

DRAFT INTERNATIONAL STANDARD

ISO/DIS 15614-1

ISO/TC 44/SC 10

Secretariat: DIN

Voting begins on:
2013-09-05

Voting terminates on:
2014-02-05

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

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

Partie 1: Soudage à l'arc et aux gaz des aciers et soudage à l'arc des nickels et alliages de nickel

[Revision of first edition (ISO 15614-1:2004) and ISO 15614-1:2004/Cor.1:2005 and ISO 15614-1:2004/Amd.1:2008]

ICS: 25.160.10

ISO/CEN PARALLEL PROCESSING

This draft has been developed within the International Organization for Standardization (ISO), and processed under the **ISO lead** mode of collaboration as defined in the Vienna Agreement.

This draft is hereby submitted to the ISO member bodies and to the CEN member bodies for a parallel five month enquiry.

Should this draft be accepted, a final draft, established on the basis of comments received, will be submitted to a parallel two-month approval vote in ISO and formal vote in CEN.

To expedite distribution, this document is circulated as received from the committee secretariat. ISO Central Secretariat work of editing and text composition will be undertaken at publication stage.

THIS DOCUMENT IS A DRAFT CIRCULATED FOR COMMENT AND APPROVAL. IT IS THEREFORE SUBJECT TO CHANGE AND MAY NOT BE REFERRED TO AS AN INTERNATIONAL STANDARD UNTIL PUBLISHED AS SUCH.

IN ADDITION TO THEIR EVALUATION AS BEING ACCEPTABLE FOR INDUSTRIAL, TECHNOLOGICAL, COMMERCIAL AND USER PURPOSES, DRAFT INTERNATIONAL STANDARDS MAY ON OCCASION HAVE TO BE CONSIDERED IN THE LIGHT OF THEIR POTENTIAL TO BECOME STANDARDS TO WHICH REFERENCE MAY BE MADE IN NATIONAL REGULATIONS.

RECIPIENTS OF THIS DRAFT ARE INVITED TO SUBMIT, WITH THEIR COMMENTS, NOTIFICATION OF ANY RELEVANT PATENT RIGHTS OF WHICH THEY ARE AWARE AND TO PROVIDE SUPPORTING DOCUMENTATION.



Reference number
ISO/DIS 15614-1:2013(E)

© ISO 2013

Copyright notice

This ISO document is a Draft International Standard and is copyright-protected by ISO. Except as permitted under the applicable laws of the user's country, neither this ISO draft nor any extract from it may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, photocopying, recording or otherwise, without prior written permission being secured.

Requests for permission to reproduce should be addressed to either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Reproduction may be subject to royalty payments or a licensing agreement.

Violators may be prosecuted.

Contents

Page

Foreword	v
Introduction.....	vii
1 Scope	1
2 Normative references	2
3 Terms and definitions	3
4 Preliminary welding procedure specification (pWPS)	3
5 Welding procedure test.....	3
6 Test piece	3
6.1 General	3
6.2 Shape and dimensions of test pieces	3
6.2.1 Butt joint in plate with full penetration	4
6.2.2 Butt joint in pipe with full penetration	4
6.2.3 T-joint.....	4
6.2.4 Branch connection	4
6.3 Welding of test pieces.....	4
7 Examination and testing	7
7.1 Type and extent of testing	7
7.2 Location and taking of test specimens	10
7.3 Non-destructive testing	13
7.4 Destructive testing	13
7.4.1 Transverse tensile test.....	13
7.4.2 Bend test	14
7.4.3 Macroscopic examination	14
7.4.4 Impact testing	14
7.4.5 Hardness testing	15
7.5 Acceptance levels	16
7.6 Re-testing	17
8 Range of qualification	18
8.1 General	18
8.2 Related to the manufacturer.....	18
8.3 Related to the parent material.....	18
8.3.1 Parent material grouping	18
8.3.2 Material thickness	21
8.3.3 Diameter of pipes and branch connections.....	23
8.3.4 Angle of branch connection	23
8.4 Common to all welding procedures	24
8.4.1 Welding processes.....	24
8.4.2 Welding positions.....	24
8.4.3 Type of joint/weld	24
8.4.4 Filler material, designation	25
8.4.5 Filler material, manufacturer	26
8.4.6 Filler material size	26
8.4.7 Type of current	26
8.4.8 Heat input	26
8.4.9 Preheat temperature.....	27
8.4.10 Interpass temperature.....	27
8.4.11 Post-heating for hydrogen release	28
8.4.13 Initial heat treatment	28

8.5	Specific to processes.....	29
8.5.1	Submerged arc welding (Process No. 12).....	29
8.5.2	Gas-shielded metal arc welding (Process No. 13).....	31
8.5.3	Gas-shielded arc welding with non-consumable electrode (Process No. 14).....	32
8.5.3	Plasma arc welding (Process No. 15).....	32
8.5.5	Oxy-acetylene welding (Process No. 311).....	32
9	Welding procedure qualification record (WPQR).....	33
Annex A (informative) Welding Procedure Qualification Record form (WPQR)		34
Bibliography.....		38

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 15614-1 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 10, and by Technical Committee CEN/TC 121, *Welding* in collaboration.

This second/third/... edition cancels and replaces the first/second/... edition (ISO 15614-1:2004), [clause(s) / subclause(s) / table(s) / figure(s) / annex(es)] of which [has / have] 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*:

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 iron

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 9: Arc underwater hyperbaric wet welding

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

Part 14: Laser-arc hybrid welding of steels, nickel and nickel alloys

Introduction

Requests for official interpretations of technical aspects of this International Standard should be directed to the Secretariat of ISO/TC 44/SC 10 via your national standards body; a listing of these bodies can be found at www.iso.org.

All new welding procedure tests are to be carried out in accordance with this standard from the date of its issue. However, this International Standard does not invalidate previous welding procedure tests made to former national standards or specifications or previous issues of this standard.

Two levels of welding procedure tests are given in order to permit application to a wide range of welded fabrication. They are designated by Levels 1 and 2.

Level 1 is based on the ASME Section IX and level 2 is based on the previous issues of this standard.

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

1 Scope

This standard specifies how a preliminary welding procedure specification is qualified by welding procedure tests.

This standard applies to production welding, repair welding and build-up welding.

This standard defines the conditions for the execution of welding procedure tests and the range of qualification for welding procedures for all practical welding operations within the range of variables.

The primary purpose of welding procedure qualification is to demonstrate the mechanical properties of the weldment.

Two levels of welding procedure tests are given in order to permit application to a wide range of welded fabrication. They are designated by numbers 1 and 2. In level 2, the extent of testing is greater and the ranges of qualification are more restrictive than in level 1.

Procedure tests carried out to Level 2 automatically qualify for level 1 requirements, but not vice-versa.

When no level is specified in a contract or application standard, all the requirements of level 2 apply.

This standard applies to the arc and gas welding of steels in all product forms and the arc welding of nickel and nickel alloys in all product forms.

Arc and gas welding are covered by the following processes in accordance with ISO 4063:2011. The sub-groups of the individual processes may be considered.

111 - manual metal arc welding (metal-arc welding with covered electrode);

114 - self-shielded tubular-cored arc welding;

12 - submerged arc welding;

13 - Gas-shielded metal arc welding;

14 - gas-shielded arc welding with non-consumable electrode;

15 - plasma arc welding;

311 - oxy-acetylene welding.

The principles of this standard may be applied to other fusion welding processes.

NOTE A former process number does not require a new qualification test according to this standard.

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

ISO 3452, *Non-destructive testing — Penetrant testing*

ISO 4136, *Destructive tests of welds in metallic materials — Traverse tensile test*

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

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

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

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

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

ISO 14175:2009, *Welding consumables — Shielding gases for arc welding and cutting*

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

ISO 15609-1:2004, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 1: Arc welding*

ISO 15609-2:2001, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 2: Gas welding*

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

ISO 17635, *Non-destructive examination of welds — General rules for metallic materials*

ISO 17636, *Non-destructive testing of welds — Radiographic testing of fusion-welded joints*

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 17640, *Non-destructive testing of welds — Ultrasonic testing of welded joints*

ISO/TR 17671-1, *Welding — Recommendations for welding of metallic materials — Part 1: General guidance for arc welding*

ISO/TR 17671-2, *Welding — Recommendations for welding of metallic materials — Part 2: Arc welding of ferritic steels*

ISO/TR 25901:2007, *Welding and related processes — Vocabulary*

ISO 4063:2010, *Welding and allied processes- Nomenclature of processes and reference numbers*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TR 25901:2007 and the following apply.

3.1

Run out length

the length of a run produced by the melting of a covered electrode

NOTE See ISO/TR 17671-2.

3.2

Initial heat treatment

parent metal heat treatment before welding

3.3

build-up welding

addition of weld metal to obtain or restore required dimensions

4 Preliminary welding procedure specification (pWPS)

The preliminary welding procedure specification shall be prepared in accordance with ISO 15609-1 or ISO 15609-2.

5 Welding procedure test

The welding and testing of test pieces shall be in accordance with clauses 6 and 7.

The welder or welding operator who undertakes the welding procedure test satisfactorily in accordance with this standard is qualified according to the relevant national/international standard being applied, providing that the relevant testing requirements of that standard are met.

