CHARTER STEEL

TECHNICAL REFERENCE GUIDE

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CHARTER STEEL OVERVIEW

Coil

- Diameters from 7/32” to 1-9/16” (5.50 to 40 millimeters)
- Available in increments of 1/64” (0.40 mm)
- 4,400 lb. to 5,600 lb. (2000 kg to 2500 kg) coils
- Processing available (clean & coat, draw, anneal)
- Micro-alloyed steels such as Boron, Vanadium and Columbium
- Japanese (JIS), German (DIN) and International Standards (ISO) or equivalent
- Nonstandard requests welcomed for capability assessments

SBQ Bar

- Diameters from 3/4” to 3-1/4” (19.00 to 82.55 millimeters)
- Lengths from 12’ to 50’ (3.7 to 15.3 meters)
- 4,000 to 10,000 lb. (1800 to 4600 kg) bundles
- Micro-alloyed steels such as Boron, Vanadium and Columbium
- Japanese (JIS), German (DIN) and International Standards (ISO) or equivalent
- Nonstandard requests welcomed for capability assessments

CHARTER STEEL OVERVIEW

Melting

- Both Cleveland and Saukville locations utilize EAF to convert scrap material to new steel
- Starts with a carefully controlled blend of raw materials that is continuously refined until Charter achieves the optimal chemistry and temperature
- Deoxidizing and alloying elements are added to create specific carbon and alloy properties
- The mix for each heat depends upon steel grade being made
- Vacuum degassing is available at both locations

Rolling

- Square billets are converted to round bar through a series of rolling stands (all rolling stands are monitored throughout to ensure consistency)
- Saukville coil diameters: 7/32”–1-3/8” (5.50-34.93 mm)
- Cleveland coil diameters: 7/32”–1-9/16” (5.50-39.69 mm)
- Cleveland SBQ diameter: 3/4”–3-1/4” (19.00-82.55 mm)
- Depending on diameter, product is coiled on either a Stelmor® Controlled Cooling Deck or Garret Coiler
- SBQ is completed and cooled on a cooling bed

Coil Processing

- Performed both in Saukville and Fostoria
- 36 annealing furnaces (box, Short Time Cycle [STC®], continuous)
- Five cleaning lines plus one mechanical descaler
- Lime, phos, lube and polymer coatings
- 0.140–1.500” diameter wire draw

STEEL CHEMISTRIES

SAE-AISI Grade Series Designations

Grade	Type of Steel	Range of Identifying Elements (%)
10XX	Plain Carbon	Mn: 0.25 – 1.00
11XX	Resulfurized	S: 0.08 – 0.33
12XX	Resulfurized and Rephosphorized	S: 0.10 – 0.35; P: 0.04 – 0.12
13XX	Manganese	Mn: 1.60 – 1.90
15XX	Plain Carbon	Mn: 0.75 – 1.65
40XX	Molybdenum	Mo: 0.20 – 0.30
41XX	Chromium-Molybdenum	Cr: 0.40 – 1.10; Mo: 0.08 – 0.35
43XX	Nickel-Chromium-Molybdenum	Ni: 1.65 – 2.00; Cr: 0.40 – 0.90; Mo: 0.20 – 0.30
46XX	Nickel-Molybdenum	Ni: 0.70 – 2.00; Mo: 0.15 – 0.30
50XX	Chromium	Cr: 0.20 – 0.60
51XX	Chromium	Cr: 0.70 – 1.15
52XXX	Chromium (Bearing)	Cr: 1.30 – 1.60
61XX	Chromium-Vanadium	Cr: 0.50 – 1.10; V: 0.10 – 0.15 or 0.15 min.
81XX	Nickel-Chromium-Molybdenum	Ni: 0.20 – 0.40; Cr: 0.30 – 0.55; Mo: 0.08 – 0.15
86XX	Nickel-Chromium-Molybdenum	Ni: 0.40 – 0.70; Cr: 0.40 – 0.60; Mo: 0.15 – 0.25
87XX	Nickel-Chromium-Molybdenum	Ni: 0.40 – 0.70; Cr: 0.40 – 0.60; Mo: 0.20 – 0.30
92XX	Silicon-Manganese	Si: 1.20 – 2.20; Mn: 0.60 – 1.00

XXBXX – denotes boron steel | XXLXX – denotes leaded steel
XXVXX - denotes vanadium steel

USA-European-Japanese Near Equivalent Grades

USA	European/DIN	Japanese
1010	C10	SWRCH10K or S10C
1018	C18	SWRCH18K
1022	21Mn4	SWRCH22K
1038	C38	SWRCH38K or S38C
1045	C45	SWRCH45K or S45C
1065	C66	N/A
1080	C80	N/A
1144	N/A	SUM43
1215	12SMn35	SUM23
1335	36Mn7	SMn438M
1541	36Mn5	SMn443
4037	36MoE3	N/A
4118	20CrMo5	SCM418
4140	42CrMo4	SCM440
4340	40NiCrMo6	SNCM439
5120	18CrMo4	SCr420
5160	55Cr3	SUP 9A
52100	100Cr6	SUJ2
6150	51CrV4	SUP10
8620	21NiCrMo2	SNCM220
8640	40NiCrMo2	SNCM240
9254	55SiCr7	SUP12

Standard Carbon Steels (Mn < 1.00%)[A]

Grade	C	Mn
1005	0.06 max.	0.35 max.
1006	0.08 max.	0.25 – 0.40
1008	0.10 max.	0.30 – 0.50
1010	0.08 – 0.13	0.30 – 0.60
1012	0.10 – 0.15	0.30 – 0.60
1013	0.11 – 0.16	0.30 – 0.60
1015	0.13 – 0.18	0.30 – 0.60
1016	0.13 – 0.18	0.60 – 0.90
1017	0.15 – 0.20	0.30 – 0.60
1018	0.15 – 0.20	0.60 – 0.90
1019	0.15 – 0.20	0.70 – 1.00
1020	0.18 – 0.23	0.30 – 0.60
1021	0.18 – 0.23	0.60 – 0.90
1022	0.18 – 0.23	0.70 – 1.00
1023	0.20 – 0.25	0.30 – 0.60
1025	0.22 – 0.28	0.30 – 0.60
1026	0.22 – 0.28	0.60 – 0.90
1029	0.25 – 0.31	0.60 – 0.90
1030	0.28 – 0.34	0.60 – 0.90
1035	0.32 – 0.38	0.60 – 0.90
1037	0.32 – 0.38	0.70 – 1.00
1038	0.35 – 0.42	0.60 – 0.90
1039	0.37 – 0.44	0.70 – 1.00
1040	0.37 – 0.44	0.60 – 0.90
1042	0.40 – 0.47	0.60 – 0.90
1043	0.40 – 0.47	0.70 – 1.00
1044	0.43 – 0.50	0.30 – 0.60
1045	0.43 – 0.50	0.60 – 0.90
1046	0.43 – 0.50	0.70 – 1.00
1049	0.46 – 0.53	0.60 – 0.90
1050	0.48 – 0.55	0.60 – 0.90
1053	0.48 – 0.55	0.70 – 1.00
1055	0.50 – 0.60	0.60 – 0.90
1060	0.55 – 0.65	0.60 – 0.90
1064	0.60 – 0.70	0.50 – 0.80
1065	0.60 – 0.70	0.60 – 0.90
1069	0.65 – 0.75	0.40 – 0.70
1070	0.65 – 0.75	0.60 – 0.90
1074	0.70 – 0.80	0.50 – 0.80
1075	0.70 – 0.80	0.40 – 0.70
1078	0.72 – 0.85	0.30 – 0.60
1080	0.75 – 0.88	0.60 – 0.90
1084	0.80 – 0.93	0.60 – 0.90
1086	0.80 – 0.93	0.30 – 0.50
1090	0.85 – 0.98	0.60 – 0.90
1095	0.90 – 1.03	0.30 – 0.50

[A] P = 0.040 max. and S = 0.050 max.

High Manganese Carbon Steels (15XX)[A]

Grade	C	Mn
1513	0.10 – 0.16	1.10 – 1.40
1518	0.15 – 0.21	1.10 – 1.40
1522	0.18 – 0.24	1.10 – 1.40
1524	0.19 – 0.25	1.35 – 1.65
1526	0.22 – 0.29	1.10 – 1.40
1527	0.22 – 0.29	1.20 – 1.50
1536	0.30 – 0.37	1.20 – 1.50
1541	0.36 – 0.44	1.35 – 1.65
1547	0.43 – 0.51	1.35 – 1.65
1548	0.44 – 0.52	1.10 – 1.40
1552	0.47 – 0.55	1.20 – 1.50
1566	0.60 – 0.71	0.85 – 1.15

[A] P = 0.040 max. and S = 0.050 max.

Resulfurized Carbon Steels (11XX)[A]

Grade	C	Mn	S
1117	0.14 – 0.20	1.00 – 1.30	0.08 – 0.13
1118	0.14 – 0.20	1.30 – 1.60	0.08 – 0.13
1126	0.23 - 0.29	0.70 - 1.00	0.08 - 0.13
1132	0.27 – 0.34	1.35 – 1.65	0.08 – 0.13
1137	0.32 – 0.39	1.35 – 1.65	0.08 – 0.13
1138	0.34 - 0.40	0.70 - 1.00	0.08 - 0.13
1140	0.37 – 0.44	0.70 – 1.00	0.08 – 0.13
1141	0.37 – 0.45	1.35 – 1.65	0.08 – 0.13
1144	0.40 – 0.48	1.35 – 1.65	0.24 – 0.33
1146	0.42 – 0.49	0.70 – 1.00	0.08 – 0.13
1151	0.48 – 0.55	0.70 – 1.00	0.08 – 0.13

[A] P = 0.030 max.

Rephosphorized and Resulfurized Carbon Steels (12XX)

Grade	C	Mn	P	S
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

Standard Alloy Steels[A]

