INTERNATIONAL STANDARD

ISO 9328-7

Second edition
2011-05-01

Steel flat products for pressure purposes — Technical delivery conditions —

Part 7: Stainless steels

Produits plats en acier pour service sous pression — Conditions techniques de livraison —

Partie 7: Aciers inoxydables

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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

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

ISO 9328-7 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 10, *Steel for pressure purposes*.

This second edition cancels and replaces the first edition (ISO 9328-7:2004), which has been technically revised.

ISO 9328 consists of the following parts, under the general title *Steel flat products for pressure purposes — Technical delivery conditions*:

— *Part 1: General requirements*

— *Part 2: Non-alloy and alloy steels with specified elevated temperature properties*

— *Part 3: Weldable fine grain steels, normalized*

— *Part 4: Nickel-alloy steels with specified low temperature properties*

— *Part 5: Weldable fine grain steels, thermomechanically rolled*

— *Part 6: Weldable fine grain steels, quenched and tempered*

— *Part 7: Stainless steels*

The clauses marked by two points (••) contain information relating to agreements that may be made at the time of enquiry and order.

Steel flat products for pressure purposes — Technical delivery conditions —

Part 7: Stainless steels

1 Scope

This part of ISO 9328 specifies requirements for flat products for pressure purposes made of stainless steels, including austenitic creep-resisting steels, in thicknesses as indicated in Tables 7 to 10.

Additionally the requirements of ISO 9328-1 also apply.

2 Normative references

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

ISO 643:2003, *Steels — Micrographic determination of the apparent grain size*

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 9328-1:2011, *Steel flat products for pressure purposes — Technical delivery conditions — Part 1: General requirements*

ISO 10474:1991, *Steel and steel products — Inspection documents*

ISO 18286, *Hot-rolled stainless steel plates — Tolerances on dimensions and shape*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9328-1 and the following apply.

3.1
cryogenic temperature
temperature lower than −75 °C used in the liquefaction of gases

4 Classification and designation

See ISO 9328-1.

NOTE Information on the designation of comparable steel grades in national or regional standards is given in Annex A.

5 Information to be supplied by the purchaser

5.1 Mandatory information

See ISO 9328-1.

5.2 Options

A number of options are specified in this part of ISO 9328 and are listed below. Additionally, the relevant options of ISO 9328-1 apply. If the purchaser does not indicate a wish to implement any of these options at the time of enquiry and order, the products shall be supplied in accordance with the basic specification (see ISO 9328-1):

a) mechanical properties for increased product thicknesses (see Table 7, footnote e);

b) higher $R_{p0,2}$ and $R_{p1,0}$ values for continuously hot rolled products (see Table 9, footnote d and Table 10, footnote b);

5.3 Example for ordering

10 plates made of a steel grade with the name X5CrNi18-10 as specified in ISO 9328-7 with nominal dimensions thickness = 8 mm, width = 2 000 mm, length = 5 000 mm and tolerances on dimensions, shape and mass as specified in ISO 18286, with "normal" flatness tolerance in process route 1D (see Table 6), and with inspection document 3.1.B as specified in ISO 10474:

10 plates ISO 18286 — 8 × 2000 × 5000 N — Steel ISO 9328-7 — X5CrNi18-10 + 1D — Inspection document 3.1.B

6 Requirements

6.1 Steelmaking process

See ISO 9328-1.

6.2 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 alternatives exist, to the treatment conditions given in Tables 7 to 10. Guidelines for further treatment, including heat treatment, are given in Annex B.

6.3 Chemical composition and chemical corrosion properties

6.3.1 The chemical composition requirements given in Tables 1 to 4 apply in respect of the chemical composition according to the cast analysis.

6.3.2 The product analysis may deviate from the limiting values for the cast analysis given in Tables 1 to 4 by the values listed in Table 5.

6.3.3 Referring to resistance to intergranular corrosion as defined in ISO 3651-2, for ferritic, austenitic and austenitic-ferritic steels, the specifications in Tables 7, 9 and 10 apply.

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

NOTE 2 The corrosion resistance of stainless steels is very 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.

6.4 Mechanical properties

6.4.1 The tensile properties at room temperature and the impact energy at room temperature and at low temperature, as specified in Tables 7 to 10, 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 of other steels, they are also useful for application at cryogenic temperatures.

6.4.2 The values in Tables 11 to 14 apply for the 0,2 % and 1,0 % proof strength at elevated temperatures. Additionally, the values in Table 15 apply for the tensile strength at elevated temperatures of austenitic steels.

Tensile strength values at elevated temperatures for austenitic-ferritic steels are given for guidance in Annex D.

6.4.3 Annex E provides for the purchaser mean values as preliminary data on the strength for 1 % (plastic) creep strain and creep rupture. These data apply for the solution annealed condition only.

6.4.4 In Annex F, preliminary data on mechanical properties at low temperatures of austenitic steels are listed.

6.5 Surface condition

See ISO 9328-1 and Table 6.

6.6 Internal soundness

See ISO 9328-1.

6.7 Post-weld heat treatment

Guidelines for the purchaser on post-weld heat treatment are given in Annex C.

6.8 Dimensions and tolerances

See ISO 9328-1.

6.9 Calculation of mass

For density of steels, see Annex G.

6.10 Physical properties

Reference data on some physical properties are given in Annex G.

7 Inspection

7.1 Types of inspection and inspection documents

See ISO 9328-1.

7.2 Tests to be carried out

See Table 16 and ISO 9328-1.

7.3 Re-tests

See ISO 9328-1.

8 Sampling

8.1 Frequency of testing

See Table 16 and ISO 9328-1.

8.2 Selection and preparation of samples and test pieces

See ISO 9328-1.

9 Test methods

See ISO 9328-1.

10 Marking

See ISO 9328-1.

Table 1 — Chemical composition (cast analysis)[a] of ferritic steels

Steel grade	ISO number[b]	Mass fraction, %										
		C max.	Si max.	Mn max.	P max.	S max.	N max.	Cr	Mo	Nb	Ni	Ti
X2CrNi12	—	0,030	1,00	1,50	0,040	0,015	0,030	10,5 to 12,5	—	—	0,30 to 1,10	
X6CrNiTi12	—	0,08	1,00	1,00	0,040	0,015	—	10,5 to 12,5	—	—	0,50 to 1,50	0,05 to 0,35
X2CrTi17	—	0,025	0,50	0,50	0,040	0,015	0,015	16,0 to 18,0	—	—	—	0,30 to 0,60
X3CrTi17	—	0,05	1,00	1,00	0,040	0,015	—	16,0 to 18,0	—	—	—	[4 × (C + N) + 0,15] to 0,80[c]
X2CrMoTi17-1	—	0,025	1,00	1,00	0,040	0,015	0,030	16,0 to 18,0	0,80 to 1,40	—	—	0,30 to 0,60
X2CrMoTi18-2	—	0,025	1,00	1,00	0,040	0,015	0,030	17,0 to 20,0	1,80 to 2,50	—	—	[4 × (C + N) + 0,15] to 0,80[c]
X6CrMoNb17-1	—	0,08	1,00	1,00	0,040	0,015	0,040	16,0 to 18,0	0,80 to 1,40	[7 × (C + N) + 0,10] to 1,00	—	—
X2CrTiNb18	4509-439-40-X	0,030	1,00	1,00	0,040	0,015	—	17,5 to 18,5	—	[3 × C + 0,30] to 1,00	—	0,10 to 0,60

[a] Elements not listed in this table may not be intentionally added to the steel without agreement of the purchaser, except for finishing of 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] ISO number according to ISO 15510.

[c] The stabilization may be made by use of titanium or niobium or zirconium. According to the atomic number of these elements and the content of carbon and nitrogen, the equivalence shall, if additional stabilizing with niobium or zirconium is used, be the following:

$$Nb = Zr = \frac{7}{4} Ti$$

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

Steel grade	ISO number[b]	Mass fraction, %								
		C max.	Si max.	Mn max.	P max.	S max.	N min.	Cr	Mo	Ni
X3CrNiMo13-4	—	0,05	0,70	0,50 to 1,00	0,040	0,015	0,020	12,0 to 14,0	0,30 to 1,00	3,5 to 4,5
X4CrNiMo16-5-1	4418-431-77-E	0,06	0,70	1,50	0,040	0,015	0,020	15,0 to 17,0	0,80 to 1,50	4,0 to 6,0

[a] Elements not listed in this table may not be intentionally added to the steel without the agreement of the purchaser, except for finishing of 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] ISO number according to ISO 15510.

