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Fracture mechanics toughness tests —

Part 1: Method for determination of K_{Ic}, critical CTOD and critical J values of metallic materials

ICS 77.040.10

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Iron and Steel Standards Policy Committee (ISM/-) and the Non-ferrous Metals Standards Policy Committee (NFM/-) to Technical Committee ISM/NFM/4, upon which the following bodies were represented:

Aluminium Federation
British Gas plc
British Non-ferrous Metals Federation
British Railways Board
British Steel Industry
Copper Development Association
Department of Trade and Industry (National Engineering Laboratory)
Department of Trade and Industry (National Measurement Accreditation Service)
Department of Trade and Industry (National Physical Laboratory)
ERA Technology Ltd.
GAMBICA (BEAMA Ltd.)
Ministry of Defence
Society of British Aerospace Companies Limited
Welding Institute

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

BCIRA
BEAMA Ltd.
Electricity Supply Industry in United Kingdom
Lloyd's Register of Shipping
Steel Casting Research and Trade Association
United Kingdom Atomic Energy Authority

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Foreword

This part of BS 7448 has been published under the direction of the Iron and Steel and the Non-ferrous Metals Standards Policy Committees.

It gives a method for determining plane strain fracture toughness (K_{Ic}), critical crack tip opening displacement (CTOD)[1] and critical J fracture toughness values for metallic materials under displacement controlled monotonic loading at quasistatic rates.

This part of BS 7448 combines and extends the methods for determining K_{Ic} values, given in BS 5447, and the method for determining crack opening displacement (COD), given in BS 5762:1979, BS 5447:1977 and BS 5762:1979 are withdrawn.

Determination of K_{Ic} for materials and conditions for which it is appropriate to determine fracture toughness in terms of K_{Ic} alone are covered in BS EN ISO 12737. General determinations of fracture toughness, where the fracture behaviour determines the relevant fracture parameters (e.g. K_{Ic}, CTOD or J) are covered in the procedures in this part of BS 7448, BS 7448-2 and BS 7448-4.

The other three parts of BS 7448 are as follows:

— *Part 2: Method for determination of K_{Ic}, critical CTOD or J values of welds in metallic materials;*

— *Part 3: Method for determination of dynamic toughness*[2]*;*

— *Part 4: Method for determination of fracture resistance curves and initiation values for stable crack extension in metallic materials.*

It has been assumed in the drafting of this standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

Safety note. It is important to note that tests of the type described involve the use of large forces, and may involve the rapid movement of machine parts and fractured test specimens. Therefore it is important to consider the safety of machine operators.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 40, an inside back cover and a back cover.

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[1] In this British Standard the term CTOD, which refers to crack tip opening displacement, is synonymous with the term COD in BS 5762.
[2] In preparation.

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1 Scope

This part of BS 7448 specifies a method for determining the opening mode plane strain fracture toughness (K_{Ic}), the critical crack tip opening displacement (CTOD) fracture toughness, and the critical J fracture toughness of metallic materials. The method uses fatigue precracked specimens. These are tested in displacement controlled monotonic loading at a constant rate of increase in stress intensity factor within the range 0.5 MPa·m$^{0.5}$s^{-1} to 3.0 MPa·m$^{0.5}$s^{-1} [3] during the initial elastic deformation. The specimens are loaded to fracture or the maximum force associated with plastic collapse. The method is especially appropriate to materials that exhibit a change from ductile to brittle behaviour with decreasing temperature. No other influences of environment are covered.

The definition of fracture toughness values relevant to particular structural integrity assessments is outside the scope of this British Standard.

NOTE 1 The titles of the publications referred to in this standard are listed on the inside back cover.

NOTE 2 Numbers in square brackets in the text refer to numbered items in the Bibliography in Appendix A.

NOTE 3 This British Standard does not cover the determination of K_{Ic} alone. Such determinations are covered in BS EN ISO 12737.

2 Definitions

For the purposes of this part of BS 7448 the following definitions apply.

2.1
stress intensity factor (K)
the magnitude of the stress field near the crack tip (a stress-field singularity) for a particular mode (see **2.2**) in a homogeneous, ideally linear-elastic body

NOTE It is a function of applied force, crack length and specimen geometry, and is expressed in units of MPa·m$^{0.5}$.

2.2
opening mode
opening displacement of the surfaces of a crack in a direction normal to the original (undeformed) crack plane near the crack tip

2.3
plane strain fracture toughness (K_{Ic})
a measure of a material's resistance to crack extension when the stress state near the crack tip is predominantly plane strain, plastic deformation is limited, and opening mode monotonic loading is applied

2.4
maximum fatigue stress intensity factor (K_f)
the maximum value of opening mode stress intensity factor which is applied during the final stages of fatigue crack extension

2.5
crack tip opening displacement (CTOD)
the displacement of the surfaces of a crack normal to the original (undeformed) crack plane at the tip of the fatigue precrack, expressed in mm

2.6
critical CTOD
a value of CTOD associated with a particular type of crack extension (see clause **3**)

2.7
***J*-integral**
a mathematical expression for a line or surface integral that encloses the crack front from one crack surface to the other, used to characterize the local stress-strain field around the crack front [1], expressed in J/mm^2 [4]

[3] 0.031 6 MPa·m$^{0.5}$ = 1 N·mm$^{-1.5}$ = 0.031 6 MN·m$^{-1.5}$.
[4] 1 J/mm^2 = 1 MJ/m^2.