Grade	C	Mn	Si[B]	Ni	Cr	Mo
1330	0.28 – 0.33	1.60 – 1.80	0.15 – 0.35			
1335	0.33 – 0.38	1.60 – 1.90	0.15 – 0.35			
1340	0.38 – 0.43	1.60 – 1.90	0.15 – 0.35			
4023	0.20 – 0.25	0.70 – 0.90	0.15 – 0.35			0.20 – 0.30
4027	0.25 – 0.30	0.70 – 0.90	0.15 – 0.35			0.20 – 0.30
4037	0.35 – 0.40	0.70 – 0.90	0.15 – 0.35			0.20 – 0.30
4047	0.45 – 0.50	0.70 – 0.90	0.15 – 0.35			0.20 – 0.30
4118	0.18 – 0.23	0.70 – 0.90	0.15 – 0.35		0.40 – 0.60	0.08 – 0.15
4120	0.18 – 0.23	0.90 – 1.20	0.15 – 0.35		0.40 – 0.60	0.13 – 0.20
4130	0.28 – 0.33	0.40 – 0.60	0.15 – 0.35		0.80 – 1.10	0.15 – 0.25
4135	0.33 – 0.38	0.70 – 0.90	0.15 – 0.35		0.80 – 1.10	0.15 – 0.25
4137	0.35 – 0.40	0.70 – 0.90	0.15 – 0.35		0.80 – 1.10	0.15 – 0.25
4140	0.38 – 0.43	0.75 – 1.00	0.15 – 0.35		0.80 – 1.10	0.15 – 0.25
4142	0.40 – 0.45	0.75 – 1.00	0.15 – 0.35		0.80 – 1.10	0.15 – 0.25
4145	0.43 – 0.48	0.75 – 1.00	0.15 – 0.35		0.80 – 1.10	0.15 – 0.25
4150	0.48 – 0.53	0.75 – 1.00	0.15 – 0.35		0.80 – 1.10	0.15 – 0.25
4161	0.56 – 0.64	0.75 – 1.00	0.15 – 0.35		0.70 – 0.90	0.25 – 0.35
4320	0.17 – 0.22	0.45 – 0.65	0.15 – 0.35	1.65 – 2.00	0.40 – 0.60	0.20 – 0.30
4340	0.38 – 0.43	0.60 – 0.80	0.15 – 0.35	1.65 – 2.00	0.70 – 0.90	0.20 – 0.30
E4340[C]	0.38 – 0.43	0.65 – 0.85	0.15 – 0.35	1.65 – 2.00	0.70 – 0.90	0.20 – 0.30
4615	0.13 – 0.18	0.45 – 0.65	0.15 – 0.35	1.65 – 2.00		0.20 – 0.30
4620	0.17 – 0.22	0.45 – 0.65	0.15 – 0.35	1.65 – 2.00		0.20 – 0.30
4720	0.17 – 0.22	0.50 – 0.70	0.15 – 0.35	0.90 – 1.20	0.35 – 0.55	0.15 – 0.25
4820	0.18 – 0.23	0.50 – 0.70	0.15 – 0.35	3.25 – 3.75		0.20 – 0.30
5015	0.12 – 0.17	0.30 – 0.50	0.15 – 0.35		0.30 – 0.50	
5115	0.13 – 0.18	0.70 – 0.90	0.15 – 0.35		0.70 – 0.90	
5120	0.17 – 0.22	0.70 – 0.90	0.15 – 0.35		0.70 – 0.90	
5130	0.28 – 0.33	0.70 – 0.90	0.15 – 0.35		0.80 – 1.10	
5132	0.30 – 0.35	0.60 – 0.80	0.15 – 0.35		0.75 – 1.00	
5140	0.38 – 0.43	0.70 – 0.90	0.15 – 0.35		0.70 – 0.90	
5150	0.48 – 0.53	0.70 – 0.90	0.15 – 0.35		0.70 – 0.90	
5160	0.56 – 0.64	0.75 – 1.00	0.15 – 0.35		0.70 – 0.90	
E52100[C]	0.98 – 1.10	0.25 – 0.45	0.15 – 0.35		1.30 – 1.60	
52100[C,D]	0.93 – 1.05	0.25 – 0.45	0.15 – 0.35		1.35 – 1.60	
6150[E]	0.48 – 0.53	0.70 – 0.90	0.15 – 0.35		0.80 – 1.10	
8615	0.13 – 0.18	0.70 – 0.90	0.15 – 0.35	0.40 – 0.70	0.40 – 0.60	0.15 – 0.25
8617	0.15 – 0.20	0.70 – 0.90	0.15 – 0.35	0.40 – 0.70	0.40 – 0.60	0.15 – 0.25
8620	0.18 – 0.23	0.70 – 0.90	0.15 – 0.35	0.40 – 0.70	0.40 – 0.60	0.15 – 0.25
8622	0.20 – 0.25	0.70 – 0.90	0.15 – 0.35	0.40 – 0.70	0.40 – 0.60	0.15 – 0.25
8627	0.25 – 0.30	0.70 – 0.90	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	0.15 – 0.35	0.40 – 0.70	0.40 – 0.60	0.15 – 0.25
8637	0.38 – 0.43	0.75 – 1.00	0.15 – 0.35	0.40 – 0.70	0.40 – 0.60	0.15 – 0.25
8640	0.38 – 0.43	0.75 – 1.00	0.15 – 0.35	0.40 – 0.70	0.40 – 0.60	0.15 – 0.25
8645	0.43 – 0.48	0.75 – 1.00	0.15 – 0.35	0.40 – 0.70	0.40 – 0.60	0.15 – 0.25
8650	0.48 – 0.53	0.75 – 1.00	0.15 – 0.35	0.40 – 0.70	0.40 – 0.60	0.15 – 0.25
8655	0.51 – 0.59	0.75 – 1.00	0.15 – 0.35	0.40 – 0.70	0.40 – 0.60	0.15 – 0.25
8720	0.18 – 0.23	0.70 – 0.90	0.15 – 0.35	0.40 – 0.70	0.40 – 0.60	0.20 – 0.30
8740	0.38 – 0.43	0.75 – 1.00	0.15 – 0.35	0.40 – 0.70	0.40 – 0.60	0.20 – 0.30
8822	0.20 – 0.25	0.75 – 1.00	0.15 – 0.35	0.40 – 0.70	0.40 – 0.60	0.30 – 0.40
9254	0.51 – 0.59	0.60 – 0.80	1.20 – 1.60		0.60 – 0.80	
9259	0.56 – 0.64	0.75 – 1.00	0.70 – 1.10		0.45 – 0.65	
9260	0.56 – 0.64	0.75 – 1.00	1.80 – 2.20			

[A] P = 0.030 max. and S = 0.040 max. unless otherwise noted

[B] Si may be specified by the purchaser as 0.10% max. The need for 0.10% max. generally relates to severe cold-formed parts.

[C] P = 0.025 max. and S = 0.025 max.

[D] The purchaser may also require the following maximums: Cu: 0.30%, Al: 0.050% and O: 0.0015%

[E] V = 0.15 min.

Standard Alloy Boron Steels[A]

Grade	C	Mn	P	S	Si	Ni	Cr	Mo
50B44	0.43 – 0.48	0.75 – 1.00	0.035 max.	0.040 max.	0.15 – 0.35		0.20 – 0.60	
50B46	0.44 – 0.49	0.75 – 1.00	0.035 max.	0.040 max.	0.15 – 0.35		0.20 – 0.35	
50B50	0.48 – 0.53	0.75 – 1.00	0.035 max.	0.040 max.	0.15 – 0.35		0.40 – 0.60	
50B60	0.56 – 0.64	0.75 – 1.00	0.035 max.	0.040 max.	0.15 – 0.35		0.40 – 0.60	
51B60	0.56 – 0.64	0.75 – 1.00	0.035 max.	0.040 max.	0.15 – 0.35		0.70 – 0.90	
81B45	0.43 – 0.48	0.75 – 1.00	0.035 max.	0.040 max.	0.15 – 0.35	0.20 – 0.40	0.35 – 0.55	0.08 – 0.15
94B17	0.15 – 0.20	0.75 – 1.00	0.035 max.	0.040 max.	0.15 – 0.35	0.30 – 0.60	0.30 – 0.50	0.08 – 0.15
94B30	0.28 – 0.33	0.75 – 1.00	0.035 max.	0.040 max.	0.15 – 0.35	0.30 – 0.60	0.30 – 0.50	0.08 – 0.15

[A] These steels can be expected to contain 0.0005% to 0.003% B. If the usual titanium additive is not permitted, the steels can be expected to contain up to 0.005% B.

Selected European Grades

Grade	C	Mn	P	S	Si	Ni	Cr	Mo	B	V
38Si7	0.35 – 0.42	0.50 – 0.80	0.025 max.	0.025 max.	1.50 – 1.80					
38B2	0.35 – 0.40	0.60 – 0.90	0.025 max.	0.025 max.	0.15 – 0.30		0.30 max.		0.0008 – 0.005	
23MnB4	0.20 – 0.25	0.90 – 1.20	0.025 max.	0.025 max.	0.30 max.		0.30 max.		0.0008 – 0.005	
36MnB4	0.33 – 0.38	0.80 – 1.10	0.025 max.	0.025 max.	0.30 max.		0.30 max.		0.0008 – 0.005	
34Cr4	0.30 – 0.37	0.60 – 0.90	0.025 max.	0.025 max.	0.40 max.		0.90 – 1.20			
32CrB4	0.30 – 0.34	0.60 – 0.90	0.025 max.	0.025 max.	0.30 max.		0.90 – 1.20		0.0008 – 0.005	
16MnCr5	0.14 – 0.19	1.00 – 1.30	0.025 max.	0.025 max.	0.30 max.		0.80 – 1.10			
16MnCrS5	0.14 – 0.19	1.00 – 1.30	0.025 max.	0.020 – 0.040	0.30 max.		0.80 – 1.10			
16MnCrB5	0.14 – 0.19	1.00 – 1.30	0.025 max.	0.025 max.	0.30 max.		0.80 – 1.10		0.0008 – 0.005	
39MnCrB6-2	0.36 – 0.42	1.40 – 1.70	0.025 max.	0.025 max.	0.40 max.		0.30 – 0.60		0.0008 – 0.005	
51CrV4	0.47 – 0.55	0.70 – 1.10	0.025 max.	0.025 max.	0.40 max.		0.90 – 1.20			0.10 – 0.25
18CrMo4	0.15 – 0.21	0.60 – 0.90	0.025 max.	0.025 max.	0.30 max.		0.90 – 1.20	0.15 – 0.25		
42CrMo4	0.38 – 0.45	0.60 – 0.90	0.025 max.	0.025 max.	0.30 max.		0.90 – 1.20	0.15 – 0.30		
42CrMoS4	0.38 – 0.45	0.60 – 0.90	0.025 max.	0.020 – 0.040	0.30 max.		0.90 – 1.20	0.15 – 0.30		
35NiCr6	0.30 – 0.37	0.60 – 0.90	0.025 max.	0.025 max.	0.40 max.	1.20 – 1.60	0.80 – 1.10			
34CrNiMo6	0.30 – 0.38	0.50 – 0.80	0.025 max.	0.025 max.	0.30 max.	1.30 – 1.70	1.30 – 1.70	0.15 – 0.30		

Other Selected Grades

Grade	C	Mn	P	S	Si	Ni	Cr	Mo	Cu
A182 grade F11[A]	0.05 – 0.16	0.30 – 0.60	0.030 max.	0.030 max.	0.50 – 1.00		1.00 – 1.50	0.44 – 0.65	
A182 grade F11[B]	0.10 – 0.20	0.30 – 0.80	0.040 max.	0.040 max.	0.50 – 1.00		1.00 – 1.50	0.44 – 0.65	
A193 grade B16[C]	0.36 – 0.47	0.45 – 0.70	0.035 max.	0.040 max.	0.15 – 0.35		0.80 – 1.15	0.50 – 0.65	
A242 (HSLA)	0.15 max.	1.00 max.	0.150 max.	0.050 max.					0.20 min.
A325 type 1[D]	0.30 – 0.52	0.60 min.	0.040 max.	0.050 max.	0.15 – 0.30				
A325 type 3A	0.33 – 0.40	0.90 – 1.20	0.035 max.	0.040 max.	0.15 – 0.35	0.25 – 0.45	0.45 – 0.65		0.25 – 0.45
A325 type 3B	0.38 – 0.48	0.70 – 0.90	0.060 – 0.120	0.040 max.	0.30 – 0.50	0.50 – 0.80	0.50 – 0.75	0.06 max.	0.20 – 0.40
A387 grade 11	0.05 – 0.17	0.40 – 0.65	0.025 max.	0.025 max.	0.50 – 0.80		1.00 – 1.05	0.45 – 0.65	
A588 grade A[E]	0.19 max.	0.80 – 1.25	0.030 max.	0.030 max.	0.30 – 0.65	0.40 max.	0.40 – 0.65		0.25 – 0.40
A681 type S2	0.40 – 0.55	0.30 – 0.50	0.030 max.	0.030 max.	0.90 – 1.20			0.30 – 0.60	

[A] Class 1

[B] Class 2

[C] V = 0.25 – 0.35 and Al = 0.015 max.

[D] Carbon Steel option

[E] V = 0.02 – 0.10

Permissible Variations for Product Analysis of Carbon Steel

(% allowed over maximum or under minimum limits)

Element	Limit or Maximum of Specified Range (%)	Over Maximum Limit or Under Minimum Limit (%)
Carbon	0.25 and under	0.02
	Over 0.25 to 0.55 inclusive	0.03
	Over 0.55	0.04
Manganese	0.90 and under	0.03
	Over 0.90 to 1.65 inclusive	0.06
Phosphorus[A]	Over maximum limit only	0.008
Sulfur[A]	Over maximum limit only	0.008
Silicon	0.35 and under	0.02
	Over 0.35 to 0.60 inclusive	0.05
Copper	Under minimum limit only	0.02

[A] Resulfurized or rephosphorized steels are not subject to rejection on product analysis for these elements.

Permissible Variations for Product Analysis of Alloy Steel

(% allowed over maximum or under minimum limits)

Element	Limit or Maximum of Specified Range (%)	Over Maximum Limit or Under Minimum Limit (%)
Carbon	0.30 and under	0.01
	Over 0.30 to 0.75 inclusive	0.02
	Over 0.75	0.03
Manganese	0.90 and under	0.03
	Over 0.90 to 2.10 inclusive	0.04
Phosphorus	Over maximum limit only	0.005
Sulfur	0.060 and under	0.005
Silicon	0.40 and under	0.02
	Over 0.40 to 2.20 inclusive	0.05
Nickel	1.00 and under	0.03
	Over 1.00 to 2.00 inclusive	0.05
	Over 2.00 to 5.30 inclusive	0.07
	Over 5.30 to 10.00 inclusive	0.10
Chromium	0.90 and under	0.03
	Over 0.90 to 2.10 inclusive	0.05
	Over 2.10 to 3.99 inclusive	0.10
Molybdenum	0.20 and under	0.01
	Over 0.20 to 0.40 inclusive	0.02
	Over 0.40 to 1.15 inclusive	0.03
Vanadium[A]	0.10 and under	0.01
	Over 0.10 to 0.25 inclusive	0.02
	Over 0.25 to 0.50 inclusive	0.03
Tungsten	1.00 and under	0.04
	Over 1.00 to 4.00 inclusive	0.08
Aluminum	0.10 and under	0.03
	Over 0.10 to 0.20 inclusive	0.04
	Over 0.20 to 0.30 inclusive	0.05
	Over 0.30 to 0.80 inclusive	0.07
	Over 0.80 to 1.80 inclusive	0.10
Copper	To 1.00 inclusive	0.03
	Over 1.00 to 2.00 inclusive	0.05

[A] If the minimum of the range is 0.01%, the under tolerance is 0.005%

STEEL PROPERTIES

End-Quench Jominy Hardenability

The following standards are associated with hardenability, jominy, DI, etc.:

