

Flat products made of steels for pressure purposes —

Part 1: General requirements

The European Standard EN 10028-1:2000, with the incorporation of amendment A1:2002, has the status of a British Standard

ICS 77.140.30

National foreword

This British Standard is the official English language version of EN 10028-1:2000, including amendment A1:2002. It supersedes BS EN 10028-1:1993 which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags $\boxed{A1}$ $\langle A1 \rangle$. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by $\boxed{A1}$ $\langle A1 \rangle$.

The UK participation in its preparation was entrusted by Technical Committee ISE/73, Steels for pressure purposes, to Subcommittee ISE/73/2, Steel plates and bars for pressure purposes, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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

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**Flat products made of steels for pressure purposes - Part 1:
General requirements**
(includes amendment A1:2002)

Produits plats en aciers pour appareils à pression - Partie 1:
Prescriptions générales
(inclut l'amendement A1:2002)

Flacherzeugnisse aus Druckbehälterstählen - Teil 1:
Allgemeine Anforderungen
(enthält Änderung A1:2002)

This European Standard was approved by CEN on 29 October 1999. Amendment A1 was approved by CEN on 16 October 2002.

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

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 Central Secretariat 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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Foreword

This European Standard has been prepared by Technical Committee ECISS/TC 22, Steels for pressure purposes - Qualities, the Secretariat of which is held by DIN.

This European Standard supersedes EN 10028-1:1992 and takes into consideration further standards of the EN 10028 series.

The other parts of this European Standard are:

Part 2: Non-alloy and alloy steels with specified elevated temperature properties;

Part 3: Weldable fine grain steels, normalized;

Part 4: Nickel-alloy steels with specified low temperature properties;

Part 5: Weldable fine grain steels, thermomechanically rolled;

Part 6: Weldable fine grain steels, quenched and tempered;

Part 7: Stainless steels.

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 October 2000, and conflicting national standards shall be withdrawn at the latest by October 2000.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

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

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

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

Foreword to amendment A1

This document EN 10028-1:2000/A1:2002) has been prepared by Technical Committee ECISS/TC 22, Steels for pressure purposes — Qualities, the Secretariat of which is held by DIN.

This amendment to the European Standard EN 10028-1:2000 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2003, and conflicting national standards shall be withdrawn at the latest by May 2003.

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(s).

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard EN 10028-1 specifies the general technical delivery conditions for flat products used principally for the construction of pressure equipments.

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

2 Normative references

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

CR 10260	Designation systems for steel - Additional symbols for steel names (CEN Report).
EN 10002-1	Metallic materials - Tensile testing - Part 1: Method of test (at ambient temperature).
EN 10002-5	Metallic materials - Tensile testing - Part 5: Method of test at elevated temperatures.
EN 10020	Definition and classification of grades of steel.
EN 10021	General technical delivery conditions for steel and steel products.
EN 10027-1	Designation systems for steel - Part 1: Steel names, principal symbols.
EN 10027-2	Designation systems for steel - Part 2: Numerical system.
EN 10028-7	Flat products made of steels for pressure purposes - Part 7: Stainless steels.
EN 10029	Hot-rolled plates 3 mm thick or above - Tolerances on dimensions, shape and mass.
EN 10045-1	Metallic materials - Charpy impact test - Part 1: Method of test.
EN 10048	Hot-rolled narrow steel strip; tolerances on dimensions and shape.
EN 10051	Continuously hot-rolled uncoated plate, sheet and strip of non-alloy and alloy steels - Tolerances on dimensions and shape.
EN 10052	Vocabulary of heat treatment terms for ferrous products.
EN 10079	Definitions of steel products.
EN 10088-1	Stainless steels - Part 1: List of stainless steels.
EN 10160	Ultrasonic testing of steel flat product of thickness equal to or greater than 6 mm (reflection method).

EN 10163-2	Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections - Part 2: Plates and wide flats.
EN 10164	Steel products with improved deformation properties perpendicular to the surface of the product - Technical delivery conditions.
EN 10168 ¹	Iron and steel products - Inspection documents - List and description of the information.
EN 10204	Metallic products - Types of inspection documents (includes amendment A1:1995).
EN 10258	Cold-rolled stainless steel narrow strip and cut lengths - Tolerances on dimensions and shape.
EN 10259	Cold-rolled stainless steel wide strip and plate/sheet - Tolerances on dimensions and shape.
EN ISO 377	Steel and steel products - Location and preparation of samples and test pieces for mechanical testing (ISO 377:1997).
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 3651-2:1998).
EN ISO 2566-1	Steel - Conversion of elongation values - Part 1: Carbon and low alloy steels (ISO 2566-1:1984).
EN ISO 2566-2	Steel - Conversion of elongation values - Part 2: Austenitic steels (ISO 2566-2:1984).
ISO 14284	Steel and iron - Sampling and preparation of samples for the determination of chemical composition.

3 Definitions

For the purpose of this European Standard the definitions in:

- EN 10020 for classification of steels;
- EN 10079 for product forms; and
- EN 10052 for types of heat treatment apply.

3.1 deviates from EN 10052, and 3.2 is additional to EN 10052. The following are defined.

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

3.1 Normalizing rolling is a rolling 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. The symbol for this delivery condition and for the normalized condition is N.

3.2 Additional to the definitions for thermomechanical treatment, quenching and tempering the following should be noted.

NOTE 1: Thermomechanical rolling (symbol M) may include processes of increased cooling rates with or without tempering including self-tempering but excluding definitively direct quenching and tempering.

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

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

4 Dimensions and tolerances on dimensions

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

4.1 For non-continuously hot-rolled flat products, refer to EN 10029.

- Unless otherwise agreed at the time of enquiry and order, class B as specified in EN 10029 applies to the tolerance on thickness of plates.

4.2 For continuously hot-rolled coil or sheet/plate cut from coils (rolled width 600 mm or above) and hot-rolled slit coil in widths less than 600 mm, refer to EN 10051.

4.3 For hot-rolled narrow strip (rolled width less than 600 mm), refer to EN 10048.

4.4 For stainless cold-rolled sheet/plate, cold-rolled coil and slit coil (rolled width 600 mm or above), refer to EN 10259 and for stainless cold-rolled coil and slit coil in rolled widths less than 600 mm, refer to EN 10258.

NOTE: EN 10258 and EN 10259 contain options providing wider dimensional choice.

5 Calculation of mass

$\sqrt{A_1}$
A density of 7,85 kg/dm³ shall be used as the basis for the calculation of the nominal mass from the nominal dimensions of all steels of EN 10028-2 to EN 10028-6. For density of corrosion-resisting steels, see annex A of EN 10088-1. For density of austenitic creep-resisting steels, see annex A of EN 10028-7. $\sqrt{A_1}$

6 Classification and designation

6.1 Classification

6.1.1 The classification of the steel grades in accordance with EN 10020 is given in the specific parts of EN 10028.

6.1.2 Steels covered in EN 10028-7 are additionally classified according to their structure into:

- ferritic steels;
- martensitic steels;
- austenitic steels;
- austenitic-ferritic steels.

NOTE: For more details see EN 10088-1.

6.2 Designation

The steel grades specified in the individual parts of EN 10028 are designated with steel names and steel numbers. The steel names have been allocated in accordance with EN 10027-1 and CR 10260. The corresponding steel numbers have been allocated in accordance with EN 10027-2.

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;
- b) the type of flat product;
- c) the European Standard specifying the tolerances on dimensions, shape and mass (see clause 4) 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 steel name or number;
- g) the delivery condition, if it differs from the usual condition specified in the individual parts of EN 10028; for stainless steels - the process route selected from the relevant table of EN 10028-7;
- h) inspection document to be issued (see 9.1.1).

7.2 Options

A number of options are specified in this part of EN 10028 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 products shall be supplied in accordance with the basic specification (see 7.1).

- a) Deviating tolerance class (see 4.1);
- b) Specification of the steelmaking process (see 8.1.1);
- c) Mechanical properties after additional heat treatment (see 8.4.1);
- d) Specification of special classes for the reduction of area (see 8.4.2);
- e) Additional tests (see 9.2.2);
- f) Deviating frequency of testing (see 10.1.1 and 10.1.3);
- g) Deviating delivery condition (see 10.2.1.3);
- h) Use of longitudinal test pieces for the impact test (see 10.2.2.3);
- i) Specification of an analytical method (see 11.1);
- j) Temperature of the tensile test at elevated temperature (see 11.3);
- k) Deviating testing temperature for the impact test (see 11.4);
- l) Marking method (see 12.1);
- m) Special marking (see 12.2 and 12.3);
- n) Information to be given by marking (see Table 1).

8 Requirements

8.1 Steelmaking process

8.1.1 •• Unless a special steelmaking process has been agreed at the time of enquiry and order, the steelmaking process for steels in accordance with this European Standard shall be at the discretion of the manufacturer.

8.1.2 Steels other than stainless steels shall be fully killed.

8.2 Delivery condition

See the individual parts of EN 10028 (see also 3.1 and 3.2).

8.3 Chemical composition

8.3.1 Cast analysis

The cast analysis reported by the steel producer shall apply and comply with the requirements of the individual parts of EN 10028.

8.3.2 Product analysis

The permissible product analysis tolerances on the limiting values given for the cast analysis are specified in the individual parts of EN 10028.

8.4 Mechanical properties

8.4.1 The values given in the individual parts of EN 10028 apply for test pieces taken and prepared in accordance with 10.2.2. The values relate to the nominal thicknesses (thicknesses on ordering) of the products and apply to the usual delivery conditions (see the specific parts of EN 10028).

•• Agreement shall be reached, where appropriate, at the time of enquiry and order about the mechanical properties to be adhered to after additional heat treatment.

8.4.2 •• For products (except products made of stainless steels) of thickness 15 mm and above, it may be agreed at the time of enquiry and order to meet the requirements of one of the quality classes Z 15, Z 25, or Z 35 as specified in EN 10164 characterized by minimum values for the reduction of area perpendicular to the product surface.

8.5 Surface condition

For plates, the requirements of surface quality as specified in EN 10163-2 shall apply as follows.

- a) For plates in accordance with EN 10028-2 to -6, class B2.
- b) For plates in accordance with EN 10028-7, class B3.

8.6 •• Internal soundness

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

For the internal soundness, where appropriate, requirements together with the conditions of their verification (see 7.2.e and 11.5.3) may be specified at the time of enquiry and order.

For possible verification of internal soundness see 9.2.2. **A₁**

9 Inspection

9.1 Types of inspection and inspection documents

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

The purchaser shall state the required type of inspection documents (3.1.A, 3.1.B, 3.1.C or 3.2) in accordance with EN 10204. If an inspection document 3.1.A, 3.1.C or 3.2 is ordered, the purchaser shall

notify the manufacturer of the name and the address of the organization or person who is to carry out the inspection and produce the inspection document. In the case of the inspection report 3.2 the party to issue the certificate shall be agreed.

9.1.2 The inspection document shall contain, in accordance with EN 10168, the following codes and information.

- a) Information blocks A, B and Z; the tempering temperature shall also be given in the case of quenched and tempered or tempered products.
- b) Results of the cast analysis in accordance with boxes C71 to C92.
- c) Results of the tensile tests at room temperature in accordance with boxes C00 to C03 and C10 to C13.
- d) Results of the impact test except for austenitic steels of EN 10028-7 in accordance with boxes C00 to C03 and C40 to C43.
- e) Result of the visual examination of the products (see information block D).
- f) If one or several of the following options have been agreed at the time of enquiry and order, the relevant information on:
 - 1) the steelmaking process (section C70);
 - 2) the product analysis in accordance with boxes C71 to C92;
 - 3) the results of the tensile test at elevated temperature (see 9.2.2) in accordance with boxes C00 to C03, C10 and C11;
 - 4) the minimum reduction of area perpendicular to the product surface boxes in accordance with boxes C00 to C03, C10 and C14 to C29;
 - 5) the ultrasonic test for internal soundness (information block F);
 - 6) impact properties of austenitic steels at room temperature in accordance with boxes C00 to C03 and C40 to C43;
 - 7) impact properties of stainless steels at low temperature in accordance with boxes C00 to C03 and C40 to C43;
 - 8) resistance of stainless steels to intergranular corrosion in accordance with boxes C60 to C69.

9.2 Tests to be carried out

9.2.1 The following tests shall be carried out:

- tensile test at room temperature;
- impact test (except for austenitic steels of EN 10028-7), but see 10.2.2.3;
- dimensional test;
- visual examination of the surface condition.

9.2.2 •• The following tests may be agreed:

- product analysis;
- tensile test for verification of 0,2 % proof strength at elevated temperature (except for steels of EN 10028-4 and EN 10028-5);
- tensile test for (simultaneous) verification of one, all, or any combination of 0,2 % proof strength, 1,0 % proof strength and tensile strength at elevated temperature for austenitic steels of EN 10028-7;
- tensile test perpendicular to the product surface (except for steels of EN 10028-7);
- impact tests for austenitic steels of EN 10028-7 at room temperature;
- impact tests for steels of EN 10028-7 (except ferritic steels) at low temperature;
- ultrasonic test for verification of internal soundness;
- determination of resistance to intergranular corrosion for steels of EN 10028-7.

9.3 Re-tests

See EN 10021.

10 Sampling

10.1 Frequency of testing

10.1.1 •• For the product analysis, unless otherwise agreed, one test piece per cast shall be taken for determining the elements indicated with numerical values for the particular steel grade in the relevant tables of the specific parts of EN 10028.

10.1.2 The test unit for products in accordance with EN 10028-2 to EN 10028-6 for the tensile test at room temperature and the impact test shall be as follows.

- For strip and sheet cut from strip, the coil.
- For sheet or plate, the rolled plate.

If a rolled plate or a coil is split up into several heat treatment batches for liquid quenching, then each individual heat treatment batch shall be regarded as a test unit. One sample shall be taken for preparing the test pieces indicated in 10.2.2 from each test unit.

For stainless steels see EN 10028-7.

10.1.3 ●● For tensile tests at elevated temperature, unless otherwise agreed, the test unit shall be the cast.

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 377 and ISO 14284. In addition, the requirements in 10.2.1.2 and, if applicable, 10.2.1.3 shall apply for sampling and sample preparation for the mechanical tests.

10.2.1.2 The samples shall be taken at $\frac{1}{4}$ product width (see Figure 1) for the tensile test at room temperature, the impact test and the tensile test at elevated temperature. In the case of strip, the samples shall be taken at a sufficient distance from the end of the strip.

NOTE: If samples have to be taken from the mid-width position in accordance with the requirements for through-thickness testing as specified in EN 10164, the samples to be taken as specified in 10.2.1.2 may also be taken from there except in cases of arbitration.

10.2.1.3 ●● If, following agreement at the time of enquiry and order, the products are not to be delivered in the usual delivery condition, the samples shall be treated to the usual delivery condition prior to the test.

10.2.2 Preparation of test pieces

10.2.2.1 General

The test pieces shall be prepared in accordance with Figure 2 (products in accordance with EN 10028-2 to -6) or Figure 3 (products in accordance with EN 10028-7).

10.2.2.2 Test pieces for the tensile test

One test piece shall be prepared in accordance with EN 10002-1 for the tensile test from each test unit and this shall be a rectangular test piece, unless a round test piece may be used (see third paragraph).

At least one rolled surface shall be retained on rectangular test pieces. However, both rolled surfaces shall generally be retained on the test piece in the case of product thicknesses ≤ 30 mm for products in

accordance with EN 10028-2 to -6 or ≤ 10 mm in the case of products in accordance with EN 10028-7. Additionally, rectangular test pieces for products in accordance with EN 10028-6, shall represent either the full product thickness or half of the product thickness retaining one rolled surface.

Round test pieces are permissible, but shall only be provided for product thicknesses > 30 mm for products in accordance with EN 10028-2 to -6 or > 10 mm for products in accordance with EN 10028-7. Test piece diameters shall be at least 10 mm for products in accordance with EN 10028-2 to -6 or at least 5 mm for products in accordance with EN 10028-7 respectively.

10.2.2.3 Test pieces for the impact test

Three transverse standard V-notched test pieces shall be prepared from the samples for the impact test, in accordance with EN 10045-1.

•• For products in accordance with EN 10028-3, EN 10028-4 and EN 10028-7 longitudinal test pieces may be agreed.

In the case of nominal product thicknesses (t) of $6 \text{ mm} \leq t \leq 10 \text{ mm}$ subsidiary size test pieces of widths of 7,5 mm or 5 mm shall be machined. Test pieces shall not be machined for product thicknesses $< 6 \text{ mm}$.

The notch shall be perpendicular to the surface of the product.

11 Test methods

11.1 •• Chemical analysis

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

11.2 Tensile test at room temperature

11.2.1 For the steels of EN 10028-2 to EN 10028-6 the tensile test at room temperature shall be carried out in accordance with EN 10002-1, generally using a proportional test piece of gauge length $L_0 = 5,65\sqrt{S_0}$ (S_0 : cross-sectional area of the test piece). Test pieces with a constant gauge length may be used; in this case, the elongation value shall be converted in accordance with EN ISO 2566-1 for the steels of EN 10028-2 to EN 10028-6.

The yield strength to be determined shall be the upper yield strength (R_{eH}) or, wherever this is not pronounced, the 0,2 % proof strength ($R_{p0,2}$).

11.2.2 For the steels of EN 10028-7 the tensile test at room temperature shall be carried out in accordance with EN 10002-1 taking into account the additional or deviating conditions specified in Figure 3. For non-proportional test pieces, the elongation values shall be converted in accordance with EN ISO 2566-2. The tensile strength and elongation after fracture shall be determined and additionally

for ferritic, martensitic and austenitic-ferritic steels the 0,2 % proof strength and for austenitic steels the 0,2 % and 1,0 % proof strength.

In cases of dispute, and where permitted (see 10.2.2.2, third paragraph), the tensile test shall be carried out on round test pieces.

11.3 Tensile test at elevated temperature

The 0,2 % proof strength, the 1,0 % proof strength and the tensile strength at elevated temperature shall be determined in accordance with EN 10002-5. Verification if required, shall be obtained at one of the temperatures given in the relevant table of the individual parts of EN 10028.

- This temperature should be agreed at the time of enquiry and order; otherwise the test shall be carried out at 300 °C except for austenitic-ferritic steels of EN 10028-7 for which the test shall be carried out at 250 °C.

11.4 Impact test

The impact test on V-notched test pieces shall be carried out in accordance with EN 10045-1. The specifications of the individual parts of EN 10028 shall apply.

- Where minimum impact energy values are specified for several temperatures, verification of the impact energy, unless otherwise agreed, shall be carried out at the temperature for which the value of 27 J is specified.

Where the minimum impact energy value specified at the lowest temperature is higher than 27 J this higher value shall be verified.

The impact energy values apply to transverse test pieces for the steel grades specified in EN 10028-2, EN 10028-5 and EN 10028-6 and for longitudinal and/or transverse test pieces for the steel grades specified in EN 10028-3, EN 10028-4 and EN 10028-7.

Where subsidiary test pieces are used (see 10.2.2.3), the minimum impact energy values given in the specific parts of EN 10028 shall be reduced in proportion to the cross-sectional area of the test piece. For product thicknesses < 6 mm, the impact test shall not be carried out.

The minimum impact values given in the individual parts of EN 10028 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 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.

11.5 Other testing

11.5.1 The surface condition of the products shall be checked by visual examination without optical aids.

11.5.2 The dimensions of the products shall be checked.

11.5.3 If an ultrasonic test has been agreed for plate of thicknesses ≥ 6 mm for verification of internal soundness, the requirements of EN 10160 shall apply.

11.5.4 If agreed, the resistance to intergranular corrosion shall be tested in accordance with EN ISO 3651-2.

11.5.5 The manufacturer shall take suitable measures to prevent materials becoming mixed up and to ensure traceability.

12 Marking

12.1 The products shall be marked with the information given in Table 1.

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

Plates and sheets shall be marked by low stress stamping or stencilling or ink marking.

Sheets in bundles and strip in coil shall be marked on a securely attached label. If requested, this may also be applied to ground or polished plates.

For products in accordance with EN 10028-7, the quality of marking shall be such that it shall be durable for at least one year in untreated storage under cover. Care must be taken that the corrosion resistance of those products is not impaired by the marking method.

12.2 •• If agreed at the time of enquiry and order, a mark applied by stamping shall have a coloured frame.

12.3 •• If any other marks are to be made, this shall be agreed upon at the time of enquiry and order.


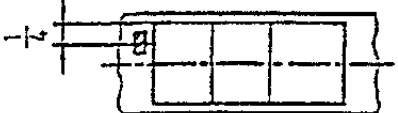
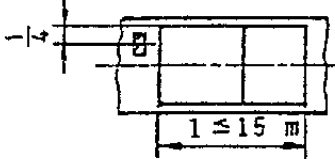
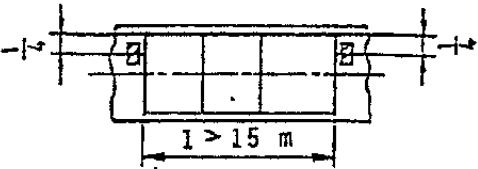
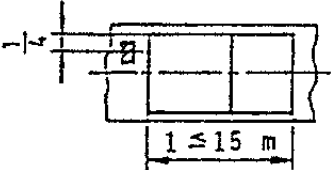
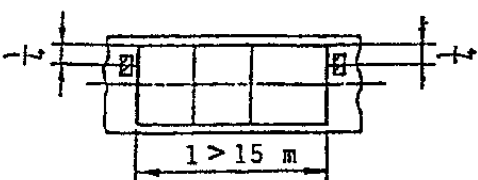
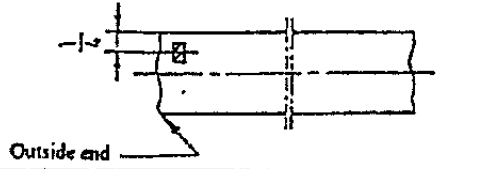
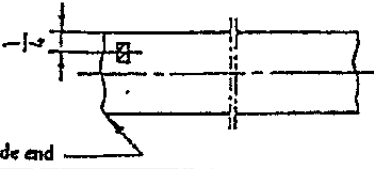
Products	Steel grade	Sheet/ plate thickness mm	Product length supplied per rolled plate m	Position of samples (plan view) ()	
Plate sheet	Non-alloy steels	≤ 50	No limitation		
		> 50	≤ 15		
		> 15	"		
	Alloy steels	No limitation	≤ 15	"	
			> 15	"	
			"	"	
Strip	No distinction	No limitation	-	"  Outside end	
<p>" The samples may also be taken from the other side of the products.</p> <p>" For the plate sheet cut from strip, the strip remains the test unit as long as the plate sheet is not quenched and tempered.</p>					

Figure 1 — Position from which the samples are taken

A1

Type of test piece	Product thickness t mm	Direction of the longitudinal axis of the test piece in relation to the principal direction of rolling	Distance of the test piece from the rolled surface mm
Tensile	≤ 30	Transverse	
	> 30		a
			b
Impact ^c	$> 10^d$	Transverse ^e	
<p>a For products in accordance with EN 10028-2 to EN 10028-4.</p> <p>b For products in accordance with EN 10028-5 and EN 10028-6.</p> <p>c The longitudinal axis of the notch shall always be perpendicular to the rolled surface of the product.</p> <p>d For impact test pieces for plate thickness ≤ 10 mm, see 10.2.2.3.</p> <p>e Unless longitudinal test pieces are agreed (see 10.2.2.3).</p> <p>f In the case of product thicknesses > 40 mm, the impact test piece shall be taken at quarter of the product thickness.</p>			

Key

- 1 Rolled surface
- 2 Alternatives

A1

Figure 2 — Position of test pieces for products in accordance with EN 10028-2 to EN 10028-6



Type of test piece	Product thickness <i>t</i> mm	Direction of the longitudinal axis of the test piece in relation to the principal direction of rolling at a product width		Distance of the test piece from the rolled surface mm
		< 300 mm	≥ 300 mm	
Tensile ^a	≤ 30	Longitudinal	Transverse	
	> 30			
Impact ^b	> 10 ^c	Longitudinal	Transverse	

^a In cases of doubt or dispute the gauge length shall be $L_0 = 5,65 \sqrt{S_0}$ for test pieces from products ≥ 3 mm thickness. For product thicknesses < 3 mm, non-proportional test pieces with a gauge length of 80 mm and a width of 20 mm shall be used, but test pieces with a gauge length of 50 mm and a width of 12,5 mm may also be applied. For product thicknesses $3 \text{ mm} \leq t \leq 10 \text{ mm}$ flat proportional test pieces with two rolled surfaces and a maximum width of 30 mm shall be used. For product thicknesses $> 10 \text{ mm}$, one of the following proportional test pieces may be used:

- either a flat test piece with a maximum thickness of 30 mm; the thickness may be reduced to 10 mm by machining, but one rolled surface must be preserved;
- or a round test piece with a diameter of $\geq 5 \text{ mm}$, the axis of which shall be located as near as possible to a plane in the outer third of half the product thickness.

