

# European standard

## French standard

**NF EN 10028-7**  
**August 2008**

Classification index: **A 36-205-7**

ICS: 77.140.20; 77.140.30; 77.140.50

## Flat products made of steels for pressure purposes

### Part 7: Stainless steels

F : Produits plats en aciers pour appareils à pression — Partie 7 : Aciers inoxydables  
D : Flacherzeugnisse aus Druckbehälterstählen — Teil 7: Nichtrostende Stähle

### *French standard approved*

by decision of the Director General of AFNOR on July 2, 2008 taking effect on August 2, 2008.

Replaces the approved standard NF EN 10028-7 dated March 2000.

**Correspondence** The European standard EN 10028-7:2007 has the status of French standard.

### *Analysis*

This document specifies requirements for flat products for pressure purposes made of stainless steels, including austenitic creep resisting steels in thicknesses.

### *Descriptors*

**Technical International Thesaurus:** iron-and steel products, metal plates, steel strips, steels, stainless steels, delivery, designation, dimensions, dimensional tolerances, chemical composition, grades: quality, classifications, tests, marking.

### *Modifications*

With respect to the replaced document, revision of the standard.

### *Corrections*



**National foreword***References to French standards*

*The correspondence between the standards figuring in the clause "Normative references" and the identical French standards is as follows:*

*EN 10028-1 : NF EN 10028-1 (classification index: A 36-205-1)*

*EN 10029 : NF EN 10029 (classification index: A 36-503)*

*EN 10088-1 : NF EN 10088-1 (classification index: A 35-572-1)*

*EN ISO 643 : NF EN ISO 643 (classification index: A 04-102)*

*EN ISO 3651-2 : NF EN ISO 3651-2 (classification index: A 05-159)*

English Version

## Flat products made of steels for pressure purposes - Part 7: Stainless steels

Produits plats en aciers pour appareils à pression - Partie  
7: Aciers inoxydables

Flacherzeugnisse aus Druckbehälterstählen - Teil 7:  
Nichtrostende Stähle

This European Standard was approved by CEN on 21 October 2007.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.



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

**Management Centre: rue de Stassart, 36 B-1050 Brussels**

## Contents

	page
Foreword.....	3
1 Scope .....	4
2 Normative references .....	4
3 Terms and definitions .....	4
4 Dimensions and tolerances on dimensions .....	5
5 Calculation of mass .....	5
6 Classification and designation.....	5
7 Information to be supplied by the purchaser .....	5
8 Requirements .....	5
9 Inspection .....	7
10 Sampling .....	7
11 Test methods.....	7
12 Marking .....	7
Annex A (informative) Guidelines for further treatment (including heat treatment in fabrication).....	29
Annex B (informative) Post weld heat treatment.....	32
Annex C (informative) Preliminary reference data for the tensile strength of austenitic-ferritic steels at elevated temperatures .....	34
Annex D (informative) Reference data of strength values for 1 % (plastic) creep strain and creep rupture .....	35
Annex E (informative) Reference data on mechanical properties of austenitic steels at room temperature and at low temperatures.....	44
Annex ZA (informative) Relationship between this European Standard and the Essential Requirements of EU Directive 97/23/EC .....	45
Bibliography .....	46

## Foreword

This document (EN 10028-7:2007) has been prepared by Technical Committee ECISS/TC 22 “Steels for pressure purposes - Qualities”, 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 June 2008, and conflicting national standards shall be withdrawn at the latest by June 2008.

This document supersedes EN 10028-7:2000.

This European Standard 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 97/23/EC.

For relationship with EU Directive 97/23/EC, see informative Annex ZA, which is an integral part of this document.

The steel grades covered by this European Standard have been selected from EN 10088-1.

EN 10028 consists of the following parts under the general title *Flat products made of steels for pressure purposes*:

- *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*

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

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, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

## **1 Scope**

This European Standard 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.

The requirements of EN 10028-1 also apply.

NOTE 1 The steel grades covered by this European Standard have been selected from EN 10088-1.

NOTE 2 Once this European Standard is published in the Official Journal of the European Union (OJEU) under Directive 97/23/EC, presumption of conformity to the Essential Safety Requirements (ESRs) of Directive 97/23/EC is limited to technical data of materials in this European Standard (Part 1 and Part 7) 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 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 amendments) applies.

EN 10028-1:2007, *Flat products made of steels for pressure purposes — Part 1: General requirements*

EN 10029, *Hot rolled plates 3 mm thick or above — Tolerances on dimensions, shape and mass*

EN 10088-1:2005, *Stainless steels — Part 1: List of stainless steels*

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

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

## **3 Terms and definitions**

For the purposes of this document, the terms and definitions given in EN 10028-1:2007 and the following apply.

### **3.1**

#### **cryogenic temperature**

temperature lower than  $-75\text{ }^{\circ}\text{C}$  used in the liquefaction of gases

## 4 Dimensions and tolerances on dimensions

Shall be according to EN 10028-1.

## 5 Calculation of mass

For density values, shall be according to EN 10088-1:2005, Annex A.

## 6 Classification and designation

Shall be according to EN 10028-1.

## 7 Information to be supplied by the purchaser

### 7.1 Mandatory information

Shall be according to EN 10028-1.

### 7.2 Options

A number of options are specified in this document and listed below. Additionally, the relevant options of EN 10028-1 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 EN 10028-1).

- 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).

### 7.3 Example for ordering

10 plates made of a steel grade with the name X5CrNi18-10 and the number 1.4301 as specified in EN 10028-7 with nominal dimensions, thickness = 8 mm, width = 2 000 mm, length = 5 000 mm; tolerances on dimensions, shape and mass as specified in EN 10029 with thickness tolerance class A and "normal" flatness tolerance according to process route 1D (see Table 6), inspection document 3.1 as specified in EN 10204:

**10 plates—EN 10029—8Ax2000x5000—steel EN 10028-7—X5CrNi18-10+1D—inspection document 3.1**

or

**10 plates— EN 10029—8Ax2000x5000—steel EN 10028-7—1.4301+1D—inspection document 3.1**

## 8 Requirements

### 8.1 Steelmaking process

Shall be according to EN 10028-1.

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

## **8.3 Chemical composition and chemical corrosion properties**

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

**8.3.2** 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.

**8.3.3** The specifications in Tables 7, 9 and 10 shall apply in respect to resistance to intergranular corrosion as defined in EN ISO 3651-2, for ferritic, austenitic and austenitic-ferritic steels.

NOTE 1 EN 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.

## **8.4 Mechanical properties**

**8.4.1** The tensile properties at room temperature and the impact energy at room and at low temperatures as specified in Tables 7 to 10 apply for the relevant specified heat treatment condition.

NOTE Austenitic stainless steels are insensitive to brittle fracture in the solution annealed condition. As they have a good resistance to shock loads, due to their high impact energy, also at very low (cryogenic) temperatures, they are useful for applications at such temperatures (see also the NOTE to Tables 9 and 10).

**8.4.2** 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.

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

**8.4.3** Annex D gives mean values as preliminary data for the purchaser about strength for 1 % (plastic) creep strain and creep rupture. These data apply for the solution annealed condition only (see Table A.3).

**8.4.4** In Annex E preliminary data on mechanical properties at low temperatures of austenitic steels are listed.

## **8.5 Surface condition**

Shall be according to EN 10028-1 and Table 6.

## **8.6 Internal soundness**

Shall be according to EN 10028-1.

## **8.7 Physical properties**

For reference data on physical properties, see Annex A of EN 10088-1:2005.



## **8.8 Post weld heat treatment**

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

## **9 Inspection**

### **9.1 Types of inspection and inspection documents**

Shall be according to EN 10028-1.

### **9.2 Tests to be carried out**

Shall be according to Table 16 and EN 10028-1.

### **9.3 Re-tests**

Shall be according to EN 10028-1.

## **10 Sampling**

### **10.1 Frequency of testing**

Shall be according to Table 16 and EN 10028-1.

### **10.2 Selection and preparation of samples and test pieces**

Shall be according to EN 10028-1.

## **11 Test methods**

Shall be according to EN 10028-1.

## **12 Marking**

Shall be according to EN 10028-1.

