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Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 9: Underwater hyperbaric wet welding (ISO/DIS 15614-9:2024)

Anforderung und Qualifizierung von Schweißverfahren für metallische Werkstoffe - Schweißverfahrensprüfung - Teil 9: Nasses hyperbares Unterwasserschweißen (ISO/DIS 15614-9:2024)

Descriptif et qualification d'un mode opératoire de soudage pour les matériaux métalliques - Epreuve de qualification d'un mode opératoire de soudage - Partie 9 : Soudage hyperbare en pleine eau (ISO/DIS 15614-9:2024)

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Specification and qualification of welding procedures for metallic materials — Welding procedure test —

Part 9: Underwater hyperbaric wet welding

*Descriptif et qualification d'un mode opératoire de soudage pour
les matériaux métalliques — Epreuve de qualification d'un mode
opératoire de soudage —*

Partie 9: Soudage hyperbare en pleine eau

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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.

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 15, *Underwater welding*.

A list of all parts in the ISO 15614 series can be found on the ISO website.

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>.

ISO/DIS 15614-9:2024(en)**Introduction**

The primary purpose of welding procedure qualification is to demonstrate that the joining process proposed for construction, including preliminary and subsequent treatment, is capable of producing joints having the required mechanical properties and conforming to the required NDT requirements for the intended application.

Before a particular welding procedure is used in production, the manufacturer should determine and document the suitability of the welding procedure specification (WPS) to produce a weld of the required quality.

In this document, the term "welding procedure specification" comprises all the activities which influence the welding result, such as preparation, welding parameters, and post treatment.

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Specification and qualification of welding procedures for metallic materials — Welding procedure test —

Part 9: Underwater hyperbaric wet welding

1 Scope

This document specifies how a preliminary welding procedure specification (pWPS) is qualified by welding procedure tests.

This document applies to production welding and repair welding.

This document is applicable to fusion welding of steels covered by groups 1, 2, 3 and 8 in accordance with ISO/TR 15608 in a hyperbaric wet environment.

This document covers the following welding processes, in accordance with ISO 4063, applicable in hyperbaric wet environment:

- 111 manual metal arc welding (metal arc welding with covered electrode);
- 114 self-shielded tubular-cored arc welding.

The principles of this document may be applied to other steel groups and fusion welding processes not listed.

Three weld quality levels, A, B, and Z, are given in order to permit application to a wide range of weldments. Each weld quality level defines a set of criteria for weldment properties that shall be established during qualification.

This document does not address the selection of the weld quality level to meet the requirements of a particular application.

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 148-1, *Metallic materials — Charpy pendulum impact test — Part 1: Test method*

ISO 4136, *Destructive tests on welds in metallic materials — Transverse tensile test*

ISO 5173, *Destructive tests on welds in metallic materials — Bend tests*

ISO 5178, *Destructive tests on welds in metallic materials — Longitudinal tensile test on weld metal in fusion welded joints*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 6947, *Welding and allied processes — Welding positions*

ISO 9015-1:2001, *Destructive tests on welds in metallic materials — Hardness testing — Part 1: Hardness test on arc welded joints*

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ISO 9016, *Destructive tests on welds in metallic materials — Impact tests — Test specimen location, notch orientation and examination*

ISO 9017, *Destructive tests on welds in metallic materials — Fracture test*

ISO 9018, *Destructive tests on welds in metallic materials — Tensile test on cruciform and lapped joints*

ISO 15609-1, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 1: Arc welding*

ISO 15618-1, *Qualification testing of welders for underwater welding — Part 1: Hyperbaric wet welding*

ISO 17636 (all parts), *Non-destructive testing of welds — Radiographic testing*

ISO 17637, *Non-destructive testing of welds — Visual testing of fusion-welded joints*

ISO 17639, *Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds*

ISO 17640, *Non-destructive testing of welds — Ultrasonic testing — Techniques, testing levels, and assessment*

