BRITISH STANDARD

BS EN
10302:2008

Creep resisting steels, nickel and cobalt alloys

ICS 77.120.01; 77.140.01; 77.150.01

BSI
British Standards

National foreword

This British Standard is the UK implementation of EN 10302:2008. It supersedes BS EN 10302:2002 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/30, Stainless steels.

A list of organizations represented on this committee can be obtained on request to its secretary.

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English Version

Creep resisting steels, nickel and cobalt alloys

Aciers et alliage à base de nickel et de cobalt résistant au fluage

Warmfeste Stähle, Nickel- und Cobaltlegierungen

This European Standard was approved by CEN on 10 February 2008.

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

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Foreword

This document (EN 10302:2008) has been prepared by Technical Committee ECISS/TC 23 “Stainless steels”, 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of an identical text or by endorsement, at the latest by September 2008, and conflicting national standards shall be withdrawn at the latest by September 2008.

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

This document supersedes EN 10302:2002.

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 the United Kingdom.

NOTE The clauses marked with a point (●) contain information relating to agreements which are to be made at the time of ordering. The clauses marked with two points (●●) contain information relating to agreements which may be made at the time of ordering.

1 Scope

1.1 This European Standard covers the grades of wrought steels and alloys listed in Table 1 and Table 2, which are usually employed for components and equipment, for which the main requirement is their creep resistance under mechanical long-time stressing at temperatures above 500 °C.

NOTE Heat resisting grades given in EN 10095 [9] may also be used for similar applications if so agreed.

1.2 This European Standard specifies the technical delivery conditions for semi-finished products, for hot or cold rolled sheet/plate and strip, hot or cold formed (cold drawn) bars, rods, wire and sections.

1.3 The general technical delivery conditions specified in EN 10021 apply in addition to the specifications of this European Standard, unless otherwise specified in this European Standard.

1.4 This European Standard does not apply to components manufactured by further processing the product forms listed in 1.2 with quality characteristics altered as a result of such further processing.

1.5 This European Standard shall not be used for aerospace and pressure purposes.

1.6 For steels and alloys with similar chemical composition, but intended for different applications, see the Bibliography.

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 10002-1, *Metallic materials - Tensile testing - Part 1: Method of test (at ambient temperature)*

EN 10002-5, *Metallic materials - Tensile testing - Part 5: Method of testing at elevated temperature*

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

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

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

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

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

EN 10079:2007, *Definition of steel products*

EN 10163-2, *Delivery requirements for surface condition of hot rolled steel plates, wide flats and sections - Part 2: Plate and wide flats*

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

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

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

prCEN/TR 10261, *Iron and steel - Review of available methods of chemical analysis*

EN ISO 377:1997, *Steel and steel products - Location and preparation of samples and test pieces for mechanical testing (ISO 377:1997)*

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

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 10020:2000, EN 10021:2006, EN 10052:1993, EN 10079:2007, EN ISO 377:1997 and EN ISO 14284:2002 and the following apply.

3.1
creep resisting materials
steels, nickel- or cobalt-alloys with a minimum of 8 % chromium, which are characterised by good mechanical behaviour at temperatures above 500 °C under long-range service conditions; i.e. primarily by creep strength to 1 % plastic strain or creep rupture strength during long-time stressing

NOTE For supplementary information on creep resisting steels and alloys see Annex B.

4 Classification and designation

4.1 Classification

Materials covered in this European Standard are classified according to their structure into:

— martensitic steels;

— austenitic steels;

— nickel alloys; and

— cobalt alloys.

4.2 Designation

The names and numbers of the steels (see Table 1) were formed in accordance with EN 10027-1 and EN 10027-2 respectively.

NOTE Explanation on the designation of nickel and cobalt alloys (see Table 2).

— name: The preceding chemical symbols indicate the main alloy elements and the figure immediately following indicates the average content of these alloys which is subsequently followed by the symbol for the other important alloying elements added.

— material number: The structure is set out according to EN 10027-2 with the number 2 for the material group number. This material group comprises chemically resistant and high temperature or heat resistant nickel and cobalt alloys.

5 Information to be supplied by the purchaser

5.1 Mandatory information ●

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

a) quantity to be delivered;

b) designation of the product form (e.g. bar or rod, strip or plate);

c) where an appropriate dimensional standard is available (see Annex A) the number of the standard and the indications required by this, also the nominal dimensions and tolerances;

d) type of material (steel, cobalt or nickel alloy);

e) number of this European Standard (EN 10302:2008);

f) name or number of the steel grade, nickel or cobalt alloy (see 4.2);

g) if for the relevant material in the table more than one treatment condition for the mechanical properties is covered, the symbol for the desired heat treatment condition or work hardened condition;

h) desired process route (see symbols in Table 5 and Table 6).

5.2 Options ●●

A number of options are specified in this European Standard and listed below. If the purchaser does not indicate his wish to implement any of these options, the supplier shall supply in accordance with the basic specification of this European Standard (see 5.1).

a) any requirement concerning a special melting or forming process (see 6.1);

b) any requirement relating to surface condition (see 7.4);

c) any requirement concerning tolerances on mass not specified in the dimensional standard (see 7.7.2);

d) any requirement to determine the product analysis (see Table 11, footnote b);

e) any requirement concerning the method of product analysis (see 8.4.1);

f) any requirement concerning elevated temperature tensile testing (see 8.4.3);

g) any requirement concerning special marking of the products (see 9.2, 9.3 and Table 12);

h) any requirement concerning the issue of an inspection document (see 8.2).

EXAMPLE

10 t rounds of a steel grade with the name X6NiCrTiMoVB25-15-2 and the number 1.4980 as specified in EN 10302 of 50 mm diameter, dimensional tolerances as specified in EN 10060, in process route 1D (see Table 6).

10 t rounds EN 10060–50
steel EN 10302 - X6NiCrTiMoVB25-15-2+1D

or

10 t rounds EN 10060–50
steel EN 10302-1.4980+1D

6 Manufacturing process

6.1 General ●●

Unless a special melting or forming process is agreed when ordering, the production process for steels and alloys conforming to this European Standard shall be at the discretion of the manufacturer.

6.2 Delivery condition ●

The products shall be supplied in the delivery condition agreed in the order by reference to the process route given in Table 5 and Table 6 and to the treatment conditions given in Table B.1 and Table B.2.

7 Requirements

7.1 Chemical composition

7.1.1 The chemical composition requirements given in Table 1 and Table 2 apply in respect to the cast analysis.

7.1.2 The product analysis may deviate from the limiting values for the cast analysis given in Table 1 and Table 2 by the values listed in Table 3 and Table 4.

7.2 Mechanical properties

7.2.1 Mechanical properties at room temperature

The mechanical properties at room temperature as specified in Table 7 and Table 8 apply for each specified heat treatment condition. This does not apply to the process route 1U (hot rolled, not heat treated, not descaled) and to semi-finished products.

● If by agreement at the time of ordering the products are to be supplied in a non-heat-treated condition, the mechanical properties specified in Table 7 and Table 8 shall be obtainable from reference test pieces which have received the appropriate heat treatment (simulated heat treatment).

7.2.2 Mechanical properties at elevated temperatures

The mechanical properties at elevated temperature as specified in Table 9 and Table 10 apply for each specified heat treatment condition. This does not apply to the process route 1U (hot rolled, not heat treated, not descaled) and to semi-finished products.

● If by agreement at the time of ordering the products are to be supplied in a non-heat-treated condition, the mechanical properties specified in Table 9 and Table 10 shall be obtainable from reference test pieces which have received the appropriate heat treatment (simulated heat treatment).

7.3 Creep properties

The creep strength to 1 % plastic strain or creep rupture strength values as specified in Annex C apply for each specified heat treatment condition. This does not apply to the process route 1U (hot rolled, not heat treated, not descaled) and to semi-finished products.

7.4 Surface condition

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

●● If more exact requirements for the surface quality are necessary, this shall be agreed at the time of enquiry and order.

When products are delivered in coil form, the degree and extent of such imperfections may be expected to be greater, due to the impractibility of removing short lengths of coil. For hot-rolled quarto-plates, the specification in EN 10163-2, class A3, applies unless otherwise agreed.

For long products, where appropriate, the requirements shall be on the basis of EN 10221.

7.5 Internal soundness

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

●● Where appropriate, requirements together with the conditions for their verification may be agreed at the time of enquiry and order.

7.6 Dimensions and tolerances on dimensions ●

The dimensions and the tolerances on dimensions are to be agreed at the time of enquiry and order, as far as possible with reference to the dimensional standards listed in Annex A.

7.7 Calculation of mass and tolerances on mass

7.7.1 When calculating the nominal mass from the nominal dimensions, the values given in Tables D.1 and D.2 shall be used as a basis for the density of the grade concerned.

7.7.2 ●● If the tolerances on mass are not specified in the dimensional standard listed in Annex A, they may be agreed at the time of enquiry and order.

8 Inspection and testing

8.1 General

The manufacturer shall carry out appropriate process control, inspection and testing to assure himself that the delivery complies with the requirements of the order.

This includes the following:

— suitable frequency of verification of the dimensions of the products,

— adequate intensity of visual examination of the surface quality of the products,

— appropriate frequency and type of test to ensure that the correct grade is used.

The nature and frequency of these verifications, examinations and tests is determined by the manufacturer, in the light of the degree of consistency that has been determined by the evidence of the quality system. In view of this, verifications by specific tests for these requirements are not necessary unless otherwise agreed.

8.2 Types and contents of inspection documents ●●

8.2.1 At the time of ordering, the issue of one of the inspection documents in accordance with EN 10204 may be agreed for each delivery.

8.2.2 If it is agreed to issue a test report 2.2 in accordance with EN 10204 it shall indicate the following information:

a) information groups A, B and Z of EN 10168:2004;

b) results of the cast analysis in accordance with the code numbers C71 to C92 in EN 10168:2004.

8.2.3 If the issuing of an inspection certificate 3.1 or 3.2 according to EN 10204 has been agreed, specific inspections according to 8.3 are to be carried out and the following information shall be given in the inspection document with the code numbers and details required by EN 10168:2004:

a) as under 8.2.2 a);

b) as under 8.2.2 b);

c) results of the mandatory tests marked in Table 11, second column, by an 'm';

d) result of the optional tensile test at elevated temperature marked in Table 11, second column, by an “o” and of any other optional test or inspection agreed when ordering.

8.3 Specific inspection and testing

8.3.1 Extent of testing

The tests to be carried out, either as mandatory (m) or by agreement (o) and the composition and size of the test units, and the number of sample products, samples and test pieces to be taken are given in Table 11.

8.3.2 Selection and preparation of samples and test pieces

8.3.2.1 The specifications of EN ISO 377 and EN ISO 14284 respectively shall be observed in sampling and sample preparation. The stipulations in 8.3.2.2 apply additionally for the mechanical tests.

8.3.2.2 The test samples for the tensile test shall be taken in accordance with Figure 1 and Figure 2 in such a way that for flat products, they are located half-way between the centre and a longitudinal edge.

The samples shall be taken from products in the delivery condition. If agreed, the samples may be taken before flattening for flat products or before straightening for bars. For samples to be given a simulated heat treatment the conditions for annealing, hardening and tempering shall be agreed.

8.4 Test methods

8.4.1 ●● The chemical analysis shall be carried out using the appropriate European Standard for the element being analysed. In the absence of an appropriate European Standard, the choice of a suitable physical or chemical analytical method for the analysis shall be at the discretion of the manufacturer. The manufacturer shall declare the test method used, if required.

The list of available European Standards on chemical analysis is given in prCEN/TR 10261.

8.4.2 The tensile test at room temperature shall be carried out in accordance with EN 10002-1. Generally, this means using proportional test pieces having a gauge length $L_0 = 5{,}65\sqrt{S_0}$. (S_0 = cross-section of the test piece). In cases of doubt and in referee testing, this type of test piece shall be used.

The 0,2 % proof strength, the tensile strength and elongation after fracture shall be determined.