ASTM A255: Standard Test Methods for Determining Hardenability of Steel

ASTM A304: Standard Specification for Carbon and Alloy Steel Bars Subject to End-Quench Hardenability Requirements

ISO 642: Steel - Hardenability Test by End Quenching (Jominy test)

JIS G 0561: Method of Hardenability Test for Steel (End Quenching Method)

SAE J1268: Hardenability Bands for Carbon and Alloy H Steels

SAE J406: Methods of Determining Hardenability of Steels

Machinability Ratings for Various Steel Grades

Grade	Condition	Average Machinability Rating
1018	Cold drawn	78
1035	Cold drawn	70
1050	Cold drawn	54
1050	Annealed and cold drawn	70
1095	Cold drawn	42
1118	Cold drawn	91
1144	Cold drawn	76
1144	Annealed and cold drawn	85
1212	Cold drawn	100
12L14	Cold drawn	158
1215	Cold drawn	136
1335	Annealed and cold drawn	55
1340	Annealed and cold drawn	50
4037	Annealed and cold drawn	70
4118	Cold drawn	60
4130	Annealed and cold drawn	70
4137	Annealed and cold drawn	70
4140	Annealed and cold drawn	65
4150	Annealed and cold drawn	55
4161	Annealed and cold drawn	50
4320	Annealed and cold drawn	60
4340	Annealed and cold drawn	50
4620	Cold drawn	65
4720	Cold drawn	65
4820	Annealed and cold drawn	50
5015	Cold drawn	65
50B44	Annealed and cold drawn	65
50B60	Spheroidized and cold drawn	55
5120	Cold drawn	70
5140	Annealed and cold drawn	65
5160	Spheroidized and cold drawn	55
E52100	Spheroidized and cold drawn	40
6118	Cold drawn	60
6150	Annealed and cold drawn	55
8615	Cold drawn	70
8620	Cold drawn	65
8630	Annealed and cold drawn	70
8640	Annealed and cold drawn	65
8655	Annealed and cold drawn	55
8740	Annealed and cold drawn	65
8822	Cold drawn	55
9260	Spheroidized and cold drawn	40

TOLERANCES

Size Tolerances - Hot Rolled Rod & Bar[A]

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

[A] Half tolerance is available on some SBQ sizes

[B] Out of Round is the difference between the maximum and minimum diameters of the bar, measured at the same transverse cross section.

Size Tolerances - Wire

Diameter (in.)	Diameter Tolerance (in.)	Maximum Out of Round (in.)
Less than 0.500	+/- 0.0015	0.0015
0.500 - 1.000	+/- 0.0020	0.0020
Greater than 1.000	+/- 0.0030	0.0030

Length Tolerances - SBQ - Mill Shearing

Specified Size (in.)	Tolerance Over Specified Length (in.). No Tolerances Under				
	5 to under 10 ft.	10 to under 20 ft.	20 to under 30 ft.	30 to under 40 ft.	40 to 60 ft. incl.
To 1, inclusive	1/2	3/4	1 ¼	1 ¾	2 ¼
Over 1 to 2, inclusive	5/8	1	1 ½	2	2 ½
Over 2 to 5, inclusive	1	1 ½	1 ¾	2 ¼	2 ¾
Over 5 to 10, inclusive	2	2 ½	2 ¾	3	3 ¼
Bar Size Shapes	5/8	1	1 ½	2	2 ½

Length Tolerances - SBQ - Hot Sawing

Specified Size (in.)	Tolerance Over Specified Length (in.). No Tolerances Under				
	5 to under 10 ft.[A]	10 to under 20 ft.	20 to under 30 ft.	30 to under 40 ft.	40 to 60 ft. incl.
To 3 ½, inclusive[A]	-----	1 ½	1 ¾	2 ¼	2 ¾
Over 3 ½ to 5, inclusive	-----	2	2 ¼	2 ⅜	3
Over 5 to 10, inclusive	-----	2 ½	2 ¾	3	3 ¼

[A] Smaller sizes and shorter lengths are not hot sawed

Length Tolerances - SBQ - Recutting Both Ends[A]

Specified Size (in.)	Tolerance Over Specified Length (in.). No Tolerances Under	
	To 12 ft., inclusive	Over 12 ft.
To 3, inclusive	1/4	5/16
Over 3 to 6, inclusive	5/16	7/16
Over 6 to 8, inclusive	7/16	9/16
Over 8 to 10, inclusive	9/16	11/16

[A] Tolerances apply only to bars meeting special straightness tolerances

Straightness Tolerances - SBQ[A]

Standard Straightness Tolerance:
¼" in any 5 ft. and (¼" x length in ft.) / 5

Special Straightness Tolerance:
⅛" in any 5 ft. and (⅛" x 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.

Machining Allowance - SBQ[A]

Minimum stock removal (diameter)

Standard Grades: 1.6% per side

Resulfurized Grades: 2.4% per side

[A] Based on bars with special straightness tolerance. Since straightness is a function of length, additional machining allowance may be required for turning on centers.

GENERAL INFORMATION

Quality Designations

Quality Designation	Description	Typical/Common Grades
AQ	Aircraft Quality	8740, 4130, 4140, 4340, B16
BQ	Bearing Quality	4118, 8620, 52100
CFQ	Cold Finish Quality	1018, 1045
FMQ	Free Machining Quality	1117, 1144, 1215
HQ	High Carbon	1065, 1080
HRQ	Restrictive High Carbon	1065, 1080
IQ	Industrial Quality	1006, 1010, 1018, 1045
RHQ	Recessed Head Quality (a.k.a. CHQ)	1010, 1018, 10B21, 1038, 1541, 4037, 4140, 4340, 8620, etc.
SEC	Secondary	
SRQ	Spring Round Quality	1045, 5160, 9254
WRQ	Weld Rod Quality	E6013, E7018, E6010, E6011
WWQ	Wool Wire Quality	1008

Abbreviations, Acronyms & Definitions

A = AISI standard chemistry
H = H-band (hardenability/DI requirement)
M = Modified chemistry (outside AISI limits)
R = Restricted chemistry (inside AISI limts)
X = Enhanced formability

SK = Silicon Killed
AK = Aluminum Killed
FG = Fine Grain
VFG = Vanadium Fine Grain
CG = Coarse Grain
CGP = Coarse Grain Practice

BL = Billet Item
FB = Finished Bar Item
GB = Green Bar Item
GC = Green Coil Item
PC = In-Process Item
PK = Packaged Finished Item

Processing Path Steps

PROCESS	SA+SAIPXF*	SA+SAFSXF*	AN+SAIP SA+SAIP AN+RAIP	AN+SAFS SA+SAFS AN+RAFS	SAIP RAIP	DFSAR DFAR	SAFS RAFS	HRSA HRAN HRSR HRSP HRLP	DD	HRCC
1	Clean/Coat	Clean/Coat	Clean/Coat	Clean/Coat	Clean/Coat	Clean/Coat	Clean/Coat	Clean/Coat	Clean/Coat	Clean/Coat
2	Anneal	Anneal	Anneal	Anneal	Draw	Anneal	Draw	Anneal	Draw	Ship
3	Clean/Coat	Clean/Coat	Clean/Coat	Clean/Coat	Anneal	Clean/Coat	Anneal	Clean/Coat or Reband	Ship	
4	Draw	Draw	Draw	Draw	Clean/Coat	Draw	Clean/Coat or Reband	Ship		
5	Anneal	Anneal	Anneal	Anneal	Draw	Ship	Ship			
6	Clean/Coat	Clean/Coat or Reband	Clean/Coat	Clean/Coat or Reband	Ship					
7	Draw	Ship	Draw	Ship						
8	Ship		Ship							

*X-Flow (XF) is a proprietary process that utilizes Charter Steel's end to end process controls to maximize material formability.

SA = Spheroidize Anneal
RA or AN = Regular Anneal
IP = In-Process
FS = Finish Size
XF = X-Flow
DFSAR = Drawn From Spheroidize Annealed Rod
DFAR = Drawn From Annealed Rod
HR = Hot Rolled
SR = Stress Relief Anneal
SP = Special Anneal
LP = Lamallar Pearlite Anneal
DD = Direct Draw
CC = Clean & Coat

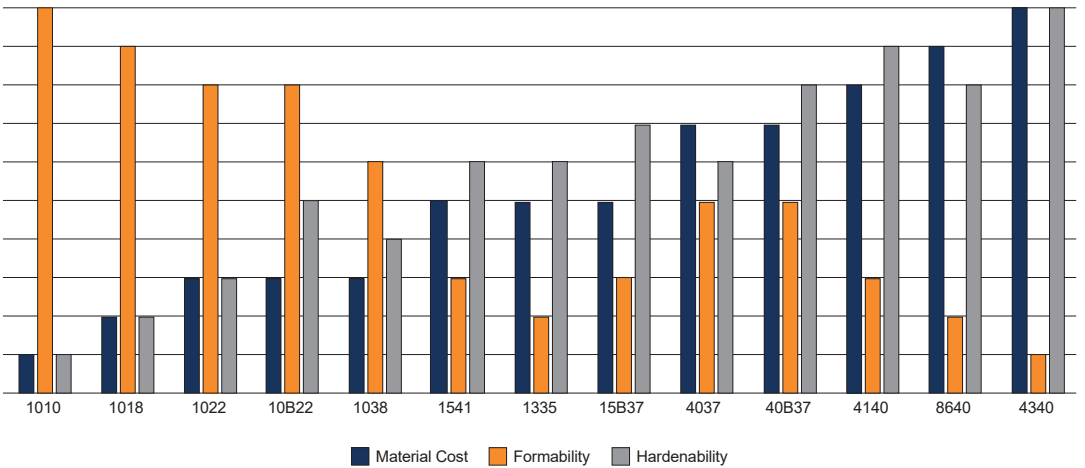
Finish drawn product (used if customer does not draw in-house)

Used if customer does draw in-house

Note - QC checks occur in-between various process steps

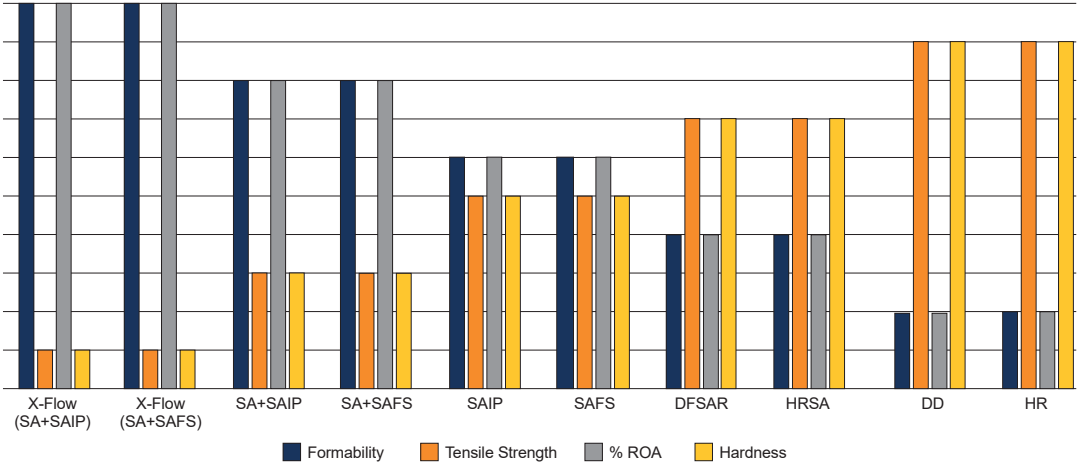
Relative Comparisons by Grade

These are intended as conceptual illustrations and do not actually correlate to specific properties.



Relative Comparisons by Processing Level

These are intended as conceptual illustrations and do not actually correlate to specific properties.



