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Stainless steel bars for pressure purposes

bsi.

National foreword

This British Standard is the UK implementation of EN 10272:2016. It supersedes BS EN 10272:2007 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/107, Steels for Pressure Purposes.

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Stainless steel bars for pressure purposes

Barres en acier inoxydable pour appareils à pression

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (EN 10272:2016) has been prepared by Technical Committee ECISS/TC 107 “Steels for pressure purposes”, the secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by January 2017, and conflicting national standards shall be withdrawn at the latest by January 2017.

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

This document supersedes EN 10272:2007.

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(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

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

Introduction

The European Committee for Standardization (CEN) draws attention to the fact that it is claimed that compliance with this document may involve the use of patents concerning two steel grades.

Outokumpu OYJ

FI – 02200 Espoo, Finland

for steel grades 1.4162 and 1.4662

1 Scope

This European Standard specifies the technical delivery conditions for hot and cold formed stainless steel bars for the construction of pressure equipment supplied in accordance with one of the process routes and surface finishes listed in Table 6.

The general technical delivery conditions in EN 10021 also apply.

NOTE Once this European Standard is published in the Official Journal of the European Union (OJEU) under Directive 2014/68/EU, presumption of conformity to the Essential Safety Requirements (ESRs) of Directive 2014/68/EU is limited to technical data of materials in this European Standard 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.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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, *General technical delivery conditions for steel products*

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

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

EN 10052:1993, *Vocabulary of heat treatment terms for ferrous products*

EN 10058, *Hot rolled flat steel bars for general purposes — Dimensions and tolerances on shape and dimensions*

EN 10059, *Hot rolled square steel bars for general purposes — Dimensions and tolerances on shape and dimensions*

EN 10060, *Hot rolled round steel bars for general purposes — Dimensions and tolerances on shape and dimensions*

EN 10061, *Hot rolled hexagon steel bars for general purposes — Dimensions and tolerances on shape and dimensions*

EN 10079:2007, *Definition of steel products*

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 10221:1995, *Surface quality classes for hot-rolled bars and rods — Technical delivery conditions*

EN 10278, *Dimensions and tolerances of bright steel products*

EN 10308, *Non destructive testing — Ultrasonic testing of steel bars*

EN ISO 148-1:2010, *Metallic materials — Charpy pendulum impact test — Part 1: Test method (ISO 148-1:2009)*

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

EN ISO 3651-2, *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)*

EN ISO 6506-1, *Metallic materials - Brinell hardness test — Part 1: Test method (ISO 6506-1)*

EN ISO 6892-1:2009, *Metallic materials - Tensile testing — Part 1: Method of test at room temperature (ISO 6892-1:2009)*

EN ISO 6892-2:2011, *Metallic materials — Tensile testing — Part 2: Method of test at elevated temperature (ISO 6892-2:2011)*

EN ISO 14284, *Steel and iron — Sampling and preparation of samples for the determination of chemical composition (ISO 14284)*

ISO 286-1, *Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes — Part 1: Basis of tolerances, deviations and fits*

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

3 Terms and definitions

For the purpose of this document the terms and definitions given in EN 10020:2000, EN 10052:1993, EN 10079:2007, EN 10088-1:2014 and the following apply.

3.1
purchaser
person or organization that orders products in accordance with this European Standard

Note 1 to entry: The purchaser is not necessarily, but may be, a manufacturer of pressure equipment.

3.2
cryogenic temperature
temperature lower than –75 °C used in the liquefaction of gases

4 Dimensions and tolerances on dimensions

The nominal dimensions and tolerances on dimensions shall be agreed at the time of enquiry and order with reference to the relevant dimensional standard EN 10058, EN 10059, EN 10060, EN 10061, EN 10278 or ISO 286-1. If the relevant standard offers the purchaser certain options, e.g. regarding tolerance classes, specific information on these aspects shall additionally be given.

5 Calculation of mass

When calculating the nominal mass from the nominal dimensions the values given in EN 10088-1 shall be used as a basis for the density of the steel concerned.

6 Classification and designation

6.1 Classification

Steels covered by this document are classified according to their metallographic structure into:

— ferritic steels;

— martensitic steels;

— austenitic steels;

— austenitic-ferritic (duplex) steels.

NOTE For more details see EN 10088–1.

6.2 Designation

The steel grades are designated with steel names in accordance with EN 10027-1. The corresponding steel numbers have been allocated in accordance with EN 10027-2.

7 Information to be supplied by the purchaser

7.1 Mandatory information

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

a) quantity to be delivered (mass, length, number of pieces);

b) shape of bar;

c) nominal dimensions of the product;

d) number of the standard specifying the tolerances on dimensions, shape and mass (see Clause 4 and Clause 5);

e) number of this European Standard, i.e. EN 10272;

f) steel name or steel number;

g) delivery condition (see 8.2);

h) process route and surface finish (see Table 6);

i) type of inspection certificate in accordance with EN 10204 (see 9.1.1).

7.2 Options

A number of options are specified in this document and listed below. If the purchaser does not indicate a wish to implement any of these options at the time of enquiry and order, the product shall be supplied in accordance with the basic specifications (see 7.1).

1) specification of the steelmaking process (see 8.1);

2) tighter carbon ranges for martensitic steels (see Table 2, footnote b);

3) specification of a controlled sulfur content (see Table 2, footnote c or Table 3, footnote b);

4) verification of resistance to intergranular corrosion (see 8.4, 9.6.4.1 and Table 14);

5) verification of tensile properties at elevated temperature (see 8.5.2, 9.6.2.2 and Table 14);

6) verification of product analysis (see 9.6.1 and Table 14);

7) test temperature for the tensile test at elevated temperature (see 9.6.2.2);

8) verification of impact properties of austenitic steels at room temperature (see 8.5.1, 9.6.3 and Table 14);

9) verification of impact properties at low temperature (see 8.5.1, 9.6.3 and Table 14);

10) special requirements on surface quality (see 8.6);

11) verification of internal soundness (see 8.7 and Table 14);

12) verification of the hardness (see 9.6.4.2 and Table 14);

13) special marking requirements (see 10.2).

7.3 Example of ordering

10 t rounds of 50 mm diameter, dimensional tolerances as specified in EN 10060 made of the steel grade X5CrNi18-10 (1.4301) as specified in EN 10272 to process route 1D (see Table 6), inspection certificate 3.1 as specified in EN 10204:

10 t rounds EN 10060–50– steel EN 10272–X5CrNi18-10+1D–inspection certificate 3.1

or

10 t rounds EN 10060–50– steel EN 10272–1.4301+1D–inspection certificate 3.1

8 Requirements

8.1 Steelmaking process

Unless a special steelmaking process is agreed at the time of enquiry and order, the steelmaking process shall be at the discretion of the manufacturer.

8.2 Delivery condition

The products shall be supplied in the delivery condition specified in the order by reference to the process route given in Table 6 and, where different alternatives exist; to the treatment conditions given in Tables 7 to 9. Guidelines for further heat treatment are given in Annex A.

8.3 Chemical composition

8.3.1 The cast analysis reported by the steel producer shall apply and comply with the requirements of Tables 2 to 4.

8.3.2 The product analysis shall not deviate from the limiting values for the cast analysis as specified in Tables 2 to 4 by more than the values given in Table 5.

8.4 Corrosion resistance

Referring to resistance to intergranular corrosion as defined in EN ISO 3651-2, for austenitic and austenitic-ferritic steels the specifications in Tables 8 and 9 apply.

NOTE 1 EN ISO 3651-2 is not applicable for testing martensitic steels.

NOTE 2 The corrosion resistance of stainless steels is strongly dependent on the type of environment and can therefore not always be clearly ascertained through laboratory tests. It is therefore advisable to draw on the available experience of the use of the steels.

8.5 Mechanical properties

8.5.1 The tensile properties at room temperature and the impact energy at 20 °C and at low temperatures as specified in Tables 7 to 9 apply for the relevant specified heat treatment condition.

NOTE Austenitic steels are insensitive to brittle fracture in the solution annealed condition because they do not have a pronounced transition temperature, which is characteristic for other steels, they are also useful for application at cryogenic temperatures (see also the NOTE to Tables 8 and 9).

8.5.2 The values in Tables 10 to 12 apply for the 0,2 % and, Table 11 only, additionally for the 1,0 %-proof strength at elevated temperatures. For austenitic steels, the values given in Table 13 apply for the tensile strength at elevated temperatures.

8.5.3 Tensile strength values at elevated temperatures for austenitic-ferritic steels are given for guidance in Table B.1.

