



管道

# PIPES AND TUBES



# 管道 (壁厚及重量标准) PIPE SCHEDULE (ASTM OR API STANDARD)

## (英制表) Imperial

Nominal pipe size inch/mm	OD inches	5S	10s	10	20	30	STD	40S	40	60	XS	80S	80	100	120	140	160	XXS
1/8 6	0.405		0.049 0.19				0.068 0.24	0.068 0.24	0.068 0.24		0.095 0.31	0.095 0.32	0.095 0.31					
1/4 8	0.540		0.065 0.34				0.088 0.42	0.088 0.43	0.088 0.42		0.119 0.54	0.119 0.55	0.119 0.54					
3/8 10	0.675		0.085 0.43				0.091 0.57	0.091 0.58	0.091 0.57		0.126 0.74	0.126 0.75	0.126 0.74					
1/2 15	0.840	0.085 0.55	0.083 0.68				0.109 0.85	0.109 0.87	0.109 0.85		0.147 1.09	0.147 1.11	0.147 1.09				0.188 1.31	0.294 1.71
3/4 20	1.050	0.086 0.70	0.083 0.68				0.113 1.13	0.113 1.15	0.113 1.13		0.154 1.47	0.154 1.50	0.154 1.47				0.219 1.94	0.308 2.44
1 25	1.315	0.085 0.89	0.109 1.43				0.133 1.68	0.133 1.71	0.133 1.68		0.179 2.17	0.179 2.21	0.179 2.17				0.250 2.84	0.358 3.66
1 1/4 32	1.660	0.085 1.13	0.109 1.85				0.140 2.27	0.140 2.3	0.140 2.27		0.191 3.00	0.191 3.06	0.191 3.00				0.250 3.76	0.382 5.21
1 1/2 40	1.900	0.085 1.31	0.109 2.13				0.145 2.72	0.145 2.77	0.145 2.72		0.200 3.63	0.200 3.70	0.200 3.63				0.281 4.86	0.400 6.41
2 50	2.375	0.085 1.84	0.109 2.69				0.154 3.65	0.154 3.72	0.154 3.65		0.218 5.02	0.218 5.12	0.218 5.02				0.344 7.46	0.436 9.03
2 1/2 65	2.875	0.085 2.63	0.120 3.60				0.203 5.79	0.203 5.91	0.203 5.79		0.276 7.66	0.276 7.81	0.276 7.66				0.375 10.01	0.552 13.69
3 80	3.500	0.085 3.09	0.120 4.42				0.216 7.58	0.216 7.73	0.216 7.58		0.300 10.25	0.300 10.40	0.300 10.25				0.438 14.32	0.600 18.58
3 1/2 90	4.000	0.085 3.65	0.120 5.07				0.226 9.11	0.226 9.29	0.226 9.11		0.318 12.50	0.318 12.76	0.318 12.50				-	-
4 100	4.500	0.085 4.03	0.120 5.72				0.237 10.79	0.237 11.01	0.237 10.79		0.337 14.98	0.337 15.26	0.337 14.98	0.438 19.00			0.531 22.51	0.674 27.54
5 125	5.563	0.109 4.69	0.134 7.93				0.258 14.62	0.258 14.91	0.258 14.62		0.375 20.78	0.375 21.80	0.375 20.78	0.500 27.04			0.625 32.96	0.750 38.55
6 150	6.625	0.109 7.75	0.134 9.49				0.280 18.97	0.280 19.35	0.280 18.97		0.432 28.57	0.432 29.14	0.432 28.57	0.562 36.39			0.719 45.35	0.864 53.16
8 200	8.625	0.109 10.12	0.140 13.57	0.250 22.36	0.277 24.70	0.322 28.55	0.322 29.12	0.322 28.55	0.406 35.64	0.500 43.39	0.500 44.26	0.500 43.39	0.594 50.95	0.719 60.71	0.844 67.76	1.000 74.89	1.125 89.67	1.000 104.13
10 250	10.750	0.134 15.49	0.163 19.02	0.250 28.04	0.307 34.24	0.365 40.48	0.365 41.29	0.365 40.48	0.500 54.74	0.500 54.74	0.500 54.74	0.594 54.74	0.719 77.03	0.844 89.29	1.000 104.13	1.125 115.64	1.000 125.49	1.000 104.13
12 300	12.750	0.156 21.40	0.188 24.65	0.250 33.36	0.312 43.77	0.375 49.56	0.375 50.55	0.375 49.56	0.500 59.52	0.500 59.52	0.500 59.52	0.594 65.42	0.719 88.63	0.844 107.32	1.000 125.49	1.125 139.67	1.000 160.27	1.000 125.49
14 350	14.000	0.156 23.53	0.188 26.26	0.250 36.71	0.312 45.61	0.375 54.57	0.375 54.57	0.375 54.57	0.500 63.44	0.500 63.44	0.500 63.44	0.594 72.09	0.719 106.13	0.844 130.85	1.000 150.79	1.125 170.21	1.000 189.11	1.000 189.11
16 400	16.000	0.156 26.46	0.188 32.39	0.250 42.05	0.312 52.27	0.375 62.58	0.375 62.58	0.375 62.58	0.500 82.77	0.500 82.77	0.500 82.77	0.594 107.50	0.719 136.61	0.844 164.82	1.000 192.43	1.125 223.64	1.000 245.25	1.000 245.25
18 450	18.000	0.156 32.06	0.188 35.45	0.250 47.39	0.312 58.94	0.375 82.15	0.375 82.15	0.375 82.15	0.500 104.67	0.500 104.67	0.500 104.67	0.594 138.17	0.719 170.92	0.844 207.96	1.000 244.14	1.125 274.22	1.000 308.50	1.000 308.50
20 500	20.000	0.188 40.58	0.218 45.96	0.250 52.73	0.375 78.60	0.500 104.13	0.375 78.60	0.375 78.60	0.594 123.11	0.812 166.40	0.500 104.13	0.594 104.13	0.719 208.87	0.844 256.10	1.000 296.37	1.125 341.09	1.000 379.17	1.000 379.17
22 550	22.000	0.188 44.66	0.218 51.72	0.250 58.07	0.375 86.61	0.500 114.81	0.375 86.61	0.375 86.61	- 197.41	0.875 114.81	0.500 114.81	0.594 114.81	0.719 250.81	0.844 302.88	1.000 353.61	1.125 403.00	1.000 451.06	1.000 451.06
24 600	24.000	0.218 56.45	0.250 64.68	0.250 63.41	0.375 94.62	0.500 140.68	0.375 94.62	0.375 94.62	0.688 171.29	0.969 238.35	0.500 25.49	0.594 25.49	0.719 296.58	0.844 367.39	1.000 429.39	1.125 483.12	1.000 542.13	1.000 542.13
26 650	26.000			0.312 85.60	0.500 136.17	- 102.63	0.375 102.63	0.375 102.63	- -	- -	0.500 136.17	0.594 136.17	0.719 136.17	0.844 136.17	1.000 136.17	1.125 136.17	1.000 136.17	1.000 136.17
28 700	28.000			0.312 92.26	0.500 146.85	0.625 182.73	0.375 110.64	0.375 110.64	- -	- -	0.500 146.85	0.594 146.85	0.719 146.85	0.844 146.85	1.000 146.85	1.125 146.85	1.000 146.85	1.000 146.85
30 750	30.000	0.250 61.02	0.312 100.81	0.312 98.93	0.500 157.53	0.625 196.08	0.375 118.65	0.375 118.65	- -	- -	0.500 157.53	0.594 157.53	0.719 157.53	0.844 157.53	1.000 157.53	1.125 157.53	1.000 157.53	1.000 157.53
32 800	32.000			0.312 105.59	0.500 168.21	0.625 209.43	0.375 126.66	0.375 126.66	0.688 230.08	0.500 168.21	0.594 168.21	0.719 168.21	0.844 168.21	1.000 168.21	1.125 168.21	1.000 168.21	1.000 168.21	1.000 168.21
34 850	34.000			0.312 112.25	0.500 178.89	0.625 222.78	0.375 134.67	0.375 134.67	0.688 244.77	0.500 178.89	0.594 178.89	0.719 178.89	0.844 178.89	1.000 178.89	1.125 178.89	1.000 178.89	1.000 178.89	1.000 178.89
36 900	36.000			0.312 118.92	0.500 189.57	0.625 236.13	0.375 142.68	0.375 142.68	0.750 282.35	0.500 189.57	0.594 189.57	0.719 189.57	0.844 189.57	1.000 189.57	1.125 189.57	1.000 189.57	1.000 189.57	1.000 189.57
38 950	38.000						0.375 150.69	0.375 150.69	- -	- -	0.500 200.25	0.594 200.25	0.719 200.25	0.844 200.25	1.000 200.25	1.125 200.25	1.000 200.25	1.000 200.25
40 1000	40.000						0.375 158.70	0.375 158.70	- -	- -	0.500 210.93	0.594 210.93	0.719 210.93	0.844 210.93	1.000 210.93	1.125 210.93	1.000 210.93	1.000 210.93
42 1050	42.000						0.375 166.71	0.375 166.71	- -	- -	0.500 221.61	0.594 221.61	0.719 221.61	0.844 221.61	1.000 221.61	1.125 221.61	1.000 221.61	1.000 221.61
44 1100	44.000						0.375 174.72	0.375 174.72	- -	- -	0.500 232.29	0.594 232.29	0.719 232.29	0.844 232.29	1.000 232.29	1.125 232.29	1.000 232.29	1.000 232.29
46 1150	46.000						0.375 182.73	0.375 182.73	- -	- -	0.500 242.97	0.594 242.97	0.719 242.97	0.844 242.97	1.000 242.97	1.125 242.97	1.000 242.97	1.000 242.97
48 1200	48.000						0.375 190.74	0.375 190.74	- -	- -	0.500 253.65	0.594 253.65	0.719 253.65	0.844 253.65	1.000 253.65	1.125 253.65	1.000 253.65	1.000 253.65

Wall Thickness = inches  
Weight = lbs./ft. (plain end mass)  
5S, 10S, 40S, 80S - ANSI B36.19



