PRODUCT GUIDES

Central Steel & Wire Company

Central Steel & Wire Company

Product Guide

STEEL PLATE

General Characteristics 2
Overview 3
Terminology 3
CCP Line Capacities 4
Tolerances 4

GENERAL CHARACTERISTICS					
Grade	CSW Thicknesses in.	Technical Data		Inside Bend Radius†	Comments
		Yield min (ksi)	Tensile min (ksi)		
1045	3/16 - 5-1/2				Bought chemistry only. Used for strength inherent in high carbon steel (gears).
COMMERICAL QUALITY (CQ)	3/16 - 5-1/2			90° 1 *t* transverse	• Very formable & weldable • Carbon will range .05 - .30%
ASTM A 36	3/16 - 6	36	58/80	90° 1-1/2 *t* transverse	Thicknesses to 3/4" have no Mn requirements
FLOOR PLATE	12 ga - 1				• Buy medium pattern • Used for increased resistance to skidding
ABRASION RESISTING					
AR 400 F	3/16 - 1/2			90° 3 *t* transverse	• Stock – over 1/2" mill special 20M# min. • Hardness guaranteed to 360 min Brinell • Used for severe sliding abrasion with forming
AR 200	3/16 - 3/8			Hot form Can be cold formed	• Stock • Typical hardness range of 185-235 Brinell • Used for sliding-type abrasion
ALLOY					
ASTM A 514 aka T1*	1/4 - 2-1/2	100	110	90° 2 *t* transverse	Do not pickle – destroys properties – shot blast only
	3 - 5	90	100		
4140 Annealed	3/16 - 5			90° 1-1/2 *t* transverse	• Intended for parts to be hardened throughout • If burned, edge hardening occurs—offer annealing
8620 As Rolled	5/8 - 4-1/2			90° 2 *t* transverse	• Intended for parts that are to be carburized • Will be used for resistance to wear and shock
HSLA					
ASTM A 572 Gr 50	3/16 - 2-1/2	50	65	90° 2 *t* transverse	About the same corrosion resistance as CQ
ASTM A 588 Gr 50 aka Cor-Ten*	3/16 - 1-3/4	50	70	90° 2 *t* transverse	• About 4 times the corrosion resistance as CQ • Do not pickle – leaves black smut
ASTM A 656 Gr 80	3/16 - 5/8	80	100	90° 2-1/2 *t* transverse	
BethStar® 80	3/16 - 3/4	80	100	90° 1 *t* transverse	Produced to longitudinal Charpy of 15ft-lbs @ –50°F
CleanForm® 100	3/16 - 3/8	100	110	90° 2 *t*	Great alternative for T1 (better cost & surface)
Domex® 100	3/16 - 1/4**	100	110	90° min. *t* ≤ .236 1.6 *t* *t* > .236 1.8 *t*	• Great alternative for T-1. Superior surface, formability & cost • Produced to longitudinal Charpy of 20ft-lbs @ –40°F
PVQ (DNS Mill Special 20M# min.)					
SA-516 Gr 70 As Rolled	3/16 - 1-1/2	38	70 - 90	90° 2 *t* transverse	Intended improved notch toughness parts needed
SA-516 Gr 70 Normalized	2-1/2 - 6	38	70 - 90	90° 2 *t* transverse	Intended improved notch toughness parts needed

* USX proprietary name
** Additional sizes available upon request
† See p. 3 for explanation

Product Guide - Steel Plate (contd)

OVERVIEW	
Cold Reduced Plate	• Higher in quality (surface, flatness and shape). • Maintains **flatness** after shearing, burning, or laser cutting and lower in **cost**.
Flatness Defect Causes	• Uneven cooling • Non-uniform thickness
Pricing Considerations	• How will it be released? • Can customer accept scant cut? • Is grain direction important?

TERMINOLOGY	
Cold Reduced	A rolling process that suppresses yield point elongation which eliminates coil breaks when decoiling
Discrete Plate	Reserved for heavier thicknesses, discrete plate is rolled from slabs directly into plate, never being coiled first. (see Strip Mill Plate)
Inside Bend Radius	During the fabrication of parts made from flat rolled steel products (sheet/plate), some of these parts require the steel to be formed (bent) into different angles (examples…45 degrees, 90 degrees). This is usually done with the use of a "press brake". The steel is forced down over a "nose die" which has a curved shape. This shape forms the inside of the bend angle. The actual curvature of this die will vary, depending on how sharp the inside radius of the bend has to be. This is known as the "INSIDE BEND RADIUS". The smaller the "IBR" the more the steel has to stretch to make the bend. Different steel grades, having different strengths and different ductilities, will react differently during bending. The same inside bend radius cannot be used for all steel grades. There are inside bend radius recommendations listed for some of the steel grades that we stock. They are shown in relation to the material thickness. For example, using a ¼" steel plate, an IBR recommendation of 1.5T would equal an inside bend radius of 3/8" (.250 x 1.5 = .375)
Integrated Mill	Product produced from a BOF (Basic Oxygen Furnace)
Mini Mill	Product from Electric Arc Furnace
Plate	Flat rolled finished steel products within the following: .180" or thicker over 48" or .230" or thicker over 8"
Strip Mill Plate	Strip mill plate is leveled from coil. This process cannot be applied with heavier thicknesses (see Discrete Plate)
Temper Pass	A temper mill is a steel sheet and/or steel plate processing line composed of a horizontal pass cold rolling mill stand. Goal is to correct shape differences along the width of the coil through cold forming. The end results/advantages of temper passing and leveling are listed below. • Thickness dimension more consistent across the width • Improved flatness • Suppression of yield point elongation (from the temper pass) results in improved dimensional stability during fabrication (product remains flat after cutting) • Improved surface finish • Slight increase in yield strength

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

CCP LINE CAPACITIES

Thickness, in.	Width, in.	Length	Material Yields		
			Ordering Spec	Thickness, in.	Max. Width, in.
.068 min - .750 max	24 min - 96 max	44" - 60 ft	100,000 min	.068 - .467	96
			80,000 min	.068 - .500	96
			50,000 min	.068 - .625	96
				Over .625 - .750	60
			A36	.068 - .750	96
			CQ	.068 - .750	96

TOLERANCES

CCP FLATNESS TOLERANCES

-Carbon and HSLA steel with specified minimum yield thru **80,000** psi.
-Tolerances applicable to any 12 ft. of length, measured as maximum deviation from a horizontal flat surface.
-The flatness variation across the width will not exceed the amount shown for the specified width.

Thickness in.	Thru 60,000 psi			Over 60,000 - 80,000 psi		
	Width, in.			Width, in.		
	Under 36	36 - 71	72 & Over	Under 36	36 - 71	72 & Over
.071 - .179	1/8	1/8	3/16	3/8	3/8	7/16
.180 - .750	1/8	3/16	1/4	3/8	7/16	1/2

DISCRETE PLATE THICKNESS TOLERANCES

Carbon, High Strength Low Alloy and Alloy Steel

15 in. & under in thickness when ordered to thickness

Specified Thickness in.	Tolerance Over Specified Thickness for Widths given, in.											
	48 & 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 & Over
To 1/4 excl	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	—	—	—
1/4 - 5/16 excl	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	—	—	—
5/16 - 3/8 excl	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.05	—	—
3/8 - 1/2 excl	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.06	0.06	—
1/2 - 5/8 excl	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.06	0.07	—
5/8 - 3/4 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
3/4 - 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 - 2 excl	0.06	0.06	0.06	0.06	0.06	0.07	0.08	0.10	0.10	0.11	0.13	0.16
2 - 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 - 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 - 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 - 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 - 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 - 15 incl	0.29	0.29	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	—

Notes: 1. Tolerance under specified thickness, 0.01 in.
2. Thickness to be measured at 3/8 to 3/4 in. from the longitudinal edge.
3. For thickness measured at any location other than that specified in Note 2, the permissible maximum over tolerance shall be increased by 75%, rounded to the nearest 0.01 in.

STRIP MILL PLATE THICKNESS TOLERANCES

Thickness in.	Minimum Thickness Purchased, in.	Tolerance Over Specified Minimum, in.		
		36	48 - 60	72
3/16	.181	N/A	.015	.016
1/4	.238	.016	.018	.020
5/16	.301	.016	.018	.020
3/8	.363	.018	.021	.022
7/16	.433	.021	.022	.024
1/2	.488	.021	.022	.024
5/8	.613	.022	.024	.027
3/4	.745	.024	.026	.028

Central Steel & Wire Company

Product Guide

STEEL SHEET

Overview 2
General Characteristics & End Uses 2-3
Coated Sheet Trade Names & Data 3
Thickness, Flatness & Camber Tolerances 4

OVERVIEW

Sheet products are stocked at CS&W in a variety of grades and thicknesses. They also have different end uses and advantages. These items can be further processed from the original mill coil by cutting to length, slitting, blanking and in sheet form they can be sheared.

For explanations of temper pass and inside bend radius, see Plate section, p. 3.

For processing capabilities – See "Processing & Packaging" section.

GENERAL CHARACTERISTICS & END USES

Material	Size Range (in.)	Purchasing Specification	Comments
HOT ROLLED			
ASTM A 1011 CS Type B	.071 - .171 x 36 - 72	Temper rolled, .10% max carbon, cold reduced	Cold reduced sheet/plate is: • Higher in quality (surface, flatness, and shape) • Maintains flatness after shearing, burning, or laser cutting • Lower in cost — easier handling (sheet to sheet) — increases tool life (less scale means less wear) — lowers burning costs (higher speeds and better dimensionally accurate parts) — lowers forming costs (more accurate bends at increased speeds) — lowers welding costs (eliminates excessive fixturing; allows increased speeds) — lowers painting costs (requires less surface preparation) • *End Use:* Unexposed applications like truck and trailer bodies and heavy equipment such as skid steers and agricultural equipment such as combines. ***** Currently stocking 12, 11, 10, & 7 Ga x 48/60 x 120 (other sizes/grades available upon request) ****** SCS finish is an extremely clean surface that resists rust without oil or preservatives.
P&O ASTM A 1011 CS Type B	.071 - .185 x 36 - 72	Temper rolled, .10% max carbon, cold reduced, mill (HCL) pickling.	
SCS ASTM A 1011 CS Type B	.071 - .185 x 36 - 72*****	Temper rolled, .10% max cold reduced, SCS finish *(see comments)*******	
AISI / SAE 1050	.071 - .171 x 36 - 72	Temper rolled, fine grain practice. Bought to chemistry only cold reduced.	
HIGH STRENGTH LOW ALLOY			
Ex-Ten H50 or ASTM A 1011 HSLAS Gr 50	.071 - .171 x 36 - 72 P&O .071 - .185	50,000 psi min yield. Temper rolled product, cold reduced.	
Cor-Ten or ASTM A 606 Type 4			
ASTM A 1011 HSLASF Gr 80	.071 - .171 x 36 - 72	80,000 psi min yield.Temper rolled product, cold reduced. Allows thinner material with higher physical properties to be used in place of Gr 50 material.	
DOMEX 100 XF	.0787 - <.137 .8*t* min bend radius ≥.137 - .160 1.2*t* min bend radius	100,000 psi min yield 110,000 psi min tensile	• Excellent strength to weight ratio • Superior surface and formability
COLD ROLLED			
ASTM A 1008 CS Type B	.017 - .128 x 36 - 60 (.055 & .071 – 72 wide is available)	.10% max carbon	• Improved formability, consistent flatness, & surface quality • *End use:* Appliance wrapper panels where flatness & surface quality are critical. Automobile parts–exposed and unexposed
QH	Refer to Sheet Dept	Rb 60-75	• Higher hardness will add extra stiffness to the part • *End use:* Furniture industry in chair bases
AKDS ASTM A 1008 DS Type B	.023 - .128 x 36 - 60	Extended anneal practice	• Maximum consistent drawability • *End use:* Deeply drawn high-speed stamped parts
AR 200	.127 - .171 x 60	Hot form Can be cold formed	• Typical hardness range of 185-235 Brinell • Used for sliding type abrasion

(Continued)

Product Guide - Steel Sheet (contd)

General Characteristics & End Uses (contd)

Material	Size Range (in.)	Purchasing Specification	Comments
COATED			
Galvanized ASTM A 653 CS Type B	.019 - .160 x 36 - 60	Surface chem. treated, dry Coating G90† Minimum spangle	• White rust inhibitor • Greater corrosion resistance • Guaranteed lock forming quality (16 ga & lighter) • UL® coating std - †Other coating wts upon request • *End Use:* air conditioning, automotive body panels, electrical boxes & rooting/siding panels
Galvannealed ASTM A 653 CS Type B	.023-.115 x 36 - 60	Dry, not chem. treated – no oil Coating A60†	• Maximum corrosion resistance • Readily paintable • UL® coating std - †Other coating wts upon request • *End Use:* highway signs, cabinets & garage doors
Paintlok (Electro-Galvanized) ASTM A 879	.017 - .070 x 36 - 60	Bonderized Coating weight 24G (80 oz)	• Readily paintable • 1/2" standard flatness tolerances • *End Use:* inner & outer body panels for auto industry
Paintgrip Galvanized ASTM A 653 CS Type B	.019 - .100 x 36 - 60	Phosphate treated for painting Coating G90†	• Minimum spangle • Extra smooth surface • Temper rolled • UL® coating std - †Other coating wts upon request • *End use:* Painted panels & other applications where flatness & surface are important
Aluminized ASTM A 463 Type 1	24 - 12 Ga x 36 - 60	Oiled Coating T1-40 (other coating wts upon request)	• Resistant to destructive scaling up 1250°F • Heat reflective up to 900°F • Critical applications where flatness is important • *End use:* Drying ovens, automotive mufflers, furnaces, and smoke stacks.

COATED SHEET TRADE NAMES & DATA

Most producing mills apply a specific trade name to their various coated sheet products. Most are in this table. Products within any given coated sheet category are not necessarily identical, because production methods vary from mill to mill.

Product	Typical Trade Names	Nominal Coating Wt. Total Both Sides	Approx. Coating Thick-ness Per Side (in)	Coating Method	Spangles	Bonderized	Paintability	Surface	RoHS Compliant	Tolerable Heat Exposure**
Galvanized	Zincgrip,Ti-Co,Jal-Zinc Tufkote, Stelcoat Dofasco, New Primer Bethcon, Weirkote Brite-Zinc, Sof-Tite Titekote, Softform	G90* coating .90 oz. per ft^2	.00153	Continuous hot-dip	Yes	No	Not recommended	Chemically surface treated to prevent white rust Dry–no oil	Yes selec-tion needed	400°F Max
Paintgrip Galvanized	Zincgrip, Paintgrip Paintbond, Titekote, Paintseal Tufkote Bonderized Jal-Zinc Bonderized	G90* coating .90 oz. per ft^2	.00153	Continuous hot-dip	Min.	Yes	Excellent	Dry–no oil	No	400°F Max
Galvannealed	Galvanite, Satincoat Paint-Tite, Zincgrip A, Weirkote JP Jet Wiped Tufkote Jet Finished	A60 coating Approx. .60 oz. per ft^2	.00102	Continuous hot-dip followed by immediate heat treatment	No	No	Excellent	Dry–no oil	Yes	700°F Max
Paintlok	Weirzin Bonderized Bethzin Gripcote Electro Paintlok Electro Galvanized	.021 & less Approx. .04 -.10 oz. per ft^2 .022 & over .08 - .16 oz. per ft^2	.00012 on .021 & less .000204 on .022 & over	Electrolytic	No	Yes	Excellent	Dry–no oil	No	400°F Max
Aluminized	Aluminized Type 1	T1-40 (regular) coating .40 oz. per ft^2	.001	Continuous hot dip	No	No	Not normally painted	Lightly oiled	Yes	Resists destructive scaling to 1250°F No discolor up to 900°F

***** UL® (Underwriters Laboratories Inc.)

****** Information based on experimental data, not guaranteed

Product Guide - Steel Sheet (contd)

TOLERANCES ARE FOR REFERENCE ONLY

Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

THICKNESS TOLERANCES

Tolerances based on 60" Width – wider sheets may have increased tolerances

Ga	HOT ROLLED			COLD ROLLED & ELECTRO			COATED (Not Aluminized)		
	Nom	Ordered Min	ASTM A 568 Tolerance	Nom	Ordered Min	ASTM A 568 Tolerance	Nom	Ordered Min	ASTM A 924 Tolerance
26				.0179	.017	+.002	.0217	.019	+.003
25				.0209	.019	+.002			
24				.0239	.023	+.003	.0276	.023	+.003
22				.0299	.028	+.003	.0336	.029	+.004
21				.0329	.030	+.003			
20				.0359	.033	+.003	.0396	.035	+.004
19				.0418	.038	+.003			
18				.0478	.044	+.004	.0516	.046	+.005
16	.0598	(.061)	+.010	.0598	.055	+.004	.0635	.057	+.005
14	.0747	.071	+.010	.0747	.070	+.005	.0785	.071	+.006
13	.0897	.083	+.010	.0897	.085	+.005			
12	.1046	.097	+.010	.1046	.098	+.005	.1084	.100	+.012
11	.1196	.112	+.012	.1196	.114	+.006	.1233	.115	+.014
10	.1345	.127	+.012	.1345	.128	+.006	.1382	.130	+.014
9	.1495	.142	+.012						
8	.1644	.156	+.012				.1681	.160	+.014
7	.1793	.171	+.012						
6	.1943	.185	+.015						

FLATNESS TOLERANCES

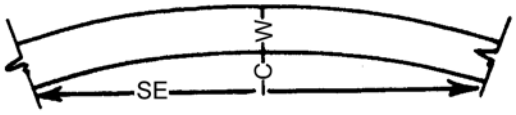
Leveled & Blanked Processed Coil – 1/2 Standard Flatness

Gage (in.)	Width (in.)	HR HRPO	HR HSLA	CR CS Paintlok	CR HSLA	Galvanized Galvannealed Aluminized
.015 - .044 incl	36 incl	-	-	3/16	3/8	-
	over 36 - 60 incl	-	-	5/16	9/16	-
	over 60 - 72 incl	-	-	7/16	3/4	-
Over .044	36 incl	-	-	1/8	3/8	-
	over 36 - 60 incl	-	-	3/16	3/8	-
	over 60 - 72 incl	-	-	5/16	9/16	-
.015 - .048 incl	36 incl	-	-	-	-	3/16
	over 36 - 60 incl	-	-	-	-	5/16
	over 60 - 72 incl	-	-	-	-	7/16
Over .048	36 incl	-	-	-	-	1/8
	over 36 - 60 incl	-	-	-	-	3/16
	over 60 - 72 incl	-	-	-	-	5/16
.044 - .057 incl	36 incl	1/4	-	-	-	-
	over 36 - 60 incl	3/8	-	-	-	-
.	over 60	1/2	-	-	-	-
Over .057 - .180 incl	60 incl	1/4	3/8	-	-	-
	over 60 - 72	3/8	9/16	-	-	-

CAMBER TOLERANCES

CR Carbon & HSLA Steel Sheet – Over 12 in. wide (ASTM A 568)

Camber is the deviation of a side edge from a straight line, the measurement being taken on the concave side with a straight edge as shown in the following sketch:



W = Width of sheet (in.)
C = Camber (in.)
SE = Straight edge

Note: Camber tolerance for coils is 1 in. in any 20 ft., 1/4 in. in 8 ft.

Cut Length, ft. (not required)	Camber Tolerance in.
To 4 incl	1/8
Over 4 - 6	3/16
Over 6 - 8 incl	1/4
Over 8 - 10 incl	5/16
Over 10 - 12 incl	3/8
Over 12 - 14 incl	1/2
Over 14 - 16 incl	5/8
Over 16 - 18 incl	3/4
Over 18 - 20 incl	7/8
Over 20 - 30 incl	1-1/4
Over 30 - 40 incl	1-1/2

Central Steel & Wire Company

Product Guide

CARBON & ALLOY STEEL BARS

General Characteristics 2
Sales Advantages 3
Technical Data 3

Tolerances
— Cold Finished Carbon Steel Bars (Size) 4
— Cold Finished Alloy Steel Bars (Size) 5
— Cold Finished Bars (Straightness) 5
— Hot Rolled Carbon & Alloy Steel Bars 6

Machining Allowances 7

Central Steel & Wire Company

Product Guide

Product

CARBON & ALLOY STEEL BARS

Grade	Machinability	Reason	Weldability	Reason	Bending	Reason	Heat Treating	Strength
CARBON								
ASTM A 36	Poor	Plain Carbon – No Free Machining Elements	Excellent	Plain Carbon – No Free Machining Elements & Low Carbon	Good	Mild Steel Strength	Structural steel not usually heat treated	36 ksi min yield strength
1018	Poor	Plain Carbon – No Free Machining Elements	Excellent	Plain Carbon – No Free Machining Elements & Low Carbon	Good	Low Strength	Can be carburized	Low
1045	Fair	Plain Carbon – No Free Machining Elements	Fair**	Medium Carbon	Fair	Med Strength	Can be thru hardened and induction hardened	Medium
1050 HDSR	Fair	Plain Carbon – No Free Machining Elements	Poor	Higher Carbon	Poor	High Strength	Can be induction hardened	High
1117	Good	Sulfur Added	Poor	Sulfur Added	Fair	Sulfur Added	Can be carburized	Low
11L17	Very Good	Lead & Sulfur Added	N/R	Lead & Sulfur Added	Fair	Lead & Sulfur Added	Can be carburized	Low
1141	Good	Sulfur Added	Poor	Sulfur Added	Poor	Med Strength & Sulfur Added	Can be thru hardened	Medium
1144	Good	Sulfur Added	Poor	Sulfur Added	Poor	Med Strength & Sulfur Added	Can be thru hardened and induction hardened	Medium
12L14	Excellent	Lead & Sulfur Added	N/R	Lead & Sulfur Added	Poor	Lead & Sulfur Added	Can be carburized	Low
12L14 w/Tel	Outstanding	Lead, Sulfur & Tellurium Added	N/R	Lead, Sulfur & Tellurium Added	Poor	Lead, Sulfur & Tellurium Added	Can be carburized	Low
1215	Very Good	Sulfur Added	Poor	Sulfur Added	Poor	Sulfur Added	Can be carburized	Low
Fatigue-Proof®	Good	Sulfur Added	Poor	Sulfur Added	Poor	High Strength	Can be induction hardened	High
INcut® 100	Excellent	Bismuth & Sulfur Added	Poor	Sulfur Added	Poor	Bismuth & Sulfur Added	Can be carburized	Low
INcut® 200	Outstanding	Bismuth & Sulfur Added	Poor	Sulfur Added	Poor	Bismuth & Sulfur Added	Can be carburized	Low
ASTM A **311 or Stressproof®**	Good	Sulfur Added	Poor	Sulfur Added	Poor	High Strength & Sulfur Added	Can be induction hardened	High
ALLOY (Annealed Condition)								
E52100	Poor	High Carbon & High Chrome	Poor	High Carbon & High Chrome	Poor	High Carbon & High Chrome	Can be thru hardened	High*
"e.t.d." 150®	Fair	Chrome-Moly Alloy	Poor	Chrome-Moly Alloy	Poor	High Strength	Can be induction hardened	High
4130	Poor	Chrome-Moly Alloy	Good	Lower Carbon than 4140	Poor	Chrome-Moly Alloy	Can be thru hardened	High*
4140	Fair	Chrome-Moly Alloy	Fair**	Medium Carbon, Chrome-Moly Alloy	Poor	Chrome-Moly Alloy	Can be thru hardened and induction hardened	High*
41L40	Good	Chrome-Moly Alloy with Lead Added	N/R	Lead Added	Poor	Chrome-Moly Alloy	Can be thru hardened and induction hardened	High*
4150	Fair	Chrome-Moly Alloy	Poor	Medium Carbon, Chrome-Moly Alloy	Poor	Chrome-Moly Alloy	Can be thru hardened and induction hardened	High*
4150 MRS	Good	Chrome-Moly Alloy with Sulfur Added	Poor	Chrome-Moly Alloy with Sulfur Added	Poor	Chrome-Moly Alloy	Can be thru hardened and induction hardened	High*
4340	Poor	Nickel-Chrome-Moly Alloy	Poor	Medium Carbon, Nickel-Chrome-Moly Alloy	Poor	Nickel-Chrome-Moly Alloy	Can be thru hardened and induction hardened	High*
8620	Fair	Nickel-Chrome-Moly Alloy	Good	Lower Carbon	Fair	Lower Carbon Alloy Steel	Can be carburized	Low
86L20	Good	Nickel-Chrome-Moly Alloy with Lead Added	N/R	Lead Added	Fair	Lower Carbon Alloy Steel	Can be carburized	Low

***** These grades can have high strength when heat treated, but have medium strength in the annealed condition. ****** These grades require special welding techniques. N/R = Not recommended

SALES ADVANTAGES Material certification is traceable to manufacturing source		
Material	**Purchasing Specification**	**Advantage**
CARBON STEEL BARS (Mill Certifications Available)		
Strand Cast Product	CS&W specifies 5:1 reduction ratio	Center soundness
1045/1095	Fine grain practice	Improved toughness in heat treating
1100 series (HR & Leaded only)	Coarse grain practice Can select .10% max Si	Improved machinability
1200 series	.03% max Si Non-nitrogen treated Coarse grain practice	• Improved machinability • Better formability in bending, flaring, staking, crimping, & thread rolling
Stressproof® / Fatigue-Proof®	100% eddy current or roto tested Machining allowance per 1000 series Demagnetized	• 5/8" & under – seams .010" max Over 5/8" rd – seams no greater than .001"/side for each 1/16" diameter • Easier machinability due to chip removal
ALLOY STEEL BARS		
	Jominy results available	• Predictable heat treatment • Fine grain practice
Strand Cast Product	CS&W specifies 5:1 reduction ratio	Center soundness
4100 Annealed	Hardness is reported	Selection
Medium Carbon	Ordered lamellar pearlitic annealed	Improved machinability
Non-Leaded	Generally calcium treated	Better machinability
CF / HR	Required sulfur .020 - .040% (aim for .025 - .030%) E52100 .010 - .025% sulfur	Better machinability
HF (Non-Leaded)	Vacuum degassed (requires selection)	Internal cleanliness

TECHNICAL DATA
Chemical Composition and Mechanical Properties - See Stock List

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

TOLERANCES – COLD FINISHED CARBON STEEL BARS

COLD DRAWN OR TURNED AND POLISHED BARS SIZE TOLERANCES

Size, in. (mm)[A]	Max. of Carbon Range 0.28% or less	Max. of Carbon Range over 0.28% to 0.55% incl	Max. of Carbon Range to 0.55% incl Stress Relieved or Annealed after Cold Finishing	Max. 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 & Polished			
To 1½ (38.1) incl, in coils or cut lgths	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 3 1/8 (79.38) incl	0.005 (.127)	0.006 (.152)	0.007 (.178)	0.009 (.229)
Over 3 1/8 (79.38) to 4 (101.60) incl	0.005 (.127)	0.006 (.152)	—	—
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 (152.40) 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 1½ (38.10) incl	0.004 (.102)	0.005 (.127)	0.008 (.203)	0.010 (.254)
Over 1½ (38.10) to 3 (76.20) incl	0.005 (.127)	0.006 (.152)	0.010 (.254)	0.012 (.305)
Over 3 (76.20) 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 CD 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 CD 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).