8.5.4 For creep rupture strength values of the grade X6CrNi25-20, see Table C.1.

8.6 Surface quality

The surface quality shall be according to agreed surface finish in Table 6.

Slight surface imperfections, inherent in the production process, are permitted.

If more exact requirements for the surface quality are necessary, these shall be agreed at the time of enquiry and order, where appropriate, on the basis of EN 10221:1995.

8.7 Internal soundness

The products shall be sound and free from defects that preclude their intended use.

Where appropriate, requirements together with the conditions for their verification (see 9.6.4.5 and Table 14) may be agreed at the time of enquiry and order.

8.8 Weldability

The choice of the appropriate welding method and parameters are under the responsibility of the equipment manufacturer.

NOTE Inappropriate post weld heat treatment (PWHT) conditions may decrease the mechanical properties. It is therefore recommended that the purchaser seeks, at the time of enquiry and order, the advice of the manufacturer and considers, where appropriate, the verification of the mechanical properties on simulated post weld heat treated samples.

8.9 Physical properties

Data concerning the physical properties of steels covered by this standard are stated in EN 10088-1:2014, Annex E.

9 Inspection

9.1 Types of inspection and inspection documents

9.1.1 The compliance with the requirements of the order shall be checked for products in accordance with this European Standard by specific inspection.

The purchaser shall specify the required type of inspection document (3.1 or 3.2) in accordance with EN 10204:2004.

If an inspection document 3.1 is specified, the manufacturer shall operate a quality assurance system, certified by a competent Body established as legal entity within the European Union and having undergone a specific assessment for materials.

If an inspection certificate 3.2 is specified, the purchaser shall notify the manufacturer of the name and address of the organization or person who is to carry out the inspection and produce the inspection document. It shall also be agreed which party shall issue the certificate.

9.1.2 The inspection certificate 3.1 or 3.2 shall include, in accordance with EN 10168:2004, the following codes and information:

A	Commercial transactions and parties involved;
B	Description of products to which the inspection certificate applies (including tempering temperature in the case of quenched and tempered or tempered products);
C03	Test temperature;
C10-C13	Tensile test at room temperature and, if applicable, at elevated temperatures;
C40-C43	Impact test, if applicable;
C50-C69	Hardness test, if applicable;
C70	Steelmaking process;
C71-C92	Cast analysis and, if applicable, product analysis;
D01	Marking and dimensional checking and, if applicable, verification of the surface quality;
D02-D99	Non-destructive tests, if applicable;
Z	Validation.

9.2 Tests to be carried out

The mandatory and optional tests to be carried out and the extent of testing are specified in Table 14.

9.3 Frequency of testing

The composition and size of test units and the number of samples and test pieces are specified in Table 14.

9.4 Re-tests, sorting and reprocessing

For retests, sorting and reprocessing the requirements of EN 10021 shall apply.

9.5 Sampling and preparation of samples and test pieces

9.5.1 Sampling and sample preparation shall be in accordance with the requirements of EN ISO 14284 and EN ISO 377. In addition, the requirements in 9.5.2 shall apply to the mechanical tests.

9.5.2 The samples shall be taken in accordance with Figures 1 and 2 for the tensile test at room temperature, the impact test and the tensile test at elevated temperatures.

9.5.3 If, following agreement (see 8.2), the products are not to be delivered in a heat treated condition, the samples shall receive a simulated heat treatment prior to the test.

9.6 Test methods

9.6.1 Chemical analysis

Unless otherwise agreed at the time of enquiry and order, the choice of a suitable physical or chemical analytical method for the product analysis shall be at the discretion of the manufacturer. In cases of dispute, the analysis shall be carried out by a laboratory approved by both parties. In this case, the analysis method to be used shall be agreed taking into account the relevant existing European Standards. The list of available documents is given in CEN/TR 10261.

9.6.2 Tensile test

9.6.2.1 The tensile test at room temperature shall be carried out as specified in EN ISO 6892-1:2009, generally using a proportional test piece of gauge length $L_0 = 5{,}65\sqrt{S_o}$ (S_0 = cross-sectional area of the test piece).

The tensile strength, elongation after fracture and 0,2 % proof strength shall be determined and for austenitic steels additionally the 1,0 % proof strength.

9.6.2.2 The tensile test at elevated temperatures if agreed shall be carried as specified in EN ISO 6892-2:2011.

If the tensile test at elevated temperatures is specified, the 0,2 %-proof strength shall be verified for ferritic and martensitic steels. For austenitic-ferritic steels, the 0,2 %-proof strength and the tensile strength shall be determined. In case of austenitic steels, the 0,2 %-proof strength, the 1,0 %-proof strength and the tensile strength shall be determined.

Unless a test temperature for which values are specified has been agreed at the time of enquiry and order, the test shall be carried out 300 °C except for austenitic-ferritic steels for which the test shall be carried out at 250 °C.

9.6.3 Impact test

The impact test shall be carried out in accordance with EN ISO 148-1:2010 at 20 °C (unless otherwise agreed), on V-notched test pieces and by using a 2 mm striker (KV_2).

The average values of a set of three test pieces shall be equal to or greater than the specified value. One individual value may be below the specified value, provided that it is not less than 70 % of that value.

If the above conditions are not satisfied then an additional set of three test pieces may be taken at the discretion of the manufacturer 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:

— average value of six test pieces shall be equal to or greater than the specified value;

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

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

If these requirements are not met the sample product is rejected and retests may be carried out on the remainder of the test unit.

According to the dimensions of the products the size of the impact test piece shall be in accordance with the following table:

Table 1 — Sizes of the impact test pieces

Test piece size	Round cross section	Rectangular cross section
		Product width ≥ 10 mm
	Nominal diameter / Nominal thickness (mm)	
No test required	d < 12	b < 6
Standard test pieces or test pieces with reduced widths at the discretion of the manufacturer. The largest width possible has to be chosen.	12 ≤ d < 15	6 ≤ b < 12
Standard 10 mm x 10 mm test pieces	d ≥ 15	b ≥ 12

Where test pieces with reduced width are used (see Table 1), the minimum impact energy values given shall be reduced in proportion to the cross-sectional area of the test piece.

9.6.4 Other tests

9.6.4.1 If a test on the resistance to intergranular corrosion has been agreed, this shall be carried out in accordance with EN ISO 3651-2.

9.6.4.2 If a Brinell hardness test has been agreed, this shall be carried out in accordance with EN ISO 6506-1.

9.6.4.3 Dimensions and dimensional tolerances of the products shall be tested in accordance with the requirements of the relevant dimensional standards, where available.

9.6.4.4 The surface condition of the products shall be checked for conformity with 8.6 by visual examination without optical aids or, at the discretion of the manufacturer, by an approved automated process.

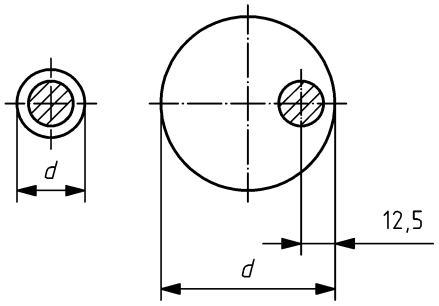
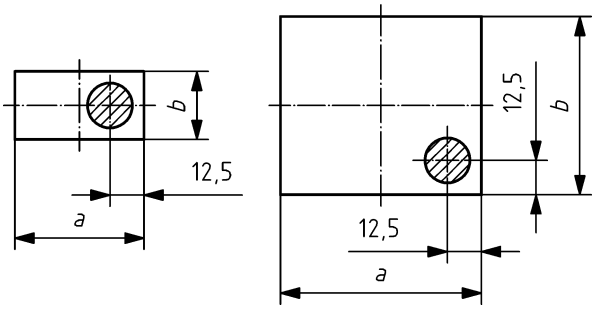
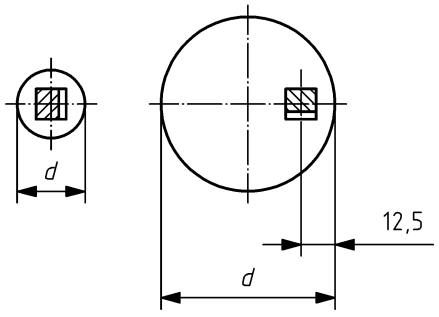
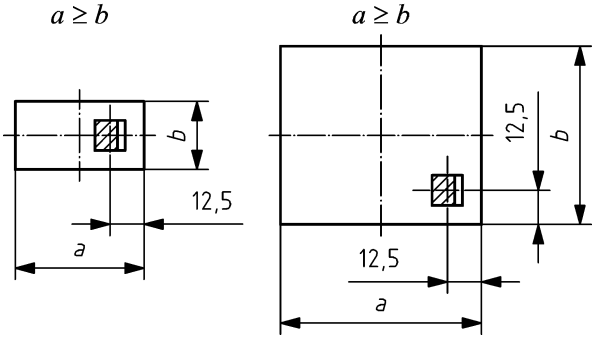
9.6.4.5 If an ultrasonic test has been agreed for verification of internal soundness, the requirements of EN 10308 shall apply.

