Member Metals Service Center Institute

Russel Metals

WILLIAMS BAHCALL

ABS Quality Evaluations, Inc. ★ Management System Certification ★

ISO 9001

Price **$7.50**

DECIMAL EQUIVALENTS

1/64	.015625
1/32	.03125
3/64	.046875
1/16	.0625
5/64	.078125
3/32	.09375
7/64	.109375
1/8	.125
9/64	.140625
5/32	.15625
11/64	.171875
3/16	.1875
13/64	.203125
7/32	.21875
15/64	.234375
1/4	.25
17/64	.265625
9/32	.28125
19/64	.296875
5/16	.3125
21/64	.328125
11/32	.34375
23/64	.359375
3/8	.375
25/64	.390625
13/32	.40625
27/64	.421875
7/16	.4375
29/64	.453125
15/32	.46875
31/64	.484375
1/2	.5

33/64	.515625
17/32	.53125
35/64	.546875
9/16	.5625
37/64	.578125
19/32	.59375
39/64	.609375
5/8	.625
41/64	.640625
21/32	.65625
43/64	.671875
3/16	.6875
45/64	.703125
23/32	.71875
47/64	.734375
3/4	.75
49/64	.765625
25/32	.78125
51/64	.796875
13/16	.8125
53/64	.828125
27/32	.84375
55/64	.859375
7/8	.875
57/64	.890625
29/32	.90625
59/64	.921875
15/16	.9375
61/64	.953125
31/32	.96875
63/64	.984375
1	1.

CONVERTING INCHES INTO
DECIMALS OF A FOOT

Inches		Decimal of a Ft.	Inches		Decimal of a Ft.	Inches		Decimal of a Ft.
	1/16	.0052		1/16	.3385		1/16	.6719
	1/8	.0104		1/8	.3438		1/8	.6771
	3/16	.0156		3/16	.3490		3/16	.6823
	1/4	.0208		1/4	.3542		1/4	.6875
	5/16	.0260		5/16	.3594		5/16	.6927
	3/8	.0313		3/8	.3646		3/8	.6979
	7/16	.0365		7/16	.3698		7/16	.7031
0"	1/2	.0417	4"	1/2	.3750	8"	1/2	.7083
	9/16	.0469	.3333	9/16	.3802	.6667	9/16	.7135
	5/8	.0521		5/8	.3854		5/8	.7188
	11/16	.0573		11/16	.3906		11/16	.7240
	3/4	.0625		3/4	.3958		3/4	.7292
	13/16	.0677		13/16	.4010		13/16	.7344
	7/8	.0729		7/8	.4063		7/8	.7396
	15/16	.0781		15/16	.4115		15/16	.7448
	1/16	.0885		1/16	.4219		1/16	.7552
	1/8	.0938		1/8	.4271		1/8	.7604
	3/16	.0990		3/16	.4323		3/16	.7656
	1/4	.1042		1/4	.4375		1/4	.7708
	5/16	.1094		5/16	.4427		5/16	.7760
	3/8	.1146		3/8	.4479		3/8	.7813
	7/16	.1198		7/16	.4531		7/16	.7865
1"	1/2	.1250	5"	1/2	.4583	9"	1/2	.7917
.0833	9/16	.1302	.4167	9/16	.4635	.7500	9/16	.7969
	5/8	.1354		5/8	.4688		5/8	.8021
	11/16	.1406		11/16	.4740		11/16	.8073
	3/4	.1458		3/4	.4792		3/4	.8125
	13/16	.1510		13/16	.4844		13/16	.8177
	7/8	.1563		7/8	.4896		7/8	.8229
	15/16	.1615		15/16	.4948		15/16	.8281
	1/16	.1719		1/16	.5052		1/16	.8385
	1/8	.1771		1/8	.5104		1/8	.8438
	3/16	.1823		3/16	.5156		3/16	.8490
	1/4	.1875		1/4	.5208		1/4	.8542
	5/16	.1927		5/16	.5260		5/16	.8594
	3/8	.1979		3/8	.5313		3/8	.8646
	7/16	.2031		7/16	.5365		7/16	.8698
2"	1/2	.2083	6"	1/2	.5417	10"	1/2	.8750
.1667	9/16	.2135	.5000	9/16	.5469	.8333	9/16	.8802
	5/8	.2188		5/8	.5521		5/8	.8854
	11/16	.2240		11/16	.5573		11/16	.8906
	3/4	.2292		3/4	.5625		3/4	.8958
	13/16	.2344		13/16	.5677		13/16	.9010
	7/8	.2396		7/8	.5729		7/8	.9063
	15/16	.2448		15/16	.5781		15/16	.9115
	1/16	.2552		1/16	.5885		1/16	.9219
	1/8	.2604		1/8	.5938		1/8	.9271
	3/16	.2656		3/16	.5990		3/16	.9323
	1/4	.2708		1/4	.6042		1/4	.9375
	5/16	.2760		5/16	.6094		5/16	.9427
	3/8	.2813		3/8	.6146		3/8	.9479
	7/16	.2865		7/16	.6198		7/16	.9531
3"	1/2	.2917	7"	1/2	.6250	11"	1/2	.9583
.2500	9/16	.2969	.5833	9/16	.6302	.9167	9/16	.9635
	5/8	.3021		5/8	.6354		5/8	.9688
	11/16	.3073		11/16	.6406		11/16	.9740
	3/4	.3125		3/4	.6458		3/4	.9792
	13/16	.3177		13/16	.6510		13/16	.9844
	7/8	.3229		7/8	.6563		7/8	.9896
	15/16	.3281		15/16	.6615		15/16	.9948

Member Metals Service Center Institute

Russel Metals
WILLIAMS BAHCALL

MILWAUKEE
(Sales Office/Service Center)
999 W. Armour Avenue
Milwaukee, WI 53221
414-481-7100
800-242-9396 (WI)
800-323-3559 (NTL)
Fax: 414-481-3439

APPLETON
(Sales Office/Service Center)
975 N. Meade Street
Appleton, WI 54911
920-734-9271
800-875-7624
Fax: 920-730-5858

GREEN BAY
(Service Center)
895 Hinkle Street
Green Bay, WI 54303
800-875-7624
Fax: 920-730-5858

Russel Metals
WILLIAMS BAHCALL

MISSION STATEMENT

To help our customers become a stronger force in the global economy by delivering superior value and unparalleled customer service. Our customers prefer Russel Metals *because service matters.*

VISION STATEMENT

We will be the preeminent distributor of carbon steel products in our chosen geographic markets. We will be the acknowledged benchmark for customer service by which all others in our industry will be measured. We will have a workplace grounded in professionalism and winning teamwork. And as a winning team, we will have fun.

VALUES

Integrity: We believe in absolute integrity in our business dealings with our customers and suppliers.

Creativity: We will excel at providing innovative and effective solutions to meet business challenges and to satisfy customer needs.

Courtesy: All employees will act with courtesy and respect towards other members of the organization and when representing the Company to customers and suppliers.

Personal Fulfillment: We will provide a fulfilling and supportive work environment wherein communication and teamwork are paramount.

Continuous Improvement: As a team, we will engage in ongoing improvement of our systems, procedures, processes and operations.

Quality: Our quality process is an integral part of our business activities and provides for our ongoing success.

Simplicity: We will keep it simple by not adding complexity to a process just to safeguard against some remote possibility.

Superior Performance: We will achieve superior financial performance to meet the requirements of our shareholders and to provide for the financial reward of our employees.

Russel Metals
WILLIAMS BAHCALL

QUALITY STATEMENT

Russel Metals Williams Bahcall will provide materials and services that meet or exceed customer requirements, create an environment for employees that emphasizes continuous improvement, and work to become a true partner with our customers and suppliers.

QUALITY POLICY

Business procedures are essential to continuity and communication within our organization and are to be followed as written. When procedures are identified as being no longer appropriate, effective, or efficient, they will be promptly reviewed and officially changed in accordance with our Quality Assurance Process.

Job training is the means by which we ensure that procedures are properly followed. It is the responsibility of all supervisors and department heads to ensure that each employee is trained and thoroughly understands the procedures and processes involved in her or his job.

Corrective action in response to errors will follow these five steps:

1. Identify the problem
2. Fix the error
3. Find the root cause
4. Remove that cause to prevent recurrence
5. Measure to assure that the problem does not recur

Continuous improvement is the responsibility of all employees. When processes and procedures are not working, are impeding productivity, or simply can be made better, employees are expected to identify the opportunity, to become involved in the improvement process, and to ensure that the improvements are instituted in accordance with the Quality Assurance Process.

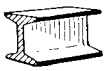
Quality forms the foundation of our organization, guides us in our daily activities, and is the ultimate measure of the value we provide to our customers.

Russel Metals
WILLIAMS BAHCALL

CONTENTS

Russel Metals
WILLIAMS BAHCALL

S BEAMS - Standard



ASTM A-36

Nominal Size	Weight per Ft. Lbs.	Thickness of Web Inches	Width of Flange Inches	Nominal Size	Weight per Ft. Lbs.	Thickness of Web Inches	Width of Flange Inches
S 3	5.7	.170	2.330	**S12**	31.8	.350	5.000
	7.5	.349	2.509		35.0	.428	5.078
S 4	7.7	.193	2.663		40.8	.462	5.252
	9.5	.326	2.796		50.0	.687	5.477
S 5	10.0	.214	3.004	**S15**	42.9	.411	5.501
					50.0	.550	5.640
S 6	12.5	.232	3.332	**S18**	54.7	.461	6.001
	17.25	.465	3.565		70.0	.711	6.251
S 7	15.3	.252	3.662	**S20**	66.0	.505	6.255
	20.0	.450	3.860	**S24**	80.0	.500	7.000
S 8	18.4	.271	4.001		100.0	.745	7.245
	23.0	.441	4.171		106.0	.620	7.870
S10	25.4	.311	4.661		121.0	.800	8.050
	35.0	.594	4.944				

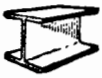
M BEAMS
JR., H or Light Beams

ASTM A-36

Nominal Size	Weight per Ft. Lbs.	Flange		Web Thickness Inches	Area Square Inches
		Width Inches	Thickness Inches		
M 5	18.9	5.003	.416	.316	5.55
M 6	4.40	1.844	.171	.114	1.29
M 8	6.50	2.281	.189	.135	1.92
M10	9.00	2.690	.206	.157	2.65
M12	11.80	3.065	.225	.177	3.47

Russel Metals
WILLIAMS BAHCALL

W BEAMS - Wide Flange



ASTM A-992

Nominal Size	Weight per Ft. Lbs.	Depth Section Inches	Flange		Web Thickness Inches
			Width Inches	Thickness Inches	
W 4 x	13.0	4.16	4.060	.371	.280
W 5 x	16.0	5.01	5.000	.360	.240
	19.0	5.15	5.030	.430	.270
W 6 x	9.0	5.90	3.940	.215	.170
	12.0	6.03	4.000	.280	.230
	15.0	5.99	5.990	.260	.230
	16.0	6.28	4.030	.405	.260
	20.0	6.20	6.020	.365	.260
	25.0	6.38	6.080	.455	.320
W 8 x	10.0	7.89	3.940	.205	.170
	13.0	7.99	4.000	.255	.230
	15.0	8.11	4.015	.315	.245
	18.0	8.14	5.250	.330	.230
	21.0	8.28	5.270	.400	.250
	24.0	7.93	6.495	.400	.245
	28.0	8.06	6.535	.465	.285
	31.0	8.00	7.995	.435	.285
	35.0	8.12	8.020	.495	.310
	40.0	8.25	8.070	.560	.360
	48.0	8.50	8.110	.685	.400
	58.0	8.75	8.220	.810	.510
	67.0	9.00	8.280	.935	.570
W10 x	12.0	9.87	3.960	.210	.190
	15.0	9.99	4.000	.270	.230
	17.0	10.11	4.010	.330	.240
	19.0	10.24	4.020	.395	.250
	22.0	10.17	5.750	.360	.240
	26.0	10.33	5.770	.440	.260
	30.0	10.47	5.810	.510	.300
	33.0	9.73	7.960	.435	.290
	39.0	9.92	7.985	.530	.315
	45.0	10.10	8.020	.620	.350
	49.0	9.98	10.000	.560	.340
	54.0	10.09	10.030	.615	.370
	60.0	10.22	10.080	.680	.420
	68.0	10.40	10.130	.770	.470
	77.0	10.60	10.190	.870	.530
	88.0	10.84	10.265	.990	.605

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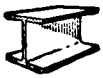
W BEAMS - Wide Flange



ASTM A-992

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Nominal Size	Weight per Ft. Lbs.	Depth of Section Inches	Flange		Web Thickness Inches
			Width Inches	Thickness Inches	
W10 x	100.0	11.10	10.340	1.120	.680
	112.0	11.36	10.415	1.250	.755
W12 x	14.0	11.91	3.970	.225	.200
	16.0	11.99	3.990	.265	.220
	19.0	12.16	4.005	.350	.235
	22.0	12.31	4.030	.425	.260
	26.0	12.22	6.490	.380	.230
	30.0	12.34	6.520	.440	.260
	35.0	12.50	6.560	.520	.300
	40.0	11.94	8.005	.515	.295
	45.0	12.06	8.045	.575	.335
	50.0	12.19	8.080	.640	.370
	53.0	12.06	9.995	.575	.345
	58.0	12.19	10.010	.640	.360
	65.0	12.12	12.000	.605	.390
	72.0	12.25	12.040	.670	.430
	79.0	12.38	12.080	.735	.470
	87.0	12.53	12.125	.810	.515
	96.0	12.71	12.160	.900	.550
	106.0	12.89	12.220	.990	.610
	120.0	13.12	12.320	1.105	.710
	136.0	13.41	12.400	1.250	.790
	190.0	14.38	12.670	1.735	1.060
W14 x	22.0	13.74	5.000	.335	.230
	26.0	13.91	5.025	.420	.255
	30.0	13.84	6.730	.385	.270
	34.0	13.98	6.745	.455	.285
	38.0	14.10	6.770	.515	.310
	43.0	13.66	7.995	.530	.305
	48.0	13.79	8.030	.595	.340
	53.0	13.92	8.060	.658	.370
	61.0	13.89	9.995	.645	.375
	68.0	14.04	10.035	.720	.415
	74.0	14.17	10.070	.785	.450
	82.0	14.31	10.130	.855	.510
	90.0	14.02	14.520	.710	.440
	99.0	14.16	14.565	.780	.485
	109.0	14.32	14.605	.860	.525
	120.0	14.48	14.670	.940	.590

continued on following page

Russel Metals
WILLIAMS BAHCALL

W BEAMS - Wide Flange

ASTM A-992

continued from preceding page

Nominal Size	Weight per Ft. Lbs.	Depth of Section Inches	Flange		Web Thickness Inches
			Width Inches	Thickness Inches	
W16 x	26.0	15.69	5.500	.345	.250
	31.0	15.88	5.525	.440	.275
	36.0	15.86	6.985	.430	.295
	40.0	16.01	6.995	.505	.305
	45.0	16.13	7.035	.565	.345
	50.0	16.26	7.070	.630	.380
	57.0	16.43	7.120	.715	.430
	67.0	16.33	10.235	.665	.395
	77.0	16.52	10.295	.760	.455
	89.0	16.75	10.365	.875	.525
	100.0	16.97	10.425	.985	.585
W18 x	35.0	17.70	6.000	.425	.300
	40.0	17.90	6.015	.525	.315
	46.0	18.06	6.060	.605	.360
	50.0	17.99	7.495	.570	.355
	55.0	18.11	7.530	.630	.390
	60.0	18.24	7.555	.695	.415
	65.0	18.35	7.590	.750	.450
	71.0	18.47	7.635	.810	.495
	76.0	18.21	11.035	.680	.425
	86.0	18.39	11.090	.770	.480
	97.0	18.59	11.145	.870	.535
	106.0	18.73	11.200	.940	.590
	119.0	18.97	11.265	1.060	.655
W21 x	44.0	20.66	6.500	.450	.350
	50.0	20.83	6.530	.535	.380
	57.0	21.06	6.555	.650	.405
	62.0	20.99	8.240	.615	.400
	68.0	21.13	8.270	.685	.430
	73.0	21.24	8.295	.740	.455
	83.0	21.43	8.355	.835	.515
	93.0	21.62	8.420	.930	.580
	101.0	21.36	12.290	.800	.500
	111.0	21.51	12.340	.875	.550
	132.0	21.83	12.440	1.035	.650
	147.0	22.06	12.510	1.150	.720
W24 x	55.0	23.57	7.005	.505	.395
	62.0	23.74	7.040	.590	.430

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W BEAMS - Wide Flange

ASTM A-992

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Nominal Size	Weight per Ft. Lbs.	Depth of Section Inches	Flange		Web Thickness Inches
			Width Inches	Thickness Inches	
W24 x	68.0	23.73	8.965	.585	.415
	76.0	23.92	8.990	.680	.440
	84.0	24.10	9.020	.770	.470
	94.0	24.31	9.065	.875	.515
	104.0	24.06	12.750	.750	.500
	117.0	24.26	12.800	.850	.550
	131.0	24.48	12.855	.960	.605
	146.0	24.74	12.900	1.090	.650
W27 x	84.0	26.71	9.960	.640	.460
	94.0	26.92	9.990	.745	.490
	102.0	27.09	10.015	.830	.515
	114.0	27.29	10.070	.930	.570
	146.0	27.38	13.965	.975	.605
W30 x	99.0	29.65	10.450	.670	.520
	108.0	29.83	10.475	.760	.545
	116.0	30.01	10.495	.850	.565
	124.0	30.17	10.515	.930	.585
	132.0	30.31	10.545	1.000	.615
	173.0	30.44	14.985	1.065	.655
	191.0	30.68	15.040	1.185	.710
	211.0	30.94	15.105	1.315	.775

TEES - BAR SIZE

ASTM A-36

Flange Inches	Stem in Inches	Stem Thickness in Inches	Weight Per Ft. Lbs.
1 1/2	1 1/2	3/16	1.90
1 1/2	1 1/2	1/4	2.43
2	2	1/4	3.62
2 1/2	2 1/2	1/4	4.60
2 1/2	2 1/2	5/16	5.50

More Tees...ST,WT,MT

In addition to the bar size sections available from stock above, any size of beam can be split to make two TEE SECTIONS.

Russel Metals
WILLIAMS BAHCALL

C CHANNELS - Bar Size

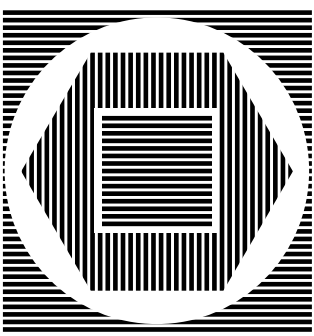
ASTM A-36

Size in Inches	Weight per Foot Lbs.	Est. Wt. 20' Bar	Size in Inches	Weight per Foot Lbs.	Est. Wt. 20' Bar
¾ x ⅜ x ⅛	.56	11.20	1½ x ¾ x ⅛	1.17	23.40
1 x ⅜ x ⅛	.68	13.60	2 x ½ x ⅛	1.43	28.60
1 x ½ x ⅛	.84	16.80	2 x 9/16 x 3/16	1.86	37.20
1⅛ x 9/16 x 3/16	1.16	23.20	2 x ⅝ x ¼	2.28	45.60
1¼ x ½ x ⅛	1.01	20.20	2 x 1 x ⅛	1.59	31.80
1½ x ½ x ⅛	1.12	22.40	2 x 1 x 3/16	2.32	46.40
1½ x 9/16 x 3/16	1.44	28.80	2½ x ⅝ x 3/16	2.27	45.40

MC CHANNELS

ASTM A-36

Size in Inches	Weight per Foot Lbs.	Est. Wt. 20' Bar	Size in Inches
8	8.5	.179	1.874
10	6.5	.152	1.127
10	8.4	.170	1.500
12	10.6	.190	1.500



C CHANNELS - Standard
MC CHANNELS - Ship & Car or Junior

ASTM A-36

Depth of Channel Inches	Weight per Ft. Lbs.	Thickness of Web Inches	Width of Flange Inches	Depth of Channel Inches	Weight per Ft. Lbs.	Thickness of Web Inches	Width of Flange Inches
C 3	4.1	.170	1.410	**MC 9**	23.9	.400	3.450
	5	.258	1.498		25.4	.450	3.500
	6	.356	1.596	**MC 10**	6.5	.152	1.127
MC 3	7.1	.312	1.938		8.4	.170	1.500
C 4	5.4	.184	1.584	**C 10**	15.3	.240	2.600
	7.25	.321	1.721		20	.379	2.739
MC 4	13.8	.500	2.500	**MC 10**	22.0	.290	3.315
				C 10	25	.526	2.886
C 5	6.7	.190	1.750	**MC 10**	25.0	.380	3.405
	9	.325	1.885		28.5	.425	3.950
C 6	8.2	.200	1.920	**C 10**	30	.673	3.033
	10.5	.314	2.034	**MC 10**	33.6	.575	4.100
MC 6	12.0	.310	2.497	**MC 12**	10.6	.190	1.500
C 6	13	.437	2.157	**C 12**	20.7	.282	2.942
MC 6	15.1	.316	2.941		25	.387	3.047
	15.3	.340	3.500		30	.510	3.170
	16.3	.375	3.000	**MC 12**	31.0	.370	3.670
	18.0	.379	3.504		35.0	.467	3.767
C 7	9.8	.210	2.090		40.0	.590	3.890
	12.25	.314	2.194		45.0	.712	4.012
MC 7	19.1	.352	3.452		50.0	.835	4.135
	22.7	.503	3.603	**MC 13**	31.8	.375	4.000
MC 8	8.5	.179	1.874		40.0	.560	4.185
					50.0	.787	4.412
C 8	11.5	.220	2.260	**C 15**	33.9	.400	3.400
	13.75	.303	2.343		40	.520	3.520
	22.8	.427	3.502		50	.716	3.716
				MC 18	42.7	.450	3.950
C 9	13.4	.233	2.433		45.8	.500	4.000
	15	.285	2.485		51.9	.600	4.100
	20	.448	2.648		58.0	.700	4.200

Russel Metals
WILLIAMS BAHCALL

BAR SIZE ANGLES

ASTM A-36

Size in Inches	Weight per Foot Lbs.	Estimated Weight 20' Bar*
½ x ½ x ⅛	.38	7.60
⅝ x ⅝ x ⅛	.48	9.60
¾ x ¾ x ⅛	.59	11.80
⅞ x ⅞ x ⅛	.70	14.00
1 x ⅝ x ⅛	.64	12.80
1 x ¾ x ⅛	.70	14.00
1 x 1 x ⅛	.80	16.00
3/16	1.16	23.20
¼	1.49	29.80
1⅛ x 1⅛ x ⅛	.90	18.00
1¼ x 1¼ x ⅛	1.01	20.20
3/16	1.48	29.60
¼	1.92	38.40
1⅜ x ⅞ x ⅛	.91	18.20
3/16	1.32	26.40
1½ x 1¼ x 3/16	1.64	32.80
1½ x 1½ x ⅛	1.23	24.60
3/16	1.80	36.00
¼	2.34	46.80
1¾ x 1¼ x ⅛	1.23	24.60
3/16	1.80	36.00
¼	2.34	46.80
1¾ x 1¾ x ⅛	1.44	28.80
3/16	2.12	42.40
¼	2.77	55.40
2 x 1¼ x 3/16	1.96	39.20
¼	2.55	51.00
2 x 1½ x ⅛	1.44	28.80
3/16	2.12	42.40
¼	2.77	55.40
2 x 2 x ⅛	1.65	33.00
3/16	2.44	48.80
¼	3.19	63.80
5/16	3.92	78.40
⅜	4.70	94.00
2½ x 1½ x 3/16	2.44	48.80
¼	3.19	63.80
5/16	3.92	78.40
2½ x 2 x 3/16	2.75	55.00
¼	3.62	72.40
5/16	4.50	90.00
⅜	5.30	106.00
2½ x 2½ x 3/16	3.07	61.40
¼	4.10	82.00
5/16	5.00	100.00
⅜	5.90	118.00
½	7.70	154.00

*Many bar size angles also available in 40'

STRUCTURAL ANGLES

ASTM A-36

Size in Inches	Weight per Ft. Lbs.	Size in Inches	Weight per Ft. Lbs.
L 3 x 2 x 3/16	3.07	**L 5** x 3 x 1/4	6.6
1/4	4.1	5/16	8.2
5/16	5.0	3/8	9.8
3/8	5.9	1/2	12.8
1/2	7.7		
		L 5 x 3 1/2 x 1/4	7.0
L 3 x 2 1/2 x 1/4	4.5	5/16	8.7
5/16	5.6	3/8	10.4
3/8	6.6	1/2	13.6
		3/4	19.8
L 3 x 3 x 3/16	3.71	**L 5** x 5 x 5/16	10.3
1/4	4.9	3/8	12.3
5/16	6.1	1/2	16.2
3/8	7.2	5/8	20.0
1/2	9.4	3/4	23.6
L 3 1/2 x 2 1/2 x 1/4	4.9	**L 6** x 3 1/2 x 5/16	9.8
5/16	6.1	3/8	11.7
3/8	7.2	1/2	15.3
1/2	9.4		
		L 6 x 4 x 5/16	10.3
L 3 1/2 x 3 x 1/4	5.4	3/8	12.3
5/16	6.6	1/2	16.2
3/8	7.9	5/8	20.0
1/2	10.2	3/4	23.6
L 3 1/2 x 3 1/2 x 1/4	5.8	**L 6** x 6 x 3/8	14.9
5/16	7.2	1/2	19.6
3/8	8.5	5/8	24.2
1/2	11.1	3/4	28.7
		7/8	33.1
L 4 x 3 x 1/4	5.8	1	37.4
5/16	7.2		
3/8	8.5	**L 7** x 4 x 3/8	13.6
1/2	11.1	1/2	17.9
		3/4	26.2
L 4 x 3 1/2 x 1/4	6.2	1	37.4
5/16	7.7		
3/8	9.1	**L 8** x 4 x 1/2	19.6
1/2	11.9	3/4	28.7
		1	37.4
L 4 x 4 x 1/4	6.6		
5/16	8.2	**L 8** x 6 x 1/2	23.0
3/8	9.8	3/4	33.8
1/2	12.8	1	44.2
5/8	15.7		
3/4	18.5	**L 8** x 8 x 1/2	26.4
		3/4	38.9
		1	51.0
		L 9 x 4 x 1/2	21.3*

*Produced by cutting an MC 18 x 45.8

Notes

CARBON STEEL PLATES

ASTM A-36*

Size in Inches	Weight per Sq. Ft.	Weight per Foot Lbs.
3/16 x 36 to 72 — Also see H.R. Sheets		
3/16 x 48	7.66	30.64
60		38.30
72		45.96
84		53.62
96		61.28
120		76.60
1/4 x 48	10.21	40.84
60		51.05
72		61.26
84		71.47
96		81.68
120		102.10
5/16 x 48	12.76	51.04
60		63.80
72		76.56
84		89.32
96		102.08
3/8 x 48	15.32	61.28
60		76.60
72		91.92
84		107.24
96		122.56
120		153.20
7/16 x 96	17.87	142.96
1/2 x 48	20.42	81.68
60		102.10
72		122.52
84		142.94
96		163.36
120		204.20
9/16 x 96	22.97	183.76
5/8 x 48	25.53	102.12
60		127.65
72		153.18
84		178.71
96		204.24
120		255.30

continued on following page

*ASME SA36 specification also applies to plates over 5/8 thick produced domestically; inquire for other sizes if ASME certification is required.

Russel Metals
WILLIAMS BAHCALL

CARBON STEEL PLATES

ASTM A-36*

continued from preceding page

Size in Inches	Weight per Sq. Ft.	Weight per Foot Lbs.
¾ x 48	30.63	122.52
60		153.15
72		183.78
84		214.41
96		245.04
120		306.30
⅞ x 48	35.74	142.96
60		178.70
96		285.92
1 x 48	40.84	163.36
60		204.20
72		245.04
84		285.88
96		326.72
120		408.40
1⅛ x 48	45.95	183.80
96		367.60
1¼ x 48	51.05	204.20
72		306.30
96		408.40
120		510.50
1⅜ x 96	56.16	449.28
1½ x 48	61.26	245.04
72		367.56
84		428.82
96		490.08
120		612.60
1⅝ x 96	66.37	530.96
1¾ x 60	71.47	357.35
96		571.76

continued on following page

*ASME SA36 specification also applies to plates over ⅝ thick produced domestically; inquire for other sizes if ASME certification is required.

CARBON STEEL PLATES

ASTM A-36*

continued from preceding page

Size in Inches	Weight per Sq. Ft.	Weight per Foot Lbs.
2 x 48	81.68	326.72
72		490.08
84		571.76
96		653.44
120		816.80
2⅛ x 96	86.78	694.24
2¼ x 96	91.89	735.12
2⅜ x 96	96.99	775.92
2½ x 48	102.10	408.40
96		816.80
2¾ x 96	112.31	898.48
3 x 72	122.52	735.12
96		980.16
3¼ x 96	132.72	1061.76
3½ x 84	142.93	1000.51
96		1143.44
3¾ x 96	153.14	1225.12
4 x 84	163.35	1143.45
96		1306.80
4¼ x 96	173.57	1388.56
4½ x 96	183.77	1470.16
4¾ x 96	193.98	1551.84
5 x 96	204.19	1633.52
5¼ x 96	214.40	1715.20
5½ x 96	224.61	1796.88
5¾ x 96	234.82	1878.56
6 x 96	245.03	1960.24
6½ x 96	265.45	2123.60
7 x 96	285.87	2286.96
7½ x 96	306.30	2450.40
8 x 96	326.71	2613.68
8½ x 96	347.13	2777.04
9 x 96	367.55	2940.40
9½ x 96	387.98	3103.84
10 x 96	408.38	3267.04
11 x 96	449.22	3593.76
12 x 96	490.06	3920.48

*ASME SA36 specification also applies to plates over ⅝ thick produced domestically; inquire for other sizes if ASME certification is required.

Russel Metals
WILLIAMS BAHCALL

CARBON STEEL PLATES
LASER QUALITY

ASTM A-36
TEMPERED LEVELED

PICKLED
AND OILED

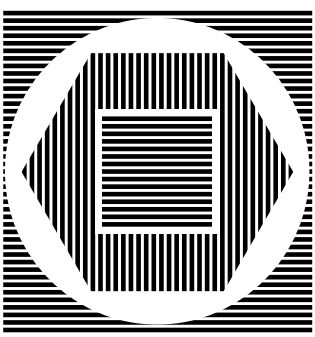
IMPROVED SURFACE QUALITY AND EXCELLENT FLATNESS STABILITY FOR LASER APPLICATIONS

Size in Inches	Weight per Sq. Ft.	Weight per Plate
3/16 x 48 x 96	7.66	245.1
48 x 120		306.4
60 x 120		382.9
1/4 x 48 x 96	10.21	326.7
48 x 120		408.4
60 x 120		510.5
72 x 120		612.6
5/16 x 48 x 120	12.76	510.5
60 x 120		638.0
3/8 x 48 x 96	15.31	489.9
48 x 120		612.4
60 x 120		765.7
1/2 x 48 x 120	20.42	816.8
60 x 120		1020.8
5/8 x 48 x 120	25.52	1020.8
60 x 120		1276.0

Notes

CARBON STEEL PLATES
C-1045

Size in Inches	Weight per Sq. Ft.	Weight per Foot Lbs.
¼ x 48	10.21	40.84
96		81.68
5/16 x 96	12.76	102.08
⅜ x 96	15.32	122.56
½ x 96	20.42	163.36
⅝ x 96	25.53	204.24
¾ x 96	30.63	245.04
⅞ x 96	35.74	285.92
1 x 96	40.84	326.72
1⅛ x 96	45.95	367.60
1¼ x 96	51.05	408.40
1½ x 96	61.26	490.08
1¾ x 96	71.47	571.76
2 x 96	81.68	653.44
2¼ x 96	91.89	735.12
2½ x 96	102.10	816.80
2¾ x 96	112.31	898.48
3 x 96	122.52	980.16
3½ x 96	142.93	1,143.44
4 x 96	163.35	1,306.80
4½ x 96	183.77	1,470.16
5 x 96	204.19	1,633.52



Russel Metals
WILLIAMS BAHCALL

HIGH STRENGTH LOW ALLOY STEEL PLATES

ASTM A-572 Gr. 50

Size in Inches	Weight per Sq. Ft.	Weight per Foot Lbs.
3/16 x 48	7.66	30.64
60		38.30
72		45.96
96		61.28
1/4 x 48	10.21	40.84
60		51.05
72		61.26
96		81.68
5/16 x 48	12.76	51.04
60		63.80
72		76.56
96		102.08
3/8 x 48	15.32	61.28
60		76.60
72		91.92
96		122.56
1/2 x 48	20.42	81.68
60		102.10
72		122.52
96		163.36
5/8 x 96	25.53	204.24
3/4 x 96	30.63	245.04
7/8 x 96	35.74	285.92
1 x 96	40.84	326.72
1 1/8 x 96	45.95	367.60
1 1/4 x 96	51.05	408.40
1 3/8 x 96	56.16	449.28
1 1/2 x 96	61.26	490.08
1 5/8 x 96	66.36	530.88
1 3/4 x 96	71.47	571.76
2 x 96	81.68	653.44
2 1/4 x 96	91.89	735.12
2 1/2 x 96	102.10	816.80
2 3/4 x 96	112.31	898.48
3 x 96	122.52	980.16
3 1/2 x 96	142.93	1,143.44
4 x 96	163.35	1,306.80
5 x 96*	204.20	1,633.60

*A-572 Gr. 42

HIGH STRENGTH LOW ALLOY STEEL PLATES

ASTM A-588 Gr. B

Size in Inches	Weight per Sq. Ft.	Weight per Foot Lbs.
½ x 96	20.42	163.36
¾ x 96	30.63	245.04
1 x 96	40.84	326.72
1½ x 96	61.26	490.08
2 x 96	81.68	653.44
3 x 96	122.52	980.16

HIGH STRENGTH LOW ALLOY PLATES WITH IMPROVED FORMABILITY

ASTM A-656 Gr. 80

Size in Inches	Weight per Sq. Ft.	Weight per Foot Lbs.
3/16 x 60	7.66	38.30
72		45.96
¼ x 60	10.21	51.05
72		61.26
⅜ x 60	15.32	76.60
72		91.92
96		122.56
½ x 60	20.42	102.10
72		122.52
96		163.36
⅝ x 48	25.53	102.12
96		204.24

Russel Metals
WILLIAMS BAHCALL

PRESSURE VESSEL QUALITY PLATES

ASTM A-516 Gr. 70
ASME SA-516 Gr. 70

Size in Inches	Weight per Sq. Ft.	Weight per Foot Lbs.
¼ x 96	10.21	81.68
5/16 x 96	12.76	102.08
⅜ x 96	15.32	122.56
½ x 96	20.42	163.36
⅝ x 96	25.53	204.24
¾ x 96	30.63	245.04
1 x 96	40.84	326.72
1¼ x 96	51.05	408.40
1⅜ x 96	56.16	440.28
1½ x 96	61.26	490.08

ABRASION RESISTING STEEL PLATES

CARBON AR-Medium | **ALLOY AR-400F**

Size in Inches	Weight per Sq. Ft.	Weight per Foot Lbs.
3/16 x 96	7.66	61.28
¼ x 96	10.21	81.68
5/16 x 96	12.76	102.08
⅜ x 96	15.32	122.56
½ x 96	20.42	163.36
⅝ x 96	25.53	204.24
¾ x 96	30.63	245.04
1 x 96	40.84	326.72
1¼ x 96	51.05	408.40
1⅜ x 96	56.16	440.28
1½ x 96	61.26	490.08
1¾ x 96	71.47	571.76
2 x 96	81.68	653.44

ALLOY STEEL PLATES

ASTM A-514
QUENCHED & TEMPERED
STRUCTURAL QUALITY

Size in Inches	Weight per Sq. Ft.	Weight per Foot Lbs.
3/16 x 96	7.66	61.28
1/4 x 96	10.21	81.68
5/16 x 96	12.76	102.08
3/8 x 96	15.32	122.56
1/2 x 96	20.42	163.36
5/8 x 96	25.53	204.24
3/4 x 96	30.63	245.04
7/8 x 96	35.74	285.92
1 x 96	40.84	326.72
1 1/8 x 96	45.95	367.60
1 1/4 x 96	51.05	408.40
1 3/8 x 96	56.16	449.28
1 1/2 x 96	61.26	490.08
1 3/4 x 96	71.47	571.76
2 x 96	81.68	653.44
2 1/4 x 96	91.89	735.12
2 1/2 x 96	102.10	816.80
3 x 96	122.52	980.16
3 1/2 x 96	142.93	1,143.44
4 x 96	163.35	1,306.80
4 1/2 x 96	173.57	1,388.56
5 x 96	204.19	1,633.52
5 1/2 x 96	224.61	1,796.88
6 x 96	245.03	1,960.24

Russel Metals
WILLIAMS BAHCALL

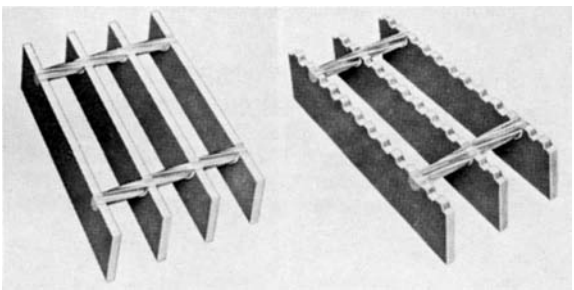
STEEL FLOOR PLATE

Conforms to ASTM A-786
MEDIUM PATTERN
14 Gauge to ½″ Thick Included

Size in Inches	Weight per Sq. Ft.	Weight per Foot Lbs.
14 Ga. x 48	3.75	15.00
12 Ga. x 48	5.25	21.00
60		26.25
⅛ x 48	6.16	24.64
72		36.96
3⁄16 x 48	8.71	34.84
60		43.55
72		52.26
¼ x 48	11.26	45.04
60	11.26	56.30
72		67.57
96		90.08
5⁄16 x 72	13.81	82.86
⅜ x 48	16.37	65.48
60		81.85
72		98.22
½ x 48	21.47	85.88
60		107.35
72		128.82

Notes

OPEN STEEL FLOOR GRATING



Smooth-surface grating Serrated-surface safety grating

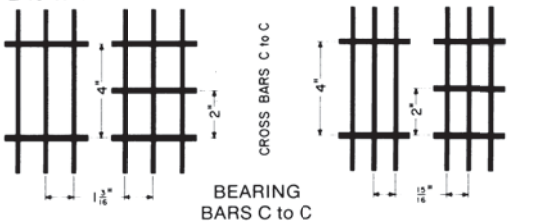
Grating available in Carbon Steel, Aluminum & Stainless

STANDARD MESH TYPES

TYPE 19-W-4 TYPE 19-W-2

CLOSE MESH TYPES

TYPE 15-W-4 TYPE 15-W-2



Usual stock width: 36″ Also available in 24″ and 48″
Usual stock length: 240″ Also available in 120″ and 288″
Other sizes also available.

WEIGHT IN LBS. PER SQ. FT.

Bearing Bars	Type 19-W-4	Type 19-W-2	Type 15-W-4	Type 15-W-2
3/4 x 1/8	4.0	4.6	4.8	5.5
3/4 x 3/16	5.6	6.3	6.9	7.5
1 x 1/8	5.1	5.7	6.2	6.9
1 x 3/16	7.3	8.0	9.0	9.6
1 1/4 x 1/8	6.1	6.8	7.5	8.2
1 1/4 x 3/16	8.9	9.6	11.1	11.7
1 1/2 x 1/8	7.3	7.9	9.0	9.6
1 1/2 x 3/16	10.6	11.2	13.1	13.8
1 3/4 x 3/16	12.2	12.9	15.2	15.8
2 x 3/16	13.9	14.5	17.3	17.9
2 1/4 x 3/16	15.4	16.1	19.2	19.9
2 1/2 x 3/16	17.1	17.7	21.3	22.0

When ordering GRATING, specify:

Type of GRATING
Size of BEARING BARS (DEPTH & WIDTH)
Span (direction of bearing bars)
Dimensions of area
Painted or Galvanized, Smooth or Serrated

Russel Metals
WILLIAMS BAHCALL

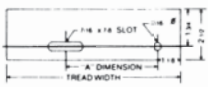
STAIRTREADS

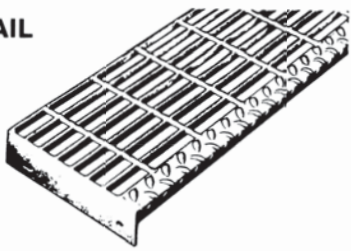
Stairtreads come complete with a carrier plate each end and checker plate nosing to ensure maximum visibility.

