

Steel forgings for pressure purposes —

Part 2: Ferritic and martensitic steels with specified elevated temperature properties

The European Standard EN 10222-2:1999 has the status of a
British Standard

ICS 77.140.30; 77.140.85

National foreword

This British Standard is the official English language version of EN 10222-2:1999. Together with BS EN 10222-1, -3, -4 and -5, it supersedes BS 1503:1989 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee ISE/73, Steel for pressure purposes, to Subcommittee ISE/73/3, Steel forgings 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.

Cross-references

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

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Summary of pages

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This European Standard was approved by CEN on 5 September 1999.

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
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Foreword

This European Standard has been prepared by Technical Committee ECISS/TC 28, Steel forgings, the Secretariat of which is held by BSI.

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 June 2000, and conflicting national standards shall be withdrawn at the latest by June 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 the relationship with EU Directive(s), see informative annex ZB, which is an integral part of this standard.

Attention is drawn to annex ZA which is an A-deviation requested by Sweden.

Attention is drawn to non-conflicting national additions requested by France and Germany. These additions shall only appear as national annexes to the members' editions of this European Standard.

The titles of the other parts of this European Standard are:

Part 1: General requirements for open die forgings

Part 3: Nickel steels with specified low temperature properties

Part 4: Weldable fine grain steels with high proof strength

Part 5: Martensitic, austenitic and austenitic-ferritic stainless steels

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.

1 Scope

This part of this European Standard specifies the technical delivery conditions for forgings for pressure purposes, made of ferritic and martensitic steels with specified elevated temperature properties. Chemical composition and mechanical properties are specified.

General information on technical delivery conditions is given in EN 10021.

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 10021	General technical delivery requirements for iron and steel products.
EN 10222-1:1998	Steel forgings for pressure purposes - Part 1: General requirements for open die forgings.

3 Chemical composition

3.1 Cast analysis

The chemical composition (cast analysis), determined in accordance with EN 10222-1, shall conform to the requirements of table 1 (see 9.1 of EN 10222-1:1998).

3.2 Product analysis

The product analysis shall not deviate from the specified cast analysis (see table 1) by more than the values specified in table 2 (see 9.2 of EN 10222-1:1998).

4 Heat treatment and mechanical properties

When heat treated in accordance with table 1, the mechanical properties, determined in accordance with EN 10222-1, shall conform to the requirements of table 1.

Elevated temperature proof strength ($R_{p0,2}$) properties shall conform to the requirements of table 3.

The testing temperature for impact properties and elevated temperature properties shall be agreed at the time of enquiry and order.

Reference data for stress rupture properties and 1 % creep limit properties are given in annex A for information.

Table 1: Chemical composition, mechanical properties and heat treatment

Steel designation			Chemical composition (cast analysis) % ¹⁾								Mechanical properties at room temperature						Heat treatment				Carbon equivalent value
Name	Number	C	Si max.	Mn	P max.	S max.	Cr	Mo	Others	Thickness of the ruling section t_R ²⁾	Yield strength R_{eH} ³⁾	Tensile strength R_m	Elongation after fracture A ⁴⁾	Notch impact KV ⁴⁾	Symbol ⁵⁾	Austenitizing or solution annealing	Tempering		Carbon equivalent value		
										mm	N/mm ² min	N/mm ²	mm %	min J		Temperature °C	Cooling in ϕ	Temperature °C	Cooling in ϕ	max. %	
P245GH	1.0352	0,08 to 0,20	0,40	0,50 to 1,30	0,025	0,015	–	–	–	$t_R \leq 35$ $35 < t_R \leq 160$	245 220	410 to 530 410 to 530	25 23	32 ⁷⁾ 32 ⁷⁾	A N NT or QT	890 to 930 890 to 930 890 to 930	f a a, o, w	– – 600 to 640	– – a, f	– 0,41	
P280GH	1.0426	0,08 to 0,20	0,40	0,90 to 1,50	0,025	0,015	–	–	–	$t_R \leq 35$ $35 < t_R \leq 160$	280 255	460 to 580 460 to 580	23 23	48 ⁷⁾ 48 ⁷⁾	N NT or QT	880 to 920 880 to 920 880 to 920	a a, o, w a, o, w	– 600 to 640 600 to 640	– a, f a, f	0,45	
P305GH	1.0436	0,15 to 0,20	0,40	0,90 to 1,60	0,025	0,015	–	–	–	$t_R \leq 35$ $35 < t_R \leq 160$ $70 < t_R \leq 100$	305 280 285	490 to 610 490 to 610 510 to 630	22 22 22	48 ⁷⁾ 48 ⁷⁾ 48 ⁷⁾	N NT QT	880 to 920 880 to 920 880 to 920	a a, o, w o, w	– 620 to 660 620 to 660	– a, f a, f	0,47	
16Mo3	1.5415	0,12 to 0,20	0,35	0,40 to 0,90	0,025	0,015	–	0,25 to 0,35	–	$t_R \leq 35$ $35 < t_R \leq 70$ $70 < t_R \leq 100$	295 285 275	440 to 570	23	50 ⁷⁾	N QT	890 to 950 890 to 960	a o, w	620 to 700	a, f	–	
13CrMo4-5	1.7335	0,08 to 0,18	0,35	0,40 to 1,00	0,025	0,015	0,70 to 1,15 ⁸⁾	0,40 to 0,60	–	$t_R \leq 250$ $250 < t_R \leq 500$ $t_R \leq 35$ $35 < t_R \leq 70$ $70 < t_R \leq 100$ $100 < t_R \leq 250$ $250 < t_R \leq 500$	265 250 295 285	440 to 570 420 to 550 440 to 590 440 to 590	23 20	50 ⁷⁾ 44 ⁷⁾	QT NT	890 to 960 890 to 950	o, w a	620 to 700 630 to 740	a, f a, f	– –	
											240	420 to 570	20	44 ⁷⁾	NT or QT	890 to 950	a, o, w	630 to 740	a, f	–	

