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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 13847 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum and natural gas industries*, Subcommittee SC 2, *Pipeline transportation systems*.

Annexes A, B, C and D of this International Standard are for information only.

Introduction

Users of this International Standard should be aware that further or differing requirements may be needed for individual applications. This International Standard is not intended to inhibit a contractor from offering, or the company from accepting, alternative engineering solutions for the individual application. This may be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the manufacturer should identify any variations from this International Standard and provide details.

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

1 Scope

This International Standard specifies the requirements for producing and inspecting girth, branch and fillet welds in the pipeline part of pipeline transportation systems for the petroleum and natural gas industries meeting the requirements of ISO 13623.

This International Standard is applicable to the requirements for welding of carbon and low-alloy steel pipes. Application is restricted to pipes with a diameter of 20 mm and larger and wall thickness of 3 mm or more, and a specified minimum yield strength of 555 MPa or less. It is also applicable to welding into pipelines, items such as spools, risers, launchers/receivers, fittings, flanges and “pups” to pipeline valves.

The welding processes covered are shielded metal arc welding, gas tungsten arc welding, gas metal arc welding, flux-cored arc welding with and without shielding gas, and submerged arc welding.

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, to “hot-tap” welding of pipelines in service or to the welding of process piping outside of the scope of ISO 13623.

NOTE Additional requirements may be necessary for welding of pipeline for particular pipeline operating conditions. 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, these additional requirements should be added to the requirements of this International Standard in a project-specific supplement.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 148:1983[1)], Steel — Charpy impact test (V-notch).

ISO 857-1:1998, *Welding and allied processes — Vocabulary — Part 1: Metal welding processes.*

ISO 1106-3:1984, *Recommended practice for radiographic examination of fusion welded joints — Part 3: Fusion welded circumferential joints in steel pipes of up to 50 mm wall thickness.*

ISO 3452:1984, *Non-destructive testing — Penetrant testing — General principles.*

ISO 3453:1984, *Non-destructive testing — Liquid penetrant inspection — Means of verification.*

ISO 4136:1989, *Fusion-welded butt joints in steel — Transverse tensile test.*

1) To be replaced by ISO 148-1:— (to be published), ISO 148-2:1998 and ISO 148-3:1998.

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

ISO 6507-1:1997, *Metallic materials — Vickers hardness test — Part 1: Test method.*

ISO 6520-1:1998, *Welding and allied processes — Classification of geometric imperfections in metallic materials — Part 1: Fusion welding.*

ISO 6947:1990, *Welds — Working positions — Definitions of angles of slope and rotation.*

ISO 7963:1985, *Welds in steel — Calibration block No. 2 for ultrasonic examination of welds*.

ISO 9712:1999, *Non-destructive testing — Qualification and certification of personnel.*

ISO 9935:1992, *Non-destructive testing — Penetrant flaw detectors — General technical requirements.*

ISO 9956-2:1995, *Specification and approval of welding procedures for metallic materials — Part 2: Welding procedure specification for arc welding.*

ISO 9956-3:1995, *Specification and approval of welding procedures for metallic materials — Part 3: Welding procedure tests for arc welding of steels.*

ISO 10474:1991, *Steel and steel products — Inspection documents.*

ISO 13623:2000, *Petroleum and natural gas industries — Pipeline transportation systems.*

ISO 14732:1998, *Welding personnel — Approval testing of welding operators for fusion welding and of resistance weld setters for fully mechanized and automatic welding of metallic materials.*

EN 876:1995[2], *Destructive tests on welds in metallic materials — Longitudinal tensile test on weld metal in fusion welded joints.*

EN 1043-1:1995, *Destructive tests on welds in metallic materials — Hardness testing — Part 1: Hardness test on arc welded joints.*

EN 1321:1996, *Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds.*

ASME[3] *Boiler and Pressure Vessel Code Section V:1998, Nondestructive examination*.

AWS A5.01-93:1993[4], *Filler metal procurement guidelines.*

AWS C5.3-91:1991, *Recommended practices for air carbon arc gouging and cutting.*

3 Terms and definitions

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

3.1
approved welder
welder who has been approved in accordance with the requirements of this International Standard

2) CEN, European Committee for Standardization, Management Centre, Rue de Stassart 36, B-1050, Brussels, Belgium.

3) American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA.

4) The American Welding Society, 550 NW LeJeune Road, Miami, FL 33126, USA.