# 管道 (壁厚及重量标准) PIPE SCHEDULE (ASTM OR API STANDARD)

## (公制表) Metric

Nominal pipe size mm/inch	OD mm	5S	10s	10	20	30	STD	40S	40	60	XS	80S	80	100	120	140	160	XXS
6 1/8	10,3		1,24 0,28				1,73 0,37	1,73 0,36	1,73 0,37		2,41 0,47	2,41 0,48	2,41 0,47					
8 1/4	13,7		1,65 0,51				2,24 0,63	2,24 0,64	2,24 0,63		3,02 0,80	3,02 0,82	3,02 0,80					
10 3/8	17,1		1,88 0,64				2,31 0,64	2,31 0,65	2,31 0,64		3,20 1,10	3,20 1,12	3,20 1,10					
15 1/2	21,3	1,65 0,82	2,11 1,01				2,77 1,27	2,77 1,28	2,77 1,27		3,73 1,62	3,73 1,65	3,73 1,62				4,78 1,95	7,47 2,55
20 3/4	26,7	1,65 1,04	2,11 1,21				2,87 1,69	2,87 1,71	2,87 1,69		3,91 2,20	3,91 2,24	3,91 2,20				5,56 2,90	7,82 3,64
25 1	33,4	1,65 1,33	2,77 2,13				3,38 2,50	3,38 2,55	3,38 2,50		4,55 3,24	4,55 3,28	4,55 3,24				6,35 4,24	9,09 5,45
32 1 1/4	42,2	1,88 1,88	2,77 2,75				3,56 3,39	3,56 3,46	3,56 3,39		4,85 4,47	4,85 4,58	4,85 4,47				6,35 5,61	9,70 7,77
40 1 1/2	48,3	1,65 1,95	2,77 3,1				3,68 4,05	3,68 4,10	3,68 4,05		5,08 5,41	5,08 5,51	5,08 5,41				7,14 7,25	10,15 9,56
50 2	60,3	1,65 2,44	2,77 4,01				3,91 5,44	3,91 5,54	3,91 5,44		5,54 7,48	5,54 7,63	5,54 7,48				8,74 11,11	11,07 13,44
65 2 1/2	73,0	2,11 3,77	3,05 5,25				5,16 8,63	5,16 8,81	5,16 8,63		7,01 11,41	7,01 11,54	7,01 11,41				9,53 14,92	14,02 20,39
80 3	88,9	2,11 4,80	3,05 6,59				5,49 11,29	5,49 11,52	5,49 11,29		7,62 15,27	7,62 15,49	7,62 15,27				11,13 21,35	15,24 27,68
90 3 1/2	101,6	2,11 5,29	3,05 7,55				5,74 13,57	5,74 13,84	5,74 13,57		8,08 18,63	8,08 19,01	8,08 18,63				-	-
100 4	114,3	2,11 5,95	3,05 8,52				6,02 16,07	6,02 16,40	6,02 16,07		8,56 22,32	8,56 22,77	8,56 22,32		11,13 28,32		13,49 33,54	17,12 41,03
125 5	141,3	2,77 9,67	3,40 11,82				6,55 21,77	6,55 22,20	6,55 21,77		9,53 30,97	9,53 31,59	9,53 30,97		12,70 40,28		15,88 49,11	19,05 57,43
150 6	168,3	2,77 11,65	3,40 14,13				7,11 28,26	7,11 28,63	7,11 28,26		10,97 42,56	10,97 43,42	10,97 42,56		14,27 54,20		18,26 67,56	21,95 79,22
200 8	219,1	2,77 15,09	3,76 20,27		6,35 33,31	7,04 36,81	8,18 42,55	8,18 43,39	8,18 42,55	10,31 53,08	12,70 64,64	12,70 65,05	12,70 64,64	15,09 75,92	18,26 90,44	20,62 100,92	23,01 111,27	22,23 107,92
250 10	273,1	3,40 23,96	4,19 26,34		6,35 41,77	7,80 51,03	9,27 60,31	9,27 61,52	9,27 60,31	12,70 81,55	12,70 81,55	12,70 81,55	12,70 81,55	15,09 96,01	18,26 114,75	21,44 133,06	25,40 155,15	25,40 155,15
300 12	323,9	3,96 31,89	4,57 36,73		6,35 49,73	8,38 65,20	9,53 73,88	9,53 75,39	9,53 73,88	14,27 108,96	14,27 97,46	14,27 99,43	14,27 132,08	17,48 159,91	21,44 186,75	25,40 208,14	28,58 238,76	25,40 186,97
350 14	355,6	3,96 38,06	4,78 42,14	6,35 54,69	7,92 67,90	9,53 81,33	9,53 81,33	9,53	11,13 94,55	15,09 126,71	12,70 107,39	12,70	12,70 158,10	19,05 194,96	23,83 224,65	27,79 253,56	31,75 281,70	35,71
400 16	406,4	4,19 42,41	4,78 48,26	6,35 62,64	7,92 77,83	9,53 93,27	9,53 93,27	9,53	12,70 123,30	16,66 160,12	12,70 123,30	12,70	21,44 203,53	26,19 245,56	30,96 286,64	36,53 333,19	40,49 365,35	40,49
450 18	457,2	4,19 47,77	4,78 54,28	6,35 70,57	7,92 87,71	11,13 122,38	9,53 105,16	9,53	14,27 155,80	19,05 205,74	12,70 139,15	12,70	23,88 254,55	29,36 309,62	34,93 363,56	39,67 408,26	45,24 459,37	45,24
500 20	508,0	4,78 50,46	5,54 70,00	8,35 78,55	9,53 117,15	12,70 155,12	9,53 117,15	9,53	15,09 183,42	20,62 247,83	12,70 155,12	12,70	26,19 311,17	32,54 381,53	38,10 441,49	44,45 508,11	50,01 564,81	50,01
550 22	558,8	4,78 58,57	5,54 77,06	8,35 86,54	9,53 129,13	12,70 171,09	9,53 129,13	9,53	-	22,23 294,25	12,70 171,09	12,70	28,58 373,83	34,93 451,42	41,28 527,02	47,63 600,63	53,98 672,26	53,98
600 24	609,6	5,54 54,16	6,35 98,37	8,35 94,53	9,53 141,12	12,70 209,64	9,53 141,12	9,53	17,48 255,41	24,61 355,26	12,70 187,06	12,70	30,96 442,08	38,89 547,71	46,02 640,03	52,37 720,15	58,54 808,22	58,54
650 26	660,4			7,92 127,36	12,70 202,72	-	9,53 152,87	9,53	-	-	12,70 202,72	12,70						
700 28	711,2			7,92 137,32	12,70 218,69	15,88 271,21	9,53 164,85	9,53	-	-	12,70 218,69	12,70						
750 30	762,0	8,35 129,72	7,92 150,36	7,92 147,28	12,70 234,67	15,88 292,18	9,53 176,84	9,53	-	-	12,70 234,67	12,70						
800 32	812,8			7,92 157,24	12,70 250,64	15,88 312,15	9,53 188,82	9,53	17,48 342,91	-	12,70 250,64	12,70						
850 34	863,6			7,92 167,20	12,70 266,61	15,88 332,12	9,53 200,31	9,53	17,48 364,90	-	12,70 266,61	12,70						
900 36	914,4			7,92 176,96	12,70 282,27	15,88 351,70	9,53 212,56	9,53	19,05 420,40	-	12,70 282,27	12,70						
950 38	965,2						9,53 224,54	9,53	-	-	12,70 298,24	12,70						
1000 40	1016,0						9,53 236,53	9,53	-	-	12,70 314,22	12,70						
1050 42	1066,8						9,53 248,52	9,53	-	-	12,70 330,19	12,70						
1100 44	1117,8						9,53 260,50	9,53	-	-	12,70 346,16	12,70						
1150 46	1168,4						9,53 272,25	9,53	-	-	12,70 351,82	12,70						
1200 48	1219,2						9,53 284,24	9,53	-	-	12,70 377,79	12,70						

Wall Thickness = mm  
Weight = kg/m (plain end mass)  
5S, 10S, 40S, 80S - ANSI B36.19

(对比表) PIPE - TUBES/ASTM-API-BS-DIN

Mechanical properties Mechanische eigenschappen Valeurs mécaniques Datos mecanicos					Chemical analysis (Ladle) Chemische analyse (Smelt) Analyse chimique Análisis químico							
Material Materiaal	Tensile strength treksterkte N/mm <sup>2</sup>	Yield point rekgrens min N/mm <sup>2</sup>	Elong- tion Rek % Min.	C %	Si %	Mn %	P % max.	S % max.	Mo %	Cr %	Ni %	Div.
St. 33 St. 34-2 St. 37-2	290-540 335-410 340-470	185 205 235	18 28 25	— max. 0,15 max. 0,17	— — —	— — —	— 0,050 0,050	— 0,050 0,050				N max. 0,009
St. 42-2 St. 44-2 St. 44-3 St. 52-3	410-490 410-540 410-540 490-630	255 275 275 355	20 22 22 22	max. 0,25 max. 0,21 max. 0,20 max. 0,20	— — — max. 0,55	— — — max. 1,60	0,060 0,050 0,040 0,040	0,050 0,050 0,040 0,040				N max. 0,009
St. 35 St. 45 St. 52	340-440 440-540 510-610	235 255 355	25 21 22	max. 0,18 max. 0,25 max. 0,20	— — max. 0,55	— — max. 1,50	0,050 0,050 0,050	0,050 0,050 0,050				
St. 35.8 St. 45.8 15Mo3 13 Cr Mo 44 10 Cr Mo 910 12 Cr Mo 19.5	360-480 410-530 450-600 440-590 450-600 410-540	235 255 270 290 280 176	25 21 22 22 20 21	max. 0,17 max. 0,21 0,12-0,20 0,10-0,18 0,08-0,15 max. 0,15	0,10-0,35 0,10-0,35 0,10-0,35 0,10-0,35 max. 0,50 0,30-0,50	0,40-0,80 0,40-1,20 0,40-0,80 0,40-0,70 0,40-0,70 0,30-0,60	0,040 0,040 0,035 0,035 0,035 0,030	0,040 0,040 0,035 0,035 0,035 0,030	— 0,25-0,35 0,45-0,65 0,90-1,20 0,45-0,65	— 0,70-1,10 2,00-2,50 4,0-6,0		
TT St. 35 TT St. 41 10 Ni 14	345-445 445-540 445-640	225 265 345	25 21 20	max. 0,17 max. 0,20 max. 0,12	max. 0,35 max. 0,35 0,10-0,35	min. 0,40 min. 0,45 0,30-0,60	0,045 0,045 0,035	0,045 0,045 0,035			3,20-3,80	
St. E 36	500-640	345	22	max. 0,20	0,10-0,50	0,90-1,60	0,040	0,040				
A 53 - Gr A A 53 - Gr B A 106 - Gr A A 106 - Gr B	min. 330 min. 415 min. 330 min. 415	205 240 205 240	variable variable 28 22	max. 0,25 max. 0,30 max. 0,25 max. 0,30	— — min. 0,10 min. 0,10	max. 0,95 max. 1,20 0,27-0,93 0,29-1,06	0,050 0,050 0,048 0,048	0,060 0,060 0,058 0,058				
A 333 Gr 1 A 333 Gr 6 A 333 Gr 3	min. 379 min. 414 min. 448	207 241 241	28 22 22	max. 0,30 max. 0,30 max. 0,19	— min. 0,10 0,18-0,37	0,40-1,06 0,29-1,06 0,31-0,64	0,050 0,048 0,050	0,060 0,058 0,050			3,18-3,82	
A 335 Gr P1 A 335 Gr P11 A 335 Gr P12 A335 Gr P22 A 335 Gr P5	min. 379 min. 414 min. 414 min. 414 min. 414	207 207 207 207 207	22 22 22 22 22	0,10-0,20 max. 0,15 max. 0,15 max. 0,15 max. 0,15	0,10-0,50 0,50-1,00 max. 0,50 max. 0,50 max. 0,50	0,30-0,80 0,30-0,60 0,30-0,61 0,30-0,60 0,30-0,60	0,045 0,030 0,045 0,030 0,030	0,045 0,030 0,045 0,030 0,030	0,44-0,65 0,44-0,65 0,44-0,65 0,87-1,13 0,45-0,65	— 1,00-1,50 0,80-1,25 1,90-2,60 4,00-6,00		
BS 1387	325-465	—	20	—	—	—	0,060	0,060				
BS3059 pt11-HFS 320 BS3059 pt11-ERW 320 BS 3059 pt2 360 BS3059 pt2 440 BS3059 pt2 243 BS3059 pt2 620 BS3059 pt2 622-440	320-480 320-480 360-500 440-580 450-600 460-610 440-590	195 195 215 245 250 180 175	25 25 24 21 22 22 20	max. 0,16 max. 0,19 max. 0,17 0,12-0,18 0,12-0,20 0,10-0,15 0,08-0,15	— — max. 0,35 0,10-0,35 0,10-0,35 0,10-0,35 max. 0,50	0,30-0,70 0,30-0,70 0,40-0,80 0,90-1,20 0,40-0,80 0,40-0,70 0,40-0,70	0,050 0,050 0,045 0,040 0,040 0,040 0,040	0,050 0,050 0,045 0,035 0,040 0,040 0,040	— — — 0,25-0,35 0,45-0,65 0,90-1,20 0,90-1,20	— — — — — 2,00-2,50	Al met 0,020 max Al met 0,020 max Al met 0,020 max	
BS3601 S320 BS3601 ERW 320 BS3601 S360 BS3601 ERW 360 BS3601 S410 BS3601 ERW 410 BS3601 SAW 410	320-440 320-440 360-480 360-480 410-530 410-530 410-530	195 195 215 215 235 235 235	25 25 24 24 22 22 22	max. 0,16 max. 0,16 max. 0,17 max. 0,17 max. 0,21 max. 0,21 max. 0,25	— — max. 0,35 max. 0,35 max. 0,35 max. 0,35 —	0,30-0,70 0,30-0,70 0,40-0,80 0,40-0,80 0,40-1,20 0,40-1,20 max. 1,20	0,050 0,050 0,050 0,050 0,050 0,050 0,050	0,050 0,050 0,050 0,050 0,050 0,050 0,050				
BS3603 HFS 410 BS 3603 HFS 503	410-530 440-590	235 245	22 16	max. 0,20 max. 0,15	max. 0,35 0,15-0,35	0,60-1,20 0,30-0,80	0,045 0,025	0,045 0,020			3,25-3,75	Al met 0,015 max
BS3604-620 (N) BS3604-622 BS3604-625	460-610 490-640 450-600	180 275 170	22 20 20	0,10-0,15 0,08-0,15 max. 0,15	0,10-0,35 max. 0,50 max. 0,50	0,40-0,70 0,40-0,70 0,30-0,60	0,040 0,040 0,040	0,040 0,040 0,040	0,45-0,65 0,90-1,20 0,45-0,65	0,70-1,10 2,00-2,50 4,00-6,00		Al met 0,020 max Al met 0,020 max
BS4360-43C BS4360-50C BS4360-50D	430-540 490-640 490-640	255 355 355	22 20 20	max. 0,21 max. 0,20 max. 0,20	max. 0,40 max. 0,40 max. 0,40	max. 1,20 max. 1,40 max. 1,40	0,050 0,050 0,040	0,050 0,050 0,040				Nb 0,003-0,10 V 0,003-0,15