¹⁾ Elements not listed in this table shall not be intentionally added to the steel without the approval 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 following elements shall not exceed the limits stated: chromium 0,30 % max., copper 0,30 % max., molybdenum 0,08 % max., nickel 0,30 % max., niobium 0,01 % max., vanadium 0,02 % max. The total of chromium + copper + molybdenum shall not exceed 0,50 %.

²⁾ The thickness ranges given in this column apply for the as heat treated thickness of forgings with the ruling section. This is characterized by rectangular shape, a width to thickness ratio of ≥ 2 and a length to thickness ratio of ≥ 4 . For forgings with other sections the equivalent thickness shall be determined according to EN 10222-1, annex B or be agreed at the time of enquiry and order.

³⁾ 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, $R_{p0,2}$ values are 10 N/mm² lower for R_{eH} values up to 355 N/mm² and 15 N/mm² lower for R_{eH} values greater than 355 N/mm².

⁴⁾ 1 – longitudinal t – transverse

⁵⁾ A – annealed N – normalized QT – quenched and tempered

⁶⁾ a – air f – furnace o – oil w – water

⁷⁾ Optional at 0 °C. The minimum requirements of the standard shall be met.

⁸⁾ If resistance to pressurized hydrogen is of importance, a min Cr of 0,80 % may be agreed at the time of enquiry and order.

¹⁾ Elements not listed in this table shall not be intentionally added to the steel without the approval 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 following elements shall not exceed the limits stated: chromium 0,30 % max., copper 0,30 % max., molybdenum 0,08 % max., nickel 0,30 % max., niobium 0,01 % max., vanadium 0,02 % max. The total of chromium + copper + molybdenum shall not exceed 0,50 %, according to EN 10222-1, annex B or be agreed at the time of enquiry and order.

²⁾ The thickness ranges given in this column apply for the as heat treated thickness of forgings with the ruling section. This is characterized by rectangular shape, a width to thickness ratio of ≥ 2 and a length to thickness ratio of ≥ 4 . For forgings with other sections the equivalent thickness shall be determined according to EN 10222-1, annex B or be agreed at the time of enquiry and order.

³⁾ 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, $R_{p0.2}$ values are 10 N/mm² lower for R_{eH} values up to 355 N/mm² and 15 N/mm² lower for R_{eH} values greater than 355 N/mm².

⁴⁾ 1) – longitudinal t – transverse tr – tangential tr – transverse

⁵⁾ A – annealed N – normalized QT – quenched and tempered NT – normalized and tempered

⁶⁾ a – air f – furnace o – oil w – water

⁷⁾ Optional at 0 °C. The minimum requirements of the standard shall be met.

⁸⁾ If resistance to pressurized hydrogen is of importance, a min Cr of 0,80 % may be agreed at the time of enquiry and order.