DRAWN, GROUND & POLISHED, GROUND & POLISHED or TURNED, GROUND & POLISHED ROUND BARS SIZE TOLERANCES

Size, in.	Tolerances, in.	Size, in.	Tolerances, in.	Size, in.	Tolerances, in.	
	Drawn G&P 1141 & 1215		G&P A 311 or STRESSPROOF® FATIGUE-PROOF® [A]		TG&P 1018, 1045	TG&P 1141
1/8 to 1-1/2 incl	± .0005			5/8 to 1 incl	–.001 to +.000	
		1-1/2 & under	+.000 to –.001	1-1/8 to 1-1/2 incl	–.0005 to –.0015	–.0005 to –.0015
		1-9/16 to 2-7/16 incl	+.000 to –.0015	1-9/16 to 2-7/16 incl	–.0005 to –.002	–.0005 to –.002
		2-1/2 to 3 incl	+.000 to –.002	2-1/2 to 3 incl	–.0005 to –.0025	–.0005 to –.0025
		3-1/16 to 4 incl	+.000 to –.003	3-1/16 to 4 incl	–.0005 to –.0035	–.0005 to –.0035
		4-1/16 to 4-1/2 incl	+.000 to –.005	4-1/16 to 6 incl	–.0005 to –.0055	–.0005 to –.0045
				6-1/16 to 8 incl	–.0005 to –.0065	

[A] or Equivalent Mechanical Properties

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

TOLERANCES – COLD FINISHED ALLOY STEEL BARS
COLD DRAWN OR TURNED AND POLISHED BARS
SIZE TOLERANCES

Size, in. (mm)[A]	Max. of Carbon Range 0.28% or less	Max. of Carbon Range over 0.28% to 0.55% incl	Max. of Carbon Range to 0.55% incl Stress Relieved or Annealed after Cold Finishing	Max. of Carbon Range over 0.55% with or without Stress Relieving or Annealing after Cold Finishing. Also, All Carbons, Quenched & Tempered (Heat Treated) or Normalized & 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 & Polished				
To 1 (25.40) incl, in coils	0.002 (.051)	0.003 (.076)	0.004 (.102)	0.005 (.127)
Cut Lengths:				
To 1½ (38.10) incl	0.003 (.076)	0.004 (.102)	0.005 (.127)	0.006 (.152)
Over 1½ (38.10) to 2½ (63.50) incl	0.004 (.102)	0.005 (.127)	0.006 (.152)	0.007 (.178)
Over 2½ (63.50) to 4 (101.60) incl	0.005 (.127)	0.006 (.152)	0.007 (.178)	0.008 (.203)
Over 4 (101.60) to 6 (152.40) incl	0.006 (.152)	0.007 (.178)	0.008 (.203)	0.009 (.229)
Over 6 (152.40) to 8 (203.20) incl	0.007 (.178)	0.008 (.203)	0.009 (.229)	0.010 (.254)
Over 8 (203.20) to 9 (228.60) incl	0.008 (.203)	0.009 (.229)	0.010 (.254)	0.011 (.279)
HEXAGONS				
To ¾ (19.05) incl	0.003 (.076)	0.004 (.102)	0.005 (.127)	0.007 (.178)
Over ¾ (19.05) to 1½ (38.10) incl	0.004 (.102)	0.005 (.127)	0.006 (.152)	0.008 (.203)
Over 1½ (38.10) to 2½ (63.50) incl	0.005 (.127)	0.006 (.152)	0.007 (.178)	0.009 (.229)
Over 2½ (63.50) to 3 1/8 (79.38) incl	0.006 (.152)	0.007 (.178)	0.008 (.203)	0.010 (.254)
Over 3 1/8 (79.38) to 4 (101.60) incl	0.006 (.152)	—	—	—
SQUARES				
To ¾ (19.05) incl	0.003 (.076)	0.005 (.127)	0.006 (.152)	0.008 (.203)
Over ¾ (19.05) to 1½ (38.10) incl	0.004 (.102)	0.006 (.152)	0.007 (.178)	0.009 (.229)
Over 1½ (38.10) to 2½ (63.50) incl	0.005 (.127)	0.007 (.178)	0.008 (.203)	0.010 (.254)
Over 2½ (63.50) to 4 (101.60) incl	0.007 (.178)	0.009 (.229)	0.010 (.254)	0.012 (.305)
Over 4 (101.60) to 5 (127.00) incl	0.011 (.279)	—	—	—
FLATS[D]				
Width				
To ¾ (19.05) incl	0.004 (.102)	0.005 (.127)	0.007 (.178)	0.009 (.229)
Over ¾ (19.05) to 1½ (38.10) incl	0.005 (.127)	0.006 (.152)	0.009 (.229)	0.011 (.279)
Over 1½ (38.10) to 3 (76.20) incl	0.006 (.152)	0.007 (.178)	0.011 (.279)	0.013 (.330)
Over 3 (76.20) to 4 (101.60) incl	0.007 (.178)	0.009 (.229)	0.012 (.305)	0.017 (.432)
Over 4 (101.60) to 6 (152.40) incl	0.009 (.229)	0.011 (.279)	0.013 (.330)	0.021 (.533)
Over 6 (152.40)	0.014 (.356)	—	—	—

[A] Standard manufacturing practice is shear cut for CD 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 CD 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 0.006 in. (.152 mm) and the thickness tolerance is the same, namely, 0.006 in. (.152 mm).

TOLERANCES - COLD FINISHED BARS[A, B, C] (Level One)
STRAIGHTNESS TOLERANCES
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)
	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)
	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.
[C] Not to be used for CF Flats – see Product Dept.

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

TOLERANCES – HOT ROLLED CARBON & ALLOY STEEL BARS

SIZE AND OUT-OF-ROUND OR OUT-OF-SQUARE TOLERANCES
Round, Square, and Round-Cornered Square Bars

Specified Size, in. (mm)	Size Tolerances, in. (mm)[A] Over	Size Tolerances, in. (mm)[A] Under	Out-of-Round or Out-of-Square, in. (mm)[B]
To 5/16 (7.94)	0.005 (.127)	0.005 (.127)	0.008 (.203)
Over 5/16 (7.94) to 7/16 (11.11) incl	0.006 (.152)	0.006 (.152)	0.009 (.229)
Over 7/16 (11.11) to 5/8 (15.88) incl	0.007 (.178)	0.007 (.178)	0.010 (.254)
Over 5/8 (15.88) to 7/8 (22.23) incl	0.008 (.203)	0.008 (.203)	0.012 (.305)
Over 7/8 (22.23) to 1 (25.40) incl	0.009 (.229)	0.009 (.229)	0.013 (.330)
Over 1 (25.40) to 1-1/8 (28.58) incl	0.010 (.254)	0.010 (.254)	0.015 (.381)
Over 1-1/8 (28.58) to 1-1/4 (31.75) incl	0.011 (.279)	0.011 (.279)	0.016 (.406)
Over 1-1/4 (31.75) to 1-3/8 (34.93) incl	0.012 (.305)	0.012 (.305)	0.018 (.457)
Over 1-3/8 (34.93) to 1-1/2 (38.10) incl	0.014 (.356)	0.014 (.356)	0.021 (.533)
Over 1-1/2 (38.10) to 2 (50.80) incl	1/64 (.397)	1/64 (.397)	0.023 (.584)
Over 2 (50.80) to 2-1/2 (63.50) incl	1/32 (.794)	0	0.023 (.584)
Over 2-1/2 (63.50) to 3-1/2 (88.90) incl	3/64 (1.191)	0	0.035 (.889)
Over 3-1/2 (88.90) to 4-1/2 (114.30) incl	1/16 (1.587)	0	0.046 (1.168)
Over 4-1/2 (114.30) to 5-1/2 (139.70) incl	5/64 (1.984)	0	0.058 (1.473)
Over 5-1/2 (139.70) to 6-1/2 (165.10) incl	1/8 (3.175)	0	0.070 (1.778)
Over 6-1/2 (165.10) to 8-1/4 (209.55) incl	5/32 (3.969)	0	0.085 (2.159)
Over 8-1/4 (209.55) to 9-1/2 (241.30) incl	3/16 (4.762)	0	0.100 (2.540)
Over 9-1/2 (241.30) to 10 (254.00) incl	1/4 (6.350)	0	0.120 (3.048)

[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.

THICKNESS AND WIDTH TOLERANCES
Square-Edge and Round-Edge Flat Bars[A]

Specified Width, in	Thickness Tolerances for Thickness Given[B] Over and Under, in. .203 to .230 excl	.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	Width Tolerances in. Over	Width Tolerances in. 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.

STRAIGHTNESS TOLERANCES[A]

Standard tolerances	1/4 in. in any 5 ft and (1/4 in. x length in ft)/5
Special tolerances	1/8 in. in any 5 ft and (1/8 in. 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 ALLOWANCES

It is important that those who machine carbon and alloy steel bars recognize that imperfections (such as seams or laps) may be present on the original diameter. Some stock removal is required to minimize or eliminate their presence on the finished parts.

The Iron & Steel Society has republished recommended machining allowances formerly issued by AISI (American Iron & Steel Institute) for various qualities, types, and finishes of steel bars by size. Steel producers in general use these as a basis to determine replacement when there is a claim for rejected material.

Restrictions:

- TG&P and Drawn G&P bars should be free from surface imperfections
- Structural Quality (such as ASTM A 36) are not subject to machining allowances
- Merchant Quality bars are not subject to machining allowances – seams are not rejectable
- Even though CD ASTM A 311 Class B and Fatigue-Proof® are produced from resulfurized steel (grade 1144), we order the material produced to the same machining allowance as non-resulfurized steel. This is done to remain technically competitive with LaSalle's products.

Minimum Recommended Machining Allowance Special Quality Carbon & Regular Quality Alloy†	
HOT ROLLED & COLD FINISHED BARS† 1/2" & Over *	
NON-RESULFURIZED 1000 Series A 311 or Stressproof® Fatigue-Proof®****	**RESULFURIZED 1100 & 1200 Series INcut**
.001" per 1/16" diameter/thickness per side (1.6%)	.0015" per 1/16" diameter/thickness per side (2.4%)

† Does not apply to A36 or M1044
* Under 1/2" - use 1/2" allowance
** Even though these grades are resulfurized, they are eddy current tested to non-resulfurized machining allowances

NOTE: This is to be used only when a customer initiated a question for starting size or when some historical experience requires use of these formulae for new orders.

To determine recommended starting size, use the following:

Non-Resulfurized 1.032 X finished diameter = theoretical start size
Resulfurized 1.048 X finished diameter = theoretical start size

Recommended Size = Theoretical Size or Closest Oversize

Central Steel & Wire Company

Product Guide

STEEL TUBING & PIPE

General Characteristics — Steel Tubing & Pipe 2
Dimensions & Weights of Steel Pipe 3
General Characteristics — Stainless Steel Tubing & Pipe 4

Technical Data Index 5

GENERAL CHARACTERISTICS

ROUND MECHANICAL STEEL TUBING

Product	OD Range (in)	Wall Range (in)	Steel Grade	ASTM Spec	Length (ft)	Thermal Condition	Comments
SEAMLESS Cold Drawn	1/8 - 11-3/4	.022 - 1-1/4	1026	A-519	17-24	Contact Tubing Dept	• Produced to OD & ID** • Cut in half to 8-12'R at no charge
SEAMLESS Hot Finished	3 - 15	.500 – 2	1026	A-519	17-24	As Rolled	• Produced to OD & wall dimensions • Cut in half to 8-12'R at no charge
DOM	1/8 - 12	.022 - .625	1020 1026	A-513 Type 5	17-24	Stress Relieved except Metalmatic	• Produced to OD & ID** • Cut in half to 8-12'R at no charge • Up to 4" OD incl (10 Ga wall & lighter): 1020 – all other sizes 1026
ELECTRIC WELDED Cold Rolled	3/8 – 3-1/2	.028 - .065	MT1010	A-513 Type 2	20'2"	As Rolled	• Under 1" – Flash in 1 – 6-1/2" – Flash controlled .010" 6-5/8" & over – Flash controlled .015" • Produced to OD & wall dimensions
ELECTRIC WELDED Hot Rolled Pickle & Oil	3/8 - 12	.058 - .250	MT1010	A-513 Type 1	20'2"	As Rolled	• Under 1" – Flash in 1 – 6-1/2" – Flash controlled .010" 6-5/8" & over* – Flash controlled .015" • Produced to OD & wall dimensions
BUTT WELDED Cold Drawn ERW	9/16 - 3	.083 - .375	1020 1026	A-512	17-24	Stress Relieved	• Produced to OD & ID** • Cut in half to 8-12'R at no charge • Up to 4" OD incl (10 Ga wall & lighter): 1020 – all other sizes 1026
HYDRAULIC Cold Drawn	1/8 - 2-1/2	.028-.120	—	SAE J525	20'R	Annealed	• Produced to OD & ID** • Cut in half to 8-12'R at no charge

***** ASTM A 135 chemistry only – see Tubing Dept for tolerances (HR) ****** See stock list for exceptions

SQUARE & RECTANGULAR ELECTRIC WELD STEEL TUBING – Mechanical & Structural (Flash In)

Additional sizes available from mill

Product	OD Range (in)	Wall Range (in)	Steel Grade	ASTM Spec	Length	Min. Yield (ksi)	Comments
SQUARE							
MECHANICAL Hot Rolled	3/8 - 3	.065 - .120	MT1010	A-513 Type 1	20'2"	32 (not guaranteed)	Purchased to OD & wall
MECHANICAL Cold Rolled	3/8 - 2	.035 - .049	MT1010	A-513 Type 2	20'2"	32 (not guaranteed)	Purchased to OD & wall
STRUCTURAL Hot Rolled	3/4 - 14	.095 - .500	—	A-500 Gr B/C	20' & 40'R*	50	Purchased to OD & wall
RECTANGULAR							
MECHANICAL Hot Rolled	1 x 1/2 - 4 x 2	.065 - .120	MT1010	A-513 Type 1	20'2"	32 (not guaranteed)	Purchased to OD & wall
STRUCTURAL Hot Rolled	2½ x 1½ - 12 x 8	.125 - .500	—	A-500 Gr B/C	20' & 40'R*	50	Purchased to OD & wall

***** 24 & 48 ft generally available

ROUND STRUCTURAL STEEL TUBING – Pipe Size Steel Tubing (Flash In)

Additional sizes available from mill

Product	OD Range (in)	Wall Range (in)	ASTM Spec	Length (ft)	Min. Yield (ksi)	Comments
Pipe Size Steel Tubing	.840 - 2-3/8 1/2 - 2 (nominal)	.083 - .154	A-500 Gr C	21	46	Purchased to OD & wall

CARBON STEEL PIPE — Uncoated Plain Ends (also available Galvanized)

Other sizes / specifications available

ASTM Specification	NPS* Range	Wall Range (Schedule)	Method of Mfg	Min Yield (ksi)	Length (ft)	Comments
A-53 Type F	1/8 - 4	40 - 80	Continuous Weld	30	21	May be A-53 Type E Gr B (check with Tubing Dept)
A-53 Type E Gr B	5 - 16	40 - XS	Electric Weld	35	16 – 22'R	

***** Nominal Pipe Size (see next page)

TOLERANCES: See page 5

DIMENSIONS AND WEIGHTS OF STEEL PIPE

TOP LINE — WALL THICKNESS SHOWN IN INCHES
BOTTOM LINE — WEIGHT PER FOOT SHOWN IN POUNDS

		PIPE SCHEDULE													
Nominal Size	OD (In.)	5	10	20	30	40	STD	60	80	XS	100	120	140	160	DBLE XS
1/8	.405	***.035*** .1383	***.049*** .1863			***.068*** .24	***.068*** .24		***.095*** .31	***.095*** .31					
1/4	.540	***.049*** .2570	***.065*** .3297			***.088*** .42	***.088*** .42		***.119*** .54	***.119*** .54					
3/8	.675	***.049*** .3276	***.065*** .4235			***.091*** .57	***.091*** .57		***.126*** .74	***.126*** .74					
1/2	.840	***.065*** .5383	***.083*** .6710			***.109*** .85	***.109*** .85		***.147*** 1.09	***.147*** 1.09				***.188*** 1.31	***.294*** 1.71
3/4	1.050	***.065*** .6838	***.083*** .8572			***.113*** 1.13	***.113*** 1.13		***.154*** 1.47	***.154*** 1.47				***.219*** 1.94	***.308*** 2.44
1	1.315	***.065*** .8678	***.109*** 1.404			***.133*** 1.68	***.133*** 1.68		***.179*** 2.17	***.179*** 2.17				***.250*** 2.84	***.358*** 3.66
1-1/4	1.660	***.065*** 1.107	***.109*** 1.806			***.140*** 2.27	***.140*** 2.27		***.191*** 3.00	***.191*** 3.00				***.250*** 3.76	***.382*** 5.21
1-1/2	1.900	***.065*** 1.274	***.109*** 2.085			***.145*** 2.72	***.145*** 2.72		***.200*** 3.63	***.200*** 3.63				***.281*** 4.86	***.400*** 6.41
2	2.375	***.065*** 1.604	***.109*** 2.638			***.154*** 3.65	***.154*** 3.65		***.218*** 5.02	***.218*** 5.02				***.344*** 7.46	***.436*** 9.03
2-1/2	2.875	***.083*** 2.475	***.120*** 3.531			***.203*** 5.79	***.203*** 5.79		***.276*** 7.66	***.276*** 7.66				***.375*** 10.01	***.552*** 13.70
3	3.500	***.083*** 3.029	***.120*** 4.332			***.216*** 7.58	***.216*** 7.58		***.300*** 10.25	***.300*** 10.25				***.438*** 14.32	***.600*** 18.58
3-1/2	4.000	***.083*** 3.472	***.120*** 4.973			***.226*** 9.11	***.226*** 9.11		***.318*** 12.51	***.318*** 12.51					***.636*** 22.85
4	4.500	***.083*** 3.915	***.120*** 5.613			***.237*** 10.79	***.237*** 10.79	***.281*** 12.66	***.337*** 14.98	***.337*** 14.98		***.438*** 19.00		***.531*** 22.51	***.674*** 27.54
4-1/2	5.000						***.247*** 12.53			***.355*** 17.61					***.710*** 32.53
5	5.563	***.109*** 6.349	***.134*** 7.770			***.258*** 14.62	***.258*** 14.62		***.375*** 20.78	***.375*** 20.78		***.500*** 27.04		***.625*** 32.96	***.750*** 38.55
6	6.625	***.109*** 7.585	***.134*** 9.289			***.280*** 18.97	***.280*** 18.97		***.432*** 28.57	***.432*** 28.57		***.562*** 36.39		***.719*** 45.39	***.864*** 53.16
7	7.625						***.301*** 23.57			***.500*** 38.05					***.875*** 63.08
8	8.625	***.109*** 9.914	***.148*** 13.40	***.250*** 22.36	***.277*** 24.70	***.322*** 28.55	***.322*** 28.55	***.406*** 35.64	***.500*** 43.39	***.500*** 43.39	***.594*** 50.95	***.719*** 60.71	***.812*** 67.76	***.906*** 74.69	***.875*** 72.42
9	9.625						***.342*** 33.90			***.500*** 48.72					
10	10.750	***.134*** 15.19	***.165*** 18.70	***.250*** 28.04	***.307*** 34.24	***.365*** 40.48	***.365*** 40.48	***.500*** 54.74	***.594*** 64.43	***.500*** 54.74	***.719*** 77.03	***.844*** 89.29	***1.000*** 104.13	***1.125*** 115.65	
11	11.750						***.375*** 45.55			***.500*** 60.07					
12	12.750	***.165*** 22.18	***.180*** 24.20	***.250*** 33.38	***.330*** 43.77	***.406*** 53.52	***.375*** 49.56	***.562*** 73.15	***.688*** 88.63	***.500*** 65.42	***.844*** 107.32	***1.000*** 125.49	***1.125*** 139.68	***1.312*** 160.27	
14	14.000		***.250*** 36.71	***.312*** 45.61	***.375*** 54.57	***.438*** 63.37	***.375*** 54.57	***.594*** 85.05	***.750*** 106.13	***.500*** 72.09	***.938*** 130.85	***1.094*** 150.79	***1.250*** 170.22	***1.406*** 189.11	
16	16.000		***.250*** 42.05	***.312*** 52.27	***.375*** 62.58	***.500*** 82.77	***.375*** 62.58	***.656*** 107.50	***.844*** 136.62	***.500*** 82.77	***1.031*** 164.82	***1.219*** 192.43	***1.438*** 223.64	***1.594*** 245.25	
18	18.000		***.250*** 47.39	***.312*** 58.94	***.438*** 82.15	***.562*** 104.67	***.375*** 70.59	***.750*** 138.17	***.938*** 170.92	***.500*** 93.45	***1.156*** 207.96	***1.375*** 244.14	***1.562*** 274.22	***1.781*** 308.50	
20	20.000		***.250*** 52.73	***.375*** 78.60	***.500*** 104.1	***.594*** 123.11	***.375*** 78.60	***.812*** 166.40	***1.031*** 208.87	***.500*** 104.10	***1.281*** 256.10	***1.500*** 296.37	***1.750*** 341.10	***1.969*** 379.17	
24	24.000		***.250*** 63.41	***.375*** 94.62	***.562*** 140.68	***.688*** 171.29	***.375*** 94.62	***.969*** 238.85	***1.219*** 296.58	***.500*** 125.49	***1.531*** 367.39	***1.812*** 429.39	***2.062*** 483.12	***2.344*** 542.14	

