
**Petroleum and natural gas
industries — Corrosion resistant alloy
clad bends and fittings for pipeline
transportation system —**

**Part 2:
Clad fittings**

*Industries du pétrole et du gaz naturel — Coudes et raccords
recouverts d'alliage résistant à la corrosion pour système de transport
par conduites —*

Partie 2: Raccords recouverts

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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 of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

A list of all parts in the ISO 24139 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.

Petroleum and natural gas industries — Corrosion resistant alloy clad bends and fittings for pipeline transportation system —

Part 2: Clad fittings

1 Scope

This document specifies the technical delivery conditions regarding design, geometric dimensions, materials, manufacturing procedures, inspection methods, non-destructive testing, marking, package and storage for factory-made, seamless and welded, corrosion resistant alloy (CRA) clad fittings for use in pipeline transportation systems for the petroleum and natural gas industries as defined in ISO 13623.

This document is applicable to CRA clad fittings for use in transportation or process pipelines transporting corrosive media-containing single-phase or multi-phase fluid such as oil, gas and water for the petroleum and natural gas industries. It can also be used as reference in other fields.

The clad fittings specified in this document include clad elbows, clad reducers, clad tees and clad caps.

Two technical delivery conditions classes for clad fittings are designated. Class B provides a standard quality level for clad fittings and Class S provides technical requirements for sour-service conditions.

Fabricated laterals, fabricated lap joint stub ends and other fittings employing circumferential or intersection welds are considered as pipe fabrication and are outside the scope of this document.

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 3183:2019, *Petroleum and natural gas industries — Steel pipe for pipeline transportation systems*

ISO 3651-1:1998, *Determination of resistance to intergranular corrosion of stainless steels — Part 1: Austenitic and ferritic-austenitic (duplex) stainless steels — Corrosion test in nitric acid medium by measurement of loss in mass (Huey test)*

ISO 3651-2:1998, *Determination of resistance to intergranular corrosion of stainless steels — Part 2: Ferritic, austenitic and ferritic-austenitic (duplex) stainless steels — Corrosion test in media containing sulfuric acid*

ISO 6507 (all parts), *Metallic materials — Vickers 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 8407, *Corrosion of metals and alloys — Removal of corrosion products from corrosion test specimens*

ISO 24139-2:2023(E)

ISO 8501-1:2007, *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 9400:1990, *Nickel-based alloys — Determination of resistance to intergranular corrosion*

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

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 10893-6, *Non-destructive testing of steel tubes — Part 6: Radiographic testing of the weld seam of welded steel tubes for the detection of 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, *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, *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 14250, *Steel — Metallographic characterization of duplex grain size and distributions*

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

ISO 15156-1, *Petroleum and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production — Part 1: General principles for selection of cracking-resistant materials*

ISO 15156-2, *Petroleum and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production — Part 2: Cracking-resistant carbon and low-alloy steels, and the use of cast irons*

ISO 15156-3:2020, *Petroleum and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production — Part 3: Cracking-resistant CRAs (corrosion-resistant alloys) and other alloys*

ISO 15590-1:2018, *Petroleum and natural gas industries — Induction bends, fittings and flanges for pipeline transportation systems — Part 1: Induction bends*

ISO 15590-2:2021, *Petroleum and natural gas industries — Factory bends, fittings and flanges for pipeline transportation systems — Part 2: Fittings*

ISO 15614-7, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 7: Overlay welding*

ISO 15614-8, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 8: Welding of tubes to tube-plate joints*

ISO 17405, *Non-destructive testing — Ultrasonic testing — Technique of testing claddings produced by welding, rolling and explosion*

ISO 17639, *Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds*

ISO 80000-1:2009, *Quantities and units — Part 1: General*

ASME BPVC Section II - Materials Part C, *Specifications for welding rods, electrodes, and filler metals*

ASME BPVC Section IX *Qualification standard for welding, brazing, and fusing procedures; welders; brazers; and welding, brazing, and fusing operators*

