INTERNATIONAL STANDARD

ISO 13847

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Petroleum and natural gas industries — Pipeline transportation systems — Welding of pipelines

Industries du pétrole et du gaz naturel — Conduites pour systèmes de transport — Soudage des conduites

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword - Supplementary information.

The committee responsible for this document is Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 2, *Pipeline transportation systems for the petroleum and natural gas industries*.

This second edition cancels and replaces the first edition (ISO 13847:2000), which has been technically revised.

The following annexes have been added compared with the first edition:

— branch and filet welding on in-service pipelines (Annex D);

— welding of European onshore natural gas transmission pipelines (Annex E);

— welding of gas distribution systems in Europe (Annex F);

— automatic ultrasonic testing of girth welds (Annex G);

— time of flight diffraction techniques (Annex I).

Introduction

Users of this International Standard are advised that further or differing requirements might be needed for individual applications, using alternative engineering solutions, particularly where there is innovative or developing technology. Where an alternative is offered, it is advisable that the manufacturer identifies any variations from this International Standard and provides details.

Petroleum and natural gas industries — Pipeline transportation systems — Welding of pipelines

1 Scope

This International Standard specifies requirements for the petroleum, petrochemical and natural gas industries, for producing and inspecting girth, branch and fillet welds in the pipeline part of pipeline transportation systems which meet the requirements of ISO 13623:2009 or equivalent.

This International Standard is applicable to the requirements for welding of carbon and low-alloy steel pipes, and includes guidance for the welding of corrosion-resistant alloy (CRA) and CRA-clad pipelines in Annex A. Application is restricted to pipes with a diameter of 20 mm or more and a wall thickness of 3 mm or more, a specified minimum yield strength of 555 MPa or less, and which are designed not to exceed permissible equivalent stresses as defined in ISO 13623:2009 or equivalent. It is also applicable to welding into pipelines of items such as spools, risers, launchers/receivers, fittings, flanges and pup pieces to pipeline valves.

Guidance for special welding applications is provided in:

— Annex B for hyperbaric welding;

— Annex C for brazing and aluminothermic welding of anode leads;

— Annex D for branch and fillet welding on in-service pipelines.

The welding processes covered are shielded metal arc welding (SMAW), gas tungsten arc welding (GTAW), gas metal arc welding (GMAW), gas-shielded flux-cored arc welding (GSFCAW), self-shielded flux-cored arc welding (SSFCAW) and submerged arc welding (SAW).

This International Standard is not applicable to flash girth welding, resistance welding, solid-phase welding or other one-shot welding processes, nor to longitudinal welds in pipe or fittings or to the welding of process piping outside the scope of ISO 13623:2009.

NOTE 1 Additional requirements might be necessary for the welding of pipeline for particular pipeline operating conditions, for pipelines with a specified yield strength exceeding 555 MPa and for pipelines designed to permissible strain criteria. These can include limitations on maximum hardness or strength, minimum impact toughness values, crack tip-opening displacement, all weld metal tensile testing or bend testing, thermal stress relief, or others. Where appropriate, it is advisable that these additional requirements be added to the requirements of this International Standard in a project-specific supplement.

NOTE 2 Annex E specifies additional requirements for the welding of onshore gas supply systems applicable only when located in European member states. Annex F specifies additional requirements for the welding of gas distribution systems applicable only when located in European member states. It is the responsibility of the company to specify the normative applicability of these annexes.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO 857-1, *Welding and allied processes — Vocabulary — Part 1: Metal welding processes*

ISO 3183, *Petroleum and natural gas industries — Steel pipe for pipeline transportation systems*

ISO 3834 (all parts), *Quality requirements for fusion welding of metallic materials*

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

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

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

ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*

ISO 6520-1, *Welding and allied processes — Classification of geometric imperfections in metallic materials — Part 1: Fusion welding*

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

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

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

ISO 10474, *Steel and steel products — Inspection documents*

ISO 10863:2011, *Non-destructive testing of welds — Ultrasonic testing — Use of time-of-flight diffraction technique (TOFD)*

ISO 13588, *Non-destructive testing of welds — Ultrasonic testing — Use of automated phased array technology*

ISO 13623:2009, *Petroleum and natural gas industries — Pipeline transportation systems*

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

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

ISO 14732, *Welding personnel — Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials*

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

ISO 15614-1:2004, *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 17636-1:2013, *Non-destructive testing of welds — Radiographic testing — Part 1: X- and gamma-ray techniques with film*

EN 1321, *Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds*

ASME, *Boiler and Pressure Vessel Code Section V, Non-destructive examination*

ASTM E1961:2011, *Standard Practice for Mechanized Ultrasonic Testing of Girth Welds Using Zonal Discrimination with Focused Search Units*

AWS A5.01, *Filler metal procurement guidelines*

AWS C5.3, *Recommended practices for air carbon arc gouging and cutting*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 857-1, ISO 6520-1 and the following apply.

3.1
approved welder
welder who has fulfilled the requirements of this International Standard

3.2
approved welding operator
welding operator who has fulfilled the requirements of this International Standard

3.3
approved WPS
welding procedure specification which has fulfilled the requirements of this International Standard

3.4
arc energy
product of welding voltage and current divided by travel speed of welding

Note 1 to entry: The often-used term "heat input" corresponds more precisely to the arc energy modified by an arc efficiency factor.

3.5
automatic welding
welding where the welding parameters and torch guidance are fully controlled mechanically or electronically

3.6
by agreement
agreed between the company and the contractor

3.7
company
owner company, operator or the engineering agency in charge of construction

Note 1 to entry: The company can act through an inspector or other authorized representative. The company can also be the contractor in some instances.

3.8
contractor
entity that performs the work covered by this International Standard

3.9
defect
imperfection or discontinuity exceeding the specified acceptance criteria

3.10
girth weld
circumferential butt weld in pipe

3.11
imperfection
discontinuity
relevant indication related to welding quality

3.12
internal repair
repair of the root pass from inside the pipe

3.13
manual welding
welding where the welding parameters and torch guidance are controlled by the welder

3.14
mechanized welding
welding where the welding parameters and torch guidance are controlled mechanically or electronically, but where minor adjustments can be manually varied during welding to maintain the required welding conditions

3.15
one-shot welding process
process characterized by fusion or metallic bonding being induced around the entire circumference of the pipe simultaneously

EXAMPLE Flash welding, friction welding or pressure welding.

3.16
relevant indication
indication from welding anomalies and related to weld quality

3.17
semi-automatic welding
welding where the welding parameters and torch guidance are controlled by the welder, but where the equipment incorporate wire feeding

3.18
penumbra
shadow produced on a radiographic image when the incident radiation is partially, but not wholly, cut off by an intervening body

Note 1 to entry: The penumbra is the region of geometric unsharpness around the image of an indication.

3.19
roll welding
welding process in which two pipes are abutted in a horizontal position and rotated while one or more welding passes are deposited between previously prepared bevels on the abutting ends

3.20
test piece
welded assembly prepared for the purpose of approving a welding procedure specification, welder or welding operator

3.21
welder
person who holds and manipulates the electrode holder, welding torch or blowpipe by hand

[SOURCE: ISO 9606-1:2012, 3.1]

3.22
weld repair
process of correcting a defect that is discovered after the weld has been completed and submitted for inspection

Note 1 to entry: The repair can involve complete removal of a cylinder of pipe, or removal of a localized area by grinding or other means, followed by additional welding.

3.23
welding operator
person who performs mechanized and/or automatic welding

[SOURCE: ISO 14732:1998, 3.10, modified]

3.24
welding procedure
specific course of action to be followed in making a weld, including reference to materials, preparation, preheating (if necessary), method and control of welding and post-weld heat treatment (if necessary) and equipment to be used

3.27
welding procedure specification
WPS
document providing the required variables for a specific welding procedure

4 Symbols and abbreviated terms

4.1 Symbols

d	outside diameter of pipe
r	nominal internal radius
t	wall thickness

4.2 Abbreviated terms

AC	alternating current
AUT	automatic ultrasonic testing
AWT	all-weld-metal tensile test
CE	carbon equivalent
CE_{pcm}	carbon equivalent, based upon the chemical portion of the Ito-Bessyo carbon equivalent equation
CRA	corrosion-resistant alloy
CTOD	crack tip opening displacement
DAC	distance amplitude correction
DC	direct current
ECA	engineering critical assessment
FCAW	flux-cored arc welding
GMAW	gas metal arc welding (ISO 4063:2009, process 13)
GSFCAW	gas-shielded flux-cored arc welding (ISO 4063:2009, processes 136)
GTAW	gas tungsten arc welding (ISO 4063:2009, process 141)
HAZ	heat-affected zone
HDM	hydrogen dissolved in metal
HV	Vickers hardness
IQI	image-quality indicator
LPT	liquid penetrant testing

MT	magnetic-particle testing
NDT	non-destructive testing
PWHT	post-weld heat treatment
RT	radiographic testing
SAW	submerged arc welding (ISO 4063:2009, process 12)
SMAW	shielded metal arc welding (ISO 4063:2009, process 111)
SMYS	specified minimum yield strength
SSFCAW	self-shielded flux-cored arc welding
ToFD	time-of-flight diffraction
UT	ultrasonic testing
VT	visual testing
WPS	welding procedure specification

5 Compliance

A quality system addressing the quality requirements of ISO 3834 (or equivalent, if agreed) can be applied to assist compliance with the requirements of this International Standard.

NOTE ISO/TS 29001 gives sector-specific guidance on quality management systems.

The contractor is responsible for complying with all of the applicable requirements of this International Standard. It is permissible for the company to make any investigation necessary in order to be ensured of compliance by the contractor and to reject any material that does not comply.

6 Information to be supplied by the company

The user of this International Standard requires the company to specify additional requirements, and company and contractor to agree optional items.

a) Items to be specified by the company:

   1) documentation of information on the NDT method for test welds (see 7.2);

   2) requirements for all-weld-metal tensile tests (see Table 1, footnote d);

   3) use of full pipe lengths for welding of test pieces (see 7.3.5.1);

   4) energy values and test temperatures for Charpy impact testing for wall thicknesses greater than 25 mm (see 7.4.3.5);

   5) permission to transfer WPS between contractors (see 7.6.2);

   6) additional destructive testing of test welds (see 8.6.2);

   7) testing of filler material with lot classification and extent of testing (see 9.10);

   8) frequency, extent and method(s) of NDT if different from ISO 13623:2009 (see 10.1);

   9) use of mechanized UT equipment (see 10.6.5);

   10) use of ECA (see 11.8);

11) weld repair from inside of the pipe (see 12.2);

12) permission for repair-on-repair welding (see 12.2);

13) tests to demonstrate adequate corrosion resistance of the weld in service (see Clause A.2);

14) additional safety measures for in-service welding based on service fluid (see Clause D.1);

15) deletion of transverse notches for detection of transverse defects (see G.4.1);

16) additional qualification when applying workmanship criteria (see G.4.2);

17) other NDT method for comparison of AUT indications (see G.4.2);

18) applicability of Annex E (see Clause E.1)[1)];

19) supplementary applicable national standards or codes (see Clause E.1)[1)];

20) proportion of different NDE techniques (see Table E.1, footnote a)[1)];

21) number of welds to be additionally examined when one weld is rejected (see E.3.1)[1)];

22) applicability of Annex F (see Clause F.1)[2)];

b) Items to be agreed:

1) use of ISO 3834 or an alternative standard for quality requirements, if applicable (see Clause 5);

2) use of an alternative standard for WPS approval (see 7.1);

3) approval of inspector (internal or external) and/or third party for WPS qualification welding and testing (see 7.1);

4) use of materials for welding of test pieces in accordance with ISO 15614-1:2004 (see 7.1);

5) extent of inspection and testing of test pieces for approval of WPS for fillet and branch welds (see 7.4.1);

6) waiving requirements for impact testing for pipe with $t \leq 6$ mm or SMYS < 360 MPa (see Table 1, footnote b);

7) if applicable, locations of test specimens made by a combination of uphill and downhill welding (see 7.4.3.1);

8) degassing of test specimens made using cellulosic-coated electrodes (see 7.4.3.2);

9) permission for hardness retesting (see 7.4.3.7);

10) permissible increase in values for CE or CE_{pcm} for sour service (see 7.6.3.2);

11) use of other type of line up clamp as used during qualification (see 7.6.4.12);

12) requirements for approval of a WPS for repair welding (see 7.7);

13) period of WPS validity (see 7.8);

14) use of another recognized standard for welders and welding operators approval (see 8.1);

15) use and properties of flat plate material for joint simulation (see 8.5.1.3);

16) use of alternative NDT method (see 8.6.1);

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1) Applicable only to gas infrastructure systems in European member states.

2) Applicable only to gas distribution systems in European member states.

17) re-test of welder or welding operator after second failure (see 8.7);

18) movement of the weld after completion of the root (see 9.6);

19) selection of electrodes and filler materials (see 9.10);

20) repair of arc strikes (see 9.13);

21) the minimum number of passes to be completed before interrupting welding (see 9.18);

22) numbering system for production welds (see 9.20);

23) use of gamma-ray (see 10.5.1);

24) use of DC prods (see 10.7);

25) use of permanent magnets or DC-yokes (see 10.7);

26) retention period and location of records (see Clause 13);

27) additional CEN requirements and/or equivalent ISO standards for ISO standards in Annex E (see Clause E.1)[1)];

28) the method(s) for NDT (see E.3.2)[1)];

29) applicable image quality class (see E.3.2)[1)];

30) standard for welder and welding operator approval (see Clause F.3)[2)];

31) use of socket joints (see Clause F.4)[2)];

32) use of alignment aids and similar temporary attachments (see Clause F.4)[2)].

7 Welding procedure specification and qualification requirements

7.1 General

The WPS shall be specified in accordance with 7.2.

To qualify a WPS in accordance with this International Standard, test pieces shall be welded, inspected and tested in accordance with ISO 15614:2004, and with 7.3 and 7.4 of this International Standard.

By agreement, a WPS may be approved in accordance with ISO 15607, ISO 15609 and ISO 15614-1:2004, or ISO 15612 or ISO 15613 without any of the requirements of 7.2 to 7.7.

A WPS shall be approved only if all the requirements of International Standard and the supplementary requirements specified by the company have been met.

The welding and testing for WPS qualification shall be witnessed by an inspector (internal or external) or third party approved by the company.

Prior to the start of production welding, the contractor shall submit to the company for agreement either the preliminary WPS(s) to be approved, or the WPS(s) already approved in accordance with this International Standard. This process may be omitted when the company has supplied the contractor with an appropriately approved WPS or preliminary WPS(s).

Test pieces should be welded using project-specific materials. By agreement, materials for welding of test pieces may be selected in accordance with ISO 15614-1:2004, 8.3.1 to 8.3.3.

7.2 Welding procedure specification

The WPS shall incorporate the technical contents specified in ISO 15609-1, in 7.6 of this International Standard and, if applicable, the following:

— steel grade and delivery condition in accordance with ISO 3183;

— number of welders for the specific weld passes;

— maximum time lapse between start of root pass and start of second (hot) pass;

— type of line-up clamp or tack welding;

— preheating procedure;

— minimum interpass temperature if different from the preheat temperature;

— extent of welding required before removal of line-up clamp or other line-up device;

— part of weld to be completed before joint is permitted to cool to ambient temperature;

— method for control of cooling;

— part of weld to be completed before lowering off, i.e. from side boom to pipe support, or barge move-up;

— action required for partially completed welds.

The company may require information on the method used for NDT of test welds to be documented.

Where the intended installation and/or service application of the welded pipeline involves significant plastic strain, such as during pipe-reeling or J-tube installation, the use of documented strain-ageing data and/or supplementary testing should be considered to demonstrate adequate evidence of strain-ageing resistance.

Weldability tests may be required to provide the necessary information for the selection of welding variables for a WPS.

All relevant welding parameters and variables shall be specified individually in accordance with ISO 15609-1 if a previously approved WPS is offered to the company for agreement.

For steel grades with increased susceptibility to delayed hydrogen cracking due to welding, the WPS shall be designed to prevent such cracking from occurring. Such welding may also require the use of low hydrogen processes, PWHT, and a delay period prior to inspection.

7.3 Welding of test piece

7.3.1 Preliminary WPS

The preparation for, and welding of, test pieces shall be carried out in accordance with a documented preliminary WPS.

7.3.2 Test welding conditions

Test pieces should be welded under conditions that simulate those of the site production location (see 9.3 and 9.4).

7.3.3 Welding position

Welding positions and limitations for the angle of slope and rotation of the test piece shall be in accordance with ISO 6947.

7.3.4 Tack welds

Test pieces shall be tack-welded only if tack welding is necessary during production welding.

7.3.5 Shape and dimensions of test pieces

7.3.5.1 Girth welds

Test pieces for the approval of a WPS for girth welding shall be made by joining pipes with a minimum length of one diameter or 300 mm, whichever is greater. Certain situations may require the use of full pipe lengths.

NOTE Longer test pieces can be required to allow the use of internal clamps selected for production welding or simulate installation conditions.

7.3.5.2 Branch connections and fillet welds

Test pieces for the approval of a WPS for welding branch connections or fillet welds shall be of the shape and dimensions specified in ISO 15614-1:2004.

7.3.5.3 Welds between different materials

Test pieces may be welded for the approval of a WPS from two different materials, provided the test pieces can provide sufficient material for all the testing required for each material.

EXAMPLE A weld between thermal mechanically controlled pipe and a quenched and tempered forged flange is subjected to appropriate mechanical testing on both sides of the weld.

7.4 Inspection and testing of test pieces

7.4.1 Scope of inspection and testing

The extent of inspection and testing of test pieces for the approval of a WPS for girth welding shall be in accordance with Table 1.

The extent of inspection and testing of test pieces for the approval of a WPS for fillet and branch welds shall be established by agreement.

Table 1 — Inspection and testing of the test pieces for girth welding

Type of inspection/test	Extent of inspection/testing
VT	100 %
RT or AUT [a]	100 %
Transverse tensile test	2 specimens
Impact test [b]	2 sets for $t \leq 20$ mm 4 sets for $t > 20$ mm
Macro-examination and hardness test	2 specimens
Bend test [c]	4 bends
All-weld-metal tensile test [d]	by agreement

[a] AUT shall be a qualified production system.

[b] Test may not be required for pipe with $t \leq 6$ mm or with SMYS < 360 MPa.

[c] For t < 12,5 mm, the total number of bends shall be split evenly between root and face bends. For $t \geq 20$ mm, side bends only are acceptable. For 12,5 mm ≤ t < 20 mm, evenly split root and face bends or side bends shall be tested.

