SLOVENSKI STANDARD

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

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

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

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

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 Management Centre 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 Management Centre has the same status as the official versions.

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COMITÉ EUROPÉEN DE NORMALISATION
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Contents

Foreword

This document (EN 10028-2:2003) 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of an identical text or by endorsement, at the latest by December 2003, and conflicting national standards shall be withdrawn at the latest by December 2003.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 supersedes EN 10028-2:1992.

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 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.

Annexes A, B, C are for information only. Annexes D and E are 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 non-alloy and alloy steels with elevated temperature properties as specified in Table 1.

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

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.

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) lower copper content and maximum tin content (see Table 1, footnote b);

b) minimum chromium content of 0,80% (see Table 1, footnote f);

c) maximum carbon content of 0,17% for product thicknesses greater than 150 mm (see Table 1, footnote g);

d) tests in the simulated normalized condition (see 8.2.2);

e) delivery conditions deviating from those specified in Table 3 (see 8.2.2 and 8.2.3);

f) maximum carbon equivalent value for P235GH, P265GH, P295GH and P355GH (see 8.3.3);

g) HIC test in accordance with EN 10229 (see 8.7);

h) step cooling test in accordance with annex E (see 8.8);

i) mid thickness test pieces for the impact test (see clause 10);

j) mechanical properties for product thicknesses > 250 mm (see Table 3, footnote a);

k) specification of the delivery condition +QT where the usual delivery condition is +NT (see Table 3, footnote c and Table 4, footnote c);

l) additional impact energy values (see Table 3, footnote f);

m) $R_{p0,2}$ values at elevated temperature for increased product thicknesses (see Table 4, 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 16Mo3 and the number 1.5415 as specified in EN 10028-2, to be delivered untreated, inspection document 3.1.B as specified in EN 10204:

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

or

10 plates – 50 x 2 000 x 10 000 – EN 10028-2 1.5415+AR – Inspection document 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, the products covered by this 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, 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,

is exceeding 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 European 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 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):

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

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

Steel grade		% by mass														
name	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	0,015	≥ 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	0,015	≥ 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	0,015	≥ 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	0,015	≥ 0,020	≤ 0,012[d]	≤ 0,30	≤ 0,30	≤ 0,08	≤ 0,020	≤ 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	4,00 to 6,00	≤ 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	≤ 0,002 B ≤ 0,015Ca
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	≤ 0,003B[h] ≤ 0,015Ca[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	8,00 to 9,50	≤ 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: ≥ 0,015 % Ti and ≥ 0,001 % B in the case of additions of Ti + B, ≥ 0,015 % Nb and ≥ 0,0005 % Ca 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 % by mass	Permissible deviation[a] of the product analysis % 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	=< 0,015	+ 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 ≤ 10,00	± 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 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.

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 H_2S 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 before and after 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.

9.2 Tests to be carried out

See EN 10028-1 and 8.7 and 8.8.

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.