

# Standards for **ALUMINUM** Mill Products

---

- Extruded Wire, Rod, Bar and Profiles
- Electrical Conductors
- Extruded Pipe and Tube
- Drawn Tube
- Cold Finished Wire, Rod and Bar

# Table of Contents

Subject	Page	Aluminum Association Table Number*
<b>CONVERSION UNITS</b>		
Decimal Equivalents . . . . .	.1	—
Conversion of Degrees to Inches . . . . .	.2	—
<b>EXTRUDED WIRE, ROD, BAR AND PROFILES</b>		
Cross-Sectional Dimension Tolerances—Profiles . . . . .	3-5	11.2
Diameter or Distance Across Flats—Round Wire and Rod – Square, Hexagonal and Octagonal Wire and Bar . . . . .	.6	11.3
Thickness or Width (Distance Across Flats)—Rectangular Wire and Bar . . . . .	.6	11.4
Length—Wire, Rod, Bar and Profiles . . . . .	.7	11.5
Straightness—Rod, Bar and Profiles . . . . .	.7	11.6
Twist—Bar and Profiles . . . . .	.8	11.7
Flatness (Flat Surfaces)—Bar, Solid Profiles and Semihollow Profiles . . . . .	.8	11.8
Flatness (Flat Surfaces)—Hollow Profiles . . . . .	.9	11.9
Surface Roughness—Extruded Wire, Rod, Bar and Profiles . . . . .	.9	11.10
Contour (Curved Surfaces)—Extruded Profiles . . . . .	.9	11.11
Squareness of Cut Ends—Extruded Rod, Bar and Profiles . . . . .	.10	11.12
Corner and Fillet Radii—Extruded Bar and Profiles . . . . .	.10	11.13
Angularity—Extruded Bar and Profiles . . . . .	.10	11.14
<b>ELECTRICAL CONDUCTORS</b>		
Thickness, Width, Diameter—Tolerances—Extruded Rod and Bar—Electric Conductors . . . . .	.11	16.22
Length—Tolerances—Extruded Rod and Bar—Electric Conductors . . . . .	.11	16.23
Flatness (Flat Surfaces)—Tolerances—Extruded Bar—Electric Conductors . . . . .	.12	16.24
Twist—Tolerances—Extruded Bar—Electric Conductors . . . . .	.12	16.25
Straightness—Tolerances—Extruded Rod and Bar—Electric Conductors . . . . .	.12	16.26
Angularity—Extruded Bar—Electric Conductors . . . . .	.12	16.27
Squareness of Cut Ends—Extruded Rod and Bar—Electric Conductors . . . . .	.12	16.28
Corner and Edge Radii—Tolerances—Extruded Bar—Electric Conductors . . . . .	.12	16.29
<b>EXTRUDED PIPE AND TUBE</b>		
Diameter—Round Tube . . . . .	.13	12.2
Width and Depth—Square, Rectangular, Hexagonal and Octagonal Tube . . . . .	.14	12.3
Wall Thickness—Round Extruded Tube . . . . .	.15	12.4
Wall Thickness—Other-than-Round Extruded Tube . . . . .	.16	12.5
Length—Extruded Tube . . . . .	.17	12.6
Twist—Other-than-Round Extruded Tube . . . . .	.17	12.7
Straightness—Extruded Tube in Straight Lengths . . . . .	.17	12.8
Flatness (Flat Surfaces)—Extruded Tube . . . . .	.18	12.9
Squareness of Cut Ends—Extruded Tube . . . . .	.18	12.10
Corner and Fillet Radii—Extruded Tube . . . . .	.18	12.11
Angularity—Extruded Tube . . . . .	.18	12.12
Surface Roughness—Extruded Tube . . . . .	.18	12.13
Dents—Extruded Tube . . . . .	.18	12.14
Outside Diameter Tolerances—Extruded Pipe and Extruded and Drawn Pipe . . . . .	.19	12.49
Wall Thickness Tolerances—Extruded Pipe or Extruded and Drawn Pipe . . . . .	.19	12.50
Weight Tolerances—Extruded Pipe or Extruded and Drawn Pipe . . . . .	.19	12.51
Length Tolerances—Extruded Pipe or Extruded and Drawn Pipe . . . . .	.19	12.52
Straightness Tolerances—Extruded Pipe or Extruded and Drawn Pipe . . . . .	.19	12.53
Standard Welding Bevels—Extruded Pipe or Extruded and Drawn Pipe . . . . .	.19	12.54
Diameters, Wall Thicknesses, Weights—Pipe . . . . .	.20,21	12.55

(continued on next page)

\* Reproduced with permission from The Aluminum Association, Inc., Aluminum Standards and Data, 2006.  
(For any secondary materials referenced in the footnotes and not contained herein, refer to the full Aluminum Association manual.)

# Table of Contents (continued)

Subject	Page	Aluminum Association Table Number*
<b>DRAWN TUBE</b>		
Diameter—Drawn Round Tube	.22	.12.20
Width and Depth—Drawn Square, Rectangular, Hexagonal and Octagonal Tube	.22	.12.21
Diameter—Drawn Oval, Elliptical and Streamline Tube	.23	.12.22
Corner Radii—Drawn Tube	.23	.12.23
Wall Thickness—Drawn Round and Other-than-Round Tube	.23	.12.24
Straightness—Drawn Tube	.24	.12.25
Twist—Drawn Tube	.24	.12.26
Length—Drawn Tube	.24	.12.27
Flatness (Flat Surfaces)—Other-than-Round Drawn Tube	.24	.12.28
Squareness of Cut Ends—Drawn Tube	.24	.12.29
Angularity—Drawn Tube	.24	.12.30
Surface Roughness—Drawn Tube	.24	.12.31
Dents—Drawn Tube	.24	.12.32
<b>ROLLED AND COLD FINISHED WIRE, ROD AND BAR</b>		
Diameter—Round Wire and Rod	.25	.10.5
Diameter—Centerless Ground Round Wire and Rod	.25	.10.6
Diameter—Rivet and Cold Heading Wire and Rod	.25	.10.7
Diameter—Drawing Stock	.25	.10.8
Thickness and Width—Rectangular Wire and Bar	.25	.10.9
Distance Across Flats—Square, Hexagonal and Octagonal Wire and Bar	.25	.10.10
Thickness and Width—Flattened Wire (Round Edge)	.25	.10.11
Thickness and Width—Flattened and Slit Wire	.26	.10.12
Length—Specific and Multiple—Rolled or Cold Finished Wire, Rod and Bar	.26	.10.13
Twist—Rolled or Cold Finished Bar and Straight Lengths	.26	.10.14
Straightness—Rolled or Cold Finished Rod and Bar in Straight Lengths Other than Screw Machine Stock	.27	.10.15
Straightness—Screw Machine Stock	.27	.10.16
Flatness—Flat Surfaces—Rolled or Cold Finished Rod and Bar	.27	.10.17
Angularity—Rolled or Cold Finished Rod and Bar	.27	.10.18
Squareness of Saw Cuts—Rolled or Cold Finished Rod and Bar	.27	.10.19
Corner Radii Bar—Rolled or Cold Finished Rod and Bar	.27	.10.20
<b>MECHANICAL PROPERTIES</b>		
Mechanical Property Limits—Wire, Rod and Bar—Rolled or Cold Finished—Heat-Treatable Alloys	.28,29	.10.2
Mechanical Property Limits—Extruded Wire, Rod, Bar and Profiles	.30-32	.11.1
Mechanical Property Limits—Drawn Tube	.33-35	.12.19
Property Limits—Rod, Bar, Tube, Pipe, Structural Profiles and Sheet—Electric Conductors	.36	.16.3
Equivalent Resistivity Values—Electric Conductors	.36	.16.4
Flatwise Bending Radii—Bus Bar	.36	.16.5
Edgewise Bending Radii—Bus Bar	.36	.16.6
<b>CHEMICAL ANALYSIS</b>		
Chemical Composition Limits of Wrought Aluminum Alloys	.37,38	.6.2
<b>ALUMINUM SPECIFICATIONS</b>		
Alloy and Mill Product Specifications	.39-44	.1.3
Specifications Covering Aluminum Mill Products	.45-48	.1.4

\* Reproduced with permission from The Aluminum Association, Inc., *Aluminum Standards and Data*, 2006.  
(For any secondary materials referenced in the footnotes and not contained herein, refer to the full Aluminum Association manual.)

# Conversion Units

## Decimal Equivalents

	Decimal Equivalent	Millimeter Equivalent		Decimal Equivalent	Millimeter Equivalent
	$\frac{1}{64}$ — .016	.397		$\frac{33}{64}$ — .516	13.097
	$\frac{1}{32}$ — .031	.794		$\frac{17}{32}$ — .531	13.494
	$\frac{3}{64}$ — .047	1.191		$\frac{35}{64}$ — .547	13.891
	$\frac{1}{16}$ — .062	1.588		$\frac{9}{16}$ — .562	14.288
	$\frac{5}{64}$ — .078	1.984		$\frac{37}{64}$ — .578	14.684
	$\frac{3}{32}$ — .094	2.381		$\frac{19}{32}$ — .594	15.081
	$\frac{7}{64}$ — .109	2.778		$\frac{39}{64}$ — .609	15.478
	$\frac{1}{8}$ — .125	3.175		$\frac{5}{8}$ — .625	15.875
	$\frac{9}{64}$ — .141	3.571		$\frac{41}{64}$ — .641	16.272
	$\frac{5}{32}$ — .156	3.968		$\frac{21}{32}$ — .656	16.669
	$\frac{11}{64}$ — .172	4.365		$\frac{43}{64}$ — .672	17.066
	$\frac{3}{16}$ — .188	4.762		$\frac{11}{16}$ — .688	17.462
	$\frac{13}{64}$ — .203	5.159		$\frac{45}{64}$ — .703	17.859
	$\frac{7}{32}$ — .219	5.556		$\frac{23}{32}$ — .719	18.256
	$\frac{15}{64}$ — .234	5.953		$\frac{47}{64}$ — .734	18.653
	$\frac{1}{4}$ — .250	6.350		$\frac{3}{4}$ — .750	19.050
	$\frac{17}{64}$ — .266	6.747		$\frac{49}{64}$ — .766	19.447
	$\frac{9}{32}$ — .281	7.144		$\frac{25}{32}$ — .781	19.844
	$\frac{19}{64}$ — .297	7.541		$\frac{51}{64}$ — .797	20.241
	$\frac{5}{16}$ — .312	7.938		$\frac{13}{16}$ — .812	20.638
	$\frac{21}{64}$ — .328	8.334		$\frac{53}{64}$ — .828	21.034
	$\frac{11}{32}$ — .344	8.731		$\frac{27}{32}$ — .844	21.431
	$\frac{23}{64}$ — .359	9.128		$\frac{55}{64}$ — .859	21.828
	$\frac{3}{8}$ — .375	9.525		$\frac{7}{8}$ — .875	22.225
	$\frac{25}{64}$ — .391	9.922		$\frac{57}{64}$ — .891	22.622
	$\frac{13}{32}$ — .406	10.319		$\frac{29}{32}$ — .906	23.019
	$\frac{27}{64}$ — .422	10.716		$\frac{59}{64}$ — .922	23.416
	$\frac{7}{16}$ — .438	11.112		$\frac{15}{16}$ — .938	23.812
	$\frac{29}{64}$ — .453	11.509		$\frac{61}{64}$ — .953	24.209
	$\frac{15}{32}$ — .469	11.906		$\frac{32}{32}$ — .969	24.606
	$\frac{31}{64}$ — .484	12.303		$\frac{63}{64}$ — .984	25.003
	$\frac{1}{2}$ — .500	12.700		$1$ — 1.000	25.400

# Conversion Units

## Conversion of Degrees to Inches

CONVERSION OF DEGREES TO INCHES  
**DEGREES**

**SURFACE WIDTH** →

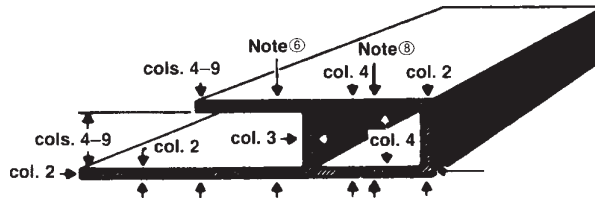
	1/4°	1/2°	3/4°	1°	1 1/4°	1 1/2°	1 3/4°	2°	2 1/4°	2 1/2°	2 3/4°	3°	3 1/4°	3 1/2°	3 3/4°	4°	4 1/4°	4 1/2°	4 3/4°	5°
1/4"	.001	.002	.003	.004	.005	.007	.008	.009	.010	.011	.012	.013	.014	.015	.016	.017	.019	.020	.021	.022
1/2"	.002	.004	.007	.009	.011	.013	.015	.017	.020	.022	.024	.026	.028	.031	.033	.035	.037	.039	.042	.044
3/4"	.003	.007	.010	.013	.016	.020	.023	.026	.029	.033	.036	.039	.043	.046	.049	.052	.056	.059	.062	.066
1"	.004	.009	.013	.017	.022	.026	.031	.035	.039	.044	.048	.052	.057	.061	.066	.070	.074	.079	.083	.087
1 1/4"	.005	.011	.016	.022	.027	.033	.038	.044	.049	.055	.060	.066	.071	.076	.082	.087	.093	.098	.104	.109
1 1/2"	.007	.013	.020	.026	.033	.039	.046	.052	.059	.065	.072	.079	.085	.092	.098	.105	.111	.118	.125	.131
1 3/4"	.008	.015	.023	.031	.038	.046	.053	.061	.069	.076	.084	.092	.099	.107	.115	.122	.130	.138	.145	.153
2"	.009	.017	.026	.035	.044	.052	.061	.070	.079	.087	.096	.105	.114	.122	.131	.140	.149	.157	.166	.175
2 1/4"	.010	.020	.029	.039	.049	.059	.069	.079	.088	.098	.108	.118	.128	.138	.147	.157	.167	.177	.187	.197
2 1/2"	.011	.022	.033	.044	.055	.065	.076	.087	.098	.109	.120	.131	.142	.153	.164	.175	.186	.197	.208	.219
2 3/4"	.012	.024	.036	.048	.060	.072	.084	.096	.108	.120	.132	.144	.156	.168	.180	.192	.204	.216	.228	.241
3"	.013	.026	.039	.052	.066	.079	.092	.105	.118	.131	.144	.157	.170	.183	.197	.210	.223	.236	.249	.262
3 1/4"	.014	.028	.043	.057	.071	.085	.099	.114	.128	.142	.156	.170	.185	.199	.213	.227	.242	.256	.270	.284
3 1/2"	.015	.031	.046	.061	.076	.092	.107	.122	.138	.153	.168	.183	.199	.214	.229	.245	.260	.275	.291	.306
3 3/4"	.016	.033	.049	.066	.082	.098	.115	.131	.147	.164	.180	.197	.213	.229	.246	.262	.279	.295	.312	.328
4"	.017	.035	.052	.070	.087	.105	.122	.140	.157	.175	.192	.210	.227	.245	.262	.280	.297	.315	.332	.350
4 1/4"	.019	.037	.056	.074	.093	.111	.130	.149	.167	.186	.204	.223	.242	.260	.279	.297	.316	.334	.353	.372
4 1/2"	.020	.039	.059	.079	.098	.118	.138	.157	.177	.197	.216	.236	.256	.275	.295	.315	.334	.354	.374	.394
4 3/4"	.021	.042	.062	.083	.104	.125	.145	.166	.187	.208	.228	.249	.270	.291	.312	.332	.353	.374	.395	.416
5"	.022	.044	.066	.087	.109	.131	.153	.175	.197	.219	.241	.262	.284	.306	.328	.350	.372	.394	.416	.437

**FORMULA:** DEGREES TOLERANCE TIMES .0175 TIMES THE WIDTH OF THE SURFACE SECTION IS BEING CHECKED ON.

# Extruded Wire, Rod, Bar and Profiles

**TABLE 11.2 Cross-Sectional Dimension Tolerances—Profiles ①**

EXCEPT FOR T3510, T4510, T6510, T73510, T76510 AND T8510 TEMPER ⑦



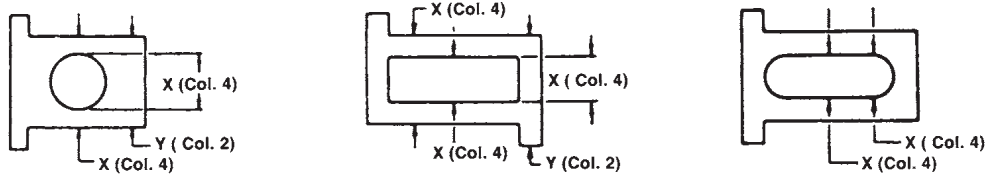
SPECIFIED DIMENSION in.	TOLERANCE ② ③—in. plus and minus																	
	METAL DIMENSIONS				SPACE DIMENSIONS													
	ALLOWABLE DEVIATION FROM SPECIFIED DIMENSION WHERE 75 PERCENT OR MORE OF THE DIMENSION IS METAL ⑨ ⑩				ALLOWABLE DEVIATION FROM SPECIFIED DIMENSION WHERE MORE THAN 25 PERCENT OF THE DIMENSION IS SPACE ⑥ ⑧													
	All Except Those Covered by Column 3		Wall Thickness ④ Completely Enclosing Space 0.11 sq. in. and Over (Eccentricity)		At Dimensioned Points 0.250–0.624 inches from Base of Leg		At Dimensioned Points 0.625–1.249 inches from Base of Leg		At Dimensioned Points 1.250–2.499 inches from Base of Leg		At Dimensioned Points 2.500–3.999 inches from Base of Leg		At Dimensioned Points 4.000–5.999 inches from Base of Leg		At Dimensioned Points 6.000–8.000 inches from Base of Leg			
Col. 2		Col. 3		Col. 4		Col. 5		Col. 6		Col. 7		Col. 8		Col. 9				
Standard Tolerance, All Except 5XXX Alloys ⑪	Precision Tolerance, All Except 5XXX Alloys	Standard Tolerance, All Except 5XXX Alloys ⑪	Precision Tolerance, All Except 5XXX Alloys	Standard Tolerance, All Except 5XXX Alloys ⑪	Precision Tolerance, All Except 5XXX Alloys	Standard Tolerance, All Except 5XXX Alloys ⑪	Precision Tolerance, All Except 5XXX Alloys	Standard Tolerance, All Except 5XXX Alloys ⑪	Precision Tolerance, All Except 5XXX Alloys	Standard Tolerance, All Except 5XXX Alloys ⑪	Precision Tolerance, All Except 5XXX Alloys	Standard Tolerance, All Except 5XXX Alloys ⑪	Precision Tolerance, All Except 5XXX Alloys	Standard Tolerance, All Except 5XXX Alloys ⑪	Precision Tolerance, All Except 5XXX Alloys			
CIRCUMSCRIBING CIRCLE SIZES LESS THAN 10 INCHES IN DIAMETER																		
Up thru 0.124	0.006	0.004	±10% of specified dimension; ±.060 max. ±.010 min.	±10% of specified dimension; ±.060 max. ±.010 min.	0.010	0.007	0.012	0.008	..	..	..	..	..	..	..			
0.125–0.249	0.007	0.005			0.012	0.008	0.014	0.009	0.016	0.011	0.012	0.020	0.013	..	..	..		
0.250–0.499	0.008	0.005			0.014	0.009	0.016	0.011	0.018	0.012	0.013	0.022	0.015	..	..	..		
0.500–0.749	0.009	0.006			0.016	0.011	0.018	0.012	0.020	0.013	0.020	0.013	0.015	..	..	..		
0.750–0.999	0.010	0.007			0.018	0.012	0.020	0.013	0.022	0.015	0.022	0.015	0.017	0.030	0.020	0.020		
1.000–1.499	0.012	0.008	±10% of specified dimension; ±.060 max. ±.010 min.	±10% of specified dimension; ±.060 max. ±.010 min.	0.021	0.014	0.023	0.015	0.026	0.017	0.030	0.020	0.035	0.023	..			
1.500–1.999	0.014	0.009			0.024	0.016	0.026	0.017	0.031	0.020	0.036	0.024	0.042	0.028	0.050	0.033		
2.000–3.999	0.024	0.016			0.034	0.022	0.038	0.025	0.048	0.032	0.057	0.038	0.068	0.045	0.080	0.053		
4.000–5.999	0.034	0.022			0.044	0.029	0.050	0.033	0.064	0.042	0.078	0.051	0.094	0.062	0.110	0.073		
6.000–7.999	0.044	0.029			0.054	0.036	0.062	0.041	0.082	0.054	0.099	0.065	0.120	0.079	0.140	0.092		
8.000–9.999	0.054	0.036			0.064	0.042	0.074	0.049	0.100	0.066	0.120	0.079	0.145	0.096	0.170	0.112		
CIRCUMSCRIBING CIRCLE SIZES 10 INCHES IN DIAMETER AND OVER																		
Up thru 0.124	0.014	0.009			±15% of specified dimension; ±.090 max. ±.015 min.	±15% of specified dimension; ±.090 max. ±.015 min.	0.018	0.012	0.020	0.013	..	..	..	..	..	..	..	
0.125–0.249	0.015	0.010	0.019	0.013			0.022	0.015	0.028	0.018	..	..	..	..	..	..		
0.250–0.499	0.016	0.011	0.020	0.013			0.024	0.016	0.030	0.020	0.050	0.033	..	..	..	..		
0.500–0.749	0.017	0.011	0.022	0.015			0.027	0.018	0.040	0.026	0.060	0.040	..	..	..	..		
0.750–0.999	0.018	0.012	0.023	0.015			0.030	0.020	0.050	0.033	0.070	0.046	0.090	0.059	..	..		
1.000–1.499	0.019	0.013	±15% of specified dimension; ±.090 max. ±.015 min.	±15% of specified dimension; ±.090 max. ±.015 min.	0.024	0.016	0.034	0.022	0.060	0.040	0.080	0.053	0.100	0.066	..			
1.500–1.999	0.024	0.016			0.034	0.022	0.044	0.029	0.070	0.046	0.090	0.059	0.110	0.073	0.170	0.112		
2.000–3.999	0.034	0.022			0.044	0.029	0.054	0.036	0.080	0.053	0.100	0.066	0.120	0.079	0.180	0.119		
4.000–5.999	0.044	0.029			0.054	0.036	0.064	0.042	0.090	0.059	0.110	0.073	0.130	0.086	0.190	0.125		
6.000–7.999	0.054	0.036			0.064	0.042	0.074	0.049	0.100	0.066	0.120	0.079	0.140	0.092	0.200	0.132		
8.000–9.999	0.064	0.042			±15% of specified dimension; ±.090 max. ±.015 min.	±15% of specified dimension; ±.090 max. ±.015 min.	0.074	0.049	0.084	0.055	0.110	0.073	0.130	0.086	0.150	0.099	0.210	
10.000–11.999	0.074	0.049					0.084	0.055	0.094	0.062	0.120	0.079	0.140	0.092	0.160	0.106	0.220	0.145
12.000–13.999	0.084	0.055					0.094	0.062	0.104	0.069	0.130	0.086	0.150	0.099	0.170	0.112	0.230	0.152
14.000–15.999	0.094	0.062	0.104	0.069			0.114	0.075	0.140	0.092	0.160	0.106	0.180	0.119	0.240	0.158		
16.000–17.999	0.104	0.069	0.114	0.075			0.124	0.082	0.150	0.099	0.170	0.112	0.190	0.125	0.250	0.165		
18.000–19.999	0.114	0.075	±15% of specified dimension; ±.090 max. ±.015 min.	±15% of specified dimension; ±.090 max. ±.015 min.			0.124	0.082	0.134	0.088	0.160	0.106	1.800	1.188	0.200	0.132	0.260	
20.000–21.999	0.124	0.082					0.134	0.088	0.144	0.095	0.170	0.112	0.190	0.125	0.210	0.139	0.270	0.178
22.000–24.000	0.134	0.088					0.144	0.095	0.154	0.102	0.180	0.119	0.200	0.132	0.220	0.145	0.280	0.185

