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

Part 7:
Overlay welding

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

Partie 7: Rechargement par soudage



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Contents

	Page
Foreword	v
Introduction	vii
1 Scope	1
2 Normative references	1
3 Terms and definitions	2
4 Preliminary welding procedure specification (pWPS)	3
4.1 Corrosion resistant overlay welding.....	3
4.2 Hardfacing.....	3
5 Welding procedure qualification test	3
6 Test piece	3
6.1 Shape and dimensions of test pieces.....	3
6.1.1 General.....	3
6.1.2 Corrosion resistant overlay welding and hardfacing.....	3
6.1.3 Intermediate layer.....	3
6.2 Welding of test pieces.....	5
7 Examination and testing	5
7.1 Extent of examination and testing.....	5
7.2 Non-destructive testing (NDT).....	6
7.3 Location and taking of test specimens.....	6
7.4 Destructive testing.....	8
7.4.1 General.....	8
7.4.2 Macroscopic examination.....	9
7.4.3 Hardness testing.....	9
7.4.4 Side bend testing.....	9
7.4.5 Chemical analysis.....	10
7.4.6 Delta ferrite content/ferrite number (FN).....	10
7.5 Acceptance criteria.....	11
7.5.1 Acceptance criteria for non-destructive testing (NDT).....	11
7.5.2 Destructive testing.....	11
7.6 Re-testing.....	12
8 Range of qualification	12
8.1 General.....	12
8.2 Qualification related to the manufacturer.....	12
8.3 Qualification related to the material.....	13
8.3.1 Parent metal.....	13
8.3.2 Parent metal thickness.....	13
8.4 Qualification related to the filler material/overlay.....	13
8.4.1 Filler material designation.....	13
8.4.2 Thickness of the overlay.....	13
8.5 Common to welding procedures.....	14
8.5.1 Welding process.....	14
8.5.2 Welding position.....	14
8.5.3 Type of current.....	14
8.5.4 Arc energy.....	14
8.5.5 Preheating temperature.....	14
8.5.6 Interpass temperature.....	14
8.5.7 Post-heating for hydrogen release.....	15
8.5.8 Post-weld heat-treatment (PWHT).....	15
8.5.9 Number of layers.....	15
8.6 Specific to welding processes.....	15

8.6.1	Process 111 [manual metal arc welding (metal arc welding with covered electrode)].....	15
8.6.2	Processes 12 (submerged arc welding) and 72 (electroslag overlay welding).....	15
8.6.3	Processes 13 [gas-shielded metal arc welding and 14 (gas-shielded arc welding with non-consumable tungsten electrode)].....	16
8.6.4	Process 15 (plasma arc welding).....	16
8.6.5	Process 153 (plasma transferred arc).....	16
8.6.6	Process 311 (oxy-acetylene welding).....	16
9	Welding procedure qualification record (WPQR).....	17
Annex A (informative) Welding procedure qualification record form (WPQR).....		18
Bibliography.....		22

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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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Quality management in the field of welding*.

This second edition cancels and replaces the first edition (ISO 15614-7:2007), which has been technically revised.

ISO 15614 consists of the following parts, under the general title *Specification and qualification of welding procedures for metallic materials — Welding procedure test*:

- *Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys*
- *Part 2: Arc welding of aluminium and its alloys*
- *Part 3: Fusion welding of non-alloyed and low-alloyed cast irons*
- *Part 4: Finishing welding of aluminium castings*
- *Part 5: Arc welding of titanium, zirconium and their alloys*
- *Part 6: Arc and gas welding of copper and its alloys*
- *Part 7: Overlay welding*
- *Part 8: Welding of tubes to tube-plate joints*
- *Part 10: Hyperbaric dry welding*
- *Part 11: Electron and laser beam welding*
- *Part 12: Spot, seam and projection welding*
- *Part 13: Upset (resistance butt) and flash welding*
- *Part 14: Laser-arc hybrid welding of steels, nickel and nickel alloys*

ISO 15614-7:2016(E)

Requests for official interpretations of any aspect of this part of ISO 15614 should be directed to the secretariat if ISO/TC 44/SC 10 via your national standards body, a complete listing which can be found at www.iso.org.

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Introduction

This part of ISO 15614 is one of a series of International Standards, the details of which are given in ISO 15607:2003, Annex A.

All new welding procedure tests are intended to be carried out in accordance with this edition of ISO 15614-7 from the date of its publication. However, qualifications performed in accordance with the previous editions of this part of ISO 15614 are still valid and it is not considered necessary to perform additional tests to fulfil its requirements for any application with reference to previous editions. Nevertheless, in order to comply with the requirements of the present edition it may be necessary to perform additional tests for previously qualified WPS.

