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Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds

Essais destructifs des soudures sur matériaux métalliques — Examens macroscopique et microscopique des assemblages soudés

Reference number
ISO 17639:2003(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 17639 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 5, *Testing and inspection of welds*.

Requests for official interpretation of any aspect of this International Standard should be directed to the Secretariat of ISO/TC 44/SC 5 via the member body in the user's country, a complete listing of which can be found at www.iso.org.

Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds

1 Scope

This International Standard gives recommendations for specimen preparation, test procedures and their main objectives for macroscopic and microscopic examination.

2 Normative references

The following referenced documents are indispensable for the application 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 6520-1, *Welding and allied processes — Classification of geometric imperfections in metallic materials — Part 1: Fusion welding*

ISO 9956-3, *Specification and approval of welding procedures for metallic materials — Part 3: Welding procedure tests for arc welding of steels*

ISO 9956-4, *Specification and approval of welding procedures for metallic materials — Part 4: Welding procedure tests for the arc welding of aluminium and its alloys*

ISO/TR 15608, *Welding — Guidelines for a metallic materials grouping system*

ISO/TR 16060, *Destructive tests on welds in metallic materials — Etchants for macroscopic and microscopic examination*

3 Terms and definitions

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

3.1
macroscopic examination
examination of a test specimen by the naked eye, or under low magnification (generally less than × 50), with or without etching

3.2
microscopic examination
examination of a test specimen by microscope with a magnification of generally × 50 to × 500, with or without etching

3.3
operator
person who performs the macroscopic and/or microscopic examination

4 Abbreviations

For the purposes of this document, the following abbreviations apply.

A Macroscopic examination

I Microscopic examination

E Etched

U Unetched

Abbreviations for parent metals shall be in accordance with the grouping systems in ISO 9956-3 for steels and ISO 9956-4 for aluminium and its alloys.

Grouping systems for other materials are given in ISO/TR 15608.

The same grouping systems shall also be used for weld metal.

The abbreviations for etchants should be taken from ISO/TR 16060 whenever applicable.

NOTE A trade mark can be used if ISO/TR 16060 is not applicable.

5 Principle

Macroscopic and microscopic examination is used to reveal the macroscopic or microscopic features of a welded joint, usually by the examination of transverse sections.

This is done by visual and/or optical examination of the prepared surface, before or after etching.

6 Purpose of the test

The purpose of macroscopic and microscopic examinations is to assess the structure (including grain structure, morphology and orientation, precipitates and inclusions) independently and/or in relation to various cracks and cavities. Sections can also provide a record of sample shape in the planes of the section. Table 1 gives guidance on the assessment of features which can be detected by macroscopic and microscopic examination.

7 Removal of test specimens

Test specimens are generally oriented perpendicular to the weld axis (transverse section), including the weld deposit and heat affected zones on both sides of the weld. However, test specimens may also apply to other orientations.

The location, orientation and number of test pieces should be specified prior to testing, for example by reference to an application standard.

Table 1 — Guidelines for assessment of features by microscopic and macroscopic examination

Features	Defect in accordance with ISO 6520-1	Macro examination without etching	Macro examination with etching	Micro examination without etching	Micro examination with etching
1 Hot cracks	100	X	X	X	X
2 Cold cracks	100	X	X	X	X
3 Lamellar tearing	100	X	X	X	X
4 Cavities	200	X	X	X	X
5 Inclusions	300	X	X	X	X
6 Lack of fusion/penetration	400	X	X	X	X
7 Geometrical shape	500	X	X	—	—
8 Heat affected zone	—	—	X	—	X
9 Runs and layers	—	—	X	—	(X)
10 Grain boundary	—	—	—	(X)	X
11 Grain structure	—	—	—	—	X
12 Solidification structure	—	—	X	—	X
13 Joint preparation	—	(X)	X	X	X
14 Direction of rolling/extrusion	—	—	X	—	X
15 Direction of fibre structure (grains)	—	—	X	—	X
16 Segregation	—	—	X	—	X
17 Precipitation	—	—	—	—	X
18 Repair and non-conformance	—	(X)	X	(X)	X
19 Mechanical/thermal effects	—	—	X	—	X
X means features revealed; (X) means features may or may not be revealed					
NOTE A number of the features listed may be beyond the resolution of an optical microscope, e.g. precipitates and inclusions.					

8 Test procedure

8.1 General

The following information shall be given:

— parent metals and welding consumables;

— object of the test;

— composition/name of the etchant;

— surface finish (see 8.3);

— etching methods (see 8.4);

— etching time;

— additional measures (see 8.6);

— any additional requirements.

8.2 Test specimen preparation

The test specimen shall be prepared for examination by cutting, mounting, grinding and/or polishing and/or etching as appropriate (see ISO/TR 16060). The surface to be examined shall not be adversely influenced by these processes.

8.3 Surface finish

The requirement for surface finish depends on aspects such as

— type of examination (macroscopic or microscopic);

— type of material;

— documentation (such as photographs).

NOTE Details of the grinding and polishing media and methods of grinding and polishing are given in ISO/TR 16060.

8.4 Etching methods

The method of etching shall be specified prior to etching. The most common methods are

— etching by immersing the test specimen in the etchant;

— etching by swabbing the surface of the test specimen;

— electrolytic etching.

Other methods may be used but should be specified, e.g. by reference to an application standard.

When etching is completed, the test specimen should be washed and dried.