^b The longitudinal axis of the notch shall always be perpendicular to the rolled surface of the product.

^c For impact test pieces for plate thicknesses $\leq 10 \text{ mm}$, see 10.2.2.3.

^d In the case of product thicknesses $> 30 \text{ mm}$, the impact test piece may be taken at quarter of the product thickness.

Key

- 1 Rolled surface
- 2 Alternatives



Figure 3 — Position of test pieces for products in accordance with EN 10028-7

Table 1: Marking of the products

Marking of	Symbol ¹⁾
Manufacturer's name, trade mark or logo	+
The number of this European Standard	(+)
Steel name or number	+
Type of finish	(+)
Identification number ²⁾	+ ⁴⁾
Direction of rolling ³⁾	(+)
Nominal thickness	(+)
Nominal dimensions other than thickness	(+)
Inspector's mark	+ ⁵⁾
Customer's order no.	(+)
<p>1) The symbols mean:</p> <p style="padding-left: 40px;">+ = the marking shall be applied;</p> <p style="padding-left: 40px;">(+)= the marking shall be applied if so agreed, or at the manufacturer's discretion.</p> <p>2) The numbers or letters used for identification shall allow the product(s) to be related to the relevant inspection certificate or inspection report.</p> <p>3) The direction of rolling is normally obvious from the shape of the product and the position of the marking. Marking may either be longitudinally applied by roller stamping or it may be near to one end of the piece and transverse to the rolling direction.</p> <p>A specific separate indication of the principal rolling direction will not normally be required, but may be requested by the customer.</p> <p>4) This shall permit the traceability of the cast number.</p> <p>5) The inspector's mark may be omitted if the relevant inspector can be identified in another way.</p>	

Annex ZA
(informative)

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

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

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

The clauses of this European Standard are likely to support the essential requirements of section 4 of annex 1, Essential safety requirements, of the Pressure Equipment Directive 97/23/EC.

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

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Flat products made of steels for pressure purposes

**Part 2: Non-alloy and alloy steels
with specified elevated temperature
properties**

ICS 77.140.30; 77.140.50

National foreword

This British Standard is the UK implementation of EN 10028-2:2009. It supersedes BS EN 10028-2:2003 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/73/2, Steel plates and bars 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.

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 30 June 2009.

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Date	Comments

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EN 10028-2

NORME EUROPÉENNE

EUROPÄISCHE NORM

June 2009

ICS 77.140.30; 77.140.50

Supersedes EN 10028-2:2003

English Version

Flat products made of steels for pressure purposes - Part 2: Non-alloy and alloy steels with specified elevated temperature properties

Produits plats en aciers pour appareils à pression - Partie
2: Aciers non alliés et alliés avec caractéristiques
spécifiées à température élevée

Flacherzeugnisse aus Druckbehälterstählen - Teil 2:
Unlegierte und legierte Stähle mit festgelegten
Eigenschaften bei erhöhten Temperaturen

This European Standard was approved by CEN on 14 May 2009.

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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 Management Centre has the same status as the official versions.

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Foreword

This document (EN 10028-2:2009) has been prepared by Technical Committee ECISS/TC 22 "Steels for pressure purposes - Qualities", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2009, and conflicting national standards shall be withdrawn at the latest by December 2009.

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 10028-2:2003.

This European Standard consists of the following parts, under the general title *Flat products made of steels for pressure purposes*:

- *Part 1: General requirements*
- *Part 2: Non-alloy and alloy steels with specified elevated temperature properties*
- *Part 3: Weldable fine grain steels, normalized*
- *Part 4: Nickel alloy steels with specified low temperature properties*
- *Part 5: Weldable fine grain steels, thermomechanically rolled*
- *Part 6: Weldable fine grain steels, quenched and tempered*
- *Part 7: Stainless steels*

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

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.

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

1 Scope

This European Standard specifies requirements for flat products for pressure equipment made of weldable non-alloy and alloy steels with elevated temperature properties as specified in Table 1.

The requirements and definitions of EN 10028-1:2007 + A1:2009 also apply.

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 (Part 1 and this Part 2 of the series) 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 referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 10028-1:2007 + A1:2009, *Flat products made of steels for pressure purposes – Part 1: General requirements*

EN 10204:2004, *Metallic products – Types of inspection documents*

EN 10229:1998, *Evaluation of resistance of steel products to hydrogen induced cracking (HIC)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 10028-1:2007 + A1:2009 apply.

4 Dimensions and tolerances on dimensions

See EN 10028-1:2007 + A1:2009.

5 Calculation of mass

See EN 10028-1:2007 + A1:2009.

6 Classification and designation

6.1 Classification

In accordance with EN 10020, the grades P235GH, P265GH, P295GH and P355GH are non-alloy quality steels. All other grades are alloy special steels.

6.2 Designation

See EN 10028-1:2007 + A1:2009.

7 Information to be supplied by the purchaser

7.1 Mandatory information

See EN 10028-1:2007 + A1:2009.

7.2 Options

A number of options are specified in this European Standard and listed below. Additionally the relevant options of EN 10028-1:2007 + A1:2009 apply. If the purchaser does not indicate a wish to implement any of these options at the time of enquiry and order, the products shall be supplied in accordance with the basic specification (see also EN 10028-1:2007 + A1:2009).

- 1) lower copper content and maximum tin content (see Table 1, footnote b);
- 2) minimum chromium content of 0,80% (see Table 1, footnote f);
- 3) maximum carbon content of 0,17% for product thicknesses greater than 150 mm (see Table 1, footnote g);
- 4) tests in the simulated normalized condition (see 8.2.2);
- 5) delivery conditions deviating from those specified in Table 3 (see 8.2.2 and 8.2.3);
- 6) maximum carbon equivalent value for P235GH, P265GH, P295GH and P355GH (see 8.3.3);
- 7) specification of a minimum impact energy of 40 J (see Table 3);
- 8) mechanical properties for product thicknesses > 250 mm (see Table 3, footnote a);
- 9) specification of the delivery condition +QT where the usual delivery condition is +NT (see Table 3, footnote c and Table 4, footnote c);
- 10) additional impact energy values (see Table 3, footnote f);
- 11) Rp0,2 values at elevated temperature for increased product thicknesses (see Table 4, footnote b);
- 12) HIC test in accordance with EN 10229 (see 8.7);
- 13) step cooling test in accordance with Annex E (see 8.8);
- 14) mid thickness test pieces for the impact test (see Clause 10);

7.3 Example for ordering

10 plates with nominal dimensions, thickness = 50 mm, width = 2 000 mm, length = 10 000 mm, made of a steel grade with the name 16Mo3 and the number 1.5415 as specified in EN 10028-2, to be delivered untreated, inspection document 3.1 as specified in EN 10204:

10 plates – 50 x 2 000 x 10 000 – EN 10028-2 16Mo3+AR - Inspection document 3.1

or

10 plates – 50 x 2 000 x 10 000 – EN 10028-2 1.5415+AR – Inspection document 3.1.

8 Requirements

8.1 Steelmaking process

See EN 10028-1:2007 + A1:2009.

8.2 Delivery condition

8.2.1 Unless otherwise agreed at the time of enquiry and order, the products covered by this European Standard shall be supplied in the usual conditions given in Table 3 (see 8.2.3).

8.2.2 •• Normalizing may, at the discretion of manufacturer, be replaced with normalizing rolling for the steel grades P235GH, P265GH, P295GH and P355GH. In this case, additional tests in the simulated normalized condition with an agreed frequency of testing may be agreed at the time of enquiry and order to verify that the specified properties are complied with.

8.2.3 •• If so agreed at the time of enquiry and order, products made of steel grades P235GH, P265GH, P295GH, P355GH and 16Mo3 may also be delivered in the untreated condition. Products made of one of the other alloy grades may be supplied in the tempered or normalized condition or, in exceptional cases, in the untreated condition if so agreed (Annex A contains heat treatment information for the purchaser).

In these cases, testing shall be carried out on test pieces in the usual delivery condition as indicated in Table 3.

NOTE The testing of the test pieces in a simulated heat treated condition does not discharge the processor from the obligation of providing proof of the specified properties in the finished product.

8.2.4 Information on welding is given in EN 1011-1 and EN 1011-2.

NOTE Excessive post weld heat treatment (PWHT) conditions can decrease the mechanical properties. When in stress relieving the intended time temperature parameter

$$P = T_s (20 + \lg t) \cdot 10^{-3},$$

where

T_s is the stress relieving temperature in K and

T is the holding time in hours,

exceeds the critical ($P_{crit.}$) values in Annex B, the purchaser should in his enquiry and order inform the manufacturer accordingly and, where appropriate, tests on simulated heat treated samples can be agreed to check whether after such a treatment the properties specified in this document can still be regarded as valid.

8.3 Chemical composition

8.3.1 The requirements of Table 1 shall apply for the chemical composition according to the cast analysis.

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

8.3.3 •• A maximum value for the carbon equivalent may be agreed upon at the time of enquiry and order for steel grades P235GH, P265GH, P295GH and P355GH. In this case, the following formula shall apply for calculation of the carbon equivalent value (CEV):

$$CEV = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Ni+Cu}{15}$$

Table 1 — Chemical composition (cast analysis) ^a

Steel grade		% by mass														
Steel name	Steel number	C	Si	Mn	P max.	S max.	Al _{total}	N	Cr	Cu ^b	Mo	Nb	Ni	Ti max.	V	Others
P235GH	1.0345	≤ 0,16	≤ 0,35	0,60 ^c to 1,20	0,025	0,010	≥ 0,020	≤ 0,012 ^d	≤ 0,30	≤ 0,30	≤ 0,08	≤ 0,020	≤ 0,30	0,03	≤ 0,02	Cr+Cu+Mo+ Ni: ≤ 0,70
P265GH	1.0425	≤ 0,20	≤ 0,40	0,80 ^c to 1,40	0,025	0,010	≥ 0,020	≤ 0,012 ^d	≤ 0,30	≤ 0,30	≤ 0,08	≤ 0,020	≤ 0,30	0,03	≤ 0,02	
P295GH	1.0481	0,08 to 0,20	≤ 0,40	0,90 ^c to 1,50	0,025	0,010	≥ 0,020	≤ 0,012 ^d	≤ 0,30	≤ 0,30	≤ 0,08	≤ 0,020	≤ 0,30	0,03	≤ 0,02	
P355GH	1.0473	0,10 to 0,22	≤ 0,60	1,10 to 1,70	0,025	0,010	≥ 0,020	≤ 0,012 ^d	≤ 0,30	≤ 0,30	≤ 0,08	≤ 0,040	≤ 0,30	0,03	≤ 0,02	
16Mo3	1.5415	0,12 to 0,20	≤ 0,35	0,40 to 0,90	0,025	0,010	^e	≤ 0,012	≤ 0,30	≤ 0,30	0,25 to 0,35	-	≤ 0,30	-	-	-
18MnMo4-5	1.5414	≤ 0,20	≤ 0,40	0,90 to 1,50	0,015	0,005	^e	≤ 0,012	≤ 0,30	≤ 0,30	0,45 to 0,60	-	≤ 0,30	-	-	-
20MnMoNi4-5	1.6311	0,15 to 0,23	≤ 0,40	1,00 to 1,50	0,020	0,010	^e	≤ 0,012	≤ 0,20	≤ 0,20	0,45 to 0,60	-	0,40 to 0,80	-	≤ 0,02	-
15NiCuMoNb5-6-4	1.6368	≤ 0,17	0,25 to 0,50	0,80 to 1,20	0,025	0,010	≥ 0,015	≤ 0,020	≤ 0,30	0,50 to 0,80	0,25 to 0,50	0,015 to 0,045	1,00 to 1,30	-	-	-
13CrMo4-5	1.7335	0,08 to 0,18	≤ 0,35	0,40 to 1,00	0,025	0,010	^e	≤ 0,012	0,70 ^f to 1,15	≤ 0,30	0,40 to 0,60	-	-	-	-	-
13CrMoSi5-5	1.7336	≤ 0,17	0,50 to 0,80	0,40 to 0,65	0,015	0,005	^e	≤ 0,012	1,00 to 1,50	≤ 0,30	0,45 to 0,65	-	≤ 0,30	-	-	-
10CrMo9-10	1.7380	0,08 to 0,14 ^g	≤ 0,50	0,40 to 0,80	0,020	0,010	^e	≤ 0,012	2,00 to 2,50	≤ 0,30	0,90 to 1,10	-	-	-	-	-
12CrMo9-10	1.7375	0,10 to 0,15	≤ 0,30	0,30 to 0,80	0,015	0,010	0,010 to 0,040	≤ 0,012	2,00 to 2,50	≤ 0,25	0,90 to 1,10	-	≤ 0,30	-	-	-
X12CrMo5	1.7362	0,10 to 0,15	≤ 0,50	0,30 to 0,60	0,020	0,005	^e	≤ 0,012	4,0 to 6,0	≤ 0,30	0,45 to 0,65	-	≤ 0,30	-	-	-
13CrMoV9-10	1.7703	0,11 to 0,15	≤ 0,10	0,30 to 0,60	0,015	0,005	^e	≤ 0,012	2,00 to 2,50	≤ 0,20	0,90 to 1,10	≤ 0,07	≤ 0,25	0,03	0,25 to 0,35	B ≤ 0,002, Ca ≤ 0,015
12CrMoV12-10	1.7767	0,10 to 0,15	≤ 0,15	0,30 to 0,60	0,015	0,005	^e	≤ 0,012	2,75 to 3,25	≤ 0,25	0,90 to 1,10	≤ 0,07 ^h	≤ 0,25	0,03 ^h	0,20 to 0,30	B ≤ 0,003 ^h , Ca ≤ 0,015 ^h
X10CrMoVNb9-1	1.4903	0,08 to 0,12	≤ 0,50	0,30 to 0,60	0,020	0,005	≤ 0,040	0,030 to 0,070	8,0 to 9,5	≤ 0,30	0,85 to 1,05	0,06 to 0,10	≤ 0,30	-	0,18 to 0,25	-

^a Elements not listed in this table shall not be intentionally added to the steel without the agreement of the purchaser except for finishing the cast. All appropriate measures shall be taken to prevent the addition from scrap or other materials used in steelmaking of these elements which may affect the mechanical properties and usability.

^b ● A lower maximum copper content and/or a maximum sum of copper and tin content, e.g. Cu + 6 Sn ≤ 0,33%, may be agreed upon at the time of enquiry and order, e.g. with regard to hot formability for the grades where only a maximum copper content is specified.

^c For product thicknesses < 6 mm, a minimum manganese content of 0,20 % lower than specified is permitted.

^d A ratio $\frac{Al}{N} \geq 2$ shall apply.

^e The Al content of the cast shall be determined and given in the inspection document.

^f ● If resistance to pressurized hydrogen is of importance, a minimum content of 0,80% Cr may be agreed upon at the time of enquiry and order.

^g ● For product thicknesses greater than 150 mm, a maximum content of 0,17% C may be agreed upon at the time of enquiry and order.

^h This grade may be produced with additions of either Ti + B or Nb + Ca. The following minimum contents shall apply: Ti ≥ 0,015 % and B ≥ 0,001 % in the case of additions of Ti + B, Nb ≥ 0,015 % and Ca ≥ 0,0005 % in the case of additions of Nb + Ca.

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

Element	Specified value in the cast analysis according to Table 1	Permissible deviation ^a of the product analysis
	% by mass	% by mass
C	≤ 0,23	± 0,02
Si	≤ 0,35	± 0,05
	> 0,35 to ≤ 1,00	± 0,06
Mn	≤ 1,00	± 0,05
	> 1,00 to ≤ 1,70	± 0,10
P	≤ 0,015	+ 0,003
	> 0,015 to ≤ 0,025	+ 0,005
S	≤ 0,010	+ 0,003
Al	≥ 0,010	± 0,005
B	≤ 0,003	± 0,0005
N	≤ 0,020	+ 0,002
	> 0,020 to ≤ 0,070	± 0,005
Cr	≤ 2,00	± 0,05
	> 2,00 to ≤ 10,0	± 0,10
Cu	≤ 0,30	± 0,05
	> 0,30 to ≤ 0,80	± 0,10
Mo	≤ 0,35	± 0,03
	> 0,35 to ≤ 1,10	+ 0,04
Nb	≤ 0,10	± 0,01
Ni	≤ 0,30	+ 0,05
	> 0,30 to ≤ 1,30	± 0,10
Cr+Cu+Mo+Ni	≤ 0,70	+ 0,05
Ti	≤ 0,03	± 0,01
V	≤ 0,05	± 0,01
	> 0,05 to ≤ 0,30	± 0,03

^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 fall short of the permissible minimum value, but not both for one cast.

8.4 Mechanical properties

8.4.1 The values given in Tables 3 and 4 (see also EN 10028-1:2007 + A1:2009 and Clause 10) shall apply.

8.4.2 Annex C gives mean values as preliminary data for the purchaser about 1% (plastic) creep strain and creep rupture.

8.5 Surface condition

See EN 10028-1:2007 + A1:2009.

8.6 Internal soundness

See EN 10028-1:2007 + A1:2009.

For possible verification of internal soundness, see also EN 10028-1:2007 + A1:2009.

8.7 Resistance to hydrogen induced cracking

Carbon and low alloy steels may be susceptible to cracking when exposed to corrosive H₂S containing environments, usually referred to as 'sour service'.

- A test to evaluate the resistance to hydrogen induced cracking in accordance with Annex D may be specified at the time of enquiry and order.

8.8 Embrittlement of CrMo steels

CrMo steels may tend to become brittle in service at temperatures between approximately 400 °C and 500 °C. This possible tendency for embrittlement can be simulated in the laboratory with the so called step cooling test. In this test a specimen is exposed to a temperature - time cycle as given in Figure E.1. The shift of a transition curve caused by the step cooling test is a measure for the embrittlement.

- A step cooling test in accordance with Annex E may be specified at the time of enquiry and order.

9 Inspection

9.1 Types of inspection and inspection documents

See EN 10028-1:2007 + A1:2009.

9.2 Tests to be carried out

See EN 10028-1:2007 + A1:2009 and 8.7 and 8.8.

9.3 Retests

See EN 10028-1:2007 + A1:2009

10 Sampling

See EN 10028-1:2007 + A1:2009.

- For the impact test, deviating from EN 10028-1:2007 + A1:2009, Table 3, footnote f, the preparation of test pieces taken from the mid thickness may be agreed at the time of enquiry and order. In this case, test temperatures and minimum impact energy values shall also be agreed.

11 Test methods

See EN 10028-1:2007 + A1:2009, and Annexes D and E.

12 Marking

See EN 10028-1:2007 + A1:2009.

Table 3 — Mechanical properties (applicable to the transverse direction)^a

Steel grade		Usual delivery condition ^{b,c}	Product thickness <i>t</i>	Tensile properties at room temperature			Impact energy <i>KV</i> J min. at a temperature in °C of		
				Yield strength <i>R_{eH}</i>	Tensile strength <i>R_m</i>	Elongation after fracture <i>A</i>			
Steel name	Steel number		mm	MPa min.	MPa	% min.	-20	0	+20
P235GH	1.0345	+N ^d	≤ 16	235	360 to 480	24	27 ^g	34 ^g	40
			16 < <i>t</i> ≤ 40	225					
			40 < <i>t</i> ≤ 60	215					
			60 < <i>t</i> ≤ 100	200					
			100 < <i>t</i> ≤ 150	185	350 to 480				
150 < <i>t</i> ≤ 250	170	340 to 480							
P265GH	1.0425	+N ^d	≤ 16	265	410 to 530	22	27 ^g	34 ^g	40
			16 < <i>t</i> ≤ 40	255					
			40 < <i>t</i> ≤ 60	245					
			60 < <i>t</i> ≤ 100	215					
			100 < <i>t</i> ≤ 150	200	400 to 530				
150 < <i>t</i> ≤ 250	185	390 to 530							
P295GH	1.0481	+N ^d	≤ 16	295	460 to 580	21	27 ^g	34 ^g	40
			16 < <i>t</i> ≤ 40	290					
			40 < <i>t</i> ≤ 60	285					
			60 < <i>t</i> ≤ 100	260					
			100 < <i>t</i> ≤ 150	235	440 to 570				
150 < <i>t</i> ≤ 250	220	430 to 570							
P355GH	1.0473	+N ^d	≤ 16	355	510 to 650	20	27 ^g	34 ^g	40
			16 < <i>t</i> ≤ 40	345					
			40 < <i>t</i> ≤ 60	335					
			60 < <i>t</i> ≤ 100	315	490 to 630				
			100 < <i>t</i> ≤ 150	295	480 to 630				
150 < <i>t</i> ≤ 250	280	470 to 630							
16Mo3	1.5415	+N ^e	≤ 16	275	440 to 590	22	f	f	31 ^g
			16 < <i>t</i> ≤ 40	270					
			40 < <i>t</i> ≤ 60	260					
			60 < <i>t</i> ≤ 100	240	430 to 580				
			100 < <i>t</i> ≤ 150	220	420 to 570				
150 < <i>t</i> ≤ 250	210	410 to 570							
18MnMo4-5	1.5414	+NT	≤ 60	345	510 to 650	20	27 ^g	34 ^g	40
		+QT	60 < <i>t</i> ≤ 150	325					
20MnMoNi4-5	1.6311	+QT	≤ 40	470	590 to 750	18	27 ^g	40	50
			40 < <i>t</i> ≤ 60	460	590 to 730				
			60 < <i>t</i> ≤ 100	450	570 to 710				
			100 < <i>t</i> ≤ 150	440					
			150 < <i>t</i> ≤ 250	400	560 to 700				
15NiCuMoNb 5-6-4	1.6368	+NT	≤ 40	460	610 to 780	16	27 ^g	34 ^g	40
			40 < <i>t</i> ≤ 60	440					
		+NT or +QT	60 < <i>t</i> ≤ 100	430	600 to 760				
		+QT	100 < <i>t</i> ≤ 150	420	590 to 740				
			150 < <i>t</i> ≤ 200	410	580 to 740				

Table 3 (continued)

Steel grade		Usual delivery condition ^{b,c}	Product thickness <i>t</i> mm	Tensile properties at room temperature			Impact energy <i>KV</i> J min. at a temperature in °C of			
				Yield strength <i>R_{eH}</i> MPa min.	Tensile strength <i>R_m</i> MPa	Elongation after fracture <i>A</i> % min.	-20	0	+20	
13CrMo4-5	1.7335	+NT	≤ 16	300	450 to 600	19	f	f	31 ^g	
			16 < <i>t</i> ≤ 60	290						
			60 < <i>t</i> ≤ 100	270						
		+NT or +QT	100 < <i>t</i> ≤ 150	255	430 to 580		f	f	27 ^g	
		+QT	150 < <i>t</i> ≤ 250	245	420 to 570					
13CrMoSi5-5	1.7336	+NT	≤ 60	310	510 to 690	20	f	27 ^g	34 ^g	
			60 < <i>t</i> ≤ 100	300						480 to 660
			100 < <i>t</i> ≤ 250	290						470 to 650
		+QT	≤ 60	400	510 to 690		27 ^g	34 ^g	40	
			60 < <i>t</i> ≤ 100	390	500 to 680					
100 < <i>t</i> ≤ 250	380	490 to 670								
10CrMo9-10	1.7380	+NT	≤ 16	310	480 to 630	18	f	f	31 ^g	
			16 < <i>t</i> ≤ 40	300						
			40 < <i>t</i> ≤ 60	290						
		+NT or +QT	60 < <i>t</i> ≤ 100	280	470 to 620		f	f	27 ^g	
		+QT	100 < <i>t</i> ≤ 150	260	460 to 610					
150 < <i>t</i> ≤ 250	250	450 to 600								
12CrMo9-10	1.7375	+ NT or +QT	≤ 250	355	540 to 690	18	27 ^g	40	70	
X12CrMo5	1.7362	+NT	≤ 60	320	510 to 690	20	27 ^g	34 ^g	40	
			60 < <i>t</i> ≤ 150	300						480 to 660
		+QT	150 < <i>t</i> ≤ 250	300	450 to 630					
13CrMoV9-10	1.7703	+ NT	≤ 60	455	600 to 780	18	27 ^g	34 ^g	40	
			60 < <i>t</i> ≤ 150	435						590 to 770
		+ QT	150 < <i>t</i> ≤ 250	415	580 to 760					
12CrMoV12-10	1.7767	+NT	≤ 60	455	600 to 780	18	27 ^g	34 ^g	40	
			60 < <i>t</i> ≤ 150	435						590 to 770
		+QT	150 < <i>t</i> ≤ 250	415	580 to 760					
X10CrMoVNb 9-1	1.4903	+NT	≤ 60	445	580 to 760	18	27 ^g	34 ^g	40	
			60 < <i>t</i> ≤ 150	435						550 to 730
		+QT	150 < <i>t</i> ≤ 250	435	520 to 700					

^a ●● For product thicknesses > 250 mm (except for grades 12CrMo9-10 and 15NiCuMoNb5-6-4) property values may be agreed.

