Steels and nickel alloys for fasteners with specified elevated and/or low temperature properties

English version of DIN EN 10269

DIN EN 10269

ICS 77.120.40; 77.140.20

This standard supersedes DIN 17240, July 1976 edition, and, together with DIN EN 10028-1, April 1993 edition, DIN EN 10028-4, November 1994 edition, DIN EN 10222-1, September 1998 edition, and DIN EN 10222-3, February 1999 edition, supersedes DIN 17280, July 1985 edition.

Stähle und Nickellegierungen für Befestigungselemente für den Einsatz bei erhöhten und/oder tiefen Temperaturen

European Standard EN 10269 : 1999 has the status of a DIN Standard.

A comma is used as the decimal marker.

National foreword

This standard has been prepared by ECISS/TC 22.

The responsible German body involved in its preparation was the *Normenausschuß Eisen und Stahl* (Steel and Iron Standards Committee).

DIN V 17006-100 is the standard corresponding to CEN Report CR 10260 referred to in clause 2 of the EN.

Amendments

DIN 17240, July 1976 edition, and DIN 17280, July 1985 edition, have been superseded by the specifications of EN 10269.

Previous editions

DIN 17240: 1976-07; DIN 17240-1: 1959-01; DIN 17240-2: 1959-01; DIN 17280: 1985-07.

National Annex NA

Standard referred to

(and not included in **Normative references** and **Annex E**)

DIN V 17006-100 Designation systems for steel – Additional symbols for steel names

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EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 10269

August 1999

ICS 77.120.40; 77.140.20

English version

Steels and nickel alloys for fasteners with specified elevated and/or low temperature properties

Aciers et alliages de nickel pour éléments de fixation utilisés à température élevée et/ou basse température

Stähle und Nickellegierungen für Befestigungselemente für den Einsatz bei erhöhten und/oder tiefen Temperaturen

This European Standard was approved by CEN on 1999-07-01.

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 Central Secretariat or to any CEN member.

The European Standards exist 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 Central Secretariat has the same status as the official versions.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

Ref. No. EN 10269 : 1999 E

Contents

Foreword

This European Standard 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 February 2000, and conflicting national standards shall be withdrawn at the latest by February 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(s).

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

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, 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 enquiry and order. The clauses marked with two points (••) contain information relating to agreements which may be made at the time of enquiry and order.

1 Scope

This European Standard specifies requirements for semi-finished products, bars and rods for fasteners with properties specified at elevated and/or low temperatures made of non-alloy and alloy (including stainless) steels and nickel alloys as given in table 1.

The general technical delivery conditions in EN 10021 also apply to products supplied in accordance with this European Standard.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

CR 10260	Designation systems for steel - Additional symbols for steel names (CEN-Report)
EN 10002-1	Metallic materials - Tensile testing - Part 1: Method of test (at ambient temperature)(includes amendment AC1:1990)
EN 10002-5	Metallic materials - Tensile testing - Part 5: Method of test at elevated temperatures
EN 10003-1	Metallic materials - Hardness test - Brinell - Part 1: Test method
EN 10020	Definition and classification of grades of steel
EN 10021	General technical delivery conditions for steel and iron products
EN 10027-1	Designation systems for steel - Part 1: Steel names, principal symbols
EN 10027-2	Designation systems for steel - Part 2: Numerical system
EN 10045-1	Metallic materials - Charpy impact test - Part 1: Method of test
EN 10052	Vocabulary of heat treatment terms for ferrous products
EN 10079	Definitions of steel products

EN 10168[1]	Iron and steel products - Inspection and delivery documents - List of information and description
EN 10204	Metallic products - Types of inspection documents (includes amendment A1:1995)
EN 10221	Surface quality classes for hot-rolled bars and rods - Technical delivery conditions
prEN 10272	Stainless steel bars for pressure purposes
EN ISO 377	Steel and steel products - Location of samples and test pieces for mechanical testing (ISO 377:1997)
ISO 14284	Steel and iron - Sampling and preparation of samples for the determination of chemical composition

3 Definitions

3.1 For the purpose of this European Standard the definitions in

- EN 10020 for classification of steels,
- EN 10052 for the types of heat treatment and
- EN 10079 for the various product forms

apply.

Additionally to the definitions in EN 10052 the following should be noted:

NOTE 1: Normalizing (symbol N) also includes normalizing forming.

NOTE 2: Quenching and tempering (symbol QT) also includes direct hardening plus tempering.

3.2 Purchaser: The person or organization that orders products in accordance with this standard. The purchaser is not necessarily, but may be, a manufacturer of pressure equipment in accordance with the EU Directive listed in Annex ZA. Where a purchaser has responsibilities under this EU Directive, this standard will provide a presumption of conformity with the essential requirements of the Directive so identified in Annex ZA.

4 • Dimensions and tolerances on dimensions

The nominal dimensions and tolerances on dimensions for the products shall be agreed at the time of enquiry and order with reference to the dimensional standards listed in annex E.

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1) In preparation; until this document is published as European Standard a corresponding national standard should be agreed at the time of enquiry and order.

5 Calculation of mass

The values of density given in annex A shall be used as the basis for the calculation of the nominal mass from the nominal dimensions. For grades not mentioned in annex A, the following density values apply:

- 11/12 % Cr steels: 7,7 kg/dm³
- X8Ni9 7,89 kg/dm³
- austenitic CrNiMo steels: 8,0 kg/dm³

For all other steels a density of 7,85 kg/dm³ applies.

6 Classification and designation

6.1 Classification

In accordance with EN 10020 the steel grades C35E, C45E and 20Mn5 are non-alloy special steels. All other steel grades are alloy special including austenitic steels. Additionally, austenitic nickel alloys are specified.

6.2 Designation

The steel grades specified in this European Standard are designated with steel names and steel numbers. The steel names have been allocated in accordance with EN 10027-1 and CR 10260. The corresponding steel numbers have been allocated in accordance with EN 10027-2.

NOTE: Explanation on the designation of nickel alloys

- name: The preceding chemical symbols indicate the main alloy elements and the figure immediately following indicates the average content of these alloys subsequently followed by the symbol for the other added important alloy elements.
- 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 resisting and heat resisting or creep resisting nickel and cobalt alloys.

7 Information to be supplied by the purchaser

7.1 Mandatory information

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

a) the quantity required (mass or number of pieces);
b) the type of product;
c) the European Standard specifying the tolerances on dimensions and shape (see clause 4) and the tolerance of mass and, if the relevant European Standard permits the purchaser certain options, e.g. regarding edge finishes or tolerance classes, specific information on these aspects;
d) the nominal dimensions of the product;
e) the number of this European Standard;

f) the material name or number;
g) the delivery condition (see 8.2.1);
h) the surface quality class (see 8.5);
i) the type of inspection document (see 9.1.1).

7.2 Options

A number of options are specified in this European Standard and listed below. If the purchaser does not indicate a wish to implement any of these options at the time of enquiry and order, the supplier shall supply in accordance with the basic specification (see 7.1).

1) special melting process (see 8.1);
2) test on simulated treated samples (see 8.2.2);
3) stress relieving treatment (see 8.2.3);
4) requirements for internal soundness (see 8.6);
5) product analysis and its extent (see table 8, footnote 2);
6) tensile test at elevated temperatures (see table 8, footnote 3);
7) impact test at room temperature for austenitic steels (see table 8, footnote 4);
8) impact test at low temperature (see table 8, footnote 5; 11.5);
9) additional tests (see table 8, footnote 6);
10) specification of an analytical method (see 11.1);
11) number of test pieces for the product analysis (see 10.1.1);
12) temperature for the tensile test at elevated temperature (see 11.4);
13) special marking (see 12.2).

7.3 Example of ordering

2 t rounds made of a steel grade with the name X8Ni9 and the number 1.5662 as specified in EN 10269 of 30 mm diameter; dimensional tolerances as specified in EURONORM 60; surface quality class B in accordance with EN 10221; inspection document 3.1.B as specified in EN 10204:

2 t rounds EURONORM 60 - 30 - Steel EN 10269 - X8Ni9
EN 10221 - class B - Inspection document 3.1.B

or

2 t rounds EURONORM 60 - 30 - Steel EN 10269 - 1.5662
EN 10221 - class B - Inspection document 3.1.B

8 Requirements

8.1 •• Melting process

Unless a special melting process is agreed at the time of enquiry and order, the melting process for the starting material in accordance with this European Standard shall be at the discretion of the manufacturer.

8.2 Delivery condition

8.2.1 • Table 3 covers delivery conditions +A, +S, +AC normally applied for further processing (such as shearing, cold heading, etc.).

Table 4 covers delivery conditions normally applied without additional heat treatment after delivery.

The purchaser shall specify in his enquiry and order the delivery condition required.

> NOTE: Depending on the type (e. g. billet) and the dimensions of the product and the intended type of further processing the material, in special cases the delivery in the untreated condition may be agreed.

8.2.2 •• When delivery in a condition not covered in table 4 is agreed, for the verification of compliance with the requirements of this European Standard tests on simulated treated samples may be agreed at the time of enquiry and order. In the case of billets, this simulated treatment may also include a hot forming operation.

8.2.3 •• By agreement at the time of enquiry and order, for the steels for quenching and tempering a stress relieving treatment after straightening may be specified. See footnote 3 to table B.1.