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

Part 7: Overlay welding

1 Scope

This part of ISO 15614 specifies how a preliminary welding procedure specification for overlay welding is qualified by welding procedure tests.

This part of ISO 15614 defines the conditions for execution of welding procedure tests and the range of qualification for welding procedures for all practical welding operations within the range of variables listed in [Clause 8](#).

This part of ISO 15614 applies to all welding processes suitable for overlay welding. In situations where qualification is carried out on a pre-production test piece, the qualification is performed in accordance with ISO 15613 except that, as far as possible, the testing is according to this part of ISO 15614. Building up and repair of parent metal is covered by ISO 15613 or ISO 15614-1.

This edition of ISO 15614-7 is applicable to all new welding procedure qualification tests. It does not invalidate previous welding procedure tests made in accordance with previous editions of this part of ISO 15614. Where additional tests are required by the present edition, it is only necessary that those additional tests be carried out on a test piece made in accordance with the existing WPS and this part of ISO 15614.

If buttering is used for welding between dissimilar materials, the welding procedure is qualified in accordance with ISO 15614-1. This buttering may be required for weld combining different material structure or properties, e.g. joining martensitic steels or ferritic steels with austenitic steels.

Additional tests may be required by application standards.

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.

ISO 3452-1, *Non-destructive testing — Penetrant testing — Part 1: General principles*

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

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

ISO 13916, *Welding — Guidance on the measurement of preheating temperature, interpass temperature and preheat maintenance temperature*

ISO 14174, *Welding consumables — Fluxes for submerged arc welding and electroslag welding — Classification*

ISO 14175, *Welding consumables — Gases and gas mixtures for fusion welding and allied processes*

ISO 15607:2003, *Specification and qualification of welding procedures for metallic materials — General rules*

ISO 15614-7:2016(E)

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

ISO 15609-2, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 2: Gas welding*

ISO 15609-3, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 3: Electron beam welding*

ISO 15609-4, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 4: Laser beam welding*

ISO 15613, *Specification and qualification of welding procedures for metallic materials — Qualification based on pre-production welding test*

ISO 15614-1, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys*

ISO 17405, *Non-destructive testing — Ultrasonic testing — Technique of testing claddings produced by welding, rolling and explosion*

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

ISO 17638, *Non-destructive testing of welds — Magnetic particle testing*

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

ISO 23277, *Non-destructive testing of welds — Penetrant testing — Acceptance levels*

ISO 23278, *Non-destructive testing of welds — Magnetic particle testing — Acceptance levels*

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

ISO/TR 18491, *Welding and allied processes — Guidelines for measurement of welding energies*

ISO/TR 25901 (all parts), *Welding and related processes — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 15607, ISO/TR 25901 and the following apply.

3.1

overlay welding

surfacing by means of welding

3.2

cladding

material deposited on the parent metal in order to produce a clad material

3.3

cladding process

surfacing used for *cladding* (3.2)

3.4

clad steel

combination of two or more dissimilar metals bonded inseparably together by a *cladding process* (3.3)

3.5

buttering

overlay welding (3.1) to provide a suitable transition between the parent metal and subsequent weld

3.6**build up**

overlay welding ([3.1](#)) to obtain or restore required dimensions

4 Preliminary welding procedure specification (pWPS)**4.1 Corrosion resistant overlay welding**

The preliminary welding procedure specification shall be in accordance with ISO 15609-1, ISO 15609-3 or ISO 15609-4 as appropriate. It shall specify the tolerances/ranges for all the relevant parameters.

4.2 Hardfacing

The preliminary welding procedure specification shall be in accordance with ISO 15609-1, ISO 15609-2, ISO 15609-3 or ISO 15609-4 as appropriate. It shall specify the tolerances/ranges for all the relevant parameters.

5 Welding procedure qualification test

A test piece shall be welded using the same welding processes or process combinations as those to be used in production.

The welding and testing of test pieces shall be in accordance with [Clauses 6](#) and [7](#).

6 Test piece**6.1 Shape and dimensions of test pieces****6.1.1 General**

The welding procedure test shall be carried out on test piece(s) in accordance with [Figures 1](#) and [2](#).

The dimensions and/or number of test pieces shall be sufficient to allow all required tests to be carried out (see [Figures 1](#) and [2](#)).