10 Marking

10.1 The products or the bundle or boxes shall be marked in a suitable way such that it is possible to determine the cast, the steel grade and the origin of the delivery (see Table 15).

10.2 Special marking may be agreed at the time of enquiry and order.

Dimensions in mm

Type of test piece	Round cross-section products	Rectangular cross-section products
Tensile	$d \leq 25$[b] $25 < d \leq 160$ 	$b \leq 25$ $a \geq b$ $25 < b \leq 160$ $a \geq b$  [c]
Impact[a]	$12 \leq d \leq 25$ $25 < d \leq 160$ 	$6 \leq b \leq 25$ $a \geq b$ $25 < b \leq 160$ $a \geq b$  [c]

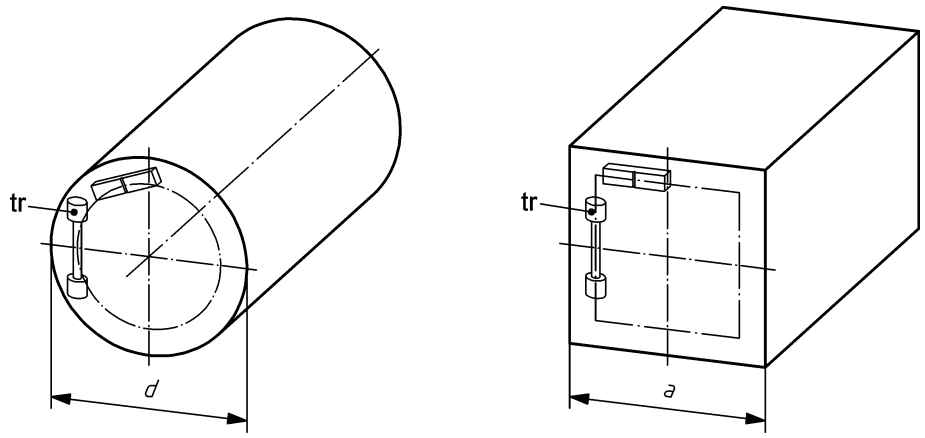
[a] For products of a circular cross-section, the axis of the notch is approximately parallel to the diameter; for products with a rectangular cross-section, the axis of the notch is perpendicular to the greatest rolled surface.

[b] Test pieces of product may alternatively be tested un-machined, in accordance with EN ISO 377.

[c] Value of 12,5 mm is valid only if a ≥ 25 mm, otherwise the value shall be at least a/2.

Figure 1 — Position of test pieces for steel bars ≤ 160 mm diameter or thickness (longitudinal test pieces)

The samples shall be protected by a thermal buffer that means they shall be taken at least at a distance of one radius far from the end of a bar.



Key

tr transverse

Figure 2 — Position of test pieces for steel bars > 160 mm diameter or thickness (transverse test pieces)

The axis of the notch on the impact test pieces shall be radial in the case of round steel bars, and perpendicular to the nearest rolled surface for rectangular bars. The location of the axis of the test piece shall be $d/6$ or $a/6$ but max. 50 mm from the surface.

Table 2 — Chemical composition (cast analysis)[a] of ferritic and martensitic stainless steels

Steel grade		% by mass								
Steel name	Steel number	C	Si max.	Mn max.	P max.	S max.	Cr	Mo	Ni	N
Ferritic stainless steel										
X2CrNi12	1.4003	≤ 0,030	1,00	1,50	0,040	0,015[c]	10,5 to 12,5	–	0,30 to 1,00	≤ 0,030
Martensitic stainless steels										
X12Cr13	1.4006	0,08 to 0,15[b]	1,00	1,50	0,040	0,015[c]	11,5 to 13,5	–	≤ 0,75	–
X17CrNi16–2	1.4057	0,12 to 0,22[b]	1,00	1,50	0,040	0,015[c]	15,0 to 17,0	–	1,50 to 2,50	–
X3CrNiMo13–4	1.4313	≤ 0,05	0,70	1,50	0,040	0,015	12,0 to 14,0	0,30 to 0,70	3,5 to 4,5	≥ 0,020
X4CrNiMo16–5-1	1.4418	≤ 0,06	0,70	1,50	0,040	0,015[c]	15,0 to 17,0	0,80 to 1,50	4,0 to 6,0	≥ 0,020

a Elements not quoted 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 shall 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 Tighter carbon ranges may be agreed at the time of enquiry and order.

c Particular ranges of sulfur content may provide improvement of particular properties. For machinability, a controlled sulfur content of 0,015 % to 0,030 % is recommended and may be agreed. For weldability, a controlled sulfur content of 0,008 % to 0,030 % is recommended and may be agreed.

Table 3 — Chemical composition (cast analysis)[a] of austenitic stainless steels

Steel grade		% by mass											
Steel name	Steel number	C	Si	Mn max.	P max.	S max.	N	Cr	Cu	Mo	Nb	Ni	Ti
X5CrNi18–10	1.4301	≤ 0,07	≤ 1,00	2,00	0,045	0,015[b]	≤ 0,10	17,5 to 19,5	–	–	–	8,0 to 10,5	–
X2CrNi19–11	1.4306	≤ 0,03	≤ 1,00	2,00	0,045	0,015[b]	≤ 0,10	18,0 to 20,0	–	–	–	10,0 to 12,0	–
X2CrNi18–9	1.4307	≤ 0,03	≤ 1,00	2,00	0,045	0,015[b]	≤ 0,10	17,5 to 19,5	–	–	–	8,0 to 10,5	–
X2CrNiN18–10	1.4311	≤ 0,03	≤ 1,00	2,00	0,045	0,015[b]	0,12 to 0,22	17,5 to 19,5	–	–	–	8,5 to 11,5	–
X1CrNiSi18–15–4	1.4361	≤ 0,015	3,7 to 4,5	2,00	0,025	0,010	≤ 0,10	16,5 to 18,5	–	≤ 0,20	–	14,0 to 16,0	–
X5CrNiMo17–12–2	1.4401	≤ 0,07	≤ 1,00	2,00	0,045	0,015[b]	≤ 0,10	16,5 to 18,5	–	2,00 to 2,50	–	10,0 to 13,0	–
X2CrNiMo17–12–2	1.4404	≤ 0,03	≤ 1,00	2,00	0,045	0,015[b]	≤ 0,10	16,5 to 18,5	–	2,00 to 2,50	–	10,0 to 13,0	–
X2CrNiMoN17–11–2	1.4406	≤ 0,03	≤ 1,00	2,00	0,045	0,015[b]	0,12 to 0,22	16,5 to 18,5	–	2,00 to 2,50	–	10,0 to 12,5	–
X2CrNiMoN17–13–3	1.4429	≤ 0,03	≤ 1,00	2,00	0,045	0,015	0,12 to 0,22	16,5 to 18,5	–	2,50 to 3,00	–	11,0 to 14,0	–
X2CrNiMo17–12–3	1.4432	≤ 0,03	≤ 1,00	2,00	0,045	0,015[b]	≤ 0,10	16,5 to 18,5	–	2,50 to 3,00	–	10,5 to 13,0	–
X2CrNiMo18–14–3	1.4435	≤ 0,03	≤ 1,00	2,00	0,045	0,015[b]	≤ 0,10	17,0 to 19,0	–	2,50 to 3,00	–	12,5 to 15,0	–
X3CrNiMo17–13–3	1.4436	≤ 0,05	≤ 1,00	2,00	0,045	0,015[b]	≤ 0,10	16,5 to 18,5	–	2,50 to 3,00	–	10,5 to 13,0	–
X2CrNiMoN17–13–5	1.4439	≤ 0,03	≤ 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	–
X1NiCrMoCuN25–20–7	1.4529	≤ 0,02	≤ 0,5	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	–
X1NiCrMoCu25–20–5	1.4539	≤ 0,02	≤ 0,7	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	–
X6CrNiTi18–10	1.4541	≤ 0,08	≤ 1,00	2,00	0,045	0,015[b]	–	17,0 to 19,0	–	–	–	9,0 to 12,0	5 x C to 0,70
X1CrNiMoCuN20–18–7	1.4547	≤ 0,02	≤ 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	–
X6CrNiNb18–10	1.4550	≤ 0,08	≤ 1,00	2,00	0,045	0,015	–	17,0 to 19,0	–	–	10 x C to 1,00	9,0 to 12,0	–
X1NiCrMoCu31–27–4	1.4563	≤ 0,02	≤ 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	–
X6CrNiMoTi17–12–2	1.4571	≤ 0,08	≤ 1,00	2,00	0,045	0,015[b]	–	16,5 to 18,5	–	2,00 to 2,50	–	10,5 to 13,5	5 x C to 0,70
X6CrNiMoNb17–12–2	1.4580	≤ 0,08	≤ 1,00	2,00	0,045	0,015	–	16,5 to 18,5	–	2,00 to 2,50	10 x C to 1,00	10,5 to 13,5	–
X6CrNi25–20	1.4951	0,04 to 0,08	≤ 0,70	2,00	0,035	0,015	≤ 0,10	24,0 to 26,0	–	–	–	19,0 to 22,0	–