3.2
approved welding operator
welding operator who has been approved in accordance with the requirements of this International Standard

3.3
approved welding procedure specification
welding procedure specification which has been approved in accordance with the requirements of this International Standard

[ISO 9956-1:1995]

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

NOTE The often-used term “heat input” is more correctly the arc energy modified by an arc efficiency factor.

3.5
by agreement
agreed between the company and the contractor

3.6
company
owner company or the engineering agency in charge of construction

NOTE The company may act through an inspector or other authorized representative. The company may also be the contractor in some instances.

3.7
contractor
entity that actually performs the work covered by this International Standard

3.8
girth weld
circumferential butt weld in pipe

3.9
internal repair
repair of the root pass from inside the pipe

3.10
mechanized welding
welding process in which the welding parameters and torch guidance are controlled mechanically or electronically but may be manually varied during welding to maintain the required welding conditions

3.11
one-shot welding process
process characterized by fusion or metallic bonding being induced around the entire circumference of the pipe simultaneously

EXAMPLES Flash welding, friction welding or pressure welding.

3.12
penumbra
shadow produced on a radiographic image when the incident radiation is partially, but not wholly, cut off by an intervening body

NOTE It is the region of geometric unsharpness around the image of an indication.

3.13
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

3.14
test piece
welded assembly prepared for the purpose of approving a welding procedure specification, welder or welding operator

3.15
welder
person who holds and manipulates the electrode holder, welding gun, torch or blowpipe by hand

[ISO 9606-1:1994/Amd.1:1998]

3.16
weld repair
process of correcting a defect that is discovered after the weld has been completed and submitted for inspection

NOTE The repair may involve complete removal of a cylinder of pipe or removal of a localized area by grinding or other means followed by additional welding.

3.17
welding operator
person who performs mechanized and/or automatic welding

[ISO 14732:1998]

3.18
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

[ISO 9956-1:1995]

3.19
welding procedure specification
WPS
document providing the required variables for a specific welding procedure

4 Symbols and abbreviated terms

AWT	All-weld-metal tensile test
CE	Carbon equivalent
CRA	Corrosion-resistant alloy
CTOD	Crack tip opening displacement
DAC	Distance amplitude correction
ECA	Engineering critical assessment
GMAW	Gas metal arc welding (Process ISO 4063-13)

GSFCAW	Gas-shielded flux-cored arc welding (Processes ISO 4063-136, 137)
GTAW	Gas tungsten arc welding (Process ISO 4063-141)
HAZ	Heat-affected zone
HV	Vickers hardness
IQI	Image quality indicator
LPE	Liquid penetrant examination
MPE	Magnetic particle examination
NDE	Non-destructive examination
OD	Outside diameter of pipe
P_{cm}	Cracking compositional parameter
PWHT	Post-weld heat treatment
r	Nominal internal radius
SAW	Submerged arc welding (Process ISO 4063-12)
SMAW	Shielded metal arc welding (Process ISO 4063-111)
SMYS	Specified minimum yield strength
SSFCAW	Self-shielded flux-cored arc welding (Process ISO 4063-114)
t	Wall thickness
UE	Ultrasonic examination
VE	Visual examination
WPS	Welding procedure specification

5 Welding procedure specification testing and approval

5.1 General

For approval of a WPS, test pieces shall be welded, inspected and tested in accordance with ISO 9956-3 and 5.3 and 5.4 of this International Standard.

A WPS shall be deemed to be approved only if all the requirements for approval specified in this International Standard and the supplementary requirements specified by the company have been met.

An inspector accepted by the company shall witness the welding and testing of the test pieces for the approval of a WPS.

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.

Test pieces should be welded using project-specific materials.

5.2 Welding procedure specification

The WPS shall incorporate the technical contents specified in ISO 9956-2, in 5.6 of this International Standard and, when applicable, the following:

— steel grade and supply condition;

EXAMPLES Normalized, quenched and tempered, cold-formed and thermomechanically processed, normalizing formed.

— number and location of welders;

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

— type of line-up clamp or tack welding;

— preheating procedure;

— 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 NDE 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 9956-2 if a previously approved WPS is offered to the company for agreement.

NOTE For steel grades with increased susceptibility to delayed hydrogen cracking due to welding, such as with a SMYS of 555 MPa or higher, the WPS may be designed to prevent such cracking from occurring. The welding of these grades of pipe may also require the use of low hydrogen processes, PWHT, and a delay period prior to inspection.

5.3 Welding of test piece

5.3.1 Preliminary WPS

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

5.3.2 Test welding conditions

Test pieces should be welded under conditions that simulate those of the site production location (see 7.3 and 7.4).

