
**Metallic materials — Steel — Method
of test for the determination of
brittle crack arrest toughness, K_{ca}**

*Matériaux métalliques — Acier — Méthode d'essai pour déterminer
la ténacité à la rupture fragile, K_{ca}*

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 4, *Fatigue, fracture and toughness testing*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

This document provides a test method for determining the crack arrest toughness of steels. Experimental methods of crack propagation and arrest are documented in Reference [1]. Among these, ASTM E1221 [2] is a test method to evaluate lower bound crack arrest toughness, K_{Ia} , under plane strain conditions. On the other hand, crack arrest testing methods using wide plates were developed in the 1950s [3] and have been used for assessing the crack arrest capabilities of cryogenic tanks [3] and pressure vessels [4][5][6]. In recent years, these methods have been extensively used for evaluating the crack arrest toughness of ship steels [7].

The wide plate crack arrest test is intended to evaluate the arrest toughness, K_{ca} , of steel plate at its thickness of actual use and not the lower bound arrest toughness, K_{Ia} . However, the relationship between the two arrest toughness values has been investigated [4][6]. It was shown that K_{Ia} and K_{ca} values agreed at lower bound of K_{ca} . Moreover, the wide plate crack arrest tests were shown to evaluate the arrest toughness at a higher temperature range at which K_{Ia} evaluation is impossible. The theoretical background of crack arrest toughness testing with a temperature gradient is described in References [8] and [9].

This document provides a test method for the determination of brittle crack arrest toughness of steel by using wide plates with a temperature gradient.

The test method can be summarized as follows: after setting a temperature gradient across the width of a test piece and applying uniform stress to the test piece, the test piece is struck to initiate a brittle crack from a mechanical notch in either edge of the test piece and cause crack arrest after propagating in the width direction (temperature gradient type arrest testing). [Annex A](#) describes typical devices and a method of setting the temperature gradient on the piece. Using the stress intensity factor, the arrest toughness, K_{ca} , is calculated from the applied stress and the arrest crack length. This value is the arrest toughness at the temperature at the point of crack arrest (arrest temperature). To determine K_{ca} at a specific temperature, such as the design temperature of a structure, the method specified in [Annex B](#) is applicable.

The method described in [Annex C](#) can be used to determine the stress intensity factor for a curved crack, in order to check the validity of a crack propagation path.

As a method for initiating a brittle crack, a secondary loading mechanism can be used (see [Annex D](#)). The arrest characteristics of the test piece can also be evaluated by welding a crack starter plate to the test plate in the width direction to enable a brittle crack initiated from the mechanical notch at the edge of the test piece to propagate in the crack running plate and observing the propagation behaviour of the crack immediately after entering the test plate (see [Annex E](#)).

The method explained in [Annex F](#) can be used to determine the dynamic behaviour of crack propagation and measure the dynamic strain of a test piece.

Metallic materials — Steel — Method of test for the determination of brittle crack arrest toughness, K_{ca}

1 Scope

This document specifies a test method for the determination of brittle crack arrest toughness.

It is applicable to ferritic steel base metals exhibiting ductile to brittle transition behaviour. Applicable materials are rolled steel plates. It is intended for materials with a tensile strength of 950 MPa or less and a test piece thickness of 200 mm or less. The range of arrest temperatures is between $-196\text{ }^{\circ}\text{C}$ and $+100\text{ }^{\circ}\text{C}$. This document can be applied to flat rolled steel plates but not to flattened steel pipes because the flattening can cause changes in arrest toughness.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at <https://www.iso.org/obp>

— IEC Electropedia: available at <http://www.electropedia.org/>

3.1

brittle fracture

fracture with predominantly cleavage

3.2

arrest

sudden halt of a propagating *brittle crack* (3.4)

3.3

arrest toughness

materials resistance against *brittle crack* (3.4) propagation expressed in terms of stress intensity factor

3.4

brittle crack

crack propagating at approximately 300 m/s or more due to a *brittle fracture* (3.1)

3.5

arrest temperature

temperature at the point where a *brittle crack* (3.4) is arrested in the temperature gradient type *arrest toughness* (3.3) test