UDC 669.14.018.44-41:621.642-98 April 1993

Flat products made from steel for pressure purposes

Unalloyed and alloy steels with elevated temperature properties

English version of DIN EN 10028 Part 2

DIN EN 10028 Part 2

Flacherzeugnisse aus Druckbehälterstählen; unlegierte und legierte warmfeste Stähle

This standard, together with DIN EN 10028 Part 1, supersedes DIN 17155, October 1983 edition.

European Standard EN 10028-2:1992 has the status of a DIN Standard.

A comma is used as the decimal marker.

National foreword

This standard has been prepared by ECISS/TC 22.

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

This standard is based in large part on the June 1989 draft of DIN 17155 Part 2 (cf. Amendments), and incorporates general requirements that will also be specified in EN 10028-4 (currently in preparation).

Continued on pages 2 and 3.

EN comprises 10 pages.

Standards referred to

See **Normative references.**

Previous editions

DIN 17155 Part 1: 10.51, 01.59; DIN 17155 Part 2: 10.51, 01.59x; Supplement to DIN 17155 Part 2: 03.64, 06.69; DIN 17155: 10.83.

Amendments

In comparison with the October 1983 edition of DIN 17155, the following amendments have been made.

a) The specifications are now covered in EN 10028 Parts 1 and 2, and have been editorially revised.

b) The steel grade UH I (material number 1.0348) has been dropped, and the steel grade 11 CrMo 9-10 is included for the first time.

c) Some of the requirements for chemical composition and mechanical properties have been amended.

d) Some of the guideline values given for the rupture stress of steel grade 16 Mo 3 as compared with 15 Mo 3 (material number 1.5415) have been changed.

e) Guideline temperatures for stress-relieving have been deleted.

f) The material designations have been changed in accordance with the table below.

Steel grade as specified in DIN EN 10028 Part 2	Equivalent steel grade as specified in DIN 17155, October 1983 edition	Material number
P235GH	H I	1.0345
P265GH	H II	1.0425
P295GH	17 Mn 4	1.0481
P355GH	19 Mn 6	1.0473
16Mo3	15 Mo 3	1.5415
13CrMo4-5	13 CrMo 4 4	1.7335
10CrMo9-10	10 CrMo 9 10	1.7380
11CrMo9-10	–	1.7383

International Patent Classification

C 22 C 38/00
C 22 C 38/22
C 21 D 1/55
G 01 N 33/20

Editor's note

*This Standard reproduces the official text of the English version of EN 10028-2 as issued by CEN. In its preparation for publication as DIN EN 10028 Part 2 (English version), certain points have been noted which we consider to be in need of correction. These have been marked *). The suggested amendments are given below and will be forwarded to the responsible CEN Secretariat for its consideration.*

In presentation, orthography, punctuation and hyphenation, the aim has been to implement the PNE Rules consistently. Obvious errorsy (e.g. redundancies and omissions) have been rectified without further reference.

Suggested amendments

1 *For the sake of consistency, the subtitle of the EN should be amended to read: 'Unalloyed and alloy steels with elevated temperature properties'.*

2 *To avoid confusion, the term 'delivery condition' should be replaced by 'heat treatment condition' in subclause 8.2 and table 3.*

3 *To facilitate comprehension, the Note to subclause 8.2.3 should be amended to read: 'In the case of samples treated as described above, the party responsible for further processing is still to provide proof that the properties of the finished product comply with the relevant requirements.'*

4 *By way of correction, the title of subclause 9.3 should read: 'Scope of testing'.*

5 *For the sake of clarity, footnote [3]) to table 1 should be amended to read: 'Subject to agreement, a lower Cu content than that given and a maximum Ti content may be specified to enhance, for example, workability.'*

6 *For the sake of clarity, the title of table 2 should be amended to read: 'Amounts by which the chemical composition as determined by product analysis may deviate from the limiting values specified for cast analysis (cf. table 1)'.*