^b +N = normalized; +NT = normalized and tempered; +QT = quenched and tempered

^c ●● For product thicknesses, where the usual delivery condition is +NT, the delivery condition +QT higher tensile strength and/or higher impact energy values may be agreed.

^d See 8.2.2.

^e This steel may also be supplied in the +NT condition at the discretion of the manufacturer.

^f ●● A value may be agreed at the time of enquiry and order.

^g ●● A minimum impact energy value of 40 J may be agreed at the time of enquiry and order.

Table 4 — Minimum values for the 0,2% proof strength at elevated temperatures^a

Steel grade		Product thickness ^{b,c} <i>t</i> mm	Minimum 0,2 % proof strength $R_{p0,2}$ MPa at a temperature in °C of									
Steel name	Steel number		50	100	150	200	250	300	350	400	450	500
P235GH ^d	1.0345	≤ 16	227	214	198	182	167	153	142	133	–	–
		16 < <i>t</i> ≤ 40	218	205	190	174	160	147	136	128	–	–
		40 < <i>t</i> ≤ 60	208	196	181	167	153	140	130	122	–	–
		60 < <i>t</i> ≤ 100	193	182	169	155	142	130	121	114	–	–
		100 < <i>t</i> ≤ 150	179	168	156	143	131	121	112	105	–	–
		150 < <i>t</i> ≤ 250	164	155	143	132	121	111	103	97	–	–
P265GH ^d	1.0425	≤ 16	256	241	223	205	188	173	160	150	–	–
		16 < <i>t</i> ≤ 40	247	232	215	197	181	166	154	145	–	–
		40 < <i>t</i> ≤ 60	237	223	206	190	174	160	148	139	–	–
		60 < <i>t</i> ≤ 100	208	196	181	167	153	140	130	122	–	–
		100 < <i>t</i> ≤ 150	193	182	169	155	142	130	121	114	–	–
		150 < <i>t</i> ≤ 250	179	168	156	143	131	121	112	105	–	–
P295GH ^d	1.0481	≤ 16	285	268	249	228	209	192	178	167	–	–
		16 < <i>t</i> ≤ 40	280	264	244	225	206	189	175	165	–	–
		40 < <i>t</i> ≤ 60	276	259	240	221	202	186	172	162	–	–
		60 < <i>t</i> ≤ 100	251	237	219	201	184	170	157	148	–	–
		100 < <i>t</i> ≤ 150	227	214	198	182	167	153	142	133	–	–
		150 < <i>t</i> ≤ 250	213	200	185	170	156	144	133	125	–	–
P355GH ^d	1.0473	≤ 16	343	323	299	275	252	232	214	202	–	–
		16 < <i>t</i> ≤ 40	334	314	291	267	245	225	208	196	–	–
		40 < <i>t</i> ≤ 60	324	305	282	259	238	219	202	190	–	–
		60 < <i>t</i> ≤ 100	305	287	265	244	224	206	190	179	–	–
		100 < <i>t</i> ≤ 150	285	268	249	228	209	192	178	167	–	–
		150 < <i>t</i> ≤ 250	271	255	236	217	199	183	169	159	–	–
16Mo3	1.5415	≤ 16	273	264	250	233	213	194	175	159	147	141
		16 < <i>t</i> ≤ 40	268	259	245	228	209	190	172	156	145	139
		40 < <i>t</i> ≤ 60	258	250	236	220	202	183	165	150	139	134
		60 < <i>t</i> ≤ 100	238	230	218	203	186	169	153	139	129	123
		100 < <i>t</i> ≤ 150	218	211	200	186	171	155	140	127	118	113
		150 < <i>t</i> ≤ 250	208	202	191	178	163	148	134	121	113	108
18MnMo4-5 ^e	1.5414	≤ 60	330	320	315	310	295	285	265	235	215	–
		60 < <i>t</i> ≤ 150	320	310	305	300	285	275	255	225	205	–
		150 < <i>t</i> ≤ 250	310	300	295	290	275	265	245	220	200	–

Table 4 (continued)

Steel grade		Product thickness ^{b, c} <i>t</i> mm	Minimum 0,2 % proof strength $R_{p0,2}$ MPa at a temperature in °C of									
Steel name	Steel number		50	100	150	200	250	300	350	400	450	500
20MnMoNi4-5	1.6311		≤ 40	460	448	439	432	424	415	402	384	–
		40 < <i>t</i> ≤ 60	450	438	430	423	415	406	394	375	–	–
		60 < <i>t</i> ≤ 100	441	429	420	413	406	398	385	367	–	–
		100 < <i>t</i> ≤ 150	431	419	411	404	397	389	377	359	–	–
		150 < <i>t</i> ≤ 250	392	381	374	367	361	353	342	327	–	–
15NiCuMoNb5-6-4	1.6368	≤ 40	447	429	415	403	391	380	366	351	331	–
		40 < <i>t</i> ≤ 60	427	410	397	385	374	363	350	335	317	–
		60 < <i>t</i> ≤ 100	418	401	388	377	366	355	342	328	309	–
		100 < <i>t</i> ≤ 150	408	392	379	368	357	347	335	320	302	–
		150 < <i>t</i> ≤ 200	398	382	370	359	349	338	327	313	295	–
13CrMo4-5	1.7335	≤ 16	294	285	269	252	234	216	200	186	175	164
		16 < <i>t</i> ≤ 60	285	275	260	243	226	209	194	180	169	159
		60 < <i>t</i> ≤ 100	265	256	242	227	210	195	180	168	157	148
		100 < <i>t</i> ≤ 150	250	242	229	214	199	184	170	159	148	139
		150 < <i>t</i> ≤ 250	235	223	215	211	199	184	170	159	148	139
13CrMoSi5-5+NT	1.7336+NT	≤ 60	299	283	268	255	244	233	223	218	206	–
		60 < <i>t</i> ≤ 100	289	274	260	247	236	225	216	211	199	–
13CrMoSi5-5 +QT	1.7336+QT	≤ 60	384	364	352	344	339	335	330	322	309	–
		60 < <i>t</i> ≤ 100	375	355	343	335	330	327	322	314	301	–
		100 < <i>t</i> ≤ 250	365	346	334	326	322	318	314	306	293	–
10CrMo9-10	1.7380	≤ 16	288	266	254	248	243	236	225	212	197	185
		16 < <i>t</i> ≤ 40	279	257	246	240	235	228	218	205	191	179
		40 < <i>t</i> ≤ 60	270	249	238	232	227	221	211	198	185	173
		60 < <i>t</i> ≤ 100	260	240	230	224	220	213	204	191	178	167
		100 < <i>t</i> ≤ 150	250	237	228	222	219	213	204	191	178	167
		150 < <i>t</i> ≤ 250	240	227	219	213	210	208	204	191	178	167
12CrMo9-10	1.7375	≤ 250	341	323	311	303	298	295	292	287	279	–
X12CrMo5	1.7362	≤ 60	310	299	295	294	293	291	285	273	253	222
		60 < <i>t</i> ≤ 250	290	281	277	275	275	273	267	256	237	208
13CrMoV9-10 ^e	1.7703	≤ 60	410	395	380	375	370	365	362	360	350	–
		60 < <i>t</i> ≤ 250	405	390	370	365	360	355	352	350	340	–
12CrMoV12-10 ^e	1.7767	≤ 60	410	395	380	375	370	365	362	360	350	–
		60 < <i>t</i> ≤ 250	405	390	370	365	360	355	352	350	340	–
X10CrMoVNb9-1	1.4903	≤ 60	432	415	401	392	385	379	373	364	349	324
		60 < <i>t</i> ≤ 250	423	406	392	383	376	371	365	356	341	316

^a The values correspond to the lower band of the relevant trend curve determined in accordance with EN 10314 with a confidence limit of about 98 % (2 s).

^b •• For product thicknesses exceeding the specified maximum thicknesses, $R_{p0,2}$ values at elevated temperatures may be agreed.

^c Delivery condition as given in Table 3 (but see footnote c to Table 3).

^d The values are reflecting the minimum values for furnace normalized test pieces.

^e $R_{p0,2}$ not determined in accordance with EN 10314. They are minimum values of the scatter band considered until now.

Annex A
(informative)

Guidelines for heat treatment

Table A.1 gives reference data for heat treatment temperatures. For stress relief annealing see Annex B.

Table A.1 — Guidelines on the temperatures for heat treatment

Steel grade		Temperature, °C		
Steel name	Steel number	Normalizing	Austenitizing	Tempering ^b
P235GH	1.0345	890 to 950 ^a	–	–
P265GH	1.0425	890 to 950 ^a	–	–
P295GH	1.0481	890 to 950 ^a	–	–
P355GH	1.0473	890 to 950 ^a	–	–
16Mo3	1.5415	890 to 950 ^a	–	^c
18MnMo4-5	1.5414	890 to 950		600 to 640
20MnMoNi4-5	1.6311	–	870 to 940	610 to 690
15NiCuMoNb5-6-4	1.6368	880 to 960		580 to 680
13CrMo4-5	1.7335	890 to 950		630 to 730
13CrMoSi5-5	1.7336	890 to 950		650 to 730
10CrMo9-10	1.7380	920 to 980		650 to 750
12CrMo9-10	1.7375	920 to 980		650 to 750
X12CrMo5	1.7362	920 to 970		680 to 750
13CrMoV9-10	1.7703	930 to 990		675 to 750
12CrMoV12-10	1.7767	930 to 1000		675 to 750
X10CrMoVNb9-1	1.4903	1040 to 1100		730 to 780
^a When normalizing, after the required temperatures have been attained over the whole cross-section, no further holding is necessary and should be generally avoided. ^b When tempering, the specified temperatures shall, when they have been attained over the whole cross-section, be maintained for an appropriate time. ^c In certain cases, tempering at 590 °C to 650 °C may be necessary.				

Annex B (informative)

Critical time temperature parameter $P_{crit.}$ and possible combinations of stress relieving temperature and holding time

Examples for stress relieving temperatures and the corresponding maximum holding time calculated on the basis of the equation in 8.2.4 for a given critical time temperature parameter $P_{crit.}$ are given in Table B.1.

Table B.1 — $P_{crit.}$ value and permissible holding time for a given stress relieving temperature

Steel type or steel grade	$P_{crit.}$	$P_{crit.}$ condition fulfilled with stress relieving temperature in °C for a holding time ^a of	
		1 h	2 h
C, CMn steels	17,3	580	575
16Mo3	17,5	590	585
18MnMo4-5	17,5	590	585
20MnMoNi4-5	17,5	590	585
15NiCuMoNb5-6-4	17,5	590	585
13CrMo4-5	18,5	640	630
13CrMoSi5-5	18,7	650	640
10CrMo9-10	19,2	675	665
12CrMo9-10	19,3	680	670
X12CrMo5	19,5	690	680
13CrMoV9-10	19,4	685	675
12CrMoV12-10	19,4	685	675
X10CrMoVNb9-1	20,5	740	730
^a Selected pairs of stress relieving temperature and holding time for guidance.			

Annex C (informative)

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

NOTE 1 The values given in Table C.1 were derived as mean values in accordance with ISO 6303 with a scatter band of $\pm 20\%$.

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

Table C.1 — Strength values for 1% (plastic) creep strain and creep rupture

Steel grade		Temperature °C	Strength for 1% (plastic)creep strain in MPa for		Creep rupture strength in MPa for		
			10 000 h	100 000 h	10 000 h	100 000 h	200 000 h
Steel name	Steel number						
P235GH, P265GH	1.0345, 1.0425	380	164	118	229	165	145
		390	150	106	211	148	129
		400	136	95	191	132	115
		410	124	84	174	118	101
		420	113	73	158	103	89
		430	101	65	142	91	78
		440	91	57	127	79	67
		450	80	49	113	69	57
		460	72	42	100	59	48
		470	62	35	86	50	40
		480	53	30	75	42	33
P295GH, P355GH	1.0481, 1.0473	380	195	153	291	227	206
		390	182	137	266	203	181
		400	167	118	243	179	157
		410	150	105	221	157	135
		420	135	92	200	136	115
		430	120	80	180	117	97
		440	107	69	161	100	82
		450	93	59	143	85	70
		460	83	51	126	73	60
		470	71	44	110	63	52
		480	63	38	96	55	44
		490	55	33	84	47	37
		500	49	29	74	41	30
16Mo3	1.5415	450	216	167	298	239	217
		460	199	146	273	208	188
		470	182	126	247	178	159
		480	166	107	222	148	130
		490	149	89	196	123	105
		500	132	73	171	101	84
		510	115	59	147	81	69
		520	99	46	125	66	55
		530	84	36	102	53	45

Table C.1 (continued)

Steel grade		Temperature °C	Strength for 1% (plastic) creep strain in MPa for		Creep rupture strength in MPa for		
Steel name	Steel number		10 000 h	100 000 h	10 000 h	100 000 h	200 000 h
18MnMo4-5	1.5414	425	392	314	421	343	
		430	383	302	407	330	
		440	360	272	380	300	
		450	333	240	353	265	
		460	303	207	325	230	
		470	271	176	295	196	
		480	239	148	263	166	
		490	207	124	229	140	
		500	177	103	196	118	
		510	150	84	165	98	
20MnMoNi4-5	1.6311	520	127	64	141	79	
		525	118	54	132	69	
		450			290	240	
		460			272	211	
		470			251		
15NiCuMoNb 5-6-4	1.6368	480			225		
		490			194		
		400	324	294	402	373	
		410	315	279	385	349	
		420	306	263	368	325	
		430	295	245	348	300	
		440	281	227	328	273	
		450	265	206	304	245	
		460	239	180	274	210	
		470	212	151	242	175	
13CrMo4-5	1.7335	480	180	120	212	139	
		490	145	84	179	104	
		500	108	49	147	69	
		450	245	191	370	285	260
		460	228	172	348	251	226
		470	210	152	328	220	195
		480	193	133	304	190	167
		490	173	116	273	163	139
		500	157	98	239	137	115
		510	139	83	209	116	96
		520	122	70	179	94	76
		530	106	57	154	78	62
		540	90	46	129	61	50
550	76	36	109	49	39		
560	64	30	91	40	32		
570	53	24	76	33	26		

Table C.1 (continued)

Steel grade		Temperature °C	Strength for 1% (plastic) creep strain in MPa for		Creep rupture strength in MPa for		
Steel name	Steel number		10 000 h	100 000 h	10 000 h	100 000 h	200 000 h
13CrMoSi5-5	1.7336	450		209		313	
		460		200		300	
		470		185		278	
		480		141		212	
		490		119		179	
		500		113		169	
		510		81		122	
		520		66		99	
		530		41		62	
		540		33		50	
		550		27		40	
		560		23		35	
		570		21		31	
		10CrMo9-10	1.7380	450	240	166	306
460	219			155	286	205	186
470	200			145	264	188	169
480	180			130	241	170	152
490	163			116	219	152	136
500	147			103	196	135	120
510	132			90	176	118	105
520	119			78	156	103	91
530	107			68	138	90	79
540	94			58	122	78	68
550	83			49	108	68	58
560	73			41	96	58	50
570	65			35	85	51	43
580	57			30	75	44	37
590	50	26	68	38	32		
600	44	22	61	34	28		
12CrMo9-10	1.7375	400			382	313	
		410			355	289	
		420			333	272	
		430			312	255	
		440			293	238	
		450			276	221	
		460			259	204	
		470			242	187	
		480			225	170	
		490			208	153	
		500			191	137	
		510			174	122	
520			157	107			

Table C.1 (continued)

Steel grade		Temperature °C	Strength for 1% (plastic) creep strain in MPa for		Creep rupture strength in MPa for			
Steel name	Steel number		10 000 h	100 000 h	10 000 h	100 000 h	200 000 h	
X12CrMo5	1.7362	450	107					
		460	96					
		470	87			147 (475°C)		
		480	83			139		
		490	78			123		
		500	70			108		
		510	56			94		
		520	50			81		
		530	44			71		
		540	39			61		
		550	35			53		
		560	31			47		
		570	27			41		
		580	24			36		
		590	21			32		
		600	18			27		
		610	16					
		620	14					
625	13							
13CrMoV9-10	1.7703	400			430	383		
		410			414	365		
		420			397	346		
		430			380	327		
		440			362	309		
		450			344	290		
		460			326	271		
		470			308	253		
		480			290	235		
		490			272	218		
		500			255	201		
		510			237	184		
		520			221	169		
530			204	144				
540			188	126				
550			173	108				

Table C.1 (continued)

Steel grade		Temperature °C	Strength for 1% (plastic)creep strain in MPa for		Creep rupture strength in MPa for		
Steel name	Steel number		10 000 h	100 000 h	10 000 h	100 000 h	200 000 h
12CrMoV12-10	1.7767	400			430	383	
		410			414	365	
		420			397	346	
		430			380	327	
		440			362	309	
		450			344	290	
		460			326	271	
		470			308	253	
		480			290	235	
		490			272	218	
		500			255	201	
		510			237	184	
		520			221	169	
		530			204	144	
		540			188	126	
550			173	108			
X10CrMoVNb 9-1	1.4903	500			289	258	246
		510			271	239	227
		520			252	220	208
		530			234	201	189
		540			216	183	171
		550			199	166	154
		560			182	150	139
		570			166	134	124
		580			151	120	110
		590			136	106	97
		600			123	94	86
		610			110	83	75
		620			99	73	65
		630			89	65	57
		640			79	56	49
650			70	49	42		
660			62	42	35		
670			55	36	-		

Annex D (normative)

Evaluation of resistance to hydrogen induced cracking

The tests to evaluate the resistance of steel products to hydrogen induced cracking shall be performed in accordance with EN 10229. The acceptance criteria for the test solution A (with pH \approx 3) apply for the classes indicated in Table D.1 where the given values are mean values from three individual test results.

•• Test solution B (with pH \approx 5) and corresponding acceptance criteria may be agreed at the time of enquiry and order.

Table D.1 – Acceptance classes for the HIC test (test solution A)

Acceptance class	CLR ^a %	CTR ^a %	CSR ^a %
I	≤ 5	$\leq 1,5$	$\leq 0,5$
II	≤ 10	≤ 3	≤ 1
III	≤ 15	≤ 5	≤ 2

^a CLR: crack length ratio, CTR: crack thickness ratio, CSR: crack sensitivity ratio

Annex E (normative)

Step cooling test

For the step cooling test a procedure to check step cooling embrittlement shall be agreed. This procedure shall include temperatures and holding times to be considered. The procedure given in Figure E.1 is recommended.

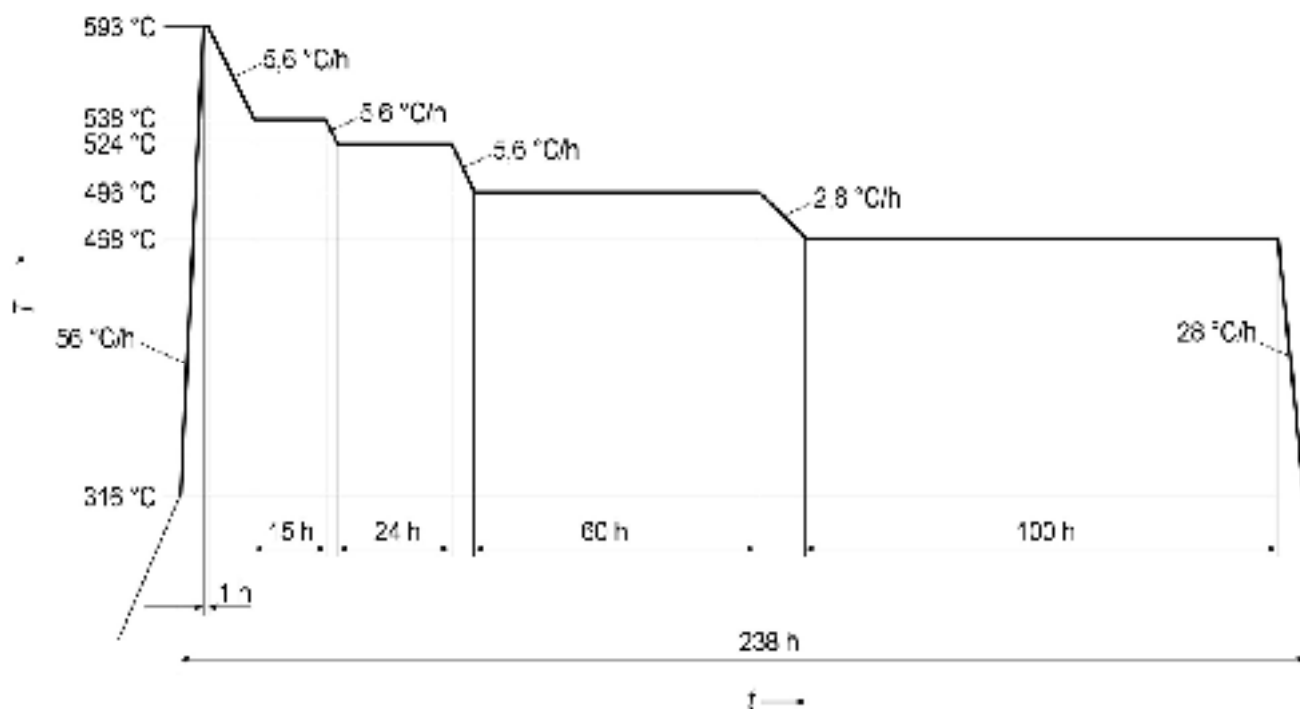


Figure E.1 — Recommended procedure for the step cooling test

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.

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

Clauses/sub-clauses of this European Standard	Essential Requirements (ERs) of Directive 97/23/EC, Annex I	Qualifying remarks/ Notes
8.4	4.1a	Appropriate material properties
8.2	4.1c	Ageing
8.2 and 8.6	4.1d	Suitable for the processing procedures
9.1	4.3	Documentation

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

Bibliography

- [1] EN 1011-1, *Welding – Recommendations for welding of metallic materials – Part 1: General guidance for arc welding*
- [2] EN 1011-2, *Welding – Recommendations for welding of metallic materials – Part 2: Arc welding of ferritic steels*
- [3] EN 10020, *Definition and classification of grades of steel*
- [4] EN 10314, *Method for the derivation of minimum values of proof strength of steel at elevated temperatures*
- [5] ISO 6303, *Pressure vessel steels not included in ISO 2604, Parts 1 to 6 – Derivation of long-time stress rupture properties*

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Flat products made of steels for pressure purposes —

Part 3: Weldable fine grain steels, normalized

The European Standard EN 10028-3:2003 has the status of a
British Standard

ICS 77.140.30; 77.140.50

National foreword

This British Standard is the official English language version of EN 10028-3:2003. It supersedes BS EN 10028-3:1993 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/73/2, Steel plates and bars for pressure purposes, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the *BSI Catalogue* under the section entitled "International Standards Correspondence Index", or by using the "Search" facility of the *BSI Electronic Catalogue* or of British Standards Online.

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This British Standard, was published under the authority of the Standards Policy and Strategy Committee on 24 June 2003

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 15 and a back cover.

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English version

Flat products made of steels for pressure purposes - Part 3:
Weldable fine grain steels, normalized

Produits plats en aciers pour appareils à pression - Partie
3: Aciers soudables à grains fins, normalisés

Flacherzeugnisse aus Druckbehälterstählen - Teil 3:
Schweißgeeignete Feinkornbaustähle, normalgeglüht

This European Standard was approved by CEN on 20 January 2003.

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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 Management Centre has the same status as the official versions.

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Foreword

This document (EN 10028-3:2003) has been prepared by Technical Committee ECISS /TC 22, "Steels for pressure purposes - Qualities", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2003, and conflicting national standards shall be withdrawn at the latest by December 2003.

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(s).

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

This document supersedes EN 10028-3:1992.

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

- Part 1: General requirements
- Part 2: Non-alloy and alloy steels with specified elevated temperature properties
- Part 3: Weldable fine grain steels, normalized
- Part 4: Nickel alloy steels with specified low temperature properties
- Part 5: Weldable fine grain steels, thermomechanically rolled
- Part 6: Weldable fine grain steels, quenched and tempered
- Part 7: Stainless steels

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

Annex A is normative.

This document includes a bibliography.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies requirements for flat products for pressure equipment made of weldable fine grain steels as specified in Table 1.

NOTE Fine grain steels are understood as steels with a ferritic grain size of 6 or finer when tested in accordance with EURONORM 103.

The requirements and definitions of EN 10028-1 also apply.

2 Normative references

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

EN 10028-1:2000 + A1:2002, *Flat products made of steels for pressure purposes – Part 1: General requirements.*

EN 10204, *Metallic products – Types of inspection documents.*

EN 10229, *Evaluation of resistance of steel products to hydrogen induced cracking (HIC).*

3 Terms and definitions

For the purposes of this European Standard the terms and definitions given in EN 10028-1 apply.

4 Dimensions and tolerances on dimensions

See EN 10028-1.

5 Calculation of mass

See EN 10028-1.

6 Classification and designation

6.1 Classification

6.1.1 The steel grades covered by this European Standard are given in four qualities:

- a) the room temperature quality (P ... N),
- b) the elevated temperature quality (P...NH),
- c) the low temperature quality (P...NL1) and
- d) the special low temperature quality (P...NL2).