ASME B16.9, *Factory-made wrought butt welding fittings*

ASME B31.8, *Gas transmission and distribution piping systems*

ASME B31.4, *Pipeline transportation systems for liquids and NDT slurries*

ASNT SNT-TC-1A, *Recommended practice No. SNT-TC-1A: Personnel qualification and certification in non-destructive testing*

ASTM A262-15, *Standard practices for detecting susceptibility to intergranular attack in austenitic stainless steels*

ASTM A263-12, *Standard specification for stainless Chromium steel-clad plate*

ASTM A264-12, *Standard specification for stainless Chromium-Nickel steel-clad plate*

ASTM A265-12, *Standard specification for Nickel and Nickel-base alloy-clad steel plate*

ASTM A370, *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-17, *Standard specification for straight-beam ultrasonic examination of rolled steel plates for special applications*

ASTM A751, *Standard test methods, practices, and terminology for chemical analysis of steel products*

ASTM A923-14, *Standard test methods for detecting detrimental intermetallic phase in duplex austenitic/ferritic stainless steels*

ASTM E3, *Standard guide for preparation of metallographic specimens*

ASTM E92, *Standard test methods for Vickers hardness and Knoop hardness of metallic materials*

ASTM E165, *Standard test method for liquid penetrant examination*

ASTM E273, *Standard practice for ultrasonic testing of the weld zone of welded pipe and tubing*

ASTM E340, *Standard practice for macroetching metals and alloys*

ASTM E353, *Standard test methods for chemical analysis of stainless, heat-resisting, maraging, and other similar Chromium-Nickel-Iron alloys*

ASTM E562, *Standard test method for determining volume fraction by systematic manual point count*

ASTM E709, *Standard guide for magnetic particle testing*

ASTM G1, *Standard practice for preparing, cleaning, and evaluating corrosion test specimens*

ASTM G28-02, *Standard test methods for detecting susceptibility to intergranular corrosion in wrought, Nickel-rich, Chromium-bearing alloys*

ASTM G39, *Standard practice for preparation and use of bent-beam stress-corrosion test specimens*

ASTM G111, *Standard guide for corrosion tests in high temperature or high pressure environment, or both*

MSS SP-75, *High-strength, wrought, butt-welding fittings*

NACE TM0177, *Standard test method — Laboratory testing of metals for resistance to sulfide stress cracking and stress corrosion cracking in H₂S environments*

NACE TM0284, *Standard test method — Evaluation of pipeline and pressure vessel steels for resistance to hydrogen-induced cracking*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 15590-2:2021 and the following 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/>

3.1.1

as agreed

as achieving consensus upon by the manufacturer and purchaser, and specified in the purchase order

3.1.2

backing steel

substrate of the clad plate, clad pipe or clad fittings withstanding mechanical load or pressure, and made of carbon steel or low alloy steel

3.1.3

clad layer

layer of the corrosion resistant alloy metallurgically bonded to the surface of the backing steel of clad plate, clad pipe or clad fittings

Note 1 to entry: Metallurgically bonded corrosion resistant alloy (CRA) layer is to be produced by hot roll bonding, weld overlaying, explosion cladding, coextruding or some other process that produces the atomic diffusion interface between CRA and carbon steel.

3.1.4

corrosion resistant alloy

CRA

alloy such as stainless steel and nickel-based alloy intended to be resistant to general and localized corrosion of oilfield environments that are corrosive to carbon steels

[SOURCE: ISO 15156-1:2020, 3.6, modified — "such as stainless steel and nickel-based alloy" has been added.]

3.1.5

if agreed

as prescribed, or more stringent than is prescribed, if achieved consensus by the manufacturer and the purchaser and specified in the purchase order

3.1.6

manufacturer

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

Note 1 to entry: The specific requirements are addressed in this document.

3.1.7**mother clad pipe**

metallurgical straight clad pipe from which the corrosion resistant alloy clad fitting is made

3.1.8**mother steel fitting**

carbon steel or low-alloy steel fitting onto which the clad fitting is made by weld overlay with corrosion resistant alloy

3.1.9**neutral zone**

zone near the neutral axis of the elbow arc

3.1.10**bond shear strength**

tangential stress per unit contact area required to separate the clad layer from the backing steel of the metallurgically bonded clad plate, clad pipe or clad fittings

3.1.11**sour environment**

exposure to oilfield environments that contain sufficient H₂S to cause cracking of metallic materials by specific mechanisms

Note 1 to entry: These mechanisms are addressed in ISO 15156-1.