Table 1: Chemical composition, mechanical properties and heat treatment (continued)

Steel designation			Chemical composition (cast analysis) % ¹⁾								Mechanical properties at room temperature							Heat treatment				Carbon equivalent value max. %
Name	Number	C	Si max.	Mn	P max.	S max.	Cr	Mo	Others	Thickness of the ruling section <i>t_R</i> ²⁾ mm	Yield strength <i>R_{eH}</i> ³⁾ N/mm ² min	Tensile strength <i>R_m</i> N/mm ²	Elongation after fracture <i>A</i> min % <i>t_R</i> ⁴⁾	Notch impact <i>KV</i> min J tr-t ⁵⁾	Symbol ⁵⁾	Austenitizing or solution annealing		Tempering				
																Temperature ° C	Cooling in ⁶⁾	Temperature ° C	Cooling in ⁶⁾			
15MnMoV4-5	1.5402	0,18 max.	0,40	0,90 to 1,40	0,025	0,015	–	0,40 to 0,60	V 0,04 to 0,08	<i>t_R</i> ≤ 35 35 < <i>t_R</i> ≤ 70 70 < <i>t_R</i> ≤ 250	345 345 325	510 to 650	23 22 21	40 ⁷⁾ 40 ⁷⁾ 40 ⁷⁾	NT or QT	875 to 925	a, w	600 to 675	a, f	–		
18MnMoNi5-5	1.6308	0,20 max.	0,40	1,15 to 1,55	0,025	0,015	–	0,45 to 0,55	Ni 0,50 to 0,80 V 0,03 max.	<i>t_R</i> ≤ 200	400	550 to 670	20	56 ⁷⁾	QT	850 to 925	w	625 to 675	a, f	–		
14MoV6-3	1.7715	0,10 to 0,18	0,40	0,40 to 0,70	0,025	0,015	0,30 to 0,60	0,50 to 0,70	V 0,22 to 0,28 Sn ≤ 0,025 Al 0,020 max.	<i>t_R</i> ≤ 500	300	460 to 610	20	27	NT or QT	950 to 990	a, o	670 to 720	a, f	–		
15MnCrMoNiV5-3	1.6920	0,17 max.	0,40	1,00 to 1,50	0,025	0,015	0,50 to 1,00	0,20 to 0,35	Ni 0,30 to 0,70 V 0,05 to 0,10	<i>t_R</i> ≤ 100	370	560 to 710	17	40	NT or QT	900 to 950	a, w	625 to 675	a, f	–		
11CrMo9-10	1.7383	0,08 to 0,15	0,50	0,40 to 0,80	0,025	0,015	2,00 to 2,50	0,90 to 1,10	–	<i>t_R</i> ≤ 200 200 < <i>t_R</i> ≤ 500	310 265	520 to 670 450 to 600	20 23	40 ⁷⁾ 60 27 ⁷⁾	NT or QT	900 to 980 900 to 980	a, o a, o, w	670 to 770 670 to 770	a, f a, f	– –		

¹⁾ Elements not listed in this table shall not be intentionally added to the steel without the approval 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 following elements shall not exceed the limits stated: chromium 0,30 % max., copper 0,30 % max., molybdenum 0,08 % max., nickel 0,30 % max., niobium 0,01 % max., vanadium 0,02 % max. The total of chromium + copper + molybdenum shall not exceed 0,50 %.

²⁾ The thickness ranges given in this column apply for the as heat treated thickness of forgings with the ruling section. This is characterized by rectangular shape, a width to thickness ratio of ≥ 2 and a length to thickness ratio of ≥ 4. For forgings with other sections the equivalent thickness shall be determined according to EN 10222-1, annex B or be agreed at the time of enquiry and order.

³⁾ 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, *R_{p0,2}* values are 10 N/mm² lower for *R_{eH}* values up to 355 N/mm² and 15 N/mm² lower for *R_{eH}* values greater than 355 N/mm².

⁴⁾ 1 – longitudinal
tr – transverse

⁵⁾ A – annealed
NT – normalized and tempered

⁶⁾ a – air
f – furnace
o – oil
w – water

⁷⁾ Optional at 0 °C. The minimum requirements of the standard shall be met.

⁸⁾ If resistance to pressurized hydrogen is of importance, a min Cr of 0,80 % may be agreed at the time of enquiry and order.

Table 1: Chemical composition, mechanical properties and heat treatment (concluded)

Steel designation		Chemical composition (cast analysis) % ¹⁾							Mechanical properties at room temperature						Heat treatment				Carbon equivalent value max. %	
Name	Number	C	Si max.	Mn	P max.	S max.	Cr	Mo	Others	Thickness of the ruling section t_R ²⁾ mm	Yield strength R_{eH} ³⁾ N/mm ² min	Tensile strength R_m N/mm ²	Elongation after fracture A min % t_R ⁴⁾	Notch impact KV min J tr.t. ⁴⁾	Symbol ⁵⁾	Austenitizing or solution annealing		Tempering		
																Temperature °C	Cooling in ₆₎	Temperature °C	Cooling in ₆₎	
X16CrMo5-1	1.7366	0,18 max.	0,40	0,30 to 0,80	0,025	0,015	4,00 to 6,00	0,45 to 0,65	–	$t_R \leq 300$	205 to 420	410 to 510 to 640 to 780	18 to 16	40 to 27	A	850 to 880 to 925 to 975	f	–	–	–
X10CrMoVN9-1	1.4903	0,08 to 0,12	0,50	0,30 to 0,60	0,025	0,015	8,00 to 9,50	0,85 to 1,05	Ni 0,40 max. Nb 0,06 to 0,10 V 0,18 to 0,25 N 0,030 to 0,070 Al 0,040 max.	$t_R \leq 130$	450	630 to 730	19	40 ⁷⁾	NT	1040 to 1090	a, o	730 to 780	a, f	–
X20CrMoV11-1	1.4922	0,17 to 0,23	0,40	0,30 to 1,00	0,025	0,015	10,00 to 12,50	0,80 to 1,20	Ni 0,30 to 0,80 V 0,20 to 0,35	$t_R \leq 100$ $100 < t_R \leq 250$ $250 < t_R \leq 330$	500 to 500 to 500	700 to 850 to 700 to 850	16 to 16 to 16	39 to 31 to 27	QT	1020 to 1070	a, o	730 to 780	a, f	–

