Designation: E 1290 – 02

Standard Test Method for Crack-Tip Opening Displacement (CTOD) Fracture Toughness Measurement[1]

This standard is issued under the fixed designation E 1290; 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 test method covers the determination of critical crack-tip opening displacement (CTOD) values at one or more of several crack extension events. These CTOD values can be used as measures of fracture toughness for metallic materials, and are especially appropriate to materials that exhibit a change from ductile to brittle behavior with decreasing temperature. This test method applies specifically to notched specimens sharpened by fatigue cracking. The recommended specimens are three-point bend [SE(B)] compact [C(T)], or arc-shaped bend [A(B)] specimens. The loading rate is slow and influences of environment (other than temperature) are not covered. The specimens are tested under crosshead or clip gage displacement controlled loading.

1.1.1 The recommended specimen thickness, *B*, for the SE(B) and C(T) specimens is that of the material in thicknesses intended for an application. For the A(B) specimen, the recommended depth, *W*, is the wall thickness of the tube or pipe from which the specimen is obtained. Superficial surface machining may be used when desired.

1.1.2 For the recommended three-point bend specimens [SE(B)], width, *W*, is either equal to, or twice, the specimen thickness, *B*, depending upon the application of the test. (See 4.3 for applications of the recommended specimens.) For SE(B) specimens the recommended initial normalized crack size is $0.45 \leq a_o/W \leq 0.70$. The span-to-width ratio (*S*/*W*) is specified as 4.

1.1.3 For the recommended compact specimen [C(T)] the initial normalized crack size is $0.45 \leq a_o/W \leq 0.70$. The half-height-to-width ratio (*H*/*W*) equals 0.6 and the width to thickness ratio *W*/*B* is specified to be 2.

1.1.4 For the recommended arc-shaped bend [A(B)] specimen, *B* is one-half the specimen depth, *W*. The initial normalized crack size is $0.45 < a_o/W < 0.70$. The span to width ratio, *S*/*W*, may be either 3 or 4 depending on the ratio of the inner to outer tube radius. For an inner radius, r_1, to an outer radius, r_2, ratio of > 0.6 to 1.0, a span to width ratio, *S*/*W*, of 4 may be used. For r_1/r_2 *ratios from 0.4 to 0.6, an S/W of 3 may be used.*

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 Machines[2]

E 8 Test Methods for Tension Testing of Metallic Materials[2]

E 399 Test Method for Plane-Strain Fracture Toughness of Metallic Materials[2]

E 646 Test Method for Tensile Strain-Hardening Exponents (n-Values) of Metallic Sheet Materials[2]

E 1820 Test Method for Measurement of Fracture Toughness[2]

E 1823 Terminology Relating to Fatigue and Fracture Testing[2]

3. Terminology

3.1 Terminology E 1823 is applicable to this test method.

3.2 *Definitions:*

3.2.1 *crack tip opening displacement, (CTOD),* $\delta[L]$—the crack displacement due to elastic and plastic deformation at variously defined locations near the original (prior to an application of force) crack tip.

3.2.1.1 *Discussion*—In this test method, CTOD is the displacement of the crack surfaces normal to the original (unloaded) crack plane at the tip of the fatigue precrack, a_o.

In CTOD testing, δ_c[L] is the value of CTOD at the onset of unstable brittle crack extension (see 3.2.13) or pop-in (see 3.2.7) when $\Delta a_p < 0.2$ mm (0.008 in.). The force P_c and the clip gage displacement v_c, for δ_c are indicated in Fig. 1.

In CTOD testing, δ_u[L] is the value of CTOD at the onset of unstable brittle crack extension (see 3.2.13) or pop-in (see 3.2.7) when the event is preceded by $\Delta a_p > 0.2$ mm (0.008 in.). The force P_u and the clip gage displacement v_u, for δ_u are indicated in Fig. 1.

In CTOD testing, δ_m[L] is the value of CTOD at the first attainment

[1] This test method is under the jurisdiction of ASTM Committee E08 on Fatigue and Fracture and is the direct responsibility of Subcommittee E08.08 on Elastic-Plastic Fracture Mechanics Technology.

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

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