8.4.3 If agreed when ordering, the tensile test at elevated temperature shall be carried out in accordance with EN 10002-5, this generally being with proportional test pieces having a gauge length $L_0 = 5{,}65\sqrt{S_0}$. (S_0 = cross-section of the test piece). In cases of doubt and in referee testing these test pieces shall be used. The temperature of testing is to be agreed.

The 0,2 % proof strength shall be determined.

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

8.5 Retests

See EN 10021:2006.

9 Marking

9.1 Marking shall be durable.

9.2 ●● Unless otherwise agreed, the requirements listed in Table 12 apply.

9.3 ●● The method and the extent of marking and the material of marking shall, unless otherwise agreed, be at the option of the manufacturer.

9.4 As an alternative for items that are wrapped, bundled or boxed, the marking may be applied to the packaging, or to a tag securely attached to it.

Dimensions in millimetres

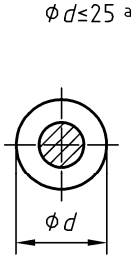
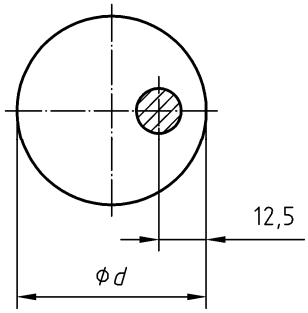
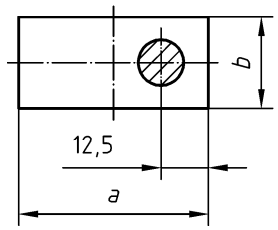
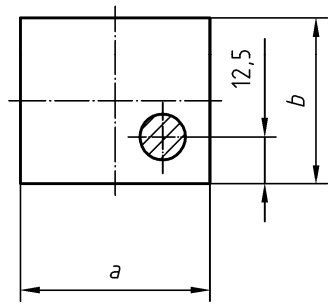
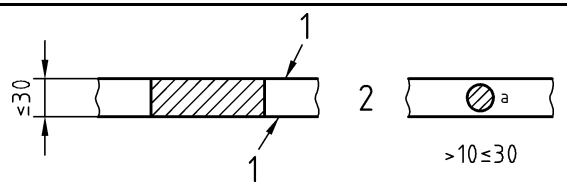
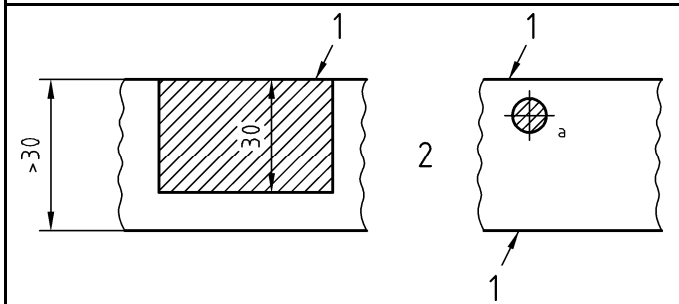
Type of test	Round cross-section products	Rectangular cross-section products
Tensile	$\phi d \leq 25$ [a]  $25 < \phi d \leq 160$ 	$b \leq 25$ $a \geq b$  $25 < b \leq 160$ $a \geq b$ 
[a] Samples of product may alternatively be tested unmachined, in accordance with EN ISO 377.		

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

Type of test piece	Product thickness t mm	Direction of the longitudinal axis of the test piece in relation to the principal direction of rolling at a rolled width of		Distance of test piece from the rolled surface Dimensions in millimetres
		< 300 mm	≥ 300 mm	
Tensile [a]	≤ 30	longitudinal	transverse	
	> 30			

[a] In cases of doubt or dispute the gauge length shall be $L_o = 5{,}65\sqrt{S_0}$ for test pieces from products $t \geq 3$ mm.

For products with a thickness $t < 3$ mm, non-proportional test pieces with a gauge length of 80 mm and a width of 20 mm shall be used, but test pieces with a gauge length of 50 mm and a width of 12,5 mm may also be applied. For products with a thickness 3 mm ≤ t ≤ 10 mm (or t ≤ 8 mm in case of alloys) flat proportional test pieces with two rolled surfaces and a maximum width of 30 mm shall be used. For products with a thickness t > 10 mm (or t > 8 mm in case of alloys), one of the following proportional test pieces may be used:

- either a flat test piece with a maximum thickness of 30 mm; the thickness may be reduced to 10 mm by machining, but one rolled surface shall be preserved.

- or a round test piece with a diameter of $d \geq 5$ mm the axis of which shall be located as near as possible to a plane in the outer third of half the product thickness.

Key
1 Rolling surface
2 Alternatives

Figure 2 — Position of the tensile test pieces in flat products

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

Steel grade		% by mass														
Name	Num-ber	C	Si	Mn	P max.	S max.	N	Al	Cr	Mo	Nb	Ni	Ti	V	W	Others
Martensitic steels																
X10CrMoVNb9-1	1.4903	0,08 to 0,12	≤ 0,50	0,30 to 0,60	0,025	0,015	0,030 to 0,070	≤ 0,030	8,0 to 9,5	0,85 to 1,05	0,060 to 0,10	≤ 0,40	-	0,18 to 0,25	-	-
X11CrMoWVNb9-1-1	1.4905	0,09 to 0,13	0,10 to 0,50	0,30 to 0,60	0,020	0,010	0,050 to 0,090	≤ 0,040	8,5 to 9,5	0,90 to 1,10	0,060 to 0,10	0,10 to 0,40	-	0,18 to 0,25	0,90 to 1,10	B: 0,0005 to 0,0050
X8CrCoNiMo10-6	1.4911	0,05 to 0,12	0,10 to 0,80	0,30 to 1,30	0,025	0,015	≤ 0,035	-	9,8 to 11,2	0,50 to 1,00	0,20 to 0,50	0,20 to 1,20	-	0,10 to 0,40	≤ 0,70	B: 0,005 to 0,015 Co: 5,0 to 7,0
X19CrMoNbVN11-1	1.4913	0,17 to 0,23	≤ 0,50	0,40 to 0,90	0,025	0,015	0,050 to 0,10	≤ 0,020	10,0 to 11,5	0,50 to 0,80	0,25 to 0,55	0,20 to 0,60	-	0,10 to 0,30	-	B: ≤ 0,0015
X20CrMoV11-1	1.4922	0,17 to 0,23	≤ 0,50	≤ 1,00	0,025	0,015	-	-	10,0 to 12,5	0,80 to 1,20	-	0,30 to 0,80	-	0,25 to 0,35	-	-
X22CrMoV12-1	1.4923	0,18 to 0,24	≤ 0,50	0,40 to 0,90	0,025	0,015	-	-	11,0 to 12,5	0,80 to 1,20	-	0,30 to 0,80	-	0,25 to 0,35	-	-
X20CrMoWV12-1	1.4935	0,17 to 0,24	0,10 to 0,50	0,30 to 0,80	0,025	0,015	-	-	11,0 to 12,5	0,80 to 1,20	-	0,30 to 0,80	-	0,20 to 0,35	0,40 to 0,60	-
X12CrNiMoV12-3	1.4938	0,08 to 0,15	≤ 0,50	0,40 to 0,90	0,025	0,015	0,020 to 0,040	-	11,0 to 12,5	1,50 to 2,00	-	2,00 to 3,00	-	0,25 to 0,40	-	-
Austenitic steels																
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	-	-	-	B: 0,0015 to 0,0050
X6CrNiMoB17-12-2	1.4919	0,04 to 0,08	≤ 1,00	≤ 2,00	0,035	0,015	≤ 0,10	-	16,5 to 18,5	2,00 to 2,50	-	10,0 to 13,0	-	-	-	B:0,0015 to 0,0050
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	5xC to 0,80	-	-	B: 0,0015 to 0,0050
X6CrNiWNbN16-16	1.4945	0,04 to 0,10	0,30 to 0,60	≤ 1,50	0,035	0,015	0,060 to 0,14	-	15,5 to 17,5	-	10xC to 1,20	15,5 to 17,5	-	-	2,50 to 3,5	-
X6CrNi25-20	1.4951	0,04 to 0,08	≤ 0,70	≤ 2,00	0,035	0,015	≤ 0,10	-	24,0 to 26,0	-	-	19,0 to 22,0	-	-	-	-
X5NiCrAlTi31-20	1.4958	0,030 to 0,08	≤ 0,70	≤ 1,50	0,015	0,010	-	0,20 to 0,50	19,0 to 22,0	-	≤ 0,10	30,0 to 32,5	0,20 to 0,50	-	-	Cu: ≤ 0,50

Table 1 *(continued)*

Steel grade		% by mass														
Name	Num-ber	C	Si	Mn	P max.	S max.	N	Al	Cr	Mo	Nb	Ni	Ti	V	W	Others
Austenitic steels *(continued)*																
X8NiCrAlTi32-21	1.4959	0,05 to 0,10	≤ 0,70	≤ 1,50	0,015	0,010	-	0,25 to 0,65	19,0 to 22,0	-	-	30,0 to 34,0	0,25 to 0,65	-	-	Cu: ≤ 0,50
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	-	10xC to 1,20	12,0 to 14,0	-	-	-	-
X12CrNiWTiB16-13	1.4962	0,07 to 0,15	≤ 0,50	≤ 1,50	0,035	0,015	-	-	15,5 to 17,5	-	-	12,5 to 14,5	0,40 to 0,70	-	2,50 to 3,00	B: 0,0015 to 0,0060
X12CrCoNi21-20	1.4971	0,08 to 0,16	≤ 1,00	≤ 2,00	0,035	0,015	0,10 to 0,20	-	20,0 to 22,5	2,50 to 3,5	0,75 to 1,25	19,0 to 21,0	-	-	2,00 to 3,00	Co: 18,5 to 21,0
X6NiCrTiMoVB25-15-2	1.4980	0,030 to 0,08	≤ 1,00	1,00 to 2,00	0,025	0,015	-	≤ 0,35	13,5 to 16,0	1,00 to 1,50	-	24,0 to 27,0	1,90 to 2,30	0,10 to 0,50	-	B: 0,0030 to 0,010
X8CrNiMoNb16-16	1.4981	0,04 to 0,10	0,30 to 0,60	≤ 1,50	0,035	0,015	-	-	15,5 to 17,5	1,60 to 2,00	10xC to 1,20	15,5 to 17,5	-	-	-	-
X6CrNiMoTiB17-13	1.4983	0,04 to 0,08	≤ 0,75	≤ 2,00	0,035	0,015	-	-	16,0 to 18,0	2,00 to 2,50	-	12,0 to 14,0	5xC to 0,80	-	-	B: 0,0015 to 0,0060
X8CrNiMoVNb16-13	1.4988	0,04 to 0,10	0,30 to 0,60	≤ 1,50	0,035	0,015	0,060 to 0,14	-	15,5 to 17,5	1,10 to 1,50	10xC to 1,20	12,5 to 14,5	-	0,60 to 0,85	-	-

[a] Elements not listed in this table may 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 2 — Chemical composition (cast analysis) [a] of creep resisting nickel and cobalt alloys

