INTERNATIONAL STANDARD

ISO 15590-2

Second edition
2021-08

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

Part 2: Fittings

Industries du pétrole et du gaz naturel — Coudes d'usine, raccords et brides pour systèmes de transport par conduites —

Partie 2: Raccords

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

Reference number
ISO 15590-2:2021(E)

© ISO 2021

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

COPYRIGHT PROTECTED DOCUMENT

© ISO 2021

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

© ISO 2021 – All rights reserved

Contents

Page

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

© ISO 2021 – All rights reserved

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

 © ISO 2021 – All rights reserved

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, *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 15590-2:2003), which has been technically revised. The main changes compared to the previous edition are as follows:

a) changed title;

b) updated the list of applicable international standards with the latest applicable editions;

c) added the possibility to execute NDE following the ISO, EN and ASTM standards;

d) updated the assembly categories in only two types (sour service and non-sour service);

e) removed references to extruded headers (they are not accessories but special products);

f) modified the references to the final preparation, now in line with MSS SP-75 (Figure 1) and body conical according to the ASME B16.9 criteria (Figure 3);

g) greater clarity on the sampling criteria (paragraph 9.2);

h) reviewed the chemical analysis to align with the ISO 3183 requirements (additional notes concerning *P*cm);

i) updated applicable standards relating to HIC and SSC;

j) modified paragraph relating to hydrotest;

k) applicability lighter than caliber (applicable only to tees);

l) added the range of qualifications of the “design proof test” in Clause B.5.

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

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

© ISO 2021 – All rights reserved

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.

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

© ISO 2021 – All rights reserved

Introduction

Further or differing requirements might be needed for individual applications. This document 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, the manufacturer should identify any variations from this document and provide details.

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

© ISO 2021 – All rights reserved

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

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

Part 2: Fittings

1 Scope

This document specifies the technical delivery conditions for unalloyed or low-alloy steel seamless and welded pipeline fittings for use in pipeline transportation systems for the petroleum and natural gas industries as defined in ISO 13623.

This document is applicable to welding-end fittings such as elbows, caps, tees, single or multiple extruded headers, reducers, and transition sections made from seamless and welded pipe of unalloyed or low-alloy steels.

This document specifies two classes of fitting one related to material used in non-sour service and one for material to be use in sour service environment as shown in Table 1.

Table 1 — Fitting class and service

Fitting class	Service
Class B	NON-SOUR SERVICE
Class S	SOUR SERVICE

This document is not applicable to the selection of the fitting class.

This document is not applicable to the materials for, or the attachment of, factory-welded extensions.

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

ISO 377, *Steel and steel products — Location and preparation of samples and test pieces for mechanical testing*

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 2566-1, *Steel — Conversion of elongation values — Part 1: Carbon and low alloy steels*

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

ISO 3834-2, *Quality requirements for fusion welding of metallic materials — Part 2: Comprehensive quality requirements*

ISO 4885, *Ferrous materials — Heat treatments — Vocabulary*

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

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

© ISO 2021 – All rights reserved

ISO 7438, *Metallic materials — Bend test*

ISO/TS 7705:2017, *Guidelines for specifying Charpy V-notch impact prescriptions in steel specifications*

ISO 9606-1, *Qualification testing of welders — Fusion welding — Part 1: Steels*

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

ISO 15614-1, *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*

EN 10204, *Metallic components: Types of inspection documents*

ASTM E112, *Standard test methods for determining average grain size*

ASTM E213, *Standard Practice for Ultrasonic Testing of Metal Pipe and Tubing*

ASTM A388, *Standard Practice for Ultrasonic Examination of Steel Forgings*

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

ASTM E165, *Standard Practice for Liquid Penetrant Testing for General Industry*

ASTM E709, *Standard Guide for Magnetic Particle Testing*

ASME BPVC Section V *Nondestructive Examination*

ASME BPVC Section VIII *Rules for Construction of Pressure Vessels Division 1*

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 NDTSlurries*

ASME BPVC Section IX *Welding, Brazing, and Fusing Qualifications*

MSS SP-75, *Specification for high test wrought butt welding fittings*

NACE TM0177-2016-SG, *Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H2S Environments*

NACE TM0284-2016-SG, *Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking*Terms and definitions

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

© ISO 2021 – All rights reserved

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4885 and the following apply.