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

Steel grade	ISO number[b]	Mass fraction,%												
		C	Si	Mn max.	P max.	S max.	N	Cr	Cu	Mo	Nb	Ni	Ti	Others
Austenitic corrosion-resisting grades														
X2CrNiN18-7	—	⩽ 0,030	⩽ 1,00	2,00	0,045	0,015	0,10 to 0,20	16,5 to 18,5	—	—	—	6,0 to 8,0	—	—
X2CrNi18-9	4307-304-03-I	⩽ 0,030	⩽ 1,00	2,00	0,045	0,015	⩽ 0,10	17,5 to 19,5	—	—	—	8,0 to 10,5	—	—
X2CrNi19-11	4306-304-03-I	⩽ 0,030	⩽ 1,00	2,00	0,045	0,015	⩽ 0,10	18,0 to 20,0	—	—	—	10,0 to 12,0	—	—
X5CrNiN19-9	—	⩽ 0,06	⩽ 1,00	2,00	0,045	0,015	0,12 to 0,22	18,0 to 20,0	—	—	—	8,0 to 11,0	—	—
X2CrNiN18-10	—	⩽ 0,030	⩽ 1,00	2,00	0,045	0,015	0,12 to 0,22	17,5 to 19,5	—	—	—	8,0 to 11,5	—	—
X5CrNi18-10	4301-304-00-I	⩽ 0,07	⩽ 1,00	2,00	0,045	0,015	⩽ 0,10	17,5 to 19,5	—	—	—	8,0 to 10,5	—	—
X6CrNiTi18-10	4541-321-00-I	⩽ 0,08	⩽ 1,00	2,00	0,045	0,015	—	17,0 to 19,0	—	—	—	9,0 to 12,0	5 × C to 0,70	—
X6CrNiNb18-10	4550-347-00-I	⩽ 0,08	⩽ 1,00	2,00	0,045	0,015	—	17,0 to 19,0	—	—	10 × C to 1,00	9,0 to 12,0	—	—
X1CrNi25-21	4335-310-02-I	⩽ 0,020	⩽ 0,25	2,00	0,025	0,010	⩽ 0,10	24,0 to 26,0	—	⩽ 0,20	—	20,0 to 22,0	—	—
X2CrNiMo17-12-2	—	⩽ 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	—	—
X2CrNiMoN17-11-2	—	⩽ 0,030	⩽ 1,00	2,00	0,045	0,015	0,12 to 0,22	16,5 to 18,5	—	2,00 to 2,50	—	10,0 to 12,5	—	—
X5CrNiMo17-12-2	—	⩽ 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	—	—
X1CrNiMoN25-22-2	4466-310-50-E	⩽ 0,020	⩽ 0,70	2,00	0,025	0,010	0,10 to 0,16	24,0 to 26,0	—	2,00 to 2,50	—	21,0 to 23,0	—	—
X6CrNiMoTi17-12-2	4571-316-35-I	⩽ 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	5 × C to 0,70	—
X6CrNiMoNb17-12-2	4580-316-40-I	⩽ 0,08	⩽ 1,00	2,00	0,045	0,015	—	16,5 to 18,5	—	2,00 to 2,50	10 × C to 1,00	10,5 to 13,5		—
X2CrNiMo17-12-3	4432-316-03-I	⩽ 0,030	⩽ 1,00	2,00	0,045	0,015	⩽ 0,10	16,5 to 18,5	—	2,50 to 3,00	—	10,5 to 13,0	—	—
X2CrNiMoN17-13-3	—	⩽ 0,030	⩽ 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	—	—
X3CrNiMo17-12-3	4436-316-00-I	⩽ 0,05	⩽ 1,00	2,00	0,045	0,015	⩽ 0,10	16,5 to 18,5	—	2,50 to 3,00	—	10,5 to 13,0	—	—
X2CrNiMo18-14-3	—	⩽ 0,030	⩽ 1,00	2,00	0,045	0,015	⩽ 0,10	17,0 to 19,0	—	2,50 to 3,00	—	12,5 to 15,0	—	—
X2CrNiMoN18-12-4	—	⩽ 0,030	⩽ 1,00	2,00	0,045	0,015	0,10 to 0,20	16,5 to 19,5	—	3,0 to 4,0	—	10,5 to 14,0	—	—
X2CrNiMo18-15-4	—	⩽ 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	—	—
X2CrNiMoN17-13-5	4439-317-26-E	⩽ 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	—	—
X1NiCrMoCu31-27-4	4563-080-28-I	⩽ 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	—	⩽ 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	—	—

Table 3 (*continued*)

Steel grade	ISO number[b]	Mass fraction, %												
		C	Si	Mn max.	P max.	S max.	N	Cr	Cu	Mo	Nb	Ni	Ti	Others
Austenitic corrosion-resisting grades														
X1CrNiMoCuN25-25-5	4537-310-92-E	⩽ 0,020	⩽ 0,70	2,00	0,030	0,010	0,17 to 0,25	24,0 to 26,0	1,00 to 2,00	4,7 to 5,7	—	24,0 to 27,0	—	—
X1CrNiMoCuN20-18-7	—	⩽ 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	—	⩽ 0,020	⩽ 0,50	2,00	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	—	—
X2CrMnNiN17-7-5	—	< 0,030	⩽ 1,00	6,0 to 8,0	0,045	0,015	0,15 to 0,20	16,0 to 17,0	—	—	—	3,5 to 5,5	—	—
X9CrMnNiCu17-8-5-2	4618-201-76-E	⩽ 0,10	⩽ 1,00	5,5 to 9,5	0,070	0,010	⩽ 0,15	16,5 to 18,5	1,00 to 2, 50	—	—	4,5 to 5,5	—	—
Austenitic creep-resisting grades														
X3CrNiMoBN17-13-3	4910-316-77-E	⩽ 0,04	⩽ 0,75	2,00	0,035	0,015	0,10 to 0,18	16,0 to 18,0	—	2,00 to 3,00	—	12,0 to 14,0	—	0,0015 to 0,005 0 B
X6CrNiTiB18-10	4941-321-09-I	0,04 to 0,08	⩽ 1,00	2,00	0,035	0,015	—	17,0 to 19,0	—	—	—	9,0 to 12,0	5 × C to 0,70	0,0015 to 0,0050 B
X6CrNi18-10	—	0,04 to 0,08	⩽ 1,00	2,00	0,035	0,015	⩽ 0,10	17,0 to 19,0	—	—	—	8,0 to 11,0	—	—
X6CrNi23-13	4950-309-08-E	0,04 to 0,08	⩽ 0,70	2,00	0,035	0,015	⩽ 0,10	22,0 to 24,0	—	—	—	12,0 to 15,0	—	—
X6CrNi25-20	—	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	—	—
X5NiCrAlTi31-20 (+RA)	—	0,03 to 0,08	⩽ 0,70	1,50	0,015	0,010	⩽ 0,03	19,0 to 22,0	⩽ 0,50	—	⩽ 0,10	30,0 to 32,5	0,20 to 0,50	0,20 to 0,50 Al Al + Ti: ⩽ 0,70 ⩽ 0,50 Co Ni + Co: 30,0 to 32,5
X8NiCrAlTi32-21	—	0,05 to 0,10	⩽ 0,70	1,50	0,015	0,010	⩽ 0,03	19,0 to 22,0	⩽ 0,50	—	—	30,0 to 34,0	0,25 to 0,65	0,25 to 0,65 Al ⩽ 0,50 Co Ni + Co: 30,0 to 34,0
X8CrNiNb16-13	4961-347-77-E	0,04 to 0,10	0,30 to 0,60	1,50	0,035	0,015	—	15,0 to 17,0	—	—	10 × C to 1,20	12,0 to 14,0	—	—

[a] Elements not listed in this table may not be intentionally added to the steel without the agreement of the purchaser, except for finishing of 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] ISO number according to ISO 15510.

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

Steel grade	ISO number[b]	Mass fraction,%										
		C max.	Si max.	Mn max.	P max.	S max.	N	Cr	Cu	Mo	Ni	W
X2CrNiN23-4	4362-323-04-I	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	—
X2CrNiN22-2	—	0,030	1,00	2,00	0,040	0,010	0,16 to 0,28	21,0 to 23,8	—	⩽ 0,45	1,5 to 2,9	—
X2CrNiMoN22-5-3	—	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	—
X2CrNiMoCuN25-6-3	4507-325-20-I	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	—
X2CrNiMoN25-7-4	4410-327-50-E	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	—
X2CrNiMoCuWN25-7-4	—	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

[a] Elements not listed in this table may not be intentionally added to the steel without the agreement of the purchaser, except for finishing of 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] ISO number according to ISO 15510.

Table 5 — Permissible product analysis tolerances on the limiting values given in Tables 1 to 4 for the cast analysis

Element	Specified value in the cast analysis in Tables 1 to 4 % by mass	Permissible deviation[a] of the product analysis % by mass
Carbon	⩽ 0,030	+0,005
	> 0,030; ⩽ 0,10	±0,01
Silicon	⩽ 1,00	+0,05
Manganese	⩽ 1,00	+0,03
	> 1,00; ⩽ 2,50	+0,04
Phosphorus	⩽ 0,030	+0,003
	> 0,030; ⩽ 0,045	+0,005
Sulfur	⩽ 0,015	+0,003
Nitrogen	⩽ 0,35	±0,01
Aluminium	⩽ 0,65	±0,10
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; ⩽ 34,0	±0,20
Cobalt	⩽ 0,50	±0,05
Titanium	⩽ 0,08	±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.