Table 1 — Chemical composition (cast analysis) <sup>a</sup> of ferritic steels

Steel grade		% by mass										
Steel name	Steel number	C max.	Si max.	Mn max.	P max.	S max.	N max.	Cr	Mo	Nb	Ni	Ti
X2CrNi12	1.4003	0,030	1,00	1,50	0,040	0,015	0,030	10,5 to 12,5	—	—	0,30 to 1,00	—
X6CrNiTi12	1.4516	0,08	0,70	1,50	0,040	0,015	—	10,5 to 12,5	—	—	0,50 to 1,50	0,05 to 0,35
X2CrTi17	1.4520	0,025	0,50	0,50	0,040	0,015	0,015	16,0 to 18,0	—	—	—	0,30 to 0,60
X3CrTi17	1.4510	0,05	1,00	1,00	0,040	0,015	—	16,0 to 18,0	—	—	—	[4 x(C+N) + 0,15] to 0,80 <sup>b</sup>
X2CrMoTi17-1	1.4513	0,025	1,00	1,00	0,040	0,015	0,020	16,0 to 18,0	0,80 to 1,40	—	—	0,30 to 0,60
X2CrMoTi18-2	1.4521	0,025	1,00	1,00	0,040	0,015	0,030	17,0 to 20,0	1,80 to 2,50	—	—	[4 x(C+N) + 0,15] to 0,80 <sup>b</sup>
X6CrMoNb17-1	1.4526	0,08	1,00	1,00	0,040	0,015	0,040	16,0 to 18,0	0,80 to 1,40	[7x(C+N) + 0,10] to 1,00	—	—
X2CrTiNb18	1.4509	0,030	1,00	1,00	0,040	0,015	—	17,5 to 18,5	—	[(3xC) + 0,30] to 1,00	—	0,10 to 0,60
<sup>a</sup> Elements not listed in this table shall 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.												
<sup>b</sup> The stabilisation may be made by use of titanium or niobium or zirconium. According to the atomic mass of these elements and the content of carbon and nitrogen, the equivalence shall be the following, in % by mass:												
$\text{Nb} = \text{Zr} = \frac{7}{4} \text{Ti}$												

**Table 2 — Chemical composition (cast analysis) <sup>a</sup> of martensitic steels**

Steel grade		% by mass								N min.
Steel name	Steel number	C max.	Si max.	Mn max.	P max.	S max.	Cr	Mo	Ni	
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	15,0 to 17,0	0,80 to 1,50	4,0 to 6,0	0,020
<sup>a</sup> 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 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.										

Table 3 — Chemical composition (cast analysis) <sup>a</sup> of austenitic steels

Steel grade		% by mass												
Steel name	Steel number	C	Si	Mn max.	P max.	S max.	N	Cr	Cu	Mo	Nb	Ni	Ti	Others
Austenitic corrosion resisting grades														
X2CrNiN18-7	1.4318	≤ 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	1.4307	≤ 0,030	≤ 1,00	2,00	0,045	0,015	≤ 0,10	17,5 to 19,5	—	—	—	8,0 to 10,5	—	—
X2CrNi19-11	1.4306	≤ 0,030	≤ 1,00	2,00	0,045	0,015	≤ 0,10	18,0 to 20,0	—	—	—	10,0 to 12,0	—	—
X5CrNiN19-9	1.4315	≤ 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	1.4311	≤ 0,030	≤ 1,00	2,00	0,045	0,015	0,12 to 0,22	17,5 to 19,5	—	—	—	8,5 to 11,5	—	—
X5CrNi18-10	1.4301	≤ 0,07	≤ 1,00	2,00	0,045	0,015	≤ 0,10	17,5 to 19,5	—	—	—	8,0 to 10,5	—	—
X6CrNiTi18-10	1.4541	≤ 0,08	≤ 1,00	2,00	0,045	0,015	—	17,0 to 19,0	—	—	—	9,0 to 12,0	5 x C to 0,70	—
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	—	—
X1CrNi25-21	1.4335	≤ 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	1.4404	≤ 0,030	≤ 1,00	2,00	0,045	0,015	≤ 0,10	16,5 to 18,5	—	2,00 to 2,50	—	10,0 to 13,0	—	—
X2CrNiMoN17-11-2	1.4406	≤ 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	1.4401	≤ 0,07	≤ 1,00	2,00	0,045	0,015	≤ 0,10	16,5 to 18,5	—	2,00 to 2,50	—	10,0 to 13,0	—	—
X1CrNiMoN25-22-2	1.4466	≤ 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	1.4571	≤ 0,08	≤ 1,00	2,00	0,045	0,015	—	16,5 to 18,5	—	2,00 to 2,50	—	10,5 to 13,5	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	—	—
X2CrNiMo17-12-3	1.4432	≤ 0,030	≤ 1,00	2,00	0,045	0,015	≤ 0,10	16,5 to 18,5	—	2,50 to 3,00	—	10,5 to 13,0	—	—
X2CrNiMoN17-13-3	1.4429	≤ 0,030	≤ 1,00	2,00	0,045	0,015	0,12 to 0,22	16,5 to 18,5	—	2,50 to 3,00	—	11,0 to 14,0	—	—
X3CrNiMo17-13-3	1.4436	≤ 0,05	≤ 1,00	2,00	0,045	0,015	≤ 0,10	16,5 to 18,5	—	2,50 to 3,00	—	10,5 to 13,0	—	—
X2CrNiMo18-14-3	1.4435	≤ 0,030	≤ 1,00	2,00	0,045	0,015	≤ 0,10	17,0 to 19,0	—	2,50 to 3,00	—	12,5 to 15,0	—	—
X2CrNiMoN18-12-4	1.4434	≤ 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	—	—

(to be continued)

Table 3 (concluded)

Steel grade		% by mass												
Steel name	Steel number	C	Si	Mn max.	P max.	S max.	N	Cr	Cu	Mo	Nb	Ni	Ti	Others
X2CrNiMo18-15-4	1.4438	≤ 0,030	≤ 1,00	2,00	0,045	0,015	≤ 0,10	17,5 to 19,5	–	3,0 to 4,0	–	13,0 to 16,0	–	–
X2CrNiMoN17-13-5	1.4439	≤ 0,030	≤ 1,00	2,00	0,045	0,015	0,12 to 0,22	16,5 to 18,5	–	4,0 to 5,0	–	12,5 to 14,5	–	–
X1NiCrMoCu31-27-4	1.4563	≤ 0,020	≤ 0,70	2,00	0,030	0,010	≤ 0,10	26,0 to 28,0	0,70 to 1,50	3,0 to 4,0	–	30,0 to 32,0	–	–
X1NiCrMoCu25-20-5	1.4539	≤ 0,020	≤ 0,70	2,00	0,030	0,010	≤ 0,15	19,0 to 21,0	1,20 to 2,00	4,0 to 5,0	–	24,0 to 26,0	–	–
X1CrNiMoCuN25-25-5	1.4537	≤ 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	1.4547	≤ 0,020	≤ 0,70	1,00	0,030	0,010	0,18 to 0,25	19,5 to 20,5	0,50 to 1,00	6,0 to 7,0	–	17,5 to 18,5	–	–
X1NiCrMoCuN25-20-7	1.4529	≤ 0,020	≤ 0,50	1,00	0,030	0,010	0,15 to 0,25	19,0 to 21,0	0,50 to 1,50	6,0 to 7,0	–	24,0 to 26,0	–	–
Austenitic creep resisting grades														
X3CrNiMoBN17-13-3	1.4910	≤ 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	–	0,001 5 to 0,005 0 B
X6CrNiTiB18-10	1.4941	0,04 to 0,08	≤ 1,00	2,00	0,035	0,015	–	17,0 to 19,0	–	–	–	9,0 to 12,0	5 x C to 0,80	0,001 5 to 0,005 0 B
X6CrNi18-10	1.4948	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	1.4950	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	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	–	–
X5NiCrAlTi31-20 (+RA)	1.4958 (+RA)	0,03 to 0,08	≤ 0,70	1,50	0,015	0,010	≤ 0,030	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	1.4959	0,05 to 0,10	≤ 0,70	1,50	0,015	0,010	≤ 0,030	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	1.4961	0,04 to 0,10	0,30 to 0,60	1,50	0,035	0,015	–	15,0 to 17,0	–	–	10 x C to 1,20	12,0 to 14,0	–	–
<sup>a</sup> Elements not listed in this table shall 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.														

**Table 4 — Chemical composition (cast analysis) <sup>a</sup> of austenitic-ferritic steels**

Steel grade		% by mass										
Steel name	Steel number	C max.	Si max.	Mn max.	P max.	S max.	N	Cr	Cu	Mo	Ni	W
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	—
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	—
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	—
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	—
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
<sup>a</sup> 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 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.												