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

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

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

3.1
by agreement
agreed between manufacturer and purchaser

3.2
extrados
outer curved section of the elbow

[SOURCE: ISO 15590-1:2018; 3.8, modified]

3.3
heat
batch of steel prepared in one steel-making process

[SOURCE: ISO 15590-1:2018; 3.9, modified]

3.4
intrados
inner curved section of the elbow

[SOURCE: ISO 15590-1:2018; 3.15, modified]

3.5
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 fitting manufacture

3.6
tangent
straight section at the ends of the fitting

[SOURCE: ISO 15590-1:2018; 3.25, modified]

3.7
test unit
fitting or test piece of the same type (tee, elbow, reducer or cap), starting material wall thickness, *heat* (3.3), manufacturing procedure specification, and heat treatment condition

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

4 Symbols and abbreviated terms

4.1 Symbols

A_0	original cross-sectional area of the parallel length of a tensile test specimen
D	outside diameter
D_1	outside diameter at the point under consideration, measured perpendicular to the longitudinal axis

© ISO 2021 – All rights reserved

D_L	outside diameter of the larger end of the reducer
D_p	specified outside diameter of matching pipe
D_n	minor outside diameter of a conical reducer or reducing tee at any point, n, under consideration, measured perpendicular to the longitudinal axis
E	factor used to calculate t_i (see A.1)
f	factor used to calculate proof test pressure (see Table B.1)
P_{cm}	crack measurement parameter (see Table 4)
p	design pressure
p_p	numerical value of the computed proof pressure
R_m	tensile strength
$R_{m,\,red}$	allowable tensile strength of a reducer
$R_{t0,5}$	yield strength for 0,5 % total elongation
R_{smys}	specified minimum yield strength
$T_{d,\,min}$	minimum design temperature specified by the purchaser
t	nominal wall thickness
t_D	wall thickness of thicker component for joints of unequal thickness (see Figure 1)
t_{DL}	nominal wall thickness of the larger end of the reducer
t_i	minimum wall thickness required in the intrados
t_p	nominal wall thickness of matching pipe
t_n	specified wall thickness of reducers and reducing tees at diameter D_n
α	included angle of a reducer (eccentric, concentric or conical)
ρ_o	radius of curvature of the external contoured portion of the outlet of a tee

4.2 Abbreviated terms

CE	carbon equivalent (see Table 4)
CTOD	crack tip opening displacement
DN	nominal size
HIC	hydrogen-induced cracking
HFW	high-frequency electric welding process for pipe during manufacturing
MT	magnetic particle testing
NDT	non-destructive testing
PT	liquid penetrant testing

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

© ISO 2021 – All rights reserved

PWHT	post-weld heat treatment of the fitting
RT	radiographic testing
SMYS	specified minimum yield strength
SAWH	submerged arc helical welding process for pipe during manufacture
SSC	sulfide stress-cracking
UT	ultrasonic testing

5 Designation of fittings

Designation of fittings, according to this document, i.e. ISO 15590-2, shall take the form:

ISO 15590-2 YY xxx-Z,

where

— YY is a textual description of the type of fitting, corresponding to one of the following: EL for elbow, TE for tee, CA for cap, CR for concentric reducer, ER for eccentric reducer and NR for conical reducer, preceded by the size designation (e.g. "DN 600 EL" is a DN 600 elbow);

— xxx is the specified minimum yield strength requirement in MPa;

— Z is the suffix B or S, B to identify the fitting class for use in non-sour service, or the suffix S to identify the use in sour-service conditions.

6 Pressure rating and design

6.1 General

The capability of the fitting to withstand internal pressure shall equal or exceed that of the matching pipe. The verification of the capability shall be made by calculation or proof testing. The calculations shall be made in accordance with Annex A. The proof test procedure shall be as defined in Annex B. Additional requirements on strength design verifications or different method of calculation, such as resistance to internal pressure under special load cases in accordance with ISO 13623, ASME B31.8, ASME B31.4 or other recognized international standards, shall be indicated at the time of enquiry or order.

The design calculations and/or results of proof testing shall be available for review at the manufacturer's facility.

If the SMYS of the fitting material is less than that of the matching pipe, the minimum thickness of the fitting end shall be increased such that the product of its thickness times its SMYS shall at least equal the product of the specified wall thickness and the SMYS of the matching pipe, in accordance with MSS SP-75.

6.2 Tees

Outlet branches in tees manufactured from seam-welded pipe shall be positioned diametrically opposite the longitudinal weld. When this positioning is not possible, the location shall be decided by agreement.

The design and welding for the attachment of guide bars of barred tees shall be decided by agreement prior to manufacture of the tee.

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

© ISO 2021 – All rights reserved

7 Information to be supplied by the purchaser

7.1 General information

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

a) fitting designation;

b) required fitting dimensions, including:

- nominal wall thickness;
- radius and type of radius (e.g. long-radius);
- the angle (for elbows);

NOTE Guidance on specific dimensions to specify is given in ISO 3545-3.

c) whether the purchaser wishes to approve the MPS prior to commencement of manufacturing.