8.3 Chemical composition

8.3.1 The information in table 1 applies for the chemical composition according to the cast analysis.

8.3.2 The product analysis shall not deviate from the specified values of the cast analysis as specified in table 1 by more than the values given in table 2.

8.4 Mechanical properties

8.4.1 General

The hardness and mechanical properties specified in this Euopean Standard apply when billets, bars and rods are delivered in a condition given in table 3 or table 4 and where the relevant tests are carried out in accordance with the sampling and testing conditions in 10.2 and clause 11.

8.4.2 Hardness and mechanical properties at room temperature

The mechanical properties at room temperature are specified in tables 3 and 4. They apply for the relevant specified heat treatment condition and dimensions.

8.4.3 Mechanical properties at elevated temperatures

The values in table 5 apply for the 0,2 % proof strength at elevated temperatures.

The values in table 6 apply for the tensile strength at elevated temperatures.

Reference data of strength values for 1 % (plastic) creep and creep rupture are given in table C.1.

Reference data for relaxation properties are given in table D.1.

8.4.4 Mechanical properties at low temperatures

Low temperature impact energy values are specified in table 7.

NOTE 1: Austenitic steels are insensitive to brittle fracture in the solution annealed condition. Because they do not have a pronounced transition temperature, which is characteristic of other steels, they are also useful for application at cryogenic temperatures.

NOTE 2: In the case of billets verification of the capability of the material to comply with the property requirements for the bars by testing simulated heat treated test pieces may be agreed.

8.5 • Surface condition

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

The purchaser shall specify a surface quality class in accordance with EN 10221.

8.6 •• Internal soundness

For the internal soundness, where appropriate, requirements together with the conditions for their verification may be agreed at the time of enquiry and order.

9 Inspection

9.1 Types of inspection and inspection documents

9.1.1 • The compliance with the requirements of the order shall be checked for products in accordance with this European Standard by non-specific or specific inspection. The applicable inspection document according to EN 10204 for products in a delivery condition in accordance with table 3 is 2.2, for all other delivery conditions 3.1.B, unless otherwise agreed.

The purchaser shall state the required type of inspection document. If an inspection document 3.1.A, 3.1.C or 3.2 is ordered, the purchaser shall notify the manufacturer of the name and the adress of the organization or person who is to carry out the inspection and produce the inspection document. In the case of the inspection report 3.2 the party to issue the certificate shall be agreed.

9.1.2 If a test report 2.2 is ordered, this shall include the following information:

a) Statement that the material complies with the requirements of the order;

b) Results of the cast analysis for all elements specified in table 1 for the material grade concerned.

9.1.3 If an inspection certificate 3.1.B or another document for specific inspection is ordered, this shall include, in accordance with EN 10168, the following codes and information:

a) Information blocks A, B and Z; the tempering temperature shall also be given in the case of quenched and tempered or tempered products.

b) Results of the cast analysis in accordance with boxes C 71 to C 92.

c) Results of the tensile tests at room temperature in accordance with boxes C 00 to C 03 and C 10 to C 13.

d) Results of the impact test in accordance with boxes C 00 to C 03 and C 40 to C 43.

e) Result of the visual examination of the products (see information block D).

f) If one or several of the following options have been agreed at the time of enquiry and order, the relevant information on:

1) the melting process (section C 70),

2) the product analysis (boxes C 71 to C 92),

3) verification of the 0,2 % proof strength at elevated temperature and, in the case of austenitic steels and nickel alloys - depending on the order -, verification of the tensile strength at elevated temperature (boxes C 00 to C 03 and C 10 to C 13),

4) verification of impact properties of austenitic materials at room temperature (boxes C 00 to C 03 and C 40 to C 43),

5) verification of impact properties at low temperature (boxes C 00 to C 03 and C 40 to C 43),

6) verification of the surface quality (see information block D) and

7) non-destructive test for verification of internal soundness (information block D).

9.2 Tests to be carried out

The tests to be carried out, either mandatorily (m) or optional (o), the size of the test units, and the number of samples and test pieces to be taken are given in table 8.

9.3 Re-tests

See EN 10021.

10 Sampling

10.1 Frequency of testing

10.1.1 •• For the product analysis, unless otherwise agreed, one sample per cast shall be taken for determining the elements indicated with numerical values for the particular steel grade in table 1.

10.1.2 The test unit for the other tests shall be the batch of products or part thereof coming from the same cast and having been heat treated in the same batch and in the same heat

treatment facility[2]. The maximum diameter may be 1,25 times the smallest diameter in the batch, provided all diameters are within the same diameter range as specified in the corresponding tables of this European Standard (see tables 4 to 7).

10.2 Selection and preparation of samples and test pieces

10.2.1 Sampling and sample preparation

10.2.1.1 Sampling and sample preparation shall be in accordance with the requirements of ISO 14284 and EN ISO 377. In addition, the requirements in 10.2.2 shall apply to the mechanical tests.

10.2.1.2 If the products are not to be delivered in the usual delivery condition (see 8.2.2) , the samples shall be treated to the usual delivery condition prior to the test.

10.2.1.3 The samples shall be taken in accordance with figure 1. All test pieces including those for the hardness test shall be taken from the same location.

10.2.2 Preparation of test pieces

10.2.2.1 Round test pieces shall be prepared in accordance with figure 1 for the tensile test at room temperature in accordance with EN 10002-1 and, where applicable, for the tensile test at elevated teperature in accordance with EN 10002-5.

10.2.2.2 Three longitudinal V-notched test pieces in accordance with EN 10045-1 shall be prepared for the impact test.

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2 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.

11 Test methods

11.1 •• Chemical analysis

Unless otherwise agreed at the time of enquiry and order, the choice of a suitable physical or chemical analytical method for the product analysis shall be at the discretion of the manufacturer. In cases of dispute, the analysis shall be carried out by a laboratory approved by both parties. In this case, the analysis method to be used shall be agreed upon, if possible, with reference to the corresponding European Standards or EURONORMs.

11.2 Hardness test

The Brinell hardness test shall be carried out in accordance with EN 10003-1.

11.3 Tensile test at room temperature

The tensile test at room temperature shall be carried out in accordance with EN 10002-1 using a proportional test piece of gauge length $L_o = 5{,}65\sqrt{S_o}$ (S_o = cross-sectional area of the test piece).

The 0,2% proof strength, the tensile strength, the elongation after fracture and, if applicable, the reduction of area shall be determined.

11.4 •• Tensile test at elevated temperature

The 0,2 % proof strength or tensile strength at elevated temperature shall be determined in accordance with EN 10002-5. Verification shall be obtained at one of the temperatures given in tables 5 and 6. This temperature shall be agreed at the time of enquiry and order.

11.5 •• Impact test

The impact test shall be carried out in accordance with EN 10045-1 at room temperature unless otherwise agreed.

The minimum impact energy values apply for the mean of three test pieces. One individual value may be lower than the specified value provided that it is not less than 70 % of this value.

If the above conditions are not met, an additional set of three test pieces shall be taken from the same sample and shall be tested. In order to regard the test unit as acceptable after testing the second set, the following requirements shall also be met:

a) the mean value of six tests shall be greater than or equal to the specified minimum value;

b) not more than two of the six individual values shall be less than the specified minimum value;

c) not more than one of the six individual values shall be less than 70 % of the specified minimum value.

If these requirements are not met, the sample product shall be rejected and re-tests shall be carried out on the remainder of the test unit.

11.6 Other testing

11.6.1 Visual examination of the surface condition shall be carried out without optical aids.

11.6.2 The dimensions of the products shall be checked.

11.6.3 If an non-destructive (e. g. ultrasonic) test has been agreed for checking internal soundness (see 8.6), the requirements shall also be agreed.

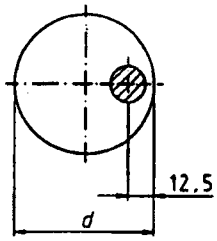
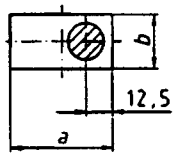
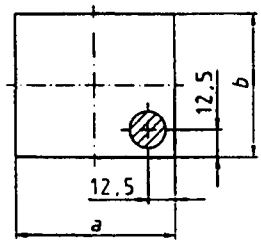
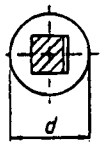
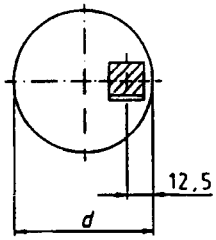
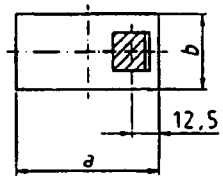
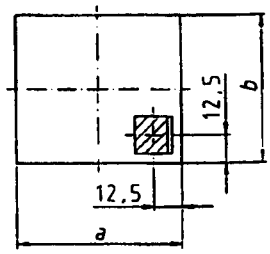
11.6.4 The manufacturer shall take suitable measures to prevent materials becoming mixed up.

12 Marking

12.1 The products or the bundles or boxes shall be marked in a suitable way such that it is possible to determine the cast, the steel grade and the origin of the delivery (see table 9).