Footnotes for Table 11.2 are found on page 5.

# Extruded Wire, Rod, Bar and Profiles

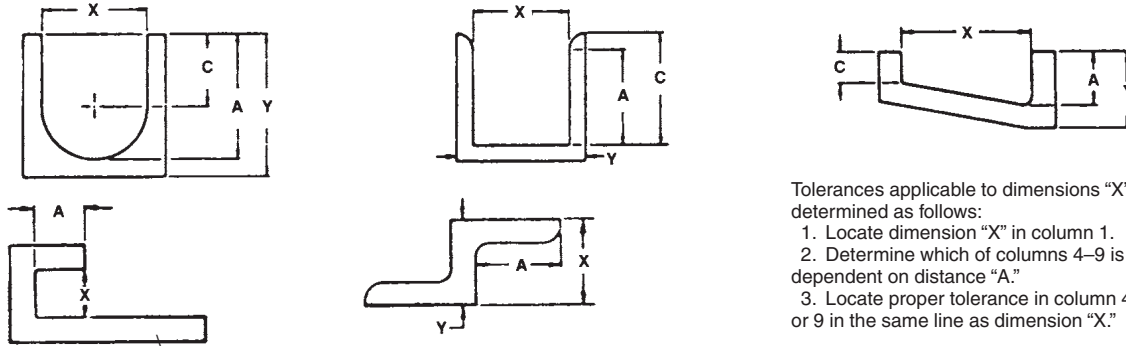
Examples Illustrating Use of Table 11.2, preceding page:

## Closed-Space Dimensions



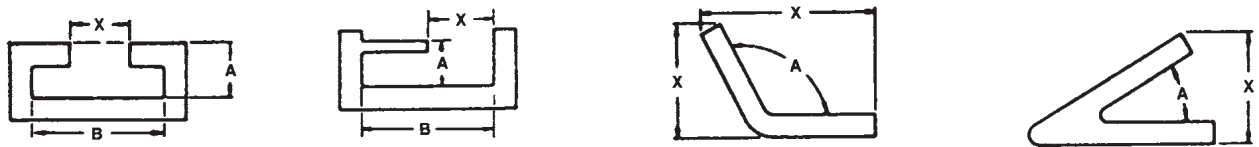
All dimensions designated "Y" are classed as "metal dimensions," and tolerances are determined from column 2.  
 Dimensions designated "X" are classed as "space dimensions through an enclosed void," and the tolerances applicable are determined from column 4 unless 75 percent or more of the dimension is metal, in which case column 2 applies.

## Open-Space Dimensions



Tolerances applicable to dimensions "X" are determined as follows:  
 1. Locate dimension "X" in column 1.  
 2. Determine which of columns 4-9 is applicable, dependent on distance "A."  
 3. Locate proper tolerance in column 4, 5, 6, 7, 8 or 9 in the same line as dimension "X."

Dimensions "Y" are "metal dimensions"; tolerances are determined from column 2.  
 Distances "C" are shown merely to indicate incorrect values for determining which of columns 4-9 apply.



Tolerances applicable to dimensions "X" are determined as follows:  
 1. Locate distance "B" in column 1.  
 2. Determine which of columns 4-9 is applicable, dependent on distance "A."  
 3. Locate proper tolerance in column 4, 5, 6, 7, 8 or 9 in the same line as value chosen in column 1.

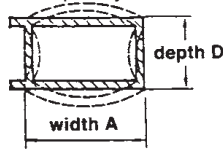
Tolerances applicable to dimensions "X" are not determined from Table 11.2; tolerances are determined by standard tolerances applicable to angles "A."

# Extruded Wire, Rod, Bar and Profiles

## Footnotes for Tables 11.2 Through 11.4:

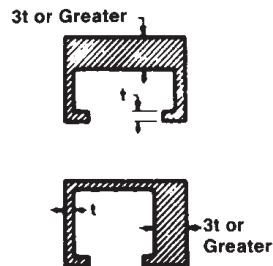
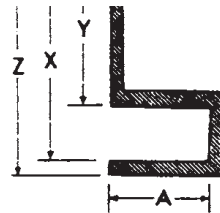
- ① These Standard and Precision Tolerances are applicable to the average profile. The extrusion conditions required to produce the wide variety of alloy-temper and profile combinations require close review between customer and producer to determine critical characteristics and tolerance capability. Aggressive profile characteristics may require wider than standard tolerance and closer than precision tolerance may be feasible for other characteristics.
- ② The tolerance applicable to a dimension composed of two or more component dimensions is the sum of the tolerances of the component dimensions if all of the component dimensions are indicated.
- ③ When a dimension tolerance is specified other than as an 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.
- ④ Where dimensions specified are outside and inside, rather than wall thickness itself, the allowable deviation (eccentricity) given in Column 3 applies to mean wall thickness. (Mean wall thickness is the average of two wall thickness measurements taken at opposite sides of the void.)
- ⑤ In the case of Class 1 Hollow Profiles the standard wall thickness tolerance for extruded round tube is applicable. (A Class 1 Hollow Profile is one whose void is round and one inch or more in diameter and whose weight is equally distributed on opposite sides of two or more equally spaced axes.)
- ⑥ At points less than 0.250 inch from base of leg the tolerances in Col. 2 are applicable.
- ⑦ Tolerances for extruded profiles in T3510, T4510, T6510, T73510, T76510 and T8510 tempers shall be as agreed upon between purchaser and vendor at the time the contract or order is entered.

⑧ The following tolerances apply where the space is completely enclosed (hollow profiles); For the width (A), the tolerance is the value shown in Col. 4 for the depth dimension (D). For the depth (D), the tolerance is the value shown in Col. 4 for the width dimension (A). In no case is the tolerance for either width or depth less than the metal dimensions (Col. 2) at the corners.



Example—Alloy 6061 hollow profile having 1 × 3 rectangular outside dimensions; width tolerance is  $\pm 0.021$  inch and depth tolerance  $\pm 0.034$  inch. (Tolerances at corners, Col. 2, metal dimensions, are  $\pm 0.024$  inch for the width and  $\pm 0.012$  inch for the depth.) Note that the Col. 4 tolerance of 0.021 inch must be adjusted to 0.024 inch so that it is not less than the Col. 2 tolerance.

“X” and “Z” of the example (right), even when “Y” is 75 percent or more of “X.” For the tolerance applicable to dimensions “X” and “Z,” use Col. 4, 5, 6, 7, 8 or 9, dependent on distance “A.”



⑩ The wall thickness tolerance for hollow or semihollow profiles shall be as agreed upon between purchaser and vendor at the time the contract or order is entered when the nominal thickness of one wall is three times or greater than that of the opposite wall.

⑪ For those 5xxx alloys with a magnesium content of greater than or equal to 4.0% nominal, tolerances are 150% of those values shown in the standard tolerance columns.

# Extruded Wire, Rod, Bar and Profiles

**TABLE 11.3 Diameter or Distance Across Flats—Round Wire and Rod - Square, Hexagonal and Octagonal Wire and Bar<sup>①</sup>**

SPECIFIED DIMENSION	TOLERANCE <sup>③</sup> —in. plus and minus							
	ALLOWABLE DEVIATION FROM SPECIFIED DIMENSION ACROSS FLATS OR DIAMETER							
	ROUND WIRE AND ROD		SQUARE WIRE AND BAR		HEXAGONAL WIRE AND BAR		OCTAGONAL WIRE AND BAR	
in.	Standard Tolerance, All Except 5XXX Alloys <sup>①</sup>	Precision Tolerance, All Except 5XXX Alloys	Standard Tolerance, All Except 5XXX Alloys <sup>①</sup>	Precision Tolerance, All Except 5XXX Alloys	Standard Tolerance, All Except 5XXX Alloys <sup>①</sup>	Precision Tolerance, All Except 5XXX Alloys	Standard Tolerance, All Except 5XXX Alloys <sup>①</sup>	Precision Tolerance, All Except 5XXX Alloys
Up thru 0.124	0.006	0.004	0.006	0.004	0.006	0.004	0.006	0.004
0.125–0.249	0.007	0.005	0.007	0.005	0.007	0.005	0.007	0.005
0.250–0.499	0.008	0.005	0.008	0.005	0.008	0.005	0.008	0.005
0.500–0.749	0.009	0.006	0.009	0.006	0.009	0.006	0.009	0.006
0.750–0.999	0.010	0.007	0.010	0.007	0.010	0.007	0.010	0.007
1.000–1.499	0.012	0.008	0.012	0.008	0.012	0.008	0.012	0.008
1.500–1.999	0.014	0.009	0.014	0.009	0.014	0.009	0.014	0.009
2.000–3.999	0.024	0.016	0.024	0.016	0.024	0.016	0.024	0.016
4.000–5.999	0.034	0.022	0.034	0.022	0.034	0.022	0.034	0.022
6.000–7.070	0.044	0.029	0.044	0.029	0.044	0.029	0.044	0.029
7.071–7.999	0.044	0.029	0.054	0.036	0.044	0.029	0.044	0.029
8.000–8.659	0.054	0.036	0.064	0.042	0.054	0.036	0.054	0.036
8.660–8.999	0.054	0.036	0.064	0.042	0.064	0.042	0.054	0.036
9.000–9.238	0.054	0.036	0.064	0.042	0.064	0.042	0.054	0.036
9.239–9.999	0.054	0.036	0.064	0.042	0.064	0.042	0.064	0.042
10.000–11.999	0.074	0.049	0.074	0.049	0.074	0.049	0.074	0.049
12.000–13.999	0.084	0.055	0.084	0.055	0.084	0.055	0.084	0.055
14.000–15.999	0.094	0.062	0.094	0.062	0.094	0.062	0.094	0.062

Note: Shaded tolerances denote products with a circumscribing circle size of 10 inches in diameter and over.

<sup>①</sup>For numbered footnotes, see preceding page 5.

**TABLE 11.4 Thickness or Width (Distance Across Flats)—Rectangular Wire and Bar<sup>①</sup>**

SPECIFIED DIMENSION IN.	TOLERANCE—in. plus and minus			
	ALLOWABLE DEVIATION FROM SPECIFIED WIDTH OR THICKNESS ACROSS FLATS			
	Standard Tolerance, All Except, 5XXX Alloys <sup>①</sup>	Precision Tolerance, All Except, 5XXX Alloys	Standard Tolerance, All Except, 5XXX Alloys <sup>①</sup>	Precision Tolerance, All Except, 5XXX Alloys
Up thru 0.124	0.006	0.004	0.014	0.009
0.125–0.249	0.007	0.005	0.015	0.010
0.250–0.499	0.008	0.005	0.016	0.011
0.500–0.749	0.009	0.006	0.017	0.011
0.750–0.999	0.010	0.007	0.018	0.012
1.000–1.499	0.012	0.008	0.019	0.013
1.500–1.999	0.014	0.009	0.024	0.016
2.000–3.999	0.024	0.016	0.034	0.022
4.000–5.999	0.034	0.022	0.044	0.029
6.000–7.999	0.044	0.029	0.054	0.036
8.000–9.999	0.054	0.036	0.064	0.042
10.000–11.999	..	..	0.074	0.049
12.000–13.999	..	..	0.084	0.055
14.000–15.999	..	..	0.094	0.062
16.000–17.999	..	..	0.104	0.069
18.000–19.999	..	..	0.114	0.075
20.000–21.999	..	..	0.124	0.082
22.000–24.000	..	..	0.134	0.088

Note: Shaded tolerances denote products with a circumscribing circle size of 10 inches in diameter and over.

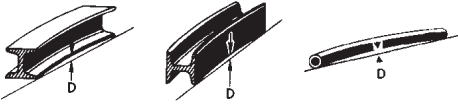
<sup>①</sup>For numbered footnotes, see preceding page 5.

# Extruded Wire, Rod, Bar and Profiles

**TABLE 11.5 Length<sup>①</sup>—Wire, Rod, Bar and Profiles**

SPECIFIED DIAMETER (WIRE AND ROD): SPECIFIED WIDTH (BAR): CIRCUMSCRIBING CIRCLE DIAMETER <sup>④</sup> : (PROFILES) in.	TOLERANCE—in. plus			
	ALLOWABLE DEVIATION FROM SPECIFIED LENGTH			
	SPECIFIED LENGTH—ft.			
	Up thru 12	Over 12 thru 30	Over 30 thru 50	Over 50
Up thru 2.999	1/8	1/4	3/8	1
3.000–7.999	3/16	5/16	7/16	1
8.000 and over	1/4	3/8	1/2	1

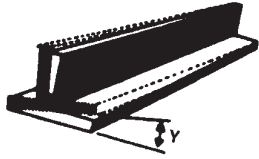
**TABLE 11.6 Straightness<sup>①</sup>—Rod, Bar and Profiles**

PRODUCT	TEMPER	SPECIFIED DIAMETER (ROD): SPECIFIED WIDTH (BAR): CIRCUMSCRIBING CIRCLE DIAMETER <sup>④</sup> : (PROFILES) in.	SPECIFIED THICKNESS (RECTANGLES): MINIMUM THICKNESS: (PROFILES) in.	TOLERANCE <sup>③</sup> —in.
				ALLOWABLE DEVIATION (D) FROM STRAIGHT <sup>⑤</sup>  IN TOTAL LENGTH OR IN ANY MEASURED SEGMENT OF ONE FT. OR MORE OF TOTAL LENGTH
Rod and Square, Hexagonal and Octagonal Bar	All except O TX510 <sup>②</sup> TX511 <sup>②</sup>	All	..	.0125 × Measured length, ft.
	O	0.500 and over	..	.050 × Measured length, ft.
	TX510 <sup>②</sup>	0.500 and over	..	.050 × Measured length, ft.
	TX511 <sup>②</sup>	0.500 and over	..	.0125 × Measured length, ft.
Rectangular Bar	All except O TX510 <sup>②</sup> TX511 <sup>②</sup>	Up thru 1.499	Up thru 0.094 <sup>⑦</sup> 0.095 and over	.050 × Measured length, ft. .0125 × Measured length, ft.
		1.500 and over	All	.0125 × Measured length, ft.
	O	Over 0.500	0.500 and over	.050 × Measured length, ft.
	TX510 <sup>②</sup>	Over 0.500	0.500 and over	.050 × Measured length, ft.
	TX511 <sup>②</sup>	Over 0.500	0.500 and over	.0125 × Measured length, ft.
Profiles	All except O TX510 <sup>②</sup> <sup>⑤</sup> TX511 <sup>②</sup>	Up thru 1.499	Up thru 0.094 <sup>⑦</sup> 0.095 and over	.050 × Measured length, ft. .0125 × Measured length, ft.
		1.500 and over	All	.0125 × Measured length, ft.
	O	0.500 and over	Up thru 0.094 <sup>⑦</sup> 0.095 and over	.200 × Measured length, ft. .050 × Measured length, ft.
	TX511 <sup>②</sup>	0.500 and over	Up thru 0.094 <sup>⑦</sup> 0.095 and over	.050 × Measured length, ft. .0125 × Measured length, ft.

For numbered footnotes, see page 9.