STANDARD

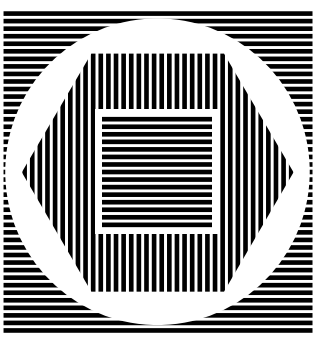
SERRATED

END PLATE DETAIL

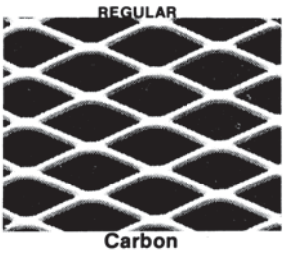




Tread Width	Number of Bearing Bars	"A" Dimension
6 3/16"	5	2 1/2"
7 3/8"	6	4 1/2"
8 9/16"	7	4 1/2"
9 3/4"	8	7"
10 15/16"	9	7"
12 1/8"	10	7"



EXPANDED METAL REGULAR



Carbon

Style Designation	Width In Inches	Length In Inches	Weight per Sq. Ft.	Approx. Size of Opening In Inches
¼ x 20	36, 48	96	.86	11/64 x 23/32
¼ x 18	36, 48	96	1.14	11/64 x 23/32
½ x 20	36, 48	96	.43	7/16 x 15/16
½ x 18	36, 48, 72	96, 120, 144	.70	7/16 x 15/16
½ x 16	36, 48, 72	96, 120, 144	.86	3/8 x 15/16
½ x 13	36, 48, 72	96, 120, 144	1.47	5/16 x 15/16
¾ x 16	36, 48, 72	96, 120, 144	.54	13/16 x 1¾
¾ x 13	36, 48, 72	96, 120, 144	.80	¾ x 1 11/16
¾ x 10	36, 48, 72	96, 120, 144	1.20	¾ x 1⅝
¾ x 9	36, 48, 72	96, 120, 144	1.80	11/16 x 1 9/16
1 x 16	48	96, 120, 144	.44	15/16 x 2 1/16
1½ x 16	48	96, 120, 144	.40	1¼ x 2⅝
1½ x 13	36, 48, 72	96, 120, 144	.60	1 3/16 x 2½
1½ x 10	36, 48, 72	96, 120, 144	.79	1 3/16 x 2½
1½ x 9	36, 48, 72	96, 120, 144	1.20	1⅛ x 2⅜
1½ x 6	36, 48, 72	96, 120, 144	2.50	1 7/64 x 2 5/16
2 x 9	48	96	.90	1 9/16 x 3⅜

The first number represents the nominal width of diamond in inches and the second number represents the approximate gauge of sheet or plate before expanding except that No. 10 is expanded from approximately No. 13 gauge. Sheets of special size can be furnished.

EXPANDED METAL GRATINGS

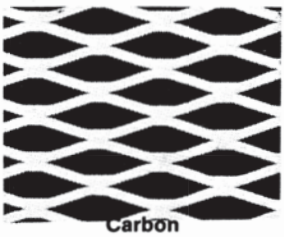
Regular

Style Designation	Width In Inches	Length In Inches	Weight per Sq. Ft.	Approx. Size of Opening In Inches
3.0 Lb. Grating	36, 48, 60, 72	96, 120, 144	3.00	15/16 x 3 7/16
3.14 Lb. Grating	36, 48, 72	120	3.14	1⅝ x 4⅞
4.0 Lb. Grating	36, 48, 60, 72	96, 120	4.00	15/16 x 3 7/16
4.27 Lb. Grating	36, 48, 72	96, 120	4.27	1 x 2⅞
6.25 Lb. Grating	36, 48, 72	96, 120	6.25	13/16 x 3⅜

Russel Metals
WILLIAMS BAHCALL

EXPANDED METAL FLATTENED

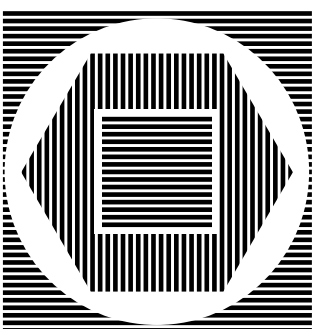
FLATTENED



Carbon

Style Designation	Width in Inches	Length in Inches	Weight per Sq. Ft.	Approx. Size of Opening in Inches
¼ x 20-22	36, 48	96	.83	3/32 x 11/16
¼ x 18-20	36, 48	96	1.11	3/32 x 11/16
½ x 20-22	36, 48	96	.40	3/8 x 1
½ x 18-20	36, 48, 72	96, 120, 144	.66	9/32 x 1
½ x 16-18	36, 48, 72	96, 120, 144	.82	¼ x 1
½ x 13-15	36, 48, 72	96, 120, 144	1.40	¼ x 1
¾ x 16-18	36, 48, 72	96, 120, 144	.51	¾ x 1¾
¾ x 14-16	36, 48, 72	96, 120	.63	11/16 x 113/16
¾ x 13-15	36, 48, 72	96, 120, 144	.75	11/16 x 125/32
¾ x 9-11	36, 48, 72	96, 120, 144	1.71	9/16 x 111/16
1 x 16-18	48	96	.41	13/16 x 2¼
1½ x 16-18	48	96	.38	1 1/16 x 2¾
1½ x 14-16	36, 48, 72	96	.46	1 1/16 x 2¾
1½ x 13-15	36, 48, 72	96	.57	1 1/16 x 2¾
1½ x 9-11	36, 48, 72	96, 120, 144	1.14	1 x 29/16

The first number represents the nominal width of diamond in inches; the second number represents the approximate original gauge before flattening and the third number represents the approximate gauge thickness after flattening.



HOT ROLLED SHEET STEEL

ASTM A-1011

Mfrs. Std. Gage & Size	Est. Wt. per Sheet
No. 7 (.1793″)	**7.50# Sq. Ft.**
48 x 96	240.0
48 x 120	300.0
48 x 144	360.0
60 x 96	300.0
60 x 120	375.0
60 x 144	450.0
72 x 120	450.0
72 x 144	540.0
Over 72″ Also See Plates	
No. 10 (.1345″)	**5.625# Sq. Ft.**
48 x 96	180.0
48 x 120	225.0
48 x 144	270.0
60 x 96	225.0
60 x 120	281.3
60 x 144	332.5
72 x 120	337.5
72 x 144	405.0
96 x 240	900.0
No. 11 (.1196″)	**5.00# Sq. Ft.**
48 x 96	160.0
48 x 120	200.0
48 x 144	240.0
60 x 120	250.0
60 x 144	300.0
72 x 120	300.0
72 x 144	360.0

Mfrs. Std. Gage & Size	Est. Wt. per Sheet
No. 11 (.1196″)	**5.00# Sq. Ft.**
72 x 240	600.0
96 x 240	800.0
No. 12 (.1046″)	**4.375# Sq. Ft.**
48 x 96	140.0
48 x 120	175.0
48 x 144	210.0
60 x 120	218.8
60 x 144	262.5
72 x 120	262.5
72 x 144	315.0
No. 14 (.0747″)	**3.125# Sq. Ft.**
36 x 120	93.8
48 x 96	100.0
48 x 120	125.0
48 x 144	150.0
60 x 120	156.3
60 x 144	187.5
72 x 120	187.5
72 x 144	225.0
No. 16 (.0598″)	**2.50# Sq. Ft.**
48 x 96	80.0
48 x 120	100.0
48 x 144	150.0
60 x 96	100.0
60 x 120	125.0

HIGH STRENGTH STEEL SHEETS

ASTM A-1011 Gr. 50

Mfrs. Std. Gage & Size	Est. Wt. per Sheet
No. 7 (.1793″)	**7.50# Sq. Ft.**
48 x 120	300.0
No. 10 (.1345″)	**5.625# Sq. Ft.**
48 x 120	225.0

Mfrs. Std. Gage & Size	Est. Wt. per Sheet
No. 12 (.1046″)	**4.375# Sq. Ft.**
48 x 120	175.0
No. 14 (.0747″)	**3.125# Sq. Ft.**
48 x 120	125.0

Russel Metals
WILLIAMS BAHCALL

HOT ROLLED STEEL SHEET

LASER QUALITY
ASTM A-1011
TEMPER LEVELED

PICKLED AND OILED

IMPROVED SURFACE QUALITY AND EXCELLENT FLATNESS STABILITY FOR LASER APPLICATIONS

Mfrs. Std. Gage & Size	Est. Wt. per Sheet
No. 7 (.1793″)	**7.50# Sq. Ft.**
48 x 120	300.0
60 x 120	375.0
72 x 120	450.0
No. 10 (.1345″)	**5.625# Sq. Ft.**
48 x 96	180.0
48 x 120	225.0
60 x 120	281.3
72 x 120	337.5
No. 11 (.1196″)	**5.00# Sq. Ft.**
48 x 96	160.0
48 x 120	200.0
60 x 120	250.0
72 x 120	300.0
No. 12 (.1046″)	**4.375# Sq. Ft.**
48 x 96	140.0
48 x 120	175.0
60 x 120	218.8
72 x 120	262.5
No. 14 (.0747″)	**3.125# Sq. Ft.**
48 x 96	100.0
48 x 120	125.0
60 x 120	156.3
No. 16 (.0598″)	**2.50# Sq. Ft.**
48 x 120	100.0

PICKLED AND OILED HOT ROLLED SHEET STEEL

ASTM A-1011

Mfrs. Std. Gage & Size	Est. Wt. per Sheet
No. 7 (.1793″)	**7.50# Sq. Ft.**
48 x 96	240.0
48 x 120	300.0
60 x 120	375.0
72 x 120	450.0
No. 8 (.1644″)	**6.875# Sq. Ft.**
48 x 96	220.0
No. 10 (.1345″)	**5.625# Sq. Ft.**
36 x 96	135.0
36 x 120	168.8
48 x 96	180.0
48 x 120	225.0
60 x 120	281.3
60 x 144	337.5
72 x 120	337.5
No. 11 (.1196″)	**5.00# Sq. Ft.**
36 x 96	120.0
36 x 120	150.0
No. 11 (.1196″)	**5.00# Sq. Ft.**
48 x 96	160.0
48 x 120	200.0
60 x 120	250.0
72 x 120	300.0
No. 12 (.1046″)	**4.375# Sq. Ft.**
48 x 96	140.0
48 x 120	175.0
60 x 120	218.8
72 x 120	262.5
No. 14 (.0747″)	**3.125# Sq. Ft.**
36 x 120	93.8
48 x 96	100.0
48 x 120	125.0
60 x 120	156.3
No. 16 (.0598″)	**2.50# Sq. Ft.**
48 x 120	100.0

COLD ROLLED STEEL SHEETS

ASTM A-1008

Mfrs. Std. Gage & Size	Est. Wt. per Sheet	Mfrs. Std. Gage & Size	Est. Wt. per Sheet
No. 11 (.1196″)	**5.00# Sq. Ft.**	**No. 18 (.0478″)**	**2.00# Sq. Ft.**
48 x 96	160.0	48 x 96	64.0
48 x 120	200.0	48 x 120	80.0
No. 12 (.1046″)	**4.375# Sq. Ft.**	60 x 120	100.0
48 x 96	140.0	**No. 20 (.0359″)**	**1.50# Sq. Ft.**
48 x 120	175.0	48 x 96	48.0
60 x 120	218.8	48 x 120	60.0
No. 14 (.0747″)	**3.125# Sq. Ft.**	60 x 120	75.0
48 x 96	100.0	**No. 22 (.0299″)**	**1.25# Sq. Ft.**
48 x 120	125.0	48 x 96	40.0
60 x 120	156.3	48 x 120	50.0
No. 16 (.0598″)	**2.50# Sq. Ft.**	**No. 24 (.0239″)**	**1.00# Sq. Ft.**
48 x 96	80.0	48 x 96	32.0
48 x 120	100.0	48 x 120	40.0
48 x 144	120.0		
60 x 120	125.0		

Russel Metals
WILLIAMS BAHCALL

GALVANIZED STEEL SHEET

ASTM A-653

Mfrs. Std. Gage & Size	Est. Wt. per Sheet
No. 10 (.1382″)	**5.781# Sq. Ft.**
48 x 120	231.2
No. 11 (.1233″)	**5.156# Sq. Ft.**
48 x 120	206.2
No. 12 (.1084″)	**4.531# Sq. Ft.**
48 x 120	181.2
60 x 120	226.6
No. 14 (.0785″)	**3.281# Sq. Ft.**
48 x 96	105.0
48 x 120	131.2
60 x 120	164.1
No. 16 (.0635″)	**2.656# Sq. Ft.**
48 x 96	85.0
48 x 120	106.2
60 x 120	132.8
No. 18 (.0516″)	**2.156# Sq. Ft.**
48 x 96	69.0
48 x 120	86.2
60 x 120	107.8
No. 20 (.0396″)	**1.656# Sq. Ft.**
48 x 96	53.0
48 x 120	66.2
60 x 120	82.8
No. 22 (.0336″)	**1.406# Sq. Ft.**
48 x 96	45.0
48 x 120	56.2
60 x 120	70.3
No. 24 (.0276″)	**1.156# Sq. Ft.**
48 x 120	46.2
60 x 120	57.8
No. 26 (.0217″)	**.906# Sq. Ft.**
48 x 120	36.2
No. 28 (.0187″)	**.781# Sq. Ft.**
36 x 120	23.4

Notes

HOT ROLLED ROUNDS

ASTM A-36

ASTM A-510 Gr. 1018

1018 Special Quality ASTM A-576

1045 Special Quality ASTM A-576

Size in Inches	Weight per Ft. Lbs.	Stock			
		ASTM A-510 Gr. 1018	ASTM A-36	1018	1045
1/4	.167	X			
5/16	.261	X			
3/8	.376	X			
7/16	.511	X			
1/2	.668		X		
9/16	.845		X		
5/8	1.043		X		
3/4	1.502		X		
7/8	2.045		X		
1	2.670		X		
1 1/8	3.380		X		
1 3/16	3.767		X		
1 1/4	4.172		X		
1 3/8	5.049		X		
1 1/2	6.008		X		
1 5/8	7.051		X		
1 3/4	8.178		X		
1 7/8	9.388		X		
2	10.68		X		
2 1/4	13.52		X		
2 3/8	15.06		X		
2 1/2	16.69		X		
2 5/8	18.40		X		
2 3/4	20.19		X		
2 7/8	22.07		X		
3	24.03		X	X	X
3 1/4	28.21			X	X
3 3/8	30.42				
3 1/2	32.71			X	X
3 5/8	35.09				
3 3/4	37.55			X	X
3 7/8	40.10				
4	42.73			X	X
4 1/4	48.23			X	X
4 1/2	54.08			X	X
4 5/8	57.12				
4 3/4	60.25			X	X
5	66.76			X	X
5 1/4	73.60			X	X
5 1/2	80.78			X	X
5 3/4	88.29			X	X

continued on following page

Russel Metals
WILLIAMS BAHCALL

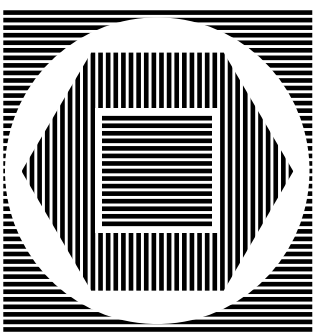
HOT ROLLED ROUNDS

1018 Special Quality ASTM A-576

1045 Special Quality ASTM A-576

continued from preceding page

Size in Inches	Weight per Ft. Lbs.	Stock		
		ASTM A-36	1018	1045
6	96.13		X	X
6¼	104.31		X	X
6½	112.82		X	X
6¾	121.67		X	X
7	130.85		X	X
7¼	140.36		X	X
7½	150.21		X	X
7¾	160.39		X	X
8	170.90		X	X
8¼	181.75		X	X
8½	192.93		X	X
8¾	204.45		X	X
9	216.30		X	X
9½	241.00		X	X
10	267.00		X	X
10½	294.70		X	X
11	323.07			X
12	384.50			X



HOT ROLLED SQUARES

ASTM A-36.

1018 Special Quality ASTM A-576

1045 Special Quality ASTM A-576

Size in Inches	Weight per Ft. Lbs.	Stock		
		A-36	1018	1045
3/8	.478	X		
7/16	.651	X		
1/2	.851	X		
5/8	1.329	X		
3/4	1.914	X		
7/8	2.605	X		
1	3.402	X		
1 1/8	4.306	X		
1 1/4	5.316	X		X
1 3/8	6.432	X		
1 1/2	7.655	X		
1 5/8	8.978	X		
1 3/4	10.413	X		
2	13.60	X		
2 1/4	17.21	X		
2 1/2	21.25	X		
2 3/4	25.71	X		
3	30.60		X	
3 1/4	35.91		X	
3 1/2	41.65		X	
4	54.40		X	
5	85.00		X	
6	122.40		X	

REINFORCING BARS

GRADES 40 & 60

ASTM A-615

Bar No.	Weight per Ft. Lbs.	Nominal Dimensions		
		Dia. Inches	Area Sq. Inches	Perimeter Inches
3	.376	.375	.11	1.178
4	.668	.500	.20	1.571
5	1.043	.625	.31	1.963
6	1.502	.750	.44	2.356
7	2.044	.875	.60	2.749
8	2.670	1.000	.79	3.142
9	3.400	1.128	1.00	3.544

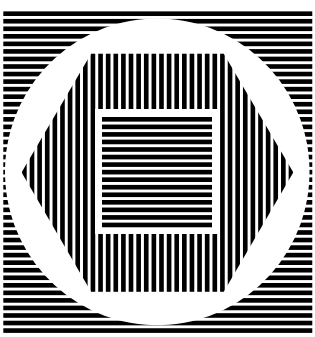
	Grade 40	Grade 60
Tensile strength, min. psi	70,000	90,000
Yield strength, min. psi	40,000	60,000

Russel Metals
WILLIAMS BAHCALL

HOT ROLLED STRIP

Low Carbon Commercial Quality
ASTM A-1011

Size in Inches	Weight per Ft. Lbs.	Size in Inches	Weight per Ft. Lbs.
1/8 (.125″)		**3/16 (.1875″)**	
½	.210	⅜	.239
⅝	.266	½	.319
¾	.319	⅝	.398
⅞	.372	¾	.478
1	.425	⅞	.558
1⅛	.478	1	.638
1¼	.531	1⅛	.717
1⅜	.584	1¼	.797
1½	.638	1⅜	.877
1¾	.744	1½	.956
2	.850	1¾	1.116
2¼	.956	2	1.275
2½	1.062	2¼	1.43
2¾	1.169	2½	1.59
3	1.275	2¾	1.75
3¼	1.381	3	1.91
3½	1.488	3¼	2.07
4	1.700	3½	2.23
4½	1.913	4	2.55
5	2.125	4½	2.87
5½	2.338	5	3.19
6	2.550	5½	3.51
7	2.975	6	3.83
8	3.400	7	4.46
		8	5.10
		10	6.38
		12	7.65



HOT ROLLED FLATS

ASTM A-36

Some sizes may be carried in special bar quality grades

Size in Inches	Weight per Ft. Lbs.	ASTM A-36
1/4 x		
⅜	.319	X
½	.425	X
⅝	.531	X
¾	.638	X
⅞	.744	X
1	.850	X
1⅛	.956	X
1¼	1.06	X
1⅜	1.17	X
1½	1.28	X
1⅝	1.38	X
1¾	1.49	X
2	1.70	X
2¼	1.91	X
2½	2.13	X
2¾	2.34	X
3	2.55	X
3¼	2.76	X
3½	2.98	X
3¾	3.19	X
4	3.40	X
4¼	3.61	X
4½	3.83	X
5	4.25	X
5½	4.68	X
6	5.10	X
7	5.95	X
8	6.80	X
9	7.65	X
10	8.50	X
11	9.36	X
12	10.21	X
5/16 x		
¾	.797	X
⅞	.930	X
1	1.06	X
1⅛	1.20	X
1¼	1.33	X
1⅜	1.46	X
1½	1.59	X
1¾	1.86	X
2	2.13	X
2¼	2.39	X
2½	2.66	X
2¾	2.92	X
3	3.19	X
3¼	3.45	X
3½	3.72	X
4	4.25	X
4½	4.78	X

Size in Inches	Weight per Ft. Lbs.	ASTM A-36
5/16 x		
5	5.31	X
5½	5.84	X
6	6.38	X
7	7.44	X
8	8.50	X
10	10.63	X
12	12.76	X
3/8 x		
½	.638	X
⅝	.797	X
¾	.956	X
⅞	1.12	X
1	1.28	X
1⅛	1.43	X
1¼	1.59	X
1⅜	1.75	X
1½	1.91	X
1⅝	2.07	X
1¾	2.23	X
2	2.55	X
2¼	2.87	X
2½	3.19	X
2¾	3.51	X
3	3.83	X
3¼	4.14	X
3½	4.46	X
4	5.10	X
4½	5.74	X
5	6.38	X
5½	7.01	X
6	7.65	X
7	8.93	X
8	10.20	X
9	11.48	X
10	12.75	X
12	15.30	X
1/2 x		
⅝	1.06	X
¾	1.28	X
⅞	1.49	X
1	1.70	X
1⅛	1.91	X
1¼	2.13	X
1⅜	2.34	X
1½	2.55	X
1⅝	2.76	X
1¾	2.98	X
2	3.40	X
2¼	3.83	X
2½	4.25	X

continued on following page

Russel Metals
WILLIAMS BAHCALL

HOT ROLLED FLATS

ASTM A-36

continued from preceding page

Size in Inches	Weight per Ft. Lbs.	ASTM A-36
1/2 x		
2¾	4.68	X
3	5.10	X
3¼	5.53	X
3½	5.95	X
4	6.80	X
4½	7.65	X
5	8.50	X
5½	9.35	X
6	10.20	X
7	11.90	X
8	13.60	X
9	15.30	X
10	17.00	X
12	20.40	X
5/8 x		
¾	1.59	X
1	2.13	X
1⅛	2.39	X
1¼	2.66	X
1⅜	2.92	X
1½	3.19	X
1⅝	3.45	X
1¾	3.72	X
2	4.25	X
2¼	4.78	X
2½	5.31	X
2¾	5.84	X
3	6.38	X
3¼	6.91	X
3½	7.44	X
4	8.50	X
4½	9.56	X
5	10.63	X
5½	11.69	X
6	12.75	X
7	14.88	X
8	17.00	X
9	19.13	X
10	21.25	X
12	25.50	X
3/4 x		
1	2.55	X
1⅛	2.87	X
1¼	3.19	X
1½	3.83	X
1⅝	4.14	X
1¾	4.46	X
2	5.10	X
2¼	5.74	X
2½	6.38	X
2¾	7.01	X
3	7.65	X
3¼	8.29	X
3½	8.93	X
4	10.20	X
4½	11.48	X
5	12.75	X
5½	14.03	X
6	15.30	X
7	17.85	X
8	20.40	X
9	22.95	X
10	25.50	X
12	30.60	X
7/8 x		
1	2.98	X
1¼	3.72	X
1⅜	4.09	X
1½	4.46	X
1¾	5.21	X
2	5.95	X
2¼	6.69	X
2½	7.44	X
2¾	8.18	X
3	8.93	X
3½	10.41	X
4	11.90	X
4½	13.39	X
5	14.88	X
5½	16.36	X
6	17.85	X
7	20.83	X
8	23.80	X
1 x		
1¼	4.25	X
1½	5.10	X
1¾	5.95	X
2	6.80	X
2¼	7.65	X
2½	8.50	X
2¾	9.35	X
3	10.20	X
3¼	11.05	X
3½	11.90	X
4	13.60	X
4½	15.30	X
5	17.00	X
5½	18.70	X
6	20.40	X
7	23.80	X

continued on following page

HOT ROLLED FLATS

ASTM A-36

continued from preceding page

Size in Inches	Weight per Ft. Lbs.	ASTM A-36
1 x		
8	27.20	X
9	30.60	X
10	34.00	X
12	40.80	X
1-1/4 x		
1½	6.28	X
2	8.50	X
2½	10.63	X
3	12.75	X
4	17.00	X
4½	19.13	X
5	21.25	X
6	25.50	X
7	29.75	X
8	34.00	X
1-1/2 x		
1¾	8.93	X
2	10.20	X
2¼	11.48	X
2½	12.75	X
3	15.30	X
4	20.40	X
5	25.50	X
6	30.60	X
8	40.80	X
1-3/4 x		
2	11.90	X
1-3/4 x		
2½	14.88	X
3	17.85	X
3½	20.83	X
4	23.80	X
5	29.75	X
2 x		
2½	17.00	X
3	20.40	X
3½	23.80	X
4	27.20	X
4½	30.60	X
5	34.00	X
6	40.80	X
2-1/4 x		
4	30.60	X
2-1/2 x		
3	25.50	X
4	34.00	X
4½	38.25	X
5	42.50	X
6	51.00	X
3 x		
4	40.80	X
5	51.00	X
6	61.20	X

HOT ROLLED FLATS

M1044 Merchant Quality
ASTM A-575

Size in Inches	Weight per Ft. Lbs.
1/4 x	
2	1.70
3	2.55
3/8 x	
1¼	1.59
2	2.55
3½	4.46
5/8 x	
2	4.25
5/8 x	
6	12.75
3/4 x	
3	7.65
4	10.20
4½	11.48
1 x	
2½	8.50

Notes

COLD FINISHED ROUNDS

1018 1045

ASTM A-108

Size in Inches	Weight per Ft. Lbs.	Stock	
		1018	1045
1/8	.042	X	
1/16	.094	X	
1/4	.167	X	
5/16	.261	X	
3/8	.376	X	
7/16	.511	X	
1/2	.668	X	X
9/16	.845	X	
5/8	1.043	X	X
11/16	1.262	X	
3/4	1.502	X	X
13/16	1.763	X	
7/8	2.045	X	X
15/16	2.347	X	X
1	2.670	X	X
1 1/16	3.015		
1 1/8	3.380	X	X
1 3/16	3.766	X	X
1 1/4	4.172	X	X
1 5/16	4.600	X	X
1 3/8	5.049	X	X
1 7/16	5.518	X	X
1 1/2	6.008	X	X
1 5/8	7.051	X	
1 11/16	7.604	X	
1 3/4	8.178	X	X
1 13/16	8.773	X	
1 7/8	9.388	X	
1 15/16	10.024	X	
2	10.68	X	X
2 1/8	12.06	X	
2 3/16	12.78	X	
2 1/4	13.52	X	X
2 5/16	14.28	X	
2 3/8	15.06	X	
2 7/16	15.87	X	
2 1/2	16.69	X	
2 5/8	18.40		X
2 3/4	20.19	X	X
2 7/8	22.07	X	
2 15/16	23.04	X	X
3	24.03	X	X
3 1/8	26.08	X	
3 3/16	27.13	X	

continued on following page

Russel Metals
WILLIAMS BAHCALL

COLD FINISHED ROUNDS

1018 1045

ASTM A-108

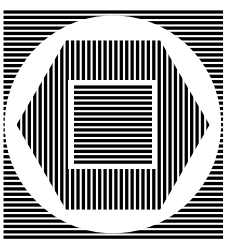
continued from preceding page

Size in Inches	Weight per Ft. Lbs.	Stock	
		1018	1045
3¼	28.21	X	X
3⅜	30.42	X	
3½	32.71	X	X
3⅝	35.09	X	
3¾	37.55	X	X
3⅞	40.10	X	X
4	42.73	X	X
4¼	48.23	X	X
4½	54.08	X	X
4⅝	57.12	X	
4¾	60.25	X	X
5	66.76	X	X
5¼	73.60	X	X
5½	80.78	X	X
5¾	88.29	X	X
6	96.13	X	X
6¼	104.31	X	X
6½	112.82	X	X
6¾	121.67	X	X

ROUNDS
STRESS RELIEVED 1144

ASTM A-311 Class B

Size In Inches	Weight per Ft. Lbs.	Size In Inches	Weight per Ft. Lbs.
½	.668	1¾	8.178
¾	1.502	1 13/16	8.773
⅞	2.045	2	10.68
1	2.670	2½	16.69
1¼	4.172	3	24.03
1½	6.008	4	42.73



TURNED GROUND AND POLISHED

SHAFTING

1045

ASTM A-108

Size In Inches	Weight per Ft. Lbs.	Stock 1045	Size In Inches	Weight per Ft. Lbs.	Stock 1045
¾	1.502	X	1¾	8.178	X
1	2.670	X	1 15/16	10.024	X
1⅛	3.380	X	2	10.68	X
1¼	4.172	X	2⅛	12.06	X
1 7/16	5.518	X	2½	16.69	X
1½	6.008	X	2 15/16	23.04	X
1⅝	7.051	X	3	24.03	X
1 11/16	7.604	X	3½	32.71	X

Notes

Russel Metals
WILLIAMS BAHCALL

COLD DRAWN HEXAGONS

1018
ASTM A-108

Size In Inches	Weight per Ft. Lbs.	Size In Inches	Weight per Ft. Lbs.
1/4	.184	1 1/8	3.73
5/16	.288	1 1/4	4.60
3/8	.414	1 5/16	5.07
7/16	.564	1 3/8	5.57
1/2	.736	1 1/2	6.63
9/16	.932	1 3/4	9.02
5/8	1.15	1 7/8	10.35
11/16	1.39	2	11.77
3/4	1.66	2 1/2	18.40
7/8	2.25	3	26.50
1	2.94	3 1/2	36.07
1 1/16	3.32	4	47.11

COLD DRAWN SQUARES

1018
ASTM A-108

Size In Inches	Weight per Ft. Lbs.	Size In Inches	Weight per Ft. Lbs.
1/8	.053	1	3.402
3/16	.120	1 1/8	4.306
1/4	.213	1 1/4	5.316
5/16	.332	1 5/16	5.861
3/8	.478	1 3/8	6.432
7/16	.651	1 1/2	7.655
1/2	.850	1 5/8	8.984
9/16	1.076	1 3/4	10.419
5/8	1.329	1 7/8	11.95
11/16	1.608	2	13.60
3/4	1.914	2 1/2	21.25
7/8	2.605	3	30.60
15/16	2.990	4	54.40

COLD DRAWN FLATS

1018

ASTM A-108

Size in Inches	Weight per Ft. Lbs.	Size in Inches	Weight per Ft. Lbs.
1/8 x		1½	1.275
⅜	.159	1¾	1.488
½	.213	2	1.700
¾	.319	2¼	1.913
1	.425	2½	2.125
1⅛	.478	3	2.550
1¼	.531	3¼	2.763
1½	.638	3½	2.975
1¾	.744	3¾	3.188
2	.850	4	3.400
2½	1.06	4¾	4.038
3	1.28	5	4.250
3½	1.49	5½	4.675
4	1.70	6	5.100
5	2.13	8	6.800
6	2.55	9	7.650
3/16 x		10	8.500
¼	.159	12	10.200
⅜	.239	**5/16 x**	
7/16	.279	½	.531
½	.319	⅝	.664
⅝	.398	¾	.797
¾	.478	1	1.063
⅞	.558	1¼	1.328
1	.638	1½	1.594
1¼	.797	1¾	1.859
1½	.956	2	2.125
1¾	1.12	3	3.188
2	1.28	4	4.250
2½	1.59	4½	4.781
3	1.91	5	5.313
3½	2.23	6	6.375
4	2.550	**3/8 x**	
4½	2.869	½	.638
5	3.188	⅝	.797
6	3.825	¾	.956
1/4 x		1	1.275
5/16	.266	1⅛	1.434
⅜	.319	1¼	1.594
½	.425	1½	1.913
⅝	.531	2	2.550
¾	.638	2½	3.188
⅞	.744	2¾	3.506
1	.850	3	3.825
1⅛	.956	3½	4.463
1¼	1.063	4	5.100
1⅜	1.169	4½	5.738

continued on following page

Russel Metals
WILLIAMS BAHCALL

COLD DRAWN FLATS

1018

ASTM A-108

Size in Inches	Weight per Ft. Lbs.
3/8 x	
5	6.375
6	7.650
8	10.200
10	12.750
12	15.300
7/16 x	
½	.744
⅝	.930
¾	1.116
1	1.488
1¼	1.859
1½	2.231
2	2.975
1/2 x	
⅝	1.063
¾	1.275
⅞	1.486
1	1.70
1¼	2.13
1⅜	2.34
1½	2.55
1¾	2.98
2	3.40
2¼	3.83
2½	4.25
2¾	4.68
3	5.10
3½	5.95
4	6.80
4½	7.65
5	8.50
5½	9.35
6	10.20
8	13.60
10	17.00
12	20.40
5/8 x	
¾	1.59
⅞	1.86
1	2.13
1⅛	2.39
1¼	2.66
1½	3.19
2	4.25
2½	5.31
3	6.38

Size in Inches	Weight per Ft. Lbs.
5/8 x	
4	8.50
5	10.63
6	12.75
8	17.00
9	19.13
10	21.25
12	25.50
3/4 x	
1	2.55
1¼	3.19
1½	3.83
2	5.10
2½	6.38
3	7.65
3¼	8.29
3½	8.93
4	10.20
4½	11.48
5	12.75
5½	14.03
6	15.30
6½	16.58
7	17.85
8	20.40
9	22.95
10	25.50
12	30.60
7/8 x	
1	2.98
1¼	3.72
1⅜	4.09
1½	4.46
2	5.95
1 x	
1⅛	3.825
1¼	4.25
1½	5.10
1¾	5.950
2	6.80
2¼	7.65
2½	8.50
2¾	9.350
3	10.20
3½	11.90
4	13.60
4½	15.30

continued on following page

COLD DRAWN FLATS

1018

ASTM A-108

Size in Inches	Weight per Ft. Lbs.
1 x	
5	17.00
5½	18.70
6	20.40
7	23.80
8	27.20
9	30.60
10	34.00
12	40.80
1-1/4 x	
1½	6.375
1¾	7.438
2	8.50
2¼	9.56
2½	10.63
2¾	11.69
3	12.75
3½	14.88
3¾	15.94
4	17.00
4½	19.13
5	21.25
5½	23.38
6	25.50
8	34.00
10	42.50
12	51.00
1-1/2 x	
1¾	8.93
2	10.20
2¼	11.48
2½	12.75
2¾	14.03
3	15.30
3½	17.85
4	20.40
4½	22.95
5	25.50
5½	28.05

Size in Inches	Weight per Ft. Lbs.
1-1/2 x	
6	30.60
8	40.80
10	51.00
12	61.20
1-3/4 x	
2	11.90
2¼	13.39
2½	14.88
2¾	16.36
3	17.85
2 x	
2¼	15.30
2½	17.00
2¾	18.70
3	20.40
3½	23.80
4	27.20
5	34.00
6	40.80
8	54.40
10	68.00
12	81.60
2-1/4 x	
2½	19.13
3	22.95
4	30.60
5	38.25
6	45.90
2-1/2 x	
3	25.50
3½	29.75
4	34.00
3 x	
4	40.80
5	51.00
6	61.20

Notes

SQUARE
ELECTRIC WELDED STEEL TUBE

LOW CARBON MECHANICAL
ASTM A-513

Size	Wall Dec.	I.D.	Wt. per Ft. Lbs.
1/2 x 1/2			
	.065	.370	.3845
5/8 x 5/8			
	.065	.495	.4950
3/4 x 3/4			
	.065	.620	.6055
	.083	.584	.7529
	.120	.510	1.028
1 x 1			
	.049	.902	.6337
	.065	.870	.8265
	.072	.856	.9200
	.083	.834	1.035
	.109	.782	1.321
	.120	.760	1.436
1-1/4 x 1-1/4			
	.049	1.152	.8003
	.065	1.120	1.048
	.083	1.084	1.317
	.109	1.032	1.691
	.120	1.010	1.844
1-1/2 x 1-1/2			
	.065	1.370	1.269
	.083	1.334	1.600
	.109	1.282	2.062
	.120	1.260	2.252
1-3/4 x 1-3/4			
	.065	1.620	1.490
	.083	1.584	1.882
	.120	1.510	2.660
2 x 2			
	.065	1.870	1.711
	.083	1.834	2.164
	.109	1.782	2.690
	.120	1.760	3.068
2-1/2 x 2-1/2			
	.065	2.370	2.153
	.083	2.334	2.728
3 x 3			
	.083	2.834	3.293

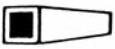
RECTANGULAR
ELECTRIC WELDED STEEL TUBE

LOW CARBON MECHANICAL
ASTM A-513

Size & Wall	Wt. per Ft. Lbs.
1½ x ¾ x .065	.9370
1½ x 1 x .083	1.317
.120	1.844
2 x 1 x .065	1.269
.083	1.600
.109	2.062
.120	2.252
2 x 1¼ x .083	1.741
2 x 1½ x .083	1.882
.120	2.660
2½ x 1 x .083	1.882
2½ x 1¼ x .083	2.023
2½ x 1½ x .083	2.164
.120	3.068
.188	4.320
3 x 1 x .083	2.164
.120	3.068
3 x 1½ x .083	2.446
3 x 2 x .083	2.728
4 x 2 x .083	3.293

Russel Metals
WILLIAMS BAHCALL

SQUARE STRUCTURAL STEEL TUBE



ASTM A-500 Gr. B

Size & Wall	Wt. per Ft. Lbs.	Size & Wall	Wt. per Ft. Lbs.
1¼ x 1¼ x .188	2.40	5 x 5 x .313	19.08
1½ x 1½ x .188	3.04	.375	22.37
.250	4.07	.500	28.43
2 x 2 x .125	3.05	6 x 6 x .188	14.53
.188	4.32	.250	19.02
.250	5.41	.313	23.34
2½ x 2½ x .125	3.90	.375	27.48
.188	5.59	.500	35.24
.250	7.11	7 x 7 x .188	17.08
3 x 3 x .125	4.75	.250	22.42
.188	6.87	.313	27.59
.250	8.81	.375	32.58
.313	10.58	.500	42.05
.375	12.80	8 x 8 x .188	19.63
3½ x 3½ x .125	5.61	.250	25.82
.188	8.15	.313	31.84
.250	10.51	.375	37.69
.313	12.70	.500	48.85
4 x 4 x .125	6.46	10 x 10 x .250	32.63
.188	9.42	.313	40.35
.250	12.21	.375	47.90
.313	14.83	.500	62.46
.375	17.27	12 x 12 x .250	39.43
.500	21.63	.313	48.86
5 x 5 x .188	11.97	.375	58.10
.250	15.62	.500	76.07

Notes

RECTANGULAR STRUCTURAL STEEL TUBE

ASTM A-500 Gr. B

Size & Wall	Wt. per Ft. Lbs.
2½ x 1½ x .188	4.32
.250	5.41
3 x 1½ x .125	3.48
.188	4.97
3 x 2 x .125	3.90
.188	5.59
.250	7.11
.313	8.44
4 x 2 x .125	4.75
.188	6.87
.250	8.81
4 x 3 x .125	5.61
.188	8.15
.250	10.15
.313	12.70
5 x 2 x .188	8.15
.250	10.15
.313	12.70
5 x 2½ x .125	5.92
.188	8.88
5 x 3 x .188	9.42
.250	12.21
.313	14.83
.375	17.27
.500	21.63
6 x 2 x .188	9.42
.250	12.21
.375	17.27
6 x 3 x .188	10.70
.250	13.91
.313	16.96
.375	19.82
.500	25.03
6 x 4 x .188	11.97
.250	15.62
.313	19.08
.375	22.37
.500	28.43
7 x 5 x .188	14.53
.250	19.02
.313	23.34
7 x 5 x .375	27.48
.500	35.24
8 x 2 x .188	11.97
.250	15.62
8 x 3 x .188	13.25
.250	17.32
.375	24.93
8 x 4 x .188	14.53
.250	19.02
.313	23.34
.375	27.48
.500	35.24
8 x 6 x .188	17.08
.250	22.42
.313	27.59
.375	32.58
.500	42.05
10 x 2 x .188	14.53
.250	19.02
10 x 3 x .250	20.72
10 x 4 x .188	17.08
.250	22.42
.375	32.58
.500	42.05
10 x 6 x .250	25.82
.313	31.84
.375	37.69
.500	48.85
10 x 8 x .250	29.23
.375	42.79
.500	55.66
12 x 2 x .188	17.08
12 x 4 x .250	25.82
.375	37.69
12 x 6 x .250	29.23
.375	42.79
.500	55.66
12 x 8 x .375	47.90
.500	62.46

Russel Metals
WILLIAMS BAHCALL

ROUND PIPE-SIZE STRUCTURAL TUBE
ASTM A-500
Black – Plain End

Size		Wall	Weight
Nominal	O.D.	Thickness	Lbs./Ft.
½	.840	.109	.85
¾	1.050	.113	1.13
1	1.315	.133	1.68
1¼	1.660	.140	2.27
1½	1.900	.145	2.72
2	2.375	.154	3.68
2½	2.875	.203	5.779
3	3.500	.216	7.58
4	4.500	.237	10.80
6	6.625	.280	18.99

Notes

CONTINUOUS WELDED STEEL PIPE

ASTM A-53

Black, Passivated and Galvanized
Plain End and Threaded and Coupled

Size Nominal	O.D.	Wall Thickness	A.S.A. Schedule	Weight, Lbs./Ft. P.E.	T & C
⅛	0.405	.068	40	0.24	0.24
		.095	80	0.31	—
¼	0.540	.088	40	0.42	0.42
		.119	80	0.54	—
⅜	0.675	.091	40 *	0.57	0.57
		.126	80	0.74	—
½	0.840	.109	40 *	0.85	0.85
		.147	80	1.09	—
¾	1.050	.113	40 *	1.13	1.13
		.154	80	1.47	—
1	1.315	.133	40 *	1.68	1.68
		.179	80	2.17	—
1¼	1.660	.140	40 *	2.27	2.28
		.191	80	3.00	—
1½	1.900	.145	40 *	2.72	2.73
		.200	80	3.63	—
2	2.375	.154	40 *	3.68	3.75
		.218	80	5.02	—
2½	2.875	.203	40 *	5.79	5.82
		.276	80	7.66	—
3	3.500	.216	40 *	7.58	7.62
		.300	80	10.25	—
3½	4.000	.226	40 *	9.11	9.20
		.318	80	12.51	—
4	4.500	.237	40 *	10.79	10.89
		.337	80	14.98	—

See Pipe Specifications in Data Section.