5.3.3 Welding position

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

5.3.4 Tack welds

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

5.3.5 Shape and dimensions of test pieces

5.3.5.1 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 pipelengths.

5.3.5.2 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 9956-3.

5.3.5.3 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 pipe and a forged flange is subjected to appropriate mechanical testing on both sides of the weld.

5.4 Inspection and testing of test pieces

5.4.1 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.

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

Type of inspection/test	Extent of inspection/testing
Visual	100 %
Radiographic[a]	100 %
Transverse tensile test	2 specimens
Impact test[b]	2 sets for $t \leqslant 20$ mm 4 sets for $t > 20$ mm
Macro-examination and hardness test[c]	1 specimen
All-weld-metal tensile test[d]	by agreement

[a] This may be supplemented by UE by agreement.

[b] Tests may not be required for pipe with $t \leqslant 12$ mm or with SMYS < 360 MPa.

[c] The company may decide that, for material with SMYS < 420 MPa, hardness testing is not necessary.

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

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.

5.4.2 Non-destructive examination

All test pieces shall be examined visually and non-destructively in accordance with clause 8 following any required PWHT and prior to cutting of the test specimens.

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

The NDE shall be reported in accordance with clause 8 and the results shall meet the acceptance criteria in clause 9.

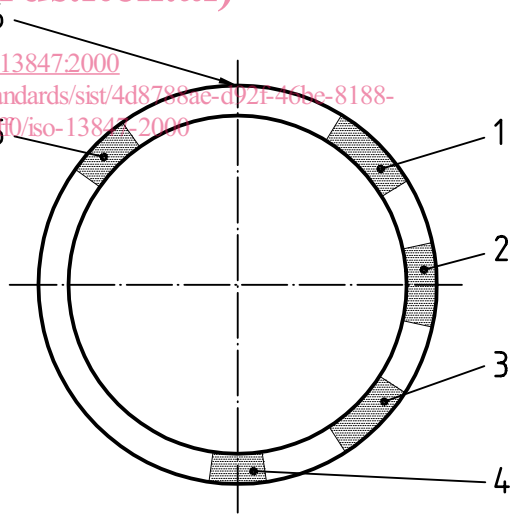
5.4.3 Destructive testing — Girth welding

5.4.3.1 Cutting of test specimens

Test specimens shall be taken from test pieces which have met the acceptance criteria for NDE. 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 NDE.

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.



Key:

1 Area 1 for:
— 1 tensile specimen

2 Area 2 for:
— Impact and additional test specimens if required

3 Area 3 for:
— 1 tensile specimen

4 Area 4 for:
— 1 macro test specimen
— 1 hardness test specimen

5 Area 5 for:
— AWT specimens

6 Top for fixed pipe

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

Key:

1 Area 1 for:
— 1 tensile specimen

2 Area 2 for:
— 1macro test specimen
— 1 hardness test specimen

3 Area 3 for:
— 1 tensile specimen

4 Area 4 for:
— Impact and additional test specimens if required

5 Area 5 for:
— AWT specimens

6 Top for fixed pipe

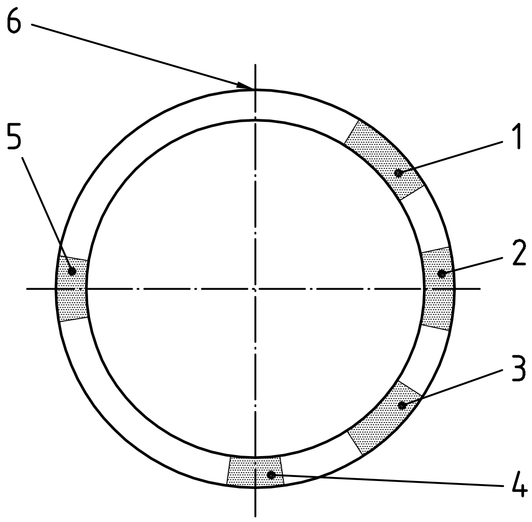


Figure 2 — Location of test specimens for a fixed-position girth weld in pipe for downwards welding

5.4.3.2 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.

5.4.3.3 Test temperature

Destructive testing shall be performed at ambient temperature except for impact testing (see 5.4.3.5) or CTOD testing. For design-service temperatures greater than 75 °C, consideration should be given to performing elevated-temperature tensile tests.

5.4.3.4 Transverse tensile testing

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

For pipes greater than 50 mm OD, 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 OD of 50 mm or less.

When 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 an equal number of 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.