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

(Dimensions in mm)

Type of test	Round cross-section products		Rectangular cross-section products	
Tensile	$d \leq 25$  (full cross section where possible)	$25 < d \leq 160$ 	$b \leq 25$ $a \geq b$ 	$25 < b \leq 160$ $a \geq b$ 
Impact[1]	$15 \leq d \leq 25$ 	$25 < d \leq 160$ 	$b \leq 25$ $a \geq b$ 	$25 < b \leq 160$ $a \geq b$ 

[1] For products of a round cross-section the axis of the notch is approximately a diagonal; for products with a rectangular cross-section the axis of the notch is perpendicular to the greatest rolled surface.

Figure 1: Position of test pieces (longitudinal test pieces)

Table 1: Chemical composition (cast analysis)[1)]

Material designation		Chemical composition, % by mass											
name	number	C	Si	Mn	P max.	S max.	Al_{tot}	B	Cr	Mo	Ni	V	Others
Steels for quenching and tempering													
19MnB4	1.5523	0,17 to 0,24	≤ 0,40	0,80 to 1,15	0,035	0,035	≥ 0,020	0,0008 to 0,0050					
C35E	1.1181	0,32 to 0,39	≤ 0,40	0,50 to 0,80	0,035	0,035			≤ 0,40	≤ 0,10	≤ 0,40		Cr+Mo+Ni: ≤ 0,63
C45E	1.1191	0,42 to 0,50	≤ 0,40	0,50 to 0,80	0,035	0,035			≤ 0,40	≤ 0,10	≤ 0,40		Cr+Mo+Ni: ≤ 0,63
35B2	1.5511	0,32 to 0,39	≤ 0,40	0,50 to 0,80	0,035	0,035	≥ 0,020	0,0008 to 0,0050					
20Mn5	1.1133	0,17 to 0,23	≤ 0,40	1,00 to 1,50	0,035	0,035	≥ 0,020		≤ 0,40	≤ 0,10	≤ 0,40		Cr+Mo+Ni: ≤ 0,63
25CrMo4	1.7218	0,22 to 0,29	≤ 0,40	0,60 to 0,90	0,035	0,035			0,90 to 1,20	0,15 to 0,30			
42CrMo4	1.7225	0,38 to 0,45	≤ 0,40	0,60 to 0,90	0,035	0,035			0,90 to 1,20	0,15 to 0,30			
42CrMo5-6	1.7233	0,39 to 0,45	≤ 0,40	0,40 to 0,70	0,035	0,035			1,20 to 1,50	0,50 to 0,70			
40CrMoV4-6	1.7711	0,36 to 0,44	≤ 0,40	0,45 to 0,85	0,030	0,030	≤ 0,015		0,90 to 1,20	0,50 to 0,65		0,25 to 0,35	
41NiCrMo7-3-2	1.6563	0,38 to 0,44	≤ 0,30	0,60 to 0,90	0,025	0,025			0,70 to 0,90	0,15 to 0,30	1,65 to 2,00		Cu: ≤ 0,25

Material designation		Chemical composition, % by mass											
name	number	C	Si	Mn	P max.	S max.	Al_{tot}	B	Cr	Mo	Ni	V	Others
21CrMoV5-7	1.7709	0,17 to 0,25	≤ 0,40	0,40 to 0,80	0,030	0,030	≤ 0,030		1,20 to 1,50	0,55 to 0,80	≤ 0,60	0,20 to 0,35	
20CrMoVTiB4-10	1.7729	0,17 to 0,23	≤ 0,40	0,35 to 0,75	0,020	0,020	0,015 to 0,080	0,001 to 0,010	0,90 to 1,20	0,90 to 1,10	≤ 0,20	0,60 to 0,80	Ti: 0,07 to 0,15 As: ≤ 0,020 Sn: ≤ 0,020 Cu: ≤ 0,20
34CrNiMo6	1.6582	0,30 to 0,38	≤ 0,40	0,50 to 0,80	0,035	0,035			1,30 to 1,70	0,15 to 0,30	1,30 to 1,70		
30CrNiMo8	1.6580	0,26 to 0,34	≤ 0,40	0,30 to 0,60	0,035	0,035			1,80 to 2,20	0,30 to 0,50	1,80 to 2,20		
X12Ni5	1.5680	≤ 0,15	≤ 0,35	0,30 to 0,80	0,020	0,010					4,75 to 5,25	≤ 0,05	
X8Ni9	1.5662	≤ 0,10	≤ 0,35	0,30 to 0,80	0,020	0,010				≤ 0,10	8,50 to 10,00	≤ 0,05	
X15CrMo5-1	1.7390	≤ 0,18	≤ 0,40	0,30 to 0,80	0,025	0,015			4,00 to 6,00	0,45 to 0,65			
X22CrMoV12-1	1.4923	0,18 to 0,24	≤ 0,50	0,40 to 0,90	0,025	0,015			11,00 to 12,50	0,80 to 1,20	0,30 to 0,80	0,25 to 0,35	
X12CrNiMoV12-3	1.4938	0,08 to 0,15	≤ 0,50	0,40 to 0,90	0,025	0,015			11,00 to 12,50	1,50 to 2,00	2,00 to 3,00	0,25 to 0,40	N: 0,020 to 0,040
X19CrMoNbVN11-1	1.4913	0,17 to 0,23	≤ 0,50	0,40 to 0,90	0,025	0,015	≤ 0,020	≤ 0,0015	10,00 to 11,50	0,50 to 0,80	0,20 to 0,60	0,10 to 0,30	Nb: 0,25 to 0,55 N: 0,05 to 0,10

(continued)

Table 1: (concluded)

Material designation		Chemical composition, % by mass											
name	number	C	Si	Mn	P max.	S max.	Al_{tot}	B	Cr	Mo	Ni	V	Others
Austenitic steels													
X2CrNi18-9	1.4307	≤ 0,030	≤ 1,00	≤ 2,00	0,045	0,030[2)]			17,50 to 19,50		8,00 to 10,00		N: ≤ 0,11
X5CrNi18-10	1.4301	≤ 0,07	≤ 1,00	≤ 2,00	0,045	0,030[2)]			17,00 to19,50		8,00 to 10,50		N: ≤ 0,11
X4CrNi18-12	1.4303	≤ 0,06	≤ 1,00	≤ 2,00	0,045	0,030[2)]			17,00 to 19,00		11,00 to13,00		N: ≤ 0,11
X2CrNiMo17-12-2	1.4404	≤ 0,030	≤ 1,00	≤ 2,00	0,045	0,030[2)]			16,50 to 18,50	2,00 to 2,50	10,00 to 13,00		N: ≤ 0,11
X5CrNiMo17-12-2	1.4401	≤ 0,07	≤ 1,00	≤ 2,00	0,045	0,030[2)]			16,50 to 18,50	2,00 to 2,50	10,00 to 13,00		N: ≤ 0,11
X2CrNiMoN17-13-3	1.4429	≤ 0,030	≤ 1,00	≤ 2,00	0,045	0,030[2)]			16,50 to 18,50	2,50 to 3,00	11,00 to 14,00		N: 0,12 to 0,22
X3CrNiCu18-9-4	1.4567	≤ 0,04	≤ 1,00	≤ 2,00	0,045	0,030[2)]			17,00 to 19,00		8,50 to 10,50		N: ≤ 0,11 Cu: 3,00 to 4,00
X6CrNi18-10	1.4948	0,04 to 0,08	≤ 1,00	≤ 2,00	0,035	0,015			17,00 to 19,00		8,00 to 11,00		N: ≤ 0,11
X10CrNiMoMnNbVB15-10-1	1.4982	0,07 to 0,13	≤ 1,00	5,50 to 7,00	0,040	0,030		0,003 to 0,009	14,00 to 16,00	0,80 to 1,20	9,00 to 11,00	0,15 to 0,40	Nb: 0,75 to 1,25 N: ≤ 0,11
X3CrNiMoBN17-13-3	1.4910	≤ 0,04	≤ 0,75	≤ 2,00	0,035	0,015		0,0015 to 0,0050	16,00 to 18,00	2,00 to 3,00	12,00 to 14,00		N: 0,10 to 0,18
X6CrNiMoB17-12-2	1.4919	0,04 to 0,08	≤ 1,00	≤ 2,00	0,035	0,015		0,0015 to 0,0050	16,50 to 18,50	2,00 to 2,50	10,00 to 13,00		N: ≤ 0,11
X6CrNiTiB18-10	1.4941	0,04 to 0,08	≤ 1,00	≤ 2,00	0,035	0,015		0,0015 to 0,0050	17,00 to 19,00		9,00 to 12,00		Ti: 5 x C ≤ 0,80
X6NiCrTiMoVB25-15-2	1.4980	0,03 to 0,08	≤ 1,00	1,00 to 2,00	0,025	0,015	≤ 0,35	0,0030 to 0,010	13,50 to 16,00	1,00 to 1,50	24,00 to 27,00	0,10 to 0,50	Ti: 1,90 to 2,30
X7CrNiMoBNb16-16	1.4986	0,04 to 0,10	0,30 to 0,60	1,50	0,045	0,030		0,05 to 0,10	15,50 to 17,50	1,60 to 2,00	15,50 to 17,50		Nb+Ta: 10 x C ≤ 1,20
Nickel alloys													
NiCr20TiAl	2.4952	0,04 to 0,10	≤ 1,00	≤ 1,00	0,020	0,015	1,00 to 1,80	≤0,008	18,00 to 21,00		≥65		Co: ≤ 1,00 Cu: ≤ 0,20 Ti: 1,80 to 2,70 Fe: ≤ 1,50
NiCr15Fe7TiAl	2.4669	≤ 0,08	≤ 0,50	≤ 1,00	0,020	0,015	0,40 to 1,00		14,00 to 17,00		≥ 70		Co: ≤ 1,00 Ti: 2,25 to 2,75 Cu: ≤ 0,50 Nb+Ta: 0,70 to 1,20 Fe: 5,00 to 9,00

[1)] 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 usefulness of the steel.