* Available in black passivated finish from stock.

Notes

Russel Metals
WILLIAMS BAHCALL

ELECTRIC RESISTANCE WELDED

ASTM A-53 Grade B
Black - Plain End

Size Nominal	O.D.	Wall Thickness	A.S.A. Schedule	Weight Lbs./Ft.
2	2.375	.154	40	3.65
		.218	80	5.02
2½	2.875	.203	40	5.79
		.276	80	7.66
3	3.500	.216	40	7.58
		.300	80	10.25
3½	4.000	.226	40	9.11
		.318	80	12.50
4	4.500	.237	40	10.79
		.337	80	14.98
5	5.563	.134	10	7.70
		.258	40	14.62
		.375	80	20.78
6	6.625	.134	10	9.28
		.280	40	18.97
		.432	80	28.57
8	8.625	.188	—	16.94
		.322	40	28.55
		.500	80	43.39
10	10.750	.365	40	40.48
		.500	60(E.H.)	54.74
12	12.750	.375	STD.	49.56
		.406	40	53.52
		.500	E.H.	65.42
14	14.000	.375	30(STD.)	54.57
		.500	E.H.	72.09
16	16.000	.375	30(STD.)	62.58
		.500	40(E.H.)	82.77
18	18.000	.375	STD.	70.59
		.500	E.H.	93.45

See Pipe Specifications in Data Section.

Notes

Notes

Metal Processing

Our service centers provide a dependable source of processing/fabricating services for our manufacturing and fabricating customers who are either not equipped to handle a wide variety of processes or who lack the capacity to meet peak loads. Whether requirements call for one-of-a-kind or production quantities, our services provide a number of economics and efficiencies that can reduce costs, reduce lead times, and provide needed on-time deliveries.

The following examples are typical, although not all inclusive. Contact the sales office in your marketing area with your requirements or questions.

Metal Processing/Fabricating Services

PLATE

Flame Cutting
Laser Cutting
Plasma Cutting
Forming
Grinding
Beveling
Drilling
Tapping
Machining
Punching
Shearing
Rolling
Bending
Welding
Galvanizing
Pickling & Oiling
Painting
Sand Blasting
Shot Blasting
Heat Treating
Stress Relieving
Ultrasonic Testing

BARS

Production Cutting
Miter Cutting
Bending
Forming
Threading
Machining
Plating
Deburring
Welding
Pickling &Oiling
Galvanizing
Sand Blasting
Shot Blasting
Painting

SHEET

Shearing
Blanking
Laser Cutting
Circle Shearing
Bending
Forming
Rolling
Punching
Notching
Welding
Pickling & Oiling
Galvanizing
Prepainting

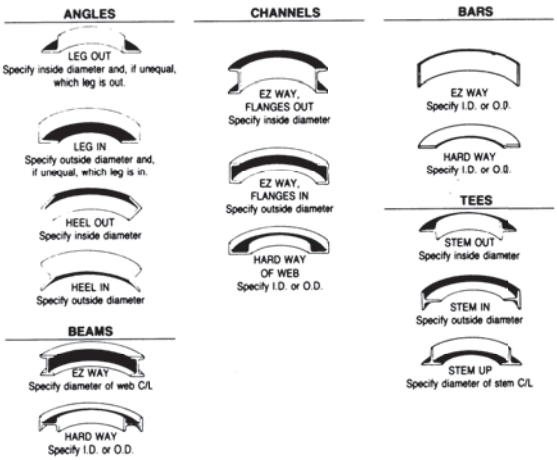
STRUCTURALS

Beam Splitting
Sawing
Bending
Forming
Miter Cutting
Punching
Welding
Rolling
Pickling & Oiling
Galvanizing
Painting & Priming
Sand Blasting
Shot Blasting
Drilling

Russel Metals
WILLIAMS BAHCALL

METALS PROCESSING

Rolled Rings



Rolled Rings
Produced to Your Specifications
From Structural Shapes and Bars

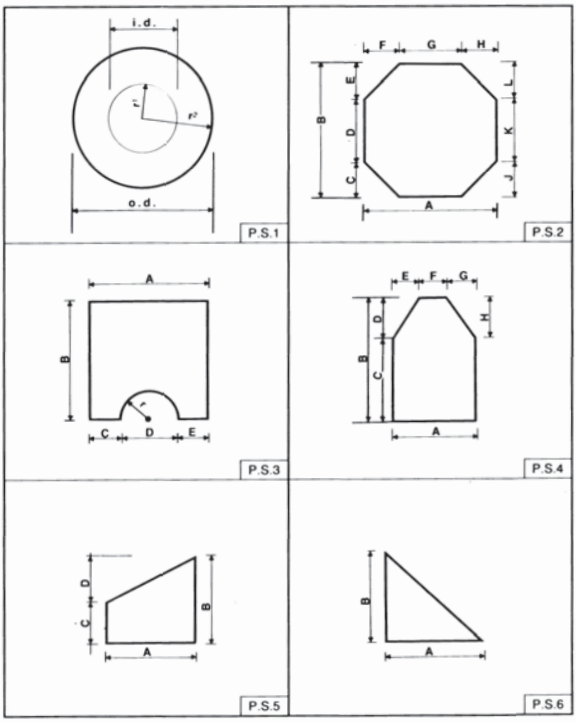
The diagrams and captions above make it easy for you to specify rolled rings and ring segments from our nearest steel service center.

In addition to the diagrammed information, your order or inquiry should also specify the following:

- Should ring joint be open butt or butt welded?
- If open, should ends be trimmed or left untrimmed? (The first and last 6 to 18 inches or a rolled length are not formed and must be trimmed before welding.)
- If trimmed, should one end or both ends be beveled?
- If butt welded by our steel service center, should weld be left "as is", or should it be rough ground, or finish ground?
- We would also like to know your end use of the product and we suggest you discuss any special requirements with a representative of our nearby steel service center.

METALS PROCESSING

Selection for Plate Shapes

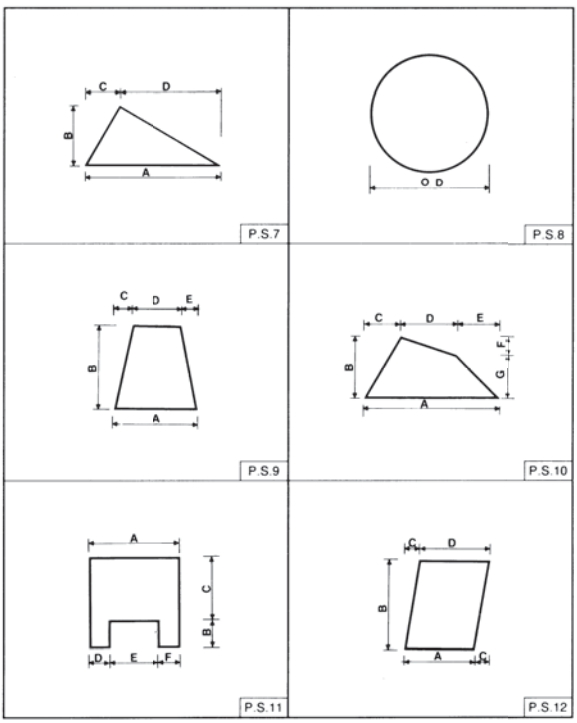


Notes: _____

Russel Metals
WILLIAMS BAHCALL

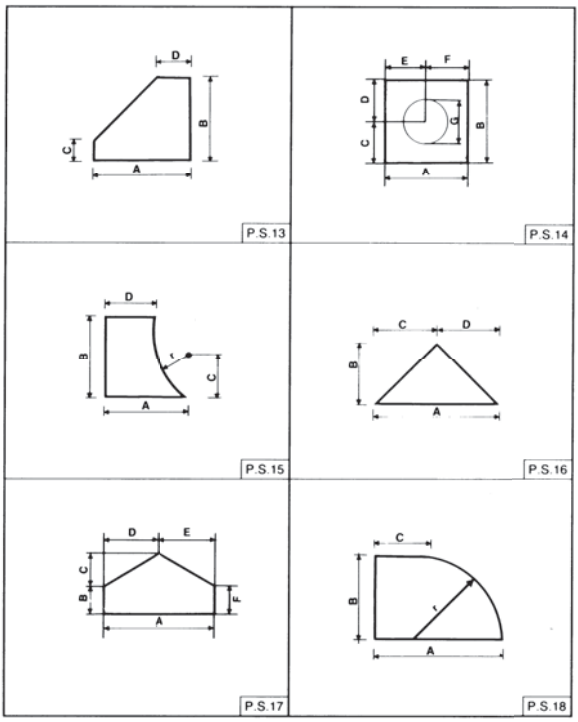
METALS PROCESSING

Selection Chart for Plate Shapes



METALS PROCESSING

Selection Chart for Plate Shapes

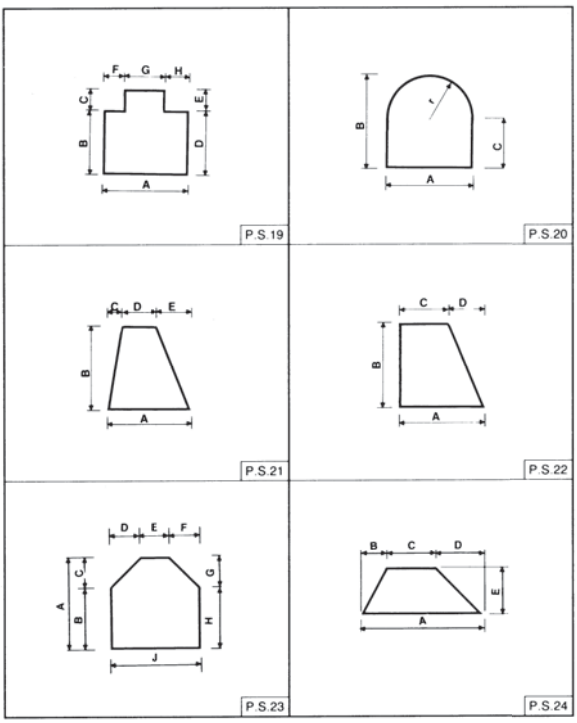


Notes: _____

Russel Metals
WILLIAMS BAHCALL

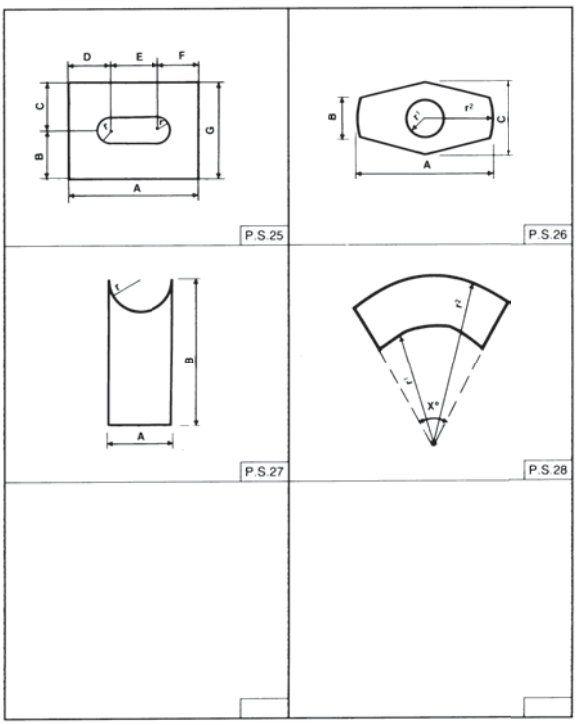
METALS PROCESSING

Selection Chart for Plate Shapes



METALS PROCESSING

Selection Chart for Plate Shapes



Notes

ASTM A6–05a

Standard Specification for General Requirements for Rolled Structural Steel Bars, Shapes & Plates

TABLE A
Permitted Variation in Product Analysis

NOTE 1—Where "..." appears in this table, there is no requirement.

Element	Upper Limit, or Maximum Specified Value, %	Permitted Variations, %	
		Under Minimum Limit	Over Maximum Limit
Carbon	to 0.15 incl	0.02	0.03
	over 0.15 to 0.40 incl	0.03	0.04
	over 0.40 to 0.75 incl	0.04	0.05
	over 0.75	0.04	0.06
Manganese[A]	to 0.60 incl	0.05	0.06
	over 0.60 to 0.90 incl	0.06	0.08
	over 0.90 to 1.20 incl	0.08	0.10
	over 1.20 to 1.35 incl	0.09	0.11
	over 1.35 to 1.65 incl	0.09	0.12
	over 1.65 to 1.95 incl	0.11	0.14
	over 1.95	0.12	0.16
Phosphorus	to 0.04 incl	...	0.010
	over 0.04 to 0.15 incl	...	[B]
Sulfur	to 0.06 incl	...	0.010
	over 0.06	[B]	[B]
Silicon	to 0.30 incl	0.02	0.03
	over 0.30 to 0.40 incl	0.05	0.05
	over 0.40 to 2.20 incl	0.06	0.06
Nickel	to 1.00 incl	0.03	0.03
	over 1.00 to 2.00 incl	0.05	0.05
	over 2.00 to 3.75 incl	0.07	0.07
	over 3.75 to 5.30 incl	0.08	0.08
	over 5.30	0.10	0.10
Chromium	to 0.90 incl	0.04	0.04
	over 0.90 to 2.00 incl	0.06	0.06
	over 2.00 to 4.00 incl	0.10	0.10
Molybdenum	to 0.20 incl	0.01	0.01
	over 0.20 to 0.40 incl	0.03	0.03
	over 0.40 to 1.15 incl	0.04	0.04
Copper	0.20 minimum only	0.02	...
	to 1.00 incl	0.03	0.03
	over 1.00 to 2.00 incl	0.05	0.05
Titanium	to 0.15 incl	0.01[C]	0.01
Vanadium	to 0.10 incl	0.01[C]	0.01
	over 0.10 to 0.25 incl	0.02	0.02
	over 0.25	0.02	0.03
	minimum only specified	0.01	...
Boron	any	[B]	[B]
Columbium	to 0.10 incl	0.01[C]	0.01
Zirconium	to 0.15 incl	0.03	0.03
Nitrogen	to 0.030 incl	0.005	0.005

[A] Permitted variations in manganese content for bars and bar size shapes shall be: to 0.90 incl ±0.03; over 0.90 to 2.20 incl ± 0.06.
[B] Product analysis not applicable.
[C] 0.005, if the minimum of the range is 0.01 %.

TABLE 1 – Permitted Variation in Thickness for Rectangular, Carbon, High-Strength, Low-Alloy, and Alloy-Steel Plates, 15 in. and Under in Thickness When Ordered to Thickness

NOTE 1—Tables 1-31, inclusive, contain permitted variations in dimensions and weight stated in inch-pound units.

NOTE 2—Permitted variation under specified thickness, 0.01 in.

NOTE 3—Thickness to be measured at ⅜ to ¾ in. from the longitudinal edge.

NOTE 4—For thicknesses measured at any location other than that specified in Note 3, the permitted variations over specified thickness shall be 1¼ times the amounts in this table, rounded to the nearest 0.01 in.

NOTE 5—Where "..." appears in this table, there is no requirement.

Specified Thickness, in.	Permitted Variations Over Specified Thickness for Widths Given in Inches, in.											
	48 and under	Over 48 to 60, excl	60 to 72, excl	72 to 84, excl	84 to 96, excl	96 to 108, excl	108 to 120, excl	120 to 132, excl	132 to 144, excl	144 to 168, excl	168 to 182, excl	182 and over
To ¼, excl	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	...	...	...
¼ to 5/16, excl	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	...	...	...
5/16 to ⅜, excl	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.05	...	...
⅜ to 7/16, excl	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.06	0.06	...
7/16 to ½, excl	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.06	0.06	...
½ to ⅝, excl	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.06	0.07	...
⅝ to ¾, excl	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.06	0.07	0.07
¾ to 1, excl	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.07	0.08	0.09
1 to 2, excl	0.05	0.06	0.06	0.08	0.06	0.07	0.08	0.10	0.10	0.11	0.13	0.16
2 to 3, excl	0.09	0.09	0.09	0.10	0.10	0.11	0.12	0.13	0.14	0.15	0.15	...
3 to 4, excl	0.11	0.11	0.11	0.11	0.11	0.13	0.14	0.14	0.14	0.15	0.17	...
4 to 6, excl	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.20	0.20	...
6 to 10, excl	0.23	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.27	0.28	...
10 to 12, excl	0.29	0.29	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.35	...
12 to 15, incl	0.29	0.29	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	...

TABLE 3 – Permitted Variation in Width and Length for Sheared Plates 1½ in. and Under in Thickness; Length Only of Universal Mill Plates 2½ in. and Under in Thickness

Specified Dimensions, in.		Permitted Variations Over Specified Width and Length[A] for Thicknesses Given in Inches or Equivalent Weights Given in Pounds per Square Foot, in.							
		To ⅜, excl		⅜ to ⅝, excl		⅝ to 1, excl		1 to 2, incl[B]	
Length	Width	To 15.3, excl		15.3 to 25.5, excl		25.5 to 40.8, excl		40.8 to 81.7, incl	
		Width	Length	Width	Length	Width	Length	Width	Length
To 120, excl	To 60, excl	⅜	½	7/16	⅝	½	¾	⅝	1
	60 to 84, excl	7/16	⅝	½	11/16	⅝	⅞	¾	1
	84 to 108, excl	½	¾	⅝	⅞	¾	1	1	1⅛
	108 and over	⅝	⅞	¾	1	⅞	1⅛	1⅛	1¼
120 to 240, excl	To 60, excl	⅜	¾	½	⅞	⅝	1	¾	1⅛
	60 to 84, excl	½	¾	⅝	⅞	¾	1	⅞	1¼
	84 to 108, excl	9/16	⅞	11/16	15/16	13/16	1⅛	1	1⅜
	108 and over	⅝	1	¾	1⅛	⅞	1¼	1⅛	1⅜
240 to 360, excl	To 60, excl	⅜	1	½	1⅛	⅝	1¼	¾	1½
	60 to 84, excl	½	1	⅝	1⅛	¾	1¼	⅞	1½
	84 to 108, excl	9/16	1	11/16	1⅛	⅞	1⅜	1	1½
	108 and over	11/16	1⅛	⅞	1¼	1	1⅜	1¼	1¾

(Table 3 cont. on Page 65)

TABLE 3 (cont. from Page 64)

Permitted Variation in Width and Length for Sheared Plates 1½ in. and Under in Thickness; Length Only of Universal Mill Plates 2½ in. and Under in Thickness

360 to 480, excl	To 60, excl	7/16	1⅛	½	1¼	⅝	1⅜	¾	1⅝
	60 to 84, excl	½	1¼	⅝	1⅜	¾	1½	⅞	1⅝
	84 to 108, excl	9/16	1¼	¾	1⅜	⅞	1½	1	1⅞
	108 and over	¾	1⅜	⅞	1½	1	1⅝	1¼	1⅞
480 to 600, excl	To 60, excl	7/16	1¼	½	1½	⅝	1⅝	¾	1⅞
	60 to 84, excl	½	1⅜	⅝	1½	¾	1⅝	⅞	1⅞
	84 to 108, excl	⅝	1⅜	¾	1½	⅞	1⅝	1	1⅞
	108 and over	¾	1½	⅞	1⅝	1	1¾	1¼	1⅞
600 to 720, excl	To 60, excl	½	1¾	⅝	1⅞	¾	1⅞	⅞	2⅛
	60 to 84, excl	⅝	1¾	¾	1⅞	⅞	1⅞	1	2⅛
	84 to 108, excl	⅝	1¾	¾	1⅞	⅞	1⅞	1⅛	2⅛
	108 and over	⅞	1¾	1	2	1⅛	2¼	1¼	2⅛
720 and over	To 60, excl	9/16	2	¾	2⅛	⅞	2¼	1	2¼
	60 to 84, excl	¾	2	⅞	2⅛	1	2¼	1⅛	2¼
	84 to 108, excl	¾	2	⅞	2⅛	1	2¼	1¼	2¼
	108 and over	1	2	1⅛	2⅜	1¼	2½	1⅜	3

[A]Permitted variation under specified width and length, ¼ in.

[B]Permitted variations in length apply alsc to Universal Mill plates up to 12 in. in width for thicknesses over 2 to 2½ in., incl, except for alloy steel up to 2 in. thick.

ASTM A6–05a

TABLE 4
Permitted Variation in Width for Mill Edge Carbon and High-Strength, Low-Alloy Plates Produced on Strip Mills (Applies to Plates Produced from Coil and to Plates Produced from an As-Rolled Structural Product)

Specified Width, in.	Permitted Variation Over Specified Width, in.[A]
To 14, excl	7/16
14 to 17, excl	1/2
17 to 19, excl	9/16
19 to 21, excl	5/8
21 to 24, excl	11/16
24 to 26, excl	13/16
26 to 28, excl	15/16
28 to 35, excl	1 1/8
35 to 50, excl	1 1/4
50 to 60, excl	1 1/2
60 to 65, excl	1 5/8
65 to 70, excl	1 3/4
70 to 80, excl	1 7/8
80 and over	2

[A]No permitted variation under specified width.

TABLE 8
Permitted Variation in Width and Length for Rectangular Plates When Gas Cuttings is Specified or Required (Applies to Alloy Steel Specifications Only).

NOTE 1—These permitted variations shall be taken all under or divided over and under, if so specified.

NOTE 2—Plates with universal rolled edges will be gas cut to length only.

Specified Thickness, in.	Permitted Variation Over Specified Width and Length, in.
To 2, excl	3/4
2 to 4, excl	1
4 to 6, excl	1 1/8
6 to 8, excl	1 5/16
8 to 15, incl	1 1/2

TABLE 9
Permitted Variation in Width and Length for Rectangular Plates When Gas Cuttings is Specified or Required (Not Applicable to Alloy Steel)

NOTE 1—These permitted variations may be taken all under or divided over and under, if so specified.

NOTE 2—Plates with universal rolled edges will be gas cut to length only.

Specified Thickness, in.	Permitted Variation Over Specified Width and Length, in.
To 2, excl	1/2
2 to 4, excl	5/8
4 to 6, excl	3/4
6 to 8, excl	7/8
8 to 15, incl	1

TABLE 12
Permitted Camber[A] for Sheared Plates and Gas-Cut Rectangular Plates, All Thicknesses (Applies to Carbon Steel Only)

Permitted camber, in. = ⅛ x (number of feet of length/5)

[A]Camber as it relates to plates in the horizontal edge curvature in the length, measured over the entire length of the plate in the flat position.

TABLE 13
Permitted Variation From a Flat Surface for Standard Flatness Carbon Steel Plates

NOTE 1—When the longer dimension is under 36 in., the permitted variation from a flat surface shall not exceed ¼ in. When the longer dimension is from 36 to 72 in., incl, the permitted variation from a flat surface shall not exceed 75 % of the tabular amount for the specified width, but in no case less than ¼ in.

NOTE 2—These permitted variations apply to plates that have a specified minimum tensile strength of not more than 60 ksi or comparable chemical composition or hardness. The limits in this table are increased 50 % for plates that have a higher specified minimum tensile strength or comparable chemical composition or hardness.

NOTE 3—This table and these notes cover the permitted variations from a flat surface for circular and sketch plates, based upon the maximum dimensions of such plates.

NOTE 4—Where "..." appears in this table, there is no requirement.

NOTE 5—Plates must be in a horizontal position on a flat surface when flatness is measured.

(Table 12 cont. on Page 68)

TABLE 13 (cont. from page 67)

Permitted Variation From a Flat Surface for Standard Flatness Carbon Steel Plates

Specified Thickness, in.	Specified Weight, lb/ft²	Permitted Variations from a Flat Surface for Specified Widths Given in Inches, in.[A,B]										
		To 36, excl	36 to 48, excl	48 to 60, excl	60 to 72, excl	72 to 84, excl	84 to 96, excl	96 to 108, excl	108 to 120, excl	120 to 144, excl	144 to 168, excl	168 and Over
To ¼ , excl	To 10.2, excl	9/16	3/4	15/16	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	...	...
¼ to 3/8 , excl	10.2 to 15.3, excl	1/2	5/8	3/4	15/16	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	...	...
3/8 to 1/2 , excl	15.3 to 20.4, excl	1/2	9/16	5/8	5/8	3/4	7/8	1	1 1/8	1 1/4	1 7/8	2 1/8
1/2 to 3/4 , excl	20.4 to 30.6, excl	7/16	1/2	9/16	5/8	5/8	3/4	1	1	1 1/8	1 1/2	2
3/4 to 1, excl	30.6 to 40.8, excl	7/16	1/2	9/16	5/8	5/8	5/8	3/4	7/8	1	1 3/8	1 3/4
1 to 2, excl	40.8 to 81.7, excl	3/8	1/2	1/2	9/16	9/16	5/8	5/8	5/8	1 1/16	1 1/8	1 1/2
2 to 4, excl	81.7 to 163.4, excl	5/16	3/8	7/16	1/2	1/2	1/2	1/2	9/16	5/8	7/8	1 1/8
4 to 6, excl	163.4 to 245.1, excl	3/8	7/16	1/2	1/2	9/16	9/16	5/8	3/4	7/8	7/8	1
6 to 8, excl	245.1 to 326.8, excl	7/16	1/2	1/2	5/8	11/16	3/4	7/8	7/8	1	1	1
8 to 10, excl	326.8 to 409.0, excl	1/2	1/2	5/8	11/16	3/4	13/16	7/8	15/16	1	1	1
10 to 12, excl	409.0 to 490.1, excl	1/2	5/8	3/4	13/16	7/8	15/16	1	1	1	1	1
12 to 15, excl	490.1 to 613.0, incl	5/8	3/4	13/16	7/8	15/16	1	1	1	1	1	...

[A] *Permitted Variation from a Flat Surface for Length*—The longer dimension specified is considered the length, and the permitted variation from a flat surface along the length shall not exceed the tabular amount for the specified width for plates up to 12 ft in length, or in any 12 ft for longer plates.

[B] *Permitted Variation from a Flat Surface for Width*—The permitted variation from a flat surface across the width shall not exceed the tabular amount for the specified width.

TABLE 14
Permitted Variation From a Flat Surface for Standard Flatness High-Strength Low-Alloy Steel and Alloy Steel Plates, Hot Rolled or Thermally Treated

NOTE 1—When the longer dimension is under 36 in., the permitted variation from a flat surface shall not exceed ⅜ in. When the longer dimension is from 36 to 72 in. incl, the permitted variation from a flat surface shall not exceed 75 % of the tabular amount for the specified width.

NOTE 2—This table and these notes cover the permitted variations from a flat surface for circular and sketch plates, based upon the maximum dimensions of such plates.

NOTE 3—Where "..." appears in this table, there is no requirement.

NOTE 4—Plates must be in a horizontal position on a flat surface when flatness is measured.

Specified Thickness, in.	Specified Weight, lb/ft²	Permitted Variations from a Flat Surface for Specified Widths, in.[A,B]										
		To 36, excl	36 to 48, excl	48 to 60, excl	60 to 72, excl	72 to 84, excl	84 to 96, excl	96 to 108, excl	108 to 120, excl	120 to 144, excl	144 to 168, excl	168 and Over
To ¼ , excl	To 10.2 excl	13/16	1⅛	1⅜	1⅝	2	2¼	2⅜	2⅝	2¾	...	...
¼ to ⅜ , excl	10.2 to 15.3, excl	¾	15/16	1⅛	1⅜	1¾	1⅞	2	2¼	2⅜	...	...
⅜ to ½ , excl	15.3 to 20.4, excl	¾	⅞	15/16	15/16	1⅛	1 5/16	1½	1⅝	1⅞	2¾	3⅛
½ to ¾ , excl	20.4 to 30.6, excl	⅝	¾	13/16	⅞	1	1⅛	1¼	1⅜	1⅝	2¼	3
¾ to 1, excl	30.6 to 40.8, excl	⅝	¾	⅞	⅞	15/16	1	1⅛	1 5/16	1⅝	2	2⅝
1 to 2, excl	40.8 to 81.7, excl	9/16	⅝	¾	13/16	⅞	15/16	1	1	1	1⅝	2¼
2 to 4, excl	81.7 to 163.4, excl	½	9/16	11/16	¾	¾	¾	¾	⅞	1	1¼	1⅝

(Table 14 cont. on Page 70)

TABLE 14 *(cont. from page 69)*

Permitted Variation From a Flat Surface for Standard Flatness High-Strength Low-Alloy Steel and Alloy Steel Plates, Hot Rolled or Thermally Treated

4 to 6, excl	163.4 to 245.1, excl	9/16	11/16	3/4	3/4	7/8	7/8	15/16	1 1/8	1 1/4	1 1/4	1 1/8
6 to 8, excl	245.1 to 326.8, excl	5/8	3/4	3/4	15/16	1	1 1/8	1 1/4	1 5/16	1 1/2	1 1/2	1 1/8
8 to 10, excl	326.8 to 409.0, excl	3/4	13/16	15/16	1	1 1/8	1 1/4	1 5/16	1 3/8	1 1/2	1 1/2	1 1/8
10 to 12, excl	409.0 to 490.1, excl	3/4	15/16	1 1/8	1 1/4	1 5/16	1 3/8	1 1/2	1 1/2	1 1/2	1 1/2	1 1/8
12 to 15, incl	490.1 to 613.0, incl	7/8	1	1 3/16	1 5/16	1 3/8	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/8

[A] *Permitted Variation from a Flat Surface for Length*—The longer dimension specified is considered the length, and the permitted variation from a flat surface along the length shall not exceed the tabular amount for the specified width in plates up to 12 ft in length, or in any 12 ft for longer plates.

[B] *Permitted Variation from a Flat Surface for Width*—The permitted variation from a flat surface across the width shall not exceed the tabular amount for the specified width.

ASTM A6–05a

TABLE 15
Permitted Variation in Waviness for Standard Flatness Plates

NOTE 1—Waviness denotes the maximum deviation of the surface of the plate from a plane parallel to the surface of the point of measurement and contiguous to the surface of the plate at each of the two adjacent wave peaks, when the plate is resting on a flat horizontal surface, as measured in an increment of less than 12 ft of length. The permitted variation in waviness is a function of the permitted variation from a flat surface as obtained from Table 13 or 14, whichever is applicable.

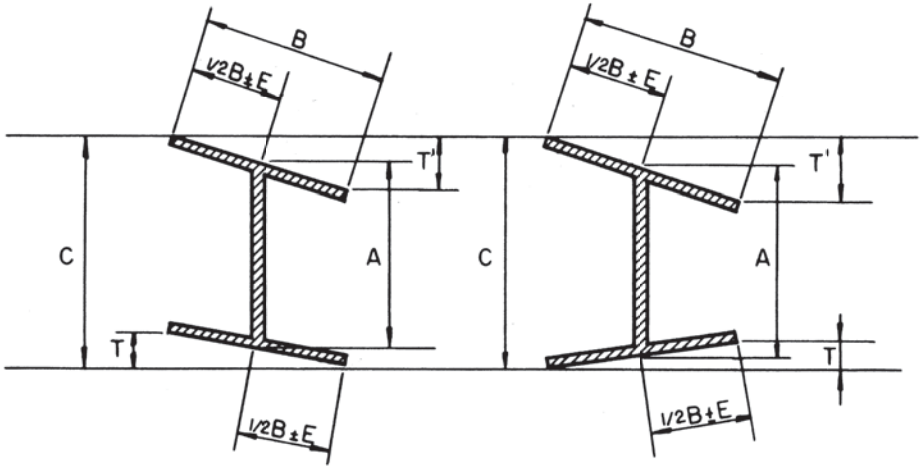
NOTE 2—Plates must be in a horizontal position on a flat surface when waviness is measured.

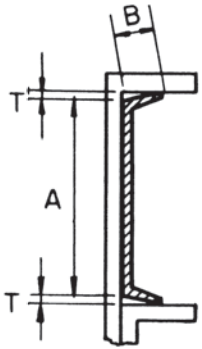
Permitted Variation from a Flat Surface (from Table 13 or 14), in.	Permitted Variation in Waviness, in., When Number of Waves in 12 ft is						
	1	2	3	4	5	6	7
5/16	5/16	1/4	3/16	1/8	1/8	1/16	1/16
3/8	3/8	5/16	3/16	3/16	1/8	1/16	1/16
7/16	7/16	5/16	1/4	3/16	1/8	1/8	1/16
1/2	1/2	3/8	5/16	3/16	3/16	1/8	1/16
9/16	9/16	7/16	5/16	1/4	3/16	1/8	1/8
5/8	5/8	1/2	3/8	1/4	3/16	1/8	1/8
11/16	11/16	1/2	3/8	5/16	3/16	3/16	1/8
3/4	3/4	9/16	7/16	5/16	1/4	3/16	1/8
13/16	13/16	5/8	7/16	5/16	1/4	3/16	1/8
7/8	7/8	11/16	1/2	3/8	1/4	3/16	1/8
15/16	15/16	11/16	1/2	3/8	5/16	1/4	3/16
1	1	3/4	9/16	7/16	5/16	1/4	3/16
1 1/8	1 1/8	7/8	5/8	1/2	3/8	1/4	3/16
1 1/4	1 1/4	15/16	11/16	1/2	3/8	5/16	1/4
1 3/8	1 3/8	1 1/16	3/4	9/16	7/16	5/16	1/4
1 1/2	1 1/2	1 1/8	7/8	5/8	1/2	3/8	1/4
1 5/8	1 5/8	1 1/4	15/16	11/16	1/2	3/8	5/16
1 3/4	1 3/4	1 5/16	1	3/4	9/16	7/16	5/16
1 7/8	1 7/8	1 7/16	1 1/16	13/16	9/16	7/16	5/16
2	2	1 1/2	1 1/8	7/8	5/8	1/2	3/8
2 1/8	2 1/8	1 5/8	1 3/16	7/8	11/16	1/2	3/8
2 1/4	2 1/4	1 11/16	1 1/4	15/16	11/16	9/16	3/8
2 3/8	2 3/8	1 13/16	1 5/16	1	3/4	9/16	7/16
2 1/2	2 1/2	1 7/8	1 7/16	1 1/16	13/16	9/16	7/16
2 5/8	2 5/8	2	1 1/2	1 1/8	13/16	5/8	7/16
2 3/4	2 3/4	2 1/16	1 9/16	1 1/8	7/8	5/8	1/2
2 7/8	2 7/8	2 3/16	1 5/8	1 3/16	15/16	11/16	1/2
3	3	2 1/4	1 11/16	1 1/4	15/16	11/16	9/16
3 1/8	3 1/8	2 3/8	1 3/4	1 5/16	1	3/4	9/16

TABLE 16 Permitted Variations in Cross Section for W, HP, S, M, C, and MC Shapes

NOTE 1—*A* is measured at center line of web for S, M, and W and HP shapes; at back of web for C and MC shapes. Measurement is overall for C shapes under 3 in. *B* is measured parallel to flange. *C* is measured parallel to web.

NOTE 2—Where "..." appears in this table, there is no requirement.





(Table 16 cont. on Page 71)

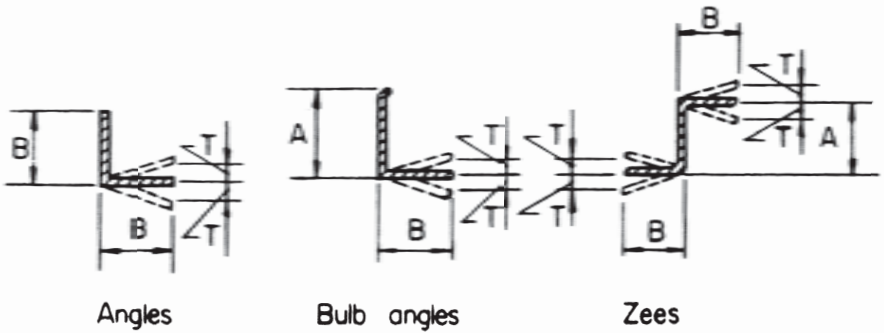
TABLE 16 *(cont. from page 72)* **Permitted Variations in Cross Section for W, HP, S, M, C, and MC Shapes**

Shape	Section Nominal Sizes, in.	Permitted Variations in Sectional Dimensions Given, in.								
		A, Depth		*B*, Flange Width		*T* + *T*′ [A] Flanges Out-of-Square[B]	*E*, Web off Center[C]	*C*, Maximum Depth at any Cross Section over Theoretical Depth, in.	Permitted Variations Over or Under Theoretical Web Thickness for Thicknesses Given in Inches, in.	
		Over Theoretical	Under Theoretical	Over Theoretical	Under Theoretical				3/16 and under	Over 3/16
W and HP	Up to 12, incl	1/8	1/8	1/4	3/16	1/4	3/16	1/4	...	...
	Over 12	1/8	1/8	1/4	3/16	5/16	3/16	1/4	...	...
S and M	3 to 7, incl	3/32	1/16	1/8	1/8	1/32	3/16	...	...	...
	Over 7 to 14, incl	1/8	3/32	5/32	5/32	1/32	3/16	...	...	...
	Over 14 to 24, incl	3/16	1/8	3/16	3/16	1/32	3/16	...	...	...
C and MC	1½ and under	1/32	1/32	1/32	1/32	1/32	...	...	0.010	0.015
	Over 1½ to 3, excl	1/16	1/16	1/16	1/16	1/32	...	...	0.015	0.020
	3 to 7, incl	3/32	1/16	1/8	1/8	1/32	...	...	...	...
	Over 7 to 14, incl	1/8	3/32	1/8	5/32	1/32	...	...	...	...
	Over 14	3/16	1/8	1/8	3/16	1/32	...	...	...	...

[A] *T* + *T*′ applies when flanges of channels are toed in or out. For channels 5/8 in. and under in depth, the permitted out-of-square is 3/64 in./in. of depth.
[B] Permitted variation is per inch of flange width for S, M, C, and MC shapes.
[C] Permitted variation of 5/16 in. max for sections over 426 lb/ft.

TABLE 17
Permitted Variations in Cross Section for Angles (L Shapes), Bulb Angles, and Zees

NOTE 1—Where "..." appears in this table, there is no requirement.



