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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);

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.