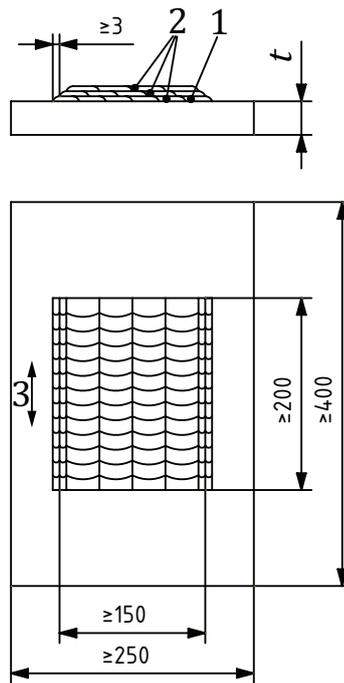
The thickness and/or diameter of the test pieces shall be selected in accordance with the range of qualification.

6.1.2 Corrosion resistant overlay welding and hardfacing

A minimum number of three runs is required for the top layer.

6.1.3 Intermediate layer

If an intermediate layer is to be used in production welding, it shall be used in welding the test piece.



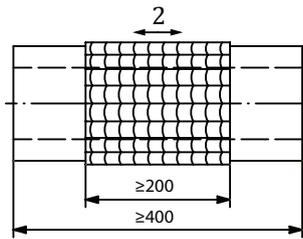
Key

- 1 intermediate layer, if necessary
- 2 number of layers in accordance with the pWPS (see 6.1.2 and 6.1.3) or thickness of overlay deposit
- 3 welding direction^a
- t* parent metal thickness
- ^a The orientation of weld runs is not defined. Specific requirements may be detailed in application standards.

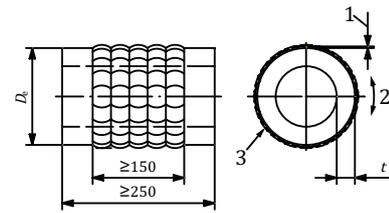
Figure 1 — Test piece — Plate

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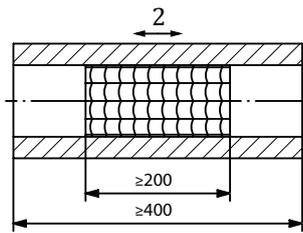
Dimensions in millimetres



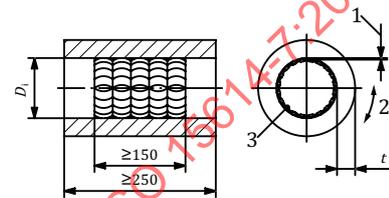
a) Axial overlay welding — External



c) Circumferential overlay welding — External



b) Axial overlay welding — Internal



d) Circumferential overlay welding — Internal

Key

- | | | | |
|---|--|-------|--------------------------|
| 1 | intermediate layer, if necessary | D_e | outside diameter of tube |
| 2 | welding direction | D_i | inside diameter of tube |
| 3 | number of layers in accordance with the pWPS (see 6.1.2 and 6.1.3) or thickness of overlay deposit | t | parent metal thickness |

Figure 2 — Test piece — Tube

6.2 Welding of test pieces

Preparation and welding of test pieces shall be carried out in accordance with the preliminary welding procedure specification (pWPS) and under the general conditions in production which they shall represent.

Welding and testing of the test pieces shall be witnessed by an examiner or an examining body.

7 Examination and testing

7.1 Extent of examination and testing

Examination and testing shall be in accordance with the requirements of [Table 1](#).

Table 1 — Examination and testing of the test pieces

Test piece	Type of test	Extent of testing	Footnote
Corrosion resistant overlay welding	— Visual testing (VT)	100 %	—
	— Ultrasonic testing (UT)	100 %	a
	— Penetrant testing (PT)	100 %	b
	— Side bend test (SBC)	2 specimens	c, d
	— Macroscopic examination	1 specimen	—
	— Chemical analysis	1 specimen	—
	— Delta ferrite content/ferrite number (FN)	1 specimen	a
	— Hardness testing	1 survey	—
Hardfacing	— Visual testing (VT)	100 %	—
	— Surface crack detection (MT/PT)	100 %	b
	— Macroscopic examination	1 specimen	—
	— Hardness testing	1 survey	—
<p>a If required, in accordance with the application standard.</p> <p>b Penetrant testing (PT) or magnetic particle testing (MT). For non-magnetic materials, penetrant testing.</p> <p>c Side bend test may be replaced by two additional macroscopic examinations.</p> <p>d The orientation of the side bend test (SBC) shall be transverse to the direction of the first layer.</p>			

7.2 Non-destructive testing (NDT)

All non-destructive testing of [Table 1](#) shall be carried out on the test pieces after post weld heat treatment, when specified, and prior to cutting of the test specimens.