(对比表) PIPE - TUBES/ASTM-API-BS-DIN

Technical standards Technische normen Normes techniques Normas técnicas			Equivalent specifications Equivalentes specificaties Qualités équivalentes Calidades equivalentes				
Material standards Material norm.	Manufact. standards fabricage norm.	Dimensional standards Afmetingen norm.	ASTM	API	BS	DIN	DIV
DIN 1626/2 DIN 17100 DIN 1626/3 DIN 17100	DIN 1626/2 DIN 2440/2441 DIN 1626/3 DIN 1626/3	DIN 2458 DIN 2440/2441 DIN 2458 DIN 2458	A 120 A53 Gr A	— 5L-Gr A	1387 3601 ERW 320		ISO-65
DIN 1626/3-4 DIN 17100 DIN 17100 DIN 17100	DIN 1626/3-4 DIN 1626/3-4 DIN 1626/3-4 DIN 1626/3-4	DIN 2458 DIN 2458 DIN 2458 DIN 2458	A 53 Gr B A 53 Gr B A 53 Gr B A381-Y52	5L Gr B 5L Gr B 5L Gr B 5LX-X52	3601 ERW 410 4360-43C 4360-43C 4360-50C		Euronorm 25 Fe 430 A Euronorm 25 Fe 430 B Euronorm 25 Fe 430 C Euronorm 25 Fe 510C/FG 36
DIN 1629/3 DIN 1629/3 DIN 1629/3	DIN 1629/3 DIN 1629/3 DIN 1629/3	DIN 2448 DIN 2448 DIN 2448	A 53 Gr A A 53 Gr B A252 Gr 3	5L Gr A 5L Gr B 5LX-X52	3601-S 360 3601-S 410 1775-HFS23		A519-1518
DIN 17175 DIN 17175 DIN 17175 DIN 17175 DIN 17175 Vd TUV 1207	DIN 17175 DIN 17175 DIN 17175 DIN 17175 DIN 17175 DIN 17175	DIN 2448 DIN 2448 DIN 2448 DIN 2448 DIN 2448 DIN 2448	A106 Gr A A106 Gr B A335 P1 A335 P11-P12 A335 P22 A335 P5	5L Gr A 5L Gr B — — — —	3602-HFS 360 3602-HFS 410 3059-243 3604-620 3604-622 3604-625	— —	BS3059 pt 2 360 BS 3601 S 410  BS 3059-620 BS 3059-622/440
SEW 680 SEW 680 SEW 680	DIN 17175 DIN 17175 DIN 17175	DIN 2448 DIN 2448 DIN 2448	A333 Gr 1 A333 Gr 6 A333 Gr 3	— — —	— 3603-410 3603-503		
SEW 089	DIN 1629/4	DIN 2448	A381-Y52	API-5LX-X52	4360-50C		Fe 510C/FG 36
A 53 A 53 A106 A106	A 53 A 53 A106/A530 A106/A530	ANSI-B 36.10 ANSI-B 36.10 ANSI-B 36.10 ANSI-B 36.10	— — — —	5L Gr A 5L Gr B 5L Gr A 5L Gr B	3601-S360 3601 S410 3602 HFS 23 3602 HFS 27	St 35 St 45 St 35.8 St 45.8	BS 3601 ERW 360 BS 3601 ERW 410
A333 A333 A333	A333/A530 A333/A530 A333/A530	ANSI-B 36.10 ANSI-B 36.10 ANSI-B 36.10	— — —	— — —	— 3603.410 3603-503	TT St 35 TT St 41 10 Ni 14	
A335 A335 A335 A335 A335	A335/A530 A335/A530 A335/A530 A335/A530 A335/A530	ANSI-B 36.10 ANSI-B 36.10 ANSI-B 36.10 ANSI-B 36.10 ANSI-B 36.10	— — — — —	— — — — —	3059-243 3604-620 3604.620 3604-622 3604-625	15 Mo 3 13 Cr Mo 44 13 Cr Mo 44 10 Cr Mo 910 12 Cr Mo 195	
BS 1387	BS 1387	BS 1387	A 120		—	St 33	
BS 3059 BS 3059 BS 3059 BS 3059 BS 3059 BS 3059 BS 3059	BS 3059 BS 3059 BS 3059 BS 3059 BS 3059 BS 3059 BS 3059	BS 3059 BS 3059 BS 3059 BS 3059 BS 3059 BS 3059 BS 3059	A106 Gr A A 53 Gr A A106 Gr A A106 Gr B A335 P1 A335 P11/P12 A335 P22	5L Gr A 5L Gr A 5L Gr A 5L Gr B — — —	— — — — — — —	St 35 St 34-2 St 35.8 St 45.8 15 Mo 3 13 Cr Mo 44 10 Cr Mo 910	
BS 3601 BS 3601 BS 3601 BS 3601 BS 3601 BS 3601 BS 3601	BS 3601 BS 3601 BS 3601 BS 3601 BS 3601 BS 3601 BS 3601	BS 3600 BS 3600 BS 3600 BS 3600 BS 3600 BS 3600 BS 3600	A106 Gr A A 53 Gr A A106 Gr A A 53 Gr A A106 Gr B A 53 Gr B A 53 Gr B	5L Gr A 5L Gr A 5L Gr A 5L Gr A 5L Gr B 5L Gr B 5L Gr B	— — — — — — —	St 35.8 St 34-2 St 35.8 St 37.2 St 45.8 St 44.3 St 44.3	BS 3602 pt1 HFS 360 BS 3602 pt1 ERW 360 BS 3602 pt1 HFS 410 BS 3602 pt1 ERW 410 BS 3602 pt2 SAW 410
BS 3603 BS 3603	BS 3603 BS 3603	BS 3600 BS 3600	A333 Gr 6 A333 Gr 3	— —	— —	TT St 41 10 Ni 14	
BS 3604 BS 3604 BS 3604	BS 3604 BS 3604 BS 3604	BS 3600 BS 3600 BS 3600	A335 P11/P12 A335-P22 A335-P5	— — —	— — —	13 Cr Mo 44 10 Cr Mo 910 12 Cr Mo 195	
BS 4360 BS 4360 BS 4360	BS 4360 BS 4360 BS 4360	— — —	A53 Gr B — —	5L Gr B/5LX-X42 5LX-X52 5LX-X52 (N)	— — —	St 45/St 44.3 St 52.3 St 52.3	Euronorm 25 Fe 430 C Euronorm 25 Fe 510 C Euronorm 25 Fe 510 D / Fg 36



# ALLOWABLE WORKING PRESSURE

## 316 管工作压力表 316 STAINLESS STEEL ANNEALED SEAMLESS TUBING ASTM A-269

ALLOWABLE STRESS = 18,750 psi between -325°F and 100°F

Tubing O.D.	WALL THICKNESS								
	.020	.028	.035	.049	.065	.083	.095	.109	.120
1/8	6881	10013	12656						
3/16	4369	8156	11813						
1/4		4613	5906	8649	11738				
5/16		3619	4613	6731	9225				
3/8			3788	5475	7538				
1/2			2775	3975	5438	7181			
5/8			2194	3131	4256	5569	6488		
3/4			1819	2588	3488	4556	5288	6169	6863
7/8			1549	2194	2962	3844	4462	5194	5775
1			1350	1894	2569	3338	3844	4481	4969

Factor of Safety = 4, Considering Tensile Strength To Be 75,000 psi

Reference: ASA 31.3 – 1959, Table 302.3.1A and Par. 304.1.2

ASME Unfired Pressure Vessels, Section VIII, Table UHA-23 and Par. UG-27 and UA-2.

### Recommended maximum working pressures (bar) for 316 stainless steel and 6 Mo tubes to ASTM A-269

Outside diameter of tube (mm)	Tube wall thickness (mm)						
	0,5	0,7	1,0	1,5	2,0	2,5	3,0
2	700						
3	450	660					
4	275	480	685				
6	205	310	515	725			
8	170	225	410	530			
10	130	180	310	490			
12	105	150	245	375	480		
14			195	340	390		
15			170	280	365		
16			160	245	350		
18			140	230	335	380	
20				195	290	335	
22				190	280	305	
25				170	230	265	325

The working pressures in the above table are based on actual tests on ASTM A-269 tubing with a safety factory of 4:1. They apply to a metal temperature range of -20° to +100°C.

For working pressures of monel tubing, multiply the above ratings by 0.8.