6 Test piece

6.1 General

The welded joint to which the welding procedure will relate in production shall be represented by making a standard test piece or pieces, as specified in 6.2.

For Level 1: Qualifications, any butt weld test qualifies all joint configurations.

For Level 2: Where the production/joint geometry requirements are not represented by the standard test pieces as shown in this standard, the use of ISO 15613 shall be required in place of this standard test piece.

6.2 Shape and dimensions of test pieces

The length or number of test pieces shall be sufficient to allow all required tests to be carried out.

Additional test pieces, or longer test pieces than the minimum size, may be prepared in order to allow for extra testing and/or for re-testing specimens (see 7.6).

For all test pieces except branch connections (see Figure 4) and T-joints (see Figure 3) the material thickness, t , shall be the same for both plates/pipes to be welded.

If required by the application standard, the direction of plate rolling shall be marked on the test piece when impact tests are required to be taken in the Heat Affected Zone (HAZ).

The thickness and/or pipe outside diameter of the test pieces shall be selected in accordance with 8.3.2 to 8.3.3.

NOTE Examples of joint preparations, see ISO 9692-1 and ISO 9692-2.

The shape and minimum dimensions of the test piece shall be as follows:

6.2.1 Butt joint in plate with full penetration

The test piece shall be prepared in accordance with Figure 1.

6.2.2 Butt joint in pipe with full penetration

The test piece shall be prepared in accordance with Figure 2.

NOTE The word “pipe”, alone or in combination, is used to mean “pipe”, “tube” or “hollow section”.

6.2.3 T-joint

The test piece shall be prepared in accordance with Figure 3.

This test piece applies to fully penetrated butt welds or fillet welds.

6.2.4 Branch connection

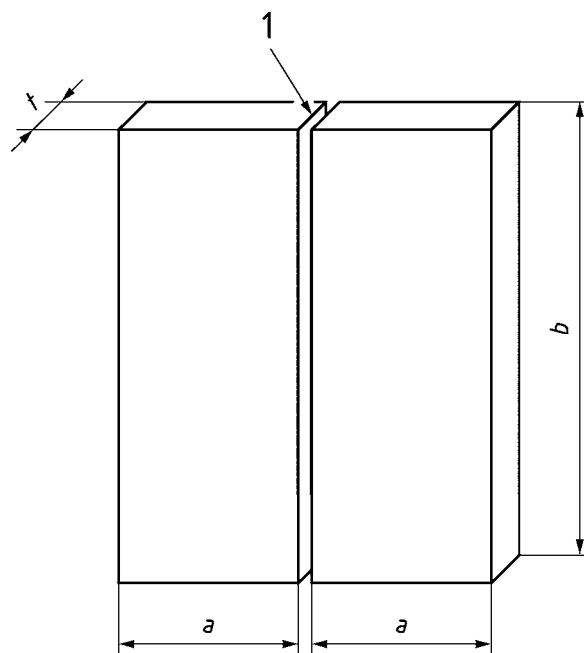
For level 1: No test piece required.

For level 2: The test piece shall be prepared in accordance with Figure 4. The angle α is the minimum one used in production. This test piece applies to fully penetrated joints (set-on, set-in or set-through joint) and for fillet welds.

6.3 Welding of test pieces

Preparation and welding of test pieces shall be carried out in accordance with the pWPS, and under the general conditions of welding in production which they shall represent. Welding positions and limitations for the angle of slope and rotation of the test piece shall be in accordance with ISO 6947. If tack welds are to be fused into the final joint they shall be included in the test piece.

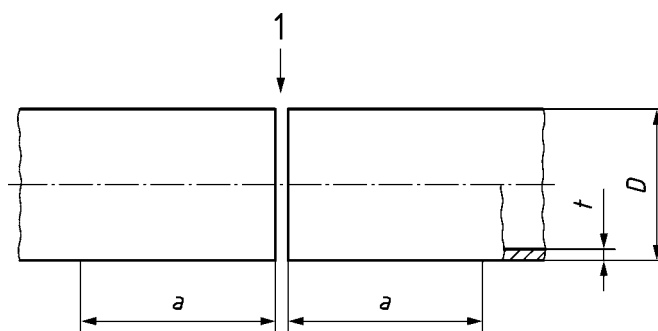
Welding and testing of the test pieces shall be witnessed by an examiner or an examining body.



Key

- 1 Joint preparation and fit-up as detailed in the preliminary Welding Procedure Specification (pWPS)
- a Minimum value 150 mm
- b Minimum value 350 mm
- t Material thickness

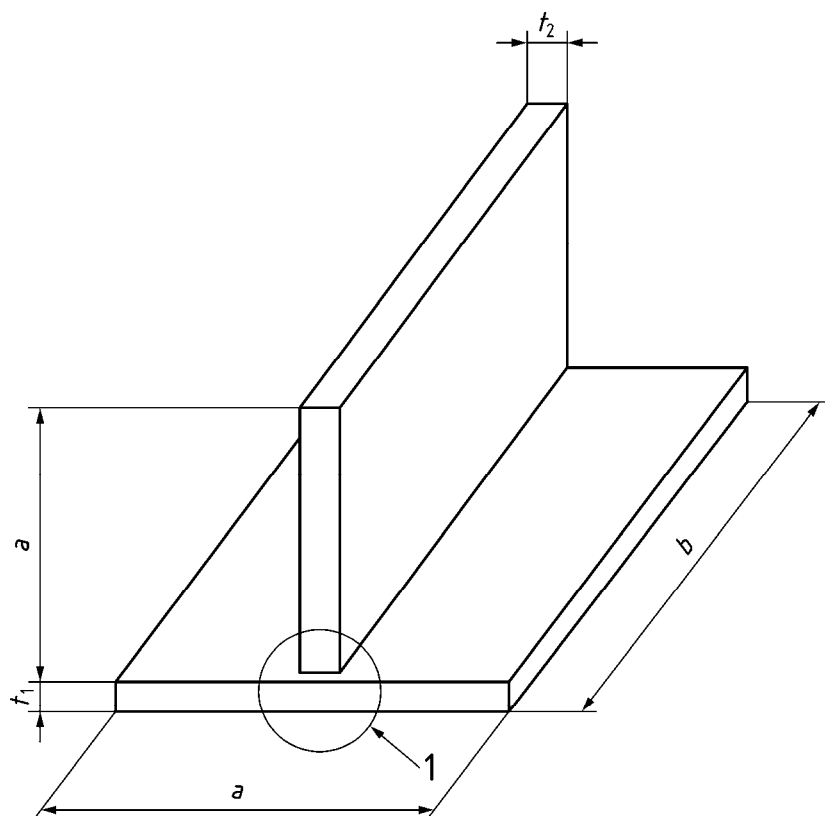
Figure 1 — Test piece for a butt joint in plate with full penetration



Key

- 1 Joint preparation and fit-up as detailed in the preliminary Welding Procedure Specification (pWPS)
- a Minimum value 150 mm
- D Outside pipe diameter
- t Material thickness

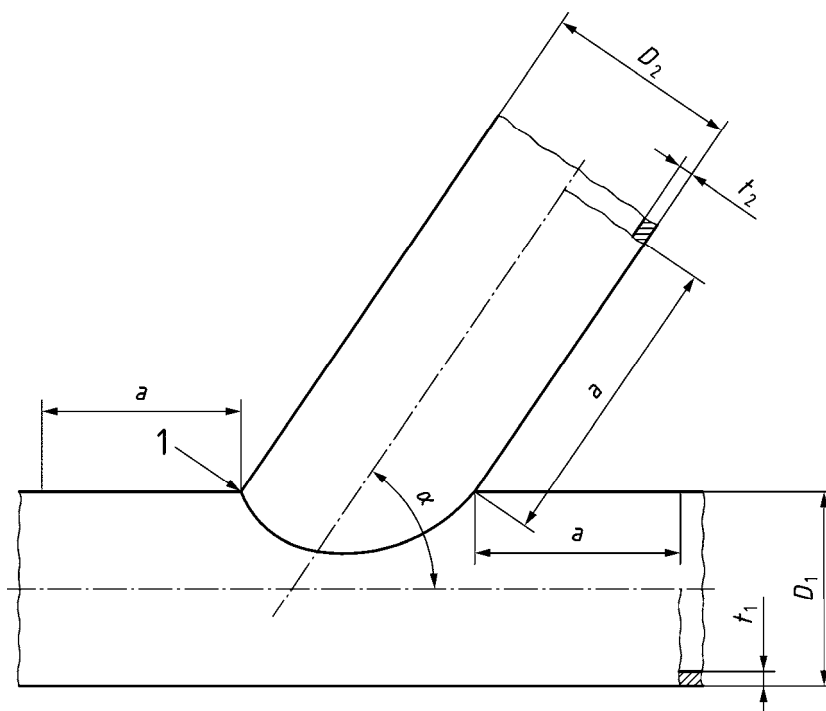
Figure 2 — Test piece for a butt joint in pipe with full penetration



Key

- 1 Joint preparation and fit-up as detailed in the preliminary Welding Procedure Specification (pWPS)
- a Minimum value 150 mm
- b Minimum value 350 mm
- t_1, t_2 Material thickness

Figure 3 — Test piece for a T-joint



Key

- | | |
|----------|--|
| 1 | Joint preparation and fit-up as detailed in the preliminary Welding Procedure Specification (pWPS) |
| α | Branch angle |
| a | Minimum value 150 mm |
| D_1 | Outside diameter of the main pipe |
| t_1 | Main pipe material thickness |
| t_2 | Branch pipe material thickness |
| D_2 | Outside diameter of the pipe |

Figure 4 — Test piece for a branch connection

7 Examination and testing

7.1 Type and extent of testing

For level 1: Type and the extent of testing shall be in accordance with the requirements of Tables 1.