[2)] A controlled sulfur content of 0,015 to 0,030 % improves the machinability and is therefore recommended.

Table 2: Permissible product analysis tolerances on the limiting values given in table 1 for the cast analysis

Element(s)	Specified limits, cast analysis % by mass		Permissible tolerance[1] % by mass
C		≤ 0,20	± 0,01
	> 0,20	≤ 0,50	± 0,02
Si		≤ 0,40	± 0,03
	> 0,40	≤ 1,00	± 0,05
Mn		≤ 2,00	± 0,04
	> 2,00	≤ 7,00	± 0,10
P		≤ 0,045	+ 0,005
S		≤ 0,015	+ 0,003
	> 0,015	≤ 0,035	+ 0,005
N		≤ 0,040	± 0,005
	> 0,040	≤ 0,18	± 0,01
Al	≥ 0,015	≤ 0,08	+ 0,01 - 0,005
	> 0,08	≤ 0,35	± 0,05
	> 0,35	≤ 1,80	± 0,10
B		≤ 0,010	± 0,0005
	> 0,010	≤ 0,10	± 0,005
Cr		≤ 2,00	± 0,05
	> 2,00	< 10,00	± 0,10
	≥ 10,00	< 15,00	± 0,15
	≥ 15,00	≤ 21,00	± 0,20
Cu		≤ 0,50	+ 0,05
	> 0,50	≤ 4,00	± 0,10
Mo		≤ 0,60	± 0,03
	> 0,60	< 1,75	± 0,05
	≥ 1,75	≤ 3,00	± 0,10
Ni		≤ 1,00	± 0,03
	> 1,00	≤ 5,00	± 0,07
	> 5,00	≤ 10,00	± 0,10
	> 10,00	≤ 20,00	± 0,15
	> 20,00	≤ 27,00	± 0,20
Cr+Mo+Ni		≤ 0,63	+ 0,05
Nb		≤ 1,25	± 0,05
Nb+Ta	≥ 0,70	≤ 1,20	± 0,10
Ti		≤ 0,15	± 0,01
	> 0,15	≤ 1,00	± 0,05
	> 1,00	≤ 2,75	± 0,10
V		≤ 0,05	± 0,01
	> 0,05	≤ 0,80	± 0,03
As		≤ 0,020	± 0,003
Sn		≤ 0,020	± 0,003
Fe[2]		≤ 1,50	+ 0,05
	> 1,50	≤ 9,00	± 0,10

[1] 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.

[2] For nickel alloys.

Table 3: Mechanical properties at room temperature for delivery conditions normally applied for further processing

Steel designation		Heat treatment condition[1)]	Hardness	Tensile strength	Reduction in area
name	number		HB max.	R_m N/mm² max.	Z % min.
19MnB4	1.5523	+AC	-	520	64
35B2	1.5511	+AC	-	570	62
25CrMo4	1.7218	+S	255	-	-
		+A	212	-	-
		+AC	-	580	59
42CrMo4	1.7225	+S	255	-	-
		+A	241	-	-
		+AC	-	630	57
42CrMo5-6	1.7233	+S	255	-	-
		+A	241	-	-
40CrMoV4-6	1.7711	+A	241	-	-
41NiCrMo7-3-2	1.6563	+A	255	-	-
21CrMoV5-7	1.7709	+S	255	-	-
		+AC	229	-	-
34CrNiMo6	1.6582	+A	255	-	-
30CrNiMo8	1.6580	+A	255	-	-
X22CrMoV12-1	1.4923	+A	302	-	-
X12CrNiMoV12-3	1.4938	+A	311	-	-
X19CrMoNbVN11-1	1.4913	+A	302	-	-

[1)] + AC = annealed to achieve spheroidized carbides;
+ S = treated for cold shearing; + A = soft annealed;

Table 4: Mechanical properties at room temperature for delivery conditions normally applied as final heat treatment

Material designation		Heat-treatment condition[1)]	Diameter d	Proof strength	Tensile strength	Elongation after fracture	Reduction in area	Impact energy (ISO-V)
name	number		mm	$R_{p0,2}$ N/mm² min.	R_m N/mm²	A % min.	Z % min.	KV J min.
Steels for quenching and tempering								
19MnB4	1.5523	+QT	d ≤ 16	640	800 to 950	14	52	40
C35E	1.1181	+N	d ≤ 60	300	500 to 650	20	-	27
		+QT	d ≤ 60	300	500 to 650	22	45	55
			60 < d ≤ 150	300	500 to 650	22	45	39
C45E	1.1191	+N	d ≤ 60	340	560 to 710	17	-	27
		+QT	d ≤ 60	340	560 to 710	19	40	50
			60 < d ≤ 150	340	560 to 710	19	40	35
35B2	1.5511	+QT	d ≤ 60	300	500 to 650	22	45	55
			60 < d ≤ 150	300	500 to 650	22	45	39
20Mn5	1.1133	+N	d ≤ 60	320	500 to 650	22	55	55
			60 < d ≤ 150	300	500 to 650	20	55	55
25CrMo4	1.7218	+QT	d ≤ 100	440	600 to 750	18	60	60
			100 < d ≤ 150	420	600 to 750	18	60	45
42CrMo4	1.7225	+QT	d ≤ 60	730	860 to 1060	14	50	50
42CrMo5-6	1.7233	+QT	d ≤ 100	700	860 to 1060	16	50	50
			100 < d ≤ 150	640	850 to 1000	16	50	40
40CrMoV4-6	1.7711	+QT	d ≤ 100	700	850 to 1000	14	45	30
			100 < d ≤ 160	640	850 to 1000	14	45	25
41NiCrMo7-3-2	1.6563	+QT	d ≤ 100	725	860 to 1060	16	50	50
			100 < d ≤ 160	690	790 to 950	15	50	50
21CrMoV5-7	1.7709	+QT	d ≤ 160	550	700 to 850	16	60	63
20CrMoVTiB4-10	1.7729	+QT	d ≤ 100	660	820 to 1000	15	50	40
			100 < d ≤ 160	660	820 to 1000	15	50	27
34CrNiMo6	1.6582	+QT	d ≤ 100	940	1040 to 1200	14	40	45
30CrNiMo8	1.6580	+QT	d ≤ 100	940	1040 to 1200	14	40	45
X12Ni5	1.5680	(+N) +NT or +QT	d ≤ 40	390	530 to 710	19	50	70
			40 < d ≤ 75	380	530 to 710	19	50	70
X8Ni9	1.5662	+N +NT or +QT	d ≤ 40	490	640 to 840	18	50	70
			40 < d ≤ 75	480	640 to 840	18	50	70
		+QT	d ≤ 40	585	680 to 820	18	50	120
			40 < d ≤ 75	575	680 to 820	18	50	120
X15CrMo5-1	1.7390	+NT or +QT	d ≤ 160	420	640 to 780	14	45	40
X22CrMoV12-1	1.4923	+QT1	d ≤ 160	600	800 to 950	14	40	27
		+QT2 [2)]	d ≤ 160	700	900 to 1050	11	35	20
X12CrNiMoV12-3	1.4938	+QT	d ≤ 160	760	930 to 1130	14	40	40
X19CrMoNbVN11-1 [2)]	1.4913	+QT	d ≤ 160	750	900 to 1050	12	40	20

(continued)

Table 4 (concluded)

