Designation: B771 − 11 (Reapproved 2021)

Standard Test Method for Short Rod Fracture Toughness of Cemented Carbides[1]

This standard is issued under the fixed designation B771; 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 the fracture toughness of cemented carbides (K_{IcSR}) by testing slotted short rod or short bar specimens.

1.2 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

1.3 *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.*

1.4 *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]

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

3. Terminology Definitions

3.1 *stress intensity factor, K_I*, (*dimensional units* $FL^{-3/2}$)—the magnitude of the ideal-crack-tip stress field for mode *1* in a linear-elastic body.

NOTE 1—Values of K for mode l are given by:

$$K_l = \lim_{r \to 0} \left[\sigma_y \sqrt{2\pi r}\right] \quad (1)$$

where:

r = distance directly forward from the crack tip to a location where the significant stress σ_y is calculated, and

σ_y = principal stress normal to the crack plane.

3.2 *Abbreviations:* fracture toughness of cemented carbide, K_{IcSR}, (*dimensional units* $FL^{-3/2}$)—the material-toughness property measured in terms of the stress-intensity factor K_I by the operational procedure specified in this test method.

4. Summary of Test Method

4.1 This test method involves the application of an opening load to the mouth of the short rod or short bar specimen which contains a chevron-shaped slot. Load versus displacement across the slot at the specimen mouth is recorded autographically. As the load is increased, a crack initiates at the point of the chevron slot and slowly advances longitudinally, tending to split the specimen in half. The load goes through a smooth maximum when the width of the crack front is about one third of the specimen diameter (short rod) or breadth (short bar). Thereafter, the load decreases with further crack growth. Two unloading-reloading cycles are performed during the test to measure the effects of any macroscopic residual stresses in the specimen. The fracture toughness is calculated from the maximum load in the test and a residual stress parameter which is evaluated from the unloading-reloading cycles on the test record.

5. Significance and Use

5.1 The property K_{IcSR} determined by this test method is believed to characterize the resistance of a cemented carbide to fracture in a neutral environment in the presence of a sharp crack under severe tensile constraint, such that the state of stress near the crack front approaches tri-tensile plane strain, and the crack-tip plastic region is small compared with the crack size and specimen dimensions in the constraint direction. A K_{IcSR} value is believed to represent a lower limiting value of fracture toughness. This value may be used to estimate the relation between failure stress and defect size when the conditions of high constraint described above would be expected. Background information concerning the basis for

[1] This test method is under the jurisdiction of ASTM Committee B09 on Metal Powders and Metal Powder Products and is the direct responsibility of Subcommittee B09.06 on Cemented Carbides.

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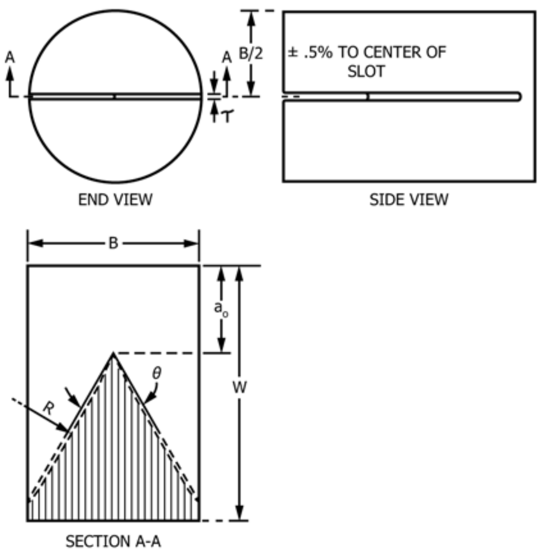
[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.



Standard Dimensions
Short Rod

	(mm)	(in.)
B	= 12.700 ± 0.025	0.500 ± 0.001
W	= 19.050 ± 0.075	0.750 ± 0.003
τ	= 0.381 ± 0.025	0.015 ± 0.001
For Curved Slot Option		
a_o	= 6.350± 0.075	0.250 ± 0.003
θ	= 58.0° ± 0.5°	
R	= 62.23 ± 1.27	02.45 ± 0.05
For Straight Slot Option		
a_o	= 6.744± 0.075	0.266 ± 0.003
θ	= 55.2° ± 0.5°	
R	= ∞	∞

FIG. 1 Short Rod Specimen

development of this test method in terms of linear elastic fracture mechanics may be found in Refs (**1-7**).[3]