An application standard may specify additional tests, e.g.:

- longitudinal weld tensile test;
- all weld metal bend test;
- corrosion tests;
- chemical analysis;
- microscopic examination;
- delta ferrite examination;
- cruciform test.

For level 1: If impact testing, hardness testing or NDT is required by an application standard or specification, they shall be carried out and assessed

For level 2: Type and the extent of testing shall be in accordance with the requirements of Tables 2.

An application standard may specify additional tests, e.g.:

- longitudinal weld tensile test;
- all weld metal bend test;
- corrosion tests;
- chemical analysis;
- microscopic examination;
- delta ferrite examination;
- cruciform test;
- hardness test;
- impact test;
- NDT.

in accordance with the requirements of level 2, unless specified by the application standard or specification.

NOTE Specific service, material or manufacturing conditions may require more comprehensive testing than is specified by this standard in order to gain more information and to avoid repeating the welding procedure test at a later date just to obtain additional test data.

Table 1 — For level 1: Examination and testing of the test pieces

Test piece	Type of test	Extent of testing	Footnote
Butt joint with full penetration - Figure 1 and Figure 2	Visual Transverse tensile test Transverse bend test	100 % 2 specimens 4 specimens	a
T-joint with full penetration - Figure 3	Visual Macroscopic examination	100 % 2 specimens	b
Fillet welds - Figure 3	Visual Macroscopic examination	100 % 2 specimens	b
^a For bend tests, see 7.4.2. ^b Where mechanical properties are relevant to the application it shall be tested accordingly. If an additional test piece is needed, the dimensions should be sufficient enough to allow testing of the mechanical properties. For this additional test piece only the welding parameters range, parent material group, filler metal and heat treatment shall be the same.			

Table 2 — For level 2: Examination and testing of the test pieces

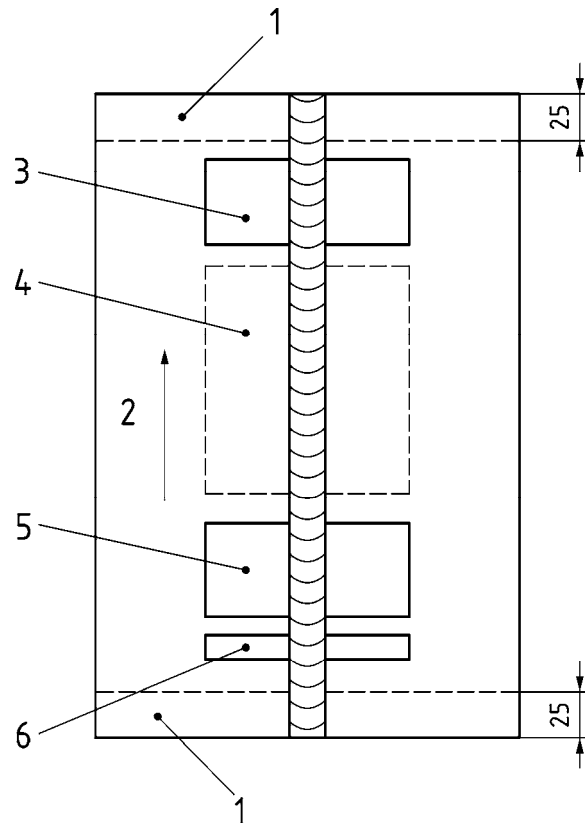
Test piece	Type of test	Extent of testing	Footnote
Butt joint with full penetration - Figure 1 and Figure 2	Visual	100 %	-
	Radiographic or ultrasonic	100 %	a
	Surface crack detection	100 %	b
	Transverse tensile test	2 specimens	-
	Transverse bend test	4 specimens	c
	Impact test	2 sets	d
	Hardness test	required	e
	Macroscopic examination	1 specimen	-
T- joint with full penetration - Figure 3 Branch connection with full penetration - Figure 4	Visual	100 %	f
	Surface crack detection	100 %	b and f
	Ultrasonic or radiographic	100 %	a, f and g
	Hardness test	required	e and f
	Macroscopic examination	2 specimens	f
Fillet welds - Figure 3 and Figure 4	Visual	100 %	f
	Surface crack detection	100 %	b and f
	Hardness test	required	e and f
	Macroscopic examination	2 specimens	f
a Ultrasonic testing shall not be used for $t < 8$ mm and not for material groups 8, 10, 41 to 48. b Penetrant testing or magnetic particle testing. For non-magnetic materials, penetrant testing. c For bend tests, see 7.4.2. d 1 set in the weld metal and 1 set in the HAZ for materials ≥ 12 mm thick and having specified impact properties. Application standards may require impact testing below 12 mm thick. The testing temperature shall be chosen by the manufacturer with regard to the application or application standard but need not be lower than the parent metal specification. For additional tests see 7.4.4. e Not required for parent metals: sub-group 1.1 and 7.1, groups 8, 10 and 41 to 48 except for dissimilar joints between sub-group 1.1 and group 8. f Where mechanical properties are relevant to the application it shall be tested accordingly. If an additional test piece is needed, the dimensions should be sufficient enough to allow testing of the mechanical properties. For this additional test piece only the welding parameters range, parent material group, filler metal and heat treatment shall be the same. g For outside diameter ≤ 50 mm no ultrasonic testing is required. For outside diameter > 50 mm and where it is not technically possible to carry out ultrasonic testing, a radiographic testing shall be carried out provided that the joint configuration will allow meaningful results.			

7.2 Location and taking of test specimens

Test specimens shall be taken in accordance with Figures 5, 6, 7 and 8.

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.

Dimensions in Millimetres

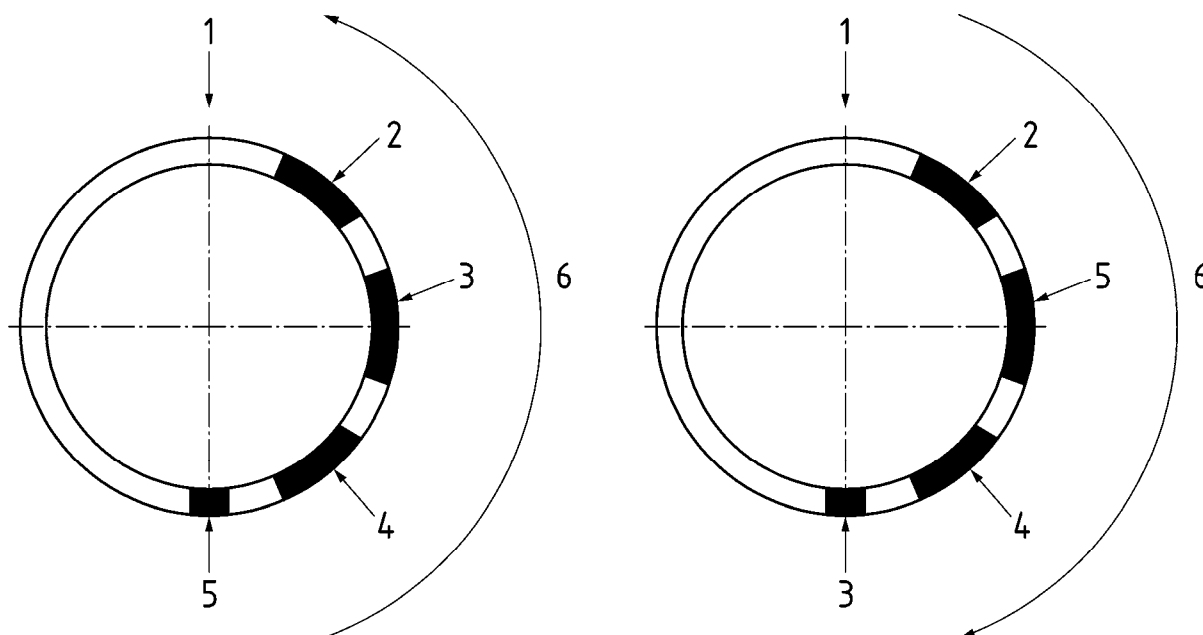


Key

- 1 Discard 25 mm
- 2 Welding direction
- 3 Area for:
 - 1 tensile test specimen;
 - bend test specimens.
- 4 Area for:
 - impact and additional test specimens if required.
- 5 Area for:
 - 1 tensile test specimen;
 - bend test specimens.
- 6 Area for:
 - 1 macro test specimen;
 - 1 hardness test specimen.

NOTE Not to scale.

