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English Version

Welded steel tubes for pressure purposes - Technical delivery conditions - Part 7: Stainless steel tubes

Tubes soudés en acier pour service sous pression - Conditions techniques de livraison - Partie 7 : Tubes en aciers inoxydables

Geschweißte Stahlrohre für Druckbeanspruchungen - Technische Lieferbedingungen - Teil 7: Rohre aus nichtrostenden Stählen

This European Standard was approved by CEN on 12 March 2021.

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European foreword

This document (EN 10217-7:2021) has been prepared by Technical Committee CEN/TC 459/SC 10 "Steel tubes and iron and steel fittings", the secretariat of which is held by UNI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2021, and conflicting national standards shall be withdrawn at the latest by October 2021.

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

This document supersedes EN 10217-7:2014.

The main changes with respect to the previous edition are listed in Annex A.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive 2014/68/EU.

For relationship with EU Directive 2014/68/EU, see informative Annex ZA, which is an integral part of this document.

EN 10217 consists of the following parts, under the general title *Welded steel tubes for pressure purposes — Technical delivery conditions*:

— *Part 1: Electric welded and submerged arc welded non-alloy steel tubes with specified room temperature properties;*

— *Part 2: Electric welded non-alloy and alloy steel tubes with specified elevated temperature properties;*

— *Part 3: Electric welded and submerged arc welded alloy fine grain steel tubes with specified room, elevated and low temperature properties;*

— *Part 4: Electric welded non-alloy and alloy steel tubes with specified low temperature properties;*

— *Part 5: Submerged arc welded non-alloy and alloy steel tubes with specified elevated temperature properties;*

— *Part 6: Submerged arc welded non-alloy steel tubes with specified low temperature properties;*

— *Part 7: Stainless steel tubes.*

Another European Standard series covering tubes for pressure purposes is:

EN 10216, *Seamless steel tubes for pressure purposes*.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This document specifies the technical delivery conditions in two test categories for welded tubes of circular cross-section made of austenitic and austenitic-ferritic stainless steel which are intended for pressure and corrosion resisting purposes at room temperature, at low temperatures or at elevated temperatures.

NOTE Once the reference of this document is published in the Official Journal of the European Union (OJEU) under Directive 2014/68/EU, pressure equipment directive, presumption of conformity to the Essential Safety Requirements (ESR) of Directive 2014/68/EU is limited to technical data of materials in this document and does not presume adequacy of the material to a specific item of equipment. Consequently, the assessment of the technical data stated in this material standard against the design requirements of this specific item of equipment to verify that the ESRs of the Pressure Equipment Directive are satisfied, needs to be done by the designer of the pressure equipment, taking also into account the subsequent manufacturing processes which could affect properties of the base materials.

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.

EN 10020:2000, *Definition and classification of grades of steel*

EN 10021:2006, *General technical delivery conditions for steel products*

EN 10027-1:2016, *Designation systems for steels - Part 1: Steel names*

EN 10027-2:2015, *Designation systems for steels - Part 2: Numerical system*

EN 10028-7:2016, *Flat products made of steels for pressure purposes - Part 7: Stainless steels*

EN 10088-1:2014, *Stainless steels - Part 1: List of stainless steels*

EN 10168:2004, *Steel products - Inspection documents - List of information and description*

EN 10204:2004, *Metallic products - Types of inspection documents*

EN 10266:2003, *Steel tubes, fittings and structural hollow sections - Symbols and definitions of terms for use in product standards*

CEN/TR 10261:2018, *Iron and steel - European standards for the determination of chemical composition*

EN ISO 148-1:2016, *Metallic materials - Charpy pendulum impact test - Part 1: Test method (ISO 148-1:2016)*

EN ISO 377:2017, *Steel and steel products - Location and preparation of samples and test pieces for mechanical testing (ISO 377:2017)*

EN ISO 1127:1996, *Stainless steel tubes - Dimensions, tolerances and conventional masses per unit length (ISO 1127:1992)*

EN ISO 2566-2:1999, *Steel - Conversion of elongation values - Part 2: Austenitic steels (ISO 2566-2:1984)*

EN 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 3651-2:1998)*

EN ISO 4885:2018, *Ferrous materials - Heat treatments - Vocabulary (ISO 4885:2018)*

EN ISO 5173:2010, *Destructive tests on welds in metallic materials - Bend tests (ISO 5173:2009)*

EN ISO 6892-1:2019, *Metallic materials - Tensile testing - Part 1: Method of test at room temperature (ISO 6892-1:2019)*

EN ISO 6892-2:2018, *Metallic materials - Tensile testing - Part 2: Method of test at elevated temperature (ISO 6892-2:2018)*

EN ISO 8492:2013, *Metallic materials - Tube - Flattening test (ISO 8492:2013)*

EN ISO 8493:2004, *Metallic materials - Tube - Drift-expanding test (ISO 8493:1998)*

EN ISO 8495:2013, *Metallic materials - Tube - Ring-expanding test (ISO 8495:2013)*

EN ISO 8496:2013, *Metallic materials - Tube - Ring tensile test (ISO 8496:2013)*

EN ISO 9712:2012, *Non-destructive testing - Qualification and certification of NDT personnel (ISO 9712:2012)*

EN ISO 10893-1:2011,[1] *Non-destructive testing of steel tubes - Part 1: Automated electromagnetic testing of seamless and welded (except submerged arc-welded) steel tubes for the verification of hydraulic leaktightness (ISO 10893-1:2011)*

EN ISO 10893-2:2011,[2] *Non-destructive testing of steel tubes - Part 2: Automated eddy current testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of imperfections (ISO 10893-2:2011)*

EN ISO 10893-6:2019, *Non-destructive testing of steel tubes - Part 6: Radiographic testing of the weld seam of welded steel tubes for the detection of imperfections (ISO 10893-6:2019)*

EN ISO 10893-7:2019, *Non-destructive testing of steel tubes - Part 7: Digital radiographic testing of the weld seam of welded steel tubes for the detection of imperfections (ISO 10893-7:2019)*

EN ISO 10893-8:2011,[3] *Non-destructive testing of steel tubes - Part 8: Automated ultrasonic testing of seamless and welded steel tubes for the detection of laminar imperfections (ISO 10893-8:2011)*

EN ISO 10893-9:2011,[4] *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 10893-9:2011)*

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1 As impacted by EN ISO 10893-1:2011/A1:2020.

2 As impacted by EN ISO 10893-2:2011/A1:2020.

3 As impacted by EN ISO 10893-8:2011/A1:2020.

4 As impacted by EN ISO 10893-9:2011/A1:2020.

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EN ISO 10893-10:2011,[5] *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 10893-10:2011)*

EN ISO 10893-11:2011,[6] *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 10893-11:2011)*

EN ISO 14284:2002, *Steel and iron - Sampling and preparation of samples for the determination of chemical composition (ISO 14284:1996)*

ISO 11484:2019, *Steel products — Employer's qualification system for non-destructive testing (NDT) personnel*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in EN 10020:2000, EN 10021:2006, EN ISO 4885:2018 and EN 10266:2003 and the following apply.

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

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

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

3.1
test category
classification that indicates the extent and level of inspection and testing

3.2
employer
organization for which a person works on a regular basis

Note 1 to entry: The employer may be either the tube manufacturer or supplier or a third party organization providing non-destructive testing (NDT) services.

4 Symbols

For the purpose of this document, the symbols given in EN 10266:2003 and the following apply.

— TC test category.

NOTE See also Table 2 for symbols of the delivery condition.

5 Classification and designation

5.1 Classification

According to the classification system in EN 10020:2000, the steel grades are classified as:

— austenitic steels (corrosion resisting);

[5] As impacted by EN ISO 10893-10:2011/A1:2020.

[6] As impacted by EN ISO 10893-11:2011/A1:2020.

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— austenitic-ferritic steels.

5.2 Designation

For the tubes covered by this document the steel designation consists of:

— the number of this document (EN 10217-7);

plus either:

— the steel name according to EN 10027-1:2016;

or:

— the steel number allocated according to EN 10027-2:2015.

6 Information to be supplied by the purchaser

6.1 Mandatory information

The following information shall be supplied by the purchaser at the time of enquiry and order:

a) the quantity (mass or total length or number);

b) the term “tube”;

c) the dimensions (outside diameter D and wall thickness T) (see 8.8.1);

d) the designation of the steel grade according to this document (see 5.2);

e) the test category (see 9.3).

6.2 Options

A number of options are specified in this document and these are listed below. In the event that the purchaser does not indicate a wish to implement any of these options at the time of enquiry and order, the tube shall be supplied in accordance with the basic specification (see 6.1).