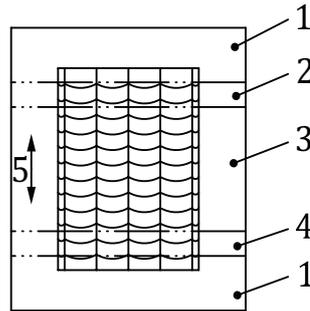
Dependant on overlay geometry, materials and the production specification, non-destructive testing (NDT) shall be carried out in accordance with ISO 17637 (visual testing), ISO 3452-1 (penetrant testing), ISO 17638 (magnetic particle testing) and ISO 17405 (ultrasonic testing).

The acceptance criteria stated in [7.5.1](#) or the criteria of product standards, when applicable, shall apply.

7.3 Location and taking of test specimens

Tests specimens shall be taken in accordance with [Figures 3](#) and [4](#) after all non-destructive testing (NDT) has been carried out and the results are satisfactory.

It is acceptable to take the test specimens from locations avoiding areas which have imperfections within the acceptance limits for the NDT method(s) used.

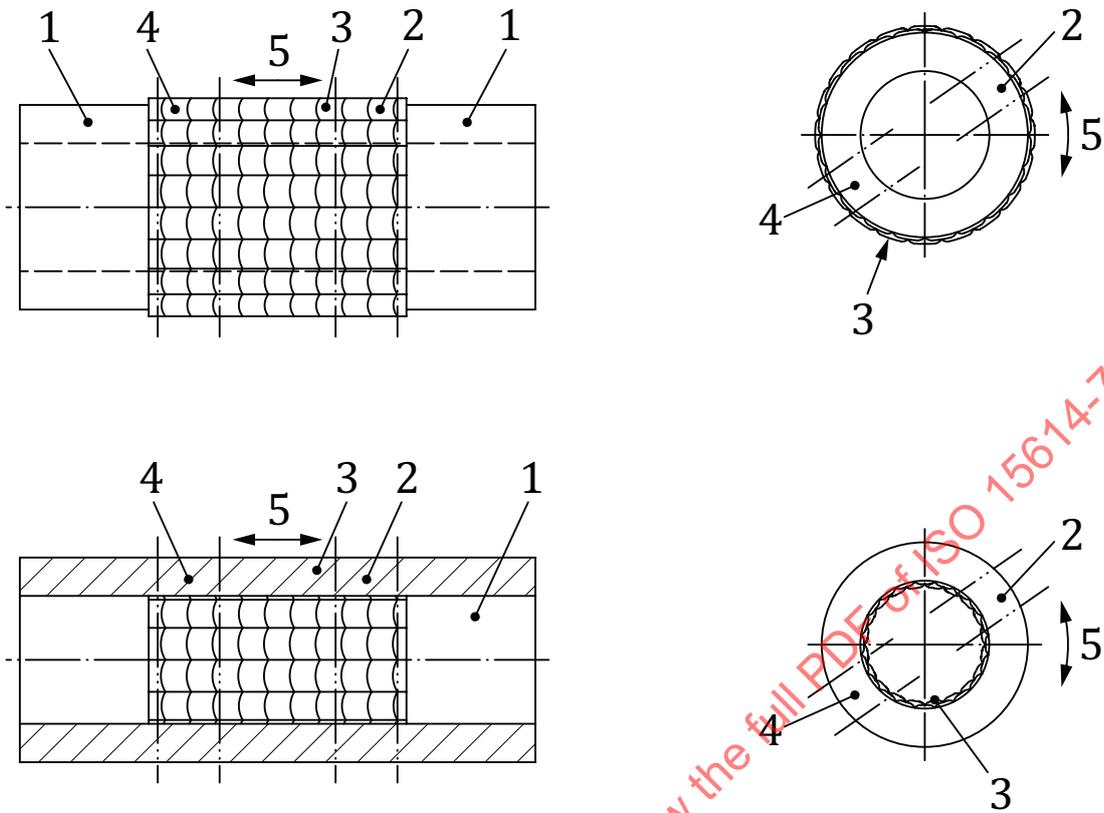


Key

- | | | | |
|---|--|---|------------------------------------|
| 1 | discard ≥ 25 mm of deposited metal | 4 | area for 1 side bend test specimen |
| 2 | area for 1 side bend test specimen | 5 | welding direction |
| 3 | area for: | | |
| | — 1 macro test specimen | | |
| | — chemical analysis, ferrite number if called up by the application standard | | |
| | — 1 hardness test specimen | | |
| | — re-test | | |

Figure 3 — Location of test specimens for overlay welding on plate

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a) Axial deposit

b) Circumferential deposit

Key

- | | | | |
|---|--|---|------------------------------------|
| 1 | discard ≥ 25 mm of deposited metal | 4 | area for 1 side bend test specimen |
| 2 | area for 1 side bend test specimen | 5 | welding direction |
| 3 | area for: | | |
| | — 1 macro test specimen | | |
| | — chemical analysis, ferrite number if called up by the application standard | | |
| | — 1 hardness test specimen | | |
| | — re-test | | |

Figure 4 — Location of tests specimens for overlay welding on tubes

7.4 Destructive testing

7.4.1 General

The extent of testing shall be as required by [Table 1](#). Additional tests may be required by the application standard or specification.