Inches to Millimeters Conversions

Fraction	Inches	Millimeters
1/64	0.0156	0.397
1/32	0.0313	0.794
3/64	0.0469	1.191
1/16	0.0625	1.588
5/64	0.0781	1.984
3/32	0.0938	2.381
7/64	0.1094	2.778
1/8	0.1250	3.175
9/64	0.1406	3.572
5/32	0.1563	3.969
11/64	0.1719	4.366
3/16	0.1875	4.763
13/64	0.2031	5.159
7/32	0.2188	5.556
15/64	0.2344	5.953
1/4	0.2500	6.350
17/64	0.2656	6.747
9/32	0.2813	7.144
19/64	0.2969	7.541
5/16	0.3125	7.938
21/64	0.3281	8.334
11/32	0.3438	8.731

Fraction	Inches	Millimeters
23/64	0.3594	9.128
3/8	0.3750	9.525
25/64	0.3906	9.922
13/32	0.4063	10.319
27/64	0.4219	10.716
7/16	0.4375	11.113
29/64	0.4531	11.509
15/32	0.4688	11.906
31/64	0.4844	12.303
1/2	0.5000	12.700
33/64	0.5156	13.097
17/32	0.5313	13.494
35/64	0.5469	13.891
9/16	0.5625	14.288
37/64	0.5781	14.684
19/32	0.5938	15.081
39/64	0.6094	15.478
5/8	0.6250	15.875
41/64	0.6406	16.272
21/32	0.6563	16.669
43/64	0.6719	17.066
11/16	0.6875	17.463

Fraction	Inches	Millimeters
45/64	0.7031	17.859
23/32	0.7188	18.256
47/64	0.7344	18.653
3/4	0.7500	19.050
49/64	0.7656	19.447
25/32	0.7813	19.844
51/64	0.7969	20.241
13/16	0.8125	20.638
53/64	0.8281	21.034
27/32	0.8438	21.431
55/64	0.8594	21.828
7/8	0.8750	22.225
57/64	0.8906	22.622
29/32	0.9063	23.019
59/64	0.9219	23.416
15/16	0.9375	23.813
61/64	0.9531	24.209
31/32	0.9688	24.606
63/64	0.9844	25.003
1	1.0000	25.400

Hardness Conversion Chart: 40 – 100 HRB

HRB	HK	HV	HRA	HR30T	HR15T	HB	APPROXIMATE TENSILE (PSI)
40	97		30.7	43.0	73.6		
41	98		31.2	43.7	74.0		
42	99		31.6	44.3	74.3		
43	100		32.0	45.0	74.6		
44	101		32.4	45.7	74.9		
45	102		32.9	46.3	75.3		
46	103		33.3	47.0	75.6		
47	104		33.7	47.7	75.9		
48	105		34.1	48.3	76.2		
49	106		34.6	49.0	76.6		
50	107		35.0	49.7	76.9		
51	108		35.5	50.3	77.2		
52	109		35.9	51.0	77.5		
53	110		36.3	51.7	77.9		
54	111		36.8	52.4	78.2		
55	112	100	37.2	53.0	78.5	100	
56	114	101	37.7	53.7	78.8	101	
57	115	103	38.1	54.4	79.2	103	
58	117	104	38.6	55.0	79.5	104	
59	118	106	39.0	55.7	79.8	106	
60	120	107	39.5	56.4	80.1	107	
61	122	108	40.0	57.0	80.5	108	
62	124	110	40.4	57.7	80.8	110	
63	125	112	40.9	58.4	81.1	112	
64	127	114	41.4	59.0	81.4	114	
65	129	116	41.8	59.7	81.8	116	
66	131	117	42.3	60.4	82.1	117	56,000
67	133	119	42.8	61.0	82.4	119	57,000
68	135	121	43.3	61.7	82.7	121	58,000
69	137	123	43.8	62.4	83.0	123	59,000
70	139	125	44.3	63.1	83.4	125	60,000
71	141	127	44.8	63.7	83.7	127	61,000
72	143	130	45.2	64.4	84.0	130	62,000
73	145	132	45.8	65.1	84.3	132	63,000
74	147	135	46.3	65.7	84.7	135	65,000
75	150	137	46.8	66.4	85.0	137	66,000
76	152	139	47.3	67.1	85.3	139	67,000
77	155	141	47.9	67.7	85.6	141	68,000
78	158	144	48.4	68.4	86.0	144	69,000
79	161	147	48.9	69.1	86.3	147	70,000
80	164	150	49.5	69.7	86.6	150	72,000
81	167	153	50.0	70.4	86.9	153	74,000
82	170	156	50.6	71.1	87.3	156	75,000
83	173	159	51.1	71.8	87.6	159	76,000
84	176	162	51.7	72.4	87.9	162	77,000
85	180	165	52.3	73.1	88.2	165	79,000
86	184	169	52.8	73.8	88.6	169	80,000
87	188	172	53.4	74.4	88.9	172	82,000
88	192	176	54.0	75.1	89.2	176	84,000
89	196	180	54.6	75.8	89.5	180	86,000
90	201	185	55.2	76.4	89.9	185	87,000
91	206	190	55.8	77.1	90.2	190	88,000
92	211	195	56.4	77.8	90.5	195	90,000
93	216	200	57.0	78.4	90.8	200	94,000
94	221	205	57.6	79.1	91.2	205	98,000
95	226	210	58.3	79.8	91.5	210	100,000
96	231	216	58.9	80.4	91.8	216	102,000
97	236	222	59.5	81.1	92.1	222	106,000
98	241	228	60.2	81.8	92.5	228	108,000
99	246	234	60.9	82.5	92.8	234	112,000
100	251	240	61.5	83.1	93.1	240	117,000

Hardness Conversion Chart: 20 – 68 HRC

HRC	HK	HV	HRA	HR30N	HR15N	HB	APPROXIMATE TENSILE (PSI)
20	251	238	60.5	41.5	69.4	226	110,000
21	256	243	61.0	42.3	69.9	231	112,000
22	261	248	61.5	43.2	70.5	237	114,000
23	266	254	62.0	44.0	71.0	243	117,000
24	272	260	62.4	45.0	71.6	247	120,000
25	278	266	62.8	45.9	72.2	253	122,000
26	284	272	63.3	46.8	72.8	258	125,000
27	290	279	63.8	47.7	73.3	264	128,000
28	297	286	64.3	48.6	73.9	271	132,000
29	304	294	64.6	49.5	74.5	279	135,000
30	311	302	65.3	50.4	75.0	286	138,000
31	318	310	65.8	51.3	75.6	294	142,000
32	326	318	66.3	52.1	76.1	301	145,000
33	334	327	66.8	53.3	76.6	311	149,000
34	342	336	67.4	54.2	77.2	319	153,000
35	351	345	67.9	55.0	77.7	327	157,000
36	360	354	68.4	55.9	78.3	336	162,000
37	370	363	68.9	56.8	78.8	344	168,000
38	380	372	69.4	57.7	79.4	353	171,000
39	391	382	69.9	58.6	79.9	362	176,000
40	402	392	70.4	59.5	80.4	371	181,000
41	414	402	70.9	60.4	80.9	381	188,000
42	426	412	71.5	61.3	81.5	390	194,000
43	438	423	72.0	62.2	82.0	400	201,000
44	452	434	72.5	63.1	82.5	409	208,000
45	466	446	73.1	64.0	83.0	421	215,000
46	480	458	73.6	64.8	83.5	432	222,000
47	495	471	74.1	65.8	83.9	443	229,000
48	510	484	74.7	66.7	84.5	455	237,000
49	526	498	75.2	67.6	85.0	469	246,000
50	542	513	75.9	68.5	85.5	481	255,000
51	558	528	76.3	69.4	85.9	496	264,000
52	576	544	76.8	70.2	86.4	512	273,000
53	594	560	77.4	71.2	86.9	525	283,000
54	612	577	78.0	72.0	87.4	543	292,000
55	630	595	78.5	73.0	87.9	560	301,000
56	650	613	79.0	73.9	88.3	577	
57	670	633	79.6	74.8	88.9	595	
58	690	653	80.1	75.7	89.3	615	
59	710	674	80.7	76.6	89.8	634	
60	732	697	81.2	77.5	90.2	654	
61	754	720	81.8	78.4	90.7	670	
62	776	746	82.3	79.3	91.1	688	
63	799	772	82.8	80.1	91.4	705	
64	822	800	83.4	81.1	91.8	722	
65	846	832	83.9	81.9	92.2	739	
66	870	865	84.5	82.8	92.5		
67	895	900	85.0	83.6	92.9		
68	920	940	85.6	84.4	93.2		

Weight Tables For Rounds (Metric): 5.5 – 33 MM

SIZE (MM)	NOMINAL DECIMAL (INCHES)	LBS. PER FOOT
5.5	0.217	0.1253
6.0	0.236	0.1491
6.5	0.256	0.1750
7.0	0.276	0.2030
7.5	0.295	0.2330
8.0	0.315	0.2651
8.5	0.335	0.2993
9.0	0.354	0.3355
9.5	0.374	0.3739
10.0	0.394	0.4142
10.5	0.413	0.4567
11.0	0.433	0.5012
11.5	0.453	0.5478
12.0	0.472	0.5965
12.5	0.492	0.6473
13.0	0.512	0.7001
13.5	0.531	0.7550
14.0	0.551	0.8119
14.5	0.571	0.8709
15.0	0.591	0.9320
15.5	0.610	0.9952
16.0	0.630	1.0605
16.5	0.650	1.1278
17.0	0.669	1.1972
17.5	0.689	1.2686
18.0	0.709	1.3421
18.5	0.728	1.4177
19.0	0.748	1.4954
19.5	0.768	1.5752
20.0	0.787	1.6570
20.5	0.807	1.7409
21.0	0.827	1.8268
21.5	0.846	1.9148
22.0	0.866	2.0049
22.5	0.886	2.0971
23.0	0.906	2.1913
23.5	0.925	2.2877
24.0	0.945	2.3860
24.5	0.965	2.4865
25.0	0.984	2.5890
25.5	1.004	2.6936
26.0	1.024	2.8003
26.5	1.043	2.9090
27.0	1.063	3.0198
27.5	1.083	3.1327
28.0	1.102	3.2477
28.5	1.122	3.3647
29.0	1.142	3.4838
29.5	1.161	3.6050
30.0	1.181	3.7282
30.5	1.201	3.8535
31.0	1.220	3.9809
31.5	1.240	4.1103
32.0	1.260	4.2419
32.5	1.280	4.3754
33.0	1.299	4.5111

Weight Tables For Rounds (Metric): 33.5 – 61 MM

SIZE (MM)	NOMINAL DECIMAL (INCHES)	LBS. PER FOOT
33.5	1.319	4.6488
34.0	1.339	4.7887
34.5	1.358	4.9305
35.0	1.378	5.0745
35.5	1.398	5.2205
36.0	1.417	5.3686
36.5	1.437	5.5188
37.0	1.457	5.6710
37.5	1.476	5.8253
38.0	1.496	5.9817
38.5	1.516	6.1401
39.0	1.535	6.3006
39.5	1.555	6.4632
40.0	1.575	6.6279
40.5	1.594	6.7946
41.0	1.614	6.9634
41.5	1.634	7.1343
42.0	1.654	7.3073
42.5	1.673	7.4823
43.0	1.693	7.6594
43.5	1.713	7.8385
44.0	1.732	8.0198
44.5	1.752	8.2031
45.0	1.772	8.3884
45.5	1.791	8.5759
46.0	1.811	8.7654
46.5	1.831	8.9570
47.0	1.850	9.1506
47.5	1.870	9.3464
48.0	1.890	9.5442
48.5	1.909	9.7440
49.0	1.929	9.9460
49.5	1.949	10.1500
50.0	1.969	10.3561
50.5	1.988	10.5642
51.0	2.008	10.7745
51.5	2.028	10.9868
52.0	2.047	11.2011
52.5	2.067	11.4176
53.0	2.087	11.6361
53.5	2.106	11.8567
54.0	2.126	12.0793
54.5	2.146	12.3041
55.0	2.165	12.5309
55.5	2.185	12.7597
56.0	2.205	12.9907
56.5	2.224	13.2237
57.0	2.244	13.4588
57.5	2.264	13.6959
58.0	2.283	13.9352
58.5	2.303	14.1764
59.0	2.323	14.4198
59.5	2.343	14.6653
60.0	2.362	14.9128
60.5	2.382	15.1623
61.0	2.402	15.4140

Weight Tables For Rounds (Metric): 61.5 – 83 MM

SIZE (MM)	NOMINAL DECIMAL (INCHES)	LBS. PER FOOT
61.5	2.421	15.6677
62.0	2.441	15.9235
62.5	2.461	16.1814
63.0	2.480	16.4413
63.5	2.500	16.7033
64.0	2.520	16.9674
64.5	2.539	17.2336
65.0	2.559	17.5018
65.5	2.579	17.7721
66.0	2.598	18.0444
66.5	2.618	18.3189
67.0	2.638	18.5954
67.5	2.657	18.8740
68.0	2.677	19.1546
68.5	2.697	19.4373
69.0	2.717	19.7221
69.5	2.736	20.0090
70.0	2.756	20.2979
70.5	2.776	20.5889
71.0	2.795	20.8820
71.5	2.815	21.1772
72.0	2.835	21.4744
72.5	2.854	21.7737
73.0	2.874	22.0750
73.5	2.894	22.3785
74.0	2.913	22.6840
74.5	2.933	22.9915
75.0	2.953	23.3012
75.5	2.972	23.6129
76.0	2.992	23.9267
76.5	3.012	24.2426
77.0	3.031	24.5605
77.5	3.051	24.8805
78.0	3.071	25.2026
78.5	3.091	25.5267
79.0	3.110	25.8529
79.5	3.130	26.1812
80.0	3.150	26.5116
80.5	3.169	26.8440
81.0	3.189	27.1785
81.5	3.209	27.5151
82.0	3.228	27.8537
82.5	3.248	28.1944
83.0	3.268	28.5372