Material designation		Heat-treatment condition[1]	Diameter d	Proof strength	Tensile strength	Elongation after fracture	Reduction in area	Impact energy (ISO-V)
name	number		mm	$R_{p0,2}$ N/mm² min.	R_m N/mm²	A % min.	Z % min.	KV J min.
Austenitic steels								
X2CrNi18-9	1.4307	+AT	d ≤ 160	175	450 to 680	45	-	100
		+C700	d ≤ 35	350	700 to 850	20	-	80
		+C800 [2]	d ≤ 25	500	800 to 1000	12	-	80
X5CrNi18-10	1.4301	+AT	d ≤ 160	190	500 to 700	45	-	100
		+ C 700	d ≤ 35	350	700 to 850	20	-	80
X4CrNi18-12	1.4303	+AT	d ≤ 160	190	500 to 700	45	-	100
		+C700	d ≤ 35	350	700 to 850	20	-	80
		+C800 [2]	d ≤ 25	500	800 to 1000	12	-	80
X2CrNiMo17-12-2	1.4404	+AT	d ≤ 160	200	500 to 700	40	-	100
		+C700	d ≤ 35	350	700 to 850	20	-	80
		+C800 [2]	d ≤ 25	500	800 to 1000	12	-	80
X5CrNiMo17-12-2	1.4401	+ AT	d ≤ 160	200	500 to 700	40	-	100
		+ C 700	d ≤ 35	350	700 to 850	20	-	80
		+ C 800 [2]	d ≤ 25	500	800 to 1000	12	-	80
X2CrNiMoN17-13-3	1.4429	+ AT	d ≤ 160	280	580 to 800	40	-	100
X3CrNiCu18-9-4	1.4567	+ AT	d ≤ 160	175	450 to 650	45	-	100
		+ C 700	d ≤ 35	350	700 to 850	20	-	80
X6CrNi18-10	1.4948	+ AT	d ≤ 160	185	500 to 700	40	-	90
X10CrNiMoMnNbVB15-10-1	1.4982	+ AT + WW	d ≤ 100	510	650 to 850	25	-	50
X3CrNiMoBN17-13-3	1.4910	+ AT	d ≤ 160	260	550 to 750	35	-	100
X6CrNiMoB17-12-2	1.4919	+ AT	d ≤ 160	205	490 to 690	35	-	100
X6CrNiTiB18-10	1.4941	+ AT	d ≤ 160	195	490 to 680	35	-	100
X6NiCrTiMoVB25-15-2	1.4980	+ AT +P	d ≤ 160	600	900 to 1150	15	-	50
X7CrNiMoBNb16-16	1.4986	+ WW+P	d ≤ 100	500	650 to 850	16	-	50
Nickel alloys								
NiCr20TiAl [2]	2.4952	+AT +P	d ≤ 160	600	1000 to 1300	12	12	20
NiCr15Fe7TiAl	2.4669	+AT +P	d ≤ 25	650	1000 to 1200	20	28	22

[1] +AT = solution annealed; +C = cold work hardened; +N = normalized; +NT = normalized and tempered; +P = precipitation hardened; +QT = quenched and tempered; WW = Warm worked.

[2] Products made to these material grades and to this heat treatment conditions respectively are unlikely to support the essential requirements of Directive 97/23/EC unless other criteria are taken into account, see Annex 1, section 7.5 of this directive

Table 5: Minimum 0,2 %-proof strength values at elevated temperatures

Material designation		Heat-treatment condition[1]	Diameter d mm	Minimum 0,2 %-proof strength $R_{p0,2}$ in N/mm² at a temperature (in °C) of												
name	number			50	100	150	200	250	300	350	400	450	500	550	600	650
Steels for quenching and tempering																
C35E	1.1181	+ N	d ≤ 60	289*)	270*)	251	229	213	192	182	173	-	-	-	-	-
		+ QT	d ≤ 60	289*)	270*)	251	229	213	192	182	173	-	-	-	-	-
			60 < d ≤ 150	287*)	264*)	242*)	220	203	186	167	147	-	-	-	-	-
C45E	1.1191	+QT	d ≤ 150	330*)	314	299*)	284	255	235	206	-	-	-	-	-	-
35B2	1.5511	+ QT	d ≤ 60	289*)	270*)	251	229	213	192	182	173	-	-		-	-
			60 < d ≤ 150	287*)	264*)	242*)	220	203	186	167	147	-	-	-	-	-
20Mn5	1.1133	+ N	d ≤ 60	306*)	283*)	260	237	213	192	182	173	-	-	-	-	-
			60 < d ≤ 150	304*)	278*)	251	229	213	192	182	173	-	-	-	-	-
25CrMo4	1.7218	+ QT	d ≤ 100	435*)	428*)	420*)	412	392	363	333	304	275	235	-	-	-
			100 < d ≤ 150	414*)	403*)	393*)	382	372	344	324	294	265	226	-	-	-
42CrMo4	1.7225	+ QT	d ≤ 60	720*)	702	677	640	602	562	518	475	420	375	-	-	-
42CrMo5-6	1.7233	+ QT	d ≤ 100	681*)	662	639	616	601	585	570	547	516	462	362	223	-
			100 < d ≤ 150	625*)	605	584	563	549	535	521	500	472	422	331	204	-
40CrMoV4-6	1.7711	+ QT	d ≤ 100	687*)	670	647	631	608	593	577	554	523	470	400	293	-
			100 < d ≤ 160	631*)	612	591	577	556	542	528	507	479	429	366	268	-
21CrMoV5-7	1.7709	+ QT	d ≤ 160	542*)	530	515*)	500	480*)	460	435*)	410	380	350	-	-	-
20CrMoVTiB4-10	1.7729	+ QT	d ≤ 160	642*)	624	603	595	581	573	559	537	508	464	406	334	-
X15CrMo5-1	1.7390	+ NT or + QT	d ≤ 160	392*)	345	335	327	323	322	316	306	285	256	-	-	-
X22CrMoV12-1	1.4923	+ QT1	d ≤ 160	585*)	560	545*)	530	505*)	480	450*)	420	380	335	280	-	-
		+ QT2	d ≤ 160	681*)	650	625*)	600	575*)	550	518*)	485	440	390	330	-	-
X12CrNiMoV12-3[2]	1.4938[2]	+ QT	d ≤ 160	730*)	680	668*)	655	653*)	650	630*)	610	560	505	400	-	-
X19CrMoNbVN11-1	1.4913	+ QT	d ≤ 160	726*)	701	676	651	643	627	610	577	544	495	412	305	-
(continued)																

Material designation		Heat-treatment condition[1]	Diameter d mm	Minimum 0,2 %-proof strength $R_{p0,2}$ in N/mm² at a temperature (in °C) of												
name	number			50	100	150	200	250	300	350	400	450	500	550	600	650
Austenitic steels[1]																
X2CrNi18-9	1.4307	+AT	d ≤ 160	164*)	145	130	118	108	100	94	89	85	81	80	-	-
X5CrNi18-10	1.4301	+AT	d ≤ 160	177*)	155	140	127	118	110	104	98	95	92	90	-	-
X4CrNi18-12	1.4303	+AT	d ≤ 160	177*)	155	140	127	118	110	104	98	95	92	90	-	-
X2CrNiMo17-12-2	1.4404	+AT	d ≤ 160	187*)	165	150	137	127	119	113	108	103	100	98	-	-
X5CrNiMo17-12-2	1.4401	+AT	d ≤ 160	191*)	175	158	145	135	127	120	115	112	110	108	-	-
X2CrNiMoN17-13-3	1.4429	+AT	d ≤ 160	256*)	215	195	175	165	155	150	145	140	138	136	-	-
X6CrNi18-10	1.4948	+ AT	d ≤ 160	174*)	157	142	127	117	108	103	98	93	88	83	78	-
X10CrNiMoMnNbVB15-10-1	1.4982	+ AT + WW	d ≤ 100	490	463	446	434	423	413	405	396	391	386	378	365	346
X3CrNiMoBN17-13-3	1.4910	+ AT	d ≤ 160	239*)	205	187	170	159	148	141	134	130	127	124	121	-
X6CrNiMoB17-12-2	1.4919	+ AT	d ≤ 160	194*)	177	162	147	137	127	122	118	113	108	103	98	-
X7CrNiTiB18-10	1.4941	+AT	d ≤ 160	183*)	162	152	142	137	132	127	123	118	113	108	103	-
X6NiCrTiMoVB25-15-2	1.4980	+ AT + P	d ≤ 160	592*)	580	570	560	550	540	530	520	510	490	460	430	380
X7CrNiMoBNb16-16	1.4986	+ WW + P	d ≤ 100	489*)	470*)	451*)	432	412	393	372	353	334	314	284	255	206
Nickel alloys																
NiCr20TiAl	2.4952	+AT +P	d ≤ 160	595*)	586*)	577*)	568	564	560	550	540	530	520	510	500	480
NiCr15Fe7TiAl	2.4669	+AT +P	d ≤ 25	625*)	620	615	610	606	601	596	592	587	582	578	573	565

[1] + AT = solution annealed; + N = normalized; + NT = normalized and tempered;
+ P = precipitation hardened; + QT = quenched and tempered; + WW = warm worked.
[2] This steel grade is generally not applied in the creep range.
*) Values calculated by linear interpolation.