[a] Elements not quoted 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 shall 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] Particular ranges of sulfur content may provide improvement of particular properties. For machinability, a controlled sulfur content of 0,015 % to 0,030 % is recommended and may be agreed. For weldability, a controlled sulfur content of 0,008 % to 0,030 % is recommended and may be agreed.

Table 4 — Chemical composition (cast analysis)[a] of austenitic-ferritic stainless steels

Steel grade		% by mass										
Steel name	Steel number	C max.	Si max.	Mn	P max.	S max.	N	Cr	Cu	Mo	Ni	W
X2CrMnNiN21–5-1[b]	1.4162	0,040	1,00	4,0 to 6,0	0,035	0,005	0,20 to 0,25	21,0 to 22,0	0,10 to 0,80	0,10 to 0,80	1,35 to 1,70	–
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	0,24 to 0,35	24,0 to 26,0	–	3,0 to 4,5	6,0 to 8,0	–
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	–
X2CrMnNiMoN21–5-3	1.4482	0,030	1,00	4,0 to 6,0	0,035	0,030	0,05 to 0,20	19,5 to 21,5	≤ 1,0	0,10 to 0,60	1,50 to 3,50	–
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	0,50 to 1,00
X2CrNiMoCuN25–6-3	1.4507	0,030	0,70	≤ 2,00	0,035	0,015	0,20 to 0,30	24,0 to 26,0	1,00 to 2,50	3,0 to 4,0	6,0 to 8,0	–
X2CrNiMnMoCuN24–4-3–2[b]	1.4662	0,030	0,70	2,50 to 4,0	0,035	0,005	0,20 to 0,30	23,0 to 25,0	0,10 to 0,80	1,00 to 2,00	3,0 to 4,5	–

[a] Elements not quoted 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 shall 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] Patented steel.

Table 5 — Permissible product analysis tolerances on the limiting values given in Tables 2 to 4 for the cast analysis

Element	Specified limits, cast analysis % by mass		Permissible tolerance[a] % by mass
Carbon		≤ 0,030	+ 0,005
	> 0,030	≤ 0,22	±0,01
Silicon		≤ 1,00	+ 0,05
	> 1,00	≤ 3,00	±0,10
	> 3,00	≤ 4,50	±0,15
Manganese	> 1,00	≤ 1,00	+ 0,03
	> 2,00	≤ 2,00	±0,04
		≤ 6,00	±0, 10
Phosphorus		≤ 0,045	+ 0,005
Sulfur		≤ 0,015	+ 0,003
	> 0,015	≤ 0,030	±0,005
Nitrogen		≤ 0,11	±0,01
	≥ 0,11	≤ 0,35	±0,02
Chromium	≥ 10,5	≤ 15,0	±0,15
	> 15,0	≤ 20,0	±0,20
	> 20,0	≤ 28,0	±0,25
Copper		≤ 1,00	±0,07
	> 1,00	≤ 2,50	±0,10
Molybdenum		≤ 0,60	±0,03
	> 0,60	≤ 1,75	±0,05
	> 1,75	≤ 7,0	±0,10
Niobium		≤ 1,00	±0,05
Nickel		≤ 1,00	±0,03
	> 1,00	≤ 5,0	±0,07
	> 5,0	≤ 10,0	±0,10
	> 10,0	≤ 20,0	±0,15
	> 20,0	≤ 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 content of an individual element determined lies 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.

Table 6 — Type of process route and surface finish[a]

	Abbreviation[b]	Type of process route	Surface finish	Notes [e]
Hot formed	1U	Hot formed, not heat treated, not de-scaled	Covered with scale (spot ground if necessary)	Suitable for products to be further hot formed. For semi-finished products, ground on all-sides can be specified.
	1C	Hot formed, heat treated [c], not de-scaled	Covered with scale (spot ground if necessary)	Suitable for products to be further processed. For semi-finished products, ground on all-sides can be specified.
	1E	Hot formed, heat treated [c], mechanically de-scaled	Largely free of scale (but some black spots may remain)	The type of mechanical de-scaling, e.g. grinding, peeling or shot blasting, is left to the manufacturer's discretion unless otherwise agreed. Suitable for products to be further processed.
	1D	Hot formed, heat treated [c], pickled	Free of scale	Tolerance ≥ IT 14 [f, g]
	1X	Hot formed, heat treated [c], rough machined (peeled or rough turned)	Metallically clean	Tolerance ≥ IT 12 [f, g]
Cold processed	2H	Heat treated [c], mechanically or chemically descaled, cold processed[d]	Smooth and bright. Substantially smoother than finishes 1E, 1D or 1X	On products formed by cold drawing without subsequent heat treatment, the tensile strength is substantially increased, particularly on austenitic structure, depending on the degree of forming. Tolerance IT 9 to IT 11 [f, g]
	2D	Cold processed [d], heat treated [c], pickled (skin-passed)	Smoother than finishes 1E or 1D	Finish for good ductility
	2B	Heat treated [c], machined (peeled), mechanically smoothed	Smoother and brighter than finishes 1E, 1D or 1X	Pre-finish for close ISO-tolerances. Tolerance IT 9 to IT 11 [f, g]
Special finishing processes	1G or 2G	Centreless ground	Uniform finish. Type and degree of grinding to be agreed	Surface roughness can be specified. Finish for close ISO-tolerances. Normally obtained from material in finishes 1E, 1D, 2H or 2B. Tolerance ≤ IT 8 [f, g]
	1P or 2P	Polished	Smoother and brighter than finish 1G or 2G. Type and degree of polishing to be agreed	Surface roughness can be specified. Finish for close ISO-tolerances. Normally obtained from material in finishes 1E, 1D, 2H, 2B, 1G or 2G. Tolerance ≤ IT 11 [f, g]

[a] Not all process routes and surface finishes are available for all steels.

[b] First digit, 1 hot formed, 2 cold processed.

[c] On ferritic, austenitic and austenitic-ferritic grades, the heat treatment may be omitted if the conditions for hot forming and subsequent cooling are such that the requirements for the mechanical properties of the product and the resistance to intergranular corrosion are obtained.

[d] The type of cold processing, e.g. cold drawing, turning, or centreless grinding, is left to the manufacturer's discretion, provided that the requirements concerning tolerances on dimensions and surface roughness are respected.

[e] The notes contain information concerning tolerances for bright bars; special agreements are necessary if such information should become obligatory. The given standard tolerance grades IT are taken from ISO 286-1.

[f] For information.

[g] Specific tolerance within the ranges shall be agreed upon at the time of enquiry and order.