(Table 17 cont. on Page 75)

TABLE 17 (cont. from page 74)

Permitted Variations in Cross Section for Angles (L Shapes), Bulb Angles, and Zees

Section	Nominal Size, in.	Permitted Variations in Sectional Dimensions Given, in.							
		A, Depth		*B*, Flange Width or Length of Leg		*T*, Out-of-Square per Inch of *B*	Permitted Variations Over or Under Theoretical Thickness for Thicknesses Given in Inches, in.		
		Over Theoretical	Under Theoretical	Over Theoretical	Under Theoretical		3/16 and under	Over 3/16 to 3/8, incl	Over 3/8
Angles[A] (L Shapes)	1 and under	...	...	1/32	1/32	3/128[B]	0.008	0.010	...
	Over 1 to 2, incl	...	...	3/64	3/64	3/128[B]	0.010	0.010	0.01[illegible]
	Over 2 to 3, excl	...	...	1/16	1/16	3/128[B]	0.012	0.015	0.01[illegible]
	3 to 4, incl	...	...	1/8	3/32	3/128[B]	...	...	...
	Over 4 to 6, incl	...	...	1/8	1/8	3/128[B]	...	...	...
	Over 6	...	...	3/16	1/8	3/128[B]	...	...	...
Bulb angles	(Depth) 3 to 4, incl	1/8	1/16	1/8	3/32	3/128[B]	...	...	...
	Over 4 to 6, incl	1/8	1/16	1/8	1/8	3/128[B]	...	...	...
	Over 6	1/8	1/16	3/16	1/8	3/128[B]	...	...	...
Zees	3 to 4, incl	1/8	1/16	1/8	3/32	3/128[B]	...	...	...
	Over 4 to 6, incl	1/8	1/16	1/8	1/8	3/128[B]	...	...	...

[A] For unequal leg angles, longer leg determines classification.
[B] 3/128 in./in. = 1½ °.

TABLE 19
Permitted Variations in Length for S, M, C, MC, L, T, Z, and Bulb Angle Shapes

NOTE 1—Where "..." appears in this table, there is no requirement.

Nominal Size,[A] in.	Permitted Variations from Specified Length for Lengths Given in Feet, in.													
	5 to 10, excl		10 to 20,excl		20 to 30, incl		Over 30 to 40, incl		Over 40 to 50, incl		Over 50 to 65, incl		Over 65 ft	
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under
Under 3	5/8	0	1	0	1½	0	2	0	2½	0	2½	0	...	...
3 and over	1	0	1½	0	1¾	0	2¼	0	2¾	0	2¾	0	...	...

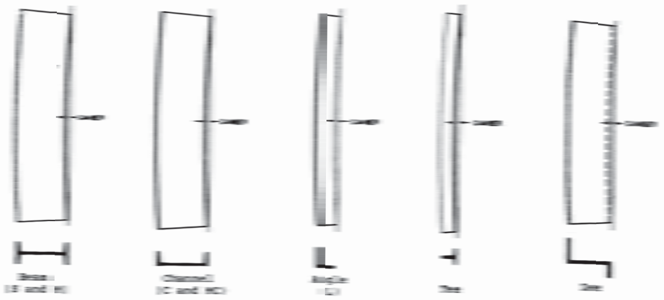
[A] Greatest cross-sectional dimension.

TABLE 20
Permitted Variations in End Out-Of-Square for S, M, C, MC, L, T, Z, and Bulb Angle Shapes

Shapes	Permitted Variation[A]
S, M, C, and MC	1/64 in. per inch of depth
L[A]	3/128 in. per inch of leg length or 1½ "
Bulb angles	3/128 in. per inch of depth or 1½ "
Rolled Tees[A]	1/64 in. per inch of flange or stem
Zees	3/128 in. per inch of sum of both flange lengths

[A] Permitted variations in end out-of-square are determined on the longer members of the shape.

TABLE 21 Permitted Variations in Straightness for S, M, C, MC, L, T, Z, and Bulb Angle Shapes



Positions for Measuring Camber of Shapes

Variable	Nominal Size,[A] in.	Permitted Variation, in.
Camber	under 3	¼ in. in any 5 ft, or ¼ × (number of feet of total length/5)
	3 and over	⅛ × (number of feet of total length/5)
Sweep	all	Due to the extreme variations in flexibility of these shapes, permitted variations for sweep are subject to negotiations between the manufacturer and the purchaser for the individual sections involved.

[A]Greatest cross-sectional dimension.

ASTM A6–05a

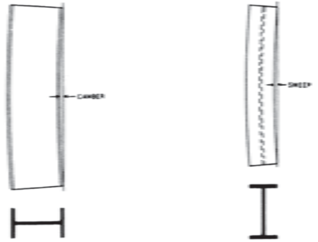
TABLE 22
Permitted Variations in Length for W and HP Shapes

W and HP Shapes	Permitted Variations from Specified Length for Lengths Given in Feet, in.[A,B]			
	30 and under		Over 30	
	Over	Under	Over	Under
Beams 24 in. and under in nominal depth	3/8	3/8	3/8 plus 1/16 for each additional 5 ft or fraction thereof	3/8
Beams over 24 in. in nominal depth and all columns	1/2	1/2	1/2 plus 1/16 for each additional 5 ft or fraction thereof	1/2

[A]For HP and W shapes specified in the order for use as bearing piles, the permitted variations in length are plus 5 in. and minus 0 in. These permitted variations in length also apply to sheet piles.

[B]The permitted variations in end out-of-square for W and HP shapes shall be 1/64 in. per inch of depth, or per inch of flange width if the flange width is larger than the depth.

TABLE 24 Permitted Variations in Straightness for W and HP Shapes



Positions for Measuring Camber and Sweep of W and HP Shapes

	Permitted Variation in Straightness, in.
Camber and sweep	⅛ × (number of feet of total length/10)[A]
When certain sections[B] with a flange width approximately equal to depth are specified in the order for use as columns:	
Lengths of 45 ft and under	⅛ × (number of feet of total length/10) but not over ⅜
Lengths over 45 ft	⅜ + [⅛ × ([number of feet of total length − 45]/10)]

[A]Sections with a flange width less than 6 in., permitted variation for sweep, in. = ⅛ × (number of feet of total length/5).

[B]Applies only to:
8-in. deep sections 31 lb/ft and heavier,
10-in. deep sections 49 lb/ft and heavier,
12-in. deep sections 65 lb/ft and heavier, and
14-in. deep sections 90 lb/ft and heavier.
For other sections specified in the order for use as columns, the permitted variation is subject to negotiation with the manufacturer.

ASTM A6–05a

TABLE 25
Permitted Variations in Dimensions for Split Tees and Split Angles (L Shapes)[A]

Specified Depth, in.	Permitted Variation Over or Under Specified Depth,[B] in.
To 6, excl (beams and channels)	1/8
6 to 16, excl (beams and channels)	3/16
16 to 20, excl (beams and channels)	1/4
20 to 24, excl (beams)	5/16
24 and over (beams)	3/8

[A]The permitted variations in length for split tees or angles are the same as those applicable to the section from which the tees or angles are split.

[B]The above permitted variations in depth of tees or angles include the permitted variations in depth for the beams or channels before splitting. Permitted variations in dimensions and straightness, as set up for the beams or channels from which these tees or angles are cut, apply, except:
straightness = 1/8 in. × (length in feet/5)

Notes

TABLE 26
Permitted Variations in Sectional Dimensions for Square-Edge and Round-Edge Flat Bars

NOTE 1—Where "..." appears in this table, there is no requirement.

Specified Widths, in.	Permitted Variations Over or Under Specified Thickness, for Thicknesses Given in Inches, in.							Permitted Variations From Specified Width, in.	
	0.203 to 0.230, excl	0.230 to ¼ , excl	¼ to ½ , incl	Over ½ to 1, incl	Over 1 to 2, incl	Over 2 to 3, incl	Over 3	Over	Under
To 1, incl	0.007	0.007	0.008	0.010	...	...	...	1/64	1/64
Over 1 to 2, incl	0.007	0.007	0.012	0.015	1/32	...	...	1/32	1/32
Over 2 to 4, incl	0.008	0.008	0.015	0.020	1/32	3/64	3/64	1/16	1/32
Over 4 to 6, incl	0.009	0.009	0.015	0.020	1/32	3/64	3/64	3/32	1/16
Over 6 to 8, incl	[A]	0.015	0.016	0.025	1/32	3/64	1/16	1/8[B]	3/32[B]

[A] Flats over 6 to 8 in., incl, in width are not available as hot-rolled carbon steel bars in thickness under 0.230 in.
[B] For flats over 6 to 8 in., in width, and to 3 in. incl in thickness.

TABLE 27
Permitted Variations in Sectional Dimensions for Round and Square Bars and Round-Cornered Squares

Specified Size, in.	Permitted Variations from Specified Size, in.		Permitted Out-of-Round or Out-of-Square, in.[A]
	Over	Under	
To 5/16	0.005	0.005	0.008
Over 5/16 to 7/16, incl	0.006	0.006	0.009
Over 7/16 to 5/8, incl	0.007	0.007	0.010
Over 5/8 to 7/8, incl	0.008	0.008	0.012
Over 7/8 to 1, incl	0.009	0.009	0.013
Over 1 to 1 1/8, incl	0.010	0.010	0.015
Over 1 1/8 to 1 1/4, incl	0.011	0.011	0.016
Over 1 1/4 to 1 3/8, incl	0.012	0.012	0.018
Over 1 3/8 to 1 1/2, incl	0.014	0.014	0.021
Over 1 1/2 to 2, incl	1/64	1/64	0.023
Over 2 to 2 1/2, incl	1/32	0	0.023
Over 2 1/2 to 3 1/2, incl	3/64	0	0.035
Over 3 1/2 to 4 1/2, incl	1/16	0	0.046
Over 4 1/2 to 5 1/2, incl	5/64	0	0.058
Over 5 1/2 to 6 1/2, incl	1/8	0	0.070
Over 6 1/2 to 8 1/4, incl	5/32	0	0.085
Over 8 1/4 to 9 1/2, incl	3/16	0	0.100
Over 9 1/2 to 10, incl	1/4	0	0.120

[A]Out-of-round is the difference between the maximum and minimum diameters of the bar, measured at the same transverse cross section. Out-of-square section is the difference in perpendicular distance between opposite faces, measured at the same transverse cross section.

ASTM A6–05a

TABLE 29
Permitted Variations in Straightness for Bars

Permitted Variations in Straightness, in.[A]
¼ in any 5 ft and ¼ × (number of feet of total length/5)

[A]Permitted variations in straightness do not apply to hot-rolled bars if any subsequent heating operation has been performed.

Notes

TABLE 30
Permitted Variations in Length for Hot-Cut Steel Bars[A]

NOTE 1—Where "..." appears in this table, there is no requirement.

Specified Sizes of Rounds, Squares, and Hexagons, in.	Specified Sizes of Flats, in.		Permitted Variations Over Specified Length Given in Feet, in. (No Variation Under)				
	Thickness	Width	5 to 10, excl	10 to 20, excl	20 to 30, excl	30 to 40, excl	40 to 60, incl
To 1, incl	To 1, incl	To 3, incl	½	¾	1¼	1¾	2¼
Over 1 to 2, incl	*Over 1*	*To 3, incl*	⅝	1	1½	2	2½
Over 1 to 2, incl	To 1, incl	Over 3 to 6, incl	⅝	1	1½	2	2½
Over 2 to 5, incl	Over 1	Over 3 to 6, incl	1	1½	1¾	2¼	2¾
Over 5 to 10, incl	...	...	2	2½	2¾	3	3¼
	0.230 to 1, incl	Over 6 to 8, incl	¾	1¼	1¾	3½	4
	Over 1 to 3, incl	Over 6 to 8, incl	1¼	1¾	2	3½	4
			Hot Sawing				
2 to 5, incl[B]	1 and over	3 and over	[B]	1½	1¾	2¼	2¾
Over 5 to 10, incl	—	—	[B]	2½	2¾	3	3¼

[A] For flats over 6 to 8 in., incl, in width and over 3 in. in thickness, consult the manufacturer for permitted variations in length.
[B] Smaller sizes and shorter lengths are not commonly hot sawed.

TABLE S27.1
Permitted Variations From a Flat Surface for As-Rolled or Normalized Carbon Steel Plates Ordered to Half-Standard Flatness

NOTE 1—*Permitted Variation From a Flat Surface Along the Length*—The longer dimension specified is considered the length, and the permitted variation from a flat surface along the length shall not exceed the tabular amount for the specified width in plates up to 12 ft. in length, or in any 12 ft. of longer plates.

NOTE 2—*Permitted Variation From a Flat Surface Across the Width*—The permitted variation from a flat surface across the width shall not exceed the tabular amount for the specified width.

NOTE 3—When the longer dimension is under 36 in., the permitted variation from a flat surface shall not exceed ¼ in. in each direction. When the longer dimension is from 36 to 72 in., incl., the permitted variation from a flat surface shall not exceed 75 % of the tabular amount for the specified width, but in no case less than ¼ in.

NOTE 4—The permitted variations given in this table apply to plates that have a minimum specified tensile strength not over 60 ksi or comparable chemistry or hardness. For plates specified to a higher minimum tensile strength or compatible chemistry or hardness, the permitted variations are 1½ times the amounts in this table.

NOTE 5—This table and these notes cover the permitted variations from a flat surface for circular and sketch plates, based upon the maximum dimensions of such plates.

NOTE 6—Permitted variations in waviness do not apply.

NOTE 7—Plates must be in a horizontal position on a flat surface when flatness is measured.

(Table S27.1 cont. on Page 85)

TABLE S27.1 *(cont. from Page 84)*

Permitted Variations From a Flat Surface for As-Rolled or Normalized Carbon Steel Plates Ordered to Half-Standard Flatness

Specified Thickness, in.	Specified Weights, lb/ft²	Permitted Variations From a Flat Surface for Specified Widths Given in Inches, in.					
		48 to 60, excl.	60 to 72, excl.	72 to 84, excl.	84 to 96, excl.	96 to 108, excl.	108 to 120, incl.
To ¼ , excl.	To 10.2, excl.	15/32	5/8	11/16	3/4	13/16	7/8
¼ to ⅜ , excl.	10.2 to 15.3, excl.	3/8	15/32	9/16	5/8	11/16	3/4
⅜ to ½ , excl.	15.3 to 20.4, excl.	5/16	5/16	3/8	7/16	1/2	9/16
½ to ¾ , excl.	20.4 to 30.6, excl.	9/32	5/16	5/16	3/8	1/2	5/8
¾ to 1, excl.	30.6 to 40.8, excl.	9/32	5/16	5/16	5/16	3/8	7/16
1 to 2, incl.	40.8 to 51.7, incl.	1/4	9/32	9/32	5/16	5/16	9/16

TABLE S27.3
Permitted Variations From a Flat Surface for As-Rolled or Normalized High-Strength Low-Alloy Steel Plates Ordered to Half-Standard Flatness

NOTE 1—*Permitted Variation From a Flat Surface Along the Length*—The longer dimension specified is considered the length, and the permitted variation from a flat surface along the length shall not exceed the tabular amount for the specified width in plates up to 12 ft. in length, or in any 12 ft. of longer plates.

NOTE 2—*Permitted Variation From a Flat Surface Across the Width*—The permitted variation from a flat surface across the width shall not exceed the tabular amount for the specified width.

NOTE 3—When the longer dimension is under 36 in., the permitted variation from a flat surface shall not exceed ⅜ in. in each direction. When the larger dimension is from 36 to 72 in., incl., the permitted variation from a flat surface shall not exceed 75 % of the tabular amount for the specified width, but in no case less than ⅜ in.

NOTE 4—This table and these notes cover the permitted variations from a flat surface for circular and sketch plates, based upon the maximum dimensions of those plates.

NOTE 5—Permitted variations in waviness do not apply.

NOTE 6—Plates must be in a horizontal position on a flat surface when flatness is measured.

(Table S27.3 cont. on Page 87)

TABLE S27.3 *(cont. frin Page 86)*
Permitted Variations From a Flat Surface for As-Rolled or Normalized High-Strength Low-Alloy Steel Plates Ordered to Half-Standard Flatness

Specified Thickness, in.	Specified Weights, lb/ft²	Permitted Variations From a Flat Surface for Specified Widths Given in Inches, in.					
		48 to 60, excl.	60 to 72, excl.	72 to 84, excl.	84 to 96, excl.	96 to 108, excl.	108 to 120, incl.
To ¼ , excl.	To 10.2 excl.	11/16	15/16	1	1 1/8	1 3/16	1 5/16
¼ to ⅜ , excl.	10.2 to 15.3, excl.	9/16	11/16	7/8	15/16	1	1 1/8
⅜ to ½ , excl.	15.3 to 20.4, excl.	15/32	15/32	9/16	21/32	¾	13/16
½ to ¾ , excl.	20.4 to 30.6, excl.	13/32	7/16	½	9/16	⅝	11/16
¾ to 1, excl.	30.6 to 40.8, excl.	7/16	7/16	15/32	½	9/16	11/16
1 to 2, incl.	40.8 to 51.7, incl.	⅜	13/32	7/16	15/32	½	⅝

ASTM A29–05

Standard Specification for General Requirements for Hot-Wrought Carbon & Alloy Steel Bars

TABLE 1 Grade Designations and Chemical Compositions of Carbon Steel Bars

Grade Designation	Heat Chemical Ranges and Limits, %			
	Carbon	Manganese	Phosphorus, max	Sulfur, max[A]
	Nonresulfurized Carbon Steels[B,C,D,E,F]			
1005	0.06 max	0.35 max	0.040	0.050
1006	0.08 max	0.25–0.40	0.040	0.050
1008	0.10 max	0.30–0.50	0.040	0.050
1010	0.08–0.13	0.30–0.60	0.040	0.050
1011	0.08–0.13	0.60–0.90	0.040	0.050
1012	0.10–0.15	0.30–0.60	0.040	0.050
1013	0.11–0.16	0.50–0.80	0.040	0.050
1015	0.13–0.18	0.30–0.60	0.040	0.050
1016	0.13–0.18	0.60–0.90	0.040	0.050
1017	0.15–0.20	0.30–0.60	0.040	0.050
1018	0.15–0.20	0.60–0.90	0.040	0.050
1019	0.15–0.20	0.70–1.00	0.040	0.050
1020	0.18–0.23	0.30–0.60	0.040	0.050
1021	0.18–0.23	0.60–0.90	0.040	0.050
1022	0.18–0.23	0.70–1.00	0.040	0.050
1023	0.20–0.25	0.30–0.60	0.040	0.050
1025	0.22–0.28	0.30–0.60	0.040	0.050
1026	0.22–0.28	0.60–0.90	0.040	0.050

(Table 1 cont. on Page 89)

TABLE 1 *(cont. from Page 88)* **Grade Designations and Chemical Compositions of Carbon Steel Bars**

Grade Designation	Heat Chemical Ranges and Limits, %			
	Carbon	Manganese	Phosphorus, max	Sulfur, max[A]
	Nonresulfurized Carbon Steels[B,C,D,E,F]			
1029	0.25–0.31	0.60–0.90	0.040	0.050
1030	0.28–0.34	0.60–0.90	0.040	0.050
1034	0.32–0.38	0.50–0.80	0.040	0.050
1035	0.32–0.38	0.60–0.90	0.040	0.050
1037	0.32–0.38	0.70–1.00	0.040	0.050
1038	0.35–0.42	0.60–0.90	0.040	0.050
1039	0.37–0.44	0.70–1.00	0.040	0.050
1040	0.37–0.44	0.60–0.90	0.040	0.050
1042	0.40–0.47	0.60–0.90	0.040	0.050
1043	0.40–0.47	0.70–1.00	0.040	0.050
1044	0.43–0.50	0.30–0.60	0.040	0.050
1045	0.43–0.50	0.60–0.90	0.040	0.050
1046	0.43–0.50	0.70–1.00	0.040	0.050
1049	0.46–0.53	0.60–0.90	0.040	0.050
1050	0.48–0.55	0.60–0.90	0.040	0.050
1053	0.48–0.55	0.70–1.00	0.040	0.050
1055	0.50–0.60	0.60–0.90	0.040	0.050
1059	0.55–0.65	0.50–0.80	0.040	0.050
1060	0.55–0.65	0.60–0.90	0.040	0.050

(Table 1 cont. on Page 90)

TABLE 1 *(cont. from Page 89)* **Grade Designations and Chemical Compositions of Carbon Steel Bars**

Grade Designation	Heat Chemical Ranges and Limits, %			
	Carbon	Manganese	Phosphorus, max	Sulfur, max[A]
	Nonresulfurized Carbon Steels[B,C,E,F]			
1064	0.60–0.70	0.50–0.80	0.040	0.050
1065	0.60–0.70	0.60–0.90	0.040	0.050
1069	0.65–0.75	0.40–0.70	0.040	0.050
1070	0.65–0.75	0.60–0.90	0.040	0.050
1071	0.65–0.70	0.75–1.05	0.040	0.050
1074	0.70–0.80	0.50–0.80	0.040	0.050
1075	0.70–0.80	0.40–0.70	0.040	0.050
1078	0.72–0.85	0.30–0.60	0.040	0.050
1080	0.75–0.88	0.60–0.90	0.040	0.050
1084	0.80–0.93	0.60–0.90	0.040	0.050
1086	0.80–0.93	0.30–0.50	0.040	0.050
1090	0.85–0.98	0.60–0.90	0.040	0.050
1095	0.90–1.03	0.30–0.50	0.040	0.050
	Resulfurized Carbon Steels[B,D,F]			
1108	0.08–0.13	0.60–0.80	0.040	0.08–0.13
1109	0.08–0.13	0.60–0.90	0.040	0.08–0.13
1110	0.08–0.13	0.30–0.60	0.040	0.08–0.13
1116	0.14–0.20	1.10–1.40	0.040	0.16–0.23

(Table 1 cont. on Page 91)

TABLE 1 *(cont. from Page 90)* **Grade Designations and Chemical Compositions of Carbon Steel Bars**

Resulfurized Carbon Steels[B,D,F]				
1117	0.14–0.20	1.00–1.30	0.040	0.08–0.13
1118	0.14–0.20	1.30–1.60	0.040	0.08–0.13
1119	0.14–0.20	1.00–1.30	0.040	0.24–0.33
1132	0.27–0.34	1.35–1.65	0.040	0.08–0.13
1137	0.32–0.39	1.35–1.65	0.040	0.08–0.13
1139	0.35–0.43	1.35–1.65	0.040	0.13–0.20
1140	0.37–0.44	0.70–1.00	0.040	0.08–0.13
1141	0.37–0.45	1.35–1.65	0.040	0.08–0.13
1144	0.40–0.48	1.35–1.65	0.040	0.24–0.33
1145	0.42–0.49	0.70–1.00	0.040	0.04–0.07
1146	0.42–0.49	0.70–1.00	0.040	0.08–0.13
1151	0.48–0.55	0.70–1.00	0.040	0.08–0.13

Rephosphorized and Resulfurized Carbon Steels[D,F]					
Grade Designation	Carbon	Manganese	Phosphorous	Sulfur	Lead
1211	0.13 max	0.60–0.90	0.07–0.12	0.10–0.15	...
1212	0.13 max	0.70–1.00	0.07–0.12	0.16–0.23	...
1213	0.13 max	0.70–1.00	0.07–0.12	0.24–0.33	...
1215	0.09 max	0.75–1.05	0.04–0.09	0.26–0.35	...
12L13	0.13 max	0.70–1.00	0.07–0.12	0.24–0.33	0.15–0.35
12L14	0.15 max	0.85–1.15	0.04–0.09	0.26–0.35	0.15–0.35
12L15	0.09 max	0.75–1.05	0.04–0.09	0.26–0.35	0.15–0.35

(Table 1 cont. on Page 92)

TABLE 1 *(cont. from Page 91)* **Grade Designations and Chemical Compositions of Carbon Steel Bars**

High-Manganese Carbon Steels[B,C,D,E,F]					
Grade Designation	Former Designation	Carbon	Manganese	Phosphorous, max	Sulfur, max
1513	...	0.10–0.16	1.10–1.40	0.040	0.050
1518	...	0.15–0.21	1.10–1.40	0.040	0.050
1522	...	0.18–0.24	1.10–1.40	0.040	0.050
1524	1024	0.19–0.25	1.35–1.65	0.040	0.050
1525	...	0.23–0.29	0.80–1.10	0.040	0.050
1526	...	0.22–0.29	1.10–1.40	0.040	0.050
1527	1027	0.22–0.29	1.20–1.50	0.040	0.050
1536	1036	0.30–0.37	1.20–1.50	0.040	0.050
1541	1041	0.36–0.44	1.35–1.65	0.040	0.050
1547	...	0.43–0.51	1.35–1.65	0.040	0.050
1548	1048	0.44–0.52	1.10–1.40	0.040	0.050
1551	1051	0.45–0.56	0.85–1.15	0.040	0.050
1552	1052	0.47–0.55	1.20–1.50	0.040	0.050
1561	1061	0.55–0.65	0.75–1.05	0.040	0.050
1566	1066	0.60–0.71	0.85–1.15	0.040	0.050
1572	1072	0.65–0.76	1.00–1.30	0.040	0.050

(Table 1 cont. on Page 93)

TABLE 1 *(cont. from Page 92)* **Grade Designations and Chemical Compositions of Carbon Steel Bars**

Heat Chemical Ranges and Limits, percent				
Merchant Quality M Series Carbon Steel Bars				
Grade Designation	Carbon	Manganese[G]	Phosphorous, max	Sulfur, max
M 1008	0.10 max	0.25–0.60	0.04	0.05
M 1010	0.07–0.14	0.25–0.60	0.04	0.05
M 1012	0.09–0.16	0.25–0.60	0.04	0.05
M 1015	0.12–0.19	0.25–0.60	0.04	0.05
M 1017	0.14–0.21	0.25–0.60	0.04	0.05
M 1020	0.17–0.24	0.25–0.60	0.04	0.05
M 1023	0.19–0.27	0.25–0.60	0.04	0.05
M 1025	0.20–0.30	0.25–0.60	0.04	0.05
M 1031	0.26–0.36	0.25–0.60	0.04	0.05
M 1044	0.40–0.50	0.25–0.60	0.04	0.05

[A] Maximum unless otherwise indicated.

[B] When silicon is required, the following ranges and limits are commonly specified: 0.10 %, max, 0.10 % to 0.20 %, 0.15 % to 0.35 %, 0.20 % to 0.40 %, or 0.30 % to 0.60 %.

[C] Copper can be specified when required as 0.20 % minimum.

[D] When lead is required as an added element to a standard steel, a range of 0.15 to 0.35 % inclusive is specified. Such a steel is identified by inserting the letter "L" between the second and third numerals of the grade designation, for example, 10 L 45. A cast or heat analysis is not determinable when lead is added to the ladle stream.

[E] When boron treatment for killed steels is specified, the steels can be expected to contain 0.0005 to 0.003 % boron. If the usual titanium additive is not permitted, the steels can be expected to contain up to 0.005 % boron.

[F] The elements bismuth, calcium, selenium, or tellurium may be added as agreed upon between purchaser and supplier.

[G] Unless prohibited by the purchaser, the manganese content may exceed 0.60 % on heat analysis to a maximum of 0.75 %, provided the carbon range on heat analysis has the minimum and maximum reduced by 0.01 % for each 0.05 % manganese over 0.60 %.

ASTM A29–05

TABLE 3
Heat Analysis Chemical Ranges and Limits of Carbon Steel Bars

Element	Chemical Ranges and Limits, %		
	When Maximum of Specified Elements is:	Range	Lowest Maximum
Carbon[A]	...	...	0.06
	to 0.12, incl	...	...
	over 0.12 to 0.25, incl	0.05	...
	over 0.25 to 0.40, incl	0.06	...
	over 0.40 to 0.55, incl	0.07	...
	over 0.55 to 0.80, incl	0.10	...
	over 0.80	0.13	...
Manganese	...	...	0.35
	to 0.40, incl	0.15	...
	over 0.40 to 0.50, incl	0.20	...
	over 0.50 to 1.65, incl	0.30	...
Phosphorus	to 0.040, incl	...	0.040[B]
	over 0.040 to 0.08, incl	0.03	...
	over 0.08 to 0.13, incl	0.05	...
Sulfur	to 0.050, incl	...	0.050[B]
	over 0.050 to 0.09, incl	0.03	...
	over 0.09 to 0.15, incl	0.05	...
	over 0.15 to 0.23, incl	0.07	...
	over 0.23 to 0.50, incl	0.09	...
Silicon[C]	...	...	0.10
	to 0.10, incl	...	...
	over 0.10 to 0.15, incl	0.08	...
	over 0.15 to 0.20, incl	0.10	...
	over 0.20 to 0.30, incl	0.15	...
	over 0.30 to 0.60, incl	0.20	...
Copper	When copper is required 0.20 min is generally used		
Lead[D]	When lead is required, a range of 0.15 to 0.35 is specified		
Bismuth[E]			
Calcium[E]			
Selenium[E]			
Tellurium[E]			

[A] The carbon ranges shown in the column headed "Range" apply when the specified maximum limit for manganese does not exceed 1.10 %. When the maximum manganese limit exceeds 1.10 %, add 0.01 to the carbon ranges shown above.

[B] For steels produced in merchant quality the phosphorus maximum is 0.04 % and the sulfur maximum is 0.05 %.

[C] It is not common practice to produce a rephosphorized and resulfurized carbon steel to specified limits for silicon because of its adverse effect on machinability.

[D] A cast or heat analysis is not determinable when lead is added to the ladle stream.

[E] Element specification range as agreed upon between purchaser and supplier.

ASTM A29–05

TABLE 5
Permissible Variations for Product Analysis of Carbon Steel

Element	Limit, or Maximum of Specified Range, %	Over Maximum Limit, %	Under Minimum Limit, %
Carbon[A]	0.25 and under	0.02	0.02
	over 0.25 to 0.55, incl	0.03	0.03
	over 0.55	0.04	0.04
Manganese	0.90 and under	0.03	0.03
	over 0.90 to 1.65, incl	0.06	0.06
Phosphorus[A,B]	basic steels	0.008	...
	acid bessemer steel	0.01	0.01
Sulfur[A,B]		0.008	...
Silicon	0.35 and under	0.02	0.02
	over 0.35 to 0.60, incl	0.05	0.05
Copper	under minimum only	...	0.02
Lead[C]	0.15 to 0.35, incl	0.03	0.03

[A] Rimmed and capped steels are not subject to rejection on product analysis unless misapplication is clearly indicated.

[B] Resulfurized or rephosphorized steels are not subject to rejection on product analysis for these elements unless misapplication is clearly indicated.

[C] Product analysis tolerance for lead applies both over and under to a specified range of 0.15 to 0.35 %.

TABLE A1.1
Permissible Variations in Cross Section for Hot-Wrought Round, Square, and Round-Cornered Square Bars of Steel

Specified Size, in.	Permissible Variation from Specified Size, in.[A]		Out-of-Round or Out-of-Square, in.[B]
	Over	Under	
To 5/16, incl	0.005	0.005	0.008
Over 5/16 to 7/16, incl	0.006	0.006	0.009
Over 7/16 to 5/8, incl	0.007	0.007	0.010
Over 5/8 to 7/8, incl	0.008	0.008	0.012
Over 7/8 to 1, incl	0.009	0.009	0.013
Over 1 to 1 1/8, incl	0.010	0.010	0.015
Over 1 1/8 to 1 1/4, incl	0.011	0.011	0.016
Over 1 1/4 to 1 3/8, incl	0.012	0.012	0.018
Over 1 3/8 to 1 1/2, incl	0.014	0.014	0.021
Over 1 1/2 to 2, incl	1/64	1/64	0.023
Over 2 to 2 1/2, incl	1/32	0	0.023
Over 2 1/2 to 3 1/2, incl	3/64	0	0.035
Over 3 1/2 to 4 1/2, incl	1/16	0	0.046
Over 4 1/2 to 5 1/2, incl	5/64	0	0.058
Over 5 1/2 to 6 1/2, incl	1/8	0	0.070
Over 6 1/2 to 8 1/4, incl	5/32	0	0.085
Over 8 1/4 to 9 1/2, incl	3/16	0	0.100
Over 9 1/2 to 10, incl	1/4	0	0.120

[A] Steel bars are regularly cut to length by shearing or hot sawing, which can cause end distortion resulting in those portions of the bar being outside the applicable size tolerance. When this end condition is objectionable, a machine cut end should be considered.

[B] Out-of-round is the difference between the maximum and minimum diameters of the bar, measured at the same cross section. Out-of-square is the difference in the two dimensions at the same cross section of a square bar between opposite faces.

ASTM A29–05

TABLE A1.2
Permissible Variations in Cross Section for Hot-Wrought Hexagonal Bars of Steel

Specified Sizes Between Opposite Sides, in.	Permissible Variations from Specified Size, in.[A]		Out-of-Hexagon (Carbon Steel and Alloy Steel) or Out-of-Octagon (Alloy Steel), in.[B]
	Over	Under	
To ½ , incl	0.007	0.007	0.011
Over ½ to 1, incl	0.010	0.010	0.015
Over 1 to 1½ , incl	0.021	0.013	0.025
Over 1½ to 2, incl	1/32	1/64	1/32
Over 2 to 2½ , incl	3/64	1/64	3/64
Over 2½ to 3½ , incl	1/16	1/64	1/16
Over 3½ to 4 1/16 , incl	5/64	1/64	5/64

[A] Steel bars are regularly cut to length by shearing or hot sawing, which can cause end distortion resulting in those portions of the bar being outside the applicable size tolerance. When this end condition is objectionable, a machine cut end should be considered.

[B] Out-of-hexagon or out-of-octagon is the greatest difference between any two dimensions at the same cross section between opposite faces.

Notes

TABLE A1.3
Permissible Variations in Thickness and Width for Hot-Wrought Square Edge and Round Edge Flat Bars[A]

Specified Width, in.	Permissible Variations in Thickness, for Thickness Given, Over and Under, in.[B]							Permissible Variations in Width, in.	
	0.203 to 0.230, excl	0.230 to ¼, excl	¼ to ½, incl	Over ½ to 1, incl	Over 1 to 2, incl	Over 2 to 3, incl	Over 3	Over	Under
To 1, incl	0.007	0.007	0.008	0.010	...	...	...	1/64	1/64
Over 1 to 2, incl	0.007	0.007	0.012	0.015	1/32	...	...	1/32	1/32
Over 2 to 4, incl	0.008	0.008	0.015	0.020	1/32	3/64	3/64	1/16	1/32
Over 4 to 6, incl	0.009	0.009	0.015	0.020	1/32	3/64	3/64	3/32	1/16
Over 6 to 8, incl	[C]	0.015	0.016	0.025	1/32	3/64	1/16	1/8	3/32

[A] When a square is held against a face and an edge of a square edge flat bar, the edge shall not deviate by more than 3° or 5 % of the thickness.

[B] Steel bars are regularly cut to length by shearing or hot sawing, which can cause end distortion resulting in those portions of the bar being outside the applicable size tolerance. When this end condition is objectionable, a machine cut end should be considered.

[C] Flats over 6 to 8 in., incl, in width, are not available as hot-wrought steel bars in thickness under 0.230 in.

ASTM A29–05

TABLE A1.4
Permissible Variations in Thickness, Length, and Out-of-Square for Hot-Wrought Bar Size Angles of Carbon Steel

Specified Length of Leg, in.[A]	Permissible Variations in Thickness, for Thicknesses Given, Over and Under, in.			Permissible Variations for Length of Leg, Over and Under, in.
	To 3/16, incl	Over 3/16 to 3/8, incl	Over 3/8	
To 1, incl	0.008	0.010	...	1/32
Over 1 to 2, incl	0.010	0.010	0.012	3/64
Over 2 to 3, excl	0.012	0.015	0.015	1/16

[A] The longer leg of an unequal angle determines the size for tolerance. The out-of-square tolerance in either direction is 1½ °.

TABLE A1.5
Permissible Variations in Thickness, Length, and Out-of-Square for Hot-Wrought Bar Size Angles of Carbon Steel

Specified Size of Channel, in.	Permissible Variations in Size, Over and Under, in.				Out-of-Square[A] if Either Flange, in./in. of Flange Width
	Depth of Section[B]	Width of Flanges[B]	Thickness of Web for Thickness Given		
			To 3/16, incl	Over 3/16	
To 1½, incl	1/32	1/32	0.010	0.015	1/32
Over 1½ to 3, excl	1/16	1/16	0.015	0.020	1/32

[A] For channels 5/8 in. and under in depth, the out-of-square tolerance is 3/64 in./in. of depth.
[B] Measurements for depth of section and width of flanges are overall.

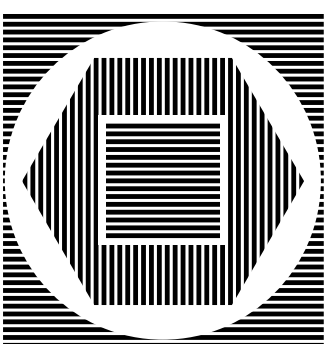


TABLE A1.6
Permissible Variations in Dimensions for Hot-Wrought Bar Size Tees of Carbon Steel

Specified Size of Tee, in.[A]	Permissible Variations in Size, in.						
	Width or Depth[B]		Thickness of Flange		Thickness of Stem		Stem out-of-Square[C]
	Over	Under	Over	Under	Over	Under	
To 1¼ , incl	3/64	3/64	0.010	0.010	0.005	0.020	1/32
Over 1¼ to 2, incl	1/16	1/16	0.012	0.012	0.010	0.020	1/16
Over 2 to 3, excl	3/32	3/32	0.015	0.015	0.015	0.020	3/32

[A] The longer member of the unequal tee determines the size for tolerances.
[B] Measurements for both width and depth are overall.
[C] Stem out-of-square is the variation from its true position of the center line of the stem measured at the point.

TABLE A1.7
Permissible Variations in Dimensions for Half-Rounds, Ovals, Half-Ovals, and Other Special Bar Size Sections

Due to mill facilities, tolerances on half-rounds, ovals, half-ovals, and other special bar size sections vary among the manufacturers and such tolerances should be negotiated between the manufacturer and the purchaser.

TABLE A1.8
Permissible Variations in Length for Hot-Wrought Rounds, Squares, Hexagons, Flats, and Bar Size Sections of Steel

Specified Size of Rounds, Squares, and Hexagons, in.	Specified Size of Flats, in.		Permissible Variations Over Specified Length, in.[A]				
	Thickness	Width	5 to 10 ft, excl	10 to 20 ft, excl	20 to 30 ft, excl	30 to 40 ft, excl	40 to 60 ft, excl
			Mill Shearing				
To 1, incl	to 1, incl	to 3, incl	½	¾	1¼	1¾	2¼
Over 1 to 2, incl	over 1	to 3, incl	⅝	1	1½	2	2½
	to 1, incl	over 3 to 6, incl	⅝	1	1½	2	2½
Over 2 to 5, incl	over 1	over 3 to 6, incl	1	1½	1¾	2¼	2¾
Over 5 to 10, incl	...	...	2	2½	2¾	3	3¼
	0.230 to 1, incl	over 6 to 8, incl	¾	1¼	1¾	3½	4
	over 1 to 3, incl	over 6 to 8, incl	1¼	1¾	2	3½	4
Bar Size Sections	...	...	⅝	1	1½	2	2½
			Hot Sawing				
2 to 3½ , incl	1 and over	3 and over	[B]	1½	1¾	2¼	2¾
Over 3½ to 5, incl				2	2¼	2⅝	3
Over 5 to 10, incl	...	...	[B]	2½	2¾	3	3¼

[A] No permissible variations under.
[B] Smaller sizes and shorter lengths are not hot sawed.

ASTM A29–05

TABLE A1.10
Permissible Variations in Straightness for Hot-Wrought Bars and Bar Size Sections of Steel[A]

Standard tolerances	¼ in. in any 5 ft and (¼ in. × length in ft)/5
Special tolerances	⅛ in. in any 5 ft and (⅛ in. × length in ft)/5

[A] Because of warpage, straightness tolerances do not apply to bars if any subsequent heating operation or controlled cooling has been performed.

ASTM A568–05

Standard Specification for General Requirements for Hot-Rolled & Cold-Rolled Structural & High-Strength, Low-Alloy Carbon Steel Sheet

TABLE 2
Tolerances for Product Analysis

Element	Limit, or Maximum of Specified Element, %	Tolerance	
		Under Minimum Limit	Over Maximum Limit
Carbon	to 0.15 incl	0.02	0.03
	over 0.15 to 0.40 incl	0.03	0.04
	over 0.40 to 0.80 incl	0.03	0.05
	over 0.80	0.03	0.06
Manganese	to 0.60 incl	0.03	0.03
	over 0.60 to 1.15 incl	0.04	0.04
	over 1.15 to 1.65 incl	0.05	0.05
Phosphorus		...[A]	0.01
Sulfur		...[A]	0.01
Silicon	to 0.30 incl	0.02	0.03
	over 0.30 to 0.60 incl	0.05	0.05
Copper		0.02	...[A]
Nickel	to 1.00 incl	...[A]	0.03
Chromium	to 0.90 incl	...[A]	0.04
Molybdenum	to 0.20 incl	...[A]	0.01
Vanadium	to 0.10 incl	0.01[B]	0.01[B]
Columbium (Niobium)	to 0.10 incl	0.01[B]	0.01[B]
Titanium	to 0.15 incl	0.01[A]	0.01[B]
Aluminum	to 0.10 incl	0.03[C]	...[A]
Nitrogen	to 0.030 incl	0.005	0.005

[A] Where an ellipsis (. . .) appears in the table, the requirements have not been defined.
[B] If the minimum of the range is 0.01%, the under tolerance is 0.005%.
[C] If the minimum of the range is 0.01%, the under tolerance is 0.005% and if the minimum of the range is 0.02%, the under tolerance is 0.01%.