Table 6: Minimum tensile strength values at elevated temperatures of austenitic steels and nickel alloys

Material designation		Heat-treatment condition[1]	Diameter d mm	Minimum tensile strength R_m in N/mm² at a temperature (in °C) of												
name	number			50	100	150	200	250	300	350	400	450	500	550	600	650
Austenitic steels[2]																
X2CrNi18-9	1.4307	+AT	d ≤ 160	440	410	380	360	350	340	340	330	-	-	-	-	-
X5CrNi18-10	1.4301	+AT	d ≤ 160	480	450	420	400	390	380	380	380	375	360	335	300	-
X4CrNi18-12	1.4303	+AT	d ≤ 160	480	450	420	400	390	380	380	380	375	360	335	300	-
X2CrNiMo17-12-2	1.4404	+AT	d ≤ 160	460	430	410	390	385	380	380	380	375	360	335	-	-
X5CrNiMo17-12-2	1.4401	+AT	d ≤ 160	480	460	440	420	415	410	410	410	405	390	375	350	-
X2CrNiMoN17-13-3	1.4429	+AT	d ≤ 160	550	520	490	460	450	440	435	435	435	430	410	380	-
X6CrNi18-10	1.4948	+AT	d ≤ 160	480	450	420	400	390	380	380	380	375	360	335	300	-
X10CrNiMoMnNbVB15-10-1	1.4982	+AT +WW	d ≤ 160	610	565	530	505	490	475	465	460	450	440	430	410	390
X3CrNiMoBN17-13-3	1.4910	+AT	d ≤ 160	550	520	490	460	450	440	435	435	435	430	410	380	-
X6CrNiMoB17-12-2	1.4919	+AT	d ≤ 160	490	460	440	420	415	410	410	410	405	390	375	350	-
X7CrNiTiB18-10	1.4941	+AT	d ≤ 160	490	460	440	420	415	410	410	410	405	390	375	350	-
X6NiCrTiMoVB25-15-2	1.4980	+AT +P	d ≤ 160	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	720	710	700	690	670	-
X7CrNiMoBNb16-16	1.4986	+WW +P	d ≤ 100	635	615	590	570	550	530	505	485	460	440	420	395	375
Nickel alloys																
NiCr20TiAl	2.4952	+AT +P	d ≤ 160	1070	1044 *)	1017 *)	990	966 *)	942	932 *)	922	903 *)	883	859 *)	834	-
NiCr15Fe7TiAl	2.4669	+AT +P	d ≤ 25	1117	1103	1096	1090	1082	1075	1055	1035	1000	975	950	896	827

[1] + AT = solution annealed; + N = normalized; + NT = normalized and tempered;
+ P = precipitation hardened; + QT =quenched and tempered; + WW = warm worked.

[2] n.a. no values available.

*) Values calculated by linear interpolation.

Table 7: Minimum impact energy (longitudinal direction) at low temperature

Material designation		Heat treatment condition[1]	Diameter d mm	Minimum impact energy in J[2] (ISO-V test pieces) at a temperature in °C of															
name	number			-270	-196	-160	-140	-120	-110	-100	-90	-80	-70	-60	-50	-40	-20	0	+20
Steels for quenching and tempering																			
19MnB4	1.5523	+ QT	d ≤ 16											27			40	40	
20Mn5	1.1133	+ N	d ≤ 60												27	31	47	55	55
			60 < d ≤ 150														40	55	55
25CrMo4	1.7218	+ QT	d ≤ 60											40	40	45	50		60
			60 < d ≤ 100												40	40	50		60
42CrMo4	1.7225	+ QT	d ≤ 60							27						40			50
41NiCrMo7-3-2	1.7233	+ QT	d ≤ 100							27							47	50	
			100 < d ≤ 160														47	50	
34CrNiMo6	1.6582	+ QT	d ≤ 100													40			45
30CrNiMo8	1.6580	+ QT	d ≤ 100													40			45
X12Ni5	1.5680	(+ N), + NT	d ≤ 45					40	45	50	55	60	60	65	65	65	70	70	70
			45 < d ≤ 75						40	45	50	55	60	60	65	65	65		70
X8Ni9	1.5662	+ N + NT (or + QT)	d ≤ 75		40	45	50	50		60		70	70	70	70	70	70	70	70
		+ QT	d ≤ 75		70			100		110		120	120	120	120	120	120	120	120
Austenitic steels																			
X2CrNi18-9	1.4307	+ C700	d ≤ 35		50														80
X5CrNi18-10	1.4301	+ AT	d ≤ 160		60														100
		+ C700	d ≤ 35		50														80
X4CrNi18-12	1.4303	+ AT	d ≤ 160		60														100
		+ C700	d ≤ 35		50														80
X2CrNiMo17-12-2	1.4404	+ C700	d ≤ 35		50														80
X5CrNiMo17-12-2	1.4401	+ C700	d ≤ 35		50														80
X2CrNiMoN17-13-3	1.4429	+ AT	d ≤ 160	50	60														100
X6CrNi18-10	1.4948	+ AT	d ≤ 160		60														100
X3CrNiMoBN17-13-3	1.4910	+ AT	d ≤ 160	50	60														100
X6CrNiMoB17-12-2	1.4919	+ AT	d ≤ 160		60														100
X6CrNiTiB18-10	1.4941	+ AT	d ≤ 160		60														100
X6NiCrTiMoVB25-15-2	1.4980	+ AT + P	d ≤ 160		40														50
Nickel alloys																			
NiCr20TiAl	2.4952	+AT + P	d ≤160		20														20
NiCr15Fe7TiAl	2.4669	+AT +P	d ≤ 25		20														22

[1] + AT = solution annealed; + C = cold work hardened; + N = normalized; + NT = normalized and tempered; + P = precipitation hardened; + QT = quenched and tempered.

[2] Average of 3 test results.

Table 8: Tests to be carried out and extent of testing

Test	Test status[1]	Number of samples for batches of			Number of test pieces per sample
		≤ 10 t	> 10 to ≤ 15 t	> 15 t	
Chemical analysis	o[2]	(see 10.1.1)			
Hardness test on homogeneity/shearability	m	(see 10.2.1.3)			
Tensile test at room temperature	m	2	3	4	1
Tensile test at elevated temperature	o[3]				1
Impact test at room temperature	m[4]				3
Impact test at low temperature	o[5]				3
Other tests	o				6)

1) Tests marked with an 'm' (mandatory) shall be carried out. In all cases, those marked with an 'o' (optional) shall be carried out as specific tests only if agreed at the time of enquiry and order.

2) •• A product analysis (per cast) may be agreed at the time of enquiry and order; additionally a deviating extent of testing may be agreed (see 10.1.1).

3) •• For materials for use at elevated temperatures.

4) •• Optional for austenitic steels, except austenitic grades for cryogenic service (> 20 mm diameter or thickness).

5) •• For materials for use at low temperatures.

6) •• see 9.1.3 f3) to f7).

Table 9: Marking of the products

Marking of	Symbol[1)]
Manufacturer's name, trade mark or logo	+
The number of this European Standard	(+)
Steel name or number	+
Type of finish	(+)
Identification number[2)]	+[3)]
Nominal diameter or thickness	(+)
Nominal dimensions other than diameter or thickness	(+)
Inspector's mark	(+)
Customer's order No.	(+)

[1)] 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.

[2)] The numbers or letters used for identification shall allow the product(s) to be related to the relevant inspection document.

[3)] This shall permit the traceability of the cast number.

Annex A
(informative)
Reference data on some physical properties

Table A.1: Density and static modulus of elasticity

Material designation		Density	Static modulus of elasticity at a temperature in °C of								
			20	100	200	300	400	500	600	700	800
name	number	kg/dm³	kN/mm²								
Steels for quenching and tempering											
C35E	1.1181	7,85	211	204	196	186	177	164	127	-	-
21CrMoV5-7	1.7709										
40CrMoV4-6	1.7711										
X22CrMoV12-1	1.4923	7,7	216	209	200	190	179	167	127	-	-
X19CrMoNbVN11-1	1.4913										
Austenitic steels											
X2CrNi18-9	1.4307	7,9	200	194	186	179	172	165	-	-	-
X5CrNi18-10	1.4301										
X4CrNi18-12	1.4303										
X2CrNiMo17-12-2	1.4404	8,0									
X5CrNiMo17-12-2	1.4401										
X2CrNiMoN17-13-3	1.4429										
X3CrNiCu18-9-4	1.4567	7,9									
X6CrNi18-10	1.4948	7,9									
X10CrNiMoMnNbVB15-10-1	1.4982	7,95	207	201	193	184	175	165	158	150	-
X3CrNiMoBN17-13-3	1.4910	8,0	198 1)	192 1)	183 1)	175 1)	167 1)	159 1)	150 1)	142 1)	-
X6CrNiMoB17-12-2	1.4919										
X6CrNiTiB18-10	1.4941	7,9									
X6NiCrTiMoVB25-15-2	1.4980	8,0	211 1)	206 1)	200 1)	192 1)	183 1)	173 1)	162 1)	-	-
X7CrNiMoBNb16-16	1.4986	7,9	196	192	186	181	174	165	157	147	-
Nickel alloys											
NiCr20TiAl	2.4952	8,2	216	212	208	202	196	189	179	161	130
NiCr15Fe7TiAl	2.4669	8,2	215	208	200	192	183	175	165	150	131
1) Dynamic modulus of elasticity.											