5.2 This test method can serve the following purposes:

5.2.1 To establish, in quantitative terms significant to service performance, the effects of fabrication variables on the fracture toughness of new or existing materials, and

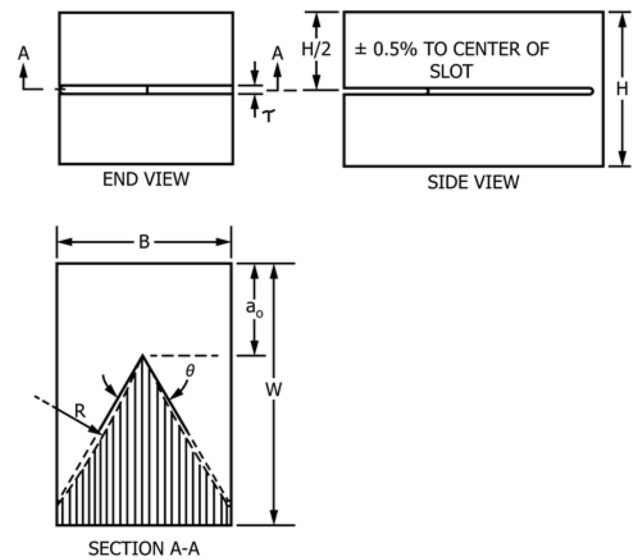
5.2.2 To establish the suitability of a material for a specific application for which the stress conditions are prescribed and for which maximum flaw sizes can be established with confidence.

6. Specimen Configuration, Dimensions, and Preparation

6.1 Both the round short rod specimen and the rectangular shaped short bar specimen are equally acceptable and have been found to have the same calibration (**5**). The short rod dimensions are given in Fig. 1; the short bar in Fig. 2.

6.2 *Grip Slot*—Depending on the apparatus used to test the specimen, a grip slot may be required in the specimen front face, as shown in Fig. 3. The surfaces in the grip slot shall have a smooth ground finish so that the contact with each grip will be along an essentially continuous line along the entire grip slot, rather than at a few isolated points or along a short segment within the grip slot.

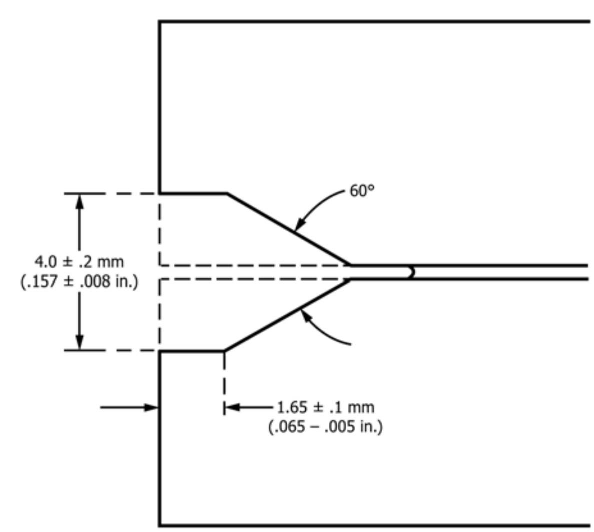
[3] The boldface numbers in parentheses refer to the list of references at the end of this standard.



Standard Dimensions
Short Bar

	(mm)	(in.)
B	= 12.700 ± 0.025	0.500 ± 0.001
H	= 11.050 ± 0.025	0.435 ± 0.001
W	= 19.050 ± 0.075	0.750 ± 0.003
τ	= 0.381± 0.025	0.015 ± 0.001
For Curved Slot Option		
a_o	= 6.350± 0.075	0.250 ± 0.003
θ	= 58.0° ± 0.5°	
R	= 62.23 ± 1.27	2.45 ± 0.05
For Straight Slot Option		
a_o	= 6.744 ± 0.075	0.266 ± 0.003
θ	= 55.2° ± 0.5°	
R	= ∞	∞

FIG. 2 Short Bar Specimen



NOTE 1—The dashed lines show the front face profile of Figs. 1 and 2 without grip slot.

FIG. 3 Short Rod and Short Bar Grip Slot in Specimen Front Face

6.3 *Crack-Guiding Slots*—These may be ground using a diamond abrasive wheel of approximately 124 ± 3 mm (4.9 ± 0.1 in.) diameter, with a thickness of 0.36 ± 0.01 mm (0.0140 ± 0.0005 in.). The resulting slots in the specimen are slightly