[SOURCE: ISO 15156-1:2020, 3.20, modified — Note 1 to entry has been added.]

3.1.12**manufacturing procedure specification****MPS**

document that specifies the process control parameters and the acceptance criteria to apply for all manufacturing, inspection and testing activities performed during clad fitting manufacture

[SOURCE: ISO 15590-2:2021, 3.5, modified — "Fitting" has been replaced with "clad fitting".]

3.2 Symbols

<i>A</i>	elongation of tensile test specimen after fracture, expressed as a percentage
<i>D</i>	nominal or calculated (from the specified inside diameter and wall thickness) outside diameter of clad fittings
<i>d</i>	specified inside diameter at end of a clad fittings
<i>R_m</i>	ultimate tensile strength
<i>R_{t0,5}</i>	yield strength for 0,5 % total elongation
<i>t</i>	minimum wall thickness of clad layer for clad fitting
<i>t_B</i>	nominal (minimum) wall thickness of backing steel for clad fitting

3.3 Abbreviated terms

AUT	automatic ultrasonic testing
HAZ	heat-affected zone
HIC	hydrogen induced cracking

MPQT	manufacturing procedure qualification test
MT	magnetic testing
NDT	non-destructive testing
PREN	pitting resistance equivalent number
PT	penetrant testing
RT	radiographic testing
SCC	stress corrosion cracking
SMYS	specified minimum yield strength
SSC	sulfide stress cracking
PWHT	post-welding heat treatment
UT	ultrasonic testing
WT	wall thickness
WPS	welding procedure specification

4 General requirements

4.1 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.

4.2 Rounding

Unless otherwise stated in this document, 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 80000-1:2009, Annex B, Rule A.

5 Information supplied by the purchaser

5.1 General information

The purchaser shall provide the following information in the order given below:

- a) a reference to this document, i.e. ISO 24139-2:2023;
- b) clad fitting designation;
- c) quantity of clad fittings;
- d) CRA material type or identification (UNS or ASTM A240/A240M, see [Annex C](#)) of clad layer;
- e) clad fittings dimensions:
 - nominal diameter, DN (in accordance with MSS SP-75 or ASME B16.9);
 - specified inside diameter at ends;

- nominal (minimum) wall thickness of backing steel;
 - nominal (minimum) wall thickness of clad layer;
 - the angle (for special elbows).
- f) end preparation if different from square ends;
- g) seamless or with longitudinal weld(s);
- h) whether the purchaser wishes to approve the MPS prior to commencement of manufacturing.

5.2 Additional information

The purchaser should specify the following additional information if applicable, which will include but not limited to:

- a) pipeline operating conditions, including composition of transported fluid, temperature and pressure;
- b) design temperature (minimum and maximum);
- c) pipeline design standard or design factors;
- d) requirements for maximum wall thickness of both backing steel and clad layer;
- e) specifications and materials of matching pipes;
- f) special dimensional requirements;
- g) supply of mother clad pipes or mother steel fittings by the purchaser or the manufacturer;
- h) requirements for gauging and other measurements of dimensions, if different from this document;
- i) requirements for supplementary inspection and testing;
- j) mechanical property requirements for backing steel at high temperatures;
- k) requirements for proof burst testing or hydrostatic testing;
- l) whether verification of the capability to withstand internal pressure shall be done by calculation or by proof testing or both (see [Clause 7](#));
- m) requirements for corrosion resistance for both backing steel (such as HIC and SSC) and clad layer;
- n) whether approval of the MPS is to be by review of previous production data or by MPQT;
- o) coating or painting requirements;
- p) marking requirements, if different from this document;
- q) packaging and shipping instructions, if different from this document;
- r) third-party inspection organization;
- s) inspection documents which are required in accordance with ISO 10474;
- t) requirements for format and additional information of the inspection documents;
- u) PWHT (see [8.5](#)).

