



Standard Guide for Plane Strain Fracture Toughness Testing of Non-Stress Relieved Aluminum Products¹

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1. Scope

1.1 This guide covers supplementary guidelines for plane-strain fracture toughness testing of aluminum products for which complete stress relief is not practicable. Guidelines for recognizing when residual stresses may be significantly biasing test results are presented, as well as methods for minimizing the effects of residual stress during testing. This guide also provides guidelines for correction and interpretation of data produced during the testing of these products. Test Method E399 is the standard test method to be used for plane-strain fracture toughness testing of aluminum alloys.

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:²

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

E561 Test Method for $K-R$ Curve Determination

E1823 Terminology Relating to Fatigue and Fracture Testing

2.2 ANSI Standard:

ANSI H35.1 Alloy and Temper Designations for Aluminum³

2.3 ISO Standard:

ISO 12737 Metallic Materials—Determination of Plane Strain Fracture Toughness⁴

¹ This guide is under the jurisdiction of ASTM Committee B07 on Light Metals and Alloys and is the direct responsibility of Subcommittee B07.05 on Testing.

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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 Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁴ Available from International Organization for Standardization (ISO), 1 rue de Varembe, Case postale 56, CH-1211, Geneva 20, Switzerland, <http://www.iso.ch>.

3. Terminology

3.1 *Definitions*—Terminology in Test Method E399 and Terminology E1823 are applicable herein.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *corrected plane-strain fracture toughness*— a test result, designated K_{Ic} (corrected), which has been corrected for residual stress bias by one of the methods outlined in this guide. The corrected result is an estimation of the K_{Ic} or K_{Ic} that would have been obtained in a residual stress free specimen. The corrected result may be obtained from a test record which yielded either an invalid K_{Ic} or valid K_{Ic} , but for which there is evidence that significant residual stress is present in the test coupon.

3.2.2 *invalid plane-strain fracture toughness*— a test result, designated K_{Ic} , that does not meet one or more validity requirements in Test Method E399 or ISO 12737 and may or may not be significantly influenced by residual stress.

3.2.3 *valid plane-strain fracture toughness*— a test result, designated K_{Ic} , meeting the validity requirements in Test Method E399 or ISO 12737 that may or may not be significantly influenced by residual stress.

4. Significance and Use

4.1 The property K_{Ic} , determined by Test Method E399 or ISO 12737, characterizes a material's resistance to fracture in a neutral environment and in the presence of a sharp crack subjected to an applied opening force or moment within a field of high constraint to lateral plastic flow (plane strain condition). A K_{Ic} value is considered to be a lower limiting value of fracture toughness associated with the plane strain state.

4.1.1 Thermal quenching processes used with precipitation hardened aluminum alloy products can introduce significant residual stresses in the product. Mechanical stress relief procedures (stretching, compression) are commonly used to relieve these residual stresses in products with simple shapes. However, in the case of mill products with thick cross-sections (for example, heavy gage plate or large hand forgings) or complex shapes (for example, closed die forgings, complex open die forgings, stepped extrusions, castings), complete mechanical stress relief is not always possible. In other instances residual stresses may be unintentionally introduced