GENERAL CHARACTERISTICS

STAINLESS STEEL TUBING

Product	Dimensions			Steel Grade	ASTM Spec	Mechanical Properties				Foot notes
	OD Range (in)	Wall Range (in)	Random Lgths (ft)			Min Tensile (ksi)	Min Yield (ksi)	Elong. 2" min.	Hardness Rb Max.	
Welded - Rd	1/8 - 1/2	.028 - .065	17 - 24	T304/ 304L	A-269	N/A	N/A	N/A	74 (30T) or 88 (15T)	A B
Welded - Rd	5/8 - 4	.028 - .188	17 - 24	T304/ 304L	A-249/ A-269	75	30	35	90	C
Seamless	1/2 - 2-1/2	.120 - .250	17 - 24	T304	A-213/ A-269	75	30	35	90	D
Welded - Rd (Mechanical)	1 - 1-5/8 1-1/4 - 1½ PST	.048 - .065	20	T304	A-554	N/A	N/A	N/A	90 max	E
Welded - Sq (Mechanical)	3/4 - 4	.049 - .250	20	T304	A-554	N/A	N/A	N/A	N/A	E
Welded - Rect (Mechanical)	2x1 - 4x2	.065 - .250	20	T304	A-554	N/A	N/A	N/A	N/A	E

A — Bright Annealed
B — 1/4" OD x .065" Wall, 5/16" OD x .065" Wall, and 1/2" OD x .095" Wall purchased ASTM A 249/269 ASME SA-249 Annealed & Pickled or Bright Annealed
C — May be cold worked in weld bead only (bead height included in wall tolerance) or drawn over mandrel. Dual Certified ASTM A 249, ASTM A 269, and ASME SA-249 (1-1/4" OD & larger stenciled) Bright Annealed (Rath, Copperweld) or Annealed & Pickled
D — Dual Certified ASTM A 213, ASME SA-213 (except average wall), and ASTM A 269 (1-1/4" OD & larger stenciled)
E — .180" Wall — ASTM A 554 chemistry only

STAINLESS TUBING NOTES:
• Purchased to OD & wall
• Not all sizes available—check CS&W Stock List for specific sizes (additional sizes & grades available from mill)

STAINLESS STEEL PIPE

Product	Dimensions			Steel Grade	ASTM Spec	Mechanical Properties		
	Nominal Pipe Size (in)	Schedule	Random Lgths (ft)			Min Tensile (ksi)	Min Yield (ksi)	Elong. 2" min.
Welded	1/8 - 6	40	17 - 24	T304/ 304L	A-312	75	30	35
	1/8 - 5	80						

STAINLESS PIPE NOTES:
• Purchased to OD & wall
• Dual Certified ASTM A 312 and ASME SA-312 (2" NPS & larger stenciled)
• Additional sizes and grades available from mill
• May be Annealed & Pickled or Bright Annealed

N/A = Not Applicable

TOLERANCES: See page 5

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

TECHNICAL DATA INDEX

Technical Data	Product	Table	Page
Chemical Composition	Hydraulic Tubing	21	16
	Structural Tubing	22	17
Mechanical Properties	Hydraulic Tubing	21	16
	Structural Tubing	22	17
Dimensions of Nominal Pipe Sizes	Carbon Steel Pipe	27-29	19-21
	Stainless Steel Pipe	38	24
Nominal Weights & Test Pressures	Carbon Steel Pipe	27-29	19-21

Tolerance	Product		Table	Page
Diameter/Outside Dimension	Carbon	Butt Weld	19	15
		DOM	6	8
		ERW—Round —HR	9	10
		—CR	12	12
		—Sq & Rect	14	13
		Hydraulic	21	16
		Seamless —CD	1	6
		—HF	3	7
		Structural	23	18
		Pipe	30	21
	Stainless	Tube —Round	31-32	22
		—Sq & Rect	35	23
		Pipe	36	24
Wall Thickness	Carbon	Butt Weld	19	15
		DOM	8	9
		ERW—Round —HR	10	11
		—CR	11	11
		—Sq & Rect	14	13
		Hydraulic	21	16
		Seamless —CD	2	7
		—HF	4	7
		Structural	24	18
		Pipe	30	21
	Stainless	Tube —Rd	34	23
		—Sq & Rect	35	23
		Pipe	37	24
Straightness	Carbon	Butt Weld	20	15
		DOM	7	8
		ERW —Rd	13	12
		—Sq & Rect	16	13
		Seamless	5	7
		Structural	26	18
	Stainless	Tube—Rd	33	23
		—Sq & Rect	35	23
Squareness of Sides	Carbon	ERW	15	13
		Structural	26	18
	Stainless	Tube	35	23
Twist	Carbon	ERW	17	14
		Structural	25	18
	Stainless	Tube	35	23
Radii of Corners	Carbon	ERW	18	14
		Structural	26	18
	Stainless	Tube	35	23
Weight	Carbon	Pipe	30	21

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

SEAMLESS

Table 1
OUTSIDE AND INSIDE DIAMETER TOLERANCES[A,B,C]
Round C.D. Seamless Tubing

Outside Diameter Size Range in.	Wall Thickness As % of Outside Diameter	Thermal Treatment after Final Cold Work Producing Size: None, or not exceeding 1100°F Nominal Temperature ★ — OD, in. Over	OD, in. Under	ID, in. Over	ID, in. Under	Heated Above 1100°F Nominal Temperature Without Accelerated Cooling — OD, in. Over	OD, in. Under	ID, in. Over	ID, in. Under	Quenched and Tempered — OD, in. Over	OD, in. Under	ID, in. Over	ID, in. Under
Up to 0.499	All	0.004	0.000	—	—	0.005	0.002	—	—	0.010	0.010	0.010	0.010
0.500– 1.699	All	0.005	0.000	0.000	0.005	0.007	0.002	0.002	0.007	0.015	0.015	0.015	0.015
1.700– 2.099	All	0.006	0.000	0.000	0.006	0.006	0.005	0.005	0.006	0.020	0.020	0.020	0.020
2.100– 2.499	All	0.007	0.000	0.000	0.007	0.008	0.005	0.005	0.008	0.023	0.023	0.023	0.023
2.500– 2.899	All	0.008	0.000	0.000	0.008	0.009	0.005	0.005	0.009	0.025	0.025	0.025	0.025
2.900– 3.299	All	0.009	0.000	0.000	0.009	0.011	0.005	0.005	0.011	0.028	0.028	0.028	0.028
3.300– 3.699	All	0.010	0.000	0.000	0.010	0.013	0.005	0.005	0.013	0.030	0.030	0.030	0.030
3.700– 4.099	All	0.011	0.000	0.000	0.011	0.013	0.007	0.010	0.010	0.033	0.033	0.033	0.033
4.100– 4.499	All	0.012	0.000	0.000	0.012	0.014	0.007	0.011	0.011	0.036	0.036	0.036	0.036
4.500– 4.899	All	0.013	0.000	0.000	0.013	0.016	0.007	0.012	0.012	0.038	0.038	0.038	0.038
4.900– 5.299	All	0.014	0.000	0.000	0.014	0.018	0.007	0.013	0.013	0.041	0.041	0.041	0.041
5.300– 5.549	All	0.015	0.000	0.000	0.015	0.020	0.007	0.014	0.014	0.044	0.044	0.044	0.044
5.550– 5.999	Under 6	0.010	0.010	0.010	0.010	0.018	0.018	0.018	0.018	—	—	—	—
	6–7-1/2	0.009	0.009	0.009	0.009	0.016	0.016	0.016	0.016	—	—	—	—
	Over 7-1/2	0.018	0.000	0.009	0.009	0.017	0.015	0.016	0.016	—	—	—	—
6.000– 6.499	Under 6	0.013	0.013	0.013	0.013	0.023	0.023	0.023	0.023	—	—	—	—
	6–7-1/2	0.010	0.010	0.010	0.010	0.018	0.018	0.018	0.018	—	—	—	—
	Over 7-1/2	0.020	0.000	0.010	0.010	0.020	0.015	0.018	0.018	—	—	—	—
6.500– 6.999	Under 6	0.015	0.015	0.015	0.015	0.027	0.027	0.027	0.027	—	—	—	—
	6–7-1/2	0.012	0.012	0.012	0.012	0.021	0.021	0.021	0.021	—	—	—	—
	Over 7-1/2	0.023	0.000	0.012	0.012	0.026	0.015	0.021	0.021	—	—	—	—
7.000– 7.499	Under 6	0.018	0.018	0.018	0.018	0.032	0.032	0.032	0.032	—	—	—	—
	6–7-1/2	0.013	0.013	0.013	0.013	0.023	0.023	0.023	0.023	—	—	—	—
	Over 7-1/2	0.026	0.000	0.013	0.013	0.031	0.015	0.023	0.023	—	—	—	—
7.500– 7.999	Under 6	0.020	0.020	0.020	0.020	0.035	0.035	0.035	0.035	—	—	—	—
	6–7-1/2	0.015	0.015	0.015	0.015	0.026	0.026	0.026	0.026	—	—	—	—
	Over 7-1/2	0.029	0.000	0.015	0.015	0.036	0.015	0.026	0.026	—	—	—	—
8.000– 8.499	Under 6	0.023	0.023	0.023	0.023	0.041	0.041	0.041	0.041	—	—	—	—
	6–7-1/2	0.016	0.016	0.016	0.016	0.028	0.028	0.028	0.028	—	—	—	—
	Over 7-1/2	0.031	0.000	0.015	0.016	0.033	0.022	0.028	0.028	—	—	—	—
8.500– 8.999	Under 6	0.025	0.025	0.025	0.025	0.044	0.044	0.044	0.044	—	—	—	—
	6–7-1/2	0.017	0.017	0.017	0.017	0.030	0.030	0.030	0.030	—	—	—	—
	Over 7-1/2	0.034	0.000	0.015	0.019	0.038	0.022	0.030	0.030	—	—	—	—
9.000– 9.499	Under 6	0.028	0.028	0.028	0.028	0.045	0.045	0.049	0.049	—	—	—	—
	6–7-1/2	0.019	0.019	0.019	0.019	0.033	0.033	0.033	0.033	—	—	—	—
	Over 7-1/2	0.037	0.000	0.015	0.022	0.043	0.022	0.033	0.033	—	—	—	—
9.500– 9.999	Under 6	0.030	0.030	0.030	0.030	0.045	0.045	0.053	0.053	—	—	—	—
	6–7-1/2	0.020	0.020	0.020	0.020	0.035	0.035	0.035	0.035	—	—	—	—
	Over 7-1/2	0.040	0.000	0.015	0.025	0.048	0.022	0.035	0.035	—	—	—	—
10.000–10.999	Under 6	0.034	0.034	0.034	0.034	0.045	0.045	0.060	0.060	—	—	—	—
	6–7-1/2	0.022	0.022	0.022	0.022	0.039	0.039	0.039	0.039	—	—	—	—
	Over 7-1/2	0.044	0.000	0.015	0.029	0.055	0.022	0.039	0.039	—	—	—	—
11.000–12.000	Under 6	0.035	0.035	0.035	0.035	0.050	0.050	0.065	0.065	—	—	—	—
	6–7-1/2	0.025	0.025	0.025	0.025	0.045	0.045	0.045	0.045	—	—	—	—
	Over 7-1/2	0.045	0.000	0.015	0.035	0.060	0.022	0.045	0.045	—	—	—	—

A Many tubes with inside diameter less than 50% of outside diameter, or with wall thickness more than 25% of outside diameter, or with wall thickness over 1-1/4 in., or weighing more than 90 lb/ft, are difficult to draw over a mandrel. Therefore, the inside diameter can vary over or under by an amount equal to 10% of the wall thickness. See also Footnote *B*.

B For those tubes with inside diameter less than 1/2 in. (or less than 5/8 in. when the wall thickness is more than 20% of the outside diameter), which are not commonly drawn over a mandrel, Footnote *A* is not applicable. Therefore, for those tubes, the inside diameter is governed by the outside diameter tolerance shown in this table and the wall thickness tolerances shown in Table 2.

C Tubing having a wall thickness less than 3% of the outside diameter cannot be straightened properly without a certain amount of distortion. Consequently, such tubes, while having an average outside diameter and inside diameter within the tolerances shown in this table, require an ovality tolerance of 1/2% over and under nominal outside diameter, this being in addition to the tolerances indicated in this table.

METRIC CONVERSION: 1 in. = 25.4 mm 1 mm = 0.0394 in.

★ CS&W STOCK

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

SEAMLESS

Table 2
WALL THICKNESS TOLERANCES
Round C.D. Seamless Tubing

Wall Thickness Range as % of Outside Diameter	Wall Thickness Tolerance Over and Under Nominal, %	
	Up to 1.499 in. (38.075 mm) ID	1.500 in. (38.100 mm) & Over
25 & under	10.0	7.5
Over 25	12.5	10.0

Table 3
OUTSIDE DIAMETER TOLERANCES[A,B,C]
Round H.F. Seamless Tubing

Outside Diameter Size Range in. (mm)	Outside Diameter Tolerance in. (mm)	
	Over	Under
Up to 2.999 (76.17)	0.020 (0.51)	0.020 (0.51)
3.000– 4.499 (76.20–114.27)	0.025 (0.64)	0.025 (0.64)
4.500– 5.999 (114.30–152.37)	0.031 (0.79)	0.031 (0.79)
6.000– 7.499 (152.40–190.47)	0.037 (0.94)	0.037 (0.94)
7.500– 8.999 (190.50–228.57)	0.045 (1.14)	0.045 (1.14)
9.000–10.750 (228.60–273.05)	0.050 (1.27)	0.050 (1.27)

A Diameter tolerances are not applicable to normalized and tempered or quenched and tempered conditions.
B The common range of sizes of hot finished tubes is 1-1/2 to 10-3/4 in. (38.1 to 273.0 mm) outside diameter with wall thickness at least 3% or more of outside diameter, but not less than 0.095 in. (2.41 mm).
C Larger sizes are available; consult manufacturer for sizes and tolerances.

Table 4
WALL THICKNESS TOLERANCES
Round H.F. Seamless Tubing

Wall Thickness Range as % of Outside Diameter	Wall Thickness Tolerance[A], Over and Under Nominal, %		
	Outside Diameter 2.999 in. (76.19 mm) & smaller	Outside Diameter 3.000 in. (76.20 mm) to 5.999 in. (152.37 mm)	Outside Diameter 6.000 in. (152.40 mm) to 10.750 in. (273.05 mm)
Under 15	12.5	10.0	10.0
15 & over	10.0	7.5	10.0

A Wall thickness tolerances may not be applicable to walls 0.199 in. (5.05 mm) and less; consult manufacturer for wall tolerances on such tube sizes.

Table 5
STRAIGHTNESS TOLERANCES
Round Seamless Tubing

Size Limits	Max Curvature in any 3 ft/in. (mm/m)	Max Curvature in Total Lengths in. (mm)	Max Curvature for Lengths under 3 ft or 1 m
OD 5 in. (127.0 m) & smaller Wall thickness, over 3% of OD	0.030 (0.83)	0.030 x (no. of ft of lgth/3) (0.83 x no. of m of lgth)	ratio of 0.010 in./ft or 0.83 mm/m
OD over 5–8 in. (127.0–203.2 mm) incl Wall thickness, over 4% of OD	0.045 (1.25)	0.045 x (no. of ft of lgth/3) (1.25 x no. of m of lgth)	ratio of 0.015 in./ft or 1.25 mm/m
OD over 8–12-3/4 in. (203.2–323.8 mm) incl Wall thickness, over 4% of OD	0.060 (1.67)	0.060 x (no. of ft of lgth/3) (1.67 x no. of m of lgth)	ratio of 0.020 in./ft or 1.67 mm/m

Notes:
1. The straightness variation for any 3 ft (0.9 m) of length is determined by measuring the concavity between the tube and a 3-ft straightedge with a feeler gage. The total variation, that is, the maximum curvature at any point in the total length of tube, is determined by rolling the tube on a surface plate and measuring the concavity with a feeler gage.
2. The tolerances apply generally to unannealed, finish-annealed, and medium-annealed cold finished or hot finished tubes. When straightening stress would interfere with the use of the end product, the straightness tolerances shown do not apply when tubing is specified "not to be straightened after furnace treatment." These straightness tolerances do not apply to soft-annealed or quenched and tempered tubes.

METRIC CONVERSION: 1 in. = 25.4 mm 1 mm = 0.0394 in.

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

DOM

Table 6
OUTSIDE AND INSIDE DIAMETER TOLERANCES
DOM Tubing

NOTE—Measurements for diameter are to be taken at least 2 in. from the ends of the tubes.

OD Size Range in. (mm)	Wall % of OD	OD, in. (mm)		ID, in. (mm)	
		Over	Under	Over	Under
Up to 0.499 (12.67)	All	0.004 (0.10)	0.000 (0.00)	—	—
0.500– 1.699 (12.70– 43.16)	All	0.005 (0.13)	0.000 (0.00)	0.000 (0.00)	0.005 (0.13)
1.700– 2.099 (43.17– 53.32)	All	0.006 (0.15)	0.000 (0.00)	0.000 (0.00)	0.006 (0.15)
2.100– 2.499 (53.33– 63.48)	All	0.007 (0.18)	0.000 (0.00)	0.000 (0.00)	0.007 (0.18)
2.500– 2.899 (63.49– 73.64)	All	0.008 (0.20)	0.000 (0.00)	0.000 (0.00)	0.008 (0.20)
2.900– 3.299 (73.65– 83.80)	All	0.009 (0.23)	0.000 (0.00)	0.000 (0.00)	0.009 (0.23)
3.300– 3.699 (83.81– 93.96)	All	0.010 (0.25)	0.000 (0.00)	0.000 (0.00)	0.010 (0.25)
3.700– 4.099 (93.97–104.12)	All	0.011 (0.28)	0.000 (0.00)	0.000 (0.00)	0.011 (0.28)
4.100– 4.499 (104.13–114.28)	All	0.012 (0.30)	0.000 (0.00)	0.000 (0.00)	0.012 (0.30)
4.500– 4.899 (114.29–124.44)	All	0.013 (0.33)	0.000 (0.00)	0.000 (0.00)	0.013 (0.33)
4.900– 5.299 (124.45–134.60)	All	0.014 (0.36)	0.000 (0.00)	0.000 (0.00)	0.014 (0.36)
5.300– 5.549 (134.61–140.95)	All	0.015 (0.38)	0.000 (0.00)	0.000 (0.00)	0.015 (0.38)
5.550– 5.999 (140.96–152.38)	Under 6	0.010 (0.25)	0.010 (0.25)	0.010 (0.25)	0.010 (0.25)
	6 & over	0.009 (0.23)	0.009 (0.23)	0.009 (0.23)	0.009 (0.23)
6.000– 6.499 (152.39–165.08)	Under 6	0.013 (0.33)	0.013 (0.33)	0.013 (0.33)	0.013 (0.33)
	6 & over	0.010 (0.25)	0.010 (0.25)	0.010 (0.25)	0.010 (0.25)
6.500– 6.999 (165.09–177.78)	Under 6	0.015 (0.38)	0.015 (0.38)	0.015 (0.38)	0.015 (0.38)
	6 & over	0.012 (0.30)	0.012 (0.30)	0.012 (0.30)	0.012 (0.30)
7.000– 7.499 (177.79–190.48)	Under 6	0.018 (0.46)	0.018 (0.46)	0.018 (0.46)	0.018 (0.46)
	6 & over	0.013 (0.33)	0.013 (0.33)	0.013 (0.33)	0.013 (0.33)
7.500– 7.999 (190.49–203.18)	Under 6	0.020 (0.51)	0.020 (0.51)	0.020 (0.51)	0.020 (0.51)
	6 & over	0.015 (0.38)	0.015 (0.38)	0.015 (0.38)	0.015 (0.38)
8.000– 8.499 (203.19–215.88)	Under 6	0.023 (0.58)	0.023 (0.58)	0.023 (0.58)	0.023 (0.58)
	6 & over	0.016 (0.41)	0.016 (0.41)	0.016 (0.41)	0.016 (0.41)
8.500– 8.999 (215.89–228.58)	Under 6	0.025 (0.64)	0.025 (0.64)	0.025 (0.64)	0.025 (0.64)
	6 & over	0.017 (0.43)	0.017 (0.43)	0.017 (0.43)	0.017 (0.43)
9.000– 9.499 (228.59–241.28)	Under 6	0.028 (0.71)	0.028 (0.71)	0.028 (0.71)	0.028 (0.71)
	6 & over	0.019 (0.48)	0.019 (0.48)	0.019 (0.48)	0.019 (0.48)
9.500– 9.999 (241.29–253.98)	Under 6	0.030 (0.76)	0.030 (0.76)	0.030 (0.76)	0.030 (0.76)
	6 & over	0.020 (0.51)	0.020 (0.51)	0.020 (0.51)	0.020 (0.51)
10.000–10.999 (253.99–279.38)	All	0.034 (0.86)	0.034 (0.86)	0.034 (0.86)	0.034 (0.86)
11.000–11.999 (279.39–304.78)	All	0.035 (0.89)	0.035 (0.89)	0.035 (0.89)	0.035 (0.89)
12.000–12.999 (304.79–329.95)	All	0.036 (0.91)	0.036 (0.91)	0.036 (0.91)	0.036 (0.91)
13.000–13.999 (330.20–355.57)	All	0.037 (0.94)	0.037 (0.94)	0.037 (0.94)	0.037 (0.94)
14.000–14.999 (355.60–380.98)	All	0.038 (0.97)	0.038 (0.97)	0.038 (0.97)	0.038 (0.97)

The ovality shall be within the above tolerances except when the wall thickness is less than 3% of the OD. In such cases the additional ovality shall be as follows, but the mean diameter shall be within the specified tolerance:

OD, in. (mm)	Additional Ovality Tolerance, in. (mm)
Up to 2.000 (50.80) incl	0.010 (0.25)
Over 2.000– 3.000 (50.80– 76.20) incl	0.015 (0.38)
Over 3.000– 4.000 (76.20–101.60) incl	0.020 (0.51)
Over 4.000– 5.000 (101.60–127.00) incl	0.025 (0.64)
Over 5.000– 6.000 (127.00–152.40) incl	0.030 (0.76)
Over 6.000– 7.000 (152.40–177.80) incl	0.035 (0.89)
Over 7.000– 8.000 (177.80–203.20) incl	0.040 (1.02)
Over 8.000– 9.000 (203.20–228.60) incl	0.045 (1.14)
Over 9.000–10.000 (228.60–254.00) incl	0.050 (1.27)
Over 10.000–11.000 (254.00–279.40) incl	0.055 (1.40)
Over 11.000–12.000 (279.40–304.80) incl	0.060 (1.52)
Over 12.000–12.500 (304.80–317.50) incl	0.065 (1.65)

Table 7
STRAIGHTNESS TOLERANCES
DOM Tubing

The straightness tolerance for round tubing is 0.030 in./3-ft (0.76 mm/1-m) lengths to 8.000 in. (203 mm) outside diameter. For 8.000 in. outside diameter and above, straightness tolerance is 0.060 in./3-ft (1.52 mm/1-m) lengths.
For lengths under 1 ft, the straightness tolerance shall be agreed upon between the purchaser and producer.

Straightness, or camber, is measured for any 3 ft (0.9 m) of length with a 3-ft (0.9-m) straightedge and a feeler gage.

