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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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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 15614-7 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 121, *Welding*, in collaboration with Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, *Unification of requirements in the field of metal welding*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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 and pressure 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: Resistance butt and flash welding*

Requests for official interpretations of any aspect of this part of ISO 15614 should be directed to the Secretariat of ISO/TC 44/SC 10 via your national standards body. A complete listing of these bodies can be found at www.iso.org.

Introduction

This part of ISO 15614 is part of a series of standards. Details of this series are given in ISO 15607:2003, Annex A.

Previous procedure qualifications to former national standards or specifications should be taken into consideration at the time of the enquiry or contract stage and agreed between the contracting parties.

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 carrying out 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.

Additional tests may be required by application standards.

This part of ISO 15614 applies to all welding processes suitable for overlay welding.

This part of ISO 15614 is applicable to all new welding procedures. However, it does not invalidate previous welding procedure tests made to former national standards or specifications. Where additional tests are carried out to make the qualification technically equivalent, they are only done on a test piece made in accordance with this part of ISO 15614.

This part of ISO 15614 does not apply to overlay welding where cracks are intentionally produced (e.g. special hardfacing applications).

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 3452, *Non destructive testing — Penetrant inspection — General principles*

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

ISO 6947, *Welds — Working positions — Definitions of angles of slope and rotation*

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

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

ISO 14175, *Welding consumables — Shielding gases for arc welding and cutting*

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

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 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 of welded joints*

ISO/TR 25901[1)], *Welding and related processes — Vocabulary*

3 Terms and definitions

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

4 Preliminary welding procedure specification (pWPS)

4.1 Overlay welding

The pWPS shall be in accordance with ISO 15609-1, ISO 15609-3 and ISO 15609-4. It shall specify the tolerances for all the relevant parameters.

The welding procedure shall be qualified in accordance with Clauses 5 to 8.

4.2 Hardfacing

The pWPS shall be in accordance with ISO 15609-1, ISO 15609-2, ISO 15609-3 and ISO 15609-4. It shall specify the tolerances for all the relevant parameters.

The welding procedure shall be qualified in accordance with Clauses 5 to 8.

1) To be published (revision of CEN/TR 14599).

4.3 Building-up

The pWPS shall be in accordance with ISO 15609-1. It shall specify the tolerances for all the relevant parameters.

The welding procedure shall be qualified in accordance with ISO 15613 or ISO 15614-1 and Clauses 5 to 8.

4.4 Buttering

The pWPS shall be in accordance with ISO 15609-1. It shall specify the tolerances for all the relevant parameters.

If buttering is used for welding between dissimilar materials, the welding procedure shall be qualified in accordance with ISO 15614-1.

If buttering is used to produce a metallurgically compatible weld metal between the parent material and overlay welding or hardfacing, the welding procedure shall be qualified in accordance with ISO 15614-1 and Clauses 5 to 8.

5 Welding procedure test

A test piece shall be welded using the same welding processes as the ones to be used in production (e.g. strip overlay welding + manual metal arc overlay welding with covered electrode).

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 standardized test piece(s) in accordance with Figures 1 and 2, and 6.2. Parent material(s) shall be used which represent the material(s) to be welded in production.

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.

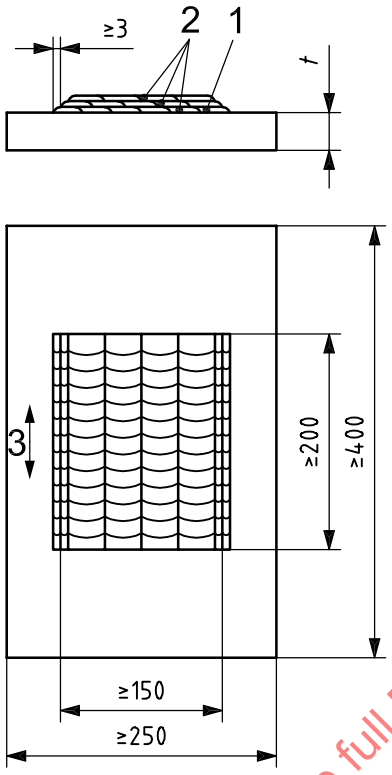
6.1.2 Overlay welding and hardfacing

A minimum of three beads for the last layer is required.