¹⁾ Elements not listed in this table shall not be intentionally added to the steel without the approval 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 following elements shall not exceed the limits stated: chromium 0,30 % max., copper 0,30 % max., molybdenum 0,08 % max., nickel 0,30 % max., niobium 0,01 % max., vanadium 0,02 % max. The total of chromium + copper + molybdenum shall not exceed 0,50 %.

²⁾ The thickness ranges given in this column apply for the as heat treated thickness of forgings with the ruling section. This is characterized by rectangular shape, a width to thickness ratio of ≥ 2 and a length to thickness ratio of ≥ 4 . For forgings with other sections the equivalent thickness shall be determined according to EN 10222-1, annex B or be agreed at the time of enquiry and order.

³⁾ 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, $R_{p0.2}$ values are 10 N/mm² lower for R_{eH} values up to 355 N/mm² and 15 N/mm² lower for R_{eH} values greater than 355 N/mm².

⁴⁾ 1 – longitudinal t – tangential tr – transverse

⁵⁾ A – annealed N – normalized QT – quenched and tempered NT – normalized and tempered.

⁶⁾ a – air f – furnace o – oil w – water

⁷⁾ Optional at 0 °C. The minimum requirements of the standard shall be met.

⁸⁾ If resistance to pressurized hydrogen is of importance, a min Cr of 0,80 % may be agreed at the time of enquiry and order.

Table 2: Permissible deviations of the product analysis from specified values of the cast analysis

Element	Specified value in the cast analysis according to table 1 %	Permissible deviations ¹⁾ of the product analysis %
C	≤ 0,23	± 0,02
Si	≤ 0,50	+ 0,05
Mn	≤ 1,00 > 1,00 ≤ 160	± 0,05 ± 0,10
P	≤ 0,025	+ 0,005
S	≤ 0,015	+ 0,003
Al	≤ 0,040	+ 0,005
Cr	≤ 1,00 > 1,00 ≤ 10,0 > 10,0 ≤ 12,5	± 0,05 ± 0,10 ± 0,15
Mo	≤ 0,35 > 0,35 ≤ 1,20	± 0,03 ± 0,04
N	≤ 0,07	± 0,01
Nb	≤ 0,10	± 0,005
Ni	≤ 0,80	+ 0,05
Sn	≤ 0,025	+ 0,005
V	≤ 0,35	± 0,03
Cu	≤ 0,30	+ 0,05
¹⁾ If several product analyses are carried out for one cast and if, in this case, values for an individual element are established which fall outside the permitted range for the chemical composition, then it is only permissible that the values either exceed the maximum permitted value or fall short of the minimum permitted value. It is not acceptable for both to apply for one cast.		

Table 3: Minimum 0,2 % proof strength ($R_{p0,2}$) properties at elevated temperatures