# TECHNICAL DATA

## 316 不锈钢管工作压力及温度表

### T316 STAINLESS STEEL PIPES

#### ALLOWABLE WORKING PRESSURE AT TEMPERATURE

#### WITH ZERO ALLOWANCE FOR CORROSION AND/OR MECHANICAL STRENGTH

NOM. PIPE SIZE	SCH. NO.	WALL THICK- NESS	ALLOWABLE WORKING PRESSURES for temperatures (in deg. F) not to exceed																							
			20 to 100	200	300	400	500	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500
1/8	5S	065	2290	2290	2180	2130	2100	2090	2080	2070	2060	2040	2010	1950	1840	1710	1490	1290	1090	870	680	510	381	299	235	191
	10S	083	2960	2960	2830	2770	2720	2700	2700	2690	2670	2650	2610	2530	2390	2220	1930	1680	1430	1140	890	670	510	393	309	251
	40S	109	4690	4690	4480	4380	4300	4280	4260	4250	4230	4190	4130	4000	3780	3500	3050	2670	2300	1840	1440	1080	810	640	500	405
	80S	147	6550	6550	6250	6110	6010	5970	5940	5900	5850	5760	5590	5270	4890	4260	3770	3320	2660	2070	1560	1170	920	730	590	450
1/4	5S	065	1810	1810	1730	1690	1660	1650	1650	1640	1630	1620	1590	1540	1460	1350	1180	1020	850	680	530	398	299	234	184	150
	10S	083	2340	2340	2230	2180	2150	2130	2130	2120	2110	2090	2060	2000	1880	1750	1520	1320	1110	890	700	530	391	306	241	196
	40S	113	3820	3820	3650	3570	3510	3490	3480	3470	3450	3420	3370	3260	3080	2860	2490	2170	1850	1480	1150	870	660	510	401	325
	80S	154	5370	5370	5120	5010	4920	4900	4880	4870	4840	4800	4720	4580	4320	4010	3490	3070	2660	2130	1660	1260	940	740	580	469
1/2	5S	065	1430	1430	1370	1340	1310	1300	1300	1290	1280	1260	1220	1150	1070	930	800	670	540	414	313	235	184	144	117	
	10S	109	2460	2460	2350	2300	2260	2240	2240	2230	2220	2200	2160	2100	1980	1840	1600	1390	1170	940	730	550	411	323	256	
	40S	133	3580	3580	3410	3340	3280	3260	3250	3240	3220	3200	3150	3050	2880	2670	2330	2020	1720	1380	1080	810	610	474	374	
	80S	179	4940	4940	4720	4610	4530	4510	4490	4480	4450	4410	4350	4220	3980	3690	3220	2820	2430	1950	1520	1150	860	680	530	429
3/4	5S	065	1130	1130	1080	1050	1030	1030	1030	1020	1020	1010	990	960	910	840	740	630	520	416	324	244	184	143	114	
	10S	109	1920	1920	1840	1800	1770	1760	1750	1740	1730	1720	1690	1640	1550	1440	1250	1080	910	730	570	425	319	250	197	
	40S	140	2950	2950	2810	2750	2700	2690	2680	2670	2660	2630	2590	2510	2370	2200	1920	1660	1400	1120	880	660	494	387	305	
	80S	191	4110	4110	3920	3840	3770	3750	3740	3730	3710	3670	3620	3510	3310	3070	2680	2330	2000	1600	1250	940	710	560	434	
1	5S	065	980	980	940	900	900	890	890	890	880	870	840	790	730	640	550	452	361	282	212	159	124	98		
	10S	109	1670	1670	1600	1560	1530	1520	1520	1510	1490	1470	1430	1350	1250	1090	940	780	630	487	368	275	216	170		
	40S	145	2650	2650	2530	2470	2430	2420	2410	2400	2390	2370	2330	2260	2130	1980	1730	1490	1260	1010	790	590	442	346		
	80S	200	3730	3730	3560	3480	3420	3410	3400	3390	3370	3340	3290	3190	3010	2790	2430	2110	1800	1440	1130	850	640	497		
2	5S	065	780	780	750	730	720	710	710	710	700	690	670	630	590	510	434	358	287	223	169	126	99			
	10S	109	1330	1330	1270	1240	1220	1210	1210	1200	1190	1170	1130	1070	990	870	740	620	492	384	289	217	170			
	40S	154	2230	2230	2130	2080	2050	2040	2030	2030	2010	2000	1970	1910	1800	1670	1450	1260	1050	840	660	493	370			
	80S	218	3120	3120	3000	3010	2960	2940	2930	2920	2910	2880	2840	2750	2600	2410	2100	1820	1540	1240	960	730	550			
2 1/2	5S	083	830	830	790	770	760	750	750	750	740	730	710	670	630	540	458	378	303	236	178	134	104			
	10S	120	1200	1200	1150	1120	1100	1100	1090	1090	1080	1060	1030	970	900	780	670	560	445	346	261	197				
	40S	203	2440	2440	2330	2280	2240	2230	2220	2210	2200	2180	2150	2080	1970	1820	1590	1370	1150	920	720	550				
	80S	276	3380	3380	3230	3160	3100	3080	3080	3070	3050	3020	2980	2890	2720	2530	2200	1910	1620	1300	1010	770				
3	5S	083	680	680	650	630	620	620	610	610	600	600	580	550	510	438	375	309	248	192	146	109				
	10S	120	980	980	940	920	900	900	890	890	880	870	840	790	740	640	550	453	362	283	212	159				
	40S	216	2120	2120	2020	1980	1950	1930	1930	1920	1910	1900	1870	1810	1710	1590	1380	1190	1000	800	620					
	80S	300	3000	3000	2860	2800	2750	2730	2730	2720	2700	2680	2640	2560	2410	2240	1950	1690	1430	1140	890					
3 1/2	5S	083	590	590	570	550	540	540	540	530	530	520	510	473	439	382	327	269	216	168	126	95				
	10S	120	860	860	830	800	790	790	780	780	770	770	760	730	690	640	560	477	394	314	245					
	40S	226	1970	1970	1850	1810	1780	1760	1750	1740	1730	1700	1650	1560	1450	1260	1090	910	730	570	425					
	80S	318	2770	2770	2640	2580	2540	2530	2520	2510	2490	2470	2440	2360	2230	2070	1800	1560	1310	1050						
4	5S	083	530	530	497	487	478	475	474	473	470	465	459	445	420	389	339	290	239	191	149	113				
	10S	120	760	760	730	710	700	700	690	690	680	670	650	610	570	493	423	348	278	218	164					
	40S	237	1800	1800	1720	1680	1650	1640	1640	1630	1620	1610	1580	1540	1450	1340	1170	1010	840	670						
	80S	337	2600	2600	2480	2420	2380	2370	2360	2350	2340	2320	2290	2220	2090	1940	1690	1460	1230							
5	5S	109	460	460	430	420	410	410	410	409	408	403	397	382	360	308	254	203	158	119	89					
	10S	134	690	690	660	640	630	630	620	620	620	610	590	550	510	444	380	313	251	196	148					
	40S	258	1580	1580	1510	1470	1450	1440	1430	1420	1410	1390	1350	1270	1180	1030	880	740	590	456						
	80S	375	2130	2130	2020	1970	1930	1920	1910	1900	1880	1840	1760	1690	1570	1410	1200	1000								
6	5S	109	464	464	443	443	426	423	422	421	419	414	408	396	374	346	302	258	212	170	133					
	10S	134	580	580	550	540	530	530	520	520	520	510	489	461	427	372	319	262	209	164						
	40S	280	1430	1430	1370	1340	1320	1310	1300	1290	1280	1260	1230	1160	1070	940	800	670	530	413						
	80S	437	2250	2250	2140	2100	2060	2050	2040	2040	2030	2010	1980	1920	1810	1680	1460	1260								
8	5S	109	496	496	464	464	443	443	442	442	442	439	432	426	413	390	361	316	270	222	177	138				
	10S	148	484	484	460	453	444	442	441	439	437	432	426	413	390	361	316	270	222	177	138					
	40S	372	1760	1760	1710	1680	1660	1650	1640	1630	1620	1610	1580	1540	1450	1340	1170	990	810	660						
	80S	500	2990	2990	2850	2800	2760	2750	2740	2730	2720	2700	2660	2580	2460	2290	2060	1810								
10	5S	134	451	451	435	432	422	422	421	419	414	408	403	397	382	360	308	254	203	158	119					
	10S	165	432	432	413	404	397	394	393	392	390	387	380	370	348	323	282	241	198	158						
	40S	365	1750	1750	1690	1660	1640	1630	1620	1610	1600	1580	1540	1450	1340	1170	990	810	660							
	80S	500	2980	2980	2840	2790	2750	2740	2730	2720																

# 技术资料词汇表

## TECHNICAL DATA

### GLOSSARY OF TUBING TERMS

#### CARBON STEELS

Steels having properties that are principally determined by the carbon content.

#### ALLOY STEELS

A steel to which one or more elements have been added, in addition to carbon, to produce specific properties.

#### NORMALISING

This is a process of heating steel to a temperature of 50° C. to 100° C. above its transformation range, followed by cooling in still air. Normalising refines the grain size, produces a more uniform structure, softens mild steel but raises the tensile strength of medium carbon steels.

#### ANNEALING

The heating and cooling of steel for the purpose of removing stresses, altering ductility or changing the physical and metallurgical properties. 18/8 stainless steels are annealed by heating to 1850° – 2050° F (1010° – 1120° C) and rapid cooling from high to low temperature. It is generally accepted that cooling from quenching temperature to black heat should be achieved within 3 minutes. Maximum softness is obtained by quenching from the top annealing temperature range.

#### BRIGHT ANNEALING

Annealing in a controlled atmosphere so that no oxide or scale is formed on the surface of the metal.

#### STRESS RELIEVING

Is a heat treatment given to relieve stresses which result in improved mechanical stability and elastic properties of cold-worked stainless steels. This heat treatment is usually in the range of 650° – 800° F (345° – 430° ).

#### AUSTENITE

A non-magnetic solid solution of carbon in Gamma iron. It is very unstable below its critical temperature but is retained in stable form at room temperature in certain alloys such as the 18%Cr – 8%Ni stainless steels.

#### CARBIDE

A complex chemical compound of carbon with chromium, iron or other elements which are sometimes found in stainless and heat resistant steels. The quantity and form of carbide can determine the properties of the steel. Chromium carbides present on the grain boundaries of austenitic stainless steels cause poor resistance to corrosion. This is usually due to improper annealing, welding and quenching.

#### WELDING PROCESS

Tubing manufactured by the inert gas shielded arc welding process provides complete fusion of the base metal. The weld has the same composition as the tube and is free from harmful inclusions.

#### FULL FINISHED

The weld bead has been entirely removed by either cold drawing or swaging after which there is no weld bead either on the outside or inside of the tubing.

#### SWAGING

Swaging is a hammering operation on tubing after welding for the purpose of removing the weld bead on both the inside and outside; it also serves as a sizing operation.

#### PROFILE ROLLED

As Welded or Annealed Circular Stainless Steel Tubes can be supplied profile rolled in sizes 1" o.d. and over in 16 gauge and lighter.

Profile Rolling imparts a smooth contour to the internal surface by planishing of the weld area. Any visible evidence remaining on the external and internal surfaces of the tube does not detract from the widespread application for this type of tubing, especially in the milk and food processing industries, breweries, and other applications where smoothness of the bore is the prime essential.

Profile Rolled Tube can be considered as a substitute for Drawn Welded Stainless Steel Tubing where the internal bore finish is not regarded as critical. It should not be specified in cases where optimum corrosion resistance is desired as Drawn Welded quality may be required to achieve the preferred metallurgical condition.

#### DRAWN WELDED

Welded Tubing which is subsequently cold drawn through a die and over a plug. Cold drawing removes the internal weld bead, breaks up the grain structure in the weld area so that optimum corrosion resistance is developed in the weld area after proper heat treatment. Cold drawing is used to produce intermediate sizes or to give higher tensile strength if tubes are not required in the annealed condition.

#### AS WELDED

As the name implies, this is tubing direct from the mill. It has a higher yield point than annealed tube and is generally used for decorative applications or in mildly corrosive conditions.

#### COLD DRAWING

The drawing of tubing through a hardened steel or tungsten carbide die while at room temperature. Cold drawing can be done with or without a plug or mandrel on the inside. The purpose of cold drawing is to reduce the O.D. or wall or both, produce a smooth surface finish and to break up weld structure which results in re-crystallization when annealed.

#### SINKING

The process of reducing the diameters of tubes by drawing through dies without any internal support in the tube. Except for extremes in wall thickness (i.e. very thin or very thick) the wall thickness remains unaltered by sinking.

#### PASSIVATING

The treating of stainless steel by dipping in a dilute solution of nitric acid to remove free iron from the surface and improve the corrosion resistance by forming a passive film on the surface.

#### PICKLING

Pickling is the immersion of a material in an acid solution for the purpose of removing oxide scale after annealing or heat treatment. Mixtures of nitric and hydrofluoric acid in water are the most effective and most widely used solutions for the removal of scale from all the Chromium Nickel grades of Stainless Steel.



# 技术资料词汇表

## TECHNICAL DATA

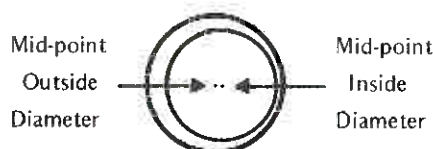
### GLOSSARY OF TUBING TERMS .....continued.

#### OVALITY

Out-of-roundness or difference between maximum and minimum dimensions of O.D. obtained by careful micrometer measurement for high and low points at any one section around the tube. The ovality tolerance is considered to be a total spread inside which both the maximum O.D. dimension and minimum O.D. dimension must fall.

#### TOLERANCE ON THICKNESS

Due to the nature of the hot working processes employed in manufacturing a hot finished tube for cold drawing, the mid-point of the inside diameter of the tube is not always coincident with the mid-point of its outside diameter. This causes a variation in thickness around the tube.