7.2 Additional information

If applicable, the purchaser shall specify the following supplementary information:

a) minimum design temperature;

b) maximum design temperature;

c) design conditions (design pressure, design factor, corrosion allowance and design code);

d) special dimensional requirements;

e) requirements for supplementary inspection and testing;

f) requirements for gauging and other measurements of dimensions where different from document;

g) mechanical property requirements at the maximum design temperature;

h) requirements for proof, burst, or hydrostatic testing;

i) activities for witnessing and approval by purchaser;

j) coating or painting requirements;

k) marking requirements where different from this document;

l) packaging and shipping instructions;

m) third-party inspection organization;

n) ISO 10474 or an equivalent regional standard, EN 10204, standard designation of inspection document required;

o) requirements for format and additional content of the inspection document;

p) whether testing of welding procedures, welders, or welding operators specific to the order is required;

q) whether approval of the MPS is to be by review of previous production data or by testing;

r) PWHT (see 9.1);

s) HIC testing (see 9.4.7);

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

 © ISO 2021 – All rights reserved

t) SCC testing (see 9.4.8);

u) end-preparation details.

8 Manufacturing

8.1 Manufacturing procedure specification

Fittings shall be manufactured in accordance with a documented MPS. If specified by the purchaser, manufacturing shall not proceed until the MPS has been accepted by the purchaser.

The MPS shall specify the following items (as appropriate):

a) for the starting material:

- name of manufacturer;
- steel-making process;
- steel grade;
- product form and dimensions;
- chemical composition, including that of the weld seam;
- welding procedure specification.

b) for fitting manufacture:

- forming procedure;
- welding procedure specification and approval record;
- heat treatment procedure including thermal cycles;
- machining requirements;
- inspection and test requirements;
- traceability.

c) additional requirements such as end preparation, coating, and marking.

An approval of the MPS might be required, either by review of the manufacturer's previous production data or by performance of the mandatory tests listed in Table 2, at the beginning of production.

8.2 Starting material

The starting material for fittings shall be blooms, billets, slabs, forging quality bar, plate, fusion-welded with filler metal or seamless tubular products, produced from fully-killed steels; the chemical composition shall conform to Table 4. Steel shall be produced by basic oxygen or electric arc furnace process. Steel shall be made to fine grain practice.

HFW and SAWH pipes shall not be used.

8.3 Fitting manufacture

8.3.1 Forming

All forming operations shall be performed in accordance with the MPS.

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

© ISO 2021 – All rights reserved

8.3.2 Welding

Welding operations shall be conducted in accordance with those elements of ISO 3834-2 decided by agreement and the requirements of this document.

Welding and repair welding shall be performed in accordance with procedures qualified in accordance with ASME BPVC Section IX or ISO15614-1.

Welders and welding operators shall be qualified in accordance with ASME BPVC Section IX or ISO 9606-1.

Acceptance criteria for all tests shall be as specified in Clause 9.

Where practicable, longitudinal butt welds should be double-sided. Backing rings shall not be used. All welds shall have complete penetration and shall be finished in accordance with Clause 9.

Temporary welded attachments shall be removed, where possible, before heat treatment and the weld area shall be treated in accordance with 9.5.3.4 and 9.5.3.5.

Fittings shall not contain girth welds.

All welds that will remain in the fitting shall be heat-treated in accordance with 8.3.3.

8.3.3 Heat treatment

All fittings shall be normalized, normalized and tempered, or quenched and tempered after welding and/or forming. The heat treatment shall be performed in accordance with a documented procedure. The procedure shall define the following parameters, where appropriate, for the type of heat treatment:

a) heating schedule;

b) soaking temperature;

c) soaking time;

d) cooling schedule;

e) quenching temperature;

f) quenching medium, including commencing and final medium temperature.

g) maximum transfer time to quench

A record shall be maintained of each heat treatment. Submission of heat treatment record shall be specified at PO stage and it shall be included in the inspection document.

The tolerances on specified nominal values of soaking temperature and soaking time shall be ±15 °C and +20 %, respectively.

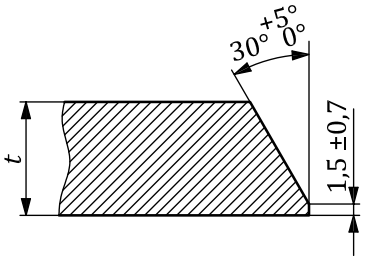
8.3.4 End preparation

Unless otherwise specified, the details of the welding end preparation shall be in accordance with Figures 1 and 2. The root face of the fittings shall be machined flat and shall not vary from the plane by more than 0,76 mm (0.03 in.) at any point. Where the body wall of the fittings exceeds that of matching pipe, the transition shall be in accordance with Figure 3.

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

© ISO 2021 – All rights reserved

Dimensions in millimetres



Or up to a nominal wall thickness (t) of 25,4 mm, at the option of the manufacturer.

Fittings NPS 24 and smaller may be furnished with 37½° ± 2½° bevel, at the option of the manufacturer.

