

Data sheet: A6.4

Plate for pressure vessel applications

Carbon manganese pressure vessel steel plate

General Description

Steels for pressure vessels have a superior ability to withstand high pressure at different temperatures. They have good weldability, as well as excellent toughness and are suitable for normalizing, annealing and stress-relief annealing (both treatments neutralise local hardening caused by welding).

Pressure Vessel Qualities Available

Grade	Thickness Range	Normal Product Condition	Alternative Product Condition
EN 10028-2: Pressure vessel steels with specified properties at elevated temperatures			
P235GH	6 – 60 mm	Normalised	
	6 – 40 mm		As-rolled (test piece normalised)
P265GH	6 – 60 mm	Normalised	
	6 – 40 mm		As-rolled (test piece normalised)
P295GH	6 – 40 mm	Normalised	
	6 – 40 mm		As-rolled (test piece normalised)
16Mo3	6 – 30 mm	Normalised	
	6 – 30 mm		As-rolled (test piece normalised)
EN 10028-3: Weldable fine grain pressure vessel steels, normalised			
P355N	6 – 60 mm	Normalised	-
P355NH	6 – 60 mm	Normalised	-
P355NL1	6 – 60 mm	Normalised	-
P355NL2	6 – 60 mm	Normalised	-
ASME SA516 / ASTM A516: Pressure vessel plates for moderate and lower temperature service with improved toughness			
Gr 60	6 – 40 mm	As-rolled	
	6 – 60 mm		Normalised
Gr 65	6 – 40 mm	As-rolled	
	6 – 60 mm		Normalised
Gr 70	6 – 40 mm	As-rolled	
	6 – 60 mm		Normalised
Suffixes: N = Normalised H = Elevated temperature quality NL1 = Low temperature quality NL2 = Special low temperature quality			

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BS 1501 has been replaced by EN 10028. ArcelorMittal South Africa will, however, as an interim measure, supply steel double certified as EN10028-2-P265GH+AR/BS1501-151/161GR430A to assist the market.

The available dimensions of plate supplied both in the as rolled and normalised conditions are shown on data sheet A1.3: Plate Mill Product Dimensions.

Chemical composition

Table 1: Chemical composition as specified by EN 10028.

Grade	C	Si	Mn	P	S	Al _{total}	N	Cr	Cu	Mo	Nb	Ni	Ti	V	Notes
EN 10028-2															
P235GH	≤ 0.16	≤ 0.35	0.60 – 1.20	≤ 0.025	≤ 0.010	≥ 0.020	≤ 0.012	≤ 0.30	≤ 0.30	≤ 0.08	≤ 0.020	≤ 0.30	≤ 0.03	≤ 0.02	2+3+5
P265GH	≤ 0.20	≤ 0.40	0.60 – 1.40	≤ 0.025	≤ 0.010	≥ 0.020	≤ 0.012	≤ 0.30	≤ 0.30	≤ 0.08	≤ 0.020	≤ 0.30	≤ 0.03	≤ 0.02	2+3+5
P295GH	0.08 – 0.20	≤ 0.40	0.90 – 1.50	≤ 0.025	≤ 0.010	≥ 0.020	≤ 0.012	≤ 0.30	≤ 0.30	≤ 0.08	≤ 0.020	≤ 0.30	≤ 0.03	≤ 0.02	2+3+5
16Mo3	0.12 – 0.20	≤ 0.35	0.40 – 0.90	≤ 0.025	≤ 0.010	-	≤ 0.012	≤ 0.30	≤ 0.30	0.25 – 0.35	-	≤ 0.30	-	-	-
EN 10028-3															
P355N	≤ 0.18	≤ 0.5	1.10 – 1.70	≤ 0.025	≤ 0.010	≥ 0.020	≤ 0.012	≤ 0.30	≤ 0.30	≤ 0.08	≤ 0.05	≤ 0.50	≤ 0.030	≤ 0.10	2+6+8
P355NH	≤ 0.18	≤ 0.5	1.10 – 1.70	≤ 0.025	≤ 0.010	≥ 0.020	≤ 0.012	≤ 0.30	≤ 0.30	≤ 0.08	≤ 0.05	≤ 0.50	≤ 0.030	≤ 0.10	2+6+8
P355 NL1	≤ 0.18	≤ 0.5	1.10 – 1.70	≤ 0.025	≤ 0.008	≥ 0.020	≤ 0.012	≤ 0.30	≤ 0.30	≤ 0.08	≤ 0.05	≤ 0.50	≤ 0.030	≤ 0.10	2+6+8
P355 NL2	≤ 0.18	≤ 0.5	1.10 – 1.70	≤ 0.020	≤ 0.005	≥ 0.020	≤ 0.012	≤ 0.30	≤ 0.30	≤ 0.08	≤ 0.05	≤ 0.50	≤ 0.030	≤ 0.10	2+6+8
Notes:	<ol style="list-style-type: none"> For product thicknesses < 6 mm, a minimum manganese content 0.20% less than the specified value is allowed. A ratio Al/N ≥ 2 shall be applied. For product thicknesses < 6 mm, a minimum manganese content of 0.60% is allowed. The sum of the percentages by mass of the four elements nickel, chromium, copper and molybdenum shall not exceed 0.70%. The sum of the percentages by mass of the three elements chromium, copper and molybdenum shall not exceed 0.45%. The sum of the percentages by mass of the three elements niobium, titanium and vanadium shall not exceed 0.05%. The sum of the percentages by mass of the three elements niobium, titanium and vanadium shall not exceed 0.12%. 														

