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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

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Contents

Page

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 44, *Welding and allied processes*, Subcommittee SC 5, *Testing and inspection of welds*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 121, *Welding and allied processes*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 17639:2003), which has been technically revised.

The main changes are as follows:

— Clause 2 has been updated;

— the designations according to ISO/TR 15608 have been updated in Clause 10.

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.

Official interpretations of ISO/TC 44 documents, where they exist, are available from this page: https://committee.iso.org/sites/tc44/home/interpretation.html.

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

1 Scope

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

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 6520-1, *Welding and allied processes — Classification of geometric imperfections in metallic materials — Part 1: Fusion welding*

3 Terms and definitions

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

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

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

— IEC Electropedia: available at https://www.electropedia.org/

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
examiner
person who performs the *macroscopic examination* (3.1) and/or *microscopic examination* (3.2)

4 Symbols and abbreviated terms

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

A macroscopic examination

I microscopic examination

E etched

U unetched

Symbols for parent metals are given as material grouping system in ISO/TR 15608.

The same grouping systems shall also be used for weld metal. For consumables not classified under ISO/TR 15608, the consumables used shall be identified in the report.

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

NOTE A trademark 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
Hot cracks	100	X	X	X	X
Cold cracks	100	X	X	X	X
Lamellar tearing	100	X	X	X	X
Cavities	200	X	X	X	X
Inclusions	300	X	X	X	X
Lack of fusion/penetration	400	X	X	X	X
Geometrical shape	500	X	X	—	—
Heat affected zone	—	—	X	—	X
Runs and layers	—	—	X	—	(X)
Grain boundary	—	—	—	(X)	X
Grain structure	—	—	—	—	X
Solidification structure	—	—	X	—	X

X features revealed

(X) features can be revealed or not

NOTE A number of the features listed can be beyond the resolution of an optical microscope, e.g. precipitates and inclusions.

Table 1 *(continued)*

Features	Defect in accordance with ISO 6520-1	Macro examination without etching	Macro examination with etching	Micro examination without etching	Micro examination with etching
Joint preparation	—	(X)	X	X	X
Direction of rolling/ extrusion	—	—	X	—	X
Direction of fibre structure (grains)	—	—	X	—	X
Segregation	—	—	X	—	X
Precipitation	—	—	—	—	X
Repair and non-conformance	—	(X)	X	(X)	X
Mechanical/thermal effects	—	—	X		X
X features revealed (X) features can be revealed or not NOTE A number of the features listed can be beyond the resolution of an optical microscope, e.g. precipitates and inclusions.					

8 Test procedure

8.1 General

The following information shall be considered:

— parent metals and welding consumables;

— object of the test;

— composition/name of the etchant;

— surface finish (see 8.3);

— etching methods (see 8.4);

— additional measures (see 8.6);

— any additional requirements (e.g, etching time).

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.

NOTE To avoid deterioration of the etched specimen, precautions can be taken, such as storage of the specimens in a protected atmosphere, or for macroscopic specimen the application of a lacquer or varnish protection of the etched surface.

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 vary 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 document (i.e. ISO 17639);

— 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).

Some welding consumables cannot be classified under ISO/TR 15608, the consumables used shall be identified in the report.

The designation may be given in a full or a shortened version (see EXAMPLES 1 and 2).

NOTE The object of the test is expressed between hyphens.

EXAMPLE 1 Full version

A microscopic examination with the following conditions:

— Etched;

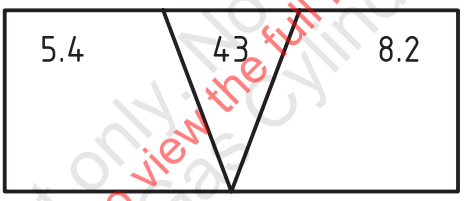
— Object of the test: 43;

— Parent metal left: 5.4

right: 8.2

— Consumable: 43

— Etchant: xy



a) Object of the test: Weld metal only

Examination - ISO 17639 - I - E - 43 - 5.4 / 8.2 / 43 / xy

where

ISO 17639 is the reference to this document;

I is the microscopic examination;

E is the = etched;

43 is the object of the test;

5.4 is the steel with 7,0 % < Cr ≤ 10,0 % and 0,7 % < Mo ≤ 1,2 %;

8.2 is the austenitic stainless steel with Cr > 19 %;

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

xy is the etchant.

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

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

Examination - ISO 17639 - I - E - 43, 5.4 - 5.4 / 8.2/ 43 / xy

where

ISO 17639 is the reference to this document;

I is the microscopic examination;

E is the etched;

43, 5.4 is the object of the test;

5.4 is the steel with 7,0 % < Cr ≤ 10,0 % and 0,7 % < Mo ≤ 1,2 %;

8.2 is the austenitic stainless steel with Cr > 19 %;

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

xy is the etchant.

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

Examination - ISO 17639 - I - E - 43, 5.4, 8.2 - 5.4 / 8.2 / 43 / xy

where

ISO 17639 is the reference to this document;

I is the microscopic examination;

E is the etched;

43, 5.4, 8.2 is the object of the test;

5.4 is the steel with 7,0 % < Cr ≤ 10,0 % and 0,7 % < Mo ≤ 1,2 %;

8.2 is the austenitic stainless steel with Cr > 19 %;

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

xy is the etchant.

EXAMPLE 2 Shortened version

A macroscopic examination with the following conditions:

— Etched;

— Object of the test: 22.4;

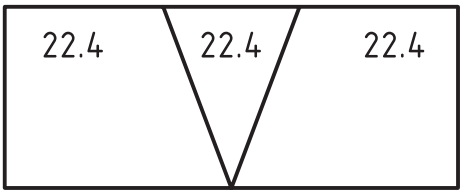
— Parent metal left: 22.4

right: 22.4

— Weld metal: 22.4

— Etchant: xy

NOTE Object of the test (22.4) means weld metal and parent metal left and right.



Examination - ISO 17639 - A - E - 22.4- 22.4 / xy

where

ISO 17639	is the reference to this document;
A	is the macroscopic examination;
E	is the etched;
22.4	is the object of the test;
22.4	is the parent and weld metals: aluminium-magnesium alloys with Mg > 3,5 %;
xy	is the etchant.

11 Test report

The test report shall contain at least the following:

a) a reference to this document (i.e. ISO 17639);

b) the designation of the examination;

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

d) the Welding Procedure Qualification Record (WPQR) 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) the type of etchant and etching method;

f) if necessary, a description of the examined surface;

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

h) the date of the test.

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