1) Information about steelmaking process (see 7.1);

2) Tube manufacturing process and/or route (see 7.2.1);

3) The inside weld is remelted (see Table 1);

4) The inside weld is worked by rolling, remelting or grinding (see Table 1);

5) Delivery condition (see 7.2.3);

6) Product analysis (see 8.2.2);

7) Additional verifications of mechanical properties on samples that have undergone a different or additional heat treatment (see 8.3.1);

8) Verification of impact energy at room temperature (see 8.3.1);

9) Verification of proof strength $R_{p0,2}$ or $R_{p1,0}$ at elevated temperatures (see 8.3.2);

10) Verification of impact energy at low temperature (see 8.3.3);

11) Intergranular corrosion test (see 8.4);

12) Repair welding (see 8.5.1.5);

13) Selection of method for verification of leak-tightness test method (see 8.5.2.2);

14) Non-destructive testing of tube ends for detection of laminar imperfections (see 8.5.2.3);

15) Non-destructive testing of strip and plate edges for detection of laminar imperfections (see 8.5.2.3);

16) Special ends preparation (see 8.7);

17) Exact lengths (see 8.8.3);

18) Tolerance class D 4 for $D \leq 168{,}3$ mm (see Table 10);

19) The type of inspection certificate 3.2 in place of the standard document (see 9.2.1);

20) Transverse tensile test on the weld (see 10.2.2.3);

21) Test pressure for hydrostatic leak-tightness test (see 11.8.1);

22) Wall thickness measurement away from the ends (see 11.9);

23) Selection of non- destructive testing method for the inspection of the weld seam (see Table 16);

24) Image quality class B of EN ISO 10893-6 for the radiographic inspection of the weld seam (see Table 16);

25) Additional marking (see 12.2);

26) Special protection (see Clause 13);

27) Image quality class B of EN ISO 10893-7 for the digital radiographic testing of the weld (see Table 16);

28) Different values for the maximum height of the weld seam are to be agreed in the purchase order (see Table 11);

29) Height of the weld seam for tubes with route 01, 05, 06 and 07 (according to Table 1) and with thicknesses over 8 mm: maximum 4 mm (see Table 11).

6.3 Examples of an order

6.3.1 Example 1

2 000 m of welded tube W1 (see Table 2) with an outside diameter of 168,3 mm, a wall thickness of 4,5 mm, tolerance classes D 3 and T 3, in accordance with this document, made of steel grade X2CrNi19-11, test category 1, with a 3.1 inspection certificate according to EN 10204:

EXAMPLE 2 000 m - Tube - 168,3 × 4,5 - EN 10217-7- X2CrNi19–11 - TC 1 - Option 5: W1

6.3.2 Example 2

300 m of cold finished welded tube WCA (see Table 2) with an outside diameter of 42,4 mm, a wall thickness of 2,6 mm, tolerance classes D 3 and T 3, in accordance with this document, made of steel grade 1.4301, test category 2, with intergranular corrosion test (EN ISO 3651-2, method A), verification of proof strength at 300 °C, non-destructive testing of strip edges for detection of laminar imperfections, with a 3.2 inspection certificate according to EN 10204 issued by the manufacturer:

EXAMPLE 300 m - Tube - 42,4 × 2,6 - EN 10217-7 - 1.4301 - TC 2 - Option 5: WCA - Option 9: 300 °C - Option 11: A - Option 15 - Option 19: 3.2 (to be issued by the manufacturer)

7 Manufacturing process

7.1 Steelmaking process

The steelmaking process is at the discretion of the manufacturer, but see Option 1.

***Option 1**: The purchaser shall be informed about the steelmaking process used. The process shall be reported in the inspection document.*

7.2 Tube manufacture and conditions

7.2.1 The tubes shall be manufactured from hot or cold rolled plate, sheet or strip in accordance with EN 10028-7:2016. They shall be longitudinally welded by fusion across the abutting edges using either an arc welding or a laser welding or an electron beam welding process, or a combination thereof. The definitions of these respective fusion welding methods are given in ISO/TR 25901-3:2016, 4.2. Welding can be performed with or without the addition of filler metal in accordance with one of the routes as specified in Table 1.

Unless Option 2 is specified, the manufacturing process and/or route are at the discretion of the manufacturer.

***Option 2**: The tube manufacturing process and/or route is specified by the purchaser.*

The finished tubes shall not include welds used for joining together lengths of the hot or cold rolled strip prior to forming.

***Option 3**: (see* Table 1*).*

***Option 4**: (see* Table 1*).*

7.2.2 The production (welding) process shall be qualified and approved under the tube manufacture's own QA system.

NOTE For tubes to be used in pressure equipment under categories II, III, or IV of European Legislation for pressure equipment, the relevant operating procedures and personnel for permanent joints will be approved by a competent third party.

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Table 1 — Tube manufacturing process, route, starting material, forming operation and weld condition

1	2	3	4	5
Route	Manufacturing process [a]	Starting material	Forming operation	Weld condition [b]
01	Arc welding	Hot or cold rolled strip	Continuous forming from strip	As welded [c e]
02				Welded, outside ground [c e] or bead worked *
03				Welded, bead worked *
04	Laser welding	Hot or cold rolled strip	Continuous forming from strip	Welded, outside ground [c] or bead worked *
05	Arc welding	Hot or cold rolled plate or sheet	Single forming from plate or sheet	As welded [d e]
06	Laser welding and arc welding **	Hot or cold rolled plate or sheet	Single forming from plate or sheet	As welded [d e]
07	Electron beam welding and arc welding **	Hot or cold rolled plate or sheet	Single forming from plate or sheet	As welded [d e]

* Bead worked = bead rolled or bead hammered.

** For these tubes, i.e. tubes welded from plate or sheet, the laser welding and the electron beam welding processes are normally used in combination with an arc welding process.

[a] Tubes with outside diameter not exceeding 168,3 mm may additionally be brought to the required tube dimensions by cold working [b] (see type of condition WCA and WCR in Table 2).

[b] The terms "as-welded", "welded, outside ground", "bead worked" and "cold working" apply to the condition of the tube before heat treatment if required in accordance with Table 2.

[c] On request, the inside weld can be re-melted. ***Option 3:*** *The inside weld is re-melted.*

[d] On request, the inside weld can be worked by rolling, remelting or grinding. ***Option 4:*** *The inside weld is worked by rolling, remelting or grinding.*

[e] The weld seam can be welded using one or more separate layers.

7.2.3 The types of delivery condition of the tubes are shown in Table 2. Unless Option 5 is specified, the selection of type of delivery condition is at the discretion of the manufacturer.

Option 5*: The type of delivery condition is specified by the purchaser.*

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Table 2 — Delivery conditions

Symbol	Type of delivery condition [a]	Surface condition
W0 [b]	Welded from hot or cold rolled plate, sheet or strip 1D, 2D, 2E, 2B, 2R	As welded [f]
W1 [b]	Welded from hot rolled plate, sheet or strip 1D, descaled and/or pickled [e]	Metallically clean
W1A [b]	Welded from hot rolled plate, sheet or strip 1D, heat treated, descaled and/or pickled [e]	
W1R [b]	Welded from hot rolled plate, sheet or strip 1D, bright annealed	Metallically bright
W2 [b]	Welded from cold rolled plate, sheet or strip 2D, 2E, 2B, 2R, descaled and/or pickled [e]	Metallically clean
W2A [b]	Welded from cold rolled plate, sheet or strip 2D, 2E, 2B, 2R, heat treated, descaled and/or pickled [e]	
W2R [b]	Welded from cold rolled plate, sheet or strip 2D, 2E, 2B, 2R, bright annealed	Metallically bright
WCA	Welded from hot rolled or cold rolled plate, sheet or strip 1D, 2D, 2E, 2B, 2R, heat treated if appropriate, at least 20 % cold formed, heat treated, with re-crystallized weld metal, descaled and/or pickled [e]	Metallically clean, weld scarcely recognizable
WCR	Welded from hot rolled or cold rolled plate, sheet or strip 1D, 2D, 2E, 2B, 2R, heat treated if appropriate, at least 20 % cold formed, bright annealed, with re-crystallized weld metal	Metallically bright, weld scarcely recognizable
WG	Ground [c]	Metallically bright-ground, the type and degree of grinding shall be agreed at the time of enquiry and order [d]
WP	Polished [c]	Metallically bright-polished, the type and degree of polishing shall be agreed at the time of enquiry and order [d]

[a] Symbols of flat products according to EN 10028-7:2016.

[b] For tubes ordered with smoothed inside welds (“bead worked”) letter “b” shall be appended to the symbol for the delivery condition (e.g. W2Ab).

[c] Conditions W2, W2A, W2R, WCA or WCR are usually used as the starting condition.

[d] It should be indicated in the enquiry or order whether grinding or polishing is to be performed internally or externally, or internally and externally.

[e] Unless specified at the time of the order the method of descaling and/or pickling is at the discretion of the manufacturer.

[f] Tubes may have residual scale, welding colours and grease residue.