Figure 5 — Location of test specimens for a butt joint in plate

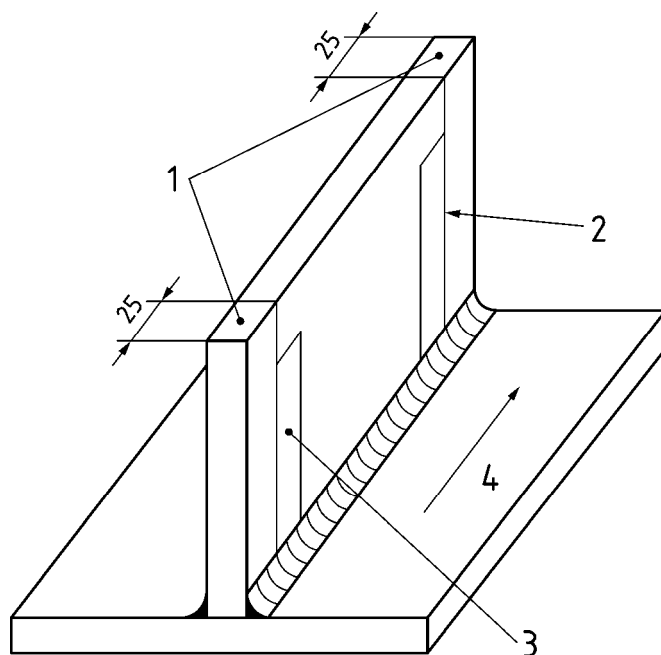


Key

- 1 Top of fixed pipe
- 2 Area for:
 - 1 tensile test specimen;
 - bend test specimens.
- 3 Area for:
 - impact and additional test specimens if required.
- 4 Area for:
 - 1 tensile test specimen;
 - bend test specimens.
- 5 Area for:
 - 1 macro test specimen;
 - 1 hardness test specimen.
- 6 Welding direction

NOTE Not to scale.

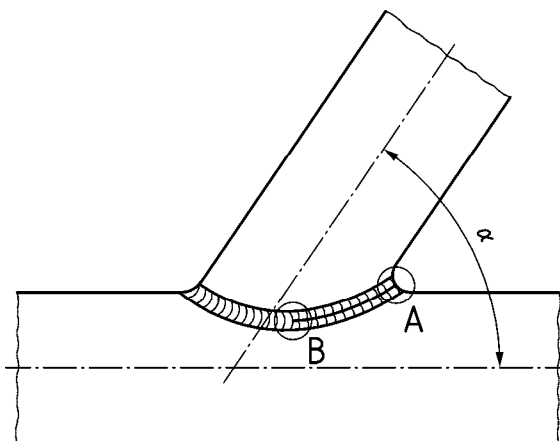
Figure 6 — Location of test specimens for a butt joint in pipe



Key

- 1 Discard 25 mm
- 2 Macro test specimen
- 3 Macro and hardness test specimen
- 4 Welding direction

Figure 7 — Location of test specimens in a T-joint



Key

- A Macro and hardness test specimen to be taken
- B Macro test specimen to be taken
- α Branch angle

Figure 8 — Location of test specimens for a branch connection on pipe

7.3 Non-destructive testing

All non-destructive testing in accordance with 7.1 and Tables 1 and Table 2 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 non-destructive testing.

For materials that are susceptible to hydrogen induced cracking and where no post heating or no post-weld heat treatment is specified, non-destructive testing should be delayed, see ISO/TR 17671-2.

Depending upon joint geometry, materials and the requirements for work, the NDT shall be carried out as required in Table 1 and Table 2 in accordance with ISO 17637 (visual testing), ISO 17636 (radiographic testing), ISO 17640 (ultrasonic testing), ISO 3452 (penetrant testing) and ISO 17638 (magnetic particle testing).

7.4 Destructive testing

7.4.1 Transverse tensile test

Specimens and testing for transverse tensile testing for butt joint shall be in accordance with ISO 4136.

For pipes > 50 mm outside diameter, the excess weld metal shall be removed on both faces to give the test specimen a thickness equal to the wall thickness of the pipe.

For pipes $\leq$ 50 mm outside diameter, and when full section small diameter pipes are used, the excess weld metal may be left undressed on the inside surface of the pipe.

The tensile strength of the test specimen shall not be less than the corresponding specified minimum value for the parent metal unless otherwise specified prior to testing.

For dissimilar parent metal joints the tensile strength shall not to be less than the minimum value specified for the parent material having the lowest tensile strength.

7.4.2 Bend test

Specimens and testing for bend testing for butt joints shall be in accordance with ISO 5173.

For thicknesses < 12 mm two root and two face bend test specimens shall be tested. For thicknesses ≥ 12 mm four side bend specimens are recommended instead of root and face bend tests.

For dissimilar metal joints or heterogeneous butt joint in plates, one root and one face longitudinal bend test specimen may be used instead of four transverse bend tests.

The diameter of the former or the inner roller shall be $4t$ and the bending angle shall be 180° for parent metal with elongation $A \geq 20\%$. For parent metal with elongation $A < 20\%$ the following formula shall be applied:

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

Where

d is the 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.

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

7.4.3 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 HAZ and the build-up of the runs.

The test specimen shall include unaffected parent metal and shall be recorded by at least one photo of macro cross-section per procedure test.

The acceptance levels shall be in accordance with 7.5.

7.4.4 Impact testing

Test specimens and testing for impact tests shall be in accordance with this standard for location of specimens and temperature of testing, and with ISO 9016 for dimensions and testing. The striker radius of 2 mm according to ISO 148-1 shall be used, unless otherwise specified.

For weld metal, test specimen type VWT (V : Charpy V-notch - W : notch in weld metal - T : notch through the thickness) and for HAZ specimen type VHT (V : Charpy V-notch - H : notch in heat affected zone - T : notch through the thickness) shall be used. From each specified location, each set shall be comprised of three specimens.

Specimens with Charpy V-notch shall be used and sampled from a maximum of 2 mm below the surface of the parent metal and transverse to the weld.

In the HAZ, the mid-point of the notch shall be at 1 mm to 2 mm from the fusion line. In the weld metal the mid-point of the notch shall be at the weld centreline.

For test piece thicknesses $t > 50$ mm, two additional sets of specimens shall be taken, one from the weld metal and one from the HAZ at the mid thickness or in the root area of the weld.

The absorbed energy shall be in accordance with the appropriate parent material standard unless modified by the application standard. The average value of the three specimens shall meet the specified requirements. For each notch location one individual value may be below the minimum average value specified, provided that it is not less than 70 % of that value.

For dissimilar metal joints impact tests shall be carried out on specimens from each HAZ in each parent metal.

Where more than one welding process or type of covering and fluxes are qualified in a single test piece, impact test specimens shall be taken from the weld metal and HAZ that include each process and type of covering and fluxes.

For level 2: See additional restriction in 8.4.1.

7.4.5 Hardness testing

Vickers hardness testing with a load of HV10 shall be performed in accordance with ISO 9015-1. Hardness measurements shall be taken in the weld, the heat affected zones and the parent metal in order to evaluate the range of hardness values across the welded joint. For material thicknesses less than or equal to 5 mm, only one row of indentations shall be made at a depth of up to 2 mm below the upper surface of the welded joint. For material thicknesses over 5 mm, two rows of indentations shall be made at a depth of up to 2 mm below the upper and lower surfaces of the of the welded joint. For double sided welds, fillet and T-butt welds, one additional row of indentations shall be made through the root area. Examples of typical indentation patterns are shown in Figures 1 a), b), e) and f) of ISO 9015-1 and Figures 3 and 4.

For each row of indentation at least 3 individual indentations in each of the following areas:

- the weld;
- both heat affected zones;
- both parent metals.

For the HAZ the first indentation shall be placed as close to the fusion line as possible.

The results from the hardness test shall meet the requirements given in Table 3. However requirements for Groups 6 (non-heat treated), 7, 10 and 11 and any dissimilar metal joints shall be specified prior to testing.

Table 3 — Permitted maximum hardness values (HV 10)

Steel groups ISO/TR 15608	Non-heat treated	Heat treated
1 ^a , 2 ^b	380	320
3 ^b	450	380
4,5	380 ^c	350 ^c
6	-	350
9.1	350	300
9.2	450	350
9.3	450	350
^a If hardness tests are required. ^b For steels with min $R_{eH} > 890 \text{ N/mm}^2$ special values shall be specified. ^c For certain materials higher values may be accepted.		

7.5 Acceptance levels

The acceptance level for imperfections corresponding to level 1 and level 2 are given in Table 4.

NOTE The correlation between the quality levels of ISO 5817 and the acceptance levels of the different NDT techniques are given in ISO 17635.

Table 4 — Acceptance levels for imperfections

ISO 5817 Ref. No.	ISO 6520-1 Ref. nr.	Designation	Level 1	Level 2 Quality level to ISO 5817
1.1	100	Crack	Not permitted	B (not permitted)
1.5	401	Lack of fusion (incomplete fusion)	Not permitted	B (not permitted)
1.6	4021	Incomplete root penetration	Not permitted	B (not permitted)
1.16	512	Excessive asymmetry of fillet weld (excessive unequal leg length)	$h \leq 3 \text{ mm}$	B
1.9	502	Excess weld metal (butt weld)	No specific requirements	C
1.10	503	Excessive convexity (Fillet weld)	No specific requirements	C
1.21	5214	Excessive throat thickness	No specific requirements	C
1.11	504	Excess penetration	No specific requirements	C
1.12	505	Incorrect weld toe	No specific requirements	C
1.7	5011 5012	Continuous undercut Intermittent undercut	No specific requirements	C
-	-	All other imperfections	No specific requirements	B

7.6 Re-testing

If any test specimen required by Table 1 or Table 2 fails to meet the applicable acceptance criteria, the test piece shall be considered as failed.