6.1.2 In accordance with EN 10020, the grades P275NH, P275NL1, P355N, P355NH and P355NL1 are non-alloy quality steels, the grades P275NL2 and P355NL2 are non-alloy special steels and the grades P460NH, P460NL1 and P460NL2 are alloy special steels.

6.2 Designation

See EN 10028-1.

7 Information to be supplied by the purchaser

7.1 Mandatory information

See EN 10028-1.

7.2 Options

A number of options are specified in this standard and listed below. Additionally the relevant options of EN 10028-1 apply. If the purchaser does not indicate a wish to implement any of these options at the time of enquiry and order, the products shall be supplied in accordance with the basic specification (see also EN 10028-1).

- a) tests in the simulated normalized condition (see 8.2.2);
- b) delivery of products in the untreated condition (see 8.2.3);
- c) maximum carbon equivalent value (see 8.3.3);
- d) application of the $R_{p0,2}$ values of Table 5 for the corresponding P...NL1 and P...NL2 grade (see 8.4.2);
- e) HIC test in accordance with EN 10229 (see 8.7);
- f) mid thickness test pieces for the impact test (see clause 10);
- g) verification of impact energy for longitudinal test pieces (see clause 11);
- h) tensile properties for increased product thicknesses (see Table 4, footnote c);
- i) $R_{p0,2}$ values at elevated temperatures for increased product thicknesses (see Table 5, footnote b);
- j) use of test solution B for the HIC test with agreed acceptance criteria (see annex A).

7.3 Example for ordering

10 plates with nominal dimensions, thickness = 50 mm, width = 2000 mm, length = 10 000 mm, made of a steel grade with the name P275NL2 and the number 1.1104 as specified in EN 10028-3, to be delivered with inspection certificate 3.1.B as specified in EN 10204:

10 plates – 50 x 2000 x 10000 – EN 10028-3 P275NL2 - Inspection certificate 3.1.B

or

10 plates – 50 x 2000 x 10000 – EN 10028-3 1.1104 – Inspection certificate 3.1.B.

8 Requirements

8.1 Steelmaking process

See EN 10028-1.

8.2 Delivery condition

8.2.1 Unless otherwise agreed at the time of enquiry and order (see 8.2.3), the products covered by this standard shall be supplied in the normalized condition.

For steels with a minimum yield strength ≥ 460 MPa, delayed cooling or additional tempering may be necessary for small product thicknesses and in special cases. If such a treatment is performed, this shall be noted in the inspection document.

8.2.2 •• Normalizing may, at the discretion of the manufacturer, be replaced with normalizing rolling for the steel grades P275NH, P275NL1, P275NL2, P355N, P355NH, P355NL1 and P355NL2 (see 3.1 in EN 10028-1:2000 + A1:2002). In this case, tests on simulated normalized samples with an agreed frequency of testing may be agreed at the time of enquiry and order to verify that the specified properties are complied with.

8.2.3 •• If so agreed at the time of enquiry and order, products covered by this standard may also be delivered in the untreated condition.

In these cases, testing shall be carried out in the simulated normalized condition (but see 8.2.1).

NOTE Testing in a simulated heat treated condition does not discharge the processor from the obligation of providing proof of the specified properties in the finished product.

8.2.4 Information on welding is given in EN 1011-1 and EN 1011-2.

NOTE Excessive post weld heat treatment (PWHT) conditions can decrease the mechanical properties. When in stress relieving the intended time temperature parameter

$$P = T_s (20 + \lg t) \times 10^{-3},$$

where

T_s is the stress relieving temperature in K and

t is the holding time in hours,

is exceeding the critical P value of $P_{crit.} = 17,3$, the purchaser should in his enquiry and order inform the manufacturer accordingly and, where appropriate, tests on simulated heat treated samples may be agreed to check whether after such a treatment the properties specified in this standard can still be regarded as valid.

8.3 Chemical composition

8.3.1 The requirements of Table 1 shall apply for the chemical composition according to the cast analysis.

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

8.3.3 •• A maximum value for the carbon equivalent in accordance with Table 3 may be agreed upon at the time of enquiry and order.

Table 1 – Chemical composition (cast analysis) ^a

Steel grade		% by mass														
name	number	C	Si	Mn	P	S	Al _{total}	N	Cr	Cu	Mo	Nb	Ni	Ti	V	Nb + Ti + V
		max.	max.		max.	max.	min.	max.	max.	max.	max.	max.	max.	max.	max.	max.
P275NH	1.0487	0,16	0,40	0,80 ^b to 1,50	0,025	0,015	0,020 ^{c,d}	0,012	0,30 ^e	0,30 ^e	0,08 ^e	0,05	0,50	0,03	0,05	0,05
P275NL1	1.0488															
P275NL2	1.1104				0,020	0,010										
P355N	1.0562															
P355NH	1.0565	0,18	0,50	1,10 to 1,70	0,025	0,015	0,020 ^{c,d}	0,012	0,30 ^e	0,30 ^e	0,08 ^e	0,05	0,50	0,03	0,10	0,12
P355NL1	1.0566															
P355NL2	1.1106				0,020	0,010										
P460NH	1.8935				0,025	0,015	0,020 ^{c,d}	0,025	0,30	0,70 ^f	0,10	0,05	0,80	0,03	0,20	0,22
P460NL1	1.8915	0,20	0,60	1,10 to 1,70												
P460NL2	1.8918				0,020	0,010										

^a Elements not listed in this table shall not be intentionally added to the steel without the agreement of the purchaser except for finishing the cast. All appropriate measures shall be taken to prevent the addition from scrap or other materials used in steelmaking of these elements which may adversely affect the mechanical properties and usability.

^b For product thicknesses < 6 mm, a minimum Mn content of 0,60 % is permitted.

^c The Al_{total} content may fall short this minimum if niobium, titanium or vanadium are additionally used for nitrogen binding.

^d If only aluminium is used for nitrogen binding, a ratio $\frac{Al}{N} \geq 2$ shall apply.

^e The sum of the percentages by mass of the three elements chromium, copper and molybdenum shall not exceed 0,45 %.

^f If the percentage by mass of copper exceeds 0,30 %, the percentage by mass of nickel shall be at least half the percentage by mass of copper.

Table 2 - Permissible deviations of the product analysis from the specified limits given in Table 1 for the cast analysis

Element	Specified limit of the cast analysis according to Table 1	Permissible deviation ^a of the product analysis
	% by mass	% by mass
C	$\leq 0,20$	+ 0,02
Si	$\leq 0,60$	+ 0,06
Mn	$\leq 1,00$	$\pm 0,05$
	$> 1,00$ to $\leq 1,70$	$\pm 0,10$
P	$\leq 0,025$	+ 0,005
S	$\leq 0,015$	+ 0,003
Al	$\geq 0,020$	- 0,005
N	$\leq 0,025$	+ 0,002
Cr	$\leq 0,30$	+ 0,05
Mo	$\leq 0,10$	+ 0,03
Cu	$\leq 0,30$	+ 0,05
	$> 0,30$ to $\leq 0,70$	+ 0,10
Nb	$\leq 0,05$	+ 0,01
Ni	$\leq 0,80$	+ 0,05
Ti	$\leq 0,03$	+ 0,01
V	$\leq 0,20$	+ 0,01

^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 fall short of the permissible minimum value, but not both for one cast.

**Table 3 – Maximum carbon equivalent value (CEV) based on cast analysis
(if agreed at the time of enquiry and order) ^a**

Steel grade		CEV ^b max. for product thicknesses <i>t</i> in mm		
		≤ 60	60 < <i>t</i> ≤ 100	100 < <i>t</i> ≤ 250
name	number			
P275NH	1.0487	0,40	0,40	0,42
P275NL1	1.0488			
P275NL2	1.1104			
P355N	1.0562	0,43	0,45	0,45
P355NH	1.0565			
P355NL1	1.0566			
P355NL2	1.1106			
P460NH	1.8935	0,53	-	
P460NL1	1.8915			
P460NL2	1.8918			
NOTE The values for the carbon equivalent are based on the percentage by mass and relate to the mechanical properties specified for the delivery condition.				
^a See 8.3.3.				
^b $CEV = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Ni+Cu}{15}$				

8.4 Mechanical properties

8.4.1 The values given in Tables 4 to 6 (see also EN 10028-1 and clause 10) shall apply.

8.4.2 •• If agreed at the time of enquiry and order, the minimum proof strength $R_{p0,2}$ values at elevated temperature specified in Table 5 for the P...NH grades may also apply to the P...NL1 and P...NL2 grades.

8.5 Surface condition

See EN 10028-1.

8.6 Internal soundness

See EN 10028-1.

For possible verification of internal soundness, see also EN 10028-1.

8.7 Resistance to hydrogen induced cracking

Carbon and low alloy steels may be susceptible to cracking when exposed to corrosive H₂S containing environments, usually referred to as 'sour service'.

- A test to evaluate the resistance to hydrogen induced cracking in accordance with annex A may be agreed at the time of enquiry and order.

9 Inspection

9.1 Types of inspection and inspection documents

See EN 10028-1.

9.2 Tests to be carried out

See EN 10028-1 and 8.7.

9.3 Retests

See EN 10028-1.

10 Sampling

See EN 10028-1.

- For the impact test, deviating from EN 10028-1:2000 + A1:2002, Figure 2, footnote f, the preparation of test pieces taken from the mid thickness may be agreed at the time of enquiry and order. In this case, test temperatures and minimum impact energy values shall also be agreed.

11 Test methods

See EN 10028-1 and EN 10229.

- For the impact test, verification of impact energy for longitudinal test pieces may be agreed at the time of enquiry and order in accordance with 10.2.2.3 and 11.4 in EN 10028-1:2000 + A1:2002.

12 Marking

See EN 10028-1.

Table 4 – Tensile properties at room temperature

Steel grade		Usual delivery condition	Product thickness t mm	Yield strength R_{eH} MPa min.	Tensile strength MPa	Elongation after fracture A % min.
name	number					
P275NH, P275NL1, P275NL2	1.0487, 1.0488, 1.1104	+N ^a	≤ 16	275	390 to 510	24
			$16 < t \leq 40$	265		
			$40 < t \leq 60$	255	370 to 490	23
			$60 < t \leq 100$	235		
			$100 < t \leq 150$	225		
$150 < t \leq 250$	215	350 to 470				
P355N, P355NH, P355NL1, P355NL2	1.0562, 1.0565, 1.0566, 1.1106	+N ^a	≤ 16	355	490 to 630	22
			$16 < t \leq 40$	345		
			$40 < t \leq 60$	335	470 to 610	21
			$60 < t \leq 100$	315		
			$100 < t \leq 150$	305		
$150 < t \leq 250$	295	450 to 590				
P460NH, P460NL1, P460NL2	1.8935, 1.8915, 1.8918	+N ^b	≤ 16	460	570 to 720 ^d	17
			$16 < t \leq 40$	445		
			$40 < t \leq 60$	430		
			$60 < t \leq 100$	400	540 to 710	
$100 \leq t \leq 250$	^c	^c	^c			
^a See 8.2.2.						
^b See 8.2.1.						
^c •• Values may be agreed at the time of enquiry and order.						
^d For product thicknesses up to 16 mm, a maximum value of 730 MPa is permitted.						

Table 5 — Minimum values for the proof strength $R_{p0,2}$ at elevated temperatures ^a

Steel grade		Product thickness t mm	Minimum proof strength $R_{p0,2}$ MPa at a temperature in °C of							
name	number		50	100	150	200	250	300	350	400
P275NH	1.0487	≤ 16	266	250	232	213	195	179	166	156
		$16 < t \leq 40$	256	241	223	205	188	173	160	150
		$40 < t \leq 60$	247	232	215	197	181	166	154	145
		$60 < t \leq 100$	227	214	198	182	167	153	142	133
		$100 < t \leq 150$	218	205	190	174	160	147	136	128
		$150 < t \leq 250$	208	196	181	167	153	140	130	122
P355NH	1.0565	≤ 16	343	323	299	275	252	232	214	202
		$16 < t \leq 40$	334	314	291	267	245	225	208	196
		$40 < t \leq 60$	324	305	282	259	238	219	202	190
		$60 < t \leq 100$	305	287	265	244	224	206	190	179
		$100 < t \leq 150$	295	277	257	236	216	199	184	173
		$150 < t \leq 250$	285	268	249	228	209	192	178	167
P460NH	1.8935	≤ 16	445	419	388	356	326	300	278	261
		$16 < t \leq 40$	430	405	375	345	316	290	269	253
		$40 < t \leq 60$	416	391	362	333	305	281	260	244
		$60 < t \leq 100$	387	364	337	310	284	261	242	227
		$100 < t \leq 250$	^b	^b	^b	^b	^b	^b	^b	^b

^a The values are reflecting the minimum values for furnace normalized test pieces (i.e. they correspond to the lower band of the relevant trend curve determined in accordance with EN 10314) with a confidence limit of about 98 % (2s).

^b •• Values may be agreed at the time of enquiry and order.

Table 6 – Minimum impact energy values for the normalized condition ^a

Steel grade	Product thickness mm	Impact energy KV J min.									
		transverse					longitudinal ^b				
		at a temperature in °C of									
		- 50	- 40	- 20	0	+ 20	- 50	- 40	- 20	0	+ 20
P...N, P...NH	5 ^c to 250 ^d	-	-	30	40	50	-	-	45	65	75
P...NL1		-	27	35	50	60	30	40	50	70	80
P...NL2		27	30	40	60	70	42	45	55	75	85

^a See 8.2.1 and 8.2.2.

^b The values apply for product thicknesses up to 40 mm.

^c See 10.2.2.3 in EN 10028-1:2000 + A1:2002.

^d For the grades P460NH, P460NL1 and P460NL2 up to product thicknesses of 100 mm.

Annex A (normative)

Evaluation of resistance to hydrogen induced cracking

The tests to evaluate the resistance of steel products to hydrogen induced cracking shall be performed in accordance with EN 10229. The acceptance criteria for the test solution A (with pH \approx 3) apply for the classes indicated in Table A.1 where the given values are mean values from three individual test results.

- Test solution B (with pH \approx 5) and corresponding acceptance criteria may be agreed at the time of enquiry and order.

Table A.1 – Acceptance classes for the HIC test (test solution A)

Acceptance class	CLR ^a %	CTR ^a %	CSR ^a %
I	≤ 5	$\leq 1,5$	$\leq 0,5$
II	≤ 10	≤ 3	≤ 1
III	≤ 15	≤ 5	≤ 2
^a CLR: crack length ratio, CTR: crack thickness ratio, CSR: crack sensitivity ratio.			

Annex ZA (informative)

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

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

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

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

Clause(s)/sub-clause(s) of this EN	Essential Requirements (ERs) of Directive 97/23/EC
All normative clauses	Annex 1, section 4

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

Bibliography

EN 1011-1, *Welding - Recommendations for welding of metallic materials – Part 1: General guidance for arc welding.*

EN 1011-2, *Welding - Recommendations for welding of metallic materials – Part 2: Arc welding of ferritic steels.*

EN 10020, *Definition and classification of grades of steel.*

EN 10314, *Method for the derivation of minimum values of proof strength of steel at elevated temperatures.*

EURONORM 103¹⁾, *Microscopic determination of the ferrite or austenitic grain size of steels.*

1) Until this EURONORM is transformed into a European Standard, it can be implemented or the corresponding national standard should be agreed at the time of enquiry and order.

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Flat products made of steels for pressure purposes

Part 4: Nickel alloy steels with specified low temperature properties

ICS 77.140.30; 77.140.50

National foreword

This British Standard is the UK implementation of EN 10028-4:2009. It supersedes BS EN 10028-4:2003 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/73/2, Steel plates and bars 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.

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Nickel alloy steels with specified low temperature properties**

Produits plats en aciers pour appareils à pression - Partie
4: Aciers alliés au nickel avec caractéristiques spécifiées à
basse température

Flacherzeugnisse aus Druckbehälterstählen - Teil 4:
Nickellegierte kaltzähe Stähle

This European Standard was approved by CEN on 14 May 2009.

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Foreword

This document (EN 10028-4:2009) has been prepared by Technical Committee ECISS/TC 22 “Steels for pressure purposes - Qualities”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2009, and conflicting national standards shall be withdrawn at the latest by December 2009.

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 10028-4:2003.

This European Standard consists of the following parts, under the general title *Flat products made of steels for pressure purposes*:

- *Part 1: General requirements*
- *Part 2: Non-alloy and alloy steels with specified elevated temperature properties*
- *Part 3: Weldable fine grain steels, normalized*
- *Part 4: Nickel alloy steels with specified low temperature properties*
- *Part 5: Weldable fine grain steels, thermomechanically rolled*
- *Part 6: Weldable fine grain steels, quenched and tempered*
- *Part 7: Stainless steels*

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

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.

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

1 Scope

This European Standard specifies requirements for flat products for pressure equipment made of nickel alloy steels as specified in Table 1.

The requirements and definitions of EN 10028-1:2007 + A1:2009 also apply.

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 (Part 1 and this Part 4 of the series) 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 referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 10028-1:2007 + A1:2009, *Flat products made of steels for pressure purposes – Part 1: General requirements*

EN 10204:2004, *Metallic products – Types of inspection documents*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 10028-1:2007 + A1:2009 apply.

4 Dimensions and tolerances on dimensions

See EN 10028-1:2007 + A1:2009.

5 Calculation of mass

See EN 10028-1:2007 + A1:2009,

6 Classification and designation

6.1 Classification

In accordance with EN 10020, all steel grades covered by this document are alloy special steels.

6.2 Designation

See EN 10028-1:2007 + A1:2009.

7 Information to be supplied by the purchaser

7.1 Mandatory information

See EN 10028-1:2007 + A1:2009.

7.2 Options

A number of options are specified in this European Standard and listed below. Additionally the relevant options of EN 10028-1:2007 + A1:2009 apply. If the purchaser does not indicate a wish to implement any of these options at the time of enquiry and order, the products shall be supplied in accordance with the basic specification (see also EN 10028-1:2007 + A1:2009).

- 1) delivery condition other than that specified in Table 3 (see 8.2.2);
- 2) delivery of products in the untreated condition (see 8.2.3);
- 3) specification of a minimum impact energy of 40 J (see NOTE to 8.4 and Table 4);
- 4) mid thickness test pieces for the impact test (see Clause 10);
- 5) verification of impact energy for longitudinal test pieces (see Clause 11).

7.3 Example for ordering

10 plates with nominal dimensions, thickness = 50 mm, width = 2 000 mm, length = 10 000 mm, made of a steel grade with the name 15NiMn6 and the number 1.6228 as specified in EN 10028-4, to be delivered with inspection document 3.1 as specified in EN 10204.

10 plates – 50 x 2000 x 10 000 – EN 10028-4 15NiMn6 – Inspection document 3.1

or

10 plates – 50 x 2000 x 10 000 – EN 10028-4 1.6228 – Inspection document 3.1.

8 Requirements

8.1 Steelmaking process

See EN 10028-1:2007 + A1:2009.

8.2 Delivery condition

8.2.1 The delivery condition shall be noted in the inspection document.

8.2.2 •• Unless otherwise agreed at the time of enquiry and order, the products covered by this document shall be supplied in the usual delivery conditions specified in Table 3.

8.2.3 •• If so agreed at the time of enquiry and order, the products may be supplied in the untreated condition.

In these cases, the specified tests shall be carried out on test pieces in the usual delivery condition as given in Table 3.

NOTE Testing in a simulated heat treated condition does not discharge the processor from the obligation of providing proof of the specified properties in the finished product.

8.3 Chemical composition

8.3.1 The requirements of Table 1 shall apply for the chemical composition according to the cast analysis.

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

Table 1 — Chemical composition (cast analysis) ^a

Steel grade		% by mass									
Steel name	Steel number	C max.	Si max.	Mn	P max.	S max.	Al _{total} min.	Mo max.	Nb max.	Ni	V max.
11MnNi5-3	1.6212	0,14	0,50	0,70 to 1,50	0,025	0,010	0,020	–	0,05	0,30 ^b to 0,80	0,05
13MnNi6-3	1.6217	0,16	0,50	0,85 to 1,70	0,025	0,010	0,020	–	0,05	0,30 ^b to 0,85	0,05
15NiMn6	1.6228	0,18	0,35	0,80 to 1,50	0,025	0,010	–	–	–	1,30 to 1,70	0,05
12Ni14	1.5637	0,15	0,35	0,30 to 0,80	0,020	0,005	–	–	–	3,25 to 3,75	0,05
X12Ni5	1.5680	0,15	0,35	0,30 to 0,80	0,020	0,005	–	–	–	4,75 to 5,25	0,05
X8Ni9	1.5662	0,10	0,35	0,30 to 0,80	0,020	0,005	–	0,10	–	8,5 to 10,0	0,05
X7Ni9	1.5663	0,10	0,35	0,30 to 0,80	0,015	0,005	–	0,10	–	8,5 to 10,0	0,01

^a Elements not listed in this Table shall not be intentionally added to the steel without the agreement of the purchaser except for finishing the cast. All appropriate measures shall be taken to prevent the addition from scrap or other materials used in steelmaking of these elements which may adversely affect the mechanical properties and usability. The content of Cr + Cu + Mo shall not exceed 0,50 %.

^b For product thicknesses ≤ 40 mm, a minimum nickel content of 0,15 % is permitted.

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

Element	Specified value in the cast analysis according to Table 1	Permissible deviation ^a of the product analysis
	% by mass	% by mass
C	≤ 0,18	+ 0,02
Si	≤ 0,50	+ 0,05
Mn	≤ 1,00	± 0,05
	> 1,00 to ≤ 1,70	± 0,10
P	≤ 0,015	+ 0,003
	> 0,015 to ≤ 0,025	+ 0,005
S	≤ 0,010	+ 0,003
Al	≥ 0,020	- 0,005
Mo	≤ 0,10	+ 0,03
Nb	≤ 0,05	+ 0,01
Ni	≤ 0,85	± 0,05
	> 0,85 to ≤ 3,75	± 0,07
	> 3,75 to ≤ 10,0	± 0,10
V	≤ 0,05	+ 0,01

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

8.4 Mechanical properties

The values given in Tables 3 and 4 (see also EN 10028-1:2007 + A1:2009 and clause 10) shall apply.

NOTE Optionally, for steel grades 11MnNi5-3, 13MnNi6-3, 15NiMn6, 12Ni14 and X12Ni5, a minimum impact energy value of 40 J may be specified for temperatures where lower minimum values are specified (see Table 4, footnote d).

Table 3 — Mechanical properties at room temperature

Steel grade		Usual delivery condition ^{a,b} (Heat treatment symbol)	Product thickness <i>t</i> mm	Yield strength <i>R_{eH}</i> MPa min.	Tensile strength <i>R_m</i> MPa	Elongation after fracture <i>A</i> % min.
Steel name	Steel number					
11MnNi5-3	1.6212	+N (+NT)	≤ 30	285	420 to 530	24
			30 < <i>t</i> ≤ 50	275		
			50 < <i>t</i> ≤ 80	265		
13MnNi6-3	1.6217	+N (+NT)	≤ 30	355	490 to 610	22
			30 < <i>t</i> ≤ 50	345		
			50 < <i>t</i> ≤ 80	335		
15NiMn6	1.6228	+N or +NT or +QT	≤ 30	355	490 to 640	22
			30 < <i>t</i> ≤ 50	345		
			50 < <i>t</i> ≤ 80	335		
12Ni14	1.5637	+N or +NT or +QT	≤ 30	355	490 to 640	22
			30 < <i>t</i> ≤ 50	345		
			50 < <i>t</i> ≤ 80	335		
X12Ni5	1.5680	+N or +NT or +QT	≤ 30	390	530 to 710	20
			30 < <i>t</i> ≤ 50	380		
X8Ni9 +NT640 ^a	1.5662 +NT640 ^a	+N plus +NT	≤ 30	490	640 to 840	18
			30 < <i>t</i> ≤ 50	480		
X8Ni9 +QT640 ^a	1.5662 +QT640 ^a	+QT	≤ 30	490	640 to 840	18
			30 < <i>t</i> ≤ 50	480		
X8Ni9 +QT680 ^a	1.5662 +QT680 ^a	+QT ^c	≤ 30	585	680 to 820	18
			30 < <i>t</i> ≤ 50	575		
X7Ni9	1.5663	+QT ^c	≤ 30	585	680 to 820	18
			30 < <i>t</i> ≤ 50	575		

^a +N: normalized; +NT: normalized and tempered; +QT: quenched and tempered; +NT640/+QT640/+QT680: Heat treatment variant with minimum tensile strength of 640 MPa or 680 MPa.
^b For temperatures and cooling conditions, see Table A.1.
^c For product thickness < 15 mm, delivery conditions +N plus +NT are also applicable.