Table 2: Chemical composition as specified by ASME/ASTM.

Grade	Thickness	C	Si	Mn	P	S	Notes
ASME SA516 / ASTM A516							
Gr 60	6 ≤ t ≤ 12,5	≤ 0,21	0,15 - 0,40	0,60 - 0,90	≤ 0,035	≤ 0,035	1+2
	12,5 < t ≤ 50	≤ 0,23	0,15 - 0,40	0,85 - 1,20	≤ 0,035	≤ 0,035	2
Gr 65	6 ≤ t ≤ 12,5	≤ 0,24	0,15 - 0,40	0,85 - 1,20	≤ 0,035	≤ 0,035	2
	12,5 < t ≤ 50	≤ 0,26	0,15 - 0,40	0,85 - 1,20	≤ 0,035	≤ 0,035	2
Gr 70	6 ≤ t ≤ 12,5	≤ 0,27	0,15 - 0,40	0,85 - 1,20	≤ 0,035	≤ 0,035	2
	12,5 < t ≤ 50	≤ 0,28	0,15 - 0,40	0,85 - 1,20	≤ 0,035	≤ 0,035	2
Notes:	<ol style="list-style-type: none"> Manganese may be 0,85 to 1,20 percent for thicknesses up to 12,5 mm. Where more stringent properties are required, Table 1 of ASME SA20 / ASTM A20 provides for the addition of elements such as Niobium, Vanadium and Titanium to achieve the required properties. 						

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In order to assist customers in determining fabrication parameters, the typical analyses of these steels as made by ArcelorMittal South Africa are given in Table 3. It must be stressed that these values are given as an indication only.

Table 3: Typical chemical composition as produced by ArcelorMittal South Africa (ladle analysis, %)

Grade	C	Si	Mn	P	S	Al _{total}	N	Cr	Cu	Mo	Nb	Ni	Ti	V	Notes
EN 10028-2															
P235GH	0,10	0,28	0,80	0,020	0,008	0,04									
P265GH	0,18	0,30	1,05	0,020	0,008	0,04									
P295GH	0,20	0,30	1,05	0,020	0,008	0,04									
16Mo3	0,17	0,28	0,70	0,020	0,008	0,04				0,30					
EN 10028-3															
P355N	0,13	0,35	1,50	0,020	0,008	0,04					0,038		0,025	0,028	
P355NH	0,13	0,35	1,50	0,020	0,008	0,04					0,038		0,025	0,028	
P355NL1	0,13	0,35	1,50	0,018	0,006	0,04					0,038		0,025	0,028	
P355NL2	0,13	0,35	1,50	0,015	0,004	0,04					0,038		0,025	0,028	
ASME SA516 / ASTM A516															
Gr 60	0,12	0,28	1,05	0,020	0,008	0,04									
Gr 65	0,18	0,30	1,05	0,020	0,008	0,04									
Gr 70	0,20	0,30	1,05	0,020	0,008	0,04									

Mechanical Properties

Table 4: Mechanical characteristics at ambient and lower temperatures for EN 10028 Grades

Grade	Thickness (mm)	Tensile Properties						Impact Properties					Notes
		R _e (MPa)	R _m (MPa)	Elongation				20°C (J)	0°C (J)	-20°C (J)	-40°C (J)	-50°C (J)	
				A 50 (%)	A 80 (%)	A 5.65√S ₀ (%)	A 200 (%)						
EN 10028-2													
P235GH	6 ≤ t ≤ 16	≥ 235	360 - 480	-		≥ 24	≥ 40	≥ 34	≥ 27	-	-		
	16 < t ≤ 40	≥ 225											
	40 < t ≤ 60	≥ 215											
P265GH	6 ≤ t ≤ 16	≥ 265	410 - 530	-		≥ 22	≥ 40	≥ 34	≥ 27	-	-		
	16 < t ≤ 40	≥ 255											
	40 < t ≤ 60	≥ 245											
P295GH	6 ≤ t ≤ 16	≥ 295	460 - 580	-		≥ 21	≥ 40	≥ 34	≥ 27	-	-		
	16 < t ≤ 40	≥ 290											
16Mo3	6 ≤ t ≤ 16	≥ 275	440 - 590		-	≥ 22	≥ 31	-	-	-	-		
	16 < t ≤ 30	≥ 270											
EN 10028-3													
P355N	6 ≤ t ≤ 16	≥ 355	490 - 630	-		≥ 22	≥ 50	≥ 40	≥ 30				
	16 < t ≤ 40	≥ 345											
	40 < t ≤ 60	≥ 335											
P355NH	6 ≤ t ≤ 16	≥ 355	490 - 630	-		≥ 22	≥ 50	≥ 40	≥ 30				
	16 < t ≤ 40	≥ 345											
	40 < t ≤ 60	≥ 335											
P355NL1	6 ≤ t ≤ 16	≥ 355	490 - 630	-		≥ 22	≥ 60	≥ 50	≥ 35	≥ 27			
	16 < t ≤ 40	≥ 345											
	40 < t ≤ 60	≥ 335											
P355NL2	6 ≤ t ≤ 16	≥ 355	490 - 630	-		≥ 22	≥ 70	≥ 60	≥ 40	≥ 30	≥ 27		
	16 < t ≤ 40	≥ 345											
	40 < t ≤ 60	≥ 335											