[d] Optional requirement to confirm overmatching of the yield strength of the weld metal.

7.4.2 Non-destructive testing

All test pieces shall be examined visually and non-destructively in accordance with Clause 10 following any required PWHT and prior to cutting of the test specimens.

Test welds for the approval of a WPS shall be subjected to NDT no sooner than 24 h after completion of welding.

The NDT shall be reported in accordance with Clause 10 and the results shall meet the acceptance criteria in Clause 11.

7.4.3 Destructive testing — girth welding

7.4.3.1 Cutting of test specimens

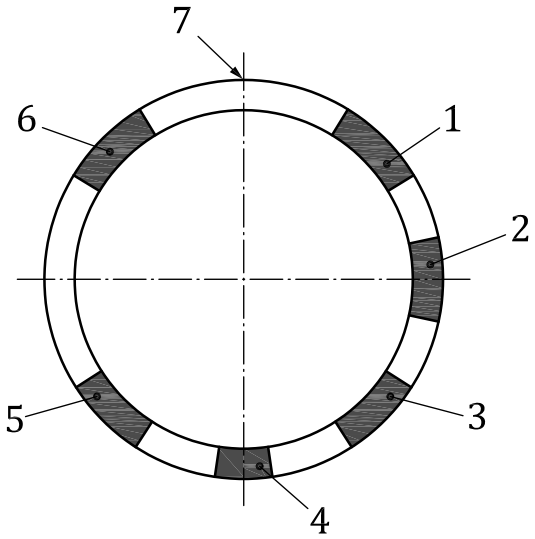
Test specimens shall be taken from test pieces which have met the acceptance criteria for NDT. Test pieces which fail to meet these criteria shall be disregarded for destructive testing for WPS approval.

Test specimens may be taken from locations free of acceptable imperfections revealed by NDT. To avoid weld imperfections in the test specimen, the location of test specimen may be rotated by not more than 15 degrees provided the longitudinal seam is avoided.

Locations of test specimens for fixed horizontal-position welding and fixed vertical-position welding should be in accordance with Figures 1 and 2. Locations of test specimens for roll welding may be selected from Figure 1 or Figure 2.

NOTE Welding positions are as indicated in Figure 4.

Locations of test specimen for welds made in PF or H-L045 positions shall be in accordance with Figure 1, for PG or J-L045 in accordance with Figure 2, and for PA and PC from Figure 1 or Figure 2. Locations of test specimen for welds made by a combination of uphill and downhill welding shall be by agreement.

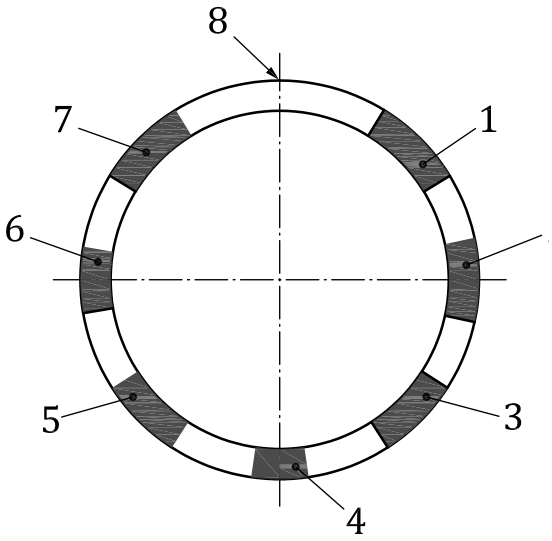


Key

1 area 1 for one tensile specimen and two bend test specimens [a]
2 area 2 for impact and additional test specimens if required
3 area 3 for one tensile specimen and two bend test specimens [a]
4 area 4 for one macro test specimen and one hardness test specimen
5 area 5 for AWT specimens [a]
6 area 6 [a]
7 area 7 top for fixed pipe

[a] If insufficient material is available for bend test specimens in areas 1 and 3, material may be taken from area 5 or 6

Figure 1 — Location of test specimens for a fixed-position girth weld in pipe for upwards welding



Key

1 area 1 for one tensile specimen and two bend test specimens [a]
2 area 2 for one macro test specimen and one hardness test specimen
3 area 3 for one tensile specimen and two bend test specimens [a]
4 area 4 for impact and additional test specimens if required
5 area 5 [a]
6 area 6 for AWT specimens
7 area 7 [a]
8 top for fixed pipe

[a] If insufficient material is available for bend test specimens in areas 1 and 3, material may be taken from area 5 or 7

Figure 2 — Location of test specimens for a fixed-position girth weld in pipe for downwards welding

7.4.3.2 Degassing of test specimens

By agreement, and only for welds made using cellulosic-coated electrodes, test specimens may be degassed by heat treatment at 250 °C for a period not exceeding 10 h.

7.4.3.3 Test temperature

Destructive testing shall be performed at ambient temperature except for impact testing (see 7.4.3.5) or CTOD testing. For design-service temperatures greater than 75 °C, consideration should be given to performing elevated-temperature tensile tests.

7.4.3.4 Transverse tensile testing

Transverse tensile specimens shall be prepared and tested in accordance with ISO 4136.

For pipes greater than 50 mm outside diameter, the weld reinforcement shall be removed on both faces of the specimen. Removal of the reinforcement is not required for specimens from pipe with an outside diameter of 50 mm or less.

If testing full-section small-diameter pipes, the weld reinforcement may be left undressed on the inside surface of the pipe if removal of the reinforcement is not possible.

Specimens shall fail in the pipe or the weld metal at the specified minimum tensile strength or higher or in the pipe metal outside the weld or fusion zone at a stress of 95 % of the specified minimum tensile strength or higher.

Failure of specimens outside the weld or fusion zone at less than 95 % of the specified minimum tensile strength may be an indication of a base material deficiency, and 2 additional specimens shall be cut from the same test joint for tensile testing. These additional specimens shall fail at the specified minimum tensile strength or higher.

If any of the additional specimens break outside the weld or fusion zone below the tensile strength stated, the pipe shall be considered suspect, and its physical properties investigated and confirmed to meet specified values before continuing with test welding for WPS approval.

7.4.3.5 Impact testing

Charpy V-notch specimens shall be sampled from 1 mm to 2 mm below the surface of the parent metal and transverse to the weld direction, as indicated in Figure 3. Full-size Charpy specimens shall be utilized where pipe wall thickness permits.

For each location indicated in Figure 3, a single impact test set shall comprise three test specimens.

For weld metal tests, the specimen notch shall be at the weld centreline. For HAZ tests the notch shall be placed at a location that results in a test containing 1/3 weld metal and 2/3 base material.

Specimen dimensions and test procedure shall be in accordance with ISO 148-1. The test temperature shall not exceed the minimum design temperature.

The results of full-size specimen impact testing for welds in pipe with a wall thickness of 25 mm or less shall meet the following requirements:

a) the average value for each set of Charpy V-notch specimens shall not be less than 40 J;

b) the minimum individual value for a maximum of one specimen of the three shall not be less than 30 J.

The above impact energy value requirements may be reduced *pro rata* for sub-size specimens in accordance with the Formula (1):

$$E = \frac{80}{A_n} \times E_n \tag{1}$$

where

E is the Charpy V-notch energy defined in this code;

E_n is the measured sub-size Charpy V-notch energy;

A_n is the specimen cross-sectional area (mm^2) at the specimen notch.

For welds in pipe with a wall thickness in excess of 25 mm, higher impact energy values or lower test temperature shall be specified by the company to maintain the applicability of the defect acceptance criteria in Clause 10.

7.4.3.6 Macro-examination

Specimens and method of macro-examination for the approval of a WPS shall be in accordance with EN 1321.

For PG, PF, H-L045 and J-L045 welding positions (see Figure 4), one specimen shall be taken at a location corresponding approximately to the 3 o'clock position and one specimen corresponding approximately to the 6 o'clock position.

The specimens shall be free from cracks and lack of fusion. Any other imperfections shall be within the limits specified in Clause 11.

7.4.3.7 Hardness testing

Hardness testing shall be in accordance with ISO 6507-1 using the Vickers method with a test force of 98,07 N.

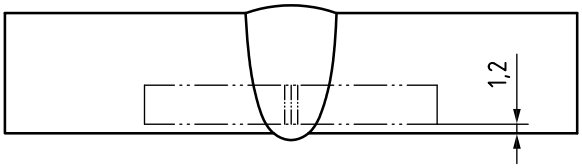
NOTE A test force of 49,03 N can be necessary for the narrow heat-affected zone in some welds made with mechanized or automatic processes.

Hardness shall be measured and recorded in rows across the weld metal, the HAZ and the parent metal as indicated in ISO 9015-1. For the HAZ, the first indentation shall be made as close as possible to the fusion line. The precise locations of each row shall be by agreement.

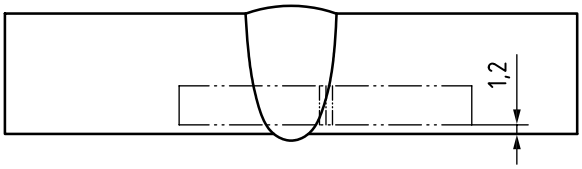
The results from hardness testing shall meet the requirements given in Table 2. By agreement, retesting is permitted only in the event that a single hardness value exceeds the maximum allowable values of Table 2.

Parent material hardness results shall be for information only.

Dimensions in millimetres

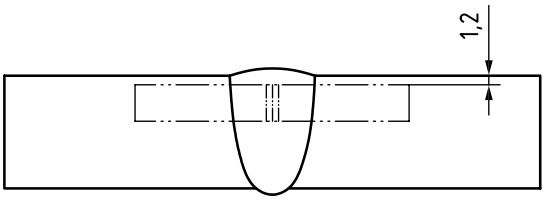


Notch location : Weld metal root

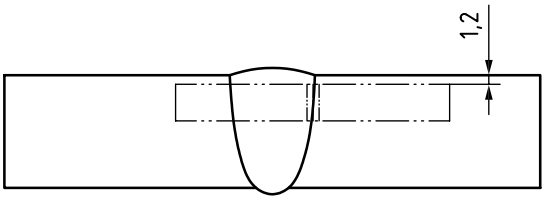


Notch location : HAZ root

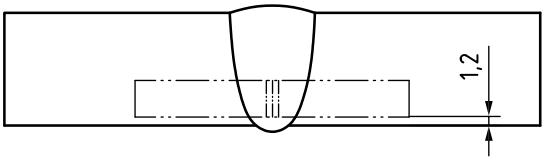
a) Wall thickness ≤ 20 mm



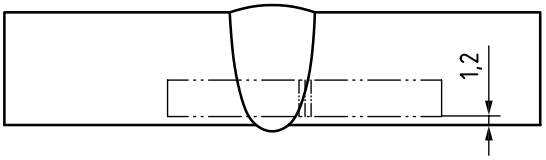
Notch location : Weld metal



Notch location : HAZ



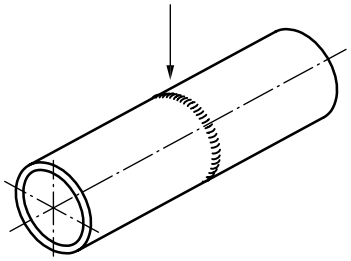
Notch location : Weld metal root



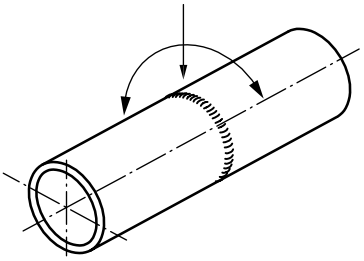
Notch location : HAZ root

b) Wall thickness > 20 mm

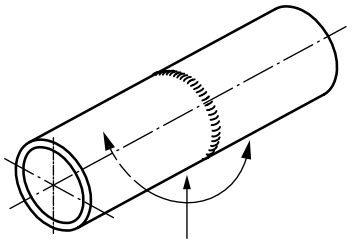
Figure 3 — Position of Charpy V-notch specimens



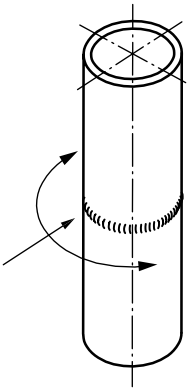
PA pipe : rotating
axis : horizontal
weld : flat



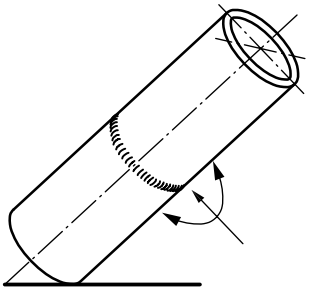
PG pipe : fixed
axis : horizontal
weld : vertical downward



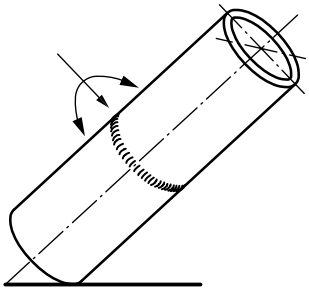
PF pipe : fixed
axis : horizontal
weld : vertical upward



PC pipe : fixed
axis : vertical
weld : horizontal



H-L045 pipe : fixed
axis : inclined
weld : upward



J-L045 pipe : fixed
axis : inclined
weld : downward

Figure 4 — Welding positions (ISO 6947)

Table 2 — Permissible maximum hardness values

Hardness location		Weld metal HV_{10}		HAZ HV_{10}	
		Root	Cover	Root	Cover
Sour service [a] and all welding processes	$t \leq 9{,}5$ mm	250	275	250	275
	$t > 9{,}5$ mm	250	275	250	275
Non-sour service and all thicknesses	Manual welding cellulosic electrodes	275	275	275	325 [b]
	Other welding processes	275 [c]	275 [c]	350	350

[a] The company shall specify when sour service requirements apply.

[b] Maximum value of 350 may be allowed by agreement.

[c] Maximum value of 300 may be allowed by agreement.

7.4.3.8 All-weld-metal tensile testing

If required by the company, test specimens for AWT shall be prepared and tested in accordance with ISO 5178.

The measured yield strength shall be greater than or equal to the SMYS of the parent pipe metal, or another value established by agreement.

7.4.4 Destructive testing — Branch and fillet welds

Test pieces for the approval of a WPS for fillet welding shall be tested as specified in ISO 15614-1:2004, Table 1, and the additional fracture testing specified below.

For pipe with a diameter of 168,3 mm or less, two fracture test specimens shall be taken from the test piece. Four specimens shall be taken for pipe with a diameter above 168,3 mm.

The specimens shall be taken from diametrically opposed positions around the circumference.

Fracture tests shall be performed by breaking specimens with the root of the weld in tension, using one of the following methods:

— supporting both ends and striking the centre of the specimen; or

— gripping one end and striking the other.

The exposed surface of each broken specimen shall be free from cracks, lack of fusion and lack of penetration. The presence of other imperfections in the weld metal shall be within the following limits.

a) Gas pores: The greatest dimension of any single pore shall not exceed 20 % of the wall thickness or 3 mm, whichever is smaller. The combined area of all pores shall not exceed 5 % of the affected area.

b) Inclusions: Individual inclusions shall not be greater than 1 mm in depth and 3 mm or 50 % of the wall thickness in length, whichever is less. There shall be at least 12 mm of sound metal between adjacent inclusions.

7.5 Re-testing

7.5.1 General

A new preliminary WPS may be prepared for approval testing in case a test piece fails to comply with the requirements of this International Standard.

7.5.2 Re-testing for approval of WPS

In case of failure to meet the requirements for destructive testing in 7.4.3 resulting from the presence of weld imperfections, two further test specimens shall be obtained for each test specimen that failed. If either of these additional specimens does not comply with the requirements, the preliminary WPS shall be regarded as not complying with this International Standard, and a new preliminary WPS shall be prepared.

In case of failure to meet the requirements for destructive testing in 7.4.3 for other reasons, one additional test piece may be welded and subjected to the inspection and testing program outlined in 7.4.

7.6 Essential variables and range of approval

7.6.1 General

An approved WPS shall be applied during production welding within the ranges for the essential variables specified in this International Standard.

NOTE The specified variations relate to the materials properties and welding parameters for the welding of the test piece.

A change in one or more of the essential variables beyond the specified range requires the approval of another WPS in accordance with this International Standard.

7.6.2 Related to the contractor

An approved WPS shall be valid in accordance with ISO 15614-1:2004.

Transfer of an approved WPS between contractors should be treated with extreme caution, and requires the agreement of the company.

7.6.3 Related to the material

7.6.3.1 Steel grade

Change of steel grade shall be allowed in accordance with ISO 15614-1:2004.

7.6.3.2 Chemical composition

CE shall be governing for C > 0,12 % and CE_{pcm} for C ≤ 0,12 %.

Based on product analysis, the CE value may be increased by a maximum of 0,030 or the CE_{pcm} value by a maximum of 0,020. For sour service, these increases shall be by agreement, but not exceed the above values.

CE shall be calculated according to Formula (2):

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Cu + Ni}{15} \quad (2)$$

CE_{pcm} shall be calculated according to Formula (3):

$$CE_{pcm} = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B \quad (3)$$

7.6.3.3 Supply condition

The WPS shall be approved only for welds in material of the same supply condition.

7.6.3.4 Thickness

For girth welding, the approved pipe thickness range shall be 0,75 to 1,5 times the wall thickness of the test piece.

For branch and fillet welding, the approved thickness range shall be as specified in ISO 15614-1:2004.

7.6.3.5 Pipe diameter

The pipe diameter shall be as indicated in Table 3.

Table 3 — Range of approval for pipe diameter

Outside diameter of the test piece, d mm	Range of approval
$d \leq 168,3$	0,5 d to 2 d
$d > 168,3$	$\geq 0,5\ d$

7.6.4 Related to all welding processes

7.6.4.1 Welding process

The WPS approval is valid only for the welding process(es) used for welding of the test piece. The sequence of welding processes, if more than one process is used, shall not be changed. These requirements shall also apply to the approval of a WPS for weld repair.

NOTE For multi-process procedures, the welding procedure qualification can be carried out with separate procedure tests for each welding process, provided the essential variable ranges are within the specified ranges.

7.6.4.2 Welding positions

For the purposes of this International Standard, the welding positions in Figure 4 shall apply.

For girth, branch and fillet welding, an approved WPS may be used for the welding positions as specified in Table 4.

A variation in the pipe angle of up to 25° may be applied to each welding position.