Table 6 — Type of process route of sheet, plate and strip[a]

	Abbreviation[b]	Type of treatment	Surface finish	Notes
Hot rolled	1C	Hot rolled, heat treated, not descaled	Covered with the rolling scale	Suitable for parts which will be descaled or machined in subsequent production or for certain heat-resisting applications.
	1E	Hot rolled, heat treated, mechanically descaled	Free of scale	The type of mechanical descaling, e.g. coarse grinding or shot blasting, depends on the steel grade and the product, and is left to the manufacturer's discretion, unless otherwise agreed
	1D	Hot rolled, heat treated, pickled	Free of scale	Usually standard for most steel types to ensure good corrosion resistance; also common finish for further processing. It is permissible for grinding marks to be present. Not as smooth as 2D or 2B.
Cold rolled	2C	Cold rolled, heat treated, not descaled	Smooth with scale from heat treatment	Suitable for parts which will be descaled or machined in subsequent production or for certain heat-resisting applications.
	2E	Cold rolled, heat treated, mechanically descaled	Rough and dull	Usually applied to steels with a scale which is very resistant to pickling solutions. May be followed by pickling.
	2D	Cold rolled, heat treated, pickled	Smooth	Finish for good ductility, but not as smooth as 2B or 2R.
	2B	Cold rolled, heat treated, pickled, skin passed	Smoother than 2D	Most common finish for most steel types to ensure good corrosion resistance, smoothness and flatness. Also a common finish for further processing. Skin passing may be by tension levelling.
	2R	Cold rolled, bright annealed[c]	Smooth, bright, reflective	Smoother and brighter than 2B. Also a common finish for further processing.
Special finishes	1G or 2G	Ground[d]	See footnote e.	Grade of grit or surface roughness can be specified. Unidirectional texture, not very reflective.
	1J or 2J	Brushed[d] or dull polished[d]	Smoother than ground. See footnote e.	Grade of brush or surface roughness can be specified. Unidirectional texture, not very reflective.
	1K or 2K	Satin polished[d]	See footnote e.	Additional specific requirements to a "J" type finish, in order to achieve adequate corrosion resistance for marine and external architectural applications. Transverse $R_a < 0{,}5$ µm with clean cut surface finish.
	1P or 2P	Bright polished[d]	See footnote e.	Mechanical polishing. Process or surface roughness can be specified. Non-directional finish, reflective with high degree of image clarity.
	2F	Cold rolled, heat treated, skin passed on roughened rolls	Uniform non-reflective matt surface	Heat treatment by bright annealing or by annealing and pickling.

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

[b] First digit: 1 = hot rolled, 2 = cold rolled.

[c] May be skin passed.

[d] One surface only, unless otherwise agreed at the time of enquiry and order.

[e] Within each finish description, the surface characteristics can vary, and more specific requirements may need to be agreed between the manufacturer and purchaser (e.g. grade of grit or surface roughness).

Table 7 — Mechanical properties at room temperature for ferritic steels in the annealed condition (see Table B.1) **and resistance to intergranular corrosion**

Steel grade	Product form[a]	Thickness mm max.	0,2 % proof strength $R_{p0,2}$ MPa min. (long.)	0,2 % proof strength $R_{p0,2}$ MPa min. (tr.)	Tensile strength R_m MPa	Elongation after fracture A_{80}[b] < 3 mm thick % min. (long. + tr.)	Elongation after fracture A[c] ⩾ 3 mm thick % min. (long. + tr.)	Resistance to intergranular corrosion[d] in the delivery condition	Resistance to intergranular corrosion[d] in the welded condition	Impact energy (ISO-V) KV J. min. (tr.)
X2CrNi12	C	8	280	320	450 to 650	20		no	no	50
	H	13,5								
	P	25[e]	250	280		18				
X6CrNiTi12	C	8	280	320	450 to 650	23		no	no	50
	H	13,5								
	P	25[e]	250	280		20				
X2CrTi17	C	4	180	200	380 to 530	24		yes	yes	—[f]
X3CrTi17	C	4	230	240	420 to 600	23		yes	yes	—[f]
X2CrMoTi17-1	C	4	200	220	400 to 550	23		yes	yes	—[f]
X2CrMoTi18-2	C	4	300	320	420 to 640	20		yes	—	—[f]
X6CrMoNb17-1	C	4	280	300	480 to 560	25		yes	yes	—[f]
X2CrTiNb18	C	4	230	250	430 to 630	18		yes	yes	—[f]

[a] C = cold-rolled strip; H = hot-rolled strip; P = hot-rolled plate.

[b] The values are related to test pieces with a gauge length of 80 mm and a width of 20 mm. Test pieces with a gauge length of 50 mm and a width of 12,5 mm may also be used.

[c] The values are related to test pieces with a gauge length of $5{,}65\sqrt{S_o}$.

[d] When tested according to ISO 3651-2.

[e] ●● For thicknesses above 25 mm up to 75 mm, the mechanical properties may be agreed upon at the time of enquiry and order.

[f] Because of the small maximum product thickness t [the requirement to prepare impact test pieces applies for $t \geqslant 6$ mm, see ISO 9328-1:2011, 8.2.2.3 c)], no verifiable values can be specified.

Table 8 — Tensile properties at room temperature and impact energy at 20 °C and at –20 °C for martensitic steels in the quenched and tempered condition (see Table B.2)

Steel grade	Product form[a]	Thickness mm max.	0,2 % proof strength $R_{p0,2}$ MPa min.	Tensile strength R_m MPa	Elongation after fracture A[b] ⩾ 3 mm thick % min. (long. + tr.)	Impact energy (ISO-V) KV J min.	
						at 20 °C (long. + tr.)	at –20 °C (tr.)
X3CrNiMo13-4	P	75	650	780 to 980	14	70	40
X4CrNiMo16-5-1	P	75	680	840 to 980	14	55	40

[a] P = hot-rolled plate.

[b] The values apply for test pieces with a gauge length of $5{,}65\sqrt{S_o}$.

Table 9 — Tensile properties at room temperature and impact energy at 20 °C and at –20 °C of austenitic steels in the solution annealed condition[a] (see Table B.3) **and resistance to intergranular corrosion**

Steel grade	Product form[b]	Thickness	0,2 % proof strength	1,0 % proof strength	Tensile strength	Elongation after fracture		Impact energy (ISO-V)			Resistance to intergranular corrosion[g]	
								KV > 10 mm thick J min.				
			$R_{p0,2}$	$R_{p1,0}$	R_m	A_{80}[e] < 3 mm thick	A[f] ⩾ 3 mm thick	at 20 °C		at –20 °C	in the delivery condition	in the sensitized condition
		mm max.	MPa min. (tr.)[c,d]		MPa	% min. (tr.)[c]	% min. (tr.)[c]	(long.)	(tr.)	(tr.)		
Austenitic corrosion-resisting grades												
X2CrNiN18-7	C	8	350	380	650 to 850	35	40	90	60	—	yes	yes
	H	13,5	330	370								
	P	75	330	370								
X2CrNi18-9	C	8	220	250	520 to 670	45	45	100	60	60	yes	yes
	H	13,5	200	240								
	P	75	200	240	500 to 650							
X2CrNi19-11	C	8	220	250	520 to 670	45	45	100	60	60	yes	yes
	H	13,5	200	240								
	P	75	200	240	500 to 650							
X5CrNiN19-9	C	8	290	320	550 to 750	40	40	100	60	60	(yes)[i]	no[i]
	H	13,5	270	310								
	P	75	270	310								
X2CrNiN18-10	C	8	290	320	550 to 750	40	40	100	60	60	yes	yes
	H	13,5	270	310								
	P	75	270	310								
X5CrNi18-10	C	8	230	260	540 to 750	45[h]	45[h]	100	60	60	(yes)[i]	no[i]
	H	13,5	210	250	520 to 720							
	P	75	210	250		45	45					

Table 9 (*continued*)

Steel grade	Product form[b]	Thickness	0,2 % proof strength	1,0 % proof strength	Tensile strength	Elongation after fracture		Impact energy (ISO-V)			Resistance to intergranular corrosion[g]	
			$R_{p0,2}$	$R_{p1,0}$	R_m	A_{80}[e] < 3 mm thick	A[f] ⩾ 3 mm thick	KV > 10 mm thick J min.			in the delivery condition	in the sensitized condition
								at 20 °C		at –20 °C		
		mm max.	MPa min. (tr.)[c,d]		MPa	% min. (tr.)[c]	% min. (tr.)[c]	(long.)	(tr.)	(tr.)		
X6CrNiTi18-10	C	8	220	250	520 to 720	40	40	100	60	60	yes	yes
	H	13,5	200	240								
	P	75	200	240	500 to 700							
X6CrNiNb18-10	H	13,5	200	240	520 to 720	40	40	100	60	40	yes	yes
	P	75	200	240	500 to 700							
X1CrNi25-21	P	75	200	240	470 to 670	40	40	100	60	60	yes	yes
X2CrNiMo17-12-2	C	8	240	270	530 to 680	40	40	100	60	–	yes	yes
	H	13,5	220	260								
	P	75	220	260	520 to 670	45	45					
X2CrNiMoN17-11-2	C	8	300	330	580 to 780	40	40	100	60	60	yes	yes
	H	13,5	280	320								
	P	75	280	320	510 to 710							
X1CrNiMoN25-22-2	P	75	250	290	540 to 740	40	40	100	60	60	yes	yes
X5CrNiMo17-12-2	C	8	240	270	530 to 680	40	40	100	60	60	(yes)[i]	no[i]
	H	13,5	220	260								
	P	75	220	260	520 to 670	45	45					
X6CrNiMoTi17-12-2	C	8	240	270	540 to 690	40	40	100	60	60	yes	yes
	H	13,5	220	260								
	P	75	220	260	520 to 670							
X6CrNiMoNb17-12-2	P	75	220	260	520 to 720	40	40	100	60	—	yes	yes

Table 9 (*continued*)

