Seamless carbon steel pipe for high-temperature service

Material Data Sheet

Steel designation:	Name	Standard
	Grade A (P235GH)	**ASTM/ASME A106 (1.0354)**
	Grade B (P265GH)	**ASTM/ASME A106 (1.0425)**
	Grade C (17Mn4/P295GH)	**ASTM/ASME A106 (1.0481)**

Scope

This data sheet applies for seamless carbon steel pipes for high-temperature service.

Application

These steels are amongst others necessary for construction parts in steam generation plants, as e. g. vessel, pipes, adapter and collectors. They can be used in permanent operation with temperatures up to about 475 °C (880 °F).

Chemical composition (Heat analysis in %)

Name	C max.	Si min.	Mn Max.	P max.	S max.	Cr[d] max.	Cu[d] max.	Mo[d] max.	Ni[d] max.	V[d] max.
Grade A	0,25[b]	0,10	0,27 - 0,93	0,035	0,035	0,40	0,40	0,15	0,40	0,08
P235GH*[a]	0,16	0,35	1,20	0,025	0,020	0,30	0,30	0,08	0,30	0,02
Grade B	0,30[c]	0,10	0,29 - 1,06	0,035	0,035	0,40	0,40	0,15	0,40	0,08
P265GH*[a]	0,20	0,40	1,40	0,025	0,020	0,30	0,30	0,08	0,30	0,02
Grade C	0,35 [c]	0,10	0,29 - 1,06	0,035	0,035	0,40	0,40	0,15	0,40	0,08
17Mn4**[a] (P295GH)	0,08-0,20	0,40	0,90 - 1,50	0,025	0,010	0,30	0,30	0,08	0,30	0,02

* Cr+Cu+Mo+Ni ≤ 0.0

** Not standardized in EN 10216-2. Values taken from EN 10028-2.

[a] $Al_{min.}$ 0,2 - This requirement does not apply, if the steel contains other nitrogen binding elements in a sufficient content, which than has to be recorded. If titanium is inserted, the manufacturer has to prove that $\left(Al+\frac{Ti}{2}\right) \geq 0{,}020\ \%$.

[b] For each reduction of 0.1 % below the specified carbon maximum, an increase of 0,06 % manganese above the specified maximum will be permitted up to a maximum of 1.35 %.

[c] Unless otherwise specified by the purchaser, for each reduction of 0.1 %, below the specified carbon maximum, an increase of 0.06 % manganese above the specified maximum will be permitted up to a maximum of 1.65 %.

[d] The five elements combined shall not exceed 1 %.

Mechanical properties at room temperature

Name	Product thickness mm	Yield/ proof strength $R_{eH}/R_{po,2}$ N/mm² min.	Tensile strength R_m N/mm²	Elongation min.		Minimum average impact energy KV J At a temperature in °C of		
				longitudinal	transverse	longitudinal		trans-verse
						0	-10	0
Grade A*	-	205	min. 330	35[c]	25[c]	-	-	-
P235GH* P235GH*	$T \leq 16$	235	360 - 500	25	23	- 40[c]	- 28[d]	- 27
	$16 < T \leq 40$	225						
	$40 < T \leq 60$	215						
Grade B*	-	240	min. 415	30[b]	16,5[b]	-	-	-
P265GH* P265GH*	$T \leq 16$	265	410 - 570	21	19	- 40[c]	- 28[d]	- 27
	$16 < T \leq 40$	255						
	$40 < T \leq 60$	245						
Grade C*	-	275	min. 485	30[b]	16,5[b]	-	-	-
17Mn4*[a] (P295GH)	$t \leq 16$	295	460 - 580	21	19	-	-	27
	$16 < t \leq 40$	290						
	$40 < T \leq 60$	285						

* Delivery condition N = normalizing incl. normalizing forming

[a] Not standardized in EN 10126-2. Values taken from EN 10028.

[b] According to Table 2 of A106/A106M

[c] Option 4: The impact test has to be proved.

