



**NATIONAL STANDARD OF THE
PEOPLE'S REPUBLIC OF CHINA**

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**Metallic materials -- Determination of plane-strain fracture
toughness**

(English Translation)

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Table of Contents

Foreword...	4
1 Scope...	6
2 Normative References...	6
3 Terms and Definitions...	6
3.1 Plane-strain stress intensity factor (KI)...	6
3.2 Plane-strain fracture toughness (K _{Ic})...	7
3.3 Crack-plane orientation...	7
3.4 Notch opening displacement (V)...	7
4 Symbols and Designations...	8
5 Principle...	9
6 Apparatus...	10
6.1 Testing machine and force measurement...	10
6.2 Fatigue cracking preparation...	10
6.3 Extensometer...	10
6.4 Testing fixtures...	11
7 Specimen Size, Shape and Preparation...	11
7.1 Specimen size...	11
7.2 Recommended specimen proportions...	12
7.3 Specimen preparation and fatigue precracking...	12
8 Test Program...	13
8.1 Specimen measurement...	13
8.2 Specimen test temperature...	14
8.3 Fixture measurement of bend specimen...	14
8.4 Fracture appearance observation...	14
9 Test Procedures...	15
10 Calculation and Interpretation of Test Results...	15
11 Test Report...	15

1 Scope

This Standard specifies the method for determining the plane-strain fracture toughness of the homogeneous metallic materials using a specimen that is notched and precracked by

fatigue and subjected to slowly increasing crack displacement force.

2 Normative References

The provisions in following documents become the provisions of this Standard through reference in this Standard. For dated references, the subsequent amendments (excluding corrigendum) or revisions do not apply to this Standard, however, parties who reach an agreement based on this Standard are encouraged to study if the latest versions of these documents are applicable. For undated references, the latest edition of the referenced document applies.

GB/T 8170 Rules of Rounding off for Numerical Values

GB/T 12160 Calibration of Extensometers Used in Uniaxial Testing (GB/T 12160:2002, idt ISO 9513:1999)

GB/T 16825.1 Verification of Static Uniaxial Testing Machines - Part 1. Tension/Compression Testing Machines -Verification and Calibration of the Force-Measuring System (GB/T 16825.1-2002, idt ISO 7500-1:1999)

GB/T 20832 Metallic Materials -Designation of Test Specimen Axes in relation to Product Texture (GB/T 20832-2007, ISO 3785-2006, IDT)

3 Terms and Definitions

The following terms and definitions are applicable to this Standard.

3.1 Plane-strain stress intensity factor (K_I)

Magnitude of the elastic stress field at the tip of the crack subjected to opening mode displacement (Mode I).

NOTE 3: For chevron notch. suggested notch root radius 0.025 mm maximum. Notch tip angle 90° maximum, A = C within 0.01W. Fatigue crack shall emerge on both surfaces of specimen.

Figure 2 - Crack Starter Notches and Maximum Permissible Notch/Crack

Envelope

6.1 Testing machine and force measurement

The testing machine shall be calibrated in accordance with GB/T 16825.1 and shall be of at least grade 1. The testing machine shall have provisions for automatic recording of the force applied to the specimen; alternatively, a computer data acquisition system may be used to record force and displacement for subsequent analysis. The combination of force-sensing device and recording system shall permit, so that the force F_Q (as defined in Clause 10) to be determined from the test diagram with the accuracy of $\pm 1\%$.

6.2 Fatigue cracking preparation

When possible, the fatigue machine and force-indicating device shall be calibrated statically in accordance with GB/T 16825 and shall have a grade of at least 2. If the machine cannot be calibrated statically, the error of applied force shall be known to no greater than $\pm 2.5\%$. Careful alignment of the specimen and test device is necessary to encourage straight fatigue cracks. The installment of test device shall be such that the stress distribution is uniform across the specimen thickness and symmetrical about the plane of the prospective crack.

6.3 Extensometer

The extensometer output shall represent the relative displacement of accuracy positions on two sides of the notch mouth. The design of the extensometer and knife edges shall allow free rotation of the points of contact between the extensometer and the knife edges.

The extensometer shall be calibrated in accordance with GB/T 12160, and shall be of at least grade 1; however, calibration shall be performed at least weekly during the time the extensometer is in use. Periodic verification of greater frequency may be required, depending on use and agreement between contractual parties.

Verification of the extensometer shall be performed at the temperature of test to $\pm 5^\circ\text{C}$. The response of the extensometer shall correspond to the calibration apparatus to $\pm$ environmentally-conditioned state. Normally, specimens shall also be machined in this final state. However, for material that cannot be machined in the final condition, the final treatment may be carried out after machining, provided that the required specimen dimensions are met; however, the specimen dimension tolerance, shape and surface roughness shall meet the requirements (see Figures B.1 and C.1), and that full account is taken of the effects of specimen size on metallurgical condition induced by certain heat treatments, e.g. water quenching of steels.

7.3.2 Crack-plane orientation

The fracture toughness of a material is usually dependent on the orientation and direction of propagation of the crack in relation to the principal directions of metal working, grain flow or otherwise-produced texture. Orientation of the crack plane shall be decided before machining (see 7.3.3), identified in accordance with the prescribed coordinate systems (see 3.3) and recorded (see Clause 11).

7.3.3 Machining

Specimen sizes, shapes, dimensional tolerances and surface finishes shall be as given in Figures B.1 and C.1.

7.3.4 Fatigue precracking

Fatigue precracking normally shall be done at room temperature with the specimen in the finally heat-treated, mechanically-worked or environmentally-conditioned state in which it is to be tested. Different fatigue precracking temperatures and intermediate thermal/mechanical/environmental treatments between fatigue precracking and testing shall be used only when such treatments are necessary to simulate the conditions for a specific structural application; and required dimensions and tolerances on specimen size and shape can be maintained. Such fatigue precracking shall be performed according to the requirements of Appendix A.

8.1 Specimen measurement

Measure specimen thickness (B) to the nearest 0.025 mm or to 0.1%, whichever is larger, at not less than three equally spaced positions along the anticipated crack extension path. Take the average of these measurements as the thickness.

Measure specimen width (W) to the nearest 0.025 mm or to 0.1%, whichever is larger, at not less than three positions near the notch location. Take the average of these measurements as the width (W). For the compact tensile specimen, measure the width from the plane of the centerline of the loading pin holes.

average width f of the central flat fracture portion shall be measured between the crack tip and the unflagged edge of the specimen; record the proportion of oblique fracture per unit thickness $(B - f)/B$. (C) type fracture is full oblique fracture.

9 Test Procedures

If a recorder is used, adjust its magnification ratio properly such that the slope of the linear portion of the force-displacement record is between 0.85 and 1.5. Alternatively, if a computer data acquisition system is used, program it to capture enough data to allow the calculations in Clause 10. In either case, the concluding requirement of 6.1 shall be satisfied.

Load the specimen such that the rate of increase of stress intensity is between 0.5 MPam^{1/2}/s and 3.0 MPam^{1/2}/s. Continue the test until the specimen can sustain no further increase in applied force. Record the maximum force (F_{max}).

10 Calculation and Interpretation of Test Results

If a recorder is used, the conditional value F_Q shall be determined as follows. Draw the secant line OF₅ (see Figure 4) from the point O with slope $(F/V)_5 = 0.95 (F/V)_0$, where $(F/V)_0$ is the slope of the tangent OA to the linear portion of the record. The force F_Q is then defined as follows. if the force at every point on the record which precedes F_5 is lower