8 Requirements

8.1 General

When supplied in a delivery condition indicated in 7.2.3 and inspected according to Clauses 9, 10 and 11, the tubes shall conform to the requirements of this document. In addition, the general technical delivery requirements specified in EN 10021:2006 shall apply.

8.2 Chemical composition

8.2.1 Cast analysis

The cast analysis reported by the steel manufacturer shall apply and conform to the requirements of Table 3 for austenitic steel and of Table 4 for austenitic-ferritic steel.

When welding tubes produced according to this document, account should be taken of the fact that the behaviour of the steel during and after welding is dependent not only on the steel, but also on the applied heat treatment and the conditions of preparing for and carrying out the welding.

8.2.2 Product analysis

Option 6*: Product analysis for the tubes shall be supplied.*

Table 5 specifies the permissible deviation of the product analysis from the specified limits on cast analysis given in Tables 3 and 4.

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Table 3 — Chemical composition (cast analysis) [a] of austenitic steels, in % by mass

Steel grade		C max	Si max	Mn max	P max	S max	N	Cr	Cu	Mo	Ni	Others
Steel name	Steel number											
X2CrNi18–9	1.4307	0,030	1,00	2,00	0,045	0,015	≤ 0,10	17,5 to 19,5	_	_	8,0 to 10,5	_
X2CrNi19–11	1.4306	0,030	1,00	2,00	0,045	0,015	≤ 0,10	18,0 to 20,0	_	_	10,0 to 12,0	_
X2CrNiN18–10	1.4311	0,030	1,00	2,00	0,045	0,015	0,12 to 0,22	17,5 to 19,5	_	_	8,5 to 11,5	_
X5CrNi18–10	1.4301	0,07	1,00	2,00	0,045	0,015	≤ 0,10	17,5 to 19,5	_	_	8,0 to 10,5	_
X6CrNiTi18–10	1.4541	0,08	1,00	2,00	0,045	0,015	_	17,0 to 19,0	_	_	9,0 to 12,0	Ti 5xC to 0,70
X6CrNiNb18–10	1.4550	0,08	1,00	2,00	0,045	0,015	_	17,0 to 19,0	_	_	9,0 to 12,0	Nb 10xC to 1,00
X2CrNiMo17–12–2	1.4404	0,030	1,00	2,00	0,045	0,015	≤ 0,10	16,5 to 18,5	_	2,00 to 2,50	10,0 to 13,0	_
X5CrNiMo17–12–2	1.4401	0,07	1,00	2,00	0,045	0,015	≤ 0,10	16,5 to 18,5	_	2,00 to 2,50	10,0 to 13,0	_
X6CrNiMoTi17–12–2	1.4571	0,08	1,00	2,00	0,045	0,015	_	16,5 to 18,5	_	2,00 to 2,50	10,5 to 13,5	Ti 5xC to 0,70
X2CrNiMo17–12–3	1.4432	0,030	1,00	2,00	0,045	0,015	≤ 0,10	16,5 to 18,5	_	2,50 to 3,0	10,5 to 13,0	
X2CrNiMoN17–13–3	1.4429	0,030	1,00	2,00	0,045	0,015	0,12 to 0,22	16,5 to 18,5	_	2,50 to 3,0	11,0 to 14,0	_
X3CrNiMo17–13–3	1.4436	0,05	1,00	2,00	0,045	0,015	≤ 0,10	16,5 to 18,5	_	2,50 to 3,0	10,5 to 13,0	_
X2CrNiMo18–14–3	1.4435	0,030	1,00	2,00	0,045	0,015	≤ 0,10	17,0 to 19,0	_	2,50 to 3,0	12,5 to 15,0	_
X2CrNiMoN17–13–5	1.4439	0,030	1,00	2,00	0,045	0,015	0,12 to 0,22	16,5 to 18,5	_	4,0 to 5,0	12,5 to 14,5	_
X2CrNiMo18–15–4	1.4438	0,030	1,00	2,00	0,045	0,015	≤ 0,10	17,5 to 19,5	_	3,0 to 4,0	13,0 to 16,0	_
X1NiCrMoCu31–27–4	1.4563	0,020	0,70	2,00	0,030	0,010	≤ 0,10	26,0 to 28,0	0,70 to 1,50	3,0 to 4,0	30,0 to 32,0	_
X1NiCrMoCu25–20–5	1.4539	0,020	0,70	2,00	0,030	0,010	≤ 0,15	19,0 to 21,0	1,20 to 2,00	4,0 to 5,0	24,0 to 26,0	_
X1CrNiMoCuN20–18–7	1.4547	0,020	0,70	1,00	0,030	0,010	0,18 to 0,25	19,5 to 20,5	0,50 to 1,00	6,0 to 7,0	17,5 to 18,5	_
X1NiCrMoCuN25–20–7	1.4529	0,020	0,50	1,00	0,030	0,010	0,15 to 0,25	19,0 to 21,0	0,50 to 1,50	6,0 to 7,0	24,0 to 26,0	_

[a] Elements not listed in this table shall not be intentionally added to the steel without the agreement of the purchaser except for finishing the cast. All appropriate precautions are to be taken to avoid the addition of such elements from scrap and other materials used in production which would impair mechanical properties and the suitability of the steel.

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Table 4 — Chemical composition (cast analysis) [a] of austenitic-ferritic steels, in % by mass

Steel grade		C max	Si max	Mn max	P [b] max	S [b] max	N	Cr	Cu	Mo	Ni	Others
Steel name	Steel number											
Austenitic-ferritic steels												
X2CrNiMoN22–5-3	1.4462	0,030	1,00	2,00	0,035	0,015	0,10 to 0,22	21,0 to 23,0	_	2,50 to 3,5	4,5 to 6,5	_
X2CrNiN23–4	1.4362	0,030	1,00	2,00	0,035	0,015	0,05 to 0,20	22,0 to 24,0	0,10 to 0,60	0,10 to 0,60	3,5 to 5,5	_
X2CrNiMoN25–7-4	1.4410	0,030	1,00	2,00	0,035	0,015	0,20 to 0,35	24,0 to 26,0	_	3,0 to 4,5	6,0 to 8,0	_
X2CrNiMoCuWN25–7-4	1.4501	0,030	1,00	1,00	0,035	0,015	0,20 to 0,30	24,0 to 26,0	0,50 to 1,00	3,0 to 4,0	6,0 to 8,0	W 0,50 to 1,00

[a] Elements not listed in this table shall not be intentionally added to the steel without the agreement of the purchaser except for finishing the cast. All appropriate precautions are to be taken to avoid the addition of such elements from scrap and other materials used in production which would impair mechanical properties and the suitability of the steel.

[b] For tubes welded without filler material the sum of sulphur and phosphorus shall be maximum 0,040 %.

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Table 5 — Permissible deviations of the product analysis from specified limits on cast analysis given in Tables 3 and 4

Element	Limiting value for the cast analysis according to Tables 3 and 4	Permissible deviation of the product analysis [a]
	% by mass	% by mass
Carbon	≤ 0,030	+ 0,005
	> 0,030 to ≤ 0,08	±0,01
Silicon	≤ 1,00	+ 0,05
Manganese	≤ 1,00	+ 0,03
	> 1,00 to ≤ 2,00	+ 0,04
Phosphorus	≤ 0,030	+ 0,003
	> 0,030 to ≤ 0,045	+ 0,005
Sulphur	≤ 0,015	+ 0,003
Nitrogen	≤ 0,35	±0,01
Chromium	≥ 16,5 to ≤ 20,0	±0,20
	> 20,0 to ≤ 28,0	±0,25
Copper	≤ 1,00	±0,07
	> 1,00 to ≤ 2,00	±0,10
Molybdenum	≤ 0,60	±0,03
	≥ 2,00 to ≤ 7,0	±0,10
Niobium	≤ 1,00	±0,05
Nickel	≤ 5,0	±0,07
	> 5,0 to ≤ 10,0	±0,10
	> 10,0 to ≤ 20,0	±0,15
	> 20,0 to ≤ 32,0	±0,20
Titanium	≤ 0,70	±0,05
Tungsten	≤ 1,00	±0,05

[a] If several product analyses are carried out on one cast, and the contents of an individual element determined lie outside the permissible range of the chemical composition specified for the cast analysis, then it is only allowed to exceed the permissible maximum value or to fall short of the permissible minimum value, but not both for one cast.

8.3 Mechanical properties

8.3.1 At room temperature

The mechanical properties of the tubes shall conform to the requirements in Tables 6 and 7 and in Clause 11 irrespective of whether they are verified or not (see Table 13).

If heat treatments different from, or additional to, the reference heat treatment, are to be carried out after the delivery of the tubes, the purchaser may request, at the time of enquiry and order, additional mechanical tests on samples, that have been given heat treatments different from or additional to, those given in Tables 6 and 7. The heat treatment of the samples and the mechanical properties to be obtained from tests on them shall be agreed at the time of enquiry and order.