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

DOM

Table 8
WALL THICKNESS TOLERANCES - DOM Tubing

Wall Thickness in. (mm)	OD, in. (mm)			
	.375 (9.53) to .875 (22.23)	Over .875 (22.23) to 1.875 (47.63)	Over 1.875 (47.63) to 3.750 (95.25)	Over 3.750 (95.25) to 12.500 (317.50)
.028 (0.71)	+.002 (+0.05) –.002 (–0.05)	+.002 (+0.05) –.002 (–0.05)	+.002 (+0.05) –.002 (–0.05)	—
.035 (0.89)	+.002 (+0.05) –.002 (–0.05)	+.002 (+0.05) –.002 (–0.05)	+.002 (+0.05) –.002 (–0.05)	—
.049 (1.24)	+.002 (+0.05) –.002 (–0.05)	+.002 (+0.05) –.003 (–0.08)	+.002 (+0.05) –.003 (–0.08)	—
.065 (1.65)	+.002 (+0.05) –.002 (–0.05)	+.002 (+0.05) –.003 (–0.08)	+.002 (+0.05) –.003 (–0.08)	+.004 (+0.10) –.004 (–0.10)
.083 (2.11)	+.002 (+0.05) –.002 (–0.05)	+.002 (+0.05) –.003 (–0.08)	+.003 (+0.08) –.003 (–0.08)	+.004 (+0.10) –.005 (–0.13)
.095 (2.41)	+.002 (+0.05) –.002 (–0.05)	+.002 (+0.05) –.003 (–0.08)	+.003 (+0.08) –.003 (–0.08)	+.004 (+0.10) –.005 (–0.13)
.109 (2.77)	+.002 (+0.05) –.003 (–0.08)	+.002 (+0.05) –.004 (–0.10)	+.003 (+0.08) –.003 (–0.08)	+.005 (+0.13) –.005 (–0.13)
.120 (3.05)	+.003 (+0.08) –.003 (–0.08)	+.002 (+0.05) –.004 (–0.10)	+.003 (+0.08) –.003 (–0.08)	+.005 (+0.13) –.005 (–0.13)
.134 (3.40)	—	+.002 (+0.05) –.004 (–0.10)	+.003 (+0.08) –.003 (–0.08)	+.005 (+0.13) –.005 (–0.13)
.148 (3.76)	—	+.002 (+0.05) –.004 (–0.10)	+.003 (+0.08) –.003 (–0.08)	+.005 (+0.13) –.005 (–0.13)
.165 (4.19)	—	+.003 (+0.08) –.004 (–0.10)	+.003 (+0.08) –.004 (–0.10)	+.005 (+0.13) –.006 (–0.15)
.180 (4.57)	—	+.004 (+0.10) –.004 (–0.10)	+.003 (+0.08) –.005 (–0.13)	+.006 (+0.15) –.006 (–0.15)
.203 (5.16)	—	+.004 (+0.10) –.005 (–0.13)	+.004 (+0.10) –.005 (–0.13)	+.006 (+0.15) –.007 (–0.18)
.220 (5.59)	—	+.004 (+0.10) –.006 (–0.15)	+.004 (+0.10) –.006 (–0.15)	+.007 (+0.18) –.007 (–0.18)
.238 (6.05)	—	+.005 (+0.13) –.006 (–0.15)	+.005 (+0.13) –.006 (–0.15)	+.007 (+0.18) –.007 (–0.18)
.259 (6.58)	—	+.005 (+0.13) –.006 (–0.15)	+.005 (+0.13) –.006 (–0.15)	+.007 (+0.18) –.007 (–0.18)
.284 (7.21)	—	+.005 (+0.13) –.006 (–0.15)	+.005 (+0.13) –.006 (–0.15)	+.007 (+0.18) –.007 (–0.18)
.300 (7.62)	—	+.006 (+0.15) –.006 (–0.15)	+.006 (+0.15) –.006 (–0.15)	+.008 (+0.20) –.008 (–0.20)
.320 (8.13)	—	+.007 (+0.18) –.007 (–0.18)	+.007 (+0.18) –.007 (–0.18)	+.008 (+0.20) –.008 (–0.20)
.344 (8.74)	—	+.008 (+0.20) –.008 (–0.20)	+.008 (+0.20) –.008 (–0.20)	+.009 (+0.23) –.009 (–0.23)
.375 (9.53)	—	—	+.009 (+0.23) –.009 (–0.23)	+.009 (+0.23) –.009 (–0.23)
.400 (10.16)	—	—	+.010 (+0.25) –.010 (–0.25)	+.010 (+0.25) –.010 (–0.25)
.438 (11.13)	—	—	+.011 (+0.28) –.011 (–0.28)	+.011 (+.028) –.011 (–0.28)
.460 (11.68)	—	—	+.012 (+0.30) –.012 (–0.30)	+.012 (+0.30) –.012 (–0.30)
.480 (12.19)	—	—	+.012 (+0.30) –.012 (–0.30)	+.012 (+0.30) –.012 (–0.30)
.531 (13.49)	—	—	+.013 (+0.33) –.013 (–0.33)	+.013 (+0.33) –.013 (–0.33)
.563 (14.30)	—	—	+.013 (+0.33) –.013 (–0.33)	+.013 (+0.33) –.013 (–0.33)
.580 (14.73)	—	—	+.014 (+0.36) –.014 (–0.36)	+.014 (+0.36) –.014 (–0.36)
.600 (15.24)	—	—	+.015 (+0.38) –.015 (–0.38)	+.015 (+0.38) –.015 (–0.38)
.625 (15.88)	—	—	+.016 (+0.41) –.016 (–0.41)	+.016 (+0.41) –.016 (–0.41)
.650 (16.51)	—	—	+.017 (+0.43) –.017 (–0.43)	+.017 (+0.43) –.017 (–0.43)

For intermediate wall: Use the tolerance for the nearest listed wall. If the intermediate wall fails equally between two listed walls, use the greater tolerance.

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances
WELDED

Table 9
DIAMETER TOLERANCES
Round
ERW Mechanical Tubing
As-Welded Hot Rolled

NOTE—Measurements for diameter are to be taken at least 2 in. from the ends of the tubes.

Outside Diameter Size Range in.	Wall Thickness		Flash In Tubing[A,E]	Flash Controlled to 0.010 in. max. Tubing[B,E]	Flash Controlled to 0.005 in. max. Tubing[C,E]	
			Outside Diameter Plus & Minus	Outside Diameter Plus & Minus	Outside Diameter Plus & Minus	Inside Diameter Plus & Minus
	Bwg[D]	in.	Tolerances, in.			
3/4–1-1/8 incl	16 to 10	0.065–0.134	0.0035	—	0.0035	0.020
Over 1-1/8–2 incl	16 to 14	0.065–0.083	0.005	0.005	0.005	0.021
	13 to 7	0.095–0.180	0.005	0.005	0.005	0.025
	6 to 5	0.203–0.220	0.005	0.005	0.005	0.029
	4 to 3	0.238–0.259	0.005	0.005	0.005	0.039
Over 2–2-1/2 incl	16 to 14	0.065–0.083	0.006	0.006	0.006	0.022
	13 to 5	0.095–0.220	0.006	0.006	0.006	0.024
	4 to 3	0.238–0.259	0.006	0.006	0.006	0.040
Over 2-1/2–3 incl	16 to 14	0.065–0.083	0.008	0.008	0.008	0.024
	13 to 5	0.095–0.220	0.008	0.008	0.008	0.026
	4 to 3	0.238–0.259	0.008	0.008	0.008	0.040
	2 to 0.320	0.284–0.320	0.010	0.010	0.010	0.048
Over 3–3-1/2 incl	16 to 14	0.065–0.083	0.009	0.009	0.009	0.025
	13 to 5	0.095–0.220	0.009	0.009	0.009	0.027
	4 to 3	0.238–0.259	0.009	0.009	0.009	0.043
	2 to 0.360	0.284–0.360	0.012	0.012	0.012	0.050
Over 3-1/2–4 incl	16 to 14	0.065–0.083	0.010	0.010	0.010	0.026
	13 to 5	0.095–0.220	0.010	0.010	0.010	0.028
	4 to 3	0.238–0.259	0.010	0.010	0.010	0.044
	2 to 0.500	0.284–0.500	0.015	0.015	0.015	0.053
Over 4–5 incl	16 to 14	0.065–0.083	0.020	0.020	0.020	0.036
	13 to 5	0.095–0.220	0.020	0.020	0.020	0.045
	4 to 3	0.238–0.259	0.020	0.020	0.020	0.054
	2 to 0.500	0.284–0.500	0.020	0.020	0.020	0.058
Over 5–6 incl	16 to 10	0.065–0.134	0.020	0.020	0.020	0.036
	9 to 5	0.148–0.220	0.020	0.020	0.020	0.040
	4 to 3	0.238–0.259	0.020	0.020	0.020	0.054
	2 to 0.500	0.284–0.500	0.020	0.020	0.020	0.058
Over 6–8 incl	11 to 10	0.120–0.134	0.025	0.025	0.025	0.043
	9 to 5	0.148–0.220	0.025	0.025	0.025	0.045
	4 to 3	0.238–0.259	0.025	0.025	0.025	0.059
	2 to 0.500	0.284–0.500	0.025	0.025	0.025	0.063

A Flash-In Tubing is produced only to outside diameter tolerances and wall thickness tolerances and the inside diameter welding flash does not exceed the wall thickness or 3/32 in., whichever is less.

B Flash Controlled to 0.010 in. max. tubing consists of tubing over 1-1/8 in. outside diameter which is commonly produced only to outside diameter tolerances and wall thickness tolerances, in which the height of the remaining welding flash is controlled not to exceed 0.010 in.

C Flash Controlled to 0.005 in. max. tubing is produced to outside diameters and wall thickness tolerance, inside diameter and wall thickness tolerances, or outside diameters and inside diameter tolerances, in which the height of the remaining flash is controlled not to exceed 0.005 in. Any remaining flash is considered to be part of the applicable inside diameter tolerances.

D Birmingham Wire Gage

E The ovality shall be within the above tolerances except when the wall thickness is less than 3% of the outside diameter. In such cases the ovality may be 50% greater than the outside tolerances, but the mean outside diameter shall be within the specified tolerance.

METRIC CONVERSION: 1 in. = 25.4 mm 1 mm = 0.0394 in.

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

WELDED

Table 10
WALL THICKNESS TOLERANCES
Round
ERW Mechanical Tubing
As-Welded Hot Rolled

Wall Thickness		Outside Diameter, in.											
		3/4 to 1 incl		Over 1 to 1-15/16 incl		Over 1-15/16 to 3-3/4 incl		Over 3-3/4 to 4-1/2 incl		Over 4-1/2 to 6 incl		Over 6 to 8 incl	
		Wall Thickness Tolerances, in. plus and minus											
in.	Bwg[A]	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus
0.065	16	0.005	0.009	0.004	0.010	0.003	0.011	0.002	0.012	0.002	0.012	—	—
0.072	15	0.005	0.009	0.004	0.010	0.003	0.011	0.002	0.012	0.002	0.012	—	—
0.083	14	0.006	0.010	0.005	0.011	0.004	0.012	0.003	0.013	0.003	0.013	—	—
0.095	13	0.006	0.010	0.005	0.011	0.004	0.012	0.003	0.013	0.003	0.013	—	—
0.109	12	0.006	0.010	0.005	0.011	0.004	0.012	0.003	0.013	0.003	0.013	0.003	0.013
0.120	11	0.006	0.010	0.005	0.011	0.004	0.012	0.003	0.013	0.003	0.013	0.003	0.013
0.134	10	0.006	0.010	0.005	0.011	0.004	0.012	0.003	0.013	0.003	0.013	0.003	0.013
0.148	9	—	—	0.006	0.012	0.005	0.013	0.004	0.014	0.004	0.014	0.004	0.014
0.165	8	—	—	0.006	0.012	0.005	0.013	0.004	0.014	0.004	0.014	0.004	0.014
0.180	7	—	—	0.006	0.012	0.005	0.013	0.004	0.014	0.004	0.014	0.004	0.014
0.203	6	—	—	—	—	0.007	0.015	0.006	0.016	0.005	0.017	0.005	0.017
0.220	5	—	—	—	—	0.007	0.015	0.006	0.016	0.005	0.017	0.005	0.017
0.238	4	—	—	—	—	0.012	0.020	0.011	0.021	0.010	0.022	0.010	0.022
0.259	3	—	—	—	—	0.013	0.021	0.012	0.022	0.011	0.023	0.011	0.023
0.284	2	—	—	—	—	0.014	0.022	0.013	0.023	0.012	0.024	0.012	0.024
0.300	1	—	—	—	—	0.015	0.023	0.014	0.024	0.013	0.025	0.013	0.025
0.320	—	—	—	—	—	0.016	0.024	0.015	0.025	0.014	0.026	0.014	0.026
0.344	—	—	—	—	—	0.017	0.025	0.016	0.026	0.015	0.027	0.015	0.027
0.360	—	—	—	—	—	0.017	0.025	0.016	0.026	0.015	0.027	0.015	0.027
0.375	—	—	—	—	—	—	—	0.016	0.026	0.015	0.027	0.015	0.027
0.406	—	—	—	—	—	—	—	0.017	0.027	0.016	0.028	0.016	0.028
0.438	—	—	—	—	—	—	—	0.017	0.027	0.016	0.028	0.016	0.028
0.469	—	—	—	—	—	—	—	—	—	0.016	0.028	0.016	0.028
0.500	—	—	—	—	—	—	—	—	—	0.016	0.028	0.016	0.028

A Birmingham Wire Gage

Table 11
WALL THICKNESS TOLERANCES
Round
ERW Mechanical Tubing
As-Welded Cold Rolled

Wall Thickness		Outside Diameter, in.											
		3/8 to 7/8 incl		Over 7/8 to 1-7/8 incl		Over 1-7/8 to 3-3/4 incl		Over 3-3/4 to 5 incl		Over 5 to 6 incl		Over 6 to 8 incl	
		Wall Thickness Tolerances, in. plus and minus											
in.	Bwg[A]	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus
0.028	22	0.001	0.005	0.001	0.005	—	—	—	—	—	—	—	—
0.035	20	0.002	0.005	0.001	0.005	0.001	0.005	—	—	—	—	—	—
0.049	18	0.003	0.006	0.002	0.006	0.002	0.006	—	—	—	—	—	—
0.065	16	0.005	0.007	0.004	0.007	0.004	0.007	0.004	0.007	0.004	0.007	—	—
0.083	14	0.006	0.007	0.005	0.007	0.004	0.007	0.004	0.007	0.004	0.008	0.004	0.008
0.095	13	0.006	0.007	0.005	0.007	0.004	0.007	0.004	0.007	0.004	0.008	0.004	0.008
0.109	12	—	—	0.006	0.008	0.005	0.008	0.005	0.008	0.005	0.009	0.005	0.009
0.120	11	—	—	0.007	0.008	0.006	0.008	0.005	0.008	0.005	0.009	0.005	0.009
0.134	10	—	—	0.007	0.008	0.006	0.008	0.005	0.008	0.005	0.009	0.005	0.009

A Birmingham Wire Gage

METRIC CONVERSION: 1 in. = 25.4 mm 1 mm = 0.0394 in.

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

WELDED

Table 12
DIAMETER TOLERANCES
Round
ERW Mechanical Tubing
As-Welded Cold Rolled

NOTE—Measurements for diameter are to be taken at least 2 in. from the ends of the tubes.

Outside Diameter Size Range in.	Wall Thickness		Flash In Tubing[A,E]	Flash Controlled to 0.010 in. max. Tubing[B,E]	Flash Controlled to 0.005 in. max. Tubing[C,E]	
			Outside Diameter Plus & Minus	Outside Diameter Plus & Minus	Outside Diameter Plus & Minus	Inside Diameter Plus & Minus
	Bwg[D]	in.	Tolerances, in.			
3/8–5/8 incl	22 to 16	0.028–0.065	0.003	—	—	—
Over 5/8–1-1/8 incl	22 to 20	0.028–0.035	0.0035	0.0035	0.0035	0.013
	18	0.049	0.0035	0.0035	0.0035	0.015
	16 to 14	0.065–0.083	0.0035	0.0035	0.0035	0.019
Over 3/4–1-1/8 incl	13	0.095	0.0035	0.0035	0.0035	0.019
Over 7/8–1-1/8 incl	12 to 11	0.109–0.120	0.0035	0.0035	0.0035	0.021
Over 1-1/8–2 incl	22 to 18	0.028–0.049	0.005	0.005	0.005	0.015
	16 to 13	0.065–0.095	0.005	0.005	0.005	0.019
	12 to 10	0.109–0.134	0.005	0.005	0.005	0.022
Over 2–2-1/2 incl	20 to 18	0.035–0.049	0.006	0.006	0.006	0.016
	16 to 13	0.065–0.095	0.006	0.006	0.006	0.020
	12 to 10	0.109–0.134	0.006	0.006	0.006	0.023
Over 2-1/2–3 incl	20 to 18	0.035–0.049	0.008	0.008	0.008	0.018
	16 to 13	0.065–0.095	0.008	0.008	0.008	0.022
	12 to 10	0.109–0.134	0.008	0.008	0.008	0.025
Over 3–3-1/2 incl	20 to 18	0.035–0.049	0.009	0.009	0.009	0.019
	16 to 13	0.065–0.095	0.009	0.009	0.009	0.023
	12 to 10	0.109–0.134	0.009	0.009	0.009	0.026
Over 3-1/2–4 incl	20 to 18	0.035–0.049	0.010	0.010	0.010	0.020
	16 to 13	0.065–0.095	0.010	0.010	0.010	0.024
	12 to 10	0.109–0.134	0.010	0.010	0.010	0.027
Over 4–6 incl	16 to 13	0.065–0.095	0.020	0.020	0.020	0.034
	12 to 10	0.109–0.134	0.020	0.020	0.020	0.037
Over 6–8 incl	14 to 13	0.083–0.095	0.025	0.025	0.025	0.039
	12 to 10	0.109–0.134	0.025	0.025	0.025	0.042

A Flash-In Tubing is produced to outside diameter tolerances and wall thickness tolerances only, and the height of the inside welding flash does not exceed the wall thickness or 3/32 in., whichever is less.

B Flash Controlled to 0.010 in. max. tubing consists of tubing over 5/8 in. outside diameter which is commonly produced to outside diameter tolerances and wall thickness tolerances only, in which the height of the remaining inside welding flash is controlled not to exceed 0.010 in.

C Flash Controlled to 0.005 in. max. tubing is produced to outside diameter tolerances and wall thickness tolerances, inside diameters tolerances and wall thickness tolerances, or outside diameter tolerances and inside diameter tolerances, in which the height of the remaining inside welding flash is controlled not to exceed 0.005 in. Any remaining flash is considered to be part of the applicable inside diameter tolerances.

D Birmingham Wire Gage

E The ovality shall be within the above tolerances except when the wall thickness is less than 3% of the outside diameter. In such cases the ovality may be 50% greater than the outside tolerances, but the mean outside diameter shall be within the specified tolerance.

Table 13
STRAIGHTNESS TOLERANCES
Round
ERW Mechanical Tubing

The straightness tolerance for round tubing is 0.030 in./3-ft (0.76 mm/1-m) lengths to 8.000 in. (203 mm) outside diameter. For 8.000 in. outside diameter and above, straightness tolerance is 0.060 in./3 ft (1.52 mm/1-m) lengths. For lengths under 1 ft, the straightness tolerance shall be agreed upon between the purchaser and producer.

Straightness, or camber, is measured for any 3 ft (0.9 m) of length with a 3-ft (0.9-m) straightedge and a feeler gage.

METRIC CONVERSION: 1 in. = 25.4 mm 1 mm = 0.0394 in.

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

WELDED

Table 14
OUTSIDE DIMENSION TOLERANCES[A]
Square and Rectangular
ERW Tubing

Largest Nominal Outside Dimension in. (mm)	Wall Thickness in. (mm)	Outside Tolerances All Sides at Corners ± in. (mm)
3/16–5/8 (4.8–15.9) incl	0.020–0.083 (0.51–2.11) incl	0.004 (0.10)
Over 5/8 –1-1/8 (15.9– 28.6) incl	0.025–0.156 (0.64–3.96) incl	0.005 (0.13)
Over 1-1/8 –1-1/2 (28.6– 38.1) incl	0.025–0.192 (0.64–4.88) incl	0.006 (0.15)
Over 1-1/2 –2 (38.1– 50.8) incl	0.032–0.192 (0.81–4.88) incl	0.008 (0.20)
Over 2 –3 (50.8– 76.2) incl	0.035–0.259 (0.89–6.58) incl	0.010 (0.25)
Over 3 –4 (76.2–101.6) incl	0.049–0.259 (1.25–6.58) incl	0.020 (0.51)
Over 4 –6 (101.6–152.4) incl	0.065–0.259 (1.65–6.58) incl	0.020 (0.51)
Over 6 –8 (152.4–203.2) incl	0.185–0.259 (4.70–6.58) incl	0.025 (0.64)

A Measured at corners at least 2 in. (50.8 mm) 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. (mm)	Tolerance ± in. (mm)
2-1/2 (63.5) & under	0.010 (0.25)
Over 2-1/2–4 (63.5–101.6)	0.015 (0.38)
Over 4 –8 (101.6–203.2)	0.025 (0.64)

Wall Thickness Tolerances—The wall thickness tolerance for hot rolled and cold rolled square and rectangular tubing is ± 10% of the nominal wall thickness.

Table 15
SQUARENESS OF SIDES TOLERANCES
Square and Rectangular
ERW Tubing

Permissible variations for squareness shall be determined by the following equation:

$$\pm b = c \times 0.006 \text{ in. } (0.152 \text{ mm})$$

where:
b = tolerance for out-of-square, and
c = largest external dimension across flats

The squareness of sides is commonly determined by one of the following methods:

A square with two adjustable contact points on each arm is placed on two sides. A fixed feeler gage is then used to measure the maximum distance between the free contact point and the surface of the tubing, *OR*

A square equipped with a direct reading vernier may be used to determine the angular deviation which, in turn, may be related to distance in inches.

Table 16
STRAIGHTNESS TOLERANCES
Square and Rectangular
ERW Tubing

The straightness tolerance is 1/16 in./3 ft (1.7 mm/1 m).

METRIC CONVERSION: 1 in. = 25.4 mm 1 mm = 0.0394 in.

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

WELDED

Table 17
TWIST TOLERANCES
Square and Rectangular
ERW Tubing

The twist in square and rectangular tubing may be measured by holding one end of the tubing on a surface plate and noting the height of either corner of the opposite end of same side above the surface plate. Twist may also be measured by the use of a beveled protractor equipped with a level, and noting the angular deviation on opposite ends, or at any point throughout the length.

Largest Dimension in. (mm)	Twist Tolerance in 3 ft. (914.4 mm) in. (mm)
1/2 (12.7) & under	0.032 (0.81)
Over 1/2–1-1/2 (12.7– 38.1) incl	0.050 (1.27)
Over 1-1/2–2-1/2 (38.1– 63.5) incl	0.062 (1.57)
Over 2-1/2–4 (63.5–101.6) incl	0.075 (1.91)
Over 4 –6 (101.6–152.4) incl	0.087 (2.21)
Over 6 –8 (152.4–203.2) incl	0.100 (2.54)

Table 18
RADII OF CORNERS TOLERANCES
Square and Rectangular
ERW Tubing
Grade MT1010

Squares & Rectangles Made from Tubes of the following Diameter Ranges, in.	Wall Thickness in Bwg[A] & in.	Radius Tolerance[B] in.
1/2–1-1/2 incl	22 (0.028)	1/32–1/16
1/2–2-1/2 incl	20 (0.035)	1/32–1/16
1/2–4 incl	18 (0.049)	3/64–5/64
1/2–4-1/8 incl	16 (0.065)	1/16–7/64
3/4–4-1/8 incl	14 (0.083)	5/64–1/8
Over 4-1/8–6 incl	14 (0.083)	3/16–5/16
1–4-1/8 incl	13 (0.095)	3/32–5/32
Over 4-1/8–6 incl	13 (0.095)	3/16–5/16
1-1/4–4 incl	12 (0.109)	1/8–13/64
Over 4–6 incl	12 (0.109)	3/16–5/16
1-1/4–4 incl	11 (0.120)	1/8–7/32
Over 4–6 incl	11 (0.120)	7/32–7/16
2–4 incl	10 (0.134)	5/32–9/32
Over 4–6 incl	10 (0.134)	7/32–7/16
2–4 incl	9 (0.148)	3/16–5/16
Over 4–8 incl	9 (0.148)	7/32–7/16
2–8 incl	8 (0.165)	1/4–1/2
2–8 incl	7 (0.180)	1/4–1/2
2-1/2–4 incl	6 (0.203)	5/16–9/16
Over 4–8 incl	6 (0.203)	5/16–9/16
2-1/2–8 incl	5 (0.220)	3/8–5/8
2-1/2–8 incl	4 (0.238)	3/8–5/8
2-1/2–8 incl	3 (0.259)	3/8–5/8

A Birmingham Wire Gage

B This table establishes a standard radius. The purchaser & producer may negotiate special radii. Slight radius flattening is more pronounced in heavier wall tubing.