Figure 1 — Recommended bevel for nominal wall thickness (t) at the end of fittings 19 mm. or less

Dimensions in millimetres

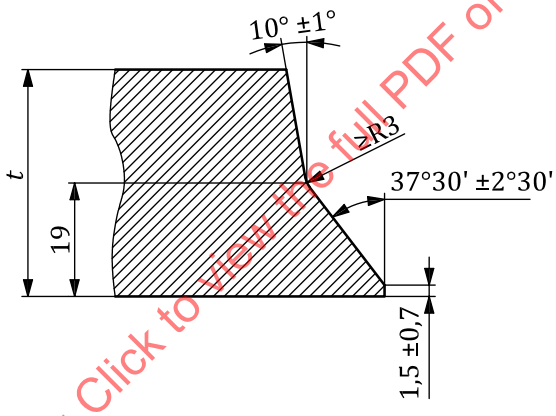
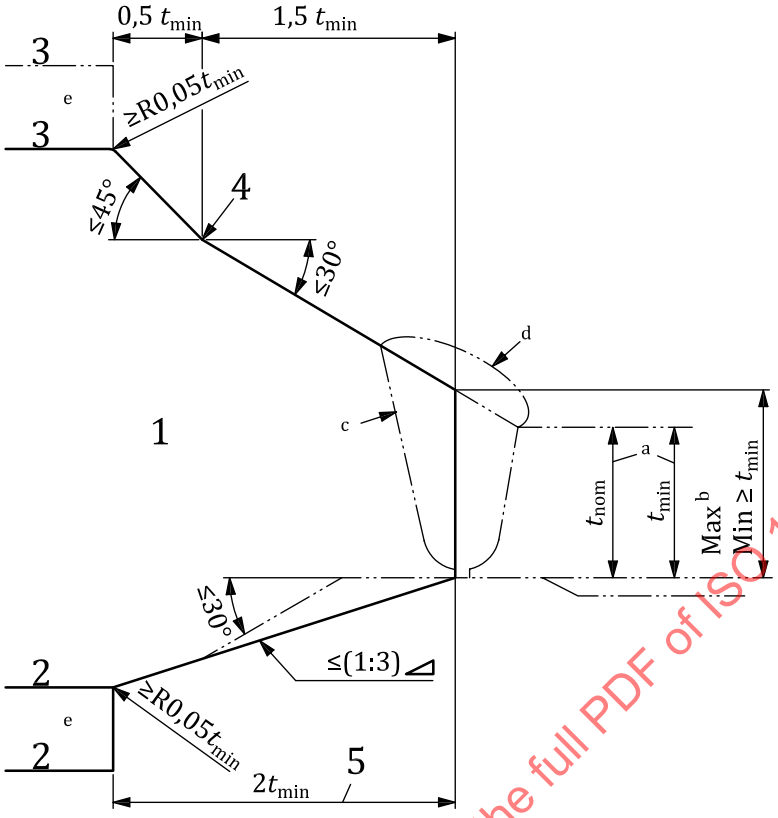


Figure 2 — Recommended bevel for nominal wall thickness (t) at the end of fittings greater than 19 mm

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

© ISO 2021 – All rights reserved

Dimensions in millimetres



Key

1 component or fitting
2 inside
3 outside
4 radius optional
5 transition region

a The value of t_{min} is the minimum permitted wall thickness as per ASME B16.9 or MSS SP-75 as applicable (see 9.6).

b The maximum thickness at the end of the component is as follows:
- the greater of t_{min} + 4 mm or 1,15 t_{min} when ordered on a minimum wall basis
- the greater of t_{min} + 4 mm or 1,10 t_{min} when ordered on a nominal wall basis

c Wall bevel shown is for illustration only.

d The weld reinforcement permitted by applicable code may lie outside the maximum envelope.

e Where transition using maximum slope do not intersect the inside or outside surfaces within the transition region, as shown by phantom outline, maximum slopes shall be used. Alternatively, radii lying within the envelope may be used.

Figure 3 — Welding ends transition

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

9 Testing and inspection

9.1 General requirements

Testing and inspection shall be carried out on fittings after final heat treatment.

If the pipeline installation techniques will require PWHT of the fitting, additional testing may be requested to demonstrate that the mechanical properties of the fitting are also achieved after PWHT.

© ISO 2021 – All rights reserved

Details of the PWHT thermal cycle to be used during pipeline installation shall be specified. The test requirements and acceptance criteria shall be by agreement.

Where the procedure requirements of 8.3.3 are not met, test pieces shall be taken from each heat treatment batch.

9.2 Extent of testing and inspection

The testing and inspection to be performed during qualification and production shall be as summarized in Table 2 for each fitting class.

Production testing shall be performed at the minimum frequency specified in Table 3.

Test pieces for mechanical testing shall be taken from one or more of the following:

— extension lengths, formed and heat-treated as part of the fitting and/or test piece attached to the fitting;

— starting material that has been subjected to the same heat treatment as the proposed fitting;

— a fitting.

