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Non-destructive testing of welds — General rules for fusion welds in metallic materials

Contrôle non destructif des assemblages soudés — Règles générales pour les soudures par fusion sur matériaux métalliques

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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 17635 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.

Non-destructive testing of welds — General rules for fusion welds in metallic materials

1 Scope

This International Standard gives guidance on the selection of method(s) for non-destructive testing of fusion welds in metallic materials based on material, weld thickness, welding process, quality control requirements and extent of testing. This International Standard specifies standards to be applied to the different types of testing and general rules for either the methodology or the acceptance level for metallic materials. The test methods may be used alone or in combination.

This International Standard also gives guidance on evaluation of the results of non-destructive testing for quality control purposes based on material, weld thickness, welding process, quality requirements application and extent of testing.

This International Standard addresses non-destructive testing of completed welds. Examination and testing of parent materials prior to welding or between welding sequences is not covered.

Acceptance levels cannot be a direct interpretation of the quality levels defined in ISO 5817 or ISO 10042. They are linked to the overall quality of the produced batch of welds.

Requirements for acceptance levels for non-destructive testing comply with the quality levels stated in ISO 5817 or ISO 10042 (moderate, intermediate, stringent), only on a general basis and not in detail for each indication.

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 5817, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections*

ISO 10042, *Arc-welded joints in aluminium and its weldable alloys — Guidance on quality levels for imperfections*

3 Terms and definitions

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

3.1
testing
testing of a material in accordance with a standard or a specification or a procedure.

3.2
testing level
degree of thoroughness and selection of parameter settings/sensitivity with which an examination or test method is applied

NOTE Different levels correspond to different sensitivities and/or probabilities of detection. The selection of examination or test levels is normally related to the quality requirements and/or the component application.

3.3
evaluation level
specified level that sets the threshold for evaluation

NOTE Indications below this level are not evaluated.

See Annex A.

3.4
recording level
specified level that sets the threshold for recording indications

NOTE Indications below this level are not recorded.

See Annex A.

3.5
acceptance level
specified level that sets the threshold for acceptance/rejection of components based on either quality assurance or fitness for purpose criteria

NOTE Any indications above this level may result in the rejection or repair of the component or further evaluation based on fitness for purpose criteria.

See Annex A.

3.6
testing organization
internal or external organization carrying out the non-destructive testing

3.7
indication
representation or signal from a discontinuity in the format recognized by the non-destructive test method used

3.8
internal imperfections
imperfections that are not open to a surface or not directly accessible

3.9
quality level
Fixed limits of imperfections corresponding to the expected quality in a weld

NOTE The limits are determined with regard to type of imperfection, their amount and their actual dimensions.

3.10
inspection lot
group of welds (a group can be a part of weld or a full weld or several welds) which would be expected to show uniform quality because of the welding procedure applied, material, type of joints, welder, environmental conditions during execution, time period or other items affecting the quality

4 Abbreviations

For the purposes of this International Standard, the abbreviations given in Table 1 apply.

Table 1 — Abbreviations

Test method	Abbreviation
Eddy current	ET
Magnetic particle	MT
Penetrant	PT
Radiographic	RT
Ultrasonic	UT
Visual	VT

5 Limitations

5.1 Stage of manufacture

This International Standard addresses non-destructive testing of completed welds. Examination and testing of parent materials prior to welding or between welding sequences is not covered.

It is recommended that examination and testing of parent materials, prior to or between welding, be performed in accordance with the relevant standards for methods and acceptance levels.

5.2 Extent of non-destructive testing

The extent of testing shall be specified before testing is started, e.g., by reference to an application standard.

Guidance on random testing is given in Annex B.

5.3 Materials

This International Standard is applicable to non-destructive testing of fusion welds in the following metals, their alloys and their combinations:

— steel;

— aluminium;

— copper;

— nickel;

— titanium.

NOTE This International Standard may be used for testing of other metallic materials but further information may be required.

6 Personnel qualification

Non-destructive testing and the evaluation of results for final acceptance of welds shall be performed by qualified and capable personnel. It is recommended that personnel be qualified in accordance with ISO 9712 or an equivalent standard at an appropriate level in the relevant industry sector.

7 Testing organization

Testing shall be carried out independent from production. The activities of the testing organization should be controlled by a quality assurance system.