If the test piece fails to comply with any of the requirements for NDT, 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. Alternatively, an analysis may be performed to determine the main cause of the defect. If it is established that the main cause of failure is not procedure related but is due to welder skill, no additional test coupon is needed and a report of the evidence shall be added to the report.

NOTE In accordance with clause 5 the welder qualification test has failed.

In the case of failure of the test piece, another test piece may be welded.

Alternatively, in the case of failure of any destructive test specimen, except for macroscopic examination, two additional test specimens may be removed from the original test piece for each test specimen that failed if adequate material is available. The test specimens shall be taken as close as possible to the original specimen location. If the new test piece passes, the welding conditions that were determined to cause the previous test failure shall be addressed by the manufacturer to ensure that the required properties are achieved in production.

Each additional test specimen shall be subjected to the same tests as the initial test specimen that failed. If any of the additional test specimens do not comply with the requirements, the welding procedure test piece shall be considered failed.

For hardness tests, if there are single hardness values in different test zones above the values indicated in Table 3 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 3.

For impact tests, where the results from a set of three specimens do not comply with the requirements, with only one value lower than 70% of the specified minimum average value, three additional specimens shall be taken. The average value of these specimens together with the initial results shall not be lower than the required average.

8 Range of qualification

8.1 General

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

8.2 Related to the manufacturer

A welding procedure test according to this standard 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 Related to the parent material

8.3.1 Parent material grouping

8.3.1.1 General

In order to minimise the number of welding procedure tests, steels, nickel and nickel alloys are grouped according to ISO/TR 15608.

Separate welding procedure qualifications are required for each parent material or parent material combinations not covered by the grouping system.

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

NOTE Minor compositional differences between similar grades arising from the use of national standards do not need re-qualification

8.3.1.2 Steels

The ranges of qualification are given in Table 5.

8.3.1.3 Nickel alloys

The ranges of qualification are given in Table 6.

8.3.1.4 Dissimilar joints between steels and nickel alloys

The ranges of qualification are given in Table 6.

Table 5 — Range of qualification for steel groups and sub-groups ^{a b c}

Test piece material A	Test piece material B										
	1	2	3	4	5	6	7	8	9	10	11
1	1-1	-	-	-	-	-	-	-	-	-	-
2	2-1 1-1	2-2 2-1 1-1	-	-	-	-	-	-	-	-	-
3	3-1 2-1	3-2 3-1	3-3 3-2 3-1	-	-	-	-	-	-	-	-
4	4-1	4-2	4-3	4-4 4-1 4-2 4-3	-	-	-	-	-	-	-
5	5-1	5-2	5-3	5-4	5-5	-	-	-	-	-	-
6	6-1	6-2	6-3	6-4	6-5	6-6 6-1 6-2 6-3 6-4 6-5	-	-	-	-	-
7	7-1	7-2 7-1	7-3 7-1 7-2	7-4	7-5	7-6 7-5	7-7	-	-	-	-
8	8-1	8-2 8-1	8-3 8-1 8-2	8-4	8-5 8-1 8-2 8-4 8-6	8-6 8-1 8-2 8-4 8-5	8-7	8-8	-	-	-
9	9-1	9-2	9-3	9-4	9-5	9-6	9-7	9-8	9-9	-	-
10	10-1	10-2 10-1	10-3 10-1 10-2	10-4	10-5 10-1 10-2 10-4 10-6	10-6 10-1 10-2 10-4	10-7	10-8	10-9	10-10	-
11	11-1 1-1	11-2	11-3	11-4	11-5	11-6	11-7	11-8	11-9	11-10	11-11 11-1 1-1

^a Test piece materials in group 1, 2, 3 and 11 qualify the equal or lower specified minimum yield strength steels (independent of the material thickness).

^b Test piece materials in group 4, 5, 6 and 9 qualify steels in the same sub-group and any lower sub-group within the same group.

^c Test piece materials in group 7, 8 and 10 qualify steels in the same sub-group.

Table 6 — Range of qualification for nickel alloy and nickel alloy/steel groups

Test piece material A	Test piece material B												
	41	42	43	44	45	46	47	48	1	2	3	5	6
41	41 ^c -41	-	-	-	-	-	-	-	-	-	-	-	-
42	42 ^c -41	42 ^c -42	-	-	-	-	-	-	-	-	-	-	-
43	43 ^c -41	43 ^c -42	43 ^c -43 45 ^c -45 47 ^c -47	-	-	-	-	-	-	-	-	-	-
44	44 ^c -41	44 ^c -42	44 ^c -43	44 ^c -44	-	-	-	-	-	-	-	-	-
45	45 ^c -41	45 ^c -42	45 ^c -43	45 ^c -44	45 ^c -45 43 ^c -43	-	-	-	-	-	-	-	-
46	46 ^c -41	46 ^c -42	46 ^c -43	46 ^c -44	46 ^c -45	46 ^c -46	-	-	-	-	-	-	-
47	47 ^c -41	47 ^c -42	47 ^c -43	47 ^c -44	47 ^c -45	47 ^c -46	47 ^c -47 43 ^c -43 45 ^c -45	-	-	-	-	-	-
48	48 ^c -41	48 ^c -42	48 ^c -43	48 ^c -44	48 ^c -45	48 ^c -46	48 ^c -47	48 ^c -48	-	-	-	-	-
1	41 ^c -1	42 ^c -1	43 ^c -1	44 ^c -1	45 ^c -1	46 ^c -1	47 ^c -1	48 ^c -1	See table 5				
2	41 ^c -2 ^a 41 ^c -1	42 ^c -2 ^a 42 ^c -1	43 ^c -2 ^a 43 ^c -1	44 ^c -2 ^a 44 ^c -1	45 ^c -2 ^a 45 ^c -1	46 ^c -2 ^a 46 ^c -1	47 ^c -2 ^a 47 ^c -1	48 ^c -2 ^a 48 ^c -1					
3	41 ^c -3 ^a 41 ^c -2 41 ^c -1	42 ^c -3 ^a 42 ^c -2 42 ^c -1	43 ^c -3 ^a 43 ^c -2 43 ^c -1	44 ^c -3 ^a 44 ^c -2 44 ^c -1	45 ^c -3 ^a 45 ^c -2 45 ^c -1	46 ^c -3 ^a 46 ^c -2 46 ^c -1	47 ^c -3 ^a 47 ^c -2 47 ^c -1	48 ^c -3 ^a 48 ^c -2 48 ^c -1					
5	41 ^c -5 ^b 41 ^c -6 41 ^c -4 41 ^c -2 41 ^c -1	42 ^c -5 ^b 42 ^c -6 42 ^c -4 42 ^c -2 42 ^c -1	43 ^c -5 ^b 43 ^c -6 43 ^c -4 43 ^c -2 43 ^c -1	44 ^c -5 ^b 44 ^c -6 44 ^c -4 44 ^c -2 44 ^c -1	45 ^c -5 ^b 45 ^c -6 45 ^c -4 45 ^c -2 45 ^c -1	46 ^c -5 ^b 46 ^c -6 46 ^c -4 46 ^c -2 46 ^c -1	47 ^c -5 ^b 47 ^c -6 47 ^c -4 47 ^c -2 47 ^c -1	48 ^c -5 ^b 48 ^c -6 48 ^c -4 48 ^c -2 48 ^c -1					
6	41 ^c -6 ^b 41 ^c -4 41 ^c -2 41 ^c -1	42 ^c -6 ^b 42 ^c -4 42 ^c -2 42 ^c -1	43 ^c -6 ^b 43 ^c -4 43 ^c -2 43 ^c -1	44 ^c -6 ^b 44 ^c -4 44 ^c -2 44 ^c -1	45 ^c -6 ^b 45 ^c -4 45 ^c -2 45 ^c -1	46 ^c -6 ^b 46 ^c -4 46 ^c -2 46 ^c -1	47 ^c -6 ^b 47 ^c -4 47 ^c -2 47 ^c -1	48 ^c -6 ^b 48 ^c -4 48 ^c -2 48 ^c -1					

NOTE: For groups 41 to 48, a procedure test carried out with a precipitation hardening alloy in a group covers all precipitation hardening alloys in that group welded to all solid solution alloys in the same group.

^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 For groups 41 to 48, a procedure test carried out with a solid solution or precipitation hardening alloy in a group covers all solid solution or precipitation hardening alloys respectively in the same group

8.3.2 Material thickness

8.3.2.1 General

Limits of qualification of both the parent material and weld metal shall be as shown in Table 7. The weld deposit limits qualified shall not be exceeded in production welds except that weld thickness associated with the fillet in combination butt/fillet welds shall not be considered.

Both parts of the parent material to be welded shall be within the limits of thickness qualified except that for dissimilar thickness parent materials, there is no limit on the thicker part provided the qualification was performed on parent material of 38 mm or greater.

For multi-process qualification, the recorded thickness of the deposited weld metal thickness of each process shall be used as a basis for the range of qualification for the individual welding process.

8.3.2.2 Range of qualification for butt joints, T- joints, branch connections and fillet welds

The qualification of a welding procedure test on thickness t shall include qualification for thickness in the following ranges given in Table 7 and Table 8.

For dissimilar thickness parent materials, there is no limit on the thicker part provided the qualification was performed on parent material of 38 mm or greater.