7.4.2 Macroscopic examination

The test specimen shall be prepared and etched in accordance with ISO 17639 on one side to clearly reveal the fusion line, the heat-affected zone (HAZ) and each deposited layer.

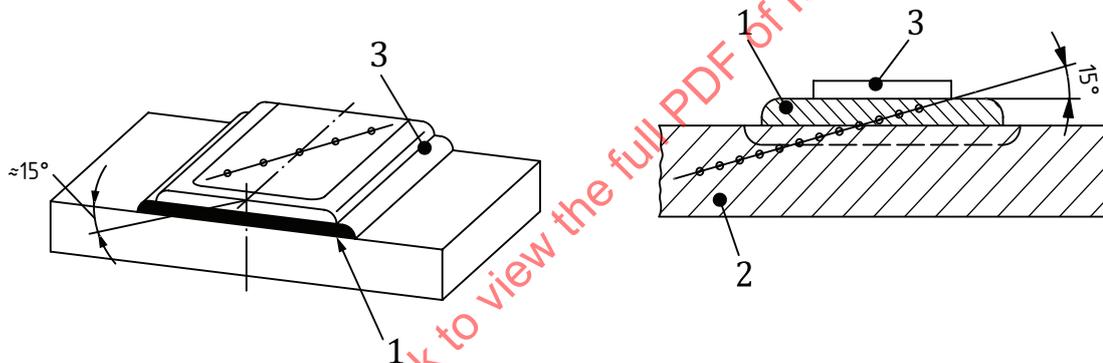
The macroscopic examination shall include unaffected parent metal and the overlay and at least one photograph shall be included in the report.

7.4.3 Hardness testing

Vickers hardness testing with a load of HV 10 or HV 5 shall be carried out in accordance with ISO 9015-1. Hardness indentations shall be made as shown in [Figure 5](#) unless specified differently in the application standard and shall be recorded. The results from the hardness testing for the parent metal and HAZ shall be in accordance with [Table 3](#) or the application standard. The results for the overlay welding shall be in accordance with specified requirements, where detailed, or provided for information.

In all cases, a hardness traverse shall be made at an angle of 15° to the surface including the overlay, heat-affected zone (HAZ) and the parent metal.

For hardfacing, a minimum of five indentations shall be made on the machined surface of the test piece.



Key

- | | | | |
|---|----------------------------------|---|---|
| 1 | intermediate layer, if necessary | 3 | hardfacing or corrosion resistant overlay |
| 2 | parent metal | | |

NOTE Distance between the measuring points along the 15° line approximately 1 mm.

Figure 5 — Hardness traverse for overlay

7.4.4 Side bend testing

For side bend testing of corrosion resistant overlay weld deposits, the test specimens and testing shall be in accordance with ISO 5173.

The diameter of the former or the inner roller shall be $4t$ and the bending angle shall be 180° for weld metal with elongation, $A \geq 20\%$. For weld metal with elongation, $A < 20\%$, [Formula \(1\)](#) shall be applied:

$$d = \frac{(100 \times t_s)}{A} - t_s \quad (1)$$

where

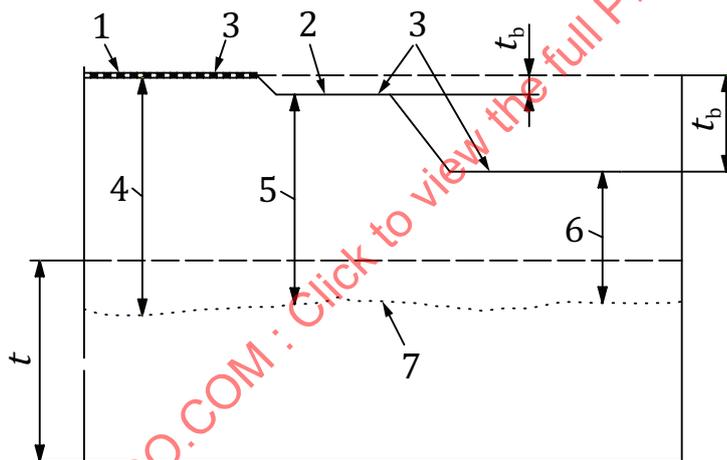
- d is the maximum diameter of the former or the inner roller;
- t_s is the thickness of the bend test specimen;
- A is the minimum tensile elongation required by the material specification.