***Option 7**: Additional mechanical tests on samples, which have undergone a different or additional heat treatment, shall be carried out.*

***Option 8**: Impact test shall be carried out at room temperature (see* Tables 6 and 7*). The location of the test pieces, either from the weld or opposite to the weld, shall be agreed at the time of enquiry and order.*

8.3.2 At elevated temperature

The minimum proof strength $R_{p0,2}$ and $R_{p1,0}$ values at elevated temperatures are specified in Tables 8 and 9.

***Option 9**: Proof strength $R_{p0,2}$ or $R_{p1,0}$ shall be verified (for austenitic-ferritic steels in* Table 9 *only $R_{p0,2}$ apply). The test temperature shall be agreed at the time of enquiry and order.*

8.3.3 At low temperature

Impact energy values at specified low temperature shall conform to the requirements in Tables 6 and 7.

***Option 10:** Impact test at low temperature shall be carried out. The location of the test pieces, either from the weld or opposite to the weld, shall be agreed at the time of enquiry and order.*

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Table 6 — Technical properties for wall thicknesses up to 60 mm of austenitic steels in the solution annealed condition (+AT) and information about intergranular corrosion

Steel grade		Tensile properties at room temperature [a]					Impact properties [a]			Reference heat treatment conditions		Resistance to intergranular corrosion	
		Proof strength		Tensile strength	Elongation		Minimum average absorbed energy *KV*2 J						
		*R*p0,2 min	*R*p1,0 min	*R*m [b]	*A* min (%)		at RT		at - 196 °C	Solution temperature [c]	Cooling in [d]	[e]	Method in EN ISO 3651-2:1998
Steel name	Steel number	MPa	MPa	MPa	l	t	l	t	t				
X2CrNi18–9	1.4307	200	240	500–700	40	35	100	60	60	1 000–1 100	w, a	yes	A
X2CrNi19–11	1.4306	180	215	460–680	40	35	100	60	60	1 000–1 100	w, a	yes	A
X2CrNiN18–10	1.4311	270	305	550–760	35	30	100	60	60	1 000–1 100	w, a	yes	A
X5CrNi18–10	1.4301	210	250	520–750	40	35	100	60	60	1 000–1 100	w, a	yes [f]	A
X6CrNiTi18–10	1.4541	200	235	500–730	35	30	100	60	60	1 020–1 120	w, a	yes	A
X6CrNiNb18–10	1.4550	205	240	510–740	35	30	100	60	60	1 020–1 120	w, a	yes	A
X2CrNiMo17–12–2	1.4404	190	225	490–690	40	30	100	60	60	1 020–1 120	w, a	yes	A
X5CrNiMo17–12–2	1.4401	205	240	510–710	40	30	100	60	60	1 020–1 120	w, a	yes [f]	A
X6CrNiMoTi17–12–2	1.4571	210	245	500–730	35	30	100	60	60	1 020–1 120	w, a	yes	A
X2CrNiMo 17–12–3	1.4432	190	225	490–690	40	30	100	60	60	1 020–1 120	w, a	yes	A
X2CrNiMoN17–13–3	1.4429	295	330	580–800	35	30	100	60	60	1 020–1 120	w, a	yes	A
X3CrNiMo17–13–3	1.4436	205	240	510–710	40	30	100	60	60	1 020–1 120	w, a	yes [f]	A
X2CrNMo18–14–3	1.4435	190	225	490–690	40	30	100	60	60	1 020–1 120	w, a	yes	A
X2CrNiMoN17–13–5	1.4439	285	315	580–800	35	30	100	60	60	1 100–1 140	w, a	yes	C

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Steel grade		Tensile properties at room temperature [a]					Impact properties [a]			Reference heat treatment conditions		Resistance to intergranular corrosion	
		Proof strength		Tensile strength	Elongation		Minimum average absorbed energy *KV2* J						
		*R*p0,2 min	*R*p1,0 min	*R*m [b]	*A* min (%)		at RT		at - 196 °C	Solution temperature [c]	Cooling in [d]	[e]	Method in EN ISO 3651-2:1998
Steel name	Steel number	MPa	MPa	MPa	l	t	l	t	t				
X2CrNiMo18–15–4	1.4438	220	250	490–690	35	30	100	60	60	1 100–1 160	w, a	yes	C
X1CrMoCu31–27–4	1.4563	215	245	500–750	40	35	120	90	60	1 100–1 160	w, a	yes	C
X1NiCrMoCu25–20–5	1.4539	220	250	520–720	35	30	120	90	60	1 100–1 150	w, a	yes	C
X1CrNiMoCuN20–18–7	1.4547	300	340	650–850	35	30	100	60	60	1 180–1 230	w, a	yes	C
X1NiCrMoCuN25–20–7	1.4529	300	340	600–800	40	40	120	90	60	1 120–1 180	w, a	yes	C

[a] l = longitudinal; t = transverse.

[b] For the delivery conditions W 0, W 1 and W 2 which do not include solution annealing, the upper R_m limit may be exceeded by 70 MPa.

[c] The maximum temperatures are for guidance only.

[d] w = water; a = air; cooling sufficiently rapid.

[e] When tested according to EN ISO 3651-2:1998 (Appropriate method, A or B or C, as indicated) up to the limit temperatures indicated in the last column of Table 8.

[f] In delivery condition. (Normally not fulfilled in the sensitized condition).

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Table 7 — Mechanical properties for wall thicknesses up to 30 mm of austenitic-ferritic steels in the solution annealed condition (+AT) and information about intergranular corrosion

Steel grade		Tensile properties at room temperature [a]				Impact properties [a]			Reference heat treatment conditions		Resistance to intergranular corrosion	
		Proof strength	Tensile strength	Elongation *A* min		Minimum average absorbed energy *KV*2 J						
		*R*p0,2 min	*R*m	(%)		at RT		At - 40 °C	Solution temperature [b]	Cooling in [c]	[d]	Method in EN ISO 3651-2:1998
Steel name	Steel number	MPa	MPa	l	t	l	t	t				
Austenitic-ferritic steels												
X2CrNiMoN22–5-3	1.4462	450	700–920	25	20	120	90	40	1 020–1 100	w, a	yes	B or C
X2CrNiN23–4	1.4362	400	600–820	25	25	120	90	40	950–1 050	w, a	yes	A
X2CrNiMoN25–7-4	1.4410	550	800–1 000	20	20	100	100	40	1 040–1 120	w	yes	B or C
X2CrNiMoCuWN 25-7-4	1.4501	550	800–1 000	20	20	100	100	40	1 080–1 160	w	yes	B or C

[a] l = longitudinal; t = transverse.

[b] The maximum temperatures are for guidance only.

[c] w = water; a = air; cooling sufficiently rapid.

[d] When tested according to EN ISO 3651-2:1998 (Appropriate method, A or B or C, as indicated) up to 250 °C.

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Table 8 — Minimum proof strength Rp0,2 and Rp1,0 at elevated temperatures for wall thicknesses up to 60 mm of austenitic steels in the solution annealed condition (+AT) and guideline for the limit temperature for intergranular corrosion

Steel grade		*R*p0,2 min MPa at a temperature (°C) of											*R*p1,0 min MPa at a temperature (°C) of											Limit temp.[a]
Steel name	Steel number	50	100	150	200	250	300	350	400	450	500	550	50	100	150	200	250	300	350	400	450	500	550	°C
X2CrNi18–9	1.4307	165	147	132	118	108	100	94	89	85	81	80	200	181	162	147	137	127	121	116	112	109	108	350
X2CrNi19–11	1.4306	165	147	132	118	108	100	94	89	85	81	80	200	181	162	147	137	127	121	116	112	109	108	350
X2CrNiN18–10	1.4311	255	205	175	157	145	136	130	125	121	119	118	282	240	210	187	175	167	161	156	152	149	147	400
X5CrNi18–10	1.4301	180	157	142	127	118	110	104	98	95	92	90	218	191	172	157	145	135	129	125	122	120	120	300
X6CrNiTi18–10	1.4541	190	176	167	157	147	136	130	125	121	119	118	222	208	196	186	177	167	161	156	152	149	147	400
X6CrNiNb18–10	1.4550	195	177	167	157	147	136	130	125	121	119	118	232	211	196	186	177	167	161	156	152	149	147	400
X2CrNiMo17–12–2	1.4404	182	166	152	137	127	118	113	108	103	100	98	217	199	181	167	157	145	139	135	130	128	127	400
X5CrNiMo17–12–2	1.4401	193	177	162	147	137	127	120	115	112	110	108	230	211	191	177	167	156	150	144	141	139	137	300
X6CrNiMoTi17–12–2	1.4571	202	185	177	167	157	145	140	135	131	129	127	232	218	206	196	186	175	169	164	160	158	157	400
X2CrNiMo 17–12–3	1.4432	182	166	152	137	127	118	113	108	103	100	98	217	199	181	167	157	145	139	135	130	128	127	400
X2CrNiMoN17–13–3	1.4429	260	211	185	167	155	145	140	135	131	129	127	290	246	218	198	183	175	169	164	160	158	157	400
X3CrNiMo17–13–3	1.4436	195	177	162	147	137	127	120	115	112	110	108	228	211	191	177	167	156	150	144	141	139	137	300
X2CrNiMo18–14–3	1.4435	180	165	150	137	127	119	113	108	103	100	98	217	200	180	165	153	145	139	135	130	128	127	400
X2CrNiMoN17–13–5	1.4439	260	225	200	185	175	165	155	150	-	-	-	290	255	230	210	200	190	180	175	-	-	-	400
X2CrNiMo18–15–4	1.4438	200	172	157	147	137	127	120	115	112	110	108	232	206	188	177	167	156	148	144	140	138	136	400
X1NiCrMoCu31–27–24	1.4563	210	190	175	160	155	150	145	135	125	120	115	240	220	205	190	185	180	175	165	155	150	145	400
X1NiCrMoCu25–20–5	1.4539	216	205	190	175	160	145	135	125	115	110	105	244	235	220	205	190	175	165	155	145	140	135	400