Table 7 — Mechanical properties at room temperature and minimum impact energy of ferritic and martensitic steels in the heat-treated (see Table A.1) condition[e]

Steel grade		Diameter *d* or thickness *b*	Heat treatment condition[a]	Hardness[b]	0,2 % proof strength	Tensile strength	Elongation after fracture		Impact energy (ISO-V) KV_2 J min.			
Steel name	Steel number	mm		*HBW* max.	$R_{p0,2}$ MPa min.	R_m MPa	*A* % min.		at 20 °C		at –20 °C	
							(long.)	(tr.)	(long.)	(tr.)	(long.)	(tr.)
Ferritic stainless steel												
X2CrNi12	1.4003	≤ 100	+ A	200[c]	260	450 to 600[c]	20[d]	–	60	–	–	–
Martensitic stainless steels												
X12Cr13	1.4006	≤ 160	+ QT650	–	450	650 to 850	15	–	27	–	–	–
X17CrNi16–2	1.4057	≤ 60	+ QT800	–	600	800 to 1050	14	–	27	–	–	–
		60 < (*d or b*) ≤ 160					14		27			
		≤ 60	+ QT900	–	700	900 to 1050	14	–	27	–	–	–
		60 < (*d or b*) ≤ 160					14		27			
X3CrNiMo13–4	1.4313	≤ 160	+ QT650	–	520	700 to 800	15	–	70	–	40	–
		160 < (*d or b*) ≤ 250					–	14	–	50	–	–
		≤ 160	+ QT780	–	620	780 to 980	15	–	70	–	–	–
		160 < (*d or b*) ≤ 250					–	14	–	50	–	–
		≤ 160	+ QT900	–	800	900 to 1 100	14	–	50	–	–	–
		160 < (*d or b*) ≤ 250					–	14	–	40	–	–
X4CrNiMo16–5-1	1.4418	≤ 160	+ QT760	–	550	760 to 960	16	–	90	–	40	–
		160 < (*d or b*) ≤ 250					–	14	–	70	–	–
		≤ 160	+ QT900	–	700	900 to 1100	16	–	80	–	–	–
		160 < (*d or b*) ≤ 250					–	14	–	60	–	–

a +A = annealed; +QT = quenched and tempered.

b Only for guidance.

c HBW_{max}-values may be raised by 60 units or $R_{m,max}$ values may be raised by 150 MPa for bars of ≤ 35 mm.

d The minimum elongation value may be lowered to 14 % for bars of ≤ 35 mm thickness having a final cold deformation.

e Those grades may also be available as bright bars.

Table 8 — Mechanical properties at room temperature and minimum impact energy of austenitic steels in the solution annealed[a] condition (see Table A.2) and resistance to intergranular corrosion

Steel grade		Diameter *d* or thickness *b*	Hardness[b, c]	0,2 %-proof strength	1,0 %-proof strength	Tensile strength	Elongation after fracture		Impact energy KV_2 (ISO-V) *J* min.			Resistance to intergranular corrosion[d]	
			HBW	$R_{p0,2}$	$R_{p1,0}$	R_m[c]	A[c]						
Steel name	Steel number	mm	max.	MPa min.		MPa	% min.		at 20 °C		at – 196 °C	in the delivery condition	in the sensitized condition[e, f]
							(long.)	(tr.)	(long.)	(tr.)			
X5CrNi18–10	1.4301	≤ 160	215	190	225	500 to 700	45	–	100	–	60	yes[f]	no[g]
		160 < (*d or b*) ≤ 400					–	35	–	60			
X2CrNi19–11	1.4306	≤ 160	215	180	215	460 to 680	45	–	100	–	60	yes	yes
		160 < (*d or b*) ≤ 400					–	35	–	60			
X2CrNi18–9	1.4307	≤ 160	215	175	210	500 to 700	45	–	100	–	60	yes	yes
		160 < (*d or b*) ≤ 400					–	35	–	60			
X2CrNiN18–10	1.4311	≤ 160	230	270	305	550 to 760	40	–	100	–	60	yes	yes
		160 < (*d or b*) ≤ 400					–	30	–	60			
X1CrNiSi18–15–4	1.4361	≤ 160	230	210	240	530 to 730	40	–	100	–	–	yes	yes
		160 < (*d or b*) ≤ 400					–	30	–	60	–		
X5CrNiMo17–12–2	1.4401	≤ 160	215	200	235	500 to 700	40	–	100	–	60	yes[f]	no[g]
		160 < (*d or b*) ≤ 450					–	30	–	60			
X2CrNiMo17–12–2	1.4404	≤ 160	215	200	235	500 to 700	40	–	100	–	60	yes	yes
		160 < (*d or b*) ≤ 400					–	30	–	60			
X2CrNiMoN17–11–2	1.4406	≤ 160	250	280	315	580 to 800	40	–	100	–	60	yes	yes
		160 < (*d or b*) ≤ 400					–	30	–	60			
X2CrNiMoN17–13–3	1.4429	≤ 160	250	280	315	580 to 800	40	–	100	–	60	yes	yes
		160 < (d or b) ≤ 400					–	30	–	60			
X2CrNiMo17–12–3	1.4432	≤ 160	215	200	235	500 to 700	40	–	100	–	60	yes	yes
		160 < (*d or b*) ≤ 400					–	30	–	60			
X2CrNiMo18–14–3	1.4435	≤ 160	215	200	235	500 to 700	40	–	100	–	60	yes	yes
		160 < (*d or b*) ≤ 400					–	30	–	60			
X3CrNiMo17–13–3	1.4436	≤ 160	215	200	235	500 to 700	40	–	100	–	60	yes	no
		160 < (d or b) ≤ 400					–	30	–	60			
X2CrNiMoN17–13–5	1.4439	≤ 160	250	280	315	580 to 800	35	–	100	–	60	yes	yes
		160 < (*d or b*) ≤ 400					–	30	–	60			
X1NiCrMoCuN25–20–7	1.4529	≤ 160	250	300	340	650 to 850	40	–	100	–	40	yes	yes
		160 < (*d or b*) ≤ 400					–	35	–	60			

Steel grade		Diameter d or thickness b	Hardness[b,c]	0,2 % proof strength $R_{p0,2}$	1,0 % proof strength $R_{p1,0}$	Tensile strength R_m[c]	Elongation after fracture A[c]		Impact energy KV_2 (ISO-V) J min.			Resistance to intergranular corrosion[d]	
			HBW									in the delivery condition	in the sensitized condition[e,f]
Steel name	Steel number	mm	max.	MPa min.		MPa	% min.		at 20 °C		at – 196 °C		
							(long.)	(tr.)	(long.)	(tr.)			
X1NiCrMoCu25–20–5	1.4539	≤ 160	230	230	260	530 to 730	35	–	100	–	60	yes	yes
		160 < (d or b) ≤ 400					–	30	–	60			
X6CrNiTi18–10	1.4541	≤ 160	215	190	225	500 to 700	40	–	100	-	60	yes	yes
		160 < (d or b) ≤ 400					–	30	–	60			
X1CrNiMoCuN20–18–7	1.4547	≤ 160	260	300	340	650 to 850	35	–	100	–	60	yes	yes
		160 < (d or b) ≤ 400					–	30	–	60			
X6CrNiNb18–10	1.4550	≤ 160	230	205	240	510 to 740	40	–	100	–	40	yes	yes
		160 < (d or b) ≤ 400					–	30	–	60			
X1NiCrMoCu31–27–4	1.4563	≤ 160	230	220	250	500 to 750	35	–	100	–	60	yes	yes
		160 < (d or b) ≤ 400					–	30	–	60			
X6CrNiMoTi17–12–2	1.4571	≤ 160	215	200	235	500 to 700	40	–	100	–	60	yes	yes
		160 < (d or b) ≤ 400					–	30	–	60			
X6CrNiMoNb17–12–2	1.4580	≤ 160	230	215	250	510 to 740	35	–	100	–	–	yes	yes
		160 < (d or b) ≤ 400					–	30	–	60			
X6CrNi25–20	1.4951	≤ 160	192	200	240	510 to 750	35	–	100	–	–	no	no
		160 < (d or b) ≤ 400					–	30	–	60			

NOTE Austenitic steels always have adequate ductility and do not need to be impact tested. In contrast, austenitic-ferritic steels need to be tested to the impact energy requirements in Table 9 to ensure that ductility is adequate.

a The solution treatment may be omitted if the conditions for hot working and subsequent cooling are such that the requirements for the mechanical properties of the product and the resistance to intergranular corrosion as defined in EN ISO 3651-2 are obtained.

b Only for guidance.

c The maximum HBW-values may be raised by 100 units or the tensile strength value may be raised by 200 MPa and the minimum elongation value be lowered to 20 % for bars of ≤ 35 mm thickness having a final cold deformation.

d When tested according to EN ISO 3651-2.

e See NOTE 2 to 8.4.

f Resistance to intergranular corrosion is given for cross sections up to 40 mm diameter or thickness.

g Resistance to intergranular corrosion in the sensitized condition is given for cross sections up to 40 mm diameter or thickness, when the sensitization treatment is carried out according to method T2 of EN ISO 3651-2 (sensitization treatment of 10 min at 650 °C ± 10 °C, followed by cooling in water).