[d] Option 5: The impact test in longitudinal direction has to be proved.

Minimum values of the proof strength $R_{p0,2}$ at elevated temperatures

Name	0,2 %-Proof strength at the temperature °F in Ksi								
	200	300	400	500	600	700	800	900	1000
Grade A ASME B31.3[a]	16,0	16,0	16,0	16,0	15,3	12,5	9,2	5,9	2,5
Grade A ASME B31.1[b]	13,7	13,7	13,7	13,7	13,7	12,5	9,0	-	-
Grade B ASME B31.3[a]	20,0	20,0	19,9	19,0	17,9	16,7	11,4	5,9	2,5
Grade B ASME B31.1[b]	17,1	17,1	17,1	17,1	17,0	15,6	10,8	-	-
Grade C ASME B31.3[a]	23,3	23,3	22,8	21,7	20,4	18,3	12,0	-	-
Grade C ASME B31.1[b]	20,0	20,0	20,0	20,0	20,0	18,3	12,0	-	-

[a] ASME 31.3 - Process Piping

[b] ASME 31.1 - Power Piping

Conversion Fahrenheit in Celsius: C = (Temp. in F - 32) x 5/9

Conversion Ksi in N/mm² (MPa): Value in Ksi x 6,895

Name	0,2 %-Proof strength at the temperature °C in N/mm² (MPa)							
	100	150	200	250	300	350	400	450
P235GH	198	187	170	15	132	120	112	108
P265GH	226	213	192	171	154	141	134	128

Reference data for some physical properties

Density at 20 °C	Modulus of elasticity kN/mm² at				Thermal conductivity at 20 °C	spec. thermal capacity at 20 °C	spec. electrical resistivity at 20 °C
Kg/dm³	20 °C	300 °C	400 °C	450 °C	W/m K	J/kg K	Ω mm²/m
7,85	210	192	184	179	51	461	0,20

Linear coefficient $10^{-6}\,K^{-1}$ of thermal expansion between 20 °C and

100 °C	200 °C	300 °C	400 °C	450 °C
12,5	13,0	13,6	14,1	14,3

Hot forming / Heat treatment (for guidance only)

Hot Forming		Heat Treatment		
Temperature °C	Cooling Type	Normalizing [1]	Stress relieving anneal [2]	Cooling Type
1100 - 950	Air	890 - 950 °C	600 - 650 °C	Air

[1] Normalizing: Holding time 1 minute per mm plate thickness, minimum 30 minutes

[2] Stress relieving anneal: Holding time 1-2 minutes per mm plate thickness, minimum 30 minutes

Processing / Welding

Standard welding processes for these steel grades are:

TIG-welding	Arc welding (E)
MAG-welding massive wire	Submerged arc welding (SAW)
MAG- welding cored wire	

Depending on the welding position and the plate thickness, maybe other filler metals have to be applied, which can be asked inquired at the manufacturer in case of need.

For these steel grades as filler metal the following electrodes and welding wires are recommended:

Process	**Filler metal**	
TIG	Union I 52	
MAG massive wire	Union K 52 Union K 56	
MAG cored wire	Union MV 70 Union BA 70 (Union RV 71)	
Arc welding (E)	Phoenix 120K Phoenix Special D	
SAW	Wire	Powder
	Union S2 (Union S2)	UV 400 (UV 306)

These steels can be welded within all thickness ranges according to the afore mentioned welding processes considering the general rules of technology by hand and automatically welding.

The mentioned filler metals apply for highest demands. The details in brackets are for lower demands.

Burning, preheating, welding and stress relieving annealing should occur under consideration of Stahl-Eisen-Material bulletin 088.

Specifications and standards concerning stress relieving anneal have to be observed.

Remark

The material is magnetizable.

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References

DIN EN 10216-2:2007-10	Beuth Verlag GmbH, Post box, D-10772 Berlin
ASME/ASTM A106:2010	ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken,PA 19428-2959
ASME 31.3:2010 ASME 31.1:2010	The American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990

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Important Hint