



Standard Practice for R-Curve Determination¹

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1. Scope

1.1 This practice covers the determination of resistance to fracturing of metallic materials by *R*-curves using either the center-cracked tension panel M(T), the compact specimen C(T), or the crack-line-wedge-loaded specimen C(W), to deliver applied stress intensity factor, *K*, to the material. An *R*-curve is a continuous record of toughness development in terms of *K_R* plotted against crack extension in the material as a crack is driven under a continuously increased stress intensity factor, *K*.

1.2 Materials that can be tested for *R*-curve development are not limited by strength, thickness, or toughness, so long as specimens are of sufficient size to remain predominantly elastic throughout the duration of the test.

1.3 Specimens of standard proportions are required, but size is variable, to be adjusted for yield strength and toughness of the materials.

1.4 Only three of the many possible specimen types that could be used to develop *R*-curves are covered in this practice.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

E 399 Test Method for Plane-Strain Fracture Toughness of Metallic Materials²

E 616 Terminology Relating to Fracture Testing²

E 647 Test Method for Measurement of Fatigue Crack Growth Rates²

3. Terminology

3.1 Definitions:

3.1.1 *crack size, a (L)*—a lineal measure of a principal planar dimension of a crack. This measure is commonly used in the calculation of quantities descriptive of the stress and displacement fields, and is often also termed crack length.

¹ This practice is under the jurisdiction of ASTM Committee E-8 on Fatigue and Fracture and is the direct responsibility of Subcommittee E08.07 on Linear-Elastic Fracture.

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

3.1.1.1 *Discussion*—In practice, the value of *a* is obtained from procedures for measurement of physical crack size, *a_p*, original crack size, *a_o*, and effective crack size, *a_e*, as appropriate to the situation being considered.

3.1.2 *physical crack size, a_p (L)*—the distance from a reference position to the observed crack front. This distance may represent an average from several measurements along the crack front. The reference position depends on the specimen form, and it is normally taken to be either the boundary, or a plane containing either the load line or the centerline of a specimen or plate.

3.1.3 *original crack size, a_o (L)*—the physical crack size at the start of testing.

3.1.4 *effective crack size, a_e (L)*—the physical crack size augmented for the effects of crack-tip plastic deformation.

3.1.4.1 *Discussion*—Sometimes the effective crack size, *a_e*, is calculated from a measured value of a physical crack size, *a_p*, plus a calculated value of a plastic-zone adjustment, *r_y*. A preferred method for calculation of *a_e* compares compliance from the secant of a load-deflection trace with the elastic compliance from a calibration of the specimen.

3.1.5 *plastic-zone adjustment, r_y (L)*—an addition to the physical crack size to account for plastic, crack-tip deformation effects on the linear-elastic stress field.

3.1.5.1 *Discussion*—Commonly the plastic-zone adjustment is given by:

$$r_y = \frac{1}{2\pi} \frac{K^2}{\sigma_y^2}, \text{ for plane-stress mode I, and}$$

$$r_y = \frac{\alpha}{2\pi} \frac{K^2}{\sigma_y^2}, \text{ for plane-strain mode I,}$$

where $\alpha \approx 1/3$ to $1/4$ and σ_y is the effective yield strength.

In this practice, plane-stress mode I is assumed.

3.1.6 *crack extension, Δa (L)*—an increase in crack size.

3.1.6.1 *Discussion*—For example, Δa_p or Δa_e is the difference between the crack size, either *a_p* (physical crack size) or *a_e* (effective crack size), and *a_o* (original crack size).

3.1.7 *stress-intensity factor, K, K₁, K₂, K₃ (FL^{-3/2})*—the magnitude of the ideal-crack-tip stress field (a stress-field singularity) for a particular mode in a homogeneous, linear-elastic body.

3.1.7.1 *Discussion*—Values of *K* for modes 1, 2, and 3 are given by:

$$K_1 = \lim_{r \rightarrow 0} [\sigma_y (2\pi r)^{1/2}],$$