7 *In table 3, it should be noted that the wording of the last column does not reflect the German text, which translates the parenthetical phrase as 'V-notch test pieces', not 'quenched test pieces'.*

8 *For ease of comprehension, footnote [2]) to table 3 should be amended to read: 'Until the values of yield stress are harmonized among the various national codes of practice, it shall be permitted to determine the 0,2 % proof stress, $R_{p0,2}$, instead of R_{eH}. In this case, the values specified for R_{eH} shall be reduced by 10 N/mm^2.'*

9 *For ease of comprehension, Note 1 to Annex A should be amended to read: 'The values given in table A.1 are for information only. However, where reference is made to them in the relevant standards or codes of practice, they shall be regarded as being binding for design purposes.'*

10 *By way of correction, Note 2 to Annex A should be amended to read: 'The values given in table A.1 for 1 % creep stress and rupture stress do not mean that the steels can be used continuously at the temperatures specified. The governing factor is the total stress in service, particularly the oxidation conditions.' For the sake of consistency, the heading of column 4 of table A.1 should then read: 'Rupture stress'.*

11 *To make the sense complete, footnote [2]) to table A.1 should be amended to read: 'The values represent the stress required to produce a permanent elongation of 1 %, relative to the initial cross section of the test piece, after 10000 or 100000 h.'*

12 *To make the sense complete, footnote [3]) to table A.1 should be amended to read: 'The values represent the stress required to cause the test piece to fracture after 10000, 100000 or 200 000 h.'*

13 *In the Note to Annex B, the term 'stress relief annealing' should be replaced by 'stress-relieving', which is the more common technical term.*

14 *To reflect the German text, the term 'quenching' as used in table B.1 should be replaced by 'quenching and tempering' (which is the more common technical term in this context).*

EUROPEAN STANDARD
NORME EUROPÉENNE
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EN 10 028-2

December 1992

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Descriptors: Iron and steel products, metal plate, steel strip, unalloyed steels, heat-resistant steels, pressure equipment, designation, specifications, heat treatment condition, tests, marking.

English version

Flat products made from steel 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 warmfeste Stähle

This European Standard was approved by CEN on 1992-12-21.

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 bibliographic 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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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

Contents

NOTE: The clauses marked ●● contain information relating to agreements which may be made at the time of ordering.

Foreword

This European Standard was prepared by ECISS/TC 22 'Steels for pressure purposes; qualities', the Secretariat of which is held by DIN.

Within the framework of the ECISS (European Committee for Iron and Steel Standardization) programme, ECISS/TC 22 was allocated the task of revising EURONORM 28-85 'Steel plate, sheet and strip with elevated temperature properties; technical delivery conditions' and (where relevant to pressure vessel construction) EURONORM 113-72 'Weldable fine grain structural steels' and replacing them with a European Standard.

At its meeting in November 1990, ECISS/TC 22 approved the present document. The following ECISS members were represented at the meeting: Austria, Finland, France, Germany, Italy, Norway, Sweden, United Kingdom.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, and conflicting national standards withdrawn, by June 1993 at the latest.

In accordance with the CEN/CENELEC Internal Regulations, the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

1.1 This Part of EN 10028 specifies requirements for flat products, used for the construction of pressure vessels, made from the weldable unalloyed and alloy steels with elevated temperature properties specified in table 1.

1.2 The requirements specified in EN 10028-1 shall 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.

EN 10020	Definition and classification of grades of steel
EN 10028-1	Flat products made from steels for pressure purposes. Part 1: General requirements

3 Definitions

See EN 10028-1.

4 Dimensions and tolerances on dimensions

See EN 10028-1.

5 Calculation of mass

See EN 10028-1.

6 Designation and ordering

See EN 10028-1.