Table 4 — Range of approval for welding positions

Position of test piece	Approval status for position					
	PA	PG	PF	PC	H-L045	J-L045
PA	approved	not approved	not approved	not approved	not approved	not approved
PG	approved	approved	not approved	not approved	not approved	not approved
PF	approved	not approved	approved	not approved	not approved	not approved
PC	approved	not approved	not approved	approved	not approved	not approved
H-L045	approved	not approved	not approved	not approved	approved	not approved
J-L045	approved	not approved	not approved	not approved	not approved	approved

7.6.4.3 Weld preparation

The approved WPS shall be used within the tolerances for weld preparation specified in the WPS.

7.6.4.4 Type of joint

The approved WPS is valid for the types of joint indicated in Table 5.

Table 5 — Range of approval for type of joint

Type of joint in test piece	Approval status for types of joint		
	Girth weld		Fillet welds
	with backing	no backing	
Girth weld with backing	approved	not approved	approved
Girth weld without backing	approved	approved	approved
Fillet weld	not approved	not approved	approved

7.6.4.5 Filler metal

If impact testing and/or AWT are required, then consumable classification is an essential variable for filler material.

Requirements for filler material shall be in accordance with ISO 15614-1:2004.

7.6.4.6 Type of current

Requirements for current shall be in accordance with ISO 15614-1:2004.

7.6.4.7 Arc energy

Arc energy is an essential variable when hardness and/or impact testing are required for WPS approval.

Arc energy shall not vary more than 15 % below the minimum value and 15 % above the maximum value representative for a weld pass segment during the welding of the test pieces.

NOTE The intent of "representative" is to avoid that extreme minimum and maximum values recorded for short periods are considered for determining arc energy values.

For sour service applications, the arc energy should not fall below the average value per pass recorded during the welding of the test pieces.

7.6.4.8 Preheat temperature

The minimum preheat temperature shall not be lower than the preheat temperature recorded during the welding of the test piece.

7.6.4.9 Interpass temperature

The approved range for the interpass temperature shall extend from the preheat temperature up to the maximum interpass temperature recorded during the welding of the test piece for each welding process.

7.6.4.10 Post-weld heating for hydrogen removal

Post-weld heating for hydrogen removal shall be in accordance with ISO 15614-1:2004.

7.6.4.11 Post-weld heat treatment

PWHT shall be applied if specified in the WPS.

The ranges of soaking temperature, soaking time and heating and cooling rates shall be in accordance with the WPS.

7.6.4.12 Type of line-up clamp

The type of line-up clamp shall be limited to the clamp used for welding of the test piece. Use of other clamps shall be by agreement.

7.6.4.13 Removal of line-up clamp

The line-up clamp shall not be removed before the weld has been completed to at least the same extent as at the time of clamp removal during welding of the test piece.

Weld completion can be expressed as a percentage of circumference of the weld, the number of passes or combination thereof.

7.6.4.14 Tack welding

If tack welds are to be included permanently in the root, then this shall be considered as an essential variable.

7.6.4.15 Back-gouging, grinding and back-welding

Back-gouging, grinding and back-welding shall be in accordance with the WPS.

7.6.4.16 Time interval

If welding with non-hydrogen-controlled consumables, the time lapse between the end of the root pass and the start of the second pass shall not exceed the time lapse recorded during welding of the test piece. Any consumable resulting in a weld deposit with a HDM over 10 ml/100 gr shall be considered non-hydrogen-controlled.

EXAMPLE Cellulosic electrodes are an example of non-hydrogen-controlled consumables.

7.6.4.17 Root pass welders

The number of root pass welders shall be at least as many as during welding of the test piece.

7.6.5 Related to specific welding processes

7.6.5.1 Shielded metal arc welding (SMAW) and self-shielded flux-cored arc welding (SSFCAW)

A change in electrode diameter shall not be permitted in the first two layers on single-sided girth welds made without backing. For other welds, the approved diameter range of the electrode for each pass shall be from one size down to one size up from the electrode diameter used during the welding of the test piece.

NOTE Changing the electrode size can result in a change in arc energy to a value outside the approved range.

7.6.5.2 Submerged arc welding (SAW)

The approved wire diameter and system shall be limited to the wire diameter and system, such as a single-wire or multiple-wire system, used in the welding of the test piece.

The approved flux shall be limited to the flux with the same make and classification as used during welding of the test piece.

The following welding parameter tolerances shall apply.

a) The approved range for the travel speed for any pass shall be the travel speed recorded during the welding of the test piece ± 10 %.

b) The approved range for the voltage for any pass shall be the voltage recorded during the welding of the test piece ± 10 %.

c) The approved range for wire feed speed or current setting for any part of the weld shall be the speed or current recorded during the welding of the test piece ± 10 %.

d) The approved range for the distance between contact tip and work piece for any pass shall be the distance recorded during the welding of the test piece ± 5 mm.

7.6.5.3 Gas metal arc welding (GMAW) and gas-shielded flux-cored arc welding (GSFCAW)

The approval given to the face and/or back-shielding gas shall be restricted to the type of gas and composition (see 9.11) used during the welding of the test piece.

The approval given to the wire diameter and system, such as single-wire or multiple-wire system, shall be restricted to the diameter and system used during the welding of the test piece.

The following welding parameter tolerances shall apply.

a) The approved range for the travel speed for any pass shall be the travel speed recorded during the welding of the test piece ± 10 %.

b) The approved range for wire feed speed or current setting for any part of the weld shall be the speed or current recorded during the welding of the test piece ± 10 %.

c) The approved range for the distance between contact tip and work piece for any pass shall be the distance recorded during the welding of the test piece ± 5 mm.

7.6.5.4 Gas tungsten arc welding (GTAW)

The approval given to the face- and/or back-shielding gas shall be restricted to the type of gas (nominal composition) used during the welding of the test piece.

The approved range for current setting is the setting used during the welding of the test piece ± 10 %.

7.6.5.5 Shielding gas flow rate

For processes GMAW, FCAW in inert or active gas protection and GTAW, the approved range for the shielding gas flow rate is the flow rate recorded during the welding of the test piece ± 15 %.

7.7 WPS for repair welding

The WPS used for the original weld may also be used for repair welding, provided the essential variables for the repair welding are within the ranges approved for the WPS except for the following repair types, which shall have a separate approval test:

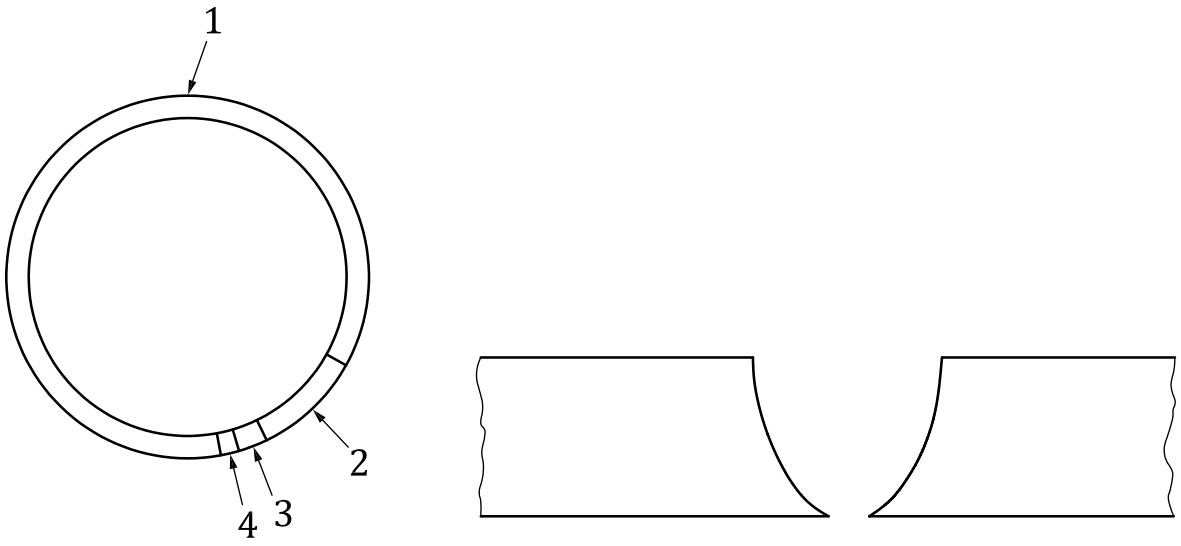
— repair weld consisting of a single pass;

— internal repairs;

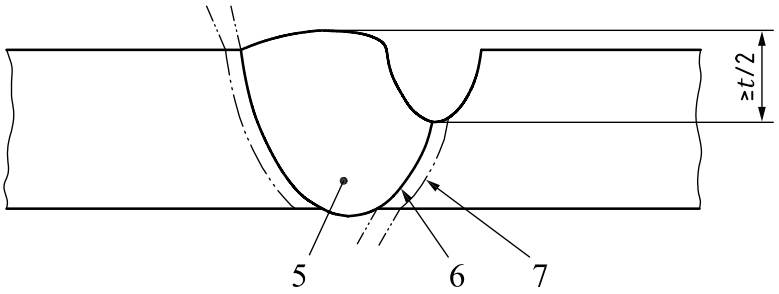
— repair of a weld joining materials with a SMYS exceeding 360 MPa.

The requirements for the approval of a WPS for repair welding shall be established by agreement.

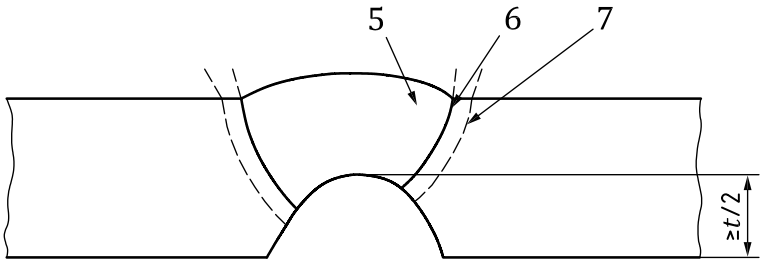
The groove for repair-welding tests shall be located typically as shown in Figure 5 and may include excavation of weld deposit or HAZ and parent metal. The extent of testing and examination, including the number and locations of test specimens, shall be established by agreement.



a) Full re-repair



b) Partial penetration repair



c) Multi-pass back-weld repair

Key

1 location of top
2 location of Charpy (optional) of pipe
3 location of tensile
4 location of macro/hardness
5 original weld
6 original weld fusion line
7 original weld heat-affected zone

Figure 5 — Location of repair excavations and destructive test specimens

7.8 Period of validity

The period of validity of an approved WPS shall be by agreement.

8 Approval and testing of welders and welding operators

8.1 General

Approval of welders and welding operators shall be in accordance with the requirements in this International Standard.

Approval of welders and welding operators may be in accordance with another recognized standard such as ISO 14732, API 1104, ISO 9606-1 for welders or ISO 14732 for welding operators, by agreement.

8.2 Approval for manual and semi-automatic welding

For approval of manual or semi-automatic welding, welders shall make a test weld in accordance with the approved WPS for inspection and testing.

A welder shall be approved for production welding only if all the requirements for inspection and testing of the test pieces specified in this clause have been met.

Except where stated otherwise in this clause, more than one welder may be employed in welding a test piece provided each welder completes at least 50 % of the circumference of a weld pass. The position of each welder shall be clearly identified when employing more than one welder.

Where more than one welding process or welder is employed in producing a test piece, the approval of the welders for production welding shall be limited to their part of the weld of the test piece.

Separate test welding shall be performed for the approval of a welder for girth, branch, and fillet welding, except that a branch welding approval shall also cover for fillet welding.

Welders who have completed the test piece for the successful approval of the WPS in accordance with Clause 5 should be approved for production welding.

8.3 Approval for mechanized welding

For mechanized welding, each welding operator shall be approved for a particular part or parts of the operation of making a welded joint. Under no circumstances shall welding operators be employed on operations other than those for which they have been approved.

8.4 Approval for automatic welding

Each welding operator shall be approved by a pre-production welding test in accordance with ISO 14732 and the requirements of this International Standard.

8.5 Test welding

8.5.1 Positional welding

8.5.1.1 Girth welds

The pipes for making the test weld shall be fixed as follows:

— horizontally for production welding on pipes positioned within 25° of the horizontal;

— vertically for production welding on pipes positioned within 25° of the vertical:

— at 45° for positions H-L045 or J-L045 (see Figure 4), and for production welding of pipes positioned between 25° to the vertical and 25° to the horizontal.

Approval for positional welding shall also approve the welder for roll welding.

8.5.1.2 Branch connections

Except where more than one welding process is used, a welder shall make all the passes on the full circumference of the test piece with a diameter of the branch less than 323,9 mm. More than one welder may be employed if the diameter of the branch is 323,9 mm or more, or when more than one welding process is used.

The position of the branch shall be

— at the top centre of a horizontal pipe (welding position PG as indicated in Figure 4) for the welding of branches positioned within 20° of the top centre of a horizontal pipe;

— at the bottom centre of a horizontal pipe (welding position PF as indicated in Figure 4) for all branches in all other positions.

8.5.1.3 Fillet welds

For approval for fillet welding, a welder shall weld a fillet weld between a sleeve, socket, slip-on-flange, weld-o-let or other type of attachment and a pipe positioned horizontally.

By agreement, simulated joints using flat plate material may be used provided the plate is positioned to cover all the welding positions for which welder approval is required. By agreement, the mechanical properties of the plate material may differ from the properties of the pipe specified in the WPS.

8.5.2 Roll welding

8.5.2.1 Girth welds

Test pieces shall be made between lengths of pipe rotating about a horizontal axis. The root pass shall include a stop/start when more than one welder is employed during production welding.

8.5.2.2 Fillet welds

Test pieces shall be made between a sleeve, socket, flange or other attachment and a piece of pipe rotating about a horizontal axis.

More than one test weld may be made on one test piece provided a short distance is left unwelded between test welds of individual welders.

8.6 Inspection and testing of test welds

8.6.1 Non-destructive testing

The weld of the test piece shall be examined visually in accordance with 9.4.

Non-destructive testing shall also include

— radiography in accordance with 9.5; or

— ultrasonic testing in accordance with 9.6; or

— an alternative method by agreement.

The results of the non-destructive testing shall be assessed against the acceptance criteria specified in Clause 10.

8.6.2 Destructive testing

The following destructive testing shall be carried out:

— macro-examination in accordance with 7.4.3.6; and

— fracture testing in accordance with 7.4.4 for fillet welding; and

— bend testing performed in accordance with ISO 5173 with test specimen from the positions as indicated in Figure 1.

Additional destructive testing may be specified.

8.7 Re-testing

A welder or welding operator may produce additional test pieces if it is agreed that failure of the test piece weld is due to metallurgical or other extraneous causes outside the control of the welder.

In case of failure resulting from lack of skill, a welder or welding operator shall receive further training before further test welding for approval is permitted. Further re-testing after a second failure shall be by agreement.

8.8 Range of approval

An approved welder or approved welding operator may be employed for production welding within the range of essential variables for welder approval specified in this International Standard. The specified ranges apply with respect to material properties and welding parameters applicable during test welding for welder approval.

Any variations beyond the specified ranges shall require a new welder or welding operator approval.

The essential variables for welder approval and applicable ranges shall be as follows:

a) welding process: same welding process(es);

b) direction of welding: same direction;

c) position:

   1) same when qualified for horizontal or vertical or L045 position;

   2) all positions if qualified for both horizontal and vertical position;

   3) roll welding if qualified in any fixed position;

d) pipe wall thickness for girth and branch welding only:

   1) all pipe wall thicknesses from 3 mm to twice the wall thickness of the pipe used for test welding, if the wall thickness for test welding is more than 3 mm and does not exceed 12 mm; or

   2) all wall thicknesses of 5 mm and more if the wall thickness for test welding exceeds 12 mm.

e) for girth and branch welding only: variations in pipe diameter in accordance with Table 3;

f) weld preparation: same weld preparation;

g) backing: use of same backing or addition of backing;

h) electrode coating for SMAW: same electrode coating type;

i) flux for continuous tubular wires, metal-cored to flux-cored or vice versa: same flux type;

j) shielding gas: same gas or gas mixture;

k) welding equipment or system: same welding equipment or system for mechanised and automatic welding;

l) other variables: other variables by agreement.

8.9 Records

All relevant variables of the test welding and the inspection and testing results for the test weld shall be recorded on the welder approval documentation.

8.10 Period of validity

The period of validity of approval for a welder or welding operator shall commence on the date that all the required testing and inspection of the test welds has been satisfactorily completed. This date may be different from the date of issue of the approval documentation.

The approval of a welder or welding operator shall remain valid for a period of two years provided that

— the welder or welding operator is engaged with reasonable continuity in welding work for which the approval is applicable. A welder or welding operator approval shall be cancelled following an interruption of six months or more in the welding to which the approval relates,

— the welder or welding operator demonstrates adequate skill and knowledge, and

— compliance with the above requirements is confirmed at six-month intervals and recorded in the welder or welding approval documentation.

The approval shall be cancelled if any of the above conditions is not fulfilled or at any time by agreement.

9 Production welding

9.1 General

All welding, including tack welding for temporary support, shall be performed by approved welders or welding operators in accordance with an approved WPS.

The distance between girth welds, circumferential fillet welds and branch welds should not be less than the outside diameter of the pipe.

Guidance on other welding scenarios which can be encountered is given in Annexes A, B and C.

9.2 Equipment

Welding equipment shall be of a capacity and type suitable for the work and shall be calibrated and maintained in a condition that allows production of acceptable welds, continuity of operation and safety of personnel. Equipment that does not meet these requirements shall be either repaired or replaced.

Arc welding equipment shall be capable of operating within the amperage and voltage ranges specified in the approved WPS.

9.3 Working clearance

If welding aboveground or on a barge, the working clearance around the pipe at the weld should not be less than 0,4 m under the pipe and 0,6 m at the side and top, unless using roll welding.

If welding in a trench, the bell hole shall be of sufficient size to provide the welders or welding operators access to the pipes and working clearance for welding. Standing water shall be removed from the bell hole before commencement of welding.

9.4 Weather conditions

Welding shall be suspended during weather conditions which, in the opinion of the contractor and/or the company, can adversely affect the weld quality. Protection from the weather may be provided to allow welding to continue.

Weld areas shall be dry and free of moisture.

Continuation of welding at ambient temperatures below –20 °C shall be only by agreement.

9.5 Pipe end preparation

Pipe ends shall be bevelled to the dimensions specified in the WPS.

Bevelling shall be performed by machining, machine thermal cutting or grinding. Machine thermal cutting may be manually or mechanically operated.

Manual thermal cutting shall be used by agreement and only if machining or machine thermal cutting is not practicable.

In case of thermal cutting, final dressing shall be by filing, grinding or other mechanical means.

