BS EN 10269:2013

BSI Standards Publication

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

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National foreword

This British Standard is the UK implementation of EN 10269:2013. It supersedes BS EN 10269:1999+A1:2006 which is withdrawn.

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

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

ISBN 978 0 580 76784 5

ICS 77.120.40; 77.140.20

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 October 2013.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 10269

October 2013

ICS 77.120.40; 77.140.20

Supersedes EN 10269:1999

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 24 August 2013.

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

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

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Ref. No. EN 10269:2013: E

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Foreword

This document (EN 10269:2013) has been prepared by Technical Committee ECISS/TC 107 “Steels for pressure purposes”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2014, and conflicting national standards shall be withdrawn at the latest by April 2014.

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 10269:1999 and EN 10269:1999/A1:2006.

For a list of significant changes that have been made in this new version, see Annex E.

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

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

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

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

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 requirements of this standard may be applied also to the finished fasteners.

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

NOTE Once this European Standard is published in the EU Official Journal (OJEU) under Directive 97/23/EC, presumption of conformity to the Essential Safety Requirements (ESRs) of Directive 97/23/EC is limited to technical data of materials in this European Standard and does not presume adequacy of the material to a specific item of equipment. Consequently, the assessment of the technical data stated in this material standard against the design requirements of this specific item of equipment to verify that the ESRs of Directive 97/23/EC are satisfied, needs to be done.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

EN 10021, *General technical delivery conditions for steel products*

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

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

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

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

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

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

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

EN 10079:2007, *Definition of steel products*

EN 10108, *Round steel rod for cold heading and cold extrusion — Dimensions and tolerances*

EN 10168, *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*

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

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

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

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

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

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

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 10020:2000, EN 10052:1993 and EN 10079:2007 apply.

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

3.1
normalizing forming
forming process in which the final deformation process is carried out in a certain temperature range leading to a material condition equivalent to that obtained after normalizing so that the specified values of the mechanical properties are retained even after normalizing

Note 1 to entry: Normalizing (symbol N) also includes normalizing forming here.

Note 2 to entry: The symbol for this delivery condition and for the normalized condition is N.

[SOURCE: EN 10052:1993, modified — definition changed and Notes to entry inserted]

3.2
purchaser
person or organization that orders products in accordance with this European Standard

Note 1 to entry: The purchaser is not necessarily, but may be, a manufacturer of pressure equipment in accordance with the EU Directive 97/23/EC.

Note 2 to entry: Where a purchaser has responsibilities under this EU Directive, this European 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 shall be agreed at the time of enquiry and order with reference to the relevant dimensional standard EN 10058, EN 10059, EN 10060, EN 10061, EN 10108 and EN 10278.

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:

— for 11/12 % Cr steels: ρ = 7,70 kg/dm^3;

— for X8Ni9: ρ = 7,89 kg/dm^3;

— for austenitic CrNiMo steels: ρ = 8,00 kg/dm^3.

For all other steels a density of 7,85 kg/dm^3 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.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);

h) the surface quality class (see 8.5);

i) the type of inspection document (see 9.1).

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 8.2.3);

3) stress relieving treatment (see 8.2.4);

4) verification of internal soundness (see 8.6 and Table 12, footnote g);

5) inspection certificate 3.2 (see 9.1);

6) product analysis, its extent (see Table 12, footnote b) and the number of test pieces (see 10.1.1);

7) verification of strength properties by tensile test at elevated temperatures (see Table 12, footnote d);

8) verification of impact properties of austenitic steels by impact test at 20°C (see Table 12, footnote e);

9) verification of impact properties by impact test at low temperature (see 11.5 and Table 12, footnote f);

10) additional tests (see Table 12, footnote h);

11) hardness test (see Table 12);

12) specification of an analytical method (see 11.1);

13) temperature of the verification tensile test at elevated temperature (see 11.4 and Table 12);

14) special marking (see 12.2);

15) testing of intergranular corrosion resistance (see 11.6.5 and Table 12);

16) S-content for special applications (see Table 1, footnote b);

17) steel grade 1.4980 for cryogenic purposes (see Table 10, footnote d);

18) verification of the surface quality (see Table 12).

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 EN 10060; surface quality class B in accordance with EN 10221; inspection certificate 3.1 as specified in EN 10204:

2 t rounds EN 10060–30–Steel EN 10269–X8Ni9–EN 10221–class B–Inspection certificate 3.1
or
2 t rounds EN 10060–30–Steel EN 10269–1.5662–EN 10221–class B–Inspection certificate 3.1

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.

Steels other than stainless steels shall be fully killed.

8.2 Delivery condition

8.2.1 General

In order to check if the steel grades listed in Table 1 fulfil the PED requirements, consult Tables 4, 6, 8 and 10.

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

Table 4 and Table 5 cover delivery conditions normally applied without additional heat treatment after delivery.

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

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.

8.2.3 •• When delivery in a condition not covered in Table 4 or Table 5 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.

8.2.4 •• 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 c) in 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.

8.3.3 For austenitic steels intergranular corrosion may occur.

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

8.4 Mechanical properties

8.4.1 General

The hardness and mechanical properties specified in this European Standard apply when billets, bars and rods are delivered in a condition given in Table 3, 4 or 5 and where the relevant tests are carried out in accordance with the sampling and testing conditions given in 10.2 and Clause 11.

However, it should be noted that the mechanical property values for delivered bars and rods shall conform to the requirements irrespective of whether they are verified or not.

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.

8.4.2 Hardness and mechanical properties at room temperature

The mechanical properties at room temperature and at 20 °C (impact energy) are specified in Tables 3, 4 and 5. They apply for the relevant specified heat treatment condition and dimensions.

8.4.3 Mechanical properties at elevated temperatures

The values in Table 6 and Table 7 apply for the 0,2 % proof strength at elevated temperatures.

The values in Table 8 and Table 9 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.

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.

8.4.4 Mechanical properties at low temperatures

Low temperature impact energy values are specified in Table 10 and Table 11.

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

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

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.

9 Inspection

9.1 Types of inspection and inspection documents

9.1.1

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

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

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

NOTE See Directive 97/23/EC, Annex I, section 4.3, third paragraph and for further information the Guidelines of the EU Commission and the Member States for its interpretation (see e.g. Guidelines 7/2 and 7/16).

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

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

— A Commercial transactions and parties involved;

— B Description of products to which the inspection certificate applies (including tempering temperature in the case of quenched and tempered or tempered products);

— C03 Test temperature;

— C10-C13 Tensile test at room temperature and, if applicable, at elevated temperatures;

— C40-C43 Impact test, if applicable;

— C50-C69 Hardness test, if applicable;

— C71-C92 Cast analysis and, if applicable, product analysis and steelmaking process;

— D01 Marking and dimensional checking and, if applicable, verification of the surface quality;

— D02-D99 NDT, if applicable;

— Z Validation.

9.2 Verification tests to be carried out

The mandatory and optional tests to be carried out, the size of the test units, and the number of samples and test pieces to be taken are specified in Table 12.

9.3 Re-tests

For re-tests, sorting and reprocessing the requirements of EN 10021 shall apply.

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[1)]. 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 Table 4 to Table 11).

For rectangular cross-sections the term "diameter d" should be replaced by "b – smaller dimension of the rectangular cross-section" (see Figure 1).

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 EN 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 8.2.3), 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 ISO 6892-1 and, where applicable, for the tensile test at elevated temperature in accordance with EN ISO 6892-2.

10.2.2.2 Three longitudinal V-notched test pieces in accordance with Figure 1 and in accordance with EN ISO 148-1 shall be prepared for the impact test.

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 taking into account the relevant existing European Standards. The list of available European Standards is given in CEN/TR 10261.

11.2 Hardness test

The Brinell hardness test shall be carried out in accordance with EN ISO 6506-1.

11.3 Tensile test at room temperature

The tensile test at room temperature shall be carried out in accordance with EN ISO 6892-1 using a proportional test piece of gauge length $L_o = 5{,}65\sqrt{S_o}$ (S_o = cross-sectional area of the parallel length of the test piece).

1) In the case of a continuous furnace or in process annealing a batch is the lot heat treated without intermission with the same process parameters.

The 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 ISO 6892-2. Verification shall be obtained at one of the temperatures given in Table 6 to Table 9. 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 ISO 148-1 at 20 °C (unless otherwise agreed), on V-notched test pieces and by using a 2 mm striker (KV_2).