METRIC CONVERSION: 1 in. = 25.4 mm 1 mm = 0.0394 in.

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

BUTT WELDED

Table 19
DIAMETER[C] AND WALL THICKNESS TOLERANCES
Round
Cold Drawn Butt Welded Mechanical Tubing

Outside Diameter Range in. (mm)	Outside Diameter in. (mm)		Inside Diameter in. (mm)		Wall Thickness %	
	Over	Under	Over	Under	Over	Under
Sunk						
Up to 1/2 (12.7) excl	0.004 (0.10)	0	—	—	15[A]	15
1/2–1-1/2 (12.7–38.1) excl	0.005 (0.13)	0	—	—	10[A]	10
1-1/2–3 (38.1–76.2) incl	0.010 (0.25)	0	—	—	10[A]	10
Mandrel Drawn						
Less than 0.156 (3.96) wall:						
Up to 1/2 (12.7) excl	0.004 (0.10)	0	0	0.010 (0.25)	12-1/2	12-1/2
1/2–1-1/2 (12.7–38.1) excl	0.005 (0.13)	0	0	0.005 (0.13)[B]	10	10
0.156 (3.96) wall & over:						
1/2–1-1/2 (12.7–38.1) excl	0.005 (0.13)	0	0	0.005 (0.13)[B]	7	7
Under 0.156 (3.96) wall:						
1-1/2 (38.1) & over	0.010 (0.25)	0	—	0.010 (0.25)	10	10
0.156 (3.96) wall & over:						
1-1/2 (38.1) & over	0.010 (0.25)	0	0	0.010 (0.25)	7	7

A Except at the weld line, where the weld pad may exceed this figure
B Tubes with an ID under 1/2 in. (12.7 mm) may require more than 0.005 in. (0.13 mm) ID tolerance & the producer should be consulted.
C Includes ovality

Table 20
STRAIGHTNESS TOLERANCES
Round
Cold Drawn Butt Welded Mechanical Tubing

A round tube shall be considered straight provided that no 3-ft (0.9 m) section departs from a straight line by more than 0.030 in. (0.76 mm). The straightness of round tubes shorter than 3 ft (0.9 m) shall be proportionate to 0.010 in./ft (0.8 mm/m). These straightness tolerances do not apply to soft-annealed tubing nor to long lengths of small diameter tubing.

METRIC CONVERSION: 1 in. = 25.4 mm 1 mm = 0.0394 in.

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

HYDRAULIC

Table 21
CHEMICAL COMPOSITION & MECHANICAL PROPERTIES
DIMENSIONAL TOLERANCES

ERW Steel Hydraulic Fluid-Line Tubing

ERW Hydraulic-Line Tubing is produced to the requirements of ANSI B93.4, NFPA Standard T3.15.67.1, and SAE J525.

CHEMICAL COMPOSITION

Carbon	0.18 max
Manganese	0.30–0.60
Phosphorus	0.040 max
Sulfur	0.050 max

MECHANICAL PROPERTIES[A]

Tensile Strength, min	45,000 psi (310 MPa)
Yield Strength, min	25,000 psi (170 MPa)
Elongation in 2 in. (50 mm), min	35%[B]
Hardness (Rockwell B), max	65[C]

A This table from SAE J525

B For tubes with OD of 0.375 in. (9.5 mm) or less, and/or wall thickness of 0.035 in. (0.9 mm) or less, a minimum elongation of 25% is permitted.

C The hardness test shall not be required on tubing with a nominal wall thickness of less than 0.065 in. (1.65 mm). Such tubing shall meet all other mechanical properties and performance requirements.

DIMENSIONAL TOLERANCES

When tubing is specified by outside diameter and inside diameter, the tolerances shown in the table below apply.

Nominal Outside Diameter in. (mm)	OD Plus & Minus in. (mm)	ID Plus & Minus in. (mm)
Up to .38 (9.5) incl	0.002 (0.05)	0.002 (0.05)
Over .38 –.63 (9.5– 15.9) incl	0.0025 (0.06)	0.0025 (0.06)
Over .63 –2 (15.9– 50.8) incl	0.003 (0.08)	0.003 (0.08)
Over 2 –2-1/2 (50.8– 63.5) incl	0.004 (0.10)	0.004 (0.10)
Over 2-1/2–3 (63.5– 76.2) incl	0.005 (0.13)	0.005 (0.13)
Over 3 –4 (76.2–101.6) incl	0.006 (0.15)	0.006 (0.15)

When tubing is specified by the outside diameter (or the inside diameter) and the nominal wall thickness, the above tolerances apply for the specified diameter, and the wall thickness allowable variation is ± 10% for tubes 3/8 in. (9.5 mm) diameter and over, and ± 15% for tubes under 3/8 in. (9.5 mm) OD.

METRIC CONVERSION: 1 in. = 25.4 mm 1 mm = 0.0394 in.

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

STRUCTURAL

Table 22
CHEMICAL COMPOSITION & MECHANICAL PROPERTIES
Structural Tubing
Grades A, B, C, and D

CHEMICAL COMPOSITION

Element	Composition, %			
	Grades A, B, and D		Grades C	
	Heat Analysis	Product Analysis	Heat Analysis	Product Analysis
Carbon, max	0.26	0.30	0.23	0.27
Manganese, max	–	–	1.35	1.40
Phosphorus, max	0.04	0.05	0.04	0.05
Sulfur, max	0.05	0.063	0.05	0.063
Copper, when copper steel is specified, min	0.20	0.18	0.20	0.18

MECHANICAL PROPERTIES

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, %[A]	25[B]	23[C]	21[D]	23[C]

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, %[A]	25[B]	23[C]	21[D]	23[C]

A The minimum elongation values specified apply only to testing performed prior to shipment because of the possibility of strain aging. Tests performed after shipment may show values below those stated.

B Applies to specified wall thicknesses 0.120 in. (3.05 mm) and over. For wall thicknesses under 0.120 in., the minimum elongation shall be calculated by the formula: percent elongation in 2 in. = $56t + 17.5$.

C Applies to specified wall thicknesses 0.180 in. (4.57 mm) and over. For wall thicknesses under 0.180 in., the minimum elongation shall be calculated by the formula: percent elongation in 2 in. = $61t + 12$.

D Applies to specified wall thicknesses 0.120 in. (3.05 mm) and over. For lighter wall thicknesses, elongation shall be by agreement with the manufacturer.

NOTE—The following table gives calculated minimum values for longitudinal strip tests:

Wall thickness, in. (mm)	Elongation in 2 in. (50.8 mm), min, %	
	Grade A	Grade B
0.180 (4.57)	–	23
0.165 (4.19)	–	22
0.148 (3.76)	–	21
0.134 (3.40)	–	20
0.120 (3.05)	25	19.5
0.109 (2.77)	23.5	19
0.095 (2.41)	23	18
0.083 (2.11)	22	17
0.065 (1.65)	21	16
0.049 (1.24)	20	15
0.035 (0.89)	19.5	14

METRIC CONVERSION: 1 in. = 25.4 mm 1 mm = 0.0394 in.

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

STRUCTURAL

Table 23
OUTSIDE DIMENSION TOLERANCES
Structural Tubing

Square and Rectangular—The specified dimensions, measured across the flats at positions at least 2 in. (50.8 mm) from either end of the tubing and including an allowance for convexity or concavity, shall not exceed the plus and minus tolerances shown in the table below.

Largest Outside Dimension Across Flats, in. (mm)	Tolerance[A] ± in. (mm)
2-1/2 (63.5) & under	0.020 (0.51)
Over 2-1/2–3-1/2 (63.5– 88.9) incl	0.025 (0.64)
Over 3-1/2–5-1/2 (88.9–139.7) incl	0.030 (0.76)
Over 5-1/2 (139.7)	1%

A Tolerances include allowance for convexity or concavity. For rectangular sections, the tolerance calculated for the larger flat dimension shall also apply to the smaller flat dimension. This tolerance may be increased 50% when applied to the smaller dimension if the ratio of the external sides is in the range from 1.5 to 3 incl, and 100% when the ratio exceeds 3.

Round—The outside diameter shall not vary more than ± 0.5% rounded to the nearest 0.005 in. (0.13 mm), of the nominal outside diameter size specified, for nominal outside diameters 1.900 in. (48.26 mm) and smaller, and ± 0.75% rounded to the nearest 0.005 in. of the nominal outside diameter for nominal outside diameters 2.00 in. (50.8 mm) and larger. The outside diameter measurements shall be made at positions at least 2 in. (50.8 mm) from either end of the tubing.

Table 24
WALL THICKNESS TOLERANCES
Structural Tubing

Round, Square, and Rectangular—The tolerance for wall thickness exclusive of the weld area shall be ± 10% of the nominal wall thickness specified. The wall thickness on square and rectangular tubing is to be measured at the center of the flat.

Table 25
TWIST TOLERANCES
Square and Rectangular
Structural Tubing

Specified Dimension of Longest Side in. (mm)	Maximum Twist in the First 3 ft (1 m) & in Each Additional 3 ft, in. (mm)
1-1/2 (38.1) & under	0.050 (1.39)
Over 1-1/2–2-1/2 (38.1– 63.5) incl	0.062 (1.72)
Over 2-1/2–4 (63.5–101.6) incl	0.075 (2.09)
Over 4 –6 (101.6–152.4) incl	0.087 (2.42)
Over 6 –8 (152.4–203.2) incl	0.100 (2.78)
Over 8 (203.2)	0.112 (3.11)

Table 26
Structural Tubing

STRAIGHTNESS TOLERANCES

The permissible variation for straightness shall be 1/8 in. times the number of feet (10.4 mm times the number of metres) of total length divided by 5.

SQUARENESS OF SIDES

Square and Rectangular—adjacent sides may deviate from 90° by a tolerance of ± 2° max.

RADIUS OF CORNERS

Square and Rectangular—the radius of any outside corner of the section shall not exceed three times the specified wall thickness.

METRIC CONVERSION: 1 in. = 25.4 mm 1 mm = 0.0394 in.

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

PIPE

Table 27
DIMENSIONS
NOMINAL WEIGHTS (Plain Ends and Threads & Couplings)
TEST PRESSURES

"Standard Weight" Pipe — Schedule 40

NPS Designator	DIMENSIONS				WEIGHTS				TEST PRESSURES[A]			
	Outside Diameter		Wall Thickness		Plain Ends		Threads & Couplings		Butt Welded		Seamless & Electric Resistance Welded	
	in.	mm	in.	mm	lb/ft	kg/m	lb/ft	kg/m	psi	MPa	psi	MPa
1/8	0.405	10.3	0.068	1.73	0.24	0.4	0.24	0.4	700	4.83	700	4.83
1/4	0.540	13.7	0.088	2.24	0.42	0.6	0.42	0.6	700	4.83	700	4.83
3/8	0.675	17.1	0.091	2.31	0.57	0.8	0.57	0.8	700	4.83	700	4.83
1/2	0.840	21.3	0.109	2.77	0.85	1.3	0.85	1.3	700	4.83	700	4.83
3/4	1.050	26.7	0.113	2.87	1.13	1.7	1.13	1.7	700	4.83	700	4.83
1	1.315	33.4	0.133	3.38	1.68	2.5	1.68	2.5	700	4.83	700	4.83
1-1/4	1.660	42.2	0.140	3.56	2.27	3.4	2.28	3.4	1000	6.89	1300	8.96
1-1/2	1.900	48.3	0.145	3.68	2.72	4.0	2.73	4.1	1000	6.89	1300	8.96
2	2.375	60.3	0.154	3.91	3.65	5.4	3.68	5.5	1000	6.89	2500	17.24
2-1/2	2.875	73.0	0.203	5.16	5.79	8.6	5.82	8.7	1000	6.89	2500	17.24
3	3.500	88.9	0.216	5.49	7.58	11.3	7.62	11.4	1000	6.89	2500	17.24
3-1/2	4.000	101.6	0.226	5.74	9.11	13.6	9.20	13.7	1200	8.27	2370	16.34
4	4.500	114.3	0.237	6.02	10.79	16.1	10.89	16.2	1200	8.27	2210	15.24

A For each pipe size, use the listed test pressure for any wall thickness not exceeding "standard weight."

METRIC CONVERSION: 1 in. = 25.4 mm 1 mm = 0.0394 in.

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

PIPE

Table 28
DIMENSIONS
NOMINAL WEIGHTS (Plain Ends)
TEST PRESSURES
"Extra Strong" (XS) Pipe — Schedule 80

This pipe can also be furnished with threads and couplings.[A]

NPS Designator	DIMENSIONS				WEIGHTS		TEST PRESSURES			
	Outside Diameter		Wall Thickness		Plain Ends		Butt Welded		Seamless & Electric Resistance Welded[C]	
	in.	mm	in.	mm	lb/ft	kg/m	psi	MPa	psi	MPa
1/8	0.405	10.3	0.095	2.41	0.31	0.47	850	5.86	850	5.86
1/4	0.540	13.7	0.119	3.02	0.54	0.80	850	5.86	850	5.86
3/8	0.675	17.1	0.126	3.20	0.74	1.10	850	5.86	850	5.86
1/2	0.840	21.3	0.147	3.73	1.09	1.62	850	5.86	850	5.86
3/4	1.050	26.7	0.154	3.91	1.47	2.20	850	5.86	850	5.86
1	1.315	33.4	0.179	4.55	2.17	3.24	850	5.86	850	5.86
1-1/4	1.660	42.2	0.191	4.85	3.00	4.47	1300	8.96	1900	13.10
1-1/2	1.900	48.3	0.200	5.08	3.63	5.41	1300	8.96	1900	13.10
2	2.375	60.3	0.218	5.54	5.02	7.48	1300	8.96	2500	17.24
2-1/2	2.875	73.0	0.276	7.01	7.66	11.41	1300	8.96	2500	17.24
3	3.500	88.9	0.300	7.62	10.25	15.27	1300	8.96	2500	17.24
3-1/2	4.000	101.6	0.318	8.08	12.51	18.63	1700	11.72	2800	19.31
4	4.500	114.3	0.337	8.56	14.98	22.32	1700	11.72	2800	19.31
5	5.563	141.3	0.375	9.52	20.78	30.94	*B*	*B*	2800	19.31
6	6.625	168.3	0.432	10.97	28.57	42.56	*B*	*B*	2740	18.89
8	8.625	219.1	0.500	12.70	43.39	64.64	*B*	*B*	2430	16.75
10*D*	10.750	273.0	0.500	12.70	54.74	81.52	—	—	1950	13.44
12*E*	12.750	323.8	0.500	12.70	65.42	97.43	*B*	*B*	1650	11.38
14*E*	14.000	355.6	0.500	12.70	72.09	107.39	—	—	1500	10.34
16*F*	16.000	406.4	0.500	12.70	82.77	123.30	—	—	1310	9.03

A The taper of threads on pipe is 3/4 in./ft. (62.5 mm/m) on the diameter for all sizes.
B Butt welded pipe is not made larger than 4 NPS.
C Seamless pipe in some of the smaller sizes may be cold drawn.
D Schedule 60 pipe
E Schedule XS (not Schedule 80 pipe)
F Schedule 40 pipe

METRIC CONVERSION: 1 in. = 25.4 mm 1 mm = 0.0394 in.

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

PIPE

Table 29
DIMENSIONS
NOMINAL WEIGHTS (Plain Ends and Threads[A] & Couplings)
TEST PRESSURES
Pipe 8 in. & Larger — Schedules 30 & 40

NPS Designator[B]	DIMENSIONS Outside Diameter in.	Outside Diameter mm	Wall Thickness[C,D] in.	Wall Thickness[C,D] mm	WEIGHTS[D] Plain Ends lb/ft	Plain Ends kg/m	Threads & Couplings lb/ft	Threads & Couplings kg/m	TEST PRESSURES[A] Seamless & Electric Resistance Welded psi	TEST PRESSURES[A] Seamless & Electric Resistance Welded MPa
8	8.625	219.1	0.277	7.04	24.70	36.3	25.55	38.1	1350	9.31
8[E]	8.625	219.1	0.322	8.18	28.55	42.5	29.35	43.7	1570	10.82
10[F]	10.750	273.0	0.279	7.09	31.20	46.5	32.75	48.8	1090	7.52
10	10.750	273.0	0.307	7.80	34.24	51.0	35.75	53.3	1200	8.27
10[E]	10.750	273.0	0.365	9.27	40.48	60.3	41.85	62.4	1430	9.86
12	12.750	323.8	0.330	8.38	43.77	65.2	45.45	67.7	1090	7.52
12[G]	12.750	323.8	0.375	9.52	49.56	73.8	51.15	76.2	1240	8.55
14	14.000	355.6	0.375	9.52	54.57	81.3	—	—	1120	7.72
16	16.000	406.4	0.375	9.52	62.58	93.2	—	—	980	6.76

A The taper of threads on pipe is 3/4 in./ft. (62.5 mm/m) on the diameter for all sizes.

B Sizes larger than those shown in the table are measured by their outside diameter. These larger sizes will be furnished with plain ends, unless otherwise specified. The weights will correspond to the manufacturer's published standards although it is possible to calculate the theoretical weight for any given size and wall thickness on the basis of 1 in.^{3} of steel weighing 0.2833 lb. For pipe over 12 NPS, and for walls other than those included in the table, the test pressures should be calculated by the following equation:

$$P = \frac{2St}{D}$$

where:
P = pressure, psi,
S = tensile strength divided by appropriate safety factor
t = specified wall thickness, in., and
D = specified outside diameter, in.

C Wall thicknesses other than shown (Schedules 10, 20, 60, etc.) are a matter of agreement between the purchaser and the manufacturer.

D As more than one weight is listed under the same size, the order must definitely specify both the weight and wall thickness required.

E Schedule 40 pipe

F 10 NPS pipe with a 0.279 in. wall is not covered by a schedule number.

G Owing to a departure from the wall thickness for 12 NPS size, Schedule 40 of the wall thickness 0.375 in. may be substituted for 0.406 in. where agreeable to the purchaser and suitable for the service conditions.

Table 30
PERMISSIBLE VARIATIONS IN WEIGHT AND DIMENSIONS

WEIGHT—The weight of the pipe covered by Tables 27, 28, and 29 shall not vary more than ± 10% from that prescribed.

DIAMETER—For pipe 1-1/2 NPS and under, the outside diameter at any point shall not vary more than1/64 in. (0.40 mm) over nor more than 1/32 in. (0.79 mm) under the standard specified. For pipe 2 NPS and over, the outside diameter shall not vary more than ± 1% from the standard specified.

WALL THICKNESS—The minimum wall thickness at any point shall not be more than 12.5% under the nominal wall thickness specified.

METRIC CONVERSION: 1 in. = 25.4 mm 1 mm = 0.0394 in.

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

STAINLESS STEEL TUBING

Table 31
PERMISSIBLE VARIATIONS IN OUTSIDE DIAMETER[A]
Pressure Tubing (ASTM A 213 [Except Average Wall], ASTM A 249*)
Welded and Cold Finished Seamless

Outside Diameter in. (mm)	Permissible Variations in. (mm)	
	Over	Under
Under 1 (25.4)	0.004 (0.10)[B]	0.004 (0.10)[B]
1-1/2 (25.4–38.1) incl	0.006 (0.15)[B]	0.006 (0.15)[B]
Over 1-1/2–2 (38.1–50.8) excl	0.008 (0.20)[B]	0.008 (0.20)[B]
2–2-1/2 (50.8–63.5) excl	0.010 (0.25)	0.010 (0.25)
2-1/2–3 (63.5–76.2) excl	0.012 (0.30)	0.012 (0.30)
3–4 (76.2–101.6) incl	0.015 (0.38)	0.015 (0.38)
Over 4–7-1/2 (101.6–190.5) incl	0.015 (0.38)	0.025 (0.64)
Over 7-1/2–9 (190.5–228.6) incl	0.015 (0.38)	0.045 (1.14)

A Except as provided in ■ these permissible variations include out-of-roundness. These permissible variations in outside diameter apply to welded and cold finished seamless tubes before other fabricating operations such as upsetting, swaging, expanding, bending, or polishing.

B For cold finished **seamless** austenitic steel tubes under 2 in. (50.8 mm) outside diameter, the maximum outside diameter variation may be ±0.010 in. (0.25 mm). This increased variation is necessitated by ovality and is not to be added to the values in Table 31.

■ Thin-wall tubes usually develop significant ovality (out-of-roundness) during final annealing or straightening, or both. Thin-wall tubes are defined as those meeting the specified outside diameters and specified wall thicknesses set forth as follows:

Specified OD	Specified Wall Thickness
2 in. (50.8mm) and less	2% or less of specified outside diameter
Greater than 2 in. (50.8 mm)	3% or less of specified outside diameter
All diameters	0.020 in. (0.51 mm) or less

The diameter tolerances of Table 31 are not sufficient to provide for additional ovality expected in thin-wall tubes and, for such tubes, are applicable only to the **mean** of the extreme (maximum and minimum) outside diameter readings in any one cross section. However, for thin-wall tubes the **difference** in extreme outside diameter readings (ovality) in any one cross section shall not exceed the following ovality allowances:

Outside Diameter	Ovality Allowance
1 in. (25.4 mm) and under	0.020 in. (0.51 mm)
Over 1 in. (25.4 mm)	2.0% of specified outside diameter

Table 32
PERMISSIBLE VARIATIONS IN DIMENSIONS
ASTM A 269*

Group	Outside Diameter in (mm)	Permissible Variations in Outside Diameter in. mm	Permissible Variations in Wall Thickness[A] %	Permissible Variations in Cut Length in. (mm)[B] Over	Under	Thin Walled Tubes[C] in. (mm)
1	Up to 1/2 (12.7)	±0.005 (0.13)	±15	1/8 (3.2)	0	—
2	1/2-1-1/2 (12.7-38.1) excl	±0.005 (0.13)	±10	1/8 (3.2)	0	less than 0.065 (1.65) nominal
3	1-1/2-3-1/2 (38.1-88.9) excl	±0.010 (0.25)	±10	3/16 (4.8)	0	less than 0.095 (2.41) nominal
4	3-1/2-5-1/2 (88.9-139.7) excl	±0.015 (0.38)	±10	3/16 (4.8)	0	less than 0.150 (3.81) nominal
5	5-1/2-8 (139.7-203.2) excl	±0.030 (0.76)	±10	3/16 (4.8)	0	less than 0.150 (3.81) nominal

A When tubes as ordered require wall thicknesses 3/4 in. (19.0 mm) or over, or an inside diameter 60% or less of the outside diameter, a wider variation in wall thickness is required. On such sizes a variation in wall thickness of 12.5% over or under will be permitted. For tubes less than 1/2 in. (12.7 mm) in inside diameter which cannot be successfully drawn over a mandrel, the wall thickness may vary ± 15% from that specified.

B These tolerances apply to cut lengths up to and including 24 ft (7.3 m). For lengths greater than 24 ft (7.3 m), the above over tolerances shall be increased by 1/8 in. (3 mm) for each 10 ft (3 m) or fraction thereof over 24 ft, or 1/2 in. (13 mm), whichever is lesser.

C The permissible variations in outside diameter given in Table 32 are not sufficient to provide for ovality in thin-walled tubes, as defined in the Table. In such tubes, the maximum and minimum diameters at any cross section shall deviate from the nominal diameter by no more than twice the permissible variation in outside diameter given in Table 32; however, the mean diameter at that cross section must still be within the given permissible variation.

METRIC CONVERSION: 1 in. = 25.4 mm 1 mm = 0.0394 in.

*Welded tubing dual certified to ASTM A 249 and ASTM A 269. The more restrictive tolerance applies.