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

Element	Specified limits, cast analysis		Permissible tolerance <sup>a</sup>
	% by mass		% 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	≤ 2,00	+ 0,04
Phosphorus	≤ 0,045		+ 0,005
Sulphur	≤ 0,015		+ 0,003
Nitrogen	≤ 0,35		± 0,01
Aluminium	≤ 0,65		± 0,10
Boron	≥ 0,001 5	≤ 0,005 0	± 0,000 3
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	≤ 1,20		± 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	≤ 0,80		± 0,05
Tungsten	≤ 1,00		± 0,05
<sup>a</sup> 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 <sup>a</sup>**

	Abbreviation <sup>b</sup>	Type of treatment <sup>c</sup>	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 common finish for further processing. Skin passing may be by tension levelling.
	2R	Cold rolled, bright annealed <sup>d</sup>	Smooth, bright, reflective	Smoother and brighter than 2B. Also common finish for further processing.
Special finishes	1G or 2G	Ground <sup>e</sup>	See footnote f.	Grade of grit or surface roughness can be specified. Unidirectional texture, not very reflective.
	1J or 2J	Brushed <sup>e</sup> or dull polished <sup>e</sup>	Smoother than ground. See footnote f	Grade of brush or surface roughness can be specified. Unidirectional texture, not very reflective.
	1K or 2K	Satin polished <sup>e</sup>	See footnote f	Additional specific requirements to a "J" type finish, in order to achieve adequate corrosion resistance for marine and external architectural applications. Transverse Ra < 0,5 µm with clean cut surface finish.
	1P or 2P	Bright polished <sup>e</sup>	See footnote f	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.

<sup>a</sup> Not all process routes and surface finishes are available for all steels.

<sup>b</sup> First digit, 1 = hot rolled, 2 = cold rolled.

<sup>c</sup> The basic heat treatment condition specified in the relevant Table 7, 8, 9 or 10 applies.

<sup>d</sup> May be skin passed.

<sup>e</sup> One surface only, unless specifically agreed at the time of enquiry and order.

<sup>f</sup> Within each finish description the surface characteristics can vary, and more specific requirements may need to be agreed between 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 A.1) and resistance to intergranular corrosion**

Steel grade		Product form <sup>a</sup>	Thick-ness  mm max.	0,2 % proof strength		Tensile strength  MPa	Elongation after fracture		Resistance to inter-granular corrosion <sup>d</sup>		Impact en-ergy (ISO-V)  KV min.  J  (tr.)
Steel name	Steel num-ber			$R_{p0,2}$  MPa min.  (long.)	(tr.)		$A_{80\text{ mm}}$ <sup>b</sup> < 3 mm thick % min. (long. + tr.)	$A$ <sup>c</sup> ≥ 3 mm thick % min. (long. + tr.)	in the delivery condi-tion	In the welded condition	
X2CrNi12	1.4003	C	8	280	320	450 to 650	20		no	no	50
		H	13,5								
		P	25 <sup>e</sup>	250	280		18				
X6CrNiTi12	1.4516	C	8	280	320	450 to 650	23		no	no	50
		H	13,5								
		P	25 <sup>e</sup>	250	280		20				
X2CrTi17	1.4520	C	4	180	200	380 to 530	24		yes	yes	_ <sup>f</sup>
X3CrTi17	1.4510	C	4	230	240	420 to 600	23		yes	yes	_ <sup>f</sup>
X2CrMoTi17-1	1.4513	C	4	200	220	400 to 550	23		yes	yes	_ <sup>f</sup>
X2CrMoTi18-2	1.4521	C	4	300	320	420 to 640	20		yes	yes	_ <sup>f</sup>
X6CrMoNb17-1	1.4526	C	4	280	300	480 to 560	25		yes	yes	_ <sup>f</sup>
X2CrTiNb18	1.4509	C	4	230	250	430 to 630	18		yes	yes	_ <sup>f</sup>

<sup>a</sup> C = cold rolled strip; H = hot rolled strip; P = hot rolled plate.

<sup>b</sup> 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.

<sup>c</sup> The values are related to test pieces with a gauge length of  $5,65 \sqrt{S_0}$ .

<sup>d</sup> When tested according to EN ISO 3651-2.

<sup>e</sup> ●● For thicknesses above 25 mm up to 75 mm, the mechanical properties may be agreed at the time of enquiry and order.

<sup>f</sup> Because of the small maximum product thickness  $t$ , no verifiable values can be specified (the requirement to prepare impact test pieces applies for  $t \geq 6$  mm, see EN 10028-1:2007, 10.2.2.3 c)).

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

Steel grade		Product form <sup>a</sup>	Thickness	0,2 % proof strength $R_{p0.2}$	Tensile strength $R_m$	Elongation after fracture $A^b$ ≥ 3 mm thick % min. (long. + tr.)	Impact energy (ISO-V)  $KV$  J min.  at 20 °C   at –20 °C (long. + tr.)	
Steel name	Steel number							
X3CrNiMo13-4	1.4313	P	75	650	780 to 980	14	70	40
X4CrNiMo16-5-1	1.4418	P	75	680	840 to 980	14	55	40
<sup>a</sup> P = hot rolled plate. <sup>b</sup> The values apply for test pieces with a gauge length of $5,65 \sqrt{S_0}$ .								

**Table 9 — Mechanical properties at room temperature and impact energy at –196 °C of austenitic steels in the solution annealed condition <sup>a</sup> and resistance to intergranular corrosion**

Steel grade		Pro- duct- form <sup>b</sup>	Thick- ness  mm max.	0,2 % proof strength	1,0 % proof strength	Tensile strength	Elongation after fracture		Impact energy (ISO-V)			Resistance to intergranular corrosion <sup>g</sup>	
Steel name	Steel num- ber			$R_{p0,2}$	$R_{p1,0}$	$R_m$	$A_{80mm}^e$		$KV$	J min.	in the delivery condition	in the sensitized condition	
							< 3 mm thick  % min.	≥ 3 mm thick  % min.					at 20 °C  (long.)
(tr.) <sup>c</sup>													
(tr.) <sup>c</sup>													
Austenitic corrosion resisting grades													
X2CrNiN18-7	1.4318	C	8	350	380	650 to 850	35	40	90	60	–	yes	yes
		H	13,5	330	370								
		P	75	330	370								
X2CrNi18-9	1.4307	C	8	220	250	520 to 700	45	45	100	60	60	yes	yes
		H	13,5	200	240								
		P	75	200	240								
X2CrNi19-11	1.4306	C	8	220	250	520 to 700	45	45	100	60	60	yes	yes
		H	13,5	200	240								
		P	75	200	240								
X5CrNiN19-9	1.4315	C	8	290	320	550 to 750	40	40	100	60	60	(yes) <sup>i</sup>	No <sup>j</sup>
		H	13,5	270	310								
		P	75	270	310								
X2CrNiN18-10	1.4311	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	1.4301	C	8	230	260	540 to 750	45 <sup>h</sup>	45 <sup>h</sup>	100	60	60	(yes) <sup>i</sup>	No <sup>j</sup>
		H	13,5	210	250	520 to 720							
		P	75	210	250	45							
X6CrNiTi18-10	1.4541	C	8	220	250	520 to 720	40	40	100	60	60	yes	yes
		H	13,5	200	240								
		P	75	200	240								
X6CrNiNb18-10	1.4550	H	13,5	200	240	520 to 720	40	40	100	60	40	yes	yes
		P	75	200	240	500 to 700							
X1CrNi25-21	1.4335	P	75	200	240	470 to 670	40	40	100	60	60	yes	yes
(to be continued)													

Table 9 (continued)

Steel grade		Pro- duct- form <sup>b</sup>	Thick- ness  mm max.	0,2 % proof strength		1,0 % proof strength		Tensile strength	Elongation after fracture		Impact energy (ISO-V)  <i>KV</i>			Resistance to intergranular corrosion <sup>g</sup>	
Steel name	Steel num- ber			<i>R</i> <sub>p0,2</sub>	<i>R</i> <sub>p1,0</sub>	<i>R</i> <sub>m</sub>	<i>A</i> <sub>80mm</sub> <sup>e</sup>  < 3 mm thick  % min.  (tr.) <sup>c</sup>	<i>A</i> <sup>f</sup>  ≥ 3 mm thick  % min.  (tr.) <sup>c</sup>	J min.		in the delivery condition	in the sensitized condition			
									MPa min. (tr.) <sup>c d</sup>	MPa			at 20 °C  (long.) (tr.)	at −196°C (tr.)	
X2CrNiMo17-12-2	1.4404	C	8	240	270	530 to 680	40	40	100	60	60	yes	yes		
		H	13,5	220	260										
		P	75	220	260	520 to 670	45	45							
X2CrNiMoN17-11-2	1.4406	C	8	300	330	580 to 780	40	40	100	60	60	yes	yes		
		H	13,5	280	320										
		P	75	280	320										
X5CrNiMo17-12-2	1.4401	C	8	240	270	530 to 680	40	40	100	60	60	yes <sup>i</sup>	no <sup>j</sup>		
		H	13,5	220	260										
		P	75	220	260	520 to 670	45	45							
X1CrNiMoN25-22-2	1.4466	P	75	250	290	540 to 740	40	40	100	60	60	yes	yes		
X6CrNiMoTi17-12-2	1.4571	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	1.4580	P	75	220	260	520 to 720	40	40	100	60	–	yes	yes		
X2CrNiMo17-12-3	1.4432	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	1.4429	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							
(to be continued)															

