



BSI Standards Publication

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

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 It supersedes BS EN 10269:1999+A1:2006 which is withdrawn.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.

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EUROPEAN STANDARD

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EUROPÄISCHE NORM

October 2013

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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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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of an identical text or by endorsement, at the latest by April 2014, and conflicting national standards shall be withdrawn at the latest by April 2014.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: $\rho = 7,70 \text{ kg/dm}^3$;
- for X8Ni9: $\rho = 7,89 \text{ kg/dm}^3$;
- for austenitic CrNiMo steels: $\rho = 8,00 \text{ kg/dm}^3$.

For all other steels a density of $7,85 \text{ kg/dm}^3$ 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 facility¹⁾. 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 $L_0 = 5,65 \sqrt{S_0}$ (S_0 = 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.

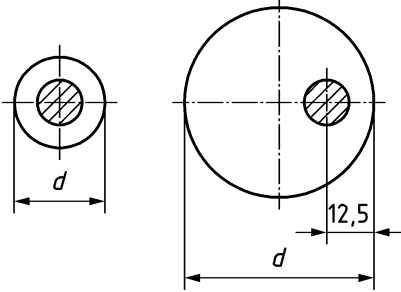
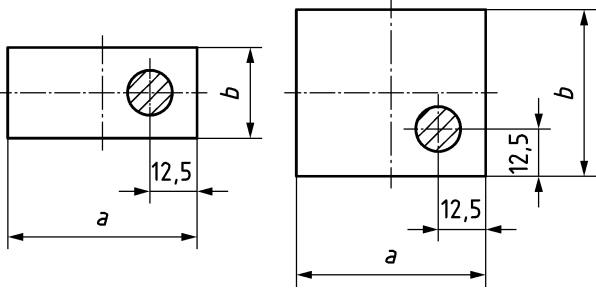
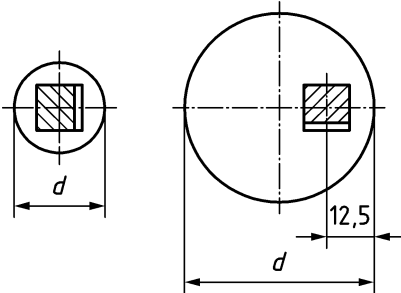
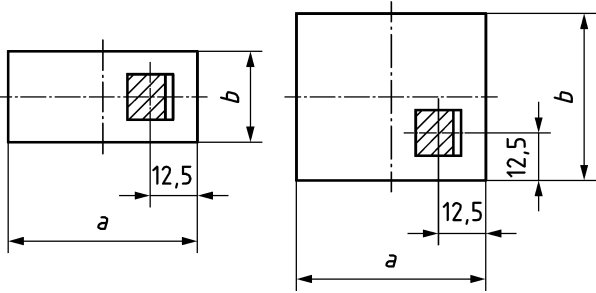
11.6.4 The manufacturer shall take suitable measures to prevent materials becoming mixed up.

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	<p>$d \leq 25$^b $25 < d \leq 160$</p>  <p>a)</p> <p>(full round cross-section, where possible)</p>	<p>$b \leq 25$ $a \geq b$ $25 < b \leq 160$ $a \geq b$</p>  <p>b)</p>
Impact ^a	<p>$15 \leq d \leq 25$ $25 < d \leq 160$</p>  <p>c)</p>	<p>$15 \leq b \leq 25$ $a \geq b$ $25 < b \leq 160$ $a \geq b$</p>  <p>d)</p>

^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
X10CrNiMoMnNbVB1 5-10-1	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
<p>^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.</p> <p>^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.</p> <p>^c For requirements regarding magnetic properties up to a maximum of 0,28 % C.</p>													

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

Table 4 (continued)