Cold drawing will tend to eliminate this, but will not completely remove it. The variation in thickness caused by the non-coincidence of diameter mid-points is referred to as **eccentricity**, and is defined as the difference between the maximum and minimum thicknesses at any section along the length of a tube. The allowable difference between the maximum and minimum thickness is called the **eccentricity tolerance**. It is also necessary to apply a tolerance to allow for the variation of the **mean thickness** from one tube to another caused by tool wear, etc. The allowable variation of the **mean thickness** from the **nominal thickness** is called the **mean thickness tolerance**. The **mean thickness** is found by taking the average of at least six equally spaced micrometer readings of the thickness around any section along the length of the tube.

#### INCLUSIONS

Particles of dirt, slag, etc., usually non-metallic, occurring in steel which did not have time to float off before solidification takes place.

#### DEFRASING (DEBURRING)

The operation of removing the ragged edges formed during cutting from the tube ends.

#### SECTION TUBING

Non-circular section tubing such as square, rectangles, ovals, etc., are first made in the round form and roll shaped or drawn as a supplementary operation.

#### NON-DESTRUCTIVE TESTING

This embraces all types of testing and inspection methods that do not destroy the material under test. While it includes methods that have been in operation for many years, such as magnetic particle and pressure testing, it has recently become more associated with ultrasonic and eddy current testing.

#### PIPE

Pipe can be defined as tubing made to definite standards usually designated by the nominal inside diameter. It has fixed wall thicknesses and outside diameter established as standard by the American Standards Association, the wall thickness depending upon the working pressures to be maintained. These fixed wall thicknesses are designated as Schedule numbers.

Schedule 5 and 10 pipe is normally used where comparatively low pressures are encountered and where butt weld fittings and connections are to be made. Schedule 40 and 80 pipe is used for high pressures and when threading is required.

#### NOMINAL BORE

In British and American practice there is a series of O.D. sizes originally used for external threading to take fittings but described in terms of the bore diameter associated with each outside diameter. Tube or pipe of a stated Nominal Bore therefore has the appropriate O.D. size listed in either B.S.1387 or A.S.T.M.A.53.

#### VAN STONE ENDS

Method of joining two tubes by flaring the ends at right angles and fitting a light back-up flange.

### OXIDATION RESISTANCE

#### Austenitic-Ferritic Stainless Steels and Nickel Alloys

The ability to resist oxidation at elevated temperatures has contributed to the ever widening use of stainless steel in industry. The selection of the proper grade of stainless steel for a particular application is a relatively complex problem and involves manufacturing, metallurgical, chemical and economic considerations. Although it is complex it has been made easier by industrial research. Data accumulated through years of research and experience gained in helping to solve varied application problems are now available to guide the user in the solution of his present problems.

When a metal is exposed to elevated temperatures for a long period of time, scale will form of sufficient thickness to flake off, causing a progressive loss of metal. The lowest temperature at which this phenomenon occurs is referred to as the "scaling" temperature of the material; the recommended temperature limits for satisfactory operation under oxidising conditions without excessive scaling.

Recommended maximum temperature limits for satisfactory operation under oxidizing conditions without excessive scaling.

AISI Type No.	Other Alloys	Temperature	
		°F	°C
301		1600	871
302		1600	871
304-304L		1600	871
309		2000	1093
310		2100	1149
314		2100	1149
316-316L		1600	871
317		1600	871
321		1600	871
347		1600	871
410		1400	760
430		1600	871
446		2100	1149
	Nickel 200	1650	899
	Nickel 201	1650	899
	Inconel 600	2150	1179
	Incoloy 800	2050	1121
	Incoloy 825		
	Monel 400	1000	538

NOTE: The temperature limits may have to be revised downward in the presence of combustion products or gases high in sulphur compounds.

# 各种管道技术资料

## TECHNICAL DATA

### WELDING OF STAINLESS STEEL FITTINGS, PIPE & TUBING

Where Stainless Steel materials are to be exposed to elevated temperatures in the range 800° F. to 1650° F. (425° C. to 870° C.) and to corrosive media, the harmful effects of Chromium carbide precipitation are avoided by addition of a minimum amount of a stabilizing element. Type 321 contains Titanium. Type 347 contains Columbium as a stabilizing element. The stabilizing elements will combine with the Carbon at a higher temperature than will Chromium, thus effectively tying up the available Carbon and thereby eliminating the vulnerable Chromium deficient areas. These materials may be welded and will retain their resistance to corrosion, even in the as-welded state. However, subsequent heat treatment, if possible, will improve the mechanical properties of the weldment.

Welding of the straight Chromium stainless steels will present much the same problems as encountered in the high Carbon or medium Carbon alloy steels. Rapid cooling of the weldment will result in a highly stressed, brittle structure. Use of these materials will make pre-heating and post-weld heat treatment mandatory.

To effectively reduce stresses during welding, a pre-heat and interpass temperature of not less than 600° F. should be maintained. When welding is completed, a stress-relief treatment must follow. However, in these materials a transformation of austenite to martensite must be complete prior to the stress-relief treatment. This can best be checked by allowing the weldment to cool until it becomes magnetic. At this time, it should be re-heated and stress relieved prior to cooling to room temperature. This treatment will result in a tempered martensitic structure which will have the desired mechanical properties.

### INSTALLATION HINTS.

Great care should be taken to see that stainless tubing is not subjected to cold working unnecessarily because of its tendency to work harden. If cold work cannot be avoided then the proper thing to do is to anneal the entire piece of tube or assembly and quench it fast following the anneal. Care should be exercised to ensure that tubing installations are free of vibration to avoid work hardening and subsequent cracking of the tube.

Stress corrosion is an acceleration of corrosion rate in a metal caused by internal stresses. These stresses may be induced in stainless tubing by bending, expanding and thermal expansion, particularly where stainless is too rigidly installed and must function under fluctuating temperature conditions.

### BENDING

As a general guide, tubing can be bent without a mandrel on a centre line radius approximately three times the diameter of the tubing. The quality of bend obtained without a mandrel depends largely on the bending equipment that is available and the heavier the wall the less distortion after bending. As a general guide, the following formula can be used to determine the minimum bending radius when the angle of bend does not exceed 90°. The formula is:

$$C/L \text{ Rad.} = \frac{(D2 - d2)}{4t}$$

D = O.D. of tube in inches  
d = I.D. of tube in inches  
t = wall thickness of tube in inches.

### WELDED STAINLESS STEEL TUBING AND PIPE

During recent years, automatic welding of stainless steel in an inert gas with a non-consumable electrode has resulted in high quality welded tubing and pipe being produced with considerable cost advantages over seamless stainless steel tubing. ASTM specifications A269 and A312 specifically permit the use of welded stainless steel pipe provided it is properly annealed after manufacture and ASTM specification A249 covers welded stainless steel tubing which has been subjected to sufficient cold work after welding and prior to the final heat treatment to assure that optimum corrosion resistance in the weld area and base metal will be developed during heat treatment.

### CORROSION

Corrosion may be simply defined as the destruction of a metal or alloy by a mechanism which is basically electrochemical in nature.

Stainless steels and many other corrosion-resistant alloys are also subject to corrosion. It is only with reservations that the metallurgists use the word "stainless" to designate certain types of steels. Yet this name has become accepted terminology because the users have found that these steels do have desirable corrosion resistance and certain "noble" characteristics. However, to fulfil the promise of their name, the austenitic stainless steels require proper handling to obtain maximum service life and corrosion resistance. By understanding the principles underlying the corrosion resistance of these steels and applying a few precautions which these principles indicate, we can maintain the desirable "noble" characteristics of these steels.

### FACTORS AND CONDITIONS WHICH MAY AFFECT CORROSION RESISTANCE OF STAIN- LESS STEEL.

**GALVANIC CORROSION** — Bi-metal attack. When two or more dissimilar metals are connected or in contact, or when metals of the same analysis have variations in surface conditions, a galvanic cell may be established when an electrolyte is present. The least noble metal in the galvanic series will become sacrificial to the more noble metal.

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## TECHNICAL DATA

### POSITION OF STAINLESS STEELS IN THE ELECTROMOTIVE SERIES.

(anodic end)	TIN
MAGNESIUM	60 Ni-15% Cr. NICKEL
MAGNESIUM ALLOYS	80 Ni-20% Cr. INCONEL
ZINC	BRASSES
ALUMINIUM 2S	COPPER
CADMIUM	BRONZES
CARBON STEEL	NICKEL SILVER
COPPER STEEL	COPPER NICKEL
CAST IRON	MONEL
4-6% Cr. STEEL	60 Ni-15% Cr. NICKEL
12-14 % Cr. STEEL	80 Ni-20% Cr. INCONEL
16-18 % Cr. STEEL	12-14% Cr. STEEL
23-30 % Cr. STEEL	16-18% Cr. STEEL
7 Ni-17% Cr. STEEL	7 Ni-17% Cr. STEEL
8 Ni-18% Cr. STEEL	8 Ni-18% Cr. STEEL
14 Ni-23% Cr. STEEL	14 Ni-23% Cr. STEEL
20 Ni-25% Cr. STEEL	23-30% Cr. STEEL
12 Ni-18% Cr.	12 Ni-18% Cr.
3% Mo STEEL	3% Mo STEEL
LEAD-TIN SOLDER	SILVER
LEAD	(cathodic end)

### PASSIVATION

Most researchers agree that the austenitic steels obtain their corrosion resistance from a thin metal oxide layer which forms a protective film on the surface of the metal. This condition is known as passivation. Air will form this film in time. However, the film formation can be greatly accelerated by exposure to an oxidizing acid such as Nitric Acid,  $\text{HNO}_3$ . Destruction of this film wholly or partially will greatly affect the corrosion resistance of this type of alloy.

Stainless Steel in the passive state appears in a relatively stable position in the galvanic series and is usually cathodic. Therefore, not subject to attack. However, under certain conditions all or portions of a piece of Stainless Steel may become active.

This active surface becomes anodic to the more noble mass and in the presence of an electrolyte a galvanic cell is set up and attack will occur. The rate of attack will vary with different electrolytes and the area relationship of the anode and cathode. A small anodic or active area in relationship to a large cathodic or passive area will result in rapid, severe attack. The rate of attack will be greater with acid solutions and those having a high degree of ionization. However, with basic solutions, even, though a high degree of ionization is possible, corrosion may not occur in basic solutions due to the insolubility of the elements which make up stainless steels.

**ELECTROLYTIC OR STRAY CURRENT CORROSION** — Stray electric currents may produce pitting attack on Stainless Steel. This attack may occur with A-C or D-C although the rate of attack with A-C is considerably less than D-C and in most cases insufficient to be considered.

If there is the possibility of current leakage, the installation should be grounded. If this is impossible, the attack can be eliminated or reduced by inducing a small counter-current into the system to neutralize the effect of stray current. Another method which may be employed is to connect sacrificial anodes, such as Magnesium, to the system.

**CHEMICAL ATTACK** — Austenitic steels are resistant to most chemicals. However, there are a few which cause serious attack. Halogen and Sulphur compounds are notorious for attack on stainless steels. Again acidic solutions cause more severe attack than basic solutions of the same elements. If possible, exposure to these harmful chemicals should be avoided. In cases where it is necessary to use compounds of this type with Stainless Steel, exposure time should be kept to a minimum and temperatures as low as possible used. In many cases inhibitors can be used in the solutions to render them less harmful.

**CONTACT OR CREVICE CORROSION** — This probably is the most common cause of pitting of stainless steels. Whenever a solid or semi-solid material adheres or lies against a Stainless Steel surface in contact with an electrolyte, pitting may occur. The passivity of the steel is destroyed under the substances, due to Oxygen starvation. This area will then become anodic to the mass and pitting will occur. The rate of attack will be governed by the relative anode and cathode areas and the type of electrolyte.

Oxygen concentration cells may also develop on crevices or fissures and may set up a galvanic cell and result in pitting attack.

These types of corrosion will spread as products of corrosion deposit on other areas of the metal and form new cells which cause further pitting. To overcome crevice, contact or concentration-cell corrosion an installation should be designed with a minimum of laps and crevices. If gaskets or seals are used they must be non-absorbent and well seated. Regular, efficient cleaning with correct cleaning agents will minimize these types of attack.

