ISO 12135:2021 (E)

Metallic materials — Unified method of test for the determination of quasistatic fracture toughness

Contents

Foreword

1 Scope

2 Normative references

3 Terms and definitions

4 Symbols and abbreviated terms

5 General requirements

5.1 General
5.2 Fracture parameters
5.3 Fracture toughness symbols
5.4 Test specimens
5.4.1 Specimen configuration and size
5.4.2 Specimen preparation
5.4.2.1 Material condition
5.4.2.2 Crack plane orientation
5.4.2.3 Machining
5.4.2.4 Fatigue precracking
5.4.2.4.1 General
5.4.2.4.2 Equipment and fixtures
5.4.2.4.3 Bend specimens
5.4.2.4.4 Compact specimens
5.4.2.5 Side grooving
5.5 Pre-test requirements
5.5.1 Pre-test measurements
5.5.2 Crack shape/length requirements
5.6 Test apparatus
5.6.1 Calibration
5.6.2 Force application
5.6.3 Displacement measurement
5.6.4 Test fixtures
5.7 Test requirements
5.7.1 Three-point bend testing
5.7.1.1 Specimen fixture alignment
5.7.1.2 Crack-tip opening displacement
5.7.1.3 J-integral
5.7.2 Compact tension testing
5.7.2.1 Specimen and fixture alignment
5.7.2.2 Crack-tip opening displacement
5.7.2.3 J-integral
5.7.3 Specimen test temperature
5.7.4 Recording
5.7.5 Testing rates
5.7.6 Test analyses
5.8 Post-test crack measurements
5.8.1 General
5.8.2 Initial crack length, a0
5.8.3 Stable crack extension, Δa
5.8.4 Unstable crack extension

6 Determination of fracture toughness for stable and unstable crack extension

6.1 General
6.2 Determination of plane strain fracture toughness, Klc
6.2.1 General
6.2.2 Interpretation of the test record for FQ
6.2.3 Calculation of KQ
6.2.4 Qualification of KQ as Klc
6.3 Determination of fracture toughness in terms of δ
6.3.1 Determination of Fc and Vc, Fu and Vu, or Fuc and Vuc
6.3.2 Determination of Fm and Vm
6.3.3 Determination of Vp
6.3.4 Calculation of δ0
6.3.5 Qualification of δ0 fracture toughness value
6.4 Determination of fracture toughness in terms of J
6.4.1 Determination of Fc and Vc or qc, Fu and Vu or qu, or Fuc and Vuc or quc
6.4.2 Determination of Fm and qm
6.4.3 Determination of Up
6.4.4 Calculation of J0
6.4.5 Qualification of J0 fracture toughness value

7 Determination of resistance curves δ-Δa and J-Δa and initiation toughness δ0,2BL and J0,2BL and δi and Ji for stable crack extension

7.1 General
7.2 Test procedure
7.2.1 General
7.2.2 Multiple-specimen procedure
7.2.3 Single-specimen procedure
7.2.4 Final crack front straightness
7.3 Calculation of J and δ
7.3.1 Calculation of J
7.3.2 Calculation of δ
7.4 R-curve plot
7.4.1 Plot construction
7.4.2 Data spacing and curve fitting
7.5 Qualification of resistance curves
7.5.1 Qualification of J-Δa resistance curves
7.5.1.1 Jmax is calculated for each specimen as the smallest of:
7.5.2 Qualification of δ−Δa resistance curves
7.6 Determination and qualification of J0,2BL and δ0,2BL
7.6.1 Determination of J0,2BL
7.6.2 Determination of δ0,2BL
7.7 Determination of initiation toughness Ji and δi by scanning electron microscopy (SEM)

8 Test report

8.1 Organization
8.2 Specimen, material and test environment
8.2.1 Specimen description
8.2.2 Specimen dimensions
8.2.3 Material description
8.2.4 Additional dimensions
8.2.5 Test environment
8.2.6 Fatigue precracking conditions
8.3 Test data qualification
8.3.1 Limitations
8.3.2 Crack length measurements
8.3.3 Fracture surface appearance
8.3.4 Pop-in
8.3.5 Resistance curves
8.3.6 Checklist for data qualification
8.4 Qualification of Klc
8.5 Qualification of δc(B), δu(B), δuc(B) or δm(B)
8.6 Qualification of Jc(B), Ju(B), Juc(B) or Jm(B)
8.7 Qualification of the δ-R Curve

8.8 Qualification of the J-R Curve
8.9 Qualification of δ0,2BL(B) as δ0,2BL
8.10 Qualification of J0,2BL(B) as J0,2BL

Annex A (informative) Determination of δi and Ji

A.1 General
A.2 Critical stretch zone width (SZW) measurement
A.3 Determination of δi
A.4 Determination of Ji

Annex B (normative) Crack plane orientation

Annex C (informative) Example test reports

C.1 Specimen, material and test environment
C.2 Data qualification
C.3 Resistance curve data
C.4 Qualification of KQ as KIc
C.5 Qualification of δc(B), δu(B), δuc(B) or δm(B)
C.6 Qualification of Jc(B), Ju(B), Juc(B) or Jm(B)
C.7 Qualification of δ-R curve
C.8 Qualification of J-R curve
C.9 Qualification of δQ0,2BL(B) as δ0,2BL
C.10 Qualification of JQ0,2BL as J0,2BL

Annex D (informative) Stress intensity factor coefficients and compliance relationships

D.1 Stress intensity factor coefficients
D.1.1 Three-point bend specimens
D.1.2 Compact specimens
D.2 Elastic compliance relationship
D.2.1 Three-point bend specimens instrumented for measurement of force F versus crack-mouth opening displacement VM1
D.2.2 Compact specimens instrumented for measurement of F versus crack-mouth opening displacement VM2
D.2.3 Three-point bend specimens instrumented for measurement of F versus load-line displacement qe1
D.2.4 Compact specimens instrumented for measurement of F versus load-line displacement qe2

Annex E (informative) Measurement of load-line displacement q in the three#point bend test

Annex F (informative) Derivation of pop-in formulae

Annex G (informative) Analytical methods for the determination of Vp and Up

G.1 General
G.2 Plastic displacement, Vp
G.3 Plastic area, Up

Annex H (informative) Guidelines for single-specimen methods

H.1 General
H.2 Unloading compliance technique
H.3 Test recommendations
H.3.1 Compliance measurement
H.3.2 Digital signal resolution
H.3.3 Autographic signal resolution
H.4 Procedure
H.4.1 Precycling
H.4.2 Loading rate
H.4.3 Crack length measurements
H.4.4 Termination of test
H.5 Crack length calculation
H.5.1 Bend specimen: Crack-mouth opening displacement (CMOD) measured at the specimen surface
H.5.2 Bend specimen: Compliance based on load-point displacement
H.5.3 Compact specimens

H.5.4 Rotation correction for compact specimens
H.6 Resistance to crack extension
H.6.1 General
H.6.2 Estimated initial crack length
H.6.3 Estimated crack extension
H.6.4 Resistance curves
H.7 Electrical potential techniques
H.7.1 AC potential method
H.7.2 Interpretation of test records
H.8 DC potential methods
H.8.1 Method 1
H.8.1.1 Procedure
H.8.1.2 Interpretation of test records
H.8.2 Method 2
H.8.2.1 Procedure
H.8.2.2 Interpretation of test records

Annex I (normative) Power-law fits to crack extension data (see Reference [42])

Page count: 100