The bevelled surface and adjacent material over a distance of at least 50 mm shall be free from scale, rust, paint, grease, moisture and other foreign matter that may adversely affect the weld quality before commencement of welding.

Examination of the pipe ends for the presence of laminations should be performed after a significant length of pipe has been removed.

9.6 Support

Pipes should not be moved during welding until both the root and second pass have been completed. Moving pipes after completion of the root pass shall be by agreement.

9.7 Line-up

Longitudinal and/or spiral welded seams of adjacent pipes shall be offset by at least 50 mm at the girth weld. Longitudinal weld seams shall be positioned as specified by the company.

Radial offsets of pipe abutting ends shall be minimized, for example by rotating the pipe, until the best possible fit has been obtained. Hammering or heating of the pipes to correct misalignment shall not be performed.

Internal misalignment shall be uniformly distributed around the pipe and shall not exceed 3 mm or 1 % of the pipe internal diameter, whichever is less, at any location around the circumference. Larger misalignments shall be corrected by tapering the pipe ends by grinding or machining, with a slope not exceeding 1:4, provided the specified minimum wall thickness of the pipe is maintained.

Root gaps shall conform to the value specified in the WPS.

Internal line-up clamps shall be used for all mainline welding, whenever practicable, and shall not be released before the root pass has been completed.

External line-up clamps shall be used when the use of internal clamps is not practicable. External line-up clamps shall not be removed before at least 50 % of the root pass, uniformly spaced around the circumference, has been completed.

Before continuing welding after removal of external line-up clamps, weld beads shall be ground at the start and stop locations.

If necessary, tack welding shall be in accordance with 9.8.

The line-up clamp shall be designed to prevent damage to the pipe and coatings.

9.8 Tack welding

Root gaps shall be maintained during the deposition of the first pass by tack welds if specified in the WPS.

Tack welds in the root shall have a minimum length of 25 mm.

Tack welding shall be carried out in accordance with the procedure specified in the WPS for welding of the root pass.

Tack welds which will be incorporated in the production weld shall be ground to a suitable taper at the start/stop locations to allow adequate fusion with the root pass.

End preparations specified in the WPS shall be maintained when removing temporary tack welds. Removal of tack welds shall be by grinding.

9.9 Earthing or grounding

Welding return cable connections shall be of sufficient cross-sectional area to prevent concentration of current and shall be securely attached to prevent arc burns. Attachment by welding shall not be performed.

Arc burns caused by a faulty attachment shall be removed in accordance with 9.13.

9.10 Electrodes and filler materials

The selection of electrodes and filler materials for production welding shall be by agreement.

If batch testing of filler materials is specified by the company, then the company shall indicate the required lot classification from AWS A5.01 and the required tests. Inspection documents for the filler materials shall be in accordance with ISO 10474.

Electrodes, filler wires and wire/flux combinations shall be used which will produce weld metal with a tensile strength at least equal to the specified minimum tensile strength of the pipe metal. In the case of joints between dissimilar materials, the tensile strength of the weld metal shall not be less than the minimum tensile strength specified for the highest strength pipe metal, unless otherwise agreed.

Welding consumables shall be stored at a temperature and humidity recommended by the manufacturer. Baking of electrodes shall also be in accordance with the recommendations of the manufacturer of the electrode.

Different grades, different brands, and when agreed, different batches of electrodes and filler materials shall be individually identifiable and be completely segregated.

Electrodes and filler materials shall be stored and handled such that damage to these materials and their containers is avoided. Electrodes and filler materials in open containers shall be protected from excessive moisture changes. Electrodes, filler wires and fluxes that exhibit signs of damage or deterioration shall not be used.

9.11 Shielding gases

Gases or gas mixtures shall be used for shielding during welding where appropriate. Purity and composition tolerances shall be in accordance with ISO 14175.

The moisture content of shielding gases shall correspond to a dewpoint of –30 °C or lower at atmospheric pressure.

For gas mixtures with specified additions, such as 2 % O_2 or 5 % O_2, the variation of such additions shall not exceed ± 10 % of that stated in the WPS.

Shielding gases shall be kept in the containers in which they are supplied and the containers shall be stored away from extremes of temperature. Gases shall not be field-intermixed in their containers.

9.12 Preheating

Pipe shall be heated before welding if specified in the WPS and when required by 8.4, in accordance with a documented procedure consistent with the requirements of ISO 13916.

Preheating shall be applied by gas or electrical means to achieve and maintain a satisfactory temperature distribution, to prevent interference with the welding operation and to avoid damage to coatings.

The preheating temperature shall not be less than the temperature specified in the WPS and sufficient for a dry and moisture free joint during welding.

The specified preheating temperature shall extend around the entire periphery of the pipe or the part being joined over a length of at least 75 mm on each side of the weld.

The preheating temperature shall be determined by temperature-indicating crayons which melt when the specified temperature is reached, or by thermocouples or pyrometers. Crayons or paints which indicate temperature by colour change should not be used.

The temperature should be measured on the face opposite of that to which the heat is applied. If this is not practicable, the heat source shall be removed and the temperature determined on the heated face once the temperature has equalized. The time between removal of the heat source and measurement of temperature shall be approximately 2 min for thicknesses up to and including 25 mm, plus 1 min for each 12 mm thickness above 25 mm.

Temperatures shall be measured immediately prior to commencement of welding. The measurements shall be at 75 mm from the bevel at least at four points on each side of the joint. The locations of the measurement shall be equally spread around the pipe.

9.13 Arc strikes

Arcs shall be struck only on fusion faces. Contact between electrodes or non-insulated parts of electrode holders and surfaces of the pipe shall be avoided.

Material affected by accidental arc strikes may be repaired only by agreement.

Arc strikes shall be removed in accordance with a documented procedure that shall define the methods for the following:

— mechanical removal of the affected pipe material;

— blending of the excavation;

— etching and/or hardness testing;

— MT;

— wall thickness measurement.

9.14 Backing

Permanent backing shall not be permitted. Temporary backing may be applied only if specified in the WPS.

9.15 Internal weld bead

The use of an internal weld bead shall be permitted only if it is specified in the WPS.

9.16 Weld metal deposition

9.16.1 Girth welding

The completed weld shall have a substantially uniform width around the entire circumference with a smooth transition to the base material. Internal and external reinforcements shall not exceed the values as specified in 11.3.1.

At least two welders should work simultaneously, one on each side, during welding on pipe with a diameter larger than 325 mm.

The width of any weaving shall not exceed the weaving in the WPS if specified.

Weld stops and starts shall be staggered when manual or partly mechanized welding methods are used and, when feasible, with mechanized and automatic welding equipment. In the case of cables inside the pipeline during welding, such as for a buckle detector, stops and starts shall be shifted sideways from the six o'clock position to avoid masking of weld stop and start images on the radiograph.

9.16.2 Other welding

The configuration of branch welds shall be as specified.

The pipe material around planned cut-out areas for branches shall be examined with UT for the presence of pipe laminations when specified. The procedure for UT and the acceptance criteria shall be by agreement.

9.17 Weld cleaning and peening

Surface slag shall be removed using hand or power tools before deposition of the next weld pass. Clusters of surface porosity, stops and starts and high points shall be removed by grinding.

NOTE Surface slag is a possible source of unacceptable weld flaws and visible defects, such as cracks, cavities and other deposition faults.

After completion of the weld, the weld and the adjacent area shall be cleaned of spatter. Peening should not be performed.

9.18 Partially completed welds

Whenever possible, welds should not be left partially completed. Where necessary due to production conditions, interrupted welds may be completed provided that welding is not discontinued before deposition of the minimum number of passes specified in the WPS. If not specified in the WPS, the minimum number of passes to be completed before interrupting welding shall be by agreement.

Upon discontinuation of welding, the joint shall be wrapped in dry insulating and heat-resisting material with a waterproof backing for cooling in a slow and uniform manner.

Prior to the recommencement of welding, the joint shall be reheated to within the interpass temperature range specified in the WPS.

Partially completed welds should be rejected when welding has been interrupted before the completion of three passes. Additional inspection may be specified in case completion of such welds is permitted.

9.19 Post-weld heat treatment

9.19.1 General

The entire circumference of the joint shall be heated in a uniform manner, without overheating, in accordance with the procedure stated in the WPS.

PWHT procedures should be submitted to the company for approval.

9.19.2 Methods of heat treatment

PWHT shall be carried out by placing the complete welded assembly in an enclosed furnace.

If this is not practicable, girth welds may be heat-treated locally by heating a band around the entire circumference, centred around the girth weld, using an electrical resistance mat, gas-fired muffles or other methods by agreement. The width of the band shall not be less than $5\sqrt{r \times t}$, where r is the internal radius of the larger component, and t is the thickness of the thicker component.

Sufficient insulation shall be fitted to ensure that the temperature of the weld and its heat-affected zone is not less than specified in the WPS, and that the temperature at the edge of the heated band is not less than half the peak temperature. In addition, the adjacent portion of the assembly outside the heating zone shall be thermally insulated so that the temperature gradient is not harmful. To meet this requirement, the total insulated band width should be at least $10\sqrt{r \times t}$.

Branches may be locally heat-treated by heating a circumferential band around the entire assembly. The width of the heated band shall include the branch weld and at least $2,5\sqrt{r \times t}$ of the pipe in each direction from the edges of the branch weld.

Assemblies of different wall thicknesses may be placed in the same furnace charge for PWHT and treated in accordance with the requirements for PWHT of the thickest assembly in the charge, provided that the minimum thickness of the charge is not less than 50 % of the thickness of the thickest assembly.

9.19.3 Post-weld heat-treatment procedure

The PWHT holding time at temperature shall be a minimum of 2,5 min per millimetre of thickness. The holding temperature shall be (580 ± 20) °C. Other holding times and temperature ranges may be specified if warranted for the composition and condition of the material to be treated.

For furnace heat treatment, the temperature in the furnace at the time the assembly is placed in the furnace shall not exceed 400 °C, and the assembly shall not be removed from the furnace until the furnace temperature has fallen below 400 °C.

During heating and cooling above 400 °C, the temperature variation of the assembly shall not exceed 150 °C in any 4,5 m of assembly length.

For both furnace and local heat treatments, the rate of heating above 400 °C shall not exceed $5\,500/t$ °C × h^{-1}, and the rate of cooling while above 400 °C shall not exceed $6\,875/t$ °C × h^{-1} with t expressed in millimetres.

Below 400 °C the weld or assembly may be cooled in still air.

The maximum and minimum temperatures of any part of the assembly or weld zone at the holding temperature shall not exceed the PWHT temperature range specified above. Temperatures shall be measured, using thermocouples in effective contact with the steel, at sufficient locations on the assembly to monitor and ensure that the whole assembly, or zone where applicable, is treated within the specified temperature range. Additional pyrometers should be used to confirm that undesirable thermal gradients do not occur.

9.20 Pipe and weld record

The weld numbering system shall be established by agreement before commencement of welding. The documentation addressed in Clause 12 should be traceable back to individual weld numbers.

10 Non-destructive testing

10.1 General

This clause specifies the requirements for performing manual and mechanized NDT.

The company shall specify the requirements for frequency, extent and method of NDT; otherwise the frequency and extent shall be as stated in ISO 13623:2009, 10.4.2.

NDT procedures shall be submitted to the company for agreement before commencement of welding.

Results of NDT shall meet the acceptance criteria specified in Clause 10 for the NDT methods employed.

Consideration should be given to the possible need to delay NDT for a certain time after completion of welding, as any delayed cracking due to hydrogen might not occur immediately upon cooling.

NOTE The need for a delay period is generally greater for those welding situations which are likely to increase the risk of such cracking. In this regard, it is important to note that the cracking risk is potentially higher in welds made with cellulose-coated electrodes and also increases with increasing pipe strength or wall thickness.

10.2 NDT personnel

Personnel shall meet the requirements of the following:

a) ASME Section V, for visual examination;

b) ISO 9712 for other NDT.

The roles and responsibilities of NDT personnel shall be as defined in ISO 9712.

10.3 NDT procedure approval

NDT procedures shall be approved by practical demonstration on welds similar to the production welds for which the procedure will be used.

Practical demonstrations shall be conducted under anticipated field conditions and with weld temperatures as foreseen during the testing of production welds.

The make and type of NDT equipment for testing of production welds shall be the same as used for the approval of NDT procedures.

10.4 Visual examination

VE procedures shall define the following:

— use of direct or remote viewing;

— surface condition;

— method or tool for surface preparation;

— requirements for illumination, including instruments or equipment;

— magnification level, if applicable;

— checklist of features to be examined;

— sequence of examination, if applicable;

— data to be documented;

— format of report including report forms to be used.

VT shall be carried out in accordance with ASME Section V.

10.5 Radiographic testing

10.5.1 Technique

Testing shall be by X-ray in accordance with ISO 17636-1:2013, Class B. Gamma-ray testing may be used only if agreed by the company.

10.5.2 Procedure

Radiographic procedures shall, where relevant, define the following:

— pipe diameter and wall thickness;

— radiation source;

— technique (equipment rating, in voltage, external or internal equipment);

— geometric relationships (source focal-spot size, film focus distance, object-film distance, radiation angle with respect to weld and film);

— penumbra or geometric unsharpness;

— film type (trade name, designation and dimensions);

— intensifying screens (front and/or back, material thickness, filters);

— exposure conditions;

— processing (developing time/temperature, stop-bath, fixation, washing, drying, manual or automatic processing);

— IQI sensitivities, in per cent of wall thickness, based on source- and film-side indicators, respectively;

— density;

— film overlap;

— weld joint geometries;

— temperature of welds during inspection;

— archival life;

— initial source strength.

10.5.3 Procedure approval testing

During radiographic procedure approval testing, wire-type IQIs shall be placed both on the source side and on the film side. Only one IQI is required for each radiograph for short film lengths where the distance between IQIs would be less than 100 mm.

IQIs shall be wire type. Sensitivities for source-side IQIs shall, for both single wall and double wall techniques, be in accordance with ISO 17636-1:2013, Class B, and Table 6 of this International Standard.

At least two radiographs shall be taken during the procedure approval testing.

All relevant data on the procedure approval testing, including results, shall be documented.

Radiographs from the procedure approval testing shall be kept available on site for reference throughout the period of production welding.

Table 6 — IQI sensitivity requirements for source-side IQI with single-wall single image technique

Pipe wall thickness mm	IQI wire diameter mm
< 6	0,10
6 to 8	0,125
8 to 10	0,16
10 to 16	0,20
16 to 25	0,25
25 to 32	0,32
32 to 40	0,40
40 to 50	0,50

10.5.4 Information on radiograph

The radiograph shall contain the following information:

— project name, project number and pipeline identification;

— weld number;

— whether the radiograph is of a repair weld, of a replacement weld or a re-shoot of radiograph;

— marker(s) indicating the position of the radiograph in relation to the weld.

10.5.5 Weld coverage

A sufficient number of film exposures shall be taken to give full circumferential coverage of the welds. Film overlaps shall not be less than 40 mm.

10.5.6 Intensifying screens

Front and back intensifying fluorometallic screens with a maximum thickness of 0,02 mm may be used by agreement.

10.5.7 Radiographic density

The density for isotopes shall not be less than 2,5.

Densities shall be measured at regular intervals.

All radiographs shall be viewed in dry condition.

10.5.8 Film storage

Radiographs shall be stored in suitable boxes in sequence with the weld numbering. Radiographs of rejected welds, repairs and re-shoots shall be stored together.

10.5.9 Radiographic images obscured by buckle-detector cable

Welds shall be radiographed again if starts or stops of welds are obscured on the radiograph.

10.6 Ultrasonic testing

10.6.1 Procedure

UT procedures shall define the following:

— type of UT equipment;

— type and dimensions of transducers;

— range of frequencies;

— method of calibration;

— surface requirements;

— coupling medium;

— testing techniques;

— weld identification method;

— reporting requirements;

— weld joint geometries;

— temperature range of welds during testing.

10.6.2 Equipment

UT equipment shall meet the requirements in ASME, Section V.

For offshore applications, probes shall be suitable for use on surfaces with elevated temperatures.

The name of the manufacturer, the identification number, the transducer frequency, the refraction angle and the output point shall be clearly marked on each probe.

10.6.3 Calibration and construction of reference curve

Reference DAC curves shall be made in accordance with ASME Section V.

Calibration block No. 2 in accordance with ISO 7963 may be used for calibration of range. This block shall not be used for determining sensitivity.

Whenever material, bevel geometry, welding method or other factors call for additional considerations in flaw detection, preparation of special calibration test pieces is required.

The sound path length from the transducer to the reflector shall not be less than 0,6 N, where N is the near-field length of the probe.

For testing of welds with surfaces at elevated temperatures, calibrations shall be made at the same surface temperatures and with the same couplant as during the testing of production welds or by using a correction table constructed by practical experiments.

10.6.4 Manual ultrasonic testing

Testing shall not be performed on surfaces with roughness or irregularities which cause the transfer measurement to vary by more than 3 dB. The total value of transfer correction should not exceed 6 dB.

Tandem techniques shall be used for girth welds with a bevel angle between 0° and 10° if specified by the company.

When using straight-beam probes for weld testing, the DAC curve shall be drawn similarly to that for angle probes.

The length of indications shall be defined as the circumferential distance over which the echo height exceeds the reporting level.

10.6.5 Mechanized testing

UT shall be by mechanized UT equipment if specified by the company.

Mechanized equipment shall be capable of providing reproducible tests and permanent records, and shall be capable of identifying defects in accordance with the categories specified in 10.5.

AUT shall be in accordance with Annex G.

10.6.6 Evaluation of indications

All indications exceeding the DAC curve by more than 20 % shall be investigated and reported. Indications exceeding the DAC either by more than 50 % or 6 dB shall be reported and evaluated in accordance with Clause 9. Length, position, and amount by which the DAC is exceeded together with echo characteristics shall be documented for these indications.

10.7 Magnetic particle testing

Specifications for MT procedures shall define the following:

— description and dimensions of material to be examined;

— welding process;

— type of magnetization;

— type of equipment;

— surface preparation;

— wet or dry testing;

— make and type of magnetic particle and contrast paint;

— method for determining the magnetic field strength in the material;

— method of demagnetization (if required);

— description of method of testing.

MT should be carried out using either AC-yoke or DC-prods. DC-prods shall not be used unless specific company agreement has been obtained. If used, prods should be tipped with lead or soft prods should be used. Care shall be taken to avoid local heating of the surfaces to be examined. Arc strikes and burn marks shall be ground out and the area re-inspected.

Use of permanent magnets or DC-yokes may only be used if agreed by the company.

MT shall be performed in accordance with the ASME Section V.