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Steel grade		*R*p0,2 min MPa at a temperature (°C) of											*R*p1,0 min MPa at a temperature (°C) of											Limit temp.[a]
Steel name	Steel number	50	100	150	200	250	300	350	400	450	500	550	50	100	150	200	250	300	350	400	450	500	550	°C
X1CrNiMoCuN20–18–7	1.4547	267	230	205	190	180	170	165	160	153	148	-	306	270	245	225	212	200	195	190	184	180	-	400
X1NiCrMoCuN25–20–7	1.4529	270	230	210	190	180	170	165	160	130	120	105	310	270	245	225	215	205	195	190	160	150	135	400

[a] Up to these temperatures, the material should, within 100 000 h, not have changed so as to show susceptibility to intergranular corrosion, when tested in conformity with EN ISO 3651-2. See also Table 6.

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Table 9 — Minimum proof strength Rp0,2 at elevated temperatures for wall thicknesses up to 30 mm of austenitic-ferritic steels in the solution annealed condition (+AT) and guideline for the limit temperature for intergranular corrosion

Steel grade		*R*p0,2 min MPa Temperature °C				
Steel name	**Steel number**	**50**	**100**	**150**	**200**	**250** [a]
Austenitic-ferritic steels						
X2CrNiMoN22–5-3	1.4462	415	360	335	310	295
X2CrNiN23–4	1.4362	370	330	300	280	265
X2CrNiMoN25–7-4	1.4410	502	450	420	400	380
X2CrNiMoCuWN25–7-4	1.4501	502	450	420	400	380

[a] Up to this temperature, the material should, within 100 000 h, not have changed so as to show susceptibility to intergranular corrosion, when tested in conformity with EN ISO 3651-2. See also Table 7.

8.4 Corrosion resistance

The information given in Tables 6 and 7 refers to the resistance of the steels to intergranular corrosion when tested according to EN ISO 3651-2:1998 to the indicated method A or B or C. Guideline values for the temperature limit for susceptibility to intergranular corrosion are indicated in Tables 7, 8 and 9.

Option 11*: A test for the resistance to intergranular corrosion shall be carried out.*

If other specific corrosion tests are required, they shall be agreed at the time of enquiry and order.

8.5 Appearance and internal soundness

8.5.1 Appearance

8.5.1.1 The tubes shall be free from external and internal surface defects that can be established by visual inspection of the surfaces that are accessible without the use of special equipment.

8.5.1.2 The internal and external surface finish of the tubes shall be typical of the manufacturing process and, where applicable, the heat treatment employed. Normally the finish and surface condition shall be such that any surface imperfections requiring dressing can be identified.

8.5.1.3 It shall be permissible to dress, only by grinding or machining, surface imperfections provided that, after doing so, the wall thickness in the dressed area is not less than the specified minimum thickness. All dressed areas shall blend smoothly into the contour of the tube.

8.5.1.4 Surface imperfections which encroach on the specified minimum wall thickness shall be considered defects and tubes containing these shall be deemed not to conform to this document.

8.5.1.5 Repairs to the weld are permitted. Any repairs shall be carried out by qualified welders according to a qualified welding procedure specification and all repaired areas shall be non-destructively tested according to 11.11. For tubes welded with or without filler metal, weld repair may be made with the addition of compatible filler metal.

Option 12*: Repair welding is only permitted with the agreement of the purchaser. The content of the repair including the relevant documentation (see* 7.2.2*) shall be agreed.*

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8.5.2 Internal soundness

8.5.2.1 General

The weld area shall be free from cracks, lack of fusion and lack of penetration.

8.5.2.2 Leak-tightness

The tubes shall pass a hydrostatic test (see 11.8.1) or eddy current test (see 11.8.2) or a test according to another agreed method, to verify leak-tightness.

Unless Option 13 is specified, the choice of the test method is at the discretion of the manufacturer.

Option 13*: The test method for verification of leak-tightness according to* 11.8.1 or 11.8.2 *is specified by the purchaser.*

8.5.2.3 Non-destructive testing

The full length of the weld seam of tubes shall be submitted to a non-destructive testing for the detection of imperfections according to 11.11.1.

Option 14*: The tubes of test category 2 shall be submitted to non-destructive testing for the detection of laminar imperfections at the tube ends according to* 11.11.2.

Option 15*: The edges of strip or plate used for the manufacture of tubes of test category 2 shall be submitted to non-destructive testing for the detection of laminar imperfections according to* 11.11.3.

All NDT activities shall be carried out by qualified and competent level 1,2 and/or 3 personnel authorized to operate by the employer.

The qualification of NDT personnel shall be according to ISO 11484:2019 (see Note 2)

It is required that the level 3 personnel be certified according to EN ISO 9712:2012 (see Note 2). The operating authorization issued by the employer shall be according to a written procedure. All NDT operations shall be authorized by a level 3 NDT individual approved by the employer.

NOTE 1 The definition of level 1, 2 and 3 can be found in appropriate standards, e.g. EN ISO 9712 and ISO 11484.

NOTE 2 Other standards are accepted by agreement.

NOTE 3 When tubes are being used for pressure equipment in categories III and IV of European Legislation for pressure equipment, the personnel will be approved by a third-party organization.

8.6 Straightness

The deviation from straightness of any tube length L shall not exceed 0,001 5 L. Deviations from straightness over any one meter length shall not exceed 3 mm.

8.7 Preparation of ends

Tubes shall be delivered with square cut ends. The ends shall be free from excessive burrs.

Option 16*: Tubes with wall thickness ≥ 3,2 mm shall be delivered with bevelled ends (see* Figure 1*). The bevel shall have an angle α of* $(30\,^{+5}_{0})°$ *with a root face C of 1,6 mm ± 0,8 mm, except that for wall thickness greater than 20 mm, an agreed alternative bevel may be specified.*

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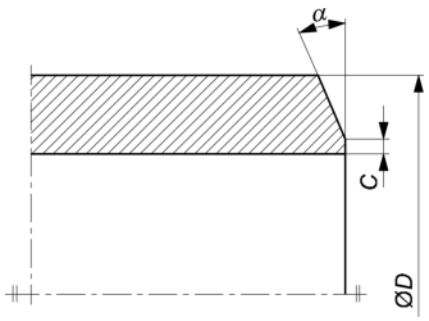

Key

D outside diameter

α bevel angle

C root face of bevelled end

Figure 1 — Tube end bevel

8.8 Dimensions, masses and tolerances

8.8.1 Outside diameter and wall thickness

Tubes shall be ordered by outside diameter D and wall thickness T. Preferred outside diameters D and wall thicknesses T are given in EN ISO 1127:1996.

8.8.2 Mass

For the calculation of mass per unit length the density values given in EN 10088-1:2014 shall be used.

8.8.3 Lengths

Unless Option 17 is specified, the tubes may be delivered in random lengths. The delivery range shall be agreed at the time of enquiry and order.

***Option 17**: The tubes shall be delivered in exact lengths and the length shall be specified at the time of enquiry and order. The tolerances on these lengths shall conform to* 8.8.4.4.

8.8.4 Tolerances

8.8.4.1 Tolerance on outside diameter and on wall thickness

The diameter and the wall thickness of the tubes shall be within the relevant tolerance limits given in Table 10. Tolerance classes are according to EN ISO 1127:1996.

Table 10 — Tolerances on outside diameter and wall thickness

Outside diameter *D* mm	Tolerance on outside diameter *(D)*		Tolerance on wall thickness *T*	
	Tolerance class	Permissible deviation	Tolerance class	Permissible deviation
D ≤ 168,3	D3	±0,75 % or ± 0,3 mm whichever is the greater	T3	±10 % or ± 0,2 mm whichever is the greater
	D4 [a]	±0,5 % or ± 0,1 mm whichever is the greater		
D > 168,3	D2	±1,0 %		

[a] ***Option 18:*** *Tolerance class D4 is specified.*

8.8.4.2 Height of the weld seam

The height of the external and internal weld seam shall be within the limits indicated in Table 11.