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

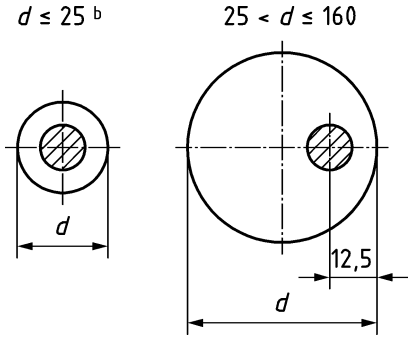
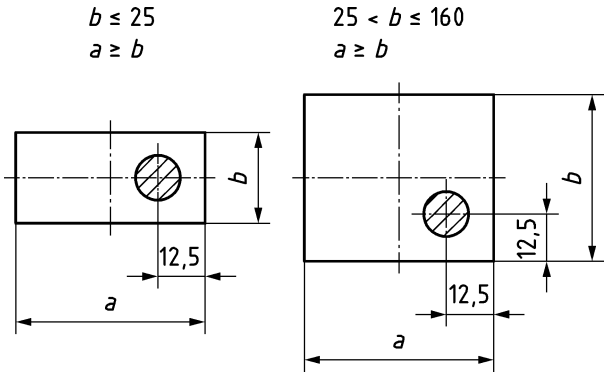
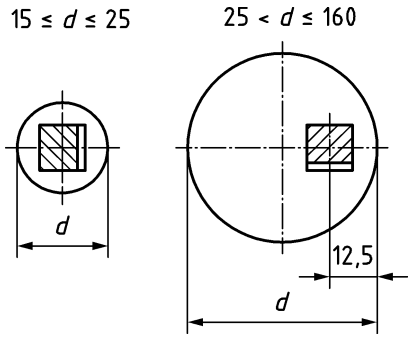
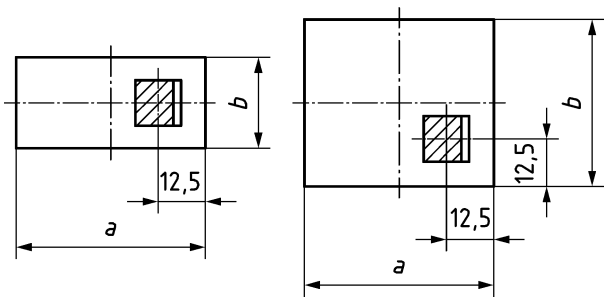
11.6.4 The manufacturer shall take suitable measures to prevent materials becoming mixed up.

11.6.5 At time of enquiry and order the testing of intergranular corrosion according to EN ISO 3651-2 may be agreed.

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 batch, the steel grade and the origin of the delivery (see Table 13).

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

Type of test	Round cross-section products	Rectangular cross-section products
Tensile	$d \le 25$ [b] $\quad 25 < d \le 160$  **a)** (full round cross-section, where possible)	$b \le 25$, $a \ge b$ $\quad 25 < b \le 160$, $a \ge b$  **b)**
Impact[a]	$15 \le d \le 25$ $\quad 25 < d \le 160$  **c)**	$15 \le b \le 25$, $a \ge b$ $\quad 25 < b \le 160$, $a \ge b$  **d)**

[a] For products of a round cross-section the axis of the notch is approximately a diameter; for products with a rectangular cross-section the axis of the notch is perpendicular to the greatest rolled surface.
[b] Samples of product may alternatively be tested un-machined, in accordance with EN ISO 377.

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

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

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													
20MnB4	1.5525	0,18 to 0,23	≤ 0,30	0,90 to 1,20	0,025	0,025	≥ 0,020	0,000 8 to 0,005 0	≤ 0,30	–	–	–	Cu ≤ 0,25
23MnB4	1.5535	0,20 to 0,25	≤ 0,30	0,90 to 1,20	0,025	0,025	≥ 0,020	0,000 8 to 0,005 0	≤ 0,30	–	–	–	Cu ≤ 0,25
23MnB3	1.5507	0,21 to 0,25	≤ 0,15	0,80 to 1,00	0,015	0,015	0,02-0,08	0,000 8 to 0,005 0	0,25 to 0,35	–	–	–	Cu ≤ 0,25 Ti ≤ 0,06
C35E	1.1181	0,32 to 0,39	≤ 0,40	0,50 to 0,80	0,030	0,015 [b]	–	–	≤ 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	0,030	0,015 [b]	–	–	≤ 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	0,030	0,015 [b]	≥ 0,020	0,000 8 to 0,005 0	–	–	–	–	–
20Mn5	1.1133	0,17 to 0,23	≤ 0,40	1,00 to 1,50	0,030	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	0,025	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	0,025	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	0,025	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	0,025	0,030	≤ 0,015	–	0,90 to 1,20	0,50 to 0,65	–	0,25 to 0,35	–
27NiCrMoV15-6	1.6957	0,22 to 0,32 [c]	≤ 0,15	0,15 to 0,40	0,010	0,007	–	–	1,20 to 1,80	0,25 to 0,45	3,40 to 4,00	0,05 to 0,15	–
26 NiCrMo 14-6	1.6958	0,25 to 0,30	0,15 to 0,30	0,20 to 0,50	0,020	0,015 [b]	0,005 to 0,050	–	1,20 to 1,70	0,35 to 0,55	3,30 to 3,80	≤ 0,12	–
21CrMoV5-7	1.7709	0,17 to 0,25	≤ 0,40	0,40 to 0,80	0,025	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	0,015 [b]	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	0,025	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	0,50 to 0,80	0,025	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	8,5 to 10,0	≤ 0,05	–

Table 1 *(continued)*

Material designation		Chemical composition, % by mass											
Name	**Number**	**C**	**Si**	**Mn**	**P max.**	**S max.**	**Al_{tot}**	**B**	**Cr**	**Mo**	**Ni**	**V**	**Others**
X15CrMo5-1	1.7390	≤ 0,18	≤ 0,40	0,30 to 0,80	0,025	0,015	–	–	4,0 to 6,0	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 [b]	–	–	11,0 to 12,5	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			11,0 to 12,5	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	≤ 0,001 5	10,0 to 11,5	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
Austenitic steels													
X2CrNi18-9	1.4307	≤ 0,030	≤ 1,00	≤ 2,00	0,045	0,015 [b]	–	–	17,5 to 19,5	–	8,0 to 10,0	–	N ≤ 0,10
X5CrNi18-10	1.4301	≤ 0,07	≤ 1,00	≤ 2,00	0,045	0,015 [b]	–	–	17,0 to 19,5	–	8,0 to 10,5	–	N ≤ 0,10
X4CrNi18-12	1.4303	≤ 0,06	≤ 1,00	≤ 2,00	0,045	0,015 [b]	–	–	17,0 to 19,0	–	11,0 to 13,0	–	N ≤ 0,10
X2CrNiN18-10	1.4311	≤ 0,030	≤ 1,00	≤ 2,00	0,045	0,015 [b]	–	–	17,5 to 19,5	–	8,5 to 11,5	–	N: 0,12 to 0,22
X6CrNi25-20	1.4951	0,04 to 0,08	≤ 0,70	≤ 2,00	0,035	0,015 [b]	–	–	24,0 to 26,0	–	19,0 to 22,0	–	N ≤ 0,10
X2CrNiMo17-12-2	1.4404	≤ 0,030	≤ 1,00	≤ 2,00	0,045	0,015 [b]	–	–	16,5 to 18,5	2,00 to 2,50	10,0 to 13,0	–	N ≤ 0,10
X5CrNiMo17-12-2	1.4401	≤ 0,07	≤ 1,00	≤ 2,00	0,045	0,015 [b]	–	–	16,5 to 18,5	2,00 to 2,50	10,0 to 13,0	–	N ≤ 0,10
X2CrNiMoN17-13-3	1.4429	≤ 0,030	≤ 1,00	≤ 2,00	0,045	0,015	–	–	16,5 to 18,5	2,50 to 3,00	11,0 to 14,0	–	N: 0,12 to 0,22
X3CrNiCu18-9-4	1.4567	≤ 0,04	≤ 1,00	≤ 2,00	0,045	0,015 [b]	–	–	17,0 to 19,0	–	8,5 to 10,5	–	N ≤ 0,10 Cu: 3,0 to 4,0
X6CrNi18-10	1.4948	0,04 to 0,08	≤ 1,00	≤ 2,00	0,035	0,015	–	–	17,0 to 19,0	–	8,0 to 11,0	–	N ≤ 0,10
X10CrNiMoMnNbVB15-10-1	1.4982	0,07 to 0,13	≤ 1,00	5,50 to 7,00	0,040	0,015 [b]	–	0,003 to 0,009	14,0 to 16,0	0,80 to 1,20	9,0 to 11,0	0,15 to 0,40	Nb: 0,75 to 1,25 N ≤ 0,10
X3CrNiMoBN17-13-3	1.4910	≤ 0,04	≤ 0,75	≤ 2,00	0,035	0,015	–	0,001 5 to 0,005 0	16,0 to 18,0	2,00 to 3,00	12,0 to 14,0	–	N: 0,10 to 0,18