Material designation		Heat treatment condition ^a	Diameter ^c <i>d</i> mm	Proof strength <i>R</i> _{p0,2} MPa min.	Tensile strength <i>R</i> _m MPa	Elongation after fracture <i>A</i> % min.	Reduction in area <i>Z</i> % min.	Impact energy (ISO-V) at 20°C <i>KV</i> ₂ J min.
Name	Number							
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							
			<i>d</i> mm	$R_{p0,2}$ MPa min.	R_m MPa	<i>A</i> % min.	<i>Z</i> % 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 <i>d</i> 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 <i>d</i> 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 <i>d</i> 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	$d \leq 160$	681 ^{*)}	650	625 ^{*)}	600	575 ^{*)}	550	518 ^{*)}	485	440	390	–	–	–
X19CrMoNbVN11-1	1.4913	+QT	$d \leq 160$	726 ^{*)}	701	676	651	643	627	610	577	544	495	412	305	–
Nickel alloys																
NiCr20TiAl	2.4952	+AT+P	$d \leq 160$	595 ^{*)}	586 ^{*)}	577 ^{*)}	568	564	560	550	540	530	520	510	500	480
NiCr19Fe19Nb5Mo3	2.4668	+P	$d \leq 160$	–	–	–	–	–	880	–	865	–	860	–	860	–
NiCr15Fe7TiAl	2.4669	+AT+P	$d \leq 25$	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 " <i>d</i> " will be replaced by " <i>b</i> " (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 <i>d</i> 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 <i>d</i> 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 " <i>d</i> " will be replaced by " <i>b</i> " (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 <i>d</i> mm	Minimum impact energy <i>KV₂</i> in J ^c (ISO-V test piece) at a test temperature in °C of:																
				-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	<i>d</i> ≤ 16	–	–	–	–	–	–	–	–	–	–	–	27	–	–	40	40	40
23MnB4	1.5535	+QT	<i>d</i> ≤ 24	–	–	–	–	–	–	–	–	–	–	–	27	–	–	40	40	40
23MnB3	1.5507	+QT	<i>d</i> ≤ 16	–	–	–	–	–	–	–	–	–	–	–	27	–	–	40	40	40
20Mn5	1.1133	+N	<i>d</i> ≤ 60	–	–	–	–	–	–	–	–	–	–	–	–	27	31	47	55	55
			60 < <i>d</i> ≤ 150	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	40	55
25CrMo4	1.7218	+QT	<i>d</i> ≤ 60	–	–	–	–	–	–	–	–	–	–	–	40	40	45	50	–	60
			60 < <i>d</i> ≤ 100	–	–	–	–	–	–	–	–	–	–	–	–	40	40	50	–	60
42CrMo4	1.7225	+QT	<i>d</i> ≤ 60	–	–	–	–	–	–	27	–	–	–	–	–	–	40	–	–	50
34CrNiMo6	1.6582	+QT	<i>d</i> ≤ 100	–	–	–	–	–	–	–	–	–	–	–	–	–	40	–	–	45
30CrNiMo8	1.6580	+QT	<i>d</i> ≤ 100	–	–	–	–	–	–	–	–	–	–	–	–	–	40	–	–	45
X12Ni5	1.5680	(+N), +NT	<i>d</i> ≤ 40	–	–	–	–	40	45	50	55	60	60	65	65	65	65	70	70	70
			40 < <i>d</i> ≤ 75	–	–	–	–	–	–	–	–	50	55	60	60	65	65	65	65	–
X8Ni9	1.5662	+N +NT (or +QT)	<i>d</i> ≤ 75	–	40	45	50	50	–	60	–	70	70	70	70	70	70	70	70	70
		+QT	<i>d</i> ≤ 75	–	70	–	–	100	–	110	–	120	120	120	120	120	120	120	120	120

Table 10 (continued)

Material designation		Heat treatment condition ^a	Diameter ^e <i>d</i> mm	Minimum impact energy KV_2 in J ^c (ISO-V test piece) at a test temperature in °C of:															
				-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 <i>d</i> mm	Minimum impact energy <i>KV</i> 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	<i>d</i> ≤ 160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	
NiCr20TiAl	2.4952	+AT+P	<i>d</i> ≤ 160	-	20	-	-	-	-	-	-	-	-	-	-	-	-	20	
NiCr15Fe7TiAl	2.4669	+AT+P	<i>d</i> ≤ 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 " <i>d</i> " will be replaced by " <i>b</i> " (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				
<p>^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.</p> <p>^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).</p> <p>^c • The number of samples and test pieces per sample shall be agreed at time of enquiry and order.</p> <p>^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.</p> <p>^e •• Optional for austenitic steels, except austenitic grades for cryogenic service (> 15 mm diameter or thickness).</p> <p>^f •• For materials for use at low temperatures.</p> <p>^g For verification of internal soundness (see 8.6).</p> <p>^h See 11.6.1 and 11.6.2.</p>						

Table 13 — Marking of the products

Marking of	Symbol ^a
Manufacturer'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.	(+)
<p>^a The symbols in the table mean: + = the marking shall be applied; (+) = the marking shall be applied if so agreed, or at the manufacturer's discretion.</p> <p>^b The numbers or letters used for identification shall allow the product(s) to be related to the relevant inspection document.</p> <p>^c This shall permit the traceability of the cast number.</p>	

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									
X5CrNi18-10	1.4301										
X4CrNi18-12	1.4303										
X2CrNiMo17-12-2	1.4404	8,0	200	194	186	179	172	165	-	-	-
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 $\frac{W}{m \cdot K}$	Specific thermal capacity at 20 °C $\frac{J}{kg \cdot K}$	Electrical resistivity at 20 °C $\frac{\Omega \cdot mm^2}{m}$		
Name	Number	100 °C	200 °C	300 °C	400 °C	500 °C	600 °C					
		$10^{-6} K^{-1}$										
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											
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						n.a.					
X4CrNi18-12	1.4303						n.a.					
X2CrNiMo17-12-2	1.4404						17,5			18,0	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.			
X6CrNi18-10	1.4948	16,3	16,9	17,3	17,6	18,2	18,5	16	450	0,71		
X10CrNiMoMnNbV B 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											
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 °C	Strength for 1% (plastic) creep strain ^c		Creep rupture strength for ^d		
Name	Number		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	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)	–

Table C.1 (2 of 7)