8.5 Etchants

Typical etchants for various parent metals, weld deposits, purposes and types of examination are given in ISO/TR 16060.

Depending on the information required, the type and concentration of the etchant as well as the etching temperature and time may be varied according to the material and type of examination.

For similar joints, different etchants may be used.

8.6 Safety measures

The following safety measures shall be observed:

— wear eye or face protection, as appropriate;

— handle etchants with suitable gloves or tongs;

— mixtures shall be made in a fume cupboard or under a fume hood;

— always pour acid into water and not vice versa;

— always pour solute into solvent; i.e. the smaller quantity (solute) into the larger quantity (solvent).

9 Examination

The prepared surface may be examined before and/or after etching, as appropriate, or in accordance with the relevant standards and/or specifications.

10 Designation

The examination shall be designated as follows:

— reference to this International Standard;

— type of examination (macroscopic or microscopic examination);

— unetched or etched;

— object of the test (weld metal and/or parent metal);

— welded joints (parent metal left, parent metal right and weld metal);

— etchant (number of the table in ISO/TR 16060).

The designation may be given in a full or a shortened version: this is shown in examples 1 and 2.

NOTE The object of the test should be expressed between hyphens.

EXAMPLE 1 Full version

A microscopic examination with the following conditions:

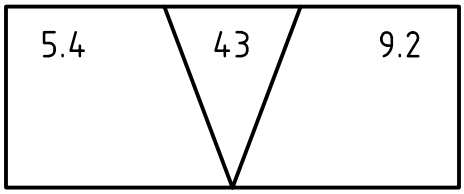
— Etched;

— Object of the test: 43;

— Parent metal left: 5.4
right: 9.2

— Consumable: 43

— Etchant: xy



EXAMPLE 1a) Object of the test: Weld metal only

Examination - ISO 17639 - I - E - 43 - 5.4 / 9.2 / 43 / xy

where

ISO 17639 = reference to this International Standard;

I = microscopic examination;

E = etched;

43 = object of the test;

5.4 = steel with Cr max. 9 %, Mo max. 1,2 %;

9.2 = austenitic stainless steel;

43 = weld metal: Ni/Fe/Cr/Mo with Ni max. 40 %;

xy = etchant.

NOTE xy stands for table number in the relevant annex of ISO/TR 16060.

EXAMPLE 1b) Object of the test: Weld metal and parent metal left

Examination - ISO 17639 - I - E - 43, 5.4 - 5.4 / 9.2 / 43 / xy

where

ISO 17639 = reference to this International Standard;

I = microscopic examination;

E = etched;

43, 5.4 = object of the test;

5.4 = steel with Cr max. 9 %, Mo max. 1,2 %;

9.2 = austenitic stainless steel;

43 = weld metal: Ni/Fe/Cr/Mo with Ni max. 40 %;

xy = etchant.

EXAMPLE 1c) Object of the test: Weld metal and parent metals left and right

Examination - ISO 17639 - I - E - 43, 5.4, 9.2 - 5.4 / 9.2 / 43 / xy

where

ISO 17639 = reference to this International Standard;

I = microscopic examination;

E = etched;

43, 5.4, 9.2 = object of the test;

5.4 = steel with Cr max. 9 %, Mo max. 1,2 %;

9.2 = austenitic stainless steel;

43 = weld metal: Ni/Fe/Cr/Mo with Ni max. 40 %;

xy = etchant.

EXAMPLE 2 Shortened version

A macroscopic examination with the following conditions:

— Etched;

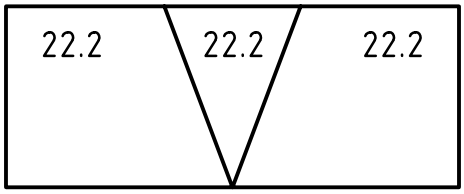
— Object of the test: 22.2;

— Parent metal left: 22.2
right: 22.2

— Weld metal: 22.2

— Etchant: xy

NOTE Object of the test (22.2) means weld metal and parent metal left and right.



Examination - ISO 17639 - A - E - 22.2- 22.2 / xy

where

ISO 17639 = reference to this International Standard;

A = macroscopic examination;

E = etched;

22.2 = object of the test;

22.2 = parent and weld metals: aluminium-magnesium alloys with a Mg content of 4 % to 5,6 %;

xy = etchant.

11 Test report

The test report should contain at least the following:

a) reference to this International Standard, i.e. ISO 17639;

b) designation of the examination;

c) location and orientation of the test specimen and the examined surface;

d) Welding Procedure Approval Record (WPAR) or, if this is not available, then at least the type of parent metal and consumables and, when used, the post-weld heat treatment and/or etching;

e) type of etchant and etching method;

f) if necessary, description of the examined surface;

g) if required, photographs and/or sketches, sizes of magnification.

An example of a typical test report is given in Annex A.

Annex A
(informative)

Example of a test report

Test report in accordance with ISO 17639 [1)]

WPAR: No. (d):

Manufacturer:

Purpose of examination:

Test piece:

Test specimen:

Parent metal:

Consumable:

Post-weld heat treatment and or ageing treatment:

Designation (b)	
Macroscopic etchant (e)	Microscopic etchant (e)
(g) and (f)	(g) and (f)
Figure: No. Location (c) Magnification (g) Surface description (f)	Figure: No. Location (c) Magnification (g) Surface description (f)
Operator (Name, date, signature)	Authorized person/body (Name, date, signature)

1) Letters in parentheses refer to Clause 11 of this International Standard.

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