Table 9 (continued)

Steel grade		Pro- duct- form <sup>b</sup>	Thick- ness   mm max.	0,2 % proof strength		1,0 % proof strength   MPa min. (tr.) <sup>c d</sup>	Tensile strength   MPa	Elongation after fracture		Impact energy (ISO-V)			Resistance to intergranular corrosion <sup>g</sup>			
Steel name	Steel num- ber			$R_{p0,2}$	$R_{p1,0}$			$R_m$	$A_{80mm}^e$  < 3 mm thick  % min.  (tr.) <sup>c</sup>	$A^f$  ≥ 3 mm thick  % min.  (tr.) <sup>c</sup>	KV			in the delivery condition	in the sensitized condition	
											J min.		at 20 °C  (long.) (tr.)			at −196°C (tr.)
X3CrNiMo17-13-3	1.4436	C	8	240	270	550 to 700	40	40	100	60	60	(yes) <sup>i</sup>	no <sup>j</sup>			
		H	13,5	220	260											
		P	75	220	260	530 to 730	40	40								
X2CrNiMo18-14-3	1.4435	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	1.4434	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	1.4438	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								
X2CrNiMoN17-13-5	1.4439	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									
X1NiCrMoCu3 1-27-4	1.4563	P	75	220	260	500 to 700	40	40	100	60	60	yes	yes			
X1NiCrMoCu2 5-20-5	1.4539	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										
X1CrNiMoCu N25-25-5	1.4537	P	75	290	330	600 to 800	40	40	100	60	60	yes	yes			
X1CrNiMoCu N20-18-7	1.4547	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									
X1NiCrMoCu N25-20-7	1.4529	P	75	300	340	650 to 850	40	40	100	60	60	yes	yes			
(to be continued)																

Table 9 (continued)

Steel grade		Pro- duct- form <sup>b</sup>	Thick- ness	0,2 % proof strength	1,0 % proof strength	Tensile strength	Elongation after fracture		Impact energy (ISO-V)			Resistance to intergranular corrosion <sup>g</sup>	
Steel name	Steel num- ber			$R_{p0,2}$	$R_{p1,0}$	$R_m$	$A_{80mm}^e$	$A^f$	$KV$		J min.	in the delivery condition	in the sensitized condition
							< 3 mm thick  % min.	≥ 3 mm thick  % min.	at 20 °C	at −196°C			
Austenitic creep resisting grades													
X3CrNiMoBN 17-13-3	1.4910	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								
X6CrNiTiB18- 10	1.4941	C	8	220	250	510 to 710	40	40	100	60	–	yes	yes
		H	13,5	200	240	490 to 690							
		P	75	200	240								
X6CrNi18-10	1.4948	C	8	230	260	530 to 740	45 <sup>h</sup>	45 <sup>h</sup>	100	60	–	no	no
		H	13,5	210	250	510 to 710	45	45					
		P	75	190	230								
X6CrNi23-13	1.4950	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	1.4951	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	1.4958	P	75	170	200	500 to 750	30	30	120	80	–	yes	no
(to be continued)													

(to be continued)

Table 9 (concluded)

Steel grade		Pro- duct- form <sup>b</sup>	Thick- ness  mm max.	0,2 % proof strength		1,0 % proof strength		Tensile strength  <i>R<sub>m</sub></i>  MPa	Elongation after fracture		Impact energy (ISO-V)  <i>KV</i>  J min.			Resistance to intergranular corrosion <sup>9</sup>	
				<i>R<sub>p0,2</sub></i>  MPa min. (tr.) <sup>c d</sup>	<i>R<sub>p1,0</sub></i>  MPa min. (tr.) <sup>c d</sup>	<i>A<sub>80mm</sub></i> <sup>e</sup>  < 3 mm thick  % min.  (tr.) <sup>c</sup>	<i>A<sup>f</sup></i>  ≥ 3 mm thick  % min.  (tr.) <sup>c</sup>		at 20 °C			at –196°C (tr.)	in the delivery condition	in the sensitized condition	
J min.															
at 20 °C															
at 20 °C															
Steel name	Steel num- ber														
X5NiCrAlTi31-20+RA <sup>k</sup>	1.4958 +RA <sup>k</sup>	P	75	210	240	500 to 750	30	30	120	80	–	yes	no		
X8NiCrAlTi32-21	1.4959	P	75	170	200	500 to 750	30	30	120	80	–	yes	no		
X8CrNiNb16-13	1.4961	P	75	200	240	510 to 690	35	35	100	60	–	yes	yes		

NOTE Austenitic steels always have adequate toughness and do not need to be impact tested. In contrast, austenitic-ferritic steels need to be tested to the impact energy requirements in Table 10 to ensure that toughness is adequate.

<sup>a</sup> See Table A.3.

<sup>b</sup> C = cold rolled strip; H = hot rolled strip; P = hot rolled plate.

<sup>c</sup> 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  $R_{p0,2}$ : minus 15 MPa
- elongation for constant gauge length  $A_{80mm}$ : minus 5 %
- elongation for proportional gauge length  $A$ : minus 2 %.

<sup>d</sup> ●● 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 at the time of enquiry and order.

<sup>e</sup> 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 can also be used.

<sup>f</sup> The values are related to test pieces with a gauge length of  $5,65 \sqrt{S_0}$ .

<sup>g</sup> When tested according to EN ISO 3651-2.

<sup>h</sup> For stretcher levelled material, the minimum value is 5 % lower.

<sup>i</sup> Normally for thicknesses up to 6 mm.

<sup>j</sup> Resistance to intergranular corrosion is given for thicknesses up to 6 mm in the welded condition.

<sup>k</sup> +RA = recrystallizing annealed condition.

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

Steel grade		Pro- duct form a	Thick- ness	0,2 % proof strength $R_{p0,2}$  MPa <sup>b</sup> min.		Tensile strength $R_m$	Elongation after fracture		Impact energy(ISO-V)			Resistance to intergranular corrosion <sup>e</sup>	
				strip width			$A_{80mm}$ < 3 mm thick c % min.	$A$ ≥ 3 mm thick d % min.	$KV$ J min.		in the delivery condition	in the sensi- tized condi- tion	
Steel name	Steel num- ber		mm max.	(long.)  < 300 mm	(tr.)  ≥ 300 mm	MPa	(long. + tr.)	(long. + tr.)	at 20 °C  (long.) (tr.)	at -40 °C  (tr.)			
X2CrNiN23-4	1.4362	C	8	405	420	600 to 850	20	20	120	90	40	yes	yes
		H	13,5	385	400								
		P	50	385	400	630 to 800	25	25					
X2CrNiMoN22-5-3	1.4462	C	8	485	500	700 to 950	20	20	150	100	40	yes	yes
		H	13,5	445	460								
		P	75	445	460	640 to 840	25	25					
X2CrNiMoCuN25-6-3	1.4507	C	8	495	510	690 to 940	20	20	150	90	40	yes	yes
		H	13,5	475	490								
		P	50	475	490	690 to 890	25	25					
X2CrNiMoN25-7-4	1.4410	C	8	535	550	750 to 1 000	20	20	150	90	40	yes	yes
		H	13,5	515	530								
		P	50	515	530	730 to 930	20	20					
X2CrNiMoCuWN25-7-4	1.4501	P	50	515	530	730 to 930	25	25	150	90	40	yes	yes

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

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 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  $5,65 \sqrt{S_0}$ .

e When tested according to EN ISO 3651-2.