Alloy grade		% by mass														
Name	Num-ber	C	Si	Mn max.	P max.	S max.	Al	Cr	Co	Cu max.	Fe	Mo	Ni	Nb + Ta	Ti	Others
Nickel alloys																
NiCr26MoW	2.4608	0,030 to 0,08	0,70 to 1,50	2,00	0,030	0,015	-	24, 0 to 26,0	2,50 to 4,0	-	Rem.	2,50 to 4,0	44,0 to 47,0	-	-	W: 2,50 to 4, 0
NiCr20Co18Ti	2.4632	≤ 0,13	≤ 1,00	1,00	0,020	0,015	1,00 to 2,00	18,0 to 21,0	15,0 to 21,0	0,20	≤ 1,50	-	Rem.	-	2,00 to 3,00	B: ≤ 0,02 Zr: ≤ 0,15
NiCr25FeAlY	2.4633	0,15 to 0,25	≤ 0,50	0,50	0,020	0,010	1,80 to 2,40	24,0 to 26,0	-	0,10	8,0 to 11,0	-	Rem.	-	0,10 to 0,20	Y: 0,05 to 0,12 Zr: 0,01 to 0,10
NiCr29Fe	2.4642	≤ 0,05	≤ 0,50	0,50	0,020	0,015	≤ 0,50	27,0 to 31,0	-	0,50	7,0 to 11,0	-	Rem.	-	-	-
NiCo20Cr20MoTi	2.4650	0,04 to 0,08	≤ 0,40	0,60	0,020	0,007	0,30 to 0,60	19,0 to 21,0	19,0 to 21,0	0,20	≤ 0,70	5,6 to 6,1	Rem.	-	1,90 to 2,40	B: ≤ 0,005 Ti+Al: 2,40 to 2,80
NiCr20Co13Mo4Ti3Al	2.4654	0,020 to 0,10	≤ 0,15	1,00	0,015	0,015	1,20 to 1,60	18,0 to 21,0	12,0 to 15,0	0,10	≤ 2,00	3,5 to 5,0	Rem.	-	2,80 to 3,3	B: 0,003 to 0,010 Zr: 0,02 to 0,08
NiCr23Co12Mo	2.4663	0,05 to 0,10	≤ 0,20	0,20	0,010	0,010	0,70 to 1,40	20,0 to 23,0	11,0 to 14,0	0,50	≤ 2,00	8,5 to 10,0	Rem.	-	0,20 to 0,60	B: ≤ 0,006
NiCr22Fe18Mo	2.4665	0,05 to 0,15	≤ 1,00	1,00	0,020	0,015	≤ 0,50	20,5 to 23,0	0,50 to 2,50	0,50	17,0 to 20,0	8,0 to 10,0	Rem.	-	-	B: ≤ 0,010 W: 0,20 to 1,00
NiCr19Fe19Nb5Mo3	2.4668	0,020 to 0,08	≤ 0,35	0,35	0,015	0,015	0,30 to 0,70	17,0 to 21,0	≤ 1,00	0,30	Rem.	2,80 to 3,3	50,0 to 55,0	4,7 to 5,5	0,60 to 1,20	B: 0,002 to 0,006
NiCr15Fe7TiAl	2.4669	≤ 0,08	≤ 0,50	1,00	0,020	0,015	0,40 to 1,00	14,0 to 17,0	≤ 1,00	0,50	5,0 to 9,0	-	≥ 70,0	0,70 to 1,20	2,25 to 2,75	-
NiCr20TiAl	2.4952	0,04 to 0,10	≤ 1,00	1,00	0,020	0,015	1,00 to 1,80	18,0 to 21,0	≤ 1,00	0,20	≤ 1,50	-	≥ 65,0	-	1,80 to 2,70	B: ≤ 0,008
NiCr25Co20TiMo	2.4878	0,03 to 0,07	≤ 0,50	0,50	0,010	0,007	1,20 to 1,60	23,0 to 25,0	19,0 to 21,0	0,20	≤ 1,00	1,00 to 2,00	Rem.	0,70 to 1,20	2,80 to 3,2	B: 0,010 to 0,015 Ta: ≤ 0,05 Zr: 0,03 to 0,07
Cobalt alloy																
CoCr20W15Ni	2.4964	0,05 to 0,15	≤ 0,40	2,00	0,020	0,015	-	19,0 to 21,0	Rem.	-	≤ 3,00	-	9,0 to 11,0	-	-	W: 14,0 to 16,0

[a] Elements not listed in this table may not be intentionally added to the alloy 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 alloy.

Table 3 — Permissible product analysis tolerances on the limiting values given in Table 1 for the cast analysis of creep resisting steels

Element	Specified limits, cast analysis % by mass		Permissible tolerance [a] % by mass
Carbon		≤ 0,030	+ 0,005
	> 0,030	≤ 0,20	± 0,01
	> 0,20	≤ 0,35	± 0,02
Silicon		≤ 1,00	± 0,05
Manganese		≤ 1,00	± 0,03
	> 1,00	≤ 2,00	± 0,04
Phosphorus		≤ 0,035	+ 0,005
Sulphur		≤ 0,015	+ 0,003
Nitrogen		≤ 0,05	± 0,005
	> 0,05	≤ 0,20	± 0,01
Aluminium		≤ 0,10	+ 0,01
	> 0,10	≤ 0,30	± 0,05
	> 0,30	≤ 0,65	± 0,10
Chromium		≤ 10,5	± 0,10
	> 10,5	≤ 15,0	± 0,15
	> 15,0	≤ 20,0	± 0,20
	> 20,0	≤ 26,0	± 0,25
Molybdenum		≤ 0,60	± 0,03
	> 0,60	≤ 1,75	± 0,05
	> 1,75	≤ 3,5	± 0,10
Niobium		≤ 1,25	± 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
Titanium		≤ 1,00	± 0,05
	> 1,00	≤ 2,30	± 0,07
Tungsten		≤ 1,00	± 0,05
	> 1,00	≤ 3,5	± 0,07
Vanadium		≤ 0,85	± 0,03
Boron		≤ 0,0015	± 0,0002
	> 0,0015	≤ 0,015	± 0,0003
Cobalt	> 1,00	≤ 7,0	± 0,10
	> 7,0	≤ 10,0	± 0,15
	> 10,0	≤ 21,0	± 0,20
Copper		≤ 0,50	± 0,07

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

Table 4 — Permissible product analysis tolerances on the limiting values given in Table 2 for the cast analysis of creep resisting nickel and cobalt alloys

Element	Specified limits, cast analysis % by mass		Permissible tolerance [a] % by mass
Carbon		≤ 0,15	± 0,01
	> 0,15	≤ 0,25	± 0,02
Silicon		≤ 0,50	± 0,03
	> 0,50	≤ 1,50	± 0,05
Manganese		≤ 1,00	± 0,03
	> 1,00	≤ 2,00	± 0,04
Phosphorus		≤ 0,030	+ 0,005
Sulphur		≤ 0,015	+ 0,003
Aluminium		≤ 1,00	± 0,05
	> 1,00	≤ 2,40	± 0,10
Chromium		≤ 15,0	± 0,15
	> 15,0	≤ 31,0	± 0,25
Cobalt		≤ 5,0	± 0,10
	> 5,0	≤ 10,0	± 0,15
	> 10,0	≤ 21,0	± 0,20
	> 21,0	≤ 60,0	± 0,35
	> 60,0	≤ 80,0	± 0,45
Copper		≤ 0,50	+ 0,05
Iron		≤ 5,0	± 0,07
	> 5,0	≤ 10,0	± 0,10
	> 10,0	≤ 20,0	± 0,20
	> 20,0	≤ 60,0	± 0,35
	> 60,0	≤ 80,0	± 0,45
Molybdenum		≤ 1,00	± 0,03
	> 1,00	≤ 2,00	± 0,05
	> 2,00	≤ 8,0	± 0,10
	> 8,0	≤ 10,0	± 0,15
Nickel		≤ 11,0	± 0,15
	> 11,0	≤ 25,0	± 0,20
	> 25,0	≤ 40,0	± 0,25
	> 40,0	≤ 60,0	± 0,35
	> 60,0	≤ 80,0	± 0,45
Niobium + Tantalum		≤ 5,50	± 0,15
Titanium		≤ 1,20	± 0,03
	> 1,20	≤ 3,3	± 0,05
Boron	> 0,0015	≤ 0,015	± 0,0003
Tungsten		≤ 4,0	± 0,07
	> 14,0	≤ 16,0	± 0,20
Yttrium and Zirconium		≤ 0,15	± 0,01

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

Table 5 — Type of process route and surface finish of sheet, plate and strip [a]

	Abbreviation [b]	Type of treatment	Surface finish	Notes
Hot rolled	1U	Hot rolled, not heat treated, not descaled	Covered with the rolling scale	Suitable for products which are to be further worked, e.g. strip for re-rolling
	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 or alloy grade and the product and is left to the manufacturer's discretion, unless otherwise agreed.
	1D	Hot rolled, heat treated, pickled	Free of scale	Common finish for most steels and alloys 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 and alloys 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 steels and alloys 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	Smooth, bright and reflective	Smoother and brighter than 2B. Also common finish for further processing.

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

b First digit: 1 = hot rolled; 2 = cold rolled.

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

	Abbreviation [b]	Type of process route	Surface finish	Form of product				Notes
				Rods	Bars, sections	Wire	Semi-finished products	
Hot formed	1U	Hot formed, not heat treated, not descaled	Covered with scale (spot ground if necessary)	x	x	-	x	Suitable for products to be further hot formed. For semi-finished products, ground on all sides can be specified.
	1C	Hot formed, heat treated[c], not descaled	Covered with scale (spot ground if necessary)	x	x	-	x	Suitable for products to be further processed. For semi-finished products, ground on all sides can be specified.
	1E	Hot formed, heat treated [c], mechanically descaled	Largely free of scale (but some black spots may remain)	x	x	-	x	The type of mechanical descaling, e.g. grinding, peeling or shot blasting is left to the manufacturer's discretion unless otherwise agreed. Suitable for products to be further processed.
	1D	Hot formed, heat treated [c], pickled	Free of scale	x	x	-	-	Tolerance ≥ IT 14 [e]
	1X	Hot formed, heat treated [c], rough machined (peeled or rough turned)	Metallically clean	-	x	-	-	Tolerance ≥ IT 12 [e]
	1Z	Warm worked with or without stress relieving	Largely free of scale (but some black spots may remain)	-	x	-	-	The type of mechanical descaling, e.g. grinding, peeling or shot blasting is left to the manufacturer's discretion unless otherwise agreed.
Cold processed	2H	Heat treated [c], mechanically or chemically descaled, cold processed[d]	Smooth and bright. Substantially smoother than finishes 1E, 1D or 1X	-	x	x	-	On products formed by cold drawing without subsequent heat treatment, the tensile strength is substantially increased, particularly on austenitic structure, depending on the degree of forming. Tolerance IT 9 or IT 11. [e]
	2D	Cold processed [d], heat treated [c], pickled (skin passed)	Smoother than finishes 1E or 1D	-	x	x	-	Finish for good ductility
	2B	Heat treated [c], machined (peeled), mechanically smoothed	Smoother and brighter than finishes 1E, 1D, 1X	-	x	-	-	Pre-finish for close ISO-tolerance, Tolerance IT 9 or IT 11.[e]

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

[b] First digit: 1 = hot formed; 2 = cold processed.