For level 1: Any fillet weld test qualifies all fillet sizes and all material thicknesses.

For level 2: The range of qualification of fillet welds qualified by a butt weld or fillet weld test is given in Table 7 and Table 8.

If a fillet weld is qualified by a butt weld, Table 8 applies.

Table 7 — Range of qualification for butt welds material thickness and weld deposit thickness

Dimensions in millimetres

Thickness of test piece t	Range of qualification			
	Parent Material Thickness			Deposited weld metal thickness Level 1 and Level 2
	Level 1	Level 2 Single run	Multi-layer	
≤ 3	0,5t to 2t			max. 2s
$3 < t \leq 12$	1,5 to 2t	0,5t (3 min.) to 1,3t	3 to 2 t	max. 2s ^a
$12 < t \leq 20$	5 to 2t	0,5t to 1,1t	0,5t to 2t	max. 2s
$20 < t \leq 40$	5 to 2t	0,5t to 1,1t	0,5t to 2t	max. 2s when $s < 20$ max. 2t when $s \geq 20$
$40 < t \leq 100$	5 to 200	-	0,5t to 2t	max. 2s when $s < 20$ max. 200 when $s \geq 20$
$100 < t \leq 150$	5 to 200	-	50 to 2t	max. 2s when $s < 20$ max. 200 when $s \geq 20$
$t > 150$	5 to 1,33t	-	50 to 2t	max. 2s when $s < 20$ max. 200 when $s \geq 20$ max. 1,33 s when $s \geq 150$
t is parent material thickness s is deposit weld metal thickness for <u>each process</u> ^a when impact requirements are specified, the range of qualification is limited to 12 mm, unless impact testing shall been performed. <u>For level 1:</u> For processes 114, 12 and 13 in which any pass is greater than 13 mm thick, the maximum parent metal thickness qualified shall be 1.1t. Where impact testing is a requirement, for test pieces 16 mm thick or greater, the minimum thickness qualified is 16 mm. For test pieces less than 16 mm thick, the minimum thickness qualified is the thickness of the test piece. For test piece thicknesses 6 mm and thinner, the minimum thickness qualified is 0,5 times the thickness of the test piece.				

Table 8 — For level 2: Range of qualification for material thickness and throat thickness of fillet welds

Thickness of test piece t	Range of qualification		
	Material thickness	Throat thickness	
		Single run	Multi-run
$t \leq 3 \text{ mm}$	$0,7 t \text{ to } 2 t$	$0,75 a \text{ to } 1,5 a$	No restriction
$3 \text{ mm} < t < 38 \text{ mm}$	$3 \text{ mm to } 2 t$	$0,75 a \text{ to } 1,5 a$	No restriction
$t \geq 38 \text{ mm}$	$\geq 5 \text{ mm}$	$0,75 a \text{ to } 1,5 a$	No restriction
Note 1: The a is the throat thickness as specified in pWPS for the test piece.			
Note 2: Where a fillet weld is qualified by means of a butt weld test, the throat thickness range shall be based on the thickness of the deposited weld metal.			

For level 2: The range of qualification, see table 8, is based on the thicker material.

8.3.3 Diameter of pipes and branch connections

For level 1: The diameter is not an essential variable. Any product form i.e. plate, pipe, forging or casting qualifies for all product forms.

For level 2: the qualification of a welding procedure test on diameter D shall include qualification for diameters in the following ranges given in Table 9. A butt weld qualification for pipes covers butt welds in plates. Qualification given for plates also covers pipes when the outside diameter is $> 500 \text{ mm}$ or when the diameter is $> 150 \text{ mm}$ welded in the PC or PA rotated position.

Table 9 — Range of qualification for pipe and branch connection diameters

Dimensions in millimetres	
Diameter of the test piece D^a , mm	Range of qualification
D	$\geq 0,5D$
NOTE For structural hollow section D is the dimension of the smaller side.	
^a D is the outside diameter for the pipe of a butt weld respectively the outside diameter of the branch pipe for a branch connection.	

8.3.4 Angle of branch connection

For level 1: The angle of branch connection is not an essential variable.

For level 2: A welding procedure test carried out on a branch connection with angle α . A test piece with a branch below 90° in the procedure test qualifies the angle $60^\circ \leq \alpha < 90^\circ$. Angle $\alpha < 60^\circ$ requires a separate test piece and shall qualify angles from α up to 90° .

8.4 Common to all welding procedures

8.4.1 Welding processes

For level 1: The degree of mechanization is not an essential variable.

For level 2: Each degree of mechanization shall be qualified independently (manual, partly mechanized, fully mechanized and automatic).

The qualification is only valid for the welding process(es) used in the welding procedure test.

For multi-process procedures the welding procedure qualification may be carried out with separate welding procedure tests for each welding process. It is also possible to make the welding procedure test as a multi-process procedure test.

For level 1: Where more than one process or consumable are used in a single test piece, each process and consumable may be used individually or in different combinations, provided:

For level 2: The qualification of a multi-process procedure is only valid for the process sequence carried out during the multi-process procedure test, unless the required destructive testing covers all welding processes used.

- a) The variables associated with each process and consumable are addressed in the WPS;
- b) The parent material and deposited weld metal thickness limits of Table 7 for each process and consumable are restricted in the WPS to the thickness limits qualified.

8.4.2 Welding positions

When neither impact nor hardness requirements are specified, welding of the test piece in any position (pipe or plate) qualifies for welding in all positions (pipe or plate).

When impact and/or hardness requirements are specified impact tests shall be taken from the weld in the highest heat input location and hardness tests shall be taken from the weld in the lowest heat input location in order to qualify for all positions.

To satisfy both hardness and impact requirements in different welding positions are required unless a single position qualification is required. Where qualification is required for all positions both test pieces shall be subjected to full visual examination and non-destructive testing.

For material of Group 10, the lowest and highest heat input positions shall be subjected to impact testing.

NOTE Other destructive tests may be taken from either test piece. One of the test pieces may be reduced length.

8.4.3 Type of joint/weld

For level 1: The range of qualification for the type of welded joints is as used in the welding procedure test subject to limitations given in other clauses (e.g. thickness) and additionally:

For level 2: The range of qualification for the type of welded joints is as used in the welding procedure test subject to limitations given in other clauses (e.g. thickness) and additionally:

- a) Full penetration butt welds in butt joints qualify full and partial penetration butt welds and fillet welds in any type of joints;
- a) Full penetration butt welds in butt joints qualify full and partial penetration butt welds and fillet welds in any type of joints;
- b) Butt joints qualify any branch connections;
- b) Butt joints in pipe qualify branch connections with an angle $\geq 60^\circ$;

- | | |
|--|--|
| <ul style="list-style-type: none"> c) Fillet welding qualifies fillet welding only; d) Welds made from one side without backing qualify welds made from both sides and welds with backing; e) Welds made with backing qualify welds made from both sides and welds made without backing; f) Welds made from both sides without gouging qualify welds made from both sides with gouging; g) Welds made from both sides with or without gouging qualify welds made from one side with backing; h) When impact or hardness requirements apply, it is not permitted to change a multi-run deposit into a single run (or single run on each side) or vice versa for a given process; i) Additional build-up welding. | <ul style="list-style-type: none"> c) Butt welds in T-joints with full penetration qualify full and partial penetration butt welds in T-joints and fillet welds; d) Fillet welding qualifies fillet welding only; e) Welds made from one side without backing qualify welds made from both sides and welds with backing; f) Welds made with backing qualify welds made from both sides; g) Welds made from both sides without gouging qualify welds made from both sides with gouging; h) Welds made from both sides with or without gouging qualify welds made from one side with backing; i) When impact or hardness requirements apply, it is not permitted to change a multi-run deposit into a single run (or single run on each side) or vice versa for a given process; j) Additional build-up welding. |
|--|--|

8.4.4 Filler material, designation

For level 1: A change from one Filler metal F-number as shown in Table 10 to another or a change in the weld metal chemical analysis from one A-number shown in Table 11 to another or a change in the manufacturer or the manufacturer's trade name when the filler metal does not conform to an F-number and an A-number, requires a separate qualification.

For level 2: Filler materials cover other filler materials as long as, according to the designation in the appropriate International standard for the filler material, they have equivalent mechanical properties, same type of covering or flux core, same nominal chemical composition and the same or lower hydrogen content.

When the WPS is to be qualified for impact-tested applications, a change in the filler metal classification within a filler metal specification or to a filler metal not covered by a filler metal specification, or from one filler metal not covered by a filler metal specification to another filler metal that is not covered by a filler metal specification, requires a re-qualification. When a filler metal conforms to a filler metal classification within a filler metal specification, re-qualification is not required if a change is made in any of the following:

- a) From a filler metal that is designated as moisture-resistant to one that is not designated as moisture-resistant and vice versa;

- b) From one diffusible hydrogen level to another;
- c) For carbon, low alloy, and stainless steel filler metals having the same minimum tensile strength and the same nominal chemical composition, a change from one low hydrogen coating type to another low hydrogen coating type;
- d) From one position-usability designation to another for flux-cored electrodes;
- e) From a classification that requires impact testing to the same classification which has a suffix which indicates that impact testing was performed at a lower temperature or exhibited greater toughness at the required temperature or both, as compared to the classification which was used during procedure qualification; from the classification qualified to another filler metal within the same filler metal specification when weld metal impact testing is not required by the application standard.