7 Classification into grades

This EN covers the steel grades given in table 1. In accordance with EN 10 020, grades P235GH, P265GH, P295GH and P355GH are unalloyed quality steels, and grades 16 Mo 3, 13 CrMo 4-5, 10 CrMo 9-10 and 11 CrMo 9-10 are alloy special steels.

8 Requirements

8.1 Steelmaking process

See EN 10028-1.

8.2 Delivery condition +)

8.2.1 ●● Unless otherwise agreed at the time of ordering, the products covered by this EN shall be supplied in one of the usual conditions given in table 3.

8.2.2 Normalizing rolling may be carried out instead of normalizing for steel grades P235GH, P265GH, P295GH and P355GH. This means that the requirements are still to be met even after subsequent normalizing.

8.2.3 ●● Subject to agreement, products made from steel grades P235GH, P265GH, P295GH, P355GH and 16 Mo 3 may also be supplied in the untreated condition, and products made from steel grades 13 CrMo 4-5, 10 CrMo 9-10 and 11 CrMo 9-10 may be supplied in the tempered or normalized condition or, in exceptional cases, in the untreated condition. (Guideline temperatures for heat treatment are given in Annex B.)

In these cases, the test pieces shall be tested in their as delivered 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. +)

8.3 Chemical composition

8.3.1 The chemical composition, as determined by cast analysis, shall be in compliance with table 1.

8.3.2 Where a product analysis is to be carried out, the results may deviate from the values given in table 1 by the amounts listed in table 2.

8.3.3 ●● A maximum value for the carbon equivalent may be agreed upon at the time of ordering for steel grades P235GH, P265GH, P295GH and P355GH.

8.4 Mechanical properties

Tables 3 and 4 shall apply for the mechanical properties (cf. EN 10 028-1).

Preliminary guideline values for creep stress are given in Annex A.

8.5 Surface condition

See EN 10028-1.

8.6 Internal soundness

See EN 10028-1.

9 Testing

See EN 10028-1.

9.1 Type and content of inspection documents

See EN 10028-1.

9.2 Tests to be carried out

See EN 10028-1.

9.3 Number of tests +)

See EN 10028-1.

9.4 Sampling and sample preparation

See EN 10028-1.

9.5 Test procedures

See EN 10028-1.

9.6 Retests

See EN 10028-1.

10 ●● Marking

See EN 10028-1.

Table 1: Chemical composition as determined by cast analysis

Material designation	Material number	Classification[1])	Percentage by mass[2]) C	Si max.	Mn	P max.	S max.	Al_{total}	Cr	Cu[3]) max.	Mo	Nb max.	Ni max.	Ti max.	V max.	Cr + Cu + Mo + Ni max.
P235GH	1.0345	UQ	max. 0,16	0,35	0,40 to 1,20	0,030	0,025	min. 0,020	max. 0,30	0,30	max. 0,08	0,010	0,30	0,03	0,02	0,70
P265GH	1.0425	UQ	max. 0,20	0,40	0,50 to 1,40	0,030	0,025	min. 0,020	max. 0,30	0,30	max. 0,08	0,010	0,30	0,03	0,02	0,70
P295GH	1.0481	UQ	0,08 to 0,20	0,40	0,90 to 1,50	0,030	0,025	min. 0,020	max. 0,30	0,30	max. 0,08	0,010	0,30	0,03	0,02	0,70
P355GH	1.0473	UQ	0,10 to 0,22	0,60	1,00 to 1,70	0,030	0,025	min. 0,020	max. 0,30	0,30	max. 0,08	0,010	0,30	0,03	0,02	0,70
16Mo3	1.5415	LE	0,12 to 0,20	0,35	0,40 to 0,90	0,030	0,025	[4])	max. 0,30	0,30	0,25 to 0,35	-	0,30	-	-	-
13CrMo4-5	1.7335	LE	0,08 to 0,18	0,35	0,40 to 1,00	0,030	0,025	[4])	0,70 to 1,15[5])	0,30	0,40 to 0,60	-	-	-	-	-
10CrMo9-10	1.7380	LE	0,08[6]) to 0,14[7])	0,50	0,40 to 0,80	0,030	0,025	[4])	2,00 to 2,50	0,30	0,90 to 1,10	-	-	-	-	-
11CrMo9-10	1.7383	LE	0,08[6]) to 0,15	0,50	0,40 to 0,80	0,030	0,025	[4])	2,00 to 2,50	0,30	0,90 to 1,10	-	-	-	-	-

[1]) UQ = unalloyed quality steel; LE = alloy special steel.

