SLOVENSKI STANDARD
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Metallic materials - Determination of plane-strain fracture toughness (ISO 12737:1996)

Metallic materials - Determination of plane-strain fracture toughness (ISO 12737:1996)

Metallische Werkstoffe - Bestimmung der Bruchzähigkeit (ebener Dehnungszustand) (ISO 12737:1996)

Matériaux métalliques - Détermination du facteur d'intensité de contrainte critique (ISO 12737:1996)

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Central Secretariat: rue de Stassart, 36 B-1050 Brussels

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Foreword

The text of the International Standard from Technical Committee ISO/TC 164 "Mechanical testing of metals" of the International Organization for Standardization (ISO) has been taken over as an European Standard by CEN/CS.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 1999, and conflicting national standards shall be withdrawn at the latest by August 1999.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Endorsement notice

The text of the International Standard ISO 12737:1996 has been approved by CEN as a European Standard without any modification.

INTERNATIONAL STANDARD

ISO 12737

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Metallic materials — Determination of plane-strain fracture toughness

Matériaux métalliques — Détermination du facteur d'intensité de contrainte critique

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 12737 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 4, *Toughness testing*.

Annexes A to C form an integral part of this International Standard. Annexes D and E are for information only.

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Metallic materials — Determination of plane-strain fracture toughness

1 Scope

This International Standard specifies the method for determining the plane-strain fracture toughness of 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 following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 7500-1:1986, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tensile testing machines.*

ISO 9513:1989, *Metallic materials — Verification of extensometers used in uniaxial testing.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 plane-strain stress intensity factor, K_I: Magnitude of the elastic stress field at the tip of a crack subjected to opening mode displacement (mode I). It is a function of applied force and test specimen size, geometry, and crack length, and has the dimensions of force times length$^{-3/2}$.

3.2 plane-strain fracture toughness, K_{Ic}: Measure, by the operational procedure of this method, of a material's resistance to crack extension when the state of stress near the crack tip is predominantly plane strain and plastic deformation is limited.

NOTE — It is the critical value of K_I at which significant crack extension occurs on increasing load with high constraint to plastic deformation.

3.3 crack plane orientation: Method for relating the plane and direction of crack extension to the characteristic directions of the product.

NOTE — A hyphenated code is used wherein the letter(s) preceding the hyphen represent(s) the direction normal to the crack plane and the letter(s) following the hyphen represent(s) the anticipated direction of crack extension (see figure 1). For wrought metals, the letter X always denotes the principal direction of grain flow, Z the direction of principal working force, and Y the direction normal to the X-Z plane. If specimen directions do not coincide with the product's characteristic directions, then two letters are used to denote the normal to the crack plane and/or the expected direction of crack extension [see figure 1 b)]. If there is no grain flow direction (as in a casting), reference axes may be arbitrarily assigned but must be clearly identified.

3.4 notch opening displacement, V**:** Displacement measured at or near the notch mouth.