Table 1 *(continued)*

Material designation		Chemical composition, % by mass											
Name	**Number**	**C**	**Si**	**Mn**	**P max.**	**S max.**	**Al_{tot}**	**B**	**Cr**	**Mo**	**Ni**	**V**	**Others**
X6CrNiMoB17-12-2	1.4919	0,04 to 0,08	≤ 1,00	≤ 2,00	0,035	0,015	–	0,001 5 to 0,005 0	16,5 to 18,5	2,00 to 2,50	10,0 to 13,0	–	N ≤ 0,10
X6CrNiTiB18-10	1.4941	0,04 to 0,08	≤ 1,00	≤ 2,00	0,035	0,015	–	0,001 5 to 0,005 0	17,0 to 19,0	–	9,0 to 12,0	–	Ti: 5 x C to 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	0,003 0 to 0,010	13,5 to 16,0	1,00 to 1,50	24,0 to 27,0	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	0,015 [b]	–	0,05 to 0,10	15,5 to 17,5	1,60 to 2,00	15,5 to 17,5	–	Nb+Ta: 10 x C to 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	18,0 to 21,0	–	≥ 65	–	Co ≤ 1,00, Cu ≤ 0,20 Ti: 1,80 to 2,70 Fe ≤ 1,50
NiCr19Fe19Nb5Mo3	2.4668	0,02 to 0,08	≤ 0,035	≤ 0,035	0,015	0,015	0,30 to 0,70	0,002 to 0,006	17,0 to 21,0	2,80 to 3,30	50,00 to 55,00	–	Cu ≤ 0,30 ; Co ≤ 1,00 Nb: 4,70 to 5,50 Ti: 0,60 to 1,20 Fe: Remaining
NiCr15Fe7TiAl	2.4669	≤ 0,08	≤ 0,50	≤ 1,00	0,020	0,015	0,40 to 1,00	–	14,0 to 17,0	–	≥ 70	–	Co ≤ 1,00, Cu ≤ 0,50 Ti: 2,25 to 2,75 Nb+Ta: 0,70 to 1,20 Fe: 5,0 to 9,0

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

[b] A controlled sulphur content of 0,015 % to 0,030 % improves the machinability and is therefore recommended and may be agreed at time of enquiry and order. For weldability, a controlled sulphur content of 0,008 % to 0,030 % is recommended and may be agreed at time of enquiry and order.

[c] For requirements regarding magnetic properties up to a maximum of 0,28 % C.

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 [a] % by mass
C		< 0,03	± 0,005
	≥ 0,03	≤ 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	≤ 7,0	± 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	± 0,000 5
	> 0,010	≤ 0,10	± 0,005
Cr		≤ 2,00	± 0,05
	> 2,00	< 10,0	± 0,10
	≥ 10,0	< 15,0	± 0,15
	≥ 15,0	≤ 21,0	± 0,20
Cu		≤ 0,50	+ 0,05
	> 0,50	≤ 4,0	± 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	≤ 5,0	± 0,07
	> 5,0	≤ 10,0	± 0,10
	> 10,0	≤ 20,0	± 0,15
	> 20,0	≤ 27,0	± 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[b]		≤ 1,50	+ 0,05
	> 1,50	≤ 9,0	± 0,10

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

[b] For nickel alloys.

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

Material designation		Heat treatment condition [a,b]	Hardness	Tensile strength	Reduction in area
Name	Number		HBW max.	R_m MPa max.	Z % min.
20MnB4	1.5525	+AC	–	520	64
23MnB4	1.5535	+AC	–	520	64
23MnB3	1.5507	+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	–	–
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	–	–

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

[b] Products made to these heat treatment conditions do not support the Essential Safety Requirements of Directive 97/23/EC, unless other criteria are taken into account, see Annex 1, 7.5 of this directive.

Table 4 — Mechanical properties at room temperature and at 20 °C of steels in delivery conditions which support the Essential Safety Requirements of Directive 97/23/EC [b]

Material designation		Heat treatment condition [a]	Diameter [c]	Proof strength	Tensile strength	Elongation after fracture	Reduction in area	Impact energy (ISO-V) at 20 °C
Name	Number		d mm	$R_{p0,2}$ MPa min.	R_m MPa	A % min.	Z % min.	KV_2 J min.
Steels for quenching and tempering								
20MnB4	1.5525	+QT	$d \leq 16$	640	800 to 950	14	52	40
23MnB4	1.5535	+QT	$d \leq 24$	640	800 to 950	14	52	40
23MnB3	1.5507	+QT	$d \leq 16$	640	800 to 950	14	52	40
C35E	1.1181	+N	$d \leq 60$	300	500 to 650	20	–	27
		+QT	$d \leq 60$	300	500 to 650	22	45	55
			$60 < d \leq 150$	300	500 to 650	22	45	39
C45E	1.1191	+N	$d \leq 60$	340	560 to 710	17	–	27
		+QT	$d \leq 60$	340	560 to 710	19	40	50
			$60 < d \leq 150$	340	560 to 710	19	40	35
35B2	1.5511	+QT	$d \leq 60$	300	500 to 650	22	45	55
			$60 < d \leq 150$	300	500 to 650	22	45	39
20Mn5	1.1133	+N	$d \leq 60$	320	500 to 650	22	55	55
			$60 < d \leq 150$	300	500 to 650	20	55	55
25CrMo4	1.7218	+QT	$d \leq 100$	440	600 to 750	18	60	60
			$100 < d \leq 150$	420	600 to 750	18	60	45
42CrMo4	1.7225	+QT	$d \leq 65$	730	860 to 1 060	14	50	50
42CrMo5-6	1.7233	+QT	$d \leq 100$	700	860 to 1 060	16	50	50
			$100 < d \leq 150$	640	850 to 1 000	16	50	40
40CrMoV4-6	1.7711	+QT	$d \leq 100$	700	850 to 1 000	14	45	40
			$100 < d \leq 160$	640	850 to 1 000	14	45	40
27NiCrMoV15-6	1.6957	+QT	$d \leq 160$	700	850 to 1 000	16	40	63
26NiCrMo14-6	1.6958	+QT	$d \leq 70$	940	1 040 to 1 240	14	50	55
			$70 < d \leq 160$					36
21CrMoV5-7	1.7709	+QT	$d \leq 160$	550	700 to 850	16	60	63
20CrMoVTiB4-10	1.7729	+QT	$d \leq 100$	660	820 to 1 000	15	50	40
			$100 < d \leq 160$	660	820 to 1 000	15	50	27
34CrNiMo6	1.6582	+QT	$d \leq 40$	940	1 040 to 1 200	14	40	45
			$40 < d \leq 120$	640	min. 800	14	52	45
30CrNiMo8	1.6580	+QT	$d \leq 40$	940	1 040 to 1 200	14	40	45
			$40 < d \leq 120$	640	min. 800	14	52	45
X12Ni5	1.5680	(+N), +NT or +QT	$d \leq 40$	390	530 to 710	19	50	70
			$40 < d \leq 75$	380	530 to 710	19	50	70

Table 4 *(continued)*

Material designation		Heat treatment condition [a]	Diameter [c]	Proof strength	Tensile strength	Elongation after fracture	Reduction in area	Impact energy (ISO-V) at 20°C
Name	Number		d mm	$R_{p0,2}$ MPa min.	R_m MPa	A % min.	Z % min.	KV_2 J min.
X8Ni9	1.5662	+N+NT (or +QT)	$d \leq 40$	490	640 to 840	18	50	70
			$40 < d \leq 75$	480	640 to 840	18	50	70
		+QT	$d \leq 40$	585	680 to 820	18	50	120
			$40 < d \leq 75$	575	680 to 820	18	50	120
X15CrMo5-1	1.7390	+NT or +QT	$d \leq 160$	420	640 to 780	14	45	40
X22CrMoV12-1	1.4923	+QT1	$d \leq 160$	600	800 to 950	14	40	27
X12CrNiMoV12-3	1.4938	+QT	$d \leq 160$	760	930 to 1 130	14	40	40
Austenitic steels								
X2CrNi18-9	1.4307	+AT	$d \leq 160$	175	450 to 680	45	–	100
		+C700	$d \leq 35$	350	700 to 850	20	–	80
X5CrNi18-10	1.4301	+AT	$d \leq 160$	190	500 to 700	45	–	100
		+C700	$d \leq 35$	350	700 to 850	20	–	80
X4CrNi18-12	1.4303	+AT	$d \leq 160$	190	500 to 700	45	–	100
		+C700	$d \leq 35$	350	700 to 850	20	–	80
X2CrNiN18-10	1.4311	+AT	$d \leq 160$	270	550 to 760	40	–	100
X6CrNi25-20	1.4951	+AT	$d \leq 160$	200	510 to 750	35	–	100
X2CrNiMo17-12-2	1.4404	+AT	$d \leq 160$	200	500 to 700	40	–	100
		+C700	$d \leq 35$	350	700 to 850	20	–	80
X5CrNiMo17-12-2	1.4401	+AT	$d \leq 160$	200	500 to 700	40	–	100
		+C700	$d \leq 35$	350	700 to 850	20	–	80
X2CrNiMoN17-13-3	1.4429	+AT	$d \leq 160$	280	580 to 800	40	–	100
X3CrNiCu18-9-4	1.4567	+AT	$d \leq 160$	175	450 to 650	45	–	100
		+C700	$d \leq 35$	350	700 to 850	20	–	80
X6CrNi18-10	1.4948	+AT	$d \leq 160$	185	500 to 700	40	–	90
X10CrNiMoMnNbVB15-10-1	1.4982	+AT+WW	$d \leq 100$	510	650 to 850	25	–	50
X3CrNiMoBN17-13-3	1.4910	+AT	$d \leq 160$	260	550 to 750	35	–	100
X6CrNiMoB17-12-2	1.4919	+AT	$d \leq 160$	205	490 to 690	35	–	100
X6CrNiTiB18-10	1.4941	+AT	$d \leq 160$	195	490 to 680	35	–	100
X6NiCrTiMoVB25-15-2	1.4980	+AT+P	$d \leq 160$	600	900 to 1 150	15	–	50
X7CrNiMoBNb16-16	1.4986	+WW+P	$d \leq 100$	500	650 to 850	16	–	50

[a] +AT = solution annealed; +C = cold work hardened; +N = normalized; +NT = normalized and tempered; +P = precipitation hardened; +QT = quenched and tempered; +WW = warm worked (see Annex B).