Table A.2: Coefficient of thermal expansion, thermal conductivity, thermal capacity and electrical resistivity

Material designation		Coefficient of thermal expansion between 20°C and						Thermal conductivity at 20 °C	Specific thermal capacity at 20°C	Electrical resistivity at 20°C 1)
name	number	100° C	200°C	300°C	400°C	500°C	600°C	$\frac{W}{m \cdot K}$	$\frac{J}{kg \cdot K}$	$\frac{\Omega \cdot mm^2}{m}$
		$10^{-6} \cdot K^{-1}$								
Steels for quenching and tempering										
C35E	1.1181	11,1	12,1	12,9	13,5	13,9	14,1	42	460	n.a.
21CrMoV5-7	1.7709							33		
40CrMoV4-6	1.7711									
Austenitic steels										
X2CrNi18-9	1.4307	16,0	16,5	17,0	18,0	18,0	n.a.	15	500	0,73
X5CrNi18-10	1.4301	16,0	16,5	17,0	17,5	18,0	n.a.			
X4CrNi18-12	1.4303						n.a.			
X2CrNiMo17-12-2	1.4404						n.a.			0,75
X5CrNiMo17-12-2	1.4401						n.a.			
X2CrNiMoN17-13-3	1.4429						n.a.			
X3CrNiCu18-9-4	1.4567	16,7	17,2	17,7	18,1	18,4	n.a.	n.a.	n.a.	n.a.
X6CrNi18-10	1.4948	16,3	16,9	17,3	17,6	18,2	18,5	16	450	0,71
X10CrNiMoMnNbVB15-10-1	1.4982	15,7	16,8	17,7	18,3	18,6	19,0	12,5	480	0,74
X3CrNiMoBN17-13-3	1.4910	16,3	16,9	17,3	17,6	18,2	18,5	16	450	0,77
X6CrNiMoB17-12-2	1.4919									0,71
X6CrNiTiB18-10	1.4941									
X6NiCrTiMoVB25-15-2	1.4980	17,0	17,5	18,7	18,0	18,2	18,5	n.a.	n.a.	n.a.
X7CrNiMoBNb16-16	1.4986	16,6	17,7	17,9	17,9	17,9	18,1	15	460	n.a.
Nickel alloys										
NiCr20TiAl	2.4952	12,9	13,4	13,8	14,3	14,7	15,2	13	460	n.a.
NiCr15Fe7TiAl	2.4669	12,6	13,0	13,4	13,9	14,4	14,8	12	431	n.a.

1) n.a. no values available

Annex B
(informative)
Guidance for heat treatment

Reference data on heat treatment temperatures and cooling media are given in table B.1.

Table B.1: Guidance for heat treatment of the products in accordance with this European Standard

Material designation		Heat treatment symbol [1]	Normalizing, quenching or solution annealing temperature °C	Type of cooling [2]	Tempering or precipitation treatment temperature (and time) [3] °C
name	number				
Steels for quenching and tempering					
C35E	1.1181	+ N	860 to 900	a	-
		+ QT	840 to 880	w, o	550 to 660
C45E	1.1191	+N	840 to 880	a	-
		+QT	820 to 860	w, o	550 to 660
35B2	1.5511	+ QT	840 to 880	w, o	550 to 660
20Mn5	1.1133	+ N	880 to 920	a	-
25CrMo4	1.7218	+ QT	840 to 880	w, o	540 to 680
42CrMo4	1.7225	+ QT	820 to 860	o, w	540 to 680
42CrMo5-6	1.7233	+ QT	840 to 870	o	600 to 700
40CrMoV4-6	1.7711	+ QT [4]	880 to 950	o	670 to 720
		+ QT [5]	940 to 970	o	600 to 700
41NiCrMo7-3-2	1.6563	+ QT	840 to 880	a, o, w	600 to 700
21CrMoV5-7	1.7709	+ QT	900 to 950	a, o	680 to 720 (min. 2 h)
20CrMoVTiB4-10	1.7729	+ QT	660 to 700 + 970 to 990	a w, o	680 to 720
34CrNiMo6	1.6582	+ QT	830 to 860	o	540 to 660
30CrNiMo8	1.6580	+ QT	830 to 860	o	540 to 660
X12Ni5	1.5680	+ N	800 to 850	a	-
		+ NT	800 to 850	a	580 to 660
X8Ni9	1.5662	+ N + N + T	880 to 930 + 770 to 830	a	540 to 600
		+ QT	770 to 830	w, o	540 to 600
X15CrMo5-1	1.7390	+ NT	925 to 975	a	690 to 750
		+ QT	925 to 975	o	690 to 750
X22CrMoV12-1	1.4923	+ QT1	1020 to 1070	a, o, w	680 to 740 (min. 2 h)
		+ QT2	1020 to 1070	a, o, w	660 to 720 (min. 2 h)
X12CrNiMoV12-3	1.4938	+ QT	1035 to 1065	o	600 to 670
X19CrMoNbVN11-1	1.4913	+ QT	1100 to 1130	a, o	670 to 720 (min. 2 h)
(continued)					

Material designation		Heat treatment symbol [1]	Normalizing, quenching or solution annealing temperature °C	Type of cooling [2]	Tempering or precipitation treatment temperature (and time) [3] °C
name	number				
Austenitic steels					
X2CrNi18-9	1.4307	+AT	1000 to 1100	w, a [8]	-
X5CrNi18-10	1.4301	+ AT	1000 to 1100	w, a [8]	-
X4CrNi18-12	1.4303	+AT	1000 to 1100	w, a [8]	-
X2CrNiMo17-12-2	1.4404	+AT	1020 to 1120	w, a [8]	-
X5CrNiMo17-12-2	1.4401	+AT	1020 to 1120	w, a [8]	-
X2CrNiMoN17-13-3	1.4429	+AT	1020 to 1120	w, a [8]	-
X3CrNiCu18-9-4	1.4567	+AT	1000 to 1100	w, a [8]	-
X6CrNi18-10	1.4948	+ AT	1000 to 1080	w, a [8]	-
X10CrNiMoMnNbVB15-10-1	1.4982	+ AT + WW	1030 to 1070 + 650 to 750 [6]	w a	-
X3CrNiMoBN17-13-3	1.4910	+ AT	1020 to 1100	w, a [8]	-
X6CrNiMoB17-12-2	1.4919	+ AT	1020 to 1100	w, a [8]	-
X6CrNiTiB18-10	1.4941	+ AT	1070 to 1150	w, a [8]	-
X6NiCrTiMoVB25-15-2	1.4980	+ AT + P	970 to 990	o, w	710 to 730
X7CrNiMoBNb16-16	1.4986	+ WW + P	[7]		750 to 800 (5 to 1 h; a [2])
Nickel alloys					
NiCr20TiAl	2.4952	+ AT + P	1050 to 1080	a	840 to 860, 24 h, a [2] + 690 to 710, 16 h, a [2]
NiCr15Fe7TiAl	2.4669	+ AT +P	1100 to 1200	a	840 to 870, 24h, a [2] + 700 to 710, 16h, a [2]

[1] + AT = solution annealed; + N = normalized; + NT = normalized and tempered; + P = precipitation hardened; + QT = quenched and tempered; + WW = warm worked;

[2] a = air; o = oil; w = water.

[3] Where in acordance with 8.2.3 a stress relieving after straightening has been agreed, the stress relieving temperature shall be chosen so that the specified properties are still obtained.

[4] For diameters ≤ 100 mm.

[5] For diameters > 100 to ≤ 160 mm.

[6] Temperature range of warmworking.

[7] warm worked at 750 to 850 °C.

[8] Cooling sufficiently rapid.

Annex C
(informative)

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

NOTE 1: The values given in table C.1 are mean values of the scatter band considered until now. If referred to in regulations, however, they will be binding for calculation purposes.

NOTE 2: The strength values for 1 % (plastic) creep strain and creep rupture given up to the elevated temperatures listed in table C.1 do not mean that the steels can be used in continuous duty up to these temperatures. The governing factor is the total stressing during operation. Where relevant, the oxidation conditions should also be taken into account.

Table C.1: Strength values for 1 % (plastic) creep strain and creep rupture[1)2)]

Material designation		Temperature	Strength for 1% (plastic) creep strain [3)]		Creep rupture strength for [4)]		
name	number	°C	10 000 h N/mm²	100 000 h N/mm²	10 000 h N/mm²	100 000 h N/mm²	200 000 h N/mm²
Steels for quenching and tempering							
C35E	1.1181	350	208	151	246	218	
		360	197	139	236	202	
		370	185	130	224	185	
		380	174	120	212	169	
		390	161	109	200	154	
		400	147	98	187	138	
		410	132	87	173	122	
		420	116	77	156	106	
		430	102	67	138	93	
		440	89	58	118	80	
		450	78	49	100	69	
		460	68	40	87	61	
		470	58	34	77	53	
		480	49	29	69	45	
		490	42	26	61	39	
		500	35	22	53	34	
20Mn5	1.1133	380			291	227	(206)
		390			266	203	(181)
		400			243	179	(157)
		410			221	157	(135)
		420			200	136	(115)
		430			180	117	(97)
		440			161	100	(82)
		450			143	85	(70)
		460			126	73	(60)
		470			110	63	(52)
		480			96	55	(44)
		490			84	(47)	(37)
		500			74	(41)	-
25CrMo4	1.7218	420	274	221	387	308	
		430	258	203	364	281	
		440	242	186	338	253	
		450	226	171	311	226	
		460	210	155	283	200	
		470	195	141	255	178	
		480	180	127	226	157	
		490	163	112	200	136	
		500	147	98	176	118	
		510	130	83	153	100	
		520	115	69	133	82	
		530	98	54	114	66	
		540	81	39	95	51	
		550	64	25	79	36	

(continued)

Table C.1[1)2)] (continued)

