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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 It supersedes BS EN 10028-3:1993 which is withdrawn.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:

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Flacherzeugnisse aus Druckbehälterstählen - Teil 3:
Schweißgeeignete Feinkornbaustähle, normalgeglüht

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

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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of an identical text or by endorsement, at the latest by December 2003, and conflicting national standards shall be withdrawn at the latest by December 2003.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 $\frac{Al}{N}$ 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	≤ 0,20	+ 0,02
Si	≤ 0,60	+ 0,06
Mn	≤ 1,00	0,05
	> 1,00 to ≤ 1,70	0,10
P	≤ 0,025	+ 0,005
S	≤ 0,015	+ 0,003
Al	≥ 0,020	- 0,005
N	≤ 0,025	+ 0,002
Cr	0,30	+ 0,05
Mo	≤ 0,10	+ 0,03
Cu	≤ 0,30	+ 0,05
	> 0,30 to ≤ 0,70	+ 0,10
Nb	≤ 0,05	+ 0,01
Ni	≤ 0,80	+ 0,05
Ti	≤ 0,03	+ 0,01
V	≤ 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 t in mm		
		60	60 < t 100	100 < t 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} MP a 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 40	265					
			40 < t 60	255					
						60 < t 100	235	370 to 490	23
						100 < t 150	225	360 to 480	
150 < t 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 40	345					
			40 < t 60	335					
						60 < t 100	315	470 to 610	21
						100 < t 150	305	460 to 600	
150 < t 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 40	445					
			40 < t 60	430					
						60 < t 100	400	540 to 710	
						100 < t 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 40	256	241	223	205	188	173	160	150
		40 < t 60	247	232	215	197	181	166	154	145
		60 < t 100	227	214	198	182	167	153	142	133
		100 < t 150	218	205	190	174	160	147	136	128
		150 < t 250	208	196	181	167	153	140	130	122
P355NH	1.0565	16	343	323	299	275	252	232	214	202
		16 < t 40	334	314	291	267	245	225	208	196
		40 < t 60	324	305	282	259	238	219	202	190
		60 < t 100	305	287	265	244	224	206	190	179
		100 < t 150	295	277	257	236	216	199	184	173
		150 < t 250	285	268	249	228	209	192	178	167
P460NH	1.8935	16	445	419	388	356	326	300	278	261
		16 < t 40	430	405	375	345	316	290	269	253
		40 < t 60	416	391	362	333	305	281	260	244
		60 < t 100	387	364	337	310	284	261	242	227
		100 < t 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									
		transverse					longitudinal ^b				
		min. at a temperature in °C of									
		- 50	- 40	- 20	0	+ 20	- 50	- 40	- 20	0	+ 20
P...N, P...NL	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 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 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	1,5	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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