Notes

TABLE 4 Standard Thickness Tolerances for Hot-Rolled Sheet (Carbon and Structural Steel Only) – ⅜-in. (Cut Edge) and ¾-in. (Mill Edge) Minimum Edge Distance (Coils and Cut Lengths, Including Pickled)

NOTE 1—Thickness is measured at any point across the width not less than ⅜ in. from a cut edge and not less than ¾ in. from a mill edge. This table does not apply to the uncropped ends of mill edge coils.

NOTE 2—The specified thickness range captions also apply when sheet is specified to a nominal thickness, and the tolerances are divided equally over and under.

NOTE 3—Micrometers used for measurement of thickness shall be constructed with anvils and spindles having minimum diameters of 0.188 in. [4.80 mm]. The tip of the spindle shall be flat, and the tip of the anvil shall be flat or rounded with a minimum radius of curvature of 0.10 in. [2.55 mm]. Micrometers with pointed tips are not suitable for thickness measurements.

Specified Width, in.	Thickness Tolerances Over, in., No Tolerance Under					
	Specified Minimum Thickness, in.					
	0.027 to 0.051, incl	Over 0.051 to 0.057, incl	Over 0.057 to 0.071, incl	Over 0.071 to 0.098, incl	Over 0.098 to 0.180, excl	0.180 to 0.230, excl
12 to 20 incl	0.010	0.010	0.012	0.012	0.014	0.014
Over 20 to 40 incl	0.010	0.010	0.012	0.014	0.014	0.016
Over 40 to 48 incl	0.010	0.012	0.012	0.014	0.016	0.018
Over 48 to 60 incl	. . .[A]	0.012	0.014	0.014	0.016	[B]
Over 60 to 72 incl	. . .[A]	0.014	0.014	0.016	0.016	[B]
Over 72	. . .[A]	. . .[A]	. . .[A]	0.016	0.016	[B]

[A] Where an ellipsis (. . .) appears in the table, the requirements have not been defined.
[B] Product not available in this size range.

TABLE 6 Standard Thickness Tolerances for Hot-Rolled Sheet (High-Strength, Low-Alloy Steel) – ⅜-in. (Cut Edge) and ¾-in. (Cut Edge) Minimum Edge Distance (Coils and Cut Lengths, Including Pickled)

NOTE 1—Thickness is measured at any point across the width not less than ⅜ in. from a cut edge and not less than ¾ in. from a mill edge. This table does not apply to the uncropped ends of mill edge coils.

NOTE 2—The specified thickness range captions also apply when sheet is specified to a nominal thickness, and the tolerances are divided equally, over and under.

NOTE 3—Micrometers used for measurement of thickness shall be constructed with anvils and spindles having minimum diameters of 0.188 in. [4.80 mm]. The tip of the spindle shall be flat, and the tip of the anvil shall be flat or rounded with a minimum radius of curvature of 0.10 in. [2.55 mm]. Micrometers with pointed tips are not suitable for thickness measurements.

Specified Width, in.	Thickness Tolerances, Over, in., No Tolerance Under						
	Specified Minimum Thickness, in.						
	0.031 to 0.051, incl	Over 0.051 to 0.059, incl	Over 0.059 to 0.070, incl	Over 0.070 to 0.082, incl	Over 0.082 to 0.098, incl	Over 0.098 to 0.180, excl	0.180 to 0.230, excl
12 to 15, incl	0.010	0.012	0.012	0.012	0.012	0.014	0.014
Over 15 to 20, incl	0.010	0.012	0.014	0.014	0.014	0.016	0.018
Over 20 to 32, incl	0.012	0.012	0.014	0.014	0.014	0.016	0.018
Over 32 to 40, incl	0.012	0.012	0.014	0.014	0.016	0.016	0.018
Over 40 to 48, incl	0.012	0.014	0.014	0.014	0.016	0.020	0.020
Over 48 to 60, incl	. . .[A]	0.014	0.014	0.014	0.016	0.020	[B]
Over 60 to 72, incl	. . .[A]	. . .[A]	0.016	0.016	0.018	0.022	[B]
Over 72 to 80, incl	. . .[A]	. . .[A]	. . .[A]	0.016	0.018	0.024	[B]
Over 80	. . .[A]	. . .[A]	. . .[A]	. . .[A]	0.020	0.024	[B]

[A] Where an ellipsis (. . .) appears in the table, the requirements have not been defined.
[B] Product not available in this size range.

ASTM A568–05

TABLE 8
Width Tolerances[A] of Hot-Rolled Mill Edge Sheet (All Designations) (Coils and Cut Lengths, Including Pickled)

Specified Width, in.	Tolerances Over Specified Width, in. No Tolerance Under
Carbon	
12 to 14 incl	7/16
Over 14 to 17 incl	1/2
Over 17 to 19 incl	9/16
Over 19 to 21 incl	5/8
Over 21 to 24 incl	11/16
Over 24 to 26 incl	13/16
Over 26 to 30 incl	15/16
Over 30 to 50 incl	1 1/8
Over 50 to 78 incl	1 1/2
Over 78	1 7/8
High-Strength Low-Alloy	
12 to 14 incl	7/16
Over 14 to 17 incl	1/2
Over 17 to 19 incl	9/16
Over 19 to 21 incl	5/8
Over 21 to 24 incl	11/16
Over 24 to 26 incl	13/16
Over 26 to 28 incl	15/16
Over 28 to 35 incl	1 1/8
Over 35 to 50 incl	1 1/4
Over 50 to 60 incl	1 1/2
Over 60 to 65 incl	1 5/8
Over 65 to 70 incl	1 3/4
Over 70 to 80 incl	1 7/8
Over 80	2

[A]The above tolerances do not apply to the uncropped ends of mill edge coils (10.1.1.1).

TABLE 9
Width Tolerances of Hot-Rolled Cut Edge Sheet and Cold-Rolled Sheet (All Designations) (Not Resquared, Coils and Cut Lengths, Including Pickled)

Specified Width, in.	Tolerances Over Specified Width, in. No Tolerance Under
Over 12 to 30 incl	1/8
Over 30 to 48 incl	3/16
Over 48 to 60 incl	1/4
Over 60 to 80 incl	5/16
Over 80	3/8

ASTM A568–05

TABLE 10
Length Tolerances of Hot-Rolled Sheet (All Designations) (Cut Lengths Not Resquared Including Pickled)

Specified Length, in.	Tolerances Over Specified Length, in. No Tolerance Under
To 15 incl	1/8
Over 15 to 30 incl	1/4
Over 30 to 60 incl	1/2
Over 60 to 120 incl	3/4
Over 120 to 156 incl	1
Over 156 to 192 incl	1 1/4
Over 192 to 240 incl	1 1/2
Over 240	1 3/4

TABLE 12
Camber Tolerances[A] for Hot-Rolled (Including Pickled) and Cold-Rolled Sheet (Over 12 in. Width) (All Designations) (Cut Lengths, not Resquared)

NOTE 1—Camber is the greatest deviation of a side edge from a straight line, the measurement being taken on the concave side with a straightedge.

Cut Length, ft	Camber Tolerances, in.
To 4 incl	1/8
Over 4 to 6 incl	3/16
Over 6 to 8 incl	1/4
Over 8 to 10 incl	5/16
Over 10 to 12 incl	3/8
Over 12 to 14 incl	1/2
Over 14 to 16 incl	5/8
Over 16 to 18 incl	3/4
Over 18 to 20 incl	7/8
Over 20 to 30 incl	1 1/4
Over 30 to 40 incl	1 1/2

[A] The camber tolerance for coils is 1 in. in any 20 ft.

TABLE 13
Out-of-Square Tolerances of Hot-Rolled Cut-Edge (Including Pickled) and Cold-Rolled Sheet (Over 12 in. Width) (All Designations) (Cut Lengths Not Resquared)

Out-of-square is the greatest deviation of an end edge from a straight line at right angle to a side and touching one corner. It is also obtained by measuring the difference between the diagonals of the cut length. The out-of-square deviation is one half of that difference. The tolerance for all thicknesses and all sizes is 1/16 in./6 in. of width or fraction thereof.

ASTM A568–05

TABLE 15
Flatness Tolerances[A] of Temper Rolled or Pickled Hot-Rolled Sheet Cut Lengths[B] (All Designations)

Specified Minimum Thickness, in.	Specified Width, in.	Flatness Tolerances,[C] in.	
		Specified Yield Strength, min, ksi	
		Under 45	45 to 50[D,E]
0.027 to 0.057 incl	over 12 to 36 incl	½	¾
	over 36 to 60 incl	¾	1⅛
	over 60	1	. . .
0.057 to 0.180 excl	over 12 to 60 incl	½	¾
	over 60 to 72 incl	¾	1⅛
	over 72	1	1½
0.180 to 0.230 excl	over 12 to 48 incl	½	¾

[A] The above table also applies to lengths cut from coils by the consumer when adequate flattening operations are performed.
[B] Application of this table to product in coil form is not appropriate unless the coil has been rolled out and adequately flattened with all coil set removed.
[C] Maximum deviation from a horizontal flat surface.
[D] Tolerances for steels with specified minimum yield strength in excess of 50 ksi are subject to negotiation.
[E] 0.071 minimum thickness of HSLA.

TABLE 16
Flatness Tolerances[A] of Non-Processed Hot-Rolled Sheet Cut Lengths[B] (All Designations)

Specified Minimum Thickness, in.	Specified Width, in.	Flatness Tolerances,[C] in.	
		Specified Yield Strength, min, ksi	
		Under 45	45 to 50[D,E]
0.027 to 0.057 incl	over 12 to 36 incl	1½	2¼
	over 36 to 60 incl	2¼	3⅜
	over 60	3	. . .
over 0.057 to 0.180 excl	over 12 to 60 incl	1½	2¼
	over 60 to 72 incl	2¼	3⅜
	over 72	3	4½
0.180 to 0.230 excl	over 12 to 48 incl	1½	2¼

[A] The above table also applies to lengths cut from coils by the consumer when adequate flattening operations are performed.
[B] Application of this table to product in coil form is not appropriate unless the coil has been rolled out and adequately flattened with all coil set removed.
[C] Maximum deviation from a horizontal flat surface.
[D] Tolerances for steels with specified minimum yield strength in excess of 50 ksi are subject to negotiation.
[E] 0.071 minimum thickness of HSLA.

TABLE 17 Standard Thickness Tolerances for Cold-Rolled Sheet (All Designations)[A]—⅜-in. Minimum Edge Distance (Coils and Cut Lengths Over 12 in. in Width)

NOTE 1—Thickness is measured at any point across the width not less than ⅜ in. from a side edge.

NOTE 2—The specified thickness range captions also apply when sheet is specified to a nominal thickness, and the tolerances are divided equally over and under.

NOTE 3—Micrometers used for measurement of thickness shall be constructed with anvils and spindles having minimum diameters of 0.188 in. [4.80 mm]. The tip of the spindle shall be flat, and the tip of the anvil shall be flat or rounded with a minimum radius of curvature of 0.10 in. [2.55 mm]. Micrometers with pointed tips are not suitable for thickness measurements.

Specified Width, in.	Thickness Tolerances, Over, in., No Tolerance Under						
	Specified Minimum Thickness, in.						
	To 0.014, excl	0.014 to 0.019, incl	Over 0.019[A] to 0.039 incl	Over 0.039 to 0.057, incl	Over 0.057 to 0.071, incl	Over 0.071 to 0.098, incl	Over 0.098 to 0.142, incl
12 to 15, incl	0.002	0.004	0.006	0.008	0.010	0.010	0.010
Over 15 to 72, incl	0.002	0.004	0.006	0.008	0.010	0.010	0.012
Over 72	. . .[B]	. . .[B]	0.006	0.008	0.010	0.012	0.014

[A] Minimum Thickness, 0.021 in. for high-strength, low-alloy.

[B] Where an ellipsis (. . .) appears in the table, the requirements have not been defined.

ASTM A568–05

TABLE 21
Length Tolerances of Cold-Rolled Sheet
(All Designations)
(Cut Lengths Over 12 in. in Width, Not Rewquared)

Specified Length, in.	Tolerances Over Specified Length, in. No Tolerances Under
Over 12 to 30, incl	1/8
Over 30 to 60, incl	1/4
Over 60 to 96, incl	1/2
Over 96 to 120, incl	3/4
Over 120 to 156, incl	1
Over 156 to 192, incl	1 1/4
Over 192 to 240 incl	1 1/2
Over 240	1 3/4

TABLE 25
Flatness Tolerances of Cold-Rolled Sheet
(All Designations)
(Cut Lengths Over 12 in. in Width)

NOTE 1—This table does not apply when product is ordered full hard, to a hardness range, or "annealed last" (dead soft).

NOTE 2—This table also applies to lengths cut from coils by the consumer when adequate flattening measures are performed.

Specified Thickness, in.	Specified Width, in.	Flatness Tolerance,[A] in.	
		Specified Yield Point, min, ksi	
		Under 45	45 to 50[B] incl.
To 0.044, incl	to 36 incl	3/8	3/4
	over 36 to 60 incl	5/8	1 1/8
	over 60	7/8	1 1/2
Over 0.044	to 36 incl	1/4	3/4
	over 36 to 60 incl	3/8	3/4
	over 60 to 72 incl	5/8	1 1/8
	over 72	7/8	1 1/2

[A] Maximum deviation from a horizontal flat surface.

[B] Tolerances for high-strength, low-alloy steel with specified minimum yield point in excess of 50 ksi are subject to negotiation.

ASTM A36–05

Standard Specification for Carbon Structural Steel

TABLE 2
Chemical Requirements

NOTE 1—Where "..." appears in this table, there is no requirement. The heat analysis for manganese shall be determined and reported as described in the heat analysis section of Specification A 6/A 6M.

Product	Shapes[A]	Plates[B]					Bars[B]			
Thickness, in. [mm]	All	To ¾ [20], incl	Over ¾ to 1½ [20 to 40], incl	Over 1½ to 2½ [40 to 65], incl	Over 2½ to 4 [65 to 100], incl	Over 4 [100]	To ¾ [20], incl	Over ¾ to 1½ [20 to 40], incl	Over 1½ to 4 [100], incl	Over 4 [100]
Carbon, max, %	0.26	0.25	0.25	0.26	0.27	0.29	0.26	0.27	0.28	0.29
Manganese, %	...	...	0.80–1.20	0.80–1.20	0.85–1.20	0.85–1.20	...	0.60–0.90	0.60–0.90	0.60–0.90
Phosphorus, max, %	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Sulfur, max, %	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Silicon, %	0.40 max	0.40 max	0.40 max	0.15–0.40	0.15–0.40	0.15–0.40	0.40 max	0.40 max	0.40 max	0.40 max
Copper, min, % when copper steel is specified	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

[A] Manganese content of 0.85–1.35 % and silicon content of 0.15–0.40 % is required for shapes with flange thickness over 3 in. [75 mm].

[B] For each reduction of 0.01 percentage point below the specified carbon maximum, an increase of 0.06 percentage point manganese above the specified maximum will be permitted, up to the maximum of 1.35 %.

ASTM A36–05

TABLE 3
Tensile Requirements[A]

Plates, Shapes,[B] and Bars:	
Tensile strength, ksi [MPa]	58–80 [400–550]
Yield point, min, ksi [MPa]	36 [250][C]
Plates and Bars[D,E]:	
Elongation in 8 in. [200 mm], min, %	20
Elongation in 2 in. [50 mm], min, %	23
Shapes:	
Elongation in 8 in. [200 mm], min, %	20
Elongation in 2 in. [50 mm], min, %	21[B]

[A]See the Orientation subsection inthe Tension Tests section of Specification A 6/A 6M.

[B]For wide flange shapes with flange thickness over 3 in. [75 mm], the 80 ksi [550 MPa] maximum tensile strength does not apply and a minimum elongation in 2 in. [50 mm] of 19 % applies.

[C]Yield point 32 ksi [220 MPa] for plates over 8 in. [200 mm] in thickness.

[D]Elongation not required to be determined for floor plate.

[E]For plates wider than 24 in. [600 mm], the elongation requirement is reduced two percentage points. See the Elongation Requirement Adjustments subsection under the Tension Tests section of Specification A 6/A 6M.

Notes

ASTM A53–05

Standard Specification for Welded & Seamless, Black & Hot-Dipped Zinc-Coated, Steel Pipe

TABLE 1
Chemical Requirements

	Composition, max, %								
	Carbon	Manganese	Phosphorus	Sulfur	Copper[A]	Nickel[A]	Chromium[A]	Molybdenum[A]	Vanadium[A]
Type S (seamless pipe)									
Grade A	0.25	0.95	0.05	0.045	0.40	0.40	0.40	0.15	0.08
Grade B	0.30	1.20	0.05	0.045	0.40	0.40	0.40	0.15	0.08
Type E (electric-resistance-welded)									
Grade A	0.25	0.95	0.05	0.045	0.50	0.40	0.40	0.15	0.08
Grade B	0.30	1.20	0.05	0.045	0.50	0.40	0.40	0.15	0.08
Type F (furnace-welded pipe)									
Grade A	0.30	1.20	0.05	0.045	0.40	0.40	0.40	0.15	0.08

[A] The total composition for these five elements shall not exceed 1.00 %.

ASTM A53–05

TABLE 2
Tensile Requirements

	Grade A	Grade B
Tensile strength, min, psi [MPa]	48 000 [330]	60 000 [415]
Yield strength, min, psi [MPa]	30 000 [205]	35 000 [240]
Elongation in 2 in. or 50 mm	[A,B]	[A,B]

[A] The minimum elongation in 2 in. [50 mm] shall be that determined by the following equation:

$$e = 625\ 000\ [1940]\ A^{0.2}/U^{0.9}$$

where:

e = minimum elongation in 2 in. or 50 mm in percent, rounded to the nearest percent,

A = the lesser of 0.75 in.^{2} [500 mm^2] and the cross-sectional area of the tension test specimen, calculated using the specified outside diameter of the pipe, or the nominal width of the tension test specimen and the specified wall thickness of the pipe, with the calculated value rounded to the nearest 0.01 in.^{2} [1 mm^2], and

U = specified minimum tensile strength, psi [MPa].

[B] See Table X4.1 or Table X4.2, whichever is applicable, for the minimum elongation values that are required for various combinations of tension test specimen size and specified minimum tensile strength.

Notes

A1. PERMISSIBLE VARIATIONS IN QUALITY CHARACTERISTICS—INCH-POUND AND METRIC UNITS

TABLE A1.1
Size Tolerances for Level One Cold-Finished Carbon Steel Bars, Cold Drawn or Turned and Polished

Size, in. (mm)[A]	Maximum of Carbon Range 0.28 % or less	Maximum of Carbon Range over 0.28 % to 0.55 % incl	Maximum of Carbon Range to 0.55 % incl, Stress Relieved or Annealed after Cold Finishing	Maximum of Carbon Range over 0.55 % or All Grades Quenched and Tempered or Normalized and Tempered before Cold Finishing
	All tolerances are in inches (mm) and are minus[B]			
	Rounds—Cold Drawn[C] to 6 in.(152.4 mm) or Turned and Polished			
To 1½ (38.1) incl, in coils, or cut lengths	0.002 (.051)	0.003 (.076)	0.004 (.102)	0.005 (.127)
Over 1½ (38.10) to 2½ (63.50) incl	0.003 (.076)	0.004 (.102)	0.005 (.127)	0.006 (.152)
Over 2½ (63.50) to 4 (101.60) incl	0.004 (.102)	0.005 (.127)	0.006 (.152)	0.007 (.178)
Over 4 (101.60) to 6 (152.40) incl	0.005 (.127)	0.006 (.152)	0.007 (.178)	0.008 (.203)
Over 6 (152.40) to 8 (203.20) incl	0.006 (.152)	0.007 (.178)	0.008 (.203)	0.009 (.229)
Over 8 (203.20) to 9 (228.60) incl	0.007 (.178)	0.008 (.203)	0.009 (.229)	0.010 (.254)
	Hexagons			
To ¾ (19.05) incl	0.002 (.051)	0.003 (.076)	0.004 (.102)	0.006 (.152)
Over ¾ (19.05) to 1½ (38.10) incl	0.003 (.076)	0.004 (.102)	0.005 (.127)	0.007 (.178)
Over 1½ (38.10) to 2½ (63.50) incl	0.004 (.102)	0.005 (.127)	0.006 (.152)	0.008 (.203)
Over 2½ (63.50) to 3⅛ (79.38) incl	0.005 (.127)	0.006 (.152)	0.007 (.178)	0.009 (.229)
Over 3⅛ (79.38) to 4 (101.60) incl	0.005 (.127)	0.006 (.152)	...	...

(Table 1 cont. on Page 115)

TABLE A1.1 *(cont. from Page 114)*

Size Tolerances for Level One Cold-Finished Carbon Steel Bars, Cold Drawn or Turned and Polished

		Squares		
To ¾ (19.05) incl	0.002 (.051)	0.004 (.102)	0.005 (.127)	0.007 (.178)
Over ¾ (19.05) to 1½ (38.10) incl	0.003 (.076)	0.005 (.127)	0.006 (.152)	0.008 (.203)
Over 1½ (38.10) to 2½ (63.50) incl	0.004 (.102)	0.006 (.152)	0.007 (.178)	0.009 (.229)
Over 2½ (63.50) to 4 (101.60) incl	0.006 (.152)	0.008 (.203)	0.009 (.229)	0.011 (.279)
Over 4 (101.60) to 5 (127.00) incl	0.010 (.254)	...	...	...
Over 5 (127.00) to 6 (152.4) incl	0.014 (.356)	...	...	...
		Flats[D]		
Width:				
To ¾ (19.05) incl	0.003 (.076)	0.004 (.102)	0.006 (.152)	0.008 (.203)
Over ¾ (19.05) to 1 ½ (38.10) incl	0.004 (.102)	0.005 (.127)	0.008 (.203)	0.010 (.254)
Over 1½ (38.10) to 3 (76.2) incl	0.005 (.127)	0.006 (.152)	0.010 (.254)	0.012 (.305)
Over 3 (76.2) to 4 (101.60) incl	0.006 (.152)	0.008 (.203)	0.011 (.279)	0.016 (.410)
Over 4 (101.60) to 6 (152.40) incl	0.008 (.203)	0.010 (.254)	0.012 (.305)	0.020 (.508)
Over 6 (152.40)	0.013 (.330)	0.015 (.381)	...	...

[A] Standard manufacturing practice is shear cut for cold drawn bars (size limits vary by producer) which can cause end distortion resulting in those portions of the bar being outside the applicable size tolerance. When this end condition is undesirable, a saw cut end to remove end distortion should be considered.

[B] While size tolerances are usually specified as minus, tolerances may be ordered all plus, or distributed plus and minus, with the sum being equivalent to the tolerances listed.

[C] Maximum allowable deviation in roundness around the circumference of the same cross-section of a round cold drawn bar is ½ the size tolerance range.

[D] Width governs the tolerances for both width and thickness of flats. For example, when the maximum of carbon range is 0.28 % or less, for a flat 2 in. (50.80 mm) wide and 1 in. (25.40 mm) thick, the width tolerance is 0.005 in. (.127 mm) and the thickness tolerance is the same, namely, 0.005 in. (.127 mm).

ASTM A108–03

TABLE A1.4
Straightness Tolerances for Level One Cold Finished Bars[A,B]

NOTE—All grades quenched and tempered or normalized and tempered to Brinell 302 max before cold finishing; and all grades stress relieved or annealed after cold finishing. Straightness tolerances are not applicable to bars having Brinell hardness exceeding 302.

Size, in. (mm)	Length, ft (mm)	Straightness Tolerances, in. (mm) (Maximum Deviation) from Straightness in any 10-ft Portion of the Bar			
		Maximum of Carbon Range, 0.28 % or Less		Maximum of Carbon Range, over 0.28 % and All Grades Thermally Treated	
		Rounds	Squares, Hexagons, and Octagons	Rounds	Squares, Hexagons, and Octagons
Less than 5⁄8 (15.88)	Less than 15 (4572)	1⁄8 (3.17)	3⁄16 (4.76)	3⁄16 (4.76)	1⁄4 (6.35)
Less than 5⁄8 (15.88)	15 (4572) and over	1⁄8 (3.17)	5⁄16 (7.94)	5⁄16 (7.94)	3⁄8 (9.53)
5⁄8 (15.88) and over	Less than 15 (4572)	1⁄16 (1.59)	1⁄8 (3.17)	1⁄8 (3.17)	3⁄16 (4.76)
5⁄8 (15.88) and over	15 (4572) and over	1⁄8 (3.17)	3⁄16 (4.76)	3⁄16 (4.76)	1⁄4 (6.35)

[A] The foregoing tolerances are based on the following method of measuring straightness: Departure from straightness is measured by placing the bar on a level table so that the arc or departure from straightness is horizontal, and the depth of the arc is measured with a feeler gage and a straightedge.

[B] It should be recognized that straightness is a perishable quality and may be altered by mishandling. The preservation of straightness in cold-finished bars requires the utmost care in subsequent handling. Specific straightness tolerances are sometimes required for carbon and alloy steels in which case the purchaser should inform the manufacturer of the straightness tolerances and the methods to be used in checking the straightness.

TABLE A1.5
Length Tolerances for Cold Finished Steel Bar

Product Tolerance Level	Tolerances, inches (mm) Plus Allowable Deviation above Specified Uniform Length		
	Cutting Process	Minimum	Maximum
Level 1	Shear Cut	0.000	2.000 (50.80)
Level 2	In-Line Saw Cut	0.000	1.000 (25.40)
Level 3	Off-Line Saw Cut	0.000	0.500 (12.70)

TABLE A1.6
Across-Corner Tolerances for Hexagon and Square Cold Drawn Steel Bar[A]

Product Tolerance Level	Tolerance Range Applied to Across Corner Calculations	
	Hexagon, Inches (mm), Minus	Square, Inches (mm), Minus
Level 1	0.025 (.64)	0.030 (.76)
Level 2	0.020 (.51)	0.025 (.64)
Level 3	0.015 (.38)	0.020 (.51)
	Sharp Corner Hexagon Calculation = $(1.1547 \times D)$	Sharp Corner Square Calculation = $(1.4142 \times D)$
	Round Corner Hexagon Calculation = $[1.1547 \times (D - 2r)] + 2r$	Round Corner Square Calculation = $[1.4142 \times (D - 2r)] + 2r$

[A] When required, type of corner must be specified at time of order inquiry.

ASTM A500–03a

Standard Specification for Cold-Formed Welded & Seamless Carbon Steel Structural Tubing in Rounds & Shapes

TABLE 1
Chemical Requirements

Element	Composition, %			
	Grades A, B, and D		Grade C	
	Heat Analysis	Product Analysis	Heat Analysis	Product Analysis
Carbon, max[A]	0.26	0.30	0.23	0.27
Manganese, max[A]	1.35	1.40	1.35	1.40
Phosphorus, max	0.035	0.045	0.035	0.045
Sulfur, max	0.035	0.045	0.035	0.045
Copper, min[B]	0.20	0.18	0.20	0.18

[A] For each reduction of 0.01 percentage point below the specified maximum for carbon, an increase of 0.06 percentage point above the specified maximum for manganese is permitted, up to a maximum of 1.50 % by heat analysis and 1.60 % by product analysis.

[B] If copper-containing steel is specified in the purchase order.

TABLE 2
Tensile Requirements

Round Structural Tubing				
	Grade A	Grade B	Grade C	Grade D
Tensile strength, min, psi (MPa)	45 000 (310)	58 000 (400)	62 000 (427)	58 000 (400)
Yield strength, min, psi (MPa)	33 000 (228)	42 000 (290)	46 000 (317)	36 000 (250)
Elongation in 2 in. (50.8 mm), min, %[D]	25[A]	23[B]	21[C]	23[B]
Shaped Structural Tubing				
	Grade A	Grade B	Grade C	Grade D
Tensile strength, min, psi (MPa)	45 000 (310)	58 000 (400)	62 000 (427)	58 000 (400)
Yield strength, min, psi (MPa)	39 000 (269)	46 000 (317)	50 000 (345)	36 000 (250)
Elongation in 2 in. (50.8 mm), min, %[D]	25[A]	23[B]	21[C]	23[B]

[A] Applies to specified wall thicknesses (t) equal to or greater than 0.120 in. (3.05 mm). For lighter specified wall thicknesses, the minimum elongation values shall be calculated by the formula: percent elongation in 2 in. (50.8 mm) = $56t + 17.5$, rounded to the nearest percent.

[B] Applies to specified wall thicknesses (t) equal to or greater than 0.180 in. (4.57 mm). For lighter specified wall thicknesses, the minimum elongation values shall be calculated by the formula: percent elongation in 2 in. (50.8 mm) = $61t + 12$, rounded to the nearest percent.

[C] Applies to specified wall thicknesses (t) equal to or greater than 0.120 in. (3.05 mm). For lighter specified wall thicknesses, the minimum elongation values shall be by agreement with the manufacturer.

[D] The minimum elongation values specified apply only to tests performed prior to shipment of the tubing.

ASTM A500–03a

TABLE 3
Permissible Variations in Outside Flat Dimensions for Square and Rectangular Structural Tubing

Specified Outside Large Flat Dimension, in. (mm)	Permissible Variations Over and Under Specified Outside Flat Dimensions,[A] in. (mm)
2½ (63.5) or under	0.020 (0.51)
Over 2½ to 3½ (63.5 to 88.9), incl	0.025 (0.64)
Over 3½ to 5½ (88.9 to 139.7), incl	0.030 (0.76)
Over 5½ (139.7)	0.01 times large flat dimension

[A] The permissible variations include allowances for convexity and concavity. For rectangular tubing having a ratio of outside large to small flat dimension less than 1.5, and for square tubing, the permissible variations in small flat dimension shall be identical to the permissible variations in large flat dimension. For rectangular tubing having a ratio of outside large to small flat dimension in the range of 1.5 to 3.0 inclusive, the permissible variations in small flat dimension shall be 1.5 times the permissible variations in large flat dimension. For rectangular tubing having a ratio of outside large to small flat dimension greater than 3.0, the permissible variations in small flat dimension shall be 2.0 times the permissible variations in large flat dimension.

TABLE 4
Length Tolerances for Specific Lengths of Structural Tubing

	22 ft (6.7 m) and Under		Over 22 ft (6.7 m)	
	Over	Under	Over	Under
Length tolerance for specific lengths, in. (mm)	½ (12.7)	¼ (6.4)	¾ (19.0)	¼ (6.4)

TABLE 5
Permissible Variations in Twist for Square and Rectangular Structural Tubing

Specified Outside Large Flat Dimension, in. (mm)	Maximum Permissible Variations in Twist per 3 ft of Length (Twist per Metre of Length)	
	in.	mm
1½ (38.1) and under	0.050	1.39
Over 1½ to 2½ (38.1 to 63.5), incl	0.062	1.72
Over 2½ to 4 (63.5 to 101.6), incl	0.075	2.09
Over 4 to 6 (101.6 to 152.4), incl	0.087	2.42
Over 6 to 8 (152.4 to 203.2), incl	0.100	2.78
Over 8 (203.2)	0.112	3.11

ASTM A513–00

Standard Specification for Electric-Resistance-Welded Carbon & Alloy Steel Mechanical Tubing

TABLE 1
Chemical Requirements for Standard Low-Carbon Steels[A]

NOTE 1— Chemistry represents heat analysis. Product analysis, except for rimmed or capped steel, is to be in accordance with usual practice as shown in Table 3.

Grade Designation	Chemical Composition Limits, %			
	Carbon	Manganese	Phosphorus, max	Sulfur, max
MT[B] 1010	0.05–0.15	0.30–0.60	0.035	0.035
MT 1015	0.10–0.20	0.30–0.60	0.035	0.035
MT X 1015	0.10–0.20	0.60–0.90	0.035	0.035
MT 1020	0.15–0.25	0.30–0.60	0.035	0.035
MT X 1020	0.15–0.25	0.70–1.00	0.035	0.035

[A] Rimmed or capped steels which may be used for the above grades are characterized by a lack of uniformity in their chemical composition, and for this reason product analysis is not technologically appropriate unless misapplication is clearly indicated.

[B] The letters MT under grade designation indicate Mechanical Tubing.

Notes

TABLE 2
Chemical Requirements for Other Carbon and Alloy Steels[A]

NOTE 1—Chemistry represents heat analysis. Product analysis, except for rimmed or capped steel, is to be in accordance with usual practice as shown in Table 3.

Grade Designation	Chemical Composition Limits, %							
	Carbon	Manganese	Phosphorus, max	Sulfur, max	Silicon	Nickel	Chromium	Molybdenum
1008	0.10 max	0.50 max	0.035	0.035	...	...	...	...
1010	0.08–0.13	0.30–0.60	0.035	0.035	...	...	...	...
1012	0.10–0.15	0.30–0.60	0.035	0.035	...	...	...	...
1015	0.12–0.18	0.30–0.60	0.035	0.035	...	...	...	...
1016	0.12–0.18	0.60–0.90	0.035	0.035	...	...	...	...
1017	0.14–0.20	0.30–0.60	0.035	0.035	...	...	...	...
1018	0.14–0.20	0.60–0.90	0.035	0.035	...	...	...	...
1019	0.14–0.20	0.70–1.00	0.035	0.035	...	...	...	...
1020	0.17–0.23	0.30–0.60	0.035	0.035	...	...	...	...
1021	0.17–0.23	0.60–0.90	0.035	0.035	...	...	...	...
1022	0.17–0.23	0.70–1.00	0.035	0.035	...	...	...	...
1023	0.19–0.25	0.30–0.60	0.035	0.035	...	...	...	...
1024	0.18–0.25	1.30–1.65	0.035	0.035	...	...	...	...
1025	0.22–0.28	0.30–0.60	0.035	0.035	...	...	...	...
1026	0.22–0.28	0.60–0.90	0.035	0.035	...	...	...	...

(Table 1 cont. on Page 122)

ASTM A513–00

TABLE 2 *(cont. from Page 121)*

(cont. from Page 121)

Chemical Requirements for Other Carbon and Alloy Steels[A]

1027	0.22–0.29	1.20–1.55	0.035	0.035	...	...	...	...
1030	0.27–0.34	0.60–0.90	0.035	0.035	...	...	...	...
1033	0.29–0.36	0.70–1.00	0.035	0.035	...	...	...	...
1035	0.31–0.38	0.60–0.90	0.035	0.035	...	...	...	...
1040	0.36–0.44	0.60–0.90	0.040	0.050	. . .	. . .	. . .	. . .
1050	0.47–0.55	0.60–0.90	0.040	0.050	. . .	. . .	. . .	. . .
1060	0.55–0.66	0.60–0.90	0.040	0.050	. . .	. . .	. . .	. . .
1340	0.38–0.43	1.60–1.90	0.035	0.040	0.15–0.35	. . .	. . .	. . .
1524	0.18–0.25	1.35–1.65	0.040	0.050	. . .	. . .	. . .	. . .
4118	0.18–0.23	0.70–0.90	0.035	0.040	0.15–0.35	. . .	0.40–0.60	0.08–0.15
4130	0.28–0.33	0.40–0.60	0.035	0.040	0.15–0.35	. . .	0.80–1.10	0.15–0.25
4140	0.38–0.43	0.75–1.00	0.035	0.040	0.15–0.35	. . .	0.80–1.10	0.15–0.25
5130	0.23–0.33	0.70–0.90	0.035	0.040	0.15–0.35	. . .	0.80–1.10	. . .
8620	0.18–0.23	0.70–0.90	0.035	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.15–0.25
8630	0.28–0.33	0.70–0.90	0.035	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.15–0.25

[A] Where the ellipsis (...) appears in this table, there is no requirement.

ASTM A513–00

TABLE 3
Tolerances for Product Analysis for Steels Shown in Tables 1 and 2[A,B]

Element	Limit, or Maximum of Specified Range, %	Variation, Over the Maximum Limit or Under the Minimum Limit	
		Under min, %	Over max, %
Carbon	to 0.15, incl	0.02	0.03
	over 0.15 to 0.40, incl	0.03	0.04
	over 0.40 to 0.55, incl	0.03	0.05
Manganese	to 0.60, incl	0.03	0.03
	over 0.60 to 1.15, incl	0.04	0.04
	over 1.15 to 1.65, incl	0.05	0.05
Phosphorus		...	0.01
Sulfur		...	0.01
Silicon	to 0.30, incl	0.02	0.03
	over 0.30 to 0.60	0.05	0.05
Nickel	to 1.00, incl	0.03	0.03
Chromium	to 0.90, incl	0.03	0.03
	over 0.90 to 2.10, incl	0.05	0.05
Molybdenum	to 0.20, incl	0.01	0.01
	over 0.20 to 0.40, incl	0.02	0.02

[A] Individual determinations may vary from the specified heat limits or ranges to the extent shown in this table, except that any element in a heat may not vary both above and below a specified range.

[B] Where the ellipsis (...) appears in this table, there is no requirement.

TABLE 13
Tolerances, Outside Dimensions[A] Square and Rectangular Tubing

Largest Nominal Outside Dimension, in.[B]	Wall Thickness, in.[B]	Outside Tolerance at All Sides at Corners ± in.[B]
3/16 to 5/8, incl	0.020 to 0.083, incl	0.004
Over 5/8 to 1 1/8, incl	0.022 to 0.156, incl	0.005
Over 1 1/8 to 1 1/2, incl	0.025 to 0.192, incl	0.006
Over 1 1/2 to 2, incl	0.032 to 0.192, incl	0.008
Over 2 to 3, incl	0.035 to 0.259, incl	0.010
Over 3 to 4, incl	0.049 to 0.259, incl	0.020
Over 4 to 6, incl	0.065 to 0.259, incl	0.020
Over 6 to 8, incl	0.185 to 0.259, incl	0.025

[A] Measured at corners at least 2 in. from the cut end of the tubing.

Convexity and concavity: Tubes having two parallel sides are also measured in the center of the flat sides for convexity and concavity. This tolerance applies to the specific size determined at the corners, and is measured on the following basis:

Largest Nominal Outside Dimension, in.	Tolerance ±, in.
2 1/2 and under	0.010
Over 2 1/2 to 4	0.015
Over 4 to 8	0.025

[B] 1 in. = 25.4 mm.

ASTM A513–00

TABLE 14
Radii of Corners of Electric-Resistance-Welded Square and Rectangular Tubing[A]

Squares and Rectangles Made from Tubes of the Following Diameter Ranges, in.[B]	Wall Thickness in Bwg and in.[B]	Radius Tolerances, in.[C]
½ to 1½ , incl	24 (0.022)	1/64 to 3/64
½ to 1½ , incl	22 (0.028)	1/32 to 1/16
½ to 2½ , incl	20 (0.035)	1/32 to 1/16
½ to 2½ , incl	19 (0.042)	3/64 to 5/64
½ to 4, incl	18 (0.049)	3/64 to 5/64
½ to 4⅛ , incl	16 (0.065)	1/16 to 3/64
¾ to 4⅛ , incl	14 (0.083)	5/64 to 1/8
Over 4⅛ to 6, incl	14 (0.083)	3/16 to 5/16
1 to 4⅛ , incl	13 (0.095)	3/32 to 5/32
Over 4⅛ to 6, incl	13 (0.095)	3/16 to 5/16
1¼ to 4, incl	12 (0.109)	1/8 to 13/64
Over 4 to 6, incl	12 (0.109)	3/16 to 5/16
1¼ to 4, incl	11 (0.120)	1/8 to 7/32
Over 4 to 6, incl	11 (0.120)	7/32 to 7/16
2 to 4, incl	10 (0.134)	5/32 to 9/32
Over 4 to 6, incl	10 (0.134)	7/32 to 7/16
2 to 4, incl	9 (0.148)	3/16 to 5/16
Over 4 to 8, incl	9 (0.148)	7/32 to 7/16
2 to 8, incl	8 (0.165)	¼ to ½
2 to 8, incl	7 (0.180)	¼ to ½
2½ to 4, incl	6 (0.203)	5/16 to 9/16
Over 4 to 8, incl	6 (0.203)	5/16 to 9/16
2½ to 8, incl	5 (0.220)	3/8 to 5/8
2½ to 8, incl	4 (0.238)	3/8 to 5/8
2½ to 8, incl	3 (0.259)	3/8 to 5/8

[A] This table establishes a standard radius. The purchaser and producer may negotiate special radii. Slight radius flattening is more pronounced in heavier wall tubing.