# Extruded Wire, Rod, Bar and Profiles

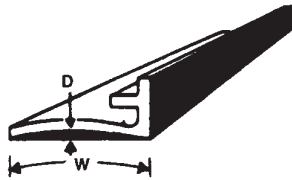
**TABLE 11.7 Twist ① ⑥—Bar and Profiles**

PRODUCT	TEMPER	SPECIFIED WIDTH (BAR): CIRCUMSCRIBING CIRCLE DIAMETER ④: (PROFILES)  in.	SPECIFIED THICKNESS (RECTANGLES):  MINIMUM THICKNESS: (PROFILES)  in.	TOLERANCE ③—Degrees		
				ALLOWABLE DEVIATION FROM STRAIGHT		
				IN TOTAL LENGTH OR IN ANY MEASURED SEGMENT OF ONE FT. OR MORE OF TOTAL LENGTH	MAXIMUM FOR TOTAL LENGTH	
Bar	All except O TX510 ② TX511 ②	Up thru 1.499 1.500–2.999 3.000 and over	All All All		7 5 3	
	O	0.500–1.499 1.500–2.999 3.000 and over	0.500 and over 0.500 and over 0.500 and over		3 × Measured length, ft. 1½ × Measured length, ft. ¾ × Measured length, ft.	21 15 9
	TX510 ②	0.500–2.999 3.000 and over	0.500 and over 0.500 and over		1½ × Measured length, ft. ½ × Measured length, ft.	7 5
	TX511 ②	0.500–1.499 1.500–2.999 3.000 and over	0.500 and over 0.500 and over 0.500 and over		1 × Measured length, ft. ½ × Measured length, ft. ¼ × Measured length, ft.	7 5 3
Profiles	All except O TX510 ② ⑤ TX511 ②	Up thru 1.499 1.500–2.999 3.000 and over	All All All	1 × Measured length, ft. ½ × Measured length, ft. ¼ × Measured length, ft.	7 5 3	
	O	0.500 and over 0.500–1.499 1.500–2.999 3.000 and over	Up thru 0.094 ⑦ 0.095 and over 0.095 and over 0.095 and over	3 × Measured length, ft. 3 × Measured length, ft. 1½ × Measured length, ft. ¾ × Measured length, ft.	21 21 15 9	
	TX511 ②	0.500 and over 0.500–1.499 1.500–2.999 3.000 and over	Up thru 0.094 ⑦ 0.095 and over 0.095 and over 0.095 and over	1 × Measured length, ft. 1 × Measured length, ft. ½ × Measured length, ft. ¼ × Measured length, ft.	7 7 5 3	

**TABLE 11.8 Flatness (Flat Surfaces) ①—Bar, Solid Profiles and Semihollow Profiles**

EXCEPT FOR PROFILES IN O ⑧, T3510, T4510, T6510, T73510, T76510 and T8510 TEMPER ⑤

MINIMUM THICKNESS OF METAL FORMING THE SURFACE in.	SURFACE WIDTH—in.										
	UP TO 5.999	6.000 TO 7.999	8.000 TO 9.999	10.000 TO 11.999	12.000 TO 13.999	14.000 TO 15.999	16.000 TO 17.999	18.000 TO 19.999	20.000 TO 21.999	22.000 TO 23.999	24.000 AND UP
	TOLERANCE										
Up thru 0.124	.004	.006	.010	.014	..	..	..	..	..	..	..
0.125–0.187	.004	.006	.008	.012	.014	.014	.014	..	..	..	..
0.188–0.249	.004	.006	.008	.010	.012	.012	.012	.014	.014	..	..
0.250–0.374	.004	.006	.006	.008	.010	.010	.012	.012	.012	.014	..
0.375–0.499	.004	.004	.006	.008	.008	.008	.010	.010	.010	.012	.014
0.500–0.749	.004	.004	.006	.006	.008	.008	.008	.008	.010	.010	.012
0.750–0.999	.004	.004	.006	.006	.008	.008	.008	.008	.008	.008	.010
1.000–1.499	.004	.004	.004	.006	.006	.008	.008	.008	.008	.008	.008
1.500–1.999	.004	.004	.004	.004	.006	.006	.006	.008	.008	.008	.008
2.000 and up	.004	.004	.004	.004	.004	.006	.006	.006	.008	.008	.008



**SURFACES WIDTHS UP THRU 1 INCH OR ANY 1 INCH INCREMENT OF WIDER SURFACES**  
Maximum Allowable Deviation D = TOLERANCE (in.)

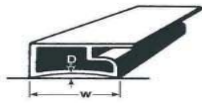
**WIDTHS OVER 1 INCH**  
Maximum Allowable Deviation D = TOLERANCE × W (in.)

For numbered footnotes, see page 9.

# Extruded Wire, Rod, Bar and Profiles

**TABLE 11.9 Flatness (Flat Surfaces) ①—Hollow Profiles** (EXCEPT FOR PROFILES IN O ⑥, T3510, T4510, T6510, T73510, T76510 and T8510 TEMPER ④)

MINIMUM THICKNESS OF METAL FORMING THE SURFACE in.	SURFACES WIDTHS UP THRU 1 INCH OR ANY 1 INCH INCREMENT OF WIDER SURFACES										
	Maximum Allowable Deviation D = TOLERANCE (in.)										
	WIDTHS OVER 1 INCH										
Maximum Allowable Deviation D = TOLERANCE × W (in.)											
SURFACE WIDTH—in.											
UP TO 5.999	6.000 TO 7.999	8.000 TO 9.999	10.000 TO 11.999	12.000 TO 13.999	14.000 TO 15.999	16.000 TO 17.999	18.000 TO 19.999	20.000 TO 21.999	22.000 TO 23.999	24.000 AND UP	
TOLERANCE											
Up thru 0.124	.006	.008	.012	.016	..	..	..	..	..	..	..
0.125–0.187	.006	.008	.010	.014	.016	..	..	..	..	..	..
0.188–0.249	.004	.006	.010	.012	.014	.014	.014	.016	..	..	..
0.250–0.374	.004	.006	.008	.010	.012	.012	.012	.014	.014	.016	..
0.375–0.499	.004	.006	.008	.010	.010	.010	.012	.012	.012	.014	.016
0.500–0.749	.004	.004	.006	.008	.008	.008	.010	.010	.012	.012	.014
0.750–0.999	.004	.004	.006	.006	.008	.008	.008	.008	.010	.010	.012
1.000 and up	.004	.004	.004	.006	.006	.008	.008	.008	.008	.008	.008



**TABLE 11.10 Surface Roughness ① ③—Extruded Wire, Rod, Bar and Profiles**

SPECIFIED SECTION THICKNESS in.	ALLOWABLE DEPTH OF CONDITIONS ② in. max.
Up thru 0.063	0.0015
0.064–0.125	0.002
0.126–0.188	0.0025
0.189–0.250	0.003
0.251–0.500	0.004
0.501- and over	0.008

For numbered footnotes, see page 10.

**TABLE 11.11 Contour (Curved Surfaces) ① ③—Extruded Profiles**

Temper	
	
All except O, TX510 ④	Allowable deviation from specified contour: 0.005 inch per inch of chord length; 0.005 inch minimum. Not applicable to contours with chord length 6 inch and over.
O	Allowable deviation from specified contour: 0.015 inch per inch of chord length; 0.015 inch minimum. Not applicable to contours with chord length 6 inches and over.

## Footnotes for Tables 11.5 through 11.8

① These Standard Tolerances are applicable to the average profile; wider tolerances may be required for some profiles, and closer tolerances may be possible for others.

② TX510 and TX511 are general designations for the following stress relieved tempers: T3510, T4510, T61510, T6510, T8510, T73510, T76510 and T3511, T4511, T61511, T6511, T8511, T73511, T76511, respectively.

③ When weight of piece on the flat surface minimizes deviation.

④ The circumscribing circle diameter is the diameter of the smallest circle that will completely enclose the cross section of the extruded product.

⑤ Tolerances for T3510, T4510, T6510, T73510, T76510, and T8510 tempers shall be as agreed upon between purchaser and vendor at the time the contract or order is entered.

⑥ Twist is normally measured by placing the extruded section on a flat surface and at any point along its length measuring the maximum distance between the bottom surface of the extruded section and the flat surface.

From this measurement, the actual deviation from straightness of the extruded section at that point is subtracted. The remainder is the twist. To convert the standard twist tolerance (degrees) to an equivalent linear value, the sine of the standard tolerance is multiplied by the width of the surface of the section that is on the flat surface. The following values are

used to convert angular tolerances to linear deviation:

Tolerance, degrees	Maximum allowable linear deviation inch per inch of width
¼	0.004
½	0.009
1	0.017
1½	0.026
3	0.052
5	0.087
7	0.122
9	0.156
15	0.259
21	0.358

⑦ Applies only if the thickness along at least ⅓ of the total perimeter is 0.094 or less. Otherwise use the tolerance shown for 0.095 and over.

⑧ Tolerance for “O” temper material is four times the standard tolerances shown.

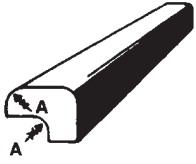
⑨ Straightness must be met in all orientations, including orientations which are not self-supporting.

# Extruded Wire, Rod, Bar and Profiles

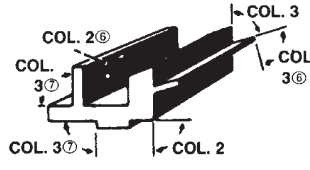
**TABLE 11.12 Squareness of Cut Ends ①—  
Extruded Rod, Bar and Profiles**

Allowable deviation from square: 1 degree
---

**TABLE 11.13 Corner and Fillet Radii ①—  
Extruded Bar and Profiles**

SPECIFIED RADIUS ⑨ in.	TOLERANCE—in.
	ALLOWABLE DEVIATION FROM SPECIFIED RADIUS
	 <p>Difference between radius A and specified radius</p>
Sharp corners	+1/64
0.016–0.187	±1/64
0.188 and over	±10%

**TABLE 11.14 Angularity ① ⑤—Extruded Bar and Profiles**

TEMPER	MINIMUM SPECIFIED LEG THICKNESS in.	TOLERANCE Degrees plus and minus		
		ALLOWABLE DEVIATION FROM SPECIFIED ANGLE		
				
		RATIO: ⑥ ⑦ LEG OR SURFACE LENGTH TO LEG OR METAL THICKNESS		
		1 and less	Over 1 thru 40	
		Col. 1	Col. 2	Col. 3
All except O, TX510 ④	Up thru 0.187	1	2	
	0.188–0.749	1	1½	
	0.750 and over	1	1	
O	Up thru 0.187	3	6	
	0.188–0.749	3	4½	
	0.750 and over	3	3	

### Footnotes for Tables 11.9 through 11.14

① These Standard Tolerances are applicable to the average profile; wider tolerances may be required for some profiles, and closer tolerances may be possible for others.

② Conditions include die lines and handling marks.

③ As measured with a contour gauge whose surface is limited to a maximum subtended angle of 90 degrees. Extruded curved surfaces comprising more than a 90-degree subtended angle are checked by sliding the gauge across the surface, thus checking two or more 90-degree portions of the surface. Extruded profile surfaces comprising arcs formed by two or more radii require the use of a separate contour gauge for each portion of the surface formed by an individual radius.

④ Tolerances for T3510, T4510, T6510, T73510, T76510 and T8510 tempers shall be as agreed upon between the purchaser and vendor and at the time the contract or order is entered.

⑤ Angles are measured with protractors or with gauges.

As illustrated, a four-point contact system is used, two contact points being as close to the angle vertex as practical, and the others near the ends of the respective surfaces forming the angle. Between these points of measurement surface flatness is the controlling tolerance.



⑥ When the area between the surface forming an angle is all metal, values in column 2 apply if the larger surface length to metal thickness ratio is 1 or less.

⑦ When two legs are involved the one having the larger ratio determines the applicable column.

⑧ Not applicable to 2219 alloy extrusions. Most profiles in 2219 alloy will have die lines about twice the depth shown in the table; however, for each profile the supplier should be contacted for the roughness value to apply.

⑨ If unspecified, the radius shall be 1/32 in. maximum including tolerances.

⑩ Tolerance for "O" temper material is four times the standard tolerances shown.

# Electrical Conductors

**TABLE 16.22 Thickness, Width, Diameter—Tolerances—Extruded Rod and Bar—Electric Conductors**

SPECIFIED THICKNESS WIDTH, OR DIAMETER in.	TOLERANCE ①—in. plus and minus
	ALLOWABLE DEVIATION FROM SPECIFIED DIMENSION
0.125–0.249	.007
0.250–0.499	.008
0.500–0.749	.009
0.750–0.999	.010
1.000–1.499	.012
1.500–1.999	.014
2.000–3.999	.024
4.000–5.999	.034
6.000–7.999	.044
8.000–9.999	.064
10.000–12.000	.074

**TABLE 16.23 Length—Tolerances—Extruded Rod and Bar—Electric Conductors**

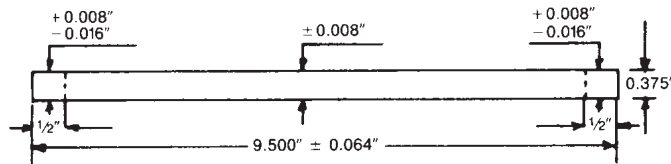
SPECIFIED WIDTH in.	TOLERANCE—in. plus	
	ALLOWABLE DEVIATION FROM SPECIFIED LENGTH	
	SPECIFIED LENGTH—ft.	
	Up thru 12	Over 12 thru 30
Up thru 2.999	1/8	1/4
3.000–7.999	3/16	5/16
8.000 and over	1/4	3/8

### Footnotes for Tables 6.22 and 16.23

① For some items of relatively thin wide bar greater thickness tolerances are required as follows:

- a. Specified bar thickness less than 0.500 in.; corner radii 1/16 in. or less; width to thickness ratio 24 to 1 and greater.

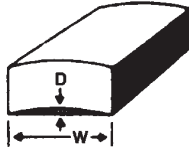
Tolerance per Table 16.22 except for distance 1/2 in. from each edge where plus tolerance of Table 16.22 applies and minus tolerance of 2 × Table 16.22 tolerance applies.



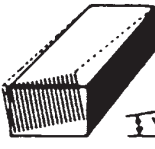
- b. Specified bar thickness 0.500 in. and greater; corner radii 3/16 in. or less; width to thickness ratio 10 to 1 and greater. Thickness tolerance per Table 16.22 except for distance 1/2 in. from edge where plus tolerance of Table 16.22 applies and minus tolerance 2 × Table 16.22 applies.

# Electrical Conductors


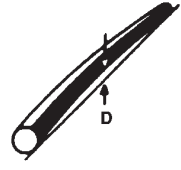
**TABLE 16.24 Flatness (Flat Surfaces)—Tolerances—Extruded Bar—Electric Conductors**

SPECIFIED WIDTH in.	TOLERANCE—in.	
	 <p>Maximum Allowable Deviation D</p>	
Up thru 1	0.004	
Over 1 thru 5.999	.004 × W (inches)	
In any 1 in. of width	0.004	

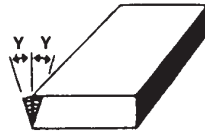
**TABLE 16.25 Twist ①—Tolerances—Extruded Bar—Electric Conductors**

SPECIFIED WIDTH in.	TOLERANCE ②—DEGREES	
	ALLOWABLE DEVIATION FROM STRAIGHT	
	 <p>Y (max.) in degrees</p>	
	IN TOTAL LENGTH OR IN ANY MEASURED SEGMENT OF ONE FT. OR MORE OF TOTAL LENGTH	MAXIMUM FOR TOTAL LENGTH
Up thru 1.499	1 × Measured length, ft.	7
1.500–2.999	½ × Measured length, ft.	5
3.000 and over	¼ × Measured length, ft.	3

**TABLE 16.26 Straightness ① ②—Tolerances—Extruded Rod and Bar—Electric Conductors**

BAR		ROD	
TOLERANCE in. in any 10 ft.	SPECIFIED DIAMETER in.	TOLERANCE in.	
			
Flatwise	Edgewise	D (max.)	IN TOTAL LENGTH OR IN ANY MEASURED SEGMENT OF ONE FT. OR MORE OF TOTAL LENGTH
D(max.) = ¼	D (max.) = ⅛	0.375–5.999 6.000 and over	.010 × Measured length, ft. .020 × Measured length, ft.

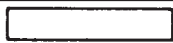

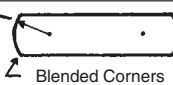

**TABLE 16.27 Angularity—Extruded Bar—Electric Conductors**

	
Allowable deviation from nominal angle: ±1 degree.	

**TABLE 16.28 Squareness of Cut Ends—Extruded Rod and Bar—Electric Conductors**

Allowable deviation from square: 1 degree.
--

**TABLE 16.29 Corner and Edge Radii—Tolerances—Extruded Bar—Electric Conductors**

	SPECIFIED EDGE CONTOUR	SPECIFIED BAR THICKNESS in.	NOMINAL RADIUS	RADIUS TOLERANCE
Square Corners		0.125–1.000 1.001 and over	.. ..	+½ in. +⅛ in.
Round Corners	Radius 	0.125–0.188 0.189–1.000 1.001 and over	⅓₂ ⅓₁₆ ⅓₆	±⅓₄ in. ±⅓₄ in. ±⅓₄ in.
Rounded Edge	Radius  Blended Corners	Up thru 0.149 0.150 and over	1¼ × Bar thickness 1¼ × Bar thickness	±⅓₄ in. ±10%
Full Rounded Edge	Radius 	Up thru 0.374 0.375 and over	½ × Bar thickness ½ × Bar thickness	±1⅓₄ in. +10%

**Footnotes for Tables 16.24 Through 16.29**

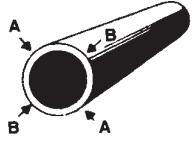
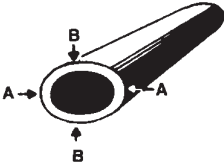
- ① Deviation from straightness shall be checked as follows: Place the bar or rod on a level surface so that the departure from straightness is horizontal. Measure the maximum depth of arc to the nearest ⅓₂ inch using a steel scale and a 120-inch-long straightedge.
- ② When weight of piece on flat surface minimizes deviation.
- ③ Twist is normally measured by placing the bar on a flat surface and at any point along its length measuring the maximum distance between the bottom surface of the bar and the flat surface. From this measurement, the actual deviation from straightness of the bar at that point is subtracted. The remainder is the twist. To convert the standard twist tolerance (degrees) to an equivalent linear value, the sine of the standard tolerance is multiplied by the width of the surface of the section that is on the flat surface. The following values are used to convert angular tolerances to linear deviation:

Tolerance, degrees	Maximum allowable linear deviation inch per inch of width
¼	0.004
½	0.009
1	0.017
1½	0.026
3	0.052
5	0.087
7	0.122
9	0.156
15	0.259
21	0.358

# Extruded Pipe and Tube

**TABLE 12.2 Diameter—Round Tube**

EXCEPT FOR T3510, T4510, T6510, T73510, T76510 AND T8510 TEMPER<sup>⑦</sup>

SPECIFIED DIAMETER <sup>①</sup> in.	TOLERANCE <sup>②</sup> —in. plus and minus			
	ALLOWABLE DEVIATION OF MEAN DIAMETER <sup>③</sup> FROM SPECIFIED DIAMETER (Size)		ALLOWABLE DEVIATION OF DIAMETER AT ANY POINT FROM SPECIFIED DIAMETER <sup>④</sup>	
	 Difference between $\frac{1}{2}(AA+BB)$ and specified diameter		 Difference between AA or BB and specified diameter	
Col. 1	Col. 2		Col. 3	
	5xxx ≥4.0 nominal Mg <sup>⑩</sup>	Other Alloys	5xxx ≥4.0 nominal Mg <sup>⑩</sup>	Other Alloys
0.500–0.999		.010		.020
1.000–1.999		.012		.025
2.000–3.999		.015		.030
4.000–5.999		.025		.050
6.000–7.999		.035		.075
8.000–9.999		.045		.100
10.000–11.999		.055		.125
12.000–13.999		.065		.150
14.000–15.999		.075		.175
16.000–17.999		.085		.200
18.000–19.999		.095		.225
20.000–21.999		.105		.250
22.000–23.999		.115		.275

## Footnotes for Tables 12.2 through 12.14

① When outside diameter, inside diameter, and wall thickness (or their equivalent dimensions in other than round tube) are all specified, standard tolerances are applicable to any two of these dimensions, but not to all three. When both outside and inside diameters or inside diameter and wall thickness are specified, the tolerance applicable to the specified or calculated O.D. dimension shall also apply to the I.D. dimension.

② When a dimension tolerance is specified other than as an equal bilateral tolerance, the value of the standard tolerance is that which applied to the mean of the maximum and minimum dimensions permissible under the tolerance for the dimension under consideration.

③ Mean diameter is the average of two diameter measurements taken at right angles to each other at any point along the length.

④ Not applicable in the annealed (O) temper if wall thickness is less than 2½ percent of outside diameter of a circle having a circumference equal to the perimeter of the tube.

⑤ The mean wall thickness of round tube is the average of two measurements taken opposite each other. The mean wall thickness of other-than-round tube is the average of two measurements taken opposite each other at approximate center line of tube and perpendicular to the longitudinal axis of the cross section.

⑥ When dimensions specified are outside and inside, rather than wall thickness itself, allowable deviation at any point (eccentricity) applies to mean wall thickness.

⑦ Tolerances for O, T3510, T4510, T6510, T73510, T76510 and T8510 tempers shall be as agreed upon between purchaser and vendor at the time the contract or order is entered.

⑧ TX510 and TX511 are general designations for the following stress-relieved tempers: T3510, T4510, T6510, T8510, T73510, T76510; and T3511, T4511, T6511, T8511, T73511, T76511, respectively.

⑨ When weight of piece on flat surface minimizes deviation.

⑩ The circumscribing circle diameter is the diameter of the smallest circle that will completely enclose the cross section of the extruded product.

⑪ Twist is normally measured by placing the extruded tube on a flat surface

and at any point along its length measuring the maximum distance between the bottom surface of the extruded tube and the flat surface. From this measurement, the actual deviation from straightness of the extruded tube at that point is subtracted. The remainder is the twist. To convert the standard twist tolerance (degrees) to an equivalent linear value, the sine of the standard tolerance is multiplied by the width of the surface of the section that is on the flat surface. The following values are used to convert angular tolerances to linear deviation:

Tolerance, degrees	Maximum allowable linear deviation inch per inch of width
¼	0.004
½	0.009
1	0.017
1½	0.026
3	0.052
5	0.087
7	0.122
9	0.156
15	0.259
21	0.358

⑫ Tolerances not applicable to TX510, or TX511 temper tube having a wall thickness less than 0.095 in.

