Designation: G168 – 17

Standard Practice for Making and Using Precracked Double Beam Stress Corrosion Specimens[1]

This standard is issued under the fixed designation G168; 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 procedures for fabricating, preparing, and using precracked double beam stress corrosion test specimens. This specimen configuration was formerly designated the double cantilever beam (DCB) specimen. Guidelines are given for methods of exposure and inspection.

1.2 The precracked double beam specimen, as described in this practice, is applicable for evaluation of a wide variety of metals exposed to corrosive environments. It is particularly suited to evaluation of products having a highly directional grain structure, such as rolled plate, forgings, and extrusions, when stressed in the short transverse direction.

1.3 The precracked double beam specimen may be stressed in constant displacement by bolt or wedge loading or in constant load by use of proof rings or dead weight loading. The precracked double beam specimen is amenable to exposure to aqueous or other liquid solutions by specimen immersion or by periodic dropwise addition of solution to the crack tip, or exposure to the atmosphere.

1.4 This practice is concerned only with precracked double beam specimen and not with the detailed environmental aspects of stress corrosion testing, which are covered in Practices G35, G36, G37, G41, G44, and G50.

1.5 *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.*

1.6 *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]

D1193 Specification for Reagent Water

E8/E8M Test Methods for Tension Testing of Metallic Materials

E399 Test Method for Linear-Elastic Plane-Strain Fracture Toughness K_{Ic} of Metallic Materials

E1823 Terminology Relating to Fatigue and Fracture Testing

G15 Terminology Relating to Corrosion and Corrosion Testing (Withdrawn 2010)[3]

G35 Practice for Determining the Susceptibility of Stainless Steels and Related Nickel-Chromium-Iron Alloys to Stress-Corrosion Cracking in Polythionic Acids

G36 Practice for Evaluating Stress-Corrosion-Cracking Resistance of Metals and Alloys in a Boiling Magnesium Chloride Solution

G37 Practice for Use of Mattsson's Solution of pH 7.2 to Evaluate the Stress-Corrosion Cracking Susceptibility of Copper-Zinc Alloys

G41 Practice for Determining Cracking Susceptibility of Metals Exposed Under Stress to a Hot Salt Environment

G44 Practice for Exposure of Metals and Alloys by Alternate Immersion in Neutral 3.5 % Sodium Chloride Solution

G49 Practice for Preparation and Use of Direct Tension Stress-Corrosion Test Specimens

G50 Practice for Conducting Atmospheric Corrosion Tests on Metals

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *stress corrosion cracking (SCC) threshold stress intensity, K_{Iscc}*—the stress intensity level below which stress corrosion cracking does not occur for a specific combination of material and environment when plane strain conditions are satisfied.

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[1] This practice is under the jurisdiction of ASTM Committee G01 on Corrosion of Metals and is the direct responsibility of Subcommittee G01.06 on Environmentally Assisted Cracking.

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[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.

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

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

3.1.1.1 *Discussion*—Terms relative to this subject matter can be found in Terminologies G15 and E1823.

4. Summary of Practice

4.1 This practice covers the preparation and testing of precracked double beam specimens for investigating the resistance to SCC (see Terminology G15) of metallic materials in various product forms. Precracking by fatigue loading and by mechanical overload are described. Procedures for stressing specimens in constant displacement with loading bolts are described, and expressions are given for specimen stress intensity and crack mouth opening displacement. Guidance is given for methods of exposure and inspection of precracked double beam specimens.

5. Significance and Use

5.1 Precracked specimens offer the opportunity to use the principles of linear elastic fracture mechanics (**1**)[4] to evaluate resistance to stress corrosion cracking in the presence of a pre-existing crack. This type of evaluation is not included in conventional bent beam, C-ring, U-bend, and tension specimens. The precracked double beam specimen is particularly useful for evaluation of materials that display a strong dependence on grain orientation. Since the specimen dimension in the direction of applied stress is small for the precracked double beam specimen, it can be successfully used to evaluate short transverse stress corrosion cracking of wrought products, such as rolled plate or extrusions. The research applications and analysis of precracked specimens in general, and the precracked double beam specimen in particular, are discussed in Appendix X1.

5.2 The precracked double beam specimen may be stressed in either constant displacement or constant load. Constant displacement specimens stressed by loading bolts or wedges are compact and self-contained. By comparison, constant load specimens stressed with springs (for example, proof rings, discussed in Test Method G49, 7.2.1.2) or by deadweight loading require additional fixtures that remain with the specimen during exposure.

5.3 The recommendations of this practice are based on the results of interlaboratory programs to evaluate precracked specimen test procedures (**2**, **3**) as well as considerable industrial experience with the precracked double beam specimen and other precracked specimen geometries (**4-8**).