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

Steel grade		Minimum 0,2 % proof strength $R_{p0,2}$ , MPa							
Steel name	Steel number	at a temperature (in °C) of							
		50 <sup>a</sup>	100	150	200	250	300	350	400
X2CrNi12	1.4003	265	240	235	230	220	215	—	—
X6CrNiTi12	1.4516	—	300	270	250	245	225	215	—
X2CrTi17	1.4520	198	195	180	170	160	155	—	—
X3CrTi17	1.4510	223	195	190	185	175	165	155	—
X2CrMoTi17-1	1.4513	—	250	240	230	220	210	205	200
X2CrMoTi18-2	1.4521	294	250	240	230	220	210	205	—
X6CrMoNb17-1	1.4526	289	270	265	250	235	215	205	—
X2CrTiNb18	1.4509	242	230	220	210	205	200	180	—
<sup>a</sup> 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 A.2)**

Steel grade		Minimum 0,2 % proof strength $R_{p0,2}$ , MPa						
Steel name	Steel number	at a temperature (in °C) of						
		50 <sup>a</sup>	100	150	200	250	300	350
X3CrNiMo13-4	1.4313	627	590	575	560	545	530	515
X4CrNiMo16-5-1	1.4418	672	660	640	620	600	580	—
<sup>a</sup> 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 A.3)**

Steel grade		Minimum 0,2 % proof strength $R_{p0,2}$ , MPa													Minimum 1,0 % proof strength $R_{p1,0}$ , MPa												
Steel name	Steel number	at a temperature (in °C) of																									
		50 <sup>a</sup>	100	150	200	250	300	350	400	450	500	550	600	50 <sup>a</sup>	100	150	200	250	300	350	400	450	500	550	600		
Austenitic corrosion resisting grades																											
X2CrNiN18-7	1.4318	309	265	200	185	180	170	165	–	–	–	–	–	–	–	235	215	210	200	195	–	–	–	–	–		
X2CrNi18-9	1.4307	180	147	132	118	108	100	94	89	85	81	80	–	218	181	162	147	137	127	121	116	112	109	108	–		
X2CrNi19-11	1.4306	180	147	132	118	108	100	94	89	85	81	80	–	218	181	162	147	137	127	121	116	112	109	108	–		
X5CrNi19-9	1.4315	246	205	175	157	145	136	130	125	121	119	118	–	284	240	210	187	175	167	161	156	152	149	147	–		
X2CrNi18-10	1.4311	246	205	175	157	145	136	130	125	121	119	118	–	284	240	210	187	175	167	161	156	152	149	147	–		
X5CrNi18-10	1.4301	190	157	142	127	118	110	104	98	95	92	90	–	228	191	172	157	145	135	129	125	122	120	120	–		
X6CrNiTi18-10	1.4541	191	176	167	157	147	136	130	125	121	119	118	–	228	208	196	186	177	167	161	156	152	149	147	–		
X6CrNiNb18-10-	1.4550	191	177	167	157	147	136	130	125	121	119	118	–	229	211	196	186	177	167	161	156	152	149	147	–		
X1CrNi25-21	1.4335	181	150	140	130	120	115	110	105	–	–	–	–	217	180	170	160	150	140	135	130	–	–	–	–		
X2CrNiMo17-12-2	1.4404	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	1.4406	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	1.4401	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	1.4466	229	195	170	160	150	140	135	–	–	–	–	–	266	225	205	190	180	170	165	–	–	–	–	–		
X6CrNiMoTi17-12-2	1.4571	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	1.4580	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	1.4432	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	1.4429	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	1.4436	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	1.4435	199	165	150	137	127	119	113	108	103	100	98	–	237	200	180	165	153	145	139	135	130	128	127	–		
(to be continued)																											

(to be continued)

Table 13 (concluded)

Steel grade		Minimum 0,2 % proof strength $R_{p0,2}$ , MPa												Minimum 1,0 % proof strength $R_{p1,0}$ , MPa											
Steel name	Steel number	at a temperature (in °C) of																							
		50 <sup>a</sup>	100	150	200	250	300	350	400	450	500	550	600	50 <sup>a</sup>	100	150	200	250	300	350	400	450	500	550	600
X2CrNiMoN18-12-4	1.4434	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	1.4438	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	1.4439	253	225	200	185	175	165	155	150	–	–	–	–	289	255	230	210	200	190	180	175	–	–	–	–
X1NiCrMoCu31-27-4	1.4563	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	1.4539	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	1.4537	271	240	220	200	190	180	175	170	–	–	–	–	307	270	250	230	220	210	205	200	–	–	–	–
X1CrNiMoCuN20-18-7	1.4547	274	230	205	190	180	170	165	160	153	148	–	–	314	270	245	225	212	200	195	190	184	180	–	–
X1NiCrMoCuN25-20-7	1.4529	274	230	210	190	180	170	165	160	130	120	105	–	314	270	245	225	215	205	195	190	160	150	135	–
Austenitic creep resisting grades																									
X3CrNiMoBN17-13-3	1.4910	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	1.4941	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	1.4948	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	1.4950	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	1.4951	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	1.4958	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	1.4958+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	1.4959	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	1.4961	191	175	166	157	147	137	132	128	123	118	118	113	227	205	195	186	176	167	162	157	152	147	147	142
<sup>a</sup> 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 A.4)**

Steel grade		Minimum 0,2 % proof strength $R_{p0,2}$ , MPa				
Steel name	Steel number	at a temperature (in °C) of				
		50 <sup>a</sup>	100	150	200	250
X2CrNiN23-4	1.4362	374	330	300	280	265
X2CrNiMoN22-5-3	1.4462	422	360	335	315	300
X2CrNiMoCuN25-6-3	1.4507	475	450	420	400	380
X2CrNiMoN25-7-4	1.4410	500	450	420	400	380
X2CrNiMoCuWN25-7-4	1.4501	500	450	420	400	380
<sup>a</sup> 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 A.3)**

Steel grade		Minimum tensile strength $R_m$ , MPa											
Steel name	Steel number	at a temperature (in °C) of											
		50 <sup>a</sup>	100	150	200	250	300	350	400	450	500	550	600
Austenitic corrosion resisting grades													
X2CrNiN18-7	1.4318	605	530	490	460	450	440	430	–	–	–	–	–
X2CrNi18-9	1.4307	466	410	380	360	350	340	340	–	–	–	–	–
X2CrNi19-11	1.4306	466	410	380	360	350	340	340	–	–	–	–	–
X5CrNiN19-9	1.4315	527	490	460	430	420	410	410	–	–	–	–	–
X2CrNiN18-10	1.4311	527	490	460	430	420	410	410	–	–	–	–	–
X5CrNi18-10	1.4301	494	450	420	400	390	380	380	380	370	360	330	–
X6CrNiTi18-10	1.4541	477	440	410	390	385	375	375	375	370	360	330	–
X6CrNiNb18-10	1.4550	476	435	400	370	350	340	335	330	320	310	300	–
X1CrNi25-21	1.4335	459	440	425	410	390	385	380	–	–	–	–	–
X2CrNiMo17-12-2	1.4404	486	430	410	390	385	380	380	380	–	360	–	–
X2CrNiMoN17-11-2	1.4406	557	520	490	460	450	440	435	–	–	–	–	–
X5CrNiMo17-12-2	1.4401	486	430	410	390	385	380	380	–	–	–	–	–
X1CrNiMoN25-22-2	1.4466	521	490	475	460	450	440	435	–	–	–	–	–
X6CrNiMoTi17-12-2	1.4571	490	440	410	390	385	375	375	375	370	360	330	–
X6CrNiMoNb17-12-2	1.4580	490	440	410	390	385	375	375	375	370	360	330	–
X2CrNiMo17-12-3	1.4432	486	430	410	390	385	380	380	380	–	360	–	–
X2CrNiMoN17-13-3	1.4429	557	520	490	460	450	440	435	435	–	430	–	–
X3CrNiMo17-13-3	1.4436	504	460	440	420	415	410	410	410	–	390	–	–
X2CrNiMo18-14-3	1.4435	482	420	400	380	375	370	370	–	–	–	–	–
X2CrNiMoN18-12-4	1.4434	525	500	470	440	430	420	415	415	415	410	390	-
X2CrNiMo18-15-4	1.4438	486	430	410	390	385	380	380	–	–	–	–	–
X2CrNiMoN17-13-5	1.4439	557	520	490	460	450	440	435	–	–	–	–	–
X1NiCrMoCu31-27-4	1.4563	485	460	445	430	410	400	395	–	–	–	–	–
X1NiCrMoCu25-20-5	1.4539	512	500	480	460	450	440	435	–	–	–	–	–
X1CrNiMoCuN25-25-5	1.4537	581	550	535	520	500	480	475	–	–	–	–	–
X1CrNiMoCuN20-18-7	1.4547	637	615	587	560	542	525	517	510	502	495	–	–
X1NiCrMoCuN25-20-7	1.4529	612	550	535	520	500	480	475	–	–	–	–	–
Austenitic creep resisting grades													
X3CrNiMoBN17-13-3	1.4910	529	495	472	450	440	430	425	420	410	400	385	365
X6CrNiTiB18-10	1.4941	460	410	390	370	360	350	345	340	335	330	320	300
X6CrNi18-10	1.4948	484	440	410	390	385	375	375	375	370	360	330	300
X6CrNi23-13	1.4950	495	470	450	430	420	410	405	400	385	370	350	320
X6CrNi25-20	1.4951	495	470	450	430	420	410	405	400	385	370	350	320
X5NiCrAlTi31-20 <sup>b</sup>	1.4958	487	465	445	435	425	420	418	415	415	415	–	–
X8NiCrAlTi32-21	1.4959	487	465	445	435	425	420	418	415	415	415	–	–
X8CrNiNb16-13	1.4961	493	465	440	420	400	385	375	370	360	350	340	320
<sup>a</sup> Determined by linear interpolation.													
<sup>b</sup> 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 <sup>a</sup>	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 <sup>b</sup>		
Tensile test at room temperature	m	Cast, thickness ± 10 %, heat treatment batch	1 test sample from each coil	a) Plates ≤ 20 mm (≤ 15 mm <sup>c</sup> ) thickness: Plates processed under identical conditions may be collected into 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.  b) Plates > 20 mm (> 15 mm <sup>c</sup> ) 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.	1
Tensile test at elevated temperature <sup>d</sup>	o		To be agreed at the time of enquiry and order.		1
Impact test at room temperature	m <sup>e</sup>		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 EN 10028-1.			
<sup>a</sup> 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.					
<sup>b</sup> A product analysis may be agreed at the time of enquiry and order (see EN 10028-1:2007, Table 1).					
<sup>c</sup> Limit value for martensitic, ferritic and austenitic-ferritic steels.					
<sup>d</sup> See EN 10028-1:2007, 11.3.					
<sup>e</sup> 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 EN 10028-1:2007, Table 1).					