The method of determining magnetic field strengths in the material shall be subject to company agreement. The field strength shall be in accordance with ASME Section V.

MT shall not be performed when surface temperatures exceed 300 °C. Only dry MT shall be used for tests with surface temperatures between 60 °C and 300 °C.

10.8 Liquid penetrant testing

LPT shall be performed in accordance with ISO 17636-1:2013 or equivalent.

Recommendations by the manufacturer of the penetrant shall be followed.

10.9 NDT report

All NDT shall be documented.

The documentation shall include the following information, where appropriate:

— contract number;

— applicable procedure specification;

— weld identification;

— test reports presenting the results of testing;

— description and location (with sketch where appropriate) of all reportable indications;

— for shop welds, reference to the fabrication drawings;

— actions taken;

— date of testing;

— name and qualification level of inspector;

— approval signature of responsible inspector.

Examples of test reports as shown in Annex H may be used.

11 Acceptance criteria for non-destructive testing

11.1 General

The acceptance criteria specified in this clause apply to imperfections detected by radiographic, ultrasonic, magnetic particle and liquid penetrant testing. They may also be applied to imperfections revealed by visual testing.

Imperfections shall be classified in accordance with ISO 6520-1.

11.2 Right of rejection

The company can reject any weld that appears to meet the criteria of this International Standard if, in the company's opinion, the depth of the imperfection is detrimental to the weld.

11.3 Visual testing

11.3.1 Weld profile

Weld reinforcement shall be uniform and shall merge smoothly with the adjacent parent metal surfaces. Both external and internal reinforcement should not exceed a height of 3 mm.

11.3.2 Undercut

When visual and mechanical means are used to determine depth, undercut adjacent to the root and cover pass shall not exceed the lengths given in 11.4.8 and shall not be deeper than 1 mm or 10 % of the pipe wall thickness, whichever is smaller.

11.4 Radiographic testing

11.4.1 Lack of penetration

Lack of penetration shall be unacceptable if any of the following conditions exist.

a) The length of an individual indication of lack of penetration exceeds 25 mm.

b) The aggregate length of indications of lack of penetration exceeds 25 mm in any continuous 300 mm length of weld.

c) The aggregate length of lack of penetration exceeds 8 % of the weld length in any weld less than 300 mm in length.

d) The aggregate length of lack of penetration in double-sided welds exceeds 50 mm in any continuous 300 mm of weld or 15 % of the weld length.

11.4.2 Lack of fusion

Lack of fusion at the root of single-sided welds shall be unacceptable if any of the following conditions exist.

a) The length of an individual indication exceeds 25 mm.

b) The aggregate length of indications exceeds 25 mm in any continuous 300 mm length of weld.

c) The aggregate length of indications exceeds 8 % of the weld length in any weld less than 300 mm in length.

Lack of side-wall fusion or lack of inter-run fusion shall be unacceptable if any of the following conditions exists.

— The length of an individual indication exceeds 50 mm.

— The aggregate length of indications exceeds 50 mm in any continuous 300 mm length of weld.

— The aggregate length of indications exceeds 15 % of the weld length.

11.4.3 Root concavity

Internal concavity up to 25 % of the total length of weld is acceptable provided the density of the radiographic image of the internal concavity does not exceed that of the thinnest adjacent base metal.

The criteria for burn-through in 11.4.4 shall be applied for root concavities with film densities exceeding the density of the thinnest base metal adjacent to the weld.

11.4.4 Burn-through

Burn-through shall be unacceptable if any of the following conditions exist.

a) The maximum dimension exceeds 6 mm and the density of the image of the burn-through exceeds that of the thinnest adjacent base metal.

b) The maximum dimension exceeds the thinner of the nominal wall thicknesses joined, and the density of the burn-through image exceeds that of the thinnest adjacent base metal.

c) More than one burn-through of any size is present and the density of more than one of the images exceeds that of the thinnest adjacent base metal.

11.4.5 Inclusions

The maximum dimension of an indication shall be considered to be its length when evaluating inclusions.

Parallel linear indications separated by approximately the width of the root bead (wagon tracks) shall be considered as single indications if the width of either of them is 0,8 mm or less and as separate indications if their widths exceed 0,8 mm.

Inclusions shall be unacceptable if any of the following conditions exist.

a) The length of a linear inclusion exceeds 50 mm.

b) The aggregate length of linear inclusions exceeds 50 mm in any continuous 300 mm length of weld.

c) The width of a linear inclusion exceeds 1,6 mm.

d) The aggregate length of isolated slag inclusions exceeds 50 mm in any continuous 300 mm length of weld.

e) The width of an isolated slag inclusion exceeds 3 mm or 50 % of the wall thickness whichever is less.

f) More than four isolated slag inclusions with the maximum width of 3 mm are present in any continuous 300 mm length of weld.

g) The aggregate length of linear and isolated slag inclusions exceeds 15 % of the weld length.

h) The width of a copper or tungsten inclusion exceeds 3 mm or 50 % of the wall thickness, whichever is less.

i) The aggregate length of copper or tungsten inclusions exceeds 12 mm in any continuous 300 mm length of weld or more than four such inclusions are present in any continuous 300 mm length of weld.

11.4.6 Porosity

The size of a pore shall be the maximum dimension of the indication seen on the radiograph.

a) **Individual gas pores or uniformly distributed porosity** shall be unacceptable if any of the following conditions exist.

   1) The size of an individual pore exceeds 3 mm.

   2) The size of an individual pore exceeds 25 % of the thinner of the nominal wall thicknesses joined.

   3) The total area, when projected radially through the weld, shall not exceed 2 % of the projected weld area in the radiograph. The area shall be the length of the weld affected by the porosity (with a minimum length of 150 mm) times the maximum width of the weld.

b) **Clustered porosity** present in any pass except the cover pass shall comply with the above criteria for individual gas pores or uniformly distributed porosity. Clustered porosity present in the finish pass shall be unacceptable if any of the following conditions exists.

   1) The size of the cluster exceeds 13 mm.

   2) The aggregate length of clustered porosity exceeds 13 mm in any continuous 300 mm of weld length.

3) An individual pore within a cluster exceeds 2 mm in size.

c) **Hollow-bead porosity** is defined as elongated linear porosity that occurs in the root pass. Hollow bead shall be unacceptable if any of the following conditions exists.

1) The length of an individual indication of hollow bead exceeds 50 mm.

2) The aggregate length of hollow bead exceeds 50 mm in any continuous 300 mm of weld length.

3) The aggregate length of hollow bead exceeds 15 % of the weld length.

11.4.7 Cracks

Cracks, other than crater and star cracks, shall not be permitted. For crater and star cracks, the maximum length shall be 4 mm.

11.4.8 Undercut

Undercutting shall be unacceptable if either of the following conditions exists.

a) The aggregate length of undercut, both external and internal, exceeds 50 mm in any continuous 300 mm of weld length.

b) The aggregate length of undercut, both external and internal, exceeds 15 % of the weld length.

11.4.9 Accumulation of discontinuities

Any accumulation of discontinuities shall be unacceptable if either of the following conditions exists.

a) The aggregate length of indications exceeds 50 mm in any continuous 300 mm of weld length.

b) The aggregate length of indications exceeds 15 % of the weld length.

11.5 Ultrasonic testing

11.5.1 General

Indications from UT shall be evaluated in accordance with the acceptance criteria in 10.4 for radiographic testing and 11.5.2 and 11.5.3.

11.5.2 Spherical porosity

Indications identified as porosity may be classified as non-planar indications.

Non-planar indications which cover a projected area of not more than 2 % on a radiograph shall be considered acceptable.

Spherical porosity may be classified as a planar indication with the area containing the porosity being evaluated as a single planar imperfection in accordance with 11.5.3.

11.5.3 Linear indications

All indications that produce a response greater than 20 % of the reference level shall, to the degree possible, be investigated to determine the location, shape, extent and type of reflector, and shall be evaluated in accordance with the following criteria.

a) All cracks are unacceptable, regardless of size or location in the weld.

b) Linear indications (other than cracks) interpreted to be open to the surface are unacceptable if they exceed 25 mm in total length in a continuous 300 mm length of weld or 8 % of the weld length.

c) Linear indications interpreted to be buried within the weld are unacceptable if they exceed 50 mm in total length in a continuous 300 mm of weld or 15 % of the weld.

11.6 Surface testing

11.6.1 Classification of indications

Indications with a maximum dimension of 2 mm or less shall be classified as non-relevant. All larger indications, even if considered not to be detrimental, shall be regarded as relevant until re-testing following surface conditioning.

Indications with a length of more than three times the width shall be classified as linear indications. Indications with a length of less than three times the width shall be classified as rounded indications.

11.6.2 Acceptance criteria

The following acceptance criteria apply to surface testing using either magnetic particle or liquid penetrant.

Relevant indications shall be unacceptable if either of the following conditions exist:

a) linear indications evaluated as cracks;

b) linear indications evaluated as incomplete fusion exceeding 25 mm in aggregate length in a continuous 300 mm length of weld, or 8 % of the weld length.

Rounded indications shall be evaluated in accordance with the acceptance criteria in 11.4.6 for individual and clustered porosities. For evaluation purposes, the maximum dimension of a rounded indication shall be considered its size.

Verification may be obtained using other NDT methods in case of uncertainty of the type of discontinuity disclosed by an indication.

11.7 Discontinuities in pipe or fittings

Laminations, arc burns, long seam discontinuities and other discontinuities in the pipe or fittings detected during non-destructive testing or visual testing shall be reported to the company. Their disposition by repair or removal shall be as directed by the company.

11.8 Acceptance criteria — ECA

At the option of the company only, an ECA may be used to derive alternative acceptance criteria. An ECA should be performed in accordance with accepted industry practices such as BS 7910, API 1104:2010, Appendix A, or EPRG guidelines.

NOTE For EPRG guidelines, see Reference [33].

ECAs shall be documented. All input data and assumptions made during the assessment shall be included in the documentation.

12 Repair and removal of defects

12.1 General

Weld repairs shall be made in accordance with the original WPS or a documented repair welding procedure specification.

A WPS for repair welding shall be approved in accordance with Clause 7, except that the extent of testing shall be established by agreement.

12.2 Authorization for repair

Repair of defects in the root and filler passes and weld repairs made from inside the pipe shall be permissible only if agreed by the company.

12.3 Multiple repairs

A weld should be rejected and removed in case of failure to meet the acceptance criteria of cause 10 following one attempt to repair. Repairs not requiring welding shall not be counted as weld repairs.

If permitted by the company, repair-on-repair welding shall be carried out in accordance with a WPS procedure approved following test welding on repaired weld metal.

12.4 Defect removal and preparation for repair

Welds not complying with the acceptance criteria of this International Standard shall be repaired or the weld removed completely.

Defects shall be removed by chipping, grinding, machining or air-arc gouging, followed by grinding. If air-arc gouging or thermal cutting is used, appropriate preheating shall be applied. If air-arc gouging is used, the last 3 mm through the root pass of the original weld shall be removed by mechanical means. Air-arc gouging shall be controlled by a procedure documenting the allowed variables as required by AWS C5.3.

Complete welds shall be removed by thermal cutting or machining.

Weld excavations shall be sufficiently deep and long to remove the defect. NDT of the excavated area, to confirm the complete removal of the defect shall be performed before commencement of repair welding.

Repairs shall be limited to 30 % of the weld length for a partial-penetration repair, or 20 % of the weld length for a full-penetration repair. More stringent limitations can be necessary for construction methods with significant loads or deformation at the location of the weld repair station, for example in case of installation from a barge.

Repaired areas shall be examined using the same testing method which located the defect. Should the testing reveal further imperfections, they shall be evaluated as new imperfections, i.e. remnants of the original defect may remain if within the acceptance criteria of this International Standard.

It is not necessary to perform NDT on the complete weld again. A sufficient length beyond the ends of the repair should be examined.

13 Documentation

Quality records should include the following:

— record of contract/design review;

— materials certificates;

— consumable certificates;

— WPSs;

— welding procedure approval test records;

— welder or welding operator approval certificates;

— non-destructive testing personnel certificates;

— heat treatment records;

— non-destructive testing and destructive testing procedures and reports;

— dimensional reports;

— records of repairs and other non-conformity reports.

The retention period and location of the records shall be decided by agreement.

Annex A
(informative)

Special requirements for welding of CRA pipelines and CRA-clad steel pipelines

A.1 General

This annex covers the requirements specific to the welding of CRA pipelines and CRA-clad steel pipelines. The requirements below are suggested as a supplement to those given in the main body of this International Standard.

A.2 Specification and approval of welding procedure

The WPS should additionally specify the following:

— minimum period of backing-gas application prior to commencement of welding;

— minimum period of backing-gas application during welding;

— minimum period of backing-gas application after welding;

— description of the back-purge dam type and method.

For CRA-clad steel pipe, a chemical analysis should be performed on the approval test weld, at a point on the centreline of the root pass, 1 mm below the surface. The complete chemical analysis should meet the requirements of the specified cladding material or as otherwise specified.

For austenitic/ferritic alloy pipe, a ferrite count should be performed on the approval test weld. This should be measured by either a point count on a metallographic specimen or estimated by other methods approved by the company.

The company may specify corrosion tests to demonstrate adequate corrosion resistance of the weld in service.

The addition or deletion of a second filler wire in the GTAW process should constitute an essential variable. A change from hot to cold wire addition or vice versa should also constitute an essential variable.

A change from a stringer pass technique to an oscillating technique in the root pass, or vice versa, should constitute an essential variable.

A reduction in the time for establishing the back purge prior to welding should constitute an essential variable.

A reduction in the number of passes deposited before discontinuing back-purging should constitute an essential variable.

A.3 Production welding

Storage and handling of CRA and CRA-clad steel pipe should be such that contact with other materials is minimized. Lifting gear, clamps and rollers should be of stainless steel or coated.

Tools (e.g. earthing clamps, brushes) should be of stainless steel. Grinding discs should be fit for stainless steel and should not have been used on other materials.

Pipe ends should be prepared by machining.

Weld surfaces should be thoroughly dried before welding. The welding preparation of CRA and CRA-clad steel should be cleaned by an organic solvent which does not contain chlorine compounds.

Prior to welding of pipe and pipeline components, internal misalignment should not exceed 1 mm.

Internal line-up clamps should have stainless-steel contact shoes to prevent contamination of the clad layer.

Welding processes using filler metal should be used for all root passes.

All welds should be a continuous operation and multi-pass.

The maximum interpass temperature should be 150 °C.

Post-weld heat treatment should not be performed, unless specifically requested.

For CRA-clad steel pipe, the chemical composition of the filler metal should be selected so that the corrosion resistance of the deposited root pass matches or exceeds that of the cladding. The fill and cap-pass filler metal should match the yield strength of the base material.

For CRA pipe, the filler metal should match both the yield strength and the corrosion resistance of the alloy material.

Consumables for welding of CRA pipelines or CRA-clad steel pipelines should be segregated from carbon steel consumables. They should be stored and handled in accordance with the manufacturer's recommendations.

The back-purge should be initiated for sufficient time before commencement of the welding operation to ensure that the backing environment contains no more than 0,05 % (500×10^{-6}) of oxygen. This time should be determined during the welding of the test pieces.

The use of hydrogen in the backing/shielding gas is not permitted.

The shielding gas back-purge should normally be maintained throughout the welding operation, however when the thickness of the weld is sufficient to prevent oxidation of the root pass by subsequent passes, back-purging may be discontinued. This should be verified during the welding of the test pieces.

A.4 Procedure for non-destructive testing

If UT is specified for CRA or CRA-clad materials, the testing procedure should be approved for detection of lack of penetration and lack of fusion in the root of the weld.

Radiography should be performed using ultrafine-grain film.

A.5 Acceptance criteria for non-destructive testing

Lack of fusion and lack of penetration in the root of the weld should not be permitted.

A.6 Repair and removal of defects

For CRA-clad steel pipes, welds containing a root defect should be cut out and rewelded.

Annex B
(informative)

Hyperbaric welding

B.1 General

The use of hyperbaric welding requires special welding procedures and the use of skilled diver-welders. Typically the work is performed by a specialist contractor with prior experience in this field. The acceptance criteria for the finished weld should be the same as for similar welds made in air.

An accepted code for underwater welding is AWS D3.6[3]. This International Standard currently references API 1104 for acceptance criteria for pipeline welds and includes multiple additional weld procedure and welder approval requirements.

Due to the severe environmental conditions and stringent welding requirements, added precautions are necessary to protect the personnel.

A list of suggested requirements for hyperbaric welding between two pipeline components is offered below.

B.2 WPS approval

Test welding for WPS approval should be conducted on pipe of the same diameter, wall thickness and material composition as the intended production joint and under conditions simulating the production weld as close as possible. The welding equipment, including the electrical cable, should be the same as that at the job site.

The test piece for WPS approval should meet all of the requirements of this International Standard for a weld made on the surface at one atmosphere.

Satisfactory test welding at the simulated depth should qualify production welding in the range from that depth plus 10 m to −20 % of it.

The following additional essential variables should be recorded:

a) preheating methods;

b) humidity in the welding chamber;

c) gas composition in the welding chamber;

d) packaging means and methods used to transfer electrodes into the welding chamber.

B.3 Welder approval

A welder should pass an approval test in a simulated environment for each WPS to be used within six months prior to the proposed weld.

In addition, welders should provide documentation satisfactory to the company to show that they meet all medical regulatory requirements for diving at the proposed location.

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3) This code has been approved by the International Institute of Welding (IIW) as Doc. CREAU-143 and is being recommended for adoption as an International Standard, to be developed by ISO/TC 44.

Operators of mechanized equipment may be approved using alternative methods to be defined by agreement.

B.4 Production welding

A confirmation test weld at least 150 mm long should be produced in the chamber before production welding begins, to confirm that the welding system is operating correctly.

All test and production welding should be monitored from the surface using video cameras or equivalent.

B.5 Inspection and testing

Detailed procedure specifications should be used for the methods of inspection and equipment to be used. These should be prepared in accordance with the requirements of this International Standard and should be fully approved prior to use.

Annex C
(informative)

Recommendations for brazing and aluminothermic welding of anode leads

C.1 Joining technique

Full details of the joining technique and associated equipment should be submitted to the company for approval prior to use. The procedure should conform to the manufacturer's recommendations.

C.2 Specification and approval of procedure

C.2.1 General

Prior to starting, the contractor should submit a procedure specification to the company for agreement.

The procedure should be approved by making three consecutive test joints, in the presence of the company, on material to be used in production. The test material should be selected by the company to represent the upper quartile of the carbon equivalent range.