6.1.3 Buffer layer

If a buffer layer is used in production welding, it shall be used in welding the test piece.

Dimensions in millimetres



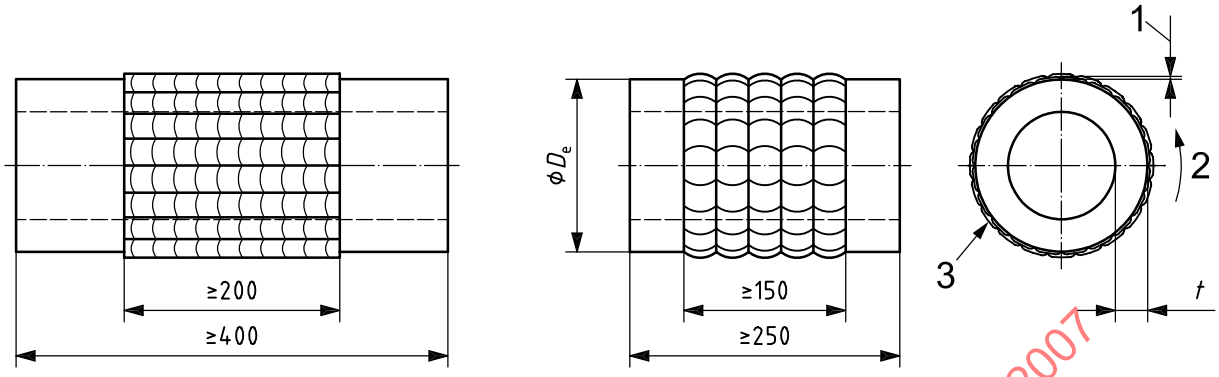
Key

1 buttering layer, if necessary
2 number of layers in accordance with the pWPS (see 6.1.2) or thickness of overlay deposit
3 welding direction

t parent material thickness

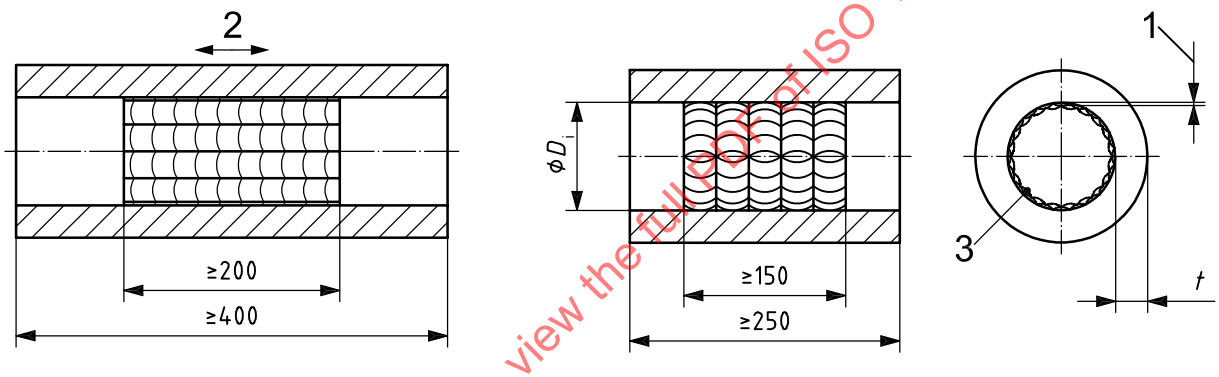
Figure 1 — Test piece — Plate

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 buttering layer, if necessary
2 welding direction
3 number of layers in accordance with the pWPS (see 6.1.2 and 6.1.3)

D_e outside diameter of tube
D_i inside diameter of tube
t parent material 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 pWPS and under the general conditions in production that 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 testing

Testing includes both non-destructive testing (NDT) and destructive testing which 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
Overlay welding	Visual testing	100 %	–
	Ultrasonic testing	100 %	a
	Surface crack detection	100 %	b
	Side bend test	2 specimens	c
	Macroscopic examination	1 specimen	–
	Microscopic examination	1 specimen	d
	Chemical analysis	1 specimen	–
	Delta ferrite content/ferrite number-FN	1 specimen	a
	Hardness testing	1 survey	d
Hardfacing	Visual testing	100 %	–
	Surface crack detection	100 %	b
	Macroscopic examination	1 specimen	–
	Hardness testing	1 survey	–
	Microscopic examination	1 specimen	d

a If required, in accordance with the application standard.

b Penetrant testing or magnetic particle testing. For non-magnetic materials, penetrant testing.

c Side bend test may be replaced by ultrasonic testing (UT) plus two additional macroscopic examinations.

d Not required for material of group 1.