[B] 1 in. = 25 mm.

[C] These radius tolerances apply to grades of steel covered in Table 1. The purchaser and producer may negotiate tolerances on other grades of steel.

ASTM A513–00

TABLE 15
Length Tolerances—Square and Rectangular Tubing

Lengths, ft[A]	Tolerances, in.[B]
1 to 3, incl	±1/16
Over 3 to 12, incl	±3/32
Over 12 to 20, incl	±1/8
Over 20 to 30, incl	±3/16
Over 30 to 40, incl	±3/8

[A] 1 ft = 0.3 m.
[B] 1 in. = 25.4 mm.

TABLE 16
Twist Tolerances Electric-Resistance-Welded for Square and Rectangular-Mechanical Tubing

Largest Dimension, in.[A]	Twist Tolerance in 3 ft[B], in.[A]
½ and under	0.032
Over ½ to 1½ , incl	0.050
Over 1½ to 2½ , incl	0.062
Over 2½ to 4, incl	0.075
Over 4 to 6, incl	0.087
Over 6 to 8, incl	0.100

[A] 1 in. = 25.4 mm.
[B] 1 ft = 0.3 m.

Notes

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ASTM A514–05

Standard Specification for High-Yield-Strength, Quenched & Tempered Alloy Steel Plate, Suitable for Welding

TABLE 1 Chemical Requirements (Heat Analysis)

NOTE 1—Where "…" appears in this table, there is no requirement.

	Chemical Composition, %							
	Grade A	Grade B	Grade E	Grade F	Grade H	Grade P	Grade Q	Grade S
	Maximum Thickness, in. [mm]							
Element	1¼ [32]	1¼ [32]	6 [150]	2½ [65]	2 [50]	6 [150]	6 [150]	2½ [65]
Carbon	0.15–0.21	0.12–0.21	0.12–0.20	0.10–0.20	0.12–0.21	0.12–0.21	0.14–0.21	0.11–0.21
Manganese	0.80–1.10	0.70–1.00	0.40–0.70	0.60–1.00	0.95–1.30	0.45–0.70	0.95–1.30	1.10–1.50
Phosphorus, max	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Sulfur, max	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.020
Silicon	0.40–0.80	0.20–0.35	0.20–0.40	0.15–0.35	0.20–0.35	0.20–0.35	0.15–0.35	0.15–0.45
Nickel	…	…	…	0.70–1.00	0.30–0.70	1.20–1.50	1.20–1.50	…
Chromium	0.50–0.80	0.40–0.65	1.40–2.00	0.40–0.65	0.40–0.65	0.85–1.20	1.00–1.50	…
Molybdenum	0.18–0.28	0.15–0.25	0.40–0.60	0.40–0.60	0.20–0.30	0.45–0.60	0.40–0.60	0.10–0.60
Vanadium	…	0.03–0.08	[A]	0.03–0.08	0.03–0.08	…	0.03–0.08	0.06
Titanium	…	0.01–0.04	0.01–0.10	…	…	…	…	[B]
Zirconium	0.05–0.15[C]	…	…	…	…	…	…	…
Copper	…	…	…	0.15–0.50	…	…	…	…
Boron	0.0025 max	0.0005–0.005	0.001–0.005	0.0005–0.006	0.0005–0.005	0.001–0.005	…	0.001–0.005
Columbium, max	…	…	…	…	…	…	…	0.06

[A] May be substituted for part or all of titanium content on a one for one basis.
[B] Titanium may be present in levels up to 0.06 % to protect the boron additions.
[C] Zirconium may be replaced by cerium. When cerium is added, the cerium/sulfur ratio should be approximately 1.5 to 1, based upon heat analysis.

TABLE 2

Tensile and Hardness Requirements

NOTE 1— See the Orientation and Preparation subsections in the Tension Tests section of Specification A 6/A 6M.
NOTE 2—Where ". . ." appears in this table there is no requirement.

Thickness, in. [mm]	Tensile Strength, ksi [MPa]	Yield Strength, min[A], ksi [MPa]	Elongation in 2 in. [50 mm], min[BCD], %	Reduction of Area, min[BC], %	Brinell Hardness Number[E]
To ¾ [20], incl	110 to 130 [760 to 895]	100 [690]	18	40[F]	235 to 293 HBW
Over ¾ [20] to 2½ [65], incl	110 to 130 [760 to 895]	100 [690]	18	40[F], 50[G]	...
Over 2½ [65] to 6 [150], incl	100 to 130 [690 to 895]	90 [620]	16	50[G]	...

[A] Measured at 0.2 % offset or 0.5 % extension under load as described in the Determination of Tensile Properties section of Test Methods and Definitions A 370.
[B] Elongation and reduction of area need not be determined for floor plates.
[C] For plates tested in the transverse direction, the elongation requirement is reduced by two percentage points and the reduction of area minimum requirement is reduced by five percentage points. See elongation requirement adjustments in the Tension Tests section of Specification A 6/A 6M.
[D] If measured on the Fig. 3 (Test Methods and Definitions A 370) 1½-in. [40-mm] wide tension test specimen, the elongation is determined in a 2-in. [50-mm] gage length that includes the fracture and shows the greatest elongation.
[E] See 7.2.
[F] If measured on the Fig. 3 (Test Methods and Definitions A 370) 1½-in. [40-mm] wide tension test specimen.
[G] If measured on the Fig. 4 (Test Methods and Definitions A 370) ½-in. [12.5-mm] round tension test specimen.

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ASTM A516–05

Standard Specification for Carbon Steel Pressure Vessel Plates, for Moderate & Lower-Temperature Service

TABLE 1 Chemical Requirements

Elements	Composition, %			
	Grade 55 [Grade 380]	Grade 60 [Grade 415]	Grade 65 [Grade 450]	Grade 70 [Grade 485]
Carbon, max[A,B]:				
½ in. [12.5 mm] and under	0.18	0.21	0.24	0.27
Over ½ in. to 2 in. [12.5 to 50 mm], incl	0.20	0.23	0.26	0.28
Over 2 in. to 4 in. [50 to 100 mm], incl	0.22	0.25	0.28	0.30
Over 4 to 8 in. [100 to 200 mm], incl	0.24	0.27	0.29	0.31
Over 8 in. [200 mm]	0.26	0.27	0.29	0.31
Manganese[B†]:				
½ in. [12.5 mm] and under:				
Heat analysis	0.60–0.90	0.60–0.90	0.85–1.20	0.85–1.20
Product analysis	0.55–0.98	0.55–0.98	0.79–1.30	0.79–1.30
Over ½ in. [12.5 mm]:				
Heat analysis	0.60–1.20	0.85–1.20	0.85–1.20	0.85–1.20
Product analysis	0.55–1.30	0.79–1.30	0.79–1.30	0.79–1.30
Phosphorus,max[A]	0.035	0.035	0.035	0.035
Sulfur, max[A]	0.035	0.035	0.035	0.035
Silicon:				
Heat analysis	0.15–0.40	0.15–0.40	0.15–0.40	0.15–0.40
Product analysis	0.13–0.45	0.13–0.45	0.13–0.45	0.13–0.45

† Footnote reference moved editorially.

[A] Applies to both heat and product analyses.

[B] For each reduction of 0.01 percentage point below the specified maximum for carbon, an increase of 0.06 percentage point above the specified maximum for manganese is permitted, up to a maximum of 1.50 % by heat analysis and 1.60 % by product analysis.

ASTM A516–05

TABLE 2
Tensile Requirements

	Grade			
	55 [380]	60 [415]	65 [450]	70 [485]
Tensile strength, ksi [MPa]	55–75 [380–515]	60–80 [415–550]	65–85 [450–585]	70–90 [485–620]
Yield strength, min,[A] ksi [MPa]	30 [205]	32 [220]	35 [240]	38 [260]
Elongation in 8 in. [200 mm], min, %[B]	23	21	19	17
Elongation in 2 in. [50 mm], min, %[B]	27	25	23	21

[A] Determined by either the 0.2 % offset method or the 0.5 % extension-under-load method.
[B] See Specification A 20/A20M for elongation adjustment.

ASTM A572–04

Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel

TABLE 1
Maximum Product Thickness or Size

Grade	Yield Point, min		Maximum Thickness or Size					
	ksi	[MPa]	Plates and Bars		Structural Shape Flange or Leg Thickness		Sheet Piling	Zees and Rolled Tees
			in.	[mm]	in.	[mm]		
42 [290][A]	42	[290]	6	[150]	all	all	all	all
50 [345][A]	50	[345]	4[B]	[100][B]	all	all	all	all
55 [380]	55	[380]	2	[50]	all	all	all	all
60 [415][A]	60	[415]	1¼[C]	[32][C]	2	[50]	all	all
65 [450]	65	[450]	1¼	[32]	2	[50]	not available	all

[A] In the above tabulation, Grades 42, 50, and 60 [290, 345, and 415], are the yield point levels most closely approximating a geometric progression pattern between 36 ksi [250 MPa], min, yield point steels covered by Specification A 36/A 36M and 100 ksi [690 MPa], min, yield strength steels covered by Specification A 514/A 514M.

[B] Round bars up to and including 11 in. [275 mm] in diameter are permitted.

[C] Round bars up to and including 3½ in. [90 mm] in diameter are permitted.

TABLE 1 Chemical Requirements[A] (Heat Analysis)

Diameter, Thickness, or Distance Between Parallel Faces, in. [mm] Plates and Bars	Structural Shape Flange or Leg Thickness, in. [mm]	Grade	Carbon, max, %	Manganese,[B] max, %	Phosphorus, max, %	Sulfur, max, %	Silicon	
							Plates to 1½ in. [40 mm] Thick, Shapes with Flange or Leg Thickness to 3 in. [75 mm] inclusive, Sheet Piling, Bars, Zees, and Rolled Tees[C]	Plates Over 1½ in. [40 mm] Thick and Shapes with Flange Thickness Over 3 in. [75 mm]
							max, %	range, %
6 [150]	all	42 [290]	0.21	1.35[D]	0.04	0.05	0.40	0.15–0.40
4 [100][E]	all	50 [345]	0.23	1.35[D]	0.04	0.05	0.40	0.15–0.40
2 [50][F]	all	55 [380]	0.25	1.35[D]	0.04	0.05	0.40	0.15-0.40
1¼ [32][F]	≤2 [50]	60 [415]	0.26	1.35[D]	0.04	0.05	0.40	[G]
>½ – 1¼ [13–32]	>1-2 [25-50]	65 [450]	0.23	1.65	0.04	0.05	0.40	[G]
≤½ [13][H]	≤ 1[H]	65 [450]	0.26	1.35	0.04	0.05	0.40	[G]

[A] Copper when specified shall have a minimum content of 0.20 % by heat analysis (0.18 % by product analysis).

[B] Manganese, minimum, by heat analysis of 0.80 % (0.75 % by product analysis) shall be required for all plates over ⅜ in. [10 mm] in thickness; a minimum of 0.60 % (0.45 % by product analysis) shall be required for plates ⅜ in. [10 mm] and less in thickness, and for all other products. The manganese to carbon ratio shall not be less than 2 to 1.

[C] Bars over 1½ in. [40 mm] in diameter, thickness, or distance between parallel faces shall be made by a killed steel practice.

[D] For each reduction of 0.01 percentage point below the specified carbon maximum, an increase of 0.06 percentage point manganese above the specified maximum is permitted, up to a maximum of 1.50 %.

[E] Round bars up to and including 11 in. [275 mm] in diameter are permitted.

[F] Round bars up to and including 3½ in. [90 mm] in diameter are permitted.

[G] The size and grade is not described in this specification.

[H] An alternative chemical requirement with a maximum carbon of 0.21 % and a maximum manganese of 1.65 % is permitted, with the balance of the elements as shown in Table 2.

ASTM A572–04

TABLE 3
Alloy Content

Type[A]	Elements	Heat Analysis, %
1	Columbium[B]	0.005–0.05[C]
2	Vanadium	0.01–0.15
3	Columbium[B]	0.005-0.05[C]
	Vanadium	0.01–0.15
	Columbium plus vanadium	0.02–0.15[D]
5	Titanium	0.006-0.04
	Nitrogen	0.003–0.015
	Vanadium	0.06 max

[A] Alloy content shall be in accordance with Type 1, 2, 3, or 5 and the contents of the applicable elements shall be reported on the test report.

[B] Columbium shall be restricted to the following thicknesses and sizes unless killed steel is furnished. Killed steel shall be confirmed by a statement of killed steel on the test report, or by a report on the presence of a sufficient quantity of a strong deoxidizing element, such as silicon at 0.10 % or higher, or aluminum at 0.015 % or higher. See table below.

[C] Product analysis limits = 0.004 to 0.06 %.

[D] Product analysis limits = 0.01 to 0.16 %.

Grades	Maximum Plate, Bar, Sheet Piling, Zees, and Rolled Tee Thicknesses, in. [mm]	Maximum Structural Shape Flange or Leg Thickness, in. [mm]
42, 50, and 55 [290, 345, and 380]	¾ [20]	1.5 [40]
60 and 65 [415 and 450]	½ [13]	1 [25]

TABLE 4
Tensile Requirements[A]

Grade	Yield Point, min		Tensile Strength, min		Minimum Elongation, %[B,C,D]	
	ksi	[MPa]	ksi	[MPa]	in 8 in. [200 mm]	in 2 in. [50 mm]
42 [290]	42	[290]	60	[415]	20	24
50 [345]	50	[345]	65	[450]	18	21
55 [380]	55	[380]	70	[485]	17	20
60 [415]	60	[415]	75	[520]	16	18
65 [450]	65	[450]	80	[550]	15	17

[A] See specimen Orientation under the Tension Tests section of Specification A 6/A 6M.

[B] Elongation not required to be determined for floor plate.

[C] For wide flange shapes over 426 lb/ft [634 kg/m], elongation in 2 in. [50 mm] of 19 % minimum applies.

[D] For plates wider than 24 in. [600 mm], the elongation requirement is reduced two percentage points for Grades 42, 50, and 55 [290, 345, and 380], and three percentage points for Grades 60 and 65 [415 and 450]. See elongation requirement adjustments in the Tension Tests section of Specification A 6/A 6M.

ASTM A656–05

Standard Specification for Hot-Rolled Structural Steel, High-Strength Low-Alloy Plate with Improved Formability

TABLE 1
Chemical Requirements

NOTE—An ellipsis (...) indicates that element is not defined for that Type.

Elements	Composition, %		
	Type 3	Type 7	Type 8
Carbon, max[A]	0.18	0.18	0.18
Manganese, max[A]	1.65	1.65	1.65
Phosphorus, max	0.025	0.025	0.025
Sulfur, max	0.035	0.035	0.035
Silicon, max	0.60	0.60	0.60
Vanadium, max	0.08	0.15[B]	0.15[A]
Nitrogen, max	0.020	0.020	0.020
Columbium	0.008–0.10	0.10 max[B]	0.10 max[A]
Titanium, max	...	...	0.15[C]

[A] For each reduction of 0.01 percentage point below the specified maximum for carbon, an increase of 0.06 percentage points above the specified maximum for manganese is permitted, up to a maximum of 1.75 % for Grades 50, 60, and 70; and up to a maximum of 1.90 % for Grade 80.

[B] The contents of columbium and vanadium shall additionally be in accordance with one of the following:
columbium 0.008-0.10 % with vanadium <0.008 %;
columbium <0.008 % with vanadium 0.008-0.15 %; or
columbium 0.008-0.10 % with vanadium 0.008-0.15 % and columbium plus vanadium not in excess of 0.20 %.

[C] The sum of Columbium, Vanadium, and Titanium shall be between 0.008 and 0.20 %.

ASTM A656–05

TABLE 2
Tensile Requirements[A]

	Grade 50 [345]	Grade 60 [415]	Grade 70 [485]	Grade 80 [550]
Yield point, min, ksi [MPa]	50 [345]	60 [415]	70 [485]	80 [550]
Tensile strength, min, ksi [MPa]	60 [415]	70 [485]	80 [550]	90 [620]
Elongation in 8 in. [200 mm], min, %[B]	20	17	14	12
Elongation in 2 in. [50 mm], min, %[B]	23	20	17	15

[A]See Specimen Orientation under the Tension Tests section of Specification A 6/A 6M.

[B]For plates wider than 24 in. [600 mm], the elongation requirement is reduced two percentage points for Grade 50 [345] and three percentage points for Grades 60, 70, and 80 [415, 485, and 550]. See Elongation Requirement Adjustments in the Tension Tests section of Specification A 6/A 6M.

ASTM A992–04a

Standard Specification for Structural Steel Shapes

TABLE 1

Chemical Requirements (Heat Analysis)

Element	Composition, %
Carbon, max	0.23
Manganese,	0.50 to 1.50[A]
Silicon, max	0.40
Vanadium, max	0.15[B]
Columbium, max	0.05[B]
Phosphorus, max	0.035
Sulfur, max	0.045
Copper, max	0.60
Nickel, max	0.45
Chromium, max	0.35
Molybdenum, max	0.15

[A] Provided that the ratio of manganese to sulfur is not less than 20 to 1, the minimum limit for manganese for shapes with flange or leg thickness not exceeding 1 in. [25 mm] shall be 0.30 %.

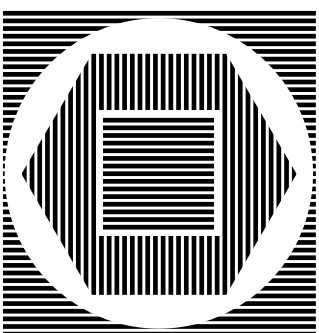
[B] The sum of columbium and vanadium shall not exceed 0.15 %.

TABLE 2

Tensile Requirements

Tensile strength, min ksi [MPa]	65 [450]
Yield point, ksi [MPa]	50 to 65 [345 to 450]
Yield to tensile ratio, max	0.85
Elongation in 8 in. [200 mm], min, %[A]	18
Elongation in 2 in. [50 mm], min, %[A]	21

[A] See elongation requirement adjustments under the Tension Tests section of Specification A 6/A 6M.



ASTM A1008–05a

Standard Specification for Cold-Rolled Structural & High Strength Low-Alloy Carbon Steel Sheet

TABLE 1 Chemical Composition[A]

For Cold Rolled Steel Sheet Designations CS, DS, DDS, and EDDS

Designation	% Heat Analysis, Element Maximum Unless Otherwise Shown												
	C	Mn	P	S	Al	Si	Cu	Ni	Cr[B]	Mo	V	Cb	Ti[C]	N
CS Type A[D,E,F,G]	0.10	0.60	0.030	0.035	. . .	. . .	0.20[H]	0.20	0.15	0.06	0.008	0.008	0.025	. . .
CS Type B[D]	0.02 to 0.15	0.60	0.030	0.035	. . .	. . .	0.20[H]	0.20	0.15	0.06	0.008	0.008	0.025	. . .
CS Type C[D,E,F,G]	0.08	0.60	0.10	0.035	. . .	. . .	0.20[H]	0.20	0.15	0.06	0.008	0.008	0.025	. . .
DS Type A[E,I]	0.08	0.50	0.020	0.030	0.01 min	. . .	0.20	0.20	0.15	0.06	0.008	0.008	0.025	. . .
DS Type B	0.02 to 0.08	0.50	0.020	0.030	0.02 min	. . .	0.20	0.20	0.15	0.06	0.008	0.008	0.025	. . .
DDS[F,G]	0.06	0.50	0.020	0.025	0.01 min	. . .	0.20	0.20	0.15	0.06	0.008	0.008	0.025	. . .
EDDS[J]	0.02	0.40	0.020	0.020	0.01 min	. . .	0.10	0.10	0.15	0.03	0.10	0.10	0.15	. . .

[A] Where an ellipsis (. . .) appears in the table, there is no requirement, but the analysis result shall be reported.
[B] Chromium is permitted, at the producer's option, to 0.25 % maximum when the carbon content is less than or equal to 0.05 %.
[C] For steels containing more than 0.02 % carbon, titanium is permitted to 0.025 %, provided the ratio of % titanium to % nitrogen does not exceed 3.4.
[D] When an aluminum deoxidized steel is required for the application, it is permissible to order Commercial Steel (CS) to a minimum of 0.01 % total aluminum.
[E] Specify Type B to avoid carbon levels below 0.02 %.
[F] It is permissible to furnish as a vacuum degassed or chemically stabilized steel, or both, at the producer's option.
[G] For carbon levels less than or equal to 0.02 %, it is permissible to use vanadium, columbium or titanium, or a combination thereof, as stabilizing elements at the producer's option. In such cases, the applicable limit for vanadium or columbium shall be 0.10 % max. and the limit on titanium shall be 0.15 % max.
[H] When copper steel is specified, the copper limit is a minimum requirement. When copper steel is not specified, the copper limit is a maximum requirement.
[I] If produced utilizing a continuous anneal process, stabilized steel is permissible at the producer's option, and Footnotes F and G apply.
[J] Shall be furnished as a vacuum degassed and stabilized steel.

TABLE 2 Chemical Composition[A]

For Cold Rolled Steel Sheet Designations SS, HSLAS, HSLAS-F, SHS, and BHS

Designation	% Heat Analysis, Element Maximum Unless Otherwise Shown													
	C	Mn	P	S	Al	Si	Cu[B]	Ni	Cr	Mo	V	Cb	Ti	N
SS:[C]														
Grade 25 [170]	0.20	0.60	0.035	0.035	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
Grade 30 [205]	0.20	0.60	0.035	0.035	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
Grade 33 [230] Type 1	0.20	0.60	0.035	0.035	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
Grade 33 [230] Type 2	0.15	0.60	0.20	0.035	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
Grade 40 [275] Type 1	0.20	0.90	0.035	0.035	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
Grade 40 [275] Type 2	0.15	0.60	0.20	0.035	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
Grade 50 [340]	0.20	0.70	0.035	0.035	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
Grade 60 [410]	0.20	0.70	0.035	0.035	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
Grade 70 [480]	0.20	0.70	0.035	0.035	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
Grade 80 [550]	0.20	0.60	0.035	0.035	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
HSLAS:[D]														
Grade 45 [310] Class 1	0.22	1.65	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	...
Grade 45 [310] Class 2	0.15	1.65	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	...
Grade 50 [340] Class 1	0.23	1.65	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	...
Grade 50 [340] Class 2	0.15	1.65	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	...
Grade 55 [380] Class 1	0.25	1.65	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	...
Grade 55 [380] Class 2	0.15	1.65	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	...
Grade 60 [410] Class 1	0.26	1.65	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	...
Grade 60 [410] Class 2	0.15	1.65	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	...

(Table 2 cont. on Page 138)

TABLE 2 *(cont. from Page 137)* Chemical Composition[A]

For Cold Rolled Steel Sheet Designations SS, HSLAS, HSLAS-F, SHS, and BHS

Designation	% Heat Analysis, Element Maximum Unless Otherwise Shown													
	C	Mn	P	S	Al	Si	Cu[B]	Ni	Cr	Mo	V	Cb	Ti	N
Grade 65 [450] Class 1	0.26	1.65	0.04	0.04	. . .	. . .	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	[E]
Grade 65 [450] Class 2	0.15	1.65	0.04	0.04	. . .	. . .	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	[E]
Grade 70 [480] Class 1	0.26	1.65	0.04	0.04	. . .	. . .	0.20	0.20	0.15	0.16	0.005 min	0.005 min	0.005 min	[E]
Grade 70 [480] Class 2	0.15	1.65	0.04	0.04	. . .	. . .	0.20	0.20	0.15	0.16	0.005 min	0.005 min	0.005 min	[E]
HSLAS-F:[D]														
Grade 50 [340] and 60 [410]	0.15	1.65	0.020	0.025	. . .	. . .	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	[E]
Grade 70 [480] and 80 [550]	0.15	1.65	0.020	0.025	. . .	. . .	0.20	0.20	0.15	0.16	0.005 min	0.005 min	0.005 min	[E]
SHS[F]	0.12	1.50	0.12	0.030	. . .	. . .	0.20	0.20	0.15	0.06	0.008	0.008	0.008	. . .
BHS[F]	0.12	1.50	0.12	0.030	. . .	. . .	0.20	0.20	0.15	0.06	0.008	0.008	0.008	. . .

[A] Where an ellipsis (. . .) appears in the table, there is no requirement but, the analysis shall be reported.

[B] When copper is specified, the copper limit is a minimum requirement. When copper steel is not specified, the copper limit is a maximum requirement.

[C] Titanium is permitted for SS designations, at the producer's option, to 0.025 % maximum, provided the ratio of % titanium to % nitrogen does not exceed 3.4.

[D] HSLAS and HSLAS-F steels contain the strengthening elements columbium (niobium), vanadium, titanium, and molybdenum added singly or in combination. The minimum requirements only apply to the microalloy elements selected for strengthening of the steel.

[E] The purchaser has the option of restricting the nitrogen content. It should be noted that, depending on the microalloying scheme (for example, use of vanadium) of the producer, nitrogen may be a deliberate addition. Consideration should be made for the use of nitrogen binding elements (for example, vanadium, titanium).

[F] For carbon levels less than or equal to 0.02 % vanadium, columbium, or titanium, or a combination thereof, are permitted to be used as stabilizing elements at the producer's option. In such cases, the applicable limit for vanadium and columbium shall be 0.10 % max., and the limit for titanium shall be 0.15 % max.

TABLE 3 Typical Ranges of Mechanical Properties[A] (Nonmandatory)[B] For Cold Rolled Steel Sheet Designations CS, DS, DDS and EDDS

Designation	Yield Strength[C]		Elongation in 2 in. [50 mm] %[C]	r_m Value[D]	n-Value[E]
	ksi	MPa			
CS Types A, B, and C	20 to 40	[140 to 275]	≥30	[F]	[F]
DS Types A and B	22 to 35	[150 to 240]	≥36	1.3 to 1.7	0.17 to 0.22
DDS	17 to 29	[115 to 200]	≥38	1.4 to 1.8	0.20 to 0.25
EDDS	15 to 25	[105 to 170]	≥40	1.7 to 2.1	0.23 to 0.27

[A] These typical mechanical properties apply to the full range of steel sheet thicknesses. The yield strength tends to increase, the elongation decreases and some of the formability values tend to decrease as the sheet thickness decreases.

[B] The typical mechanical property values presented here are nonmandatory. They are provided to assist the purchaser in specifying a suitable steel for a given application. Values outside of these ranges are to be expected.

[C] Yield Strength and elongation are measured in the longitudinal direction in accordance with Test Methods and Definitions A 370.

[D] Average plastic strain ratio (r_m value) as determined by Test Method E 517.

[E] The strain hardening exponent (n-value) as determined by Test Method E 646.

[F] No typical properties have been established.

TABLE 4 Mechanical Property Requirements[A]

For Cold Rolled Steel Sheet Designations SS, HSLAS, and HSLAS-F

Designation	Yield Strength, min		Tensile Strength, min		Elongation in 2 in. or 50 mm, min, %
	ksi	[MPa]	ksi	[MPa]	
SS:					
Grade 25 [170]	25	[170]	42	[290]	26
Grade 30 [205]	30	[205]	45	[310]	24
Grade 33 [230] Types 1 and 2	33	[230]	48	[330]	22
Grade 40 [275] Types 1 and 2	40	[275]	52	[360]	20
Grade 50 [340]	50	[340]	65	[410]	18
Grade 60 [410]	60	[410]	75	[480]	12
Grade 70 [480]	70	[480]	85	[540]	6
Grade 80 [550]	80[B]	[550]	82	[565]	[C]
HSLAS:					
Grade 45 [310] Class 1	45	[310]	60	[410]	22
Grade 45 [310] Class 2	45	[310]	55	[380]	22
Grade 50 [340] Class 1	50	[340]	65	[450]	20
Grade 50 [340] Class 2	50	[340]	60	[410]	20

(Table 4 cont. on Page 141)

TABLE 4 *(cont. from Page 140)* **Mechanical Property Requirements**[A]
For Cold Rolled Steel Sheet Designations SS, HSLAS, and HSLAS-F

Designation	Yield Strength, min		Tensile Strength, min		Elongation in 2 in. or 50 mm, min, %
	ksi	[MPa]	ksi	[MPa]	
Grade 55 [380] Class 1	55	[380]	70	[480]	18
Grade 55 [380] Class 2	55	[380]	65	[450]	18
Grade 60 [410] Class 1	60	[410]	75	[520]	16
Grade 60 [410] Class 2	60	[410]	70	[480]	16
Grade 65 [450] Class 1	65	[450]	80	[550]	15
Grade 65 [450] Class 2	65	[450]	75	[520]	15
Grade 70 [480] Class 1	70	[480]	85	[585]	14
Grade 70 [480] Class 2	70	[480]	80	[550]	14
HSLAS-F:					
Grade 50 [340]	50	[340]	60	[410]	22
Grade 60 [410]	60	[410]	70	[480]	18
Grade 70 [480]	70	[480]	80	[550]	16
Grade 80 [550]	80	[550]	90	[620]	14

[A] For coil products, testing by the producer is limited to the end of the coil. Mechanical properties throughout the coil shall comply with the minimum values specified.
[B] On this full-hard product, the yield strength approaches the tensile strength and since there is no halt in the gage or drop in the beam, the yield point shall be taken as the yield stress at 0.5 % extension under load.
[C] There is no requirement for elongation in 2 in. for SS Grade 80.

Russel Metals
WILLIAMS BAHCALL

ASTM A1011–05

Standard Specification for Hot-Rolled Structural & High Strength Low-Alloy Carbon Steel Sheet & Strip

TABLE 1 Chemical Composition[A]

For Hot Rolled Steel Sheet and Strip Designations CS and DS

	Composition, % Heat Analysis Element maximum unless otherwise shown													
	C	Mn	P	S	Al	Si	Cu	Ni	Cr[B]	Mo	V	Cb	Ti[C]	N
CS Type A[D,E,F,G]	0.10	0.60	0.030	0.035	. . .	. . .	0.20[H]	0.20	0.15	0.06	0.008	0.008	0.025	. . .
CS Type B[F]	0.02 to 0.15	0.60	0.030	0.035	. . .	. . .	0.20[H]	0.20	0.15	0.06	0.008	0.008	0.025	. . .
CS Type C[D,E,F,G]	0.08	0.60	0.10	0.035	. . .	. . .	0.20[H]	0.20	0.15	0.06	0.008	0.008	0.025	. . .
CS Type D[F]	0.10	0.70	0.030	0.035	. . .	. . .	0.20[H]	0.20	0.15	0.06	0.008	0.008	0.008	. . .
DS Type A[D,E,G]	0.08	0.50	0.020	0.030	0.01 min	. . .	0.20	0.20	0.15	0.06	0.008	0.008	0.025	. . .
DS Type B	0.02 to 0.08	0.50	0.020	0.030	0.01 min	. . .	0.20	0.20	0.15	0.06	0.008	0.008	0.025	. . .

[A] Where an ellipsis (. . .) appears in the table, there is no specified limit, but the analysis shall be reported.
[B] Chromium is permitted, at the producer's option, to 0.25 % maximum when the carbon content is less than or equal to 0.05 %.
[C] Titanium is permitted, at producer's option, to 0.025 % provided the ratio of % titanium to % nitrogen does not exceed 3.4.
[D] Specify Type B to avoid carbon levels below 0.02 %.
[E] For carbon levels less than or equal to 0.02 %, it is permissible to use vanadium, columbium, or titanium, or combinations thereof, as stabilizing elements at the producer's option. In such case, the limits for these elements are 0.10 % for vanadium or columbium and 0.15 % for titanium.
[F] When an aluminum deoxidized steel is required, it is permissible to order a minimum of 0.01 % total aluminum.
[G] It is permissible to furnish as a vacuum degassed or chemically stabilized steel, or both, at producer's option.
[H] When copper steel is specified, the copper limit is a minimum requirement. When copper steel is not specified, the copper limit is a maximum requirement.

TABLE 2 Chemical Composition[A]

For Hot Rolled Steel Sheet and Strip Designations SS, HSLAS, and HSLAS-F

Designation	% Heat Analysis, Element Maximum unless otherwise shown													
	C	Mn	P	S	Al	Si	Cu[B]	Ni	Cr	Mo	V	Cb	Ti	N
SS:[C]														
Grade 30 [205]	0.25	0.90	0.035	0.04	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
Grade 33 [230]	0.25	0.90	0.035	0.04	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
Grade 36 [250] Type 1	0.25	0.90	0.035	0.04	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
Grade 36 [250] Type 2[D]	0.25	1.35	0.035	0.04	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
Grade 40 [275]	0.25	0.90	0.035	0.04	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
Grade 45 [310][D]	0.25	1.35	0.035	0.04	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
Grade 50 [340][D]	0.25	1.35	0.035	0.04	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
Grade 55 [380][D]	0.25	1.35	0.035	0.04	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
Grade 60 [410]	0.25	1.35	0.035	0.04	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
Grade 70 [480]	0.25	1.35	0.035	0.04	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
Grade 80 [550]	0.25	1.35	0.035	0.04	...	...	0.20	0.20	0.15	0.06	0.008	0.008	0.025	...
HSLAS:[E]														
Grade 45 [310] Class 1[D]	0.22	1.35	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	...
Grade 45 [310] Class 2	0.15	1.35	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	...
Grade 50 [340] Class 1[D]	0.23	1.35	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	...
Grade 50 [340] Class 2	0.15	1.35	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	...
Grade 55 [380] Class 1[D]	0.25	1.35	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	...
Grade 55 [380] Class 2	0.15	1.35	0.04	0.04	...	...	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	...

(Table 2 cont. on Page 144)

TABLE 2 *(cont. from Page 143)* Chemical Composition[A]

For Hot Rolled Steel Sheet and Strip Designations SS, HSLAS, and HSLAS-F

Designation	% Heat Analysis, Element Maximum unless otherwise shown													
	C	Mn	P	S	Al	Si	Cu[B]	Ni	Cr	Mo	V	Cb	Ti	N
Grade 60 [410] Class 1	0.26	1.50	0.04	0.04	. . .	. . .	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	. . .
Grade 60 [410] Class 2	0.15	1.50	0.04	0.04	. . .	. . .	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	. . .
Grade 65 [450] Class 1	0.26	1.50	0.04	0.04	. . .	. . .	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	[F]
Grade 65 [450] Class 2	0.15	1.50	0.04	0.04	. . .	. . .	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	[F]
Grade 70 [480] Class 1	0.26	1.65	0.04	0.04	. . .	. . .	0.20	0.20	0.15	0.16	0.005 min	0.005 min	0.005 min	[F]
Grade 70 [480] Class 2	0.15	1.65	0.04	0.04	. . .	. . .	0.20	0.20	0.15	0.16	0.005 min	0.005 min	0.005 min	[F]
HSLAS-F:[E]														
Grade 50 [340] and 60 [410]	0.15	1.65	0.020	0.025	. . .	. . .	0.20	0.20	0.15	0.06	0.005 min	0.005 min	0.005 min	[F]
Grade 70 [480] and 80 [550]	0.15	1.65	0.020	0.025	. . .	. . .	0.20	0.20	0.15	0.16	0.005 min	0.005 min	0.005 min	[F]

[A] Where an ellipsis (. . .) appears in the table, there is no requirement but the analysis shall be reported.

[B] When copper is specified, the copper limit is a minimum requirement. When copper steel is not specified, the copper limit is a maximum requirement.

[C] Titanium is permitted for SS designations, at the producer's option, to 0.025 % maximum, providing the ratio of % titanium to % nitrogen does not exceed 3.4.

[D] For each reduction of 0.01 % below the specified carbon maximum, an increase of 0.06 % manganese above the specified maximum will be permitted up to a maximum of 1.50 % .

[E] HSLAS and HSLAS-F steels contain the strengthening elements columbium (niobium), vanadium, titanium, and molybdenum added singly or in combination. The minimum requirements only apply to the microalloy elements selected for strengthening of the steel.

[F] The purchaser has the option of restricting the nitrogen content. It should be noted that, depending on the microalloying scheme (for example, use of vanadium) of the producer, nitrogen may be a deliberate addition. Consideration should be made for the use of nitrogen binding elements (for example, vanadium, titanium).

ASTM A1011–05

TABLE 3

Typical Ranges of Mechanical Properties[A] (Nonmandatory)[B] For Hot-Rolled Steel Sheet and Strip Designations CS and DS

Designation	Yield Strength[C]		Elongation in 2 in. [50 mm]%[C]
	ksi	MPa	
CS Types A, B, C, and D	30 to 50	[205 to 340]	≥25
DS Types A and B	30 to 45	[205 to 310]	≥28

[A] The yield strength tends to increase and the elongation tends to decrease as the sheet thickness decreases. These properties represent those typical of material in the thickness range of 0.100 to 0.150 in. [2.5 to 3.5 mm] for CS Types A, B, and DS Types A and B and in the thickness ranges of 0.060 to 0.075 in. [1.5 to 1.9 mm] for CS Type D.

[B] The typical mechanical property values presented here are nonmandatory. They are provided to assist the purchaser in specifying a suitable steel for a given application. Values outside these ranges are to be expected.

[C] Yield strength and elongation are measured in the longitudinal direction in accordance with Test Methods and Definitions A 370.

Notes

TABLE 4 Chemical Property Requirements[A]

For Hot Rolled Steel Sheet and Strip Designations SS, HSLAS, and HSLAS-F

Designation	Yield Strength	Tensile Strength[B]	Elongation in 2 in. [50 mm] min, % for Thicknesses:			Elongation in 8 in. [200 mm], % for Thickness:
	ksi [MPa] min	ksi [MPa] min	Under 0.230 [6.0 mm] to 0.097 [2.5 mm]	Under 0.097 [2.5 mm] to 0.064 [1.6 mm]	Under 0.064 [1.6 mm] to 0.025 [0.65 mm]	Under 0.230 [6.0 mm]
SS:						
Grade 30 [205]	30 [205]	49 [340]	25	24	21	19
Grade 33 [230]	33 [230]	52 [360]	23	22	18	18
Grade 36 [250] Type 1	36 [250]	53 [365]	22	21	17	17
Grade 36 [250] Type 2	36 [250]	58-80 [400-550]	21	20	16	16
Grade 40 [275]	40 [275]	55 [380]	21	20	15	16
Grade 45 [310]	45 [310]	60 [410]	19	18	13	14
Grade 50 [340]	50 [340]	65 [450]	17	16	11	12
Grade 55 [380]	55 [380]	70 [480]	15	14	9	10
Grade 60 [410]	60 [410]	75 [480]	14	13	8	9
Grade 70 [480]	70 [480]	85 [550]	13	12	7	8
Grade 80 [550]	80 [550]	95 [620]	12	11	6	7
HSLAS:			Over 0.097 in. [2.5 mm]	Up to 0.097 [2.5 mm]		. . .
Grade 45 [310] Class 1	45 [310]	60 [410]	25	23		. . .
Grade 45 [310] Class 2	45 [310]	55 [380]	25	23		. . .
Grade 50 [340] Class 1	50 [340]	65 [450]	22	20		. . .

(Table 4 cont. on Page 147)

TABLE 4 *(cont. from Page 146)* **Chemical Property Requirements**[A]

For Hot Rolled Steel Sheet and Strip Designations SS, HSLAS, and HSLAS-F

Designation	Yield Strength	Tensile Strength[B]	Elongation in 2 in. [50 mm] min, % for Thicknesses:			Elongation in 8 in. [200 mm], % for Thickness:
	ksi [MPa] min	ksi [MPa] min	Under 0.230 [6.0 mm] to 0.097 [2.5 mm]	Under 0.097 [2.5 mm] to 0.064 [1.6 mm]	Under 0.064 [1.6 mm] to 0.025 [0.65 mm]	Under 0.230 [6.0 mm]
Grade 50 [340] Class 2	50 [340]	60 [410]	22	20		. . .
Grade 55 [380] Class 1	55 [380]	70 [480]	20	18		. . .
Grade 55 [380] Class 2	55 [380]	65 [450]	20	18		. . .
Grade 60 [410] Class 1	60 [410]	75 [520]	18	16		. . .
Grade 60 [410] Class 2	60 [410]	70 [480]	18	16		. . .
Grade 65 [450] Class 1	65 [450]	80 [550]	16	14		. . .
Grade 65 [450] Class 2	65 [450]	75 [520]	16	14		. . .
Grade 70 [480] Class 1	70 [480]	85 [585]	14	12		. . .
Grade 70 [480] Class 2	70 [480]	80 [550]	14	12		. . .
HSLAS-F:						
Grade 50 [340]	50 [340]	60 [410]	24	22		. . .
Grade 60 [410]	60 [410]	70 [480]	22	20		. . .
Grade 70 [480]	70 [480]	80 [550]	20	18		. . .
Grade 80 [550]	80 [550]	90 [620]	18	16		. . .