Table 11 — Maximum height of the weld seam

Dimensions in millimetres

Route (according to Table 1)	Weld condition	Maximum height of the weld seam	
		***T* ≤ 8**	***T* > 8**
01, 05, 06 and 07	As welded	0,10 *T* + 0,5	*T*/6 [a] [b]
02 and 04	Welded, outside ground for *D* ≤ 114,3	0,06 *T* + 0,3	-
	Welded, outside ground for *D* > 114,3	0,05 *T* + 0,5	*T*/10
02, 03 and 04	Welded, bead worked	0,15	-

[a] ***Option 28:*** Different values for the Maximum height of the weld seam are to be agreed in the purchase order.

[b] ***Option 29:*** maximum 4 mm

8.8.4.3 Radial offset of plate or strip edges at the weld

The radial offset of the abutting plate or strip edges shall be within 10 % of the specified wall thickness.

8.8.4.4 Tolerances on exact lengths

The tolerances for exact lengths shall be as given in Table 12.

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Table 12 — Tolerances on exact lengths

Length *L* (mm)	**Tolerance on exact length** (mm)
$L \leq 6\,000$	+ 5 0
$6\,000 < L \leq 12\,000$	+ 10 0
$L > 12\,000$	+ by agreement 0

8.8.4.5 Out of roundness

The out-of-roundness (0) shall be calculated using the following formula:

$$O = \frac{D_{\max} - D_{\min}}{D} \times 100 \quad (1)$$

where

O is the out-of-roundness, in %;

$D_{\max}$, $D_{\min}$ is the maximum and minimum outside diameter, measured in the same plane, in mm;

D is the specified outside diameter, in mm.

For tubes of outside diameter $D \leq 406{,}4$ mm, out-of-roundness, shall be included in the limits of the diameter tolerances.

For tubes of outside diameter $D > 406{,}4$ mm and with $D/T \leq 100$, out-of-roundness shall not exceed 2 %.

For tubes with a D/T ratio > 100 the values for out-of-roundness shall be agreed at the time of enquiry and order.

9 Inspection

9.1 Type of inspection

Conformity to the requirements of the order, for tubes according to this document, shall be verified by specific inspection.

When an inspection document 3.1 is specified, the material manufacturer shall state in the confirmation of the order whether they are operating according to a “quality-assurance system”, certified by a Competent Body established within the EU, and having undergone a specific assessment for materials and processes relevant to manufacture of welded tubes, including welding procedure approvals, welder/weld operator approval and NDT operator approval.

9.2 Inspection documents

9.2.1 Types of inspection documents

Unless option 19 is specified, an inspection certificate 3.1, according to EN 10204:2004, shall be issued.

Option 19*: An inspection certificat*e 3.2 a*ccording to* EN 10204 *shall be issued.*

If an inspection certificate 3.2 is specified, the name and address of the organization or person who is to carry out the inspection and produce the inspection document shall be notified.

In the case of the inspection certificate 3.2 it shall be agreed which party shall issue the certificate.

Document 3.1 and 3.2 shall be validated according to requirements in EN 10204:2004, 4.1 and 4.2.

9.2.2 Content of inspection documents

The content of the inspection documents shall be according to EN 10168:2004.

In all types of inspection documents a statement on the conformity of the products delivered with the requirements of the specification and the order shall be included.

The inspection certificate shall contain the following codes and information:

— A commercial transactions and parties involved;

— B description of products to which the inspection document applies;

— C01-C03 location of the samples and direction of the test pieces and testing temperature;

— C10-C13 tensile test;

— C40-C43 impact test if applicable;

— C60-C69 other tests (e.g. flattening);

— C71-C92 chemical composition on cast analysis (product analysis if applicable);

— D01 marking and identification, surface appearance, shape and dimensional properties;

— D02-D99 statement confirming that leak tightness test and NDT of the weld seam has been carried out, and the test results are satisfactory;

— Reference to welding procedure approval;

— Reference to welder and or welding operator approval;

— Reference to non-destructive testing operators approval;

— Z validation.

In addition for inspection document 3.1 the manufacturer shall state the references to the certificate (see 9.1) of the appropriate “quality-assurance system”, if applicable.

9.3 Summary of inspection and verification testing

The tubes shall be inspected and tested according to test category 1 or test category 2 as specified at the time of enquiry and order (see 6.1).

Inspection and testing shall be carried out as stated in Table 13.

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10 Sampling

10.1 Test unit

A test unit shall comprise tubes of the same specified diameter and wall thickness, the same steel grade, the same cast, the same manufacturing process, subjected to the same finishing treatment in a continuous furnace or heat treated in the same furnace charge in a batch-type furnace. The number of tubes, in random manufacturing lengths[7] per test unit shall be max 100 with a total length of max. 1 800 m whichever is the lesser.

Table 13 — Summary of inspection and testing

Type of inspection and test		Frequency of testing Test category 1	Test category 2	Refer to	Testing standard
Mandatory tests	Cast analysis	one per cast	one per cast	11.1	
	Tensile test at room temperature	one per test unit	two per test unit	11.2.1	EN ISO 6892-1:2019
	Flattening test [a] or	one per test unit	each tube [c]	11.4.2	EN ISO 8492:2013
	Ring tensile test [a] or			11.4.3	EN ISO 8496:2013
	Drift expanding test [a] or			11.4.4	EN ISO 8493:2004
	Ring expanding test [a] or			11.4.5	EN ISO 8495:2013
	Weld bend test			11.5	EN ISO 5173:2010
	Leak tightness test	each tube	each tube	11.8	
	a) Hydrostatic test			11.8.1	
	b) Eddy current test			11.8.2	EN ISO 10893-1:2011[1]
	Dimensional inspection			11.9	
	Visual examination			11.10	
	NDT of the weld seam [b]			11.11	
	c) Eddy current				EN ISO 10893-2:2011[2]
	d) Ultrasonic test				EN ISO 10893-11:2011[6]
	e) Radiographic test				EN ISO 10893-6:2019
	f) Digital radiographic testing				EN ISO 10893-7:2019
	Material identification			11.12	
Optional tests	Product analysis (Option 6)	one per cast	one per cast	11.1	
	Tensile test at elevated temperature (Option 9)	as agreed upon or one per cast and same heat treatment condition	as agreed upon or one per cast and same heat treatment condition	11.2.2	EN ISO 6892-2
	Tensile test of the weld (Option 20)			11.3	EN ISO 6892-1
	Impact test at room temperature (Option 8)			11.6	EN ISO 148-1
	Impact test at low temperature (Option 10)			11.6	EN ISO 148-1
	Intergranular corrosion test (Option 11)			11.7	EN ISO 3651-2
	Wall thickness measurement away from tube ends (Option 22)	each tube	each tube	11.9	

7 The random manufacturing lengths may differ from the delivery length (see 8.3.3)

Type of inspection and test		Frequency of testing Test category 1	 Test category 2	Refer to	Testing standard
	Ultrasonic testing of strip and plate edges for detection of laminar imperfections (Option 15)	-		11.11	EN ISO 10893-9
	Ultrasonic testing for laminar imperfections (Option 14)	-		11.11	EN ISO 10893-8
[a] Testing method shall be in accordance with Table 14. [b] Testing method to consider footnote [a] in Table 16. [c] For continuously welded tubes, one test from one end of each manufacturing length (maximum 18 m).					

10.2 Preparation of samples and test pieces

10.2.1 Selection and preparation of samples for product analysis

Samples for product analysis shall be taken from the test pieces or samples for mechanical testing or from the whole thickness of the tube at the same location as for the mechanical test samples, according to EN ISO 14284:2002.

10.2.2 Location, orientation and preparation of samples and test pieces for mechanical tests

10.2.2.1 General

Samples and test pieces shall be taken at the tube ends and according to EN ISO 377:2017.

For tubes welded from plate or sheet with outside diameter ≥ 600 mm, specimens may be taken from a work sample from plate or sheet in the same condition of the final pipe.

10.2.2.2 Test pieces for the tensile test of the base material

The test pieces for the tensile test of the base material at room temperature shall be prepared according to EN ISO 6892-1:2019. The test pieces for the tensile test of the base material at elevated temperature shall be prepared according to EN ISO 6892-2:2018.

At the manufacturer's discretion:

— for tubes with an outside diameter $D \leq 219{,}1$ mm, the test piece shall be either a full tube section or a strip section and be taken in a direction longitudinal to the axis of the tube;

— for tubes with an outside diameter $D > 219{,}1$ mm and ≤ 508 mm, the test piece shall be taken in a direction either transverse, where possible, or longitudinal to the axis of the tube. The test piece shall be either a flattened strip or an unflattened and machined round bar specimen;

— for tubes with an outside diameter $D > 508$ mm the test piece shall be taken in a direction transverse to the axis of the tube;

Strip sections and round bar specimens shall be taken from the side opposite the weld.