8 Documentation

8.1 Documentation prior to testing

8.1.1 General

All preliminary information required by the non-destructive testing standards shall be provided prior to testing.

8.1.2 Written procedures

All non-destructive testing shall be performed in accordance with written procedures, e.g., as defined in standards for the individual test methods.

8.1.3 Testing plan

All non-destructive testing shall be defined in a testing plan. The testing plan shall describe the method(s) to be used, the sequence of testing, the extent of testing and other relevant aspects for control of testing and other related activities.

NOTE In certain cases, it is necessary to use more than one non-destructive test method (other than visual examination) or multiple applications of one method.

8.2 Documentation after testing

8.2.1 Records of individual tests

All test results shall be recorded in accordance with specified written procedures or in accordance with the standards used for the individual test methods.

8.2.2 Final report

For each component or group of components that has been tested, the final report shall contain all the information required by the testing plan and shall as a minimum include:

— identity of the component;

— identity of welds examined and/or reference to documents identifying those welds;

— system for marking of the individual welds and/or reference to documents indicating the description of the coordinate system used for the non-destructive test;

— identity of personnel and organizations that have performed the test(s);

— all the reports prepared in accordance with the referenced testing standards;

— reference to the individual test records including status (not inspected, accepted, rejected);

— record of deviations from the applied standard regarding testing technique and acceptance levels.

9 Selection of non-destructive test method

9.1 General

The non-destructive test method(s) should be selected according to the type of material(s) and type(s) of fusion welds. Test methods may be used alone or in combination. Testing should be in accordance with the standards referred to in Annex C. However, other methods may be specified, e.g. in an application standard.

Before selecting the test methods and levels, the following items should be considered:

— welding processes;

— parent material, welding consumables and any heat treatment;

— joint type and geometry;

— component configuration (accessibility, surface condition);

— quality levels;

— expected imperfection type and orientation.

9.2 Butt- and T-joints with full penetration

Tables 2 and 3 provide guidance on the methods to be used for the detection of surface and internal imperfections.

9.3 Butt- and T butt joints without full penetration, and fillet welds

For partial penetration welds and fillet welds, the unfused root can prevent satisfactory volumetric examination when using the methods given in Table 3. Unless additional test methods are specified to overcome this, the quality of the weld shall be assured by control of the welding process.

It may be necessary to carry out tests specific to the joint geometry in order to determine the degree of penetration or to target specific types of imperfection.

It is recommended that welds in the following materials be tested using additional method(s) as well as VT in accordance with Table 2:

— ferritic steel with a minimum yield strength above 280 N/mm^2;

— austenitic steel;

— aluminium and its alloys;

— nickel and its alloys;

— copper and its alloys;

— titanium and its alloys.

Table 2 — Recommended methods for detection of accessible surface imperfections for all types of welds including fillet welds

Materials	Test method
Ferritic steel	VT VT and MT VT and PT VT and (ET)
Austenitic steel, aluminium and alloys, nickel and alloys, copper and alloys and titanium and alloys	VT VT and PT VT and (ET)
NOTE Parentheses indicate that the method is applicable but the results may provide limited information, unless specific techniques are used.	

Table 3 — Recommended methods for detection of internal imperfections for butt- and T- joints with full penetration

Materials and type of joint	Thickness [a] mm		
	$t \leqslant 8$	$8 < t \leqslant 40$	$t > 40$
	Detection method		
Ferritic butt-joints	RT or (UT)	RT or UT	UT or (RT)
Ferritic T-joints	(UT) or (RT)	UT or (RT)	UT or (RT)
Austenitic butt-joints	RT	RT or (UT)	RT or (UT)
Austenitic T-joints	(UT) or (RT)	(UT) or (RT)	(UT) or (RT)
Aluminium butt-joints	RT	RT or UT	RT or UT
Aluminium T-joints	(UT) or (RT)	UT or (RT)	UT or (RT)
Nickel- and copper-alloys butt joints	RT	RT or (UT)	RT or (UT)
Nickel- and copper-alloys T-joints	(UT) or (RT)	(UT) or (RT)	(UT) or (RT)
Titanium butt-joints	RT	RT or (UT)	
Titanium T-joints	(UT) or (RT)	UT or (RT)	
NOTE Parentheses indicate that the method is applicable but the results may provide limited information, unless specific techniques are employed.			
[a] Thickness, t, is the nominal thickness of the parent material to be welded.			