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

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

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

Table 7 — Mechanical properties at room temperature for creep resisting steels in the usual delivery condition (see Table B.1)

Steel grade		Heat treatment	$R_{p0,2}$	R_m	A % min.		
Name	Number		MPa[a] min.	MPa [a]	Long products	Flat products 0,5 ≤ a < 3 l, tr	Flat products 3 ≤ a tr
Martensitic steels							
X10CrMoVNb9-1	1.4903	+QT	450	620 to 850	20	-	-
X11CrMoWVNb9-1-1	1.4905	+QT	450	620 to 850	19	-	-
X8CrCoNiMo10-6	1.4911	+QT	850	1000 to 1140	10	-	-
X19CrMoNbVN11-1	1.4913	+QT (d ≤ 160)	750	900 to 1050	12	-	-
X20CrMoV11-1	1.4922	+QT	500	700 to 850	16	-	15
X22CrMoV12-1	1.4923	+QT (d ≤ 160)	600	800 to 950	14	-	14
X20CrMoWV12-1	1.4935	+QT 700	500	700 to 850	16	-	15
		+QT 800	600	800 to 950	14	-	-
X12CrNiMoV12-3	1.4938	+QT (d ≤ 160)	760	930 to 1130	14	-	14
Austenitic steels							
X3CrNiMoBN17-13-3	1.4910	+AT (d ≤ 160)	260	550 to 750	35	-	35
X6CrNiMoB17-12-2	1.4919	+AT (d ≤ 160)	205	490 to 690	35	30	35
X6CrNiTiB18-10	1.4941	+AT (d ≤ 160)	195	490 to 680	35	30	35
X6CrNiWNbN16-16	1.4945	+AT	250	540 to 740	30	-	30
		+WW (warm worked) (d≤ 60)	490	630 to 840	17	-	-
X6CrNi25-20	1.4951	+AT	200	510 to 710	35	35	35
X5NiCrAlTi31-20	1.4958	+AT (d ≤ 160)	170	500 to 750	35	30	30
		+RA	210	500 to 750	35	30	30
X8NiCrAlTi32-21	1.4959	+AT (d ≤ 160)	170	500 to 750	35	30	30
X8CrNiNb16-13	1.4961	+AT	200	510 to 690	35	30	35
X12CrNiWTiB16-13	1.4962	+AT	230	500 to 750	30	-	30
		+WW (warm worked) (d≤ 60)	440	590 to 790	20	-	-
X12CrCoNi21-20	1.4971	+AT	300	690 to 900	30	-	35
X6NiCrTiMoVB25-15-2	1.4980	+P (d ≤ 160)	600	900 to 1150	15	-	15
X8CrNiMoNb16-16	1.4981	+AT	215	530 to 690	35	-	35
X6CrNiMoTiB17-13	1.4983	+AT	205	530 to 730	35	30	35
X8CrNiMoVNb16-13	1.4988	+P	255	540 to 740	30	-	30

[a] 1 MPa = 1 N/mm².

Table 8 — Mechanical properties at room temperature for creep resisting nickel and cobalt alloys in the usual delivery condition (see Table B.2) [a]

Alloy grade		Heat treatment	$R_{p0,2}$	R_m	A % min.	
Name	Number		MPa[e] min.	MPa [e] min.	Long products	Flat products $3 \le a^{b}$ tr
Nickel alloys						
NiCr26MoW	2.4608	+AT	240	550	30	30
NiCr20Co18Ti	2.4632	+P	700	1100	15	-
NiCr25FeAlY	2.4633	+AT	270	680	30	30
NiCr29Fe	2.4642	+AT	240	590	30	30
NiCo20Cr20MoTi	2.4650	+P	(570)[c,d]	(970)[c,d]	(30)[c,d]	(30)[c,d]
NiCr20Co13Mo4Ti3Al	2.4654	+P	760	1100	15	20
NiCr23Co12Mo	2.4663	+AT	270	700	35	35
NiCr22Fe18Mo	2.4665	+AT	270	690	30	30
NiCr19Fe19Nb5Mo3	2.4668	+P	1030	1230	12	12
NiCr15Fe7TiAl	2.4669	+P980	630	980	8	-
		+P1170	790	1170	15	15
NiCr20TiAl	2.4952	+P	600	1000	18	18
NiCr25Co20TiMo	2.4878	+P1080	650	1080	15	-
		+P1100	700	1100	12	-
Cobalt alloy						
CoCr20W15Ni	2.4964	+AT	340	860	35	35

[a] The tensile properties apply to long products ≤ 160 mm thickness/diameter or flat products ≤ 20 mm thickness.

[b] For a < 3 mm minimum elongation values for flat products are five units lower.

[c] This grade is not tested at room temperature, but if tested at a temperature of 780 °C the following values apply: $R_{P0,2} \ge 400$ MPa; $R_m \ge 540$ MPa; $A \ge 12$ % (long and flat products).

[d] The values in brackets are for information only.

[e] 1 MPa = 1 N/mm².

Table 9 — Minimum 0,2 %-proof strength values at elevated temperatures for creep resisting steels in the usual delivery condition

Steel grade		Heat treatment[a]	Minimum 0,2 %-proof strength, MPa at a temperature (in °C) of															
Name	Number		50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900
Martensitic steels																				
X10CrMoVNb9-1	1.4903	+QT	-	410	-	380	370	360	350	340	320	300	270	215	-	-	-		-	
X11CrMoWVNb9-1-1	1.4905	+QT	-	412	-	390	383	376	357	356	342	319	287	231	167	-	-		-	
X8CrCoNiMo10-6	1.4911	+QT	-	-	-	800	795	780	745	690	635	590	470	340	-	-	-		-	
X19CrMoNbVN11-1	1.4913	+QT (d ≤ 160)	726[*)]	701	676	651	643	627	610	577	544	495	412	305	-	-	-		-	
X20CrMoV11-1	1.4922	+QT	465	460	445	430	415	390	380	360	330	290	250	-	-	-	-		-	
X22CrMoV12-1	1.4923	+QT (d ≤ 160)	585[*)]	560	545[*)]	530	505[*)]	480	450[*)]	420	380	335	280	-	-	-	-		-	
X20CrMoWV12-1	1.4935	+QT 700	465	460	445	430	415	390	380	360	330	290	250	-	-	-	-		-	
		+QT 800	585	560	545	530	505	480	450	420	380	335	280	-	-	-	-		-	
X12CrNiMoV12-3	1.4938	+QT (d ≤ 160)	730[*)]	680	668[*)]	655	653[*)]	650	630[*)]	610[*)]	560[*)]	505[*)]	400[*)]	-	-	-	-		-	
Austenitic steels																				
X3CrNiMoBN17-13-3	1.4910	+AT	234	205	187	170	159	148	141	134	130	127	124	121	-	-	-		-	
X6CrNiMoB17-12-2	1.4919	+AT	194[*)]	177	162	147	137	127	122	118	113	108	103	98	-	-	-		-	
X6CrNiTiB18-10	1.4941	+AT	183[*)]	162	152	142	137	132	127	123	118	113	108	103	-	-	-		-	
X6CrNiWNbN16-16	1.4945	+AT	-	225	-	195	-	175	-	165	-	155	150	145	-	-	-		-	
		+WW	-	450	-	410	-	365	-	315	-	265	235	205	165	120	-		-	
X6CrNi25-20	1.4951	+AT	177[*)]	140	128	116	108	100	94	91	86	85	84	82	-	-	-		-	
X5NiCrAlTi31-20	1.4958	+AT	157	140	127	115	105	95	90	85	82	80	75	75	-	-	-		-	
		+RA	-	180	170	160	152	145	137	130	125	120	115	110	-	-	-		-	
X8NiCrAlTi32-21	1.4959	+AT	157	140	127	115	105	95	90	85	82	80	75	75	-	-	-		-	

Table 9 *(continued)*

Steel grade		Heat treatment[a]	Minimum 0,2 %-proof strength, MPa at a temperature (in °C) of															
Name	Number		50	100	150	200	250	300	350	400	450	500	550	600	650	700	750 800	850 900
X8CrNiNb16-13	1.4961	+AT	197	175	166	157	147	137	132	128	123	118	118	113	-	-	-	-
X12CrNiWTiB16-13	1.4962	+AT	-	225	-	195	-	185	-	175	-	155	145	135	120	100	-	-
		+WW	-	420	-	400	-	390	-	375	-	355	345	335	315	285	-	-
X12CrCoNi21-20	1.4971	+AT	-	290	-	275	-	260	-	245	-	230	215	200	185	170	155 130	105 80
X6NiCrTiMoVB25-15-2	1.4980	+P	592[*)]	580	570	560	550	530	520	510	500	490	460	430	380	295	200 -	- -
X8CrNiMoNb16-16	1.4981	+AT	202	195	-	177	-	157	-	147	-	137	137	132	-	-	-	-
X6CrNiMoTiB17-13	1.4983	+AT	-	-	-	-	-	-	-	135	-	130	-	120	-	-	-	-
X8CrNiMoVNb16-13	1.4988	+P	239	215	-	196	-	177	-	167	-	157	152	147	-	-	-	-

[a] +AT = solution annealed; +P = precipitation hardened; +QT = quenched and tempered; +RA = recristallisation annealed; +WW = warm worked

[*)] Values calculated by linear interpolation

Table 10 — Minimum 0,2 %-proof strength values at elevated temperatures for creep resisting nickel and cobalt alloys in the usual delivery condition

Alloy grade		Heat treat-ment[a]	Minimum 0,2 %-proof strength, MPa at a temperature (in °C) of																			
Name	Number		50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950 1000	1100 1200
Nickel alloys																						
NiCr26MoW	2.4608	+AT	-	280	-	240	-	210	-	190	190	190	185	180	180	180	180	180	-	-	-	-
NiCr20Co18Ti	2.4632	+P	-	635	-	610	-	585	-	565	-	545	530	520	510	500	465	395	-	-	-	-
NiCr25FeAlY	2.4633	+AT	-	240	-	220	-	200	-	190	-	180	-	175	-	170	-	160	-	125	- 80	65 30
NiCr29Fe	2.4642	+AT	-	236	-	228	-	220	-	216	-	210	-	200	-	156	-	120	-	-	-	-
NiCo20Cr20MoTi	2.4650	+P	[b]	(520)[b,c]	[b]	(490)[b, c]	[b]	(480)[b, c]	[b]	(480)[b, c]	[b]	(480)[b, c]	[b]	(470)[b, c]	[b]	(460)[b, c]	[b]	[b]	[b]	[b]	[b]	[b]
NiCr20Co13Mo4Ti3Al	2.4654	+P	-	-	-	800	-	790	-	750	-	740	-	700	-	660	-	-	-	-	-	-
NiCr23Co12Mo	2.4663	+AT	-	270	250	230	225	220	215	210	205	200	195	190	187	185	180	-	-	-	-	-
NiCr22Fe18Mo	2.4665	+AT	-	260	-	245	-	230	-	215	-	200	195	190	185	180	170	165	160	140	110 80	-
NiCr19Fe19Nb5Mo3	2.4668	+P	-	-	-	-	-	880	-	865	-	860	-	860	-	800	-	615	-	-	-	-
NiCr15Fe7TiAl	2.4669	+P980	625[*)]	620	615	610	606	601	596	592	587	582	578	573	565	-	-	-	-	-	-	-
		+P1170	-	-	-	760	-	746	-	732	-	715	-	692	-	642	-	415	-	-	-	-
NiCr20TiAl	2.4952	+P	595[*)]	586[*)]	577[*)]	568	564	560	550	540	530	520	510	500	480	-	-	-	-	-	-	-
NiCr25Co20TiMo	2.4878	+P1080	-	632	-	610	-	590	-	570	561	553	550	549	547	538	504	412	366	-	-	-
		+P1100	-	640	-	635	-	630	-	625	620	610	600	590	580	570	560	490	350	200	-	-
Cobalt alloy																						
CoCr20W15Ni	2.4964	+AT	-	290	-	210	-	200	-	160	-	-	-	140	-	-	-	120	-	-	-	-

[a] +AT = solution annealed; +A = soft annealed; +P = precipitation hardened

[b] This grade is tested at a temperature of 780 °C only, where a minimum value of 400 MPa applies.

[C] The values in brackets are for information only.

[*)] Values calculated by linear interpolation.

Table 11 — Tests to be carried out, test units and extent of testing in specific testing

Test	[a]	Test Unit	Product forms Flat products, rods, bars and sections	Number of test piece per sample
Chemical analysis	m	cast	The cast analysis is given by the manufacturer [b]	-
Tensile test at ambient temperature	m	batch [c]	1 sample per 30 t; maximum of 2 per test unit	1
Tensile test at elevated temperature	o	batch [c]	1 sample per 30 t, maximum of 2 per test unit	1

[a] Tests marked with a 'm' (mandatory) shall be carried out as specific tests in all cases, optional tests shall be carried out as specific tests only if agreed at the time of ordering.

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

[c] Each batch consists of products coming from the same cast having been subject to the same heat treatment cycle in the same furnace, in the case of a continuous furnace or in process annealing a batch is the lot heat treated without intermission with the same process parameters.

