
**Petroleum and natural gas industries —
Induction bends, fittings and flanges for
pipeline transportation systems —**

**Part 1:
Induction bends**

iTeh STANDARD PREVIEW
*Industries du pétrole et du gaz naturel — Coudes d'induction, raccords
et brides pour systèmes de transport par conduites —
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Partie 1: Coudes d'induction

ISO 15590-1:2009

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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 2.

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

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

ISO 15590-1 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 2, *Pipeline transportation systems*.

This second edition cancels and replaces the first edition (ISO 15590-1:2001), which has been technically revised.

It is the intent of ISO/TC 67 that the first and second edition of ISO 15590-1 both be applicable, at the option of the purchaser (as defined in 4.20), for a period of six months from the first day of the calendar quarter immediately following the date of publication of this second edition, after which period ISO 15590-1:2001 will no longer be applicable.

ISO 15590 consists of the following parts, under the general title *Petroleum and natural gas industries — Induction bends, fittings and flanges for pipeline transportation systems*:

- *Part 1: Induction bends*
- *Part 2: Fittings*
- *Part 3: Flanges*

Introduction

This International Standard makes reference to line pipe and bends with delivery conditions based on ISO 3183. Following significant revision of ISO 3183 (ISO 3183:2007), ISO 15590-1 has been reviewed and redrafted taking cognizance of the changes to ISO 3183. In addition to general revision, and in common with ISO 3183:2007, the Technical Committee have introduced additional requirements for special applications as follows:

- Manufacturing procedure specification (Annex A);
- PSL 2 bends for sour service (Annex B).

The requirements of the annexe(s) apply only when it is (they are) specified on the purchase order.

This International Standard does not provide guidance on when it is necessary to specify the above supplementary requirements. Instead it is the responsibility of the purchaser to specify, based upon the intended use and design requirements, which, if any, of the supplementary requirements apply for a particular purchase order.

It is necessary that users of this part of ISO 15590 be aware that further or differing requirements can be needed for individual applications. This part of ISO 15590 is not intended to inhibit a manufacturer from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This can be particularly applicable where there is innovative or developing technology. Where an alternative is offered, it is the responsibility of the manufacturer to identify any variations from this part of ISO 15590 and provide details.

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Petroleum and natural gas industries — Induction bends, fittings and flanges for pipeline transportation systems —

Part 1: Induction bends

1 Scope

This part of ISO 15590 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 part of ISO 15590 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 part of ISO 15590 specifies the requirements for the manufacture of two product specification levels (PSLs) of induction bend corresponding to product specification levels given for pipe in ISO 3183.

This part of ISO 15590 is not applicable to the selection of the induction bend product specification level. It is the responsibility of the purchaser to specify the PSL, based upon the intended use and design requirements; see also ISO 3183:2007, Introduction.

This part of ISO 15590 is not applicable to pipeline bends made by other manufacturing processes.

2 Conformance

2.1 Units of measurement

In this International Standard, data are expressed in both SI units and USC 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.

For data expressed in SI units, a comma is used as the decimal separator and a space is used as the thousands separator. For data expressed in USC units, a dot (on the line) is used as the decimal separator and a space is used as the thousands separator.

2.2 Rounding

Unless otherwise stated in this International Standard, to determine conformance 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 31-0:1992, Annex B, Rule A.

NOTE For the purposes of this provision, the rounding method of ASTM E29-04^[2] is equivalent to ISO 31-0:1992, Annex B, Rule A.

2.3 Compliance to standard

A quality management system should be applied to assist compliance with the requirements of this International Standard.

NOTE ISO/TS 29001^[1] gives sector-specific guidance on quality management systems.

A contract may specify that the manufacturer shall be responsible for complying with all of the applicable requirements of this International Standard. It shall be permissible for the purchaser to make any investigation necessary in order to be assured of compliance by the manufacturer and to reject any material that does not comply.

3 Normative references

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

ISO 31-0:1992, *Quantities and units — Part 0: General principles*

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

ISO 783, *Metallic materials — Tensile testing at elevated temperature*

ISO 3183:2007, *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, *Metallic materials — Tensile testing at ambient 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 9303:1989, *Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Full peripheral ultrasonic testing for the detection of longitudinal imperfections*

ISO 9305, *Seamless steel tubes for pressure purposes — Full peripheral ultrasonic testing for the detection of transverse imperfections*

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

ISO 9764:1989, *Electric resistance and induction welded steel tubes for pressure purposes — Ultrasonic testing of the weld seam for the detection of longitudinal imperfections*

ISO 10124, *Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Ultrasonic testing for the detection of laminar imperfections*

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

ISO 11496, *Seamless and welded steel tubes for pressure purposes — Ultrasonic testing of tube ends for the detection of laminar imperfections*

ISO 12094, *Welded steel tubes for pressure purposes — Ultrasonic testing for the detection of laminar imperfections in strips/plates used in the manufacture of welded tubes*

ISO 12095, *Seamless and welded steel tubes for pressure purposes — Liquid penetrant testing*

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

ISO 13663, *Welded steel tubes for pressure purposes — Ultrasonic testing of the area adjacent to the weld seam for the detection of laminar imperfections*

ISO 13664, *Seamless and welded steel tubes for pressure purposes — Magnetic particle inspection of the tube ends for the detection of laminar imperfections*

ISO 13665, *Seamless and welded steel tubes for pressure purposes — Magnetic particle inspection of the tube body for the detection of surface imperfections*