7.4.5 Chemical analysis

For corrosion resistant overlay welds, the chemical composition shall be determined in accordance with the application standard and/or the specification at the designated overlay thickness. If the corrosion resistant overlay is subjected to erosion in service, an additional chemical analysis shall be carried out in the area of the minimum acceptable end of service life thickness (see [Figure 6](#)).

When a chemical analysis is conducted on the as welded or machined surface, the distance from the fusion line to the final as welded or machined surface shall become the minimum qualified overlay thickness. The chemical analysis may be performed directly on the surface or on chips of material taken from the surface or a drilled horizontal sample.

When a chemical analysis is conducted on material removed by a horizontal sample, the distance from the fusion line to the uppermost side of the drilled cavity shall become the minimum qualified overlay thickness. The chemical analysis may be performed on chips of material removed from the drilled cavity.



Key

- 1 overlay surface as welded
- 2 overlay after machining
- 3 chemical analysis samples
- 4 total overlay thickness
- 5 total overlay thickness after machining
- 6 surface for corrosion resistant overlay after estimated erosion at final service life
- 7 fusion line
- t parent metal thickness
- t_b thickness of overlay material removed prior to chemical analysis

Figure 6 — Chemical analysis specimen for corrosion resistant overlay

7.4.6 Delta ferrite content/ferrite number (FN)

When required, the delta ferrite content/ferrite number (FN) shall be determined in accordance with the application standard or specification.

7.5 Acceptance criteria

7.5.1 Acceptance criteria for non-destructive testing (NDT)

Unless otherwise specified, the acceptance criteria for NDT shall be in accordance with [Table 2](#).

Table 2 — Acceptance criteria for NDT

NDT method	Corrosion resistant overlay welding	Hardfacing
Visual testing (VT)	Cracks and other linear imperfections are not permitted	Linear and other planar imperfections are not permitted
	Surface pores are not permitted	Surface pores ≤ 2 mm are permitted
Penetrant testing (PT)	Acceptance level 2X according to ISO 23277	
Magnetic particle testing (MT)	Acceptance level 2X according to ISO 23278	
Ultrasonic testing (UT)	An imperfection giving a signal greater than that specified in the application standard is not permitted	

7.5.2 Destructive testing

Unless otherwise specified, the acceptance criteria for destructive testing shall be in accordance with [Table 3](#). For hardfacing, classifications and dimensions of the imperfections shall be specified.

Table 3 — Acceptance criteria for destructive testing

Destructive test	Corrosion resistant overlay welding	Hardfacing
Macroscopic examination	Cracks and other planar defects are not permitted.	To be specified for linear imperfections.
	Individual pores or clusters of pores ≤ 2 mm are permitted.	
Hardness testing	The hardness values for parent metal and the heat affected zone (HAZ) shall not exceed the values in Table 4 .	
		The minimum surface hardness values of the overlay shall be specified.
Side bend test	During testing, the test specimens shall not reveal any single imperfection > 3 mm in any direction. Imperfections appearing at the corners of a test specimen during testing shall be ignored in the evaluation.	Not applicable.

Table 4 — Maximum hardness values for parent metal

Material groups ISO/TR 15608	Non-heat treated [HV 5 or HV 10]	Heat treated [HV 5 or HV 10]
1a, 2 ^b	380	320
3 ^b	450	380
4, 5	380 ^c	350 ^c
6	—	350 ^c
9.1	350	300
9.2	450	350
9.3	450	350

a If hardness tests are required.

b For steels with min $R_{eH} > 890$ MPa, the maximum values shall be specified.

c Maximum value may be exceeded by agreement.

7.6 Re-testing

If the test piece fails to comply with any of the requirements for non-destructive testing specified in [Table 2](#), one further test piece shall be welded and subjected to the same examination. If this additional test piece does not comply with the requirements, the welding procedure test has failed.

If any test specimens fail to comply with the requirements for destructive testing in accordance with [7.4](#), but only due to weld imperfections, two further test specimens shall be tested for each one that failed. The additional test specimens can be taken from the same test piece if there is sufficient material or from a new test piece. Each additional test specimen shall be subjected to the same tests as the initial test specimen that failed. If either of the additional test specimens does not comply with the requirements, the welding procedure test has failed.

If a bend test specimen fails to meet the requirements of [7.4.4](#), two further test specimens shall be obtained for each one that failed. Both shall satisfy the requirements of [Table 3](#).

If there are single hardness values in parent metal or HAZ above the values indicated in [Table 4](#), additional hardness tests may be carried out (on the reverse of the specimen or after sufficient grinding of the tested surfaces). None of the additional hardness values shall exceed the maximum hardness values given in [Table 4](#). Additional hardness tests may be carried out.

If there are single hardness values in the hardfacing overlay below the specified minimum required values, none of the additional hardness values shall be below the minimum hardness values specified.