Steel grade	Product form[b]	Thickness	0,2 % proof strength	1,0 % proof strength	Tensile strength	Elongation after fracture		Impact energy (ISO-V)			Resistance to intergranular corrosion[g]	
			$R_{p0,2}$	$R_{p1,0}$	R_m	A_{80}[e] < 3 mm thick	A[f] ⩾ 3 mm thick	KV > 10 mm thick J min.			in the delivery condition	in the sensitized condition
		mm max.	MPa min. (tr.)[c,d]		MPa	% min. (tr.)[c]	% min. (tr.)[c]	at 20 °C (long.)	at 20 °C (tr.)	at –20 °C (tr.)		
X2CrNiMo17-12-3	C	8	240	270	550 to 700	40	40	100	60	60	yes	yes
	H	13,5	220	260								
	P	75	220	260	520 to 670	45	45					
X2CrNiMoN17-13-3	C	8	300	330	580 to 780	35	35	100	60	60	yes	yes
	H	13,5	280	320								
	P	75	280	320		40	40					
Austenitic corrosion-resisting grades												
X3CrNiMo17-13-3	C	8	240	270	550 to 700	40	40	100	60	60	(yes)[i]	no[j]
	H	13,5	220	260								
	P	75	220	260	530 to 730							
X2CrNiMo18-14-3	C	8	240	270	550 to 700	40	40	100	60	60	yes	yes
	H	13,5	220	260								
	P	75	220	260	520 to 670	45	45					
X2CrNiMoN18-12-4	C	8	290	320	570 to 770	35	35	100	60	60	yes	yes
	H	13,5	270	310								
	P	75	270	310	540 to 740	40	40					
X2CrNiMo18-15-4	C	8	240	270	550 to 700	35	35	100	60	60	yes	yes
	H	13,5	220	260								
	P	75	220	260	520 to 720	40	40					

Table 9 (*continued*)

Steel grade	Product form[b]	Thickness	0,2 % proof strength	1,0 % proof strength	Tensile strength	Elongation after fracture		Impact energy (ISO-V)			Resistance to intergranular corrosion[g]	
			$R_{p0,2}$	$R_{p1,0}$	R_m	A_{80}[e] < 3 mm thick	A[f] ⩾ 3 mm thick	KV > 10 mm thick J min.			in the delivery condition	in the sensitized condition
		mm max.	MPa min. (tr.)[c,d]		MPa	% min. (tr.)[c]	% min. (tr.)[c]	at 20 °C (long.)	at 20 °C (tr.)	at –20 °C (tr.)		
X2CrNiMoN17-13-5	C	8	290	320	580 to 780	35	35	100	60	60	yes	yes
	H	13,5	270	310								
	P	75	270	310		40	40					
X1NiCrMoCu31-27-4	P	75	220	260	500 to 700	40	40	100	60	60	yes	yes
X1NiCrMoCu25-20-5	C	8	240	270	530 to 730	35	35	100	60	60	yes	yes
	H	13,5	220	260								
	P	75	220	260	520 to 720	40	40					
X1CrNiMoCuN25-25-5	P	75	290	330	600 to 800	40	40	100	60	60	yes	yes
X1CrNiMoCuN20-18-7	C	8	320	350	650 to 850	35	35	100	60	60	yes	yes
	H	13,5	300	340								
	P	75	300	340		40	40					
X1NiCrMoCuN25-20-7	P	75	300	340	650 to 850	40	40	100	60	60	yes	yes
X2CrMnNiN17-7-5	C	8,0	330	380	650 to 850	40	45	100	60	60	yes	yes
	H	13,5	300	370								
	P	75,0	300	370								
X9CrMnNiCu17-8-5-2	C	8,0	230	250	540 to 850	45	45	100	60	60	yes	no
	H	13,5	230	250	520 to 830							
	P	75,0	210	240	520 to 830							
Austenitic creep-resisting grades												
X3CrNiMoBN17-13-3	C	8	300	330	580 to 780	35	40	100	60	—	yes	yes
	H	13,5	260	300	550 to 750							
	P	75	260	300								

Table 9 (*continued*)

Steel grade	Product form[b]	Thickness	0,2 % proof strength	1,0 % proof strength	Tensile strength	Elongation after fracture		Impact energy (ISO-V)			Resistance to intergranular corrosion[g]	
			$R_{p0,2}$	$R_{p1,0}$	R_m	A_{80}[e] < 3 mm thick	A[f] ⩾ 3 mm thick	KV > 10 mm thick J min.			in the delivery condition	in the sensitized condition
								at 20 °C		at –20 °C		
		mm max.	MPa min. (tr.)[c,d]		MPa	% min. (tr.)[c]	% min. (tr.)[c]	(long.)	(tr.)	(tr.)		
X6CrNiTiB18-10	C	8	220	250	510 to 710	40	40	100	60	—	yes	yes
	H	13,5	200	240								
	P	75	200	240	490 to 690							
X6CrNi18-10	C	8	230	260	530 to 740	45[h]	45[h]	100	60	—	no	no
	H	13,5	210	250	510 to 710	45	45					
	P	75	190	230								
X6CrNi23-13	C	8	220	250	530 to 730	35	35	100	60	—	no	no
	H	13,5	200	240	510 to 710							
	P	75	200	240								
X6CrNi25-20	C	8	220	250	530 to 730	35	35	100	60	—	no	no
	H	13,5	200	240	510 to 710							
	P	75	200	240								
X5NiCrAlTi31-20	P	75	170	200	500 to 750	30	30	120	80	—	yes	no
X5NiCrAlTi31-20+RA[k]	P	75	210	240	500 to 750	30	30	120	80	—	yes	no
X8NiCrAlTi32-21	P	75	170	200	500 to 750	30	30	120	80	—	yes	no
X8CrNiNb16-13	P	75	200	240	510 to 690	35	35	100	60	—	yes	yes

Table 9 (*continued*)

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 ISO 3651-2 are obtained.
b C = cold-rolled strip; H = hot-rolled strip; P = hot-rolled plate.
c If, in the case of strip in rolling widths < 300 mm, longitudinal test pieces are taken, the minimum values are reduced as follows: — proof strength: minus 15 MPa; — elongation for constant gauge length: minus 5 %; — elongation for proportional gauge length: minus 2 %.
d •• For continuously hot-rolled products, 20 MPa higher minimum values of $R_{p0,2}$ and 10 MPa higher minimum values of $R_{p1,0}$ may be agreed upon at the time of enquiry and order.
e The values are related to test pieces with a gauge length of 80 mm and a width of 20 mm; test pieces with a gauge length of 50 mm and a width of 12,5 mm may also be used.
f The values are related to test pieces with a gauge length of $5{,}65\sqrt{S_o}$.
g When tested according to ISO 3651-2.
h For stretcher-levelled material, the minimum value is 5 % lower.
i Normally for thicknesses up to 6 mm.
j Resistance to intergranular corrosion is given for thicknesses up to 6 mm in the welded condition.
k +RA = recrystallizing annealed condition.

Table 10 — Tensile properties at room temperature and impact energy at 20 °C and at –40 °C of austenitic-ferritic steels in the solution annealed condition (see Table B.4) **and resistance to intergranular corrosion**

Steel grade	Product form[a]	Thickness	0,2 % proof strength		Tensile strength	Elongation after fracture		Impact energy (ISO-V)			Resistance to intergranular corrosion[e]	
			$R_{p0,2}$ MPa[b] min.		R_m	A_{80} < 3 mm thick[c]	A ≥ 3 mm thick[d]	KV J min.				
		mm max.	width		MPa	% min.	% min.	at 20 °C		at –40 °C	in the delivery condition	in the sensitized condition
			(long.) < 300 mm	(tr.) ≥ 300 mm		(long. + tr.)	(long. + tr.)	(long.)	(tr.)	(tr.)		
X2CrNiN23-4	C	8	405	420	600 to 850	20	20	120	90	40	yes	yes
	H	13,5	385	400								
	P	75	385	400	630 to 800	25	25					

Table 10 (*continued*)

Steel grade	Product form[a]	Thickness mm max.	0,2 % proof strength $R_{p0,2}$ MPa[b] min. width (long.) < 300 m mm	0,2 % proof strength $R_{p0,2}$ MPa[b] min. width (tr.) ⩾ 300 m mm	Tensile strength R_m MPa	Elongation after fracture A_{80} < 3 mm thick[c] % min. (long. + tr.)	Elongation after fracture $A^{\square}$ ⩾ 3 mm thick[d] % min. (long. + tr.)	Impact energy (ISO-V) KV J min. at 20 °C (long.)	Impact energy (ISO-V) KV J min. at 20 °C (tr.)	Impact energy (ISO-V) KV J min. at –40 °C (tr.)	Resistance to intergranular corrosion[e] in the delivery condition	Resistance to intergranular corrosion[e] in the sensitized condition
X2CrNiN22-2	C	8	465	480	650 to 850	25	25	100	60	30	yes	yes
	H	13,5	435	450								
	P	25[f]	435	450		30	30					
X2CrNiMoN22-5-3	C	8	485	500	700 to 950	20	20	150	100	40	yes	yes
	H	13,5	445	460		25	25					
	P	75	445	460	640 to 840	25	25					
X2CrNiMoCuN25-6-3	C	8	495	510	690 to 940	20	20	150	90	40	yes	yes
	H	13,5	475	490								
	P	75	475	490	690 to 890	25	25					
X2CrNiMoN25-7-4	C	8	535	550	750 to 1000	20	20	150	90	40	yes	yes
	H	13,5	515	530								
	P	75	515	530	730 to 930	20	20					
X2CrNiMoCuWN25-7-4	P	75	515	530	730 to 930	25	25	150	90	40	yes	yes

a C = cold-rolled strip; H = hot-rolled strip; P = hot-rolled plate.

b •• For continuously hot rolled products, 20 MPa higher minimum values of $R_{p0,2}$ may be agreed upon at the time of enquiry and order.

c The values are related to test pieces with a gauge length of 80 mm and a width of 20 mm; test pieces with a gauge length of 50 mm and a width of 12,5 mm may also be used.

d The values are related to test pieces with a gauge length of $5{,}65\sqrt{S_o}$.

e When tested according to ISO 3651-2.

f According to VdTÜV (Verband der Technischen Überwachungs-Vereine).