ASNT SNT-TC-1A¹⁾, *Recommended Practice No. SNT-TC-1A: Personnel Qualification and Certification in Nondestructive Testing*

ASTM A370²⁾, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM A435, *Standard Specification for Straight-Beam Ultrasonic Examination of Steel Plates*

ASTM A578/ A578M, *Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications*

ASTM E18, *Standard Test Methods for Rockwell Hardness of Metallic Materials*

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ASTM E92, *Standard Test Method for Vickers Hardness of Metallic Materials*

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

ASTM E165, *Standard Test Method for Liquid Penetrant Examination*

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

ASTM E709, *Standard Guide for Magnetic Particle Testing*

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

ASTM G39, *Standard Practice for Preparation and Use of Bent-Beam Stress-Corrosion Test Specimens*

NACE TM0177-2005³⁾, *Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking in Hydrogen Sulfide (H₂S) Environments*

NACE TM0284-2003, *Standard Test Method — Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking*

1) American Society for Nondestructive Testing, 1711 Arlingate Lane, Columbus, OH 43228-0518, USA.

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

3) NACE International, 1440 South Creek Drive, P.O. Box 201009, Houston, TX 77084-4906, USA.

4 Terms and definitions

For the purposes of this part of ISO 15590, the following terms and definitions apply.

- 4.1**
arc
curved portion of a bend
- 4.2**
as agreed
requirement that shall be as agreed upon by the manufacturer and purchaser, and specified in the purchase order

Modified from ISO 3183:2007, 4.1.

- 4.3**
bend angle
amount of directional change through the bend
- 4.4**
bend qualification test
qualification test that produces a bend in accordance with the MPS and demonstrates that bends that meet the specified requirements of this part of ISO 15590 can be produced

- 4.5**
bend radius
distance from the centre of curvature to the centreline axis of the bent pipe

- 4.6**
defect
imperfection of a size and/or population density greater than the acceptance criteria specified in this part of ISO 15590

- 4.7**
extrados
outer curved section of the bend arc

- 4.8**
heat
batch of steel prepared in one steel-making operation

- 4.9**
if agreed
requirement that shall be as prescribed, or more stringent than is prescribed, if agreed upon by the manufacturer and the purchaser and specified in the purchase order

Modified from ISO 3183:2007, 4.19.

- 4.10**
imperfection
discontinuity or irregularity in the product wall or on the product surface that is detectable by inspection methods outlined in this International Standard

- 4.11**
indication
evidence obtained by non-destructive inspection

4.12**induction bending**

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

4.13**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

[ISO 3183:2007, 4.22]

4.14**intrados**

inner curved section of the bend arc

4.15**lamination**

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

4.16**manufacturer**

firm, company, or corporation responsible for making and marking the product in accordance with the requirements of this International Standard

4.17**manufacturing procedure specification****MPS**

document that specifies the properties and description of the mother pipe, the bending procedure, the post-bending heat treatment equipment and cycle, the qualification bend testing results, the non-destructive testing procedures and the weld end bevel details used for the manufacture of the bends

4.18**mother pipe**

straight section of pipe from which an induction bend is made

4.19**non-destructive inspection**

inspection to reveal imperfections, using radiographic, ultrasonic or other methods specified in this International Standard that do not involve disturbance, stressing or breaking of the materials

[ISO 3183:2007, 4.30]

4.20**purchaser**

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

[ISO 3183:2007, 4.38]

4.21**service condition**

condition of use that is specified by the purchaser in the purchase order

NOTE In this International Standard, the terms “sour service” and “offshore service” are service conditions.

[ISO 3183:2007, 4.45]

4.22

strip/plate end weld

weld that joins strip or plate ends together

4.23

tangent

straight section at the ends of an induction bend

4.24

transition zone

areas of the start and stop points of induction heating, which include material that extends from the unheated mother pipe to the material that has been heated to the full bending temperature

4.25

wall thinning

amount of reduction from the original wall thickness of the pipe to the wall thickness in the extrados after bending

5 Symbols and abbreviated terms

5.1 Symbols

A	elongation of tensile test specimen after fracture, expressed as a percentage
CVD, 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 diameter, outside or inside
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
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, or other applicable design code, for the straight pipe adjacent to the bend, including any corrosion allowance

5.2 Abbreviated terms

BQT	bend qualification test
CTOD	crack tip opening displacement testing
DWT	drop-weight tear testing
HAZ	heat-affected zone
HIC	hydrogen-induced cracking
HFW	high-frequency electric welding process for pipe during manufacturing

MPS	manufacturing procedure specification
MT	magnetic particle testing
NDT	non-destructive testing
PSL	product specification level
PT	liquid-penetrant testing
RT	radiographic testing
SAWL	submerged arc longitudinal welding process for pipe during manufacture
SAWH	submerged arc helical welding process for pipe during manufacture
SSC	sulfide stress-cracking
SWC	step-wise cracking
UT	ultrasonic testing
WPS	welding procedure specification

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.

7 Pressure rating and design

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

Compliance with this requirement shall be demonstrated either by calculations or by satisfying both of the following requirements.

- a) The wall thickness of the bend extrados shall be at least t_{\min} .
- b) The wall thickness at the bend intrados shall be at least as given in Equation (1):

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

For pipelines not designed in accordance with ISO 13623, the wall thickness of the bend extrados may be less than t_{\min} .

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