8.4.5 Filler material, manufacturer

When impact testing is required at temperatures less than -20 °C, for processes 111, 114, 12, 136 and 138, the range of validity is restricted to the manufacturer trade name of the filler material used in the procedure test. It is permissible to change the manufacturer of filler material to another with the same compulsory part of the designation provided one additional test piece is welded using the maximum heat input qualified and only weld metal impact test specimens shall be tested.

NOTE This provision does not apply to solid wire and rods with the same designation and nominal chemical compositions.

8.4.6 Filler material size

It is permitted to change the size of filler material providing that the requirements of 8.4.8 are satisfied.

NOTE When neither impact nor hardness testing is required, there is no limitation on filler material size.

8.4.7 Type of current

The qualification is given for the type of current [alternating current (AC), direct current (DC), pulsed current] and polarity used in the welding procedure test. For process 111, alternating current also qualifies direct current (both polarities) unless impact testing is required.

8.4.8 Heat input

When impact requirements apply the upper limit of heat input qualified is:

- the maximum heat input used when welding the test piece; or
- an average value of the heat input used when welding the test piece, plus 25 %.

When hardness requirements apply the lower limit of heat input qualified is:

- the minimum heat input used when welding the test piece; or

— an average value of the heat input used when welding the test piece minus 25 %.

The heat input shall be calculated in accordance with ISO/TR 17671-1 for typical runs in the root, filling and capping layers. For covered electrode the heat input average shall be calculated for each diameter in order to define the maximum qualified heat input.

For level 2: If welding procedure tests have been performed at both a high and a low heat input level, then all intermediate heat inputs are also qualified taking into account the different sequences of runs (root, filling and capping).

NOTE Heat input may be replaced by arc energy (J/mm) = $\frac{\text{Voltage} \times \text{current} \times 60}{\text{Travel Speed (mm/min)}}$

For process 111, the heat input may also be measured by the run out length per unit length of electrode.

Alternatively, the arc energy may be determined using instantaneous energy or power:

- 1) for instantaneous energy measurements in joules (J)

$$\text{Arc energy (J/mm)} = \frac{\text{Energy (J)}}{\text{Weld Bead Length (mm)}}$$

- 2) for instantaneous power measurements in joules per second (J/s) or Watts (W)

$$\text{Arc energy (J/mm)} = \frac{\text{Power (J/s or W)} \times \text{arc time (s)}}{\text{Weld Bead Length (mm)}}$$

When the welding time is too short and when the length of the weld is not significant (e.g. for small repair, for tack welds), the heat input need not to be verified only the adjustable parameters should be checked like amperage and/or voltage.

8.4.9 Preheat temperature

When preheating is used in the welding procedure test, a decrease of more than 50 °C from the recorded preheating temperature on the WPQR requires a re-qualification.

NOTE Pre-heating temperature may be specified e. g. by a material data sheet and depends on the material thickness. ISO/TR 17671-2 gives information regarding preheating.

8.4.10 Interpass temperature

For level 1: When impact test is required, an increase of more than 50°C in the maximum interpass temperature reached in the welding procedure test shall require re-qualification. This limitation does not apply when a WPS qualified with a PWHT above the upper transformation temperature or when an austenitic material is solution annealed after welding.

For level 2: The upper limit of the qualification is the highest interpass temperature reached in the welding procedure test.

8.4.11 Post-heating for hydrogen release

For level 1: Post-heating for hydrogen release is not an essential variable.

For level 2: The temperature and duration of post-heating for hydrogen release shall not be reduced. Post-heating shall not be omitted, but may be added.

8.4.12 Heat-treatment

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.

When impact testing is required, the test piece shall be subjected to PWHT time of at least 80 % of the aggregated time(s) at temperature(s) that will be encountered by production welds. The total time(s) at temperature(s) may be applied in one test piece heating cycle.

8.4.13 Initial heat treatment

For level 1: Initial heat treatment is not an essential variable.

For level 2: A change in the initial heat treatment condition of precipitation hardening materials requires a re-qualification.

8.5 Specific to processes

8.5.1 Submerged arc welding (Process No. 12)

A change as described below requires a requalification.

For level 1:

- a) A change in the minimum tensile strength when the flux/wire combination is classified in filler metal specification. A change in either the flux trade name or wire trade name when neither the flux nor the wire is classified. A change in the flux trade name when the wire is classified but the flux is not.
- b) A change in the flux trade name for A-No. 8 or 9 deposits, as shown in Table 11.
- c) If the weld metal alloy content is dependent upon the composition of the flux, any change in the welding procedure which would result in the important weld metal alloying elements being outside the specified chemical composition range of the WPS.
- d) An addition or deletion of supplementary filler metal (powder or wire), or a change of more than $\pm 10\%$ in the ratio of electrode to supplemental filler material.
- e) A change in flux type (i.e., neutral to active or vice versa) for multilayer welds for material groups 1 and 11 according to in ISO/TR 15608.
- f) When flux from re-crushed slag is used, each batch or blend, shall be tested in accordance with the filler metal specification requirements by either the manufacturer or user, or qualified as an unclassified flux as required by a).
- g) When the WPS is to be qualified for impact-tested applications, re-qualification is required if there is a change in the flux/wire classification or a change in either the electrode or flux trade name when not classified in a filler metal specification. Re-qualification is not required when a wire/flux combination conforms to a filler metal specification and a change is made from one diffusible hydrogen level to another. This variable does not apply when the weld metal is exempt from impact testing by other product standards.

For level 2:

- a) Each variant of process 12 (121 to 126) shall be qualified independently. Any change in the number of electrodes require re-qualification. Any addition or deletion of wires (cold wire or hot wire) shall require re-qualification. Also a change of more than $\pm 10\%$ of the ratio of the supplementary filler material to the electrode require re-qualification.
- b) The qualification of the welding procedure test is restricted to the manufacturer and trade name of the flux used in the test.

Table 10 — Grouping of filler metals and electrodes for qualification (Grouping of welding electrodes and rods for qualification)

Steels			
F- No.	ISO-Standard	A Classification by Yield Strength (or Nom. Comp.)	B Classification by Tensile Strength (or Alloy Type)
1	ISO 2560	EXXxA13, EXXxA33, EXXxRR4, EXXxRA 54, EXXxB53	EXX20, EXX24, EXX27, EXX28
	ISO 3581	EXX XX Bx3, EXX XX Rx3	ESXXX(X)-25, ESXXX(X)-26
	ISO 2560	EXXxMo	EXX20-1M3, EXX27-1M3
2	ISO 2560	EXXxR12, EXXxR32, EXXxRA12	EXX12, EXX13, EXX14, EXX19
	ISO 2560	-	EXX13-XX
3	ISO 2560	EXXxC21, EXXxC11	EXX10, EXX11
	ISO 2560	EXXxMoC21, EXXxMoC11	EXX10-XX, EXX11-XX
4	ISO 2560	EXXxB22, EXXxB12, EXXxB32, EXXxB35	EXX15, EXX16, EXX18, EXX48
	ISO 3581 other than austenitic and duplex	E13 XX Bx1, E13 XX Rx1 E17 XX Bx1, E17 XX Rx1	ES4XX(X)-15, ES4XX(X)-16, ES4XX(X)-17 ES6XX(X)-15, ES6XX(X)-16, ES6XX(X)-17
	ISO 3580, ISO 18275 ISO 2560 ISO 18275	E XXX B EXXXx1.5NiMo B EXXxMn2NiCrMo B, EXXxMn2Ni1CrMo B	EXX15-XX, EXX16-XX, EXX18-XX EXX18-N3M1, EXX18-N3M2 EXX18-N4CM2, EXX18-N4CM2M2
5	ISO 3581 austenitic and duplex	EXX XX Bx1, EXX XX Rx1	ESXXX(X)-15, ESXXX(X)-16, ESXXX(X)-17
6	ISO 14343	All classifications	All classifications
	ISO 14171	All classifications	All classifications
	ISO 14341	All classifications	All classifications
	ISO 636	All classifications	All classifications
	ISO 17632	All classifications	All classifications
	ISO 17633	All classifications	All classifications
	ISO 24598	All classifications	All classifications
	ISO 26304	All classifications	All classifications
	ISO 16834	All classifications	All classifications
	ISO 21952	All classifications	All classifications
	ISO 17634	All classifications	All classifications
	ISO 18276	All classifications	All classifications
Nickel and Nickel alloys			
F- No.	ISO- Standard	Classification	
41	ISO 14172	ENi 2061	
	ISO 18274	SNI 2061	
42	ISO 14172	ENi 4060	
	ISO 18274	SNI 4060, SNI 5504	
43	ISO 14172	ENi 6062, ENi 6133, ENi 6182, ENi 6093, ENi 6152, ENi 6094, ENi 6095, ENi 6025, ENi 6002, ENi 6625, ENi 6276, ENi 6275, ENi 6620, ENi 6455, ENi 6022, ENi 6627, ENi 6059, ENi 6686, ENi 6200, ENi 6650, ENi 6117	
	ISO 18274	SNI 6082, SNI 6072, SNI 6076, SNI 6062, SNI 7092, SNI 6052 SNI 7069, SNI 6601, SNI 6025, SNI 6693, SNI 6002, SNI 6625, SNI 6276, SNI 6455, SNI 6022, SNI 6059, SNI 6686, SNI 6057, SNI 6200, SNI 6650, SNI 6660, SNI 6205, SNI 6231, SNI 6617	
44	ISO 14172	ENi 1001, ENi 1004, ENi 1066, ENi 1008, ENi 1009, ENi 1067, ENi 1069	
	ISO 18274	SNI 1001, SNI 1003, SNI 1004, SNI 1066, SNI 1008, SNI 1009, SNI 1067, SNI 1069	
45	ISO 14172	ENi 6985, ENi 6030	
	ISO 18274	SNI 6975, SNI 6985, SNI 6030, SNI 8065	
46	ISO 18274	SNI 6160	