10 Performance of testing

10.1 Determination of standard to be applied

The test methods and levels listed in Annex C should be used. However, if other methods are specified, e.g. in an application standard, the testing levels listed in Annex C may be used for guidance.

10.2 Conditions for testing

Prior to testing, the personnel performing non-destructive testing shall have access to all relevant information including:

a) the welding parameters and conditions used to make the weld;

b) all preliminary information required by the testing standard(s);

c) testing plan, if required;

d) actions to be taken in case of detection of non-conforming welds;

e) responsibility for coordination of the inspection of parts of subassemblies manufactured by subcontractors.

The time and place of testing should be recorded.

10.3 Time of testing

Unless otherwise specified, testing shall be carried out after completion of all required heat treatments. For welds in materials sensitive to hydrogen cracking (e.g. high strength steels) or other time-delayed cracking, the time delay before testing shall be specified.

Non-destructive testing for surface breaking imperfections should be carried out prior to any tests for internal imperfections in order to minimize costs if unacceptable imperfections are detected at the surface.

10.4 Non-acceptable indications

The procedure for handling any non-acceptable indications shall be specified, e.g. by reference to an application standard.

Any repaired welds shall be tested to at least the same level required for the original weld.

Further guidance on additional testing after the detection of non-acceptable indications is given in Annex D.

Annex A
(informative)

Classification of indications

See Figure A.1.

