BRITISH STANDARD

BS EN
10028-3:2009

Flat products made of steels for pressure purposes

Part 3: Weldable fine grain steels, normalized

ICS 77.140.30; 77.140.50

BSI
British Standards

National foreword

This British Standard is the UK implementation of EN 10028-3:2009. It supersedes BS EN 10028-3:2003 which is withdrawn.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.

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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 14 May 2009.

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Contents

Foreword

This document (EN 10028-3:2009) 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of an identical text or by endorsement, at the latest by December 2009, and conflicting national standards shall be withdrawn at the latest by December 2009.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 10028-3:2003.

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 fine grain steels as specified in Table 1.

NOTE 1 Fine grain steels are understood as steels with a ferritic grain size of 6 or finer when tested in accordance with EN ISO 643.

The requirements and definitions 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 3 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

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

a) room temperature quality (P ... N),

b) elevated temperature quality (P...NH),

c) low temperature quality (P...NL1) and

d) special low temperature quality (P...NL2).

6.1.2 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 10028-1:2007 + 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) tests in the simulated normalized condition (see 8.2.2);

2) delivery of products in the untreated condition (see 8.2.3);

3) maximum carbon equivalent value (see 8.3.3);

4) tensile properties for increased product thicknesses (see Table 4, footnote c);

5) modified values for R_{eH} and R_m for grades P460NH and P460NL1 (see Table 4, footnote d)

6) application of the $R_{p0,2}$ values of Table 5 for the corresponding P...NL1 and P…NL2 grade (see 8.4.2);

7) $R_{p0,2}$ values at elevated temperatures for increased product thicknesses (see Table 5, footnote b);

8) specification of a minimum impact energy of 40 J (see NOTE to 8.4.1 and Table 6);

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

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

11) verification of impact energy for longitudinal test pieces (see clause 11);

12) 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 as specified in EN 10204:

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

or

10 plates – 50 x 2000 x 10000 – EN 10028-3 1.1104 – Inspection certificate 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 (see 8.2.3), the products covered by this document 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 10028-1:2007 + A1:2009). In this case, additional 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 document 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,

exceeds the critical value $P_{crit.}$ of

— 17,3 for all steel grades except P460NH, P460NL1 and P460NL2

— 16,7 in the case of steel grade P460NH and

— 16,3 in the case of steel grades P460NL1 and P460NL2,

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 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 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														
Steel name	Steel number	C max.	Si max.	Mn	P max.	S max.	Al_{total} min.	N max.	Cr max.	Cu max.	Mo max.	Nb max.	Ni max.	Ti max.	V max.	Nb + Ti + V max.
P275NH	1.0487	0,16	0,40	0,80 [b] to 1,50	0,025	0,010	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					0,008										
P275NL2	1.1104				0,020	0,005										
P355N	1.0562	0,18	0,50	1,10 to 1,70	0,025	0,010	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
P355NH	1.0565															
P355NL1	1.0566					0,008										
P355NL2	1.1106				0,020	0,005										
P460NH	1.8935	0,20	0,60	1,10 to 1,70	0,025	0,010	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					0,008										
P460NL2	1.8918				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 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 % by mass	Permissible deviation[a] of the product analysis % 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	≤ 0,010	+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		
Steel name	Steel number	≤ 60	60 < t ≤ 100	100 < t ≤ 250
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 10028-1:2007 + A1:2009 and Clause 10) shall apply.

NOTE Optionally, a minimum impact energy value of 40 J may be specified for temperatures where lower minimum values are specified (see Table 6, footnote d).

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 10028-1:2007 + 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 H_2S 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 EN 10028-1:2007 + A1:2009.

9.2 Tests to be carried out

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

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 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 10028-1:2007 + A1:2009.

12 Marking

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

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.
Steel name	Steel 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[d]	460	570 to 730	17
			16[d] < t ≤ 40	445	570 to 720	
			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] •• In the case of P460NH and P460NL1, up to 20 mm product thickness, a minimum R_{eH} of 460 MPa and a R_m range of 630 MPa to 725 MPa may be agreed at the time of enquiry and order.

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

Steel grade		Product thickness t	Minimum proof strength $R_{p0,2}$ MPa at a temperature in °C of							
Steel name	Steel number	mm	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 reflect 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 at a temperature in °C of					longitudinal [b] at a temperature in °C of				
		–50	–40	–20	0	+20	–50	–40	–20	0	+20
P…N, P...NH	≤ 250 [c]	–	–	30[d]	40	50	–	–	45	65	75
P…NL1		–	27[d]	35[d]	50	60	30[d]	40	50	70	80
P...NL2		27[d]	30[d]	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] For the grades P460NH, P460NL1 and P460NL2 up to product thicknesses of 100mm.

[d] •• A minimum impact energy value of 40 J may be agreed at the time of enquiry and order.

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

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