Table 11 — Minimum values for the 0,2 % proof strength of ferritic steels at elevated temperatures in the annealed condition (see Table B.1)

Steel grade	Minimum 0,2 % proof strength $R_{p0,2}$, MPa at a temperature (in °C) of							
	50[a]	100	150	200	250	300	350	400
X2CrNi12	265	240	235	230	220	215	—	—
X6CrNiTi12	—	300	270	250	245	225	215	—
X2CrTi17	198	195	180	170	160	155	—	—
X3CrTi17	223	195	190	185	175	165	155	—
X2CrMoTi17-1	—	250	240	230	220	210	205	200
X2CrMoTi18-2	294	250	240	230	220	210	205	—
X6CrMoNb17-1	289	270	265	250	235	215	205	—
X2CrTiNb18	242	230	220	210	205	200	180	—

[a] Determined by linear interpolation.

Table 12 — Minimum values for the 0,2 % proof strength of martensitic steels at elevated temperatures in the quenched and tempered condition (see Table B.2)

Steel grade	Minimum 0,2 % proof strength $R_{p0,2}$, MPa at a temperature (in °C) of						
	50[a]	100	150	200	250	300	350
X3CrNiMo13-4	627	590	575	560	545	530	515
X4CrNiMo16-5-1	672	660	640	620	600	580	—

[a] Determined by linear interpolation.

Table 13 — Minimum values for the 0,2 % and 1,0 % proof strength of austenitic steels at elevated temperatures in the solution annealed condition
(see Table B.3)

Steel grade	Minimum 0,2 % proof strength $R_{p0,2}$, MPa at a temperature (in °C) of												Minimum 1,0 % proof strength $R_{p1,0}$, MPa at a temperature (in °C) of											
	50[a]	100	150	200	250	300	350	400	450	500	550	600	50[a]	100	150	200	250	300	350	400	450	500	550	600
Austenitic corrosion-resisting grades																								
X2CrNiN18-7	309	265	200	185	180	170	165	—	—	—	—	—	—	—	235	215	210	200	195	—	—	—	—	—
X2CrNi18-9	180	147	132	118	108	100	94	89	85	81	80	—	218	181	162	147	137	127	121	116	112	109	108	—
X2CrNi19-11	180	147	132	118	108	100	94	89	85	81	80	—	218	181	162	147	137	127	121	116	112	109	108	—
X5CrNiN19-9	246	205	175	157	145	136	130	125	121	119	118	—	284	240	210	187	175	167	161	156	152	149	147	—
X2CrNiN18-10	246	205	175	157	145	136	130	125	121	119	118	—	284	240	210	187	175	167	161	156	152	149	147	—
X5CrNi18-10	190	157	142	127	118	110	104	98	95	92	90	—	228	191	172	157	145	135	129	125	122	120	120	—
X6CrNiTi18-10	191	176	167	157	147	136	130	125	121	119	118	—	228	208	196	186	177	167	161	156	152	149	147	—
X6CrNiNb18-10	191	177	167	157	147	136	130	125	121	119	118	—	229	211	196	186	177	167	161	156	152	149	147	—
X1CrNi25-21	181	150	140	130	120	115	110	105	—	—	—	—	217	180	170	160	150	140	135	130	—	—	—	—
X2CrNiMo17-12-2	200	166	152	137	127	118	113	108	103	100	98	—	237	199	181	167	157	145	139	135	130	128	127	—
X2CrNiMoN17-11-2	254	211	185	167	155	145	140	135	131	128	127	—	292	246	218	198	183	175	169	164	160	158	157	—
X5CrNiMo17-12-2	204	177	162	147	137	127	120	115	112	110	108	—	242	211	191	177	167	156	150	144	141	139	137	—
X1CrNiMoN25-22-2	229	195	170	160	150	140	135	—	—	—	—	—	266	225	205	190	180	170	165	—	—	—	—	—
X6CrNiMoTi17-12-2	207	185	177	167	157	145	140	135	131	129	127	—	244	218	206	196	186	175	169	164	160	158	157	—
X6CrNiMoNb17-12-2	207	185	177	167	157	145	140	135	131	129	127	—	244	218	206	196	186	175	169	164	160	158	157	—
X2CrNiMo17-12-3	200	166	152	137	127	118	113	108	103	100	98	—	237	199	181	167	157	145	139	135	130	128	127	—
X2CrNiMoN17-13-3	254	211	185	167	155	145	140	135	131	129	127		292	246	218	198	183	175	169	164	160	158	157	—
X3CrNiMo17-13-3	204	177	162	147	137	127	120	115	112	110	108	—	252	211	191	177	167	156	150	144	141	139	137	—
X2CrNiMo18-14-3	199	165	150	137	127	119	113	108	103	100	98	–	237	200	180	165	153	145	139	135	130	128	127	—

Table 13 (*continued*)

Steel grade	Minimum 0,2 % proof strength $R_{p0,2}$, MPa at a temperature (in °C) of												Minimum 1,0 % proof strength $R_{p1,0}$, MPa at a temperature (in °C) of											
	50[a]	100	150	200	250	300	350	400	450	500	550	600	50[a]	100	150	200	250	300	350	400	450	500	550	600
X2CrNiMoN18-12-4	248	211	185	167	155	145	140	135	131	129	127	—	286	246	218	198	183	175	169	164	160	158	157	—
X2CrNiMo18-15-4	202	172	157	147	137	127	120	115	112	110	108	—	240	206	188	177	167	156	148	144	140	138	136	—
X2CrNiMoN17-13-5	253	225	200	185	175	165	155	150	—	—	—	—	289	255	230	210	200	190	180	175	—	—	—	—
X1NiCrMoCu31-27-4	209	190	175	160	155	150	145	135	125	120	115	—	245	220	205	190	185	180	175	165	155	150	145	—
X1NiCrMoCu25-20-5	214	205	190	175	160	145	135	125	115	110	105	—	251	235	220	205	190	175	165	155	145	140	135	—
X1CrNiMoCuN25-25-5	271	240	220	200	190	180	175	170	—	—	—	—	307	270	250	230	220	210	205	200	—	—	—	—
X1CrNiMoCuN20-18-7	274	230	205	190	180	170	165	160	153	148	—	—	314	270	245	225	212	200	195	190	184	180	—	—
X1NiCrMoCuN25-20-7	274	230	210	190	180	170	165	160	130	120	105	—	314	270	245	225	215	205	195	190	160	150	135	—
X2CrMnNiN17-7-5	246	205	175	127	120	110	104	100	95	92	90	—	284	240	210	157	145	135	129	125	122	120	120	—
X9CrMnNiCu17-8-5-2	190	160	150	125	120	110	104	100	95	92	90	—	230	200	180	157	145	135	129	125	122	120	120	—
Austenitic creep-resisting grades																								
X3CrNiMoBN17-13-3	239	205	187	170	159	148	141	134	130	127	124	121	277	240	220	200	189	178	171	164	160	157	154	151
X6CrNiTiB18-10	186	162	152	142	137	132	127	123	118	113	108	103	225	201	191	181	176	172	167	162	157	152	147	142
X6CrNi18-10	178	157	142	127	117	108	103	98	93	88	83	78	215	191	172	157	147	137	132	127	122	118	113	108
X6CrNi23-13	177	140	128	116	108	100	94	91	86	85	84	82	219	185	167	154	146	139	132	126	123	121	118	114
X6CrNi25-20	177	140	128	116	108	100	94	91	86	85	84	82	219	185	167	154	146	139	132	126	123	121	118	114
X5NiCrAlTi31-20	159	140	127	115	105	95	90	85	82	80	75	75	185	160	147	135	125	115	110	105	102	100	95	95
X5NiCrAlTi31-20+RA	199	180	170	160	152	145	137	130	125	120	115	110	227	205	193	180	172	165	160	155	150	145	140	135
X8NiCrAlTi32-21	159	140	127	115	105	95	90	85	82	80	75	75	185	160	147	135	125	115	110	105	102	100	95	95
X8CrNiNb16-13	191	175	166	157	147	137	132	128	123	118	118	113	227	205	195	186	176	167	162	157	152	147	147	142

[a] Determined by linear interpolation.

Table 14 — Minimum values for the 0,2 % proof strength of austenitic-ferritic steels at elevated temperatures in the solution annealed condition (see Table B.4)

Steel grade	Minimum 0,2 % proof strength $R_{p0,2}$, MPa at a temperature (in °C) of				
	50[a]	100	150	200	250
X2CrNiN23-4	374	330	300	280	265
X2CrNiN22-2	430	380	350	330	320
X2CrNiMoN22-5-3	422	360	335	315	300
X2CrNiMoCuN25-6-3	475	450	420	400	380
X2CrNiMoN25-7-4	500	450	420	400	380
X2CrNiMoCuWN25-7-4	500	450	420	400	380

[a] Determined by linear interpolation.