5.3 Information on the mother clad pipe

5.3.1 If the mother clad pipe is supplied by the purchaser, the following information on the mother clad pipe shall be provided to the manufacturer:

- a) purchasing specification;
- b) pipe diameter, inside or outside;
- c) pipe wall thickness (nominal or minimum values for both backing steel and clad layer);
- d) pipe length;
- e) grade of backing steel;
- f) CRA type of clad layer;
- g) pipe manufacturer.

5.3.2 If the mother clad pipe is supplied by the purchaser, the following additional information should also be provided to the manufacturer if applicable:

- a) material specification and material certificates of clad pipe, including chemical composition, heat treatment, mechanical properties, results of NDT and hydrostatic testing;
- b) WPS and weld metal chemical composition for welded clad pipe;
- c) weld repair record and weld-seam-repair WPS for welded clad pipe.

5.4 Information on the mother steel fitting

5.4.1 If the mother steel fittings are supplied by the purchaser, the following information shall be provided to the manufacturer:

- a) purchasing specification;
- b) fitting designation;
- c) required fitting dimensions, including:
 - nominal diameter, DN,
 - specified inside diameter at ends,
 - nominal wall thickness,
 - radius and type of radius (if applicable), and
 - the angle (if applicable).

5.4.2 If the mother steel fittings are supplied by the purchaser, the following additional information should also be provided to the manufacturer if applicable:

- a) material specification and material certificates of the steel fitting, including chemical composition, heat treatment, mechanical properties, and results of NDT;
- b) WPS for welded fittings;
- c) heat treatment status or PWHT for welded fittings.

6 Designation

Designation of clad fittings shall take the form of “XXX- YYY/CCC-Z”, where:

- the letters “XXX” represents the codes of clad fittings, which are shown in [Table 1](#);
- the letters “YYY” is the specified minimum yield strength (SMYS) of backing steel, expressed in megapascals (MPa);
- the letters “CCC” is the CRA type of clad layer (see [Annex C](#));
- the letter “Z” is the suffix B or S, B to identify the technical delivery conditions class for clad fittings in non-sour service, or the suffix S to identify the use in sour-service conditions.

EXAMPLE “45CEL(L)-245/UNS S31603-B” is a 45 deg. long radius clad elbow, the SMYS of backing steel is 245 MPa, and the CRA type of clad layer is UNS S31603, and identifies the use in non-sour service.

Table 1 — Types and codes of clad fittings

Types	Category	Codes
45 deg. clad elbows	Long radius (1.5D)	45CEL(L)
	3D	45CEL(3D)
90 deg. clad elbows	Long radius	90CEL(L)
	Long radius reducing	90CEL(LR)
	Short radius (1D)	90CEL(S)
Clad reducers	3D	90CEL(3D)
	Concentric	CCR
	Eccentric	CER
	Conical	CNR
Clad tees	Straight	CTE(S)
	Reducing outlet	CTE(R)
Clad caps	-	CCA

7 Design

The design documents of clad fittings shall at least include design drawings and strength calculations or proof test report. The design parameters of clad fittings shall be consistent with those of their matching pipes.

The strength design and material selection of clad fittings shall follow the principle of the backing steel for withstanding of internal fluid pressure and additional special load and clad layer for corrosion resistance of conveying fluid.

The capability of the clad fitting to withstand internal pressure shall equal or exceed that of the matching pipe. The verification of the capability shall be made by design calculation or proof testing or both.

The calculations of the minimum wall thickness (or design thickness) of the backing steel shall be made in accordance with ISO 15590-2:2021, Annex A. The calculations of the nominal wall thickness (t_B) of the backing steel shall be made by Barlow's formula. The hoop stress in the clad fitting due to the internal fluid pressure shall not exceed the hoop stress for the tangent permitted in ISO 13623 or other applicable design code.

The proof test procedure shall be as defined in ISO 15590-2:2021, Annex B. The pressure design thickness (or equivalent pipe wall or schedule rating) for critical areas of each type of clad fitting shall be determined and recorded. Critical areas are normally the extrados and intrados of elbows, the crotch of tees, the knuckle of caps, and the large end of reducers.