[b] Products made of steel grades and these final heat treatment conditions support the Essential Safety Requirements of Directive 97/23/EC, see Annex 1, 7.5 of this directive.

[c] For rectangular cross-sections "d" will be replaced by "b" (see Figure 1).

Table 5 — Mechanical properties at room temperature and at 20°C of steels and nickel alloys in delivery conditions which do not support the Essential Safety Requirements of Directive 97/23/EC [b]

Material designation		Heat treatment condition [a]	Diameter [c]	Proof strength	Tensile strength	Elongation after fracture	Reduction in area	Impact energy (ISO-V) at 20°C
Name	Number		d mm	$R_{p0,2}$ MPa min.	R_m MPa	A % min.	Z % min.	KV_2 J min.
Steels for quenching and tempering								
X22CrMoV12-1	1.4923	+QT2	$d \leq 160$	700	900 to 1 050	11	35	20
X19CrMoNbVN11-1	1.4913	+QT	$d \leq 160$	750	900 to 1 050	12	40	20
Austenitic steels								
X2CrNi18-9	1.4307	+C800	$d \leq 25$	500	800 to 1 000	12	–	80
X4CrNi18-12	1.4303	+C800	$d \leq 25$	500	800 to 1 000	12	–	80
X2CrNiMo17-12-2	1.4404	+C800	$d \leq 25$	500	800 to 1 000	12	–	80
X5CrNiMo17-12-2	1.4401	+C800	$d \leq 25$	500	800 to 1 000	12	–	80
Nickel alloys								
NiCr19Fe19Nb5Mo3	2.4668	+P	$d \leq 160$	1030	min. 1 230	12	–	12
NiCr20TiAl	2.4952	+AT+P	$d \leq 160$	600	1 000 to 1 300	12	12	20
NiCr15Fe7TiAl	2.4669	+AT+P	$d \leq 25$	650	1 000 to 1 200	20	28	22

[a] +AT = solution annealed; +C = cold work hardened; +N = normalized; +NT = normalized and tempered; +P = precipitation hardened; +QT = quenched and tempered; +WW = warm worked (see Annex B).

[b] Products made to these steel grades and these final heat treatment conditions do not support the Essential Safety Requirements of Directive 97/23/EC, unless other criteria are taken into account; see Annex 1, 7.5 of this directive.

[c] For rectangular cross-sections "d" will be replaced by "b" (see Figure 1).

Table 6 — Minimum 0,2 %-proof strength values at elevated temperature of steels in delivery conditions which support the Essential Safety Requirements of Directive 97/23/EC [d]

Material designation		Heat treatment condition [a]	Diameter [e] d mm	Minimum 0,2 %-proof strength $R_{p0,2}$ in MPa 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	$d \leq 60$	289*)	270*)	251	229	213	192	182	173	–	–	–	–	–
		+QT	$d \leq 60$	289*)	270*)	251	229	213	192	182	173	–	–	–	–	–
			$60 < d \leq 150$	287*)	264*)	242*)	220	203	186	167	147	–	–	–	–	–
C45E	1.1191	+QT	$d \leq 150$	330*)	314	299*)	284	255	235	206	–	–	–	–	–	–
35B2	1.5511	+QT	$d \leq 60$	289*)	270*)	251	229	213	192	182	173	–	–	–	–	–
			$60 < d \leq 150$	287*)	264*)	242*)	220	203	186	167	147	–	–	–	–	–
20Mn5	1.1133	+N	$d \leq 60$	306*)	283*)	260	237	213	192	182	173	–	–	–	–	–
			$60 < d \leq 150$	304*)	278*)	251	229	213	192	182	173	–	–	–	–	–
25CrMo4	1.7218	+QT	$d \leq 100$	435*)	428*)	420*)	412	392	363	333	304	275	235	–	–	–
			$100 < d \leq 150$	414*)	403*)	393*)	382	372	344	324	294	265	226	–	–	–
42CrMo4	1.7225	+QT	$d \leq 60$	720*)	702	677	640	602	562	518	475	420	375	–	–	–
42CrMo5-6	1.7233	+ QT	$d \leq 100$	681*)	662	639	616	601	585	570	547	516	462	362	223	–
			$100 < d \leq 150$	625*)	605	584	563	549	535	521	500	472	422	331	204	–
40CrMoV4-6	1.7711	+QT	$d \leq 100$	687*)	670	647	631	608	593	577	554	523	470	400	293	–
			$100 < d \leq 160$	631*)	612	591	577	556	542	528	507	479	429	366	268	–
27NiCrMoV15-6	1.6957	+QT	$d \leq 160$	–	660	–	625	600	580	550	(510) [c]	(460) [c]	(400) [c]	–	–	–
26 NiCrMo14-6	1.6958	+QT	$70 < d \leq 160$	–	853	843	834	804	785	765	–	–	–	–	–	–
21CrMoV5-7	1.7709	+QT	$d \leq 160$	542*)	530	515*)	500	480*)	460	435*)	410	380	350	–	–	–
20CrMoVTiB4-10	1.7729	+QT	$d \leq 160$	642*)	624	603	595	581	573	559	537	508	464	406	334	–
X15CrMo5-1	1.7390	+NT or +QT	$d \leq 160$	392*)	345	335	327	323	322	316	306	285	256	–	–	–
X22CrMoV12-1	1.4923	+QT1	$d \leq 160$	585*)	560	545*)	530	505*)	480	450*)	420	380	335	–	–	–

Table 6 *(continued)*

Material designation		Heat treatment condition [a]	Diameter [e] d mm	Minimum 0,2 %-proof strength $R_{p0,2}$ in MPa at a temperature (in °C) of:												
Name	Number			50	100	150	200	250	300	350	400	450	500	550	600	650
X12CrNiMoV12-3 [b]	1.4938	+QT1	$d \leq 160$	730*)	680	668*)	655	653*)	650	630*)	610	560	505	400	–	–
Austenitic steels																
X2CrNi18-9	1.4307	+AT	$d \leq 160$	164*)	145	130	118	108	100	94	89	85	81	80	–	–
X5CrNi18-10	1.4301	+AT	$d \leq 160$	177*)	155	140	127	118	110	104	98	95	92	90	–	–
X4CrNi18-12	1.4303	+AT	$d \leq 160$	177*)	155	140	127	118	110	104	98	95	92	90	–	–
X2CrNiN18-10	1.4311	+AT	$d \leq 160$	246	205	175	157	145	136	130	125	121	119	118	–	–
X6CrNi25-20	1.4951	+AT	$d \leq 160$	177	140	128	116	108	100	94	91	86	85	84	–	–
X2CrNiMo17-12-2	1.4404	+AT	$d \leq 160$	187*)	165	150	137	127	119	113	108	103	100	98	–	–
X5CrNiMo17-12-2	1.4401	+AT	$d \leq 160$	191*)	175	158	145	135	127	120	115	112	110	108	–	–
X2CrNiMoN17-13-3	1.4429	+AT	$d \leq 160$	256*)	215	195	175	165	155	150	145	140	138	136	–	–
X6CrNi18-10	1.4948	+AT	$d \leq 160$	174*)	157	142	127	117	108	103	98	93	88	83	78	–
X10CrNiMoMnNbVB15-10-1	1.4982	+AT+WW	$d \leq 100$	490	463	446	434	423	413	405	396	391	386	378	365	346
X3CrNiMoBN17-13-3	1.4910	+AT	$d \leq 160$	239*)	205	187	170	159	148	141	134	130	127	124	121	–
X6CrNiMoB17-12-2	1.4919	+AT	$d \leq 160$	194*)	177	162	147	137	127	122	118	113	108	103	98	–
X6CrNiTiB18-10	1.4941	+AT	$d \leq 160$	183*)	162	152	142	137	132	127	123	118	113	108	103	–
X6NiCrTiMoVB25-15-2	1.4980	+AT+P	$d \leq 160$	592*)	580	570	560	550	540	530	520	510	490	460	430	380
X7CrNiMoBNb16-16	1.4986	+WW+P	$d \leq 100$	489*)	470*)	451*)	432	412	393	372	353	334	314	284	255	206

[a] +AT = solution annealed; +C = cold work hardened; +N = normalized; +NT = normalized and tempered; +P = precipitation hardened; +QT = quenched and tempered; +WW = warm worked (see Annex B).