Table 15 — Minimum values for the tensile strength of austenitic steels at elevated temperatures in the solution annealed condition (see Table B.3)

Steel grade	Minimum tensile strength R_m, MPa, at a temperature (in °C) of											
	50[a]	100	150	200	250	300	350	400	450	500	550	600
Austenitic corrosion-resisting grades												
X2CrNiN18-7	605	530	490	460	450	440	430	—	—	—	—	—
X2CrNi18-9	466	410	380	360	350	340	340	—	—	—	—	—
X2CrNi19-11	466	410	380	360	350	340	340	—	—	—	—	—
X5CrNiN19-9	527	490	460	430	420	410	410	—	—	—	—	—
X2CrNiN18-10	527	490	460	430	420	410	410	—	—	—	—	—
X5CrNi18-10	494	450	420	400	390	380	380	380	370	360	330	—
X6CrNiTi18-10	477	440	410	390	385	375	375	375	370	360	330	—
X6CrNiNb18-10	476	435	400	370	350	340	335	330	320	310	300	—
X1CrNi25-21	459	440	425	410	390	385	380	—	—	—	—	—
X2CrNiMo17-12-2	486	430	410	390	385	380	380	380	—	360	—	—
X2CrNiMoN17-11-2	557	520	490	460	450	440	435	—	—	—	—	—
X5CrNiMo17-12-2	486	430	410	390	385	380	380	—	—	—	—	—
X1CrNiMoN25-22-2	521	490	475	460	450	440	435	—	—	—	—	—
X6CrNiMoTi17-12-2	490	440	410	390	385	375	375	375	370	360	330	—
X6CrNiMoNb17-12-2	490	440	410	390	385	375	375	375	370	360	330	—
X2CrNiMo17-12-3	486	430	410	390	385	380	380	380	—	360	—	—
X2CrNiMoN17-13-3	557	520	490	460	450	440	435	435	—	430	—	—
X3CrNiMo17-13-3	504	460	440	420	415	410	410	410	—	390	—	—
X2CrNiMo18-14-3	482	420	400	380	375	370	370	—	—	—	—	—
X2CrNiMoN18-12-4	525	500	470	440	430	420	415	415	415	410	390	—
X2CrNiMo18-15-4	486	430	410	390	385	380	380	—	—	—	—	—
X2CrNiMoN17-13-5	557	520	490	460	450	440	435	—	—	—	—	—
X1NiCrMoCu31-27-4	485	460	445	430	410	400	395	—	—	—	—	—
X1NiCrMoCu25-20-5	512	500	480	460	450	440	435	—	—	—	—	—
X1CrNiMoCuN25-25-5	581	550	535	520	500	480	475	—	—	—	—	—
X1CrNiMoCuN20-18-7	637	615	587	560	542	525	517	510	502	495	—	—
X1NiCrMoCuN25-20-7	612	550	535	520	500	480	475	—	—	—	—	—
X2CrMnNiN17-7-5	527	490	460	430	420	410	400	380	370	360	330	—
X9CrMnNiCu17-8-5-2	500	450	420	400	390	380	380	380	370	360	330	—
Austenitic creep-resisting grades												
X3CrNiMoBN17-13-3	529	495	472	450	440	430	425	420	410	400	385	365
X6CrNiTiB18-10	460	410	390	370	360	350	345	340	335	330	320	300
X6CrNi18-10	484	440	410	390	385	375	375	375	370	360	330	300
X6CrNi23-13	495	470	450	430	420	410	405	400	385	370	350	320
X6CrNi25-20	495	470	450	430	420	410	405	400	385	370	350	320
X5NiCrAlTi31-20[b]	487	465	445	435	425	420	418	415	415	415	—	—
X8NiCrAlTi32-21	487	465	445	435	425	420	418	415	415	415	—	—
X8CrNiNb16-13	493	465	440	420	400	385	375	370	360	350	340	320

[a] Determined by linear interpolation.

[b] The tensile strength values also apply for the recrystallizing annealed condition (+RA).

Table 16 — Tests to be carried out, test units and extent of testing

Test	Test status[a]	Test unit	Product form		Number of test pieces per test sample
			Strip and sheet cut from strip in rolling width (C,H)	Rolled plate (P)	
Chemical analysis	m	Cast	Cast analysis[b]		
Tensile test at room temperature	m	Cast, thickness ±10 %, heat treatment batch	1 test sample from each coil	a) Plates ⩽ 20 mm (⩽ 15 mm)[c] thickness: Plates processed under identical conditions may be collected in a batch comprising not more than 20 plates. One test sample per batch shall be taken from heat-treated plates up to 15 m in length. One test sample shall be taken from each end of the longest plate in the batch where heat-treated plates are longer than 15 m. However, see ISO 9328-1:2011, Table 2, footnote a. b) Plates > 20 mm (> 15 mm)[c] thickness: Each single plate; one test sample shall be taken from heat-treated plates up to 15 m long and one sample shall be taken from each end of heat-treated plates longer than 15 m. However, see ISO 9328-1:2011, Table 2, footnote a.	1
Tensile test at elevated temperature[d]	o		To be agreed at the time of enquiry and order.		1
Impact test at room temperature	m[e]		To be agreed at the time of enquiry and order.		3
Impact test at low temperature	o		To be agreed at the time of enquiry and order.		3
Resistance to intergranular corrosion	o		To be agreed at the time of enquiry and order.		1
Other tests	o	See ISO 9328-1.			

[a] Tests marked with an “m” (mandatory) shall be carried out as acceptance tests. In all cases, those marked with an “o” (optional) shall be carried out as acceptance tests only if agreed at the time of enquiry and order.

[b] A product analysis may be agreed at the time of enquiry and order; the extent of testing shall be specified at the same time.

[c] Limit value for martensitic, ferritic and austenitic-ferritic steels.

[d] See ISO 9328-1:2011, 9.3.

[e] For ferritic, martensitic and austenitic-ferritic grades > 6 mm thickness, and for austenitic grades for cryogenic service > 20 mm thickness; optional for austenitic grades for other applications (see ISO 9328-1:2011, Table 1).

Annex A
(informative)

Steel designations in accordance with this part of ISO 9328 and designation of comparable steel grades in national or regional standards

Table A.1 — Steel designations in accordance with this part of ISO 9328[a] and designation of comparable[b] steel grades in national or regional standards

Steel designation in			
ISO 9328-7	**EN 10028-7[c]**	**ASTM A959**	**JIS**
Ferritic steels			
X2CrNi12	1.4003	S41003	—
X6CrNiTi12	1.4516	S40975	—
X2CrTi17	1.4520		—
X3CrTi17	1.4510	S43035	SUS 430LX
X2CrMoTi17-1	1.4513		SUS 436L
X2CrMoTi18-2	1.4521	S44400	SUS 444
X6CrMoNb17-1	1.4526	S43600	—
X2CrTiNb18	1.4509		—
Martensitic steels			
X3CrNiMo13-4	1.4313	S41500	SUS F6NM
X4CrNiMo16-5-1	1.4418	—	—
Austenitic corrosion-resisting steels			
X2CrNiN18-7	1.4318	S30153	SUS 301L
X2CrNi18-9	1.4307	S30403	SUS 304L
X2CrNi19-11	1.4306	S30403	SUS 304L
X5CrNiN19-9	1.4315	S30451	SUS 304N1
X2CrNiN18-10	1.4311	S30453	SUS 304LN
X5CrNi18-10	1.4301	S30400	SUS 304
X6CrNiTi18-10	1.4541	S32100	SUS 321
X6CrNiNb18-10	1.4550	S34700	SUS 347
X1CrNi25-21	1.4335	S31002	—
X2CrNiMo17-12-2	1.4404	S31603	SUS 316L
X2CrNiMoN17-11-2	1.4406	S31653	SUS 316LN
X5CrNiMo17-12-2	1.4401	S31600	SUS 316
X1CrNiMoN25-22-2	1.4466	S31050	—
X6CrNiMoTi17-12-2	1.4571	S31635	SUS316TI
X6CrNiMoNb17-12-2	1.4580	S31640	—
X2CrNiMo17-12-3	1.4432	S31603	SUS 316L

Table A.1 (*continued*)

Steel designation in			
ISO 9328-7	**EN 10028-7[c]**	**ASTM A959**	**JIS**
X2CrNiMoN17-13-3	1.4429	S31653	SUS 316LN
X3CrNiMo17-13-3[d]	1.4436	S31600	SUS 316
X2CrNiMo18-14-3	1.4435	S31603	SUS 316L
X2CrNiMoN18-12-4	1.4434	S31753	SUS 317LN
X2CrMnNiN17-7-5	1.4371	S20153	—
X9CrMnNiCu17-8-5-2	1.4618	S20100	—
X2CrNiMo18-15-4	1.4438	S31703	SUS 317L
X2CrNiMoN17-13-5	1.4439	S31726	—
X1NiCrMoCu31-27-4	1.4563	N08028	—
X1NiCrMoCu25-20-5	1.4539	N08904	SUS 890L
X1CrNiMoCuN25-25-5	1.4537	NO8932	—
X1CrNiMoCuN20-18-7	1.4547	S31254	SUS 312L
X1NiCrMoCuN25-20-7	1.4529	N08926	—
Austenitic creep-resisting steels			
X3CrNiMoBN17-13-3	1.4910		—
X6CrNiTiB18-10	1.4941	S32109	—
X6CrNi18-10	1.4948	S30409	SUS 304H
X6CrNi23-13	1.4950	S30908	SUS 309S
X6CrNi25-20	1.4951	S31008	SUS 310S
X5NiCrAlTi31-20(+RA)	1.4958 (+RA)	—	—
X8NiCrAlTi32-21	1.4959	—	—
X8CrNiNb16-13	1.4961	—	—
Austenitic-ferritic steels			
X2CrNiN23-4	1.4362	S32304	—
X2CrNiN22-2	1.4062	S32202	—
X2CrNiMoN22-5-3	1.4462	S32205	SUS 329J3L
X2CrNiMoCuN25-6-3	1.4507	S32550	—
X2CrNiMoN25-7-4	1.4410	S32750	—
X2CrNiMoCuWN25-7-4	1.4501	S32760	—

[a] In accordance with ISO/TS 4949.