8 Range of qualification

8.1 General

Each of the conditions given in [Clause 7](#) shall be met in order to comply with this part of ISO 15614.

Changes outside the ranges specified shall require a new welding procedure test.

8.2 Qualification related to the manufacturer

A welding procedure test according to this part of ISO 15614 prepared by a manufacturer is valid for welding in workshops or sites when the manufacturer who performed the welding procedure test retains complete responsibility for all welding carried out to it.

8.3 Qualification related to the material

8.3.1 Parent metal

In order to minimize the unnecessary multiplication of welding procedure tests, parent metal shall be grouped as shown in ISO/TR 15608.

The ranges of qualification are listed in [Table 5](#). Materials not listed in [Table 5](#) require a separate test piece with the range of qualification limited to material group/sub-group tested.

Table 5 — Range of qualification for material groups and sub-groups

Parent metal group of test piece	Range of qualification of parent metal
1	1 ^a
2	2 ^a , 1
3	3 ^a , 1, 2
4	4 ^a , 1, 2, 3
5	5 ^a , 1, 2, 3, 4
6	6 ^a , 1, 2, 3, 4, 5
7	7 ^a
8	8 ^a
9	9
10	10
11	11 ^a , 1

^a Covers steels in the same sub-group and any lower sub-group within the same group.

8.3.2 Parent metal thickness

The range of qualification for the parent metal thickness is given in [Table 6](#).

Table 6 — Range of qualification for parent metal thickness

Thickness of the test piece <i>t</i>	Range of qualification ^a
$t < 25 \text{ mm}^a$	0,5 <i>t</i> to 2 <i>t</i> ^b
$t \geq 25 \text{ mm}^a$	25 mm to unlimited

^a For laser beam welding, 12 mm instead of 25 mm.
^b Unless specified differently in application standard.

8.4 Qualification related to the filler material/overlay

8.4.1 Filler material designation

Filler materials cover other filler materials as long as they have the same designation in accordance with the appropriate International Standard for the filler material or with the same nominal composition.

8.4.2 Thickness of the overlay

For hardfacing deposits, hardness testing in accordance with [7.4.3](#) shall be used to determine the minimum overlay thickness of the deposit.

For corrosion resistant overlays, the minimum qualified overlay thickness shall be determined by chemical analysis in accordance with [7.4.5](#).

For corrosion resistant overlay, an additional sampling for chemical analysis may be required at the estimated end of service life thickness.

The minimum qualified overlay thicknesses are the following:

- for hardfacing, the thinnest section tested in [7.4.3](#) that meets the specified requirements;
- for corrosion resistant overlay, the thinnest section tested in accordance with [7.4.5](#) and [Figure 6](#) that meets the specified requirements.

8.5 Common to welding procedures

8.5.1 Welding process

The range of qualification is restricted to the welding process(es) used in the welding procedure test.

The qualification given is restricted to any supplementary device, e.g. oscillation technique, used during the welding qualification procedure test.

When overlay welding in production is carried out with several welding processes, it shall be performed in the same order as they were used in the welding procedure test.

8.5.2 Welding position

The range of qualification is restricted to the welding position tested. However, welding position PC qualifies welding position PA.

8.5.3 Type of current

The range of qualification is restricted to the type of current (AC, DC, pulsed current) and polarity used in the welding procedure test for each welding process.

8.5.4 Arc energy

The arc energy shall be determined according to ISO/TR 18491.

The range of qualification for the arc energy for each layer are the following:

- for corrosion resistant overlay and hardfacing, the arc energy for the first and second layer (if any) shall be $\pm 25\%$ of the arc energy for that layer in the qualification test. For subsequent layers, the maximum arc energy shall be $+25\%$ maximum of the recorded arc energy of the second or subsequent layers.

8.5.5 Preheating temperature

The minimum preheating temperature recorded for the first layer shall be the minimum qualified preheating temperature for all layers, except if the pWPS specifies a particular sequence without preheating. Measurement of preheating temperature is specified in ISO 13916.

8.5.6 Interpass temperature

The upper limit of the qualification is the highest interpass temperature reached in the welding procedure test. Measurement of interpass temperature is specified in ISO 13916.

8.5.7 Post-heating for hydrogen release

The temperature and duration of post-heating for hydrogen release shall not be reduced. Post-heating shall not be omitted, but may be added.

8.5.8 Post-weld heat-treatment (PWHT)

Addition or deletion of post-weld heat-treatment is not permitted.