10.2.2.3 Test pieces for the tensile test of the weld

The test piece for the tensile test of the weld shall be taken transverse to the weld with the weld at the centre of the test piece. The test piece shall be a strip section with the full thickness of the tube and may be flattened; the weld bead may be removed.

Option 20*: For tubes with an outside diameter greater than 219,1 mm a transverse tensile test on the weld is carried out.*

10.2.2.4 Test pieces for the flattening, ring tensile, drift expanding and ring expanding tests

The test piece for the flattening, ring tensile, drift expanding and ring expanding tests shall consist of a full tube section according to EN ISO 8492:2013, EN ISO 8496:2013 or EN ISO 8493:2004 or EN ISO 8495:2013 respectively.

10.2.2.5 Test pieces for weld bend test

The test pieces for the weld bend test at the root and face shall be taken and prepared according to EN ISO 5173:2010.

10.2.2.6 Test pieces for the impact test

Three standard Charpy V-notch test pieces shall be prepared according to EN ISO 148-1:2016. If the nominal product thickness is such that standard test pieces cannot be produced without flattening of the section, then test pieces of width less than 10 mm, but not less than 5 mm shall be prepared; the largest obtainable width shall be used.

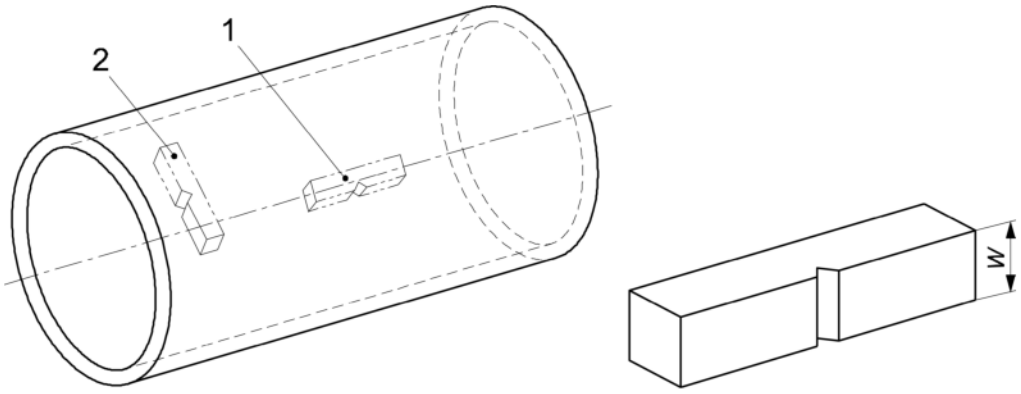
Where test pieces of at least 5 mm width cannot be obtained, the tubes shall not be subjected to impact testing.

The test pieces shall be taken transverse to the tube axis unless D_{min}, as calculated by the following formula, is greater than the specified outside diameter, in which case longitudinal test pieces shall be used:

$$D_{min} = (T-5) + [756{,}25 / (T-5)] \quad (2)$$

For the location of the test pieces see 8.3, Options 8 and 12.

The test pieces shall be taken and prepared such that the axis of the notch is perpendicular to the surface of the tube, see Figure 2.



Key

1 longitudinal test piece

2 transverse test piece

W width of test piece

Figure 2 — Impact test piece orientation

10.2.2.7 Test pieces for the intergranular corrosion test

The test piece for the intergranular corrosion test shall be taken according to EN ISO 3651-2:1998.

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11 Verification test methods

11.1 Chemical analysis

The elements to be determined and reported shall be those specified in Tables 3 and 4. The choice of a suitable physical or chemical analytical method for the analysis shall be at the discretion of the manufacturer. In case of dispute the method used shall be agreed at the time of the enquiry and the order taking into account CEN/TR 10261:2018.

11.2 Tensile test on the base material

11.2.1 At room temperature

The test shall be carried out at room temperature according to EN ISO 6892-1:2019, and the following determined:

— the tensile strength (R_m);

— the 0,2 % proof strength ($R_{p0,2}$) and, where applicable, the 1,0 % proof strength ($R_{p1,0}$);

— the percentage elongation after fracture with a reference to a gauge length (L_0) of 5,65 $\sqrt{S_0}$; if a non-proportional test piece is used, the percentage elongation value shall be converted to the value for a gauge length L_0 = 5,65 $\sqrt{S_0}$ using the conversion Tables given in EN ISO 2566-2:1999.

11.2.2 At elevated temperature

The test shall be carried out in accordance with EN ISO 6892-2:2018 at the temperature agreed at the time of enquiry and order (see 6.2) and the 0,2 % proof strength ($R_{p0,2}$) and, where applicable, the 1,0 % proof strength ($R_{p1,0}$) shall be determined.

11.3 Transverse tensile test on the weld

The test shall be carried out in accordance with EN ISO 6892-1:2019 at room temperature and the 0,2 % proof strength ($R_{p0,2}$) shall be determined.

11.4 Technological tests

11.4.1 General

Depending on the tube dimensions one of the tests given in Table 14 shall be carried out.

Table 14 — Technological tests

Outside diameter *D*	Wall thickness T mm			
mm	< 2	≥ 2 ≤ 16	> 16 ≤ 40	> 40
≤ 18	Flattening test [a] [b]	Flattening test [a] [b]	—	—
18 < D ≤ 150	Flattening test [a] [b]	Ring expanding test [b]	Flattening test [a] [d]	—
> 150	Ring tensile test [c]	Ring tensile test [c] [d]	Ring tensile test [c] [d]	Flattening test [a, d, e]

[a] Weld alternatively in the horizontal position (3 o'clock position) or vertical position (12 o`clock position).

[b] This test may, at the discretion of the manufacturer, be replaced by drift expanding test.

[c] This test may, at the discretion of the manufacturer, be replaced by flattening test.

[d] This test may, at the discretion of the manufacturer, be replaced by weld bend test.

[e] This test may, at the discretion of the manufacturer, be replaced by non-destructive testing of both tube ends as described in 11.11.2 - Option 14.

11.4.2 Flattening test

The test shall be carried out according to EN ISO 8492:2013.

The tube section shall be flattened in a press until the distance *H* between the platens reaches the value given by the following formula:

$$H = \frac{1 + C}{C + T / D} \times T \tag{3}$$

where

H is the distance between platens, in mm, to be measured under load;

D is the specified outside diameter, in mm;

T is the specified wall thickness, in mm;

C is the deformation factor, which is 0,07 for austenitic-ferritic steel and 0,09 for austenitic steel.

After testing, the test piece shall be free from cracks or breaks. However, slight incipient cracks at its edges shall not be regarded as justification for rejection.

11.4.3 Ring tensile test

The test shall be carried out according to EN ISO 8496:2013.

The tube section shall be subjected to strain in the circumferential direction until fracture occurs.

After fracture the test pieces shall not show any visible cracks without the use of magnifying aids (excluding the fracture point).

11.4.4 Drift expanding test

The test shall only be carried out for tubes having an outside diameter $D < 150$ mm and a wall thickness $T < 10$ mm. The test shall be carried out according to EN ISO 8493:2004.

The tube section shall be expanded with a 60° conical tool until the % increase in outside diameter *D* shown in Table 15 is reached.

After testing, the test piece (excluding the fracture point) shall be free from cracks or breaks. However, slight incipient cracks at its edges shall not be regarded as justification for rejection.

Table 15 — Drift expanding test requirements

d/D [a]	% increase in OD
≤ 0,6	9
> 0,6 ≤ 0,8	15
> 0,8	17
[a] d = D - 2T	

11.4.5 Ring expanding test

The test shall be carried out according to EN ISO 8495:2013.

The tube section shall be expanded with a conical tool until it breaks. If an expansion of 40 % of the inside diameter for austenitic steel and of 30 % for austenitic-ferritic steel is reached the test may be considered as finished.

The surface outside the fracture zone shall excluding the fracture point be free from cracks or breaks. However, slight incipient cracks at its edges shall not be regarded as justification for rejection.

11.5 Weld bend test

The test shall be carried out according to EN ISO 5173:2010 using a mandrel of a diameter of 3T. After testing the test piece shall show no cracks or flaws but slight premature failure at its edges shall not be regarded as a justification for rejection.

11.6 Impact test

11.6.1 If agreed at the time of enquiry and order the impact test shall be carried out according to EN ISO 148-1:2016 using a 2 mm striker at the temperature specified (see 6.2, Option 8 or 10)

11.6.2 The mean value of the three standard Charpy V notch test pieces shall meet the requirements given in Table 6 or Table 7. One individual value may be below the specified value, provided that it is not less than 70 % of that value.