Table 12 — ●● Marking of the products

Marking of	Products	
	with specific testing [a]	without specific testing [a]
Manufacturer's name, trade mark or logo	+	+
Steel number or name	+	+
Cast number	+	+
Identification number [b]	+	(+)

[a] The symbols in the table mean: + = the marking shall be applied; (+) = the marking shall be applied if so agreed, or at the manufacturer's discretion.

[b] If specific tests are to be carried out, the numbers or letters used for identification shall allow the product(s) to be related to the relevant inspection certificate.

Annex A
(informative)

Applicable dimensional standards

EN 10017, *Steel rod for drawing and/or cold rolling – Dimensions and tolerances*

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

EN 10048, *Hot rolled narrow steel strip - Tolerances on dimensions and shape*

EN 10051 + A1, *Continuously hot rolled uncoated plate, sheet and strip of non-alloy and alloy steels - Tolerances on dimensions and shape (includes amendment A1:1997)*

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

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

EN 10060, *Hot rolled round steel bars - Dimensions and tolerances on shape and dimensions*

EN 10061, *Hot rolled hexagon steel bars - Dimensions and tolerances on shape and dimensions*

EN 10218-2, *Steel wire and wire products - General - Part 2: Wire dimensions and tolerances*

EN ISO 9445, *Continuously cold-rolled stainless steel narrow strip, wide strip, plate/sheet and cut lengths - Tolerances on dimensions and form (ISO 9445:2002)*

prEN ISO 286-1, *Geometrical product specifications (GPS) - ISO code system for tolerances of linear sizes - Part 1: Basis of tolerances, deviations and fits (ISO/DIS 286-1:2007)*

Annex B
(informative)

Technical information on creep resisting steels, nickel and cobalt alloys

B.1 Introduction

Property values listed in the preceding specification are requirements of delivery. Property values indicated in this annex are not requirements of delivery. The data in this annex are provided only as a guide to the relative performance of the different steels and alloys. Users should assure themselves of the actual properties achieved in practice.

B.2 Groups of creep resisting steels and alloys

Several groups of material may be distinguished:

— tempered martensitic chromium steels with 8 % to 12 % Cr and special carbide- and nitride-formers suitable for service temperatures up to 600 °C (650 °C);

As the austenitic structure is basic for high temperature creep resistance above 550 °C to 600 °C reference is given to

— solution-annealed steels and nickel- or cobalt-alloys, strengthened by solid-solution hardening, occasionally stress relieved (800 °C to 950 °C),

— thermomechanically worked, and

— precipitation-hardened austenitic steels and alloys containing Al plus Ti to form γ'- phase, i.e. face-centered cubic Ni_3 (Al, Ti), and partially alloyed with Nb which forms γ''-phase, also known as body-centered tetragonal Ni_3Nb.

The strongest alloys are the so-called superalloys. They require special metallurgical practices, e.g. vacuum induction melting and consumable remelting, primarily in order to obtain microstructural cleanliness and to avoid or minimize segregations.

B.3 Heat-treatment

Information on heat-treatment is given in Table B.1 and Table B.2.

B.4 Creep resistance

In Tables C.1 and C.2, the mean creep strength to 1 % plastic strain ($R_{p1,0/t/T}$) and creep rupture strength ($R_{u/t/T}$) after durations of 10 000 h and 100 000 h are given for guidance only. These strength values in relation to time are the main limiting factor during operation at high temperatures, provided the environment is sufficiently mild regarding corrosivity. In addition the interactions between total stressing and oxidation behaviour may be taken into account.

B.5 Heat resistance

The creep resisting steels and alloys given in Table 1 and Table 2 contain sufficient chromium for resistance to oxidation and hot corrosion at elevated temperature; otherwise the surface must be shielded. In general, steels and alloys may be used up to the highest temperature indicated in Table C.1 and Table C.2. The maximum service temperature of the materials is, however, largely dependent on the conditions of exposure.

B.6 Physical properties

In Annex D, the physical properties of the steels and alloys are given for guidance.

B.7 Technological properties

B.7.1 The steels and alloys are suitable for hot working. The optimum hot-working conditions shall, where necessary, be requested from the manufacturer. The tendency of austenitic materials to work-harden should be noted.

B.7.2 The steels and alloys may generally be welded by the usual welding processes. It is, however, recommended that users who have no experience in welding these materials should consult the suppliers regarding appropriate welding conditions.

B.7.3 The long-time properties of steels and alloys may be adversely affected by cold-forming and welding. Therefore, customers should ask for appropriate advice concerning fabrication.

Table B.1 — Guidelines on heat treatment of creep resisting steels

Steel grade		Heat treatment symbol	Quenching or solution annealing temperature °C	Type of cooling	Tempering or precipitation treatment temperature (and time) °C
Name	Number				
Martensitic steels					
X10CrMoVNb9-1	1.4903	+QT	1040 to 1100	oil	730 to 780 (min 1 h)
X11CrMoWVNb9-1-1	1.4905	+QT	1040 to 1080	oil	740 to 770 (2 min per mm thickness)
X8CrCoNiMo10-6	1.4911	+QT	1160 to 1180	air or faster	590 to 640 (double)
X19CrMoNbVN11-1	1.4913	+QT (d ≤ 250)	1100 to 1130	air or oil	670 to 720 (min 2 h)
X20CrMoV11-1	1.4922	+QT	1020 to 1070	air or oil	720 to 780 (min 2 h)
X22CrMoV12-1	1.4923	+QT (d ≤ 250)	1020 to 1070	air or oil	680 to 740 (min 2 h)
X20CrMoWV12-1	1.4935	+QT 700	1020 to 1070	air or oil	720 to 780 (min 2 h)
		+QT 800	1020 to 1070	air or oil	680 to 740 (min 2 h)
X12CrNiMoV12-3	1.4938	+QT (d ≤ 250)	1035 to 1065	oil	600 to 700
Austenitic steels					
X3CrNiMoBN17-13-3	1.4910	+AT	1020 to 1100	air or faster	-
X6CrNiMoB17-12-2	1.4919	+AT	1020 to 1100	air or faster	-
X6CrNiTiB18-10	1.4941	+AT	1070 to 1150	air or faster	-
X6CrNiWNbN16-16	1.4945	+AT	1050 to 1150	air or faster	-
X6CrNi25-20	1.4951	+AT	1050 to 1150	air or faster	-
X5NiCrAlTi31-20	1.4958	+AT	1100 to 1200	air or faster	-
		+RA	920 to 1000	air or faster	-
X8NiCrAlTi32-21	1.4959	+AT	1100 to 1200	air or faster	-
X8CrNiNb16-13	1.4961	+AT	1050 to 1150	air or faster	-
X12CrNiWTiB16-13	1.4962	+AT	1050 to 1150	air or faster	-
X12CrCoNi21-20	1.4971	+AT	1150 to 1200	air or faster	-
X6NiCrTiMoVB25-15-2	1.4980	+P	970 to 990	oil, water	710 to 730 (16 h) [+)]
X8CrNiMoNb16-16	1.4981	+AT	1050 to 1100	air or faster	-
X6CrNiMoTiB17-13	1.4983	+AT	1050 to 1150	air or faster	-
X8CrNiMoVNb16-13	1.4988	+P	1100 to 1150	air or faster	750 to 880 (1 h to 5 h/air)[+)]

[+)] Recommended time.

Table B.2 — Guidelines on heat treatment of creep resisting nickel and cobalt alloys

Alloy grade		Heat treatment	Solution annealing temperature	Type of	Precipitation treatment
Name	Number	symbol	°C	cooling	temperature (and time) °C
Nickel alloys					
NiCr26MoW	2.4608	+AT	1100 to 1180	air or faster	-
NiCr20Co18Ti	2.4632	+P	1050 to 1100	air or faster	680 to 730 for 16 h, air cool (long products)
		+P	1100 to 1150	air or faster	740 to 760 for 4 h, air cool (flat products)
NiCr25FeAlY	2.4633	+AT	1180 to 1220	air or faster	-
NiCr29Fe	2.4642	+AT	1050 to 1150	air or faster	-
NiCo20Cr20MoTi	2.4650	+P	1130 to 1170	air or faster	780 to 820 for 8 h[+)], air cool
NiCr20Co13Mo4Ti3Al	2.4654	+P	995 to 1080	air or faster	840 to 860 for 4 h + 740 to 770 for 16 h, air cool
NiCr23Co12Mo	2.4663	+AT	1150 to 1200	air or faster	-
NiCr22Fe18Mo	2.4665	+AT	1140 to 1190	air or faster	-
NiCr19Fe19Nb5Mo3	2.4668	+P	950 to 1010	air or faster	710 to 730 for 8 h[+)] furnace cooling down to 610 to 630, hold at 610 to 630. Total treatment time min. 18 h[+)]
NiCr15Fe7TiAl	2.4669	+P 980	1100 to 1200	air or faster	840 to 860 for 24 h[+)], air cool + 690 to 710 for 20 h[+)], air cool
		+P 1170	950 to 1000	air or faster	same as 2.4668
NiCr20TiAl	2.4952	+P	1050 to 1080	air	840 to 860 for 24 h[+)], air cool + 690 to 710 for 16 h[+)], air cool
NiCr25Co20TiMo	2.4878	+P 1080	1090 to 1110	air	640 to 660 for 24 h[+)], air cool + 750 to 770 for 8 h[+)], air cool
		+P 1100	1130 to 1180	air or faster	840 to 860 for 16 h[+)], air cool
Cobalt alloy					
CoCr20W15Ni	2.4964	+AT	1180 to 1230	air or faster	-

[+)] Recommended time.

Annex C
(informative)

Preliminary reference data for creep strength to 1 % plastic strain and creep rupture strength

NOTE 1 The values given in Table C.1 and Table C.2 are only for information purposes.

NOTE 2 The values for creep strength to 1 % plastic strain and the creep rupture strength at elevated temperatures listed in Table C.1 and Table C.2 are mean values of the scatter bands considered until now. They are closely related to the heat treatment and mechanical properties at room temperature in Table 7 and Table 8 of this standard.

According to experience with long-time creep-testing it is common that scattering of data between batches for the creep rupture strength is about ± 20 % in the long-range endurance of about 10^5 hours up to 700 °C to 800 °C. Above that temperature range, scattering is gradually more or less enlarged and can be summarized with about 35 % to 40 % at a testing temperature of 1 000 °C - testing temperature. However, individual deviations must be presumed, especially with alloys at higher strength levels.

Observe that the scatter between batches is much larger for the mean creep strength to 1 % plastic strain than for the mean creep rupture strength.

Table C.1 — Guidance values for creep strength to 1 % plastic strain and creep rupture strength of creep resisting steels [a]

Steel grade		Temperature	Creep strength to 1 % plastic strain for [b]		Creep rupture strength for [c]		
Name	Number	°C	10 000 h	100 000 h	10 000 h	100 000 h	200 000 h
			MPa	MPa	MPa	MPa	MPa
Martensitic steels							
X10CrMoVNb9-1	1.4903	470	323	277	356	317	
		480	298	256	332	295	
		490	274	232	309	274	
		500	253	213	287	253	
		510	231	193	268	234	
		520	212	177	250	215	
		530	193	161	232	197	
		540	177	146	214	179	
		550	161	132	199	162	
		560	147	119	182	145	
		570	133	107	165	130	
		580	121	97	150	115	
		590	109	86	135	102	
		600	98	77	122	90	
		610	88	68	110	78	
		620	79	61	96	68	
		630	70		88	58	
		640	62		79	51	
		650	56		70	44	
X11CrMoWVNb9-1-1	1.4905	480	279	(241)	322	288	
		490	259	(224)	305	271	
		500	240	(208)	288	255	
		510	223	(193)	271	239	
		520	208	(179)	255	223	
		530	193	(166)	239	208	
		540	180	(154)	224	193	
		550	167	(142)	212	182	
		560	155	(131)	197	166	
		570	143	(120)	182	150	
		580	132	(110)	167	135	
		590	122	(100)	154	121	
		600	112	(90)	140	108	
		610	102	(81)	128	95	
		620	92	(72)	115	83	
		630	83	(64)	104	72	
		640	74	(56)	93	62	
		650	66		82	53	
X8CrCoNiMo10-6	1.4911	500			600	500	
		600			265	195	
X19CrMoNbVN11-1	1.4913	450	500	448	559	500	486
		460	475	416	529	472	450
		470	450	388	500	444	425
		480	424	358	473	414	395
		490	398	328	446	383	364
		500	374	298	417	349	330
		510	349	268	392	314	291
		520	323	238	366	276	253
		530	298	210	340	237	209
		540	274	181	314	201	172
		550	250	153	288	161	130
		560	225		259	132	102
		570	201		234	105	81
		580	177		208	86	66
		590	154		181	72	52
		600	133		155	65	49

[a,b,c] see last page of Table C.1.