**STRESS CORROSION AND CORROSION FATIGUE** — This type of corrosion cracking is a result of residual or applied stresses. Metal under stress is slightly anodic in relation to the unstressed metal of the same analysis. Austenitic steels under stress are subject to attack when exposed to certain corrosive agents. The Halogen salts are probably the most serious offenders.

Correct heat treatment after forming and fabrication will eliminate residual stresses from these operations. It is also important in designing an installation to eliminate sources of stress such as applied loads, vibrations, flexing and excessive expansion and contraction due to changes in temperatures.

**EROSION CORROSION** — Certain liquids or gases moving at high speed may cause erosion corrosion, though these same materials if motionless would not affect the Stainless Steel. It is believed, by most investigators, that the attack is due in part to the destruction of the passive film on the surfaces. The action of fluids in rapid motion is not always destructive. In some cases the scouring effect keeps the Stainless Steel free of deposits and sludge which may cause other types of corrosion. Many Oxygen bearing solutions maintain the passivity of the stainless steels even at high velocities. To reduce the possibility of erosion corrosion, turbulence and impingement should be kept to a minimum. This will also improve the overall flow efficiency.

Austenitic stainless steels offer excellent corrosion resistance to most corrosives. By correct application, design and maintenance, stainless steels will perform in accordance with their noble characteristics.



# 各种管道技术资料

## TECHNICAL DATA

### STAINLESS STEEL AUSTENITIC ALLOYS

#### TYPE 301 17/7

This alloy has less chromium and nickel than others in the type 300 series. The alloy is unstable austenite which transforms to martensitic type phase with severe cold working. It develops valuable mechanical properties up to 300,000 PSI when cold worked and the high tensile strength developed makes it specially suitable for applications requiring high wear resistance such as in the automotive, kitchenware and furniture hardware items as well as structural members of transport vehicles.

#### TYPE 302

This grade is the basic 18/8 type in the 300 series and offers good corrosion resistance combined with good physical properties. For intermittent service involving frequent heating and cooling in air, it is recommended that the upper temperature limit should be 1600° F (870° C). Because of the possibility of carbide precipitation in the temperature range 800° – 1600° F (425° – 870° C) the unmodified 18/8 alloys may be subject to attack by severely corrosive solutions.

Carbide precipitation is not in itself harmful, but it does leave the metal susceptible to intergranular-type corrosion in the presence of severe corrosive agents.

#### TYPE 303

An 18%Cr – 9%Ni nonhardenable alloy containing selenium and extra amounts of sulphur and phosphorus. Most readily machinable of all austenitic grades. Properties close to those of Type 304, elongation somewhat lower. Nonmagnetic in annealed condition. Weldable by resistance methods-fusion welding not recommended. Resistant to scaling up to 1650° F. For use where a free cutting material is required; offers high resistance to corrosion; assures good end product surface. Typical applications: bushings, casters, shafts, rivets, valve and pump parts.

#### TYPE 304

A widely used grade that has high strength at elevated temperatures and good corrosion resisting properties for applications in a wide range of corrosive media. Less susceptible to precipitations of carbides and therefore suitable for use where welding conditions do not involve prolonged exposures to temperatures in the 800° – 1600° F (425° – 870° C) range. Excellent mechanical properties as low as –325° F (–198° C). Extensively used in the food and drink processing equipment decorative applications and heat exchangers. Scale resistant in continuous service to 1600° F and 1450° F for intermittent service.

#### TYPE 304L

A low carbon variation of Type 304 with a greatly reduced tendency to inter-crystalline disintegration after welding.

#### TYPE 305

A high-nickel variant of 18-8. Behaves much the same as Type 304 in corrosion resistance, carbide precipitation, and scale resistance. Low magnetic permeability (1.005 max.) even when mildly cold worked. Low work-hardening rate for severe forming.

For applications where severe forming is involved. Used for electrical instruments, cathode ray tube anodes and grid cups.

#### TYPE 309

A higher chromium and nickel content than the basic 18/8 types. Primarily a heat resistant alloy containing 25%Cr and 12%Ni with good high tensile and creep strength at elevated temperatures. Subject to carbide precipitation in range 800–1600° F (425° – 870° C). This alloy is easily welded or machined, is ductile and malleable. Resists oxidation up to 2000° F (1095° C) for continuous service. Not recommended for heat resistant applications of a cyclic nature because the different rates of expansion of the scale formed and the parent metal results in progressive scaling. Intermittent service to 1800° F (982° C).

#### TYPE 310

This is a heat resistant alloy containing 25%Cr and 20%Ni suitable for use at elevated temperatures up to 2100° F (1150° C) for continuous service or in applications involving cyclic operation to 1900° F (1038° C) providing reducing sulphur gases are not present. Nonmagnetic at room temperatures in annealed condition with excellent weldability. Mechanical and corrosion resistance properties similar to, but better than Type 304. Offers good resistance to sea water and fuming nitric acid at room temperatures. Used extensively for furnace components, still tubes and fuel lines. Silicon content 1.5% max.

#### TYPE 314

This is a heat resistant alloy of the Austenitic type containing 25% chromium and 20% nickel very similar to Type 310. The important difference lies in the silicon content which is 1.5–3%. The effect of silicon on the heat resisting properties of iron-chromium-nickel alloys is well recognised and has the effect of reducing carbon and sulphur pick up and to reduce damaging scale formation and increased resistance to intergranular attack. Used extensively for manufacture of chain links and mesh belts and other furnace parts subjected to cyclic operations or continuous service up to 2100° F (1150° C).

#### TYPE 316

A 18% Cr – 10% Ni – 2 – 3% Mo. alloy that offers the best corrosion resistance of the standard Austenitic grades. This type, with the molybdenum content, is particularly resistant to sulphur, sulphur acids, phosphoric, formic and various hot organic acids.

Offers increased resistance to pitting and pinhole type corrosion when in contact with acid vapours and salt solutions of the halide group in general, and has good high temperature and creep strength. Since this grade is not stabilized it is susceptible to inter-granular corrosion when exposed to the critical temperature range 800° – 1600° F (425° – 870° C) and therefore must be heat treated after welding. Extensively used in pulp and paper, chemical, petro-chemical and dyeing industries for the more corrosive service applications. Scale resistance to 1600° F (871° C) max. for continuous and 1500° F (816° C) for intermittent service.

#### TYPE 316L

Low carbon modification of Type 316. Can be welded and heated in the range 800° – 1600° F (425° – 870° C) without damage to corrosion resistance.

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## TECHNICAL DATA

### STAINLESS STEEL AUSTENITIC ALLOYS cont.

#### TYPE 316Ti

A versatile grade of stainless steel which combines the advantages of AISI Type 316, 321 and 316L. Basically Type 316 stainless steel but with the addition of a minimum titanium content of 5 x carbon. This gives the steel particular application in structures subjected to temperatures in the 800°–1600°F (425°–870°C) where the steel is in contact with corrosive media. Type 316Ti can be stress relieved without risk of inter-granular corrosion.

#### TYPE 317

A higher molybdenum and chromium bearing austenitic stainless steel than Type 316. Has optimum corrosion resistance. Is more resistant to inter-granular attack than Type 316 and is preferred where light gauge material is to be welded. Suitable for applications requiring resistance to sulphuric acid concentrations up to 5% at temperatures to 840°F (450°C). Also where condensation of sulphur-bearing gases occurs and increased resistance to pitting corrosion is desired.

#### TYPE 321

An 18% Cr – 10% Ni titanium-stabilised alloy designed to overcome susceptibility to carbide precipitation and resultant inter-granular corrosion. Can be welded without subsequent annealing.

Corrosion resistance similar to Type 304 but with higher creep resistance suitable for use up to 1600°F (870°C) for intermittent service and up to 1475°F (800°C) for continuous service and can be used in corrosive applications at these temperatures. Recommended for use where heavy welded or field-erected equipment cannot be annealed. Also used where it is necessary for equipment to be cooled slowly through sensitizing range or where operating temperature is between 800° – 1600°F (425° – 870°C).

#### TYPE 330

An austenitic, nonmagnetic, corrosion-resisting high nickel-chromium alloy steel. It will endure high heat and is most useful at operating temperatures between 1500 and 2150°F. Will also withstand prolonged heating in air at temperatures up to 1900°F without excessive scaling. Can be machined, bent, drawn and spun. Can be welded by use of a rod of special chemical composition to prevent weld cracking.

Used for furnace parts, pyrometer protection tubes and heat resisting parts in jet engines.

#### TYPE 347

Similar properties to Type 321 but stabilised by columbium instead of titanium. Superior to Type 321 when subjected to corrosive service in the sensitizing temperature range.

#### NYBY 20-25 UMoCuT

A high-purity austenitic stainless steel with very good resistance to general corrosion in solutions of sulphuric or phosphoric acid. Has high resistance to pitting and stress corrosion and used in salt and brackish waters.

Suitable for use in severe environments in the inorganic and organic chemical process industries, polymer and plastic industry, explosive and petrochemical industries. Some applications:—

- Pulp and paper industry — bleaching equipment
- Petrochemical industry — heat exchangers
- Chemical industry — process equipment where sulphuric or phosphoric acids are frequent and where chlorides and fluorides occur.

- Marine applications — heat exchangers
- Textile and fibres industry — equipment in dyeworks
- Mechanical industry — pickling tanks.

#### KIN 800 AT STEEL (20 Cr-33Ni-Al-Ti)

For use in heat exchangers and piping that must be oxidation and corrosion resistant at high temperatures and in similar application to Incoloy 800.\*

#### KIN 600 STEEL (15 Cr-72 Ni)

Similar applications to KIN 800 AT and to Inconel 600.\*

### STAINLESS STEEL MARTENSITIC ALLOYS

#### TYPE 410

Type 410 is a basic hardenable alloy containing 12% Cr; Magnetic in all conditions and can be hardened to Rockwell C36-40 by quenching or air cooling from 1750-1850°F. Not subject to carbide precipitation, but low in impact properties at low temperatures. Air hardening, they present some difficulty in welding. Widely used wherever good spring properties are needed. Excellent for Bourdon springs, medical instruments and turbine parts.

### STAINLESS STEEL FERRITIC ALLOYS

#### TYPE 430

Basic type of straight chromium ferritic alloy steel combining useful corrosion resistance, mechanical properties, ease of formability and low cost. Used extensively as automotive trim. Resistance to nitric acid permits the use of Type 430 for specific chemical applications. Has good resistance to atmospheric corrosion away from coastal areas. Under oxidising conditions a tight protective scale is formed on the surface making it useful for equipment subjected to repeated heating and cooling up to 1600°F (870°C). It is magnetic in all tempers and non-hardenable.

#### TYPE 430Ti

Analysis similar to T430 with addition of Titanium 0.60% max. to eliminate coarse grain welds of low ductility. Mechanical properties resemble those of low-carbon steel and machines better than austenitic grades.

#### TYPE 446

A ferritic alloy, 27% chromium stainless steel with excellent resistance to corrosion and oxidation. Has the highest heat resistance to all ferritic stainless steels. A nitrogen addition is used to prevent embrittlement through the 1200° – 1800°F (649°C–982°C) range and also to help control grain size. Type 446 resists oxidation up to 2150°F (1175°C) for intermittent service and 2000°F (1095°C) for continuous service. At high temperature a tightly, adherent scale forms preventing further oxidation. Resists attack by sulphurous gases at elevated temperatures. Excellent corrosion resistance to nitric acid, concentrated sulphuric acid and most alkalis. Hot strength is rather low and it is somewhat brittle at room temperatures. Used extensively for furnace parts, thermocouple sheaths, chemical processing equipment, muffle tubes, etc.