The electrical resistance of each weld should be measured and should not exceed 0,1 Ω. The mechanical strength of the weld should be tested by means of a sharp blow from a 1 kg hammer.

All three of the test welds should be sectioned and prepared for metallographic testing. The tests described in C.2.2 and C.2.3 should be performed on the sections.

C.2.2 Copper penetration measurement

The depth of copper penetration below the surface of the pipe material should be measured metallographically. The fusion line of the weld or braze should not be more than 1 mm below the pipe surface. Intergranular copper penetration of pipe material shall not exceed 0,5 mm beyond the fusion line when a specimen is examined at a magnification not exceeding ×50.

C.2.3 Hardness survey

Each test section should be tested using a 98,07 N load. A traverse should be made across the weld zone. The traverse should consist of at least six impressions; two in the heat-affected zone each side of the weld/braze and one in the parent metal each side of the weld/braze.

The hardness values should not exceed 275 HV_{10} for sour service and pipe thickness less than 9,5 mm, 300 HV_{10} for sour service and pipe thickness above 9,5 mm and 325 HV for non-sour service.

Annex D
(informative)

Branch and fillet welding on in-service pipelines

D.1 General

This annex provides recommendations for the welding of branch connections or sleeves on in-service pipelines. This annex is not applicable to the welding on existing pipelines that have been fully isolated and decommissioned.

NOTE 1 The recommendations in this annex have been drafted with the objective of managing the risk of burning through and hydrogen cracking, which are the two primary concerns when welding on in-service pipelines. The use of low hydrogen welding filler metal and/or low yield filler metal can reduce the risk of hydrogen cracking. The risk of burn-through can be reduced by establishing the minimum wall thickness and maximum heat input for a given operating pressure and flow condition.

NOTE 2 This annex is applicable for the welding of branch connections for hot-tapping on in-service pipelines.

In-service piping is piping containing a service fluid which may or may not be pressurized and/or flowing. Examples of service fluids are oil crude, natural gases and petroleum products.

The pipeline operator should specify additional safety measures when the risk exists of

a) the service fluid becoming explosively unstable upon the application of heat of the potential, and/or

b) the service fluid may affect the pipeline material by rendering is susceptible to ignition, stress corrosion cracking or embrittlement.

The recommendations in this annex apply in addition to the requirements in the main part of this International Standard unless stated otherwise.

D.2 General recommendations

D.2.1 Pipeline operators should include in their operating and maintenance manuals procedures for in-service welding. Such procedures should amongst others include the maximum pipeline pressure during the in-service welding and the recommendations for supervision, safety induction and emergency response.

D.2.2 Production welds should not be made at weld cooling rates or restraint levels that are higher than those used for qualification of the welding procedure specification and welder qualification. Welding on in-service piping with a thickness less than 6,4 mm should be performed using welding procedures that control the potential for burn-through.

NOTE 1 Cooling rates that are much lower than the cooling rates used in the qualification of the welding procedure specification can result in burn-through areas.

NOTE 2 Both the type of fluid and the flow rate influence the weldment cooling rate.

NOTE 3 References [31] and [32] provide information on the evaluation of cooling rates and heat input.

D.2.3 Weld beads directly on the pipe surface should be tempered by an additional weld pass. Consideration should be given to the complete removal of the final tempering pass by grinding.

D.2.4 Low-hydrogen welding practices should be used where rapid cooling of the weldment is anticipated.

D.3 Specification, testing and approval of WPS

D.3.1 Procedure specification

D.3.1.1 Essential information

The WPS for in-service welding should include the following additional information:

a) the specified minimum yield strength and the maximum carbon equivalent of the materials to which the procedure applies;

b) the pipeline operations conditions, such as service fluid, operating pressure, flow rate, type of weld configuration, weld geometry and weld fit up during the in-service welding;

NOTE The service fluid, operating pressure and flow rate are normally specified by the pipeline operator.

c) the required heat input range, and procedure for heat input and heat input control;

d) the required weld deposition sequence.

D.3.2 Essential variables

The following additional recommendations apply for essential variables for in-service welding:

a) pipeline operating conditions: a change in operating conditions which can result in a cooling rate above the rate specified in the procedure specification;

b) carbon equivalent: an increase in the carbon equivalent of more than 0,02, or the CE_{pcm} of more than 0,01, from that of the material used for the WPS qualification;

c) pipe wall thickness: minimum pipe wall thickness related to pipeline operating condition is;

d) weld deposition sequence: a change from a temper bead deposition sequence to some other deposition sequence;

e) filler material: a change of make or brand and type of filler material;

f) pipe position: a change in the position of the pipe by more than 10 degrees in the vertical.

D.3.3 Welding of test pieces

Test pieces should be welded in accordance with the-preliminary WPS and be of sufficient size to provide the test specimen recommended in this annex for approval testing of the welding procedure.

The cooling rates and type of weld configuration and fit up should be representative for the production welding to be qualified.

During welding all essential variables should be measured and recorded.

D.3.4 Inspection and testing of test pieces

D.3.4.1 Scope of testing

The extent of testing of the test pieces for WPS should be in accordance with Table D.1.

Test specimens should be cut from test welds at locations as shown in Figure D.1. The sides should be smooth and parallel, and the long edges rounded. The sleeve or branch and weld reinforcements should

be removed flush with the surfaces, but not below the surface of the test specimen. Any undercut should not be removed.

Table D.1 — Testing for WPS approval for fillet and branch connection welding on in-service pipelines

Type of inspection/test	Extent of testing
Face bend test	2 specimens for $d \leq 60{,}3$ mm 4 specimens for $60{,}3 \text{ mm} \leq d \leq 323{,}9$ mm 5 specimens for $d \geq 323{,}9$ mm
Macro section	2 specimens for $d \leq 60{,}3$ mm 4 specimens for $60{,}3 \text{ mm} \leq d \leq 323{,}9$ mm 5 specimens for $d \geq 323{,}9$ mm
Macro-examination and hardness test	2 specimens

D.3.4.2 Face-bend testing

The test specimens should be bent in accordance with API 1104:2010 appendix B, Figure B5. Test specimens should be placed on the die with the weld at mid-span. Test specimens should be placed with the face of the weld directed toward the gap. The plunger should be forced into the gap until the test specimen is approximately U-shaped.

The face-bend test should be considered acceptable if, after bending, no openings or imperfections, in any direction, exceeding the lesser of 3 mm and 0,5 times the nominal wall thickness are present in the weld metal or the heat-affected zone. Cracks that originate along the edges of the test specimen and are less than 6 mm, measured in any direction, should be disregarded unless obvious defects are observed.

D.3.4.3 Macrosection tests

The macrosection test specimens should be treated with a suitable etchant to clearly show cross-sections of the weld metal and heat-affected zones.

The etched macrosection test specimens should be visually inspected and show complete penetration and fusion, and there should be no cracks, gas pockets with the greatest dimension exceeding 1,5 mm, slag inclusions exceeding 1 mm in depth, or concavity or convexity exceeding 3 mm.

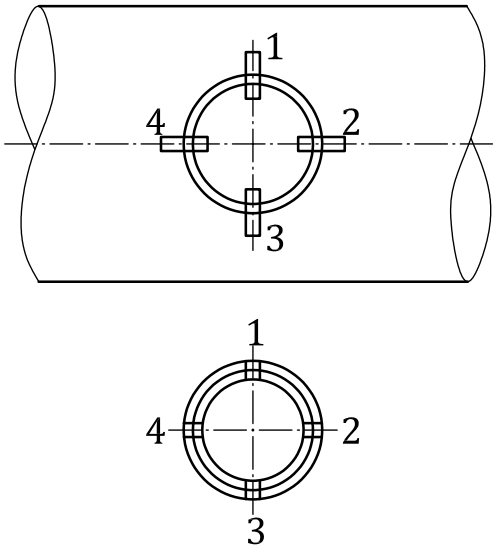
D.3.4.4 Macro examination and hardness testing

For the qualification of welding procedure specifications, two cross-sections, cut from locations as shown in Figure D.1 should be prepared for hardness testing as specified in ASTM E92 or EN 1321.

The hardness of the deposited weld metal and the heat-affected zone should be determined. A minimum of five indentations should be made in the coarse-grained heat-affected zone at each weld toe.

Hardness values should not exceed 350 HV_{10}. Welding procedure specifications resulting in weld metal or heat-affected zone hardness values in excess of 350 HV_{10} should be evaluated to determine that they are suitable for the avoidance of hydrogen-induced cracking.

In service welding on pipelines that have been exposed to sour fluids is not recommended. For in-service welding on pipelines not yet exposed to sour service, but intended to be exposed at a future time, the recommendations for sour service of Table 2 apply.



a) Location of test specimens for pipe with d < 60,3 mm

Key

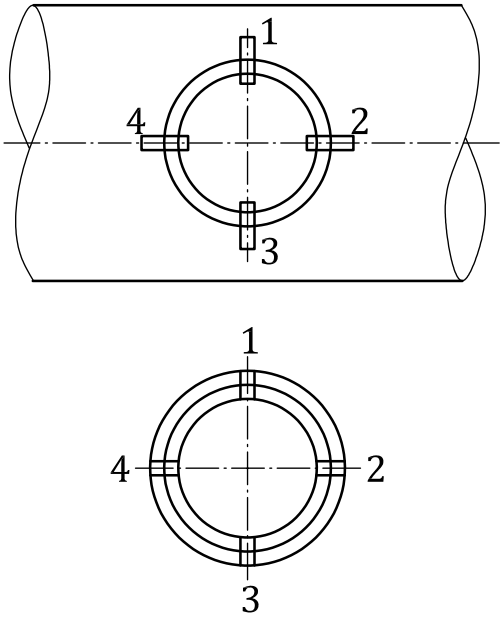
1 area 1 for one face bend test specimen and one macro-examination and hardness test specimen

2 area 2 for one macrosection specimen

3 area 3 for one face bend test specimen and one macro-examination and hardness test specimen

4 area 4 for one face bend test specimen

NOTE Two or more test welds might be required to provide sufficient material



b) Location of test specimens for pipe with 60,3 mm ≤ d < 323,9 mm

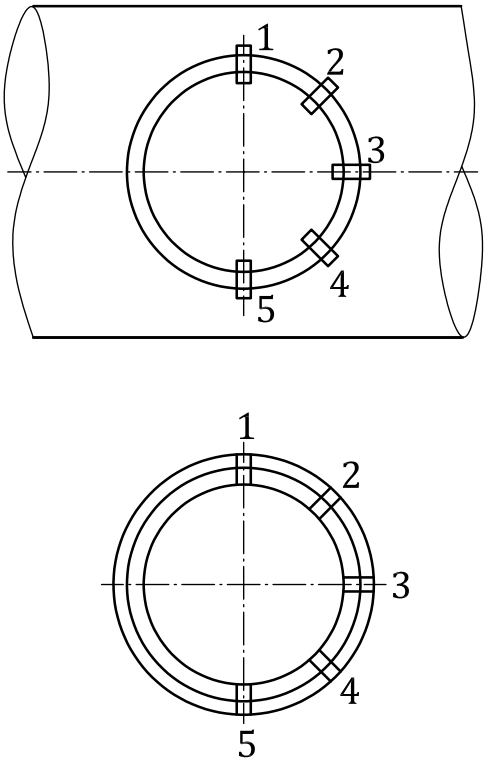
Key

1 area 1 for one face bend test specimen and one macrosection specimen

2 area 2 for one face bend test specimen, one macrosection specimen and one macro-examination and hardness test specimen

3 area 3 for one face bend test specimen, one macrosection specimen and one macro-examination and hardness test specimen

4 area 4 for one face bend test specimen and one macrosection specimen



c) Location of test specimens for pipe with d > 323,9 mm

Key

1 area 1 for one face bend test specimen and one macrosection specimen

2 area 2 for one face bend test specimen and one macrosection specimen

3 area 3 for one face bend test specimen, one macrosection specimen and one macro-examination and hardness test specimen

4 area 4 for one face bend test specimen and one macrosection specimen

5 area 4 for one face bend test specimen, one macrosection specimen and one macro-examination and hardness test specimen

Figure D.1 — Location of test specimen

D.4 Testing and approval of welders

D.4.1 For the approval of in-service welding, welders should make a test weld as recommended in Clause D.3 for the testing and approval of the WPS.

D.4.2 A welder should be approved if all recommendations in Clause D.3 for the approval of the WPS Welders have been satisfied.

D.5 Production welding

D.5.1 Safety

The pipeline operator should specify the maximum safe operating pressures and minimum flow conditions during the in-service welding.

Welders should be instructed by, or on behalf of, the operating company on the prevention of burn-through, prevention of hydrogen-induced cracking, measures for personnel safety and measures for emergency response.

D.5.2 Inspection of in-service pipe

Before welding is performed on in-service piping, the areas to be welded should be inspected with applicable non-destructive testing techniques to determine the adequacy of wall thickness and that they are free of imperfections that can adversely affect the weld.

D.5.3 Use of approved WPS and welders

All welding should be performed in accordance with WPS and by welders approved in accordance with this International Standard.

D.5.4 Supervision

Welding on in-service piping should be performed by

a) welders employed by the operating company; or

b) contract welders supervised by an operating company representative responsible for adherence to the prescribed procedures.

D.5.5 Weld testing

Welds (including those in branch connections) made on in-service piping should be non-destructively inspected for defects upon completion of welding using visual inspection, magnetic particle inspection and, where appropriate, ultrasonic inspection. Visual testing should include verification of bead sequence and distance of temper bead to base material.

The company should consider the risk of delayed cracking and determine whether:

a) non-destructive inspection should be repeated after a suitable delay to allow for the detection of delayed cracking; and

b) special measures such as pressure reduction and support of the connection should be taken to prevent propagation of such cracks until the second inspection is complete.

NOTE 1 Procedures for magnetic particle inspection and ultrasonic inspection can be as specified in the ASME Boiler and Pressure Vessel Code, Section V, or EN 1290 and EN 1714 level B.

NOTE 2 Factors to consider in establishing a suitable delay between the completion of the weld and the commencement of its final non-destructive inspection include, but are not limited to:

— material strength and composition;

— weld metal strength and composition;

— material temperature;

— material thickness;

— previous experience with similar welds; and

— any post-weld heating.

NOTE 3 A time delay of 48 h is generally considered suitable for carbon and low-alloy steel materials. Shorter delays might be suitable based upon experience or research. Longer delays might be necessary for high-grade and thick materials, over-matched weld metal, and very low material temperatures after welding. It is advisable that the rationale for the delay selected be documented.

Annex E
(informative)

Welding of European onshore natural gas transmission pipelines

E.1 General

This annex is mandatory for European member states. This annex contains requirements and specifies common basic principles for non-destructive testing and their frequency and destructive testing of production welds of weld joints for the installation and modification of onshore steel pipelines and pipework used in gas infrastructure systems within European member states, including in-service pipelines, for the carriage of processed, non-toxic and non-corrosive natural gas in accordance with ISO 13686, where:

a) the pipeline elements are made of unalloyed or low-alloyed carbon steel;

b) the pipeline is not located within commercial or industrial premises as integral part of the industrial process on those premises except for any pipelines and facilities supplying such premises;

c) the pipework is not located within household installations in accordance with EN 1775;

d) the design temperature of the system is between −40 °C and 120 °C inclusive.

NOTE Annex E applies only when specified by the company.

Additional requirements may be specified when, for example, the following are considered critical:

— the strain on pipelines and systems;

— the materials;

— the line routing;

— the design or the welding technique.

This annex is not applicable to the welds produced prior to the publication of this International Standard.

Users of this annex should be aware that more detailed national standards and/or codes of practice in European member states may exist.

This annex is intended to be applied in association with these national standards and/or codes of practice setting out the above-mentioned basic principles.

In the event of conflicts, in terms of more restrictive requirements in national legislation/regulation with the requirements of this International Standard, the national legislation/regulation shall take precedence.

Any specific CEN requirements for the ISO standards in this annex shall also apply and be agreed. This agreement may include a listing of the equivalent ISO standards.

E.2 Weld quality

Weld quality shall be ensured by inspection of the welds using destructive tests and/or non-destructive testing. The results of these tests shall be documented.

Non-destructive testing shall be carried out in accordance with approved procedures.

E.3 Non-destructive inspection of the weld joint

E.3.1 General

The non-destructive inspection shall comprise final visual inspection and non-destructive testing.

The minimum extent of non-destructive testing, in respect of the quality requirement category and the type/position of the weld joint, is given in Table E.1.

The pipeline operator shall select which welds are to be tested.

Where less than 100 % non-destructive testing is performed and the quality of the weld joint does not meet the requirements, further welds shall be tested to determine the extent of the problem. Except when otherwise agreed, two further welds shall be inspected for each rejected weld.

Table E.1 — Minimum extent of non-destructive testing

Pipelines and pipe work category as a function of the working pressure, pipe materials used and example of activity area	Type/position of the weld joint	Visual testing by welding supervisor	Radiography or US impulse echo or US ToFD ultrasonic testing [a]	Surface crack test
B ≤ 0,5 MPa Material group 1.1, 1.2 and 1.4 in accordance with ISO/TR 15608 $R_{t\,0,5} \leq 360$ N/mm[h]	Circumferential welds	[b]	[b,c]	
	Branches, nozzles and fillet welds	[b]		[b]
	Longitudinal seams	100 %	10 %	
	Unconcealed pipe spans; pipelines on bridges, pipeline sections crossing railways, major roads and motorways, navigable waterways or landing strips/ runways	100 %	[d]	
C > 0,5 MPa and ≤ 1,6 MPa Material group 1.1, 1.2 and 1.4 in accordance with ISO/TR 15608 $R_{t\,0,5} \leq 360$ N/mm[h]	Circumferential welds	20 %	10 %	
	Branches, nozzles and fillet welds	100 %		10 %
	Longitudinal seams	100 %	100 %	
	Weld joints not included in the pressure test	100 %	100 %	
	Unconcealed pipe spans; pipelines on bridges, pipeline sections crossing railways, major roads and motorways, navigable waterways or landing strips/ runways	100 %	100 %	

[a] The proportion of techniques shall be agreed.

[b] Representative random sample on the basis of the total number of weld joints made by a welder during the course of one year.

[c] One destructive test of field weld per year by means of tensile and/or bending test for welders qualified only for gas welding (procedure no. 311) or only for fillet welds.

[d] The pipeline operator shall specify the extent of non-destructive testing taking into account the design conditions, for example:

- external loads in addition to internal pressure;
- supports.

[e] Pipelines having hoop stresses at design pressure up to 30 % of specified minimum yield strength and operated at a pressure up to 2,4 MPa can be allocated to quality requirement category C by the pipeline operator.