11.6.3 If the width (W) of the test piece is less than 10 mm, the measured impact energy (KV_p) shall be converted to impact energy (KV_c) using the following Formula (4):

$$KV_c = \frac{10 \times KV_p}{W} \quad (4)$$

where

KV_c is the calculated impact energy, in J;

KV_p is the measured impact energy, in J;

W is the width of the test piece, in mm.

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The calculated impact energy KV_c shall comply with the requirements given in 11.6.2.

11.6.4 If the requirements of 11.6.2 are not met, then an additional set of three standard Charpy V notch test pieces may be taken, by agreement at the time of the enquiry and the order, from the same sample and tested. To consider the test unit as conforming, after testing the second set, the following conditions shall be satisfied simultaneously:

— the average value of six tests shall be equal to or greater than the specified minimum average value;

— not more than two of six individual values may be lower than the specified minimum average value;

— not more than one of the six individual values may be lower than 70 % of the specified minimum average value.

11.6.5 The dimensions in millimetres of test pieces, the measured impact energy values and the resulting average value shall be reported.

11.7 Intergranular corrosion test

The intergranular corrosion test shall be carried out according to EN ISO 3651-2:1998 to the specified method (A or B or C).

11.8 Leak tightness test

11.8.1 Hydrostatic test

The hydrostatic test shall be carried out at a test pressure of 70 bar[8] or at a test pressure calculated using the following Formula (5), whichever is lower:

$$P = 20\frac{S \times T}{D} \tag{5}$$

where

P is the test pressure, in bar;

D is the specified outside diameter, in mm;

T is the specified wall thickness, in mm;

S is the stress, in MPa, corresponding to 70 % of the specified minimum proof strength (see Tables 6 and 7) for the steel grade concerned.

The test pressure shall be held for not less than 5 s for tubes with an outside diameter $D \leq 457$ mm and for not less than 10 s for tubes with an outside diameter $D > 457$ mm.

The tube shall withstand the test without showing leakage.

NOTE This hydrostatic leak-tightness test is not a strength test.

***Option 21**: A test pressure different from that specified in* 11.8.1 *and corresponding to a stress below 90 % of the specified minimum proof strength ($R_{p0,2}$) (see* Tables 6 and 7*) for the steel grade concerned is specified.*

11.8.2 Eddy current test

The test shall be carried out according to EN ISO 10893-1:2011[1].

[8] 1 bar = 100 kPa

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11.9 Dimensional inspection

Specified dimensions, including straightness, shall be verified.

The outside diameter shall be measured at the tube ends. For tubes with a $D \geq 168{,}3$ mm, the diameter may be measured using a circumference tape.

Unless Option 22 is specified, the wall thickness shall be measured at both tube ends.

***Option 22**: The wall thickness shall be measured away from the tube ends according to an agreed procedure.*

11.10 Visual examination

Tubes shall be visually examined to ensure conformity to the requirements of 8.5.1.

11.11 Non-destructive testing

11.11.1 The full length of the weld seam of tubes shall be tested in accordance with the testing method and acceptance level given in Table 16.

Table 16 — Testing method and acceptance level for non-destructive testing of weld seam

Testing method [a]	Acceptance level for	
	Test category 1	Test category 2
EN ISO 10893-2:2011[2] [b]	E1H or E2	E1H or E2
EN ISO 10893-10:2011[5]	U3, sub-category C	U2, sub-category C
EN ISO 10893-11:2011[6] [c]	U3	U2
EN ISO 10893-6:2019 [d]	image class A	
EN ISO 10893-7:2019 [e]	image class A	image class A

[a] Unless Option 23 is specified, the test method used shall be at the discretion of the manufacturer. ***Option 23:** The non-destructive inspection method has to be required at the time of the enquiry and the order.*

[b] Only for tubes with wall thickness not greater than 6 mm.

[c] For submerged arc-welded tubes.

[d] ***Option 24:** The image quality class B of* EN ISO 10893-6:2019 *shall be applied for the radiographic inspection of the weld seam.*

[e] **Option 27**: Image quality class B as per EN ISO 10893-7:2019 shall be valid for the digital radiographic testing of the weld.

Weld seam at the tube ends not automatically tested shall either be subjected to manual/semi-automatic ultrasonic testing according to EN ISO 10893-10:2011[6] to acceptance level U3, sub-category C for test category 1 and U2, sub-category C for test category 2 or be cropped off.

11.11.2 If Option 14 (see 8.5.2.3) is specified, the tubes of test category 2 shall be submitted to an ultrasonic testing for the detection of the laminar imperfections at the tube ends according to EN ISO 10893-8:2011[3].

11.11.3 If Option 15 (see 8.5.2.3) is specified, the strip/plate edges used for the manufacture of tubes of test category 2 shall be submitted to an ultrasonic testing for the detection of laminar imperfections according to EN ISO 10893-9:2011[4] to acceptance level U2.

11.12 Material identification

Each tube shall be tested by an appropriate method to ensure that the correct grade is being supplied.

11.13 Retests, sorting and reprocessing

See EN 10021:2006.

12 Marking

12.1 Marking to be applied

Depending on the size of the tubes, the following marking shall either be applied on a label attached to the bundle or the box of tubes, or be marked indelibly on each tube at least at one end.

The marking shall include the following information:

— the manufacturer's name or trade mark;

— the dimension of the tubes;

— the number of this document and the steel name (or number) and the test category TC 1 or TC 2 (see 5.2);

— the cast number or a code number;

— the mark of the inspection representative;

— an identification number (e.g. order or item/tube number) which permits the correlation of the product or delivery unit to the related document.

— the symbol identifying the delivery condition (see Table 2).

Example of marking:

EXAMPLE X - 168,3 X 4,5 - EN 10217-7 - X5CrNi18–10 - TC1 - W1 - Y - Z1 - Z2

where

X is the manufacturer’s mark;

TC1 is the designation of the test category 1;

W1 is the identification of the delivery condition as welded;

Y is the cast number or a code number;

Z1 is the mark of the inspection representative;

Z2 is the identification number.

12.2 Additional marking

Option 25*: Additional marking, as agreed upon at the time of enquiry and order, shall be applied.*

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13 Handling and packaging

The tubes shall be protected from carbon steel strapping, which shall not come into contact with the tubes.

***Option 26**: A special protection, as specified at the time of enquiry and order, shall be applied.*

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Annex A
(informative)

Technical changes from the previous edition

A.1 Introduction

This informative annex is intended to guide the user to places where significant technical changes have been introduced into the previous edition of this International Standard. Editorial changes are not included in this annex. References refer to the previous edition.

While this annex is intended to be comprehensive, users should satisfy themselves that they fully understand the changes which have been made. The user is ultimately responsible for recognizing any differences between this edition and the previous edition of the document.

A.2 Technical changes

— 2 Normative references dated

— 6.2 Options

— 6.3.2 Example 2

— 7.2.2 Text and Table 1

— 7.2.3 Table 2

— 8.2.2 Table 3

— 8.3.1

— 8.3.2

— 8.3.3 Text, Table 6 and Table 8

— 8.4

— 8.5.1.1

— 8.5.1.5

— 8.5.2.2

— 8.5.2.3

— 8.7 Figure 1

— 8.8.3

— 8.8.4.1 Table 10

— 8.8.4.2 Table 11

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— 9.1

— 9.2.1

— 10.1 Table 13

— 10.2.2.1

— 10.2.2.3

— 10.2.2.6 Figure 2

— 11.4.1 Table 14

— 11.4.4 text, Table 15

— 11.6

— 11.8.1

— 11.9

— 11.11.1 Table 16

— 11.11.2

— 11.11.3

— 12.1

— 12.2

— 13

— Table ZA.1

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Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of Directive 2014/68/EU aimed to be covered

This European Standard has been prepared under a Commission's standardization request M/071 to provide one voluntary means of conforming to Essential Requirements of Directive 2014/68/EU.

Once this standard is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of Directive 2014/68/EU, and associated EFTA regulations.

Table ZA.1 — Correspondence between this European Standard and Annex 1 of Directive 2014/68/EU

Requirements of Directive 2014/68/EU	Clauses/subclauses of this EN	Remarks/Notes
4.1a	8.3	Appropriate material properties
4.1c	8.2 and 8.3.2 Table 3, Table 4, Table 8 and Table 9	Ageing
4.1d	7.2	Suitable for the processing procedures
4.3	Clause 9	Inspection documentation
7.5	8.3.3 Table 6 and Table 7	Material characteristics

WARNING 1 — Presumption of conformity stays valid only as long as a reference to this European Standard is maintained in the list published in the Official Journal of the European Union. Users of this standard should consult frequently the latest list published in the Official Journal of the European Union.

WARNING 2 — Other Union legislation may be applicable to the product(s) falling within the scope of this standard.

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Bibliography

ISO/TR 25901-3:2016, *Welding and allied processes — Vocabulary — Part 3: Welding processes*