[A] For coil products, testing by the producer is limited to the end of the coil. Mechanical properties throughout the coil shall comply with the minimum values specified.
[B] A minimum and maximum tensile strength has been specified for SS36 Type 2.

Notes

EXPLANATION OF THE S.A.E. NUMBERING SYSTEM

The numerical index system, commonly referred to as the S.A.E. Standard System, was developed by the Society of Automotive Engineers, Inc., to provide a simple means of indicating the chemical composition of the various steel grades in more common use. The present revision has been brought about by the development and general application of numerous new steel analyses during recent years and the necessity for extending the system to cover them.

The system is based on the use of numbers composed of four or five digits, and certain letters used as prefixes. The first digit of the standard number indicates the type to which the particular steel belongs. Thus "1" indicates a carbon steel, "2" a nickel steel, "3" a nickel chromium steel, "4" a molybdenum steel, etc. In the case of the alloy steels, the second digit, and sometimes the third, usually indicate the approximate percentage of the principal alloy, — in the case of simple alloys, the alloy from which the steel is named. The final two (sometimes three) digits indicate the mean carbon content in "points," or one-hundredths of one percent. Thus, "2320" indicates a nickel steel of approximately 3% nickel content (3.25%/3.75%) and .20% average carbon (.15%/.25%); "52100" indicates a chromium steel of more than 1% average chromium content (1.20%/1.50%, as compared with .60%/.90% or .80%/1.10% for the 5100 series) and 1.00% carbon (.95%/1.10%), while "71360" indicates a tungsten steel of 13% tungsten content (12%/15%) and .60% carbon (.50/.70%).

The prefix "X" is used in several instances to indicate variations in the range of sulphur, manganese and chromium, and the prefix "T" is used with Manganese Steels to indicate a higher range of manganese than that found in steels of the X1300 series.

Basic numerals of the system are:

Carbon Steels — First Digit — 1

Plain Carbon	10
Free Cutting (Screw Stock)	11
Free Cutting (Manganese)	X13
High Manganese	T13
Medium Manganese — Speed Case & Speed Treat	*X15

Alloy Steels — Nickel — First Digit — 2

.50% Nickel	20
1.50% Nickel	21
3.50% Nickel	23
5.00% Nickel	25

Nickel-Chromium — First Digit — 3

1.25% Nickel, .60% Chromium	31
1.75% Nickel, 1.00% Chromium	32
3.50% Nickel, 1.50% Chromium	33
3.00% Nickel, .80% Chromium	34
Corrosion & Heat Resisting (Stainless)	30

Molybdenum — First Digit — 4

Chromium-Molybdenum	41
Chromium-Nickel-Molybdenum	43
Nickel-Molybdenum	46 & 48

Chromium — First Digit — 5

Low Chromium (up to 1.10%)	51
Medium Chromium	52
Corrosion & Heat Resisting (Stainless)	51
Chromium-Vanadium (.80%/1.10% Chromium)	61
Manganese-Nickel-Chromium	8
Silico-Manganese	9

*Not a part of any A.I.S.I. or S.A.E. system of identification.

EXPLANATION OF THE A.I.S.I.

System of Identification

A system of symbols is used to identify the grades of standard steels. In those symbols a capital letter prefix "B" is used to indicate acid Bessemer steel, and "L" within the grade number is used to identify leaded steels. Numbers are used to indicate grades of steel by chemical composition as described below.

Numerical Designations. A four-numeral series designates carbon steel or alloy steel specified to chemical composition ranges. Five numerals are used to designate certain types of alloy steels.

The last two digits of four-numeral series are intended, so far as feasible, to indicate approximate middle of the carbon range; for example, 35 represents a range of 0.32 to 0.38 per cent. It is necessary however to deviate from this rule and to interpolate numbers in the case of some carbon ranges; and for variations in manganese, phosphorus, sulphur, chromium, or other elements.

The first two digits of the four-numeral series for the various grades of steel and their meaning are as follows:

Series Designation	Types and Classes
10xx	Nonsulphurized Carbon Steel Grades.
11xx	Resulphurized Carbon Steel Grades.
12xx	Rephosphorized and resulphurized Carbon Steel Grades.
13xx	Manganese 1.60 to 1.90 Per Cent
*15xx	Manganese 1.00 to 1.35 Per Cent, Sulphur .20 to .30 Per Cent
23xx	Nickel 3.50 Per Cent
25xx	Nickel 5.00 Per Cent
31xx	Nickel 1.25 Per Cent — Chromium 0.65 or 0.80 Per Cent
33xx	Nickel 3.50 Per Cent — Chromium 1.55 Per Cent
40xx	Molybdenum 0.25 Per Cent
41xx	Chromium 0.95 Per Cent — Molybdenum 0.20 Per Cent
43xx	Nickel 1.80 Per Cent — Chromium 0.50 or 0.80 Per Cent — Molybdenum 0.25 Per Cent
46xx	Nickel 1.80 Per Cent — Molybdenum 0.25 Per Cent
48xx	Nickel 3.50 Per Cent — Molybdenum 0.25 Per Cent
50xx	Chromium 0.30 or 0.60 Per Cent
51xx	Chromium 0.80, 0.95 or 1.05 Per Cent
5xxxx	Carbon 1.00 Per Cent — Chromium 0.50, 1.00 or 1.45 Per Cent
61xx	Chromium 0.80 or 0.95 Per Cent — Vanadium 0.10 or 0.15 Per Cent
86xx	Nickel 0.55 Per Cent — Chromium 0.50 Per Cent — Molybdenum 0.20 Per Cent
87xx	Nickel 0.55 Per Cent — Chromium 0.50 Per Cent — Molybdenum 0.25 Per Cent
92xx	Manganese 0.85 Per Cent — Silicon 2.00 Per Cent
93xx	Nickel 3.25 Per Cent — Chromium 1.20 Per Cent — Molybdenum 0.12 Per Cent
94xx	Manganese 1.00 Per Cent — Nickel 0.45 Per Cent — Chromium 0.40 Per Cent — Molybdenum 0.12 Per Cent
97xx	Nickel 0.55 Per Cent — Molybdenum 0.20 Per Cent — Chromium 0.17 Per Cent
98xx	Nickel 1.00 Per Cent — Chromium 0.80 Per Cent — Molybdenum 0.25 Per Cent

Not a part of any A.I.S.I. or S.A.E. system of identification.

A.I.S.I. AND COMPARATIVE S.A.E. Specifications

Nonressulphurized Standard Carbon Steels

Table 1 — Ladle Chemcial Ranges and Limits

A.I.S.I. No.	Chemical Composition Limits, Per Cent C	Mn	P Max.	S Max.	S.A.E. No.
1008	0.10 Max.	0.30/0.50	0.040	0.50	—
1010	0.08/0.13	0.30/0.60	0.040	0.050	1010
1012	0.10/0.15	0.30/0.60	0.040	0.050	1012
1015	0.13/0.18	0.30/0.60	0.040	0.050	1015
1016	0.13/0.18	0.60/0.90	0.040	0.050	1016
1017	0.15/0.20	0.30/0.60	0.040	0.050	1017
1018	0.15/0.20	0.60/0.90	0.040	0.050	1018
1019	0.15/0.20	0.70/1.00	0.040	0.050	1019
1020	0.18/0.23	0.30/0.60	0.040	0.050	1020
1021	0.18/0.23	0.60/0.90	0.040	0.050	1021
1022	0.18/0.23	0.70/1.00	0.040	0.050	1022
1023	0.20/0.25	0.30/0.60	0.040	0.050	1023
1024	0.19/0.25	1.35/1.65	0.040	0.050	1024
1025	0.22/0.28	0.30/0.60	0.040	0.050	1025
1026	0.22/0.28	0.60/0.90	0.040	0.050	1026
1027	0.22/0.29	1.20/1.50	0.040	0.050	1027
1029	0.22/0.31	0.60/0.90	0.040	0.050	—
1030	0.28/0.34	0.60/0.90	0.040	0.050	1030
1035	0.32/0.38	0.60/0.90	0.040	0.050	1035
1036	0.30/0.37	1.20/1.50	0.040	0.050	1036
1037	0.32/0.38	0.70/1.00	0.040	0.050	1037
1038	0.35/0.42	0.60/0.90	0.040	0.050	1038
1039	0.37/0.44	0.70/1.00	0.040	0.050	1039
1040	0.37/0.44	0.60/0.90	0.040	0.050	1040
1041	0.36/0.44	1.35/1.65	0.040	0.050	1041
1042	0.40/0.47	0.60/0.90	0.040	0.050	1042
1043	0.40/0.47	0.70/1.00	0.040	0.050	1043
1044	0.43/0.50	0.30/0.60	0.040	0.050	1044
1045	0.43/0.50	0.60/0.90	0.040	0.050	1045
1046	0.43/0.50	0.70/1.00	0.040	0.050	1046
1048	0.44/0.52	1.10/1.40	0.040	0.050	1048
1049	0.46/0.53	0.60/0.90	0.040	0.050	1049
1050	0.48/0.55	0.60/0.90	0.040	0.050	1050
1051	0.45/0.56	0.85/1.15	0.040	0.050	—
1052	0.47/0.55	1.20/1.50	0.040	0.050	1052
1053	0.48/0.55	0.70/1.00	0.040	0.050	—
1055	0.50/0.60	0.60/0.90	0.040	0.050	1055
1060	0.55/0.65	0.60/0.90	0.040	0.050	1060
1070	0.65/0.75	0.60/0.90	0.040	0.050	1070
1078	0.72/0.85	0.30/0.60	0.040	0.050	1078
1080	0.75/0.88	0.60/0.90	0.040	0.050	1080
1084	0.80/0.93	0.60/0.90	0.040	0.050	1084
1090	0.85/0.98	0.60/0.90	0.040	0.050	1090
1095	0.90/1.03	0.30/0.50	0.040	0.050	1095

continued on following page

continued from preceding page

Silicon: Applicable to Table 1.
SPECIAL QUALITY: — Steels of special quality may be specified to standard silicon limitations as outlined below:

AISI DESIGNATION	Silicon Limitations
Up to 1015 Excl.	0.010 Max.
1015 to 1025 Incl.	0.10 Max., 0.10/0.20, or 0.15/0.30
Over 1025	0.10/0.20 or 0.15/0.30

If other limitations required, grade becomes non-standard.

A.I.S.I. AND COMPARATIVE S.A.E.

Specifications

Standard Steels

Open-Hearth and Electric Furnace Alloy Steels Subject to Permissible Variations for Check Analyses

A.I.S.I. No.	C	Mn	P	S	Si	Ni	Cr	Mo	S.A.E. No.
1330	.28/0.33	1.60/1.90	.040	.040	0.20/0.35	—	—	—	1330
1335	.33/0.38	1.60/1.90	.040	.040	0.20/0.35	—	—	—	1335
1340	.38/0.43	1.60/1.90	.040	.040	0.20/0.35	—	—	—	1340
1345	.43/0.48	1.60/1.90	.040	.040	0.20/0.35	—	—	—	1345
3140	.38/0.43	0.70/0.90	.040	.040	0.20/0.35	1.10/1.40	0.55/0.75	—	3140
E3310	.08/0.13	0.45/0.60	.025	.025	0.20/0.35	3.25/3.75	1.40/1.75	—	3310
4012	.09/0.14	0.75/1.00	.040	.040	0.20/0.35	—	—	.15/.25	4012
4023	.20/0.25	0.70/0.90	.040	.040	0.20/0.35	—	—	.20/.30	4023
4024	.20/0.25	0.70/0.90	.040	.035					
				.050	0.20/0.35	—	—	.20/.30	4024
4027	.25/0.30	0.70/0.90	.040	.040	0.20/0.35	—	—	.20/.30	4027
4028	.25/0.30	0.70/0.90	.040	.035					
				.050	0.20/0.35	—	—	.20/.30	4028
4037	.35/0.40	0.70/0.90	.040	.040	0.20/0.35	—	—	.20/.30	4037
4042	.40/0.45	0.70/0.90	.040	.040	0.20/0.35	—	—	.20/.30	4042
4047	.45/0.50	0.70/0.90	.040	.040	0.20/0.35	—	—	.20/.30	4047
4063	.60/0.67	0.75/1.00	.040	.040	0.20/0.35	—	—	.20/.30	4063
4418	.18/0.23	0.70/0.90	.040	.040	0.20/0.35	—	0.40/0.60	.08/.15	4418
4130	.28/0.33	0.40/0.60	.040	.040	0.20/0.35	—	0.80/1.10	.15/.25	4130
4135	.33/0.38	0.70/0.90	.040	.040	0.20/0.35	—	0.80/1.10	.15/.25	4135
4137	.35/0.40	0.70/0.90	.040	.040	0.20/0.35	—	0.80/1.10	.15/.25	4137
4140	.38/0.43	0.75/1.00	.040	.040	0.20/0.35	—	0.80/1.10	.15/.25	4140
4142	.40/0.45	0.75/1.00	.040	.040	0.20/0.35	—	0.80/1.10	.15/.25	4142
4145	.43/0.48	0.75/1.00	.040	.040	0.20/0.35	—	0.80/1.10	.15/.25	4145
4147	.45/0.50	0.75/1.00	.040	.040	0.20/0.35	—	0.80/1.10	.15/.25	4147
4150	.48/0.53	0.75/1.00	.040	.040	0.20/0.35	—	0.80/1.10	.15/.25	4150
4320	.17/0.22	0.45/0.65	.040	.040	0.20/0.35	1.65/2.00	0.40/0.60	.20/.30	4320
4337	.35/0.40	0.60/0.80	.040	.040	0.20/0.35	1.65/2.00	0.70/0.90	.20/.30	4337
E4337	.35/0.40	0.65/0.85	.025	.025	0.20/0.35	1.65/2.00	0.70/0.90	.20/.30	—
4340	.38/043	0.60/0.80	.040	.040	0.20/0.35	1.65/2.00	0.70/0.90	.20/.30	4340
E4340	.38/0.43	0.65/0.85	.025	.025	0.20/0.35	1.65/2.00	0.70/0.90	.20/.30	4340
4422	.20/.025	0.70/0.90	.040	.040	0.20/0.35	—	—	.35/.45	4422
4427	.24/0.29	0.70/0.90	.040	.040	0.20/0.35	—	—	.35/.45	4427
4520	.18/0.23	0.45/0.65	.040	.040	0.20/0.35	—	—	.35/.60	4520
4615	.13/0.18	0.45/0.65	.040	.040	0.20/0.35	1.65/2.00	—	.20/.30	4615
E4617	.15/0.20	0.45/0.65	.025	.025	0.20/0.35	1.65/2.00	—	.20/.27	4617
4620	.17/0.22	0.45/0.65	.040	.040	0.20/0.35	1.65/2.00	—	.20/.30	4620
4621	.18/0.23	0.70/0.90	.040	.040	0.20/0.35	1.65/2.00	—	.20/.30	4621
4718	.16/0.21	0.70/0.90	.040	.040	0.20/0.35	0.90/1.20	0.35/0.55	.30/.40	4718
4720	.17/0.22	0.50/0.70	.040	.040	0.20/0.35	0.90/1.20	0.35/0.55	.15/.25	4720
4815	.13/0.18	0.40/0.60	.040	.040	0.20/0.35	3.25/3.75	—	.20/.30	4815
4817	.15/0.20	0.40/0.60	.040	.040	0.20/0.35	3.25/3.75	—	.20/.30	4817
4820	.18/0.23	0.50/0.70	.040	.040	0.20/0.35	3.25/3.75	—	.20/.30	4820
5015	.12/0.17	0.30/0.50	.040	.040	0.20/0.35	—	0.30/0.50	—	5015
5046	.43/0.50	0.75/1.00	.040	.040	0.20/0.35	—	0.20/0.35	—	5046
5115	.13/0.18	0.70/0.90	.050	.040	0.20/0.35	—	0.70/0.90	—	5115
5120	.17/0.22	0.70/0.90	.040	.040	0.20/0.35	—	0.70/0.90	—	5120
5130	.28/0.33	0.70/0.90	.040	.040	0.20/0.35	—	0.80/1.10	—	5130
5132	.30/0.35	0.60/0.80	.040	.040	0.20/0.35	—	0.75/1.00	—	5132
5135	.33/0.38	0.60/0.80	.040	.040	0.20/0.35	—	0.80/1.05	—	5135
5140	.38/0.43	0.70/0.90	.040	.040	0.20/0.35	—	0.70/0.90	—	5140
5145	.43/0.48	0.70/0.90	.040	.040	0.20/0.35	—	0.70/0.90	—	5145
5147	.45/0.52	0.70/0.95	.040	.040	0.20/0.35	—	0.85/1.15	—	5147

A.I.S.I. AND COMPARATIVE S.A.E.
Specifications
Standard Steels
Open-Hearth and Electric Furnace Alloy Steels
Subject to Permissible Variations for Check Analyses

continued from preceding page

A.I.S.I. No.	C	Mn	P	S	Si	Ni	Cr	Mo	S.A.E. No.
5150	.48/0.53	0.70/0.90	.040	.040	0.20/0.35	—	0.70/0.90	—	5150
5155	.50/0.60	0.70/0.90	.040	.040	0.20/0.35	—	0.70/0.90	—	5155
5160	.55/0.65	0.75/1.00	.040	.040	0.20/0.35	—	0.70/0.90	—	5160
E50100	.95/1.00	0.25/0.45	.025	.025	0.20/0.35	—	0.40/0.60	—	50100
E51100	.95/1.00	0.25/0.45	.025	.025	0.20/0.35	—	0.90/1.15	—	51100
E52100	.95/1.10	0.25/0.45	.025	.025	0.20/0.35	—	1.30/1.60	—	52100
6118	.16/0.21	0.50/0.70	.040	.040	0.20/0.35	—	0.50/0.70	.10/.15V	6118
6120	.17/0.22	0.70/0.90	.040	.040	0.20/0.35	—	0.70/0.90	.10V	—
6150	.48/0.53	0.70/0.90	.040	.040	0.20/0.35	—	0.80/1.10	15V	6150
8115	.13/0.18	0.70/0.90	.040	.040	0.20/0.35	0.20/0.40	0.30/0.50	.08/.15	8115
8615	.13/0.18	0.70/0.90	.040	.040	0.20/0.35	0.40/0.70	0.40/0.60	.15/.25	8615
8617	.15/0.20	0.70/0.90	.040	.040	0.20/0.35	0.40/0.70	0.40/0.60	.15/.25	8617
8620	.18/0.23	0.70/0.90	.040	.040	0.20/0.35	0.40/0.70	0.40/0.60	.15/.25	8620
8622	.20/0.25	0.70/0.90	.040	.040	0.20/0.35	0.40/0.70	0.40/0.60	.15/.25	8622
8625	.23/0.28	0.70/0.90	.040	.040	0.20/0.35	0.40/0.70	0.40/0.60	.15/.25	8625
8627	.25/0.30	0.70/0.90	.040	.040	0.20/0.35	0.40/0.70	0.40/0.60	.15/.25	8627
8630	.28/0.33	0.70/0.90	.040	.040	0.20/0.35	0.40/0.70	0.40/0.60	.15/.25	8630
8637	.35/0.40	0.75/1.00	.040	.040	0.20/0.35	0.40/0.70	0.40/0.60	.15/.25	8637
8640	.38/0.43	0.75/1.00	.040	.040	0.20/0.35	0.40/0.70	0.40/0.60	.15/.25	8640
8642	.40/0.45	0.75/.100	.040	.040	0.20/0.35	0.40/0.70	0.40/0.60	.15/.25	8642
8645	.43/0.48	0.75/1.00	.040	.040	0.20/0.35	0.40/0.70	0.40/0.60	.15/.25	8645
8650	.48/0.53	0.75/1.00	.040	.040	0.20/0.35	0.40/0.70	0.40/0.60	.15/.25	8650
8655	.50/0.60	0.75/1.00	.040	.040	0.20/0.35	0.40/0.70	0.40/0.60	.15/.25	8655
8660	.55/0.65	0.75/1.00	.040	.040	0.20/0.35	0.40/0.70	0.40/0.60	.15/.25	8660
8720	.18/0.23	0.70/0.90	.040	.040	0.20/0.35	0.40/0.70	0.40/0.60	.20/.30	8720
8735	.33/0.38	0.75/1.00	.040	.040	0.20/0.35	0.40/0.70	0.40/0.60	.20/.30	8735
8740	.38/0.43	0.75/1.00	.040	.040	0.20/0.35	0.40/0.70	0.40/0.60	.20/.30	8740
8742	.40/0.45	0.75/1.00	.040	.040	0.20/0.35	0.40/0.70	0.40/0.60	.20/.30	8742
8822	.20/0.25	0.75/1.00	.040	.040	0.20/0.35	0.40/0.70	0.40/0.60	.30/.40	8822
9255	.50/0.60	0.70/0.95	.040	.040	1.80/2.20	—	—	—	9255
9260	.55/0.65	0.70/1.00	.040	.040	1.80/2.20	—	—	—	9260
9262	.55/0.65	0.75/1.00	.040	.040	1.80/2.20	—	0.25/0.40	—	9262
E9310	.08/0.13	0.45/0.65	.025	.025	0.20/0.35	3.00/3.50	1.00/1.40	.08/.15	9310
9840	.38/0.43	0.70/0.90	.040	.040	0.20/0.35	0.85/1.15	0.70/0.90	.20/.30	9840
9850	.48/0.53	0.70/0.90	.040	.040	0.20/0.35	0.85/1.15	0.70/0.90	.20/.30	9850

NOTE 1. The lowest standard maximum phosphorus or sulphur limit that may be specified for acid open-hearth or acid electric furnace steel is 0.05 per cent.

NOTE 2. Lowest minimum silicon limit to be specified for acid electric furnace alloy steel is 0.15 per cent.

NOTE 3. Phosphorus and sulphur on basic open-hearth product shall be 0.040 max. phosphorus and sulphur on basic electric furnace product shall be 0.025 max.

NOTE 4. Small quantities of certain elements may be found in alloy steel which are not specified or required. These elements are to be considered as incidental and acceptable to the following maximum amounts: copper, 0.35 per cent; nickel, 0.25 per cent; chromium, 0.20 per cent; molybdenum, 0.06 per cent.

NOTE 5. When a grade is specified to a method of manufacture (electric furnace or open-hearth) not listed in the above table the phosphorous and sulphur limits shall be, unless otherwise specified, as follows: Basic electric furnace — 0.025 max., Basic open-hearth — 0.040 max., Acid open-hearth or electric — 0.050 max.

Russel Metals
WILLIAMS BAHCALL

A.I.S.I. AND COMPARATIVE S.A.E. Specifications

Resulphurized Standard Carbon Steels

Table 2 — Ladle Chemcial Ranges and Limits

A.I.S.I. No.	Chemical Composition Limits, Per Cent C	Mn	P Max.	S	S.A.E. No.
1109	0.08/0.13	0.60/0.90	0.040	0.08/0.13	1109
1110	0.08/0.13	0.30/0.60	0.040	0.80/0.13	—
1116	0.14/0.20	1.10/1.40	0.040	0.16/0.23	1116
1117	0.14/0.20	1.00/1.30	0.040	0.08/0.13	1117
1118	0.14/0.20	1.30/1.60	0.040	0.08/0.13	1118
1119	0.14/0.20	1.00/1.30	0.040	0.25/0.33	1119
1132	0.27/0.34	1.35/1.65	0.040	0.08/0.13	1132
1137	0.32/0.39	1.35/1.65	0.040	0.08/0.13	1137
1139	0.35/0.43	1.35/1.65	0.040	0.13/0.20	—
1140	0.37/0.44	0.70/1.00	0.040	0.08/0.13	1140
1141	0.37/0.45	1.35/1.65	0.040	0.08/0.13	1141
1144	0.40/0.48	1.35/1.65	0.040	0.24/0.33	1144
1145	0.42/0.49	0.70/1.00	0.040	0.04/0.07	1145
1146	0.42/0.49	0.70/1.00	0.040	0.08/0.13	1146
1151	0.48/0.55	0.70/1.00	0.040	0.08/0.13	1151

Silicon: Applicable to Table 2.
When silicon is required, the following ranges and limits are commonly used.

AISI Designation	Silicon Limitations
1108 to 1110 Incl.	0.10 Max.
1116 and over	0.10 Max., 0.10/0.20 or 0.15/0.30

If other limitations required, grade becomes non-standard.

REPHOSPHORIZED, RESULPHURIZED AND LEAD BEARING STANDARD CARBON STEELS

Table 2A — Ladle Chemcial Ranges and Limits

A.I.S.I. No.	Chemical Composition Limits, Per Cent C	Mn	P Max.	S Max.	S.A.E. No.
1211	0.13 Max.	0.60/0.90	0.07/0.12	0.10/0.15	—
1212	0.13 Max.	0.70/1.00	0.07/0.12	0.16/0.23	1112
1213	0.13 Max.	0.70/1.00	0.07/0.12	0.24/0.33	1113
1215†	0.09 Max.	0.75/1.05	0.04/0.09	0.26/0.35	—
*Type "A" Leaded					
12L14	0.15 Max.	0.85/1.15	0.04/0.09	0.26/0.35	—

*0.15 to 0.35% lead added.
†Nitrogen treated.

SILICON: — It is not common practice to produce steels listed in Table 2A to specified limits for silicon.

LEAD: — When lead is required as an added element to a standard steel it is identified by inserting the letter "L" between the second and third numerals of the A.I.S.I. number, e.g. 12L14.

APPROXIMATE MINIMUM MECHANICAL PROPERTIES OF SOME STEELS

Hot Rolled – Cold Drawn – Annealed – Quenched & Tempered at 1000°F.

The following table represents an average of results obtained from a large number of tests and is offered only as a guide. In accordance with standard procedure, the specimens used were 1" diameter. Under no condition do we guarantee these statistics to be accurate.

The section size, finishing temperature and cooling rate during the rolling process influence the final mechanical properties of any steel in the As-Rolled condition. The amount of size reduction in cold drawing will affect the mechanical properties of Cold Drawn Bars. Turned and Polished as well as Turned, Ground & Polished Bars have approximately the same mechanical properties as the Hot Rolled Bars from which they were produced.

Approximate Mechanical Properties

(Tensile and Yield Expressed in Thousands of Pounds Per Square Inch)

AISI Grade	Condition	Machinability B1112 equals 100%	S.F. M.	Strength T.S.	Strength Y.P.	Ductility EL. 2"- %	Ductility RA	Hardness Brnl.	Hardness Rockwell
1018	H.R.	52	86	58	32	25	50	116	68B
1018	C.D.	78	129	64	54	15	40	126	72B
M1020	H.R.	50	83	55	30	25	50	110	66B
1035	H.R.	65	107	70	30	20	35	155	83B
1035	C.D.	67	111	90	75	10	40	170	87B
1035	Q&T			95	70	19	55	191	92B
1042	H.R.	61	101	80	50	15	35	175	88B
1042	C.D.	63	104	90	75	12	30	185	91B
1042	Q&T			105	80	15	40	215	96B
M1044	H.R.	53	87	82	49	15	30	170	87B
1045	H.R.	56	92	85	50	15	30	175	88B
1045	C.D.	60	99	90	80	10	30	195	93B
1045	Q&T			110	80	16	40	230	98B
1095	HRA	45	74	90	55	15	40	190	90B
1095	Q&T			170	120	10	30	360	39C
1117	H.R.	85	140	60	35	20	45	115	68B
1117	C.D.	91	150	75	60	15	40	143	79B
11L17	H.R.	92	152	60	35	20	45	115	68B
11L17	C.D.	100	165	75	60	15	40	143	79B
1137	H.R.	70	116	85	50	18	35	179	89B
1137	C.D.	75	124	100	85	10	30	197	93B
1137	Q&T			110	85	15	40	250	24C
1141	H.R.	65	107	90	60	15	25	180	89B
1141	C.D.	70	116	100	85	8	20	195	93B
1141	Q&T			120	100	10	35	270	28C
1144	H.R.	75	124	95	60	15	30	200	94B
1144	C.D.	85	140	100	90	7	20	210	96B
1144	Q&T			130	110	15	45	286	30C
1212	C.D.	100	165	80	70	10	40	170	87B
1213	C.D.	136	225	80	70	10	40	170	87B
B1113	C.D.	136	225	80	70	10	40	170	87B

Notes

CIRCUMFERENCE AND AREA OF CIRCLES

Diameter In Inches	Circumference In Feet	Circumference In Inches	Area Sq. Ft.	Diameter In Inches	Circumference In Feet	Circumference In Inches	Area Sq. Ft.
1/16		13/64		5 1/4	1	4 7/16	.1503
1/8		25/64		5 3/8	1	4 7/8	.1576
3/16		19/32		5 1/2	1	5 1/4	.1650
1/4		25/32		5 5/8	1	5 5/8	.1726
5/16		63/64		5 3/4	1	6	.1803
3/8		1 11/64		5 7/8	1	6 7/16	.1883
7/16		1 3/8		6	1	6 13/16	.1964
1/2		1 37/64		6 1/8	1	7 3/16	.2046
9/16		1 49/64		6 1/4	1	7 5/8	.2131
5/8		1 15/16		6 3/8	1	8	.2217
11/16		2 5/32		6 1/2	1	8 3/8	.2304
3/4		2 23/64		6 5/8	1	8 3/4	.2394
13/16		2 35/64		6 3/4	1	9 3/16	.2485
7/8		2 3/4		6 7/8	1	9 9/16	.2578
15/16		2 15/16		7	1	9 15/16	.2673
1		3 9/64	.0055	7 1/8 1/8	1	10 3/8	.2769
1 1/8		3 1/2	.0069	7 1/4	1	10 3/4	.2867
1 1/4		3 7/8	.0085	7 3/8	1	11 1/8	.2967
1 3/8		4 5/16	.0103	7 1/2	1	11 1/2	.3068
1 1/2		4 11/16	.0123	7 5/8	1	11 5/16	.3171
1 5/8		5 1/16	.0144	7 3/4	2	5/16	.3276
1 3/4		5 7/16	.0167	7 7/8	2	11/16	.3382
1 7/8		5 7/8	.0192	8	2	1 1/8	.3491
2		6 1/4	.0218	8 1/8	2	1 1/2	.3601
2 1/8		6 5/8	.0246	8 1/4	2	1 7/8	.3712
2 1/4		7	.0276	8 3/8	2	2 1/4	.3826
2 3/8		7 7/16	.0308	8 1/2	2	2 11/16	.3941
2 1/2		7 13/16	.0341	8 5/8	2	3 1/16	.4057
2 5/8		8 3/16	.0376	8 3/4	2	3 7/16	.4176
2 3/4		8 5/8	.0412	8 7/8	2	3 7/8	.4296
2 7/8		9	.0451	9	2	4 1/4	.4418
3		9 3/8	.0491	9 1/8	2	4 5/8	.4541
3 1/8		9 13/16	.0533	9 1/4	2	5	.4667
3 1/4		10 3/16	.0576	9 3/8	2	5 7/16	.4794
3 3/8		10 9/16	.0621	9 1/2	2	5 13/16	.4922
3 1/2		10 15/16	.0668	9 5/8	2	6 3/16	.5053
3 5/8		11 3/8	.0717	9 3/4	2	6 5/8	.5185
3 3/4		11 3/4	.0767	9 7/8	2	7	.5319
3 7/8	1	1/8	.0819	10	2	7 3/8	.5454
4	1	9/16	.0873	10 1/8	2	7 3/4	.5591
4 1/8	1	15/16	.0928	10 1/4	2	8 3/16	.5730
4 1/4	1	1 5/16	.0985	10 3/8	2	8 9/16	.5871
4 3/8	1	1 11/16	.1044	10 1/2	2	8 15/16	.6013
4 1/2	1	2 1/8	.1104	10 5/8	2	9 3/8	.6157
4 5/8	1	2 1/2	.1167	10 3/4	2	9 3/4	.6303
4 3/4	1	2 7/8	.1231	10 7/8	2	10 1/8	.6450
4 7/8	1	3 5/16	.1296	11	2	10 1/2	.6600
5	1	3 11/16	.1364	11 1/8	2	10 15/16	.6750
5 1/8	1	4 1/16	.1433	11 1/4	2	11 5/16	.6903

continued on following page

Russel Metals
WILLIAMS BAHCALL

CIRCUMFERENCE AND AREA OF CIRCLES

continued from preceding page

Diameter In Inches	Circumference In Feet	Inches	Area Sq. Ft.	Diameter In Inches	Circumference In Feet	Inches	Area Sq. Ft.
11 3/8	2	11 11/16	.7057	17 1/2	4	6 15/16	1.670
11 1/2	3	1/8	.7213	17 5/8	4	7 5/16	1.694
11 5/8	3	1/2	.7371	17 3/4	4	7 3/4	1.718
11 3/4	3	7/8	.7530	17 7/8	4	8 1/8	1.743
11 7/8	3	1 1/4	.7691	18	4	8 1/2	1 767
12	3	1 11/16	.7854	18 1/8	4	8 15/16	1 792
12 1/8	3	2 1/16	.8019	18 1/4	4	9 5/16	1 817
12 1/4	3	2 7/16	.8185	18 3/8	4	9 3/4	1 842
12 3/8	3	2 7/8	.8353	18 1/2	4	10 1/16	1 867
12 1/2	3	3 1/4	.8522	18 5/8	4	10 1/2	1 892
12 5/8	3	3 5/8	.8693	18 3/4	4	10 7/8	1 918
12 3/4	3	4	.8866	18 7/8	4	11 1/4	1 943
12 7/8	3	4 7/16	.9041	19	4	11 5/8	1.969
13	3	4 13/16	.9218	19 1/8	5	1/16	1.995
13 1/8	3	5 3/16	.9396	19 1/4	5	7/16	2.021
13 1/4	3	5 5/8	.9576	19 3/8	5	13/16	2.047
13 3/8	3	6	.9757	19 1/2	5	1 1/4	2.074
13 1/2	3	6 3/8	.9940	19 5/8	5	1 5/8	2.101
13 5/8	3	6 3/4	1.013	19 3/4	5	2	2.127
13 3/4	3	7 3/16	1.031	19 7/8	5	2 7/16	2.154
13 7/8	3	7 9/16	1.050	20	5	2 13/16	2.182
14	3	8	1.069	20 1/8	5	3 3/16	2.209
14 1/8	3	8 3/8	1.088	20 1/4	5	3 9/16	2.237
14 1/4	3	8 3/4	1.108	20 3/8	5	4	2.264
14 3/8	3	9 1/8	1.127	20 1/2	5	4 3/8	2.292
14 1/2	3	9 1/2	1.147	20 5/8	5	4 3/4	2.320
14 5/8	3	9 15/16	1.167	20 3/4	5	5 3/16	2.348
14 3/4	3	10 5/16	1.187	20 7/8	5	5 9/16	2.377
14 7/8	3	10 11/16	1.207	21	5	5 15/16	2.405
15	3	11 1/16	1.227	21 1/8	5	6 5/16	2.434
15 1/8	3	11 1/2	1.248	21 1/4	5	6 3/4	2.463
15 1/4	3	11 7/8	1.268	21 3/8	5	7 1/8	2.492
15 3/8	4	1/4	1.289	21 1/2	5	7 1/2	2.521
15 1/2	4	5/8	1.310	21 5/8	5	7 7/8	2.551
15 5/8	4	1 1/16	1.332	21 3/4	5	8 5/16	2.580
15 3/4	4	1 1/2	1.353	21 7/8	5	8 11/16	2.610
15 7/8	4	1 15/16	1.375	22	5	9 1/16	2.640
16	4	2 1/4	1.396	22 1/8	5	9 1/2	2.670
16 1/8	4	2 5/8	1.418	22 1/4	5	9 7/8	2.700
16 1/4	4	3	1.440	22 3/8	5	10 1/4	2.731
16 3/8	4	3 7/16	1.463	22 1/2	5	10 5/8	2.761
16 1/2	4	3 13/16	1.485	22 5/8	5	11 1/16	2.792
16 5/8	4	4 1/4	1.508	22 3/4	5	11 7/16	2.823
16 3/4	4	4 5/8	1.530	22 7/8	5	11 13/16	2.854
16 7/8	4	5	1.553	23	6	1/4	2.885
17	4	5 3/8	1.576	23 1/8	6	5/8	2.917
17 1/8	4	5 3/4	1.600	23 1/4	6	1	2.948
17 1/4	4	6 3/16	1.623	23 3/8	6	1 3/8	2.980
17 3/8	4	6 9/16	1.647	23 1/2	6	1 13/16	3.012

continued on following page

CIRCUMFERENCE AND AREA OF CIRCLES

continued from preceding page

Diameter In Inches	Circumference In Feet	Inches	Area Sq. Ft.	Diameter In Inches	Circumference In Feet	Inches	Area Sq. Ft.
23⅝	6	2³/₁₆	3.044	35½	9	3½	6.874
23¾	6	2⁹/₁₆	3.076	35¾	9	4¼	6.971
23⅞	6	3	3.109	36	9	5¹/₁₆	7.069
24	6	3⅜	3.142	36¼	9	5⅞	7.167
24¼	6	4⅛	3.207	36½	9	6⅝	7.266
24½	6	4¹⁵/₁₆	3.274	36¾	9	7⁷/₁₆	7.366
24¾	6	5¾	3.341	37	9	8³/₁₆	7.466
25	6	6½	3.409	37¼	9	9	7.568
25¼	6	7⁵/₁₆	3.477	37½	9	9¾	7.670
25½	6	8¹/₁₆	3.547	37¾	9	10⁹/₁₆	7.773
25¾	6	8⅞	3.616	38	9	11⅜	7.876
26	6	9⅝	3.687	38¼	10	⅛	7.980
26¼	6	10⁷/₁₆	3.758	38½	10	¹⁵/₁₆	8.084
26½	6	11¼	3.830	38¾	10	1¹¹/₁₆	8.190
26¾	7	—	3.903	39	10	2½	8.296
27	7	³/₁₆	3.976	39¼	10	3¼	8.403
27¼	7	1⁹/₁₆	4.050	39½	10	4¹/₁₆	8.510
27½	7	2⅜	4.125	39¾	10	4⅞	8.618
27¾	7	3⅛	4.200	40	10	5⅝	8.727
28	7	3¹⁵/₁₆	4.276	40¼	10	6⁷/₁₆	8.836
28¼	7	4¹¹/₁₆	4.353	40½	10	7³/₁₆	8.946
28½	7	5½	4.430	40¾	10	8	9.057
28¾	7	6¼	4.508	41	10	8¾	9.168
29	7	7¹/₁₆	4.587	41¼	10	9⁹/₁₆	9.281
29¼	7	7⅞	4.666	41½	10	10⅜	9.393
29½	7	8⅝	4.746	41¾	10	11⅛	9.507
29¾	7	9⁷/₁₆	4.827	42	10	11¹⁵/₁₆	9.621
30	7	10³/₁₆	4.909	42¼	11	¹¹/₁₆	9.736
30¼	7	11	4.991	42½	11	1½	9.852
30½	7	11¹³/₁₆	5.074	42¾	11	2¼	9.968
30¾	8	⁹/₁₆	5.157	43	11	3¹/₁₆	10.085
31	8	1⅜	5.241	43¼	11	3¹³/₁₆	10.202
31¼	8	2⅛	5.326	43½	11	4⅝	10.321
31½	8	2¹⁵/₁₆	5.412	43¾	11	5⅜	10.440
31¾	8	3¹¹/₁₆	5.498	44	11	6³/₁₆	10.559
32	8	4½	5.585	44¼	11	7	10.680
32¼	8	5⁵/₁₆	5.673	44½	11	7¾	10.801
32½	8	6¹/₁₆	5.761	44¾	11	8⁹/₁₆	10.922
32¾	8	6⅞	5.850	45	11	9⅜	11.045
33	8	7⅝	5.940	45¼	11	10⅛	11.168
33¼	8	8⁷/₁₆	6.030	45½	11	10¹⁵/₁₆	11.291
33½	8	9³/₁₆	6.121	45¾	11	11¹¹/₁₆	11.416
33¾	8	10	6.213	46	12	½	11.541
34	8	10¹³/₁₆	6.305	46¼	12	1¼	11.667
34¼	8	11⁹/₁₆	6.398	46½	12	2¹/₁₆	11.793
34½	9	⅜	6.492	46¾	12	2¹³/₁₆	11.920
34¾	9	1⅛	6.586	47	12	3⅝	12.048
35	9	1¹⁵/₁₆	6.681	47¼	12	4⁷/₁₆	12.177
35¼	9	2¹¹/₁₆	6.777	47½	12	5³/₁₆	12.306