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

STAINLESS STEEL TUBING

Table 33
PERMISSIBLE VARIATIONS IN STRAIGHTNESS

ASTM A 213	Each tube shall be reasonably straight
ASTM A 249	.030 in 3 ft
ASTM A 269	Each tube shall be reasonably straight

Table 34
PERMISSIBLE VARIATIONS IN WALL THICKNESS

Wall thickness tolerances shall be ± 10% of nominal wall for all tubing sizes.

Table 35
PERMISSIBLE VARIATIONS IN DIMENSIONS
Square and Rectangular Tubing
(Except .180 Wall)

OUTSIDE DIMENSION TOLERANCES

Largest Nominal Outside Dimension Across Flats, in. (mm)	Wall Thickness in. (mm)	Convexity or Concavity in. (mm), incl. plus or minus
To 1-1/4 (31.8) incl	All	0.015 (0.38)
Over 1-1/4–2-1/2 (31.8–63.5) incl	All	0.020 (0.51)
Over 2-1/2–5-1/2 (63.5–139.7) incl	All	0.030 (0.76)
Over 5-1/2–8 (139.7–203.2) incl	All	0.060 (1.52)

MAXIMUM RADII OF CORNERS

Wall Thickness in. (mm)	Radii of. Corners, max. in. (mm)
Over 0.020–0.049 (0.51–1.24) incl	3/32 (2.4)
Over 0.049–0.065 (1.24–1.65) incl	1/8 (3.2)
Over 0.065–0.083 (1.65–2.11) incl	9/64 (3.6)
Over 0.083–0.095 (2.11–2.42) incl	3/16 (4.8)
Over 0.095–0.109 (2.42–2.77) incl	13/64 (5.2)
Over 0.109–0.134 (2.77–3.40) incl	7/32 (5.6)
Over 0.134–0.156 (3.40–3.96) incl	1/4 (6.4)
Over 0.156–0.200 (3.96–5.08) incl	3/8 (9.5)
Over 0.200–0.250 (5.08–6.35) incl	1/2 (12.7)
Over 0.250–0.375 (6.35–9.53) incl	3/4 (19.1)

TWIST TOLERANCES

Largest Size in. (mm)	Twist in 3 ft. max. in. (mm/m)
Under 1/2 (12.7)	0.050 (1.4)
1/2–1-1/2 (12.7–38.1) incl	0.075 (2.1)
Over 1-1/2–2-1/2 (38.1–63.5) incl	0.095 (2.6)
Over 2-1/2 (63.5)	0.125 (3.5)
Over 4–6 (101.6–152.4) incl	0.250 (6.9)
Over 6 (152.4)	0.375 (10.4)

SQUARENESS OF SIDES

Plus and Minus $B = C \times 0.006$

where:
B = tolerance for out-of-square, and
C = length of longest side

STRAIGHTNESS TOLERANCES

The straightness tolerance is 0.075 in. in 3 ft or 2.1 mm in 1 m using a 3-ft (1-m) straightedge and a feeler gage.

WALL THICKNESS TOLERANCES

Wall tolerance is ± 10% of nominal wall thickness.

METRIC CONVERSION: 1 in. = 25.4 mm 1 mm = 0.0394 in.

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

STAINLESS STEEL PIPE

Table 36
PERMISSIBLE VARIATIONS IN OUTSIDE DIAMETER
Seamless and Welded Pipe

Nominal Pipe Size in. (mm)	Permissible Variations in Outside Diameter			
	Over		Under	
	in.	mm	in.	mm
1/8–1-1/2 (3.18–38.10) incl	1/64 (0.015)	0.4	1/32 (0.031)	0.8
Over 1-1/2– 4 (38.10– 101.6) incl	1/32 (0.031)	0.8	1/32 (0.031)	0.8
Over 4 – 8 (101.6 – 203.2) incl	1/16 (0.062)	1.6	1/32 (0.031)	0.8
Over 8 –18 (203.2 – 457.2) incl	3/32 (0.093)	2.4	1/32 (0.031)	0.8
Over 18 –26 (457.2 – 660.4) incl	1/8 (0.125)	3.2	1/32 (0.031)	0.8
Over 26 –34 (660.4 – 863.6) incl	5/32 (0.156)	4.0	1/32 (0.031)	0.8
Over 34 –48 (863.6 –1219.2) incl	3/16 (0.187)	4.8	1/32 (0.031)	0.8

Table 37
PERMISSIBLE VARIATIONS IN WALL THICKNESS
Seamless and Welded Pipe
(No Filler Metal Added)

The minimum wall thickness at any point shall not be more than 12.5% under the nominal wall thickness specified.

Table 38
DIMENSIONS
Seamless and Welded Stainless Steel Pipe
The decimal thickness listed for the respective pipe sizes represents their nominal or average wall dimensions.

NPS Designator	Outside Diameter		Nominal Wall Thickness							
			Schedule 5S[A]		Schedule 10S[A]		Schedule 40S		Schedule 80S	
	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
1/8	0.405	10.29	—	—	0.049	1.24	0.068	1.73	0.095	2.41
1/4	0.540	13.72	—	—	0.065	1.65	0.088	2.24	0.119	3.02
3/8	0.675	17.15	—	—	0.065	1.65	0.091	2.31	0.126	3.20
1/2	0.840	21.34	0.065	1.65	0.083	2.11	0.109	2.77	0.147	3.73
3/4	1.050	26.67	0.065	1.65	0.083	2.11	0.113	2.87	0.154	3.91
1.0	1.315	33.40	0.065	1.65	0.109	2.77	0.133	3.38	0.179	4.55
1-1/4	1.660	42.16	0.065	1.65	0.109	2.77	0.140	3.56	0.191	4.85
1-1/2	1.900	48.26	0.065	1.65	1.109	2.77	0.145	3.68	0.200	5.08
2	2.375	60.33	0.065	1.65	0.109	2.77	0.154	3.91	0.218	5.54
2-1/2	2.875	73.03	0.083	2.11	0.120	3.05	0.203	5.16	0.276	7.01
3	3.500	88.90	0.083	2.11	0.120	3.05	0.216	5.49	0.300	7.62
3-1/2	4.000	101.60	0.083	2.11	0.120	3.05	0.226	5.74	0.318	8.08
4	4.500	114.30	0.083	2.11	0.120	3.05	0.237	6.02	0.337	8.56
5	5.563	141.30	0.109	2.77	0.134	3.40	0.258	6.55	0.375	9.52
6	6.625	168.28	0.109	2.77	0.134	3.40	0.280	7.11	0.432	10.97
8	8.625	219.08	0.109	2.77	0.148	3.76	0.322	8.18	0.500	12.70
10	10.750	273.05	0.134	3.40	0.165	4.19	0.365	9.27	0.500[B]	12.70[B]
12	12.750	323.85	0.156	3.96	0.180	4.57	0.375[B]	9.52[B]	0.500[B]	12.70[B]
14	14.000	355.60	0.156	3.96	0.188[B]	4.78[B]	—	—	—	—
16	16.000	406.40	0.165	4.19	0.188[B]	4.78[B]	—	—	—	—
18	18.000	457.20	0.165	4.19	0.188[B]	4.78[B]	—	—	—	—
20	20.000	508.00	0.188	4.78	0.218[B]	5.54[B]	—	—	—	—
22	22.000	558.80	0.188	4.78	0.218[B]	5.54[B]	—	—	—	—
24	24.000	609.60	0.218	5.54	0.250	6.35	—	—	—	—
30	30.000	762.00	0.250	6.35	0.312	7.92	—	—		

A Schedules 5S & 10S wall thicknesses do not permit threading in accordance with the American National Standard for Pipe Threads (ANSI B1.20.1).
B These do not conform to the American National Standard for Welded & Seamless Wrought Steel Pipe (ANSI B36.10-1979).

METRIC CONVERSION: 1 in. = 25.4 mm 1 mm = 0.0394 in.

Central Steel & Wire Company

Product Guide

STAINLESS STEEL

Overview 2
General Characteristics 2
Sizes and Shapes 3
Vinyl Coverings 3
Finishes and Color 3
End Uses 4
Sales Advantages 4

Tolerances
— Sheets 5
— Plates 5
— Bars ..... 5 - 6

Recommended Machining Allowances 7

Technical Data 7

OVERVIEW

WHAT IS STAINLESS STEEL? It is an iron-based metal that has at least 10.5% chromium. Other alloying elements, such as nickel, molybdenum, manganese, can be added as well as additional amounts of chromium to achieve specific corrosion resistance and physical properties.

The terms "Martensite" and "Austenite" describe different types of microstructures that exist in certain types of stainless steel.

Martensitic T-4XX – Those grades of stainless steel with chromium as their major alloy addition, and are hardenable by heat treatment. These grades are also magnetic.

Austenitic T-3XX – Those grades of stainless steel with both chromium and nickel as their major alloying additions. These grades are non-hardenable, and are non-magnetic. They also represent superior corrosion resistance when compared with the T-4XX grades.

WHY DOESN'T IT RUST? Stainless steel does not RUST (red rust that one normally sees on carbon steel is iron oxide), because it contains chromium and has a very low carbon content (compared to mild steel). The chromium combines with oxygen in the air to form a very adherent surface passive film that resists further oxidation. No iron is oxidized; therefore, no red rust.

GENERAL CHARACTERISTICS

Specific stainless steel grades are primarily selected because of their corrosion resistance, mechanical properties, and weldability

Relative Corrosion Resistance*	Machinability (1212=100%)	Attracted to Magnet	Heat Treatable	Relative Weldability	Comments
BEST					
T316/T316L	40%	No	No	Very Good	Consists of chromium (16%) *and* nickel (10%), but also contains 2% molybdenum. The additional alloying increases the resistance to salt corrosion. "L" grades enhance weldability.
T304 T304L T304/T304L	45%	No	No	Very Good	T304 represents the most widely used austenitic stainless steel grade. It has a carbon of .08% max, which is lower than T302 (.15% max). This lower carbon serves as an advantage in welding applications because the lower carbon helps to minimize harmful carbide precipitation near the weld which damages the corrosion resistance. T304L was developed as an improvement to T304. It has even lower carbon (.030% max Carbon). This lowered carbon protects the corrosion resistance even further during welding, and would be preferred when welding is involved, and there is exposure to extreme chemicals. Whenever possible, we order our material dual certified to meet both grades. We describe this as T304/T304L. This material is produced to meet both grades, and can be sold either way.
T321	42%	No	No	Very Good	
17-4 Cond A	45%	Yes	Yes	Good	"17-4 PH" is a trade name that describes the same product as our "17-4". Both products are produced to the same ASTM and AMS specifications.
T303	73%	No	No	Poor	
T430	55%	Yes	No	Fair	Straight chromium type stainless (no nickel) with 16% chromium.
T440 FSe	48%	Yes	Yes	Poor	
T416	90%	Yes	Yes	Poor	
LEAST					

***** The letter L in some of the listed grade designations stands for low carbon. We cannot select T304 to comply with T304L due to differences in the yield strength and the lack of the corrosion test specified with T304L. All items of T316/316L are currently purchased "dual certified".

Product Guide - Stainless Steel (contd)

SIZES AND SHAPES	
Stock Sizes – See Stock List	
Sheets	0.001 – under 0.020" is called "foil" 0.020 – under 0.375" (either as cut sheets or as coils) Nonstandard sheet lgth may be available thru the "Coil Program"
Plates	0.375" thk & over – up to 10" thk Plate Mill Plate (PMP): Item 96" wide or 1/2 - 1-3/4" thk x 48/60" wide & 96,120,144 or 240" lgth Continuous Mill Plate (CMP): 3/16 – 3/8" thk & 72" wide and less x any stock lgth
Long Products (Rd, Sq, Rect, Hex, Octagon)	0.1875" thk & up
Rectangles	True bar: closer tolerance than strip or plate flat, but 30/40% more expensive Strip flat: slit from coil. Special widths & lgths available not listed in our stock list (lower in cost) Plate flat: sheared from plate. Special widths available up to 10" generally available 3/8 & 1/2", but also in 5/8 & 3/4" (lower in cost)
Wire	0.703 to 0.003" rd

VINYL COVERINGS		
May not be available in all widths – check with Stainless Dept for availability		
Vinyl	**Thickness**	**Comments**
Black/White	3.5/4.0 mil	Customers use for protection when fabricating on either 2B finish or polished stainless
Clear	3.5/4.0 mil	Allows customers some limited visibility for surface imperfections prior to fabricating
Generic Laser – Blue Stencil	3.5/4.0 mil	We stock from two manufacturers. Blue stencil denotes the tackiest which is the most difficult to remove
Nitto Laser – Blue Stencil	3.5/4.0 mil	Some customers request this type only. There should be no difference between Nitto and any other manufacturer of laser vinyl. Other colors are available that are less tacky: grey and red. We don't stock these other colors.
Laserite Duo	3.5/4.0 mil	Laser vinyl designed for both Fiber Optic & CO2 machines. Manufacturer claims that it is easier to remove than blue stencil material. It is a grey film.

FINISHES & COLOR	
SHEET & PLATE	
In addition to standard finishes, there are several special finishes that are available. Finishes can be "rolled-on", embossed or etched in a wide variety of patterns and designs. Very different and remarkable finishes can be achieved by mechanical treatments to the surface to provide interesting textures and patterns including perforations, knitting, weaving and cutting and expanding the material. Stainless can be "colored" by electrochemical coloring, sputtering, plating and by using resin-based paints. All customer inquiries regarding the "RA" surface finish of any product should be reviewed with the Stainless Department.	
No. 1	Hot rolled, annealed & descaled – dull gray
No. 2D	Cold rolled, annealed & descaled – dull metallic gray
No. 2 B	Cold rolled, annealed, descaled & temper rolled – bright velvety
Bright Annealed	Bright cold rolled finish retained by final annealing in a controlled atmosphere furnace
No. 3	Intermediate polished finish, usually 100 grit, 1 or 2 sides
No. 4	General purpose polished finish, usually 150 grit, 1 or 2 sides
No. 4 Dairy	Similar to No. 4 – guaranteed pit free
Kool Line	Rolled on embossed finish with similar appearance as #4 Dairy – proprietary J&L product
No. 6	Dull satin finish, Tampico brushed, 1 or 2 sides
No. 7	High luster finish or near mirror (has some lines)
No. 8	Mirror finish
ROUND BAR	
CF	Least expensive, machining allowances required to removed surface defects
ST or Ground *	Surface is defect-free within the standard diameter tolerance
G&P	Best finish (rms 20 or finer) – 3/16 - 1" is stocked with special tolerance (+.000 –.0005) which is half standard
RT	Produced on plus side and will be defect free at nominal size

* Smooth Turned or Ground

END USES

FABRICATION

Stainless steel can be fabricated by methods similar to those used for carbon steel and other common metals. However, changes may be necessary to the extent that they differ in yield strength and rate of work hardening. All stainless steels have a work hardening rate higher than carbon steel; the 300 series (304, 316) are characterized by large increases in strength and hardness when cold worked. For example: if one can cut or shear a piece of carbon steel 0.40" in thickness, then the equipment used to cut will only be able to shear a piece of stainless steel 0.20" in thickness. Every time a piece of stainless steel is bent or a saw blade passes over the surface, the material will increase in hardness and become stiffer. Stainless steels also tend to "springback" after being bent, to a much greater extent than mild steel. It is therefore necessary to over bend stainless to obtain the desired bend. Care in the shop is extremely important when fabricating stainless steel. Care should be taken to protect the surface of the material (plastic film is available on certain finishes and should be left on during processing.) Contact with carbon steel tools or handling equipment should be prevented as the stainless steel can pick up carbon steel particles, which will lodge in the surface and subsequently will rust. If you see red rust on the surface of stainless steel, it is probably from some source of contamination, such as the use of a steel brush (steel wool) on the surface of the stainless steel was dragged over a carbon steel support member. A chemical cleaning process called passivation is effective in removing this contamination.

WELDING

As is the case for carbon steel grades, most stainless grades we stock are weldable, but some are not (see "General Characteristics" page 2). For those stainless grades that are weldable, the welding processes and welding electrode selection is different from carbon steel.

MACHINABILITY

Stainless steels can be machined; however, the "gummy" nature of the material makes the standard grades difficult. Several specially developed stainless grades exist that have been altered to provide excellent machining characteristics.

SALES ADVANTAGES

Material certification is traceable to manufacturing source

Material	Type*	Purchasing Specification	Advantage
ALL STAINLESS		Certified free from mercury contamination	Nuclear requirement
ANGLES	304, 316	Both grades are dual certified	Improved weldability
BARS	304, 316	Spec calls for .030% max S CS&W aim for .020 - .030% S Both grades are dual certified	Optimum machinability Improved weldability
	303	Spec calls for .15% min S CS&W .32 S (aim for .35% min S)	Optimum machinability
	416	CS&W .32 min S (aim for .35% S) Special chemistry	Optimum machinability Hardenability to RC 35-45
	17-4	Spec calls for .030% max S CS&W aim for .010 - .030% S	Optimum machinability
SHEETS			More sizes in stock available for immediate shipment than any other service center in the industry.
	304/304L 316/316L 430	#3 POS 10-23 RA (100 grit) #4 POS 24-35 RA (150 grit) Polish sheets with full back pass	Mill flat sheet, 100% inspected Consistent finish
PLATES		Product dual certified	More sizes in stock available for immediate shipment than any other service center in the industry
	304 2B	Polishing quality	Reduces mechanical finishing costs

*****Types designated with two grades are dual certified. They meet the requirements of both specifications.

TOLERANCES ARE FOR REFERENCE ONLY

Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

TOLERANCES – STAINLESS STEEL SHEETS, PLATES, BARS

SHEETS

	304 - 304L – 316/316L – 430 (Up to 72" wide)		321 (Up to 48" wide)	
Pricing Gage	Nominal Size, in.	Producing Range	Nominal Size, in.	Producing Range
7	.1874	.1804 - .1944		
8	.165	.158 - .172		
10	.135	.129 - .141		
11	.120	.114 - .124		
12	.105	.098 - .108		
13	.090	.083 - .091		
14	.075	.071 - .079	.080	.076 - .084
16	.060	.0565 - .0625	.063	.060 - .066
18	.048	.045 - .051	.050	.047 - .053
19	.042	.039 - .045		
20	.036	.0335 - .0375	.036	.034 - .038
22	.030	.027 - .031		
24	.024	.022 - .025		
26	.018	.0163 - .0193		
28	.015	.0131 - .0161		

FLATNESS TOLERANCES – SHEETS*

Specified Thickness, in.	Width, in.	Flatness Tolerance**, in.
Less than 0.062	60 or narrower	0.40
	Greater than 60	0.50
0.062 and thicker	60 or narrower	0.40
	Greater than 60	0.50

*Not specified to stretcher-leveled standard of flatness, and not including hard tempers of 2xx and 3xx Series, dead-soft sheets, and deep-drawing sheets.
**Maximum deviation from a horizontal flat surface. (Flatness tolerance applies only in the stock size condition.)

PLATES

	Width, in.			
	Up to 60	Over 60 to 72	Over 72 to 84	Over 84 to 96
Thickness, in.	Tolerances* (Plus)			
3/16 - 5/16	.022	.022	.045	.050
Over 5/16 - 3/8 excl	.028	.028	.045	.050
3/8 - 1/2	.028	.030	.055	.060
Over 1/2 - 3/4 excl	.055	.055	.055	.060
3/4 - 1 excl	.060	.060	.065	.065
1 - 2 excl	.070	.070	.070	.075
2 - 3 excl	.125	.125	.125	.150
3 - 4 excl	.175	.175	.175	.210

* Measured longitudinal edge 3/8 to 3" from original edge
Tolerance under specified thickness is minus .010. Floor Plate tolerance not included

ROUNDS

Size, in.	CF (Surface Finish RA55 & Above) Smooth Turned** (RA32/50)	Rough Turned	
	Tolerance, in.		
.0440 - .3125 excl	±.001		
.3125 - .5000 excl	±.0015		
.5000 - 1.000 excl	±.002		
1.000 - 1.500 excl	±.0025		
1.500 - 2.500 incl	±.003	+1/32	–0
Over 2.500 - 3.500 incl	±.003	+3/64	–0
Over 3.500 - 4.000 incl	±.003	+1/16	–0
Over 4.000 - 4.500 incl	±.005	+1/16	–0
Over 4.500 - 5.000 incl	±.008	+5/64	–0
Over 5.000 - 5.50 incl	±.008	+5/64	–0
Over 5.50 - 6.00 incl	±.008	+1/8	–0
Over 6.00 - 8.00 incl	CFA not available over 6" rd	+5/32	–0
Over 8.00 - 12.00 incl		+3/16	–0

* G&P Accuracy – Half Std Tolerance (Surface Finish RA20 or less)

CF BARS

Straightness Tolerance 1/16" in any 5 ft.

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

TOLERANCES
STAINLESS STEEL BARS, STRIP & PLATE FLATS

BEARING SHAFT QUALITY BARS

Size, in.	Size, in.
.4995/.4985	1.3120/1.3110
.6245/6235	1.3745/1.3735
.7495/.7485	1.4370/1.4360
.8745/.8735	1.4995/1.4985
.9995/.9985	1.7495/1.7480
1.1245/1.1235	1.9995/1.9980
1.1870/1.1860	2.2495/2.2480
1.2495/1.2485	2.4995/2.4975

HEXAGONS & SQUARES

Size, in.	Tolerance, in.* All Minus +.000
.125 - .3125 excl	–.002
.3125 - .500 excl	–.003
Over .500 - 1.000 incl	–.004
Over 1 - 2 incl	–.006
Over 2 - 3 incl	–.008
Over 3	–.010

***** Double tolerances if heat treated

STRIP & PLATE FLATS

Order Thickness	Permitted Variation in Thickness in. (mm)		Permitted Variation[A] in Width			
			Widths to 4 (100)		Widths Over 4 (100)	
	Over	Under	Over	Under	Over	Under
Over 0.114 - 0.130 (2.90 - 3.30) incl	0.010 (0.25)	0.010 (0.25)	0.094 (2.40)	0.031 (0.80)	0.094 (2.40)	0.094 (2.40)
Over 0.130 - 0.145 (3.30 - 3.70) incl	0.012 (0.30)	0.012 (0.30)	0.094 (2.40)	0.031 (0.80)	0.094 (2.40)	0.094 (2.40)
Over 0.145 - under 3/16 (3.70 - 4.80)	0.014 (0.35)	0.014 (0.35)	0.094 (2.40)	0.031 (0.80)	0.094 (2.40)	0.094 (2.40)
3/16 - 3/8 (4.80 - 9.00) excl	0.050 (1.25)	0.010 (0.25)	0.094 (2.40)	0.031 (0.80)	0.094 (2.40)	0.094 (2.40)
3/8 - 3/4 (9.00 - 19.00) excl	0.060 (1.50)	0.010 (0.25)	0.094 (2.40)	0.031 (0.80)	0.094 (2.40)	0.094 (2.40)
3/4 - 1 (19.00 - 25.00) excl	0.065 (1.65)	0.010 (0.25)	0.094 (2.40)	0.031 (0.80)	0.094 (2.40)	0.094 (2.40)
1 - 2 (25.00 - 50.00) excl	0.075 (1.90)	0.010 (0.25)	0.094 (2.40)	0.031 (0.80)	0.094 (2.40)	0.094 (2.40)

SOURCE: ASTM A 484-11

[A] By agreement between purchaser and seller, tolerances can be shifed as desired to any combination of plus-minus tolerance between all minus and all plus.