Material designation		Temperature °C	Strength for 1% (plastic) creep strain ^c		Creep rupture strength for ^d		
Name	Number		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	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	–
		42CrMo5-6	1.7233	450	–	–	495
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
		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
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

Table C.1 (3 of 7)

Material designation		Temperature °C	Strength for 1% (plastic) creep strain ^c		Creep rupture strength for ^d		
			10 000 h MPa	100 000 h MPa	10 000 h MPa	100 000 h MPa	200 000 h MPa
Name	Number						
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	–	–
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			164	113	96
		510			145	96	80
		520	–	–	129	81	68
		530			114	70	57
		540			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	–

Table C.1 (4 of 7)

Material designation		Temperature °C	Strength for 1% (plastic) creep strain ^c		Creep rupture strength for ^d				
Name	Number		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	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		
		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		
X10CrNiMoMnNbVB 15-10-1	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				

Table C.1 (5 of 7)

Material designation		Temperature	Strength for 1% (plastic) creep strain ^c		Creep rupture strength for ^d				
			10 000 h MPa	100 000 h MPa	10 000 h MPa	100 000 h MPa	200 000 h MPa		
Name	Number	°C							
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 °C	Strength for 1% (plastic) creep strain ^c		Creep rupture strength for ^d		
			10 000 h MPa	100 000 h MPa	10 000 h MPa	100 000 h MPa	200 000 h MPa
Name	Number						
		800			25	14	11
		810			23	12	10
		820	–	–	21	11	–
		830			19	10	–
		840			18	–	–
		850	–	–	16	–	–
		X7CrNiTiB18-10	1.4941	550			223
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
X6NiCrTiMoVB25-15-2	1.4980			500	580	495	608
		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
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	

Table C.1 (7 of 7)

Material designation		Temperature °C	Strength for 1% (plastic) creep strain ^c		Creep rupture strength for ^d		
Name	Number		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	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	–		
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	
<p>^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.</p> <p>^b * and () indicate values of extended stress extrapolation or time extrapolation, respectively.</p> <p>^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.</p> <p>^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.</p>							

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 ϵ_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	0,15	211	205	201	—
		400		198	179	164	
		450		157	118	96	
		500		93	30		
40CrMoV4-6	1.7711	400	0,15	234	215	192	—
		450		188	157	141	
		500		136	83	47	
21CrMoV5-7	1.7709	300	0,2	328	325	317	—
		350		318	300	290	280
		360		315	296	286	276
		370		311	292	282	271
		380		307	288	278	266
		390		302	282	272	260
		400		295	275	265	250
		410		287	266	254	238
		420		278	255	240	222
		430		267	242	227	205
		440	253	228	210	185	
		450	240	210	190	165	
		460	225	189	166	140	
		470	209	162	139	111	
		480	190	133	109	82	
		490	171	107	81	59	
		500	155	85	60	38	
		510	139	68	47	28	
		520	122	55	37	20	
		530	107	46	28	15	
540	91	39	22	10			
550	77	33	17	7			
20CrMoVTiB 4-10	1.7729	400	0,15	247	224	212	—
		450		216	188	173	
		500		180	141	118	
		550		134	70	42	
		600		61	—	—	

Table D.1 (continued)

Material designation		Temperature	for an initial strain $\epsilon_{A \text{ total, } \%}$	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	0,2	307	280	265	245
		410		294	264	249	229
		420		280	249	232	212
		430		267	232	218	197
		440		252	218	200	180
		450		238	202	185	165
		460		225	188	170	152
		470		211	175	157	139
		480		198	162	144	126
		490		183	150	132	114
		500		170	137	120	102
		510		157	124	107	90
		520		143	110	94	79
		530		130	96	81	67
		540		118	82	68	55
		550		105	70	57	43
		560		94	60	47	–
		570		84	52	39	–
		580		75	45	31	–
		590		66	38	23	–
600	56	30	15	–			
X19CrMoNbVN11-1	1.4913	400	0,2	262	237	206	–
		410		257	231	202	–
		420		252	225	199	–
		430		246	218	195	–
		440		240	212	190	–
		450		234	206	185	–
		460		228	198	180	–
		470		221	191	173	–
		480		214	183	165	–
		490		207	175	157	–
		500		199	166	147	–
		510		190	155	136	–
		520		181	143	124	–
		530		171	130	108	–
		540		160	114	92	–
		550		149	98	79	–
560	134	78	66	–			
570	118	63	53	–			
580	100	48	40	–			
590	80	39	30	–			
600	61	30	21	–			
X10CrNiMoMnNbVB 15-10-1	1.4982	550	0,15	–	200	–	–
		600		165	–	–	
		625		140	–	–	
		650		122	–	–	
		700		55	–	–	

Table D.1 (continued)

Material designation		Temperature	for an initial strain $\epsilon_{A, total}$, %	Residual stress in MPa after stressing duration for			
Name	Number			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	0,15	255	218	196	–
		560		249	209	187	
		570		244	201	176	
		580		238	193	166	
		590	231	183	155		
		600	0,15 and 0,20	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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