Weight Tables for Rounds (English): 7/32 – 1 3/64

FRACTIONAL SIZE	NOMINAL DECIMAL (INCHES)	LBS. PER FOOT
7/32	0.219	0.1279
15/64	0.234	0.1468
1/4	0.250	0.1670
17/64	0.266	0.1886
9/32	0.281	0.2114
19/64	0.297	0.2356
5/16	0.313	0.2610
21/64	0.328	0.2877
11/32	0.344	0.3158
23/64	0.359	0.3452
3/8	0.375	0.3758
25/64	0.391	0.4078
13/32	0.406	0.4411
27/64	0.422	0.4757
7/16	0.438	0.5115
29/64	0.453	0.5487
15/32	0.469	0.5872
31/64	0.484	0.6270
1/2	0.500	0.6681
33/64	0.516	0.7106
17/32	0.531	0.7543
35/64	0.547	0.7993
9/16	0.563	0.8456
37/64	0.578	0.8933
19/32	0.594	0.9422
39/64	0.609	0.9924
5/8	0.625	1.0440
41/64	0.641	1.0968
21/32	0.656	1.1510
43/64	0.672	1.2064
11/16	0.688	1.2632
43/64	0.672	1.2064
11/16	0.688	1.2632
45/64	0.703	1.3213
23/32	0.719	1.3806
47/64	0.734	1.4413
3/4	0.750	1.5033
49/64	0.766	1.5666
25/32	0.781	1.6312
51/64	0.797	1.6971
13/16	0.813	1.7643
53/64	0.828	1.8328
27/32	0.844	1.9026
55/64	0.859	1.9738
7/8	0.875	2.0462
57/64	0.891	2.1199
29/32	0.906	2.1949
59/64	0.922	2.2713
15/16	0.938	2.3489
61/64	0.953	2.4279
31/32	0.969	2.5081
63/64	0.984	2.5897
1	1.000	2.6725
1 1/64	1.016	2.7567
1 1/32	1.031	2.8422
1 3/64	1.047	2.9290

Weight Tables for Rounds (English): 1 1/16 – 1 57/64

FRACTIONAL SIZE	NOMINAL DECIMAL (INCHES)	LBS. PER FOOT
1 1/16	1.063	3.0170
1 5/64	1.078	3.1065
1 3/32	1.094	3.1971
1 7/64	1.109	3.2892
1 1/8	1.125	3.3824
1 9/64	1.141	3.4771
1 5/32	1.156	3.5729
1 11/64	1.172	3.6702
1 3/16	1.188	3.7687
1 13/64	1.203	3.8686
1 7/32	1.219	3.9697
1 15/64	1.234	4.0721
1 1/4	1.250	4.1758
1 17/64	1.266	4.2809
1 9/32	1.281	4.3872
1 19/64	1.297	4.4949
1 5/16	1.313	4.6039
1 21/64	1.328	4.7142
1 11/32	1.344	4.8257
1 23/64	1.359	4.9386
1 3/8	1.375	5.0528
1 25/64	1.391	5.1683
1 13/32	1.406	5.2850
1 27/64	1.422	5.4032
1 7/16	1.438	5.5225
1 29/64	1.453	5.6433
1 15/32	1.469	5.7653
1 31/64	1.484	5.8886
1 1/2	1.500	6.0132
1 33/64	1.516	6.1392
1 17/32	1.531	6.2664
1 35/64	1.547	6.3949
1 9/16	1.563	6.5247
1 37/64	1.578	6.6559
1 19/32	1.594	6.7883
1 39/64	1.609	6.9221
1 5/8	1.625	7.0572
1 41/64	1.641	7.1936
1 21/32	1.656	7.3312
1 43/64	1.672	7.4702
1 11/16	1.688	7.6105
1 43/64	1.672	7.4702
1 11/16	1.688	7.6105
1 45/64	1.703	7.7521
1 23/32	1.719	7.8949
1 47/64	1.734	8.0392
1 3/4	1.750	8.1846
1 49/64	1.766	8.3315
1 25/32	1.781	8.4796
1 51/64	1.797	8.6290
1 13/16	1.813	8.7797
1 53/64	1.828	8.9318
1 27/32	1.844	9.0850
1 55/64	1.859	9.2397
1 7/8	1.875	9.3956
1 57/64	1.891	9.5529

Weight Tables for Rounds (English): 1 29/32 – 2 47/64

FRACTIONAL SIZE	NOMINAL DECIMAL (INCHES)	LBS. PER FOOT
1 29/32	1.906	9.7114
1 59/64	1.922	9.8713
1 15/16	1.938	10.0324
1 61/64	1.953	10.1950
1 31/32	1.969	10.3587
1 63/64	1.984	10.5238
2	2.000	10.6901
2 1/64	2.016	10.8579
2 1/32	2.031	11.0268
2 3/64	2.047	11.1972
2 1/16	2.063	11.3687
2 5/64	2.078	11.5417
2 3/32	2.094	11.7158
2 7/64	2.109	11.8914
2 1/8	2.125	12.0682
2 9/64	2.141	12.2463
2 5/32	2.156	12.4257
2 11/64	2.172	12.6065
2 3/16	2.188	12.7885
2 13/64	2.203	12.9719
2 7/32	2.219	13.1565
2 15/64	2.234	13.3425
2 1/4	2.250	13.5297
2 17/64	2.266	13.7183
2 9/32	2.281	13.9081
2 19/64	2.297	14.0994
2 5/16	2.313	14.2918
2 21/64	2.328	14.4856
2 11/32	2.344	14.6807
2 23/64	2.359	14.8771
2 3/8	2.375	15.0748
2 25/64	2.391	15.2738
2 13/32	2.406	15.4741
2 27/64	2.422	15.6758
2 7/16	2.438	15.8786
2 29/64	2.453	16.0829
2 15/32	2.469	16.2884
2 31/64	2.484	16.4953
2 1/2	2.500	16.7033
2 33/64	2.516	16.9128
2 17/32	2.531	17.1235
2 35/64	2.547	17.3356
2 9/16	2.563	17.5489
2 37/64	2.578	17.7637
2 19/32	2.594	17.9796
2 39/64	2.609	18.1969
2 5/8	2.625	18.4154
2 41/64	2.641	18.6354
2 21/32	2.656	18.8565
2 43/64	2.672	19.0791
2 11/16	2.688	19.3028
2 43/64	2.672	19.0791
2 11/16	2.688	19.3028
2 45/64	2.703	19.5280
2 23/32	2.719	19.7543
2 47/64	2.734	19.9821

Weight Tables for Rounds (English): 2 3/4 – 3 1/4

FRACTIONAL SIZE	NOMINAL DECIMAL (INCHES)	LBS. PER FOOT
2 3/4	2.750	20.2110
2 49/64	2.766	20.4414
2 25/32	2.781	20.6730
2 51/64	2.797	20.9060
2 13/16	2.813	21.1402
2 53/64	2.828	21.3758
2 27/32	2.844	21.6125
2 55/64	2.859	21.8508
2 7/8	2.875	22.0902
2 57/64	2.891	22.3310
2 29/32	2.906	22.5730
2 59/64	2.922	22.8164
2 15/16	2.938	23.0610
2 61/64	2.953	23.3071
2 31/32	2.969	23.5543
2 63/64	2.984	23.8030
3	3.000	24.0528
3 1/64	3.016	24.3041
3 1/32	3.031	24.5565
3 3/64	3.047	24.8104
3 1/16	3.063	25.0654
3 5/64	3.078	25.3219
3 3/32	3.094	25.5796
3 7/64	3.109	25.8387
3 1/8	3.125	26.0990
3 9/64	3.141	26.3607
3 5/32	3.156	26.6235
3 11/64	3.172	26.8879
3 3/16	3.188	27.1534
3 13/64	3.203	27.4203
3 7/32	3.219	27.6884
3 15/64	3.234	27.9579
3 1/4	3.250	28.2286

Common Consensus Standards & Specifications

SPECIFICATION	TYPE	TITLE	COMMENTS
AMS 2301	Test Method	Steel Cleanliness, Aircraft Quality Magnetic Particle Inspection Procedure	Used for AQ
ASTM A29	Material	Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought	
ASTM A108	Material	Standard Specification for Steel Bar, Carbon & Alloy, Cold Finished	Typically supplied as CFQ as opposed to CHQ (or RHQ). Higher sulfur, not intended for cold heading
ASTM A255	Test Method	Standard Test Methods for Determining Hardenability of Steel	Typically used by the steel producer
ASTM A304	Material	Standard Specification for Carbon and Alloy Steel Bars Subject to End-Quench Hardenability Requirements	H-Band steels
ASTM A322	Material	Standard Specification for Steel Bars, Alloy, Standard Grades	
ASTM A370	Test Method	Standard Test Methods & Definitions for Mechanical Testing of Steel Products	
ASTM A534	Test Method	Standard Specification for Carburizing Steels for Anti-Friction Bearings	Used for BQ
ASTM F568/568M	Material	Carbon and Alloy Steel Externally Threaded Fasteners	Fastener specific
ASTM A574	Material	Standard Specification for Alloy Steel Socket-Head Cap Screws	Fastener specific
ASTM A576	Material	Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality	
ASTM A892	Test Method	Standard Guide for Defining and Rating the Microstructure of High Carbon Bearing Steels	Used for BQ

Common Consensus Standards & Specifications

SPECIFICATION	TYPE	TITLE	COMMENTS
ASTM E3	Test Method	Standard Guide for Preparation of Metallic Specimens	
ASTM E8/E8M	Test Method	Standard Test Methods for Tension Testing of Metallic Materials	
ASTM E10	Test Method	Standard Test Method for Brinell Hardness of Metallic Materials	
ASTM E18	Test Method	Standard Test Methods for Rockwell Hardness of Metallic Materials	
ASTM E45	Test Method	Standard Test Methods for Determining the Inclusion Content of Steel	Typically used by the steel producer
ASTM E112	Test Method	Standard Test Methods for Determining Average Grain Size	Typically used by the steel producer
ASTM E381	Test Method	Standard Method of Macroetch Testing Steel Bars, Billets, Blooms, & Forgings	Typically used by the steel producer
ASTM E384	Test Method	Standard Test Method for Microindentation Hardness of Materials	
ASTM E415	Test Method	Standard Test Method for Analysis of Carbon and Low-Alloy Steel by Spark Atomic Emission Spectrometry	Typically used by the steel producer
ASTM E1019	Test Method	Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Inert Gas Fusion Techniques	Typically used by the steel producer
ASTM E1077	Test Method	Standard Test Methods for Estimating the Depth of Decarburization of Steel Specimens	
ASTM E1268	Test Method	Standard Practice for Assessing the Degree of Banding or Orientation of Microstructures	

Common Consensus Standards & Specifications

SPECIFICATION	TYPE	TITLE	COMMENTS
ASTM E2283	Test Method	Standard Practice for Extreme Value Analysis of Nonmetallic Inclusions in Steel and Other Microstructural Features	
ASTM F606/606M	Test Method	Standard Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets	Fastener specific
ASTM F1554	Material	Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength	Fastener specific
ASTM F2282	Material	Standard Specification for Quality Assurance Requirements for Carbon and Alloy Steel Wire, Rods, and Bars for Mechanical Fasteners	Fastener specific
ASTM F3125/ F3125M	Material	Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength	Fastener specific. Consolidates and replaces six ASTM standards, including; A325, A325M, A490, A490M, F1852 and F2280.
DIN 50602	Test Method	Microscopic examination of special steels using standard diagrams to assess the content of non-metallic inclusions	Typically used by the steel producer
DIN EN 10263-1	Material	Steel Rod, Bars and Wire for Cold Heading and Cold Extrusion	General delivery conditions
DIN EN 10263-2	Material	Steel Rod, Bars and Wire for Cold Heading and Cold Extrusion	Without subsequent heat treat
DIN EN 10263-3	Material	Steel Rod, Bars and Wire for Cold Heading and Cold Extrusion	With case hardening heat treat
DIN EN 10263-4	Material	Steel Rod, Bars and Wire for Cold Heading and Cold Extrusion	With quench & temper heat treat

Common Consensus Standards & Specifications

SPECIFICATION	TYPE	TITLE	COMMENTS
ISO 683-1	Material	Heat-Treatable Steels, Alloy Steels and Free-Cutting Steels	Non-Alloy Steels for Quenching and Tempering
ISO 683-2	Material	Heat-Treatable Steels, Alloy Steels and Free-Cutting Steels	Alloy Steels for Quenching and Tempering
ISO 683-3	Material	Heat-Treatable Steels, Alloy Steels and Free-Cutting Steels	Case-Hardening Steels
ISO 683-4	Material	Heat-Treatable Steels, Alloy Steels and Free-Cutting Steels	Free-Cutting Steels
ISO 683-14	Material	Heat-Treatable Steels, Alloy Steels and Free-Cutting Steels	Hot-Rolled Steels for Quenched and Tempered Springs
ISO 683-17	Material	Heat-Treatable Steels, Alloy Steels and Free-Cutting Steels	Ball and Roller Bearing Steels
ISO 898-1	Material	Mechanical Properties of Fasteners Made from Carbon Steel and Alloy Steel	Fastener specific
ISO 4967	Test Method	Steel - Determination of Content of Nonmetallic Inclusions - Micrographic Method Using Standard Diagrams	Typically used by the steel producer
ISO 16574	Test Method	Determination of Percentage of Resolvable Pearlite in the High Carbon Steel Wire Rod	
JIS G 3505	Material	Low Carbon Steel Wire Rods	
JIS G 3506	Material	High Carbon Steel Wire Rods	
JIS G 3507	Material	Carbon Steels for Cold Heading	
JIS G 3508	Material	Boron Steels for Cold Heading	
JIS G 4051	Material	Carbon Steels for Machine Structural Use	
JIS G 4052	Material	Structural Steels with Specified Hardenability Bands	
JIS G 4053	Material	Low-Alloyed Steels for Machine Structural Use	