Steel designation		Thickness of the ruling section, t_R , or equivalent thickness mm	$R_{p0.2}$ min. in N/mm ² at a temperature of:											
Name	Number		100 °C	150 °C	200 °C	250 °C	300 °C	350 °C	400 °C	450 °C	500 °C	550 °C	600 °C	
P245GH	1.0352	$t_R \leq 50$ $50 < t_R \leq 160$	195 180	185 175	175 165	160 155	145 135	135 130	125 120	— —	— —	— —	— —	
P280GH	1.0426	$t_R \leq 50$ $50 < t_R \leq 160$	250 210	235 200	225 195	205 185	185 170	170 155	155 135	— —	— —	— —	— —	
P305GH	1.0436	$t_R \leq 50$ $50 < t_R \leq 160$	270 250	255 240	240 230	220 210	200 195	190 175	165 155	— —	— —	— —	— —	
16 Mo3	1.5415	$t_R \leq 60$ $60 < t_R \leq 90$ $90 < t_R \leq 150$ $150 < t_R \leq 375$ $375 < t_R \leq 500$	264 250 240 235 220	245 230 220 210 200	225 210 200 190 180	205 195 185 175 165	180 170 160 155 145	170 160 155 145 140	160 150 145 140 135	155 145 140 135 130	150 140 135 130 125	— — — — —	— — — — —	
13 CrMo4-5	1.7335	$t_R \leq 60$ $60 < t_R \leq 90$ $90 < t_R \leq 150$ $150 < t_R \leq 375$ $375 < t_R \leq 500$	260 250 250 240 220	245 240 235 225 210	240 230 220 210 200	230 220 210 200 190	215 205 195 185 175	200 190 180 175 165	190 180 170 165 160	180 170 160 155 150	175 165 155 150 145	— — — — —	— — — — —	
15 MnMoV4-5	1.5402	$t_R \leq 250$	—	—	309	294	284	265	235	218	—	—	—	
18 MnMoNi 5-5	1.6308	$t_R \leq 200$	375	370	360	350	340	330	310	—	—	—	—	
14 MoV 6-3	1.7715	$t_R \leq 500$	282	276	267	241	225	216	209	203	200	197	164	
15 MnCrMoNiV 5-3	1.6920	$t_R \leq 100$	341	330	322	312	306	298	288	282	269	255	221	
11 CrMo 9-10	1.7383	$t_R \leq 200$ $200 < t_R \leq 500$	265 245	250 230	235 215	230 210	220 200	205 185	195 175	185 165	175 155	— —	— —	
X16 CrMo 5-1 ¹⁾	1.7366	$t_R \leq 300$	345	335	327	323	322	316	306	285	256	—	—	
X16 CrMo 5-1 ²⁾	1.7366	$t_R \leq 300$	156	150	148	147	145	142	137	129	116	—	—	
X10 CrMo VNb 9-1	1.4903	$t_R \leq 130$	410	395	380	370	360	350	340	320	300	270	215	
X20 CrMo V11-1	1.4922	$t_R \leq 330$	460	445	430	415	390	380	360	330	290	250	—	

¹⁾ Normalized and tempered or quenched and tempered.

²⁾ Annealed.

¹⁾ Normalized and tempered or quenched and tempered.

²⁾ Annealed.

Annex A (informative)

Reference data for stress rupture properties and 1% creep limit properties

Table A.1: Stress rupture properties

Steel designation		Rupture time	Average stress in N/mm ² for rupture at a temperature of: ¹⁾												
Name	Number	h	380 °C	390 °C	400 °C	410 °C	420 °C	430 °C	440 °C	450 °C	460 °C	470 °C	480 °C	490 °C	500 °C
P245GH	1.0352	10 000	229	211	191	174	158	142	127	113	100	86	75	—	—
		100 000	165	148	132	118	103	91	79	69	59	50	42	—	—
		200 000	145	129	115	101	89	78	67	57	48	40	33	—	—
P280GH	1.0426	10 000	291	266	243	221	200	180	161	143	126	110	96	—	—
P305GH	1.0436	100 000	227	203	179	157	136	117	100	85	73	63	55	—	—
		200 000	206	181	157	135	115	97	82	70	60	52	44	—	—
16Mo3	1.5415	10 000	—	—	—	—	—	—	—	298	273	247	222	196	171
		100 000	—	—	—	—	—	—	—	245	209	174	143	117	93
		200 000	—	—	—	—	—	—	—	228	189	153	121	96	75
13CrMo4-5	1.7335	10 000	—	—	—	—	—	—	—	370	348	328	304	273	239
		100 000	—	—	—	—	—	—	—	285	251	220	190	163	137
		200 000	—	—	—	—	—	—	—	260	226	195	167	139	115
15MnMoV4-5	1.5402	10 000	—	—	—	—	—	353	323	294	262	229	196	170	144
		100 000	—	—	—	—	—	265	321	198	168	143	118	98	78
14MoV6-3	1.7715	10 000	—	—	—	—	—	—	—	380	353	328	304	280	257
		100 000	—	—	—	—	—	—	—	321	294	268	242	217	193
		200 000	—	—	—	—	—	—	—	301	274	247	221	196	172

¹⁾ Some values in table A.1 have been obtained by extrapolation.

¹⁾ Some values in table A.1 have been obtained by extrapolation.