⑬ Conditions include die lines, mandrel lines and handling marks.

⑭ For tube over 12.750 in. O.D. the 2000 and 7000 series alloys and 5000 series alloys with nominal magnesium content of 3 percent or more are excluded.

⑮ Not applicable to O temper tube.

⑯ Tolerances apply to 5xxx alloys with ≥4.0% Mg.

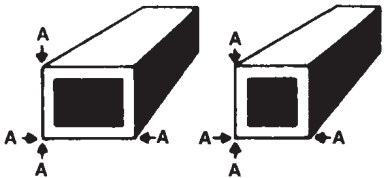

⑰ Not applicable to 2219 alloy tube. Most tubes in 2219 alloy will have die lines about twice the depth shown in the table; however, for each tube size the supplier should be contacted for the roughness value to apply.

⑱ If unspecified, the radius shall be ½ in. maximum including tolerances.

# Extruded Pipe and Tube

**TABLE 12.3 Width and Depth—Square, Rectangular, Hexagonal and Octagonal Tube**


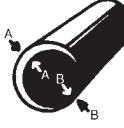
EXCEPT FOR T3510, T4510, T6510, T73510, T76510 AND T8510 TEMPERS ⑦

SPECIFIED WIDTH OR DEPTH in.	TOLERANCE ②—in. plus and minus				
	ALLOWABLE DEVIATION OF WIDTH OR DEPTH AT CORNERS FROM SPECIFIED WIDTH OR DEPTH		ALLOWABLE DEVIATION OF WIDTH OR DEPTH NOT AT CORNERS FROM SPECIFIED WIDTH OR DEPTH ④		
	 Difference between AA and specified width or depth		 Difference between AA and specified width, depth, or distance across flats		
	SQUARE, RECTANGULAR		SQUARE HEXAGONAL, OCTAGONAL	RECTANGULAR	
Col. 1	Col. 2		Col. 3		Col. 4
	5xxx ≥4.0 nominal Mg ⑩	Other Alloys	5xxx ≥4.0 nominal Mg ⑩	Other Alloys	All Alloys
0.500–0.749		.012		.020	The tolerance for the width is the value in the previous column for a dimension equal to the depth, and conversely, but in no case is the tolerance less than at the corners.  Example: The width tolerance of a 1 × 3 inch alloy 6061 rectangular tube is ±0.025 inch and the depth tolerance ±0.035 inch.
0.750–0.999		.014		.020	
1.000–1.999		.018		.025	
2.000–3.999		.025		.035	
4.000–4.999		.035		.045	
5.000–5.999		.045		.055	
6.000–6.999		.055		.065	
7.000–7.999		.065		.075	
8.000–8.999		.075		.085	
9.000–9.999		.085		.095	
10.000–10.999		.095		.105	
11.000–12.999		.105		.115	

For all numbered footnotes, see preceding page 13.

# Extruded Pipe and Tube

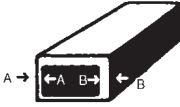

**TABLE 12.4 Wall Thickness—Round Extruded Tube**

SPECIFIED WALL THICKNESS ⑥  in.	TOLERANCE ① ②—in. plus and minus								ALLOWABLE DEVIATION OF WALL THICKNESS AT ANY POINT FROM MEAN WALL THICKNESS ⑤ (Eccentricity)    Difference between AA and mean wall thickness
	ALLOWABLE DEVIATION OF MEAN WALL THICKNESS ⑤ FROM SPECIFIED WALL THICKNESS    Difference between 1/2 (AA + BB) and specified wall thickness								
	OUTSIDE DIAMETER—IN.								
	Under 1.250		1.250–2.999		3.000–4.999		5.000 and over		
Col. 1	Col. 2		Col. 3		Col. 4		Col. 5		Col. 6
	5xxx ≥4.0 nominal Mg ⑬	Other Alloys	5xxx ≥4.0 nominal Mg ⑬	Other Alloys	5xxx ≥4.0 nominal Mg ⑬	Other Alloys	5xxx ≥4.0 nominal Mg ⑬	Other Alloys	All Alloys
Under 0.047		.006		..		..		..	Plus and minus 10% of mean wall thickness
0.047–0.061		.007		.008		.008		.010	
0.062–0.077		.008		.008		.009		.012	
0.078–0.124		.009		.009		.010		.015	
0.125–0.249		.009		.009		.013		.020	
0.250–0.374		.011		.011		.016		.025	
0.375–0.499		..		.015		.021		.035	
0.500–0.749		..		.020		.028		.045	
0.750–0.999		..		..		.035		.055	
1.000–1.499		..		..		.045		.065	
1.500–2.000		..		..		..		.075	
2.001–2.499		..		..		..		.085	±0.120
2.500–2.999		..		..		..		.095	
3.000–3.499		..		..		..		.105	
3.500–4.000		..		..		..		.115	

For all numbered footnotes, see page 13.

# Extruded Pipe and Tube

**TABLE 12.5 Wall Thickness—Other-Than-Round Extruded Tube**

SPECIFIED WALL THICKNESS ⑤  in.	TOLERANCE ① ②—in. plus and minus					
	ALLOWABLE DEVIATION OF MEAN WALL THICKNESS ⑤ FROM SPECIFIED WALL THICKNESS		ALLOWABLE DEVIATION OF WALL THICKNESS AT ANY POINT FROM MEAN WALL THICKNESS ⑤ (Eccentricity)			
	 Difference between $\frac{1}{2}(AA + BB)$ and specified wall thickness		 Difference between AA and mean wall thickness			
	CIRCUMSCRIBING CIRCLE DIAMETER ⑩—in.					
Col. 1	Under 5.000		5.000 and over		Under 5.000	5.000 and over
	Col. 2		Col. 3		Col. 4	Col. 5
	5xxx≥4.0 nominal Mg ⑯	Other Alloys	5xxx≥4.0 nominal Mg ⑯	Other Alloys	All Alloys	All Alloys
Under 0.047		.005		.008	.005	Plus and minus 10% of mean wall thickness
0.047–0.061		.006		.009	.007	
0.062–0.124		.007		.010	.010	
0.125–0.249		.008		.015	.015	
0.250–0.374		.011		.020	.025	
0.375–0.499		.014		.030	.030	max ±0.060 min ±0.010
0.500–0.749		.025		.040	.040	
0.750–0.999		.035		.050	.050	
1.000–1.499		.045		.060	.060	
1.500–2.000		..		.070	..	

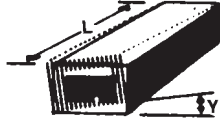
For all numbered footnotes, see page 13.

# Extruded Pipe and Tube


**TABLE 12.6 Length—Extruded Tube**

SPECIFIED OUTSIDE DIAMETER OR WIDTH  in.	TOLERANCE— <sup>9</sup> in. plus excepted as noted			
	ALLOWABLE DEVIATION FROM SPECIFIED LENGTH			
	STRAIGHT			
	SPECIFIED LENGTH—ft.			
	Up thru 12	Over 12 thru 30	Over 30 thru 50	Over 50
0.500–1.249	1/8	1/4	3/8	1
1.250–2.999	1/8	1/4	3/8	1
3.000–7.999	3/16	5/16	7/16	1
8.000 and over	1/4	3/8	1/2	1

**TABLE 12.7 Twist<sup>11</sup>—Other-than-Round Extruded Tube**

TEMPER	SPECIFIED WIDTH in.	SPECIFIED THICKNESS in.	TOLERANCE <sup>9</sup> —Degrees	
			ALLOWABLE DEVIATION FROM STRAIGHT	
			 Y (max.) in degrees	
			IN TOTAL LENGTH OR IN ANY SEGMENT OF ONE FT. OR MORE OF TOTAL LENGTH	MAXIMUM FOR TOTAL LENGTH
All except O, TX510, TX511 <sup>8</sup>	0.500 thru 1.499	All	1 × Measured length, ft.	7
	1.500–2.999	All	1/2 × Measured length, ft.	5
	3.000 and over	All	1/4 × Measured length, ft.	3
O, TX510 <sup>8</sup>	0.500 and over	0.095 and over	⑦	⑦
TX511 <sup>8</sup>	0.500–1.499	0.095 and over	1 × Measured length, ft.	7
	1.500–2.999	0.095 and over	1/2 × Measured length, ft.	5
	3.000 and over	0.095 and over	1/4 × Measured length, ft.	3

**TABLE 12.8 Straightness—Extruded Tube in Straight Lengths**

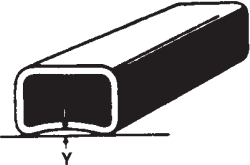
TEMPER	SPECIFIED WIDTH in.	TOLERANCE <sup>9</sup> <sup>12</sup> —in.
		ALLOWABLE DEVIATION (D) FROM STRAIGHT
		 IN TOTAL LENGTH OR IN ANY SEGMENT OF ONE FT. OR MORE OF TOTAL LENGTH
All except O, TX510 <sup>8</sup>	0.500–5.999	.010 × Measured length, ft.
	6.000 and over	.020 × Measured length, ft.
O, TX510 <sup>8</sup>	0.500 and over	⑦

For all numbered footnotes, see page 13.

# Extruded Pipe and Tube

**TABLE 12.9 Flatness (Flat Surfaces)—  
Extruded Tube**

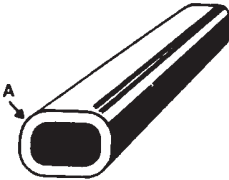
EXCEPT FOR O, T3510, T4510, T6510, T73510, T76510 AND T8510 TEMPER<sup>⑦</sup>

MINIMUM THICKNESS OF METAL FORMING THE SURFACE in.	TOLERANCE—in.	
	 <p>Maximum Allowable Deviation Y</p>	
	WIDTHS UP THRU 1 IN. OR ANY 1 IN. INCREMENT OF WIDER SURFACES	WIDTHS OVER 1 IN. THRU 5.999 IN.
Up thru 0.187 0.188 and over	0.006 0.004	0.006 × W (inches) 0.004 × W (inches)

**TABLE 12.10 Squareness of Cut Ends—  
Extruded Tube**

Allowable deviation from square: 1 degree.

**TABLE 12.11 Corner and Fillet Radii—Extruded  
Tube**

SPECIFIED RADIUS <sup>⑩</sup> in.	TOLERANCE—in.
	 <p>Difference between radius A and specified radius</p>
Sharp corners	+ $\frac{1}{64}$
0.016–0.187	$\pm\frac{1}{64}$
0.188 and over	$\pm 10\%$

**TABLE 12.12 Angularity—Extruded Tube**

Allowable deviation from square:  $\pm 2$  degrees.

For all numbered footnotes, see page 13.

**TABLE 12.13 Surface Roughness<sup>⑭ ⑰</sup>—  
Extruded Tube**

Specified Outside Diameter in.	Specified Wall Thickness in.	Allowable Depth of Conditions <sup>⑬</sup> in., max.
Up thru 12.750	Up thru 0.063	0.0025
	0.064–0.125	0.003
	0.126–0.188	0.0035
	0.189–0.250	0.004
	0.251–0.500	0.005
12.751–15.000	0.501 and over	0.008
	Up thru 0.500	0.010
15.001–20.000	0.501 and over	0.012
	Up thru 0.500	0.015
20.001 and over	0.501 and over	0.015
	Up thru 0.500	0.020

**TABLE 12.14 Dents<sup>⑮</sup>—Extruded Tube**

Depth of dents shall not exceed twice the tolerances specified in Table 12.2 for diameter at any point from specified diameter, except for tube having a wall thickness less than 2.5 percent of the outside diameter, in which case the following multipliers apply:

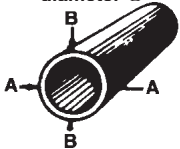

2% to 2½% exclusive—2.5 × tolerance (max.)

1½% to 2% exclusive—3.0 × tolerance (max.)

1% to 1½% exclusive—4.0 × tolerance (max.)

# Extruded Pipe and Tube

**TABLE 12.49 Outside Diameter Tolerances—Extruded Pipe and Extruded and Drawn Pipe**

PIPE SIZE in.	TOLERANCE—in.	
	Allowable deviation of mean <sup>②</sup> diameter from nominal diameter <sup>①</sup>	Allowable deviation of diameter at any point from nominal diameter <sup>①</sup>
		
	Difference between $\frac{1}{2}(AA+BB)$ and nominal diameter	Difference between AA and nominal diameter
	SCHEDULES 5 AND 10	SCHEDULE 20 AND GREATER
Under 2	+0.015–.031	+0.015–.031
2–4	+0.031–.031	+1%–1%
5–7	+0.062–.031	+1%–1%
8–12	+0.093–.031	+1%–1%

**TABLE 12.50 Wall Thickness Tolerances—Extruded Pipe or Extruded and Drawn Pipe**

SCHEDULE NUMBER	TOLERANCE
	ALLOWABLE DEVIATION OF WALL THICKNESS AT ANY POINT FROM NOMINAL <sup>①</sup> WALL THICKNESS
5 and 10 20 and greater	$\pm 12.5\%$ , $\pm 0.012$ in. min. $-12.5\%$ <sup>③</sup>

**TABLE 12.51 Weight Tolerances—Extruded Pipe or Extruded and Drawn Pipe**

SCHEDULE NUMBER	TOLERANCE
	ALLOWABLE DEVIATION FROM THEORETICAL WEIGHT
5 and 10 20 and greater	<sup>⑤</sup> $+8\%$ <sup>⑥</sup>


**Footnotes for Tables 12.49 Through 12.54**

- ① Nominal diameter and wall thickness are those listed in Table 12.55.
- ② Mean diameter is the average of any two diameter measurements taken at right angles to each other at any point along the length.
- ③ Maximum wall thickness is controlled by weight tolerance.

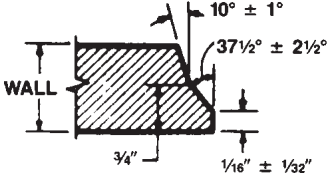
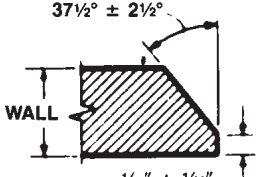
**TABLE 12.52 Length Tolerances—Extruded Pipe or Extruded and Drawn Pipe**

SPECIFIED LENGTH ft.	TOLERANCE in. plus
	ALLOWABLE DEVIATION FROM SPECIFIED LENGTH
Up thru 20	0.25
Over 20 thru 40	0.50

**TABLE 12.53 Straightness Tolerances—Extruded Pipe or Extruded and Drawn Pipe**

PIPE SIZE in.	TOLERANCE <sup>④</sup> —in.
	ALLOWABLE DEVIATION FROM STRAIGHT
	
	IN TOTAL LENGTH OR IN ANY MEASURED SEGMENT OF ONE FT. OR MORE OF TOTAL LENGTH
Under 6 6–12	.010 × Measured length, ft. .020 × Measured length, ft.

**TABLE 12.54 Standard Welding Bevels—Extruded Pipe or Extruded and Drawn Pipe**

DOUBLE LEVEL For Wall Thickness Over 0.750 in.	STRAIGHT BEVEL For Wall Thickness 0.750 in. and Less
	

- ④ When weight of pipe on flat surface minimizes deviation.
- ⑤ For schedule 5 and 10, only diameter, wall thickness and length tolerances apply.
- ⑥ Minimum weight is controlled by tolerances for outside diameter and wall thickness.

# Extruded Pipe and Tube

**TABLE 12.55 Diameters, Wall Thicknesses, Weights—Pipe**

NOMINAL PIPE SIZE ① IN.	SCHEDULE NUMBER	OUTSIDE DIAMETER in.			INSIDE DIAMETER in.	WALL THICKNESS in.			WEIGHT PER FOOT lb.	
		Nom. ①	Min ② ④	Max. ② ④	Nom.	Nom. ①	Min ②	Max. ②	Nom. ③	Max. ② ③
1/8	40	0.405	0.374	0.420	0.269	0.068	0.060	..	0.085	0.091
	80	0.405	0.374	0.420	0.215	0.095	0.083	..	0.109	0.118
1/4	40	0.540	0.509	0.555	0.364	0.088	0.077	..	0.147	0.159
	80	0.540	0.509	0.555	0.302	0.119	0.104	..	0.185	0.200
3/8	40	0.675	0.644	0.690	0.493	0.091	0.080	..	0.196	0.212
	80	0.675	0.644	0.690	0.423	0.126	0.110	..	0.256	0.276
1/2	5	0.840	0.809	0.855	0.710	0.065	0.053	0.077	0.186	..
	10	0.840	0.809	0.855	0.674	0.083	0.071	0.095	0.232	..
	40	0.840	0.809	0.855	0.622	0.109	0.095	..	0.294	0.318
	80	0.840	0.809	0.855	0.546	0.147	0.129	..	0.376	0.406
	160	0.840	0.809	0.855	0.464	0.188	0.164	..	0.453	0.489
3/4	5	1.050	1.019	1.065	0.920	0.065	0.053	0.077	0.237	..
	10	1.050	1.019	1.065	0.884	0.083	0.071	0.095	0.297	..
	40	1.050	1.019	1.065	0.824	0.113	0.099	..	0.391	0.422
	80	1.050	1.019	1.065	0.742	0.154	0.135	..	0.510	0.551
	160	1.050	1.019	1.065	0.612	0.219	0.192	..	0.672	0.726
1	5	1.315	1.284	1.330	1.185	0.065	0.053	0.077	0.300	..
	10	1.315	1.284	1.330	1.097	0.109	0.095	0.123	0.486	..
	40	1.315	1.284	1.330	1.049	0.133	0.116	..	0.581	0.627
	80	1.315	1.284	1.330	0.957	0.179	0.157	..	0.751	0.811
	160	1.315	1.284	1.330	0.815	0.250	0.219	..	0.984	1.062
1 1/4	5	1.660	1.629	1.675	1.530	0.065	0.053	0.077	0.383	..
	10	1.660	1.629	1.675	1.442	0.109	0.095	0.123	0.625	..
	40	1.660	1.629	1.675	1.380	0.140	0.122	..	0.786	0.849
	80	1.660	1.629	1.675	1.278	0.191	0.167	..	1.037	1.120
	160	1.660	1.629	1.675	1.160	0.250	0.219	..	1.302	1.407
1 1/2	5	1.900	1.869	1.915	1.770	0.065	0.053	0.077	0.441	..
	10	1.900	1.869	1.915	1.682	0.109	0.095	0.123	0.721	..
	40	1.900	1.869	1.915	1.610	0.145	0.127	..	0.940	1.015
	80	1.900	1.869	1.915	1.500	0.200	0.175	..	1.256	1.357
	160	1.900	1.869	1.915	1.338	0.281	0.246	..	1.681	1.815
2	5	2.375	2.344	2.406	2.245	0.065	0.053	0.077	0.555	..
	10	2.375	2.344	2.406	2.157	0.109	0.095	0.123	0.913	..
	40	2.375	2.351	2.399	2.067	0.154	0.135	..	1.264	1.365
	80	2.375	2.351	2.399	1.939	0.218	0.191	..	1.737	1.876
	160	2.375	2.351	2.399	1.687	0.344	0.301	..	2.581	2.788
2 1/2	5	2.875	2.844	2.906	2.709	0.083	0.071	0.095	0.856	..
	10	2.875	2.844	2.906	2.635	0.120	0.105	0.135	1.221	..
	40	2.875	2.846	2.904	2.469	0.203	0.178	..	2.004	2.164
	80	2.875	2.846	2.904	2.323	0.276	0.242	..	2.650	2.862
	160	2.875	2.846	2.904	2.125	0.375	0.328	..	3.464	3.741
3	5	3.500	3.469	3.531	3.334	0.083	0.071	0.095	1.048	..
	10	3.500	3.469	3.531	3.260	0.120	0.105	0.135	1.498	..
	40	3.500	3.465	3.535	3.068	0.216	0.189	..	2.621	2.830
	80	3.500	3.465	3.535	2.900	0.300	0.262	..	3.547	3.830
	160	3.500	3.465	3.535	2.624	0.438	0.383	..	4.955	5.351
3 1/2	5	4.000	3.969	4.031	3.834	0.083	0.071	0.095	1.201	..
	10	4.000	3.969	4.031	3.760	0.120	0.105	0.135	1.720	..
	40	4.000	3.960	4.040	3.548	0.226	0.198	..	3.151	3.403
	80	4.000	3.960	4.040	3.364	0.318	0.278	..	4.326	4.672

For all numbered footnotes, see page 21.