[b] This steel grade is generally not applied in the creep range.

[c] Values in brackets signify that the steel is not intended for use (and testing) at those temperatures.

[d] Products made to these steel grades and these final heat treatment conditions support the Essential Safety Requirements of Directive 97/23/EC; see Annex 1, 7.5 of this directive.

[e] For rectangular cross sections "d" will be replaced by "b" (see Figure 1).

*) Values calculated by linear interpolation.

Table 7 — Minimum 0,2 %-proof strength values at elevated temperature of steels and nickel alloys in delivery conditions which do not support the Essential Safety Requirements of Directive 97/23/EC [b]

Material designation		Heat treatment condition [a]	Diameter [c] d mm	Minimum 0,2 %-proof strength $R_{p0,2}$ in MPa 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																
X22CrMoV12-1	1.4923	+QT2	d ≤160	681*)	650	625*)	600	575*)	550	518*)	485	440	390	–	–	–
X19CrMoNbVN11-1	1.4913	+QT	d ≤ 160	726*)	701	676	651	643	627	610	577	544	495	412	305	–
Nickel alloys																
NiCr20TiAl	2.4952	+AT+P	d ≤ 160	595*)	586*)	577*)	568	564	560	550	540	530	520	510	500	480
NiCr19Fe19Nb5Mo3	2.4668	+P	d ≤ 160	–	–	–	–	–	880	–	865	–	860	–	860	–
NiCr15Fe7TiAl	2.4669	+AT+P	d ≤ 25	625*)	620	615	610	606	601	596	592	587	582	578	573	565

[a] +AT = solution annealed; +C = cold work hardened; +N = normalized; +NT = normalized and tempered; +P = precipitation hardened; +QT = quenched and tempered; +WW = warm worked (see Annex B).

[b] Products made to these steel grades and these final heat treatment conditions do not support the Essential Safety Requirements of Directive 97/23/EC, unless other criteria are taken into account; see Annex 1, 7.5 of this directive.

[c] For rectangular cross sections "d" will be replaced by "b" (see Figure 1).

*) Values calculated by linear interpolation.

Table 8 — Minimum tensile strength values at elevated temperatures of steels in delivery conditions which support the Essential Safety Requirements of Directive 97/23/EC [b]

Material designation		Heat treatment condition [a]	Diameter [c] d mm	Minimum tensile strength R_m in MPa at a temperature (in °C) of:												
Name	Number			50	100	150	200	250	300	350	400	450	500	550	600	650
Austenitic steels																
X2CrNi18-9	1.4307	+AT	$d \leq 160$	440	410	380	360	350	340	340	330	–	–	–	–	–
X5CrNi18-10	1.4301	+AT	$d \leq 160$	480	450	420	400	390	380	380	380	375	360	335	300	–
X4CrNi18-12	1.4303	+AT	$d \leq 160$	480	450	420	400	390	380	380	380	375	360	335	300	–
X2CrNiN18-10	1.4311	+AT	$d \leq 160$	527	490	460	430	420	410	410	–	–	–	–	–	–
X6CrNi25-20	1.4951	+AT	$d \leq 160$	495	470	450	430	420	410	405	400	385	370	350	320	–
X2CrNiMo17-12-2	1.4404	+AT	$d \leq 160$	460	430	410	390	385	380	380	380	375	360	335	–	–
X5CrNiMo17-12-2	1.4401	+AT	$d \leq 160$	480	460	440	420	415	410	410	410	405	390	375	350	–
X2CrNiMoN17-13-3	1.4429	+AT	$d \leq 160$	550	520	490	460	450	440	435	435	435	430	410	380	–
X6CrNi18-10	1.4948	+AT	$d \leq 160$	480	450	420	400	390	380	380	380	375	360	335	300	–
X10CrNiMoMnNbVB15-10-1	1.4982	+AT+WW	$d \leq 100$	610	565	530	505	490	475	465	460	450	440	430	410	390
X3CrNiMoBN17-13-3	1.4910	+AT	$d \leq 160$	550	520	490	460	450	440	435	435	435	430	410	380	–
X6CrNiMoB17-12-2	1.4919	+AT	$d \leq 160$	490	460	440	420	415	410	410	410	405	390	375	350	–
X7CrNiTiB18-10	1.4941	+AT	$d \leq 160$	490	460	440	420	415	410	410	410	405	390	375	350	–
X6NiCrTiMoVB25-15-2	1.4980	+AT+P	$d \leq 160$	–	–	–	–	–	–	–	720	710	700	690	670	–
X7CrNiMoBNb16-16	1.4986	+WW+P	$d \leq 100$	635	615	590	570	550	530	505	485	460	440	420	395	375

[a] +AT = solution annealed; +C = cold work hardened; +N = normalized; +NT = normalized and tempered; +P = precipitation hardened; +QT = quenched and tempered; +WW = warm worked (see Annex B).

[b] Products made to these steel grades and these final heat treatment conditions support the Essential Safety Requirements of Directive 97/23/EC; see Annex 1, 7.5 of this directive.

[c] For rectangular cross-sections "*d*" will be replaced by "*b*" (see Figure 1).

Table 9 — Minimum tensile strength values at elevated temperatures of nickel alloys in delivery conditions which do not support the Essential Safety Requirements of Directive 97/23/EC [b]

Material designation		Heat treatment condition [a]	Diameter [c] d mm	Minimum tensile strength R_m in MPa at a temperature (in °C) of:												
Name	Number			50	100	150	200	250	300	350	400	450	500	550	600	650
Nickel alloys																
NiCr19Fe19Nb5Mo3	2.4668	+P	$d \leq 160$	–	–	–	–	–	–	–	–	–	–	–	–	–
NiCr20TiAl	2.4952	+AT+P	$d \leq 160$	1000	975	950	900	900	900	900	900	900	890	880	850	–
NiCr15Fe7TiAl	2.4669	+AT+P	$d \leq 25$	1000	975	950	900	900	900	900	900	900	890	880	850	–

[a] +AT = solution annealed; +C = cold work hardened; +N = normalized; +NT = normalized and tempered; +P = precipitation hardened; +QT = quenched and tempered; +WW = warm worked (see Annex B).

[b] Products made to these steel grades and these final heat treatment conditions do not support the Essential Safety Requirements of Directive 97/23/EC, unless other criteria are taken into account; see Annex 1, 7.5 of this directive.

[c] For rectangular cross-sections "*d*" will be replaced by "*b*" (see Figure 1).

Table 10 — Minimum impact energy (longitudinal direction) at low temperature of steels in delivery conditions which support the Essential Safety Requirements of Directive 97/23/EC [b]

Material designation		Heat treatment condition [a]	Diameter [e] d mm	Minimum impact energy KV_2 in J [c] (ISO-V test piece) at a test 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																			
20MnB4	1.5525	+QT	$d \leq 16$	–	–	–	–	–	–	–	–	–	–	27	–	–	40	40	40
23MnB4	1.5535	+QT	$d \leq 24$	–	–	–	–	–	–	–	–	–	–	27	–	–	40	40	40
23MnB3	1.5507	+QT	$d \leq 16$	–	–	–	–	–	–	–	–	–	–	27	–	–	40	40	40
20Mn5	1.1133	+N	$d \leq 60$	–	–	–	–	–	–	–	–	–	–	–	27	31	47	55	55
			$60 < d \leq 150$	–	–	–	–	–	–	–	–	–	–	–	–	–	40	55	55
25CrMo4	1.7218	+QT	$d \leq 60$	–	–	–	–	–	–	–	–	–	–	40	40	45	50	–	60
			$60 < d \leq 100$	–	–	–	–	–	–		–	–	–	–	40	40	50	–	60
42CrMo4	1.7225	+QT	$d \leq 60$	–	–	–	–	–	–	27	–	–	–	–	–	40	–	–	50
34CrNiMo6	1.6582	+QT	$d \leq 100$	–	–	–	–	–	–	–	–	–	–	–	–	40	–	–	45
30CrNiMo8	1.6580	+QT	$d \leq 100$	–	–	–	–	–	–	–	–	–	–	–	–	40	–	–	45
X12Ni5	1.5680	(+N), +NT	$d \leq 40$	–	–	–	–	40	45	50	55	60	60	65	65	65	70	70	70
			$40 < d \leq 75$	–	–	–	–	–	–	–	50	55	60	60	65	65	65		70
X8Ni9	1.5662	+N +NT (or +QT)	$d \leq 75$	–	40	45	50	50	–	60	–	70	70	70	70	70	70	70	70
		+QT	$d \leq 75$	–	70	–	–	100	–	110	–	120	120	120	120	120	120	120	120