Table A.1: Stress rupture properties (continued)

Steel designation		Rupture time h	Average stress in N/mm ² for rupture at a temperature of: ¹⁾														
Name	Number		380 °C	390 °C	400 °C	410 °C	420 °C	430 °C	440 °C	450 °C	460 °C	470 °C	480 °C	490 °C	500 °C		
15MnCrMoNiV5-3	1.6920	10 000	–	–	454	445	432	415	394	371	346	321	294	265	234		
		100 000	–	–	417	405	388	367	341	309	272	235	201	168	139		
		200 000	–	–	399	385	368	346	518	287	249	208	171	141	113		
11CrMo9-10	1.7383	10 000	–	–	–	–	–	–	–	306	286	264	241	219	196		
		100 000	–	–	–	–	–	–	–	221	205	188	170	152	135		
		200 000	–	–	–	–	–	–	–	201	186	169	152	136	120		
X16CrMo5-1 ²⁾	1.7366	10 000	–	–	10 000	–	–	–	–	–	–	226	220	190	164		
		100 000	–	–	100 000	–	–	–	–	276	218	181	153	132	113		
		200 000	–	–	200 000	–	–	–	–	237	192	158	135	114	96		
X16CrMo5-1 ³⁾	1.7366	10 000	–	–	10 000	–	–	–	–	205	190	175	160	145	130		
		100 000	–	–	–	–	–	–	–	158	143	128	113	100	90		
		200 000	–	–	–	–	–	–	–	145	129	115	102	89	79		
X10CrMoVNb9-1	1.4903	10 000	–	–	–	–	–	–	–	–	–	–	–	–	289		
		100 000	–	–	–	–	–	–	–	–	–	–	–	–	258		
		200 000	–	–	–	–	–	–	–	–	–	–	–	–	246		
X20CrMoV11-1	1.4922	10 000	–	–	–	–	–	–	–	–	–	–	348	319	292		
		100 000	–	–	–	–	–	–	–	–	–	–	289	263	236		
		200 000	–	–	–	–	–	–	–	–	–	–	270	242	218		

¹⁾ Some values in table A.1 have been obtained by extrapolation.

²⁾ Normalized and tempered or quenched and tempered.

³⁾ Annealed.

Table A.1: Stress rupture properties (continued)

Steel designation		Rupture time h	Average stress in N/mm ² for rupture at a temperature of: ¹⁾														
Name	Number		510 °C	520 °C	530 °C	540 °C	550 °C	560 °C	570 °C	580 °C	590 °C	600 °C	610 °C	620 °C	630 °C	640 °C	650 °C
P245GH	1.0352	10 000	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		100 000	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		200 000	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
P280GH P305GH	1.0426 1.0436	10 000	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		100 000	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		200 000	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
16Mo3	1.5415	10 000	147	125	102	—	—	—	—	—	—	—	—	—	—	—	—
		100 000	74	59	47	—	—	—	—	—	—	—	—	—	—	—	—
		200 000	57	45	36	—	—	—	—	—	—	—	—	—	—	—	—
13CrMo4-5	1.7335	10 000	209	179	154	129	109	91	76	—	—	—	—	—	—	—	—
		100 000	116	94	78	61	49	40	33	—	—	—	—	—	—	—	—
		200 000	96	76	62	50	39	32	26	—	—	—	—	—	—	—	—
15MnMoV4-5	1.5402	10 000	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		100 000	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14Mo63	1.7715	10 000	234	212	190	170	151	133	118	104	92	81	—	—	—	—	—
		100 000	170	149	130	113	99	86	73	—	—	—	—	—	—	—	—
		200 000	150	130	113	98	85	71	—	—	—	—	—	—	—	—	—

¹⁾ Some values in table A.1 have been obtained by extrapolation.

¹⁾ Some values in table A.1 have been obtained by extrapolation.

Table A.1: Stress rupture properties (concluded)