ISO/TR 25901-1:2016, *Welding and allied processes — Vocabulary — Part 1: General terms*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TR 25901-1 and the following 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 hyperbaric wet welding

process of welding in a wet environment in excess of surface pressure with no mechanical barrier between the arc and the water

[SOURCE: ISO 15618-1:2016, 3.2]

3.2 essential variable

welding parameter that requires qualification

[SOURCE: ISO/TR 25901-1:2016, 2.4.4]

3.3 non-essential variable

welding parameter addressed in the *welding procedure specification* (3.8) but not requiring qualification

[SOURCE: ISO/TR 25901-1:2016, 2.4.5]

3.4 examiner

person who has been appointed to verify conformity to the applicable standard

Note 1 to entry: In certain cases, an external independent examiner can be required.

[SOURCE: ISO/TR 25901-1:2016, 2.5.29, modified — Definition revised.]

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3.5

examining body

organization that has been appointed to verify conformity to the applicable standard

Note 1 to entry: In certain cases, an external independent examining body can be required.

[SOURCE: ISO/TR 25901-1:2016, 2.5.30, modified — Definition revised.]

3.6

preliminary welding procedure specification

pWPS

document containing the required variables of the *welding procedure specification* (3.8) which has to be qualified

[SOURCE: ISO/TR 25901-1:2016, 2.5.6]

3.7

welding procedure qualification record

WPQR

record comprising all necessary data needed for qualification of a *preliminary welding procedure specification* (3.8)

[SOURCE: ISO/TR 25901-1:2016, 2.5.12]

3.8

welding procedure specification

WPS

document that has been qualified and provides the required variables of the welding procedure to ensure repeatability during production welding

[SOURCE: ISO/TR 25901-1:2016, 2.5.4]

3.9

primary welding position

most demanding welding position as it relates to the lowest expected mechanical test results. This can be chosen based on, but is not limited to, the following general criteria:

- PE can be more demanding than PC;
- PC can be more demanding than PG;
- PG can be more demanding than PA;

but generally, not in reverse.

Note 1 to entry: the primary welding position is to be specified prior to testing.

3.10

verification

confirmation, through the provision of objective evidence, that specified requirements have been fulfilled

[SOURCE: ISO 9000:2015, 3.8.12]

4 Qualification of welding procedure specifications

4.1 General

[Annex A](#) gives information on the different phases and parties involved in welding procedure qualification.

A preliminary welding procedure specification (pWPS) shall be prepared in accordance with ISO 15609-1. The pWPS shall specify the relevant variables given in [Table 2](#).

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4.2 Related to the parent material

4.2.1 Parent material grouping

In order to minimize the number of welding procedure tests, steels are grouped in accordance with ISO/TR 15608. Where materials are assigned to groups in accordance with ISO/TR 20172, ISO/TR 20173 or ISO/TR 20174, those assignments shall be used.

Separate welding procedure qualifications are required for each parent material or parent material combinations not covered by the grouping system according to ISO/TR 20172, ISO/TR 20173, ISO/TR 20174 or ISO/TR 15608.

Permanent backing material shall be considered as parent material within the approval (sub-)group.

Additional requirements and/or limitations can be applied by regulations, application standards or contract documents.

In accordance with ISO/TR 15608:2017:

- Group 1 covers Steels with a specified minimum yield strength, $R_{eH} \leq 460 \text{ N/mm}^2$;
- Group 2 covers Thermomechanically treated fine-grain steels and cast steels with a specified minimum yield strength, $R_{eH} > 360 \text{ N/mm}^2$;
- Group 3 covers Quenched and tempered and precipitation hardened fine-grain steels except stainless steels with a specified minimum yield strength, $R_{eH} > 360 \text{ N/mm}^2$;
- Group 8 covers Austenitic stainless steels, $Ni \leq 35 \%$.

The range of qualification shall be in accordance with [Table 1](#), except when there is:

- an increase in the carbon equivalent (CE) and/or carbon percent of the steel above that qualified (not applicable to austenitic stainless steel);
- an increase in the specified minimum yield strength beyond that qualified.