Table 10 *(continued)*

Material designation		Heat treatment condition [a]	Diameter [e] d mm	Minimum impact energy KV_2 in J [c] (ISO-V test piece) at a test temperature in °C of:														
Name	Number			–270	–196	–160	–140	–120	–110	–100	–90	–80	–70	–60	–50	–40	–20	0	+20
Austenitic steels																			
X2CrNi18-9	1.4307	+C700	$d \leq 35$	–	50	–	–	–	–	–	–	–	–	–	–	–	–	–	80
X5CrNi18-10	1.4301	+AT	$d \leq 160$	–	60	–	–	–	–	–	–	–	–	–	–	–	–	–	100
		+C700	$d \leq 35$	–	50	–	–	–	–	–	–	–	–	–	–	–	–	–	80
X4CrNi18-12	1.4303	+AT	$d \leq 160$	–	60	–	–	–	–	–	–	–	–	–	–	–	–	–	100
		+C700	$d \leq 35$	–	50	–	–	–	–	–	–	–	–	–	–	–	–	–	80
X2CrNiN18-10	1.4311	+AT	$d \leq 160$	–	60	–	–	–	–	–	–	–	–	–	–	–	–	–	100
X6CrNi25-20	1.4951	+AT	$d \leq 160$	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	100
X2CrNiMo17-12-2	1.4404	+C700	$d \leq 35$	–	50	–	–	–	–	–	–	–	–	–	–	–	–	–	80
X5CrNiMo17-12-2	1.4401	+C700	$d \leq 35$	–	50	–	–	–	–	–	–	–	–	–	–	–	–	–	80
X2CrNiMoN17-13-3	1.4429	+AT	$d \leq 160$	50	60	–	–	–	–	–	–	–	–	–	–	–	–	–	100
X6CrNi18-10	1.4948	+AT	$d \leq 160$	–	60	–	–	–	–	–	–	–	–	–	–	–	–	–	100
X3CrNiMoBN17-13-3	1.4910	+AT	$d \leq 160$	50	60	–	–	–	–	–	–	–	–	–	–	–	–	–	100
X6CrNiMoB17-12-2	1.4919	+ AT	$d \leq 160$	–	60	–	–	–	–	–	–	–	–	–	–	–	–	–	100
X6CrNiTiB18-10	1.4941	+ AT	$d \leq 160$	–	60	–	–	–	–	–	–	–	–	–	–	–	–	–	100
X6NiCrTiMoVB25-15-2	1.4980 [d]	+AT+P	$d \leq 160$	–	40	–	–	–	–	–	–	–	–	–	–	–	–	–	50

[a] +AT = solution annealed; +C = cold work hardened; +N = normalized; +NT = normalized and tempered; +P = precipitation hardened; +QT = quenched and tempered; +WW = warm worked (see Annex B).
[b] Products made to these steel grades and these final heat treatment conditions support the Essential Safety Requirements of Directive 97/23/EC; see Annex 1, 7.5 of this directive.
[c] Average of 3 test results.
[d] Steel grade 1.4980 may be ordered for cryogenic purposes with impact values of 50 J at -270 °C, 60 J at -196 °C and 70 J at 20 °C.
[e] For rectangular cross sections "d" will be replaced by "b" (see Figure 1).

Table 11 — Minimum impact energy (longitudinal direction) at low temperature of nickel alloys in delivery conditions which do not support the Essential Safety Requirements of Directive 97/23/EC [b]

Material designation		Heat treatment condition [a]	Diameter [d] d mm	Minimum impact energy KV_2 in J [c] (ISO-V test piece) at a test temperature in °C of:															
Name	Number			–270	–196	–160	–140	–120	–110	–100	–90	–80	–70	–60	–50	–40	–20	0	+20
Nickel alloys																			
NiCr19Fe19Nb5Mo3	2.4668	+P	d ≤160	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	12
NiCr20TiAl	2.4952	+AT+P	d ≤160	–	20	–	–	–	–	–	–	–	–	–	–	–	–	–	20
NiCr15Fe7TiAl	2.4669	+AT+P	d ≤ 25	–	20	–	–	–	–	–	–	–	–	–	–	–	–	–	22

[a] +AT = solution annealed; +C = cold work hardened; +N = normalized; +NT = normalized and tempered; +P = precipitation hardened; +QT = quenched and tempered; +WW = warm worked (see Annex B).
[b] Products made to these steel grades and these final heat treatment conditions do not support the Essential Safety Requirements of Directive 97/23/EC; see Annex 1, 7.5 of this directive.
[c] Average of 3 test results.
[d] For rectangular cross sections "d" will be replaced by "b" (see Figure 1).

Table 12 — Verification tests to be carried out and extent of testing

Test		Test status[a]	Number of samples for batches of			Number of test pieces per sample
			≤ 10 t	> 10 t to ≤ 15 t	> 15 t	
Chemical analysis	cast	m	1/cast (see 8.3.1 and 11.1)			
	product	O[b]	(see 10.1.1)			
Hardness test on homogeneity / shearing		O[c]	(see 10.1.2 and 10.2.1.3)			
Intergranular corrosion resistance		O[c]	(see 11.6.5)			
Tensile test at room temperature		m	2	3	4	1
Tensile test at elevated temperature		O[d]				1
Impact test at room temperature		M[e]				3
Impact test at low temperature		O[f]				3
Non-destructive testing		O[g]	not applicable			
Verification of surface quality		o				
Other tests		M[h]				

[a] Tests marked with a '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.

[b] •• 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).

[c] • The number of samples and test pieces per sample shall be agreed at time of enquiry and order.

[d] •• For verification of $R_{p0,2}$ and, in the case of austenitic steels and nickel alloys, of the tensile strength at elevated temperatures for products to be used at elevated temperatures.

[e] •• Optional for austenitic steels, except austenitic grades for cryogenic service (> 15 mm diameter or thickness).

[f] •• For materials for use at low temperatures.

[g] For verification of internal soundness (see 8.6).

[h] See 11.6.1 and 11.6.2.

Table 13 — Marking of the products

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

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

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

[c] 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/dm^3	GPa								
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										
26NiCrMo14-6	1.6958		213[a]	208[a]	202[a]	194[a]	186[a]	175[a]	164[a]		
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[a]	198[a]	183[a]	175[a]	167[a]	159[a]	150[a]	142[a]	–
X6CrNiMoB17-12-2	1.4919										
X6CrNiTiB18-10	1.4941	7,9									
X6NiCrTiMoVB25-15-2	1.4980	8,0	211[a]	206[a]	200[a]	192[a]	183[a]	173[a]	162[a]	–	–
X7CrNiMoBNb16-16	1.4986	7,9	196	192	186	181	174	165	157	147	-
Nickel alloys											
NiCr20TiAl	2.4952	8,2	216[a]	212[a]	208[a]	202[a]	196[a]	189[a]	179[a]	161[a]	130[a]
NiCr15Fe7TiAl	2.4669	8,2	215	208	200	192	183	175	165	150	131

[a] Dynamic modulus of elasticity.

Table A.2 — Coefficient of thermal expansion, thermal conductivity, thermal capacity and electrical resistivity [a]

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
Name	Number	100 °C	200 °C	300 °C	400 °C	500 °C	600 °C			
		$10^{-6}\ K^{-1}$						$\frac{W}{m \cdot K}$	$\frac{J}{kg \cdot K}$	$\frac{\Omega \cdot mm^2}{m}$
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									
26NiCrMo14-6	1.6958	11,2	11,6	12,1	12,2	–	–	29	–	
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
X10CrNiMoMnNbVB 15-10-1	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									
X6CrNiTiB18-10	1.4941									0,71
X6NiCrTiMoVB25-15-2	1.4980	17,0	17,5	17,8	18,0	18,2	18,5	13	490	0,91
X7CrNiMoBNb16-16	1.4986	16,6	17,7	17,9	17,9	17,9	18,1	15	460	n.a.
Nickel alloys										
NiCr19FeNb5Mo3	2.4668	–	13,4	13,8	14,1	–	14,6	13	440	1,23
NiCr20TiAl	2.4952	12,9	13,4	13,8	14,3	14,7	15,2	11,4	460	1,24
NiCr15Fe7TiAl	2.4669	12,6	13,0	13,4	13,9	14,4	14,8	12	431	1,21

[a] n.a. – no values available.