[2]) Elements not listed in this table shall not be intentionally added to the steel without the purchaser's consent, except for finishing the cast. All appropriate measures shall be taken to prevent the addition of these elements from scrap or other materials used, which may adversely affect the mechanical properties and usability of the steel.

[3]) ●● A lower Cu content and a maximum tin content may be agreed upon at the time of ordering, e.g. with regard to formability.+)

[4]) The Al content of the cast shall be determined and given in the inspection document.

[5]) ●● If resistance to pressurized hydrogen is of relevance, a minimum Cr content of 0,80 % by mass may be agreed upon at the time of ordering.

[6]) ●● For product thicknesses less than 10 mm, a minimum carbon content of 0,06 % by mass may be agreed upon at the time of ordering.

[7]) ●● For product thicknesses greater than 150 mm, a maximum carbon content of 0,17 % by mass may be agreed upon at the time of ordering.

Table 2: Permissible deviations in the results of the product analysis from specified values applicable to the cast analysis (see table 1)*)

Element	Content as determined by cast analysis, according to table 1 Percentage by mass	Limit deviations[1]) in the product analysis from the limiting values specified in table 1 for the cast analysis Percentage by mass		Element	Content as determined by cast analysis, according to table 1 Percentage by mass	Limit deviations[1]) in the product analysis from the limiting values specified in table 1 for the cast analysis Percentage by mass
C	≤ 0,22	± 0,02		Mo	≤ 0,35 > 0,35 to ≤ 1,10	± 0,03 ± 0,04
Si	≤ 0,35 > 0,35 to ≤ 0,60	+ 0,05 + 0,06		Cu	≤ 0,30	+ 0,05
Mn	≤ 1,00 > 1,00 to ≤ 1,70	± 0,05 ± 0,10		Nb	≤ 0,010	+ 0,005
P	≤ 0,030	+ 0,005		Ni	≤ 0,30	+ 0,05
S	≤ 0,025	+ 0,005		Ti	≤ 0,03	+ 0,01
Al	≥ 0,020	− 0,005		V	≤ 0,02	+ 0,01
Cr	≤ 1,00 > 1,00 to ≤ 2,50	± 0,05 ± 0,10				

[1]) If several product analyses are carried out for one cast and if the values established for an individual element fall outside the permitted range, then the values shall either exceed the maximum permitted value or be lower than the minimum permitted value, but not both at the same time.

Table 3: Mechanical properties (applicable to transverse test pieces)