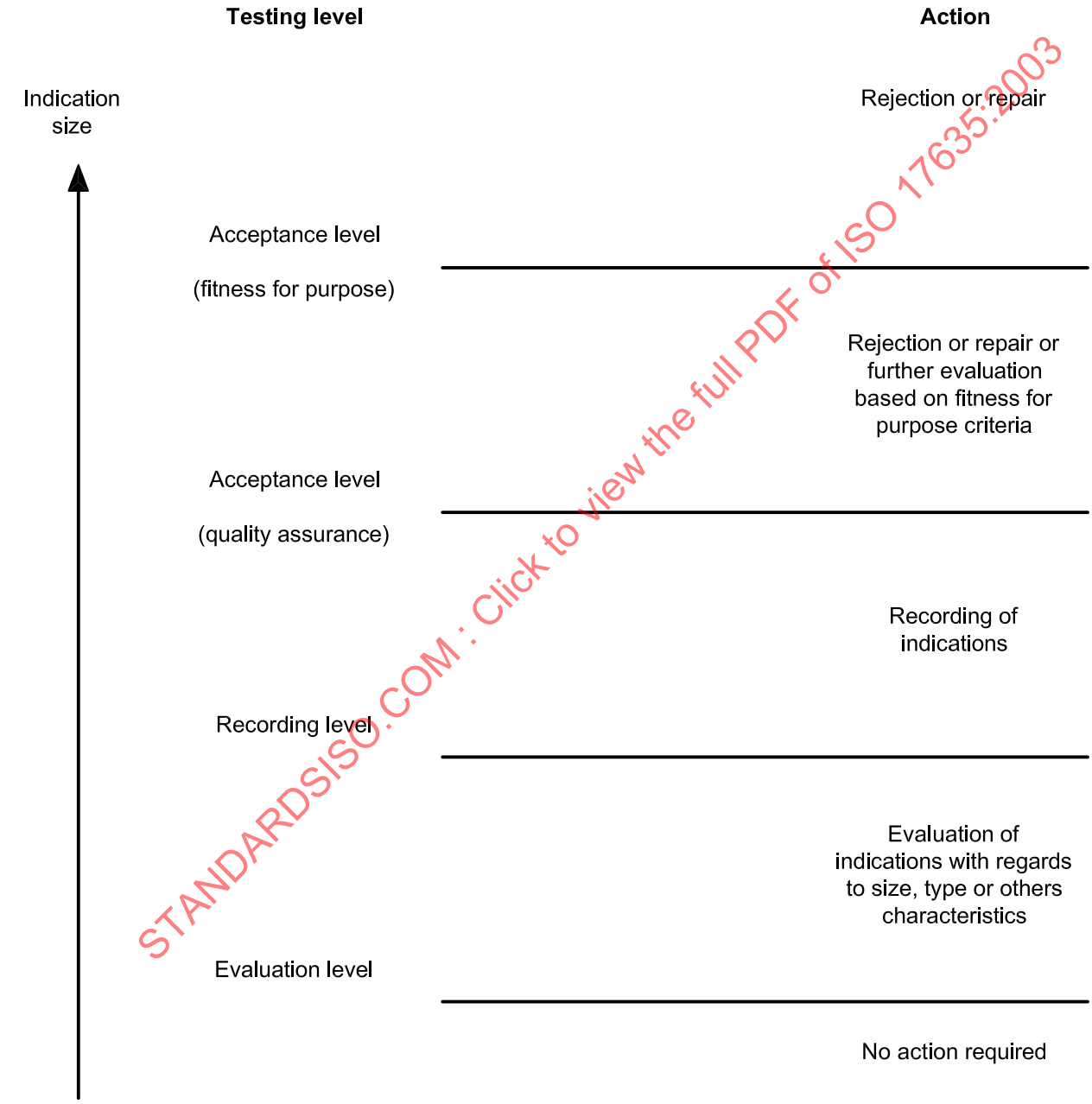

Figure A.1 — Classification of indications

Annex B
(informative)

Extent of testing

The extent of testing may be defined using the parameters x (length) and p (part %).

— each weld in the inspection lot should be tested along a minimum length p % of the individual length. The area to be tested should be selected randomly;

— if the total length of all the welds in an inspection lot is less than a specified length, x, (where e.g., x = 1 m), at least one weld should be tested along its entire length regardless of the p %.

— if an inspection lot consists of several identical welds of individual lengths less than a specified length x (e.g. where x = 1 m), randomly selected welds with a total length of minimum p % of the total length of all welds in the inspection lot should be tested along their entire length.

Annex C
(informative)

Recommended rules and standards

C.1 General

This annex gives the correlation between the quality levels of ISO 5817 or ISO 10042 and testing techniques, testing levels and acceptance levels for commonly used non-destructive testing standards.

It shall be noted that the correlations are not quantitative links.

C.2 Visual testing

See Table C.1.

Table C.1 — Visual testing (VT)

Quality levels in accordance with ISO 5817 or ISO 10042	Testing techniques and levels in accordance with ISO 17637	Acceptance levels[a]
B	Level not specified	B
C	Level not specified	C
D	Level not specified	D
[a] The acceptance levels for visual testing are equal to the quality levels in ISO 5817 or ISO 10042.		

C.3 Penetrant testing

See Table C.2.

Table C.2 — Penetrant testing (PT)

Quality levels in accordance with ISO 5817 or ISO 10042	Testing techniques and levels in accordance with ISO 3452-1	Acceptance levels in accordance with EN 1289
B	Level not specified	2 X
C	Level not specified	2 X
D	Level not specified	3 X

C.4 Magnetic particle testing

See Table C.3.

Table C.3 — Magnetic particle testing (MT)

Quality levels in accordance with ISO 5817	Testing techniques and levels in accordance with ISO 17638	Acceptance levels in accordance with EN 1291
B	Level not specified	2 X
C	Level not specified	2 X
D	Level not specified	3 X

C.5 Eddy current testing

See Table C.4.

Table C.4 — Eddy current testing (ET)

Quality levels in accordance with ISO 5817 or ISO 10042	Testing techniques and levels in accordance with ISO 17643	Acceptance levels
B	Level not specified	To be specified prior to testing, e.g. by reference to an application standard
C		
D		

C.6 Radiographic testing

See Table C.5.

Table C.5 — Radiographic testing (RT)

Quality levels in accordance with ISO 5817 or ISO 10042	Testing techniques and levels in accordance with ISO 17636	Acceptance levels in accordance with EN 12517
B	B	1
C	B[a]	2
D	A	3

[a] Nevertheless, the maximum area for a single exposure shall correspond to the requirements of class A of ISO 17636:2003.

C.7 Ultrasonic testing

See Table C 6.

Table C.6 — Ultrasonic testing (UT)

Quality levels in accordance with ISO 5817 or ISO 10042	Testing techniques and levels in accordance with ISO 17640[a]	Acceptance levels in accordance with EN 1712
B	At least B	2
C	At least A	3
D	Level not applicable [b]	Not applicable [b]

[a] When characterization of indications is required, EN 1713 shall apply.

[b] UT is not recommended but may be specified, for example in an application standard (with the same requirements as quality level C).