Table 4 — Minimum impact energy values

Steel grade		Heat treatment condition ^{a,b}	Product thickness mm	Direction	Minimum impact energy KV' in J											
Steel name	Steel number				at a temperature in °C of											
				20	0	-20	-40	-50	-60	-80	-100	-120	-150	-170	-196	
11MnNi5-3	1.6212	+N (+NT)	≤ 80	longitudinal	70	60	55	50	45	40	–	–	–	–	–	
13MnNi6-3	1.6217			transverse	50	50	45	35 ^d	30 ^d	27 ^d	–	–	–	–	–	–
15NiMn6	1.6228	+N or +NT or +QT		longitudinal	65	65	65	60	50	50	40	–	–	–	–	–
				transverse	50	50	45	40	35 ^d	35 ^d	27 ^d	–	–	–	–	–
12Ni14	1.5637	+N or +NT or +QT		longitudinal	65	60	55	55	50	50	45	40	–	–	–	–
				transverse	50	50	45	35 ^d	35 ^d	35 ^d	30 ^d	27 ^d	–	–	–	–
X12Ni5	1.5680	+N or +NT or +QT	longitudinal	70	70	70	65	65	65	60	50	40 ^c	–	–	–	
			transverse	60	60	55	45	45	45	40	30 ^d	27 ^{c,d}	–	–	–	
X8Ni9+NT640; X8Ni9+QT640 ^a	1.5662+NT640; 1.5662+QT640 ^a	+N plus +NT; +QT	longitudinal	100	100	100	100	100	100	100	90	80	70	60	50	
			transverse	70	70	70	70	70	70	70	60	50	50	45	40	
X8Ni9 +QT680 ^a	1.5662 +QT680 ^a	+QT	longitudinal	120	120	120	120	120	120	120	110	100	90	80	70	
			transverse	100	100	100	100	100	100	100	90	80	70	60	50	
X7Ni9	1.5663	+QT	longitudinal	120	120	120	120	120	120	120	120	120	120	120	110	100
			transverse	100	100	100	100	100	100	100	100	100	100	100	90	80

^a +N: normalized; +NT: normalized and tempered; +QT: quenched and tempered; +NT640/+QT640/+QT680: Heat treatment variant with minimum tensile strength of 640 MPa or 680 MPa.
^b For temperatures and cooling conditions, see Table A.1.
^c The values are applicable for product thicknesses ≤ 25 mm at –110 °C and for product thicknesses of 25 mm < t ≤ 30 mm at –115 °C.
^d ●● A minimum impact energy value of 40 J may be agreed at the time of enquiry and order.

8.5 Surface condition

See EN 10028-1:2007 + A1:2009.

8.6 Internal soundness

See EN 10028-1:2007 + A1:2009.

For possible verification of internal soundness, see also EN 10028-1:2007 + A1:2009.

9 Inspection

9.1 Types of inspection and inspection documents

See EN 10028-1:2007 + A1:2009.

9.2 Tests to be carried out

See EN 10028-1:2007 + A1:2009.

9.3 Retests

See EN 10028-1:2007 + A1:2009.

10 Sampling

See EN 10028-1:2007 + A1:2009.

•• For the impact test, deviating from EN 10028-1:2007 + A1:2009, Table 3, footnote f, the preparation of test pieces taken from the mid thickness may be agreed at the time of enquiry and order. In this case, test temperatures and minimum impact energy values shall also be agreed.

11 Test methods

See EN 10028-1:2007 + A1:2009.

•• For the impact test, verification of impact energy for longitudinal test pieces may be agreed at the time of enquiry and order in accordance with 10.2.2.3 and 11.4 in EN 10028-1:2007 + A1:2009.

12 Marking

See EN 10028-1:2007 + A1:2009.

NOTE For the grade X8Ni9 the relevant heat treatment variant (+NT640 or +QT640 or +QT680) belongs to the steel name or steel number.

Annex A (informative)

Guidelines for heat treatment

Reference data on heat treatment temperatures and cooling media are given in Table A.1.

Table A.1 — Guidelines on the temperatures and cooling media of heat treatment

Steel grade		Heat treatment condition ^a	Heat treatment			
Steel name	Steel number		Austenitizing °C	Cooling ^b	Tempering °C	Cooling ^b
11MnNi5-3	1.6212	+N (+NT)	880 to 940	a	580 to 640	a
13MnNi6-3	1.6217	+N (+NT)	880 to 940	a	580 to 640	a
15NiMn6	1.6228	+N	850 to 900	a	-	-
		+NT	850 to 900	a	600 to 660	a or w
		+QT	850 to 900	w or o	600 to 660	a or w
12Ni14	1.5637	+N	830 to 880	a	-	-
		+NT	830 to 880	a	580 to 640	a or w
		+QT	820 to 870	w or o	580 to 640	a or w
X12Ni5	1.5680	+N	800 to 850	a	-	-
		+NT	800 to 850	a	580 to 660	a or w
		+QT	800 to 850	w or o	580 to 660	a or w
X8Ni9 +NT640	1.5662 +NT640	+N plus +NT	880 to 930 + 770 to 830	a	540 to 600	a or w
X8Ni9 +QT640	1.5662 +QT640	+QT	770 to 830	w or o	540 to 600	a or w
X8Ni9 +QT680	1.5662 +QT680	+QT ^c	770 to 830	w or o	540 to 600	a or w
X7Ni9	1.5663	+QT ^c	770 to 830	w or o	540 to 600	a or w

^a +N: normalized; +NT: normalized and tempered; +QT: quenched and tempered; +NT640/+QT640/+QT680: Heat treatment variant with minimum tensile strength of 640 MPa or 680 MPa.

^b a: air; o: oil; w: water.

^c See Table 3, footnote c.

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.

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

Clauses/sub-clauses of this European Standard	Essential Requirements (ERs) of Directive 97/23/EC, Annex I	Qualifying remarks/ Notes
8.4	4.1a	Appropriate material properties
8.2	4.1c	Ageing
8.2 and 8.6	4.1d	Suitable for the processing procedures
9.1	4.3	Documentation

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

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[1] EN 10020, *Definition and classification of grades of steel*

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Flat products made of steels for pressure purposes

**Part 5: Weldable fine grain steels,
thermomechanically rolled**

ICS 77.140.30; 77.140.50

National foreword

This British Standard is the UK implementation of EN 10028-5:2009. It supersedes BS EN 10028-5:2003 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/73/2, Steel plates and bars 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.

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English Version

**Flat products made of steels for pressure purposes - Part 5:
Weldable fine grain steels, thermomechanically rolled**

Produits plats en acier pour appareils à pression - Partie 5:
Aciers soudables à grains fins, laminés
thermomécaniquement

Flacherzeugnisse aus Druckbehälterstählen - Teil 5:
Schweißgeeignete Feinkornbaustähle, thermomechanisch
gewalzt

This European Standard was approved by CEN on 14 May 2009.

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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 Management Centre has the same status as the official versions.

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Foreword

This document (EN 10028-5:2009) has been prepared by Technical Committee ECISS/TC 22 “Steels for pressure purposes - Qualities”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2009, and conflicting national standards shall be withdrawn at the latest by December 2009.

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 10028-5:2003.

This European Standard consists of the following parts, under the general title *Flat products made of steels for pressure purposes*:

- *Part 1: General requirements*
- *Part 2: Non-alloy and alloy steels with specified elevated temperature properties*
- *Part 3: Weldable fine grain steels, normalized*
- *Part 4: Nickel alloy steels with specified low temperature properties*
- *Part 5: Weldable fine grain steels, thermomechanically rolled*
- *Part 6: Weldable fine grain steels, quenched and tempered*
- *Part 7: Stainless steels*

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

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.

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

1 Scope

This European Standard specifies the requirements for flat products for pressure equipments made of thermomechanically rolled steels as specified in Table 1.

The steels are not suitable for hot forming.

NOTE 1 At the time of publication of this European Standard, no sufficient data for the standardization of the elevated temperature properties of these steels was available. If their use at such temperatures is intended the conditions for this should be specially agreed between the interested parties.

The requirements of EN 10028-1:2007 + A1:2009 also apply.

NOTE 2 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 (Part 1 and this Part 5 of the series) 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 referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 10028-1:2007 + A1:2009, *Flat products made of steels for pressure purposes – Part 1: General requirements*

EN 10204:2004, *Metallic products – Types of inspection documents*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 10028-1:2007 + A1:2009 apply.

4 Dimension and tolerances

See EN 10028-1:2007 + A1:2009.

5 Calculation of mass

See EN 10028-1:2007 + A1:2009.

6 Classification and designation

6.1 Classification

6.1.1 This European Standard covers the steel grades given in Table 1 in three qualities:

- a) the basic series (P...M)
- b) series with low temperature properties down to -40 °C (P...ML1);
- c) series with low temperature properties down to -50 °C (P...ML2).

6.1.2 In accordance with EN 10020 all the steels specified in this document are alloy special steels.

6.2 Designation

See EN 10028-1:2007 + A1:2009.

7 Information to be supplied by the purchaser

7.1 Mandatory information

See EN 10028-1:2007 + A1:2009.

7.2 Options

A number of options are specified in this document and listed below. Additionally the relevant options of EN 10028-1:2007 + A1:2009 apply. If the purchaser does not indicate a wish to implement any of these options at the time of enquiry and order, the products shall be supplied in accordance with the basic specification (see also EN 10028-1:2007 + A1:2009).

- 1) providing data on suitable welding conditions (see 8.2.3) ;
- 2) maximum carbon equivalent (see 8.3.3);
- 3) specification of a minimum impact energy of 40 J (see Note to 8.4 and Table 5);
- 4) mid thickness test pieces for the impact test (see Clause 10).

7.3 Example for ordering

10 plates with nominal dimensions, thickness = 50 mm, width = 2 000 mm, length = 10 000 mm, made of a steel grade with the name P355ML2 and the number 1.8833 as specified in EN 10028-5, inspection certificate 3.1 as specified in EN 10204:

10 plates – 50 x 2 000 x 10 000 – EN 10028-5 P355ML2 – Inspection certificate 3.1

or

10 plates – 50 x 2 000 x 10 000 – EN 10028-5 1.8833 - Inspection certificate 3.1.

8 Requirements

8.1 Steelmaking process

See EN 10028-1:2007 + A1:2009.

8.2 Delivery condition

8.2.1 The products covered by this European Standard shall be supplied in the thermomechanically rolled condition.

8.2.2 The steels specified in this European Standard are suitable for welding processes in current use (see Notes 1 to 3 to 8.2.3).

8.2.3 •• The manufacturer shall, if requested, provide the purchaser with data on suitable welding conditions determined on the basis of weld procedure tests.

NOTE 1 With increasing product thickness and strength level cold cracking can occur. Cold cracking is caused by the following factors in combination:

9.2 Tests to be carried out

See EN 10028-1:2007 + A1:2009.

9.3 Retests

See EN 10028-1:2007 + A1:2009.

10 Sampling

See EN 10028-1:2007 + A1:2009.

For the impact test, deviating from EN 10028-1:2007 + A1:2009, Table 3, footnote f, the preparation of test pieces taken from the mid thickness may be agreed at the time of enquiry and order. In this case, test temperatures and minimum impact energy values shall also be agreed.

11 Test methods

See EN 10028-1:2007 + A1:2009.

12 Marking

See EN 10028-1:2007 + A1:2009.

9.2 Tests to be carried out

See EN 10028-1:2007 + A1:2009.

9.3 Retests

See EN 10028-1:2007 + A1:2009.

10 Sampling

See EN 10028-1:2007 + A1:2009.

For the impact test, deviating from EN 10028-1:2007 + A1:2009, Table 3, footnote f, the preparation of test pieces taken from the mid thickness may be agreed at the time of enquiry and order. In this case, test temperatures and minimum impact energy values shall also be agreed.

11 Test methods

See EN 10028-1:2007 + A1:2009.

12 Marking

See EN 10028-1:2007 + A1:2009.

Table 1 — Chemical composition (cast analysis)^a

Steel grade		Content, % by mass																									
Steel name	Steel number	C max.	Si max.	Mn ^b max.	P max.	S max.	Al _{total} ^c min.	N max.	Mo ^e max.	Nb ^f max.	Ni max.	Ti ^f max.	V ^f max.	Other													
P355M	1.8821	0,14	0,50	1,60	0,025	0,010	0,020 ^d	0,015	0,20	0,05 ^g	0,50	0,05	0,10	e													
P355ML1	1.8832				0,020	0,008																					
P355ML2	1.8833				0,020	0,005																					
P420M	1.8824	0,16	0,50	1,70	0,025	0,010		0,020							0,020	0,20	0,05 ^g	0,50	0,05	0,10	e						
P420ML1	1.8835				0,020	0,008																					
P420ML2	1.8828				0,020	0,005																					
P460M	1.8826	0,16	0,60	1,70	0,025	0,010		0,020							0,020							0,20	0,05 ^g	0,50	0,05	0,10	e
P460ML1	1.8837				0,020	0,005																					
P460ML2	1.8831				0,020	0,005																					

^a Elements not listed in this table shall not be intentionally added to the steel without the agreement of the purchaser except for finishing the cast. All appropriate measures shall be taken to prevent the addition from scrap and other materials used in steelmaking of these elements which may adversely affect the mechanical properties and usability.

^b For each reduction of 0,02 % below the maximum carbon content, an increase of 0,05 % Mn above the specified maximum value is permitted, up to a maximum of 2,00 % Mn.

^c The Al content of the cast shall be determined and given in the inspection document.

^d The minimum value for Al_{total} does not apply if adequate contents of other nitrogen-fixing elements are present.

^e (Cr + Cu + Mo) ≤ 0,60 %

^f The total of V + Nb + Ti shall not exceed a value of 0,15 %.

^g If the carbon content is restricted to ≤ 0,07 %, a maximum niobium content of 0,10 % is permitted. In this case, special care shall be taken to avoid problems in the heat affected zone at operation temperatures of –40 °C and below or after PWHT.

Table 2 — Permissible deviations of the chemical composition in the results of the product analysis from the specified values applicable to the cast analysis

Element	Specified value in the cast analysis according to Table 1 % by mass	Permissible deviation ^a of the product analysis % by mass
C	≤ 0,16	+ 0,02
Si	≤ 0,60	+ 0,06
Mn	≤ 2,00	+ 0,10
P	≤ 0,025	+ 0,005
S	≤ 0,010	+ 0,003
Al	≥ 0,020	- 0,005
N	≤ 0,020	+ 0,002
Mo	≤ 0,20	+ 0,03
Nb	≤ 0,10	+ 0,01
Ni	≤ 0,50	+ 0,05
Ti	≤ 0,05	+ 0,01
V	≤ 0,10	+ 0,01
Cr+Cu+Mo	≤ 0,60	+ 0,10
V+Nb+Ti	≤ 0,15	+ 0,03

^a If several product analyses are carried out on one cast, and then 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 fall short of the permissible minimum value, but not both for one cast.

**Table 3 — Maximum values for the carbon equivalent (CEV) based on cast analysis
 (if agreed at the time of enquiry and order)^a**

Steel grade	CEV ^b max. for product thickness <i>t</i> in mm		
	<i>t</i> ≤ 16	16 < <i>t</i> ≤ 40	40 < <i>t</i> ≤ 63
P355M/ML1/ML2	0,39	0,39	0,40
P420M/ML1/ML2	0,43	0,45	0,46
P460M/ML1/ML2	0,45	0,46	0,47

^a See 8.3.3.

^b $CEV = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Cu + Ni}{15}$

Table 4 — Mechanical properties at room temperature

Steel grade		Yield strength ^a R_{eH} for product thickness t in mm			Tensile strength R_m	Elongation after fracture A
Steel name	Steel number	$t \leq 16$	$16 < t \leq 40$	$40 < t \leq 63$	MPa	% min.
P355M	1.8821	355			450 to 610	22
P355ML1	1.8832					
P355ML2	1.8833					
P420 M	1.8824	420	400	390	500 to 660	19
P420ML1	1.8835					
P420ML2	1.8828					
P460M	1.8826	460	440	430	530 to 720	17
P460ML1	1.8837					
P460ML2	1.8831					

^a The yield strength to be determined shall be the upper yield strength R_{eH} or, if this is not pronounced, the 0,2 % proof strength $R_{p0,2}$.

Table 5 — Minimum impact energy values (valid for transverse test pieces)

Steel grade	Product thickness mm	Impact energy KV J min. at a temperature in °C of				
		-50	-40	-20	0	+20
P...M	≤ 63	–	–	27 ^a	40	60
P...ML1		–	27 ^a	40	60	–
P...ML2		27 ^a	40	60	80	–
^a •• A minimum impact energy value of 40 J may be agreed at the time of enquiry and order.						

Annex ZA (informative)

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8.4	4.1a	Appropriate material properties
8.2	4.1c	Ageing
8.2 and 8.6	4.1d	Suitable for the processing procedures
9.1	4.3	Documentation

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

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- [1] EN 1011-1, *Welding - Recommendations for welding of metallic materials – Part 1: General guidance for arc welding*
- [2] EN 1011-2, *Welding - Recommendations for welding of metallic materials – Part 2: Arc welding of ferritic steels*
- [3] EN 10020, *Definition and classification of grades of steel*

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Flat products made of steels for pressure purposes

Part 6: Weldable fine grain steels, quenched and tempered

ICS 77.140.30; 77.140.50

National foreword

This British Standard is the UK implementation of EN 10028-6:2009. It supersedes BS EN 10028-6:2003 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/73/2, Steel plates and bars 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.

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English Version

Flat products made of steels for pressure purposes - Part 6: Weldable fine grain steels, quenched and tempered

Produits plats en acier pour appareils à pression - Partie 6:
Aciers soudables à grains fins, trempés et revenus

Flacherzeugnisse aus Druckbehälterstählen - Teil 6:
Schweißgeeignete Feinkornbaustähle, vergütet

This European Standard was approved by CEN on 14 May 2009.

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Foreword

This document (EN 10028-6:2009) has been prepared by Technical Committee ECISS/TC 22 "Steels for pressure purposes - Qualities", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2009, and conflicting national standards shall be withdrawn at the latest by December 2009.

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 10028-6:2003.

This European Standard consists of the following parts, under the general title *Flat products made of steels for pressure purposes*:

- *Part 1: General requirements*
- *Part 2: Non-alloy and alloy steels with specified elevated temperature properties*
- *Part 3: Weldable fine grain steels, normalized*
- *Part 4: Nickel alloy steels with specified low temperature properties*
- *Part 5: Weldable fine grain steels, thermomechanically rolled*
- *Part 6: Weldable fine grain steels, quenched and tempered*
- *Part 7: Stainless steels*

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

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.

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

1 Scope

This European Standard specifies the requirements for flat products for pressure equipments made of quenched and tempered steels as specified in Table 1.

The requirements in EN 10028-1:2007 + A1:2009 also apply.

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 (Part 1 and this Part 6 of the series) 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 referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 10028-1:2007 + A1:2009, *Flat products made of steels for pressure purposes – Part 1: General requirements*

EN 10204:2004, *Metallic products – Types of inspection documents*

3 Terms and definitions

For the purposes of this document the terms and definitions given in EN 10028-1:2007 + A1:2009 apply.

4 Dimensions and tolerances

See EN 10028-1:2007 + A1:2009.

5 Calculation of mass

See EN 10028-1:2007 + A1:2009.

6 Classification and designation

6.1 Classification

6.1.1 This document covers the steel grades given in Table 1 in four qualities:

- a) the basic series (P...Q);
- b) series with elevated temperature properties (P...QH);
- c) series with low temperature properties down to -40 °C (P...QL1);
- d) series with low temperature properties down to -60 °C (P...QL2).

6.1.2 In accordance with EN 10020 all the steels specified in this document are alloy special steels.

6.2 Designation

See EN 10028-1:2007 + A1:2009.

7 Information to be supplied by the purchaser

7.1 Mandatory information

See EN 10028-1:2007 + A1:2009.

7.2 Options

A number of options is specified in this document and listed below. Additionally the relevant options of EN 10028-1:2007 + A1:2009 apply. If the purchaser does not indicate a wish to implement any of these options at the time of enquiry and order, the products shall be supplied in accordance with the basic specification (see also EN 10028-1:2007 + A1:2009).

- 1) providing data on suitable welding conditions (see 8.2.3);
- 2) mid thickness test pieces for the impact test (see Clause 10);
- 3) lower copper content and maximum tin content (see Table 1, footnote c);
- 4) mechanical properties for thicknesses > 150 mm (see Table 3, footnote b);
- 5) specification of a minimum impact energy of 40 J (see Note to 8.4 and Table 4, footnote a);
- 6) applicability of elevated temperature values for QL grades (see Table 5, footnote b).

7.3 Example for ordering

10 plates with nominal dimensions, thickness = 50 mm, width = 2 000 mm, length = 10 000 mm, made of a steel grade with the name P355QL2 and the number 1.8869 as specified in EN 10028-6, inspection certificate 3.1 as specified in EN 10204:

10 plates – 50 x 2 000 x 10 000 – EN 10028-6 P355QL2 – Inspection certificate 3.1

or

10 plates – 50 x 2 000 x 10 000 – EN 10028-6 1.8869 – Inspection certificate 3.1.

8 Requirements

8.1 Steelmaking process

See EN 10028-1:2007 + A1:2009.

8.2 Delivery condition

8.2.1 The products covered by this European Standard shall be supplied in the quenched and tempered condition.

8.2.2 The steels specified in this European Standard shall be suitable for welding processes in current use (see Notes 1 to 3 to 8.2.3).

8.2.3 •• The manufacturer shall, if requested, provide the purchaser with data on suitable welding conditions determined on the basis of weld procedure tests.

NOTE 1 With increasing product thickness and strength level cold cracking can occur. Cold cracking is caused by the following factors in combination:

- a) the amount of diffusible hydrogen in the weld metal;
- b) brittle structure of the heat affected zone;

c) tensile stress concentrations in the welded joint.

NOTE 2 When using recommendations as laid down, for example in EN 1011-1 and EN 1011-2, the recommended welding conditions and the various welding ranges of the steel grades can be determined depending on the product thickness, the applied welding energy, the design requirements, the electrode efficiency, the welding process and the weld metal properties.

NOTE 3 Excessive post weld heat-treatment (PWHT) conditions can decrease the mechanical properties. It is therefore recommended that the purchaser seeks, at the time of enquiry and order, the advice of the manufacturer and considers, where appropriate, the verification of the mechanical properties on simulated post weld heat treated samples.

8.3 Chemical composition

8.3.1 The requirements of Table 1 apply for the chemical composition according to the cast analysis.

8.3.2 The product analysis may deviate from the specified values of the cast analysis given in Table 1 by the values given in Table 2.

8.4 Mechanical properties

The values given in Tables 3 to 5 apply (see also EN 10028-1:2007 + A1:2009 and Clause 10).

NOTE Optionally, a minimum impact energy value of 40 J may be specified for temperatures where lower minimum values are specified (see Table 4, footnote a).

8.5 Surface condition

See EN 10028-1:2007 + A1:2009.

8.6 Internal soundness

See EN 10028-1:2007 + A1:2009.

For possible verification, see also EN 10028-1:2007 + A1:2009.

9 Inspection

9.1 Types of inspections and inspections documents

See EN 10028-1:2007 + A1:2009.

9.2 Tests to be carried out

See EN 10028-1:2007 + A1:2009.

9.3 Retests

See EN 10028-1:2007 + A1:2009.

10 Sampling

See EN 10028-1:2007 + A1:2009.

For the impact test, deviating from EN 10028-1:2007 + A1:2009, Table 3, footnote f, the preparation of test pieces taken from the mid thickness may be agreed at the time of enquiry and order. In this case, test temperatures and minimum impact energy values shall also be agreed.

11 Test methods

See EN 10028-1:2007 + A1:2009.

12 Marking

See EN 10028-1:2007 + A1:2009.

Table 1 — Chemical composition (cast analysis)^{a,b}

Steel grade		Maximum contents, % by mass														
Steel name	Steel number	C	Si	Mn	P	S	N	B	Cr	Mo	Cu ^c	Nb ^d	Ni	Ti ^d	V ^d	Zr ^d
P355Q	1.8866	0,16	0,40	1,50	0,025	0,010	0,015	0,005	0,30	0,25	0,30	0,05	0,50	0,03	0,06	0,05
P355QH	1.8867				0,020	0,008										
P355QL1	1.8868					0,005										
P355QL2	1.8869															
P460Q	1.8870	0,18	0,50	1,70	0,025	0,010	0,015	0,005	0,50	0,50	0,30	0,05	1,00	0,03	0,08	0,05
P460QH	1.8871				0,020	0,008										
P460QL1	1.8872					0,005										
P460QL2	1.8864															
P500Q	1.8873	0,18	0,60	1,70	0,025	0,010	0,015	0,005	1,00	0,70	0,30	0,05	1,50	0,05	0,08	0,15
P500QH	1.8874				0,020	0,008										
P500QL1	1.8875					0,005										
P500QL2	1.8865															
P690Q	1.8879	0,20	0,80	1,70	0,025	0,010	0,015	0,005	1,50	0,70	0,30	0,06	2,50	0,05	0,12	0,15
P690QH	1.8880				0,020	0,008										
P690QL1	1.8881					0,005										
P690QL2	1.8888															

^a Elements not listed in this table shall not be intentionally added to the steel without the agreement of the purchaser except for finishing the cast. All appropriate measures shall be taken to prevent the addition from scrap and other materials used in steelmaking of these elements which may adversely affect the mechanical properties and usability.