A separate procedure qualification is required for each of the following conditions:

- a) for ISO/TR 15608 groups. 1, 2, 3, 4, 5, 6, 7, 9, 10 and 11 materials, the following post weld heat treatment conditions apply:
 - 1) PWHT below the lower transformation temperature;
 - 2) PWHT above the upper transformation temperature (e.g. normalizing);
 - 3) PWHT above the upper transformation temperature followed by heat treatment below the lower transformation temperature (e.g. normalizing or quenching followed by tempering);
 - 4) PWHT between the upper and lower transformation temperatures.
- b) For all other materials, PWHT within a specified temperature range.

More rigorous requirements may be detailed in application standards or specifications.

8.5.9 Number of layers

For corrosion resistant overlay welding, a single-layer welding qualifies a multi-layer welding provided that the welding conditions are identical. A multi-layer welding does not qualify a single-layer welding.

For hardfacing, a single-layer welding qualifies only a single-layer welding. A multi-layer welding does not qualify a single-layer welding. A multi-layer welding with N layers qualifies a multi-layer welding performed up to (N + 4) layers.

With certain hardfacing alloys, an additional layer may result in cracking. The advice of the manufacturer of the hardfacing alloy should be obtained before allowing up to four additional layers to be deposited in excess of the number qualified to be included in the WPS.

8.6 Specific to welding processes

8.6.1 Process 111 [manual metal arc welding (metal arc welding with covered electrode)]

The qualification given is for the diameter of electrode used in the welding procedure test plus or minus one electrode diameter size for each layer provided the requirement for arc energy are satisfied.

8.6.2 Processes 12 (submerged arc welding) and 72 (electroslag overlay welding)

The qualification is restricted to the wire/strip system used in the welding procedure tests (e.g. single-wire/strip or multiple wire/strip-system).

The qualification given for the flux in combination with a grade of wire/strip is restricted to the classification in accordance with ISO 14174.

For hardfacing, the qualification given for an alloyed flux (class 3 in accordance with ISO 14174) is restricted to the make of flux and the grade of wire/strip.

The qualification given is restricted to any supplementary device used during the welding procedure qualification test, e.g. oscillation of the electrodes. Addition of a device to control the magnetic field acting on the weld pool is permitted, but not a deletion.

The qualification is restricted to the wire diameter or strip size used in the welding procedure test.

8.6.3 Processes 13 [gas-shielded metal arc welding and 14 (gas-shielded arc welding with non-consumable tungsten electrode)]

The qualification is restricted to nominal composition of the shielding gas used in the procedure test. The designation of ISO 14175 shall be used to specify the shielding gas composition, e.g. ISO 14175:2008-M21-ArC-18 or ISO 14175:2008-I3-ArHe-30.

A deviation of max. 10 % (relative) of the nominal composition of the CO₂ content is allowed for process 13.

A deviation of max. 10 % (relative) of the nominal composition of the He content is allowed for process 14.

However, an intentional addition or deletion of maximum 0,1 % of any gas component does not require a new welding procedure test.

The qualification given is restricted to the wire system used in the welding procedure test (e.g. single-wire or multiple-wire system or wire oscillation).

8.6.4 Process 15 (plasma arc welding)

In addition to [8.6.3](#), the following requirements apply.

The qualification given is restricted to the filler metal form used in the welding procedure test.

The qualification given is restricted to the make, particle size and type of the powder used in the welding procedure test.

The qualification given is restricted to the powder feed rate ± 10 % used in the welding procedure test.

The qualification given is restricted to the transfer mode used in the welding procedure test.

The qualification given is restricted to the torch orifice diameter used in the welding procedure test.

8.6.5 Process 153 (plasma transferred arc)

For hardfacing only, the following requirements shall apply, in addition to [8.6.4](#).

The maximum particle size range is that qualified ± 20 %.

The qualification is restricted to the plasma gas used in the welding procedure test.

The qualification is restricted to the symbol of the powder-feeding gas (plasma arc spray) qualified in the welding procedure test.

The qualification is restricted to the type and size of tungsten electrode used in the welding procedure test.

The qualification is restricted to the torch-work piece distance qualified ± 10 %.

8.6.6 Process 311 (oxy-acetylene welding)

For hardfacing only, the qualification is restricted to

- fuel gas used in the welding procedure test,
- the maximum fuel gas pressure used in the welding procedure test, and
- the type of blowpipe and tip size used in the welding procedure test.

9 Welding procedure qualification record (WPQR)

The welding procedure qualification record (WPQR) is a statement of the results of assessing each test piece including re-tests. The relevant items listed for the WPS in the relevant part of ISO 15609 shall be included, together with details of any features that would be rejectable by the requirements of [Clause 7](#). 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 or examining body.

A WPQR format shall be used to record details for the welding procedure and the test results, in order to facilitate uniform presentation and assessment of the data.

An example of WPQR format is shown in [Annex A](#).

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