## Annex A (informative)

### Guidelines for further treatment (including heat treatment in fabrication)

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

**Table A.1 — Guidelines on the temperatures for hot forming and heat treatment <sup>a</sup> of ferritic stainless steels**

Steel grade		Hot forming		Heat-treatment-symbol <sup>b</sup>	Annealing	
Steel name	Steel number	Temperature °C	Type of cooling		Temperature <sup>c</sup> °C	Type of cooling
X2CrNi12	1.4003	1 100 to 800	air	+A	700 to 750	air, water
X6CrNiTi12	1.4516				790 to 850	
X2CrTi17	1.4520				820 to 880	
X3CrTi17	1.4510				770 to 830	
X2CrMoTi17-1	1.4513				790 to 850	
X2CrMoTi18-2	1.4521				820 to 880	
X6CrMoNb17-1	1.4526				800 to 860	
X2CrTiNb18	1.4509				870 to 930	
<sup>a</sup> The temperatures of annealing should be agreed for simulated heat treated test pieces.						
<sup>b</sup> +A = annealed.						
<sup>c</sup> If heat treatment is carried out in a continuous furnace, the upper part of the range specified is usually preferred, or even exceeded.						

**Table A.2 — Guidelines on the temperatures for hot forming and heat treatment <sup>a</sup> of martensitic stainless steels**

Steel grade		Hot forming		Heat treatment symbol <sup>b</sup>	Quenching		Tempering
Steel name	Steel number	Temperature °C	Type of cooling		Temperature <sup>c</sup> °C	Type of cooling	Temperature °C
X3CrNiMo13-4	1.4313	1150 to 900	air	+QT	950 to 1 050	oil, air, water	560 to 640
X4CrNiMo16-5-1	1.4418			+QT	900 to 1 000		570 to 650
<sup>a</sup> The temperatures of annealing should be agreed for simulated heat treated test pieces.							
<sup>b</sup> +QT = quenched and tempered.							
<sup>c</sup> If heat treatment is carried out in a continuous furnace, the upper part of the range specified is usually preferred, or even exceeded.							

**Table A.3 — Guidelines on the temperatures for hot forming and heat treatment <sup>a</sup> of austenitic stainless steels**

Steel grade		Hot forming		Heat treatment symbol <sup>b</sup>	Solution annealing <sup>c</sup> (but see footnote g)	
Steel name	Steel number	Temperature °C	Type of cooling		Temperature <sup>d e</sup> °C	Type of cooling
Austenitic corrosion resisting grades						
X2CrNiN18-7	1.4318	1 150 to 850	air	+AT	1 020 to 1 100	water, air <sup>f</sup>
X2CrNi18-9	1.4307				1 000 to 1 100	
X2CrNi19-11	1.4306				1 000 to 1 100	
X5CrNiN19-9	1.4315				1 000 to 1 100	
X2CrNiN18-10	1.4311				1 000 to 1 100	
X5CrNi18-10	1.4301				1 000 to 1 100	
X6CrNiTi18-10	1.4541				1 000 to 1 100	
X6CrNiNb18-10	1.4550				1 020 to 1 120	
X1CrNi25-21	1.4335				1 030 to 1 110	
X2CrNiMo17-12-2	1.4404				1 030 to 1 110	
X2CrNiMoN17-11-2	1.4406				1 030 to 1 110	
X5CrNiMo17-12-2	1.4401				1 030 to 1 110	
X1CrNiMoN25-22-2	1.4466				1 070 to 1 150	
X6CrNiMoTi17-12-2	1.4571				1 030 to 1 110	
X6CrNiMoNb17-12-2	1.4580				1 030 to 1 110	
X2CrNiMo17-12-3	1.4432				1 030 to 1 110	
X2CrNiMoN17-13-3	1.4429				1 030 to 1 110	
X3CrNiMo17-13-3	1.4436				1 030 to 1 110	
X2CrNiMo18-14-3	1.4435				1 030 to 1 110	
X2CrNiMoN18-12-4	1.4434				1 070 to 1 150	
X2CrNiMo18-15-4	1.4438				1 070 to 1 150	
X2CrNiMoN17-13-5	1.4439				1 060 to 1 140	
X1NiCrMoCu31-27-4	1.4563				1 070 to 1 150	
X1NiCrMoCu25-20-5	1.4539				1 060 to 1 140	
X1CrNiMoCuN25-25-5	1.4537				1 120 to 1 180	
X1CrNiMoCuN20-18-7	1.4547				1 140 to 1 200	
X1NiCrMoCuN25-20-7	1.4529				1 120 to 1 180	
Austenitic creep resisting grades						
X3CrNiMoBN17-13-3	1.4910	1 150 to 850	air	+AT	1 020 to 1 100	water, air <sup>f</sup>
X6CrNiTiB18-10	1.4941				1 050 to 1 110	
X6CrNi18-10	1.4948				1 050 to 1 110	
X6CrNi23-13	1.4950				1 050 to 1 150	
X6CrNi25-20	1.4951				1 050 to 1 150	
X5NiCrAlTi31-20	1.4958				1 100 to 1 200	
X5NiCrAlTi31-20+RA	1.4958 (+RA)			+RA	920 to 1 000 <sup>g</sup>	
X8NiCrAlTi32-21	1.4959			+AT	1 100 to 1 200 <sup>h</sup>	
X8CrNiNb16-13	1.4961				1 050 to 1 110	
<div>a The temperatures of annealing should be agreed for simulated heat treated test pieces.</div> <div>b +AT = solution annealed, +RA = re-crystallizing annealed.</div> <div>c 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.</div> <div>d If heat treatment is carried out in a continuous furnace, the upper part of the range specified is usually preferred, or even exceeded.</div> <div>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 %.</div> <div>f Cooling sufficiently rapid.</div> <div>g Re-crystallizing annealing.</div> <div>h After solution annealing the grain size according to EN ISO 643 shall be 1 to 5.</div>						



**Table A.4 — Guidelines on the temperatures for hot forming and heat treatment <sup>a</sup> of austenitic-ferritic stainless steels**

Steel grade		Hot forming		Heattreat- ment	Solution annealing <sup>c</sup>	
		Temperature	Type of cooling	Symbol <sup>b</sup>	Temperature <sup>d</sup>	Type of cooling
Steel name	Steel number	°C			°C	
X2CrNiN23-4	1.4362	1 150 to 950	air	+AT	1 000 ± 50	water, air
X2CrNiMoN22-5-3	1.4462				1 060 ± 40	
X2CrNiMoCuN25-6-3	1.4507	1 150 to1 000	air	+AT	1 080 ± 40	water, air
X2CrNiMoN25-7-4	1.4410					
X2CrNiMoCuWN25-7-4	1.4501					
<div><div>a</div><div>The temperatures of annealing, should be agreed for simulated heat treated test pieces.</div><div>b</div><div>+AT = Solution annealed.</div><div>c</div><div>Solution annealing in the range specified followed by sufficiently rapid cooling to avoid precipitation of deleterious phases is essential after hot forming these steels.</div><div>d</div><div>If heat treatment is carried out in a continuous furnace, the upper part of the range specified is usually preferred, or even exceeded.</div></div>						

**A.2** Flame cutting may adversely affect edge areas; they should be machined.

**A.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.

**A.4** For further information see EN 1011-3 [1].

## **Annex B** (informative)

### **Post weld heat treatment**

**B.1** In general, welded assemblies of stainless steels covered by this European Standard are not subjected to any heat treatment with the following exceptions:

- martensitic grades are retempered and
- ferritic grades are reannealed

if there is any risk of residual martensite in the heat affected zone; for appropriate temperatures see Tables A.1 and A.2.

**B.2** During heating of high chromium and molybdenum austenitic-ferritic or austenitic steel weldments containing some ferrite, intermetallic phases may be formed which need to 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 given in Tables A.3 and A.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 European Standard.