[f] Company should consider these methods for branches and nozzles,

[g] Seams shall be tested 100 % by two different testing methods.

[h] $R_{t0,5}$ is specified minimum yield strength in accordance with ISO 3183, PSL2.

Table E.1 *(continued)*

Pipelines and pipe work category as a function of the working pressure, pipe materials used and example of activity area	Type/position of the weld joint	Visual testing by welding supervisor	Radiography or US impulse echo or US ToFD ultrasonic testing [a]	Surface crack test
D > 1,6 MPa [e] Material group 1, 2 and 3 in accordance with ISO/TR 15608	Circumferential welds	100 %	100 %	
	Branches, nozzles, fillet welds	100 %	[f]	20 %
	Longitudinal seams Sweepolets	100 %	100 %	
	Weld joints not included in the pressure test	100 %	100 % [g]	
	If pipelines/units are laid or installed in built-up areas	100 %	100 %	
	Unconcealed pipe spans; pipelines on bridges, pipeline sections crossing railways, major roads and motorways, navigable waterways or landing strips/ runways	100 %	100 %	

[a] The proportion of techniques shall be agreed.

[b] Representative random sample on the basis of the total number of weld joints made by a welder during the course of one year.

[c] One destructive test of field weld per year by means of tensile and/or bending test for welders qualified only for gas welding (procedure no. 311) or only for fillet welds.

[d] The pipeline operator shall specify the extent of non-destructive testing taking into account the design conditions, for example:

- external loads in addition to internal pressure;
- supports.

[e] Pipelines having hoop stresses at design pressure up to 30 % of specified minimum yield strength and operated at a pressure up to 2,4 MPa can be allocated to quality requirement category C by the pipeline operator.

[f] Company should consider these methods for branches and nozzles,

[g] Seams shall be tested 100 % by two different testing methods.

[h] $R_{t0,5}$ is specified minimum yield strength in accordance with ISO 3183, PSL2.

E.3.2 Non-destructive testing

The method or combination of methods, for visual and non-destructive testing of the welds shall be specified by the pipeline operator. Prior to commencement of welding, the non-destructive testing procedures shall be submitted to the pipeline operator for acceptance. Inspection test methods may be replaced by other methods, if agreed by the pipeline operator.

Non-destructive testing procedures shall be approved by an NDT expert Level III in accordance with ISO 9712 for the appropriate testing technique.

Other forms of non-destructive testing can be required, depending on the material used, the design and/or the welding technique.

Radiographic testing shall be carried out in accordance with ISO 17636-1:2013. If not otherwise agreed by the pipeline operator, the image quality class shall be class A for categories B and C, and class B for category D. The test laboratory contracted for radiographic work should be accredited to ISO/IEC 17025.

Ultrasonic ToFD testing in accordance with CEN/TS 14751 may be used for detection and sizing of weld defects and defects adjacent to the weld. Supplementary recommendations are given in Annex I.

NOTE In processes 114, 135 and 136, which can be used in the short circuit mode, in accordance with ISO 4063, supplementary ultrasonic testing can be required based on a higher risk for lack of fusion defects.

Non-destructive testing and, if applicable, testing level shall be in accordance with Table E.2.

Table E.2 — Non-destructive testing procedures and testing levels

Examination method	Standard and examination level
Visual	ISO 5817 or ISO 17637
Magnetic	ISO 17638
Penetrant	ISO 3452-1
Radiographic	ISO 17636-1:2013 class B
Manual ultrasonic	ISO 17640 level B
UT for laminations	ISO 10893-8
Time of flight diffraction	ISO 10863 level C

E.3.3 Time of inspection

All non-destructive testing shall be carried out before pressure testing, with the exception of final tie-in welds which are not subjected to the pressure test ("golden welds").

If welds are not pressure tested and exceed all of the following criteria:

— yield strength $R_{t0,5}$ > 360 N/mm^2;

— wall thicknesses > 10 mm;

— diameter ≥ 300 mm.

These welds shall also be ultrasonically examined as one of the required inspection techniques (see Table E.1, footnote g). If the weld is made with the use of cellulosic electrodes, this testing shall be carried out not sooner than 24 h after the welding has been completed. If soaking is performed the testing can be performed after completion of the soaking procedure.

E.3.4 Destructive testing of production welds

Destructive testing of production welds shall be applied to category D, Table E.1. The minimum number of production welds to be tested shall be in accordance with Table E.3. Welds shall be non-destructively tested in accordance with the project specifications before destructive testing.

The destructive tests shall be in accordance with ISO 15614-1:2004. A cut out weld shall be representative for all the production welds of the related pipeline length.

If one of the results is not acceptable further investigations, approved by the pipeline operator, shall be made in order to define the cause of the unacceptable results, identify the unacceptable part(s) of the pipeline and analyse the consequences of the results. The pipeline operator shall decide on the acceptance of the pipeline.

Table E.3 — Minimum number of production test welds as function of pipeline length

Pipeline length, L km	Number of samples
$1 < L \leq 10$	1
$10 < L \leq 50$	2
$L > 50$	2 plus 1 further sample per length of 50 km or part thereof

Annex F
(informative)

Welding of gas distribution systems in Europe

F.1 General

This annex contains specific requirements for the welding and inspection of gas distribution systems in Europe, with a maximum operating pressure up to and including 1,6 MPa MOP.

NOTE Annex F applies only when specified by the company.

Gas distribution systems include above and below ground piping and all other equipment necessary to deliver the gas to the consumer at the agreed conditions.

The maximum operating pressure is the pressure at which a system can be operated continuously under normal conditions.

This annex is not applicable to the welds produced prior to the publication of this International Standard.

This annex is intended to be applied in association with national standards and/or codes of practice if any, setting out the above-mentioned basic principles. In the event of conflicts in terms of more restrictive requirements in national legislation/regulation with the requirements of this International Standard, the national legislation/regulation shall take precedence.

F.2 Approving of welders and welding operators

Approval of welders and welding operators shall be in accordance with ISO 9606-1.

If agreed by the network operator, for approval of welders and welding operators ISO 14732 and API 1104 for welders or ISO 14732 for welding operators may also be applied.

F.3 Production welding

All welding, including repairs and welding of patches for repair, shall be carried out in accordance with the approved welding procedure specification.

Oxyfuel gas welding may be applied for pipes with an operating pressure less or equal to 10 kPa.

If feasible, working pits or bell holes should be constructed in the pipe trench. They should have a minimum free length of 1,5 m at the weld area. The distance from pipe to bell hole bottom should be not less than 0,4 m and from pipe to trench wall not less than 0,6 m.

Bell holes shall be kept free of water during welding work.

Segmental cuts up to 7,5° (tangents up to 15°) are permitted for pipelines and systems ≤ 0,5 MPa. Segmental cuts up to 2,5° (tangents up to 5°) are permitted for pipelines and systems between 0,5 MPa and 1,6 MPa.

In areas subject to ground movements and at unconcealed pipe spans and at pipelines on bridges, changes of direction using segmental cuts shall not be permitted.

F.4 Joint preparation

Socket joints in accordance with EN 1708-1 are allowed for all diameters for pipelines and systems ≤ 0,5 MPa, if agreed by the network operator.

Bell and spigot, socket or sleeve welds shall be set up so that the root gap of the fillet weld is the minimum possible. No tools with sharp edges shall be used during this process. Where the end of the socket shall be forged, it shall be heated to a forging temperature suitable for the material quality.

The welding of alignment aids and similar temporary attachments onto pipelines should be avoided. If necessary, alignment aids and similar temporary attachments can be used with the approval of the network operator.

F.5 Non-destructive inspection of the weld joint

Non-destructive inspection of the weld joint shall be in accordance with Annex E.

Annex G
(normative)

Automatic ultrasonic testing of girth welds

G.1 General

This annex provides requirements for the automatic ultrasonic testing (AUT) of girth welds in pipelines with a nominal wall thickness of 8 mm or over.

Requirements are given for testing using workmanship acceptance criteria and for acceptance criteria defined by engineering critical assessment (ECA).

G.2 AUT system requirements

The system shall be capable of locating and measuring the position of welding anomalies if applied in conjunction with workmanship acceptance criteria. The system shall also be capable of determining the through wall height of the anomaly if ECA based criteria are used.

The AUT system used shall provide an adequate number of inspection channels for the complete volumetric inspection of the weld and heat affected zone in one circumferential scan. This requirement may be deviated from only in cases where full coverage in one scan cannot be obtained.

The weld shall be divided into vertical testing zones taking into account the weld bevel configuration and welding passes. Where practicable, the height of the testing zone should not exceed the height of the welding pass.

The AUT techniques shall use Pulse echo (using either fixed angle or phased array probes), ToFD (time-of-flight diffraction) and mapping channels.

NOTE ToFD provides additional information for the evaluation of the overall AUT inspection result and enhancing the ability to determine the through-thickness dimension and the depth position of imperfections within the weld volume.

The AUT system functionality shall be in accordance with ASTM E1961:2011, Clause 6, and the following:

a) ToFD shall meet the requirements of ISO 10863. A single ToFD configuration shall be used for wall thickness ≤ 25mm, whereas a dual ToFD configuration shall be used for wall thickness > 25mm;

b) phased array equipment shall meet the requirements of ISO 13588;

c) mapping channels shall be used to:

   — visualize the presence of the geometrical weld features such as weld cap reinforcement and excess root penetration, and

   — characterize and quantify volumetric imperfections such as porosity and porosity clusters;

d) the AUT system shall incorporate inspection techniques for the detection of transverse imperfections when required by the company.

G.3 Procedure

The procedure for AUT shall be documented in accordance with ASTM E1961.

G.4 Qualification of AUT system

G.4.1 Calibration blocks

Calibration blocks in accordance with ASTM E1961:2011, Annex 3, shall be used to establish system sensitivity, for qualification and to monitor system performance during testing of production welds.

NOTE In the event of ECA based acceptance criteria, smaller reference reflectors dimensions can be required to achieve the necessary probability of detection.

The principal reflector for porosity detection shall be a 1,5 mm FBH.

ToFD notches shall be added in accordance with ISO 10863.

Unless specified otherwise by the company, two transverse notches shall be added if the detection of transverse defects is required. The notches shall be 10 mm long and 2 mm deep, and one notch shall be positioned on the internal pipe surface and one notch on the outside surface.

Holes shall normally be protected from degradation by covering the hole with a suitable sealant. Filling of surface notches and other near surface reflectors may influence the reflecting ability of the reference reflector and shall be avoided.

If workmanship acceptance criteria are used, then the calibration block shall be from pipe material with similar diameter, thickness, heat treatment and acoustic properties (attenuation value of not more than ± 3dB from the actual project material).

If ECA acceptance criteria are used, then the material for the calibration blocks shall be from pipe material of the same source, grade, production route and of similar dimensions.

G.4.2 Specific requirements for use with workmanship acceptance criteria

This subclause defines the specific requirements for system qualification where flaw acceptance is based on workmanship criteria.

NOTE 1 Acceptable amplitude response limit and length indication are the principal parameters for acceptance when applying workman acceptance criteria. Accurate determination of flaw height is not normally a requirement.

Qualification of the system and procedure shall be by demonstration that the response obtained for all reflectors meets the requirements of ASTM E1961.

Further confirmation of the performance of the system may be obtained by testing of at least two butt welds containing seven flaws at or near the limit of the acceptance criteria. The AUT indications should be compared with the results of radiography, manual ultrasonic testing and any other method requited by the company. Discrepancies between the indications given by the system and by the other methods should be resolved by sectioning the weld at the location of the indication and metallographic testing.

The AUT system shall be qualified for the anticipated ranges for weld, probe and ambient temperature.

NOTE 2 Temperate range qualification can be by testing or justification, or a combination the two.

G.4.3 Specific requirements for use with acceptance criteria determined by ECA

This subclause defines the specific requirements for AUT systems where the flaw acceptance criteria are based on engineering critical assessment (ECA), requiring the determination of both flaw length and height.

The detection ability of the AUT system shall be deemed sufficient if the probability of detecting of a defect of the smallest allowable height determined is demonstrated to be at least 90 % shown with a 95 % confidence level.

Sizing accuracy shall be established during the qualification programme over the full range of expected defect sizes.

Based on the above sizing accuracy, the under sizing error tolerances giving less than or equal to 5 % probability of under sizing shall be determined and used in relation to any ECA specified defect sizes.

No specific tolerance is required for over sizing of imperfections. Over sizing of imperfections should however be within reasonable limits since excessive over sizing will result in unnecessary repairs during pipeline construction.

The qualification shall be system, weld geometry and weld method specific as stated in the procedure.

Qualification shall be by testing of representative welds containing flaws covering, as far as practical, the range of defect sizes as determined by ECA and for all types of defects which may be expected during production welding A sufficient number of flaws shall be examined to confirm the required level of probability of flaw detection and sizing accuracy to the required confidence level.

The flaw detection and sizing reported shall be confirmed by other methods of NDT and by metallographic testing. The actual flaw dimensions shall be determined by the taking of metallographic sections at intervals of not more than 2mm over the indicated length of the flaw or other suitable means. The variation between these measured dimensions and those indicated by the ultrasonic testing shall be used to determine sizing accuracy and confidence levels.

NOTE Further guidance on system qualification for offshore pipelines is given in DNV-RP-F118.

G.5 Validity

The essential variables related to this qualification are:

— welding method and groove geometry;

— probe set-up;

— reference reflectors;

— working temperature range;

— system equipment data acquisition and data processing;

— system software;

— temperate ranges;

— material for calibration block.

G.6 Operator qualification

Ultrasonic operators shall meet the following requirements:

— the requirements of ISO 9712 Level II for UT, and

— a minimum of 40 h training specific to the system to be used; this training shall include theoretical and practical aspects, and shall be documented.

G.7 Acceptance criteria for AUT

G.7.1 Workmanship criteria

G.7.1.1 General

The reference level shall be based on 3 mm flat bottomed hole and 1 mm deep surface notches.

All AUT indications with a response over 40 % of the reference level shall be evaluated in accordance with this paragraph.

G.7.1.2 Cracks

Indications which by their location and orientation may suggest the presence of a crack shall be investigated. Indications confirmed to be a crack shall be considered defects.

G.7.1.3 Linear surface (LS)

Linear surface (LS) imperfections (other than cracks) interpreted to be open to the inner or outer pipe surface shall be considered defects should any of the following conditions exist:

a) the length of an individual indication exceeds 25 mm;

b) the aggregate length of indications exceeds 25 mm in any continuous 300 mm length of weld;

c) the aggregate length of indications exceeds 8 % of the weld length in any weld less than 300 mm in length.

G.7.1.4 Linear buried (LB)

Linear buried (LB) indications (other than cracks) interpreted to be subsurface within the weld and not surface-connected shall be considered defects should any of the following conditions exist:

a) the length of an individual indication exceeds 50 mm;

b) the aggregate length of indications exceeds 50 mm in any continuous 300 mm length of weld;

c) the aggregate length of indications exceeds 15 % of the weld length.

G.7.1.5 Transverse (T)

All transverse indications exceeding 40 % FSH shall be further inspected with manual UT or other appropriate inspection techniques.

Transverse (T) indications (other than cracks) shall be considered volumetric and evaluated using the criteria for volumetric indications below. The letter T shall be used to designate all reported transverse indications.

G.7.1.6 Signals in volumetric channels

Volumetric cluster (VC) indications shall be considered defects when the maximum dimension of VC indications exceeds 12,5 mm.

Volumetric single indications shall be considered acceptable regardless of amplitude height unless present in more than one zone. If in more than one zone and in the same circumferential position, then these indications shall be considered as defect.

G.7.1.7 Accumulation of imperfections (AR)

Any accumulation of relevant indications (AR) shall be considered a defect when either of the following conditions exist:

a) the aggregate length of indications above evaluation level exceeds 50 mm in any 300 mm length of weld;

b) the aggregate length of indications above evaluation level exceeds 8 % of the weld length.

G.7.2 ECA criteria

Such defect acceptance criteria shall be based on critical defect sizes determined in accordance with 11.8 plus the AUT uncertainties in flaw sizing.

Annex H
(informative)

Examples of NDT reports

Table H.1 — Ultrasonic testing report

Order No.			**Client**				**Identification No.**				
			Contractor				**Purchase order**				
Project			**Fabr. order No.**				**Test No.** **Conseq. No.**		**Sequence No.**		
Component			**Code word**				**Page**		**of**		
ULTRASONIC TESTING RECORD							**Record No.**				
							Sheet		**of**	**sheets**	
Drawing No./Isometric Fabr. Plan No.							**Position**				
Material			**Welding process**				**Testing after/before heat treatment**				
Testing in accordance with					**Condition of examination area**						
Test class			**Test equipment**				**Couplant**				
Calibration block					**Search units**						
Recording threshold (reference reflector)											
Sensitivity calibration: DEGS scale IXiS diagram Reference reflector											
Transfer dB			**Sound attenuation dB m**				**Primary gain level dB**				
Weld No. or testing areas	**Dimensions** $d \times t$	**TESTING RESULTS**								**Evaluation**	
		Search unit			**Distance from**		**Echo amplitude** [b] dB	**Registration length**	**Depth of indication** mm		
		Position [a]	**Angle beam probe** °	**Frequency** MHz	**Reference point** mm	**Weld centre** mm				Acceptable	Not acceptable
[a] In accordance with the back of the record or UE-PLAN.											
[b] Echo amplitude in above recording threshold.											
Place – Date			**Examiner**				**Testing supervisor**				

Table H.2 — Magnetic particle testing report

Order No.	**Client**	**Identification No.**
	Contractor	**Purchase order**
Project	**Fabr. order No.**	**Test No.** **Sequence No.**
		Conseq. No.
Component		**Page** **of**
MAGNETIC PARTICLE TESTING RECORD		**Record No.**
		Sheet **of** **sheets**
Drawing No. Isometric Fabr. Plan No.		**Position**
Material	**Welding process**	**Testing after/before heat treatment**
Testing in accordance with	**Preparation of workpiece**	
Test class	**Test equipment**	
Type of current	**Magnetic ink used**	
Measure of magnetic field strength	**Contrast**	**Testing light**

Weld No. or testing area	**Dimensions** ($d \times t$)	**TESTING RESULTS**			
		Position	**Dimension** (mm)	**Acceptable**	**Not acceptable**
Place – Date		**Examiner**		**Testing supervisor**	

Table H.3 — Radiographic testing report

Order No.	**Client**			**Identification No.**			
	Contractor			**Purchase order**			
Project	**Fabr. order No.**			**Test No.**		**Sequence No.**	
				Conseq. No.			
Component				**Page**		**of**	
RADIOGRAPHIC TESTING RECORD				**Record No.**			
				Sheet		**of**	**sheets**
Drawing No./Isometric Fabr. Plan No.				**Position**			
Material	**Welding process**			**Testing after/before heat treatment**			
Testing in accordance with procedure							
Test class	**Test equipment**			**Film position**			
Radiation source	**Tube voltage** (kV)			**Current** (MA)			
Time exposure			**Source to film distance**				
Reading of IQI			**Film density**				
Film system			**Type position of image quality indicator**				

Weld No. or testing area	**Dimensions** ($d \times t$)	**TESTING RESULTS**					
		Type of defect	**Position**	**Registration length**	**Position lap centre roof**	**Acceptable**	**Not acceptable**
Place – Date	**Examiner**			**Testing supervisor**			

Table H.4 — Liquid penetrant testing report

Order No.		**Client**		**Identification No.**	
		Contractor		**Purchase order**	
Component				**Page of**	
LIQUID PENETRANT TESTING RECORD				**Record No.**	
				Sheet of sheets	
Drawing No./Isometric Fabr. Plan No.				**Position**	
Material		**Welding process**		**Testing after/before heat treatment**	
Testing in accordance with procedure			**Preparation of workpiece**		
Test class		**Test equipment**		**Type of penetrant**	
Temperature		**Time**		**Emulsifier**	
Developer			**Application**		
Testing light					
Weld No. or testing area	**Dimensions** ($d \times t$)	**TESTING RESULTS**			
		Position	**Dimension** (mm)	**Acceptable**	**Not acceptable**
Place – Date		**Examiner**		**Testing supervisor**	

Annex I
(informative)

Time of flight diffraction technique (ToFD)

I.1 General

This annex provides further information on the use of ISO 10863:2011 for TOFD for NDT of pipeline welds.