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Table 5: Mechanical Characteristics at Ambient and Lower Temperatures for ASME/ASTM Grades

Grade	Thickness (mm)	Tensile Properties						Impact Properties					Notes
		R _e (MPa)	R _m (MPa)	Elongation				20°C (J)	0°C (J)	-20°C (J)	-40°C (J)	-50°C (J)	
				A 50 (%)	A 80 (%)	A 5.65√S ₀ (%)	A 200 (%)						
ASME SA516 / ASTM A516													
Gr 60	6 ≤ t ≤ 60	≥ 220	415 - 550	≥ 25			≥ 21						1
Gr 65	6 ≤ t ≤ 60	≥ 240	450 - 585	≥ 23			≥ 19						1
Gr 70	6 ≤ t ≤ 60	≥ 260	485 - 620	≥ 21			≥ 17						1
Notes: 1. Supplementary requirements as listed in ASME SA20 / ASTM A20 may be available subject to agreement.													

For these steels, a tensile test at room temperature shall be carried out in accordance with EN 10002-1, generally using a proportional test piece of gauge length $L_0 = 5.65/S_0$ (S_0 = initial cross-sectional area of the test piece).

Impact tests shall be carried out for thicknesses ≥ 6 mm where required. Where minimum impact energy values are specified for several temperatures, verification of the impact energy, unless otherwise agreed, shall be carried out at the temperature for which the value of 27 J is specified. Where the minimum impact energy value specified at the lowest temperature is higher than 27 J, this higher value shall be verified. For thicknesses below 12 mm subsidiary test pieces will be used. Impact values will be reduced proportional to the cross-sectional area of the test piece.

For steels designed for higher temperature use a hot tensile test shall be done. Unless otherwise agreed these tests will be carried out at 300°C.

Table 6: Mechanical characteristics at high temperature Re (MPa)

Steel grade	Thickness (mm)	50°C	100°C	150°C	200°C	250°C	300°C	350°C	400°C	450°C	500°C
EN 10028-2											
P235GH	6 ≤ t ≤ 16	227	214	198	182	167	153	142	133		
	16 < t ≤ 40	218	205	190	174	160	147	136	128		
	40 < t ≤ 60	208	196	181	167	153	140	130	122		
P265GH	6 ≤ t ≤ 16	256	241	223	205	188	173	160	150	-	-
	16 < t ≤ 40	247	232	215	197	181	166	154	145		
	40 < t ≤ 60	237	223	206	190	174	160	148	139		
P295GH	6 ≤ t ≤ 16	285	268	249	228	209	192	178	167		
	16 < t ≤ 40	280	264	244	225	206	189	175	165		
16Mo3	6 ≤ t ≤ 16	273	264	250	233	213	194	175	159	147	141
	16 < t ≤ 40	268	259	245	228	209	190	172	156	145	139
EN 10028-3											
P355NH	6 ≤ t ≤ 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		

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Specification comparison table

Approximate equivalent grades are given in the table below:

EN 10028-2	ASTM	BS 1501
P235GH	A285 Gr C	
P265GH	A516 Gr 60	151Gr 430A 161Gr 430A 151Gr 430B 161Gr 430B
P295GH	A516 Gr 65	
	A516 Gr 70	224 Gr 490B
16Mo3		

EN 10028-3:2009	ASTM	BS 1501
P355N		
P355NH		223 Gr 490B
P355NL1		
P355NL2		

Tolerances

All ASME/ASTM plates are supplied with dimensional tolerances in accordance with ASME SA20/ASTM A20. EN 10028 plates are supplied with dimensional tolerances in accordance with EN 10029.

Surface inspection

All ASME/ASTM plates are inspected and defects are repaired in accordance with ASME SA20/ASTM A20. EN 10028 plates are inspected and defects are repaired in accordance with EN 10163.

Ultrasonic testing

Testing to ASTM A435, ASTM A578 or EN 10160 can be done on enquiry.

Certification

All plates are supplied with test and analysis certificates.

Supply conditions

Plate for pressure vessels is supplied in terms of Price Lists 110 and 120 and ArcelorMittal South Africa's General conditions of Sale.

Information to be indicated during order placement:

- 1) Full specification description
- 2) Plate dimensions
- 3) Delivery condition (As-rolled or Normalised)
- 4) Low temperature test requirements
- 5) Elevated temperature test requirements
- 6) Ultrasonic testing requirements
- 7) Thickness nominal or minimum

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