Steel designation		Rupture time h	Average stress in N/mm ² for rupture at a temperature of: ¹⁾																	
Name	Number		510 °C	520 °C	530 °C	540 °C	550 °C	560 °C	570 °C	580 °C	590 °C	600 °C	610 °C	620 °C	630 °C	640 °C	650 °C	660 °C	670 °C	
15MnCrMoNiV5-3	1.6920	10 000	205	117	150	125	102	83	69	—	—	—	—	—	—	—	—	—	—	
		100 000	113	90	70	53	39	—	—	—	—	—	—	—	—	—	—	—	—	
		200 000	88	66	50	34	23	—	—	—	—	—	—	—	—	—	—	—	—	
11CrMo9-10	1.7383	10 000	176	156	138	122	108	96	85	75	68	61	—	—	—	—	—	—	—	
		100 000	118	103	90	78	68	58	51	44	38	34	—	—	—	—	—	—	—	
		200 000	105	91	79	68	58	50	43	37	32	28	—	—	—	—	—	—	—	
X16CrMo5-1 ²⁾	1.7366	10 000	145	129	114	100	88	77	68	60	53	46	—	—	—	—	—	—	—	
		100 000	96	81	70	59	50	43	37	—	—	—	—	—	—	—	—	—	—	
		200 000	80	68	57	47	40	—	—	—	—	—	—	—	—	—	—	—	—	
X16CrMo5-1 ³⁾	1.7366	10 000	119	108	98	88	79	71	64	57	50	43	—	—	—	—	—	—	—	
		100 000	81	73	65	57	50	44	38	33	28	24	—	—	—	—	—	—	—	
		200 000	70	63	56	49	42	35	30	26	23	20	—	—	—	—	—	—	—	
X10CrMoV9-1	1.4903	10 000	271	252	234	216	199	182	166	151	136	123	110	99	89	79	70	62	55	
		100 000	239	220	201	183	166	150	134	120	106	94	83	73	65	56	49	42	36	
		200 000	227	208	189	171	154	139	124	110	97	86	75	65	57	49	42	35	—	
X20CrMoV11-1	1.4922	10 000	269	247	225	205	184	165	147	130	113	97	84	72	61	52	44	—	—	
		100 000	212	188	167	147	128	111	95	81	69	59	51	43	36	31	26	—	—	
		200 000	194	170	149	129	112	96	81	68	58	49	42	36	30	—	—	—	—	
¹⁾ Some values in table A.1 have been obtained by extrapolation.																				
²⁾ Normalized and tempered or quenched and tempered.																				
³⁾ Annealed.																				
NOTE 1: The values given in table A.1 are mean values of the scatter band considered until now.																				
NOTE 2: The strength values for 1% (plastic) creep strain and creep rupture 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. Where relevant, the oxidation conditions should also be taken into account.																				

Table A.2: 1 % creep limit properties

Steel designation		Time h	1 % creep limit in N/mm ² at a temperature of: ¹⁾															
Name	Number		380 °C	390 °C	400 °C	410 °C	420 °C	430 °C	440 °C	450 °C	460 °C	470 °C	480 °C	490 °C	500 °C			
P245GH	1.0352	10 000	164	150	136	124	113	101	91	80	72	62	53	—	—			
		100 000	118	106	95	84	73	65	57	49	42	35	30	—	—			
P280GH	1.0426	10 000	195	182	167	150	135	120	107	93	83	71	63	—	—			
P305GH	1.0436	10 000	153	137	118	105	92	80	69	59	51	44	38	—	—			
16Mo3	1.5415	10 000	—	—	—	—	—	—	—	216	199	182	166	149	132			
		100 000	—	—	—	—	—	—	—	167	146	126	107	89	73			
13CrMo4-5	1.7335	10 000	—	—	—	—	—	—	—	245	228	210	193	173	157			
		100 000	—	—	—	—	—	—	—	191	172	152	133	116	98			
15MnMoV4-5	1.5402	10 000	—	—	—	—	—	—	—	333	302	271	224	208	177			
		100 000	—	—	—	—	—	—	—	240	209	177	150	126	103			
14MoV6-3 ²⁾	1.7715	10 000	—	—	—	—	—	—	—	—	—	—	231	210	191			
		100 000	—	—	—	—	—	—	—	—	—	—	172	152	134			

¹⁾ Some values in table A.2 have been obtained by extrapolation.

²⁾ These data are based on “High temperature design data for ferritic pressure vessel steels” published by the Creep of Steels Working Party of the Institute of Mechanical Engineers, Great Britain.

Table A.2: 1 % creep limit properties (continued)

Steel designation		Time h	1 % creep limit in N/mm ² at a temperature of: ¹⁾														
Name	Number		380 °C	390 °C	400 °C	410 °C	420 °C	430 °C	440 °C	450 °C	460 °C	470 °C	480 °C	490 °C	500 °C		
11CrMo9-10	1.7383	10 000	—	—	—	—	—	—	—	240	219	200	180	163	147		
		100 000	—	—	—	—	—	—	—	166	155	145	130	116	103		
X16CrMo5-1 ³⁾	1.7366	10 000	—	—	—	—	—	—	—	—	—	—	—	88	85		
		100 000	—	—	—	—	—	—	—	—	—	—	—	63	61		
X16CrMo5-1 ⁴⁾	1.7366	10 000	—	—	—	—	—	—	—	131	123	115	107	99	91		
		100 000	—	—	—	—	—	—	—	99	91	82	75	70	65		
X20CrMoV11-1	1.4922	10 000	—	—	—	—	—	—	—	—	—	324	299	269	247		
		100 000	—	—	—	—	—	—	—	—	—	260	236	213	190		

¹⁾ Some values in table A.2 have been obtained by extrapolation.

³⁾ Normalized and tempered or quenched and tempered.

⁴⁾ Annealed.

