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Oil and gas industries including lower carbon energy — Factory bends, fittings and flanges for pipeline transportation systems — —

Part 1: Induction bends

Industries du pétrole et du gaz, y compris les énergies à faible teneur en carbone — Coudes d'usine, raccords et brides pour systèmes de transport par conduites —

Partie 1: Coudes fabriqués par induction

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Foreword

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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 document 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).

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This document was prepared by Technical Committee ISO/TC 67, *Oil and gas industries including lower carbon energy*, Subcommittee SC 2, *Pipeline transportation systems*.

This fourth edition cancels and replaces the third edition (ISO 15590--1:2018), which has been technically revised.

The main changes are as follows:

— ——changed the title is changed to be consistent with the new title of ISO/TC67 toTC 67 in response to the green and lower carbon development;

— ——classified the induction bending process into local heating process and global heating process according to the steel grade;

— ——removed the testing requirements of welds in transition zone;

— ——added a testing requirement for extracting samples from the bend neutral axis base metal;

— ——added the delaminated test pieces with reduced thickness for tensile testing;

— ——added requirements for retesting;

— ——added an additional condition for non-destructive testing in regards of copper pollution.

A list of all parts in the ISO 15590 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Oil and gas industries including lower carbon energy — Factory bends, fittings and flanges for pipeline transportation systems— —

Part 1: Induction bends

1 Scope

This document specifies the technical delivery conditions for bends made by the induction bending process for use in pipeline transportation systems for the petroleum and natural gas industries as defined in ISO 13623.

This document is applicable to induction bends made from seamless and welded pipe of unalloyed or low-alloy steels.

NOTE These are typically C-Mn steels or low-alloy steels that are appropriate for the corresponding level and grade of line pipe in accordance with ISO 3183.

This document specifies the requirements for the manufacture of two product specification levels (PSLs) of induction bends corresponding to product specification levels given for pipe in ISO 3183.

This document is not applicable to the selection of the induction bend PSL.

This document is not applicable to pipeline bends made by other manufacturing processes.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 80000-1:2022, *Quantities and units — Part 1: General*

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

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

ISO 6507 (all parts), *Metallic materials — Vickers hardness test*

ISO 6508 (all parts), *Metallic materials — Rockwell hardness test*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 6892-2, *Metallic materials — Tensile testing — Part 2: Method of test at elevated temperature*

ISO 7438, *Metallic materials — Bend test*

ISO 7539-2, *Corrosion of metals and alloys — Stress corrosion testing — Part 2: Preparation and use of bent-beam specimens*

ISO 8501--1, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings*

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

ISO 10893--4, *Non-destructive testing of steel tubes — Part 4: Liquid penetrant inspection of seamless and welded steel tubes for the detection of surface imperfections*

ISO 10893--5, *Non-destructive testing of steel tubes — Part 5: Magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections*

ISO 10893--8, *Non-destructive testing of steel tubes — Part 8: Automated ultrasonic testing of seamless and welded steel tubes for the detection of laminar imperfections*

ISO 10893--9, *Non-destructive testing of steel tubes — Part 9: Automated ultrasonic testing for the detection of laminar imperfections in strip/plate used for the manufacture of welded steel tubes*

ISO 10893--10:2011, *Non-destructive testing of steel tubes — Part 10: Automated full peripheral ultrasonic testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of longitudinal and/or transverse imperfections*

ISO 10893--11:2011, *Non-destructive testing of steel tubes — Part 11: Automated ultrasonic testing of the weld seam of welded steel tubes for the detection of longitudinal and/or transverse imperfections*

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

ISO 17640, *Non-destructive testing of welds — Ultrasonic testing — Techniques, testing levels, and assessment*

ASTM E112, *Standard Test Methods for Determining Average Grain Size*

ASTM E214, *Standard Practice for Ultrasonic Pulse-Echo Straight-Beam Contact Testing*

ASTM E340, *Standard Test Method for Macroetching Metals and Alloys*

ASTM E797, *Standard Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method*

NACE TM0177:2016, *Standard Test Method — Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H_2S Environments*

NACE TM0284:2016, *Test Method — Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ——ISO Online browsing platform: available at https://www.iso.org/obp

— ——IEC Electropedia: available at https://www.electropedia.org/

3.1
arc
curved portion of a bend

3.2
bend angle
amount of directional change through the bend

3.3
bend qualification test
BQT
qualification test that produces a bend in accordance with the *MPS* (3.20(3.20)) and demonstrates that bends that meet the specified requirements can be produced

Note 1 to entry: Clause 10 Clause 10 specifies requirements for bends.