# Extruded Pipe and Tube

**TABLE 12.55 Diameters, Wall Thicknesses, Weights—Pipe (concluded)**

NOMINAL PIPE SIZE ① IN.	SCHEDULE NUMBER	OUTSIDE DIAMETER in.			INSIDE DIAMETER in.	WALL THICKNESS in.			WEIGHT PER FOOT lb.		
		Nom. ①	Min ② ④	Max. ② ④		Nom.	Nom. ①	Min ②	Max. ②	Nom. ③	Max. ② ③
4	5	4.500	4.469	4.531	4.334	0.083	0.071	0.095	1.354	..	
	10	4.500	4.469	4.531	4.260	0.120	0.105	0.135	1.942	..	
	40	4.500	4.455	4.545	4.026	0.237	0.207	..	3.733	4.031	
	80	4.500	4.455	4.545	3.826	0.337	0.295	..	5.183	5.598	
	120	4.500	4.455	4.545	3.624	0.438	0.383	..	6.573	7.099	
	160	4.500	4.455	4.545	3.438	0.531	0.465	..	7.786	8.409	
5	5	5.563	5.532	5.625	5.345	0.109	0.095	0.123	2.196	..	
	10	5.563	5.532	5.625	5.295	0.134	0.117	0.151	2.688	..	
	40	5.563	5.507	5.619	5.047	0.258	0.226	..	5.057	5.461	
	80	5.563	5.507	5.619	4.813	0.375	0.328	..	7.188	7.763	
	120	5.563	5.507	5.619	4.563	0.500	0.438	..	9.353	10.10	
	160	5.563	5.507	5.619	4.313	0.625	0.547	..	11.40	12.31	
6	5	6.625	6.594	6.687	6.407	0.109	0.095	0.123	2.624	..	
	10	6.625	6.594	6.687	6.357	0.134	0.117	0.151	3.213	..	
	40	6.625	6.559	6.691	6.065	0.280	0.245	..	6.564	7.089	
	80	6.625	6.559	6.691	5.761	0.432	0.378	..	9.884	10.67	
	120	6.625	6.559	6.691	5.501	0.562	0.492	..	12.59	13.60	
	160	6.625	6.559	6.691	5.187	0.719	0.629	..	15.69	16.94	
8	5	8.625	8.594	8.718	8.407	0.109	0.095	0.123	3.429	..	
	10	8.625	8.594	8.718	8.329	0.148	0.130	0.166	4.635	..	
	20	8.625	8.539	8.711	8.125	0.250	0.219	..	7.735	8.354	
	30	8.625	8.539	8.711	8.071	0.277	0.242	..	8.543	9.227	
	40	8.625	8.539	8.711	7.981	0.322	0.282	..	9.878	10.67	
	60	8.625	8.539	8.711	7.813	0.406	0.355	..	12.33	13.31	
	80	8.625	8.539	8.711	7.625	0.500	0.438	..	15.01	16.21	
	100	8.625	8.539	8.711	7.437	0.594	0.520	..	17.62	19.03	
	120	8.625	8.539	8.711	7.187	0.719	0.629	..	21.00	22.68	
	140	8.625	8.539	8.711	7.001	0.812	0.710	..	23.44	25.31	
	160	8.625	8.539	8.711	6.813	0.906	0.793	..	25.84	27.90	
	10	5	10.750	10.719	10.843	10.482	0.134	0.117	0.151	5.256	..
10		10.750	10.719	10.843	10.420	0.165	0.144	0.186	6.453	..	
20		10.750	10.642	10.858	10.250	0.250	0.219	..	9.698	10.47	
30		10.750	10.642	10.858	10.136	0.307	0.269	..	11.84	12.79	
40		10.750	10.642	10.858	10.020	0.365	0.319	..	14.00	15.12	
60		10.750	10.642	10.858	9.750	0.500	0.438	..	18.93	20.45	
80		10.750	10.642	10.858	9.562	0.594	0.520	..	22.29	24.07	
100		10.750	10.642	10.858	9.312	0.719	0.629	..	26.65	28.78	
12		5	12.750	12.719	12.843	12.438	0.156	0.136	0.176	7.258	..
		10	12.750	12.719	12.843	12.390	0.180	0.158	0.202	8.359	..
	20	12.750	12.622	12.878	12.250	0.250	0.219	..	11.55	12.47	
	30	12.750	12.622	12.878	12.090	0.330	0.289	..	15.14	16.35	
	40	12.750	12.622	12.878	11.938	0.406	0.355	..	18.52	20.00	
	60	12.750	12.622	12.878	11.626	0.562	0.492	..	25.31	27.33	
	80	12.750	12.622	12.878	11.374	0.688	0.602	..	30.66	33.11	

Footnotes for pages 20 and 21.

**Footnotes for Table 12.55**

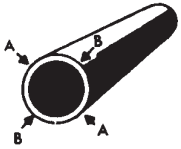
- ① In accordance with ANSI/ASME Standards B36.10M and B36.19M
- ② Based on standard tolerances for outside diameter, wall thickness and weight shown earlier in this section.

- ③ Based on nominal dimensions, plain ends, and a density of 0.098 lb per cu in., the density of 6061 alloy. For alloy 6063 multiply by 0.99 and for alloy 3003 multiply by 1.011.

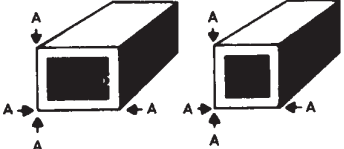

- ④ For schedules 5 and 10 these values apply to mean outside diameters.

# Drawn Tube

**TABLE 12.20 Diameter—Drawn Round Tube**

SPECIFIED DIAMETER in.	TOLERANCE ②—in. plus and minus			
	ALLOWABLE DEVIATION OF MEAN DIAMETER ③ FROM SPECIFIED DIAMETER (Size)	ALLOWABLE DEVIATION OF DIAMETER AT ANY POINT FROM SPECIFIED DIAMETER ④		
	 Difference between ½ (AA + BB) and specified diameter	Difference between AA or BB and specified diameter		
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5
Up thru 0.500	.003	.003	.006	.018
0.501–1.000	.004	.004	.008	.024
1.001–2.000	.005	.005	.010	.030
2.001–3.000	.006	.006	.012	.036
3.001–5.000	.008	.008	.016	.048
5.001–6.000	.010	.010	.020	.060
6.001–8.000	.015	.015	.030	.090
8.001–10.000	.020	.020	.040	.120
10.001–12.000	.025	.025	.050	.150

**TABLE 12.21 Width and Depth—Drawn Square, Rectangular, Hexagonal and Octagonal Tube**

SPECIFIED WIDTH OR DEPTH ① in.	TOLERANCE ②—in. plus and minus		
	ALLOWABLE DEVIATION OF WIDTH OR DEPTH AT CORNERS FROM SPECIFIED WIDTH OR DEPTH	ALLOWABLE DEVIATION OF WIDTH OR DEPTH NOT AT CORNERS FROM SPECIFIED WIDTH OR DEPTH ④ ⑦	
	 Difference between AA and specified width or depth	 Difference between AA and specified width, depth, or distance across flats	
Col. 1	SQUARE, RECTANGULAR Col. 2	SQUARE, HEXAGONAL, OCTAGONAL Col. 3	RECTANGULAR Col. 4
Up thru 0.500	.003	.006	The tolerance for the width is the value in Col. 3 for the dimension equal to the depth, and conversely, but in no case is the tolerance less than at the corners. ⑥
0.501–1.000	.004	.008	
1.001–2.000	.005	.010	
2.001–3.000	.006	.012	
3.001–5.000	.008	.016	
5.001–6.000	.010	.020	
6.001–8.000	.015	.030	
8.001–10.000	.020	.040	
10.001–12.000	.025	.050	



**Footnotes for Tables 12.20 and 12.21**

- ① When outside diameter, inside diameter, and wall thickness (or their equivalent dimensions in other than round tube) are all specified, standard tolerances are applicable to any two of these dimensions, but not to all three. When both outside and inside diameters or inside diameter and wall thickness are specified, the tolerance applicable to the specified or calculated O.D. dimension shall also apply to the I.D. dimension.
- ② When a dimension tolerance is specified other than as an 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 of the dimension under consideration.
- ③ Mean diameter is the average of two diameter measurements taken at right angles to each other at the same longitudinal location on the tube.

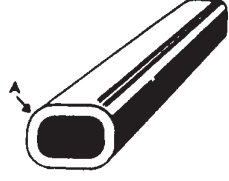
- ④ Not applicable to coiled tube or tube having a wall thickness less than 2½ percent of the specified outside diameter. The tolerance for tube with wall thickness less than 2½ percent of the specified outside diameter is determined by multiplying the applicable tolerance in columns 3 thru 5 as follows:  
 2% to 2½% exclusive—1.5 × tolerance  
 1½% to 2% exclusive—2.0 × tolerance  
 1% to 1½% exclusive—3.0 × tolerance  
 ½% to 1% exclusive—4.0 × tolerance
- ⑤ For the T8 tempers of 6063 the tolerance in Column 3 apply.
- ⑥ Example: The width tolerance of 1 × 3 inch rectangular tube is plus and minus 0.008 inch, and the depth tolerance is plus and minus 0.012 in.
- ⑦ Not applicable to annealed (O temper) tube.

# Drawn Tube

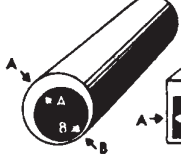
**TABLE 12.22 Diameter—Drawn Oval, Elliptical and Streamline Tube**

EQUIVALENT ROUND DIAMETER <sup>⑤</sup> in.	TOLERANCE <sup>① ②</sup> —in.			
	LENGTH OF MAJOR AXIS, in.		LENGTH OF MAJOR AXIS, in.	
				
	Difference between AA and specified length		Difference between AA and specified length	
Col. 1	Col. 2		Col. 3	
Up thru 2.500	+0.040	-.025	+0.025	-.015
2.501–4.250	+0.050	-.035	+0.035	-.025
4.251–6.000	+0.070	-.050	+0.055	-.040
6.001–8.000	+0.100	-.085	+0.080	-.060
8.001–10.000	+0.160	-.140	+0.115	-.085

**TABLE 12.23 Corner Radii—Drawn Tube**

SPECIFIED <sup>⑦</sup> RADIUS in.	TOLERANCE <sup>②</sup> —in.
	ALLOWABLE DEVIATION FROM SPECIFIED RADIUS
	
	Difference between radius A and specified radius
Sharp Corners	+1/64
0.016–0.187	±1/64
0.188 and over	±10%

**TABLE 12.24 Wall Thickness—Drawn Round and Other-Than-Round Tube**

SPECIFIED THICKNESS <sup>④</sup> in.	TOLERANCE <sup>① ②</sup> —in. plus and minus		
	ALLOWABLE DEVIATION OF MEAN WALL THICKNESS <sup>③</sup> FROM SPECIFIED WALL THICKNESS	ALLOWABLE DEVIATION OF WALL THICKNESS AT ANY POINT FROM SPECIFIED WALL THICKNESS (Eccentricity)	
	 Difference between 1/2(AA+BB) and specified wall thickness	ROUND, NON-HEAT-TREATABLE ALLOYS <sup>⑥</sup>	ROUND, HEAT-TREATABLE ALLOYS AND OTHER THAN ROUND, ALL ALLOYS
Col. 1	Col. 2	Col. 3	Col. 4
0.010–0.035	.002	.002	Plus and minus 10% of specified wall thickness, min ±0.003
0.036–0.049	.003	.003	
0.050–0.083	.004	.004	
0.084–0.120	.005	.006	
0.121–0.203	.006	.008	
0.204–0.300	.008	.012	
0.301–0.375	.015	.020	
0.376–0.500	.020	.030	

**Footnotes for Tables 12.22 Through 12.24**

- ① When outside diameter, inside diameter, and wall thickness (or their equivalent dimensions in other-than-round tube) are all specified, standard tolerances are applicable to any two of these dimensions, but not to all three. When both outside and inside diameters or inside diameter and wall thickness are specified, the tolerance applicable to the specified or calculated O.D. dimension shall also apply to the I.D. dimension.
- ② When a dimension tolerance is specified other than as an 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.
- ③ The mean wall thickness of round tube is the average of two measurements taken opposite each other. The mean wall thickness of other-than-round tube is the average of two measurements taken opposite each other at approximate center line of tube and perpendicular to the longitudinal axis of the cross section.
- ④ When dimensions specified are outside and inside, rather than wall thickness itself, allowable deviation at any point (eccentricity) is plus and minus 10 percent of the mean wall thickness but not less than ±0.003 inch.
- ⑤ Equivalent round diameter is the diameter of the circle having a circumference equal to the perimeter of the tube.
- ⑥ For coiled tube, values in Column 4 apply.
- ⑦ If unspecified, the radius shall be 1/32 in. maximum including tolerances.


**Footnotes for Tables 12.25 Through 12.30**

- ① Tolerance is applicable when weight of tube on flat surface minimizes deviation.
- ② Not applicable to annealed (O temper) tube.
- ③ Not applicable to annealed (O temper) tube, coiled tube, or tube having a wall thickness less than 0.020 inch or less than 2 1/2% of the equivalent round diameter. Equivalent round diameter is the diameter of a circle having a circumference equal to the perimeter of the tube.
- ④ Twist is normally measured by placing the drawn tube on a flat surface and at any point along its length measuring the maximum distance between the bottom surface of the drawn tube and the flat surface. From this measurement, the actual deviation from straightness of the drawn tube at that point is subtracted. The remainder is the twist. To convert the standard twist tolerance (degrees) to an equivalent linear value, the sine of the standard tolerance is multiplied by the width of the surface of the section that is on the flat surface. The following values are used to convert angular tolerances to linear deviation:

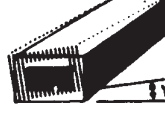
Tolerance, degrees	Maximum allowable linear deviation inch per inch of width
1/4	0.004
1/2	0.009
1	0.017
1 1/2	0.026
3	0.052
5	0.087
7	0.122
9	0.156
15	0.259
21	0.358

# Drawn Tube

**TABLE 12.25 Straightness—Drawn Tube**

SPECIFIED OUTSIDE DIAMETER OR WIDTH  in.	TOLERANCE ① ②—in.	
	ALLOWABLE DEVIATION FROM STRAIGHT	
	 D(max)	
	IN TOTAL LENGTH OR IN ANY MEASURED SEGMENT OF ONE FT. OR MORE OF TOTAL LENGTH	
Up thru 0.374	.500 × Measured length, ft.	
0.375–5.999	.010 × Measured length, ft.	
6.000 and over	.020 × Measured length, ft.	

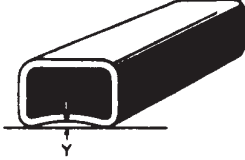
**TABLE 12.26 Twist ④—Drawn Tube**

SPECIFIED WIDTH  in.	TOLERANCE ① ②—Degree	
	ALLOWABLE DEVIATION FROM STRAIGHT	
	 Y (max) in degrees	
	IN TOTAL LENGTH OR IN ANY MEASURED SEGMENT OF ONE FT. OR MORE OF TOTAL LENGTH	MAXIMUM FOR TOTAL LENGTH
Up thru 1.499	1 × Measured length, ft.	7
1.500–2.999	½ × Measured length, ft.	5
3.000 and over	¼ × Measured length, ft.	3

**TABLE 12.27 Length—Drawn Tube**

SPECIFIED OUTSIDE DIAMETER OR WIDTH  in.	TOLERANCE—in. plus except as noted							
	ALLOWABLE DEVIATION FROM SPECIFIED LENGTH							
	STRAIGHT				COILED			
	SPECIFIED LENGTH—ft.							
	Up thru 12	Over 12 thru 30	Over 30 thru 50	Over 50	Up thru 100	Over 100 to 250	250 to 500	500 and over
Up thru 0.249	¼	⅜	½	..	+5%, -0%	±10%	±15%	±20%
0.250–1.249	⅜	¼	⅜	1	+5%, -0%	±10%	±15%	±20%
1.250–2.999	½	½	⅜	1	..	..	..	..
3.000–7.999	¾	¾	½	1	..	..	..	..
8.000 and over	1	1	½	1	..	..	..	..

**TABLE 12.28 Flatness (Flat Surfaces)—Other-Than-Round Drawn Tube**

SPECIFIED WIDTH OR DEPTH  in.	TOLERANCE ③—in.	
	ALLOWABLE DEVIATION FROM FLAT	
	 Maximum allowable distance Y	
Up thru 0.500	.003	
0.501–1.000	.004	
1.001–2.000	.005	
2.001–3.000	.006	
3.001–5.000	.008	
5.001–6.000	.010	
6.001–8.000	.015	
8.001–10.000	.020	
10.001–12.000	.025	

**TABLE 12.31 Surface Roughness—Drawn Tube ②**

Depth of surface conditions shall not exceed 10% of the smaller (or nominal) wall thickness or 0.005 inch, whichever is smaller.

② not applicable to annealed (O Tempers) tube

**TABLE 12.32 Dents—Drawn Tube**

SPECIFIED DIAMETER in.	TOLERANCES—in.		
	NON-ANNEALED AND NON-HEAT-TREATED TUBE	HEAT-TREATED TUBE ⑤	ANNEALED TUBE
	Col. 1	Col. 2	Col. 3
Up thru 0.500	.006	.012	.036
0.501–1.000	.008	.016	.048
1.001–2.000	.010	.020	.060
2.001–3.000	.012	.024	.072
3.001–5.000	.016	.032	.096
5.001–6.000	.020	.040	.120
6.001–8.000	.030	.060	.180
8.001–10.000	.040	.080	.240
10.001–12.000	.050	.100	.300

For tube having a wall thickness less than 2½ percent of the outside diameter, the following multipliers of the above tolerances apply.

Percent of Wall Thickness

- 2% to 2.5% exclusive—1.25 × tolerance (max.)
- 1.5% to 2% exclusive—1.50 × tolerance (max.)
- 1% to 1.5% exclusive—2.0 × tolerance (max.)
- 0.5% to 1% exclusive—2.5 × tolerance (max.)

⑤ For the T8 tempers of 6063 the tolerances of column 2 apply.

**TABLE 12.29 Squareness of Cut Ends—Drawn Tube**

Allowable deviation from square: 1 degree

**TABLE 12.30 Angularity—Drawn Tube**

Allowable deviation from specified angle: ±2 degrees

For numbered footnotes, Tables 12.25 through 12.30 see previous page.

# Cold Finished Wire, Rod and Bar

**TABLE 10.5 Diameter—Round Wire and Rod**

SPECIFIED DIAMETER in.	TOLERANCE—in. plus and minus Except as noted			
	ALLOWABLE DEVIATION FROM SPECIFIED DIAMETER			
	Drawn Wire	Cold Finished Rod	Rolled Rod	
Plus			Minus	
Up thru 0.035	.0005	...	...	...
0.036–0.064	.001	...	...	...
0.065–0.374	.0015	...	...	...
0.375–0.500	...	.0015	.020	.020
0.501–1.000	...	.002	.025	.025
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	...	...