Annex B
(informative)

Guidance for heat treatment

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

Material designation		Heat-treatment symbol[a]	Normalizing, quenching or solution annealing temperature °C	Type of cooling[b]	Tempering or precipitation treatment (and time)[c] °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[d]	880 to 950	w , o	670 to 720
		+QT[e]	940 to 970	w , o	600 to 700
21CrMoV5-7	1.7709	+QT	880 to 950	a, o, w	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	w , o	540 to 660
30CrNiMo8	1.6580	+QT	830 to 860	w , o	540 to 660
27NiCrMoV15-6	1.6957	+ QT	840 to 870	w, o	530 to 620
26 NiCrMo14-6	1.6958	+ QT	840 to 870	w, o	530 to 620 (min. 2 h)
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	1 020 to 1 070	a, o, w	680 to 740 (min. 2 h)
		+QT2	1 020 to 1 070	a, o, w	660 to 720 (min. 2 h)
X12CrNiMoV12-3	1.4938	+QT	1 035 to 1 065	o	600 to 670
X19CrMoNiNbVN11-1	1.4913	+QT	1 100 to 1 130	a, o	670 to 720 (min. 2 h)

Table B.1 *(continued)*

Material designation		Heat-treatment symbol[a]	Normalizing, quenching or solution annealing temperature °C	Type of cooling[b]	Tempering or precipitation treatment (and time)[c] °C
Name	**Number**				
Austenitic steels					
X2CrNi18-9	1.4307	+AT	1 000 to 1 100	w, a[h]	–
X5CrNi18-10	1.4301	+AT	1 000 to 1 100	w, a[h]	–
X4CrNi18-12	1.4303	+AT	1 000 to 1 100	w, a[h]	–
X2CrNiMo17-12-2	1.4404	+AT	1 020 to 1 120	w, a[h]	–
X5CrNiMo17-12-2	1.4401	+AT	1 020 to 1 120	w, a[h]	–
X2CrNiMoN17-13-3	1.4429	+AT	1 020 to 1 120	w, a[h]	–
X3CrNiCu18-9-4	1.4567	+AT	1 000 to 1 100	w, a[h]	–
X6CrNi18-10	1.4948	+AT	1 000 to 1 080	w, a[h]	–
X10CrNiMoMnNbVB15-10-1	1.4982	+AT+WW	1 030 to 1 070 + 650 to 750[f]	w a	–
X3CrNiMoBN17-13-3	1.4910	+AT	1 020 to 1 100	w, a[h]	–
X6CrNiMoB17-12-2	1.4919	+AT	1 020 to 1 100	w, a[h]	–
X6CrNiTiB18-10	1.4941	+AT	1 070 to 1 150	w, a[h]	–
X6NiCrTiMoVB25-15-2	1.4980	+AT+P	970 to 990	o, w	710 to 730
X7CrNiMoBNb16-16	1.4986	+WW+P	g	–	750 to 800 (5 to 1 h); a[b]
Nickel alloys					
NiCr19Fe19Nb5Mo3	2.4668	+P	950 to 1 010	a	710 to 730 for 8 h[+)] furnace cooling down to 610 to 630, hold at 610 to 630. Total treatment time min. 18 h[+)]
NiCr20TiAl	2.4952	+AT+P	1 050 to 1 080	a	840 to 860, 24 h, a[b] + 690 to 710, 16 h, a[b]
NiCr15Fe7TiAl	2.4669	+AT+P	1 100 to 1 200	a	840 to 870, 24h, a[b] + 700 to 710, 16h, a[b]

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

[b] a = air; o = oil; w = water or water-based medium.

[c] Where in accordance with 8.2.4 a stress relieving after straightening has been agreed, the stress relieving temperature shall be chosen so that the specified properties are still obtained.

[d] For diameters ≤ 100 mm.

[e] For diameters > 100 mm to 160 mm.

[f] Temperature range of warm working.

[g] Warm worked from 750 °C to 850 °C.

[h] Cooling sufficiently rapid.

[+] Recommended time.

Annex C
(informative)

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

NOTE The values given in Table C.1 are mean values of the scatter band considered until now.

The strength values for 1 % (plastic) creep strain and creep rupture given to the elevated temperatures listed in Table C.1 do not mean that the steels can be used 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[a,b]

Material designation		Temperature	Strength for 1% (plastic) creep strain[c]		Creep rupture strength for[d]		
Name	Number	°C	10 000 h MPa	100 000 h MPa	10 000 h MPa	100 000 h MPa	200 000 h MPa
Steels for quenching and tempering							
C35E	1.1181	350 360 370 380 390	208 197 185 174 161	151 139 130 120 109	246 236 224 212 200	218 202 185 169 154	–
		400 410 420 430 440	147 132 116 102 89	98 87 77 67 58	187 173 156 138 118	138 122 106 93 80	–
		450 460 470 480 490	78 68 58 49 42	49 40 34 29 26	100 87 77 69 61	69 61 53 45 39	–
		500	35	22	53	34	–
20Mn5	1.1133	380 390	–	–	291 266	227 203	(206) (181)
		400 410 420 430 440	–	–	243 221 200 180 161	179 157 136 117 100	(157) (135) (115) (97) (82)
		450 460 470 480 490	–	–	143 126 110 96 84	85 73 63 55 (47)	(70) (60) (52) (44) (37)
		500	–	–	74	(41)	–

Table C.1 *(2 of 7)*

Material designation		Temperature	Strength for 1% (plastic) creep strain[c]		Creep rupture strength for[d]		
Name	Number	°C	10 000 h MPa	100 000 h MPa	10 000 h MPa	100 000 h MPa	200 000 h MPa
25 CrMo4	1.7218	420 430 440	274 258 242	221 203 186	387 364 338	308 281 253	–
		450 460 470 480 490	226 210 195 180 163	171 155 141 127 112	311 283 255 226 200	226 200 178 157 136	–
		500 510 520 530 540	147 130 115 98 81	98 83 69 54 39	176 153 133 114 95	118 100 82 66 51	–
		550	64	25	79	36	–
42CrMo5-6	1.7233	450 460 470 480 490	–	–	495 450 399 342 281	410 345 276 219 177	381 310 242 193 158
		500 510 520 530 540	–	–	229 190 160 137 118	148 124 102 – –	131 109 84 – –
		550	–	–	98	–	–
40CrMoV4-6	1.7711	450 460 470 480 490	–	–	513 483 451 413 371	463 422 374 319 259	446 400 347 286 229
		500 510 520 530 540	–	–	321 269 223 187 160	210 174 146 122 –	187 155 130 103 –
		550	–	–	137	–	–
21CrMoV5-7	1.7709	420 430 440	429 407 385	365 340 315	466 443 420	399 375 350	379 353 328
		450 460 470 480 490	363 339 314 289 263	288 262 235 208 182	396 373 349 325 301	325 300 274 249 224	303 277 252 226 201
		500 510 520 530 540	238 212 186 161 138	156 132 109 89 71	277 253 228 204 180	199 174 150 126 103	176 151 127 104 82
		550	116	56	157	82	62

Table C.1 (*3 of 7*)

Material designation		Temperature	Strength for 1% (plastic) creep strain[c]		Creep rupture strength for[d]		
		°C	10 000 h	100 000 h	10 000 h	100 000 h	200 000 h
Name	**Number**		MPa	MPa	MPa	MPa	MPa
20CrMoVTiB4-10	1.7729	450 460 470 480 490	–	–	520 491 463 437 412	453 423 394 365 337	(430) (399) (369) (338) (307)
		500 510 520 530 540	–	–	388 364 340 315 288	307 276 241 204 169	(274) (237) (198) 162 135
		550 560 570 580 590	–	–	261 231 200 170 146	142 121 103 – –	114 96 – – –
		600	–	–	127	–	–
X15CrMo5-1	1.7390	450 460 470 480 490	88	63	– – 226 220 190	276 218 181 153 132	237 192 158 135 114
		500 510 520 530 540	–	–	164 145 129 114 100	113 96 81 70 59	96 80 68 57 47
		550 560 570 580 590	49 43 37 – –	32 30 26 – –	88 77 68 60 53	50 43 37 – –	40 – – – –
		600	–	–	46	–	–
X22CrMoV12-1	1.4923	450 460 470 480 490	436 405 375 344 316	373 341 308 278 248	480 451 422 394 366	432 397 368 336 306	–
		500 510 520 530 540	289 262 235 211 187	221 195 170 148 127	338 312 286 261 235	275 245 216 187 161	–
		550 560 570 580 590	165 144 126 108 92	108 91 77 64 53	211 187 165 143 122	137 118 99 83 70	–
		600	79	44	103	59	–

Table C.1 (*4 of 7*)