continued on following page

Russel Metals
WILLIAMS BAHCALL

CIRCUMFERENCE AND AREA OF CIRCLES

continued from preceding page

Diameter in Inches	Circumference in Feet	Inches	Area Sq. Ft.	Diameter in Inches	Circumference in Feet	Inches	Area Sq. Ft.
47¾	12	6	12.436	60	15	8 7/16	19.635
48	12	6¾	12.566	60¼	15	9¼	19.799
48¼	12	7 9/16	12.698	60½	15	10 1/16	19.964
48½	12	8⅜	12.830	60¾	15	10 13/16	20.129
48¾	12	9⅛	12.962	61	15	11⅝	20.295
49	12	9 15/16	13.095	61¼	16	⅜	20.462
49¼	12	10 11/16	13.229	61½	16	1 3/16	20.629
49½	12	11½	13.364	61¾	16	1 15/16	20.797
49¾	13	¼	13.499	62	16	2¾	20.966
50	13	1 1/16	13.635	62¼	16	3 9/16	21.135
50¼	13	1 13/16	13.772	62½	16	4 5/16	21.305
50½	13	2⅝	13.909	62¾	16	5⅛	21.476
50¾	13	3⅜	14.048	63	16	5⅞	21.648
51	13	4 3/16	14.186	63¼	16	6 11/16	21.820
51¼	13	5	14.326	63½	16	7 7/16	21.993
51½	13	5¾	14.466	63¾	16	8¼	22.166
51¾	13	6 9/16	14.607	64	16	9	22.340
52	13	7 5/16	14.748	64¼	16	9 13/16	22.515
52¼	13	8⅛	14.890	64½	16	10⅝	22.691
52½	13	8⅞	15.033	64¾	16	11⅜	22.867
52¾	13	9 11/16	15.177	65	17	3/16	23.044
53	13	10½	15.321	65¼	17	15/16	23.221
53¼	13	11¼	15.466	65½	17	1¾	23.400
53½	14	1/16	15.611	65¾	17	2½	23.579
53¾	14	13/16	15.757	66	17	3 5/16	23.758
54	14	1⅝	15.904	66¼	17	4⅛	23.939
54¼	14	2⅜	16.052	66½	17	4⅞	24.120
54½	14	3 3/16	16.200	66¾	17	5 11/16	24.301
54¾	14	4	16.349	67	17	6 7/16	24.484
55	14	4¾	16.499	67¼	17	7¼	24.667
55¼	14	5 9/16	16.649	67½	17	8	24.851
55½	14	6 5/16	16.800	67¾	17	8 13/16	25.035
55¾	14	7⅛	16.952	68	17	9⅝	25.220
56	14	7⅞	17.104	68¼	17	10⅜	25.406
56¼	14	8 11/16	17.257	68½	17	11 3/16	25.592
56½	14	9½	17.411	68¾	17	11 15/16	25.779
56¾	14	10¼	17.565	69	18	¾	25.967
57	14	11 1/16	17.721	69¼	18	1½	26.156
57¼	14	11 13/16	17.876	69½	18	2 5/16	26.345
57½	15	⅝	18.033	69¾	18	3⅛	26.535
57¾	15	1⅜	18.190	70	18	3⅞	26.725
58	15	2 3/16	18.348	70¼	18	4 11/16	26.917
58¼	15	2 15/16	18.506	70½	18	5 7/16	27.109
58½	15	3¾	18.666	70¾	18	6¼	27.301
58¾	15	4 9/16	18.825	71	18	7	27.494
59	15	5 5/16	18.986	71½	18	7 13/16	27.688
59¼	15	6⅛	19.147	71½	18	8 9/16	27.883
59½	15	6⅞	19.309	71¾	18	9⅜	28.078
59¾	15	7 11/16	19.472	72	18	10 3/16	28.274

continued on following page

CIRCUMFERENCE AND AREA OF CIRCLES

continued from preceding page

Diameter In Inches	Circumference In Feet	Inches	Area Sq. Ft.	Diameter In Inches	Circumference In Feet	Inches	Area Sq. Ft.
72½	18	11¾	28.668	96½	25	3⅛	50.791
73	19	1 5/16	29.065	97	25	4 11/16	51.318
73½	19	2⅞	29.465	97½	25	6¼	51.849
74	19	4 7/16	29.867	98	25	7⅞	52.382
74½	19	6	30.272	98½	25	9 7/16	52.918
75	19	7 9/16	30.680	99	25	11	53.456
75½	19	9 3/16	31.090	99½	26	9/16	53.998
76	19	10¾	31.503	100	26	2⅛	54.542
76½	20	5/16	31.919	100½	26	3 11/16	55.088
77	20	1⅞	32.338	101	26	5¼	55.638
77½	20	3 7/16	32.759	101½	26	6 13/16	56.190
78	20	5	33.183	102	26	8 7/16	56.745
78½	20	6 9/16	33.610	102½	26	10	57.303
79	20	8⅛	34.039	103	26	11 9/16	57.863
79½	20	9¾	34.472	103½	27	1⅛	58.426
80	20	11 5/16	34.907	104	27	2 11/16	58.992
80½	21	⅞	35.344	104½	27	4¼	59.561
81	21	2 7/16	35.785	105	27	5 13/16	60.132
81½	21	4	36.228	105½	27	7 7/16	60.706
82	21	5 9/16	36.674	106	27	9	61.283
82½	21	7⅛	37.122	106½	27	10 9/16	61.863
83	21	8¾	37.574	107	28	⅛	62.445
83½	21	10 5/16	38.028	107½	28	1 11/16	63.030
84	21	11⅞	38.485	108	28	3¼	63.617
84½	22	1 7/16	38.944	108½	28	4 13/16	64.208
85	22	3	39.406	109	28	6⅜	64.801
85½	22	4 9/16	39.871	109½	28	8	65.397
86	22	6⅛	40.339	110	28	9 9/16	65.995
86½	22	7 11/16	40.809	110½	28	11⅛	66.597
87	22	9 5/16	41.283	111	29	11/16	67.201
87½	22	10⅞	41.758	111½	29	2¼	67.808
88	23	7/16	42.237	112	29	3 13/16	68.417
88½	23	2	42.718	112½	29	5⅜	69.029
89	23	3 9/16	43.202	113	29	7	69.644
89½	23	5⅛	43.689	113½	29	8 9/16	70.262
90	23	6 11/16	44.179	114	29	10⅛	70.882
90½	23	8 5/16	44.671	114½	29	11 11/16	71.505
91	23	9⅞	45.166	115	30	1¼	72.131
91½	23	11 7/16	45.664	115½	30	2 13/16	72.760
92	24	1	46.164	116	30	4⅜	73.391
92½	24	2 9/16	46.667	116½	30	5 15/16	74.025
93	24	4⅛	47.173	117	30	7 9/16	74.662
93½	24	5 11/16	47.682	117½	30	9⅛	75.302
94	24	7¼	48.193	118	30	10 11/16	75.944
94½	24	8⅞	48.707	118½	31	¼	76.589
95	24	10 7/16	49.224	119	31	1 13/16	77.236
95½	25	—	49.743	119½	31	3⅜	77.887
96	25	1 9/16	50.266	120	31	4 15/16	78.540

Russel Metals
WILLIAMS BAHCALL

Inches to Millimeters

Fraction	Inches	M/M	Fraction	Inches	M/M
1/64	.01563	.397	33/64	.51563	13.097
1/32	.03125	.794	17/32	.53125	13.494
3/64	.04688	1.191	35/64	.54688	13.891
1/16	.06250	1.587	9/16	.56250	14.287
5/64	.07813	1.984	37/64	.57813	14.684
3/32	.09375	2.381	19/32	.59375	15.081
7/64	.10938	2.778	39/64	.60938	15.478
1/8	.12500	3.175	5/8	.62500	15.875
9/64	.14063	3.572	41/64	.64063	16.272
5/32	.15625	3.969	21/32	.65625	16.669
11/64	.17188	4.366	43/64	.67188	17.066
3/16	.18750	4.762	11/16	.68750	17.462
13/64	.20313	5.159	45/64	.70313	17.859
7/32	.21875	5.556	23/32	.71875	18.256
15/64	.23438	5.953	47/64	.73438	18.653
1/4	.25000	6.350	3/4	.75000	19.050
17/64	.26563	6.747	49/64	.76563	19.447
9/32	.28125	7.144	25/32	.78125	19.844
19/64	.29688	7.541	51/64	.79688	20.241
5/16	.31250	7.937	13/16	.81250	20.637
21/64	.32813	8.334	53/64	.82813	21.034
11/32	.34375	8.731	27/32	.84375	21.431
23/64	.35938	9.128	55/64	.85938	21.828
3/8	.37500	9.525	7/8	.87500	22.225
25/64	.39063	9.922	57/64	.89063	22.622
13/32	.40625	10.319	29/32	.90625	23.019
27/64	.42188	10.716	59/64	.92188	23.416
7/16	.43750	11.113	15/16	.93750	23.912
29/64	.45313	11.509	61/64	.95313	24.209
15/32	.46875	11.906	31/32	.96875	24.606
31/64	.48438	12.303	63/64	.98438	25.003
1/2	.50000	12.700	1	1.00000	25.400

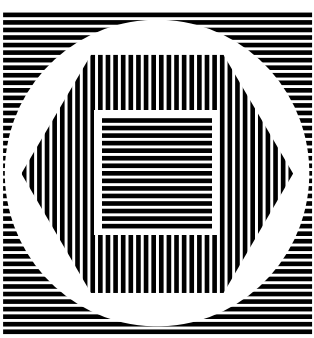
To Convert Inches to Millimeters Multiply by 25.4

Notes: _____

Millimeters to Inches

Milli-meters	Inches	Milli-meters	Inches	Milli-meters	Inches	Milli-meters	Inches
.1	.00394	27	1.0630	62	2.4409	97	3.8189
.2	.00787	28	1.1024	63	2.4803	98	3.8583
.3	.01181	29	1.1417	64	2.5197	99	3.8976
.4	.01575	30	1.1811	65	2.5590	100	3.9370
.5	.01968	31	1.2205	66	2.5984	105	4.1338
.6	.02362	32	1.2598	67	2.6378	110	4.3307
.7	.0275	33	1.2992	68	2.6772	115	4.5275
.8	.0315	34	1.3886	69	2.7165	120	4.7244
.9	.03541	35	1.3779	70	2.7559	125	4.9212
1	.0394	36	1.4173	71	2.7953	130	5.1181
2	.0787	37	1.4567	72	2.8346	135	5.3149
3	.1181	38	1.4961	73	2.8740	140	5.5118
4	.1575	39	1.5354	74	2.9134	145	5.7086
5	.1968	40	1.5748	75	2.9527	150	5.9055
6	.2362	41	1.6142	76	2.9921	155	6.1023
7	.2756	42	1.6535	77	3.0315	160	6.2992
8	.3150	43	1.6929	78	3.0709	165	6.4960
9	.3543	44	1.7323	79	3.1102	170	6.6929
10	.3937	45	1.7716	80	3.1496	175	6.8897
11	.4331	46	1.8110	81	3.1890	180	7.0866
12	.4724	47	1.8504	82	3.2283	185	7.2834
13	.5118	48	1.8898	83	3.2677	190	7.4803
14	.5512	49	1.9291	84	3.3071	195	7.6771
15	.5905	50	1.9685	85	3.3464	200	7.8740
16	.6299	51	2.0079	86	3.3858	205	8.0708
17	.6693	52	2.0472	87	3.4252	210	8.2677
18	.7087	53	2.0866	88	3.4646	215	8.4645
19	.7480	54	2.1260	89	3.5039	220	8.6614
20	.7874	55	2.1653	90	3.5433	225	8.8582
21	.8268	56	2.2047	91	3.5827	230	9.0551
22	.8661	57	2.2441	92	3.6220	235	9.2519
23	.9055	58	2.2835	93	3.6614	240	9.4488
24	.9449	59	2.3228	94	3.7008	245	9.6456
25	.9842	60	2.3622	95	3.7401	250	9.8425
26	1.0236	61	2.4016	96	3.7795	255	10.0393

To Convert Millimeters to Inches Multiply by .0394



Russel Metals
WILLIAMS BAHCALL

METRIC CONVERSION FACTORS

English to Metric

Multiply	by	to obtain
Pounds (avoirdupois)	.45359	Kilograms
Net Tons (2000 Lbs.)	.90718	Metric Tons
Gross Tons (2240 Lbs.)	1.01605	Metric Tons
Inches	25.4001	Millimeters
Feet	.304801	Meters
Yards	.914402	Meters
Miles (statute)	1.60935	Kilometers
Square Inches	6.45163	Sq. Centimeters
Square Feet	.092903	Square Meters
Pounds per Lineal Ft.	1.48816	Kilograms per Lineal Meter
Pounds per Sq. Inch	.07031	Kilograms per Sq. Centimeter
Pounds per Sq. Ft.	4.88241	Kilograms per Sq. Meter
Pounds per Cu. Foot	16.01837	Kilograms per Cu. Meter

Metric to English

Kilograms	2.20462	Lbs. (avoirdupois)
*Metric Tons	1.10231	Net Tons 2000 Pounds
*Metric Tons	.98421	Gross Tons 2240 Pounds
Millimeters	.03937	Inches
Meters	3.280833	Feet
Meters	1.09361	Yards
Kilometers	.62137	Miles (statute)
Square Centimeters	.155	Square Inches
Square Meters	10.76387	Square Feet
Kilograms per Lineal Meter	.67197	Lbs. per Lineal Ft.
Kilograms per Sq. Centimeter	14.2234	Pounds per Sq. In.
Kilograms per Square Meter	.20482	Pounds per Sq. Ft.
Kilograms per Cubic Meter	.06243	Pounds per Cu. Ft.

NOTE: Length, width and cube denote meters
Mass and weight denote Grams
Capacity denotes Liters
*One Metric Ton = 2204.62 Lbs.

ABBREVIATIONS

Kilometer — km	Kilogram — kg
Meter — m	Gram — g or gm
Centimeter — cm	Centigram — cg
Millimeter — mm	Milligram — mg

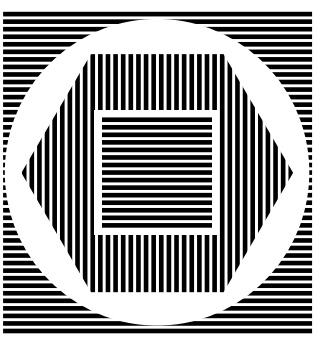
FORMULAS (Area-Volumes)

AREAS

Circle	= square of the diameter x .7854.
Elipse	= product of both diameters x .7854.
Hexagon	= square of diameter of inscribed circle x .866.
Octagon	= square of diameter of inscribed circle x .828.
Parallelogram	= base x altitude.
Rectangle	= length multiplied by breadth.
Regular Polygon	= half the perimeter x the perpendicular distance from the center to any one side.
Sector of Circle	= number of degrees in arc x square of radius x 0.008727.
Segment of Circle	= area of sector with same arc minus area of triangle formed by radii of the arc and chord of the segment.
Sphere	= area of its great circle x 4; or square of diameter x 3.14159.
Trapezoid	= half the sum of the two parallel sides x the perpendicular distance between them.
Triangle	= half base x altitude.

VOLUMES

Cone	= area of base x one-third of altitude.
Cylinder	= area of base x altitude.
Prism	= area of base x altitude.
Sphere	= cube of diameter x 0.5236.
Wedge	= length of edge plus twice length of base x one-sixth of the product of the height of the Wedge and the breadth of its base.



USEFUL INFORMATION

To find circumference of a circle, multiply diameter by 3.1416.

To find diameter of a circle, multiply circumference by .31831.

To find side of an inscribed square, multiply diameter by 0.7071 or multiply circumference by 0.2251 or divide circumference by 4.4428.

Side of inscribed cube = radius of sphere x 1.1547.

To find side of an equal square, multiply diameter by .8862.

Square. A side multiplied by 1.4142 equals diameter of its circumscribing circle.

A side multiplied by 4.443 equals circumference of its circumscribing circle.

A side multiplied by 1.128 equals diameter of an equal circle.

A side multiplied by 3.547 equals circumference of an equal circle.

Surface of frustrum of cone or pyramid = sum of circumference of both ends x ½ slant height plus area of both ends.

Contents of frustrum of cone or pyramid = multiply area of two ends and get square root. Add the 2 areas and x ⅓ altitude.

Doubling the diameter of a circle increases its area four times.

A gallon of water (U.S. Standard) weighs 8⅓ lbs. and contains 231 cubic inches.

A U.S. gallon is equal to .8333 Imperial gallons.

A cubic foot of water contains 7½ gallons, 1728 cubic inches and weighs 62½ lbs.

To find the pressure in pounds per square inch of a column of water, multiply the height of the column in feet by .434.

Steam rising from water at its boiling point (212° F.) has a pressure equal to the atmosphere (14.7 lbs. to the square inch).

A standard horse power: the evaporation of 30 lbs. of water per hour from a feed water temperature of 100° F. into steam at 70 lbs. gauge pressure.

To find capacity of tanks any size, given dimensions of a cylinder in inches, to find its capacity in U.S. gallons: square the diameter, multiply by the length and by .0034.

To ascertain heating surface in tubular boilers, multiply ⅔ the circumference of boiler by length of boiler in inches and add to it the area of all the tubes.

One knot is a unit of speed equal to 1.152 miles per hour.

Fahrenheit — Centigrade Conversion:

Degrees F = ⅘ Degrees C + 32
Degrees C = ⅝ (Degrees F - 32)

APPROXIMATE STEEL WEIGHT ESTIMATION SHORT-CUTS

ROUNDS = Dia.²x2.67 = Wt. Per Ft.
FLATS = Width x thickness x 3.4 = Wt. Per Ft.
SHEETS = 36 x 96 - Multiply thickness by 1000.
36 x 120 - Multiply thickness by 1250.
48 x 96 - Multiply thickness by 1330.
48 x 120 - Multiply thickness by 1660.
48 x 144 - Multiply thickness by 2000.
= Wt. Per Sheet
.0359" thickness x 96" long weighs same as width (i.e., .0359" x 6" x 96" = 6#).
ALUMINUM = Approximately ⅓rd the weight of steel.

DEFINITIONS

OF TERMS COMMONLY USED IN THE MANURACTURE AND TREATMENT OF STEEL

ACID BRITTLENESS — Brittleness caused by pickling in dilute acid to remove scale.

ACID STEEL — Steel melted in a furnace having an acid bottom and lining and under a slag with acid reaction.

AGING — The process or sometimes the effects of allowing metal to remain at ordinary temperatures or in heat treatment at temperatures above normal to hasten changes that take place in normal aging.

ALLOY ELEMENTS — Elements added to improve or change properties of the metal.

ANNEALING — Annealing is a reheating and cooling operation of a material in the solid state.

Note a — Annealing usually implies a relatively slow cooling.
Note b — Annealing is a comprehensive term. The purpose of such a heat treatment may be:
(1) To remove stresses.
(2) To induce softness.
(3) To alter ductility, toughness, electrical, magnetic or other physical properties.
(4) To refine the crystalline structure.

In annealing, the temperature of the operation and the rate of cooling depend upon the material being heat treated and the purpose of the treatment.

BASIC STEEL — Steel melted in a furnace with a basic bottom and lining and under a slag having a basic reaction.

BESSEMER PROCESS — A steel making process in which air is blown through the molten iron so that the impurities are thus removed by oxidation.

BILLET — A rectangular semi-finished rolled ingot of from 4 to 36 square inches in cross section, with a width less than twice the thickness.

BINARY ALLOY — An alloy having two principal elements.

BLACK ANNEALING — A method of annealing sheets or other products, used when it is not important that the product be free of scale discoloration.

BLUE ANNEALING — A method of annealing sheets which gives them a bluish-black color. The heavier gauges are allowed to cool slowly after rolling: the lighter ones are passed singly through an open furnace to bring them to the proper annealing temperature.

BLUE BRITTLENESS — Brittleness occurring in steel at 400 to 700° F. or after cooling when worked at these temperatures.

BOX ANNEALING — Annealing steel by heating in a closed metal box which protects it from oxidation.

BRIGHT ANNEALING — Annealing done in closed containers with a reducing atmosphere which prevents the oxidation and discoloration of the surface.

CARBON STEEL — Steel which derives its properties from various percentages of carbon without any great amount of other alloying elements.

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CARBURIZING (Cementation) — Adding carbon to iron base alloys by heating the metal below its melting point in contact with carbonaceous material.

Note: The term "carbonizing" used in this sense is undesirable and its use should be discouraged.

CASE — That portion of a carburized bar in which the carbon content has been increased.

CASE HARDENING — Carburizing and subsequently hardening by suitable heat-treatment, all or part of the surface portions of a piece of iron base alloy.

CHIPPING — Removing seams and other surface defects from steel by means of hand or power chisels.

CLEAVAGE PLANE — Planes along which crystals break more easily.

COGGING — Reducing ingots to blooms by rolling or forging.

COGGING HAMMER — Forging hammer for reducing ingots to blooms.

COLD SHUT — A place in metal where two portions of the metal in either a molten or plastic condition have come together but have failed to unite into a solid mass.

COLD WORKING — The operation of forming the metal, without the application of heat, by rolling, hammering, drawing, pressing or other means to obtain accurate size, fine finish or increased strength.

CORE — That portion of a carburized iron base alloy article in which the carbon content has not been substantially increased.

CROP — The defective ends of a rolled or forged product which are cut off and discarded.

CUP FRACTURE — A type of fracture in a tensile test specimen which looks like a cup having the exterior portion extended with the interior slightly depressed.

CYANIDING — Surface hardening of an iron base alloy article or portion of it by heating at a suitable temperature in contact with a cyanide salt, followed by quenching.

DECARBURIZATION — Removal of Carbon.

DIFFERENTIAL HEATING — Heating so that various portions of an article reach different temperatures in order that different properties will be produced upon cooling.

DRAWING — Reheating after quenching for hardening, to some temperature below the lower limit of the critical range, followed by cooling as desired.

ELASTIC LIMIT — The elastic limit is determined by an extensometer reading of .0002 inches. The extensometer is attached to the specimen at the gauge marks and not to the shoulders of the specimen or to any part of the testing machine. When the specimen is in place and the extensometer attached, the testing machine shall be operated so as to increase the load on the specimen at a uniform rate. The load at which the rate of elongation increased suddenly on the extensometer is called the elastic limit.

ENDURANCE LIMIT — Maximum stress to which material may be submitted without causing fatigue failure.

EUTECTOID STEEL — A steel consisting of nothing but pearlite (about .90 carbon).

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FERRO ALLOYS — Iron alloyed with some element such as manganese, chrome, or silicon, etc., used for adding the element to steel.

FIBER — A fiborous or woody appearing structure found in fractures of wrought metal, and generally indicating directional properties.

FIBER STRESS — Unit stress at a section over which the stress is not uniform.

FINISHING TEMPERATURE — Temperature at which the hot working is finished.

FLASH — A fin of metal formed on the sides of a forging when the metal is forced out between the edges of the forging dies and which does not unite with the parent metal.

FORGING STRAINS — Strains caused by forging or by cooling after forging.

FRACTURE — The surface of a broken piece of metal.

FRACTURE TEST — Breaking metal to determine structure composition of physical condition by examining the fracture.

FULL ANNEALING — Heating to above the critical temperature range followed by slow cooling through the range.

GRAINS — Metal crystals.

GRAIN GROWTH — Increase in grain size.

GRANULATION — The formation of grains immediately upon solidification.

GRAPHITIZING — Graphitizing is a type of annealing of cast iron whereby some or all of the combined carbon is transformed to free or uncombined carbon.

HARDENING — Heating and quenching certain iron base alloys from a temperature either within or above the critical temperature range.

HEAT TREATMENT — An operation or combination of operations involving the heating and cooling of a metal or an alloy in the solid state.

Note: This is for the purpose of obtaining certain desirable conditions or properties. Heating and cooling for the sole purpose of mechanical working are excluded from the meaning of this definition.

HOT SHORTNESS — Brittleness in hot metal.

HOT WORKING — The operation of rolling, hammering, pressing or extruding metal which has been made plastic by heating.

HYPEREUTECTOID STEEL — A steel having more than the eutectoid percentage of carbon.

HYPOEUTECTOID STEEL — Steel with less than the eutectoid percentage of carbon.

IMPACT TEST — A method of testing specimens to determine resistance to blows or shock.

INGOT — A casting for subsequent rolling or forging.

INGOT IRON — Open hearth iron low in carbon, manganese and other impurities.

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KILLED STEEL — Molten steel held in a laddle or furnace until all the gas has gone out and the metal is quiet.

LAP — A seam over fins or sharp corners in hot metal and then rolling or forging them into the surface.

LAP WELD — Weld made on overlapped edges of scarfed or beveled skelp to form tubing or pipe.

MACROSTRUCTURE — The structure of ground or polished sample revealed by slight magnification or the naked eye.

MALLEABLIZING — Malleablizing is a type of annealing operation with slow cooling whereby combined carbon in white cast iron is transformed to temper carbon and in some cases the carbon is entirely removed from the iron.

Note: Temper carbon is free carbon in the form of rounded nodules made up of an aggregate of minute crystals.

MATRIX — The main substance in which a constituent substance is embedded.

MECHANICAL WORKING — Working metal through tools, presses, hammers, etc., tc change its shape, properties or structure.

MODULUS OF ELASTICITY — Within the limits of elasticity the M.E. is the ratio of the load applied to the corresponding movement caused by the load.

NETWORK STRUCTURE — A structure in which the crystals of one constituent are surrounded by envelopes of another constituent which gives a network appearance to an etched test specimen.

NITRIDING — Adding nitrogen by heating at a temperature below the critical in contact with some nitrogenous material.

NORMALIZING — Heating iron base alloys above the critical temperature range followed by cooling to below that range in still air or ordinary temperature.

Note: In the case of hypereutectoid steel, it is often desirable to heat above the ACcm line.

OVERHEATING — Heating to such a temperature that while the properties of the metal are impaired, it has not been burned and can therefore be restored by heat treatment.

PATENTING — Heating to above the critical and cooling in air or molten lead at a temperature of about 700° F.

PERCENTAGE ELONGATION — The percentage of increase in length of a tension test specimen after rupture.

PERCENTAGE REDUCTION OF AREA — The percentage of decrease of cross-sectional area of a tension test-specimen after rupture.

PIPE — A hole or cavity formed in ingots when the metal solidifies.

PROCESS ANNEALING — Heating to a temperature below or close to the lower limit of the critical and then cooling.

PROPORTIONAL LIMIT — See Elastic Limit.

QUATERNARY ALLOY — An alloy having four principal elements.

QUENCHING — The operation of rapidly cooling in a suitable medium.

RED SHORTNESS - Brittleness in red hot steel.

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REFINING TEMPERATURE — Temperature at which the grain size and structure of the steel is refined, usually just above Ac_3.

REGENERATIVE QUENCHING — Double quenching carburized parts to refine case and core.

RIMMED STEEL — By control of analysis, temperature, etc., it is possible to produce a steel which when poured into molds will partly deoxidize itself on the surface which is in contact with the mold. This type of deoxidation or killing leaves a surface of almost pure iron and drives the other constituents and impurities towards the center of the ingot. When such an ingot is sectioned and etched the skin or rim shows up plainly and thus the name "rimmed steel" was suggested. Rimmed Steel is usually under 0.25 carbon and low in silicon and manganese, and is largely used for the production of soft wire, sheets, etc.

SEAM — A crack caused by a blowhole or other defect which has been closed but not welded.

SELF-HARDENING STEEL — An alloy tool steel that hardens when cooled in air and which will hold a cutting edge at temperatures nearing a light red.

SEMI-STEEL — Steel of an intermediate carbon range between iron and steel.

SHORE HARDNESS — The reading of a conventional scale determined by the rebound of the hammer of the Shore scleroscope on striking the surface of the specimen.

SKELP — Steel or iron plate from which pipe or tubing is made.

SLAB — A very thick rectangular piece of steel for rolling down into plates.

SLABBING MILL — Heavy plate mill.

SOAKING — Holding steel at fixed temperature long enough for a complete uniform penetration of the heat.

SOLIDIFICATION RANGE — Temperature at which metal solidifies.

SPALLING — Cracking and flaking of the metal surface.

SPHEROIDIZING — Prolonged heating of iron base alloys at a temperature in the neighborhood of, but generally slighty below, the critical temperature range, usually followed by relatively slow cooling.

Note a — In the case of small objects of high carbon steels, the spheroidizing result is achieved more rapidly by prolonged heating to temperatures alternately within and slightly below the critical temperature range.

Note b — The object of this heat treatment is to produce a globular condition of the carbide.

TEMPERING (also termed drawing) — Reheating, after hardening to some temperature below the critical temperature range followed by any rate of cooling.

Note a — Although the terms "tempering" and "drawing" are practically synonymous as used in commercial practice, the term "tempering" is preferred.

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Note b — Tempering meaning the operation of hardening followed by reheating is a usage which is illogical and confusing in the present state of the art of heat treating and should be discouraged.

TENSILE STRENGTH — The maximum load per unit of original cross-sectional area obtained before rupture.

TEMPER CARBON — Graphite produced by heating at a temperature below the melting point.

TERNARY ALLOY — Alloy having three principal elements.

WORK HARDNESS — Hardness resulting from mechanical working.

YIELD POINT — The loader per unit of original cross-section at which a marked increase in the deformation of the specimen occurs without increase of load. It is usually calculated from the load determined by the drop of the beam of the testing machine or by use of dividers.

Notes:

RUSSEL METALS
WILLIAMS BAHCALL

TERMS AND CONDITIONS OF SALE

The following terms and conditions of sale are applicable to all quotes and sales to your Company.

1. **Prices and Payment**. Prices and charges are subject to change without notice and will reflect those of Vendor in effect at the time of shipment. Balances past due shall bear interest at 1½% per month (18% per annum). Mathematical and typographical errors are subject to correction. Terms of payment shall be as set forth in the invoice, or if no such terms are set forth therein, payment shall be due 30 days after the date of shipment. All payments shall be made in U.S. dollars.

2. **Title and Risk.** Title, ownership and risk of loss or damage to the goods shall pass to Purchaser immediately upon Vendor packaging goods unless otherwise specified as being on delivery. All sales are F.O.B. Vendor's warehouse unless otherwise stipulated. Charges for spotting, switching, handling, storage or other accessory services and demurrage shall be at Purchaser's expense.

3. **Orders.** Vendor's interpretation of a verbal order shall be final and binding where shipment is made prior to receipt of written confirmation. Unless brought to the attention of Vendor within 10 days, Vendor cannot be responsible for any errors or discrepancies contained in the order. All sales by Vendor shall be only upon the terms and conditions set forth herein. No understandings or agreements which differ from or add to these terms and conditions, and no additions, deletions or modifications of the terms and conditions of sale provided by Purchaser in its printed forms or otherwise shall bind Vendor unless specifically accepted by Vendor in writing, regardless of whether such understandings, agreements, additions, deletions or modifications would materially alter the terms hereof. Vendor rejects all such additions and/or different terms.

4. **Warranties.** Should any of the goods received by Purchaser not conform, as determined by Vendor's inspection, to the specifications and descriptions

contained herein, subject to Vendor's regular practice concerning over and under shipment and normal industry tolerances, variations and limitations of dimension, weight, shape and composition, Purchaser acknowledges that Vendor's only liability will be to replace or repair such goods or to refund the purchase price, at the option of Vendor, provided the terms of payment have been met and Purchaser notified Vendor in writing within 10 days of receipt of the goods. Except for test samples, goods may not be returned which Purchaser has cut, processed or altered in any way.

Where Purchaser has directed Vendor to perform certain shaping, cutting or other processing on the goods in accordance with Purchaser's particular specifications, Vendor does not make any representations or warranties except that those goods shall conform to the specifications supplied by Purchaser and that all processing applied by Vendor is performed in a good workmanlike manner in accordance with applicable industry trade standards and practices subject to any tolerances and variations consistent with the usual trade practices or as specified by Purchaser.

Purchaser acknowledges that no other express warranty is made with respect to the goods. If any model or sample was shown to Purchaser, such model or sample was used merely to illustrate the general type and quality of the goods and not to represent that the goods would necessarily conform to the model or sample in all respects.

THE FOREGOING REPRESENTS VENDOR'S SOLE EXPRESS WARRANTY WITH RESPECT TO THE GOODS SOLD TO PURCHASER. ALL OTHER WARRANTIES, EXPRESS AND/OR IMPLIED, INCLUDING WITHOUT LIMITATION, IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS ARE HEREBY EXPRESSLY EXCLUDED.

5. **Indemnification of Vendor.** Vendor will not be responsible for and Purchaser shall indemnify and hold harmless Vendor from and against any loss, damages, expenses, claims, repairs, suits or judgments whether direct, indirect or otherwise, arising in any way out of the use of the goods and that Vendor's sole liability shall be to replace or repair

the goods, or refund the purchase price, at Vendor's option. Where Purchaser has supplied the design for all or any part of the goods, Purchaser hereby agrees to indemnify and hold harmless Vendor from and against all loss, damages, expenses, claims, suits and judgments arising, directly or indirectly, out of the design, installation, maintenance or operation of the goods or any allegation that the goods, or any part thereof, infringe any patent, industrial design or intellectual property right.

Purchaser assumes all responsibility, risk and liability and agrees ti indemnify and save harmless Vendor from and against any liability, loss, cost, damages, claims or expenses in respect of any defect in the whole or any part or parts of any good or goods manufactured or fabricated, incorporating or otherwise using the goods sold under this agreement.

6. **Delivery.** Delivery of goods is subject to stock availability. Unavailability of the goods from Vendor's suppliers shall constitute a force majeure in this agreement. Vendor shall promptly notify Purchaser of the absence or shortage of supply of goods. Vendor shall exercise its best efforts to deliver within the times quoted but does not guarantee delivery time and shall not be liable for any damages, loss, claim or expense of any kind or nature whatsoever or howsoever caused by the delay in delivery or unavailability of goods.

7. **Force Majeure.** Neither party shall be responsible to the other for non-performance or delay in performance occasioned by any causes beyond its control including without limitation any acts or omissions of the other party, such as: acts of civil or military authority, strikes, lockouts, trade actions, embargoes, insurrections or acts of God.

8. **Claims and Credits.** Vendor shall not be liable for any shortages or errors in or damage to the goods shipped to Purchaser unless written details of such shortages, errors or damages are given by Purchaser to Vendor within 10 days of receipt of the goods.

9. **Changes or Cancellation.** Vendor may accept Purchaser's request to change the specifications

or processing of the goods, but shall reserve the right to charge Purchaser for all costs and services necessary for such changes. Orders for goods may not be cancelled and materials may not be returned by Purchaser except with the written consent of Vendor.

10. **Suspension of Orders.** Vendor reserves the right, without liability and without prejudice to any other remedies, to delay or stop shipment of all or any part of the goods if any time reasonable doubt exists as to Purchaser's financial situation.

11. **Entire Agreement.** This writing is intended by the parties as a final expression of their agreement and is intended also as a complete and exclusive statement of the terms of their agreement. Acceptance or acquiescence in a course of performance rendered under this agreement shall not be relevant to determine the meaning of this agreement even though the accepting or acquiescing party has knowledge of the nature of the performance and opportunity for objection.

    Purchaser's order will be filled in accordance with the terms and conditions set our above. This acknowledgment constitutes acceptance of Purchaser's offer subject to the conditions of sale above and it constitutes a contract made in the United States for the sale of goods described herein.

12. **Limitation of Remedies.** Vendor shall not be liable in contract, tort or otherwise for any loss, damages, costs, claims, expenses or repairs resulting from any defect, failure to conform to specifications or breach of this agreement whether any such loss, damage, cost, claim, expense or repair is direct, indirect or consequential. Vendor's liability shall be limited in all circumstances to the invoice price paid by Purchaser for the goods purchased under this agreement. The foregoing limitation of liability is a condition of sale of the goods at the price or prices quoted and shall apply notwithstanding any defect in or failure of, including the total failure of, any product.

    VENDOR SHALL IN NO EVENT BE LIABLE FOR ANY CONSEQUENTIAL INCIDENTAL OR SPECIAL DAMAGES.

13. **Assignment.** This agreement is not transferable or assignable by Purchaser.

14. **Modifications.** This agreement can be modified or rescinded only by a writing signed by both the parties or their duly authorized agents.

15. **Waiver.** No claim or right arising out of a breach of this agreement can be discharged in whole or in part by a waiver or renunciation of the claim or right unless the waiver or renunciation is supported by consideration and is in writing signed by the aggrieved party.

16. **Governing Law.** This agreement shall be governed by the law of the State of Wisconsin, including the Uniform Commercial Code as adopted by the State of Wisconsin as effective and in force on the date of this agreement.

Notes

Notes

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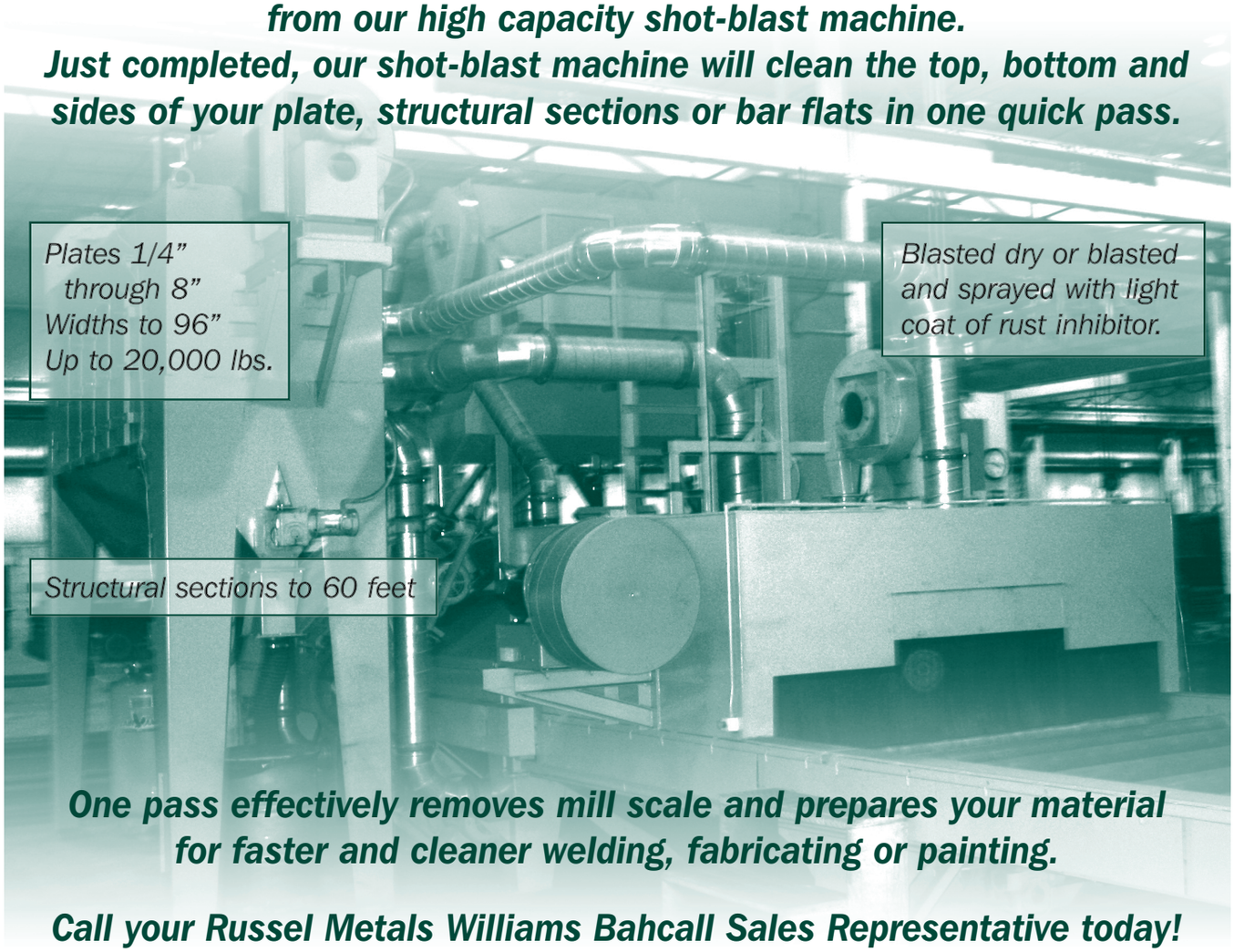

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