The sample of starting material shall be in the same heat treatment condition of the fittings.

Fittings heat-treated within the tolerance requirements of 8.3.3 shall be considered as being in the same heat treatment condition.

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

Table 2 — Summary of testing and inspection requirements

Test		Class B	Class S	Clause number specifying acceptance criteria
Chemical analysis	Chemical composition	M	M	9.3
Physical tests	Tensile – base metal	M	M	9.4.2.3
	Transverse weld tensile	M[a]	M[a]	9.4.2.3
	Impact – fitting body	M	M	9.4.3.3
	Impact – weld seam	M	M	9.4.3.3
	Through-thickness hardness	M	M	9.4.4.2
	Surface hardness	O	O	9.4.5
	Metallography	Q	Q	9.4.6.2
	HIC	N	O[b,c]	9.4.7
	SSC	N	O[b,c]	9.4.8
	CTOD	O	O	9.4.9
	Guided bend (weld seam)	Q	Q	9.4.10.3

M: Requirement mandatory in production

N: Not required

O: Requirement for test or inspection at the purchaser's option

Q: Required for approval of the welding procedure only, otherwise at the purchaser's option

[a] May be omitted for fittings with $D < 210$ mm.

[b] If applied, this testing may be performed as part of the MPS qualification testing.

[c] May be carried out on the starting material by agreement.

[d] By agreement.

[e] UT may be omitted for fittings with $D < 114{,}3$ mm

© ISO 2021 – All rights reserved

Table 2 *(continued)*

Test		Class B	Class S	Clause number specifying acceptance criteria
NDT	Visual inspection	M	M	9.5.3
	End preparation (MT or PT)	M	M	9.5.4
	Fitting end (UT)	M[e]	M[e]	9.5.4
	Weld seam (RT or UT)[c]	M	M	9.5.5
	Fitting body (UT or MT)[d]	O[e]	O[e]	9.5.7
	Residual magnetism	M	M	9.5.8
Dimensions	Wall thickness	M	M	9.6
	Inside diameter at ends	M	M	9.6
	Out-of-roundness at ends	M	M	9.6
	Specific dimensions	M	M	9.6

M: Requirement mandatory in production

N: Not required

O: Requirement for test or inspection at the purchaser's option

Q: Required for approval of the welding procedure only, otherwise at the purchaser's option

[a] May be omitted for fittings with $D < 210$ mm.

[b] If applied, this testing may be performed as part of the MPS qualification testing.

[c] May be carried out on the starting material by agreement.

[d] By agreement.

[e] UT may be omitted for fittings with $D < 114{,}3$ mm.

Table 3 — Extent of testing and inspection

Type of test	Number of tests
Chemical composition	One per heat
Tensile — base metal	One per test unit
Transverse weld tensile	One per test unit
Impact — base metal	One set per test unit
Impact — weld seam	37 mm thickness and above: two sets per test unit (one near the OD and one near the ID) less than 37 mm: 1 set per test unit
Through-thickness hardness	One per test unit
Surface hardness	By agreement
Metallography	By agreement
HIC	By agreement
SSC	By agreement
CTOD	By agreement
Guided bend (weld seam)	Two per qualification test
NDT	Every fitting[a]
Dimensional inspection	Every fitting

[a] Except for determining residual magnetism, which shall be at a frequency to be established by agreement for fittings demagnetized during production, otherwise 25 % of the fittings shall be selected at random.

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

© ISO 2021 – All rights reserved

9.3 Chemical composition

The product analysis shall be in accordance with Table 4.

9.4 Mechanical testing

9.4.1 Preparation of test pieces

Test pieces shall be prepared in accordance with ISO 377.

9.4.2 Tensile testing

9.4.2.1 Test pieces

Orientation of the base metal test pieces shall be as follows:

— transverse to the major axis of the fitting for $D \geq 210$ mm;

— longitudinal to the major axis of the fitting for $D < 210$ mm.

Transverse test pieces shall be cold-flattened. Round bar made from a test piece may be used. Round-bar test pieces machined from unflattened samples can be used.

Welds shall be ground flush. Local imperfections and mill scale shall be removed.

9.4.2.2 Test method

Tensile testing at room temperature shall be carried out in accordance with ISO 6892-1. If specified, tensile testing at elevated temperatures shall be carried out in accordance with ISO 6892-2 and the frequency and acceptance criteria shall be by agreement.

For base metal, $R_{t0,5}$, R_m, and percentage elongation after fracture shall be determined. For tensile tests transverse to the weld, it is required only to determine R_m.

The percentage elongation after fracture shall be reported with reference to a gauge length of $5{,}65\sqrt{A_o}$. If other gauge lengths are used, the elongation referred to a gauge length of $5{,}65\sqrt{A_o}$ shall be determined in accordance with ISO 2566-1.