Material designation	Material number	Usual delivery condition[1])*)	Product thickness mm Over	Product thickness mm Up to	Yield strength[2]) R_{eH} N/mm² min.	Tensile strength R_m N/mm²	Elongation at fracture ($L_0 = 5{,}65\sqrt{S_0}$) A % min.	Impact energy (quenched test pieces)*) KV Test temperature °C	Impact energy (quenched test pieces)*) KV Mean value from three test pieces J min.
P235GH	1.0345	N[3])		16	235	360 to 480	25[5])	0	27
			16	40	225				
			40	60	215				
			60	100	200		24		
			100	150	185	350 to 480			
			150		[4])	[4])	[4])		[4])
P265GH	1.0425	N[3])		16	265	410 to 530	23[6])	0	27
			16	40	255				
			40	60	245				
			60	100	215		22		
			100	150	200	400 to 530			
			150		[4])	[4])	[4])		[4])
P295GH	1.0481	N[3])		16	295	460 to 580	22	0	27
			16	40	290				
			40	60	285				
			60	100	260		21		
			100	150	235	440 to 570			
			150		[4])	[4])	[4])		[4])
P355GH	1.0473	N[3])		16	355	510 to 650	21	0	27
			16	40	345				
			40	60	335				
			60	100	315	490 to 630	20		
			100	150	295	480 to 630			
			150		[4])	[4])	[4])		[4])
16Mo3	1.5415	N[7])		16	275	440 to 590	24	+ 20	31[8])
			16	40	270				
			40	60	260		23		
			60	100	240	430 to 580	22		27[8])
			100	150	220	420 to 570	19		
			150		[4])	[4])	[4])		[4])
13CrMo4-5	1.7335	N + T		16	300	450 to 600	20	+ 20	31[9])
			16	60	295				
		N + T or QA or QL	60	100	275	440 to 590	19		27[8])
		QL	100	150	255	430 to 580			
			150		[4])	[4])	[4])		[4])
10CrMo9-10	1.7380	N + T		16	310	480 to 630	18	+ 20	31
			16	40	300				
			40	60	290				
		N + T or QA or QL	60	100	270	470 to 620	17		27
		QL	100	150	250	460 to 610			
			150		[4])	[4])	[4])		[4])
11CrMo9-10	1.7383	N + T or QA or QL		60	310	520 to 670	18	+ 20	31[9])
		QL	60	100			17		27[8])

[1]) N = normalized; QA = quenched in air; QL = quenched in liquid; T = tempered.
[2]) Until the yield point criteria are harmonized in the various national codes, determination of R_{eH} may be replaced by determination of $R_{p0,2}$. In this case, 10 N/mm² lower minimum values apply for $R_{p0,2}$.*)
[3]) See 8.2.2.
[4]) ●● Subject to agreement.
[5]) Where the elongation at fracture has been determined on tensile test pieces having an original gauge length, L_0, equal to 80 mm and a width of 20 mm, a minimum value of 19 % shall apply for product thicknesses over 2 mm up to 2,5 mm, or 20 % for product thicknesses over 2,5 mm to less than 3 mm.
[6]) Where the elongation at fracture has been determined on tensile test pieces having an original gauge length, L_0, equal to 80 mm and a width of 20 mm, a minimum value of 17 % shall apply for product thicknesses over 2 mm up to 2,5 mm, or 18 % for product thicknesses over 2,5 mm to less than 3 mm.
[7]) This steel may also be supplied in the N + T condition, at the manufacturer's discretion.
[8]) ●● If a test at 0 °C has been agreed, a minimum value of 24 J shall apply.
[9]) ●● If a test at 0 °C has been agreed, a minimum value of 27 J shall apply.

Table 4: Elevated temperature 0,2 % proof strength[1])

Material designation	Product thickness mm		0,2 % proof strength at a temperature, in °C, of									
			50	100	150	200	250	300	350	400	450	500
	Over	Up to	N/mm² min.									
P235GH		60	206	190	180	170	150	130	120	110	–	–
	60	100	191	175	165	160	140	125	115	105	–	–
	100	150	176	160	155	150	130	115	110	100	–	–
P265GH		60	234	215	205	195	175	155	140	130	–	–
	60	100	207	195	185	175	160	145	135	125	–	–
	100	150	192	180	175	165	155	135	130	120	–	–
P295GH		60	272	250	235	225	205	185	170	155	–	–
	60	100	249	230	220	210	195	180	165	145	–	–
	100	150	226	210	200	195	185	170	155	135	–	–
P355GH		60	318	290	270	255	235	215	200	180	–	–
	60	100	298	270	255	240	220	200	190	165	–	–
	100	150	278	250	240	230	210	195	175	155	–	–
16Mo3		60	–	–	–	215	200	170	160	150	145	140
	60	100	–	–	–	200	185	165	155	145	140	135
	100	150	–	–	–	190	175	155	145	140	135	130
13CrMo4-5		60	–	–	–	230	220	205	190	180	170	165
	60	100	–	–	–	220	210	195	185	175	165	160
	100	150	–	–	–	210	200	185	175	170	160	155
10CrMo9-10		60	–	–	–	245	230	220	210	200	190	180
	60	100	–	–	–	225	220	210	195	185	175	165
	100	150	–	–	–	215	205	195	185	175	165	155
11CrMo9-10		100	–	–	–	–	255	235	225	215	205	195