7.2 Non-destructive testing (NDT)

All NDT in accordance with 7.1 and Table 1 shall be carried out on the test pieces prior to cutting of the test specimens. Any post-weld heat treatment that is specified shall be completed prior to NDT.

Depending on overlay geometry, materials and the production specification, NDT shall be carried out in accordance with ISO 17637 (visual examination), ISO 3452 (penetrant testing) and ISO 17640 [ultrasonic testing (UT)].

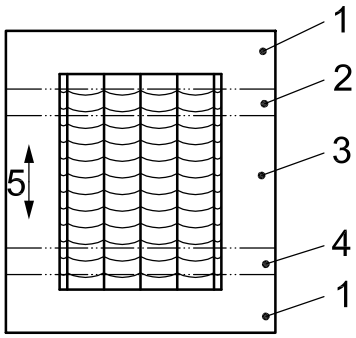
The acceptance criteria stated in 7.5.1 shall apply.

7.3 Location and taking of test specimens

Test specimens shall be taken in accordance with Figures 3 and 4.

Tests specimens shall be taken after all NDT has been carried out and they have passed the relevant inspection criteria for the NDT method(s) used.

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



Key

1 Discard ⩾ 25 mm of deposited metal

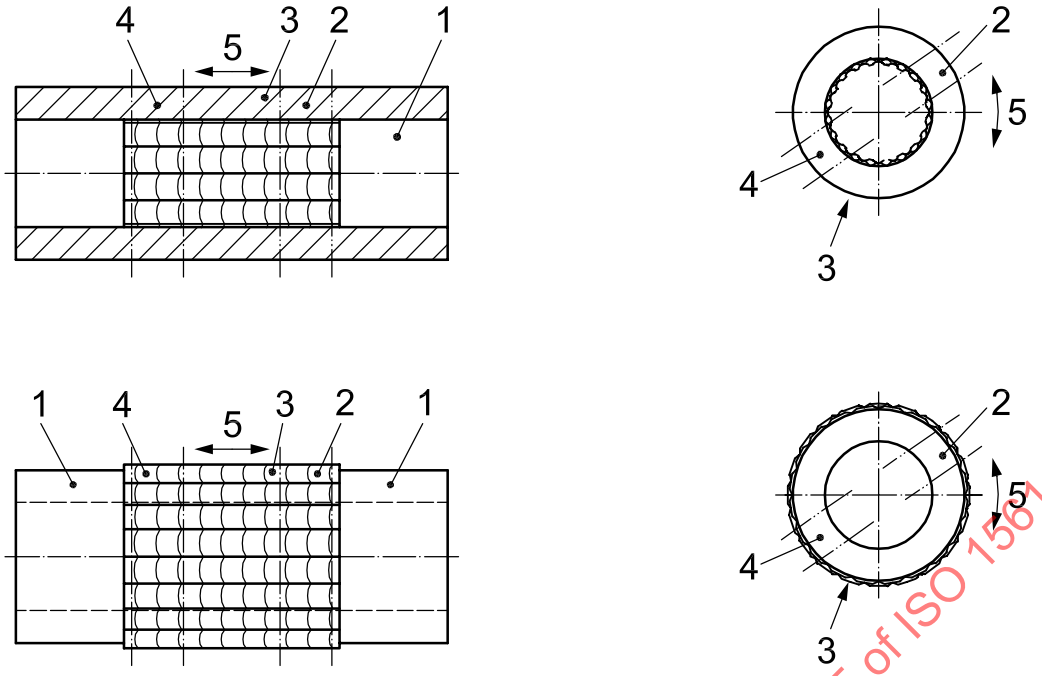
2 Area for:
- 1 side bend test specimen

3 Area for:
- 1 macro test specimen
- chemical analysis, ferrite number
- 1 micro test specimen with hardness test
- retest

4 Area for:
- 1 side bend test specimen

5 Welding direction

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



a) **Axial deposit** b) **Circumferential deposit**

Key

1 Discard ⩾ 25 mm of deposited metal

2 Area for:
- 1 side bend test specimen (see Table 1)

3 Area for:
- 1 macro test specimen
- chemical analysis, ferrite number, if required by the application standard
- 1 micro test specimen with hardness test
- retest

4 Area for:
- 1 side bend test specimen (see Table 1)

5 Welding direction

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.