Common Consensus Standards & Specifications

SPECIFICATION	TYPE	TITLE	COMMENTS
JIS G 4102	Material	Nickel Chromium Steels	
JIS G 4103	Material	Nickel Chromium Molybdenum Steels	
JIS G 4104	Material	Chromium Steels	
JIS G 4105	Material	Chromium Molybdenum Steels	
JIS G 4106	Material	Manganese and Manganese Chromium Steels	
JIS G 4202	Material	Aluminium Chromium Molybdenum Steels	
SAE J121/ J121M	Test Method	Decarburization in Hardened and Tempered Threaded Fasteners	Fastener specific
SAE J403	Material	Chemical Compositions of SAE Carbon Steels	
SAE J404	Material	Chemical Compositions of SAE Alloy Steels	
SAE J406	Test Method	Methods for Determining Hardenability of Steels	Typically used by the steel producer
SAE J419	Test Method	Methods of Measuring Decarburization	
SAE J422	Test Method	Microscopic Determination of Inclusions in Steels	
SAE J429	Material	Mechanical and Material Requirements for Externally Threaded Fasteners	Fastener specific
SAE J1199	Material	Mechanical and Material Requirements for Metric Externally Threaded Steel Fasteners	Fastener specific
SAE J1268	Material	Hardenability Bands for Carbon and Alloy H Steels	H-Band steels
SAE/USCAR-8	Test Method	Grain Flow Pattern for Bolts, Screws, and Studs	Fastener specific
SEP 1520	Test Method	Microscopic Examination of Carbide Structure in Steels by Means of Diagram Series	

Reduction Ratios (Metric): 5.5 – 35 MM

ROD/BAR SIZE (MM)	NOMINAL DECIMAL (INCHES)	7" X 7" (Cleveland)	5.5" x 5.5" (Saukville)
5.5	0.217	1331:1	821:1
6.0	0.236	1118:1	690:1
6.5	0.256	953:1	588:1
7.0	0.276	821:1	507:1
7.5	0.295	716:1	442:1
8.0	0.315	629:1	388:1
8.5	0.335	557:1	344:1
9.0	0.354	497:1	307:1
9.5	0.374	446:1	275:1
10.0	0.394	403:1	248:1
10.5	0.413	365:1	225:1
11.0	0.433	333:1	205:1
11.5	0.453	304:1	188:1
12.0	0.472	280:1	173:1
12.5	0.492	258:1	159:1
13.0	0.512	238:1	147:1
13.5	0.531	221:1	136:1
14.0	0.551	205:1	127:1
14.5	0.571	191:1	118:1
15.0	0.591	179:1	110:1
15.5	0.610	168:1	103:1
16.0	0.630	157:1	97:1
16.5	0.650	148:1	91:1
17.0	0.669	139:1	86:1
17.5	0.689	131:1	81:1
18.0	0.709	124:1	77:1
18.5	0.728	118:1	73:1
19.0	0.748	111:1	69:1
19.5	0.768	106:1	65:1
20.0	0.787	101:1	62:1
20.5	0.807	96:1	59:1
21.0	0.827	91:1	56:1
21.5	0.846	87:1	54:1
22.0	0.866	83:1	51:1
22.5	0.886	80:1	49:1
23.0	0.906	76:1	47:1
23.5	0.925	73:1	45:1
24.0	0.945	70:1	43:1
24.5	0.965	67:1	41:1
25.0	0.984	64:1	40:1
25.5	1.004	62:1	38:1
26.0	1.024	60:1	37:1
26.5	1.043	57:1	35:1
27.0	1.063	55:1	34:1
27.5	1.083	53:1	33:1
28.0	1.102	51:1	32:1
28.5	1.122	50:1	31:1
29.0	1.142	48:1	30:1
29.5	1.161	46:1	29:1
30.0	1.181	45:1	28:1
30.5	1.201	43:1	27:1
31.0	1.220	42:1	26:1
31.5	1.240	41:1	25:1
32.0	1.260	39:1	24:1
32.5	1.280	38:1	24:1
33.0	1.299	37:1	23:1
33.5	1.319	36:1	22:1
34.0	1.339	35:1	21:1
34.5	1.358	34:1	21:1
35.0	1.378	33:1	20:1

Reduction Ratios (Metric): 35.5 – 65 MM

ROD/BAR SIZE (MM)	NOMINAL DECIMAL (INCHES)	7" X 7" (Cleveland)	5.5" x 5.5" (Saukville)
35.5	1.398	32:1	20:1
36.0	1.417	31:1	19:1
36.5	1.437	30:1	19:1
37.0	1.457	29:1	18:1
37.5	1.476	29:1	18:1
38.0	1.496	28:1	17:1
38.5	1.516	27:1	17:1
39.0	1.535	26:1	16:1
39.5	1.555	26:1	16:1
40.0	1.575	25:1	16:1
40.5	1.594	25:1	15:1
41.0	1.614	24:1	15:1
41.5	1.634	23:1	14:1
42.0	1.654	23:1	14:1
42.5	1.673	22:1	14:1
43.0	1.693	22:1	13:1
43.5	1.713	21:1	13:1
44.0	1.732	21:1	13:1
44.5	1.752	20:1	13:1
45.0	1.772	20:1	12:1
45.5	1.791	19:1	12:1
46.0	1.811	19:1	12:1
46.5	1.831	19:1	11:1
47.0	1.850	18:1	11:1
47.5	1.870	18:1	11:1
48.0	1.890	17:1	11:1
48.5	1.909	17:1	11:1
49.0	1.929	17:1	10:1
49.5	1.949	16:1	10:1
50.0	1.969	16:1	10:1
50.5	1.988	16:1	10:1
51.0	2.008	15:1	10:1
51.5	2.028	15:1	9:1
52.0	2.047	15:1	9:1
52.5	2.067	15:1	9:1
53.0	2.087	14:1	9:1
53.5	2.106	14:1	9:1
54.0	2.126	14:1	9:1
54.5	2.146	14:1	8:1
55.0	2.165	13:1	8:1
55.5	2.185	13:1	8:1
56.0	2.205	13:1	8:1
56.5	2.224	13:1	8:1
57.0	2.244	12:1	8:1
57.5	2.264	12:1	8:1
58.0	2.283	12:1	7:1
58.5	2.303	12:1	7:1
59.0	2.323	12:1	7:1
59.5	2.343	11:1	7:1
60.0	2.362	11:1	7:1
60.5	2.382	11:1	7:1
61.0	2.402	11:1	7:1
61.5	2.421	11:1	7:1
62.0	2.441	10:1	6:1
62.5	2.461	10:1	6:1
63.0	2.480	10:1	6:1
63.5	2.500	10:1	6:1
64.0	2.520	10:1	6:1
64.5	2.539	10:1	6:1
65.0	2.559	10:1	6:1

Reduction Ratios (Metric): 65.5 – 83 MM

ROD/BAR SIZE (MM)	NOMINAL DECIMAL (INCHES)	7" X 7" (Cleveland)	5.5" x 5.5" (Saukville)
65.5	2.579	9:1	6:1
66.0	2.598	9:1	6:1
66.5	2.618	9:1	6:1
67.0	2.638	9:1	6:1
67.5	2.657	9:1	5:1
68.0	2.677	9:1	5:1
68.5	2.697	9:1	5:1
69.0	2.717	8:1	5:1
69.5	2.736	8:1	5:1
70.0	2.756	8:1	5:1
70.5	2.776	8:1	5:1
71.0	2.795	8:1	5:1
71.5	2.815	8:1	5:1
72.0	2.835	8:1	5:1
72.5	2.854	8:1	5:1
73.0	2.874	8:1	5:1
73.5	2.894	7:1	5:1
74.0	2.913	7:1	5:1
74.5	2.933	7:1	4:1
75.0	2.953	7:1	4:1
75.5	2.972	7:1	4:1
76.0	2.992	7:1	4:1
76.5	3.012	7:1	4:1
77.0	3.031	7:1	4:1
77.5	3.051	7:1	4:1
78.0	3.071	7:1	4:1
78.5	3.091	7:1	4:1
79.0	3.110	6:1	4:1
79.5	3.130	6:1	4:1
80.0	3.150	6:1	4:1
80.5	3.169	6:1	4:1
81.0	3.189	6:1	4:1
81.5	3.209	6:1	4:1
82.0	3.228	6:1	4:1
82.5	3.248	6:1	4:1
83.0	3.268	6:1	4:1

Reduction Ratios (English): 7/32 – 1 7/64

FRACTIONAL SIZE	NOMINAL DECIMAL (INCHES)	7" X 7" (Cleveland)	5.5" x 5.5" (Saukville)
7/32	0.219	1304:1	805:1
15/64	0.234	1136:1	701:1
1/4	0.250	998:1	616:1
17/64	0.266	884:1	546:1
9/32	0.281	789:1	487:1
19/64	0.297	708:1	437:1
5/16	0.313	639:1	394:1
21/64	0.328	579:1	358:1
11/32	0.344	528:1	326:1
23/64	0.359	483:1	298:1
3/8	0.375	444:1	274:1
25/64	0.391	409:1	252:1
13/32	0.406	378:1	233:1
27/64	0.422	351:1	216:1
7/16	0.438	326:1	201:1
29/64	0.453	304:1	188:1
15/32	0.469	284:1	175:1
31/64	0.484	266:1	164:1
1/2	0.500	250:1	154:1
33/64	0.516	235:1	145:1
17/32	0.531	221:1	136:1
35/64	0.547	209:1	129:1
9/16	0.563	197:1	122:1
37/64	0.578	187:1	115:1
19/32	0.594	177:1	109:1
39/64	0.609	168:1	104:1
5/8	0.625	160:1	99:1
41/64	0.641	152:1	94:1
21/32	0.656	145:1	89:1
43/64	0.672	138:1	85:1
11/16	0.688	132:1	81:1
43/64	0.672	138:1	85:1
11/16	0.688	132:1	81:1
45/64	0.703	126:1	78:1
23/32	0.719	121:1	75:1
47/64	0.734	116:1	71:1
3/4	0.750	111:1	68:1
49/64	0.766	106:1	66:1
25/32	0.781	102:1	63:1
51/64	0.797	98:1	61:1
13/16	0.813	95:1	58:1
53/64	0.828	91:1	56:1
27/32	0.844	88:1	54:1
55/64	0.859	84:1	52:1
7/8	0.875	81:1	50:1
57/64	0.891	79:1	49:1
29/32	0.906	76:1	47:1
59/64	0.922	73:1	45:1
15/16	0.938	71:1	44:1
61/64	0.953	69:1	42:1
31/32	0.969	66:1	41:1
63/64	0.984	64:1	40:1
1	1.000	62:1	39:1
1 1/64	1.016	60:1	37:1
1 1/32	1.031	59:1	36:1
1 3/64	1.047	57:1	35:1
1 1/16	1.063	55:1	34:1
1 5/64	1.078	54:1	33:1
1 3/32	1.094	52:1	32:1
1 7/64	1.109	51:1	31:1