Table A.2: 1 % creep limit properties (continued)

Steel designation		Time h	1 % creep limit in N/mm ² at a temperature of: ¹⁾																640 °C	650 °C
Name	Number		510 °C	520 °C	530 °C	540 °C	550 °C	560 °C	570 °C	580 °C	590 °C	600 °C	610 °C	620 °C	630 °C					
P245	1.0352	10 000	—	—	—	—	—	—	—	—	—	—	—	—	—	—				
		100 000	—	—	—	—	—	—	—	—	—	—	—	—	—					
P280GH P305GH	1.0426 1.0436	10 000	—	—	—	—	—	—	—	—	—	—	—	—	—	—				
		100 000	—	—	—	—	—	—	—	—	—	—	—	—	—					
16Mo3	1.5415	10 000	115	99	84	—	—	—	—	—	—	—	—	—	—	—				
		100 000	59	46	36	—	—	—	—	—	—	—	—	—	—					
13CrMo4-5	1.7335	10 000	139	122	106	90	76	64	53	—	—	—	—	—	—	—				
		100 000	83	70	57	46	36	30	24	—	—	—	—	—	—					
15MnMoV4-5	1.5402	10 000	—	—	—	—	—	—	—	—	—	—	—	—	—	—				
		100 000	—	—	—	—	—	—	—	—	—	—	—	—	—					
14MoV6-3 ²⁾	1.7715	10 000	170	154	139	126	114	102	93	82	73	65	—	—	—	—				
		100 000	118	103	90	78	66	57	48	—	—	—	—	—	—					

¹⁾ Some values in table A.2 have been obtained by extrapolation.

²⁾ These data are based on “High temperature design data for ferritic pressure steels” published by the Creep of Steels Working Party of the Institute of Mechanical Engineers, Great Britain.

¹⁾ Some values in table A.2 have been obtained by extrapolation.

²⁾ These data are based on “High temperature design data for ferritic pressure steels” published by the Creep of Steels Working Party of the Institute of Mechanical Engineers, Great Britain.

Table A.2: 1 % creep limit properties (concluded)

Steel designation		Time h	1 % creep limit in N/mm ² at a temperature of: ¹⁾																
			510 °C	520 °C	530 °C	540 °C	550 °C	560 °C	570 °C	580 °C	590 °C	600 °C	610 °C	620 °C	630 °C	640 °C	650 °C		
Name	Number																		
11CrMo9-10	1.7383	10 000	132	119	107	94	83	73	65	57	50	44	—	—	—	—	—		
		100 000	90	78	68	58	49	41	35	30	26	22	—	—	—	—	—		
X16CrMo5-1 ³⁾	1.7366	10 000	76	67	60	55	49	43	37	—	—	—	—	—	—	—	—		
		100 000	54	47	42	37	32	30	26	—	—	—	—	—	—	—	—		
X16CrMo5-1 ⁴⁾	1.7366	10 000	83	75	67	59	52	46	41	36	32	28	—	—	—	—	—		
		100 000	60	55	50	45	40	35	30	25	20	17	—	—	—	—	—		
X20CrMoV11-1	1.4922	10 000	227	207	187	170	151	135	118	103	90	75	64	53	44	36	29		
		100 000	169	147	130	114	98	85	72	61	52	43	36	30	25	20	17		

¹⁾ Some values in table A.2 have been obtained by extrapolation.

³⁾ Normalized and tempered or quenched and tempered.

⁴⁾ Annealed.

NOTE 1: The values given in table A.2 are mean values of the scatter band considered until now.

NOTE 2: The strength values for 1 % (plastic) creep strain and creep rupture given up to the elevated temperatures listed in table A.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, the oxidation conditions should also be taken into account.

Annex ZA (informative)

A-deviations

A-deviation: National deviation due to regulations, the alteration of which is for the time being outside the competence of the CEN/CENELEC member.

This European Standard falls under Directive 97/23/EEC (Pressure equipment)

NOTE: (from CEN/CENELEC IR Part 2.3.1.9): Where standards fall under EC Directives, it is the view of the Commission of the European Communities (OJ No C 59, 1982-03-09) that the effect of the decision of the Court of Justice in case 815/79 Cremonini/Vrankovich (European Court Reports 1980, p. 3583) is that compliance with A-deviations is not longer mandatory and that the free movement of products complying with such a standard should not be restricted except under the safeguard procedure provided for in the relevant Directive.

A-deviations in an EFTA country are valid instead of the relevant provisions of the European Standard in that country until they have been removed.

Clause	Deviation
	Sweden (Ordinance AFS 1994: 39 Chapter 3, Section 1
General	Only the following grades are regarded as adequately validated and documented according to Swedish regulations: 1.0352, 1.0426, 1.0436, 1.5415, 1.7335, 1.5402, 1.6308, 1.7715, 1.6920, 1.7383, 1.7366, 1.4922.

Annex ZB (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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