Table 11 — Grouping of ferrous weld metal by chemical analysis
Not applicable to nonferrous materials

A-No.	Type of weld metal	Chemical composition, weight percent ^a					
		C	Cr	Mo	Ni	Mn	Si
1	Mild Steel (non alloy steel)	0,20	0,20	0,30	0,50	1,60	1,00
2	Carbon-Molybdenum	0,15	0,50	0,40 to 0,65	0,50	1,60	1,00
3	Chrome (0,4 % to 2 %)-Molybdenum	0,15	0,40 to 2,00	0,40 to 0,65	0,50	1,60	1,00
4	Chrome (2 % to 4 %)-Molybdenum	0,15	2,00 to 4,00	0,40 to 1,50	0,50	1,60	2,00
5	Chrome (4 % to 10,5 %)-Molybdenum	0,15	4,00 to 10,50	0,40 to 1,50	0,80	1,20	2,00
6	Chrome-Martensitic	0,15	11,00 to 15,00	0,70	0,80	2,00	1,00
7	Chrome-Ferritic	0,15	11,00 to 30,00	1,00	0,80	1,00	3,00
8	Chromium-Nickel	0,15	14,50 to 30,00	4,00	7,50 to 15,00	2,50	1,00
9	Chromium-Nickel	0,30	19,00 to 30,00	6,00	15,00 to 37,00	2,50	1,00
10	Nickel to 4 %	0,15	0,50	0,55	0,80 to 4,00	1,70	1,00
11	Manganese-Molybdenum	0,17	0,50	0,25 to 0,75	0,85	1,25 to 2,25	1,00
12	Nickel-Chrome-Molybdenum	0,15	1,50	0,25 to 0,80	1,25 to 2,80	0,75 to 2,25	1,00

^a single values are maximum values.
Note Only listed elements are used to determine A-numbers.

8.5.2 Gas-shielded metal arc welding (Process No. 13)

8.5.2.1 Shielding gases

The qualification is restricted to nominal composition of the shielding gas used in the procedure test.

A deviation of more than 10 % (relative) of the nominal composition of the CO₂ content requires a re-qualification.

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

The designation of ISO 14175 may be used to specify the shielding gas composition, e.g. M21 (82/18).

8.5.2.2 Process variants

For level 1: The addition, deletion, or change of more than 10 % in the volume of supplemental filler metal. Where the alloy content of the weld metal is largely dependent upon the composition of the supplemental filler metal, any change in any part of the welding procedure that would result in the important alloying elements in the weld metal being outside of the specification range of chemistry given in the Welding Procedure Specification.

For level 2: The qualification given is restricted to the wire system used in the welding procedure test (e.g. single-wire or multiple-wire system).

When the WPS is to be qualified for impact-tested applications, re-qualification is required if there is a

change from single electrode to multiple electrode acting in the same weld pool, or vice versa.

8.5.2.3 Transfer mode

For solid and metal cored wires, the qualification using short circuiting transfer qualifies only short circuiting transfer. Qualification using spray, pulse or globular transfer qualifies spray, pulse and globular transfer.

8.5.3 Gas-shielded arc welding with non-consumable electrode (Process No. 14)

8.5.3.1 Shielding gases

The qualification is restricted to nominal composition of the shielding gas used in the procedure test.

A deviation of more than 10 % (relative) of the nominal composition of the helium content requires a re-qualification.

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

The designation of ISO 14175 may be used to specify the shielding gas composition, e.g. I3 (ArHe-30).

8.5.3.2 Backing

A butt weld procedure test made without a backing gas qualifies a welding procedure with backing gas, but not vice versa. All inert low reactive and reducing backing gases cover each other, except for groups 7, 8, 10, 41 to 48.

If production welds are made on material backing support with a thickness greater than 5 mm, the deletion of backing gas is acceptable.

8.5.2.3 Filler material

Welding with filler material does not qualify for welding without filler material or vice versa.

8.5.3 Plasma arc welding (Process No. 15)

Qualification of the welding procedure is restricted to the nominal composition of plasma gas used in the welding procedure test. The qualification is restricted to nominal composition of the shielding gas used in the procedure test. Welding with filler material does not qualify for welding without filler material or vice versa.

If impact tests are required for plasma arc welding (PAW), a change in the type of joint preparation (groove) requires a re-qualification.

8.5.5 Oxy-acetylene welding (Process No. 311)

Welding with filler material does not qualify for welding without filler material or vice versa.

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 the examining body.

A WPQR format shall be used to record details and level 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.

Annex A (informative)

Welding Procedure Qualification Record form (WPQR)

Welding procedure qualification - Test certificate

Manufacturer's WPQR No.:

Examiner or examining body

Manufacturer :

Reference No.:

Address:

Code/Testing Standard:

Level:

Date of Welding:

Test piece

Range of qualification

Product form:

Welding Process(es) :

	Welding processes used		
	No. 1	No. 2	No. 3
Process			
Deposited Thickness (mm) :			

Type of joint and weld:

Parent material group(s) and sub group(s):

Parent Material Thickness (mm) :

Throat Thickness (mm)

Single layer/Multi layer:

Outside Pipe Diameter (mm) :

Filler Material Designation:

Filler Material Make:

Filler Material Size

Designation of Shielding Gas/Flux:

Designation of Backing Gas:

Type of Welding Current and Polarity:

Transfer mode:

Heat Input:

Welding Positions :

Preheat Temperature:

Interpass Temperature:

Post-Heating:

Post-Weld Heat-Treatment:

Other Information (see also 8.5):

We confirm that the statements in this record are correct and that the test pieces were prepared, welded, tested and have fulfilled the requirements in accordance with ISO 15614-1.

.....		
Location	Date of issue	Examiner or examining body Name, date and signature

Record of weld test

Location: Manufacturer's pWPS No: Manufacturer's WPQR No: Manufacturer : Welder's/Operator's Name: Mode of Metal Transfer: Joint Type and Weld: Weld Preparation Details (Sketch)* :	Examiner or examining body: Method of Preparation and Cleaning: Parent Material Specification: Material Thickness (mm): Outside Pipe Diameter (mm): Welding Position:
---	--

Joint Design	Welding Sequences

Welding Details

Run	Welding Process	Size of Filler Material	Current A	Voltage V	Type of current/ Polarity	Wire Feed Speed	Travel Speed*	Heat input*	Metal transfer

Filler Material Designation and Make:

Any Special Baking or Drying:

Gas/Flux : shielding

Backing:

Gas Flow Rate – Shielding:

Backing:

Tungsten Electrode Type/Size:

Details of Back Gouging/Backing:

Preheat Temperature:

Interpass Temperature:

Post-Heating:

Post-Weld Heat Treatment:

(Time, Temperature, Method:

Heating and Cooling Rates*):

Other information* e.g.:

Weaving (maximum width of run):

Oscillation: amplitude, frequency, dwell time

Pulse welding details:

Distance contact tube/ workpiece:

Plasma welding details:

Torch angle:

 Manufacturer

Name, date and signature

* If required

 Examiner or examining body

Name, date and signature

Test results

Manufacturer's WPQR No:

Examiner or examining body

Visual:

Reference No.:

Penetrant/Magnetic Particle*

Radiography*:

Tensile Tests

Ultrasonic*:

Temperature:

Type/No.	R _e MPa	R _m MPa	A % on	Z %	Fracture Location	Remarks
Requirement						

Bend Tests

Former Diameter:

Type/No.	Bend Angle	Elongation*	Results

Macroscopic
Examination:

Impact Test*

Type:

Size:

Requirement:

Notch Location/Direction	Temp. °C	Values			Average	Remarks
		1	2	3		

Hardness Test* (Type/Load)

Location of Measurements (Sketch*)

Parent Metal:

HAZ:

Weld metal:

Other Tests:

Remarks:

Tests Carried out in accordance with the
requirements of:

Laboratory Report Reference No.:

Test results were acceptable/not acceptable

(Delete as appropriate)

Test carried out in the presence of:

* If required

.....

Examiner or examining body

Bibliography

ISO 9606-1, *Approval testing of welders — Fusion welding — Part 1: Steels*

ISO 9606-4, *Approval testing of welders — Fusion welding — Part 4: Nickel and nickel alloys*

ISO 14732, *Welding personnel — Approval testing of welding operators for fusion welding and of resistance weld setters for fully mechanized and automatic welding of metallic materials*

ISO/TR 20172, *Welding — Grouping systems for materials — European materials*

ISO/TR 20173, *Welding — Grouping systems for materials — American materials*

ISO/TR 20174, *Welding — Grouping systems for materials — Japanese materials*