Reduction Ratios (English): 1 1/8 – 2 7/64

FRACTIONAL SIZE	NOMINAL DECIMAL (INCHES)	7" X 7" (Cleveland)	5.5" x 5.5" (Saukville)
1 1/8	1.125	49:1	30:1
1 9/64	1.141	48:1	30:1
1 5/32	1.156	47:1	29:1
1 11/64	1.172	45:1	28:1
1 3/16	1.188	44:1	27:1
1 13/64	1.203	43:1	27:1
1 7/32	1.219	42:1	26:1
1 15/64	1.234	41:1	25:1
1 1/4	1.250	40:1	25:1
1 17/64	1.266	39:1	24:1
1 9/32	1.281	38:1	23:1
1 19/64	1.297	37:1	23:1
1 5/16	1.313	36:1	22:1
1 21/64	1.328	35:1	22:1
1 11/32	1.344	35:1	21:1
1 23/64	1.359	34:1	21:1
1 3/8	1.375	33:1	20:1
1 25/64	1.391	32:1	20:1
1 13/32	1.406	32:1	19:1
1 27/64	1.422	31:1	19:1
1 7/16	1.438	30:1	19:1
1 29/64	1.453	30:1	18:1
1 15/32	1.469	29:1	18:1
1 31/64	1.484	28:1	17:1
1 1/2	1.500	28:1	17:1
1 33/64	1.516	27:1	17:1
1 17/32	1.531	27:1	16:1
1 35/64	1.547	26:1	16:1
1 9/16	1.563	26:1	16:1
1 37/64	1.578	25:1	15:1
1 19/32	1.594	25:1	15:1
1 39/64	1.609	24:1	15:1
1 5/8	1.625	24:1	15:1
1 41/64	1.641	23:1	14:1
1 21/32	1.656	23:1	14:1
1 43/64	1.672	22:1	14:1
1 11/16	1.688	22:1	14:1
1 43/64	1.672	22:1	14:1
1 11/16	1.688	22:1	14:1
1 45/64	1.703	22:1	13:1
1 23/32	1.719	21:1	13:1
1 47/64	1.734	21:1	13:1
1 3/4	1.750	20:1	13:1
1 49/64	1.766	20:1	12:1
1 25/32	1.781	20:1	12:1
1 51/64	1.797	19:1	12:1
1 13/16	1.813	19:1	12:1
1 53/64	1.828	19:1	12:1
1 27/32	1.844	18:1	11:1
1 55/64	1.859	18:1	11:1
1 7/8	1.875	18:1	11:1
1 57/64	1.891	17:1	11:1
1 29/32	1.906	17:1	11:1
1 59/64	1.922	17:1	10:1
1 15/16	1.938	17:1	10:1
1 61/64	1.953	16:1	10:1
1 31/32	1.969	16:1	10:1
1 63/64	1.984	16:1	10:1
2	2.000	16:1	10:1
2 1/64	2.016	15:1	9:1

Reduction Ratios (English): 2 59/64 – 2 41/64

FRACTIONAL SIZE	NOMINAL DECIMAL (INCHES)	7" X 7" (Cleveland)	5.5" x 5.5" (Saukville)
2 1/32	2.031	15:1	9:1
2 3/64	2.047	15:1	9:1
2 1/16	2.063	15:1	9:1
2 5/64	2.078	14:1	9:1
2 3/32	2.094	14:1	9:1
2 7/64	2.109	14:1	9:1
2 1/8	2.125	14:1	9:1
2 9/64	2.141	14:1	8:1
2 5/32	2.156	13:1	8:1
2 11/64	2.172	13:1	8:1
2 3/16	2.188	13:1	8:1
2 13/64	2.203	13:1	8:1
2 7/32	2.219	13:1	8:1
2 15/64	2.234	12:1	8:1
2 1/4	2.250	12:1	8:1
2 17/64	2.266	12:1	8:1
2 9/32	2.281	12:1	7:1
2 19/64	2.297	12:1	7:1
2 5/16	2.313	12:1	7:1
2 21/64	2.328	12:1	7:1
2 11/32	2.344	11:1	7:1
2 23/64	2.359	11:1	7:1
2 3/8	2.375	11:1	7:1
2 25/64	2.391	11:1	7:1
2 13/32	2.406	11:1	7:1
2 27/64	2.422	11:1	7:1
2 7/16	2.438	11:1	6:1
2 29/64	2.453	10:1	6:1
2 15/32	2.469	10:1	6:1
2 31/64	2.484	10:1	6:1
2 1/2	2.500	10:1	6:1
2 33/64	2.516	10:1	6:1
2 17/32	2.531	10:1	6:1
2 35/64	2.547	10:1	6:1
2 9/16	2.563	10:1	6:1
2 37/64	2.578	9:1	6:1
2 19/32	2.594	9:1	6:1
2 39/64	2.609	9:1	6:1
2 5/8	2.625	9:1	6:1
2 41/64	2.641	9:1	6:1
2 21/32	2.656	9:1	5:1
2 43/64	2.672	9:1	5:1
2 11/16	2.688	9:1	5:1
2 43/64	2.672	9:1	5:1
2 11/16	2.688	9:1	5:1
2 45/64	2.703	9:1	5:1
2 23/32	2.719	8:1	5:1
2 47/64	2.734	8:1	5:1
2 3/4	2.750	8:1	5:1
2 49/64	2.766	8:1	5:1
2 25/32	2.781	8:1	5:1
2 51/64	2.797	8:1	5:1
2 13/16	2.813	8:1	5:1
2 53/64	2.828	8:1	5:1
2 27/32	2.844	8:1	5:1
2 55/64	2.859	8:1	5:1
2 7/8	2.875	8:1	5:1
2 57/64	2.891	7:1	5:1
2 29/32	2.906	7:1	5:1
2 59/64	2.922	7:1	5:1

Reduction Ratios (English): 2 15/16 – 3 1/4

FRACTIONAL SIZE	NOMINAL DECIMAL (INCHES)	7" X 7" (Cleveland)	5.5" x 5.5" (Saukville)
2 15/16	2.938	7:1	4:1
2 61/64	2.953	7:1	4:1
2 31/32	2.969	7:1	4:1
2 63/64	2.984	7:1	4:1
3	3.000	7:1	4:1
3 1/64	3.016	7:1	4:1
3 1/32	3.031	7:1	4:1
3 3/64	3.047	7:1	4:1
3 1/16	3.063	7:1	4:1
3 5/64	3.078	7:1	4:1
3 3/32	3.094	7:1	4:1
3 7/64	3.109	6:1	4:1
3 1/8	3.125	6:1	4:1
3 9/64	3.141	6:1	4:1
3 5/32	3.156	6:1	4:1
3 11/64	3.172	6:1	4:1
3 3/16	3.188	6:1	4:1
3 13/64	3.203	6:1	4:1
3 7/32	3.219	6:1	4:1
3 15/64	3.234	6:1	4:1
3 1/4	3.250	6:1	4:1

GLOSSARY

Role of Alloying Elements

Aluminum (Al): Used to deoxidize steel and control grain size. Grain size control is effected by forming a fine dispersion with nitrogen and oxygen which restricts austenite grain growth. Aluminum is also an extremely effective nitride former in nitriding steels.

Boron (B): Usually added between 0.0005-0.003% to significantly increase the hardenability, especially for low carbon alloys. It does not affect the strength of ferrite, and therefore not sacrificing ductility, formability or machinability in the annealed state.

Calcium (Ca): Used in certain steels to control the shape, size and distribution of oxide and/or sulfide inclusions. Benefits may include improved ductility, impact strength and/or machinability.

Carbon (C): The most important alloying element, which is essential for the formation of cementite, pearlite, spheriodite, bainite, and iron-carbon martensite. Compared to steels with similar microstructures, strength, hardness, hardenability, and ductile-to-brittle transition temperature are increased with increasing carbon content up to approximately 0.60%. Toughness and ductility of pearlite steels are decreased with increasing carbon content.

Chromium (Cr): Used in alloy steels to increase 1) resistance to corrosion and oxidation, 2) high temperature strength, 3) hardenability, and 4) abrasion resistance in high carbon alloys. Straight chromium steels are susceptible to temper embrittlement and can be brittle.

Copper (Cu): Detrimental to hot workability and subsequent surface quality. It is used in certain steels to improve resistance to atmospheric corrosion.

Lead (Pb): Improves machinability. It does not dissolve in the steel but stays as globules. Environmental concerns are resulting in a decreased usage of lead in the steel industry.

Manganese (Mn): An important alloying element because it deoxidizes the melt and facilitates hot working of the steel by reducing the susceptibility to hot shortness. It combines with sulfur to form MnS stringers which increase machinability. Manganese contributes to the effectiveness of normalizing for strengthening, to the formation of fine pearlite, and lowers the Ms tempurature, therefore increasing the porbability of retained austentite.

Molybdenum (Mo): Increases hardenability of steels and helps maintain a specified hardenability. It increases high temperature tensile and creep strengths. Molybdenum-hardened steels require higher tempering temperatures for softening purposes.

Nickel (Ni): Used in low-alloy steels to reduce the sensitivity of the steel to variations in heat treatment and distortion and cracking on quenching. It also improves low temperature toughness and hardenability.

Niobium (Nb)/ Columbium (Cb): Lowers transition temperature and raises the strength of low-carbon steel. Niobium increases strength at elevated temperatures, results in finer grain size and forms stable carbides, lowering the hardenability of the steel.

Role of Alloying Elements

Nitrogen (N): Increases the strength, hardness, and machinability of steel, but it decreases the ductility and toughness. In aluminum-killed steels, nitrogen combines with the aluminum to provide grain size control. Nitrogen can reduce the effect of boron on the hardenability of steels.

Phosphorus (P): Generally restricted to below 0.04 weight percent to minimize its detrimental effect on ductility and toughness. Certain steels may contain higher levels to enhance machinability, strength, and/or atmospheric corrosion resistance.

Silicon (Si): One of the principal deoxidizers with the amount used dependent on the deoxidization practice. It slightly increases the strength of ferrite without a serious loss of ductility. In larger quantities, it aids the resistance to scaling up to 500°F in air and decreases magnetic hysteresis loss.

Sulfur (S): Detrimental to transverse strength and impact resistance. It affects longitudinal properties to a lesser degree. Existing primarily in the form of manganese sulfide stringers, sulfur is typically added to improve machinability.

Titanium (Ti): Added to boron steels because it combines with oxygen and nitrogen, thus increasing the effectiveness of boron. Titanium, as titanium carbide, also provides grain size control at elevated temperatures in micro-alloy steels. In excess, titanium is detrimental to machinability and internal cleanness.

Tellurium (Te): Added to steel to modify sulfide-type inclusion size, morphology, and distribution. The resulting sulfide-type inclusions are finer and remain ellipsoidal in shape following hot working, thereby improving transverse properties.

Vandium (V): Inhibits grain growth during heat-treating while improving strength and toughness of hardened and tempered steels. Additions up to 0.05% increase hardenability, whereas larger amounts tend to reduce hardenability because of carbide formation. Vanadium is also utilized in ferrite/pearlite micro-alloy steels to increase hardness through carbonitride precipitation strengthening of the matrix.

Metallurgical Terms: A – Ca

Alloy Steel
Steel with > 1.65% manganese or a definite minimum quantity for any of the following elements is specified: chromium, molybdenum, nickel, or any other alloying element added to obtain a desired alloying effect.

Annealing
General term applied to a variety of thermal treatments for the purpose of softening or homogenizing material properties. There are several specific types of annealing.

Austenite
The face-centered cubic (FCC) crystal structure of iron that is stable at high temperatures (>≈1340 °F). Austenite is non-magnetic and can dissolve more carbon than ferrite.

Austenitizing
The heating of steel above critical temperature to allow the mircostructure to transform to austenite. The final microstructure is dependent upon the cooling rate.

Bar
A solid rolled or forged section of steel that is long in relationship to its cross-sectional dimensions with a relatively constant cross-section throughout its length.

Billet
A solid semifinished round or square that has been hot worked, usually smaller than a bloom. Also a general term for wrought starting stock for forgings or extrusions.

Bloom
A semifinished hot rolled rectangular product. The width of the bloom is no more than twice its thickness and the cross-sectional area is usually ≥ 36 square inches.

Brinell Hardness
A type of indentation hardness test using a large steel or carbide ball and a known force. Hardness values (HB or HBW) are calculated from the diameter of the depression left in the workpiece (see ASTM E10).

Carbon Steel
Steel containing carbon typically ≤ 1.0% and only residual amounts of other alloying elements except those added for composition control/ deoxidation (silicon usually limited to 0.60% and manganese to 1.65% maximum).

Carburization
A process where carbon diffuses into the steel surface, creating a higher carbon level at the surface as compared to the core.

Case Hardening
A heat treat process where carbon diffuses into the steel surface intentionally, producing a surface hardness substantially higher than its core. This can provide a hard, wear-resistant surface while retaining a softer, tougher core. There are several specific types of case hardening.

Metallurgical Terms: Ce – F

Cementite (carbide)
A very hard, brittle compound of iron, also known as iron carbide and present in cast iron and most steels.

Coarse Grain
An austenitic grain size generally < 5 per ASTM E112.

Coarse Grain Practice
Does not involve deoxidation for grain size control and therefore, grain size limits are not applicable.

Decarburization (Decarb)
The loss of carbon at the surface of the steel due to interraction with the atmosphere during heat treatment (ref. ASTM E1077 and/or SAE J419). Complete decarburization (free ferrite) is characterized by a loss of carbon sufficient to show only clearly defined ferrite grains. Partial decarburization is characterized by a loss of carbon sufficient to cause a lighter shade of tempered martensite than the immediately adjacent base metal, but insufficient carbon loss to show clearly defined ferrite grains.

DI (Ideal Diameter)
DI is an alternate method for predicting hardenability. It represents the maximum theoretical bar diameter that will harden at the center with at least 50% martensite when subjected to an "ideal" quench.

DRI (Direct Reduced Iron)
DRI is a high-quality, ore-based metallic raw material used in various steelmaking processes and is produced by removing oxygen from iron ore using a reducing gas, without melting the iron.