7.4.2 Macro/microscopic examination

The test specimen shall be prepared and etched in accordance with ISO 17639 on one side in order to reveal clearly the fusion line, the heat-affected zone (HAZ) and the building-up of the layers.

The macroscopic examination shall include unaffected parent material and shall be recorded by taking at least one macro specimen per procedure test.

When microscopic examination is required (see Table 1), a macro specimen of the parent material and of the transition to the parent material (heat-affected zone) and the overlay shall be taken.

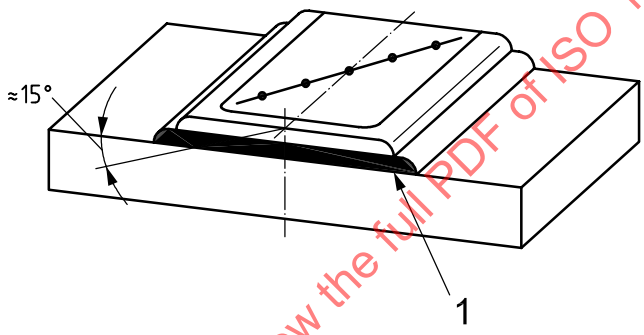
The acceptance levels stated in 7.5.2.1 and 7.5.2.2 shall apply.

7.4.3 Hardness testing

Vickers hardness testing with a load of Vickers number 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. The results of the hardness testing shall be in accordance with 7.5.2.3.

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 material.

For hardfacing, a minimum of five indentations shall be made on the machined surface of the test piece. Since surface hardness is a function of the thickness of the surfacing, these results should be recorded for information.



Key

1 buffer layer

Figure 5 — Hardness traverse for overlay

7.4.4 Side bend testing

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 120° for weld metal with an elongation of $A \geqslant 20$ %. For weld metal with an elongation of $A < 20$ %, the following formula shall be applied:

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

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 manufacturer material specification.

7.4.5 Chemical analysis

For corrosion-resistant cladding, the chemical composition shall be determined in accordance with the application standard and/or the specification. If the corrosion-resistant cladding is to be machined in production, an additional chemical analysis shall be carried out in the area of the minimum thickness after machining (see Figure 6).

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 applicable standard and/or specification.

7.5 Acceptance criteria

7.5.1 Non-destructive testing

7.5.1.1 Visual examination

Cracks and other planar defects are not permitted.

NOTE Small individual cracks can be accepted in the case of overlay welding with cobalt alloys.

Surface pores $\leqslant$ 2 mm are permitted unless otherwise specified (e.g. in severe corrosion conditions).

7.5.1.2 Surface crack detection

Linear indications are not permitted.

7.5.1.3 Ultrasonic testing

Any imperfection giving a signal greater than that obtained from an 8 mm diameter flat-bottom hole is not permitted.

7.5.2 Destructive tests

7.5.2.1 Macroscopic examination

Cracks and other planar defects are not permitted.

Individual pores greater than 2 mm are not permitted. Small individual cracks ($<$ 1,5 mm) may be accepted if limited to the overlay surface in the case of hardfacing and nickel/cobalt alloy overlay.

7.5.2.2 Microscopic examination

Cracks greater than 1,5 mm are not permitted unless otherwise specified.

7.5.2.3 Hardness testing

The hardness values shall not exceed the values in Table 2.

For hardfacing, the maximum hardness values of the overlay shall be specified.

Table 2 — Maximum hardness values

Material groups ISO/TR 15608	Non-heat-treated	Heat-treated
1[a], 2	380	320
3[b]	450	380
4,5	380	320
6	—	350

[a] If hardness tests are required.