9.4.2.3 Requirements

The tensile properties shall meet the requirements of the ISO 3183.

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

© ISO 2021 – All rights reserved

Table 4 — Chemical composition for product analyses

Element	Maximum permitted alloy content, mass fraction, %	
	Class B	Class S
C	0,18	0,18
Mn	1,60	1,50
Si	0,45	0,45
P	0,025	0,020
S	0,015	0,003[e]
V	0,11	0,10
Nb	0,06	0,05
Ti	0,07	0,06
Cr	0,25	0,25
Mo	0,10	0,10
Ni	0,50	0,50
Cu	0,35	0,35
$Al_{(tot)}$	0,06	0,06
N	0,012	0,012
B	0,000 5	0,000 5
Ca	no limit	0,006
CE[a]	0,43	0,42
P_{cm}[b,c,d]	0,25	0,22

V+Nb+Ti shall not exceed 0,15 %.

Cr+Mo+Ni+Cu shall not exceed 0,6 %. Higher Cr, Mo and Ni content may be acceptable by agreement, where required for special applications such as low temperatures and/or thick sections.

The total Al/N ratio shall not be less than 2:1.

[a] Carbon equivalent, calculated as follows:

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

[b] Crack measurement parameter, calculated as follows:

$$P_{cm} = C + \frac{Si}{30} + \frac{Ni}{60} + \frac{V}{10} + \frac{Mo}{15} + \frac{Cr + Mn + Cu}{20} + 5B$$

[c] Based upon product analysis. CE limits apply if C > 0,12 % and the CE Pcm limits apply if C ≤ 0,12 %.

[d] For SMLS pipe in sour service, the listed CE Pcm value may be increased by 0,03.

[e] The maximum limit for S may be increased to ≤0,008 % for SMLS fittings

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

9.4.3 Charpy V-notch impact testing

9.4.3.1 Test pieces

Charpy V-notch test pieces shall be prepared in accordance with ISO 148-1, with the axis of the notch perpendicular to the fitting surface.

The orientation and size of the test pieces shall be transverse with the greatest possible width between 5 mm and 10 mm. If transverse test pieces with a minimum width of 5 mm are not possible, longitudinal test pieces with the greatest possible width between 5 mm and 10 mm shall be used.

© ISO 2021 – All rights reserved

Impact testing is not required if the fitting dimensions are insufficient to extract longitudinal base metal test pieces with a minimum width of 5 mm.

Charpy V-notch test pieces shall be taken from the sample in accordance with ISO 3183.

Test pieces for welds shall be taken from the weld centreline. Test pieces of the fusion line should be taken by agreement, in which case the notch location shall be as shown in Figure 4.

a) Symmetric weld **b) Asymmetric weld**

Key

1 weld
2 fusion line
3 test piece edges
4 charpy notch
t is the length of Charpy V-notch

Figure 4 — Location of Charpy V-notch in weld fusion lines

9.4.3.2 Test method

Each set of impact tests shall consist of three adjacent test pieces taken from a single, non-flattened sample.

Charpy V-notch impact testing shall be in accordance with ISO 148-1, a 8 mm striker radius shall be used. An additional requirement to report shear area of the fracture surface shall be by agreement.

The impact test temperature shall be established in accordance with Table 5.

Table 5 — Maximum Charpy V-notch test temperature

Nominal wall thickness mm	**Test temperature** °C	
	Class B	**Class S**
$t \leq 20$	$T_{d,\,min}$	$T_{d,\,min} - 10$
$20 < t \leq 25$	$T_{d,\,min}$	$T_{d,\,min} - 20$
$t > 25$	By agreement	By agreement
In no case shall the test temperature exceed 0 °C. Minimum test temperature shall not be lower than -46 °C.		

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

© ISO 2021 – All rights reserved

9.4.3.3 Requirements

The results of the Charpy V-notch impact tests shall meet the following requirements:

a) for each set of tests, the minimum average absorbed energy, in joules, in the transverse direction shall be

$$\frac{R_{smys}}{10}$$

where R_{smys} is the specified minimum yield strength, expressed in MPa.

For steel grade L245, the minimum average Charpy-V absorbed energy in the transverse direction shall be 27 J;

b) the minimum individual value in any set of tests shall not be less than 75 % of the minimum required average value;

c) the minimum average and minimum individual values when testing test pieces taken in the longitudinal direction shall be 1,5 times the values stated for transverse test pieces;

d) if specified (see 9.4.3.2), the shear area shall be an average of 50 % with a minimum individual value of 40 %.

For sub-size test pieces, the minimum required absorbed energy values shall be adjusted in accordance with ISO/TS 7705:2017, Clause 6.