Carbon equivalent shall be calculated in accordance with [formula 1](#):

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad (1)$$

When only carbon and manganese are known, the following alternative [formula 2](#) can be used:

$$CE = C + \frac{Mn}{6} + 0,05 \quad (2)$$

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Table 1 — Range of qualification for steel groups and sub-groups

Test piece material A	Test piece material B			
	1	2	3	8
1	1-1	—	—	—
2	1-1 2-1	1-1 2-1 2-2	—	—
3	1-1 2-1 3-1	1-1 2-1 2-2 3-1 3-2 3-3	1-1 2-1 2-2 3-1 3-2 3-3	—
8	8-1	8-1 8-2	8-1 8-2 8-3	8-8

4.3 Welding procedure qualification record (WPQR)

The WPQR is a statement of the results of assessing each test piece, including re-tests. The relevant items listed for the WPS shall be included. If no rejectable features or unacceptable test results are found, a WPQR detailing the welding procedure test piece results is qualified and shall be signed and dated by the examiner and/or the examining body.

An example of a WPQR is shown in [Annex C](#).

4.4 Welding procedure specification (WPS)

A WPS shall be prepared in accordance with ISO 15609-1. It shall include the relevant welding variables detailed in the WPQR.

A change in any essential variable outside the range permitted requires requalification of the WPS (see [Table 2](#)).

5 Classification of Welds

5.1 Definitions of weld quality levels

Welds produced to a specified weld quality level shall meet all the criteria specified for that weld quality level.

- Level A: Level A underwater welds are intended to be suitable for applications and design stresses comparable to their equivalent surface welding counterparts.
- Level B: Level B underwater welds are intended to be suitable for applications and design stresses where reduced weld joint properties can be tolerated.
- Level Z: Level Z underwater welds are intended to meet the requirements of another code, standard or specification agreed upon by the contracting parties and the requirements of this document which are specific to the underwater welding environment.

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5.2 Selection of the weld quality level

The selection of the weld quality level is determined by:

- a) the application standard;
- b) the customer/designer;
- c) third parties such as classification societies and regulatory bodies.

The weld quality level can be influenced by the weldability and environmental conditions.

6 Welding variables and range of qualification

The welding variables and range of qualification are given in [Table 2](#).

Table 2 — Welding variables

1. Joints	
a) Fillet weld to butt weld	Essential
b) Butt weld to fillet weld	Non-essential
c) Multiple pass fillet weld to single pass fillet weld	Essential
d) Single pass fillet weld to multiple pass fillet weld	Essential
e) Omission of backing	Essential
f) Butt joint geometry: — a decrease in included angle $> 10^\circ$; — a decrease in root opening beyond the range qualified; — an increase of the root face > 2 mm.	Essential
NOTE Joint assembly dimensions and tolerances are to be specified on the pWPS.	
g) Fillet weld size: — For single pass fillet welding procedure qualification, the maximum weld size qualified shall be $1,2z$ and the minimum weld size qualified shall be $0,8z$; — For multiple pass fillet welding procedure qualification, the maximum weld size qualified shall be $z + (0,2z + 1 \text{ mm})$, and the minimum qualified weld size shall be $0,7z$.	Essential
Where z is the leg length of the qualification weld.	
2. Parent metal	
a) Thickness: For butt welding procedure qualification tests, test plate or pipe wall thickness, t — Where $t \geq 6$ mm, the range of production plate or pipe wall thickness shall be $0,5 t \leq t \leq 1,5 t$ and a minimum of $t = 6$ mm; — Where $t < 6$ mm, the range of production plate or pipe wall thickness shall be $t \leq 1,5 t$.	Essential
b) An increase in carbon equivalent and/or carbon percent of the steel above that qualified (not applicable to austenitic stainless steel).	Essential
c) An increase in the specified minimum yield strength beyond that qualified	Essential
3. Filler Material ^{a)}	
a) Manufacturer	Essential
b) Manufacturer's trade name	Essential
c) Diameter	Essential
a) The recommendations of the filler material manufacturer shall be followed.	