BAR FLATS (HRAP)

Specified Width in. (mm)	Permitted Variations in Thickness for Thicknesses Given in. (mm)				Permitted Variations in Width in. (mm)	
	1/8 – 1/2 (3.2 - 13) incl		Over 1/2 - 1 (13 - 25) incl			
	Over	Under	Over	Under	Over	Under
To 1 (25.00) incl	0.008 (0.20)	0.008 (0.20)	0.010 (0.25)	0.010 (0.25)	0.015 (0.40)	0.015 (0.40)
Over 1 - 2 (25.00 - 50.00) incl	0.012 (0.30)	0.012 (0.30)	0.015 (0.40)	0.015 (0.40)	0.031 (0.80)	0.031 (0.80)
Over 2 - 4 (50.00 -100.00) incl	0.015 (0.40)	0.015 (0.40)	0.020 (0.50)	0.020 (0.50)	0.062 (1.60)	0.031 (0.80)
Over 4 - 6 (100.00 - 150.00) incl	0.015 (0.40)	0.015 (0.40)	0.020 (0.50)	0.020 (0.50)	0.093 (2.40)	0.062 (1.60)

SOURCE: ASTM A 484-11

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

RECOMMENDED MACHINING ALLOWANCES – STAINLESS STEEL

CF BARS (Rd, Sq, Hex)	
Size, in.	**Recommended Stock Removal Per Side**
Up to .3125	.003
Over .3125	1% of size

CENTERLESS GROUND OR GROUND & POLISHED (RT produced oversize to clean up defect-free at size)
• Material expected to be free of surface defects • Light handling scratches may be present

FLATS	
Strip flats	Defects no deeper than undersize tolerance
Plate flats	Defects no deeper than undersize tolerance
Bar flats	See table below per side

	Width, in.				
Thickness, in.	**Up to 1**	**Over 1 to 2**	**Over 2 to 3**	**Over 3 to 4**	**Over 4 to 6**
1/8 - 1/2 excl	.008	.012	.015	.015	.015
1/2 - 1 excl	.010	.015	.020	.020	.020
1 - 2 excl	—	.031	.031	.031	.031
Removal from width each side	.015	.031	.047	.062	.093

TECHNICAL DATA

Chemical Composition & Mechanical Properties – See Stock List

Central Steel & Wire Company

Product Guide

ALUMINUM

General Characteristics / Overview
— Bar 2
— Sheet 3
— Tube 3
— Plate 4
— Structural Shapes 4
Technical Data 5
Tolerances 6

GENERAL CHARACTISTICS

BAR

Grade		Machinability	Strength	Anodizing	Corrosion Resistance	Comments
2011-T3	CF	A	Medium to High	Inconsistent	D	Long tool wear
2017-T4/T451	CF	A	Medium to High	Inconsistent	D	• We are one of the few warehouses that stock this grade • Good for deep drilling applications
2024	CF	B	High	Inconsistent	D	
4032-T6/T651	CF	B	High	Inconsistent	C	• Developed to eliminate the need for hard coat anodizing • Good wear resistance
6020	CF	A	Medium	Excellent	B	No lead (tin additive)
6061-T6/T651	CF	C	Medium	Excellent	B	Losing market share to extruded version of the alloy
6101-T61 Bus Bar	Extruded					*End use:* electrical applications
6061-T6511	Extruded	C	Medium	Excellent	B	• When you get a 6061-T6/T651 request, ask customer if they can use T6511 (price both ways) huge cost savings. If tolerances are an issue, offer special tolerance which has a price extra but will still be below CF price (see Stock List, p. 169 for tolerances). Same straightness tolerance as CF version (.100 in 12 ft). • In 3/4" & larger cross section, we stock the "H" temper which equates to higher strength & more uniform grain structure, which improves the machining thru better chip formation.
6063-T5/T52	Extruded	C to D	Low to Medium	Excellent	High	*End use:* architectural applications, irrigation pipe, furniture
6262-T8/T9	CF	B	Medium to High	Excellent	B	• 6061 alloy with lead which improves machining • T8 temper offers residual stress control after machining but has lower strength than T9
6262-T6511	Extruded	B	Medium to High	Excellent	B	• 6061 alloy with lead improves machinability • Lower cost than CF version but has lower strength • **Rectangles not recommended for forming**
7075	CF	B	Highest	Good	C	• Highest strength we carry • *End use:* aircraft parts

A = Best B = Good C = Fair D = Poor

Product Guide – Aluminum (contd)

GENERAL CHARACTERISTICS

SHEET

Grade	Temper	Corrosion Resistance	Strength	Forming	Comments
1100		Almost pure aluminum	Low	Excellent	
	O Dead soft				Good for drawing applications
	H14 Half hard				Offers more rigidity & higher strength than the “O” temper
2024	T3 Bare	Poor	High	Poor	Used where higher strength is needed
	T3 Alclad	Good due to cladding			Alcad product is produced by taking a 2024 aluminum ingot & attaching another grade of aluminum sheet to the top & bottom of the ingot. It is then rolled & the 2024 becomes the core metal while the “other” grade attached to the top/bottom of the ingot before rolling becomes the surface. This surface improves the corrosion resistance of the product and the 2024 core gives the product its strength.
3003		Good	Slightly higher than 1100 series	Good	Popular grade due to its forming capabilities & moderate strength
	O Dead soft				Used more for drawing applications like 1100-O
	H14 Half hard				Has higher strength than “O” temper
5052		Good	Higher than 3003	Good	Popular grade due to its forming and strength characteristics. Alcoa guarantees 1/8" flatness after cutting. *End use:* electrical boxes, cabinets
	O Dead soft				Strength improves as tempers go higher but formability declines, all tempers have good forming characteristics but H32 will form slightly better than H34
	H32 Quarter hard				
	H34 Half hard				
6061		Good	High		
	O				Used for forming along with improved corrosion resistance
	T4				Used for higher strength & moderate forming
	T6				Used for higher strength & is **not** recommended for forming
Roofing & Siding (Corrugated, V-Beam, Ribbed)					*End use:* construction purposes

TUBE

Majority of tube stocked is 6061 in 3 types – this grade is very difficult to bend & is not recommended for forming.
Stock 3003-H14 can be formed using proper bend radius & technique.

Type	Comments
Extruded Seamless *	• Extruded from a hollow or solid ingot • Good for pressure & forming applications • Gives a more uniform anodizing response
Drawn Seamless *	• Produced from extruded hollows. Thru a series of draws it is reduced to its finished size – lighter walls can be made from this process • Tighter tolerances and more expensive than extruded seamless
Extruded Structural *	• Extruded from a solid ingot using a bridge or porthole die. Metal separates & re-welds forming seams down the length • **Not recommended for applications involving pressure, forming, consistent anodizing response** • Seamless is more expensive

***** Refer to Aluminum Dept for tolerances

Product Guide – Aluminum (contd)

OVERVIEW – PLATE	
Selling cut plate	Creates: • added value with the use of our precision saws • reduces work in process • faster throughput

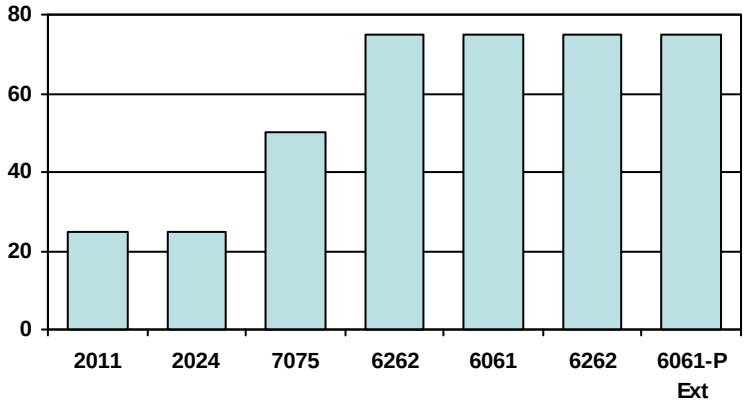
GENERAL CHARACTERISTICS – PLATE		
Grade	**Strength**	**Comments**
1100-F (common alloy plate)	Low	• Bought for forming purposes • Almost pure aluminum • Good conductivity
2024-T351 Bare	High	• Used where higher strength is needed • Poor machining & corrosion resistance
3003-F (common alloy plate)		• Bought for forming purposes • Used when higher strength is needed than 1100-F but still retains good forming characteristics
5052-H32 (common alloy plate)		• Bought for forming purposes • Used when higher strength is needed than 3003-F but will give up some formability
6013	Higher than 6061	• Developed to take out weight & maintain strength
6061-O		• Used when strength is not an issue & where moderate forming is needed along with the corrosion resistance of the 6061 alloy
6061-T651	High typical 40 - 42 ksi yield	• Most popular plate grade • Good weldability • Rolled heat treated product that is stretcher stress relieved for minimum distortion during machining • Used where moderately high mechanical properties are an important consideration
7075-T651	Highest strength we stock	• High cost • *End use:* aerospace
Cast Tool & Jig Plate	Low	• Flatness guaranteed before & after cutting • Thickness tolerance +/– .005" • Tradenames: Mic 6, Alca Plus, & Alca Max • Cast product that is stress relieved & machined with a guaranteed micro finish • Dimensionally stable before & after cutting • *End use:* dies, assembly jigs, inspection fixtures, machinery bases **Note:** if customer asks for "Tool" or "Tooling Plate," you must determined if they want a ROLLED plate (6061-T651) or a CAST plate (Cast Aluminum Tool & Jig Plate)
QC-7 Mold Plate	High	• Dimensionally stable after cutting • Good machining • *End use:* plastic molds
Tread Plate 6061-T6		*End use:* safety applications
Tread Plate 3003-H22 (Bright)		• Can be purchased as fire truck quality (FTQ) which means that the diamond size has controlled tolerances which allows for diamond size consistency, so when using multiple pieces the diamond size will stay consistent • *End use:* cosmetic application

OVERVIEW – STRUCTURAL SHAPES
We stock a wide range of profiles – refer to Stock List for sizes available
Designations are either American Standard, Aluminum Association, or Architectural Shapes
When a customer places an inquiry/order and references one of the designations listed above, double check to make sure that all dimensions match the customers requirements. For example, a 6" american standard channel will have different dimensions than a 6" aluminum association channel
Architectural shapes are typically sharp cornered and are often ordered by using die numbers which are listed in our stock list

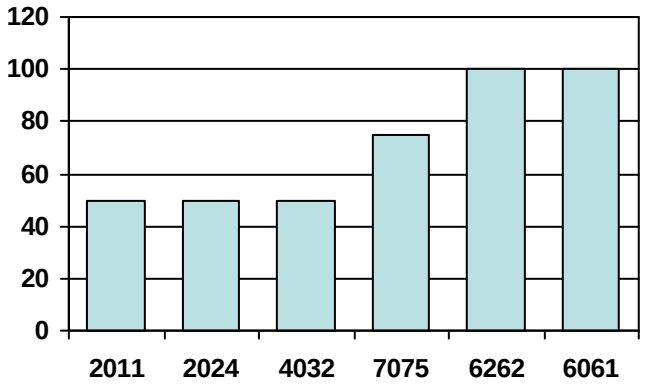
TECHNICAL DATA

Chemical Composition and Mechanical Properties - See Stock List

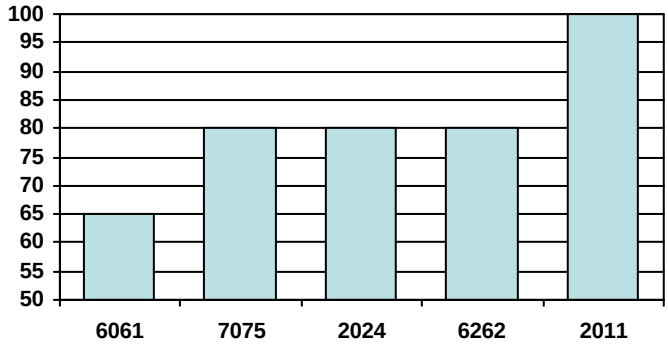
Relative Corrosion Resistance



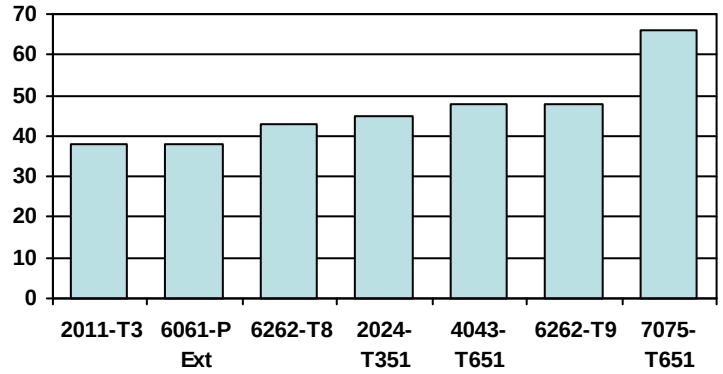
Relative Anodizing Response



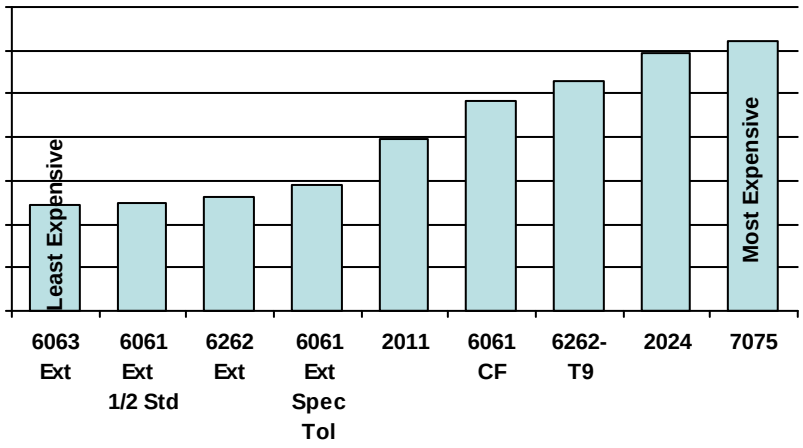
Relative Machinability



Minimum Yield Strength



Relative Prices



TOLERANCES ARE FOR REFERENCE ONLY

Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

TOLERANCES

Aluminum Coil, Sheet, Plate, Bar, Wire (Tubing, Pipe & Extruded Shapes - Refer to Aluminum Dept.)

When slit from Coil - use tolerance of width slit from.

Table 1
SHEET & PLATE THICKNESS TOLERANCES*

Applicable to all alloys not included in the Aerospace Alloys Table 2 or not specified for aerospace applications
NOTE: Also applicable to alloys when supplied as Alclad

SPECIFIED THICKNESS in.		SPECIFIED WIDTH, in.		
		Up thru 39.37	Over 39.37 thru 59.06	Over 59.06 thru 78.74
Over	Thru	Tolerance, in. Plus & Minus		
0.0059	0.016	0.0010	0.0015	—
0.016	0.025	0.0015	0.0020	0.0030
0.025	0.032	0.0020	0.0025	0.0035
0.032	0.039	0.0020	0.0030	0.0035
0.039	0.047	0.0025	0.0035	0.0045
0.047	0.063	0.0030	0.0035	0.0050
0.063	0.079	0.0035	0.0040	0.006
0.079	0.098	0.0035	0.0045	0.006
0.098	0.126	0.0045	0.006	0.007
0.126	0.158	0.006	0.007	0.009
0.158	0.197	0.007	0.009	0.011
0.197	0.248	0.009	0.011	0.013
0.248	0.315	0.012	0.014	0.015
0.315	0.394	0.015	0.017	0.020
0.394	0.630	0.023	0.023	0.027
0.630	0.984	0.031	0.031	0.037
0.984	1.575	0.039	0.039	0.047
1.575	2.362	0.055	0.055	0.060
2.362	3.150	0.075	0.075	0.085
3.150	3.937	0.100	0.100	0.115
3.937	6.299	0.130	0.130	0.145

Table 2
SHEET & PLATE THICKNESS TOLERANCES*

For Aerospace Alloys 2014, 2024, 2124, 2219, 2324, 2419, 7050, 7075, 7150, 7178 & 7475 and other alloys when specified for aerospace applications
NOTE: Also applicable to alloys when supplied as Alclad

SPECIFIED THICKNESS in.		SPECIFIED WIDTH, in.				
		Up thru 39.37	Over 39.37 thru 47.24	Over 47.24 thru 55.12	Over 55.12 thru 59.06	Over 59.06 thru 70.87
Over	Thru	Tolerance, in. Plus & Minus				
0.0059	0.010	0.0010	0.0020	0.0020	0.0020	—
0.010	0.025	0.0015	0.0025	0.0025	0.0025	—
0.025	0.039	0.0015	0.0015	0.0020	0.0030	0.0030
0.039	0.047	0.0020	0.0020	0.0030	0.0030	0.0030
0.047	0.063	0.0020	0.0020	0.0030	0.0030	0.0030
0.063	0.079	0.0020	0.0020	0.0030	0.0035	0.0035
0.079	0.098	0.0025	0.0025	0.0035	0.0040	0.0040
0.098	0.126	0.0035	0.0035	0.0035	0.0045	0.0045
0.126	0.158	0.0040	0.0040	0.0045	0.007	0.007
0.158	0.197	0.0055	0.007	0.007	0.009	0.009
0.197	0.248	0.009	0.012	0.012	0.012	0.017
0.248	0.315	0.012	0.015	0.015	0.015	0.019
0.315	0.394	0.017	0.018	0.018	0.018	0.022
0.394	0.630	0.023	0.023	0.023	0.023	0.028
0.630	0.984	0.031	0.031	0.031	0.031	0.037
0.984	1.575	0.039	0.039	0.039	0.039	0.047
1.575	2.362	0.055	0.055	0.055	0.055	0.060
2.362	3.150	0.075	0.075	0.075	0.075	0.085
3.150	3.937	0.100	0.100	0.100	0.100	0.115
3.937	6.299	0.130	0.130	0.130	0.130	0.145

Table 1 & 2 Note: Capability to provide lighter tolerances may vary with supplier.
* When a dimension tolerance is specified other than as equal bilateral tolerance, the value of the standard tolerance is that which applies to the mean of the maximum and minimum dimensions permissible under the tolerance for the dimension under consideration.

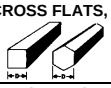
Table 3
TOLERANCES
DRAWN ROUND WIRE & COLD FINISHED ROD

SPECIFIED DIAMETER in.	TOLERANCE, in. Plus & Minus Allowable deviation from specified diameter	
	DRAWN WIRE	COLD FINISHED ROD
Up thru .035	.0005	—
.036 - .064	.001	—
.065 - .374	.0015	—
.375 - .500	—	.0015
.501 - 1.000	—	.002
1.001 - 1.500	—	.0025
1.501 - 2.000	—	.004
2.001 - 3.000	—	.006
3.001 - 3.499	—	.008
3.500 - 5.000	—	.012
5.001 - 6.000	—	.020
6.001 - 7.000	—	.025
7.001 - 8.000	—	.030

RECTANGLES - COLD FINISHED BAR

SPECIFIED THICKNESS & WIDTH, in.	TOLERANCE, in. Plus & Minus Allowable deviation from specified thickness & width	
	Thickness	Width
.125 - .500	.002	.002
.501 - .750	.0025	.0025
.751 - 1.000	.0025	.0025
1.001 - 1.500	.003	.003
1.501 - 2.000	.005	.005
2.001 - 3.000	.008	.008
3.001 - 4.000	Tol subject to inquiry	.010
4.001 - 7.000	"	Tol subject to inquiry

SQUARES & HEXAGONS - DRAWN WIRE & CF BAR



SPECIFIED DISTANCE ACROSS FLATS, in.	TOLERANCE, in. Plus & Minus Allowable deviation from specified distance across flats	
	DRAWN WIRE	COLD FINISHED BAR
.187 - .374	.002	—
.375 - .500	—	.002
.501 - 1.000	—	.0025
1.001 - 1.500	—	.003
1.501 - 2.000	—	.005
2.001 - 3.000	—	.008
3.001 - 5.000	—	Tol subject to inquiry

EXTRUDED BAR TOLERANCES †

SPECIFIED THICKNESS & WIDTH, in.

6063-T5, 6061-T6511, 6262-T6511 Rds, Sqs & Flats
6101-T61 Bus Bar

All Tolerances are Plus or Minus

Size	Tol.	Size	Tol.
Thru .124	.006	2.000 - 3.999	.024
.124 - .249	.007	4.000 - 5.999	.034
.250 - .499	.008	6.000 - 7.999	.044
.500 - .749	.009	8.000 - 9.999	.054
.750 - .999	.010	10.000 - 11.999	.074
1.000 - 1.499	.012	12.000 - 13.999	.084
1.500 - 1.999	.014		

† Special Tolerance Rod not included, see CSW Stock List

Table 4
FLATNESS TOLERANCES - FLAT SHEET

Not applicable to cut-to-length sheet, panel flat sheet, coiled sheet, or sheet over 60 in. wide. Flatness tolerances, including coil set flatness tolerances, for these excluded products, should be as agreed upon in advance between producer and purchaser. Tolerances not applicable to O, F and HX8 and harder tempers; and not applicable to end or corner turnup. Tolerances below do not apply once a stock size sheet is cut.

ALLOY (includes Alclads)	SPECIFIED THICKNESS, in.	Longitudinal or Transverse Distance (ft.) - Center to Center of Buckles or Edge Waves* TOLERANCE, in.**				
		Up thru 2	Over 2 thru 3	Over 3 thru 4	Over 4 thru 6	Over 6
1060, 1100, 1350, 3003, 3005	0.020 thru 0.064	1/8	3/16	3/16	5/16	3/8
3105, 5005, 5050, 5X57	0.065 thru 0.249	1/8	3/16	5/16	3/8	1/2
3004, 5052, 5083, 5086, 5252	0.020 thru 0.064	3/16	3/16	5/16	3/8	1/2
5X54, 5456, 5652, brazing sht, & all heat treatable alloys	0.065 thru 0.249	3/16	5/16	3/8	1/2	9/16

* Also applicable to overall length of width of sheet if only one longitudinal and/or transverse buckle or edge wave is present.
** Allowable deviation from flat with the sheet positioned on flat horizontal surface to minimize deviation.