Ductility
The property of a metal that enables it to stretch/deform before fracturing. It may be thought of as the opposite of brittleness.

Eddy Current Testing (EC)
A non-destructive test (NDT) method that uses electromagnetic induction to detect flaws and assess material properties in conductive materials.

Elongation
In tensile testing, the increase in gage length (measured after the fracture of a specimen), expressed as a percentage of the original gage length.

End Quench Hardenability (Jominy) Test
A standardized test used to determine a steel's ability to be hardened at varying depths below the surface when quenched from a specified temperature (see ASTM A255).

Ferrite
The body-centered cubic (BCC) crystal structure of iron that is stable at low temperatures (<≈1340 °F). Ferrite is magnetic and can dissolve less carbon than austenite.

Fine Grain
An austenitic grain size generally ≥ 5 per ASTM E112.

Free Ferrite
Ferrite grains in steel containing no carbide (cementite) precipitates.

Metallurgical Terms: G – In

Grain Growth (Blown Grains)
The increase in size of individual grains when the steel is heated to high temperatures. Typically based on a combination of prior cold work and time/temperature upon heating.

Grain Size
An expression that rates the number of grains per unit area of cross-section (ref. ASTM E112). Typically performed by metallographic examination or automated image analysis.

Green Rod
As-hot rolled steel that has not been processed in any way.

Hardenability
A steel's ability to transform into martensite at a given depth below the surface when quenched from above the transformation temperature range.

Hardening (Quench & Temper)
Hardening steel by heating in a furnace to a temperature within or above the critical range followed by quenching. This is a longer process as compared to induction hardening, but uses a controlled atmosphere. Common furnace types include continuous, batch and vacuum.

Hardness
A measure of a material's ability to resist plastic deformation by indentation, abrasion or both. Commonly used measurement methods are Rockwell (ASTM E18), Microhardness (ASTM E384) and Brinell (ASTM E10).

HBI (Hot Briquetted Iron)
HBI is a low residual, low nitrogen iron source made from iron ore. A compacted form of Direct Reduced Iron (DRI).

Heat Treating
Any process where the steel is heated to specific times and temperatures to change the physical or mechanical properties.

Hot Rolled
Product rolled at elevated temperatures which provides a layer of scale (iron oxide) on the surface.

Impact Strength (Toughness)
A measure of toughness often referred to as impact energy. It is the amount of energy required to fracture a steel specimen.

Impact Test
A pendulum-type test to determine the behavior of metals when subjected to high loading rates. The two types used are Charpy (specimen supported at both ends) and Izod (specimen supported at one end). See ASTM E23.

Inclusion (Non-Metallic Inclusion)
Inclusions in steel are non-metallic compounds, like oxides or sulfides, that become trapped within the steel matrix during solidification. Indigenous (endogenous) inclusions are a direct by-product of steelmaking processes (e.g. manganese sulfide), while exogenous inclusions are foreign material (e.g. slag or refractories) that is entrained into the liquid steel during casting.

Induction Hardening
Hardening steel by heating rapidly with an induced electric current to a temperature within or above the critical range, followed by quenching. The steel is heated for only a short time and there is no atmosphere control.

Metallurgical Terms: In – M

Ingot
A casting of a simple shape which can be used for hot working or re-rolling into blooms or billets.

Killed Steel
Steel treated with a strong deoxidizer (typically aluminum or silicon) to reduce oxygen to a level where no reaction occurs between carbon and oxygen during solidification.

Lap
A linear-type surface imperfection caused by the folding over of hot metal, fins or sharp corners and then rolling or forging them into the surface, but not welding them.

Lamellar Pearlite or LP Annealing (Full Annealing)
Heating the steel above its critical temperature (Ac3), holding it at that temperature, then slowly cooling it to promote the formation of a lamellar pearlitic microstructure. This process is typically used when enhanced machinability is required.

Macroetch
A test procedure used to evaluate conditions such as porosity, inclusions, segregations, carburizations and flow lines form hot or cold working. After applying a suitable etching solution to the polished metal surface, the structure revealed by the action of the reagent can be observed visually.

Magnetic Flux Leakage Testing (MFLT)
A non-destructive testing (NDT) method used to detect surface defects in steel.

Magnetic Particle Testing
A non-destructive testing (NDT) method used to detect surface and near-surface flaws in steel by inducing a magnetic field in the material and then applying magnetic particles to the surface. If there's a flaw, the magnetic field is disrupted, causing the particles to accumulate and form a visible indication.

Martensite
A steel structure that occurs when the steel is cooled rapidly (quenched) from high temperatures, usually by oil or water. Martensite is very hard and brittle in the un-tempered condition, but becomes strong and tough after tempering.

Mechanical Properties
These describe how steel behaves under applied forces, encompassing characteristics such as hardness, tensile strength, yield strength, elongation, reduction of area, ductility, toughness, malleability, fatigue strength, and weldability.

Microalloyed (HSLA) Steel
A type of steel strengthened by adding small amounts of alloying elements like niobium, vanadium, or titanium, typically less than 0.15%, to low-carbon steel. These additions, along with controlled processing, enhance strength, toughness, and weldability without significantly increasing the overall alloy content.

Microstructure
The structure and internal condition of metals as revealed on a ground and polished (and usually etched) surface when observed at high magnification.

Metallurgical Terms: N – Re

Normalizing
Normalizing is a heat treatment process used to improve mechanical properties and microstructure. It involves heating the metal to a specific temperature above its upper critical temperature, holding it there, and then cooling it in still air. This process refines the grain structure, reduces internal stresses, and enhances ductility and toughness.

Overfill
A protrusion on one or both ends of a hot rolled bar caused by the section being too large for the roll pass during hot rolling. If not corrected, overfill frequently leads to laps in subsequent mill stands. It can sometimes occur on the front or back ends of the coils.

Pearlite
A steel structure characterized by alternating plates of ferrite and cementite. It arises from the transformation of austenite during slow cooling and contributes to the steel's strength and ductility.

Pickling
Using an acid (typically sulfuric or hydrochloric) to remove iron oxide scale and other impurities (like rust) from the steel's surface. This process is crucial for preparing steel for further processing by ensuring a clean, scale-free surface.

Product Analysis (Check Analysis)
A supplemental chemical analysis obtained from the semi-finished or finished product.

Quench Crack
A crack that occurs during the rapid cooling (quenching) process due to internal stresses induced by the phase transformation from austenite to martensite. This transformation causes a volume increase, and if the resulting stresses exceed the material's strength, cracks can develop.

Quenching
The process of rapidly cooling steel from the austenitizing range by a suitable medium (typically oil, water, polymer or salt) to obtain desired mechanical properties, microstructure or hardness.

Recarburization (Recarb)
A process where carbon diffuses into the steel surface unintentionally, creating a higher carbon level at the surface as compared to the core.

Recrystallization
The process by which deformed grains in the steel are replaced by a new set of undeformed grains. This process involves heating the steel to a temperature below its critical point, allowing new grains to nucleate and grow, replacing the strained microstructure.

Reduction of Area (ROA)
A measure of the ductility of the material, specifically how much the cross-sectional area of a test specimen decreases before it breaks during a tensile test. It's calculated as the percentage difference between the original cross-sectional area and the minimum area at the fracture point. Higher values indicate greater ductility.

Residuals
Small quantities of elements present in steel that were not added intentionally during the steelmaking process, often coming from raw materials like iron ore or scrap steel.

Metallurgical Terms: Re – Sp

Residual Stress
Internal stresses in a material/part that exist without any external applied forces and are caused by prior deformation.

Rockwell Hardness
A method for determining the hardness of materials by measuring the depth of indentation caused by a standardized indenter under a specific load. For steel, the “B” scale (steel/tungsten carbide ball indenter) is used for softer materials (40-100 HRB) while the “C” scale (diamond point indenter) is used for harder materials (20-65 HRC). See ASTM E18 & E140.

Rod
Produced from hot rolled billets, usually rolled in a multiple strand mill to a round cross section then coiled into one continuous length.

Scab
Irregularly shaped (often oval or round), flattened protrusion on the surface of a steel product. Scabs are typically present before hot rolling and can be mistaken for other imperfections like slivers or rolled-in scale.

Scale
An iron oxide layer that forms on the steel surface at high temperatures. Scale is brittle and abrasive, and must be removed before subsequent processing.

Seam
A linear-type surface imperfection whose origin is usually from the billet, but is elongated during hot rolling.

Segregation
The non-uniform distribution of alloying elements, impurities or microphases within the material, leading to variations in composition and properties.

Shot Blasting
A process that uses high-velocity steel shot to clean steel surfaces. It’s a mechanical cleaning method that removes rust, scale, and other surface contaminants and prepares a surface for further processing.

Shot Peening
A process that uses high-velocity steel or ceramic shot to induce work hardening and create compressive residual stresses at the surface of a part in order to improve fatigue and wear resistance.

Sliver
An elongated, thin piece of steel attached to the base metal at one end only and rolled onto the surface. Often caused by tearing during hot rolling, particularly in lower-strength steels that are more easily torn. These imperfections can be mistaken for other issues like shearing or scabs.

Spheroidization
An annealing process in which carbides form a spheroidal/globular shape within the ferrite matrix. This structure is optimal for ductility and formability. Percentage of spheroidization is a rating of the level of spheroidization for a given steel.

Spheroidize Annealing
(See Spheroidization) Spheroidize annealing involves holding the steel near the Ac1 transition temperature for an extended period of time followed by slow cooling.

Metallurgical Terms: St – T

Stelmor® Cooling
A process of employing a controlled cooling rate after the steel exits to rolling mill to achieve the desired mechanical properties and microstructure. It involves laying the steel rod in a ring formation on a conveyor where controlled cooling is achieved through manipulation of forced air blown through the rings, conveyor speed and hoods (up or down).

Strand Casting (Continuous Casting)
A process used in which a cast shape is continuously withdrawn through the bottom of a mold as the steel solidifies. The strand is then cut into specific lengths to produce blooms or billets.

Stress Relieving
An annealing process with a peak temperature well below the Ac1 transition temperature where no recrystallization occurs. This process helps to minimize distortion, cracking, and other issues that can arise from residual stresses.

Tempering
Reheating an as-quenched or normalized steel to a temperature below the transformation temperature to obtain the desired hardness, microstructure or mechanical properties. A typical heat treat/hardening process involves austenitizing, quenching and tempering.

Tensile Strength
A mechanical test used to measure a steel’s ability to withstand pulling or stretching forces before breaking. It’s calculated by dividing the maximum load by the original cross-sectional area. Typical units are KSI, PSI, N/mm² or MPa.

Toughness
The steel’s ability to absorb energy and plastically deform before fracturing. It’s a measure of how much a material can withstand impact or stress without breaking or cracking.

Transformation Temperature
The specific temperatures at which steel undergoes changes in its crystal structure, impacting its properties. These temperatures are crucial for heat treatment processes like hardening and annealing. The key temperatures are as follows:

Ac_1: The temperature at which austenite begins to form upon heating. This temperature is around 723°C (1333°F) for most plain carbon steels.

Ac_3: The temperature at which the transformation of ferrite to austenite is completed during heating. This temperature varies depending on the carbon content of the steel, generally ranging from 800°C (1472°F) to 910°C (1670°F).

Ar_3: The temperature at which the austenite begins to transform to ferrite (or to ferrite plus cementite) during cooling.

Ar_1: The temperature at which transformation of austenite to ferrite (or to ferrite plus cementite) is completed during cooling.

Ms: The temperature at which the transformation of austenite to martensite starts during rapid cooling (quenching).

Mf: The temperature at which the transformation of austenite to martensite finishes during rapid cooling (quenching).

Metallurgical Terms: U – Z

Ultrasonic Testing (UT)
A non-destructive testing (NDT) method used to inspect steel for internal flaws and thickness. It uses high-frequency sound waves to detect defects like cracks, voids, and inclusions, ensuring the material's structural integrity.

Upset Test
A mechanical test used to evaluate formability and inspect for surface defects. The steel is cut to a given length and compressed longitudinally.

Vacuum Degassing
A secondary steelmaking process that removes dissolved or trapped gases like hydrogen, oxygen, and nitrogen from molten steel using a vacuum environment.

Wire
Material cold drawn through a die, as opposed to hot rolled rod. Wire has much tighter dimensional tolerances than rod or bar.

Yield Point
The stress level at which the material begins to deform plastically, meaning it will not return to its original shape after the stress is removed. It's the boundary between elastic (reversible) and plastic (permanent) deformation.

Yield Strength
A mechanical test used to measure the stress level at which the steel begins to deform permanently (plastic deformation). Typical units are KSI, PSI, N/mm^2 or MPa.

Notes

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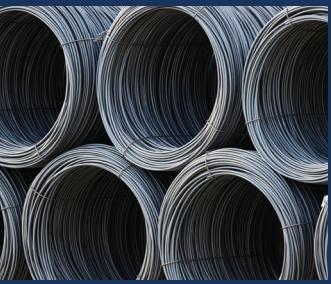

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