[b] "Comparable" covers both identical or similar steel grades but does not necessarily imply "substitutable".

[c] In addition to the steel name (identical to the corresponding steel name used in this part of ISO 9328), the listed steel number is specified.

[d] Steel name in ISO 15510: X3CrNiMo17-12-3.

Annex B
(normative)

Guidelines for further treatment (including heat treatment) in fabrication

B.1 The guidelines given in Tables B.1 to B.4 are intended for hot forming and heat treatment.

B.2 Thermal cutting may adversely affect edge areas; they should be machined.

B.3 Scale and annealing colours produced during hot forming, heat treatment or welding may adversely affect the corrosion resistance. They should be removed as far as possible before use, e.g. by pickling or grinding.

B.4 For further information, see appropriate documents, e.g. EN 1011-3.

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

Steel grade	Hot forming		Heat treatment symbol[b]	Annealing	
	Temperature °C	Type of cooling		Temperature[c] °C	Type of cooling
X2CrNi12	1 100 to 800	air	+A	700 to 750	air, water
X6CrNiTi12				790 to 850	
X2CrTi17				820 to 880	
X3CrTi17				770 to 830	
X2CrMoTi17-1				790 to 850	
X2CrMoTi18-2				820 to 880	
X6CrMoNb17-1				800 to 860	
X2CrTiNb18				870 to 930	

[a] The temperatures of annealing should be agreed for simulated heat-treated test pieces.

[b] +A = annealed.

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

Table B.2 — Guidelines on the temperature for hot forming and heat treatment[a] of martensitic stainless steels

Steel grade	Hot forming		Heat treatment symbol[b]	Quenching		Tempering
	Temperature °C	Type of cooling		Temperature[c] °C	Type of cooling	Temperature °C
X3CrNiMo13-4	1 150 to 900	air	+QT	950 to 1 050	oil, air, water	560 to 640
X4CrNiMo16-5-1			+QT	900 to 1 000		570 to 650

[a] The temperatures of quenching and tempering should be agreed for simulated heat-treated test pieces.

[b] +QT = Quenched and tempered.

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

Table B.3 — Guidelines on the temperature for hot forming and heat treatment[a] of austenitic stainless steels

Steel grade	Hot forming		Heat treatment[b] symbol	Solution annealing[c] (but see footnote g)	
	Temperature °C	Type of cooling		Temperature[d,e] °C	Type of cooling
Austenitic corrosion-resisting grades					
X2CrNiN18-7	1 150 to 850	air	+AT	1 020 to 1 100	water, air[f]
X2CrNi18-9				1 000 to 1 100	
X2CrNi19-11				1 000 to 1 100	
X5CrNiN19-9				1 000 to 1 100	
X2CrNiN18-10				1 000 to 1 100	
X5CrNi18-10				1 000 to 1 100	
X6CrNiTi18-10				1 000 to 1 100	
X6CrNiNb18-10				1 020 to 1 120	
X1CrNi25-21				1 030 to 1 110	
X2CrNiMo17-12-2				1 030 to 1 110	
X2CrNiMoN17-11-2				1 030 to 1 110	
X1CrNiMoN25-22-2				1 070 to 1 150	
X5CrNiMo17-12-2				1 030 to 1 110	
X6CrNiMoTi17-12-2				1 030 to 1 110	
X6CrNiMoNb17-12-2				1 030 to 1 110	
X2CrNiMo17-12-3				1 030 to 1 110	
X2CrNiMoN17-13-3				1 030 to 1 110	
X3CrNiMo17-13-3				1 030 to 1 110	
X2CrNiMo18-14-3				1 030 to 1 110	
X2CrNiMoN18-12-4				1 070 to 1 150	
X2CrNiMo18-15-4				1 070 to 1 150	
X2CrNiMoN17-13-5				1 060 to 1 140	
X1NiCrMoCu31-27-4				1 070 to 1 150	
X1NiCrMoCu25-20-5				1 060 to 1 140	
X1CrNiMoCuN25-25-5				1 120 to 1 180	
X1CrNiMoCuN20-18-7				1 140 to 1 200	
X1NiCrMoCuN25-20-7				1 120 to 1 180	
X2CrMnNiN17-7-5				1 000 to 1 100	
X9CrMnNiCu17-8-5-2				1 000 to 1 100	

Table B.3 (*continued*)

Steel grade	Hot forming		Heat treatment[b] symbol	Solution annealing[c] (but see footnote g)	
	Temperature °C	Type of cooling		Temperature[d,e] °C	Type of cooling
Austenitic creep-resisting grades					
X3CrNiMoBN17-13-3	1 150 to 850	air	+AT	1 020 to 1 100	water, air[f]
X6CrNiTiB18-10				1 050 to 1 110	
X6CrNi18-10				1 050 to 1 110	
X6CrNi23-13				1 050 to 1 150	
X6CrNi25-20				1 050 to 1 150	
X5NiCrAlTi31-20				1 100 to 1 200	
X5NiCrAlTi31-20+RA			+RA	920 to 1 000[g]	
X8NiCrAlTi32-21			+AT	1 100 to 1 200[h]	
X8CrNiNb16-13				1 050 to 1 110	

[a] The temperatures of annealing should be agreed for simulated heat-treated test pieces.

[b] +AT = solution annealed, +RA = recrystallizing annealed.

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

[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] 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 a 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 %.

[f] Cooling is sufficiently rapid.

[g] Recrystallizing annealing.

[h] After solution annealing, the grain size according to ISO 643 shall be 1 to 5.

Table B.4 — Guidelines on the temperature for hot forming and heat treatment[a] of austenitic-ferritic steels

Steel grade	Hot forming		Heat treatment	Solution annealing[c]	
	Temperature °C	Type of cooling	Symbol[b]	Temperature[d] °C	Type of cooling
Standard grades					
X2CrNiN23-4	1 150 to 950	air	+AT	1 000 ±50	water, air
X2CrNiMoN22-5-3				1 060 ±40	
X2CrNiN22-2	1 100 to 950			1 040 ±60	
Special grades					
X2CrNiMoCuN25-6-3	1 150 to 1 000	air	+AT	1 080 ±40	water, air
X2CrNiMoN25-7-4					
X2CrNiMoCuWN25-7-4					

[a] The temperatures of annealing should be agreed for simulated heat-treated test pieces.

[b] +AT = solution annealed.

[c] Solution annealing in the range specified, followed by sufficiently rapid cooling to avoid precipitation of deleterious phases, is essential after hot forming these steels.

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

Annex C
(informative)

Post-weld heat treatment

C.1 In general, welded assemblies of stainless steels covered by this part of ISO 9328 are not subjected to any heat treatment with the following exception:

— martensitic grades are retempered;

— ferritic grades are reannealed if there is any risk of residual martensitic in the heat-affected zones; for appropriate temperatures see Tables B.1 and B.2.

C.2 During heating of high chromium and molybdenum austenitic-ferritic or austenitic steel weldments containing some ferrite, intermetallic phases may be formed which should be re-dissolved during post-weld heat treatment. As most filler metals are overalloyed in comparison with the equivalent basic grades, minimum solution temperatures higher than those in Tables B.3 and B.4 may be necessary.

In the case of fully austenitic weld structures, it should be verified that mechanical properties of heat-treated weldments conform to this part of ISO 9328.

Oxidation of surfaces which necessitates pickling and possible distortion of the welded construction may raise further difficulties.

Consequently, post-weld heat treatment of duplex and austenitic steels should be avoided, and therefore welding should be planned carefully.

C.3 In special cases, e.g. for parts with a greater wall thickness, requirements concerning stress-relief and resistance to intergranular corrosion, in order to avoid failure by stress corrosion cracking or corrosion fatigue, may prove the necessity for post-weld heat treatment. This should be carried out according to Table C.1 by holding at an intermediate stage below the usual solution temperature (see Table B.3) and is defined as stabilizing annealing for the niobium- or titanium-bearing grades and as stress-relieving for the unstabilized low-carbon grades.

In some cases, post-weld heat treatment may also be performed as solution annealing according to Table B.3 or at a temperature below the precipitation range of carbides and intermetallic phases; however, the latter reduces only peak stresses.

C.4 Preheating of austenitic-ferritic steels is a very effective precaution against excessive stress increase caused by shrinkage of thicker welded cross-sections, because temperatures of 200 °C to 250 °C bring down room-temperature yield strength by about 50 %. Thus preheating is often more appropriate to avoid high stress levels in those weldments than any post-weld heat treatment. Preheating temperature between 120 °C and 200 °C according to the particular steel and thickness may be applied. Excessive preheating or excess weld heat input may promote the formation of undesirable intermetallic phases.