Table C.1 [a] *(continued)*

Steel grade		Temperature	Creep strength to 1 % plastic strain for [b]		Creep rupture strength for [c]		
Name	Number	°C	10 000 h MPa	100 000 h MPa	10 000 h MPa	100 000 h MPa	200 000 h MPa
X20CrMoV11-1	1.4922	470	324	260	368	309	285
		480	299	236	345	284	262
		490	269	213	319	260	237
		500	247	190	294	235	215
		510	227	169	274	211	191
		520	207	147	253	186	167
		530	187	130	232	167	147
		540	170	114	213	147	128
		550	151	98	192	128	111
		560	135	85	173	112	96
		570	118	72	154	96	81
		580	103	61	136	82	68
		590	90	52	119	70	58
		600	75	43	101	59	48
		610	64	36	87	50	40
		620	53	30	73	42	33
		630	44	25	60	34	27
		640	36	20	49	28	22
		650	29	17	40	23	18
X22CrMoV12-1	1.4923	450	436	373	480	432	
		460	405	341	451	397	
		470	375	308	422	368	
		480	344	278	394	336	
		490	316	248	366	306	
		500	289	221	338	275	
		510	262	195	312	245	
		520	235	170	286	216	
		530	211	148	261	187	
		540	187	127	235	161	
		550	165	108	211	137	
		560	144	91	187	118	
		570	126	77	165	99	
		580	108	64	143	83	
		590	92	53	122	70	
		600	79	44	103	59	
X20CrMoWV12-1 (+QT 700)	1.4935 (+QT 700)	470	324	260	368	309	285
		480	299	236	345	284	262
		490	269	213	319	260	237
		500	247	190	294	235	215
		510	227	169	274	211	191
		520	207	147	253	186	167
		530	187	130	232	167	147
		540	170	114	213	147	128
		550	151	98	192	128	111
		560	135	85	173	112	96
		570	118	72	154	96	81
		580	103	61	136	82	68
		590	90	52	119	70	58
		600	75	43	101	59	48
		610	64	36	87	50	40
		620	53	30	73	42	33
		630	44	25	60	34	27
		640	36	20	49	28	22
		650	29	17	40	23	18

[a,b,c] see last page of Table C.1.

Table C.1 [a] *(continued)*

Steel grade		Temperature	Creep strength to 1 % plastic strain for [b]		Creep rupture strength for [c]		
Name	Number	°C	10 000 h MPa	100 000 h MPa	10 000 h MPa	100 000 h MPa	200 000 h MPa
X20CrMoWV12-1 (+QT 800)	1.4935 (+QT 800)	450	436	373	480	432	
		460	405	341	451	397	
		470	375	308	422	368	
		480	344	278	394	336	
		490	316	248	366	306	
		500	289	221	338	275	
		510	262	195	312	245	
		520	235	170	286	216	
		530	211	148	261	187	
		540	187	127	235	161	
		550	165	108	211	137	
		560	144	91	187	118	
		570	126	77	165	99	
		580	108	64	143	83	
		590	92	53	122	70	
		600	79	44	103	59	
X12CrNiMoV12-3[d]	1.4938[d]	500			347	215	
		550			157	102	
		600			96	57	
Austenitic steels							
X3CrNiMoBN17-13-3	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)

[a, b, c, d] see last page of Table C.1.

Table C.1 [a] *(continued)*

Steel grade		Temperature	Creep strength to 1 % plastic strain for [b]		Creep rupture strength for [c]		
Name	Number		10 000 h	100 000 h	10 000 h	100 000 h	200 000 h
		°C	MPa	MPa	MPa	MPa	MPa
X6CrNiMoB17-12-2	1.4919	550			247	188	172
		560			230	172	157
		570			213	158	142
		580			198	144	129
		590			183	130	117
		600			168	118	105
		610			155	107	94
		620			142	96	85
		630			130	87	76
		640			119	78	68
		650			109	70	61
		660			99	63	54
		670			90	56	48
		680			82	50	43
		690			75	45	38
		700			68	40	34
		710			61	36	30
		720			56	32	27
		730			50	29	24
		740			46	26	22
		750			41	23	19
		760			37	21	17
		770			34	19	16
		780			31	17	14
		790			28	15	13
		800			25	14	11
		810			23	12	10
		820			21	11	
		830			19	10	
		840			18		
		850			16		
X6CrNiTiB18-10	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
X6CrNiWNbN16-16 (+AT)	1.4945 (+AT)	580	188	140	280	196	169
		590	178	129	256	178	153
		600	167	118	235	162	139
		610	156	107	215	146	125
		620	145	96	196	131	110
		630	134	86	178	116	98
		640	124	77	162	102	86
		650	113	69	147	90	77
		660	103	62	133	81	67
		670	94	56	121	73	59
		680	85	50	110	65	52
		690	76	44	100	57	45
		700	69	39	91	49	39
		710	62	34	83	42	33
		720	55	29	75	36	29
		730	49	25	68	32	24
		740	44	21	61	27	20
		750	39	17	54	23	17

[a, b, c] see last page of Table C.1.

Table C.1 [a] *(continued)*

Steel grade		Temperature	Creep strength to 1 % plastic strain for [b]		Creep rupture strength for [c]		
Name	Number	°C	10 000 h MPa	100 000 h MPa	10 000 h MPa	100 000 h MPa	200 000 h MPa
X6CrNiWNbN16-16 (+WW)	1.4945 (+WW)	550	(255)	(195)	(345)	(260)	
		600	215	140	255	175	
		650	145	88	155	98	
X6CrNi25-20 [e]	1.4951	600			137	(92)	(82)
		610			120	(79)	(71)
		620			105	(69)	(61)
		630			92	(60)	(54)
		640			81	(53)	(47)
		650			72	(47)	(42)
		660			64	(42)	(38)
		670			57	(38)	(34)
		680			51	(34)	(31)
		690			47	(31)	(28)
		700			42	(28)	(25)
		710			39	(26)	(23)
		720			35	(23,5)	(21)
		730			32	(22)	(19,5)
		740			30	(20)	(18)
		750			28	(18,5)	(16,5)
		760			26	(17)	(15)
		770			24	(15,5)	(14)
		780			22	(14,5)	(13)
		790			21	(13,5)	(12)
		800			19,5	(12,5)	(11)
		810			18	(11,5)	(10)
		820			17	(10,5)	(9,5)
		830			16	(10)	
		840			15	(9)	
		850			14		
		860			13		
		870			12		
		880			11,5		
		890			10,5		
		900			10,0		
		910			9,5		
X5NiCrAlTi31-20 (+AT)	1.4958 (+AT)	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	115	(85)	140	95	(83)
		610	109	(79)	128	85	(74)
		620	102	(74)	118	78	(68)
		630	96	(69)	109	72	(63)
		640	90	(64)	103	67	(59)
		650	84	(59)	97	63	(55)
		660	78	(55)	91	59	(52)
		670	73	(51)	85	55	(48)
		680	68	(47)	80	52	(45)
		690	53	(43)	74	48	(41)
		700	58	(40)	69	44	(38)

[a, b, c, e] see last page of Table C.1.

Table C.1 [a] *(continued)*

Steel grade		Temperature	Creep strength to 1 % plastic strain for [b]		Creep rupture strength for [c]		
Name	Number	°C	10 000 h MPa	100 000 h MPa	10 000 h MPa	100 000 h MPa	200 000 h MPa
X5NiCrAlTi31-20 (+RA)	1.4958 (+RA)	500			315	258	(242)
		510			297	241	(225)
		520			280	224	(207)
		530			262	206	(190)
		540			243	189	(172)
		550	164	(132)	224	171	(155)
		560	154	(122)	204	153	(138)
		570	144	(111)	184	136	(122)
		580	133	(101)	165	119	(106)
		590	132	(92)	147	104	(92)
		600	113	(82)	131	90	(80)
		610	103	(74)	117	79	(70)
		620	93	(65)	106	70	(62)
		630	84	(58)	96	62	(55)
		640	75	(51)	87	56	(49)
		650	67	(46)	80	51	(44)
		660	60	(41)	73	46	(40)
		670	55	(37)	67	42	(36)
		680	50	(33)	61	38	(33)
		690	45	(30)	55	34	(29)
		700	41	(27)	50	30	(26)
X8NiCrAlTi32-21 [f]	1.4959	700	59	42	73	44,8	(38,2)
		710	55,5	38,0	67,8	41,4	(35,2)
		720	52	34,4	63	38,3	(32,5)
		730	48,5	31,3	58,5	35,4	(30)
		740	45,0	28,4	54,4	32,8	(27,7)
		750	41,7	26,0	50,6	30,3	(25,6)
		760	38,4	23,5	47	28	(23,6)
		770	35,6	21,3	43,7	25,9	(21,8)
		780	32,9	19,3	40,7	24	(20,1)
		790	30,5	17,6	37,8	22,1	(18,5)
		800	28,2	16,0	35,2	20,4	(17)
		810	26,2	14,7	32,7	18,9	(15,6)
		820	24,2	13,4	30,4	17,4	(14,4)
		830	22,4	12,1	28,3	16	(13,2)
		840	20,8	11,1	26,3	14,8	(12,1)
		850	19,1	10,0	24,4	13,6	(11,1)
		860	17,6	9,1	22,7	12,5	(10,1)
		870	16,1	8,2	21	11,5	(9,23)
		880	14,7	7,3	19,5	10,5	(8,41)
		890	13,4	6,5	18,1	9,60	(7,63)
		900	12,1	5,7	16,8	8,76	(6,91)
		910	10,9	5,0	15,6	7,98	(6,23)
		920	9,8	4,4	14,4	7,25	(5,60)
		930	8,8	3,9	13,3	6,57	(5,01)
		940	7,8	3,4	12,3	5,93	(4,45)
		950	6,9	2,9	11,4	5,33	(3,93)
		960	6,1	2,5	10,5	(4,77)	(3,43)
		970	5,3	2,1	9,63	(4,23)	(2,95)
		980	4,6	1,8	8,85	(3,73)	-
		990	4,0	1,6	8,11	(3,25)	-
		1000	3,5	1,4	7,42	(2,79)	-

[a, b, c, f] see last page of Table C.1.