Material designation		Tempe-rature	Strength for 1% (plastic) creep strain [3)]		Creep rupture strength for [4)]		
name	number	°C	10 000 h N/mm²	100 000 h N/mm²	10 000 h N/mm²	100 000 h N/mm²	200 000 h N/mm²
42CrMo5-6	1.7233	450			495	410	381
		460			450	345	310
		470			399	276	242
		480			342	219	193
		490			281	177	158
		500			229	148	131
		510			190	124	109
		520			160	102	84
		530			137	-	-
		540			118	-	-
		550			98	-	-
40CrMoV4-6	1.7711	450			513	463	446
		460			483	422	400
		470			451	374	347
		480			413	319	286
		490			371	259	229
		500			321	210	187
		510			269	174	155
		520			223	146	130
		530			187	122	103
		540			160	-	-
		550			137	-	-
21CrMoV5-7	1.7709	420	429	365	466	399	379
		430	407	340	443	375	353
		440	385	315	420	350	328
		450	363	288	396	325	303
		460	339	262	373	300	277
		470	314	235	349	274	252
		480	289	208	325	249	226
		490	263	182	301	224	201
		500	238	156	277	199	176
		510	212	132	253	174	151
		520	186	109	228	150	127
		530	161	89	204	126	104
		540	138	71	180	103	82
		550	116	56	157	82	62
20CrMoVTiB4-10	1.7729	450			520	453	(430)
		460			491	423	(399)
		470			463	394	(369)
		480			437	365	(338)
		490			412	337	(307)
		500			388	307	(274)
		510			364	276	(237)
		520			340	241	(198)
		530			315	204	162
		540			288	169	135
		550			261	142	114
		560			231	121	96
		570			200	103	-
		580			170	-	-
		590			146	-	-
		600			127	-	-

(continued)

Table C.1[1)2)] (continued)

Material designation		Temperature	Strength for 1% (plastic) creep strain [3)]		Creep rupture strength for [4)]		
name	numbe r	°C	10 000 h N/mm²	100 000 h N/mm²	10 000 h N/mm²	100 000 h N/mm²	200 000 h N/mm²
X15CrMo5-1	1.7390	450			-	276	237
		460			-	218	192
		470			226	181	158
		480			220	153	135
		490	88	63	190	132	114
		500	85	61	164	113	96
		510	76	54	145	96	80
		520	67	47	129	81	68
		530	60	42	114	70	57
		540	55	37	100	59	47
		550	49	32	88	50	40
		560	43	30	77	43	-
		570	37	26	68	37	-
		580			60	-	-
		590			53	-	-
		600			46	-	-
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	
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

(continued)

Table C.1[1)2)] (continued)

Material designation		Temperature	Strength for 1% (plastic) creep strain [3)]		Creep rupture strength for [4)]		
name	number	°C	10 000 h N/mm²	100 000 h N/mm²	10 000 h N/mm²	100 000 h N/mm²	200 000 h N/mm²
Austenitic steels							
X6CrNi18-10	1.4948	550	121	96	191	140	125
		560	116	92	177	128	114
		570	111	88	165	117	104
		580	106	84	154	107	95
		590	100	79	143	98	86
		600	94	74	132	89	78
		610	88	69	122	81	70
		620	82	63	113	73	62
		630	75	56	104	65	55
		640	68	49	95	58	49
		650	61	43	87	52	43
		660	55	37	80	47	38
		670	49	32	73	42	34
		680	44	28	67	37	30
		690	39	25	61	32	26
		700	35	22	55	28	22
X10CrNiMoMnNbVB15-10-1	1.4982	550			410	365	350
		560			400	350	335
		570			385	335	315
		580			370	315	295
		590			355	295	275
		600			340	275	250
		610			325	250	215
		620			305	215	185
		630			285	180	150
		640			265	155	135
		650			240	135	115
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)

(continued)

Table C.1[1)2)] (continued)

Material designation		Temperature	Strength for 1% (plastic) creep strain [3)]		Creep rupture strength for [4)]		
name	number	°C	10 000 h N/mm²	100 000 h N/mm²	10 000 h N/mm²	100 000 h N/mm²	200 000 h N/mm²
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	-	-
X7CrNiTiB18-10	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

(continued)

Table C.1[1)2)] (continued)

Material designation		Temperature	Strength for 1% (plastic) creep strain [3)]		Creep rupture strength for [4)]		
name	number	°C	10 000 h N/mm²	100 000 h N/mm²	10 000 h N/mm²	100 000 h N/mm²	200 000 h N/mm²
X6NiCrTiMoVB25-15-2	1.4980	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	460	375	500	415	
		560	435	345	475	385	
		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	
X7CrNiMoBNb16-16	1.4986	580	358	302	381	323	
		590	336	278	364	298	
		600	324	255	344	275	
		610	306	230	325	251	
		620	287	204	306	228	
		630	268	179	287	204	
		640	247	153	267	181	
		650	226	128	245	157	
		660	204	104	221	133	
		670	182	85	198	113	
Nickel alloys							
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	

(continued)

Table C.1[1)2)] (concluded)

Material designation		Temperature	Strength for 1% (plastic) creep strain [3)]		Creep rupture strength for [4)]		
name	number	°C	10 000 h N/mm²	100 000 h N/mm²	10 000 h N/mm²	100 000 h N/mm²	200 000 h N/mm²
NiCr15Fe7TiAl	2.4669	500	790	650	800	659	
		550	596	477	605	488	
		600	425	345	440	360	
		650	325	258	340	265	
		700	245	75	255	135	
		750	65	16	123	61	
		800	15	4	60	28	

[1)] The values given in this table are the mean values of the scatter band so far obtained, which will be checked from time to time as further test results become available and if necessary corrected.

[2)] * and () indicate values of extended stress extrapolation or time extrapolation, respectively.

[3)] 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.

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

Annex D
(informative)

Reference data for the relaxation properties

Table D.1[1]: Reference data for the relaxation properties

Material designation		Temperature	for an initial strain	Residual stress in N/mm² after stressing duration for		
name	number		$\epsilon_{A\,total}$ %	1 000 h	10 000 h	30 000 h
42CrMo5-6	1.7233	350 400 450 500	0,15	211 198 157 93	205 179 118 30	201 164 96
40CrMoV4-6	1.7711	400 450 500	0,15	234 188 136	215 157 83	192 141 47
21CrMoV5-7	1.7709	300	0,2	328	325	317
		350		314	299	292
		400 410 420 430 440		288 281 273 263 253	262 252 242 227 211	250 235 222 200 180
		450 460 470 480 490		239 224 208 191 172	186 163 138 117 98	154 130 108 90 70
		500 510 520 530 540		150 128 109 92 75	81 67 53 41 33	56 43 33 25 18
20CrMoVTiB4-10	1.7729	400 450 500 550 600	0,15	247 216 180 134 61	224 188 141 70	212 173 118 42
X22CrMoV12-1	1.4923	400 410 420 430 440	0,2	255 250 243 234 225	232 223 212 200 189	216 206 193 180 170
		450 460 470 480 490		216 206 195 183 170	173 159 143 130 115	155 140 125 110 98
		500 510 520 530 540		157 142 127 114 100	103 91 80 69 60	85 75 64 54 45
		550 560 570 580		87 75 65 56	51 44 37 32	38 30 25 20

(continued)

Table D.1 (concluded)

Material designation		Temperature	for an initial strain	Residual stress in N/mm² after stressing duration for		
name	number		$\epsilon_{A\,total}$ %	1 000 h	10 000 h	30 000 h
X19CrMoNbVN11-1	1.4913	400 410 420 430 440	0,2	262 257 252 246 240	237 231 225 218 212	206 202 199 195 190
		450 460 470 480 490		234 228 221 214 207	206 198 191 183 175	185 180 173 165 157
		500 510 520 530 540		199 190 181 171 160	166 155 143 130 114	147 136 124 108 92
		550 560 570 580 590		149 134 118 100 80	98 78 63 48 39	79 66 53 40 30
		600		61	30	21
X10CrNiMoMnNbVB15-10-1	1.4982	550 600 625 650 700	0,15		200 165 140 122 55	
NiCr20TiAl	2.4952	450	0,15	280	266	256
		500 510 520 530 540		271 269 266 263 259	250 245 239 232 225	234 228 221 213 205
		550 560 570 580 590		255 249 244 238 231	218 209 201 193 183	196 187 176 166 155
		600 610 620 630 640		224 216 208 200 190	174 163 153 141 129	144 133 121 108 96
		650 660 670 680 690	0,15 and 0,20	181 170 160 149 138	119 107 97 88 79	85 75 65 56 48
		700 710 720 730 740		127 117 107 97 88	70 61 53 45 38	40 33 27 22 17
		750		79	31	13

[1] The values given in this table are the mean values of the scatter band so far obtained, which will be checked from time to time as further test results become available and if necessary corrected.

Annex E
(informative)

Bibliography

EURONORM 58	Hot rolled flat steel for general use
EURONORM 59	Hot rolled square steel for general use
EURONORM 60	Hot rolled round steel for general use
EURONORM 61	Hot rolled hexagon steel
EURONORM 108	Round steel wire rod for cold-formed screws; dimensions and tolerances

Annex ZA
(informative)

Clauses of this European Standard addressing essential requirements or other provisions of EU Directives

This European Standard has been prepared under a mandate given to CEN by the European Commission and supports essential requirements of EU Directive 97/23/EC.

Warning: Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this European Standard.

The clauses of this European Standard are likely to support the essential requirements of section 4 of annex 1, "Essential safety requirements" of the Pressure Equipment Directive 97/23/EC (but see table 4, footnote 2).

Compliance with this European Standard provides one means of conforming with the specific essential requirements of the Directive concerned.