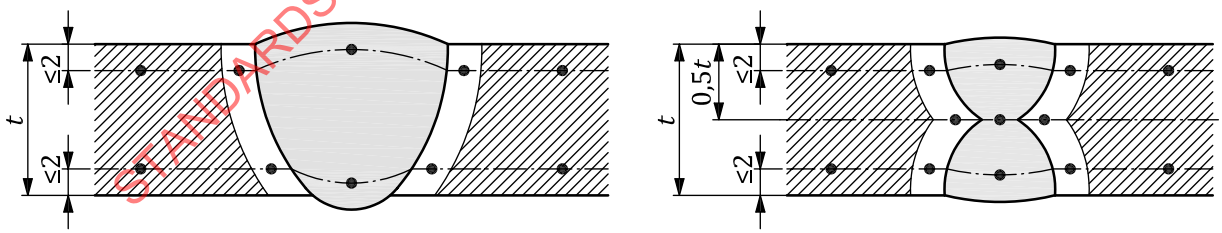
At the option of the manufacturer, a low test temperature given by Table 5 may be used as long as the specified absorbed energy is achieved.

9.4.4 Through-thickness hardness testing

9.4.4.1 Test method

Through-thickness hardness testing shall be performed using the Vickers method in accordance with ISO 6507-1, method HV 10 (i.e. with a test force of 98,07 N).

Hardness indent locations for welded fittings shall be in accordance with Figure 5. For seamless fittings, hardness indent locations shall be made at a distance of 1 mm to 2 mm from the inside and outside surfaces containing four indents spaced at 5 mm arranged similarly to Figure 5.



Key

- base material
- heat-affected zone
- weld seam

t is the thickness

Figure 5 — Hardness indent locations for welded fittings

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

© ISO 2021 – All rights reserved

9.4.4.2 Acceptance criteria

No hardness reading shall exceed

— 300 HV 10 for class B fittings;

— 250 HV 10 for class S fittings.

9.4.5 Surface hardness testing

The test method and acceptance criteria shall be established by agreement.

9.4.6 Metallographic examination

9.4.6.1 Test method

The specimens for through-thickness hardness testing shall be examined, prior to hardness testing, at a magnification of not less than ×100. Grain-size measurement shall be performed in accordance with ASTM E112.

The type of microstructure and actual grain size shall be recorded on the manufacturing procedure qualification test report.

9.4.6.2 Acceptance criteria

The minimum average grain size number shall be 7.

9.4.7 HIC testing

If HIC testing is specified, the test procedures and acceptance criteria shall be in accordance with NACE TM0284-2016-SG.

9.4.8 SSC testing

If SSC testing is specified, test procedures and acceptance criteria shall be in accordance with NACE TM0177-2016-SG.

9.4.9 CTOD testing

CTOD testing is not required for any fitting class, except by agreement.

Test methods and requirements shall be decided by agreement.

9.4.10 Guided weld bend testing

9.4.10.1 Test pieces

The test pieces shall be in accordance with ISO 7438.

Full-thickness curved-section test pieces are required for fittings with wall thicknesses of 20 mm and above. For fittings with a wall thickness less than 20 mm, the test pieces may be machined to provide a rectangular cross-section with a thickness of 19 mm. The weld reinforcement shall be removed from both faces.

9.4.10.2 Test method

The mandrel dimensions shall be as defined in the ISO 3183 for the grade of fitting.

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

© ISO 2021 – All rights reserved

Both test pieces shall be bent through approximately 180°, one with the root of the weld and the other with the face of the weld directly under the mandrel.

9.4.10.3 Acceptance criteria

The test pieces shall

a) not fracture completely;

b) not reveal any crack or rupture in the weld metal greater than 3 mm in length, regardless of depth;

c) not reveal any crack or rupture in the parent metal, heat-affected zone or fusion line longer than 3 mm and deeper than the wall thickness tolerance of the matching pipe.

Cracks that occur at the edges of the specimen and that are less than 6 mm in length shall not be cause for rejection, regardless of their depth.

If a fracture or crack in a test piece is caused by imperfections, the test piece may be discarded and a new test piece substituted.

9.5 Non-destructive testing

9.5.1 NDT procedures and personnel

All NDT shall be conducted in accordance with documented procedures. If specified by the purchaser, NDT procedures shall be decided by agreement before commencement of fitting manufacture.

All NDT personnel shall be qualified in accordance with ISO 9712 or equivalent to the appropriate level of competence. The minimum level of competence for UT shall be NDT level 2.

9.5.2 Condition of fittings

Except where radiography of the weld seam of the starting material has been specified (see Table 2), all NDT for acceptance of fittings in accordance with the requirements of this document shall be performed after final heat treatment of fittings.

The surface to be examined shall be dry and free of all dirt, grease, lint, scale, welding flux and spatter, oil or other extraneous matter that could interfere with NDT.

Fitting surfaces shall be finished so that surface imperfections can be detected by visual inspection.