6. Interferences

6.1 *Interferences in Testing:*

6.1.1 The accumulation of solid corrosion products or oxide films on the faces of an advancing stress corrosion crack can generate wedge forces that add to the applied load, thereby increasing the effective stress intensity at the crack tip (**6-9**). This self-loading condition caused by corrosion product wedging can accelerate crack growth and can prevent crack arrest from being achieved. The effect of corrosion product wedging on crack growth versus time curve is shown schematically in Fig. 1 (**9**). When wedging forces occur, they can invalidate further results and the test should be ended.

6.1.2 Crack-tip blunting or branching out, or both, of the plane of the precrack can invalidate the test. For valid tests, the crack must remain within ±10° of the centerline of the specimen.

6.1.3 Drying or contamination of the corrodent in the crack during interim measurements of the crack length may affect the cracking behavior during subsequent exposure.

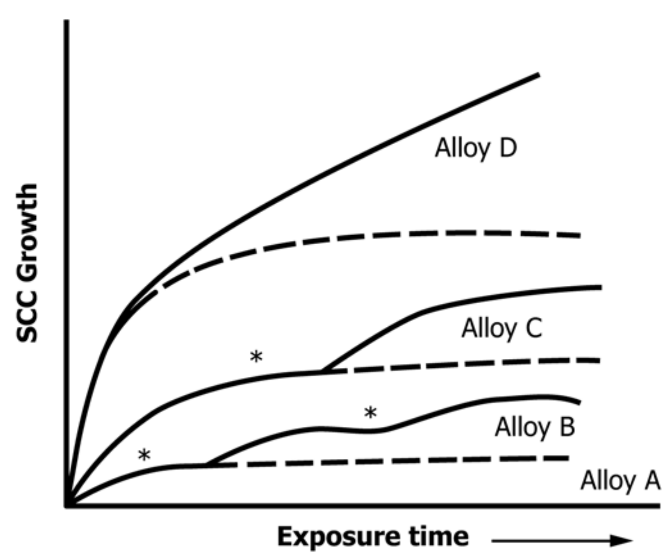
NOTE 1—Do not allow corrodent in the crack to dry during periodic measurements to avoid repassivation at the crack tip and the resulting change in corrosion conditions. Remove one specimen at a time from corrodent. For tests conducted in deaerated test environments or in environments that contain readily oxidizable species or corrosion products, interim crack length examinations may produce changes in the conditions at the crack tip that can, in turn, affect cracking behavior during the subsequent exposure period.

6.2 *Interferences in Visual Crack Length Measurements:*

6.2.1 Corrosion products on the side surfaces of the specimen can interfere with accurate crack length measurements. Corrosion products on these surfaces may be removed by careful scrubbing with a nonmetallic abrasive pad. However, for interim measurements, a minimum area of surface should be cleaned to allow for visual crack length measurements if reexposure is planned.

6.2.2 Measurement on side grooved specimens may be difficult if the advancing crack travels up the side of the groove. This is especially difficult with V-shaped grooves. Adjustment of the direction and intensity of the lighting may highlight the location of the crack tip.

6.2.3 Often the crack length measured at the specimen surface is less than in the interior, due to decreased stress



NOTE 1—Schematic of the influence of corrosion product wedging on SCC growth versus time curves in a decreasing K (constant displacement) test. Solid lines: actually measured curve for case of corrosion product wedging that results in increase in crack growth with time; asterisks indicate temporary crack arrest. Dashed lines: true crack growth curve excluding the effect of corrosion product wedging (**9**).

FIG. 1 Effect of Corrosion Product Wedging on Growth Crack Versus Time Curve

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

triaxiality at the specimen surface. Alternatively, some conditions produce an increase in crack length at the surface due to availability of the corrodent. Ultrasonic methods can be used to obtain interim crack length measurements at the interior of the specimen but not near the specimen surface.

6.2.4 Transport of species in solution in the through-thickness direction can be important for precracked double beam specimens. This may affect measurement of crack length since it can produce curvature of the crack front (that is, variation in crack length from the edge to the center of the specimen).

