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Metallic materials — Fatigue testing — Fatigue crack growth method

Matériaux métalliques — Essais de fatigue — Méthode d'essai de propagation de fissure en fatigue

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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.

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on 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 the following URL: 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.

This third edition cancels and replaces the second edition (ISO 12108:2012), which has been technically revised. The main changes compared to the previous edition are as follows:

— The document has been reorganized to move the formulae and drawings for each of the test specimens from the main body of the document into a separate normative annex for each specimen.

— Guidance on the effects of residual stress on fatigue crack growth rate data has been expanded.

Introduction

This document is intended to provide specifications for generation of fatigue crack growth rate data. Test results are expressed in terms of the fatigue crack growth rate as a function of crack-tip stress-intensity factor range, Δ*K*, as defined by the theory of linear elastic fracture mechanics[15][16][17][18][19][20]. Expressed in these terms, the results characterize a material's resistance to subcritical crack extension under cyclic force test conditions. This resistance is independent of specimen planar geometry and thickness, within the limitations specified in Clause 6.

This document describes a method of subjecting a precracked notched specimen to a cyclic force. The crack length, *a*, is measured as a function of the number of elapsed force cycles, *N*. From the collected crack length and corresponding force cycles relationship, the fatigue crack growth rate, d*a*/d*N*, is determined and is expressed as a function of stress-intensity factor range, Δ*K*.

Materials that can be tested by this method are limited by size, thickness and strength only to the extent that the material remains predominantly in an elastic condition during testing and that buckling is precluded.

Specimen size can vary over a wide range. Proportional planar dimensions for six standard configurations are presented. The choice of a particular specimen configuration can be dictated by the actual component geometry, compression test conditions or suitability for a particular test environment.

Specimen size is a variable that is subjective to the test material's 0,2 % proof strength and the maximum stress-intensity factor applied during test. Specimen thickness can vary independently of the planar size, within defined limits, so long as large-scale yielding is precluded and out-of-plane distortion or buckling is not encountered. Any alternate specimen configuration other than those included in this document can be used, provided there exists an established stress-intensity factor calibration expression, i.e. stress-intensity factor geometry function, *g* (*a*/*W*)[21][22][23].

Residual stresses[24][25], crack closure[26][27], specimen thickness, cyclic waveform, frequency and environment, including temperature, can markedly affect the fatigue crack growth data but are in no way reflected in the computation of Δ*K*, and so should be recognized in the interpretation of the test results and be included as part of the test report. All other demarcations from this method should be noted as exceptions to this practice in the final report.

For crack growth rates above 10^{-5} mm/cycle, the typical scatter in test results generated in a single laboratory for a given Δ*K* can be in the order of a factor of two[28]. For crack growth rates below 10^{-5} mm/cycle, the scatter in the d*a*/d*N* calculation can increase to a factor of 5 or more. To ensure the correct description of the material's d*a*/d*N* versus Δ*K* behaviour, a replicate test conducted with the same test parameters is highly recommended.

Service conditions can exist where varying Δ*K* under conditions of constant K_{max} or K_{mean} control[29] can be more representative than data generated under conditions of constant force ratio; however, these alternate test procedures are beyond the scope of this document.

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WARNING — This document does not address safety or health concerns, should such issues exist, that can be associated with its use or application. The user of this document has the sole responsibility to establish any appropriate safety and health concerns.

1 Scope

This document describes tests for determining the fatigue crack growth rate from the fatigue crack growth threshold stress-intensity factor range, ΔK_{th}, to the onset of rapid, unstable fracture.

This document is primarily intended for use in evaluating isotropic metallic materials under predominantly linear-elastic stress conditions and with force applied only perpendicular to the crack plane (mode I stress condition), and with a constant force ratio, R.

2 Normative references

There are no normative references in this document.

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
crack length
a
crack size
linear measure of a principal planar dimension of a crack from a reference plane to the crack tip

3.2
cycle
smallest segment of a force-time or stress-time function which is repeated periodically

Note 1 to entry: The terms “fatigue cycle”, “force cycle” and “stress cycle” are used interchangeably. The letter N is used to represent the number of elapsed cycles.

3.3
fatigue crack growth rate
$\mathrm{d}a/\mathrm{d}N$
extension in crack length

3.4
maximum force
F_{max}
force having the highest algebraic value in the cycle, a tensile force being positive and a compressive force being negative