Table 9 — Mechanical properties at room temperature and minimum impact energy of austenitic-ferritic steels in the solution annealed[a] condition (see Table A.3) and resistance to intergranular corrosion[f]

Steel grade		Thickness *b* or diameter *d*	Hardness[b] *HBW*	0,2 % proof strength $R_{p0,2}$	Tensile strength R_m[e]	Elongation after fracture A[e]	Impact energy (ISO-V) KV_2		Resistance to intergranular corrosion[c]	
Steel name	Steel number	mm	max.	MPa min.	MPa	% min. (long.)	*J* min. at 20 °C (long.)	*J* min. at -40 °C (long.)	in the delivery condition	in the welded condition[d]
X2CrMnNiN21–5-1	1.4162	≤ 160	290	400	650 to 900	25	60	–	yes	yes
X2CrNiN23–4	1.4362	≤ 160	260	400	600 to 830	25	100	40	yes	yes
X2CrNiMoN25–7-4	1.4410	≤ 160	290	530	730 to 930	25	100	40	yes	yes
X2CrNiMoN22–5-3	1.4462	≤ 160	270	450	650 to 880	25	100	40	yes	yes
X2CrMnNiMoN21–5-3	1.4482	≤ 160	290	400	650 to 900	25	100	60	yes	yes
X2CrNiMoCuWN25–7-4	1.4501	≤ 160	290	530	730 to 930	25	100	40	yes	yes
X2CrNiMoCuN25–6-3	1.4507	≤ 160	270	500	700 to 900	25	100	40	yes	yes
X2CrNiMnMoCuN24–4-3–2	1.4662	≤ 160	290	450	650 to 900	25	60	–	yes	yes

NOTE Austenitic-ferritic steels need to be tested to the above impact energy requirements to ensure that ductility is adequate. In contrast, austenitic steels always have adequate ductility and do not need to be tested.

a The solution treatment may be omitted if the conditions for hot working and subsequent cooling are such that the requirements for the mechanical properties of the product and the resistance to intergranular corrosion as defined in EN ISO 3651-2 are obtained.

b Only for guidance.

c When tested according to EN ISO 3651-2.

d See NOTE 2 to 8.4.

e The tensile strength value may be raised by 200 MPa and the minimum elongation value be lowered to 20 % for bars having a final cold deformation.

f Those grades may also be available as bright bars.

Table 10 — Minimum values for the 0,2 % proof strength of ferritic and martensitic steels at elevated temperatures

Steel grade		Heat treatment condition[a]	0,2 % proof strength $R_{p0,2}$ MPa min. at a temperature (in °C) of						
Steel name	Steel number		100	150	200	250	300	350	400
Ferritic stainless steel									
X2CrNi12	1.4003	+ A	240	230	220	215	210	–	–
Martensitic stainless steels									
X12Cr13	1.4006	+ QT650	420	410	400	385	365	335	305
X17CrNi16–2	1.4057	+ QT800	515	495	475	460	440	405	355
		+ QT900	565	525	505	490	470	430	375
X3CrNiMo13–4	1.4313	+ QT650	500	490	480	470	460	450	–
		+ QT780	590	575	560	545	530	515	–
		+ QT900	720	690	665	640	620	–	–
X4CrNiMo16–5-1	1.4418	+ QT760	520	510	500	490	480	–	–
		+ QT900	660	640	620	600	580	–	–

[a] + A = annealed; + QT = quenched and tempered

Table 11 — Minimum values for the 0,2 % and 1,0 % -proof strength of austenitic steels at elevated temperatures in the solution annealed condition (see Table A.2)

Steel grade		0,2 % proof strength $R_{p0,2}$ [MPa] min. at a temperature (in °C) of										1,0 % proof strength $R_{p1,0}$ [MPa] min. at a temperature (in °C) of										Limit temperature[a] °C
Steel name	Steel number	100	150	200	250	300	350	400	450	500	550	100	150	200	250	300	350	400	450	500	550	
X5CrNi18–10	1.4301	155	140	127	118	110	104	98	95	92	90	190	170	155	145	135	129	125	122	120	120	300
X2CrNi19–11	1.4306	145	130	118	108	100	94	89	85	81	80	180	160	145	135	127	121	116	112	109	108	350
X2CrNi18–9	1.4307	145	130	118	108	100	94	89	85	81	80	180	160	145	135	127	121	116	112	109	108	350
X2CrNiN18–10	1.4311	205	175	157	145	136	130	125	121	119	118	240	210	187	175	167	160	156	152	149	147	400
X1CrNiSi18–15–4	1.4361	185	160	145	135	125	120	115	–	–	–	210	190	175	165	155	150	–	–	–	–	350
X5CrNiMo17–12–2	1.4401	175	158	145	135	127	120	115	112	110	108	210	190	175	165	155	150	145	141	139	137	300
X2CrNiMo17–12–2	1.4404	165	150	137	127	119	113	108	103	100	98	200	180	165	153	145	139	135	130	128	127	400
X2CrNiMoN17–11–2	1.4406	215	195	175	165	155	150	145	140	138	136	245	225	205	195	185	180	175	170	168	166	400
X2CrNiMoN17–13–3	1.4429	215	195	175	165	155	150	145	140	138	136	245	225	205	195	185	180	175	170	168	166	400
X2CrNiMo17–12–3	1.4432	165	150	137	127	119	113	108	103	100	98	200	180	165	153	145	139	135	130	128	127	400
X2CrNiMo18–14–3	1.4435	165	150	137	127	119	113	108	103	100	98	200	180	165	153	145	139	135	130	128	127	400
X3CrNiMo17–13–3	1.4436	175	158	145	135	127	120	115	112	110	108	210	190	175	165	155	150	145	141	139	137	300
X2CrNiMoN17–13–5	14439	225	200	185	175	165	155	150	–	–	–	255	230	210	200	190	180	175	–	–	–	400
X1NiCrMoCuN25–20–7	1.4529	230	210	190	180	170	165	160	–	–	–	270	245	225	215	205	195	190	–	–	–	400
X1NiCrMoCu25–20–5	1.4539	205	190	175	160	145	135	125	115	110	105	235	220	205	190	175	165	155	145	140	135	400
X6CrNiTi18–10	1.4541	175	165	155	145	136	130	125	121	119	118	205	195	185	175	167	161	156	152	149	147	400
X1CrNiMoCuN20–18–7	1.4547	230	205	190	180	170	165	160	153	148	–	270	245	225	212	200	195	190	184	180	–	400
X6CrNiNb18–10	1.4550	175	165	155	145	136	130	125	121	119	118	210	195	185	175	167	161	156	152	149	147	400
X1NiCrMoCu31–27–4	1.4563	190	175	160	155	150	145	135	125	120	115	220	205	190	185	180	175	165	155	150	145	400
X6CrNiMoTi17–12–2	1.4571	185	175	165	155	145	140	135	131	129	127	215	205	192	183	175	169	164	160	158	157	400
X6CrNiMoNb17–12–2	1.4580	186	177	167	157	145	140	135	131	129	127	221	206	196	186	175	169	164	160	158	157	400
X6CrNi25–20	1.4951	140	128	116	108	100	94	91	86	85	84	185	167	154	146	139	132	126	123	121	118	800

[a] When used up to temperatures listed in the table, and for service times up to 100 000 h, no intergranular corrosion will occur when tested as described in EN ISO 3651-2.

Table 12 — Minimum values for the 0,2 %-proof strength of austenitic–ferritic steels at elevated temperatures in the solution annealed condition (see Table A.3)

Steel grade		0,2 % proof strength $R_{p0,2}$ MPa min. at a temperature (in °C) of				Limit temperature[a] °C
Steel name	Steel number	100	150	200	250	
X2CrMnNiN21–5-1	1.4162	365	325	295	275	250
X2CrNiN23–4	1.4362	330	300	280	265	250
X2CrNiMoN25–7-4	1.4410	450	420	400	380	250
X2CrNiMoN22–5-3	1.4462	360	335	315	300	250
X2CrMnNiMoN21–5-3	1.4482	340	315	300	280	250
X2CrNiMoCuWN25–7-4	1.4501	450	420	400	380	250
X2CrNiMoCuN25–6-3	1.4507	450	420	400	380	250
X2CrNiMnMoCuN24–4-3–2	1.4662	385	345	325	315	250

[a] When used up to temperatures listed in the table, and for service times up to 100 000 h, no intergranular corrosion will occur when tested as described in EN ISO 3651-2.