REFERENCE: ANSI H35.2 - 2006

Central Steel & Wire Company

Product Guide

BRASS & COPPER

General Characteristics
—Rod & Bar 2
—Tubing & Pipe 2
—Sheet & Plate 3
Technical Data 3
Sales Advantages 4
Tolerances 5-7

GENERAL CHARACTISTICS – ROD & BAR				
Alloy & Description	**Machinability**	**Strength**	**Corrosion Resistance**	**Comments**
BRASS				
360	100% (Best)	Medium		Leaded
353	90% (Good)	Medium		• Low lead • Used for thread rolling & knurling
464	30%	High	Good	• Tin additive • *End use:* marine applications
485	70%	High	Good	Tin additive with lead for better machining
COPPER & COPPER ALLOYS				
110	20% (Poor)	Medium	Good	Best conductivity
110 Bus Bar	20%	Medium	Good	• Good conductivity • Square & full round edges • *End use:* electrical switchboards
145	85% (Good)	Medium	Good	• With tellurium • Good conductivity
147	85% (Good)	Medium	Good	• With sulfur • Good conductivity
182 Chromium Copper	20%	Very high		List 2 sizes, stronger than Ampco 18 & 45
316 Commercial Bronze	80%	High	Good	*End use:* belts, fasteners
544 Phosphor Bronze	80%	High		Good wear characteristics
624 Ampco 18W (Rd)	50%	Very high		• Extruded aluminum bronze • Closer tolerance • Extremely good wear resistance
630 Ampco 45	30%	Very high		• Extruded nickel aluminum bronze • Closer tolerance, high strength than Ampco
642 Aluminum Silicon Bronze	60%	Very high	Good	*End use:* valve parts, marine, outdoor hardware
792 Nickel Silver	60%	High		Copper alloy with appearance of silver
932 Bronze Bushing SAE 660	70%	Medium		• Continuous cast solid or tubular • Good wear characteristics
954 Aluminum Bronze (Sq & Rect)	50%	Very high		• Continuous cast • Extremely good wear resistance

GENERAL CHARACTERISTICS – TUBING & PIPE			
Alloy & Description	**Product**	**Temper**	**Comments**
BRASS			
230 Red Brass	Pipe	DGP H58	• Schedule 40 & 80 • Lower zinc improves corrosion resistance • *End use:* decorative applications
330 Brass	Seamless Tube	DGP H58	• Bought OD & wall dimensions • Lead additive improves machinability
COPPER			
122	Seamless Tube	DGP H58	• Produced OD & wall dimension • Good corrosion resistance • *End use:* plumbing applications
	Tubing - 50 ft coils	Soft 060	*End use:* refrigeration & hydraulic lines for machining
	Pipe	Hard Drawn H80	Schedule 40 & 80

Product Guide – Brass & Copper (contd)

GENERAL CHARACTERISTICS – SHEET & PLATE				
Alloy & Description	**Temper**	**Strength**	**Corrosion Resistance**	**Comments**
BRASS				
220 Commercial Bronze	Soft & 1/2 hard	Fair	Good	• Less zinc improves corrosion resistance because of dezincification • *End use:* decorative applications such as hardware molding for doorways
260 Brass (aka Cartridge Brass)	Soft	Excellent	Good	• Excellent for forming • Deep drawing & spinning quality • *End use:* decorative applications
	1/4 hard	Good	Good	• Rockwell B 40-65 approx • Temper chosen for best forming qualities • *End use:* decorative application
	1/2 Hard	Fair	Good	• Rockwell B 60-77 approx • Mechanical properties increase with graduating hardness of temper
	Hard	Fair	Good	Rockwell B 79-86 approx.
280 Muntz Metal	1/4 hard (H01)			• High zinc promotes a true "brassy" appearance • *End use:* decorative, architectural applications
353 Leaded Brass	1/2 hard	Fair		• 1.8% lead included to improve machinability • *End use:* parts that are blanked and machined (keys)
464 Naval Brass	Soft (M20)	Fair	Better corrosion w/addition of tin	End use: certain tank & heat exchanger applications
510 Phosphor Bronze	Spring (H08)	Fair	Good	• Rockwell B 92-98 approx • High strength levels • *End use:* spring & wear surfaces, applications requiring good corrosion resistance
614 Aluminum Bronze ASTM B 169	Soft	Poor		Extremely good wear resistance, high temperature strength, & low temperature impact resistance
COPPER				
110 CR ASTM B 152	Soft (060)	Excellent	Extremely Good	• Soft anneal • Good for forming & good conductivity
	Soft (05025)	Excellent	Extremely Good	• Annealed temper designates grain size .05025 is a nominal • Average size .005 mm good for deep drawing • Good conductivity
	1/8 to 1/4 hard	Excellent	Extremely Good	• Rockwell F 54-84 approx • 48" DHP (deoxidized high residual phosphorus) alloy 122 • Good conductivity • *End use:* decorative applications
	1/2 hard	Good	Extremely Good	• Rockwell F 77-89 approx • Good conductivity • *End use:* decorative applications
CR ASTM B 101 Lead coated both sides		Good	Extremely Good	• 12 - 15 lbs of lead per 100 sq ft total (both sides) • *End use:* roofing & flashing applications
Roofing – HR ASTM B 370	Soft (060)	Good	Extremely Good	• Same as Alloy 110 with a HR dull finish • Cheaper than CR • Ounces relate to wts per ft
Roofing – CR ASTM B 370	1/8 Quarter Hard (H00)	Good	Extremely Good	• Same as Alloy 110 with a CR bright finish • Ounces relate to wts per ft

TECHNICAL DATA
Chemical Composition and Mechanical Properties - See Stock List

SALES ADVANTAGES Material certification is traceable to manufacturing source		
Material	**Purchasing Specification**	**Advantage**
FC Brass CA 360	Standard ASTM	• We hold chemistry ranges much tighter than normal ASTM ranges for consistent quality • We offer scrap return program thru CS&W & Mill well above the commercial market
Alloy 954	Purchased as Ampco 18 (thermal treated) 3" dia & under - extruded rod	• Higher physical properties • More uniform bars (no hard or soft spots)

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

DIAMETER TOLERANCES
ROD - ROUNDS & HEXAGONS

NON-REFRACTORY ALLOYS: CA110, CA145, CA147, CA316, CA353, CA360, CA464, CA485

REFRACTORY ALLOYS: CA544, CA642, CA792

Diameter in distance between parallel surfaces, in.	All tolerances are plus and minus in inches†				
	Non-Refractory Alloys			Refractory Alloys	
	Round	Hexagonal		Round	Hexagonal
*Up to .150 incl.	.0013	.0025		.002	–
*Over .150 to .500 incl.	.0015	.003		.002	.004
Over .500 to 1.00 incl.	.002	.004		.003	.005
Over 1.00 to 2.00 incl.	.0025	.005		.004	.006
Over 2.00 to 2.125 incl.	.003	.006		.004	.008
Over 2.125 to 2.250 incl.	.003	.007		.005	.009
Over 2.250 to 2.375 incl.	.004	.007		.005	.009
Over 2.375 to 2.625 incl.	.004	.008		.005	.010
2.750	.004	.008		.006	.011
2.875	.004	.009		.006	.012
3.00	.005	.009		.006	.012
Over 3.125 to 3.25 incl.	.005	.010		–	–
Over 3.50 to 3.625 incl	.005	.011		–	–
3.750	.006	.011		–	–
Over 4.00 to 4.250 incl.	.006	.012		–	–
Over 4.50 to 4.750 incl.	.007	–		–	–
5.00	.008	–		–	–
6.00	.009	–		–	–
7.00	.011	–		–	–
8.00	.012	–		–	–
10.00	.015	–		–	–

* All Round FC Brass Rod 3/32 to 1/4 inch incl. are carried to "Swiss Tolerances" (±.0005).
† Flanging Brass (356) is all plus .000 minus .002.

SOURCE: ASTM B 249-06

THICKNESS TOLERANCES
DRAWN OR ROLLED SQUARE & RECTANGULAR BAR
CA110 ALLOY
Tolerances plus and minus*, in. (mm)

Thickness, in. (mm)	Width, in. (mm)			
	2 (50) & under	Over 2 (50) to 4 (100) incl	Over 4 (100) to 8 (200) incl	Over 8 (200) to 12 (300) incl
Up to 0.250 (6) incl	0.0025 (0.06)	0.003 (0.08)	0.0035 (0.09)	0.005 (0.13)
Over 0.250 (6) to 0.375 (10) incl	0.003 (0.08)	0.004 (0.10)	0.0045 (0.11)	0.005 (0.13)
Over 0.375 (10) to 0.500 (13) incl	0.0035 (0.09)	0.0045 (0.11)	0.005 (0.13)	0.006 (0.15)
Over 0.500 (13) to 0.750 (19) incl	0.0055 (0.14)	0.0055 (0.14)	0.0055 (0.14)	0.007 (0.18)
Over 0.750 (19) to 1.000 (25) incl	0.007 (0.18)	0.007 (0.18)	0.007 (0.18)	0.009 (0.23)
Over 1.000 (25) to 1.500 (38) incl	0.015 (0.38)	0.020 (0.50)	0.022 (0.55)	0.025 (0.50)
Over 1.500 (38) to 2.000 (50) incl	0.020 (0.50)	0.024 (0.60)	0.026 (0.65)	0.030 (0.75)

* When tolerances are specified as all plus or all minus, double the values given.

WIDTH TOLERANCES
DRAWN OR ROLLED SQUARE & RECTANGULAR BAR
CA110 ALLOY

Width, in. (mm)	Tolerances, plus and minus* in. (mm)
2 (50) & under	0.008 (.2)
Over 2 (50) to 4 (100) incl	0.012 (.3)
Over 4 (100) to 12 (300) incl	0.30†

* When tolerances are specified as all plus or all minus, double the values given.
† Percent of specified width expressed to the nearest 0.001 in. (0.01 mm).

SOURCE: ASTM B 187-06

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

THICKNESS TOLERANCES
SHEET AND STRIP
All tolerances are plus and minus in inches

NON-REFRACTORY ALLOYS
110, 220, 230, 260, 353 & 464

Thickness in.	Width, in. Up to 8 incl.	Over 8 to 12 incl.	Over 12 to 14 incl.	Over 14 to 20 incl.	Over 20 to 28 incl.	Over 28 to 36 incl.	Over 36 to 48 incl.
Up to .004 incl.	.0003	.0006	.0006	–	–	–	–
Over .004 to .006 incl.	.0004	.0008	.0008	.0013	–	–	–
Over .006 to .009 incl.	.0006	.0010	.0010	.0015	–	–	–
Over .009 to .013 incl.	.0008	.0013	.0013	.0018	.0025	.003	.0035
Over .013 to .017 incl.	.0010	.0015	.0015	.002	.0025	.003	.0035
Over .017 to .021 incl.	.0013	.0018	.0018	.002	.003	.0035	.004
Over .021 to .026 incl.	.0015	.002	.002	.0025	.003	.0035	.004
Over .026 to .037 incl.	.002	.002	.002	.0025	.0035	.004	.005
Over .037 to .050 incl.	.002	.0025	.0025	.003	.004	.005	.006
Over .050 to .073 incl.	.0025	.003	.003	.0035	.005	.006	.007
Over .073 to .130 incl.	.003	.0035	.0035	.004	.006	.007	.008
Over .130 to .188 incl.	.0035	.004	.004	.0045	.007	.008	.010
Over .188 to .205 incl.	.0035	.004	.004	.0045	.007	.008	.010
Over .205 to .300 incl.	.004	.0045	.0045	.005	.009	.010	.012
Over .300 to .500 incl.	.0045	.005	.005	.006	.012	.013	.015
Over .500 to .750 incl.	.0055	.007	.007	.009	.015	.017	.019
Over .750 to 1.00 incl.	.007	.009	.009	.011	.018	.021	.024
Over 1.00 to 1.50 incl.	.022	.022	.022	.022	.022	.025	.029
Over 1.50 to 2.00 incl.	.026	.026	.026	.026	.026	.030	.036

REFRACTORY ALLOYS
280, 510, 752 & 770

Thickness in.	Width, in. Up to 8 incl.	Over 8 to 12 incl.	Over 12 to 14 incl.	Over 14 to 20 incl.	Over 20 to 28 incl.	Over 28 to 36 incl.	
Up to .004 incl.	.0004	.0008	.0008	–	–	–	
Over .004 to .006 incl.	.0006	.0010	.0010	.0015	–	–	
Over .006 to .009 incl.	.0008	.0013	.0013	.002	–	–	
Over .009 to .013 incl.	.0010	.0015	.0015	.0025	–	–	
Over .013 to .017 inc.	.0013	.002	.002	.0025	–	–	
Over .017 to .021 incl.	.0015	.0025	.0025	.003	–	–	
Over .021 to .026 incl.	.002	.0025	.0025	.003	.004	.005	
Over .026 to .037 incl.	.0025	.003	.003	.0035	.005	.006	
Over .037 to .050 incl.	.003	.0035	.0035	.004	.006	.007	
Over .050 to .073 incl.	.0035	.004	.004	.0045	.007	.008	
Over .073 to .130 incl.	.004	.0045	.0045	.005	.008	.010	
Over .130 to .188 incl.	.0045	.005	.005	.006	.010	.012	
Over .188 to .205 incl.	.0045	.005	.005	.006	.010	.012	
Over .205 to .300 incl.	.005	.006	.006	.007	.012	.014	
Over .300 to .500 incl.	.006	.007	.007	.008	.015	.017	
Over .500 to .750 incl.	.008	.010	.010	.012	.019	.021	
Over .750 to 1.00 incl.	.010	.012	.012	.015	.023	.026	
Over 1.00 to 1.50 incl.	.028	.028	.028	.028	.028	.032	
Over 1.50 to 2.00 incl.	.033	.033	.033	.033	.033	.038	

SOURCE: ASTM B 248-01

TOLERANCES ARE FOR REFERENCE ONLY
Refer to Appropriate ASTM Specifications for Up-To-Date Tolerances

WALL TOLERANCES
ROUND SEAMLESS BRASS & COPPER TUBE
Applicable to ASTM B68, B75, B135, B743
All tolerances are plus and minus in inches

Wall Thickness in.	Outside Diameter, in.*						
	1/32 to 1/8 incl.	Over 1/8 to 5/8 incl.	Over 5/8 to 1 incl.	Over 1 to 2 incl.	Over 2 to 4 incl.	Over 4 to 7 incl.	Over 7 to 10 incl.
Up to .017 incl.	.002	.001	.0015	.002	–	–	–
Over .017 to .024 incl .	.003	.002	.002	.0025	–	–	–
Over .024 to .034 incl .	.003	.0025	.0025	.003	.004	–	–
Over .034 to .057 incl .	.003	.003	.0035	.0035	.005	.007	–
Over .057 to .082 incl .	–	.0035	.004	.004	.006	.008	.010
Over .082 to .119 incl.	–	.004	.005	.005	.007	.009	.011
Over .119 to .164 incl .	–	.005	.006	.006	.008	.010	.012
Over .164 to .219 incl .	–	.007	.009	.009	.011	.012	.014
Over .219 to .283 incl .	–	–	.011	.012	.014	.015	.016
Over .283 to .379 incl .	–	–	.014	6%**	6%**	7%**	7%**
Over .379	–	–	–	6%**	6%**	7%**	7%**

* When round tube is ordered by outside and inside diameters, the maximum plus and minus deviation of the wall thickness from the nominal at any point shall not exceed the values given in the table by more than 50%.
** Percent of specified wall expressed to the nearest 0.001 in.

AVERAGE O.D. TOLERANCES
BRASS & COPPER TUBE
Applicable to ASTM B68, B75, B135, B743
All tolerances are plus and minus in inches
Tube sold to OD and Wall Tolerance

Specified Outside Diameter in.	Tolerance, in.		Specified Outside Diameter in.	Tolerance, in.	
	Non-Refractory Alloys	Refractory Alloys		Non-Refractory Alloys	Refractory Alloys
Up to 1/8 incl.	.002	.0025	Over 3 to 4 incl.	.005	.006
Over 1/8 to 5/8 incl.	.002	.0025	Over 4 to 5 incl.	.006	.008
Over 5/8 to 1 incl.	.0025	.003	Over 5 to 6 incl.	.007	.009
Over 1 to 2 incl.	.003	.004	Over 6 to 8 incl.	.008	.010
Over 2 to 3 incl.	.004	.005	Over 8 to 9-5/8 incl.*	.010	.013

*10” OD & Over – Consult Office

ROUNDNESS TOLERANCES
For tube and pipe in drawn unannealed tempers in straight lengths
Not applicable to As-Extruded Tube, Redraw Tube, Annealed Tube or any furnished in coils, or Drawn Tube whose wall thickness is under .016 in.

Compliance with roundness tolerance shall be determined by taking measurements on the outside diameter only, irrespective of the manner in which the tube dimensions are specified; whether outside diameter and wall thickness, outside diameter and inside diameter, or inside diameter and wall thickness.

T/D (Ratio of Nominal Wall Thickness to Nominal Outside Diameter)	Roundness Tolerances** In Percent of Nominal Outside Diameter (Expressed to the nearest .001 in.)
.01 to .03 incl	1.5%
Over .03 to .05 incl	1.0%
Over .05 to .10 incl	.8% or .002 in. whichever value is greater
Over .10	.7% or .002 in. whichever value is greater

**The deviation from roundness is measured as the difference between major and minor outside diameters, as determined at any one cross-section of the tube.

Central Steel & Wire Company

Product Guide

PROCESSING & PACKAGING

Standard Processing Tolerances ..... 2 – 4
Work Order Restrictions and Limitations 5

STANDARD TOLERANCES

Guidelines for Common Cutting Processes. Alternative processes may be available upon request.
See ISM for other applications

Capabilities and tolerances are a guideline and are subject to review at time of inquiry/order entry.

BURNING OXY-FUEL

(Cleanup required see below)

Product	Thickness (in.) Greater than	Thickness (in.) Or equal to	TOLERANCE Plus/Minus
CARBON	.1875	.9999	.062
	1.0000	2.7499	.093
	2.7500	5.4999	.125
	5.5000	8.4999	.187
	8.5000	11.6249	.250
	11.6250	14.6250	.312

Product	Thickness (in.) Greater than	Thickness (in.) Or equal to	MACHINING ALLOWANCE PER EDGE
CARBON	.1875	.9999	.125
	1.0000	2.7499	.125
	2.7500	5.4999	.250
	5.5000	8.4999	.250
	8.5000	11.6249	.375
	11.6250	14.6250	.500

Notes

Grades to be heat treated after burning:
1045 - Stress Relieve; 4140 - Fully Anneal;
FM 45 Stress Relieve

If machining allowance is required, refer to Fabrication Division.

BURNING (HD) PRECISION PLASMA

Based on top profile

Product	Thickness (in.) Greater than	Thickness (in.) Or equal to	TOLERANCE Plus/Minus
CARBON / STAINLESS	.1875	.4999	.030
	.5000	1.0000	.060
	1.0001	2.0000	.090

Product	Thickness (in.) Greater than	Thickness (in.) Or equal to	MACHINING ALLOWANCE PER EDGE
CARBON / STAINLESS	.1875	.4999	.125
	.5000	1.0000	
	1.0001	2.0000	

Notes

Physical characteristic of this type of burning process requires a clear understanding of the quality of cut. Plasma arc creates inherent bevel of +/– 2° which makes the machining allowance critical. For special tolerance requirements refer to Fabricating.
Grades to be heat treated after burning: 1045 - Stress Relieve; 4140 - Fully Anneal; FM 45 – Stress Relieve

If machining allowance is required, refer to Fabrication Division.

PLATE SAW

Process		Capacities (in.)	Thickness (in.)	TOLERANCE Plus/Minus	Notes
TYSAMAN	Nonferrous	72 x 156	6	1/32	
CONTOUR	Nonferrous	See note	6	1/16	Part must be ≤ 300 lbs
PRECISION	Nonferrous	144 x 160	6	1/64	+/– .005 on application (nonferrous)

COIL PROCESSING

Process	TOLERANCE Plus/Minus	Notes
SLITTING	.005	Squareness - See Shearing
CUT TO LENGTH (Shear)	1/32	
BLANKING	Slit = .005 Shear = 1/32	

LEVELLER

	Size (in.) Thickness	Width	Lgth	TOLERANCE Plus/Minus	Notes
DRY LINE	10 - 26 Ga	—	15 – 251	1/32	
OIL LINE	10 - 26 Ga	—	15 – 204		

BLANKER

	Size (in.) Thickness	Width	Lgth	TOLERANCE Plus/Minus	Notes
HEAVY GAGE	10 - 26 Ga	8 min 62 max	12 min 146 max	Width: .005 Length: 1/32 Diagonal within 1/16	
LIGHT GAGE	16 - 26 Ga (no leveler)	6 min 60 max	12 min 120 max		

(Continued)

STANDARD PROCESSING TOLERANCES (contd)

Capabilities and tolerances are a guideline and are subject to review at time of inquiry/order entry.

SHEAR

Product/Process	TOLERANCE Plus/Minus	Notes
PLATE	1/16	
SHEET	1/32	Thicker than 10 GA. is +/- 1/16
SQUARENESS	Diagonals within 2 x shear tol	Requires 2-way shear

CCP COIL PROCESSING LINE

Size (in.)			LENGTH TOLERANCE	Notes
Thickness	Width	Lgth		
.068 min 3/4 max	24 min 96 max	44 min 720 max	Up to 12 ft. +1/16 – 0 12 - 24 ft. incl. +1/8 – 0 Over 24 ft. +1/4 – 0	

BAND SAW

Product/Process	SINGLE CUT TOLERANCE Plus/Minus	MULTI CUT TOLERANCE Plus/Minus	Notes
STRUCTURAL	1/16	1/8	
BAR/TUBE	1/16	1/8	
MITER SAW	1/16	N/A	60° max miter
PRODUCTION	1/32	1/16	24" max lgth & qty determination

DEBURRING MACHINE (Burrmaster)

Product	Capacity (in.)		Notes
	Size	Length	
ROUNDS SQUARES RECTS (Tubing & Solid)	5/8 OD min 4 OD max	6.750 min 120 max	–Part weight not to exceed **30 lbs**. –Steel tees & angles are good as long as both legs are of equal length.
SHAPES	4" cross section		

HIGH SPEED PRECISION COLD SAW

Product	Machine Size (in.)	Lgth (in.) min max	Limits (in.) * min max	TOLERANCE Plus/Minus	Notes
CARBON/STAINLESS**					
ROUNDS	2	3/8 - 23.6	.4 - 2.75 Rd	.005	* –Part weight not to exceed **30 lbs**. –Stainless parts to be at least 5/8" in length. –Stainless bars min. diameter is .625" ** Stainless 17-4 Condition A cannot be precision cut
	4	3/8 - 23.6	.875 - 4 Rd		
	6	3/8 - 23.6	1.18 - 6.25 Rd		
SQUARES	2	3/8 - 23.6	2.36 Sq		
	4	3/8 - 23.6	3.125 Sq		
	6	3/8 - 23.6	5.9 Sq		

HIGH SPEED NON-FERROUS PRECISION COLD SAW

Product	Size (in.)	Lgth (in.) min max	TOLERANCE Plus/Minus	Notes
ROUNDS	.400 – 7.800	.650 – 39.370	.005	--Max. rectangular bar size is 5.900 H x 11.800 W
SQUARES	.400 – 5.900			

PRECISION CUT-OFF LATHE

Product	Length	TOLERANCE Plus/Minus
RD TUBE	1-1/2" - 12"	.005
	Over 12"	.010

CAPACITIES (in.)						CHAMFER (in.)		
OD	Wall Thickness		Wall Thickness Tube cut-off only, no chamfer of ID		Length	OD	Min Tube ID	ID Max Wall
	Stock Dia	Min Wall	Stock Dia	Max Wall				
1 - 7	1-3 OD	.034	1	.25	1.50 - 144	1 - 7	2	1/2
	3-5 OD	.063	1.5	.50				
	5-7 OD	.125	2	.75				
			2.5 - 7	1.00				

STANDARD PROCESSING TOLERANCES (contd)

Capabilities and tolerances are a guideline and are subject to review at time of inquiry/order entry.

PRECISION TUBE CUTTING	Product	OD (in.) min max	Wall Thickness (in.) min max	Cut Length (in.) min max	TOLERANCE Plus/Minus
	RD TUBE	1/2 - 3-1/2	.039 - .188	13/16 - 118 (44# max per pc)	.010
	SQ TUBE	1/2 - 3			
	RECT TUBE	7/16 x 5/8 - 2-1/2 x 3-1/4			
	RD SOLID BAR	5/16 - 1-1/2			
CAPACITIES					
Deburr		6" min - 118" max lgth			
Measuring Component (deburr parts only)					
Stacking					

SHOT BLASTING	Size (in.)			Notes
	Max Height	Max Width	Max Length	
	20	96	288	-Parts less than 40" in length must be placed on parts rack. Parts on rack must not exceed 2100 lbs. Racks are 4" tall.
	44	58	288	-Max. part weight on rollers is 500 lbs./ft. (of length).

CNC MILLING	Capacity (in.)			TOLERANCE Plus/Minus	Notes
	Max Height	Width	Length		
	50	32	64	Application specific. See fabricating	-10,000 lbs. max load on table.

CNC LATHE	Capacity (in.)			TOLERANCE Plus/Minus	Notes
	Max Diameter	Max Length	Max Swing		
	25.5	44	34.5	Application specific. See fabricating	

FACING & CENTER DRILLING	Capacity (in.)		TOLERANCE Plus/Minus	Notes
	Diameter	Length		
	.875 – 3.875	4.000 – 52.000	Length: .0025 Drilling: .005	-Other sizes are possible. See Fabrication if part is outside of this capacity.

WORK ORDER RESTRICTIONS AND LIMITATIONS

It is important to be aware of certain instances where customers may request our Company to provide outside services (work orders) that are not always best for the material in question. Please use the following as a guide to avoid these work order situations. Some of the situations listed below could do serious damage to the material.

1. No pickling of T-1 (A514), or AR 400 Formable due to hydrogen embrittlement. Mechanically descale as alternative.

2. No work order thermal treating of stainless, copper, brass, or aluminum alloys.*****

3. T-1 (A514) weldments should not be stress relieved due to resulting low impact properties in the heat-affected zone. Suggest vibratory stress relieving as an alternative if necessary.

4. No quench and temper orders for carbon steels. Results are too erratic and unpredictable.*****

5. No case hardening such as carburizing, nitriding, flame hardening, or induction hardening.*****

6. No normalizing of ASTM A 516 Grade 70 - 1½" thick or thinner. Existing test report results represent the as-rolled properties and would no longer be valid after normalizing.*****

   * In these situations we can offer to drop ship material to a heat treater of our customer's choice and **they can make their own arrangement.**

At one time or another these situations may have come up and were dealt with individually. For better control, we thought grouping them would reduce the risk of an inadvertent breakdown in communication.

The list will be periodically updated as new situations arise or circumstances change.