[b] For steels with minimum yield stress, $R_{eH} > 890$ N/mm^2, the maximum values shall be specified.

7.5.2.4 Side bend test

During testing, the test specimens shall not reveal a single flaw > 3 mm in any direction. Flaws appearing at the corners of a test specimen during testing shall be ignored in the evaluation.

7.6 Retesting

If the test piece fails to comply with any of the requirements for visual examination or NDT specified in 7.5, 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 specified in 7.4 only as a result of 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 test specimen fails to meet the requirements of 7.4.2, two further test specimens shall be obtained for each one that failed. Both shall satisfy the requirements of 7.4.2.

If there are single hardness values in different test zones above the values indicated in Table 2, 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 2.

8 Range of qualification

8.1 General

Each of the conditions specified 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 qualification of a pWPS obtained by a manufacturer by means of a welding procedure test in accordance with this part of ISO 15614 is valid for welding in workshops or sites under the same technical and quality control of the manufacturer.

Welding is considered to fall under the same technical management and the same quality control when the manufacturer who performed the welding procedure test retains complete responsibility for all welding carried out according to it.

8.3 Qualification related to the material

8.3.1 Parent material

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

A separate test piece is necessary for each material group in accordance with ISO/TR 15608, with a test on any one material of a group being valid for all the materials of the same group.

For steels, an extension of the range of qualification is given in Table 3.

Table 3 — Range of qualification for material groups and sub-groups

Material group(s) of test piece	Range of qualification
1 – 1	1 [a] – 1
2 – 2	2 [a] – 2, 1 – 1, 2 [a] – 1
3 – 3	3 [a] – 3, 1 – 1, 2 – 1, 2 – 2, 3 [a] – 1, 3 [a] – 2
4 – 4	4 [b] – 4, 4 [b] – 1, 4 [b] – 2
5 – 5	5 [b] – 5, 5 [b] – 1, 5 [b] – 2
6 – 6	6 [b] – 6, 6 [b] – 1, 6 [b] – 2
7.1 – 7.1	7.1 [c] – 7.1
7.2 – 7.2	7.2 [c] – 7.2 , 7.1 [c] – 7.1, 7.2 [c] – 7.1
8 – 8	8 [c] – 8
10.1 – 10.1	10.1 [b] – 10.1
11.1 – 11.1	11 [b] – 11, 11 [b] – 1

[a] Covers the equal or lower specified yield strength steels of the same group.

[b] Covers steels in the same sub-group and any lower sub-group within the same group.

[c] Covers steels in the same sub-group.

8.3.2 Parent material thickness

The range of qualification for the parent material thickness is given in Table 4.

Table 4 — Range of qualification for parent material thickness

Thickness of the test piece t	Range of qualification [a]
$t < 25$ mm [a]	$0{,}8t$ to $1{,}5t$
$t \geqslant 25$ mm [a]	25 mm and above

[a] For laser beam welding, 12 mm instead of 25 mm.

8.3.3 Outside pipe diameter

For welding on pipes with an outside diameter < 150 mm, the qualification shall be performed on a pipe. The qualification test piece covers outside diameters > 0,75 times the outside diameter of the test piece.

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 equivalent mechanical properties, the same type of coating, the same nominal composition and a hydrogen content in accordance with the designation in the appropriate standard for the filler material concerned.

8.4.2 Thickness of the overlay

For hardfacing, when the overlay is machined, the minimum thickness of the deposit shall be tested by hardness measurement on the final machined surface (see 7.4.3).

For corrosion-resistant overlay, an additional sampling for chemical analysis shall be performed, where needed, on the final machined surface.

If the overlay is machined in production, the minimum qualified thickness is as follows:

— for hardfacing, the thickness tested in 7.4.3;