^b The manufacturer may add one or several alloying element(s) up to the maximum values specified in the order as a function of the product thickness and the steelmaking conditions in order to attain the specified properties. The chemical composition range for each manufacturer's analysis shall be given in the offer and confirmation of order.

^c •• For reasons of hot formability, a lower copper content and a maximum tin content may be agreed at the time of enquiry and order.

^d The percentage of grain refining elements shall be at least 0,015 %. Aluminium is also included in these elements. The minimum content of 0,015 % applies here to dissolved aluminium. This value is regarded as attained if the total aluminium content is at least 0,018 %; in cases of dispute, the dissolved aluminium content is to be determined.

Table 2 — Permissible deviations of the chemical composition in the results of the product analysis from the specified values applicable to the cast analysis

Element	Specified value in the cast analysis according to Table 1 % by mass	Permissible deviation ^a of the product analysis % by mass
C	≤ 0,20	+ 0,02
Si	≤ 0,80	+ 0,05
Mn	≤ 1,70	+ 0,10
P	≤ 0,025	+ 0,005
S	≤ 0,010	+ 0,003
Al _{total}	≥ 0,018	– 0,005
N	≤ 0,015	+ 0,002
B	≤ 0,005	+ 0,0005
Cr	≤ 1,50	+ 0,10
Mo	≤ 0,70	+ 0,04
Cu	≤ 0,30	+ 0,05
Ni	≤ 2,50	+ 0,10
Nb	≤ 0,06	+ 0,01
Ti	≤ 0,05	+ 0,01
V	≤ 0,12	+ 0,01
Zr	≤ 0,15	+ 0,01

^a If several product analysis are carried out on one cast, and then 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 fall short of the permissible minimum value, but not both for one cast.

Table 3 — Mechanical properties at room temperature

Steel grade		Yield strength ^a R_{eH} for product thickness t in mm			Tensile strength R_m for product thickness t in mm		Elongation after fracture A % min.
		$t \leq 50$	$50 < t \leq 100$	$100 < t \leq 150^b$	$t \leq 100$	$100 < t \leq 150^b$	
Steel name	Steel number	MPa min.			MPa		
P355Q	1.8866	355	335	315	490 to 630	450 to 590	22
P355QH	1.8867						
P355QL1	1.8868						
P355QL2	1.8869						
P460Q	1.8870	460	440	400	550 to 720	500 to 670	19
P460QH	1.8871						
P460QL1	1.8872						
P460QL2	1.8864						
P500Q	1.8873	500	480	440	590 to 770	540 to 720	17
P500QH	1.8874						
P500QL1	1.8875						
P690QL2	1.8865						
P690Q	1.8879	690	670	630	770 to 940	720 to 900	14
P690QH	1.8880						
P690QL1	1.8881						
P460QL2	1.8888						

^a The yield strength to be determined shall be the upper yield strength R_{eH} or, if this is not pronounced, the 0,2 % proof strength $R_{p0.2}$.

^b •• Other product thicknesses may be agreed at the time of enquiry and order.

Table 4 — Impact energy (valid for transverse test pieces)

Steel grade	Product thickness mm	Impact energy KV J min. at a temperature in °C of				
		-60	-40	-20	0	+20
P...Q P...QH	≤ 150	—	—	27 ^a	40	60
P...QL1		—	27 ^a	40	60	—
P...QL2		27 ^a	40	60	80	—

^a •• A minimum impact energy value of 40 J may be agreed at the time of enquiry and order.

Table 5 — Minimum 0,2 % proof strength $R_{p0,2}$ at elevated temperatures^a

Steel grade ^b		Minimum 0,2 % proof strength $R_{p0,2}$ values ^c in MPa at a temperature in °C of					
Steel name	Steel number	50	100	150	200	250	300
P355QH	1.8867	340	310	285	260	235	215
P460QH	1.8871	445	425	405	380	360	340
P500QH	1.8874	490	470	450	420	400	380
P690QH	1.8880	670	645	615	595	575	570

^a The values shall be proven by means of a tensile test at elevated temperature for the specified service temperature. An agreement at the time of enquiry and order shall be reached on this between the purchaser and manufacturer.

^b •• If agreed at the time of enquiry and order, these values also apply to the grades P...QL with specified low temperature properties.

^c These values are valid for product thicknesses $t \leq 50$ mm. For larger thicknesses, the minimum 0,2 % proof strength values are reduced by:

- 20 MPa for $50 \text{ mm} < t \leq 100 \text{ mm}$ and by
- 60 MPa for $t > 100 \text{ mm}$.

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.

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

Clauses/sub-clauses of this European Standard	Essential Requirements (ERs) of Directive 97/23/EC, Annex I	Qualifying remarks/ Notes
8.4	4.1a	Appropriate material properties
8.2	4.1c	Ageing
8.2 and 8.6	4.1d	Suitable for the processing procedures
9.1	4.3	Documentation

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

Bibliography

- [1] EN 1011-1, *Welding – Recommendations for welding of metallic materials – Part 1: General guidance for arc welding*
- [2] EN 1011-2, *Welding – Recommendations for welding of metallic materials – Part 2: Arc welding of ferritic steels*
- [3] EN 10020, *Definition and classification of grades of steel*

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**Flat products made of steels for pressure purposes –
Part 7: Stainless steels
English version of DIN EN 10028-7:2008-02**

Flacherzeugnisse aus Druckbehälterstählen –
Teil 7: Nichtrostende Stähle
Englische Fassung DIN EN 10028-7:2008-02

Document comprises 48 pages



National foreword

This standard has been prepared by Technical Committee ECISS/TC 22 “Steels for pressure purposes – Qualities” (Secretariat: DIN, Germany).

The responsible German body involved in its preparation was the *Normenausschuss Eisen und Stahl* (Iron and Steel Standards Committee), Technical Committee NA 04-02 *Stähle für den Druckbehälterbau*.

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

Amendments

This standard differs from DIN EN 10028-7:2000-06 and DIN EN 10028-7 Corrigendum 1:2006-05 as follows:

- a) Remarks regarding harmonization with Directive 97/23/EC have been made more precise.
- b) Austenitic steels have been divided into corrosion resisting grades and creep resisting grades.
- c) Chemical compositions have been brought in line with the relevant specifications in DIN EN 10088-1 and DIN EN 10088-2.
- d) Minimum impact energy values for austenitic-ferritic steels have been increased.
- e) Some of the maximum thickness values for cold-rolled and hot-rolled strip of austenitic-ferritic steel have been increased.
- f) Values for the maximum thickness of hot-rolled plate of austenitic-ferritic steel have been modified.
- g) Proof strength values for steels at 50 °C – which were determined by linear interpolation – are now specified.
- h) Annex ZA has been revised.
- i) The standard has been editorially revised.

Previous editions

DIN 17440: 1967-01, 1972-12, 1985-07, 1996-09

DIN 17441: 1985-07, 1997-02

DIN 17460: 1992-09

DIN EN 10028-7: 2000-06

DIN EN 10028-7 Corrigendum 1: 2006-05

National Annex NA (informative)

Bibliography

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

DIN EN 10088-2, *Stainless steels — Part 2: Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes*

English Version

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

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

Flacherzeugnisse aus Druckbehälterstählen - Teil 7:
Nichtrostende Stähle

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

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Foreword

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This document supersedes EN 10028-7:2000.

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

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

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

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

- *Part 1: General requirements*
- *Part 2: Non-alloy and alloy steels with specified elevated temperature properties*
- *Part 3: Weldable fine grain steels, normalized*
- *Part 4: Nickel alloy steels with specified low temperature properties*
- *Part 5: Weldable fine grain steels, thermomechanically rolled*
- *Part 6: Weldable fine grain steels, quenched and tempered*
- *Part 7: Stainless steels*

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

1 Scope

This European Standard specifies requirements for flat products for pressure purposes made of stainless steels, including austenitic creep resisting steels, in thicknesses as indicated in Tables 7 to 10.

The requirements of EN 10028-1 also apply.

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

NOTE 2 Once this European Standard is published in the Official Journal of the European Union (OJEU) under Directive 97/23/EC, presumption of conformity to the Essential Safety Requirements (ESRs) of Directive 97/23/EC is limited to technical data of materials in this European Standard (Part 1 and Part 7) and does not presume adequacy of the material to a specific item of equipment. Consequently, the assessment of the technical data stated in this material standard against the design requirements of this specific item of equipment to verify that the ESRs of the Pressure Equipment Directive are satisfied, needs to be done.

2 Normative references

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

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

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

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

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

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

3 Terms and definitions

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

3.1

cryogenic temperature

temperature lower than -75 °C used in the liquefaction of gases

4 Dimensions and tolerances on dimensions

Shall be according to EN 10028-1.

5 Calculation of mass

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

6 Classification and designation

Shall be according to EN 10028-1.

7 Information to be supplied by the purchaser

7.1 Mandatory information

Shall be according to EN 10028-1.

7.2 Options

A number of options are specified in this document and listed below. Additionally, the relevant options of EN 10028-1 apply. If the purchaser does not indicate a wish to implement any of these options at the time of enquiry and order, the products shall be supplied in accordance with the basic specification (see EN 10028-1).

- a) mechanical properties for increased product thicknesses (see Table 7, footnote e);
- b) higher $R_{p0,2}$ and $R_{p1,0}$ values for continuously hot rolled products (see Table 9, footnote d and Table 10, footnote b).

7.3 Example for ordering

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

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

or

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

8 Requirements

8.1 Steelmaking process

Shall be according to EN 10028-1.

8.2 Delivery condition

The products shall be supplied in the delivery condition specified in the order by reference to the process route given in Table 6 and, where alternatives exist, to the treatment conditions given in Tables 7 to 10. Guidelines for further treatment including heat treatment are given in Annex A.

8.3 Chemical composition and chemical corrosion properties

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

8.3.2 The product analysis may deviate from the limiting values for the cast analysis given in Tables 1 to 4 by the values listed in Table 5.

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

NOTE 1 EN ISO 3651-2 is not applicable for testing martensitic steels.

NOTE 2 The corrosion resistance of stainless steels is very dependent on the type of environment and can therefore not always be clearly ascertained through laboratory tests. It is therefore advisable to draw on the available experience of the use of the steels.

8.4 Mechanical properties

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

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

8.4.2 The values in Tables 11 to 14 apply for the 0,2 % and 1,0 % proof strength at elevated temperatures. Additionally, the values in Table 15 apply for the tensile strength at elevated temperatures.

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

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

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

8.5 Surface condition

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

8.6 Internal soundness

Shall be according to EN 10028-1.

8.7 Physical properties

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

8.8 Post weld heat treatment

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

9 Inspection

9.1 Types of inspection and inspection documents

Shall be according to EN 10028-1.

9.2 Tests to be carried out

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

9.3 Re-tests

Shall be according to EN 10028-1.

10 Sampling

10.1 Frequency of testing

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

10.2 Selection and preparation of samples and test pieces

Shall be according to EN 10028-1.

11 Test methods

Shall be according to EN 10028-1.

12 Marking

Shall be according to EN 10028-1.

Table 1 — Chemical composition (cast analysis) ^a of ferritic steels

Steel grade		% by mass										
Steel name	Steel number	C max.	Si max.	Mn max.	P max.	S max.	N max.	Cr	Mo	Nb	Ni	Ti
X2CrNi12	1.4003	0,030	1,00	1,50	0,040	0,015	0,030	10,5 to 12,5	–	–	0,30 to 1,00	–
X6CrNiTi12	1.4516	0,08	0,70	1,50	0,040	0,015	–	10,5 to 12,5	–	–	0,50 to 1,50	0,05 to 0,35
X2CrTi17	1.4520	0,025	0,50	0,50	0,040	0,015	0,015	16,0 to 18,0	–	–	–	0,30 to 0,60
X3CrTi17	1.4510	0,05	1,00	1,00	0,040	0,015	–	16,0 to 18,0	–	–	–	[4 x(C+N) + 0,15] to 0,80 ^b
X2CrMoTi17-1	1.4513	0,025	1,00	1,00	0,040	0,015	0,020	16,0 to 18,0	0,80 to 1,40	–	–	0,30 to 0,60
X2CrMoTi18-2	1.4521	0,025	1,00	1,00	0,040	0,015	0,030	17,0 to 20,0	1,80 to 2,50	–	–	[4 x(C+N) + 0,15] to 0,80 ^b
X6CrMoNb17-1	1.4526	0,08	1,00	1,00	0,040	0,015	0,040	16,0 to 18,0	0,80 to 1,40	[7x(C+N) + 0,10] to 1,00	–	–
X2CrTiNb18	1.4509	0,030	1,00	1,00	0,040	0,015	–	17,5 to 18,5	–	[(3xC) + 0,30] to 1,00	–	0,10 to 0,60

^a Elements not listed in this table shall not be intentionally added to the steel without the agreement of the purchaser except for finishing of the cast. All appropriate precautions are to be taken to avoid the addition of such elements from scrap and other materials used in production which would impair mechanical properties and the suitability of the steel.

^b The stabilisation may be made by use of titanium or niobium or zirconium. According to the atomic mass of these elements and the content of carbon and nitrogen, the equivalence shall be the following, in % by mass:

$$\text{Nb} = \text{Zr} = \frac{7}{4} \text{Ti}$$

Table 2 — Chemical composition (cast analysis) ^a of martensitic steels

Steel grade		% by mass								
Steel name	Steel number	C max.	Si max.	Mn max.	P max.	S max.	Cr	Mo	Ni	N min.
X3CrNiMo13-4	1.4313	0,05	0,70	1,50	0,040	0,015	12,0 to 14,0	0,30 to 0,70	3,5 to 4,5	0,020
X4CrNiMo16-5-1	1.4418	0,06	0,70	1,50	0,040	0,015	15,0 to 17,0	0,80 to 1,50	4,0 to 6,0	0,020

^a Elements not quoted in this table shall not be intentionally added to the steel without the agreement of the purchaser except for finishing the cast. All appropriate precautions are to be taken to avoid the addition of such elements from scrap and other materials used in production which would impair mechanical properties and the suitability of the steel.

Table 3 — Chemical composition (cast analysis) ^a of austenitic steels

Steel grade		% by mass												
Steel name	Steel number	C	Si	Mn max.	P max.	S max.	N	Cr	Cu	Mo	Nb	Ni	Ti	Others
Austenitic corrosion resisting grades														
X2CrNi18-7	1.4318	≤ 0,030	≤ 1,00	2,00	0,045	0,015	0,10 to 0,20	16,5 to 18,5	–	–	–	6,0 to 8,0	–	–
X2CrNi18-9	1.4307	≤ 0,030	≤ 1,00	2,00	0,045	0,015	≤ 0,10	17,5 to 19,5	–	–	–	8,0 to 10,5	–	–
X2CrNi19-11	1.4306	≤ 0,030	≤ 1,00	2,00	0,045	0,015	≤ 0,10	18,0 to 20,0	–	–	–	10,0 to 12,0	–	–
X5CrNi19-9	1.4315	≤ 0,06	≤ 1,00	2,00	0,045	0,015	0,12 to 0,22	18,0 to 20,0	–	–	–	8,0 to 11,0	–	–
X2CrNi18-10	1.4311	≤ 0,030	≤ 1,00	2,00	0,045	0,015	0,12 to 0,22	17,5 to 19,5	–	–	–	8,5 to 11,5	–	–
X5CrNi18-10	1.4301	≤ 0,07	≤ 1,00	2,00	0,045	0,015	≤ 0,10	17,5 to 19,5	–	–	–	8,0 to 10,5	–	–
X6CrNiTi18-10	1.4541	≤ 0,08	≤ 1,00	2,00	0,045	0,015	–	17,0 to 19,0	–	–	–	9,0 to 12,0	5 x C to 0,70	–
X6CrNiNb18-10	1.4550	≤ 0,08	≤ 1,00	2,00	0,045	0,015	–	17,0 to 19,0	–	–	10 x C to 1,00	9,0 to 12,0	–	–
X1CrNi25-21	1.4335	≤ 0,020	≤ 0,25	2,00	0,025	0,010	≤ 0,10	24,0 to 26,0	–	≤ 0,20	–	20,0 to 22,0	–	–
X2CrNiMo17-12-2	1.4404	≤ 0,030	≤ 1,00	2,00	0,045	0,015	≤ 0,10	16,5 to 18,5	–	2,00 to 2,50	–	10,0 to 13,0	–	–
X2CrNiMoN17-11-2	1.4406	≤ 0,030	≤ 1,00	2,00	0,045	0,015	0,12 to 0,22	16,5 to 18,5	–	2,00 to 2,50	–	10,0 to 12,5	–	–
X5CrNiMo17-12-2	1.4401	≤ 0,07	≤ 1,00	2,00	0,045	0,015	≤ 0,10	16,5 to 18,5	–	2,00 to 2,50	–	10,0 to 13,0	–	–
X1CrNiMoN25-22-2	1.4466	≤ 0,020	≤ 0,70	2,00	0,025	0,010	0,10 to 0,16	24,0 to 26,0	–	2,00 to 2,50	–	21,0 to 23,0	–	–
X6CrNiMoTi17-12-2	1.4571	≤ 0,08	≤ 1,00	2,00	0,045	0,015	–	16,5 to 18,5	–	2,00 to 2,50	–	10,5 to 13,5	5 x C to 0,70	–
X6CrNiMoNb17-12-2	1.4580	≤ 0,08	≤ 1,00	2,00	0,045	0,015	–	16,5 to 18,5	–	2,00 to 2,50	10 x C to 1,00	10,5 to 13,5	–	–
X2CrNiMo17-12-3	1.4432	≤ 0,030	≤ 1,00	2,00	0,045	0,015	≤ 0,10	16,5 to 18,5	–	2,50 to 3,00	–	10,5 to 13,0	–	–
X2CrNiMoN17-13-3	1.4429	≤ 0,030	≤ 1,00	2,00	0,045	0,015	0,12 to 0,22	16,5 to 18,5	–	2,50 to 3,00	–	11,0 to 14,0	–	–
X3CrNiMo17-13-3	1.4436	≤ 0,05	≤ 1,00	2,00	0,045	0,015	≤ 0,10	16,5 to 18,5	–	2,50 to 3,00	–	10,5 to 13,0	–	–
X2CrNiMo18-14-3	1.4435	≤ 0,030	≤ 1,00	2,00	0,045	0,015	≤ 0,10	17,0 to 19,0	–	2,50 to 3,00	–	12,5 to 15,0	–	–
X2CrNiMoN18-12-4	1.4434	≤ 0,030	≤ 1,00	2,00	0,045	0,015	0,10 to 0,20	16,5 to 19,5	–	3,0 to 4,0	–	10,5 to 14,0	–	–

(to be continued)

Table 3 (concluded)

Steel grade		% by mass												
Steel name	Steel number	C	Si	Mn max.	P max.	S max.	N	Cr	Cu	Mo	Nb	Ni	Ti	Others
X2CrNiMo18-15-4	1.4438	≤ 0,030	≤ 1,00	2,00	0,045	0,015	≤ 0,10	17,5 to 19,5	–	3,0 to 4,0	–	13,0 to 16,0	–	–
X2CrNiMoN17-13-5	1.4439	≤ 0,030	≤ 1,00	2,00	0,045	0,015	0,12 to 0,22	16,5 to 18,5	–	4,0 to 5,0	–	12,5 to 14,5	–	–
X1NiCrMoCu31-27-4	1.4563	≤ 0,020	≤ 0,70	2,00	0,030	0,010	≤ 0,10	26,0 to 28,0	0,70 to 1,50	3,0 to 4,0	–	30,0 to 32,0	–	–
X1NiCrMoCu25-20-5	1.4539	≤ 0,020	≤ 0,70	2,00	0,030	0,010	≤ 0,15	19,0 to 21,0	1,20 to 2,00	4,0 to 5,0	–	24,0 to 26,0	–	–
X1CrNiMoCuN25-25-5	1.4537	≤ 0,020	≤ 0,70	2,00	0,030	0,010	0,17 to 0,25	24,0 to 26,0	1,00 to 2,00	4,7 to 5,7	–	24,0 to 27,0	–	–
X1CrNiMoCuN20-18-7	1.4547	≤ 0,020	≤ 0,70	1,00	0,030	0,010	0,18 to 0,25	19,5 to 20,5	0,50 to 1,00	6,0 to 7,0	–	17,5 to 18,5	–	–
X1NiCrMoCuN25-20-7	1.4529	≤ 0,020	≤ 0,50	1,00	0,030	0,010	0,15 to 0,25	19,0 to 21,0	0,50 to 1,50	6,0 to 7,0	–	24,0 to 26,0	–	–
Austenitic creep resisting grades														
X3CrNiMoBN17-13-3	1.4910	≤ 0,04	≤ 0,75	2,00	0,035	0,015	0,10 to 0,18	16,0 to 18,0	–	2,00 to 3,00	–	12,0 to 14,0	–	0,001 5 to 0,005 0 B
X6CrNiTiB18-10	1.4941	0,04 to 0,08	≤ 1,00	2,00	0,035	0,015	–	17,0 to 19,0	–	–	–	9,0 to 12,0	5 x C to 0,80	0,001 5 to 0,005 0 B
X6CrNi18-10	1.4948	0,04 to 0,08	≤ 1,00	2,00	0,035	0,015	≤ 0,10	17,0 to 19,0	–	–	–	8,0 to 11,0	–	–
X6CrNi23-13	1.4950	0,04 to 0,08	≤ 0,70	2,00	0,035	0,015	≤ 0,10	22,0 to 24,0	–	–	–	12,0 to 15,0	–	–
X6CrNi25-20	1.4951	0,04 to 0,08	≤ 0,70	2,00	0,035	0,015	≤ 0,10	24,0 to 26,0	–	–	–	19,0 to 22,0	–	–
X5NiCrAlTi31-20 (+RA)	1.4958 (+RA)	0,03 to 0,08	≤ 0,70	1,50	0,015	0,010	≤ 0,030	19,0 to 22,0	≤ 0,50	–	≤ 0,10	30,0 to 32,5	0,20 to 0,50	0,20 to 0,50 Al Al+Ti: ≤ 0,70 ≤ 0,50 Co Ni+Co: 30,0 to 32,5
X8NiCrAlTi32-21	1.4959	0,05 to 0,10	≤ 0,70	1,50	0,015	0,010	≤ 0,030	19,0 to 22,0	≤ 0,50	–	–	30,0 to 34,0	0,25 to 0,65	0,25 to 0,65 Al ≤ 0,50 Co Ni+Co: 30,0 to 34,0
X8CrNiNb16-13	1.4961	0,04 to 0,10	0,30 to 0,60	1,50	0,035	0,015	–	15,0 to 17,0	–	–	10 x C to 1,20	12,0 to 14,0	–	–
^a Elements not listed in this table shall not be intentionally added to the steel without the agreement of the purchaser except for finishing of the cast. All appropriate precautions are to be taken to avoid the addition of such elements from scrap and other materials used in production which would impair mechanical properties and the suitability of the steel.														

Table 4 — Chemical composition (cast analysis) ^a of austenitic-ferritic steels

Steel grade		% by mass										
Steel name	Steel number	C max.	Si max.	Mn max.	P max.	S max.	N	Cr	Cu	Mo	Ni	W
X2CrNiN23-4	1.4362	0,030	1,00	2,00	0,035	0,015	0,05 to 0,20	22,0 to 24,0	0,10 to 0,60	0,10 to 0,60	3,5 to 5,5	–
X2CrNiMoN22-5-3	1.4462	0,030	1,00	2,00	0,035	0,015	0,10 to 0,22	21,0 to 23,0	–	2,50 to 3,5	4,5 to 6,5	–
X2CrNiMoCuN25-6-3	1.4507	0,030	0,70	2,00	0,035	0,015	0,20 to 0,30	24,0 to 26,0	1,00 to 2,50	3,0 to 4,0	6,0 to 8,0	–
X2CrNiMoN25-7-4	1.4410	0,030	1,00	2,00	0,035	0,015	0,24 to 0,35	24,0 to 26,0	–	3,0 to 4,5	6,0 to 8,0	–
X2CrNiMoCuWN25-7-4	1.4501	0,030	1,00	1,00	0,035	0,015	0,20 to 0,30	24,0 to 26,0	0,50 to 1,00	3,0 to 4,0	6,0 to 8,0	0,50 to 1,00

^a Elements not quoted in this table shall not be intentionally added to the steel without the agreement of the purchaser except for finishing the cast. All appropriate precautions are to be taken to avoid the addition of such elements from scrap and other materials used in production which would impair mechanical properties and the suitability of the steel.