3.4
bend radius
distance from the centre of curvature to the centreline axis of the bent pipe

3.5
by agreement
agreed between the *manufacturer* (3.19(3.19)) and the *purchaser* (3.23(3.23))

[SOURCE: ISO15590ISO 15590-2:2021, 3.1]

3.6
chord
line segment connecting start and stop points of the bend zone measured at the centreline axis

3.7
defect

imperfection (3.12(3.12)) of a size and/or population density greater than the specified acceptance criteria

Note 1 to entry: 10.5 Clause 10.5 and Clause B.7B.7 specifies specify the acceptance criteria.

3.8
extrados
outer curved section of the bend *arc* (3.1(3.1))

3.9
global heating technology
induction bending (3.14(3.14)) process in which the entire bend including *arc* (3.1(3.1)) and *tangent* (3.27(3.27)) sections is pushed through the induction heating coil and heated to the full bending temperature

3.10
heat
batch of steel prepared in one steel-making operation

3.11
if agreed
as prescribed, or more stringent than is prescribed, if achieved consensus by the *manufacturer* (3.19(3.19)) and the *purchaser* (3.23(3.23)) and specified in the purchase order

[SOURCE: ISO 24139-2:2023, 3.1.5]

3.12
imperfection
discontinuity or irregularity in the product wall or on the product surface that is detectable by *inspection* (3.15(3.15)) methods outlined in this document

3.13
indication
evidence obtained by *non-destructive inspection* (3.22(3.22))

3.14
induction bending
continuous bending process that utilizes induction heating to create a narrow, circumferential, heated band around the material being bent

3.15
inspection
activities, such as measuring, examining, testing, weighing or gauging one or more characteristics of a product and comparing the results of such activities with the specified requirements in order to determine conformity

3.16
intrados
inner curved section of the bend *arc* (3.1(3.1))

3.17
lamination
internal metal separation that creates layers, generally parallel to the pipe/bend surface

3.18
local heating technology
induction bending (3.14(3.14)) process in which only the *arc* (3.1(3.1)) of a bend is pushed through the induction heating coil and heated to the full bending temperature

3.19
manufacturer
firm, company, or corporation responsible for making and marking the product in accordance with the specified requirements

Note 1 to entry: Clauses 9 Clause 9 and 1010 specifies specify requirements for manufacturers.

3.20
manufacturing procedure specification
MPS
document that specifies the properties and description of the *mother pipe* (3.21(3.21),), the bending procedure, the post-bending heat treatment equipment and cycle (if needed), the qualification bend testing results, the non-destructive testing procedures and the weld end bevel details used for the manufacture of the bends

3.21
mother pipe
straight section of pipe from which an induction bend is made

3.22
non-destructive inspection
inspection (3.15(3.15)) to reveal *imperfections* (3.12(3.12),), using radiographic, ultrasonic or other methods specified in this document that do not involve disturbance, stressing or breaking of the materials

3.23
purchaser
party responsible for both the definition of requirements for a product order and for payment of that order

3.24
submerged-arc welding
SAW
welding process that produces melting and coalescence of metals by heating them with an arc or arcs between a bare metal consumable electrode or electrodes and the workpiece, wherein the arc and molten metal are shielded by a blanket of granular flux

[SOURCE: ISO 15590-4:2019, 3.22]

3.25
service condition
condition of use that is specified by the *purchaser* (3.23(3.23)) in the purchase order

Note 1 to entry: In this document, the terms “sour service” and “offshore service” are service conditions.