[1]) The values given in this table have not been derived from the method given in ISO 2605-1.

Annex A (informative)

Preliminary guideline values for creep stress[1])

NOTE 1: The values given in table A.1 are only for information purposes. If referred to in regulations, however, they will be binding for calculation purposes.[+])

NOTE 2: The 1 % creep stress and creep strength values given up to the elevated temperatures listed in table A.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, particularly the oxidation conditions.[+])

Table A.1

Steel grade	Temperature	1 % creep stress after [2])		Creep strength after [3])[+])		
Name	°C	10 000 h N/mm²	100 000 h N/mm²	10 000 h N/mm²	100 000 h N/mm²	200 000 h N/mm²
P235GH P265GH	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	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	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

For [1]), [2]) and [3]), see page 9.

(continued)

Table A.1 (concluded)

Steel grade Name	Temperature °C	1 % creep stress after [2] 10 000 h N/mm²	 100 000 h N/mm²	Creep strength after [3] [+] 10 000 h N/mm²	 100 000 h N/mm²	 200 000 h N/mm²
13CrMo4-5	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
10CrMo9-10	450	240	166	306	221	201
	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
11CrMo9-10	450	–	–	–	221	–
	460	–	–	–	205	–
	470	–	–	–	188	–
	480	–	–	–	170	–
	490	–	–	–	152	–
	500	–	–	–	135	–
	510	–	–	–	118	–
	520	–	–	–	103	–

[1] The values represent mean values from scatterbands established to date and may be revised at a later date, as investigations continue. According to current data based on creep testing, it may be assumed that the lower limit of the scatterband is approximately 20 % lower than the mean value specified.

[2] This is the stress relative to the initial cross section leading to a permanent elongation of 1 % after 10 000 and 100 000 hours (h).[+]

[3] This is the stress relative to the initial cross section leading to fracture after 10 000, 100 000 and 200 000 hours (h).[+]

Annex B (informative)

Guideline temperatures for heat treatment

Table B.1 gives guideline temperatures for heat treatment.

NOTE: The conditions for stress relief annealing+) are currently being discussed by experts of CEN/TC 54 'Unfired pressure vessels' and ECISS/TC 22 'Steels for pressure purposes'. The results of these discussions will probably be published initially in an annex to the EN on unfired pressure vessels and subsequently in a revised edition of EN 10 028-2. Until then, the relevant annex of the EN on unfired pressure vessels may contain additional or deviating data regarding the annealing of steels.

Table B.1: Guideline temperatures for heat treatment

Material designation	Temperature range for		
	normalizing[1])	quenching+)	
		Austenitizing	Tempering[2])
P235GH	890 to 950	-	-
P265GH	890 to 950	-	-
P295GH	890 to 950	-	-
P355GH	890 to 950	-	-
16Mo3	890 to 950	-	-[3])
13CrMo4-5	-	890 to 950	630 to 730
10CrMo9-10	-	920 to 980	680 to 760
11CrMo9-10	-	920 to 980	670 to 750

[1]) When normalizing, after the specified temperatures have been reached over the whole cross section, no further holding is necessary and should usually be avoided.

[2]) When tempering, after the specified temperatures have been reached over the whole cross section, they shall be maintained for at least 30 minutes.

[3]) In certain cases, tempering at 590 to 650 °C may be necessary.