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

Element	Specified limits, cast analysis		Permissible tolerance ^a % by mass
	% by mass		
Carbon	≤	0,030	+ 0,005
	> 0,030	≤ 0,10	± 0,01
Silicon	≤	1,00	+ 0,05
Manganese	≤	1,00	+ 0,03
	> 1,00	≤ 2,00	+ 0,04
Phosphorus	≤	0,045	+ 0,005
Sulphur	≤	0,015	+ 0,003
Nitrogen	≤	0,35	± 0,01
Aluminium	≤	0,65	± 0,10
Boron	≥ 0,001 5	≤ 0,005 0	± 0,000 3
Chromium	≥ 10,5	< 15,0	± 0,15
	≥ 15,0	≤ 20,0	± 0,20
	> 20,0	≤ 28,0	± 0,25
Copper	≤	1,00	± 0,07
	> 1,00	≤ 2,50	± 0,10
Molybdenum	≤	0,60	± 0,03
	> 0,60	< 1,75	± 0,05
	≥ 1,75	≤ 7,0	± 0,10
Niobium	≤	1,20	± 0,05
Nickel	≤	1,00	± 0,03
	> 1,00	≤ 5,0	± 0,07
	> 5,0	≤ 10,0	± 0,10
	> 10,0	≤ 20,0	± 0,15
	> 20,0	≤ 34,0	± 0,20
Cobalt	≤	0,50	+ 0,05
Titanium	≤	0,80	± 0,05
Tungsten	≤	1,00	± 0,05
^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.			

Table 6 — Type of process route of sheet, plate and strip ^a

	Abbreviation ^b	Type of treatment ^c	Surface finish	Notes
Hot rolled	1C	Hot rolled, heat treated, not descaled	Covered with the rolling scale	Suitable for parts which will be descaled or machined in subsequent production or for certain heat-resisting applications.
	1E	Hot rolled, heat treated, mechanically descaled	Free of scale	The type of mechanical descaling, e.g. coarse grinding or shot blasting, depends on the steel grade and the product, and is left to the manufacturer's discretion, unless otherwise agreed.
	1D	Hot rolled, heat treated, pickled	Free of scale	Usually standard for most steel types to ensure good corrosion resistance; also common finish for further processing. It is permissible for grinding marks to be present. Not as smooth as 2D or 2B.
Cold rolled	2C	Cold rolled, heat treated, not descaled	Smooth with scale from heat treatment	Suitable for parts which will be descaled or machined in subsequent production or for certain heat-resisting applications.
	2E	Cold rolled, heat treated, mechanically descaled	Rough and dull	Usually applied to steels with a scale which is very resistant to pickling solutions. May be followed by pickling.
	2D	Cold rolled, heat treated, pickled	Smooth	Finish for good ductility, but not as smooth as 2B or 2R.
	2B	Cold rolled, heat treated, pickled, skin passed	Smoother than 2D	Most common finish for most steel types to ensure good corrosion resistance, smoothness and flatness. Also common finish for further processing. Skin passing may be by tension levelling.
	2R	Cold rolled, bright annealed ^d	Smooth, bright, reflective	Smoother and brighter than 2B. Also common finish for further processing.
Special finishes	1G or 2G	Ground ^e	See footnote f.	Grade of grit or surface roughness can be specified. Unidirectional texture, not very reflective.
	1J or 2J	Brushed ^e or dull polished ^e	Smoother than ground. See footnote f	Grade of brush or surface roughness can be specified. Unidirectional texture, not very reflective.
	1K or 2K	Satin polished ^e	See footnote f	Additional specific requirements to a "J" type finish, in order to achieve adequate corrosion resistance for marine and external architectural applications. Transverse Ra < 0,5 µm with clean cut surface finish.
	1P or 2P	Bright polished ^e	See footnote f	Mechanical polishing. Process or surface roughness can be specified. Non-directional finish, reflective with high degree of image clarity.
	2F	Cold rolled, heat treated, skin passed on roughened rolls	Uniform non-reflective matt surface	Heat treatment by bright annealing or by annealing and pickling.

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

^b First digit, 1 = hot rolled, 2 = cold rolled.

^c The basic heat treatment condition specified in the relevant Table 7, 8, 9 or 10 applies.

^d May be skin passed.

^e One surface only, unless specifically agreed at the time of enquiry and order.

^f Within each finish description the surface characteristics can vary, and more specific requirements may need to be agreed between manufacturer and purchaser (e.g. grade of grit or surface roughness).

Table 7 — Mechanical properties at room temperature for ferritic steels in the annealed condition (see Table A.1) and resistance to intergranular corrosion

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

^a C = cold rolled strip; H = hot rolled strip; P = hot rolled plate.

^b The values are related to test pieces with a gauge length of 80 mm and a width of 20 mm. Test pieces with a gauge length of 50 mm and a width of 12,5 mm may also be used.

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

^d When tested according to EN ISO 3651-2.

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

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

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

Steel grade		Product form ^a	Thickness	0,2 % proof strength $R_{p0.2}$	Tensile strength R_m	Elongation after fracture A^b	Impact energy (ISO-V)	
Steel name	Steel number						mm max.	MPa min.
X3CrNiMo13-4	1.4313	P	75	650	780 to 980	14	70	40
X4CrNiMo16-5-1	1.4418	P	75	680	840 to 980	14	55	40

^a P = hot rolled plate.

^b The values apply for test pieces with a gauge length of $5,65 \sqrt{S_0}$.

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

Steel grade		Product-form ^b	Thick-ness mm max.	0,2 % proof strength	1,0 % proof strength	Tensile strength	Elongation after fracture		Impact energy (ISO-V) <i>KV</i>			Resistance to intergranular corrosion ^g		
				<i>R_{p0,2}</i>	<i>R_{p1,0}</i>	<i>R_m</i>	<i>A_{80mm}</i> ^e < 3 mm thick % min.	<i>Aⁱ</i> ≥ 3 mm thick % min.	J min.		at 20 °C (long.)	at –196°C (tr.)	in the delivery condition	in the sensitized condition
Steel name	Steel number			MPa min. (tr.) ^{c,d}	MPa	MPa	(tr.) ^c	(tr.) ^c						
Austenitic corrosion resisting grades														
X2CrNi18-7	1.4318	C	8	350	380	650 to 850	35	40	90	60	–	yes	yes	
		H	13,5	330	370									
		P	75	330	370									
X2CrNi18-9	1.4307	C	8	220	250	520 to 700	45	45	100	60	60	yes	yes	
		H	13,5	200	240									
		P	75	200	240	500 to 700								
X2CrNi19-11	1.4306	C	8	220	250	520 to 700	45	45	100	60	60	yes	yes	
		H	13,5	200	240									
		P	75	200	240	500 to 700								
X5CrNi19-9	1.4315	C	8	290	320	550 to 750	40	40	100	60	60	(yes) ⁱ	No ^j	
		H	13,5	270	310									
		P	75	270	310									
X2CrNi18-10	1.4311	C	8	290	320	550 to 750	40	40	100	60	60	yes	yes	
		H	13,5	270	310									
		P	75	270	310									
X5CrNi18-10	1.4301	C	8	230	260	540 to 750	45 ^h	45 ^h	100	60	60	(yes) ⁱ	No ^j	
		H	13,5	210	250	520 to 720								
		P	75	210	250	45	45							
X6CrNiTi18-10	1.4541	C	8	220	250	520 to 720	40	40	100	60	60	yes	yes	
		H	13,5	200	240									
		P	75	200	240	500 to 700								
X6CrNiNb18-10	1.4550	H	13,5	200	240	520 to 720	40	40	100	60	40	yes	yes	
		P	75	200	240	500 to 700								
X1CrNi25-21	1.4335	P	75	200	240	470 to 670	40	40	100	60	60	yes	yes	

(to be continued)

Table 9 (continued)

Steel grade		Product-form ^b	Thick-ness mm max.	0,2 % proof strength		Tensile strength R_m MPa	Elongation after fracture		Impact energy (ISO-V) KV J min.			Resistance to intergranular corrosion ^g	
				$R_{p0,2}$	$R_{p1,0}$		A_{80mm}^e < 3 mm thick % min. (tr.) ^c	A^f ≥ 3 mm thick % min. (tr.) ^c	at 20 °C		at -196°C (tr.)	in the delivery condition	in the sensitized condition
Steel name	Steel num-ber			MPa min. (tr.) ^{c,d}	MPa			(long.)	(tr.)				
X2CrNiMo17-12-2	1.4404	C	8	240	270	530 to 680	40	40	100	60	60	yes	yes
		H	13,5	220	260								
		P	75	220	260	520 to 670	45	45					
X2CrNiMoN17-11-2	1.4406	C	8	300	330	580 to 780	40	40	100	60	60	yes	yes
		H	13,5	280	320								
		P	75	280	320								
X5CrNiMo17-12-2	1.4401	C	8	240	270	530 to 680	40	40	100	60	60	yes ⁱ	no ^j
		H	13,5	220	260								
		P	75	220	260	520 to 670	45	45					
X1CrNiMoN25-22-2	1.4466	P	75	250	290	540 to 740	40	40	100	60	60	yes	yes
X6CrNiMoTi17-12-2	1.4571	C	8	240	270	540 to 690	40	40	100	60	60	yes	yes
		H	13,5	220	260								
		P	75	220	260	520 to 670							
X6CrNiMoNb17-12-2	1.4580	P	75	220	260	520 to 720	40	40	100	60	-	yes	yes
X2CrNiMo17-12-3	1.4432	C	8	240	270	550 to 700	40	40	100	60	60	yes	yes
		H	13,5	220	260								
		P	75	220	260	520 to 670	45	45					
X2CrNiMoN17-13-3	1.4429	C	8	300	330	580 to 780	35	35	100	60	60	yes	yes
		H	13,5	280	320								
		P	75	280	320		40	40					

(to be continued)

Table 9 (continued)

Steel grade		Product-form ^b	Thick-ness mm max.	0,2 % proof strength	1,0 % proof strength	Tensile strength R_m MPa	Elongation after fracture		Impact energy (ISO-V) KV J min.			Resistance to intergranular corrosion ^g	
				$R_{p0,2}$	$R_{p1,0}$		A_{80mm}^e < 3 mm thick % min. (tr.) ^c	A^f ≥ 3 mm thick % min. (tr.) ^c	at 20 °C		at -196°C (tr.)	in the delivery condition	in the sensitized condition
Steel name	Steel num-ber			MPa min. (tr.) ^{c,d}					(long.)	(tr.)			
X3CrNiMo17-13-3	1.4436	C	8	240	270	550 to 700	40	40	100	60	60	(yes) ⁱ	no ^j
		H	13,5	220	260								
		P	75	220	260	530 to 730	40	40					
X2CrNiMo18-14-3	1.4435	C	8	240	270	550 to 700	40	40	100	60	60	yes	yes
		H	13,5	220	260								
		P	75	220	260	520 to 670	45	45					
X2CrNiMoN18-12-4	1.4434	C	8	290	320	570 to 770	35	35	100	60	60	yes	yes
		H	13,5	270	310								
		P	75	270	310	540 to 740	40	40					
X2CrNiMo18-15-4	1.4438	C	8	240	270	550 to 700	35	35	100	60	60	yes	yes
		H	13,5	220	260								
		P	75	220	260	520 to 720	40	40					
X2CrNiMoN17-13-5	1.4439	C	8	290	320	580 to 780	35	35	100	60	60	yes	yes
		H	13,5	270	310								
		P	75	270	310		40	40					
X1NiCrMoCu3 1-27-4	1.4563	P	75	220	260	500 to 700	40	40	100	60	60	yes	yes
X1NiCrMoCu2 5-20-5	1.4539	C	8	240	270	530 to 730	35	35	100	60	60	yes	yes
		H	13,5	220	260								
		P	75	220	260	520 to 720							
X1CrNiMoCu N25-25-5	1.4537	P	75	290	330	600 to 800	40	40	100	60	60	yes	yes
X1CrNiMoCu N20-18-7	1.4547	C	8	320	350	650 to 850	35	35	100	60	60	yes	yes
		H	13,5	300	340								
		P	75	300	340		40	40					
X1NiCrMoCu N25-20-7	1.4529	P	75	300	340	650 to 850	40	40	100	60	60	yes	yes

(to be continued)

Table 9 (continued)

Steel grade		Product-form ^b	Thickness	0,2 % proof strength $R_{p0,2}$	1,0 % proof strength $R_{p1,0}$	Tensile strength R_m	Elongation after fracture		Impact energy (ISO-V)			Resistance to intergranular corrosion ^g		
							A_{80mm}^e < 3 mm thick % min. (tr.) ^c	A^f ≥ 3 mm thick % min. (tr.) ^c	KV		J min.		in the delivery condition	in the sensitized condition
Steel name	Steel number		mm max.	MPa min. (tr.) ^{c,d}		MPa			at 20 °C (long.)	at -196 °C (tr.)				
Austenitic creep resisting grades														
X3CrNiMoBN 17-13-3	1.4910	C	8	300	330	580 to 780	35	40	100	60	-	yes	yes	
		H	13,5	260	300	550 to 750								
		P	75	260	300									
X6CrNiTiB18-10	1.4941	C	8	220	250	510 to 710	40	40	100	60	-	yes	yes	
		H	13,5	200	240	490 to 690								
		P	75	200	240									
X6CrNi18-10	1.4948	C	8	230	260	530 to 740	45 ^h	45 ^h	100	60	-	no	no	
		H	13,5	210	250	510 to 710	45	45						
		P	75	190	230									
X6CrNi23-13	1.4950	C	8	220	250	530 to 730	35	35	100	60	-	no	no	
		H	13,5	200	240	510 to 710								
		P	75	200	240									
X6CrNi25-20	1.4951	C	8	220	250	530 to 730	35	35	100	60	-	no	no	
		H	13,5	200	240	510 to 710								
		P	75	200	240									
X5NiCrAlTi31-20	1.4958	P	75	170	200	500 to 750	30	30	120	80	-	yes	no	

(to be continued)

Table 9 (concluded)

Steel grade		Pro-duct-form ^b	Thick-ness mm max.	0,2 % proof strength		1,0 % proof strength		Tensile strength		Elongation after fracture		Impact energy (ISO-V)			Resistance to intergranular corrosion ^g	
				$R_{p0,2}$	$R_{p1,0}$	R_m	A_{80mm}^e	A^f	KV		J min.		in the delivery condition		in the sensitized condition	
Steel name	Steel number			MPa min. (tr.) ^{c,d}		MPa	% min. (tr.) ^c		at 20 °C (long.) (tr.)		at -196°C (tr.)					
X5NiCrAlTi31-20+RA ^k	1.4958 +RA ^k	P	75	210	240	500 to 750	30	30	120	80	–	yes	no			
X8NiCrAlTi32-21	1.4959	P	75	170	200	500 to 750	30	30	120	80	–	yes	no			
X8CrNiNb16-13	1.4961	P	75	200	240	510 to 690	35	35	100	60	–	yes	yes			

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

a See Table A.3.

b C = cold rolled strip; H = hot rolled strip; P = hot rolled plate.

c If, in the case of strip in rolling widths < 300 mm, longitudinal test pieces are taken, the minimum values are reduced as follows:

- proof strength $R_{p0,2}$: minus 15 MPa
- elongation for constant gauge length A_{80mm} : minus 5 %
- elongation for proportional gauge length A : minus 2 %.

d ●● For continuously hot rolled products, 20 MPa higher minimum values of $R_{p0,2}$ and 10 MPa higher minimum values of $R_{p1,0}$ may be agreed at the time of enquiry and order.

e The values are related to test pieces with a gauge length of 80 mm and a width of 20 mm; test pieces with a gauge length of 50 mm and a width of 12,5 mm can also be used.

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

g When tested according to EN ISO 3651-2.

h For stretcher levelled material, the minimum value is 5 % lower.

i Normally for thicknesses up to 6 mm.

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

k +RA = recrystallizing annealed condition.

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

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

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

a C = cold rolled strip; H = hot rolled strip; P = hot rolled plate.

b ●● For continuously hot rolled products, 20 MPa higher minimum values of $R_{p0.2}$ may be agreed at the time of enquiry and order.

c The values are related to test pieces with a gauge length of 80 mm and a width of 20 mm; test pieces with a gauge length of 50 mm and a width of 12,5 mm may also be used.

d The values are related to test pieces with a gauge length of $5,65 \sqrt{S_0}$.

e When tested according to EN ISO 3651-2.

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

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

^a Determined by linear interpolation.

Table 12 — Minimum values for the 0,2 % proof strength of martensitic steels at elevated temperatures in the quenched and tempered condition (see Table A.2)

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

^a Determined by linear interpolation.

Table 13 — Minimum values for the 0,2 % and 1,0 % proof strength of austenitic steels at elevated temperatures in the solution annealed condition (see Table A.3)

Steel grade		Minimum 0,2 % proof strength $R_{p0,2}$, MPa													Minimum 1,0 % proof strength $R_{p1,0}$, MPa												
Steel name	Steel number	at a temperature (in °C) of																									
		50 ^a	100	150	200	250	300	350	400	450	500	550	600	50 ^a	100	150	200	250	300	350	400	450	500	550	600		
Austenitic corrosion resisting grades																											
X2CrNiN18-7	1.4318	309	265	200	185	180	170	165	–	–	–	–	–	–	–	235	215	210	200	195	–	–	–	–	–		
X2CrNi18-9	1.4307	180	147	132	118	108	100	94	89	85	81	80	–	218	181	162	147	137	127	121	116	112	109	108	–		
X2CrNi19-11	1.4306	180	147	132	118	108	100	94	89	85	81	80	–	218	181	162	147	137	127	121	116	112	109	108	–		
X5CrNiN19-9	1.4315	246	205	175	157	145	136	130	125	121	119	118	–	284	240	210	187	175	167	161	156	152	149	147	–		
X2CrNiN18-10	1.4311	246	205	175	157	145	136	130	125	121	119	118	–	284	240	210	187	175	167	161	156	152	149	147	–		
X5CrNi18-10	1.4301	190	157	142	127	118	110	104	98	95	92	90	–	228	191	172	157	145	135	129	125	122	120	120	–		
X6CrNiTi18-10	1.4541	191	176	167	157	147	136	130	125	121	119	118	–	228	208	196	186	177	167	161	156	152	149	147	–		
X6CrNiNb18-10-	1.4550	191	177	167	157	147	136	130	125	121	119	118	–	229	211	196	186	177	167	161	156	152	149	147	–		
X1CrNi25-21	1.4335	181	150	140	130	120	115	110	105	–	–	–	–	217	180	170	160	150	140	135	130	–	–	–	–		
X2CrNiMo17-12-2	1.4404	200	166	152	137	127	118	113	108	103	100	98	–	237	199	181	167	157	145	139	135	130	128	127	–		
X2CrNiMoN17-11-2	1.4406	254	211	185	167	155	145	140	135	131	128	127	–	292	246	218	198	183	175	169	164	160	158	157	–		
X5CrNiMo17-12-2	1.4401	204	177	162	147	137	127	120	115	112	110	108	–	242	211	191	177	167	156	150	144	141	139	137	–		
X1CrNiMoN25-22-2	1.4466	229	195	170	160	150	140	135	–	–	–	–	–	266	225	205	190	180	170	165	–	–	–	–	–		
X6CrNiMoTi17-12-2	1.4571	207	185	177	167	157	145	140	135	131	129	127	–	244	218	206	196	186	175	169	164	160	158	157	–		
X6CrNiMoNb17-12-2	1.4580	207	185	177	167	157	145	140	135	131	129	127	–	244	218	206	196	186	175	169	164	160	158	157	–		
X2CrNiMo17-12-3	1.4432	200	166	152	137	127	118	113	108	103	100	98	–	237	199	181	167	157	145	139	135	130	128	127	–		
X2CrNiMoN17-13-3	1.4429	254	211	185	167	155	145	140	135	131	129	127	–	292	246	218	198	183	175	169	164	160	158	157	–		
X3CrNiMo17-13-3	1.4436	204	177	162	147	137	127	120	115	112	110	108	–	252	211	191	177	167	156	150	144	141	139	137	–		
X2CrNiMo18-14-3	1.4435	199	165	150	137	127	119	113	108	103	100	98	–	237	200	180	165	153	145	139	135	130	128	127	–		

(to be continued)

Table 13 (concluded)

Steel grade		Minimum 0,2 % proof strength $R_{p0,2}$, MPa												Minimum 1,0 % proof strength $R_{p1,0}$, MPa											
Steel name	Steel number	at a temperature (in °C) of																							
		50 ^a	100	150	200	250	300	350	400	450	500	550	600	50 ^a	100	150	200	250	300	350	400	450	500	550	600
X2CrNiMoN18-12-4	1.4434	248	211	185	167	155	145	140	135	131	129	127	–	286	246	218	198	183	175	169	164	160	158	157	–
X2CrNiMo18-15-4	1.4438	202	172	157	147	137	127	120	115	112	110	108	–	240	206	188	177	167	156	148	144	140	138	136	–
X2CrNiMoN17-13-5	1.4439	253	225	200	185	175	165	155	150	–	–	–	–	289	255	230	210	200	190	180	175	–	–	–	–
X1NiCrMoCu31-27-4	1.4563	209	190	175	160	155	150	145	135	125	120	115	–	245	220	205	190	185	180	175	165	155	150	145	–
X1NiCrMoCu25-20-5	1.4539	214	205	190	175	160	145	135	125	115	110	105	–	251	235	220	205	190	175	165	155	145	140	135	–
X1CrNiMoCuN25-25-5	1.4537	271	240	220	200	190	180	175	170	–	–	–	–	307	270	250	230	220	210	205	200	–	–	–	–
X1CrNiMoCuN20-18-7	1.4547	274	230	205	190	180	170	165	160	153	148	–	–	314	270	245	225	212	200	195	190	184	180	–	–
X1NiCrMoCuN25-20-7	1.4529	274	230	210	190	180	170	165	160	130	120	105	–	314	270	245	225	215	205	195	190	160	150	135	–
Austenitic creep resisting grades																									
X3CrNiMoBN17-13-3	1.4910	239	205	187	170	159	148	141	134	130	127	124	121	277	240	220	200	189	178	171	164	160	157	154	151
X6CrNiTiB18-10	1.4941	186	162	152	142	137	132	127	123	118	113	108	103	225	201	191	181	176	172	167	162	157	152	147	142
X6CrNi18-10	1.4948	178	157	142	127	117	108	103	98	93	88	83	78	215	191	172	157	147	137	132	127	122	118	113	108
X6CrNi23-13	1.4950	177	140	128	116	108	100	94	91	86	85	84	82	219	185	167	154	146	139	132	126	123	121	118	114
X6CrNi25-20	1.4951	177	140	128	116	108	100	94	91	86	85	84	82	219	185	167	154	146	139	132	126	123	121	118	114
X5NiCrAlTi31-20	1.4958	159	140	127	115	105	95	90	85	82	80	75	75	185	160	147	135	125	115	110	105	102	100	95	95
X5NiCrAlTi31-20+RA	1.4958+RA	199	180	170	160	152	145	137	130	125	120	115	110	227	205	193	180	172	165	160	155	150	145	140	135
X8NiCrAlTi32-21	1.4959	159	140	127	115	105	95	90	85	82	80	75	75	185	160	147	135	125	115	110	105	102	100	95	95
X8CrNiNb16-13	1.4961	191	175	166	157	147	137	132	128	123	118	118	113	227	205	195	186	176	167	162	157	152	147	147	142
^a Determined by linear interpolation.																									

Table 14 — Minimum values for the 0,2 % proof strength of austenitic-ferritic steels at elevated temperatures in the solution annealed condition (see Table A.4)

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

^a Determined by linear interpolation.