**TABLE 10.6 Diameter—Centerless Ground Round Wire and Rod**

SPECIFIED DIAMETER in.	TOLERANCE in. plus and minus
	ALLOWABLE DEVIATION FROM SPECIFIED DIAMETER
0.125–0.625	.0005
0.626–1.500	.0010
1.501–2.000	.0025

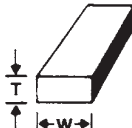
**TABLE 10.7 Diameter—Rivet and Cold Heading Wire and Rod**

SPECIFIED DIAMETER in.	TOLERANCE			
	ALLOWABLE DEVIATION FROM SPECIFIED DIAMETER			
	Rivet Wire		Rivet Rod	
	in. plus	in. minus	in. plus	in. minus
Up thru 0.061	.0005	.0005	...	...
0.062–0.123	.001	.0005	...	...
0.124–0.154	.001	.001	...	...
0.155–0.374	.002	.001	...	...
0.375–0.500	...	...	.002	.001
0.501–1.000	...	...	.003	.001

**TABLE 10.8 Diameter—Drawing Stock**

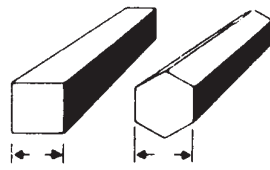
SPECIFIED DIAMETER in.	TOLERANCE—in. plus and minus
	ALLOWABLE DEVIATION FROM SPECIFIED DIAMETER
0.375–0.500	.020
0.501–1.000	.025

**TABLE 10.9 Thickness and Width—Rectangular Wire and Bar**



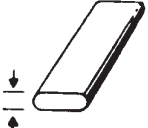
SPECIFIED THICKNESS OR WIDTH in.	TOLERANCE in. plus and minus			
	ALLOWABLE DEVIATION FROM SPECIFIED THICKNESS AND WIDTH			
	Drawn Wire and Cold Finished Bar		Rolled Bar	
	Thickness	Width	Thickness	Width
Up thru 0.035	.001	..	..	..
0.036–0.064	.0015	..	..	..
0.065–0.500	.002	.002	.006	..
0.501–0.750	.0025	.0025	.008	.016
0.751–1.000	.0025	.0025	.012	.016
1.001–1.500	.003	.003	.016	.016
1.501–2.000	.005	.003	.016	.031
2.001–3.000	.008	.008	.020	.031
3.001–4.000	..	.010	.020	.031
4.001–6.000	..	..	..	.047
6.001–10.000	..	..	..	.062

**TABLE 10.10 Distance across Flats—Square, Hexagonal and Octagonal Wire and Bar**



SPECIFIED DISTANCE ACROSS FLATS in.	TOLERANCE in. plus and minus		
	ALLOWABLE DEVIATION FROM SPECIFIED DISTANCE ACROSS FLATS		
	Drawn Wire	Cold Finished Bar	Rolled Bar
Up thru 0.035	.001	..	..
0.036–0.064	.0015	..	..
0.065–0.374	.002	..	..
0.375–0.500	..	.002	..
0.501–1.000	..	.0025	..
1.001–1.500	..	.003	..
1.501–2.000	..	.005	.016
2.001–3.000	..	.008	.020
3.001–4.000	..	..	.020

**TABLE 10.11 Thickness and Width—Flattened Wire (Round Edge)**



SPECIFIED THICKNESS in.	TOLERANCE in. plus and minus	SPECIFIED WIDTH in.	TOLERANCE in. plus and minus
	ALLOWABLE DEVIATION FROM SPECIFIED THICKNESS		ALLOWABLE DEVIATION FROM SPECIFIED THICKNESS
Up thru 0.020	.001	Up thru 0.875	.007
0.021–0.060	.0015	0.876–2.000	.010
0.061–0.187	.002		

# Cold Finished Wire, Rod and Bar

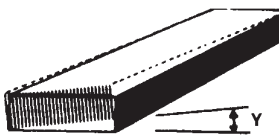
**TABLE 10.12 Thickness and Width—Flattened and Slit Wire**

SPECIFIED THICKNESS in.	TOLERANCE in. plus and minus	SPECIFIED WIDTH in.	TOLERANCE in. plus and minus
	ALLOWABLE DEVIATION FROM SPECIFIED THICKNESS		ALLOWABLE DEVIATION FROM SPECIFIED WIDTH
0.018–0.020	0.001	0.500–0.625	0.0025
0.021–0.060	0.0015	0.626–1.500	0.004
0.061–0.080	0.002	1.501–4.750	0.006

**TABLE 10.13 Length—Specific and Multiple—Rolled or Cold Finished Wire, Rod, and Bar**

SPECIFIED DIAMETER, WIDTH OR DISTANCE ACROSS FLATS in.	TOLERANCE ⑤—in. plus			
	ALLOWABLE DEVIATION FROM SPECIFIED LENGTH			
	SPECIFIED LENGTH—ft.			
	Up thru 12	Over 12 thru 30	Over 30 thru 50	Over 50
Up thru 2.999	1/8	1/4	3/8	1
3.000–7.999	3/16	5/16	7/16	1
8.000 and over	1/4	3/8	1/2	1

**TABLE 10.14 Twist<sup>④</sup>—Rolled or Cold Finished Bar and Straight Lengths**

PRODUCT	TEMPER	SPECIFIED WIDTH (RECTANGLES):  SPECIFIED DISTANCE ACROSS FLATS: (SQUARES, HEXAGONS AND OCTAGONS) in.	TOLERANCE ① ③—DEGREES	
			ALLOWABLE DEVIATION FROM STRAIGHT	
				
			Y (max.) in degrees	
			IN TOTAL LENGTH OR IN ANY MEASURED SEGMENT OF ONE FT. OR MORE OF TOTAL LENGTH	MAXIMUM FOR TOTAL LENGTH
Square, Rectangular and Octagonal Bar	All except O and TX51 ②	Up thru 1.499 1.500–2.999 3.000 and over	1 × Measured length, ft 1/2 × Measured length, ft 1/4 × Measured length, ft	7 5 3
	TX51 ②	0.500–2.999 3.000 and over	1 1/2 × Measured length, ft 1/2 × Measured length, ft	7 5
Hexagonal Bar	All except O	Up thru 1.499 1.500–2.999 3.000 and over	1 × Measured length, ft 1/2 × Measured length, ft 1/4 × Measured length, ft	7 5 3

① For TX51 tempers, tolerance is applicable only to thicknesses of 0.500 in. and over.

② TX51 is a general designation for the following stress-relieved tempers: T351, T451, T651, T851, and T7351.

③ When weight of piece on flat surface minimizes deviation.

④ Twist is normally measured by placing the bar on a flat surface and at any point along its length measuring the maximum distance between the bottom surface of the bar and the flat surface. From this measurement, the actual deviation from straightness of the bar at that point is subtracted. The remainder is the twist. To convert the standard twist tolerance (degrees) to an equivalent linear value, the sine of the standard tolerance is multiplied by the width of the surface of the section that is on the flat surface. The following values are used to convert angular tolerances to linear deviation:

Tolerance, degrees	Maximum allowable linear deviation inch per inch of width
1/4	0.004
1/2	0.009
1	0.017
1 1/2	0.026
3	0.052
5	0.087
7	0.122
9	0.156
15	0.259
21	0.358

⑤ For wire, rod and bar ordered as standard screw machine stock, the length tolerance is plus 3/8 in.

# Cold Finished Wire, Rod and Bar

**TABLE 10.15 Straightness—Rolled or Cold Finished Rod and Bar in Straight Lengths Other than Screw Machine Stock**

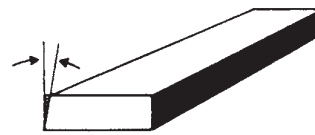
PRODUCT	TEMPER	SPECIFIED DIAMETER (ROD); SPECIFIED DISTANCE ACROSS FLATS: (SQUARES, HEXAGONS AND OCTAGONS) SPECIFIED THICKNESS (RECTANGLES)  in.	TOLERANCE ①—in.
			IN TOTAL LENGTH OR IN ANY MEASURED SEGMENT OF ONE FT. OR MORE OF TOTAL LENGTH
<b>ROLLED</b>			
Rod and Hexagonal, Square, Rectangular and Octagonal Bar	All except O	All	0.050 × Measured length, ft.
<b>COLD FINISHED</b>			
Rod and Hexagonal Bar	All except O and TX51 ②	All	0.025 × Measured length, ft.
	TX51 ②	0.500 and over	0.025 × Measured length, ft.
Square, Rectangular and Octagonal Bar	All except O and TX51 ②	All	0.025 × Measured length, ft.
	TX51 ②	0.500 and over	0.050 × Measured length, ft.



**TABLE 10.16 Straightness—Screw Machine Stock**

SPECIFIED DIAMETER, (ROD); SPECIFIED DISTANCE ACROSS FLATS (HEXAGONAL BAR) in.	TEMPER	TOLERANCE ① in.	
		ALLOWABLE DEVIATION FROM STRAIGHT	
		In any foot or less of length	In 12 feet
All	All Except TX51 ②	0.0125	0.100
0.500 and over	TX51 ②	0.0125	0.100

**TABLE 10.18 Angularity—Rolled or Cold Finished Rod and Bar**



Allowable deviation from nominal angle: ±1 degree

**TABLE 10.17 Flatness—Flat Surfaces—Rolled or Cold Finished Rod and Bar**

SURFACE WIDTH in.	TOLERANCE, in.
Up thru 1	0.004
Over 1	0.004 × W (inches)
In any 1 in. of width	0.004

**TABLE 10.19 Squareness of Saw Cuts—Rolled or Cold Finished Rod and Bar**

Allowable deviation from square: 1 degree

**TABLE 10.20 Corner Radii Bar—Rolled or Cold Finished Rod and Bar**

Thickness, inches	Corner Radii inches, max.
Up thru 0.500	0.016
0.501–2.000	0.032
2.001 and thicker	0.050

① When weight of piece on flat surface minimizes deviation.

② TX51 is a general designation for the following stress-relieved tempers: T351, T451, T851, and T7351.

# Mechanical Properties

**TABLE 10.2 Mechanical Property Limits—Wire, Rod and Bar—Rolled or Cold Finished—Heat-Treatable Alloys <sup>①</sup> <sup>⑫</sup>**

ALLOY AND TEMPER	SPECIFIED DIAMETER OR THICKNESS OR MINIMUM DISTANCE ACROSS FLATS in.	TENSILE STRENGTH—ksi			ELONGATION <sup>②</sup> percent min. in 2 in. or 4D <sup>③</sup>	
		ULTIMATE		YIELD <sup>②</sup>		
		min.	max.			
<b>2011</b>						
2011-T3	0.125–1.500	45.0	..	38.0	10	
	1.501–2.000	43.0	..	34.0	12	
	2.001–3.500	42.0	..	30.0	12	
2011-T4 and T451 <sup>⑧</sup>	0.375–8.000	40.0	..	18.0	16	
	2011-T8	0.125–3.250	54.0	..	40.0	10
<b>2014</b>						
2014-O	Up thru 8.000	..	35.0	..	12	
2014-T4, T42 <sup>⑩</sup> <sup>⑮</sup> and T451 <sup>⑧</sup>	Up thru 8.000 <sup>④</sup>	55.0	..	32.0	16	
2014-T6, T62 <sup>⑩</sup> <sup>⑮</sup> and T651 <sup>⑧</sup>	Up thru 8.000 <sup>④</sup>	65.0	..	55.0	8	
<b>2017</b>						
2017-O	Up thru 8.000	..	35.0	..	16	
2017-T4, T42 <sup>⑩</sup> <sup>⑮</sup> and T451 <sup>⑧</sup>	Up thru 8.000 <sup>⑥</sup>	55.0	..	32.0	12	
<b>2024</b>						
2024-O	Up thru 8.000	..	35.0	..	16	
	2024-T36	Up thru 0.375	69.0	..	52.0	10
	2024-T4	Up thru 0.499	62.0	..	45.0 <sup>⑮</sup>	10
2024-T42 <sup>⑩</sup> <sup>⑮</sup>	0.500–4.500 <sup>④</sup>	62.0	..	42.0 <sup>⑮</sup>	10	
	4.501–6.500 <sup>⑮</sup>	62.0	..	40.0	10	
	6.501–8.000 <sup>⑮</sup>	58.0	..	38.0	10	
	Up thru 0.124	62.0	..	..	..	
	0.125–1.000	62.0	..	40.0	10	
2024-T351	1.001–6.500 <sup>④</sup>	62.0	..	40.0	10	
	0.500–6.500 <sup>④</sup>	62.0	..	45.0	10	
2024-T6	Up thru 6.500 <sup>④</sup>	62.0	..	50.0	5	
2024-T62 <sup>⑩</sup> <sup>⑮</sup>	Up thru 6.500 <sup>④</sup>	60.0	..	46.0	5	
2024-T851	0.500–6.500 <sup>④</sup>	66.0	..	58.0	5	
<b>2219</b>						
2219-T851	0.500–2.000	58.0	..	40.0	4	
	2.001–4.000	57.0	..	39.0	4	
<b>6061</b>						
6061-O	Up thru 8.000	..	22.0	..	18	
6061-T4 and T451 <sup>⑧</sup>	Up thru 8.000 <sup>⑥</sup>	30.0	..	16.0	18	
6061-T42 <sup>⑩</sup> <sup>⑮</sup>	Up thru 8.000 <sup>⑥</sup>	30.0	..	14.0	18	
6061-T6, T62 <sup>⑩</sup> <sup>⑮</sup> and T651 <sup>⑧</sup>	Up thru 8.000 <sup>⑥</sup>	42.0	..	35.0	10	
6061-T89	Up thru 0.374	54.0	..	47.0	..	
6061-T913	Up thru 0.374	63.0	..	..	..	
6061-T94	Up thru 0.374	54.0	..	47.0	..	
<b>6262</b>						
6262-T6 and T651 <sup>⑧</sup>	Up thru 8.000 <sup>④</sup>	42.0	..	35.0	10	
6262-T9	0.125–2.000	52.0	..	48.0	5	
	2.001–3.000	50.0	..	46.0	5	
<b>7075</b>						
7075-O	Up thru 8.000	..	40.0	..	10	
7075-T6 and T62 <sup>⑩</sup> <sup>⑮</sup>	Up thru 4.000 <sup>⑤</sup>	77.0	..	66.0	7	
	Up thru 4.000 <sup>⑤</sup>	77.0	..	66.0	7	
	4.001–6.000	75.0	..	64.0	7	
7075-T73 <sup>⑨</sup> and T7351 <sup>⑧</sup> <sup>⑨</sup>	6.001–7.000	73.0	..	62.0	7	
	Up thru 4.000	68.0	..	56.0	10	
	4.001–5.000	66.0	..	55.0	8	
	5.001–6.000	64.0	..	52.0	8	

For numbered footnotes, see next page.

# Mechanical Properties

## Footnotes for Table 10.2

- ① Mechanical test specimens are taken as detailed under "Sampling and Testing," page 4-1. The data base and criteria upon which these mechanical property limits are established are outlined on page 6-1 under "Mechanical Properties."
- ② The measurement of elongation and yield strength is not required for wire less than 0.125 inch in thickness or diameter.
- ③ D represents specimen diameter.
- ④ Properties listed for this full size increment are applicable to rod. Properties listed are only applicable for square, rectangular, hexagonal or octagonal bar having a maximum thickness of 4 in. and a maximum cross-sectional area of 36 square inches.
- ⑤ Properties listed for this full size increment are applicable to rod. Properties listed are only applicable for square, hexagonal or octagonal bar having a maximum thickness of 3½ inches; for rectangular bar having a maximum thickness of 3 inches with corresponding maximum width of 6 inches. For rectangular bar less than 3 inches in thickness, maximum width is 10 inches.
- ⑥ For bar maximum cross-sectional area is 50 square inches.
- ⑦ Rivet and cold heading wire and rod, and the fasteners produced from it, shall upon proper heat treatment (T4 and T42 tempers) or heat treatment and aging (T6, T61, T7 and T73 tempers) be capable of developing the properties presented in Table 10.4. Tensile tests are preferred for the rivet and cold heading wire and rod, and shear tests for the fasteners made from it.
- ⑧ For stress-relieved tempers the characteristics and properties other than those specified may differ somewhat from the corresponding characteristics and properties of material in the basic temper.

## Footnotes for Table 11.1

- ① The thickness of the cross section from which the tension test specimen is taken determines the applicable mechanical properties. The data base and criteria upon which these mechanical property limits are established are outlined on page 6-1 under "Mechanical Properties."
- ② For material of such dimensions that a standard test specimen cannot be taken, or for profiles thinner than 0.062 inch, the test for elongation is not required.
- ③ D represents specimen diameter.
- ④ These properties can usually be obtained by the user when the material is properly solution heat treated or solution and precipitation heat treated from the O (annealed) or F (as fabricated) temper. These properties also apply to samples of material in the O or F tempers that are solution heat treated or solution and precipitation treated by the producer to determine that the material will respond to proper heat treatment. Properties attained by the user, however, may be lower than those listed if the material has been formed or otherwise cold or hot worked, particularly in the annealed temper, prior to solution heat treatment.
- ⑤ For stress-relieved tempers the characteristics and properties other than those specified may differ somewhat from the corresponding characteristics and properties of material in the basic temper.
- ⑥ Processes such as flattening, leveling, or straightening coiled products subsequent to shipment by the producer may alter the mechanical properties of the metal (refer to Certification Documentation, Section 4).
- ⑦ Upon artificial aging, T31, T3510, T3511, T4, T4510 and T4511 temper material shall be capable of developing the mechanical properties applicable to the T81, T8510, T8511, T6, T6510 and T6511 tempers, respectively.
- ⑧ This temper is not available from the material producer.
- ⑨ Material in this temper, 0.750 inch and thicker, when tested in accordance with ASTM G47 in the short transverse direction at a stress level of 75 percent of the specified minimum yield strength, will exhibit no evidence of stress corrosion cracking. Capability of individual lots to resist stress cor-

- ⑨ Material in this temper, 0.750 inch and thicker, when tested in accordance with ASTM G47 in the short transverse direction at a stress level of 75 percent of the specified minimum yield strength, will exhibit no evidence of stress corrosion cracking. Capability of individual lots to resist stress corrosion is determined by testing the previously selected tensile test sample in accordance with the applicable lot acceptance criteria outlined on pages 6-7 and 6-8.
- ⑩ These properties can usually be obtained by the user when the material is properly solution heat treated or solution and precipitation heat treated from the O (annealed) or F (as fabricated) temper. These properties also apply to samples of material in the O or F tempers that are solution heat treated or solution and precipitation treated by the producer to determine that the material will respond to proper heat treatment. Properties attained by the user, however, may be lower than those listed if the material has been formed or otherwise cold or hot worked, particularly in the annealed temper, prior to solution heat treatment.
- ⑪ These yield strengths determined only when specifically requested.
- ⑫ Except in the annealed (O temper) condition, the temper of nonheat-treatable alloy rod and bar cannot be closely controlled and will vary according to size.
- ⑬ Minimum yield strength for 2024-T4 wire and rod, produced in coil form for both straight length and coiled products, is 40.0 ksi.
- ⑭ Applicable to rod only.
- ⑮ This temper is not available from the material producer.
- ⑯ Processes such as flattening, leveling, or straightening coiled products subsequent to shipment by the producer may alter the mechanical properties of the metal (refer to Certification Documentation, page 4-12).

rosion is determined by testing the previously selected tensile test sample in accordance with the applicable lot acceptance criteria outlined on pages 6-7 through 6-10.

- ⑩ Material in this temper, when tested in accordance with ASTM G34, will exhibit exfoliation less than that shown in Photo EB, Figure 2 of ASTM G34. Also, material 0.750 inch and thicker, when tested in accordance with ASTM G47 in the short transverse direction at a stress level of 25 ksi, will exhibit no evidence of stress corrosion cracking. Capability of individual lots to resist exfoliation corrosion and stress corrosion cracking is determined by testing the previously selected tensile test sample in accordance with the applicable lot acceptance criteria outlined on pages 6-7 through 6-10.
- ⑪ Material in this temper, when tested at the t/10 plane in accordance with ASTM G34, will exhibit exfoliation less than that shown in Photo EB, Figure 2 of ASTM G34. Also, material 0.750 inch and thicker, when tested in accordance with ASTM G47 in the short transverse direction at a stress level of 35 ksi, will exhibit no evidence of stress corrosion cracking. Capability of individual lots to resist exfoliation corrosion and stress corrosion cracking is determined by testing the previously selected tensile test sample in accordance with the applicable lot acceptance criteria outlined on pages 6-7 through 6-10.
- ⑫ Material in this temper, when tested at the t/10 plane in accordance with ASTM G34, will exhibit exfoliation less than that shown in Photo EB, Figure 2 of ASTM G34. Also, material 0.750 inch and thicker, when tested in accordance with ASTM G47 in the short transverse direction at a stress level of 17 ksi, will exhibit no evidence of stress corrosion cracking. Capability of individual lots to resist exfoliation corrosion and stress corrosion cracking is determined by testing the previously selected tensile test sample in accordance with the applicable lot acceptance criteria outlined on pages 6-7 through 6-10.
- ⑬ T74 type tempers, although not previously registered, have appeared in the literature and in some specifications as T736 type tempers.