Additions to and substitutions of the requirements in ISO 10863:2011 are indicated as follows:

— ADDITION;

— SUBSTITUTION.

When using TOFD additional NDE shall be considered with regard to possible TOFD limitations of the detection of surface, near surface defects and defects transverse to the scanning direction.

I.2 Additional and substitutional requirements to ISO 10863:2011

I.2.1 Addition to ISO 10863:2011, Clause 1 (Scope)

ADDITION of paragraph:

Acceptance criteria for weld flaws shall be determined by the pipeline operator at his discretion.

I.2.2 Addition to ISO 10863:2011, Clause 3 (Terms and definitions)

ADDITION definitions:

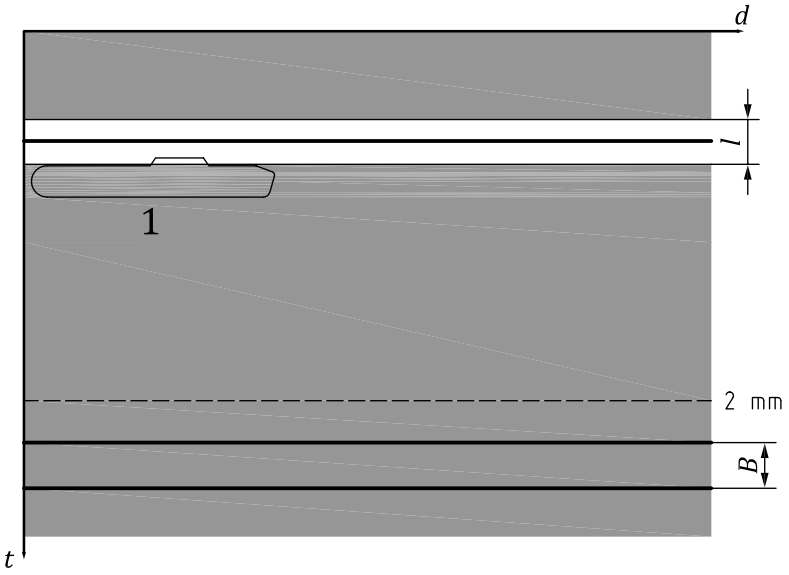
Embedded defects

Applying TOFD-inspection a weld flaw is regarded as embedded when the diffraction signal over its entire length is separated more than 2 mm from the back wall.

Surface breaking defects

A weld flaw within 2 mm from the back wall is regarded as surface breaking. Near surface defects are also considered as surface breaking in case of insufficient resolution of the ultrasonic system.

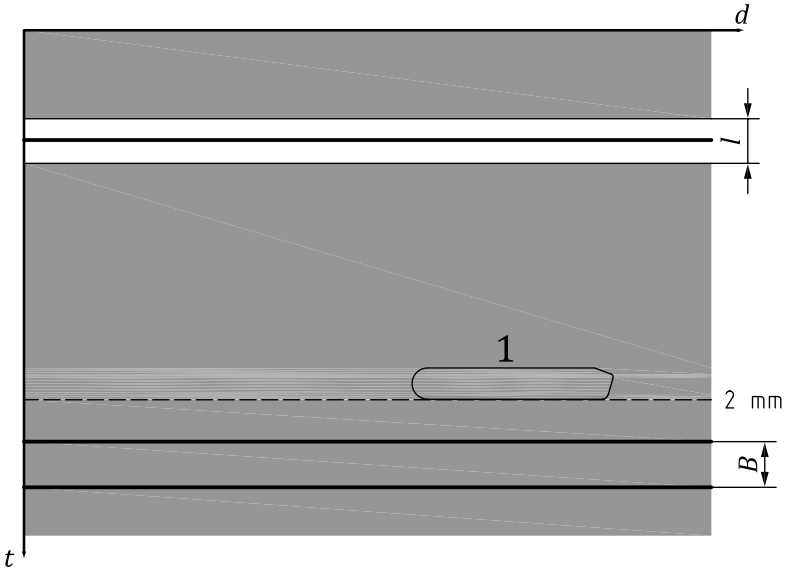
Figure I.1 and Figure I.2 provide schematic examples of a surface breaking and an embedded weld flaw respectively.



Key

1 surface breaking indication
B back wall echo
t time (μs)
d distance (mm)
l lateral wave (mm)

Figure I.1 — Schematic example of a surface breaking weld flaw



Key

1 surface breaking indication
B back wall echo
t time (μs)
d distance (mm)
l lateral wave (mm)

Figure I.2 — Schematic example of a surface embedded weld flaw

I.2.3 Addition to ISO 10863:2011, Clause 5 (Testing levels)

ADDITION of paragraph:

NOTE Annex E, Table E.2 specifies examination level C. With regard to Table 1, footnote a, an offset scan is required in case of repairs to the weld.

I.2.4 Addition to ISO 10863:2011, 7.2.2 (Ultrasonic probes)

ADDITION of paragraph:

The height of the dead zone (lateral wave) shall be typically 3,0 mm or 20 % of the wall thickness whichever is greater.

I.2.5 Substitution of ISO 10863:2011, Clause 11 (Weld testing), 3rd paragraph

SUBSTITUTION of 3rd paragraph:

The following criteria on missed data are applicable:

— Only single lines are allowed to be missed.

— Two lines are allowed to be missed provided these are separated by at least 20 lines, i.e. the minimum distance between two missed lines is 20 lines.

— The lowest value of 2 % of the total number of lines or 80 mm cumulative weld length collected in one scan is allowed to be missed.

I.2.6 Substitution of ISO 10863:2011, 12.5.2 (Sizing)

I.2.6.1 General

SUBSTITUTION of 12.5.2 by four new subjects:

— dimensions of weld defects;

— misalignment (HiLo);

— treatment of lateral wave;

— single diffraction signals.

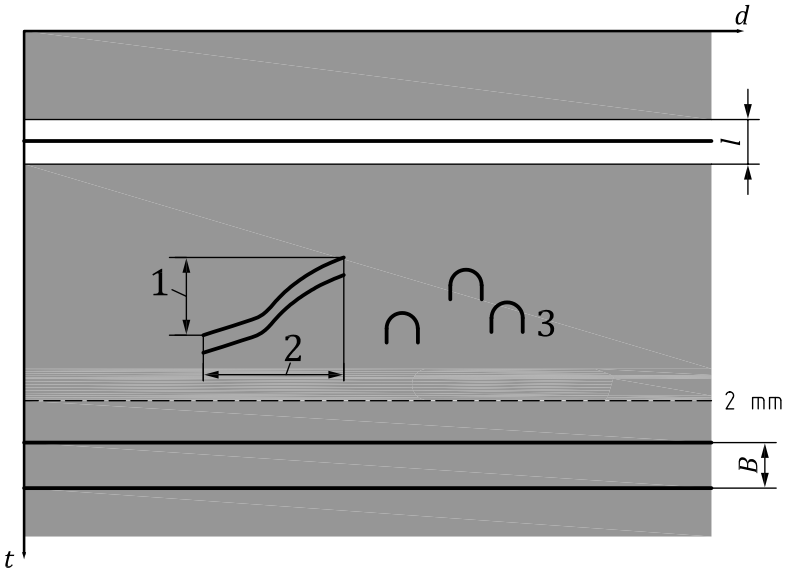
I.2.6.2 Dimensions of weld defects

The characterization of weld flaws shall take place in terminology of h·l_{max} where:

a) l_{max} is the maximum allowable length of the weld flaw in mm in circumferential direction.

b) h is the maximum allowable height dimension of a weld defect in any other direction of a weld flaw in mm.

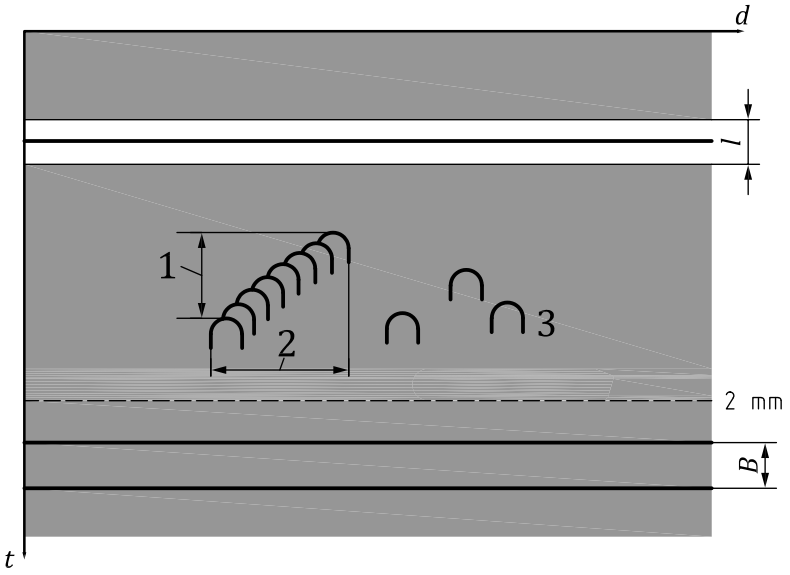
Figure I.3 and Figure I.4 provide schematic examples of stacked defects.



Key

1 weld flaw height (h) (mm)
2 weld flaw length (l) (mm)
3 single diffraction signals
B back wall echo
t time (µs)
d distance (mm)
l lateral wave (mm)

Figure I.3 — Schematic example of stacked defects



Key

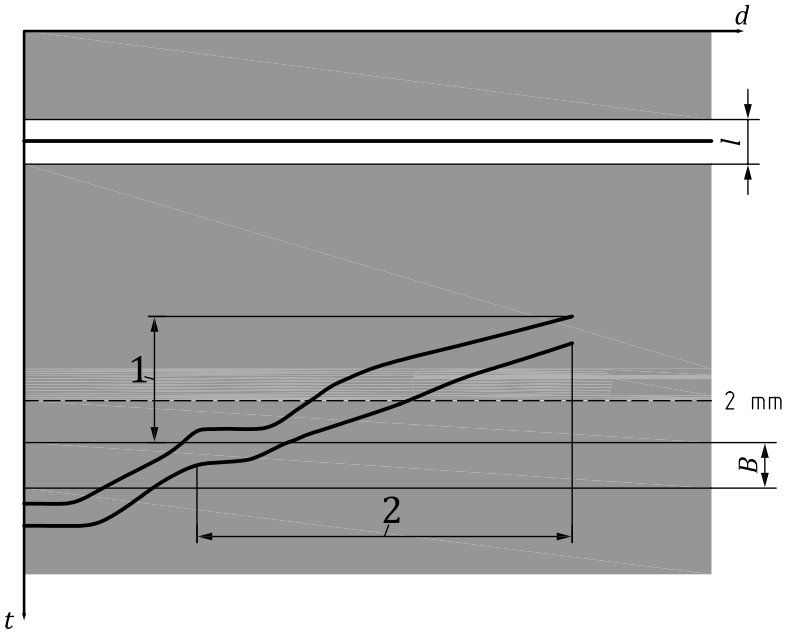
1 weld flaw height (h) (mm)
2 weld flaw length (l) (mm)
3 single diffraction signals
B back wall echo
t time (µs)
d distance (mm)
l lateral wave (mm)

Figure I.4 — Schematic example of stacked defects

a) Where TOFD indications are considered surface breaking according Figure I.1 or Figure I.2, the distance till the surface shall be included in the defect height determination.

b) For the length determination of the weld flaw the TOFD signals from both tips shall be taken. In the case of out surface defects the height of the dead zone (lateral wave) at both sides shall be included in the length determination. In the case of inner side defects the length shall be taken where the first TOFD signal can be distinguished from the back at the start and the end of the weld flaw.

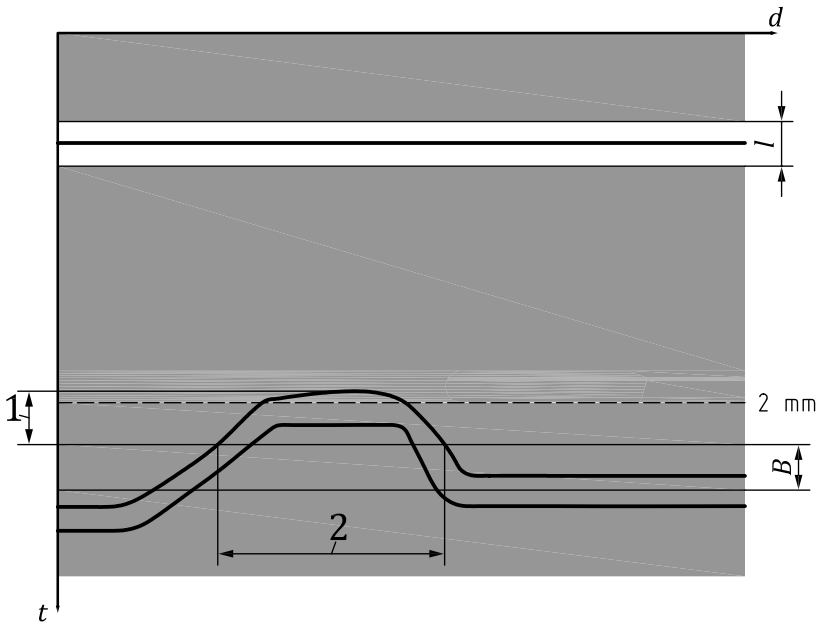
Figure I.5 and Figure I.6 provide schematic examples.



Key

1 weld flaw height (h) (mm)
2 weld flaw length (l) (mm)
B back wall echo
t time (μs)
d distance (mm)
l lateral wave (mm)

Figure I.5 — Schematic example of a partly surface breaking weld defect and the relevant borderlines for determination of the defect sizing



Key

1 weld flaw height (h) (mm)
2 weld flaw length (l) (mm)
B back wall echo
t time (µs)
d distance (mm)
l lateral wave (mm)

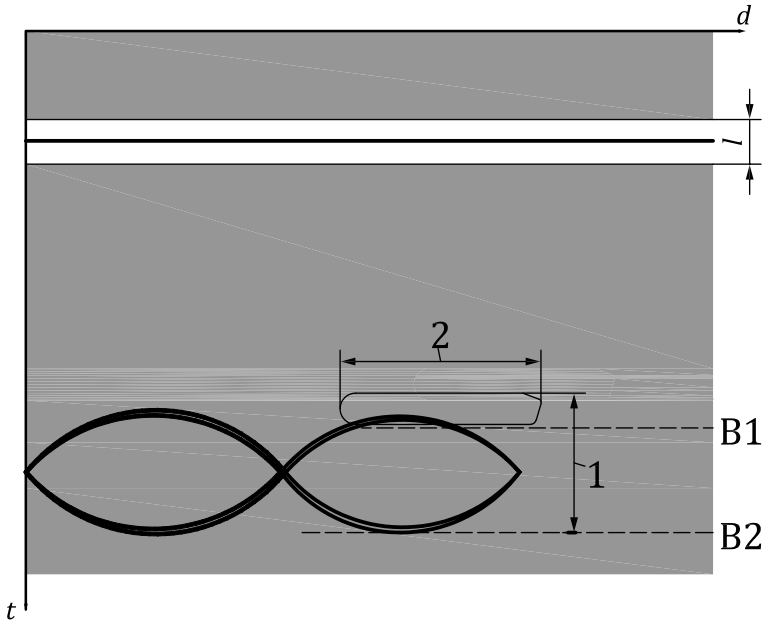
Figure I.6 — Schematic example of a partly surface and the relevant borderlines for determination of the defect sizing

I.2.6.3 Misalignment (HiLo)

Where diffraction signals fades in and fades out gradually to the normal root pattern and run parallel to it, are deemed misalignments.

In combination with HiLo the defect height shall be determined by h, whereby the topside of the flaw is represented by the upper TOFD signal and bottom side of the flaw is taken from the lowest back wall echo.

Figure I.7 provides a schematic example.



Key

1 weld flaw height (h) (mm)
2 weld flaw length (l) (mm)
B back wall echo
B1 upper back wall echo
B2 lower back wall echo
t time (μs)
d distance (mm)
l lateral wave (mm)

Figure I.7 — Schematic figure for determination of weld defects in combination with HiLo

I.2.6.4 Treatment of lateral wave

It is allowed to apply an electronic treatment of the lateral wave, whereby the distance of the upper tip of the defect till the outer surface can be determined. This manipulation is only acceptable when weakening of the upper tip signal not occurs. A weld defect is observed as surface breaking after this manipulation, when the distance of the upper tip of the defect is less than the maximum measured defect height. In the case of surface breaking defects, this distance shall be included in the measured defect height. Foregoing this further inquiry the height of the "dead zone" shall be determined and reported on the NDE report. Any further inquiry shall be reported and is subject for verification.

Where defects manifest on the pipe outer surface or in case of misalignment, defect heights shall be corrected on the basis of visual examination, but only after confirmation.

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