Table 13 — Minimum values for the tensile strength of austenitic steels at elevated temperatures in the solution annealed condition (see Table A.2)

Steel grade		Tensile strength R_m MPa min. at a temperature (in °C) of									
Steel name	Steel number	100	150	200	250	300	350	400	450	500	550
X5CrNi18–10	1.4301	450	420	400	390	380	380	380	370	360	330
X2CrNi19–11	1.4306	410	380	360	350	340	340	–	–	–	–
X2CrNi18–9	1.4307	410	380	360	350	340	340	–	–	–	–
X2CrNiN18–10	1.4311	490	460	430	420	410	410	–	–	–	–
X1CrNiSi18–15–4	1.4361	490	470	450	435	420	410	400	–	–	–
X5CrNiMo17–12–2	1.4401	430	410	390	385	380	380	–	–	–	–
X2CrNiMo17–12–2	1.4404	430	410	390	385	380	380	380	–	360	–
X2CrNiMoN17–11–2	1..4406	520	490	460	450	440	435	–	–	–	–
X2CrNiMoN17–13–3	1.4429	520	490	460	450	440	435	435	–	430	–
X2CrNiMo17–12–3	1.4432	430	410	390	385	380	380	380	375	360	–
X2CrNiMo18–14–3	1.4435	420	400	380	375	370	370	–	–	–	–
X3CrNiMo17–13–3	1.4436	460	440	420	415	410	410	410	–	390	–
X2CrNiMoN17–13–5	1..4439	520	490	460	450	440	435	–	–	–	–
X1NiCrMoCuN25–20–7	1.4529	610	585	560	540	525	515	510	–	–	–
X1NiCrMoCu25–20–5	1.4539	500	480	460	450	440	435	–	–	–	–
X6CrNiTi18–10	1.4541	440	410	390	385	375	375	375	370	360	330
X1CrNiMoCuN20–18–7	1.4547	615	587	560	542	525	517	510	502	495	–
X6CrNiNb18–10	1.4550	435	400	370	350	340	335	330	320	310	300
X1NiCrMoCu31–27–4	1.4563	460	445	430	410	400	395	–	–	–	–
X6CrNiMoTi17–12–2	1.4571	440	410	390	385	375	375	375	370	360	330
X6CrNiMoNb17–12–2	1.4580	440	410	390	385	375	375	375	370	360	330
X6CrNi25–20	1.4951	470	450	430	420	410	405	400	385	370	350

Table 14 — Tests to be carried out, test units and extent of testing in specific testing

Test		Test status[a]	Test unit	Number of samples per test unit	Number of test pieces per sample	Refer to
Chemical analysis	Cast	m	Cast	(The analysis provided by the steel manufacturer applies.)	–	8.3.1
	Product	o	Cast	[b]	[b]	8.3.2 and 9.6.1
Tensile test at room temperature		m	Batch[c]	1 sample per 2 000 kg, maximum of 2 per test unit taken from 2 different bars; for individual bars of masses of more than 2 000 kg, only 1 sample shall be taken per bar	1	8.5.1 and 9.6.2.1
Impact test at room temperature		m[d]			3	8.5.1 and 9.6.3
Tensile test at elevated temperature		o[e]		[g]	1	8.5.1 and 9.6.2.2
Dimensional and visual inspection		m	Each product	–	–	9.6.4.3 and 9.6.4.4
Hardness test		o	Batch[c]	[g]	[g]	9.6.4.2
Impact test at low temperature		o[f]		[g]	3	8.5.1 and 9.6.3
Resistance to intergranular corrosion		o		[g]	1	8.4 and 9.6.4.1
Verification of internal soundness		o		[g]	[g]	8.7 and 9.6.4.5

a Tests marked with a "m" (mandatory) shall be carried out as specific tests in all cases. Those marked with an "o" (optional) shall be carried out as specific tests only if agreed at the time of enquiry and order.

b Unless otherwise agreed, one test piece per cast shall be taken for determining the elements indicated with numerical values for the particular steel grade in Tables 2 to 4.

c Each batch consists of products coming from the same cast. The products shall have been subject to the same heat treatment cycle in the same furnace. In the case of a continuous furnace or in process annealing a batch is the lot heat treated without intermission with the same process parameters.
The shape and size of cross sections of products in a single batch may be different providing that the ratio of the largest to the smallest areas shall be equal or less than three.

d Optional for austenitic steels.

e See 9.6.2.2.

f For steels for use at low temperatures.

g To be agreed at the time of enquiry and order.

Table 15 — Marking of the products

Marking of	Symbol[a]
Manufacturer's name, trade mark or logo	+
Steel name or number	+
Cast number	+
Identification number[b]	+
Inspector's mark	+

a The symbol "+" means that the marking shall be applied.

b The numbers or letters used for identification shall allow the product(s) to be related to the relevant inspection certificate and to this document.

Annex A
(informative)

Guidelines for further treatment (including heat treatment) in fabrication

A.1 The guidelines given in Tables A.1 to A.3 are intended for hot forming and heat treatment.

A.2 Flame cutting may adversely affect edge areas; where necessary, they should be machined.

A.3 As the corrosion resistance of stainless steels is only ensured with a metallically clean surface, layers of scale and annealing colours produced during hot forming; heat treatment or welding should be removed as far as possible before use. Finished parts made of ferritic and martensitic steels with a minimum of 10,5 % Cr also require the best surface condition (e.g. polished) in order to achieve maximum resistance to corrosion.

Table A.1 — Guidelines on the temperatures for hot forming and heat treatment[a] of ferritic and martensitic stainless steels

Steel grade		Hot forming		Heat treatment symbol	Annealing		Quenching		Tempering
Steel name	Steel number	Temperature °C	Type of cooling		Temperature[b] °C	Type of cooling	Temperature[b] °C	Type of cooling	Temperature °C
ferritic stainless steel									
X2CrNi12	1.4003	1 100 to 800	air	+ A	680 to 740	air	–	–	–
martensitic stainless steels									
X12Cr13	1.4006	1 000 to 800	air	+ A	745 to 825	air	–	–	–
				+ QT650	–	–	950 to 1 000	oil, air	680 to 780
X17CrNi16–2	1.4057		slow cooling	+ A[c]	680 to 800	furnace, air	–	–	–
				+ QT800[d]	–	–	950 to 1 050	oil, air	750 to 800 + 650 to 700[d]
				+ QT900	–	–	950 to 1 050	oil, air	600 to 650
X3CrNiMo13–4	1.4313	1 150 to 900	air	+ A[e]	600 to 650	furnace, air	–	–	–
				+ QT650	–	–	950 to 1 050	oil, air	650 to 700 + 600 to 620
				+ QT780	–	–	950 to 1 050	oil, air	550 to 600
				+ QT900	–	–	950 to 1 050	oil, air	520 to 580
X4CrNiMo16–5-1	1.4418			+ A[e]	600 to 650	air, furnace	–	–	–
				+ QT760	–	–	950 to 1 050	oil, air	590 to 620[f]
				+ QT900	–	–	950 to 1 050	oil, air	550 to 620

a The temperatures of annealing, quenching and tempering shall be agreed for simulated heat-treated test pieces.

b If heat treatment is carried out in a continuous furnace, the upper part of the range specified is usually preferred, or even exceeded.

c Double annealing might be advisable.

d In the case that the nickel is at the lower side of the range specified in Table 2 a single tempering at 620 °C to 720 °C may be sufficient.

e Tempering after martensitic transformation.

f Either 2 × 4 h or 1 × 8 h as minimum time.