# Mechanical Properties

**TABLE 11.1 Mechanical Property Limits—Extruded Wire, Rod, Bar and Profiles ⑥**

ALLOY AND TEMPER	SPECIFIED DIAMETER OR THICKNESS ① OR MINIMUM DISTANCE ACROSS FLATS in.	AREA sq. in.	TENSILE STRENGTH—ksi				ELONGATION ② percent min. in 2 in. or 4D ③
			ULTIMATE		YIELD		
			min.	max.	min.	max.	
<b>1100</b>							
1100-O	All	All	11.0	15.5	3.0	..	25
1100-H112	All	All	11.0	..	3.0	..	..
<b>2014</b>							
2014-O	All	All	..	30.0	..	18.0	12
2014-T4, T4510 ⑤ ⑦ and T4511 ⑤ ⑦	All	All	50.0	..	35.0	..	12
2014-T42 ④ ⑧	All	All	50.0	..	29.0	..	12
2014-T6, T6510 ⑤ and T6511 ⑤	Up thru 0.499	All	60.0	..	53.0	..	7
	0.500–0.749	All	64.0	..	58.0	..	7
	0.750 and over	Up thru 25	68.0	..	60.0	..	7
	0.750 and over	Over 25 thru 32	68.0	..	58.0	..	6
2014-T62 ④ ⑧	Up thru 0.749	All	60.0	..	53.0	..	7
	0.750 and over	Up Thru 25	60.0	..	53.0	..	7
	0.750 and over	Over 25 thru 32	60.0	..	53.0	..	6
<b>2024</b>							
2024-O	All	All	..	35.0	..	19.0	12
2024-T3, T3510 ⑤ ⑦ and T3511 ⑤ ⑦	Up thru 0.249	All	57.0	..	42.0	..	12
	0.250–0.749	All	60.0	..	44.0	..	12
	0.750–1.499	All	65.0	..	46.0	..	10
	1.500 and over	Up thru 25	70.0	..	52.0	..	10
2024-T42 ④ ⑧	Up thru 0.749	All	57.0	..	38.0	..	12
	0.750–1.499	All	57.0	..	38.0	..	10
	1.500 and over	Up thru 25	57.0	..	38.0	..	10
	1.500 and over	Over 25 thru 32	57.0	..	38.0	..	8
2024-T81, T8510 ⑤ and T8511 ⑤	0.050–0.249	All	64.0	..	56.0	..	4
	0.250–1.499	All	66.0	..	58.0	..	5
	1.500 and over	Up thru 32	66.0	..	58.0	..	5
<b>2219</b>							
2219-O	All	All	..	32.0	..	18.0	12
2219-T31, T3510 ⑤ ⑦ and T3511 ⑤ ⑦	Up thru 0.499	Up thru 25	42.0	..	26.0	..	14
	0.500–2.999	Up thru 25	45.0	..	27.0	..	14
2219-T62 ④ ⑧	Up thru 0.999	Up thru 25	54.0	..	36.0	..	6
	1.000 and over	Up thru 32	54.0	..	36.0	..	6
2219-T81, T8510 ⑤ and T8511 ⑤	Up thru 2.999	Up thru 25	58.0	..	42.0	..	6
<b>3003</b>							
3003-O	All	All	14.0	19.0	5.0	..	25
3003-H112	All	All	14.0	..	5.0	..	..
<b>5083</b>							
5083-O	Up thru 5.000	Up thru 32	39.0	51.0	16.0	..	14
5083-H111	Up thru 5.000	Up thru 32	40.0	..	24.0	..	12
5083-H112	Up thru 5.000	Up thru 32	39.0	..	16.0	..	12
<b>5086</b>							
5086-O	Up thru 5.000	Up thru 32	35.0	46.0	14.0	..	14
5086-H111	Up thru 5.000	Up thru 32	36.0	..	21.0	..	12
5086-H112	Up thru 5.000	Up thru 32	35.0	..	14.0	..	12
<b>5154</b>							
5154-O	All	All	30.0	41.0	11.0	..	..
5154-H112	All	All	30.0	..	11.0	..	..
<b>5454</b>							
5454-O	Up thru 5.000	Up thru 32	31.0	41.0	12.0	..	14
5454-H111	Up thru 5.000	Up thru 32	33.0	..	19.0	..	12
5454-H112	Up thru 5.000	Up thru 32	31.0	..	12.0	..	12
<b>6005</b>							
6005-T1	Up thru 0.500	All	25.0	..	15.0	..	16
6005-T5	Up thru 0.124	All	38.0	..	35.0	..	8
	0.125–1.000	All	38.0	..	35.0	..	10

For numbered footnotes, see page 29.

# Mechanical Properties

**TABLE 11.1 Mechanical Property Limits—Extruded Wire, Rod, Bar and Profiles <sup>⑥</sup>**  
(continued)

ALLOY AND TEMPER	SPECIFIED DIAMETER OR THICKNESS <sup>①</sup> OR MINIMUM DISTANCE ACROSS FLATS in.	AREA sq. in.	TENSILE STRENGTH—ksi				ELONGATION <sup>②</sup> percent min. in 2 in. or 4D <sup>③</sup>
			ULTIMATE		YIELD		
			min.	max.	min.	max.	
<b>6005A</b>							
6005A-T1	Up thru 0.249	All	25.0	..	14.5	..	15
6005A-T5	Up thru 0.249	All	38.0	..	31.0	..	7
	0.250-0.999	All	38.0	..	31.0	..	9
6005A-T61	Up thru 0.249	All	38.0	..	35.0	..	8
	0.250-1.000	All	38.0	..	35.0	..	10
<b>6061</b>							
6061-O	All	All	..	22.0	..	16.0	16
6061-T1	Up thru 0.625	All	26.0	..	14.0	..	16
6061-T4, T4510 <sup>⑤</sup> <sup>⑦</sup> and T4511 <sup>⑤</sup> <sup>⑦</sup>	All	All	26.0	..	16.0	..	16
6061-T42 <sup>④</sup> <sup>⑧</sup>	All	All	26.0	..	12.0	..	16
6061-T51	Up thru 0.625	All	35.0	..	30.0	..	8
6061-T6, T62 <sup>④</sup> <sup>⑧</sup> , T6510 <sup>⑤</sup> and T6511 <sup>⑤</sup>	Up thru 0.249	All	38.0	..	35.0	..	8
	0.250 and over	All	38.0	..	35.0	..	10
<b>6063</b>							
6063-O	All	All	..	19.0	..	..	18
6063-T1	Up thru 0.500	All	17.0	..	9.0	..	12
	0.501-1.000	All	16.0	..	8.0	..	12
6063-T4 and T42 <sup>④</sup> <sup>⑧</sup>	Up thru 0.500	All	19.0	..	10.0	..	14
	0.501-1.000	All	18.0	..	9.0	..	14
6063-T5	Up thru 0.500	All	22.0	..	16.0	..	8
	0.501-1.000	All	21.0	..	15.0	..	8
6063-T52	Up thru 1.000	All	22.0	30.0	16.0	25.0	8
6063-T6 and T62 <sup>④</sup> <sup>⑧</sup>	Up thru 0.124	All	30.0	..	25.0	..	8
	0.125-1.000	All	30.0	..	25.0	..	10
<b>6066</b>							
6066-O	All	All	..	29.0	..	18.0	16
6066-T4, T4510 <sup>⑤</sup> <sup>⑦</sup> and T4511 <sup>⑤</sup> <sup>⑦</sup>	All	All	40.0	..	25.0	..	14
6066-T42 <sup>④</sup> <sup>⑧</sup>	All	All	40.0	..	24.0	..	14
6066-T6, T6510 <sup>⑤</sup> and T6511 <sup>⑤</sup>	All	All	50.0	..	45.0	..	8
6066-T62 <sup>④</sup> <sup>⑧</sup>	All	All	50.0	..	42.0	..	8
<b>6070</b>							
6070-T6 and T62 <sup>④</sup> <sup>⑧</sup>	Up thru 2.999	Up thru 32	48.0	..	45.0	..	6
<b>6082</b>							
6082-T6, T6511	0.200-0.750	All	45.0	..	38.0	..	6
	0.751-6.000	All	45.0	..	38.0	..	8
	6.001-8.000	All	41.0	..	35.0	..	6
<b>6105</b>							
6105-T1	Up thru 0.500	All	25.0	..	15.0	..	16
6105-T5	Up thru 0.500	All	38.0	..	35.0	..	8
<b>6162</b>							
6162-T5, T5510 <sup>⑤</sup> and T5511 <sup>⑤</sup>	Up thru 1.000	All	37.0	..	34.0	..	7
6162-T6, T6510 <sup>⑤</sup> and T6511 <sup>⑤</sup>	Up thru 0.249	All	38.0	..	35.0	..	8
	0.250-0.499	All	38.0	..	35.0	..	10
<b>6262</b>							
6262-T6, T62 <sup>④</sup> <sup>⑧</sup> , T6510 <sup>⑤</sup> and T6511 <sup>⑤</sup>	All	All	38.0	..	35.0	..	10

For numbered footnotes, see page 29.

# Mechanical Properties

**TABLE 11.1 Mechanical Property Limits—Extruded Wire, Rod, Bar and Profiles <sup>⑥</sup>**  
(concluded)

ALLOY AND TEMPER	SPECIFIED DIAMETER OR THICKNESS <sup>①</sup> OR MINIMUM DISTANCE ACROSS FLATS in.	AREA sq. in.	TENSILE STRENGTH—ksi				ELONGATION <sup>②</sup> percent min. in 2 in. or 4D <sup>③</sup>
			ULTIMATE		YIELD		
			min.	max.	min.	max.	
<b>6351</b>							
6351-T1	Up thru 0.499	Up thru 20	26.0	..	13.0	..	15
6351-T4	Up thru 0.749	All	32.0	..	19.0	..	16
6351-T5	Up thru 0.249	All	38.0	..	35.0	..	8
	0.250–1.000	All	38.0	..	35.0	..	10
6351-T51	0.125–1.000	Up thru 20	36.0	..	33.0	..	10
6351-T54	Up thru 0.500	Up thru 20	30.0	..	20.0	..	10
6351-T6	Up thru 0.124	All	42.0	..	37.0	..	8
	0.125–0.749	All	42.0	..	37.0	..	10
<b>6463</b>							
6463-T1	Up thru 0.500	Up thru 20	17.0	..	9.0	..	12
6463-T5	Up thru 0.500	Up thru 20	22.0	..	16.0	..	8
6463-T6 and T62 <sup>④</sup> <sup>⑧</sup>	Up thru 0.124	Up thru 20	30.0	..	25.0	..	8
	0.125–0.500	Up thru 20	30.0	..	25.0	..	10
<b>7005</b>							
7005-T53	Up thru 0.750	All	50.0	..	44.0	..	10
<b>7050</b>							
7050-T73510 <sup>⑤</sup> <sup>⑨</sup> and T73511 <sup>⑤</sup> <sup>⑨</sup>	Up thru 5.000	Up thru 32	70.0	..	60.0	..	8
7050-T74510 <sup>⑤</sup> <sup>⑪</sup> <sup>⑬</sup> and T74511 <sup>⑤</sup> <sup>⑪</sup> <sup>⑬</sup>	Up thru 5.000	Up thru 32	73.0	..	63.0	..	7
7050-T76510 <sup>⑫</sup> and T76511 <sup>⑫</sup>	Up thru 0.499	Up thru 32	77.0	..	68.0	..	7
	0.500–5.000	Up thru 32	79.0	..	69.0	..	7
<b>7075</b>							
7075-O	All	All	..	40.0	..	24.0	10
7075-T6, T62 <sup>④</sup> <sup>⑧</sup> , T6510 <sup>⑤</sup> and T6511 <sup>⑤</sup>	Up thru 0.249	All	78.0	..	70.0	..	7
	0.250–0.499	All	81.0	..	73.0	..	7
	0.500–1.499	All	81.0	..	72.0	..	7
	1.500–2.999	All	81.0	..	72.0	..	7
	3.000–4.499	Up thru 20	81.0	..	71.0	..	7
	3.000–4.499	Over 20 thru 32	78.0	..	70.0	..	6
	4.500–5.000	Up thru 32	78.0	..	68.0	..	6
7075-T73 <sup>⑨</sup> , T73510 <sup>⑤</sup> <sup>⑨</sup> and T73511 <sup>⑤</sup> <sup>⑨</sup>	0.062–0.249	Up thru 20	68.0	..	58.0	..	7
	0.250–1.499	Up thru 25	70.0	..	61.0	..	8
	1.500–2.999	Up thru 25	69.0	..	59.0	..	8
	3.000–4.499	Up thru 20	68.0	..	57.0	..	7
	3.000–4.499	Over 20 thru 32	65.0	..	55.0	..	7
	4.500–5.000	Up thru 36	65.0	..	53.0	..	7
7075-T76 <sup>⑩</sup> , T76510 <sup>⑤</sup> <sup>⑩</sup> and T76511 <sup>⑤</sup> <sup>⑩</sup>	Up thru 0.049	All	73.0	..	63.0	..	7
	0.050–0.124	All	74.0	..	64.0	..	7
	0.125–0.249	Up thru 20	74.0	..	64.0	..	7
	0.250–0.499	Up thru 20	75.0	..	65.0	..	7
	0.500–1.000	Up thru 20	75.0	..	65.0	..	7
	1.001–2.000	Up thru 20	75.0	..	65.0	..	7
	2.001–3.000	Up thru 20	74.0	..	64.0	..	7
	3.001–4.000	Up thru 20	74.0	..	63.0	..	7
<b>7178</b>							
7178-O	All	Up thru 32	..	40.0	..	24.0	10
7178-T6, T6510 <sup>⑤</sup> and T6511 <sup>⑤</sup>	Up thru 0.061	All	82.0	..	76.0	..	..
	0.062–0.249	Up thru 20	84.0	..	76.0	..	5
	0.250–1.499	Up thru 25	87.0	..	78.0	..	5
	1.500–2.499	Up thru 25	86.0	..	77.0	..	5
	1.500–2.499	Over 25 thru 32	84.0	..	75.0	..	5
	2.500–2.999	Up thru 32	82.0	..	71.0	..	5
7178-T62 <sup>④</sup> <sup>⑧</sup>	Up thru 0.061	All	79.0	..	73.0	..	..
	0.062–0.249	Up thru 20	82.0	..	74.0	..	5
	0.250–1.499	Up thru 25	86.0	..	77.0	..	5
	1.500–2.499	Up thru 25	86.0	..	77.0	..	5
	1.500–2.499	Over 25 thru 32	84.0	..	75.0	..	5
	2.500–2.999	Up thru 32	82.0	..	71.0	..	5
7178-T76 <sup>⑩</sup> , T76510 <sup>⑤</sup> <sup>⑩</sup> and T76511 <sup>⑤</sup> <sup>⑩</sup>	0.125–0.249	Up thru 20	76.0	..	66.0	..	7
	0.250–0.499	Up thru 20	77.0	..	67.0	..	7
	0.500–1.000	Up thru 20	77.0	..	67.0	..	7
<b>7475</b>							
7475-T62	1.001–2.000	All	75.0	..	66.0	..	7

For numbered footnotes, see page 29.

# Mechanical Properties

**TABLE 12.19 Mechanical Property Limits <sup>① ⑦</sup>—Drawn Tube**

ALLOY AND TEMPER	SPECIFIED WALL THICKNESS in.	TENSILE STRENGTH—ksi				ELONGATION percent min. in 2 in. or 4D <sup>②</sup>	
		ULTIMATE		YIELD		FULL-SECTION SPECIMEN <sup>③</sup>	CUT-OUT SPECIMEN <sup>④</sup>
		min.	max.	min.	max.		
<b>1060 <sup>⑤</sup></b>							
1060-O	0.010–0.500	8.5	13.5	2.5	..	..	..
1060-H12	0.010–0.500	10.0	..	4.0	..	..	..
1060-H14	0.010–0.500	12.0	..	10.0	..	..	..
1060-H18	0.010–0.500	16.0	..	13.0	..	..	..
1060-H113 <sup>⑩</sup>	0.010–0.500	8.5	..	2.5	..	..	..
<b>1100 <sup>⑤</sup></b>							
1100-O	0.014–0.500	11.0	15.5	3.5	..	..	..
1100-H12	0.014–0.500	14.0	..	11.0	..	..	..
1100-H14	0.014–0.500	16.0	..	14.0	..	..	..
1100-H16	0.014–0.500	19.0	..	17.0	..	..	..
1100-H18	0.014–0.500	22.0	..	20.0	..	..	..
1100-H113 <sup>⑩</sup>	0.014–0.500	11.0	..	3.5	..	..	..
<b>2011</b>							
2011-T3	0.018–0.049	47.0	..	40.0	..	..	..
	0.050–0.500	47.0	..	40.0	..	10	8
2011-T4511	0.018–0.049	44.0	..	25.0	..	..	..
	0.050–0.259	44.0	..	25.0	..	20	18
	0.260–0.500	44.0	..	25.0	..	20	20
2011-T8	0.018–0.500	58.0	..	46.0	..	10	8
<b>2014</b>							
2014-O	0.018–0.500	..	32.0	..	16.0	..	..
2014-T4 and T42 <sup>⑥ ⑧</sup>	0.018–0.024	54.0	..	30.0	..	10	..
	0.025–0.049	54.0	..	30.0	..	12	10
	0.050–0.259	54.0	..	30.0	..	14	10
	0.260–0.500	54.0	..	30.0	..	16	12
2014-T6 and T62 <sup>⑥ ⑧</sup>	0.018–0.024	65.0	..	55.0	..	7	..
	0.025–0.049	65.0	..	55.0	..	7	6
	0.050–0.259	65.0	..	55.0	..	8	7
	0.260–0.500	65.0	..	55.0	..	9	8
<b>2024</b>							
2024-O	0.018–0.500	..	32.0	..	15.0	..	..
2024-T3	0.018–0.024	64.0	..	42.0	..	10	..
	0.025–0.049	64.0	..	42.0	..	12	10
	0.050–0.259	64.0	..	42.0	..	14	10
	0.260–0.500	64.0	..	42.0	..	16	12
2024-T42 <sup>⑥ ⑧</sup>	0.018–0.024	64.0	..	40.0	..	10	..
	0.025–0.049	64.0	..	40.0	..	12	10
	0.050–0.259	64.0	..	40.0	..	14	10
	0.260–0.500	64.0	..	40.0	..	16	12
<b>3003 <sup>⑤</sup></b>							
3003-O	0.010–0.024	14.0	19.0	5.0	..	..	..
	0.025–0.049	14.0	19.0	5.0	..	30	20
	0.050–0.259	14.0	19.0	5.0	..	35	25
	0.260–0.500	14.0	19.0	5.0	..	..	30
3003-H12	0.010–0.500	17.0	..	12.0	..	..	..
3003-H14	0.010–0.024	20.0	..	17.0	..	3	..
	0.025–0.049	20.0	..	17.0	..	5	3
	0.050–0.259	20.0	..	17.0	..	8	4
	0.260–0.500	20.0	..	17.0	..	..	..
3003-H16	0.010–0.024	24.0	..	21.0	..	..	..
	0.025–0.049	24.0	..	21.0	..	3	2
	0.050–0.259	24.0	..	21.0	..	5	4
	0.260–0.500	24.0	..	21.0	..	..	..
3003-H18	0.010–0.024	27.0	..	24.0	..	2	..
	0.025–0.049	27.0	..	24.0	..	3	2
	0.050–0.259	27.0	..	24.0	..	5	3
	0.260–0.500	27.0	..	24.0	..	..	..
3003-H113 <sup>⑩</sup>	0.010–0.500	14.0	..	5.0	..	..	..

For numbered footnotes, see page 35.

