discussed briefly in Ref. (**1**).

6. Test Specimen

6.1 *Configuration and Notation*—The SCT test specimen and the notation used herein are shown in Fig. 1. Grip details have been omitted, since grip design may depend on specimen size (5.3.1) and material toughness. In general, the only