Table A.2 — Guidelines on the temperatures for hot forming and heat treatment[a] of austenitic stainless steels

Steel grade		Hot forming		Heat treatment symbol	Solution annealing[b]	
Steel name	Steel number	Temperature °C	Type of cooling		Temperature[c, d] °C	Type of cooling
X5CrNi18–10	1.4301	1 200 to 900	air	+ AT	1 000 to 1 100	water, air[e]
X2CrNi19–11	1.4306	1 200 to 900			1 000 to 1 100	
X2CrNi18–9	1.4307	1 200 to 900			1 000 to 1 100	
X2CrNiN18–10	1.4311	1 200 to 900			1 000 to 1 100	
X1CrNiSi18–15–4	1.4361	1 150 to 900			1 100 to 1 160	
X5CrNiMo17–12–2	1.4401	1 200 to 900			1 020 to 1 120	
X2CrNiMo17–12–2	1.4404	1 200 to 900			1 020 to 1 120	
X2CrNiMoN17–11–2	1.4406	1 200 to 900			1 020 to 1 120	
X2CrNiMoN17–13–3	1.4429	1 200 to 900			1 020 to 1 120	
X2CrNiMo17–12–3	1.4432	1 200 to 900			1 020 to 1 120	
X2CrNiMo18–14–3	1.4435	1 200 to 900			1 020 to 1 120	
X3CrNiMo17–13–3	1.4436	1 200 to 900			1 020 to 1 120	
X2CrNiMoN17–13–5	1.4439	1 200 to 900			1 020 to 1 120	
X1NiCrMoCuN25–20–7	1.4529	1 200 to 950			1 120 to 1 180	
X1NiCrMoCu25–20–5	1.4539	1 200 to 900			1 050 to 1 150	
X6CrNiTi18–10	1.4541	1 200 to 900			1 020 to 1 120	
X1CrNiMoCuN20–18–7	1.4547	1 200 to 950			1 140 to 1 200	
X6CrNiNb18–10	1.4550	1 150 to 850			1 020 to 1 120	
X1NiCrMoCu31–27–4	1.4563	1 150 to 850			1 050 to 1 150	
X6CrNiMoTi17–12–2	1.4571	1 200 to 900			1 020 to 1 120	
X6CrNiMoNb17–12–2	1.4580	1 150 to 850			1 020 to 1 120	
X6CrNi25–20	1.4951	1 100 to 850			1 050 to 1 150	

a The temperatures of solution annealing shall be agreed for simulated heat-treated test pieces.

b The solution treatment may be omitted if the conditions for hot working and subsequent cooling are such that the requirements for the mechanical properties of the product and the resistance to intergranular corrosion as defined in EN ISO 3651-2 are obtained and provided these requirements are met even after appropriate subsequent solution annealing.

c The lower end of the range specified for solution annealing should be aimed at for heat treatment as part of further processing, because otherwise the mechanical properties might be affected. If the temperature of hot forming does not drop below the lower temperature for solution annealing, a temperature of 980 °C is adequate as lower limit for Mo-free steels, a temperature of 1 000 °C for steels with Mo contents up to 3 % and a temperature of 1 020 °C for steels with Mo contents exceeding 3 %.

d If heat-treatment is carried out in a continuous furnace, the upper part of the range specified is usually preferred, or even exceeded.

e Cooling sufficiently rapid in order to avoid occurrence of intergranular corrosion as defined in EN ISO 3651-2.

Table A.3 — Guidelines on the temperatures for hot forming and heat treatment[a] of austenitic-ferritic stainless steels

Steel grade		Hot forming		Heat treatment symbol	Solution annealing	
Steel name	Steel number	Temperature °C	Type of cooling		Temperature[b] °C	Type of cooling
X2CrMnNiN21–5-1	1.4162	1 100 to 900	air	+ AT	1 020 to 1 080	water, air
X2CrNiN23–4	1.4362	1 150 to 950			950 to 1 050	water, air[c]
X2CrNiMoN25–7-4	1.4410	1 150 to 1 000			1 040 to 1 120	water, air[c]
X2CrNiMoN22–5-3	1.4462	1 150 to 950			1 020 to 1 100	water, air[c]
X2CrMnNiMoN21–5-3	1.4482	1 150 to 950			900 to 1 050	water, air[c]
X2CrNiMoCuWN25–7-4	1.4501	1 150 to 1 000			1 040 to 1 120	water, air[c]
X2CrNiMoCuN25–6-3	1.4507	1 150 to 1 000			1 040 to 1 120	water, air[c]
X2CrNiMnMoCuN24–4-3–2	1.4662	1 150 to 900			1 000 to 1 150	water, air

a The temperatures of solution annealing shall be agreed for simulated heat treated test pieces.

b If heat treatment is carried out in a continuous furnace, the upper part of the range specified is usually preferred, or even exceeded.

c Cooling sufficiently rapid in order to avoid precipitation.

Annex B
(informative)

Tensile strength of austenitic-ferritic steels at elevated temperatures

Table B.1 — Preliminary reference data for the minimum values for the tensile strength of austenitic–ferritic steels at elevated temperatures in the solution annealed condition (see A.3)

Steel grade		Tensile strength R_m MPa min. at a temperature (in °C) of			
Steel name	Steel number	100	150	200	250
X2CrMnNiN21–5-1	1.4162	590	560	540	540
X2CrNiN23–4	1.4362	540	520	500	490
X2CrNiMoN25–7-4	1.4410	680	660	640	630
X2CrNiMoN22–5-3	1.4462	590	570	550	540
X2CrMnNiMoN21–5-3	1.4482	580	540	520	500
X2CrNiMoCuWN25–7-4	1.4501	680	660	640	630
X2CrNiMoCuN25–6-3	1.4507	660	640	620	610
X2CrNiMnMoCuN24–4-3–2	1.4662	615	590	575	560

Annex C
(informative)

Reference data of strength values for creep rupture

NOTE The values given in Tables C.1 are mean values of the scatter band considered until now. If referred to in regulations, however, they will be binding for calculation purposes. According to experience with long-time creep-testing it seems apparent that scattering of data are about ± 20 % in the long-range endurance of about 10^5 h up to 700 °C to 800 °C. However, individual deviations need to be presumed.

The strength values for creep rupture given up to the elevated temperatures listed in Tables C.1 do not mean that the steels can be used in continuous duty up to these temperatures. The governing factor is the total stressing during operation. Where relevant, the oxidation conditions should also be taken into account.

Table C.1 — Creep rupture strength of the specified austenitic creep-resisting steel grade in the solution annealed condition (see Table A.2)

Steel grade		Tempe-rature	Strength for rupture[a] in MPa for						
Steel name	Steel number	°C	10 000 h	30 000 h	50 000 h	100 000 h	150 000 h	200 000 h	250 000 h
X6CrNi25–20[b]	1.4951	600	137	113	104*	92*	89*	82*	79*
		610	120	98	90*	79*	74*	71*	68*
		620	105	85	78*	69*	64*	61*	59*
		630	92	75	68*	60*	56*	54*	52*
		640	81	66	60*	53*	50*	47*	46*
		650	72	58	53*	47*	44*	42*	41*
		660	64	52	47*	42*	39*	38*	36*
		670	57	46	42*	38*	35*	34*	33*
		680	51	42	38	34*	32*	31*	29*
		690	47	38	35	31*	29*	28*	27*
		700	42	34	32	28*	26*	25*	24*
		710	39	31	29	26*	24*	23*	22*
		720	35	29	26	23,5*	22*	21*	20*
		730	32	27	24,5*	22*	20*	19,5*	18,5*
		740	30	24,5	22,5*	20*	18,5*	18*	17*
		750	28	22,5	21*	18,5*	17*	16,5*	16*

a Values with asterisk mark time extrapolation.

b Values were taken from BS PD 6525 Part 1.

Annex D
(informative)

Significant changes to the previous version EN 10272:2007

Significant changes to the previous version EN 10272:2007 are listed below:

1) Normative references actualised;

2) New steel grades 1.4162, 1.4662 and 1.4361 with the correspondence data inserted in the standard;

3) Data concerning inspection documents in 9.1 updated;

4) New table with sizes of the impact test pieces added;

5) Contain of Mn in the Table 5 for product analysis updated and extended with the range 2 % to 10 %;

6) Contain of Si in the Table 5 for product analysis updated;

7) Figure 1 concerning test pieces for impact testing revised;

8) Correspondence data for Figure 2 updated;

9) Reference to impact testing only in transversal direction in the heading of Table 8 deleted;

10) New data on steel gradeX2CrMnNiMoN21-5-3 in Table 9 updated and a new footnote added;

11) Content of Table 14 concerning testing and extent of testing updated;

12) Table ZA.1 revised; New relationship to the Directive 2014/68/EU;

13) Editorial changes.

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of Directive 2014/68/EU

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 I of Directive 2014/68/EU

Requirements of Directive 2014/68/EU	Clause(s)/sub-clause(s) of this EN	Remarks/Notes
4.1a	8.5.1; Tables 7,8 and 9	Appropriate material properties
4.1d	8.2, 8.6, 8.7 and Table 6	Suitable for the processing procedures
4.3	9.1, 9.6.2.1, 9.6.3 and Table 14	Inspection documentation NOTE For details related to 9.1.1 see EC PED guidelines 7/2 and 7/16 which specify the material manufacturer obligations in respect to the QA system and the specific assessment for materials.

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.

Bibliography

[1] BS PD 6525 *Part 1:1990*, *Elevated temperature properties for steels for pressure purposes — Part 1: Stress rupture properties*

[2] Guidelines 7/2 and 7/16 of the EU Commission and the Member States for its interpretation

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