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 be planned carefully.

**B.3** In special cases, e.g. for parts with 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 B.1 by holding at an intermediate stage below the usual solution temperature (see Table A.3) and is defined as stabilizing annealing for the niobium or titanium bearing grades and as stress-relieving for the un-stabilized low carbon grades.

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

**B.4** Preheating of austenitic-ferritic steels is a very effective precaution against stress increase 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, and a preheating temperature between 120 °C and 200 °C according to the particular steel and thickness should be applied.

The same is advisable for complex welds of austenitic steels.

**Table B.1 — Guideline on post weld heat treatment of austenitic steels**

Steel grade		Temperature <sup>a</sup>	Type of cooling
Steel name	Steel number		
Stabilized steels			
X6CrNiTi18-10	1.4541	900 to 940	air
X6CrNiNb18-10	1.4550		
X6CrNiMoTi17-12-2	1.4571	not recommended	
X6CrNiMoNb17-12-2	1.4580		
Steels with ≤ 0,07 % C			
X5CrNiN19-9	1.4315	not recommended	
X5CrNi18-10	1.4301		
X5CrNiMo17-12-2	1.4401		
X3CrNiMo17-13-3	1.4436		
Steels with ≤ 0,03 % C			
X2CrNiN18-7	1.4318	900 to 940	air
X2CrNi18-9	1.4307		
X2CrNi19-11	1.4306		
X2CrNi18-10	1.4311		
X2CrNiMo17-12-2	1.4404	960 to 1 040 <sup>c</sup>	forced air
X2CrNiMoN17-11-2	1.4406		
X2CrNiMo17-12-3	1.4432		
X2CrNiMoN17-13-3	1.4429		
X2CrNiMo18-14-3	1.4435		
X2CrNiMoN18-12-4	1.4434		
X2CrNiMo18-15-4	1.4438		
X2CrNiMoN17-13-5	1.4439		
Higher alloyed austenitic steels with ≤ 0,02 % C			
X1CrNi25-21	1.4335	not recommended	
X1CrNiMoN25-22-2	1.4466		
X1NiCrMoCu31-27-4	1.4563		
X1NiCrMoCu25-20-5	1.4539		
X1CrNiMoCuN25-25-5	1.4537		
X1CrNiMoCuN20-18-7	1.4547		
X1NiCrMoCuN25-20-7	1.4529		
Creep resisting steels			
X3CrNiMoBN17-13-3	1.4910	900 to 950 <sup>b</sup>	air
X6CrNiTiB18-10	1.4941		
X6CrNi18-10	1.4948	not recommended	
X6CrNi23-13	1.4950		
X6CrNi25-20	1.4951		
X5NiCrAlTi31-20 (+RA)	1.4958 (+RA)	900 to 950 <sup>b</sup>	air
X8NiCrAlTi32-21	1.4959		
X8CrNiNb16-13	1.4961		
<sup>a</sup> Minimum holding time: 30 min.			
<sup>b</sup> Recommended for components with greater wall thickness.			
<sup>c</sup> Not recommended if welded with stabilized filler metal.			

## Annex C

(informative)

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

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

Steel grade		Minimum tensile strength, MPa at a temperature (in °C) of				
Steel name	Steel number					
		50 <sup>a</sup>	100	150	200	250
X2CrNiN23-4	1.4362	577	540	520	500	490
X2CrNiMoN22-5-3	1.4462	621	590	570	550	540
X2CrNiMoCuN25-6-3	1.4507	679	660	640	620	610
X2CrNiMoN25-7-4	1.4410	711	680	660	640	630
X2CrNiMoCuWN25-7-4	1.4501	711	680	660	640	630
<sup>a</sup> Determined by linear interpolation.						

## **Annex D**

(informative)

### **Reference data of strength values for 1 % (plastic) creep strain and creep rupture**

NOTE 1 The values given in Tables D.1 and D.2 are mean values of the scatter band considered until now. If these are 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 is about  $\pm 20\%$  in the long-range endurance of about  $10^5$  h up to  $700\text{ }^{\circ}\text{C}$  to  $800\text{ }^{\circ}\text{C}$ . Above that temperature, scattering may be gradually more or less enlarged and be summarized with about  $35\%$  to  $40\%$  at  $1\,000\text{ }^{\circ}\text{C}$  testing temperature. However, individual deviations need to be presumed.

NOTE 2 The strength values for 1 % (plastic) creep strain and creep rupture given up to the elevated temperatures listed in Tables D.1 and D.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 are taken into account.

**Table D.1 — Strength for 1 % (plastic) creep strain of austenitic creep resisting steels in the solution annealed condition (see Table A.3)**

Steel grade		Temperature  °C	Strength for 1 % (plastic) creep strain <sup>a</sup> in MPa for	
Steel name	Steel number		10 000 h	100 000 h
X6CrNi18-10 <sup>b</sup>	1.4948	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 <sup>c</sup>	1.4950	550	107	60
		600	80	35
		650	50	22
		700	25	12
		750		
		800	10	
X5NiCrAlTi31-20 <sup>b</sup>	1.4958	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)
		(to be continued)		

Table D.1 (continued)

Steel grade		Temperature °C	Strength for 1 % (plastic) creep strain <sup>a</sup> in MPa for	
Steel name	Steel number		10 000 h	100 000 h
X5NiCrAlTi31-20 +RA <sup>b</sup>	1.4958 + 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)
X8NiCrAlTi32-21 <sup>b</sup>	1.4959	700	59,0	42,0
		710	55,5	38,0
		720	52,0	34,4
		730	48,5	31,3
		740	45,0	28,4
		750	41,7	26,0
		760	38,4	23,5
		770	35,6	21,3
		780	32,9	19,3
		790	30,5	17,6
		800	28,2	16,0
		810	26,2	14,7
		820	24,2	13,4
		830	22,4	12,1
		840	20,8	11,1
		850	19,1	10,0
		860	17,6	9,1
		870	16,1	8,2
		880	14,7	7,3
		890	13,4	6,5
		900	12,1	5,7
		910	10,9	5,0
		920	9,8	4,4
		930	8,8	3,9
		940	7,8	3,4
		950	6,9	2,9
		960	6,1	2,5
		970	5,3	2,1
		980	4,6	1,8
		990	4,0	1,6
		1000	3,5	1,4

(to be continued)

Table D.1 (concluded)

Steel grade		Temperature  °C	Strength for 1 % (plastic) creep strain <sup>a</sup> in MPa for	
Steel name	Steel number		10 000 h	100 000 h
X8CrNiNb16-13 <sup>b</sup>	1.4961	580	127	91
		590	120	84
		600	113	78
		610	106	73
		620	99	67
		630	92	61
		640	85	55
		650	78	49
		660	72	44
		670	66	39
		680	59	34
		690	54	30
		700	49	26
		710	45	24
		720	42	21
		730	39	19
		740	36	17
		750	34	16
<sup>a</sup> Values in parentheses involved extended time and/or stress extrapolation.				
<sup>b</sup> Values were taken from DIN 17460 [3].				
<sup>c</sup> Those preliminary values were taken from NFA 36-209 [4].				



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

Steel grade		Tempe- rature	Strength for rupture <sup>a</sup> 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
X3CrNiMoBN17- 13-3 <sup>b</sup>	1.4910	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 <sup>b</sup>	1.4941	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		39	
		690	66			39		33	
		700	60			35		29	
(to be continued)									

Table D.2 (continued)

Steel grade		Tempe- rature	Strength for rupture <sup>a</sup> 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
X6CrNi18-10 <sup>b</sup>	1.4948	500	250			192		176	
		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	109	102	81		70	
		620	113	101	94	73		62	
		630	104	94	87	65		55	
		640	95			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 <sup>c</sup>	1.4950	550	160			90			
		600	120			65			
		650	70			35			
		700	36			16			
		750							
		800	18			7,5			
X6CrNi25-20 <sup>d</sup>	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*
(to be continued)									

Table D.2 (continued)