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## TECHNICAL DATA

### STAINLESS STEEL FERRITIC ALLOYS cont.

#### FERRALIUM ALLOY †

A patented ferritic-austenitic stainless steel combining high mechanical strength, ductility and hardness with outstanding resistance to corrosion and erosion. Optimum properties are achieved by a simple heat treatment and the alloy is supplied either:—

- (a) Solution treated at 1120°C followed by a rapid cool, or
- (b) Solution treated as (a) and age-hardened at 510°C ± 10°C. Has excellent resistance to sulphuric, phosphoric, nitric, acetic, formic and many other acids and salts.

Because of its outstanding wear and erosion resistance and good anti-galling properties, Ferralium alloy is particularly suitable for pumps, agitators and other critical components handling hot corrosive slurries or where galling is a problem.

#### SHOMAC 302 (30Cr-2Mo-ULC Ferritic Stainless)

This is a high purity high corrosive ferritic stainless steel with an ultra low carbon of 0.005% max. Developed to give remarkable resistance to chlorine induced stress corrosion cracking and excellent resistance to both pitting and crevice corrosion. Suitable for components in:—

- Strongly corrosive organic acid plants
- Oxidising inorganic acid processing plants
- Evaporators in caustic soda solutions produced through the diaphragm process.
- Processing plants involving polluted brackish water
- Condensers or coolers in which coolant is chlorine containing water or sea water.

Subject to embrittlement at temperatures of about 475°C.

### NICKEL & NICKEL BASE ALLOYS

#### NICKEL 200

Combines excellent mechanical properties with corrosion resistance that is generally good and is outstanding under many conditions of exposure. Strength and hardness may be increased by cold working. Scale resistant in sulphur free atmospheres to 1650°F (900°C). Extensively used in contact with reducing acids, food, chemical processing liquors and caustic solutions. Carbon 0.15% max.

#### NICKEL 201

Is the low carbon grade of Nickel 200. Carbon content 0.02% max. This alloy has excellent resistance to corrosion and may be used in oxidising temperatures to 1650°F (900°C). Recommended for severe manipulation and use in thermocouple tubing in molten salt bath furnaces.

#### INCONEL 600\*

This alloy is superior in corrosion resistance to commercially pure nickel under oxidising conditions. Its higher nickel content enables it to retain considerable corrosion resistance under reducing conditions. It resists oxidation at elevated temperatures up to 2150°F (1170°C). Resistant to salt at elevated temperatures up to 1832°F (1000°C). Can be readily welded, brazed and soldered. Extensively used for thermocouple protection tubing, sheathing on electric elements and food processing.

#### INCOLOY 800\*

This alloy has good resistance to oxidation up to 2050°F (1100°C) and retains its strength at elevated temperatures. Has excellent workability and welding properties and is superior to Inconel 600 in resisting sulphur and fused neutral salts; comparable in resistance to oxidation; inferior in resistance to nitriding, halogen gases and molten caustics. Used extensively for sheathing on electric elements, furnace muffles and heat exchangers.

#### INCOLOY 825\*

Formerly known as Ni-o-nel\* Alloy 825, is a titanium stabilised nickel-chromium-iron-molybdenum-copper alloy. It is fully austenitic and resistant to attack by many mineral and organic acids, particularly under oxidising conditions. Has greatly increased resistance to sulphuric acid and phosphoric acid when fluorides are present than the 300 series stainless steels. This alloy resists stress-corrosion cracking when subjected to a wide range of temperature and the more aggressive mineral acids, chlorine, ammonia and ammonium hydroxide solutions.

#### MONEL 400\*

Combines high strength, ductility and excellent resistance to corrosion and is scale resistant in sulphur free atmospheres to 1000°F (540°C). Has more resistance than nickel to corrosion under reducing conditions and more resistance than copper to corrosion under oxidising conditions. Used extensively in the chemical, food processing industries, power generating apparatus, medical instruments, electric heating elements and marine equipment.

#### CARPENTER 20Cb-3

This alloy provides excellent resistance to corrosion by sulphuric acid as well as other corrosive solutions. The presence of columbium in the alloy minimises precipitation of carbides during welding.

#### TITANIUM

This metal has outstanding strength to weight ratio and excellent corrosion resistance for certain applications in the chemical industry. Used extensively in the aluminium anodising field and in the food industry or the manufacture of fine chemicals when traces of iron, nickel or chromium can ruin the product. Readily fusion welded provided the metal is thoroughly protected from contamination by oxygen, nitrogen and hydrogen by the conventional shielded arc using a tungsten electrode. Used extensively for electrochemical anodes, chlorine applications, sea water, inhibited reducing acids, nitric acid, urea equipment anodising and plating, textile, food, petroleum industries.

#### HASTELLOY "C"

Excellent corrosion resistance, especially to ferric chloride and cupric chloride. Also to wet chlorine gas and hypochlorite and chlorine dioxide solutions. Has excellent high temperature strength. Resistant to oxidizing and reducing atmospheres to 2000°F.

Primarily used where exceptional corrosion resistance and high temperature strength are required. Typical are the outer sheath for electric tubular heating elements, thermocouple rakes, probes, photographic processing equipment, and lubricating lines for chemical equipment.

\*Monel, Inconel and Incoloy are Registered Trade Names of The International Nickel Co.

†Ferralium Alloy is Registered Trade Name of Langley Alloys Ltd.



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## TECHNICAL DATA

### AMERICAN SOCIETY OF TESTING MATERIALS SPECIFICATIONS

#### Abbreviations

- ASA - American Standards Published by the American Standards Association
- ASTM - American Society of Testing Materials
- ASME - American Society of Mechanical Engineers
- API - American Petroleum Institute
- ASA B31.1 - Code for Pressure Piping
- ASA B31.3 - Code for Pressure Piping: Petroleum Refinery Piping
- ASA B31.8 - Gas Transmission and Distributing Piping Systems
- API STD 5A - API Specification for Casing, Tubing and Drill Pipe
- API STD 5L - API Specification for Line Pipe
- API STD 5LX - API Specification for High Test Line Pipe

#### DIMENSIONAL PIPE SPECIFICATIONS:

- ASA B36.10 - Wrought Steel and Wrought-Iron Pipe covers diameters and wall thicknesses of pipe 1/4" to 36" with the exception of Schedules 5S and 10S.
- ASA B36.19 - Stainless Steel Pipe covers diameters and wall thicknesses of Stainless Steel pipe in Schedules 5S, 10S, 40S and 80S in sizes 1/8" to 30".

### ASTM-A53 GRADE A & B

This specification covers seamless and welded black and hot-dipped galvanized steel pipe in nominal sizes 1/8 in. to 26 in. incl. (3.18mm to 660.40mm) with nominal (average) wall thickness.

### ASTM-A106 GRADES A, B & C

This specification covers seamless carbon steel pipe for high-temperature service in nominal sizes 1/8 in. to 26 in. inclusive (3.18 mm to 660.40 mm) with nominal (average) wall thickness.

- |         |   |
|---------|---|
| Grade A | Carbon 0.25% max. Manganese 0.27 to 0.93% |
| Grade B | Carbon 0.30% max. Manganese 0.29 to 1.06% |
| Grade C | Carbon 0.35% max. Manganese 0.29 to 1.06% |

All grades have same values for Sulphur 0.058% max. Phosphorus 0.048% max. Silicon 0.10% min.

### ASTM-A120

This specification covers black and hot-dipped galvanized welded and seamless steel pipe in nominal sizes 1/8 in. to 16 in. inclusive (3.18 mm to 406.40 mm) with nominal (average) wall thickness.

### ASTM-A155

This specification covers electric-fusion-welded steel pipe suitable for high-pressure service and for use at high, intermediate, or lower temperatures, depending upon grade of material specified, in outside diameters 16 in. (406.40mm) and larger with wall thicknesses up to 3 in. (76.20mm) incl.

### ASTM-A161

This specification covers seamless, hot-finished and cold-drawn, low-carbon and carbon-molybdenum steel still tubes, for use in carrying fluids at elevated temperatures and pressures in various types of heaters, in which the tubes may be subjected to a furnace temperature higher than that of the contained fluid.

### ASTM-A178

This specification covers electric-resistance-welded tubes made of carbon steel and intended for use as boiler tubes, boiler flues, superheater flues, and safe ends and covers tubes 1/2 in. to 5 in. incl. (12.70 mm to 127.00 mm) in outside diameter and 0.035 in. to 0.320 in. incl. (0.89 mm to 8.13mm) in minimum wall thickness.

### ASTM-A179

Seamless Cold Drawn Low-Carbon Steel Heat Exchanger and Condenser Tubes. - 1/8 in. to 3 in. inclusive (3.18 mm to 76.20 mm) in outside diameter and specifies minimum wall thickness.

### ASTM-A199

This specification covers several grades of chromium-molybdenum and chromium-molybdenum-silicon seamless cold-drawn intermediate alloy steel tubes for heat exchanger, condensers, and similar heat transfer apparatus and covers tubes 1/8 in. to 3 in. incl. (3.18mm to 76.20 mm) in outside diameter.

Grade covered as in A199 are T3b-T4-T5-T7-T9-T11-T21-T22.

### ASTM-A200

This specification covers several grades of chromium-molybdenum and chromium-molybdenum-silicon seamless, hot-finished and cold-drawn, intermediate alloy steel still tubes, for use in carrying fluids at elevated temperatures and pressures in various types of heaters, in which the tubes may be subjected to a furnace temperature higher than that of the contained fluid and covers tubes 2 in. to 9 in. inclusive (50.80 mm to 228.60 mm) in outside diameter and over 0.220 in. (5.59 mm) in minimum wall thickness.

### ASTM-A209

This specification covers several grades of seamless carbon-molybdenum alloy-steel boiler and superheater tubes and covers tubes 1/2 in. to 5 in. incl. (12.70 mm to 127.00 mm) in outside diameter and 0.035 in. to 0.500 in. inclusive (0.89 mm to 12.70 mm) in minimum wall thickness.

### ASTM-A210

This specification covers seamless medium-carbon steel boiler tubes and boiler flues, including safe ends, arch and stay tubes, and superheater tubes and covers tubes 1/2 in. to 5 in. incl. (12.70 mm to 127.00 mm) in outside diameter and 0.035 in. to 0.500 in. inclusive (0.89 mm to 12.70 mm) in minimum wall thickness.

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### ASTM-A213

Seamless Ferritic and Austenitic Alloy-Steel Boiler, Super-Heater and Heat Exchanger Tubes, ½ in. to 5 in. inclusive (12.70 mm to 127.00 mm) in outside diameter having wall thicknesses of 0.035 in. to 0.500 in. inclusive (0.89 mm to 12.70 mm) in minimum wall thickness. The steels covered include 12 grades of ferritic in the chromium-molybdenum range as well as a similar range of stainless steels as detailed in ASTM-A249 with the exception of TP305, TP 309 and TP317.

### ASTM-A214

Electric-Resistance Welded Carbon Steel Heat Exchanger and Condenser Tubes, up to and including 3 in. (76.20 mm) in outside diameter and specified minimum wall thickness.

### ASTM-A249

Welded Austenitic Steel Boiler, Super-Heater, Heat Exchanger, and Condenser Tubes ½ in. to 5 in. inclusive (12.70 mm to 127.00 mm) in outside diameter and 0.035 in. to 0.320 in. (0.89 mm to 8.13 mm) and specified minimum wall thickness. The grades covered by this specification include those listed under A269 plus additional grades such as TP304H, TP305, TP309, TP310, TP316H, TP321H, TP347H and TP348H. Specification lays down that subsequent to welding and final heat-treatment the tube shall be cold worked to ensure that optimum corrosion resistance in the welded area and base metal will be developed during heat treatment.

### ASTM-A254

This specification covers copper brazed steel tubing 3/16 in. (4.76 mm) and over in outside diameter. This tubing is suitable for general engineering uses, particularly in the automobile, refrigerator, and stove industries for fuel lines, brake lines, oil lines, heating and cooling units.