Table C.1 [a] *(continued)*

Steel grade		Temperature	Creep strength to 1 % plastic strain for [b]			Creep rupture strength for [c]		
Name	Number		10 000 h	100 000 h	200 000 h	10 000 h	100 000 h	200 000 h
		°C	MPa	MPa	MPa	MPa	MPa	MPa
		580	127	91		182	129	115
		590	120	84		170	119	105
		600	113	78		157	108	94
		610	106	73		145	98	85
		620	99	67		134	89	77
		630	92	61		124	80	69
		640	85	55		113	72	61
		650	78	49		103	64	53
X8CrNiNb16-13	1.4961	660	72	44		93	57	47
		670	66	39		84	50	41
		680	59	34		76	44	36
		690	54	30		70	39	31
		700	49	26		64	34	27
		710	45	24		59	30	25
		720	42	21		55	27	22
		730	39	19		51	25	19
		740	36	17		47	22	17
		750	34	16		44	20	15
		600	164	106		191	120	
X12CrNiWTiB 16-13	1.4962	650	109	64		135	90	
(+AT)	(+AT)	700	74	47		100	67	
		750	45	25		67	36	
		500	438	404	392	466	430	417
X12CrNiWTiB16-13	1.4962	550	348	287	267	370	303	282
(+WW)	(+WW)	600	225	148	125	240	163	140
		650	145	67	48	162	86	65
		700	73	21	14	103	38	27
		550	257	172		411	307	276
		600	201	135		303	222	195
		650	154	102		217	153	134
X12CrCoNi21-20	1.4971	700	114	74		156	105	91
(+AT)	(+AT)	750	79	50		108	70	59
		800	51	30		72	44	36
		850	27	13		44	25	19
		900				24		
		500	580	495		608	545	
		510	555	475		590	520	
		520	530	450		570	495	
		530	505	425		550	470	
		540	485	400		525	445	
		550	465	375		500	415	
X6NiCrTiMoVB25-15-2	1.4980	560	435	345		475	385	
(+P)	(+P)	570	410	315		450	355	
		580	380	280		420	320	
		590	350	250		395	285	
		600	320	220		365	250	
		610	290	195		340	220	
		620	260	170		310	195	
		630	235	150		285	170	
		640	210	130		260	150	
		650	190	110		235	132	

[a, b, c] see last page of Table C.1.

Table C.1 [a] *(continued)*

Steel grade		Temperature	Creep strength to 1 % plastic strain for [b]		Creep rupture strength for [c]		
Name	Number	°C	10 000 h MPa	100 000 h MPa	10 000 h MPa	100 000 h MPa	200 000 h MPa
X8CrNiMoNb16-16	1.4981	580	177	128	270	186	162
		590	167	118	246	169	147
		600	157	108	225	152	132
		610	147	98	205	136	118
		620	137	88	186	122	103
		630	128	79	169	107	91
		640	118	72	152	94	80
		650	108	64	137	83	71
		660	98	56	124	75	63
		670	89	49	111	66	55
		680	80	43	100	59	49
		690	72	38	91	51	42
		700	64	34	83	44	35
		710	58	29	77	37	29
		720	53	26	70	31	24
		730	47	22	64	26	20
		740	44	19	59	23	17
		750	42	17	54	20	15
X6CrNiMoTiB17-13 (+AT)	1.4983 (+AT)	600	170	118	230	157	
		650	118	75	152	94	
		700	72	43	94	57	
X8CrNiMoVNb16-13	1.4988	580	202	152	299	209	180
		590	194	145	274	189	164
		600	186	137	250	172	147
		610	176	128	228	156	132
		620	165	117	207	139	117
		630	152	106	189	125	105
		640	139	95	173	111	93
		650	128	83	157	98	82

[a] ( ) indicates values that have involved extended time extrapolation.

[b] This is the stress relative to the initial cross-section leading to a permanent elongation of 1 % after 10 000 h and 100 000 h.

[c] This is the stress relative to the initial cross-section leading to fracture after 10 000 h, 100 000 h and 200 000 h.

[d] This steel grade is generally not applied in the creep range, but these values are needed for risk assessments.

[e] Values were taken from BS PD 6525 Part 1 [8].

[f] Values were prepared by ECCC, WG 3.3 [1].

Table C.2 — Guidance values for creep strength to 1 % plastic strain and creep rupture strength of creep resisting nickel and cobalt alloys [a]

Alloy grade		Temperature	Creep strength to 1 % plastic strain [b]		Creep rupture strength [c]	
Name	Number	°C	10 000 h MPa	100 000 h MPa	10 000 h MPa	100 000 h MPa
Nickel alloys						
NiCr26MoW (+AT)	2.4608 (+AT)	600	72	(60)	150	(110)
		650	51	(38)	110	(82)
		700	38	(25)	80	(60)
		750	25	(18)	58	(45)
		800	19	(13)	42	(32)
		850	12	(9)	28	(20)
		900	9	(6,1)	17,5	(12)
		950	6	(4)	10	(6,5)
		1000	4,2	(2,5)	6,9	(4)
		1050	3			
NiCr20Co18Ti[d] (+P)	2.4632[d] (+P)	550			730	580
		600			580	430
		650			420	280
		700	260	130	275	140
		750	150	70	160	80
		800	60	20	85	35
NiCr25FeAlY (+AT)	2.4633 (+AT)	650	145	115	170	130
		700	102	75	120	90
		750	45	26	65	48
		800	20	12	35	25
		850	14	8	23	16
		900	9,4	5,6	17	11,5
		950	6,5	3,8	12	8,5
		1000	4,3	2,7	9,3	6,4
		1100	2,2	1,2	5,1	3,0
		1200	1	-	3	1,4
NiCr29Fe (+AT)	2.4642 (+AT)	700	42	30	56	39
		750	30	19,3	41	30
		800	20	12	30	21
		850	12,8	7,6	21,5	14,4
		900	8,2	4,8	15,4	10
		950	5,3	3,0	10,9	7
		1000	3,4	1,9	7,7	4,8
		1050	2,2	1,2	5,4	3,4
NiCo20Cr20MoTi (+P)	2.4650 (+P)	500	562	543	800	775
		600	500	440	550	465
		650	410	330	450	370
		700	310	230	345	250
		750	200	105	220	135
		800	90	35	125	68
		850	30	11	64	33
		900	10	3,5	32	17
NiCr20Co13Mo4Ti3Al (+P)	2.4654 (+P)	650			470	360
		700			340	245
		800			140	94

[a, b, c, d] see last page of Table C.2.

Table C.2 [a] *(continued)*

Alloy grade		Temperature	Creep strength to 1 % plastic strain [b]		Creep rupture strength [c]	
Name	Number	°C	10 000 h MPa	100 000 h MPa	10 000 h MPa	100 000 h MPa
NiCr23Co12Mo (+AT)	2.4663 (+AT)	580				230
		590				210
		600			260	190
		610			240	170
		620			220	155
		630			200	143
		640			185	133
		650	148	97	170	125
		660	135	90	160	119
		670	124	83	150	113
		680	115	77	141	107
		690	107	71	132	101
		700	99	66	123	95
		710	92	61	116	89
		720	85	56	109	83
		730	79	52	102	77
		740	73	48	96	71
		750	68	44	90	65
		760	63	40	84	60
		770	58	37	79	55
		780	53	34	74	51
		790	49	31	69	47
		800	45	28	65	43
		810	41	26	61	39
		820	38	24	57	36
		830	35	22	53	33
		840	32	20	49	30
		850	29	18	45	27
		860	27	16	42	24
		870	25	14,5	39	22
		880	23	13	36	20
		890	21	11,5	33	18
		900	19	10	30	16
		910	17	8,5	27	14
		920	15,5	7	24	12,5
		930	14	6	22	11
		940	12,5	5	20	9,5
		950	11	4	18	8,5
		960	9,5	3,2	16	7,5
		970	8,5	2,5	14,5	6,5
		980	7,5	1,9	13	(5,5)
		990	6,5	1,4	11,5	(5)
		1000	5,5	1,0	10	(4,5)
NiCr22Fe18Mo (+AT)	2.4665 (+AT)	550			360	275
		600	164	117	254	188
		650	109	76	175	126
		700	78	52	119	82
		750	51	34	79	52
		800	33	20	51	32
		850	20	11	32	19
		900	11	5,4	19,5	10,6
		950	5,5	2,0	11,2	5,5
		1000	1,9		6,0	2,5

[a, b, c] see last page of Table C.2.

Table C.2 [a] *(continued)*

Alloy grade		Temperature	Creep strength to 1 % plastic strain [b]		Creep rupture strength [c]	
Name	Number	°C	10 000 h MPa	100 000 h MPa	10 000 h MPa	100 000 h MPa
NiCr19Fe19Nb5Mo3	2.4668	500	957	867	940	860
		550	783	643	810	673
		600	580	430	620	505
		650	370	240	425	290
		700	200	88	248	132
		750	70	23	125	44
		800	19	6,1	36	12
NiCr15Fe7TiAl (+P980)	2.4669 (+P980)	650	320	217	340	250
		700	208	65	217	115
		750	55	14	105	51
		800	12	3	51	22
NiCr15Fe7TiAl (+P1170)	2.4669 (+P1170)	500	790	650	800	659
		550	596	477	605	488
		600	425	345	440	360
		650	325	255	340	265
		700	245	75	255	135
		750	65	16	123	61
		800	15	4	60	28
NiCr20TiAl	2.4952	500	624	530	(745)	(578)
		510	608	504	(711)	(545)
		520	586	477	(680)	(510)
		530	567	450	646	480
		540	544	418	615	447
		550	523	390	582	416
		560	500	362	552	384
		570	474	334	520	354
		580	450	308	491	327
		590	425	282	462	298
		600	398	257	433	272
		610	370	230	403	247
		620	348	210	378	222
		630	326	187	351	198
		640	303	167	325	176
		650	275	149	300	157
		660	260	132	275	135
		670	240	115	251	118
		680	219	99	229	102
		690	201	85	208	88
		700	183	72	186	75
		710	167	64	170	65
		720	150	55	153	57
		730	135	47	137	49
		740	122	40	125	44
		750	106	33	114	37
		760	97	29	103	33
		770	85	24	94	29
		780	75	20	86	25
		790	68	17	78	23
		800	58	16	70	20

[a, b, c] see last page of Table C.2.

Table C.2 [a] *(continued)*

Alloy grade		Temperature °C	Creep strength to 1 % plastic strain [b]		Creep rupture strength [c]	
Name	Number		10 000 h MPa	100 000 h MPa	10 000 h MPa	100 000 h MPa
NiCr25Co20TiMo (+P1100) [e]	2.4878 (+P1100) [e]	550			860	720
		600	640	490	680	510
		650	510	350	540	370
		700	340	220	370	230
		750	210	120	230	130
		800	120	55	130	65
		850	60	20	70	30
		900	(28)	(6)	35	12
Cobalt alloy						
CoCr20W15Ni	2.4964	700	130	(88)	160	(120)
		750	82		110	
		800	47	(21)	68	(35)
		850	23	(9,7)	35	(18)
		900	11,3	(4,0)	20,5	(9)
		950	5,6	(1,8)	11,2	(4)
		1000	2,8		5,4	

[a] ( ) indicates values that have involved extended time extrapolation.

[b] This is the stress relative to the initial cross-section leading to a permanent elongation of 1% after 10 000 h and 100 000 h.

[c] This is the stress relative to the initial cross-section leading to fracture after 10 000 and 100 000 hours (h).

[d] The grade NiCr20Co18Ti (2.4632) has a high notch sensitivity in the temperature range 550 °C to 650 °C.

[e] For condition +P1080, which is the alternative condition to +P1100 shown here, preliminary tests suggest that long term values are to be expected to lie in the lower half of the scatter range given here.