Material designation		Temperature	Strength for 1% (plastic) creep strain[c]		Creep rupture strength for[d]		
Name	Number	°C	10 000 h MPa	100 000 h MPa	10 000 h MPa	100 000 h MPa	200 000 h MPa
X19CrMoNbVN11-1	1.4913	450 460 470 480 490	500 475 450 424 398	448 416 388 358 328	559 529 500 473 446	500 472 444 414 383	486 450 425 395 364
		500 510 520 530 540	374 349 323 298 274	298 268 238 210 181	417 392 366 340 314	349 314 276 237 201	330 291 253 209 172
		550 560 570 580 590	250 225 201 177 154	153 – – – –	288 259 234 208 181	161 132 105 86 72	130 102 81 66 52
		600	133	–	155	65	49
Austenitic steels							
X6CrNi18-10	1.4948	550 560 570 580 590	121 116 111 106 100	96 92 88 84 79	191 177 165 154 143	140 128 117 107 98	125 114 104 95 86
		600 610 620 630 640	94 88 82 75 68	74 69 63 56 49	132 122 113 104 95	89 81 73 65 58	78 70 62 55 49
		650 660 670 680 690	61 55 49 44 39	43 37 32 28 25	87 80 73 67 61	52 47 42 37 32	43 38 34 30 26
		700	35	22	55	28	22
X10CrNiMoMnNbVB 15-10-1	1.4982	550 560 570 580 590	–	–	410 400 385 370 355	365 350 335 315 295	350 335 315 295 275
		600 610 620 630 640	–	–	340 325 305 285 265	275 250 215 180 155	250 215 185 150 135
		650	–	–	240	135	115

Table C.1 (*5 of 7*)

Material designation		Temperature	Strength for 1% (plastic) creep strain[c]		Creep rupture strength for[d]		
		°C	10 000 h MPa	100 000 h MPa	10 000 h MPa	100 000 h MPa	200 000 h MPa
Name	**Number**						
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)
X3CrNiMoBN17-13-3	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

Table C.1 (*6 of 7*)

Material designation		Temperature	Strength for 1% (plastic) creep strain[c]		Creep rupture strength for[d]		
			10 000 h	100 000 h	10 000 h	100 000 h	200 000 h
Name	Number	°C	MPa	MPa	MPa	MPa	MPa
		800 810 820 830 840	–	–	25 23 21 19 18	14 12 11 10 –	11 10 – – –
		850	–	–	16	–	–
X7CrNiTiB18-10	1.4941	550 560 570 580 590	–	–	223 210 196 182 170	170 154 140 127 114	150 135 122 110 100
		600 610 620 630 640	–	–	156 142 130 119 108	102 92 84 76 68	91 82 74 67 60
		650 660 670 680 690	–	–	98 89 80 73 66	62 56 50 44 39	54 49 43 39 33
		700	–	–	60	35	29
X6NiCrTiMoVB25-15-2	1.4980	500 510 520 530 540	580 555 530 505 485	495 475 450 425 400	608 590 570 550 525	545 520 495 470 445	–
		550 560 570 580 590	460 435 410 380 350	375 345 315 280 250	500 475 450 420 395	415 385 355 320 285	–
		600 610 620 630 640	320 290 260 235 210	220 195 170 150 130	365 340 310 285 260	250 220 195 170 150	–
		650	190	110	235	132	–
X7CrNiMoBNb16-16	1.4986	580 590	358 336	302 278	381 364	323 298	–
		600 610 620 630 640	324 306 287 268 247	255 230 204 179 153	344 325 306 287 267	275 251 228 204 181	–
		650 660 670	226 204 182	128 104 85	245 221 198	157 133 113	–

Table C.1 (*7 of 7*)

Material designation		Temperature	Strength for 1% (plastic) creep strain[c]		Creep rupture strength for[d]		
Name	Number	°C	10 000 h MPa	100 000 h MPa	10 000 h MPa	100 000 h MPa	200 000 h MPa
Nickel alloys							
NiCr20TiAl	2.4952	500 510 520 530 540	624 608 586 567 544	530 504 477 450 418	(745) (711) (680) 646 615	(578) (545) (510) 480 447	–
		550 560 570 580 590	523 500 474 450 425	390 362 334 308 282	582 552 520 491 462	416 384 354 327 298	–
		600 610 620 630 640	398 370 348 326 303	257 230 210 187 167	433 403 378 351 325	272 247 222 198 176	–
		650 660 670 680 690	275 260 240 219 201	149 132 115 99 85	300 275 251 229 208	157 135 118 102 88	–
		700 710 720 730 740	183 167 150 135 122	72 64 55 47 40	186 170 153 137 125	75 65 57 49 44	–
		750 760 770 780 790	106 97 85 75 68	33 29 24 20 17	114 103 94 86 78	37 33 29 25 23	–
		800	58	16	70	20	–
NiCr15Fe7TiAl	2.4669	500 550 600 650 700 750 800	790 596 425 325 245 65 15	650 477 345 258 75 16 4	800 605 440 340 255 123 60	659 488 360 265 135 61 28	–

[a] The values given in 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.

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

[c] 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.

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

Annex D
(informative)

Reference data for the relaxation properties

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

Material designation		Temperature	for an initial strain $\varepsilon_{A\ total}$ %	Residual stress in MPa after stressing duration for			
Name	Number			1 000 h	10 000 h	30 000 h	100 000 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	300 350 360 370 380 390	0,2	328 318 315 311 307 302	325 300 296 292 288 282	317 290 286 282 278 272	– 280 276 271 266 260
		400 410 420 430 440 450		295 287 278 267 253 240	275 266 255 242 228 210	265 254 240 227 210 190	250 238 222 205 185 165
		460 470 480 490 500		225 209 190 171 155	189 162 133 107 85	166 139 109 81 60	140 111 82 59 38
		510 520 530 540 550		139 122 107 91 77	68 55 46 39 33	47 37 28 22 17	28 20 15 10 7
20CrMoVTiB 4-10	1.7729	400 450 500 550 600	0,15	247 216 180 134 61	224 188 141 70 –	212 173 118 42 –	–

Table D.1 *(continued)*

Material designation		Temperature	for an initial strain $\varepsilon_{A\ total}$, %	Residual stress in MPa after stressing duration for			
Name	**Number**			1 000 h	10 000 h	30 000 h	100 000 h
X22CrMoV12-1	1.4923	400 410 420 430 440	0,2	307 294 280 267 252	280 264 249 232 218	265 249 232 218 200	245 229 212 197 180
		450 460 470 480 490		238 225 211 198 183	202 188 175 162 150	185 170 157 144 132	165 152 139 126 114
		500 510 520 530 540		170 157 143 130 118	137 124 110 96 82	120 107 94 81 68	102 90 79 67 55
		550 560 570 580 590		105 94 84 75 66	70 60 52 45 38	57 47 39 31 23	43 – – – –
		600		56	30	15	–
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	0,15	61	30	21	–
X10CrNiMoMnNbVB 15-10-1	1.4982	550 600 625 650 700		–	200 165 140 122 55	–	–

Table D.1 *(continued)*

Material designation		Temperature	for an initial strain	Residual stress in MPa after stressing duration for			
Name	Number		$\varepsilon_{A\ total}$, %	1 000 h	10 000 h	30 000 h	100 000 h
NiCr20TiAl	2.4952	450	0,15	280	266	256	–
		500		271	250	234	
		510		269	245	228	
		520		266	239	221	–
		530		263	232	213	
		540		259	225	205	
		550		255	218	196	
		560		249	209	187	
		570		244	201	176	–
		580		238	193	166	
		590		231	183	155	
		600		224	174	144	
		610		216	163	133	
		620		208	153	121	–
		630		200	141	108	
		640		190	129	96	
		650	0,15 and 0,20	181	119	85	
		660		170	107	75	
		670		160	97	65	–
		680		149	88	56	
		690		138	79	48	
		700		127	70	40	
		710		117	61	33	
		720		107	53	27	–
		730		97	45	22	
		740		88	38	17	
		750		79	31	13	–

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

Annex E
(informative)

Significant changes to the previous version EN 10269:1999

Some significant changes to the version EN 10269:1999 are:

a) Scope of the standard has been extended;

b) new steel grades (e.g. 20MnB4, 23MnB4, 26NiCrMo14-6) added;

c) old steel grades (e.g. 19MnB4, 41NiCrMo7-3-2) deleted;

d) additional data concerning impact testing (chapter 11.5) added;

e) splitting of steel grades and of according tables in those which fulfil or do not fulfil the PED requirements;

f) in Table 12 new option concerning testing of hardness added;

g) data in the tables generally updated;

h) normative references actualized;

i) editorial corrections.

Annex ZA
(informative)

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

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

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations (but consider also Table 4 and Table 5).

Table ZA.1 — Correspondence between this European Standard and the essential requirements of the EU Directive 97/23/EC, Annex I

Clauses /subclauses of this EN	Essential Requirements (ERs) of Annex I of the Directive 97/23/EC	Qualifying remarks / Notes
8.4; Tables 4, 6, 8 and 10	4.1a	Appropriate material properties
8.2.1; 8.5 and 8.6	4.1d	Suitable for the processing procedures
9; 10.1.2 and 11.3	4.3	Documentation
12.1 and Table 13	3.1.5	Traceability

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

Bibliography

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

[2] Directive 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment

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