9.5.3 Treatment of imperfections

9.5.3.1 Defects

Fittings shall be free of the following defects:

a) dents with sharp-bottom gouges;

b) dents, without sharp-bottom gouges, exceeding 3 mm in depth;

c) peaks exceeding 3 mm in height;

d) hard spots;

e) weld reinforcement exceeding 3 mm, for fittings with a wall thickness of 12 mm or less;

f) weld reinforcement exceeding 4 mm for fittings with a wall thickness greater than 12 mm;

g) incompletely-filled weld preparations;

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

© ISO 2021 – All rights reserved

h) radial offset of plate edges, or plate misalignment, exceeding 2 mm, for fittings with a wall thickness of 12 mm or less;

i) radial offset of plate edges, or plate misalignment, exceeding 3 mm, for fittings with a wall thickness greater than 12 mm;

j) laps, flats, tears, pulls and similar defects.

NOTE Definitions and visual examples of some of these imperfections can be found in ASM International's Metals Handbook.

9.5.3.2 Treatment of surface imperfections

Imperfections not classified as defects may remain in the fitting without repair. Localized grinding, however, may be performed.

9.5.3.3 Treatment of dressable surface defects

All dressable surface defects shall be dressed out by grinding. Grinding shall be carried out in such a way that the dressed area blends in smoothly with the contour of the pipe. Complete removal of defects shall be verified by local visual inspection, aided if necessary by suitable NDT methods. After grinding, the remaining wall thickness in the dressed area shall be checked for conformance with 9.6.

9.5.3.4 Treatment of non-dressable surface defects

Fittings containing non-dressable defects shall be given one of the following dispositions.

— Weld defects in welded fittings shall be repaired in accordance with 9.5.3.5.

— The fitting shall be rejected.

9.5.3.5 Repair of defects by welding

Repair by welding on weld seams may be performed only by the following processes:

— submerged arc welding;

— manual metal-arc welding;

— metal inert gas/metal active gas welding;

— tungsten inert gas welding.

Weld defects separated by less than 100 mm shall be repaired as a continuous single weld repair.

Each single repair shall be carried out with a minimum of two weld passes over a minimum length of 50 mm.

The weld repair work shall be performed using procedures qualified in accordance with 8.3.2.

After weld repair, the total area of the repaired zone shall be subjected to RT in accordance with 9.5.5.

9.5.4 Fitting ends

The complete end preparation shall be subjected to MT in accordance with ISO 10893-5 or ASTM E709, or PT in accordance with ISO 10893-4 or ASTM E165. The MT technique should employ fluorescent ink or colour contrast.

For MT and PT, linear indications with a length less than 2 mm shall be acceptable.

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

© ISO 2021 – All rights reserved

For all fittings, a 50-mm wide band at each end shall be inspected for laminar imperfections by UT in accordance with ISO 10893-8, ASTM A578, ASTM E213 or ASTM A388. This 50-mm band shall extend from the intersection of the weld bevel and fitting outside diameter back along the body of the fitting. Laminar imperfections shall not exceed a length of 6 mm in the circumferential direction and their area shall not exceed 100 mm^2.

9.5.5 Weld seams

Weld seams shall be subjected to RT in accordance with ISO 10893-6 or ASME BPVC Section V. The image quality class shall be R1. The acceptance criteria shall be in accordance with ISO 10893-6 or ASME BPVC Section VIII Division 1. Instead of radiographic examination, ultrasonic examination may be substituted by agreement.

9.5.6 Guide bar attachment welds

Guide bar attachment welds shall be subjected to MT or PT in accordance with ASTM E 709 or ASTM E165.

9.5.7 Fitting body

If specified, the methods and acceptance criteria for fitting body NDT shall be decided by agreement prior to fitting manufacture.

9.5.8 Residual magnetism

The residual magnetic flux density at the fitting ends shall not exceed 3 mT.

9.6 Dimensions

Dimensions and tolerances shall be in accordance with MSS SP-75 and, for nominal sizes less than DN 400, ASME B16.9.

9.7 Gauging

The requirements for gauging, including pigging assessments, shall be decided by agreement and can apply only to tees.

9.8 Hydrostatic testing

Hydrostatic testing of fittings is not mandatory. The manufacturer shall certify that the fitting will withstand an internal pressure at least as high as that specified for the matching pipe.

10 Inspection document

The purchaser shall specify the required ISO 10474 or an equivalent regional standard, EN 10204, designation of the inspection document and any specific requirements for the format and content of the document.

11 Marking

Marking shall be placed close to the bevel ends on the external surface of the fittings (close to one or both ends of each fitting) and shall include the following information:

— purchase order and item number;

— fitting designation, as defined in Clause 5;

STANDARDSISO.COM : Click to view the full PDF of ISO 15590-2:2021

© ISO 2021 – All rights reserved