Annex D
(informative)

Guideline values for the physical properties of creep resisting steels, nickel and cobalt alloys

Table D.1 — Physical properties of martensitic and austenitic creep resisting steels (for guidance only)

Steel grade		Density	Linear expansion coefficient $10^{-6}K^{-1}$ between 20 °C and												Thermal conductivity W/(m K)		Specific heat capacity kJ/(kg K)		Specific electrical resistivity Ω mm²/m at 20 °C
Name	Number	kg/dm³	100 °C	200 °C	300 °C	400 °C	500 °C	550 °C	600 °C	650 °C	700 °C	800 °C	900 °C	1000 °C	at 20 °C	at 500 °C	at 20 °C	at 500 °C	
Martensitic steels																			
X10CrMoNb9-1	1.4903	7,7	10,9	11,3	11,7	12,0	12,3	12,4	12,6	12,7	-	-	-	-	26	30	0,43	0,68	0,50
X11CrMoWVNb9-1-1	1.4905	7,8	10,7	11,1	11,5	11,9	12,3	12,5	12,6	12,7	-	-	-	-	26	31	0,45	0,55	0,47
X8CrCoNiMo10-6	1.4911	7,8	10,6	11,2	11,4	11,6	11,8	-	12,0	-	-	-	-	-	20	-	0,46	-	0,65
X19CrMoNbVN11-1	1.4913	7,7	10,5	11	11,5	12	12,3	-	12,5	-	-	-	-	-	24	29	0,46	0,50	-
X20CrMoV11-1	1.4922	7,7	10,5	10,9	11,3	11,6	12,0	-	12,2	-	-	-	-	-	24	29	0,46	0,54	0,60
X22CrMoV12-1	1.4923	7,7	10,5	11	11,5	12	12,3	-	12,5	-	-	-	-	-	24	29	0,46	0,54	0,60
X20CrMoWV12-1	1.4935	7,7	10,5	11	11,5	12	12,3	-	12,5	-	-	-	-	-	24	29	0,46	0,54	0,60
X12CrNiMoV12-3	1.4938	7,8	10,8	11	11,3	11,6	11,9	-	12,1	-	-	-	-	-	30	-	0,46	-	0,60
Austenitic steels																			
X3CrNiMoBN17-13-3	1.4910	8,0	16,3	16,9	17,3	17,6	18,2	-	18,5	-	18,7	-	-	-	16	-	0,45	-	0,77
X6CrNiMoB17-12-2	1.4919	8,0	16,3	16,9	17,3	17,6	18,2	-	18,5	-	18,7	-	-	-	16	-	0,45	-	0,71
X6CrNiTiB18-10	1.4941	7,9	16,3	16,9	17,3	17,6	18,2	-	18,5	-	18,7	-	-	-	16	-	0,45	-	0,71
X6CrNiWNbN16-16	1.4945	8,0	16,7	17,2	17,7	18,1	18,4	-	18,8	-	19,1	-	-	-	14	26	0,44	0,56	0,60
X6CrNi25-20	1.4951	7,9	-	15,5	16,3	17,0	17,3	-	17,5	-	18,0	18,5	18,8	19,0	15	-	0,50	-	0,85
X5NiCrAlTi31-20	1.4958	8,0	15,4	16,0	16,5	16,8	17,2	-	17,5	-	17,9	18,3	18,6	19,0	12	19	0,46	0,54	0,99
X8NiCrAlTi32-21	1.4959	8,0	15,4	16,0	16,5	16,8	17,2	-	17,5	-	17,9	18,3	18,6	19,0	12	19	0,46	0,54	0,99
X8CrNiNb16-13	1.4961	7,9	16,3	16,9	17,3	17,6	18,2	-	18,5	-	18,7	-	-	-	16	-	0,45	-	0,78
X12CrNiWTiB16-13	1.4962	8,0	15,6	16,8	17,5	18,0	18,3	18,5	18,6	18,7	18,8	-	-	-	14	22	0,50	0,60	0,74
X12CrCoNi21-20 (+AT) and (+P)	1.4971 (+AT) and (+P)	8,3	-	15,4	15,8	16,2	16,4	-	16,7	16,9	17,2	17,6	-	-	13	21	0,42	-	-
X6NiCrTiMoVB25-15-2	1.4980	8,0	17,0	17,5	17,8	18,0	18,2	-	18,5	-	-	-	-	-	13	21	0,49	0,60	0,91
X8CrNiMoNb16-16	1.4981	8,0	16,3	16,9	17,3	17,8	18,2	-	18,5	-	18,7	-	-	-	16	-	0,45	-	0,77
X6CrNiMoTiB17-13	1.4983	8,0	-	17,0	-	18,0	-	-	-	-	-	19,0	-	-	15	22	0,50	-	0,74
X8CrNiMoVNb16-13	1.4988	8,0	16,3	16,9	17,3	17,8	18,2	-	18,5	-	18,7	-	-	-	15	-	0,45	-	0,79

Table D.2 — Physical properties of creep resisting nickel and cobalt alloys (for guidance only)

Alloy grade		Density	Linear expansion coefficient $10^{-6}K^{-1}$ between 20 °C and						Thermal conductivity W/(m K)					Specific heat capacity kJ/(kg K)	Specific electrical resistivity Ω mm²/m
Name	Number	kg/dm³	200 °C	300 °C	400 °C	600 °C	800 °C	1000 °C	at 20 °C	at 100 °C	at 500 °C	at 700 °C	at 900 °C	at 20 °C	at 20 °C
Nickel alloys															
NiCr26MoW	2.4608	8,2	13,9	14,7	15,0	16,0	16,8	17,8	11,1	-	18,8	-	-	0,44	1,14
NiCr20Co18Ti	2.4632	8,2	12,4	13,1	13,5	14,6	16,5	19,2	13	14	20	23	27	0,45	1,18
NiCr25FeAlY	2.4633	7,9	13,5	14,0	14,5	14,9	16,6	17,5	11,3	12,7	19,2	22,2	26,1	0,45	1,18
NiCr29Fe	2.4642	8,2	14,3	14,5	14,8	15,7	16,6	17,3	12,0	13,5	21,4	24,8	28,5	0,45	1,15
NiCo20Cr20MoTi	2.4650	8,4	11,9	12,5	13,1	14,2	16,2	18,2	12,0	13,0	20	24	27	0,43	1,15
NiCr20Co13Mo4Ti3Al	2.4654	8,3	12,4	12,9	13,3	14,1	15,3	17,5	13	14	19	23	27	-	-
NiCr23Co12Mo	2.4663	8,3	12,6	13,1	13,6	14,0	15,4	16,3	13,4	14,6	20,9	24	27,7	0,42	1,22
NiCr22Fe18Mo	2.4665	8,3	14,2	14,2	14,2	14,6	15,5	16,7	12	13	19	24	28	0,42	1,15
NiCr19FeNb5Mo3	2.4668	8,2	13,4	13,8	14,1	14,7	16,4	-	13	13	19	23	27	0,44	1,23
NiCr15Fe7TiAl	2.4669	8,3	13,0	13,4	13,9	14,8	-	-	12	14,0	18,5	23,7	28,9	0,43	1,21
NiCr20TiAl	2.4952	8,2	12,6	13,1	13,5	14,0	-	-	11,4	12,1	18,5	23,9	-	0,46	1,24
NiCr25Co20TiMo	2.4878	8,1	12,1	13,0	13,6	14,8	16,0	-	10,9	11,8	16,9	20,0	-	0,45	-
Cobalt alloy															
CoCr20W15Ni	2.4964	9,1	13,0	13,5	14,0	15,0	16,1	17,1	15	17	22	25	-	0,42	0,89

Table D.3 — Values for the modulus of elasticity of creep resisting steels, nickel and cobalt alloys [a] (for guidance only)

NOTE The dynamic modulus of elasticity can differ from the static modulus of elasticity (determined by tensile testing), especially at higher temperatures. The deviation between single values is about ± 4 %.

Steel grade		Modulus of elasticity, E dyn, GPa at a temperature (in °C) of														
Name	Number	20	100	200	300	400	450	500	550	600	650	700	800	900	1000	1100
Martensitic Steels																
X10CrMoVNb9-1	1.4903	218	213	206	198	190	-	180	174	167	159	-	-	-	-	-
X11CrMoWVNb9-1-1	1.4905	218	213	206	198	190	-	180	174	167	159	-	-	-	-	-
X8CrCoNiMo10-6	1.4911	215	-	211	206	196	-	186	176	-	-	-	-	-	-	-
X19CrMoNbVN11-1	1.4913	(216)	(209)	(200)	(190)	(179)	(175)	(167)	(157)	(127)	-	-	-	-	-	-
X20CrMoV11-1	1.4922	(216)	(209)	(200)	(190)	(179)	(175)	(167)	(157)	(127)	-	-	-	-	-	-
X22CrMoV12-1	1.4923	(216)	(209)	(200)	(190)	(179)	(175)	(167)	(157)	(127)	-	-	-	-	-	-
X20CrMoWV12-1	1.4935	(216)	(209)	(200)	(190)	(179)	(175)	(167)	(157)	(127)	-	-	-	-	-	-
X12CrNiMoV12-3	1.4938	(216)	(209)	(200)	(190)	(179	(175)	(167)	(157)	(127)	-	-	-	-	-	-
Austenitic Steels																
X3CrNiMoBN17-13-3	1.4910	198	192	183	175	167	-	159	-	150	-	142	-	-	-	-
X6CrNiMoB17-12-2	1.4919	198	192	183	175	167	-	159	-	150	-	142	-	-	-	-
X6CrNiTiB18-10	1.4941	198	192	183	175	167	-	159	-	150	-	142	-	-	-	-
X6CrNiWNbN16-16	1.4945	196	192	186	181	174	-	165	-	157	-	147	-	-	-	-
X6CrNi25-20	1.4951	200	190	185	175	170	-	160	-	155	-	145	140	135	125	-
X5NiCrAlTi31-20	1.4958	200	190	185	175	170	-	160	-	155	-	145	140	135	125	-
X8NiCrAlTi32-21	1.4959	200	190	185	175	170	-	160	-	155	-	145	140	135	125	-
X8CrNiNb16-13	1.4961	200	190	185	175	170	-	160	-	155	-	145	-	-	-	-
X12CrNiWTi16-13	1.4962	196	191	182	175	167	-	159	155	151	147	143	-	-	-	-
X12CrCoNi21-20	1.4971	200	195	190	185	178	-	170	165	160	155	150	140	128	-	-
X6NiCrTiMoVB25-15-2	1.4980	211	206	200	192	183	-	173	-	162	152	-	-	-	-	-
X8CrNiMoNb16-16	1.4981	198	192	183	175	167	-	159	-	150	-	142	-	-	-	-
X6CrNiMoTiB17-13	1.4983	200	190	185	175	170	-	160	-	155	-	145	-	-	-	-
X8CrNiMoVNb16-13	1.4988	198	192	183	175	167	-	159	-	150	-	142	-	-	-	-

Table D.3 *(continued)*

Alloy grade		Modulus of elasticity, E dyn, GPa at a temperature (in °C) of													
Name	Number	20	100	200	300	400	450	500	600	650	700	800	900	1000	1100
Nickel alloys															
NiCr26MoW	2.4608	201	198	194	187	179	-	172	165	-	157	148	135	123	110
NiCr20Co18Ti	2.4632	227	221	215	208	201	-	194	186	-	178	167	155	140	-
NiCr25FeAlY	2.4633	215	209	201	197	192	-	189	185	-	169	154	137	118	102
NiCr29Fe	2.4642	212	206	201	195	189	-	182	175	-	167	155	-	-	-
NiCo20Cr20MoTi	2.4650	222	218	212	206	199	-	192	184	-	176	165	159	143	-
NiCr20Co13Mo4Ti3Al	2.4654	212	208	204	200	194	-	188	181	-	173	164	-	-	-
NiCr23Co12Mo	2.4663	215	210	203	196	189	-	182	174	-	167	160	153	146	-
NiCr22Fe18Mo	2.4665	199	196	190	184	178	-	171	164	161	157	149	141	133	-
NiCr19Fe19Nb5Mo3	2.4668	199	195	190	185	179	-	174	167	-	163	149	134	120	100
NiCr15Fe7TiAl	2.4669	214 (215)	206 (208)	202 (200)	196 (192)	190 (183)	-	185 (175)	180 (165)	-	171 (150)	161 (131)	149	135	-
NiCr20TiAl	2.4952	216 (212)	212 (207)	208 (202)	202 (195)	196 (188)	-	189 (180)	179 (168)	(160)	161 (148)	130 (115)	-	-	-
NiCr25Co20TiMo	2.4878	212 (212)	209 (209)	205 (205)	201 (200)	196 (192)	193 (188)	190 (183)	183 (172)	179 (166)	175 (160)	166 (146)	-	-	-
Cobalt alloy															
CoCr20W15Ni	2.4964	226	222	216	210	202	-	196	186	-	178	171	164	148	140

[a] Values in brackets indicate values for the static modulus of elasticity.

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[1] 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)

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[6] EN 10222-5, Steel forgings for pressure purposes - Part 5: Martensitic, austenitic and austenitic-ferritic stainless steels

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