Table 15 — Minimum values for the tensile strength of austenitic steels at elevated temperatures in the solution annealed condition (see Table A.3)

Steel grade		Minimum tensile strength R_m , MPa at a temperature (in °C) of											
Steel name	Steel number	50 ^a	100	150	200	250	300	350	400	450	500	550	600
Austenitic corrosion resisting grades													
X2CrNiN18-7	1.4318	605	530	490	460	450	440	430	—	—	—	—	—
X2CrNi18-9	1.4307	466	410	380	360	350	340	340	—	—	—	—	—
X2CrNi19-11	1.4306	466	410	380	360	350	340	340	—	—	—	—	—
X5CrNiN19-9	1.4315	527	490	460	430	420	410	410	—	—	—	—	—
X2CrNiN18-10	1.4311	527	490	460	430	420	410	410	—	—	—	—	—
X5CrNi18-10	1.4301	494	450	420	400	390	380	380	380	370	360	330	—
X6CrNiTi18-10	1.4541	477	440	410	390	385	375	375	375	370	360	330	—
X6CrNiNb18-10	1.4550	476	435	400	370	350	340	335	330	320	310	300	—
X1CrNi25-21	1.4335	459	440	425	410	390	385	380	—	—	—	—	—
X2CrNiMo17-12-2	1.4404	486	430	410	390	385	380	380	380	—	360	—	—
X2CrNiMoN17-11-2	1.4406	557	520	490	460	450	440	435	—	—	—	—	—
X5CrNiMo17-12-2	1.4401	486	430	410	390	385	380	380	—	—	—	—	—
X1CrNiMoN25-22-2	1.4466	521	490	475	460	450	440	435	—	—	—	—	—
X6CrNiMoTi17-12-2	1.4571	490	440	410	390	385	375	375	375	370	360	330	—
X6CrNiMoNb17-12-2	1.4580	490	440	410	390	385	375	375	375	370	360	330	—
X2CrNiMo17-12-3	1.4432	486	430	410	390	385	380	380	380	—	360	—	—
X2CrNiMoN17-13-3	1.4429	557	520	490	460	450	440	435	435	—	430	—	—
X3CrNiMo17-13-3	1.4436	504	460	440	420	415	410	410	410	—	390	—	—
X2CrNiMo18-14-3	1.4435	482	420	400	380	375	370	370	—	—	—	—	—
X2CrNiMoN18-12-4	1.4434	525	500	470	440	430	420	415	415	415	410	390	—
X2CrNiMo18-15-4	1.4438	486	430	410	390	385	380	380	—	—	—	—	—
X2CrNiMoN17-13-5	1.4439	557	520	490	460	450	440	435	—	—	—	—	—
X1NiCrMoCu31-27-4	1.4563	485	460	445	430	410	400	395	—	—	—	—	—
X1NiCrMoCu25-20-5	1.4539	512	500	480	460	450	440	435	—	—	—	—	—
X1CrNiMoCuN25-25-5	1.4537	581	550	535	520	500	480	475	—	—	—	—	—
X1CrNiMoCuN20-18-7	1.4547	637	615	587	560	542	525	517	510	502	495	—	—
X1NiCrMoCuN25-20-7	1.4529	612	550	535	520	500	480	475	—	—	—	—	—
Austenitic creep resisting grades													
X3CrNiMoBN17-13-3	1.4910	529	495	472	450	440	430	425	420	410	400	385	365
X6CrNiTiB18-10	1.4941	460	410	390	370	360	350	345	340	335	330	320	300
X6CrNi18-10	1.4948	484	440	410	390	385	375	375	375	370	360	330	300
X6CrNi23-13	1.4950	495	470	450	430	420	410	405	400	385	370	350	320
X6CrNi25-20	1.4951	495	470	450	430	420	410	405	400	385	370	350	320
X5NiCrAlTi31-20 ^b	1.4958	487	465	445	435	425	420	418	415	415	415	—	—
X8NiCrAlTi32-21	1.4959	487	465	445	435	425	420	418	415	415	415	—	—
X8CrNiNb16-13	1.4961	493	465	440	420	400	385	375	370	360	350	340	320

^a Determined by linear interpolation.

^b The tensile strength values also apply for the recrystallizing annealed condition (+RA).

Table 16 — Tests to be carried out, test units and extent of testing

Test	Test status ^a	Test unit	Product form		Number of test pieces per test sample
			Strip and sheet cut from strip in rolling width (C, H)	Rolled plate (P)	
Chemical analysis	m	Cast	Cast analysis ^b		
Tensile test at room temperature	m	Cast, thickness $\pm 10\%$, heat treatment batch	1 test sample from each coil	<p>a) Plates ≤ 20 mm (≤ 15 mm ^c) thickness: Plates processed under identical conditions may be collected into a batch comprising not more than 20 plates. One test sample per batch shall be taken from heat treated plates up to 15 m in length. One test sample shall be taken from each end of the longest plate in the batch where heat treated plates are longer than 15 m.</p> <p>b) Plates > 20 mm (> 15 mm ^c) thickness: Each single plate; one test sample shall be taken from heat treated plates up to 15 m long and one sample shall be taken from each end of heat treated plates longer than 15 m.</p>	1
Tensile test at elevated temperature ^d	o		To be agreed at the time of enquiry and order.	1	
Impact test at room temperature	m ^e		To be agreed at the time of enquiry and order.	3	
Impact test at low temperature	o		To be agreed at the time of enquiry and order.	3	
Resistance to intergranular corrosion	o		To be agreed at the time of enquiry and order.	1	
Other tests	o	See EN 10028-1.			

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

^b A product analysis may be agreed at the time of enquiry and order (see EN 10028-1:2007, Table 1).

^c Limit value for martensitic, ferritic and austenitic-ferritic steels.

^d See EN 10028-1:2007, 11.3.

^e For ferritic, martensitic and austenitic-ferritic grades > 6 mm thickness and for austenitic grades for cryogenic service > 20 mm thickness, optional for austenitic grades for other applications (see EN 10028-1:2007, Table 1).

Annex A (informative)

Guidelines for further treatment (including heat treatment in fabrication)

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

Table A.1 — Guidelines on the temperatures for hot forming and heat treatment ^a of ferritic stainless steels

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

Table A.2 — Guidelines on the temperatures for hot forming and heat treatment ^a of martensitic stainless steels

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

Table A.3 — Guidelines on the temperatures for hot forming and heat treatment ^a of austenitic stainless steels

Steel grade		Hot forming		Heat treatment symbol ^b	Solution annealing ^c (but see footnote g)			
Steel name	Steel number	Temperature °C	Type of cooling		Temperature ^{d e} °C	Type of cooling		
Austenitic corrosion resisting grades								
X2CrNiN18-7	1.4318	1 150 to 850	air	+AT	1 020 to 1 100	water, air ^f		
X2CrNi18-9	1.4307				1 000 to 1 100			
X2CrNi19-11	1.4306				1 000 to 1 100			
X5CrNiN19-9	1.4315				1 000 to 1 100			
X2CrNiN18-10	1.4311				1 000 to 1 100			
X5CrNi18-10	1.4301				1 000 to 1 100			
X6CrNiTi18-10	1.4541				1 000 to 1 100			
X6CrNiNb18-10	1.4550				1 020 to 1 120			
X1CrNi25-21	1.4335				1 030 to 1 110			
X2CrNiMo17-12-2	1.4404				1 030 to 1 110			
X2CrNiMoN17-11-2	1.4406				1 030 to 1 110			
X5CrNiMo17-12-2	1.4401				1 030 to 1 110			
X1CrNiMoN25-22-2	1.4466				1 070 to 1 150			
X6CrNiMoTi17-12-2	1.4571				1 030 to 1 110			
X6CrNiMoNb17-12-2	1.4580				1 030 to 1 110			
X2CrNiMo17-12-3	1.4432				1 030 to 1 110			
X2CrNiMoN17-13-3	1.4429				1 030 to 1 110			
X3CrNiMo17-13-3	1.4436				1 030 to 1 110			
X2CrNiMo18-14-3	1.4435				1 030 to 1 110			
X2CrNiMoN18-12-4	1.4434				1 070 to 1 150			
X2CrNiMo18-15-4	1.4438				1 070 to 1 150			
X2CrNiMoN17-13-5	1.4439				1 060 to 1 140			
X1NiCrMoCu31-27-4	1.4563				1 070 to 1 150			
X1NiCrMoCu25-20-5	1.4539				1 060 to 1 140			
X1CrNiMoCuN25-25-5	1.4537				1 120 to 1 180			
X1CrNiMoCuN20-18-7	1.4547				1 140 to 1 200			
X1NiCrMoCuN25-20-7	1.4529	1 120 to 1 180						
Austenitic creep resisting grades								
X3CrNiMoBN17-13-3	1.4910	1 150 to 850	air	+AT	1 020 to 1 100	water, air ^f		
X6CrNiTiB18-10	1.4941				1 050 to 1 110			
X6CrNi18-10	1.4948				1 050 to 1 110			
X6CrNi23-13	1.4950				1 050 to 1 150			
X6CrNi25-20	1.4951				1 050 to 1 150			
X5NiCrAlTi31-20	1.4958				1 100 to 1 200			
X5NiCrAlTi31-20+RA	1.4958 (+RA)						+RA	920 to 1 000 ^g
X8NiCrAlTi32-21	1.4959							+AT
X8CrNiNb16-13	1.4961							
<p>^a The temperatures of annealing should be agreed for simulated heat treated test pieces.</p> <p>^b +AT = solution annealed, +RA = re-crystallizing annealed.</p> <p>^c The solution treatment may be omitted if the conditions for hot working and subsequent cooling are such that the requirements for the mechanical properties of the product and the resistance to intergranular corrosion as defined in EN ISO 3651-2 are obtained and provided these requirements are met even after appropriate subsequent solution annealing.</p> <p>^d If heat treatment is carried out in a continuous furnace, the upper part of the range specified is usually preferred, or even exceeded.</p> <p>^e The lower end of the range specified for solution annealing should be aimed at for heat treatment as part of further processing, because otherwise the mechanical properties might be affected. If the temperature of hot forming does not drop below the lower temperature for solution annealing, a temperature of 980 °C is adequate as a lower limit for Mo-free steels, a temperature of 1 000 °C for steels with Mo contents up to 3 % and a temperature of 1 020 °C for steels with Mo contents exceeding 3 %.</p> <p>^f Cooling sufficiently rapid.</p> <p>^g Re-crystallizing annealing.</p> <p>^h After solution annealing the grain size according to EN ISO 643 shall be 1 to 5.</p>								

Table A.4 — Guidelines on the temperatures for hot forming and heat treatment ^a of austenitic-ferritic stainless steels

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

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

A.3 Scale and annealing colours produced during hot forming, heat treatment or welding may adversely affect the corrosion resistance. They should be removed as far as possible before use, e.g. by pickling.

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

Annex B (informative)

Post weld heat treatment

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

- martensitic grades are retempered and
- ferritic grades are reannealed

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

B.2 During heating of high chromium and molybdenum austenitic-ferritic or austenitic steel weldments containing some ferrite, intermetallic phases may be formed which need to be re-dissolved during post weld heat treatment. As most filler metals are overalloyed in comparison with the equivalent basic grades, minimum solution temperatures higher than those given in Tables A.3 and A.4 may be necessary.

In the case of fully austenitic weld structures it should be verified that mechanical properties of heat treated weldments conform to this European Standard.

Oxidation of surfaces which necessitates pickling, and possible distortion of the welded construction may raise further difficulties.

Consequently post weld heat treatment of duplex and austenitic steels should be avoided, and therefore welding be planned carefully.

B.3 In special cases, e.g. for parts with greater wall thickness, requirements concerning stress-relief and resistance to intergranular corrosion, in order to avoid failure by stress corrosion cracking or corrosion fatigue, may prove the necessity for post weld heat treatment. This should be carried out according to Table B.1 by holding at an intermediate stage below the usual solution temperature (see Table A.3) and is defined as stabilizing annealing for the niobium or titanium bearing grades and as stress-relieving for the un-stabilized low carbon grades.

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

B.4 Preheating of austenitic-ferritic steels is a very effective precaution against stress increase by shrinkage of thicker welded cross-sections, because temperatures of 200 °C to 250 °C bring down room temperature yield strength by about 50 %. Thus preheating is often more appropriate to avoid high stress levels in those weldments than any post weld heat treatment, and a preheating temperature between 120 °C and 200 °C according to the particular steel and thickness should be applied.

The same is advisable for complex welds of austenitic steels.

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

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

Annex C
 (informative)

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

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

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

^a Determined by linear interpolation.

Annex D (informative)

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

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

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

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

Steel grade		Temperature °C	Strength for 1 % (plastic) creep strain ^a in MPa for	
Steel name	Steel number		10 000 h	100 000 h
X6CrNi18-10 ^b	1.4948	500	147	114
		510	142	111
		520	137	108
		530	132	104
		540	127	100
		550	121	96
		560	116	92
		570	111	88
		580	106	84
		590	100	79
		600	94	74
		610	88	69
		620	82	63
		630	75	56
		640	68	49
		650	61	43
		660	55	37
		670	49	32
		680	44	28
		690	39	25
700	35	22		
710	(31)	(15)		
720	(28)	(14)		
730	(26)	(13)		
740	(25)	(12)		
750	(24)	(11)		
X6CrNi23-13 ^c	1.4950	550	107	60
		600	80	35
		650	50	22
		700	25	12
		750		
		800	10	
X5NiCrAlTi31-20 ^b	1.4958	600	115	(85)
		610	109	(79)
		620	102	(74)
		630	96	(69)
		640	90	(64)
		650	84	(59)
		660	78	(55)
		670	73	(51)
		680	68	(47)
		690	63	(43)
700	58	(40)		

(to be continued)

Table D.1 (continued)

Steel grade		Temperature °C	Strength for 1 % (plastic) creep strain ^a in MPa for	
Steel name	Steel number		10 000 h	100 000 h
X5NiCrAlTi31-20 +RA ^b	1.4958 + RA	550	164	(132)
		560	154	(122)
		570	144	(111)
		580	133	(101)
		590	123	(92)
		600	113	(82)
		610	103	(74)
		620	93	(65)
		630	84	(58)
		640	75	(51)
		650	67	(46)
		660	60	(41)
		670	55	(37)
		680	50	(33)
690	45	(30)		
700	41	(27)		
X8NiCrAlTi32-21 ^b	1.4959	700	59,0	42,0
		710	55,5	38,0
		720	52,0	34,4
		730	48,5	31,3
		740	45,0	28,4
		750	41,7	26,0
		760	38,4	23,5
		770	35,6	21,3
		780	32,9	19,3
		790	30,5	17,6
		800	28,2	16,0
		810	26,2	14,7
		820	24,2	13,4
		830	22,4	12,1
		840	20,8	11,1
		850	19,1	10,0
		860	17,6	9,1
		870	16,1	8,2
		880	14,7	7,3
		890	13,4	6,5
900	12,1	5,7		
910	10,9	5,0		
920	9,8	4,4		
930	8,8	3,9		
940	7,8	3,4		
950	6,9	2,9		
960	6,1	2,5		
970	5,3	2,1		
980	4,6	1,8		
990	4,0	1,6		
1000	3,5	1,4		

(to be continued)

Table D.1 (concluded)

Steel grade		Temperature °C	Strength for 1 % (plastic) creep strain ^a in MPa for	
Steel name	Steel number		10 000 h	100 000 h
X8CrNiNb16-13 ^b	1.4961	580	127	91
		590	120	84
		600	113	78
		610	106	73
		620	99	67
		630	92	61
		640	85	55
		650	78	49
		660	72	44
		670	66	39
		680	59	34
		690	54	30
		700	49	26
		710	45	24
		720	42	21
		730	39	19
740	36	17		
750	34	16		

^a Values in parentheses involved extended time and/or stress extrapolation.
^b Values were taken from DIN 17460 [3].
^c Those preliminary values were taken from NFA 36-209 [4].

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

Steel grade		Temperature	Strength for rupture ^a in MPa for						
Steel name	Steel number	°C	10 000 h	30 000 h	50 000 h	100 000 h	150 000 h	200 000 h	250 000 h
X3CrNiMoBN17-13-3 ^b	1.4910	550	290			220		200*	
		560	272			202		184*	
		570	254			186		166*	
		580	237			170		151*	
		590	220			155		137*	
		600	205			141		122*	
		610	190			127		113*	
		620	174			114		100*	
		630	162			102		91*	
		640	148			92		81*	
		650	135			83		73*	
		660	122			75		65*	
		670	112			68		58*	
		680	102			61		52*	
		690	93			56		46*	
		700	84			52		42*	
		710	78			48		39*	
		720	71			45		36*	
		730	65			41		34*	
		740	58			37		31*	
750	52			34		28*			
760	48			31		26*			
770	44			28		24*			
780	41			25		21*			
790	37			22		19*			
800	33			20		17*			
X6CrNiTiB18-10 ^b	1.4941	550	223			170		150	
		560	210			154		135	
		570	196			140		122	
		580	182			127		110	
		590	170			114		100	
		600	156			102		91	
		610	142			92		82	
		620	130			84		74	
		630	119			76		67	
		640	108			68		60	
		650	98			62		54	
		660	89			56		49	
		670	80			50		43	
		680	73			44		39	
690	66			39		33			
700	60			35		29			

(to be continued)

Table D.2 (continued)

Steel grade		Temperature °C	Strength for rupture ^a in MPa for						
Steel name	Steel number		10 000 h	30 000 h	50 000 h	100 000 h	150 000 h	200 000 h	250 000 h
X6CrNi18-10 ^b	1.4948	500	250			192		176	
		510	239			182		166	
		520	227			172		156	
		530	215			162		146	
		540	203			151		136	
		550	191	165	155	140		125	
		560	177	154	145	128		114	
		570	165	144	136	117		104	
		580	154	135	126	107		95	
		590	143	126	118	98		86	
		600	132	117	110	89		78	
		610	122	109	102	81		70	
		620	113	101	94	73		62	
		630	104	94	87	65		55	
		640	95			58		49	
		650	87			52		43	
		660	80			47		38	
		670	73			42		34	
		680	67			37		30	
		690	61			32		26	
700	55			28		22			
710	(45)			(22)					
720	(41)			(20)					
730	(38)			(18)					
740	(36)			(16)					
750	(34)			(15)					
X6CrNi23-13 ^c	1.4950	550	160			90			
		600	120			65			
		650	70			35			
		700	36			16			
		750							
		800	18			7,5			
X6CrNi25-20 ^d	1.4951	600	137	113	104*	92*	89*	82*	79*
		610	120	98	90*	79*	74*	71*	68*
		620	105	85	78*	69*	64*	61*	59*
		630	92	75	68*	60*	56*	54*	52*
		640	81	66	60*	53*	50*	47*	46*
		650	72	58	53*	47*	44*	42*	41*
		660	64	52	47*	42*	39*	38*	36*
		670	57	46	42*	38*	35*	34*	33*
		680	51	42	38	34*	32*	31*	29*
		690	47	38	35	31*	29*	28*	27*
		700	42	34	32	28*	26*	25*	24*
		710	39	31	29	26*	24*	23*	22*
		720	35	29	26	23,5*	22*	21*	20*
		730	32	27	24,5*	22*	20*	19,5*	18,5*
740	30	24,5	22,5*	20*	18,5*	18*	17*		
750	28	22,5	21*	18,5*	17*	16,5*	16*		

(to be continued)

Table D.2 (continued)

Steel grade		Temperature °C	Strength for rupture ^a in MPa for						
Steel name	Steel number		10 000 h	30 000 h	50 000 h	100 000 h	150 000 h	200 000 h	250 000 h
X6CrNi25-20 ^d	1.4951	760	26	21	19*	17*	16*	15*	14,5*
		770	24	19,5	18*	15,5*	14,5*	14*	13,5*
		780	22	18	16,5*	14,5*	13,5*	13*	12,5*
		790	21	17	15,5*	13,5*	12,5*	12*	11,5*
		800	19,5	15,5	14*	12,5*	11,5*	11*	10,5*
		810	18	14,5	13*	11,5*	10,5*	10*	9,5*
		820	17	13,5	12*	10,5*	10*	9,5*	9*
		830	16	12,5	11,5*	10*	9*		
		840	15	12	10,5*	9*			
		850	14	11	10*				
		860	13	10	9*				
		870	12	9,5					
		880	11,5	9*					
		890	10,5						
		900	10,0						
	910	9,5							
X5NiCrAlTi31-20	1.4958	500	290			215		(196)	
		510	279			205		(186)	
		520	267			195		(176)	
		530	254			184		(166)	
		540	240			172		(155)	
		550	225			160		(143)	
		560	208			147		(130)	
		570	190			133		(117)	
		580	172			119		(105)	
		590	155			106		(93)	
		600	140			95		(83)	
		610	128			85		(74)	
		620	118			78		(68)	
		630	109			72		(63)	
		640	103			67		(59)	
650	97			63		(55)			
660	91			59		(52)			
670	85			55		(48)			
680	80			52		(45)			
690	74			48		(41)			
700	69			44		(38)			
X5NiCrAlTi31-20+RA ^b	1.4958 +RA	500	315			258		(242)	
		510	297			241		(225)	
		520	280			224		(207)	
		530	262			206		(190)	
		540	243			189		(172)	
		550	224			171		(155)	
		560	204			153		(138)	
		570	184			136		(122)	
		580	165			119		(106)	
		590	147			104		(92)	
		600	131			90		(80)	
		610	117			79		(70)	
		620	106			70		(62)	
		630	96			62		(55)	
		640	87			56		(49)	
650	80			51		(44)			

(to be continued)

Table D.2 (continued)

Steel grade		Temperature °C	Strength for rupture ^a in MPa for						
Steel name	Steel number		10 000 h	30 000 h	50 000 h	100 000 h	150 000 h	200 000 h	250 000 h
X5NiCrAlTi31-20+RA ^b	1.4958 +RA	660	73			46		(40)	
		670	67			42		(36)	
		680	61			38		(33)	
		690	55			34		(29)	
		700	50			30		(26)	
X8NiCrAlTi32-21 ^e	1.4959	700	73,0	58,2		44,8		38,2*	
		710	67,8	54,0		41,4		35,2*	
		720	63,0	50,1		38,3		32,5*	
		730	58,5	46,5		35,4		30,0*	
		740	54,4	43,1		32,8		27,7*	
		750	50,6	40,0		30,3		25,6*	
		760	47,0	37,1		28,0		23,6*	
		770	43,7	34,4		25,9		21,8*	
		780	40,7	31,9		24,0		20,1*	
		790	37,8	29,6		22,1		18,5*	
		800	35,2	27,4		20,4		17,0*	
		810	32,7	25,4		18,9		15,6*	
		820	30,4	23,6		17,4		14,4*	
		830	28,3	21,8		16,0		13,2*	
		840	26,3	20,2		14,8		12,1*	
		850	24,4	18,7		13,6		11,1*	
		860	22,7	17,3		12,5		10,1*	
		870	21,0	16,0		11,5		9,23*	
		880	19,5	14,8		10,5		8,41*	
		890	18,1	13,6		9,60		7,63*	
900	16,8	12,6		8,76		6,91*			
910	15,6	11,6		7,98		6,23*			
920	14,4	10,6		7,25		5,60*			
930	13,3	9,77		6,57		5,01*			
940	12,3	8,95		5,93		4,45*			
950	11,4	8,19		5,33		3,93*			
960	10,5	7,47		4,77*		3,43*			
970	9,63	6,80		4,23*		2,95*			
980	8,85	6,17		3,73*					
990	8,11	5,57		3,25*					
1000	7,42	5,01		2,79*					

(to be continued)

Table D.2 (concluded)

Steel grade		Temperature	Strength for rupture ^a in MPa for						
Steel name	Steel number	°C	10 000 h	30 000 h	50 000 h	100 000 h	150 000 h	200 000 h	250 000 h
X8CrNiNb16-13 ^b	1.4961	580	182			129		115	
		590	170			119		105	
		600	157			108		94	
		610	145			98		85	
		620	134			89		77	
		630	124			80		69	
		640	113			72		61	
		650	103			64		53	
		660	93			57		47	
		670	84			50		41	
		680	76			44		36	
		690	70			39		31	
		700	64			34		27	
		710	59			30		25	
		720	55			27		22	
730	51			25		19			
740	47			22		17			
750	44			20		15			

^a Values in parantheses involved time and/or stress extrapolation; values with asterisk involved time extrapolation.
^b Values were taken from DIN 17460 [3].
^c Those preliminary values were taken from NFA 36-209 [4].
^d Values were taken from BS PD 6525 Part 1 [5].
^e Values were prepared by ECCC, WG 3.3 [6].

Annex E
(informative)

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

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

Steel grade		20 °C				- 80 °C				- 150 °C				- 196 °C			
		0,2 % proof strength $R_{p0.2}$ min. MPa	1,0 % proof strength $R_{p1.0}$ min. MPa	Tensile strength R_m min. MPa	Elongation after fracture A min. %	0,2 % proof strength $R_{p0.2}$ min. MPa	1,0 % proof strength $R_{p1.0}$ min. MPa	Tensile strength R_m min. MPa	Elongation after fracture A min. %	0,2 % proof strength $R_{p0.2}$ min. MPa	1,0 % proof strength $R_{p1.0}$ min. MPa	Tensile strength R_m min. MPa	Elongation after fracture A min. %	0,2 % proof strength $R_{p0.2}$ min. MPa	1,0 % proof strength $R_{p1.0}$ min. MPa	Tensile strength R_m min. MPa	Elongation after fracture A min. %
Steel name	Steel number																
X2CrNi18-9	1.4307	200	240	500	45	220	290	830	35	225	325	1070	30	300	400	1200	30
X5CrNi19-9	1.4315	270	310	550	40	385	455	890	40	450	550	1180	35	550	650	1350	35
X2CrNi18-10	1.4311	270	310	550	40	350	420	850	40	450	550	1050	35	550	650	1250	35
X5CrNi18-10	1.4301	210	250	520	45	270	350	860	35	315	415	1100	30	300	400	1250	30
X6CrNiTi18-10	1.4541	200	240	500	40	260	290	855	35	350	420	1100	35	390	470	1200	30
X2CrNiMo17-12-2	1.4404	220	260	520	45	275	355	840	40	315	415	1070	40	350	450	1200	35
X2CrNiMoN17-11-2	1.4406	280	320	580	40	380	450	800	35	500	600	1000	35	600	700	1150	30
X2CrNiMoN17-13-3	1.4429	280	320	580	35	380	450	800	30	500	600	1000	30	600	700	1150	30

NOTE For any temperature between 20 °C and -196 °C, mechanical properties may be estimated by linear interpolation.

Annex ZA
(informative)

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

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

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

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

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

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

Bibliography

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