

BS 8571:2014



BSI Standards Publication

Method of test for determination of fracture toughness in metallic materials using single edge notched tension (SENT) specimens

bsi.

...making excellence a habit.
AVA Documents™
Document Sharing Hub

Publishing and copyright information

The BSI copyright notice displayed in this document indicates when the document was last issued.

© The British Standards Institution 2014

Published by BSI Standards Limited 2014

ISBN 978 0 580 74928 5

ICS 25.160.40

The following BSI references relate to the work on this document:

Committee reference ISE/101

Draft for comment 14/30291891 DC

Publication history

First published December 2014

Amendments issued since publication

Date	Text affected
------	---------------

Contents

Foreword *ii*

1	Scope	1
2	Normative references	1
3	Terms, definitions and symbols	1
4	Principle	2
5	Test sample and test specimen preparation	3
6	Test procedure	9
7	Determination of resistance curves δ - Δa and J - Δa	11
8	Determination of single point fracture toughness	18
9	Test data qualification	19

Annexes

Annex A (informative)	Example calculation of J for SENTs	20
-----------------------	--------------------------------------	----

Bibliography	21
--------------	----

List of figures

Figure 1	Flowchart showing how to use the standard	4
Figure 2	SENT test specimen configuration	5
Figure 3	W/B ratios in SENT test specimens	6
Figure 4	Machining tolerances and surface finish for a SENT specimen	7
Figure 5	Crack plane orientation code for fracture toughness specimens of parent metal and weld metal	8
Figure 6	Example knife edges and notch geometries	10
Figure 7	Determination of U_p , V_p and V_e	13
Figure 8	Determination of CTOD (δ) from the double clip gauge arrangement	17
Figure 9	Fitting the R-curve to the SENT crack extension data	18

List of tables

Table 1	Values of constants n_i , m_i , q_i and r_i	14
---------	---	----

Summary of pages

This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 22, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 1 December 2014. It was prepared by Subcommittee ISE/101/4, *Toughness testing*, under the authority of Technical Committee ISE/101, *Test methods for metals*. A list of organizations represented on these committees can be obtained on request to their secretary.

Information about this document

This standard has been developed primarily to meet the needs of the steel pipeline industry where this method has been used to determine the fracture toughness of girth welds experiencing plastic straining during installation.

Hazard warnings

WARNING. This British Standard calls for the use of substances and/or procedures that can be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

Use of this document

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its methods are expressed as a set of instructions, a description, or in sentences in which the principal auxiliary verb is “shall”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This British Standard gives methods for determining fracture toughness in metallic materials in terms of δ (crack tip opening displacement, CTOD) and J (experimental equivalent of the J -integral) using single edge notched tension (SENT) specimens.

This British Standard gives a method for determining fracture toughness as a resistance to ductile crack extension (R-curve). A method for single point determination of fracture toughness is also given. The method uses specimens which have been notched and fatigue pre-cracked into parent metal, weld metal or heat affected zone (HAZ). The specimens are loaded in tension, and the force and crack mouth opening displacement are recorded.

NOTE Methods to evaluate the suitability of a weld for notch placement within the target area and, where appropriate, to evaluate the effectiveness of the fatigue crack in sampling these areas are given in BS EN ISO 15653.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS EN ISO 15653:2010, *Metallic materials – Method of test for the determination of quasistatic fracture toughness of welds*

ISO 12135:2002, *Metallic materials – Unified method of test for the determination of quasistatic fracture toughness*

3 Terms, definitions and symbols

For the purposes of this British Standard, the following terms, definitions and symbols apply.

3.1 Terms and definitions

3.1.1 blunting

apparent crack extension not associated with the creation of new fracture surface prior to the onset of unstable crack extension, pop-in or slow stable crack extension and occurring within the same plane as the fatigue pre-crack

3.1.2 target area

intended fatigue pre-crack tip position within the parent metal, weld metal or heat affected zone (HAZ)

3.1.3 pop-in

abrupt discontinuity in the force versus displacement record, indicated by a sudden increase in displacement and, generally, a sudden decrease in force, subsequent to which displacement and force increase to above their previous values

3.1.4 sample

un-notched blank cut from the source material

3.1.5 specimen

machined and notched sample ready for testing

3.2 Symbols

For the purposes of this British Standard, the symbols given in BS EN ISO 15653 and ISO 12135 apply, together with the following:

a	crack length, in millimetres (mm);
a_0	initial crack length, in millimetres (mm);
B	specimen thickness, perpendicular to the width, in millimetres (mm);
B_N	specimen thickness after side-grooving, in millimetres (mm);
E	modulus of elasticity, in megapascals (MPa);
H	distance between clamped grips, in millimetres (mm);
J	J -integral fracture toughness, in kilojoules per metre squared or newtons per millimetre (kJ/m ² or N/mm);
L_c	gauge length in a pin-loaded SENT specimen, in millimetres (mm);
P	nominal force in a SENT specimen, in newtons (N);
$R_{p0.2b}$	0.2% offset yield strength of the parent metal at the temperature of the fracture toughness test, in megapascals (MPa);
$R_{p0.2w}$	0.2% offset yield strength of the weld metal at the temperature of the fracture toughness test, in megapascals (MPa);
V_0	crack mouth opening displacement (CMOD), in millimetres (mm);
V_1, V_2	clip gauge displacements, in millimetres (mm);
V_{e1}, V_{e2}	elastic components of clip gauge displacement, in millimetres (mm);
V_{p1}, V_{p2}	plastic components of clip gauge displacement, in millimetres (mm);
W	specimen width, measured in the direction of the notch, in millimetres (mm);
δ	crack tip opening displacement (CTOD), in millimetres (mm);
ν	Poisson's ratio;
σ	nominal stress in a pin-loaded SENT specimen, in newtons per millimetre (N/mm ²);
Δa	sum of stable crack extension and crack tip blunting, in millimetres (mm).