Steel grade		Tempe- rature	Strength for rupture <sup>a</sup> 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 <sup>d</sup>	1.4951	760	26	21	19*	17*	16*	15*	14,5*
		770	24	19,5	18*	15,5*	14,5*	14*	13,5*
		780	22	18	16,5*	14,5*	13,5*	13*	12,5*
		790	21	17	15,5*	13,5*	12,5*	12*	11,5*
		800	19,5	15,5	14*	12,5*	11,5*	11*	10,5*
		810	18	14,5	13*	11,5*	10,5*	10*	9,5*
		820	17	13,5	12*	10,5*	10*	9,5*	9*
		830	16	12,5	11,5*	10*	9*		
		840	15	12	10,5*	9*			
		850	14	11	10*				
		860	13	10	9*				
		870	12	9,5					
		880	11,5	9*					
		890	10,5						
		900	10,0						
X5NiCrAlTi31-20	1.4958	910	9,5						
		500	290			215		(196)	
		510	279			205		(186)	
		520	267			195		(176)	
		530	254			184		(166)	
		540	240			172		(155)	
		550	225			160		(143)	
		560	208			147		(130)	
		570	190			133		(117)	
		580	172			119		(105)	
		590	155			106		(93)	
		600	140			95		(83)	
		610	128			85		(74)	
		620	118			78		(68)	
		630	109			72		(63)	
		640	103			67		(59)	
		650	97			63		(55)	
		660	91			59		(52)	
		670	85			55		(48)	
		680	80			52		(45)	
		690	74			48		(41)	
700	69			44		(38)			
X5NiCrAlTi31- 20+RA <sup>b</sup>	1.4958 +RA	500	315			258		(242)	
		510	297			241		(225)	
		520	280			224		(207)	
		530	262			206		(190)	
		540	243			189		(172)	
		550	224			171		(155)	
		560	204			153		(138)	
		570	184			136		(122)	
		580	165			119		(106)	
		590	147			104		(92)	
		600	131			90		(80)	
		610	117			79		(70)	
		620	106			70		(62)	
		630	96			62		(55)	
		640	87			56		(49)	
650	80			51		(44)			
(to be continued)									

Table D.2 (continued)

Steel grade		Tempe- rature	Strength for rupture <sup>a</sup> 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
X5NiCrAlTi31- 20+RA <sup>b</sup>	1.4958 +RA	660	73			46		(40)	
		670	67			42		(36)	
		680	61			38		(33)	
		690	55			34		(29)	
		700	50			30		(26)	
X8NiCrAlTi32-21 <sup>e</sup>	1.4959	700	73,0	58,2		44,8		38,2*	
		710	67,8	54,0		41,4		35,2*	
		720	63,0	50,1		38,3		32,5*	
		730	58,5	46,5		35,4		30,0*	
		740	54,4	43,1		32,8		27,7*	
		750	50,6	40,0		30,3		25,6*	
		760	47,0	37,1		28,0		23,6*	
		770	43,7	34,4		25,9		21,8*	
		780	40,7	31,9		24,0		20,1*	
		790	37,8	29,6		22,1		18,5*	
		800	35,2	27,4		20,4		17,0*	
		810	32,7	25,4		18,9		15,6*	
		820	30,4	23,6		17,4		14,4*	
		830	28,3	21,8		16,0		13,2*	
		840	26,3	20,2		14,8		12,1*	
		850	24,4	18,7		13,6		11,1*	
		860	22,7	17,3		12,5		10,1*	
		870	21,0	16,0		11,5		9,23*	
		880	19,5	14,8		10,5		8,41*	
		890	18,1	13,6		9,60		7,63*	
		900	16,8	12,6		8,76		6,91*	
		910	15,6	11,6		7,98		6,23*	
		920	14,4	10,6		7,25		5,60*	
		930	13,3	9,77		6,57		5,01*	
		940	12,3	8,95		5,93		4,45*	
		950	11,4	8,19		5,33		3,93*	
		960	10,5	7,47		4,77*		3,43*	
		970	9,63	6,80		4,23*		2,95*	
		980	8,85	6,17		3,73*			
		990	8,11	5,57		3,25*			
		1000	7,42	5,01		2,79*			
(to be continued)									

Table D.2 (concluded)

Steel grade		Tempe- rature	Strength for rupture <sup>a</sup> 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
X8CrNiNb16-13 <sup>b</sup>	1.4961	580	182			129		115	
		590	170			119		105	
		600	157			108		94	
		610	145			98		85	
		620	134			89		77	
		630	124			80		69	
		640	113			72		61	
		650	103			64		53	
		660	93			57		47	
		670	84			50		41	
		680	76			44		36	
		690	70			39		31	
		700	64			34		27	
		710	59			30		25	
		720	55			27		22	
		730	51			25		19	
		740	47			22		17	
		750	44			20		15	
<sup>a</sup> Values in parantheses involved time and/or stress extrapolation; values with asterisk involved time extrapolation.									
<sup>b</sup> Values were taken from DIN 17460 [3].									
<sup>c</sup> Those preliminary values were taken from NFA 36-209 [4].									
<sup>d</sup> Values were taken from BS PD 6525 Part 1 [5].									
<sup>e</sup> Values were prepared by ECCC, WG 3.3 [6].									

## Annex E

(informative)

### Reference data on mechanical properties of austenitic steels at room temperature and at low temperatures

**Table E.1 — Tensile properties at room temperature and at low temperatures**

Steel grade		20 °C				- 80 °C				- 150 °C				- 196 °C			
		0,2 % proof strength $R_{p0.2}$ min. MPa	1,0 % proof strength $R_{p1.0}$ min. MPa	Tensile strength $R_m$ min. MPa	Elongation after fracture $A$ min. %	0,2 % proof strength $R_{p0.2}$ min. MPa	1,0 % proof strength $R_{p1.0}$ min. MPa	Tensile strength $R_m$ min. MPa	Elongation after fracture $A$ min. %	0,2 % proof strength $R_{p0.2}$ min. MPa	1,0 % proof strength $R_{p1.0}$ min. MPa	Tensile strength $R_m$ min. MPa	Elongation after fracture $A$ min. %	0,2 % proof strength $R_{p0.2}$ min. MPa	1,0 % proof strength $R_{p1.0}$ min. MPa	Tensile strength $R_m$ min. MPa	Elongation after fracture $A$ min. %
Steel name	Steel number																
X2CrNi18-9	1.4307	200	240	500	45	220	290	830	35	225	325	1070	30	300	400	1200	30
X5CrNi19-9	1.4315	270	310	550	40	385	455	890	40	450	550	1180	35	550	650	1350	35
X2CrNi18-10	1.4311	270	310	550	40	350	420	850	40	450	550	1050	35	550	650	1250	35
X5CrNi18-10	1.4301	210	250	520	45	270	350	860	35	315	415	1100	30	300	400	1250	30
X6CrNiTi18-10	1.4541	200	240	500	40	260	290	855	35	350	420	1100	35	390	470	1200	30
X2CrNiMo17-12-2	1.4404	220	260	520	45	275	355	840	40	315	415	1070	40	350	450	1200	35
X2CrNiMo17-11-2	1.4406	280	320	580	40	380	450	800	35	500	600	1000	35	600	700	1150	30
X2CrNiMo17-13-3	1.4429	280	320	580	35	380	450	800	30	500	600	1000	30	600	700	1150	30
NOTE For any temperature between 20 °C and -196 °C, mechanical properties may be estimated by linear interpolation.																	

## Annex ZA (informative)

### Relationship between this European Standard and the Essential Requirements of EU Directive 97/23/EC

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 97/23/EC.

Once this standard is cited in the Official Journal of the European Communities under that Directive and has been implemented as a national standard in at least one Member State, compliance with the 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 that Directive and associated EFTA regulations.

**Table ZA.1 — Correspondence between this European Standard and Directive 97/23/EC**

Clauses/subclauses of this European Standard	Essential Requirements (ERs) of Directive 97/23/EC  Annex I	Content
8.4	4.1a	Appropriate material properties
8.3.3	4.1b	Chemical resistance <sup>a</sup>
8.2	4.1c	Ageing
8.2 and 8.6	4.1d	Suitable for processing procedures
9.1	4.3	Documentation
<sup>a</sup> But see Tables 7 and 9, column "Resistance to intergranular corrosion", where this resistance is, for several steel grades, restricted or even excluded.		

**WARNING —** Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

## Bibliography

- [1] EN 1011-3, *Welding — Recommendation for welding of metallic materials — Arc welding — Part 3: Arc welding of stainless steels*
- [2] EN 10204:2004, *Metallic products — Types of inspection documents*
- [3] DIN 17460:1992, *Hochwarmfeste austenitische Stähle — Technische Lieferbedingungen für Blech, kalt- und warmgewalztes Band, Stäbe und Schmiedestücke (High temperature austenitic steels — Technical delivery conditions for plate, cold and hot rolled strip, bars and forgings)*
- [4] NFA 36-209:1990, *Produits sidérurgiques — Tôles en aciers inoxydables austénitiques et austénoferriques pour chaudières et appareils à pression (Iron and steel — Austenitic and austenitic-ferritic stainless steel plates for boilers and pressure vessels)*
- [5] BS PD 6525 Part 1:1990, *Elevated temperature properties for steels for pressure purposes — Part 1: Stress rupture properties*
- [6] Results of investigations of the European Creep Collaborative Committee (ECCC, WG 3.3), submitted to ECISS/TC 22 and ECISS/TC 28 by fax of 1996-11-20 (Document ECISS/TC 22 N 372)