4 Symbols and designations

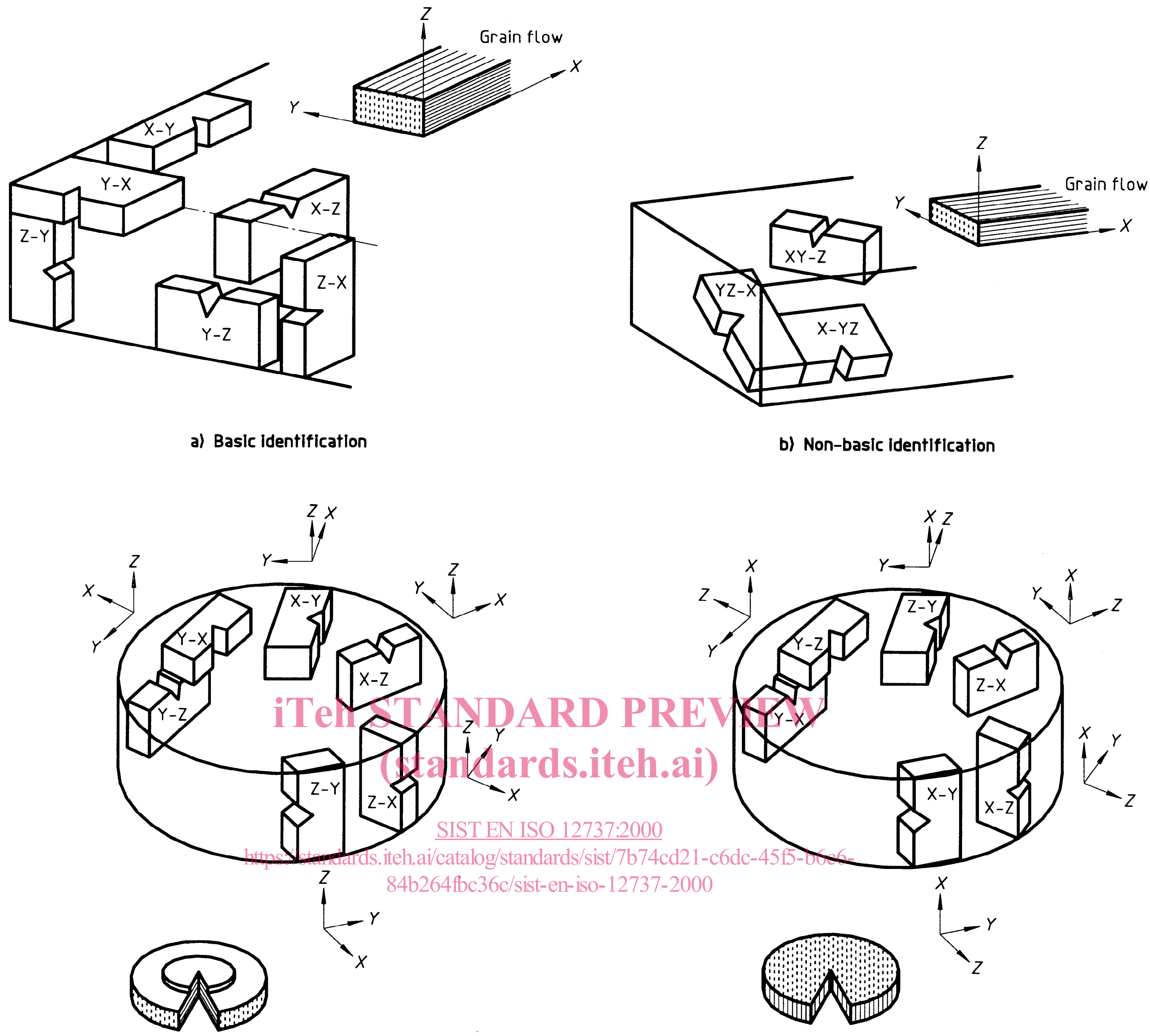
For the purposes of this International Standard the following symbols apply (see also figures 1, 2 and 4).

Symbol	Unit	Designation
a	mm	Crack length
B	mm	Specimen thickness
E	MPa	Young's modulus
F	kN	Applied force
F_Q	kN	Particular value of F (see figure 4)
F_5	kN	Particular value of F (see figure 4)
K_f	$MPa \cdot m^{1/2}$ 1)	Maximum stress intensity factor during the final stage of fatigue cracking
K_Q	$MPa \cdot m^{1/2}$	Provisional value of K_{Ic}
K_I	$MPa \cdot m^{1/2}$	Opening mode stress intensity factor (mode I)
K_{Ic}	$MPa \cdot m^{1/2}$	Critical value of K_I (plane-strain fracture toughness)
R	—	Ratio of minimum to maximum fatigue cracking force during any single cycle of fatigue operation
$R_{p0,2}$	MPa	0,2 % offset yield strength
S	mm	Span between outer loading points
V	mm	Notch opening displacement
W	mm	Width for bend specimen or effective width for compact specimen
ΔK_I	$MPa \cdot m^{1/2}$	Difference between maximum and minimum values of K_I during any single cycle of fatigue operation

1) $0{,}031\,6\ MPa \cdot m^{1/2} = 1\ N \cdot mm^{-3/2} = 0{,}031\,6\ MN \cdot m^{-3/2}$

5 Principle

This method covers the determination of the plane strain fracture toughness (K_{Ic}) of metallic materials by increasing-force tests of fatigue-precracked test specimens. Details of the test specimens and experimental procedures are given in annexes B and C. Force versus notch opening displacement is recorded autographically, or converted to digital form for accumulation in a computer information storage facility and subsequent processing. The force corresponding to 2 % apparent crack extension is established by a specified deviation from the linear portion of the test record. If certain validity requirements are satisfied, the value of K_{Ic} is calculated from this force.



a) Basic identification

b) Non-basic identification

c) Radial grain flow, axial working direction

d) Axial grain flow, radial working direction

Figure 1 — Crack plane identification

The property K_{Ic} characterizes the resistance of a material to fracture in the presence of a sharp crack under severe tensile constraint, such that

a) the state of stress near the crack front approaches plane strain; and

b) the crack-tip plastic zone is small compared to the crack size, specimen thickness, and ligament ahead of the crack.

K_{Ic} is believed to represent a lower limiting value of fracture toughness in the environment and at the temperature of test.

Cyclic or sustained loads can cause crack extension at K_I values less than K_{Ic}. Crack extension under cyclic or sustained loads can be influenced by temperature and environment. Therefore when K_{Ic} is applied to the design of service components, differences between laboratory test and field conditions should be considered.