4 Principle

A test sample is cut from the source material. The sample is machined and notched to provide a test specimen with the tip of the notch located in either the parent metal, the weld metal or the HAZ.

A fatigue crack is extended from the notch tip into the target area by applying a controlled alternating force to the specimen in bending. The specimen is then tested in tension by clamping or by pin-loading the specimen in the grips of a tensile test machine.

The force and clip gauge displacement are continuously recorded during the test. To construct a resistance curve a number of identical specimens are tested to different displacements and then unloaded. These data, together with measurements of specimen and crack dimensions, are used to determine fracture toughness and crack extension for the resistance curve. Alternatively, it is possible to test a single specimen to obtain a value of fracture toughness.

If specified by the customer, post-test metallography is performed to confirm that the crack tip was located in the target weld feature and/or microstructure and to determine the microstructure through which crack extension has taken place.

NOTE A flowchart illustrating how to use this British Standard is given in Figure 1.

5 Test sample and test specimen preparation

5.1 Test sample

A blank sample shall be cut from the test source material.

NOTE The choice of specimen design should take into consideration the likely outcome of the test, any preference for J or CTOD fracture toughness values, the crack plane orientation of interest and the quantity and condition of the material available.

5.2 Test specimen

A test specimen shall be prepared from the sample. The SENT test specimen configuration shall be as shown in Figure 2a) or Figure 2b). The cross-section dimensions shall be expressed as the specimen thickness (B) $\times$ width (W). The W/B ratio of the test specimen shall be between 0.5 and 2, as illustrated in Figure 3.

Figure 1 Flowchart showing how to use the standard

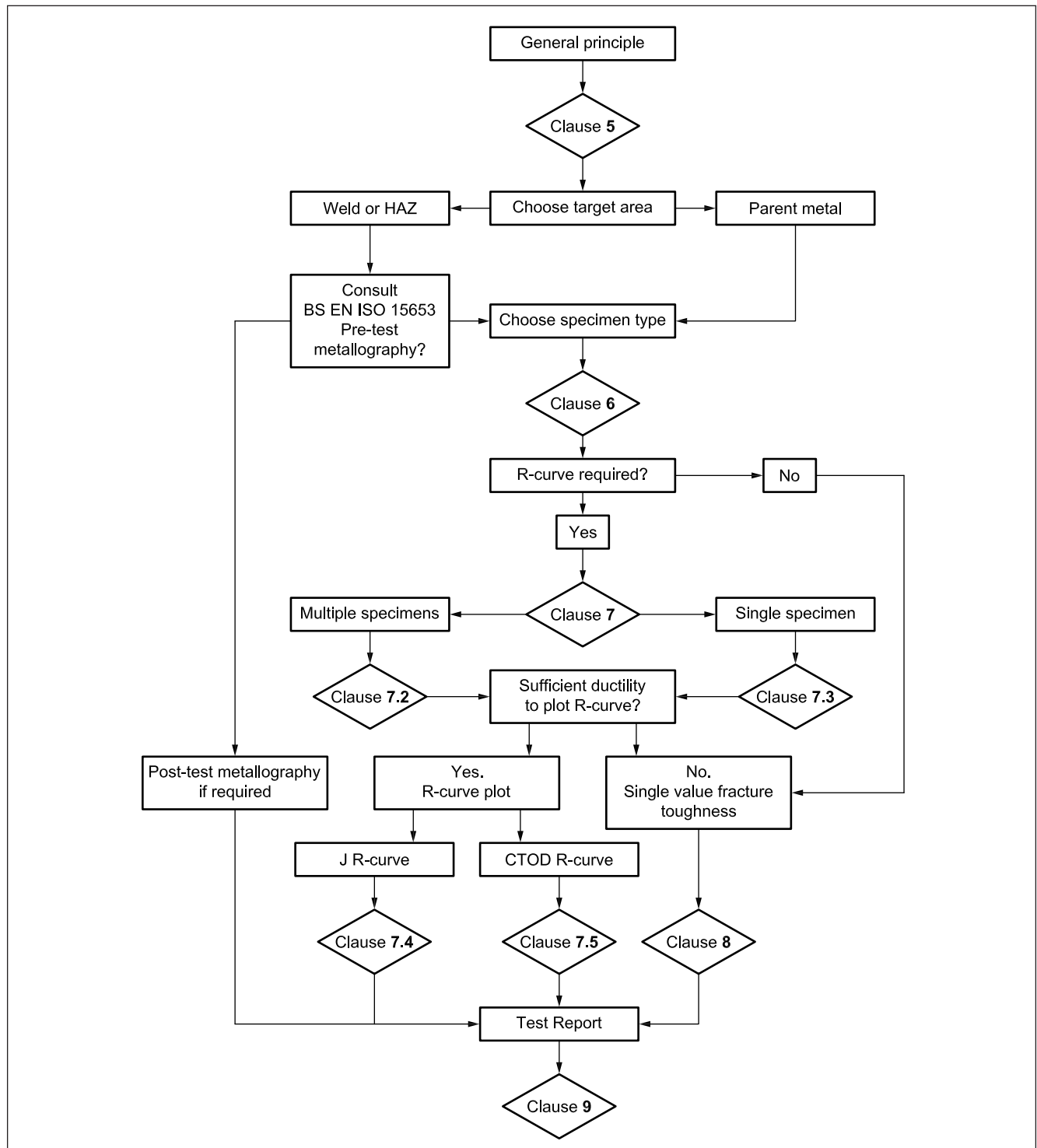


Figure 2 SENT test specimen configuration