7. Specimen Size, Configuration, and Preparation

7.1 *Specimen Dimensions and Fabrication:*

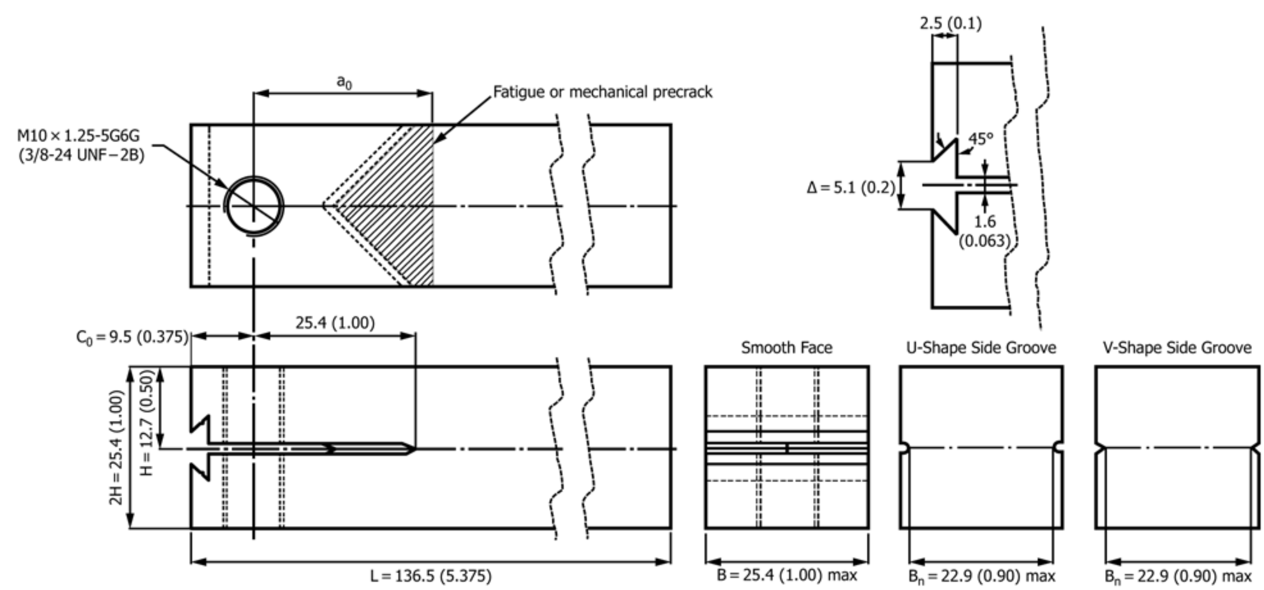
7.1.1 Dimensions for the recommended specimen are given in Figs. 2 and 3. As a general guideline, specimen dimensions should ensure that plane strain conditions are maintained at the crack tip (**1, 10**). While there are no established criteria for ensuring adequate constraint for a plane strain SCC test, some guidelines are given herein regarding specimen dimensions (see 7.1.3).

7.1.2 Specimen machining shall be in accordance with the standards outlined in Test Method E399. The principal considerations in machining are that the sides, top, and bottom of the specimen should be parallel; the machined notch should be centered; and the bolt holes should be aligned and centered. A typical bolt loaded specimen is shown in Fig. 4.

7.1.3 Recommendations for determining the minimum specimen thickness, *B*, which will ensure that plane strain conditions are maintained at the tip of an SCC crack, are discussed in Brown (**1**) and Dorward and Helfrich (**8**). Based on a conservative estimate for plane strain conditions, the minimum specimen thickness shall be calculated as $B \geq 2.5\ (K_{Ic}/\sigma_{YS})^2$, where K_{Ic} is determined per Test Method E399 and σ_{YS} is the 0.2 % offset yield strength in tension per Test Method E8/E8M. For bolt loaded precracked double beam specimens, the thickness, *B*, may also be influenced by the size of the loading bolts and the minimum thickness needed to support the bolt loading.

7.1.4 The specimen half-height, *H*, may be reduced for material under 25 mm (1 in.) thick. The minimum *H* that can be used is constrained by the onset of plastic deformation upon precracking or stresses in the leg of the specimen since this influences the calculation of *K*. Outer fiber stresses shall not exceed the yield strength of the test material during precracking or stressing.

NOTE 2—The effect of notch geometry on specimen compliance and stress intensity solutions, noted in 7.3.4.4, Note 4, 8.1.3, and Note 5, is



NOTE 1—All dimensions in mm (in.). Top and front views are shown for smooth specimen only; side view is shown for both smooth and side grooved configuration.

NOTE 2—For Chevron notch crack starter, cutter tip angle 90° max.

NOTE 3—Radius at notch bottom to be 0.25 mm (0.01 in.) or less.

NOTE 4—Crack starter to be perpendicular to specimen length and thickness to within ±2°.

NOTE 5—Initial COD (Δ) may be increased to 12.7 mm (0.5 in.) to accommodate COD gage.

NOTE 6—All surfaces 32 µin. or better, tolerances not specified ±0.127 (0.005).

NOTE 7—For V-shape side groove, continue with Chevron cutter on surface to machine grooves. For U-shape side groove, machine groove with radius cutting tool such as a ball end mill, size equal to notch height.

NOTE 8—Loading bolt holes shall be perpendicular to specimen center lines within ±5°.

NOTE 9—Center line of holes shall be parallel and perpendicular to specimen surfaces within ±2°.

NOTE 10—Center line of holes shall be coincident within ±0.127 mm (0.005 in.).

NOTE 11—The crack length at the start of the exposure test (a_0) is achieved by fatigue or mechanical precracking. Precracking length shall extend 2.5 to 3.8 mm (0.10 to 0.15 in.) from the tip of the machine notch at the specimen surface, see 7.3.4.3.

FIG. 2 Detailed Machine Drawing for Smooth Face and Side Grooved DCB Specimen