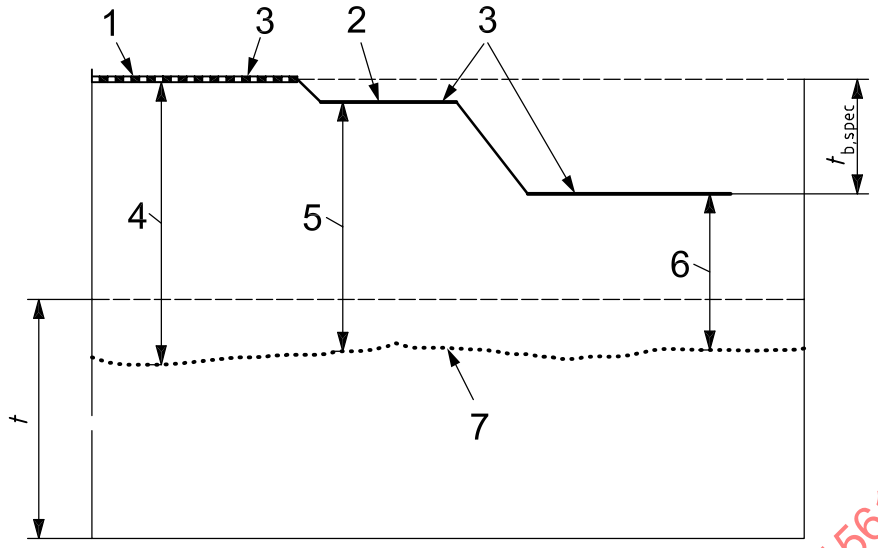
— for corrosion-resistant overlay, the thickness tested in 7.4.5 and in accordance with Figure 6.

8.4.3 Chemical analysis

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

When a chemical analysis is conducted after material has been removed from the as welded surface, the distance from the approximate fusion line to the prepared surface shall become the minimum qualified overlay thickness. The chemical analysis may be made directly on the prepared surface or on chips of material taken from the prepared surface.

When a chemical analysis is conducted on material removed by a horizontal sample, the distance from the approximate 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 for corrosion-resistant cladding
7 approximate fusion line

t parent material thickness
$t_{b,spec}$ qualified overlay thickness below final surface (in accordance with relevant specification, typically 3 mm)

Figure 6 — Chemical analysis specimen for corrosion-resistant overlay, building-up and hardfacing weld overlay

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.

8.5.2 Working position

The range of qualification is restricted to the working position tested. However, working position PC qualifies working positions PA and PB. The working positions shall be in accordance with ISO 6947.

8.5.3 Type of current

The range of qualification is restricted to the type of current (a.c., d.c., pulsed current) and polarity used in the welding procedure test.

8.5.4 Heat input

The range of qualification for the heat input for each layer is restricted to values 25 % greater than those that applied for the same layer during the welding procedure qualification test.

The range of qualification for the heat input for each layer is restricted to values 10 % lower than those that applied for the same layer during the welding procedure qualification test.

8.5.5 Preheat temperature

The minimum preheat temperature for each layer shall be the nominal temperature applied at the start of the corresponding layer during the welding procedure test.

8.5.6 Interpass temperature

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

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

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

The temperature range validated is the holding temperature used in the welding procedure test ± 20 °C unless otherwise specified. Where required, heating rates, cooling rates and holding time shall be related to the product.

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.

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 the electrode used in the welding procedure test plus or minus one electrode diameter size for each run, providing the requirements for heat input are satisfied.

8.6.2 Processes 12 (Submerged arc welding) and 72 (Electroslag 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. control of the magnetic field acting on the weld pool or oscillation of the electrodes.

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

8.6.3 Processes 131 (Metal inert gas welding; MIG welding), 135 (Metal active gas welding; MAG welding), 136 (Tubular cored metal arc welding with active gas shield), 137 (Tubular cored metal arc welding with inert gas shield) and 141 (Tungsten inert gas welding; TIG welding)

The qualification given to the shielding gas is restricted to the symbol of the gas in accordance with ISO 14175 used in the welding procedure qualification 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 additional 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 15 [Plasma transferred arc (PTA)]

For hardfacing only, in addition to 8.6.4, the following requirements shall apply:

— the maximum thickness of the hardfacing shall be the thickness qualified;

— the maximum particle size range is the qualified size ± 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 distance torch-work piece qualified ± 10 %.

8.6.6 Process 311 (Oxy-acetylene welding)

For hardfacing only, the following requirements apply:

— the qualification is restricted to fuel gas used in the welding procedure test;

— the qualification is restricted to the maximum fuel gas pressure used in the welding procedure test;

— the qualification is restricted to the type of blowpipe or tip size used in the welding procedure test.