Table C.1 — Guidelines on post-weld heat treatment of austenitic steels

Steel grade	Temperature[a]	Type of cooling
Stabilized steels		
X6CrNiTi18-10	900 to 940	air
X6CrNiNb18-10		
X6CrNiMoTi17-12-2	not recommended	
X6CrNiMoNb17-12-2		
Steels with ⩽ 0,07 % C		
X5CrNi19-9	not recommended	
X5CrNi18-10		
X5CrNiMo17-12-2		
X3CrNiMo17-13-3		
X9CrMnNiCu17-8-5-2		
Steels with ⩽ 0,03 % C		
X2CrNiN18-7	900 to 940	air
X2CrNi18-9		
X2CrNi19-11		
X2CrNiN18-10		
X2CrMnNiN17-7-5		
X2CrNiMo17-12-2	960 to 1 040[b]	air
X2CrNiMoN17-11-2		
X2CrNiMo17-12-3		
X2CrNiMoN17-13-3		
X2CrNiMo18-14-3		
X2CrNiMoN18-12-4		
X2CrNiMo18-15-4		
X2CrNiMoN17-13-5		
Higher alloyed austenitic steels with ⩽ 0,02 % C		
X1CrNi25-21	not recommended	
X1CrNiMoN25-22-2		
X1NiCrMoCu31-27-4		
X1NiCrMoCu25-20-5		
X1CrNiMoCuN25-25-5		
X1CrNiMoCuN20-18-7		
X1NiCrMoCuN25-20-7		
Creep-resisting steels		
X3CrNiMoBN17-13-3	900 to 950[c]	air
X6CrNiTiB18-10		
X6CrNi18-10	not recommended	
X6CrNi23-13		
X6CrNi25-20		
X5NiCrAlTi31-20 (+RA)	900 to 950[c]	air
X8NiCrAlTi32-21		
X8CrNiNb16-13		

[a] Minimum holding time: 30 min.

[b] Not recommended if welded with stabilized filler metal.

[c] The higher temperatures are recommended for components with greater wall thickness.

Annex D
(informative)

Preliminary reference data for the tensile strength of austenitic-ferritic steels at elevated temperatures

Table D.1 — Minimum values for the tensile strength of austenitic-ferritic steels at elevated temperatures in the solution annealed condition (see Table B.4)

Steel grade	Minimum tensile strength R_m (MPa) at a temperature (in °C) of				
	50	100	150	200	250
X2CrNiN23-4	577	540	520	500	490
X2CrNiN22-2	630	590	560	540	540
X2CrNiMoN22-5-3	621	590	570	550	540
X2CrNiMoCuN25-6-3	679	660	640	620	610
X2CrNiMoN25-7-4	711	680	660	640	630
X2CrNiMoCuWN25-7-4	711	680	660	640	630

Annex E
(informative)

Reference data on strength values for 1 % (plastic) creep strain and creep rupture

The values given in Tables E.1 and E.2 and taken from EN 10028-7 are mean values of the scatter band considered to date. According to experience with long-time creep-testing it seems apparent that scattering of data is about ±20 % in the long-range endurance of about 10^5 h up to 700 °C to 800 °C. Above that temperature, scattering may be gradually more or less enlarged and be summarized with about 35 % to 40 % at a 1 000 °C testing temperature. However, individual deviations must be presumed.

The strength values for 1 % (plastic) creep strain and creep rupture given up to the elevated temperatures listed in Tables E.1 and E.2 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, it is important that the oxidation conditions also be taken into account.

Table E.1 — Strength for 1 % (plastic) creep strain of austenitic creep-resisting steels in the solution annealed condition (see Table B.3)

Steel grade	Temperature °C	Strength for 1 % (plastic) creep strain[a] (MPa) for	
		10 000 h	100 000 h
X6CrNi18-10	500	147	114
	510	142	111
	520	137	108
	530	132	104
	540	127	100
	550	121	96
	560	116	92
	570	111	88
	580	106	84
	590	100	79
	600	94	74
	610	88	69
	620	82	63
	630	75	56
	640	68	49
	650	61	43
	660	55	37
	670	49	32
	680	44	28
	690	39	25
	700	35	22
	710	(31)	(15)
	720	(28)	(14)
	730	(26)	(13)
	740	(25)	(12)
	750	(24)	(11)
X6CrNi23-13	550	107	60
	600	80	35
	650	50	22
	700	25	12
	750		
	800	10	

Table E.1 (*continued*)

Steel grade	Temperature °C	Strength for 1 % (plastic) creep strain[a] (MPa) for	
		10 000 h	100 000 h
X5NiCrAlTi31-20	600	115	(85)
	610	109	(79)
	620	102	(74)
	630	96	(69)
	640	90	(64)
	650	84	(59)
	660	78	(55)
	670	73	(51)
	680	68	(47)
	690	63	(43)
	700	58	(40)
X5NiCrAlTi31-20+RA	550	164	(132)
	560	154	(122)
	570	144	(111)
	580	133	(101)
	590	123	(92)
	600	113	(82)
	610	103	(74)
	620	93	(65)
	630	84	(58)
	640	75	(51)
	650	67	(46)
	660	60	(41)
	670	55	(37)
	680	50	(33)
	690	45	(30)
	700	41	(27)

Table E.1 (*continued*)

Steel grade	Temperature °C	Strength for 1 % (plastic) creep strain[a] (MPa) for 10 000 h	100 000 h
X8NiCrAlTi32-21	700	59,0	42,0
	710 720 730 740 750	55,5 52,0 48,5 45,0 41,7	38,0 34,4 31,3 28,4 26,0
	760 770 780 790 800	38,4 35,6 32,9 30,5 28,2	23,5 21,3 19,3 17,6 16,0
	810 820 830 840 850	26,2 24,2 22,4 20,8 19,1	14,7 13,4 12,1 11,1 10,0
	860 870 880 890 900	17,6 16,1 14,7 13,4 12,1	9,1 8,2 7,3 6,5 5,7
	910 920 930 940 950	10,9 9,8 8,8 7,8 6,9	5,0 4,4 3,9 3,4 2,9
	960 970 980 990 1 000	6,1 5,3 4,6 4,0 3,5	2,5 2,1 1,8 1,6 1,4
X8CrNiNb16-13	580 590 600	127 120 113	91 84 78
	610 620 630 640 650	106 99 92 85 78	73 67 61 55 49
	660 670 680 690 700	72 66 59 54 49	44 39 34 30 26
	710 720 730 740 750	45 42 39 36 34	24 21 19 17 16

[a] Values in parentheses involved extended time and/or stress extrapolation.

Table E.2 — Creep rupture strength of austenitic creep-resisting steels in the solution annealed condition (see Table B.3)

Steel grade	Temperature °C	Creep rupture strength[a] (MPa) for						
		10 000 h	30 000 h	50 000 h	100 000 h	150 000 h	200 000 h	250 000 h
X3CrNiMoBN17-13-3	550	290			220		200*	
	560	272			202		184*	
	570	254			186		166*	
	580	237			170		151*	
	590	220			155		137*	
	600	205			141		122*	
	610	190			127		113*	
	620	174			114		100*	
	630	162			102		91*	
	640	148			92		81*	
	650	135			83		73*	
	660	122			75		65*	
	670	112			68		58*	
	680	102			61		52*	
	690	93			56		46*	
	700	84			52		42*	
	710	78			48		39*	
	720	71			45		36*	
	730	65			41		34*	
	740	58			37		31*	
	750	52			34		28*	
	760	48			31		26*	
	770	44			28		24*	
	780	41			25		21*	
	790	37			22		19*	
	800	33			20		17*	
X6CrNiTiB18-10	550	223			170		150	
	560	210			154		135	
	570	196			140		122	
	580	182			127		110	
	590	170			114		100	
	600	156			102		91	
	610	142			92		82	
	620	130			84		74	
	630	119			76		67	
	640	108			68		60	
	650	98			62		54	
	660	89			56		49	
	670	80			50		43	
	680	73			44		38	
	690	66			39		33	
	700	60			35		29	

Table E.2 (*continued*)

Steel grade	Temperature °C	Creep rupture strength[a] (MPa) for						
		10 000 h	30 000 h	50 000 h	100 000 h	150 000 h	200 000 h	250 000 h
X6CrNi18-10	510	239			182		166	
	520	227			172		156	
	530	215			162		146	
	540	203			151		136	
	550	191	165	155	140		125	
	560	177	154	145	128		114	
	570	165	144	136	117		104	
	580	154	135	126	107		95	
	590	143	126	118	98		86	
	600	132	117	110	89		78	
	610	122			81		70	
	620	113	109	102	73		62	
	630	104	101	94	65		55	
	640	95	94	87	58		49	
	650	87			52		43	
	660	80			47		38	
	670	73			42		34	
	680	67			37		30	
	690	61			32		26	
	700	55			28		22	
	710	(45)			(22)			
	720	(41)			(20)			
	730	(38)			(18)			
	740	(36)			(16)			
	750	(34)			(15)			
X6CrNi23-13	550	160			90			
	600	120			65			
	650	70			35			
	700	36			16			
	750							
	800	18			7,5			
X6CrNi25-20	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*