### ASTM-A268

This specification covers eight grades of stainless steel tubing for general corrosion-resisting and high-temperature service. These grades are commonly known as the "straight-chromium" types and are characterized by being ferromagnetic. Two of these grades, TP410 and TP329, are amenable to hardening by heat treatment, and the high-chromium, ferritic alloys are sensitive to notch-brittleness on slow cooling to ordinary temperatures. These features should be recognized in the use of these materials. Grade T409 may be ordered with no final heat treatment provided certain requirements are met. Modification 1 of TP430 is used primarily for hot water tank service and does not require post weld heat treatment to prevent attack of the heat affected zone.

### ASTM-A269

Seamless and Welded Austenitic Stainless Steel Tubing for General Service, from 1/8 in. to 8 in. (3.18 mm to 203.20 mm) O.D. and specific average wall thickness. This specification covers grades of stainless steel tubing for general corrosion resistance and low or high temperature service in the following grades:

TP304-TP304L-TP316-TP316L-TP317-TP321-TP347-TP348.

### ASTM-A270

This specification covers a grade of seamless and welded austenitic stainless steel sanitary tubing intended for use in the dairy and food industry and having special surface finishes and covers tubes in sizes up to and including 4 in. (101.60 mm) in outside diameter.

### ASTM-A271

This specification covers grades of seamless, hot-finished and cold-finished, austenitic chromium-nickel steel still tubes for use in carrying fluids at elevated temperatures and pressures in various types of heaters, in which the tubes may be subjected to a furnace temperature higher than that of the contained fluid. The specification covers tubes 2 to 9 in. incl. (50.80 to 228.60 mm) in outside diameter and over 0.220 in. (5.59 mm) in minimum wall thickness.

### ASTM-A312

This specification covers seamless and welded austenitic steel pipe intended for high-temperature and general corrosive service. Sixteen grades are covered. The grades of austenitic stainless steel pipe furnished in accordance with this specification have been found suitable for low-temperature service down to -325°F (-198°C), where Charpy notched bar impact values of 15 ft-lb (2.07 m-kJ), minimum, are required, and need not be impact tested.

### ASTM-A333

This specification covers nominal (average) wall seamless and welded carbon and alloy steel pipe intended for use at low temperatures. All Pipe furnished under this specification must be tested for impact resistance at the minimum temperature ranging from -50°F (-46°C) for Grade 1. to -100°F (-73°C) for Grade 9.

### ASTM-A334

This specification covers several grades of seamless and welded carbon and alloy-steel tubes intended for use at low temperatures.

### ASTM-A335

This specification covers nominal (average) wall seamless alloy-steel pipe intended for high-temperature service. Pipe ordered to this specification shall be suitable for bending, flanging (van-stoning), and similar forming operations, and for fusion welding. Selection will depend upon design, service conditions, mechanical properties, and high-temperature characteristics. Grades covered:

P1-P2-P5-P5b-P5c-P7-P9-P11-P12-P15-P21-P22.

### ASTM-A358

This specification covers electric fusion-welded austenitic chromium-nickel alloy steel pipe suitable for corrosive or high-temperature service, or both. Commercial practice is commonly limited to sizes not less than 8 in. (203 mm) nominal diameter and covers seven grades of alloy steel.

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### ASTM-A376

This specification covers seamless austenitic steel pipe intended for high-temperature and central-station service. Among the ten grades covered are five H grades which are specifically intended for high-temperature service.

### ASTM-A381

This specification covers straight seam, double submerged-arc-welded steel pipe suitable for high-pressure transmission service, 16 in. (406 mm) to 42 in. (1077 mm), incl., in outside diameter, with wall thicknesses 5/16 in. to 1½ in. (7.9 to 38 mm) incl. The pipe is intended for carrying liquid, gas, or vapor. Pipe shall be suitable for bending, flanging (van-stoning), corrugating, and similar operations.

### ASTM-A405

This specification covers nominal (average) wall seamless, annealed or normalized and tempered alloy steel pipe intended for high-temperature service after special heat treatment. Pipe ordered to this specification shall be suitable for bending, flanging (van-stoning), and similar forming operations, and for fusion welding. The pipe shall be given a special heat treatment after any shop fabrication and prior to installation in service.

### ASTM-A409

#### WELDED LARGE OUTSIDE DIAMETER LIGHT-WALL AUSTENITIC CHROMIUM-NICKEL ALLOY STEEL PIPE

This specification covers electric fusion-welded, light wall, austenitic chromium-nickel alloy steel pipe for corrosive or high-temperature service. The sizes covered are 14 to 30 in. (355 to 762 mm) incl., in nominal diameter with extra light (schedule 5S) and light (schedule 10S) wall thicknesses. Eight grades of alloy steel are covered. Additional special grades may be specified by the purchaser.

The minimum wall thickness at any point shall not be more than 0.018 in. (0.46 mm) under the specified wall thickness. **Specified Diameter** — Where the specified wall thickness is less than 0.188 in. (4.78 mm), the actual outside diameter, based on circumferential measurement, shall not vary more than  $\pm 0.20$  per cent from the specified outside diameter. Where the specified wall thickness is 0.188 in. (4.78 mm) and heavier, the actual outside diameter, based on circumferential measurement, may vary a maximum of  $\pm 0.40$  per cent from the specified outside diameter.

**Straightness** — Using a 10 ft. (305 cm) straightedge placed so that both ends are in contact with the pipe, the camber shall not be more than 3/16 in. (1.59 mm).

Grades covered: TP304-309-310-321-347-316-317-348.

### ASTM-A423

This specification covers seamless and electric resistance welded low-alloy steel tubes for pressure containing parts such as economizers or other applications where corrosion resistance is important and covers tubes ½ to 5 in. inclusive (12.7 mm to 127.00 mm) in outside diameter and 0.035 to 0.500 in. inclusive (0.89 mm to 12.70 mm) in minimum wall thickness.

### ASTM-A430

**AUSTENITIC STEEL FORGED AND BORED PIPE** intended primarily for high-temperature central station service. Pipe ordered to this specification shall be suitable for bending and other forming operations and for fusion welding. The "H" grades are specifically intended for high-temperature service. Nine grades of austenitic steels are covered.

### ASTM-A450

This specification covers a group of common requirements which, when specified in the purchase order or in an individual specification, shall apply to hot-finished and cold-drawn, welded and seamless carbon steel, and ferritic and austenitic alloy steel under each of the following specifications issued by the American Society for Testing and Materials (or any other ASTM specification which invokes this specification or portion thereof).

Specifications covered are: A161-A178-A179-A192-A199-A200-A209-A210-A213-A214-A226-A249-A250-A254-A268-A269-A270-A271-A334-A423-A556-A557.

### ASTM-A498

#### SEAMLESS AND WELDED CARBON, FERRITIC, AND AUSTENITIC ALLOY STEEL HEAT-EXCHANGER TUBES WITH INTEGRAL FINS

This specification covers external helical, integral finned, Seamless or welded low-carbon steel, alloy steel, and stainless steel tubes for use in tubular heat exchangers, surface condensers, evaporators, superheaters, and similar heat-transfer apparatus in unfinned end diameter up to 2 in. inclusive. The finned tubes shall be manufactured from plain tubes which conform to one of the following specifications of the American Society for Testing and Materials: A179-A199-A213-A214-A249-A334.

### ASTM-A500

This specification covers cold-formed welded and seamless carbon steel round, square, rectangular, or special shape structural tubing for welded, riveted, or bolted construction of bridges and buildings, and for general structural purposes. This tubing is produced in welded sized with a maximum periphery of 32 in. (812.80 mm) and a maximum wall of 0.375 in. (9.53 mm) and in seamless with a maximum periphery of 32 in. (812.80 mm) and a maximum wall of 0.500 in. (12.70 mm).

### ASTM-A501

This specification covers hot-formed welded and seamless carbon steel square, round, rectangular, or special shape structural tubing for welded, riveted, or bolted construction of bridges and buildings, and for general structural purposes. Square and rectangular tubing is furnished in sizes 1 to 10 in. (25.40 to 254.00 mm) across flat sides with wall thicknesses 0.095 to 1.000 in. (2.41 to 25.40 mm), depending on size; round tubing is furnished in nominal diameters 1/2 to 24 in., incl. (12.70 to 609.60 mm) with nominal (average) wall thicknesses 0.109 to 1.000 in. (2.77 to 25.40 mm) depending on size.

### ASTM-A511

#### SEAMLESS STAINLESS STEEL MECHANICAL TUBING

This specification covers seamless stainless tubing for use in mechanical applications where corrosion resistant or high temperature strength is needed. This specification covers seamless cold-finished mechanical tubing and seamless hot-finished mechanical tubing in sizes up to 12¼ in. (323.85 mm) in outside diameter (for round tubing) with wall thickness as required.



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### ASTM-A512

This specification covers cold-drawn butt-welded carbon steel tubes for use as mechanical tubing. This specification covers round, square, rectangular and special shape mechanical tubing. Round tube size ranges covered are outside diameters up to 3½ in. (88.90 mm), and wall thicknesses from 0.035 to 0.500 in. (0.89 to 12.70 mm).

### ASTM-A513

This specification covers electric-resistance-welded carbon and alloy steel tubing for use as mechanical tubing, and made from hot- or cold-rolled steel and round, square, rectangular, and special shape tubing.

### ASTM-A519

This specification covers several grades of carbon and alloy steel seamless mechanical tubing and covers both seamless hot-finished mechanical tubing and seamless cold-finished mechanical tubing in sizes up to and including 12¾ in. (323.85 mm) outside diameter for round tubes.

### ASTM-A524

This specification covers seamless carbon steel pipe primarily for process piping applications, in nominal sizes 1/8 to 26 in., incl. (3.18 to 660.4 mm), with nominal (average) wall thickness as given in USA Standard USAS B36.10-1959. Pipe ordered to this specification shall be suitable both for welding, and for bending, flanging, and similar forming operations.

### ASTM-A530

#### GENERAL REQUIREMENTS FOR SPECIALIZED CARBON AND ALLOY STEEL PIPE

This specification covers common requirements which, when specified in the purchase order or in an individual specification, shall apply to hot-finished and cold-drawn, welded, seamless, forged and bored, and centrifugally cast carbon steel, ferritic, and austenitic alloy steel pipe under each of the following specifications issued by the American Society for Testing and Materials, or any other ASTM specification that invokes this specification or a portion thereof.

Grades covered: A106-A155-A312-A333-A335-A358-A369-A376-A381-A405-A409-A426-A430-A451-A452-A524.

### ASTM-A554

This specification covers welded stainless steel tubing for mechanical applications where appearance, mechanical properties or corrosion resistance is needed and covers as-welded or cold-reduced mechanical tubing in sizes to 16 in. (406.40 mm) outside diameter, incl. (for round tubing) and in wall thicknesses 0.020 in. (0.51 mm) and over.

### ASTM-A556

This specification covers seamless cold-drawn carbon steel tubes including bending into the form of U-tubes, if specified, for use in tubular feedwater heaters. The tubing sizes covered shall be 5/8 to 1¼ in. (16 to 32 mm) outside diameter incl., with minimum wall thicknesses equal to or greater than 0.045 in. (1.14 mm).

### ASTM-A557

This specification covers electric-resistance-welded carbon steel tube including those bent, if specified, into the form of U-tubes for application in tubular feedwater heaters. The tubing sizes covered shall be 5/8 to 1¼ in. (16 to 32 mm) outside diameter incl. and wall thicknesses equal to or greater than 0.045 in. (1.14 mm).

### ASTM-A587

This specification covers electric-resistance-welded low-carbon steel pipe intended for use as process lines. Pipe ordered under this specification shall be suitable for severe forming operations involving flanging and bending to close radii and covers nominal sizes ½ to 4 in. (12.7 to 101.6 mm).

### ASTM-A632

#### SEAMLESS AND WELDED AUSTENITIC STAINLESS STEEL TUBING (SMALL-DIAMETER) FOR GENERAL SERVICE

This specification covers grades of stainless steel tubing in sizes under ½ in. down to 0.050 in. (12.700 to 1.270 mm) in outside diameter and wall thicknesses less than 0.065 in. down to 0.005 in. (1.600 to 0.127 mm) for general corrosion-resisting and low- or high-temperature service.