3.26
end weld
weld that joins strip or plate ends together

3.27
tangent
straight section at the end of an induction bend

3.28
transition zone
area of the start and stop points of induction heating, which includes material that extends from the unheated *mother pipe* (3.21(3.21)) to the material that has been heated to the full bending temperature

3.29
wall thinning
amount of reduction from the original wall thickness of the pipe to the wall thickness in the *extrados* (3.8(3.8)) after bending

4 Symbols and abbreviated terms

4.1 Symbols

A elongation of tensile test specimen after fracture, expressed as a percentage

L_{CVD}	crest to valley depth
D_2 and D_4	outside diameters of two adjacent crests
D_3	outside diameter of the intervening valley
D	specified outside diameter
D_a	manufacturer-designated outside diameter after sizing, expressed in millimeters
D_b	manufacturer-designated outside diameter before sizing, expressed in millimeters
D_{max}	maximum measured diameter, outside or inside
D_{min}	minimum measured diameter, outside or inside
l	distance between adjacent crests for waving
O	out-of-roundness
r_b	bend centreline radius
r_p	nominal mid-thickness radius of the mother pipe
R_m	ultimate tensile strength
$R_{t0,5}$	yield strength for 0,5 % total elongation~~sizing ratio~~
~~S_r~~	
S_r	sizing ratio
T_{dmin}	minimum design temperature specified by the purchaser
t_i	minimum wall thickness at the bend intrados
t_{min}	minimum wall thickness required in accordance with ISO 13623, for the straight pipe adjacent to the bend, including any corrosion allowance

4.2 Abbreviated terms

CTOD	crack tip opening displacement testing
CVD	crest to valley depth
HAZ	heat-affected zone
HIC	hydrogen-induced cracking
HFW	high-frequency electric welding process for pipe during manufacturing
IB	induction bend
MT	magnetic particle testing
NDT	non-destructive testing
PSL	product specification level
PT	liquid-penetrant testing
RT	radiographic testing
SAWH	submerged arc helical welding process for pipe during manufacture
SAWL	submerged arc longitudinal welding process for pipe during manufacture

~~SI~~	~~International System of Units~~
SI	International System of Units
SSC	sulfide stress-cracking
SWC	step-wise cracking
UT	ultrasonic testing
WPS	welding procedure specification

5 General requirements

5.1 Units of measurement

In this document, data are expressed in SI units. For a specific order item, unless otherwise stated, only one system of units shall be used, without combining data expressed in the other system.

5.2 Rounding

Unless otherwise stated in this document, to determine conformity with the specified requirements, observed or calculated values shall be rounded to the nearest unit in the last right-hand place of figures used in expressing the limiting value, in accordance with ISO 80000-1:2022, Annex B, Rule A.

NOTE See also ASTM E29-04.

5.3 Conformity to this document

A quality management system should be applied to assist conformity to the requirements of this document.

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

A contract may specify that the manufacturer is responsible for conforming to all the applicable requirements of this document. It shall be permissible for the purchaser to make any investigation necessary to be assured of conformity by the manufacturer and to reject any material that does not conform.

6 Designation

Designation of induction bends shall take the form “IB xxx-PSL 1” or “IB xxx-PSL 2” or “IB xxx-PSL 2S”, where

— ~~—~~“xxx” is the specified minimum yield strength, expressed in megapascals (MPa);

— ~~—~~the letters “PSL 1” or “PSL 2” identify the technical delivery conditions class for induction bends in non-~~-~~sour service;

— ~~—~~the letters “PSL 2S” identify PSL 2 bends for use in sour service conditions;

— ~~—~~the letters “PSL 2O” identify PSL 2 bends for use in offshore service conditions;

— ~~—~~the letters “PSL 2SO” identify PSL 2 bends for use in both offshore and sour service conditions.

7 Pressure rating and design

The hoop stress in the induction bend due to internal fluid pressure shall not exceed the hoop stress permitted in ISO 13623, for straight pipe in the location of the bend.

NOTE 1 The purchaser normally performs the pressure design and specifies the minimum wall thickness t_{min}.

The wall thickness of the bend extrados shall be at least t_{min}.

The wall thickness at the bend intrados shall be at least as given in Formula (1)Formula (1)::

(1)

$$t_i = t_{min} \times \frac{2r_b - r_p}{2(r_b - r_p)} \quad (1)$$

NOTE 2 For pipelines not designed in accordance with ISO 13623, the minimum required wall thickness of the bend extrados can be less than t_{min}.

NOTE 3 The requirements in this clause address the design of a bend against internal pressure. The purchaser or designer can also consider other loads, both static and dynamic, and pipeline test conditions to demonstrate compliance with the strength requirements of ISO 13623.

NOTE 4 The geometric dimension of the bend is shown in Figure 1Figure 1..