# Mechanical Properties

**TABLE 12.19 Mechanical Property Limits <sup>① ⑦</sup>—Drawn Tube (continued)**

ALLOY AND TEMPER	SPECIFIED WALL THICKNESS in.	TENSILE STRENGTH—ksi				ELONGATION percent min. in 2 in. or 4D <sup>②</sup>	
		ULTIMATE		YIELD		FULL-SECTION SPECIMEN <sup>③</sup>	CUT-OUT SPECIMEN <sup>④</sup>
		min.	max.	min.	max.		
<b>ALCLAD 3003 <sup>⑤</sup></b>							
Alclad 3003-O	0.010–0.024	13.0	19.0	4.5	..	..	..
	0.025–0.049	13.0	19.0	4.5	..	30	20
	0.050–0.259	13.0	19.0	4.5	..	35	25
	0.260–0.500	13.0	19.0	4.5	..	..	30
Alclad 3003-H14	0.010–0.024	19.0	..	16.0	..	..	..
	0.025–0.049	19.0	..	16.0	..	5	3
	0.050–0.259	19.0	..	16.0	..	8	4
	0.260–0.500	19.0	..	16.0	..	..	..
Alclad 3003-H18	0.010–0.500	26.0	..	23.0	..	..	..
Alclad 3003-H113 <sup>⑩</sup>	0.010–0.500	13.0	..	4.5	..	..	..
<b>3004 <sup>⑤</sup></b>							
3004-O	0.018–0.450	23.0	29.0	8.5	..	..	..
3004-H34	0.018–0.450	32.0	..	25.0	..	..	..
3004-H36	0.018–0.450	35.0	..	28.0	..	..	..
3004-H38	0.018–0.450	38.0	..	30.0	..	..	..
<b>5050 <sup>⑤</sup></b>							
5050-O	0.010–0.500	18.0	24.0	6.0	..	..	..
5050-H32	0.010–0.500	22.0	..	16.0	..	..	..
5050-H34	0.010–0.500	25.0	..	20.0	..	..	..
5050-H36	0.010–0.500	27.0	..	22.0	..	..	..
5050-H38	0.010–0.500	29.0	..	24.0	..	..	..
<b>5052 <sup>⑤</sup></b>							
5052-O	0.010–0.450	25.0	35.0	10.0	..	..	..
5052-H2	0.010–0.450	31.0	..	23.0	..	..	..
5052-H34	0.010–0.450	34.0	..	26.0	..	..	..
5052-H36	0.010–0.450	37.0	..	29.0	..	..	..
5052-H38	0.010–0.450	39.0	..	31.0	..	..	..
<b>5086 <sup>⑤</sup></b>							
5086-O	0.010–0.450	35.0	46.0	14.0	..	..	..
5086-H32	0.010–0.450	40.0	..	28.0	..	..	..
5086-H34	0.010–0.450	44.0	..	34.0	..	..	..
5086-H36	0.010–0.450	47.0	..	38.0	..	..	..
<b>5154 <sup>⑤</sup></b>							
5154-O	0.010–0.500	30.0	41.0	11.0	..	10	10
5154-H34	0.010–0.500	39.0	..	29.0	..	5	5
5154-H38	0.010–0.250	45.0	..	34.0	..	..	..
<b>6061</b>							
6061-O	0.018–0.500	..	22.0	..	14.0	15	15
6061-T4	0.025–0.049	30.0	..	16.0	..	16	14
	0.050–0.259	30.0	..	16.0	..	18	16
	0.260–0.500	30.0	..	16.0	..	20	18
6061-T42 <sup>⑥ ⑧</sup>	0.025–0.049	30.0	..	14.0	..	16	14
	0.050–0.259	30.0	..	14.0	..	18	16
	0.260–0.500	30.0	..	14.0	..	20	18
6061-T6 and T62 <sup>⑥ ⑧</sup>	0.025–0.049	42.0	..	35.0	..	10	8
	0.050–0.259	42.0	..	35.0	..	12	10
	0.260–0.500	42.0	..	35.0	..	14	12
<b>6063</b>							
6063-O	0.018–0.500	..	19.0	..	..	..	..
6063-T4 and T42 <sup>⑥ ⑧</sup>	0.025–0.049	22.0	..	10.0	..	16	14
	0.050–0.259	22.0	..	10.0	..	18	16
	0.260–0.500	22.0	..	10.0	..	20	18

For numbered footnotes, see page 35.

# Mechanical Properties

**TABLE 12.19 Mechanical Property Limits <sup>① ⑦</sup>—Drawn Tube (concluded)**

ALLOY AND TEMPER	SPECIFIED WALL THICKNESS in.	TENSILE STRENGTH—ksi				ELONGATION percent min. in 2 in. or 4D <sup>②</sup>	
		ULTIMATE		YIELD		FULL-SECTION SPECIMEN <sup>③</sup>	CUT-OUT SPECIMEN <sup>④</sup>
		min.	max.	min.	max.		
<b>6063 (Continued)</b>							
6063-T6 and T62 <sup>⑤ ⑧</sup>	0.025–0.049	33.0	..	28.0	..	12	8
	0.050–0.259	33.0	..	28.0	..	14	10
	0.260–0.500	33.0	..	28.0	..	16	12
6063-T83	0.025–0.259	33.0	..	30.0	..	5	..
6063-T831	0.025–0.259	28.0	..	25.0	..	5	..
6063-T832	0.025–0.049	41.0	..	36.0	..	8	5
	0.050–0.259	40.0	..	35.0	..	8	5
<b>6066</b>							
6066-O	0.018–0.500	..	28.0	..	18.0	16	16
6066-T4 and T42 <sup>⑤ ⑧</sup>	0.025–0.500	40.0	..	25.0	..	14	12
6066-T6 and T62 <sup>⑤ ⑧</sup>	0.025–0.050	50.0	..	45.0	..	8	8
	0.051–0.500	50.0	..	45.0	..	10	8
<b>6262</b>							
6262-T6 and T62 <sup>⑤ ⑧</sup>	0.025–0.049	42.0	..	35.0	..	10	8
	0.050–0.259	42.0	..	35.0	..	12	10
	0.260–0.500	42.0	..	35.0	..	14	12
6262-T9	0.025–0.375	48.0	..	44.0	..	5	4
<b>7075</b>							
7075-O	0.025–0.049	..	40.0	..	21.0 <sup>⑨</sup>	10	8
	0.050–0.500	..	40.0	..	21.0 <sup>⑨</sup>	12	10
7075-T6 and T62 <sup>⑤ ⑧</sup>	0.025–0.259	77.0	..	66.0	..	8	7
	0.260–0.500	77.0	..	66.0	..	9	8
7075-T73 <sup>⑩</sup>	0.025–0.259	66.0	..	56.0	..	10	8
	0.260–0.500	66.0	..	56.0	..	12	10

**Footnotes for Table 12.19**

- ① The data base and criteria upon which these mechanical property limits are established are outlined on page 6-1 under "Mechanical Properties."
- ② D represents diameter of cut-out specimen.
- ③ Round tube 2 inches or less in outside diameter and square tube 1½ inches or less on a side are tested in full section unless the limitations of the testing machine precludes the use of such a specimen.
- ④ For round tube over 2 inches in diameter, for square tube over 1½ inches on a side, for all sizes of tube other than round or square, or in those cases when a full-section specimen cannot be used, a cut-out specimen is used.
- ⑤ In this alloy, tube other than round is produced only in the O, F and H113 tempers. Properties for the F temper are not specified or guaranteed.
- ⑥ These properties can usually be obtained by the user when the material is properly solution heat treated or solution and precipitation heat treated from the O (annealed) or F (as fabricated) temper. These properties also apply to samples of material in the O or F tempers, which are solution heat treated or solution and precipitation treated by the producer to determine that the material will respond to proper heat treatment. Properties attained by the user, however, may be lower than those listed if the material has been formed or otherwise cold or hot worked, particularly in the annealed temper, prior to solution heat treatment.

- ⑦ Processes such as flattening, levelling or straightening coiled products subsequent to shipment by the producer may alter the mechanical properties of the metal (refer to Certification Documentation, Section 4).
- ⑧ This temper is not available from the material producer.
- ⑨ Applicable only to round tube. The maximum yield strength for other-than-round tube shall be negotiated.
- ⑩ Material in this temper, 0.750 inch and thicker, when tested in accordance with ASTM G47 in the short transverse direction at a stress level of 75 percent of the specified minimum yield strength, will exhibit no evidence of stress corrosion cracking. Capability of individual lots to resist stress corrosion is determined by testing the previously selected tensile test sample in accordance with the applicable lot acceptance criteria outlined on page 6-8.
- ⑪ This temper applies to other than round tube that is fabricated from the annealed round tube.

# Mechanical Properties

**TABLE 16.3 Property Limits—Rod, Bar, Tube, Pipe, Structural Profiles and Sheet <sup>④</sup>—Electric Conductors**

PRODUCT	ALLOY AND TEMPER	SPECIFIED THICKNESS in.	TENSILE STRENGTH ksi				ELECTRICAL CONDUCTIVITY <sup>①</sup> min. percent IACS at 68F
			ULTIMATE		YIELD		
			min.	max.	min.	max.	
Extruded rod, bar, tube, pipe, and structural profiles	1350-H111	All	8.5	..	3.5	..	61.0
	6101-H111	0.250–2.000	12.0	..	8.0	..	59.0
	6101-T6	0.125–0.500	29.0	..	25.0	..	55.0
	6101-T61	0.125–0.749	20.0	..	15.0	..	57.0
		0.750–1.499	18.0	..	11.0	..	57.0
		1.500–2.000	15.0	..	8.0	..	57.0
	6101-T63	0.125–1.000	27.0	..	22.0	..	56.0
6101-T64	0.125–1.000	15.0	..	8.0	..	59.5	
6101-T65	0.125–0.749	25.0	32.0	20.0	27.0	56.5	
Rolled bar	1350-H12	0.125–1.000	12.0	..	8.0	..	61.0
Sawed-plate bar	1350-H112	0.125–0.499	11.0	..	6.0	..	61.0
		0.500–1.000	10.0	..	4.0	..	61.0
		1.001–1.500	9.0	..	3.5	..	61.0
Sheet	1350-O	0.006–0.125	8.0	14.0	..	..	61.8

**TABLE 16.4 Equivalent Resistivity Values—Electric Conductors**

VOLUME CONDUCTIVITY percent IACS at 68°F	EQUIVALENT RESISTIVITY AT 68°F <sup>⑥</sup>	
	VOLUME	
	ohm—circular mil/ft.	microhm—in.
52.5	19.754	1.2929
53.5	19.385	1.2687
53.8	19.277	1.2617
53.9	19.241	1.2593
54.0	19.206	1.2570
54.3	19.099	1.2501
55.0	18.856	1.2341
56.0	18.520	1.2121
56.5	18.356	1.2014
57.0	18.195	1.1908
59.0	17.578	1.1505
59.5	17.430	1.1408
61.0	17.002	1.1128
61.2	16.946	1.1091
61.3	16.918	1.1073
61.4	16.891	1.1055
61.5	16.863	1.1037
61.8	16.782	1.0983
62.0	16.727	1.0948
62.1	16.700	1.0931
62.2	16.674	1.0913
62.3	16.647	1.0896
62.4	16.620	1.0878

**Footnotes for Tables 16.1 Through 16.4**

- ① To convert conductivity to maximum resistivity use Table 16.4.
- ② Any test in a lot.
- ③ Average of all tests in a lot.
- ④ The data base and criteria upon which these mechanical property limits are established are outlined on page 6-1 under "Mechanical Properties."
- ⑤ Applicable up thru 0.250 in.
- ⑥ Equivalent weight resistivity in ohm-lb./mile<sup>2</sup> at 68°F equals:

$$9844.8 \times \frac{1}{N} \times \delta$$

where N is the volume conductivity from the first column and  $\delta$  is the alloy density in lbs./in.<sup>3</sup> (see Table 2.4)

**TABLE 16.5 Flatwise Bending Radii—Bus Bar**

TYPE OF BAR	ALLOY AND TEMPER	THICKNESS in.	RADIUS min. <sup>①</sup>
Extruded	1350-H111	All	1 × thickness
	6101-H111	0.250–0.750	1 × thickness
		0.751–1.000	2 × thickness
	6101-T6	0.125–0.375	2 × thickness
		0.376–0.500	2½ × thickness
	6101-T61	0.125–0.500	1 × thickness
		0.501–0.749	2 × thickness
		0.750–1.000	3 × thickness
		1.001–1.625	4 × thickness
	6101-T63	0.125–0.375	1 × thickness
		0.376–0.500	1½ × thickness
		0.501–1.000	2½ × thickness
6101-T64	0.125–0.750	1 × thickness	
	0.751–1.000	2 × thickness	
6101-T65	0.125–0.500	1 × thickness	
	0.501–0.749	2 × thickness	
Rolled	1350-H12	All	1 × thickness
Sawed plate	1350-H112	All	1 × thickness

① Applicable to widths up through 6 inches in the T6, T61, T63 and T65 tempers and to widths up through 12 inches for all other listed tempers. Bend radii for greater widths are subject to inquiry.

**TABLE 16.6 Edgewise Bending Radii—Bus Bar 1350-H12, H111**

WIDTH OF BAR—in.	MANDREL RADIUS
Up thru 0.500	½
0.501–1.000	1
1.001–1.500	1½
1.501–2.000	2
2.001–2.500	2½
2.501–3.000	3
3.001–3.500	3½
3.501–4.000	4

# Chemical Analysis

**TABLE 6.2 Chemical Composition Limits of Wrought Aluminum Alloys** <sup>① ②</sup>

AA DESIG- NATION	SILICON	IRON	COPPER	MAN- GANESE	MAG- NESIUM	CHROMIUM	NICKEL	ZINC	TITANIUM	OTHERS <sup>②</sup>		ALUMI- NUM Min. <sup>④</sup>
										Each <sup>⑩</sup>	Total <sup>③</sup>	
1050	0.25	0.40	0.05	0.05	0.05	..	..	0.05	0.03	0.03 <sup>⑨</sup>	..	99.50
1060	0.25	0.35	0.05	0.03	0.03	..	..	0.05	0.03	0.03 <sup>⑨</sup>	..	99.60
1100	0.95 Si + Fe		0.05-0.20	0.05	..	..	..	0.10	..	0.05 <sup>⑫</sup>	0.15	99.00
1145 <sup>⑧</sup>	0.55 Si + Fe		0.05	0.05	0.05	..	..	0.05	0.03	0.03 <sup>⑨</sup>	..	99.45
1200	1.00 Si + Fe		0.05	0.05	..	..	..	0.10	0.05	0.05	0.15	99.00
1230 <sup>⑦</sup>	0.70 Si + Fe		0.10	0.05	0.05	..	..	0.10	0.03	0.03 <sup>⑨</sup>	..	99.30
1235	0.65 Si + Fe		0.05	0.05	0.05	..	..	0.10	0.06	0.03 <sup>⑨</sup>	..	99.35
1345	0.30	0.40	0.10	0.05	0.05	..	..	0.05	0.03	0.03 <sup>⑨</sup>	..	99.45
1350 <sup>⑥</sup>	0.10	0.40	0.05	0.01	..	0.01	..	0.05	..	0.03 <sup>⑬</sup>	0.10	99.50
2011	0.40	0.7	5.0-6.0	..	..	..	..	0.30	..	0.05 <sup>⑩</sup>	0.15	Remainder
2014	0.50-1.2	0.7	3.9-5.0	0.40-1.2	0.20-0.8	0.10	..	0.25	0.15	0.05	0.15	Remainder
2017	0.20-0.8	0.7	3.5-4.5	0.40-1.0	0.40-0.8	0.10	..	0.25	0.15	0.05	0.15	Remainder
2018	0.9	1.0	3.5-4.5	0.20	0.45-0.9	0.10	1.7-2.3	0.25	..	0.05	0.15	Remainder
2024	0.50	0.50	3.8-4.9	0.30-0.9	1.2-1.8	0.10	..	0.25	0.15	0.05	0.15	Remainder
2025	0.50-1.2	1.0	3.9-5.0	0.40-1.2	0.05	0.10	..	0.25	0.15	0.05	0.15	Remainder
2036	0.50	0.50	2.2-3.0	0.10-0.40	0.30-0.6	0.10	..	0.25	0.15	0.05	0.15	Remainder
2117	0.8	0.7	2.2-3.0	0.2	0.20-0.50	0.1	..	0.25	..	0.05	0.15	Remainder
2124	0.20	0.30	3.8-4.9	0.30-0.9	1.2-1.8	0.10	..	0.25	0.15	0.05	0.15	Remainder
2218	0.9	1.0	3.5-4.5	0.20	1.2-1.8	0.10	1.7-2.3	0.25	..	0.05	0.15	Remainder
2219	0.20	0.30	5.8-6.8	0.20-0.40	0.02	..	..	0.10	0.02-0.10	0.05 <sup>⑭</sup>	0.15	Remainder
2319	0.20	0.30	5.8-6.8	0.20-0.40	0.02	..	..	0.10	0.10-0.20	0.05 <sup>⑭</sup>	0.15	Remainder
2618	0.10-0.25	0.9-1.3	1.9-2.7	..	1.3-1.8	..	0.9-1.2	0.10	0.04-0.10	0.05	0.15	Remainder
3003	0.6	0.7	0.05-0.20	1.0-1.5	..	..	..	0.10	..	0.05	0.15	Remainder
3004	0.30	0.7	0.25	1.0-1.5	0.8-1.3	..	..	0.25	..	0.05	0.15	Remainder
3005	0.6	0.7	0.30	1.0-1.5	0.20-0.6	0.1	..	0.25	0.10	0.05	0.15	Remainder
3105	0.6	0.7	0.3	0.30-0.8	0.20-0.8	0.20	..	0.40	0.10	0.05	0.15	Remainder
4032	11.0-13.5	1.0	0.50-1.3	..	0.8-1.3	0.10	0.50-1.3	0.25	..	0.05	0.15	Remainder
4043	4.5-6.0	0.8	0.30	0.05	0.05	..	..	0.10	0.20	0.05 <sup>⑮</sup>	0.15	Remainder
4045 <sup>⑪</sup>	9.0-11.0	0.8	0.30	0.05	0.05	..	..	0.10	0.20	0.05	0.15	Remainder
4047 <sup>⑪</sup>	11.0-13.0	0.8	0.30	0.15	0.10	..	..	0.20	..	0.05 <sup>⑮</sup>	0.15	Remainder
4145 <sup>⑪</sup>	9.3-10.7	0.8	3.3-4.7	0.15	0.15	0.15	..	0.20	..	0.05 <sup>⑮</sup>	0.15	Remainder
4343 <sup>⑪</sup>	6.8-8.2	0.8	0.25	0.10	..	..	..	0.20	..	0.05	0.15	Remainder
4643	3.6-4.6	0.8	0.10	0.05	0.10-0.30	..	..	0.10	0.15	0.05 <sup>⑮</sup>	0.15	Remainder
5005	0.30	0.7	0.20	0.20	0.50-1.1	0.10	..	0.25	..	0.05	0.15	Remainder
5050	0.40	0.7	0.20	0.10	1.1-1.8	0.10	..	0.25	..	0.05	0.15	Remainder
5052	0.25	0.40	0.10	0.10	2.2-2.8	0.15-0.35	..	0.10	..	0.05	0.15	Remainder
5056	0.30	0.40	0.10	0.05-0.20	4.5-5.6	0.05-0.20	..	0.10	..	0.05	0.15	Remainder
5083	0.40	0.40	0.10	0.40-1.0	4.0-4.9	0.05-0.25	..	0.25	0.15	0.05	0.15	Remainder
5086	0.40	0.50	0.10	0.20-0.7	3.5-4.5	0.05-0.25	..	0.25	0.15	0.05	0.15	Remainder
5154	0.25	0.40	0.10	0.10	3.1-3.9	0.15-0.35	..	0.20	0.20	0.05 <sup>⑮</sup>	0.15	Remainder
5183	0.40	0.40	0.10	0.50-1.0	4.3-5.2	0.05-0.25	..	0.25	0.15	0.05 <sup>⑮</sup>	0.15	Remainder
5252	0.08	0.10	0.10	0.10	2.2-2.8	..	..	0.05	..	0.03 <sup>⑨</sup>	0.10	Remainder
5254	0.45 Si + Fe		0.05	0.01	3.1-3.9	0.15-0.35	..	0.20	0.05	0.05	0.15	Remainder
5356	0.25	0.40	0.10	0.05-0.20	4.5-5.5	0.05-0.20	..	0.10	0.06-0.20	0.05 <sup>⑮</sup>	0.15	Remainder
5454	0.25	0.40	0.10	0.50-1.0	2.4-3.0	0.05-0.20	..	0.25	0.20	0.05	0.15	Remainder
5456	0.25	0.40	0.10	0.50-1.0	4.7-5.5	0.05-0.20	..	0.25	0.20	0.05	0.15	Remainder
5457	0.08	0.10	0.20	0.15-0.45	0.8-1.2	..	..	0.05	..	0.03 <sup>⑨</sup>	0.10	Remainder
5554	0.25	0.40	0.10	0.50-1.0	2.4-3.0	0.05-0.20	..	0.25	0.05-0.20	0.05 <sup>⑮</sup>	0.15	Remainder
5556	0.25	0.40	0.10	0.50-1.0	4.7-5.5	0.05-0.20	..	0.25	0.05-0.20	0.05 <sup>⑮</sup>	0.15	Remainder
5652	0.40 Si + Fe		0.04	0.01	2.2-2.8	0.15-0.35	..	0.10	..	0.05	0.15	Remainder
5654	0.45 Si + Fe		0.05	0.01	3.1-3.9	0.15-0.35	..	0.20	0.05-0.15	0.05 <sup>⑮</sup>	0.15	Remainder
5657	0.08	0.10	0.10	0.03	0.6-1.0	..	..	0.05	..	0.02 <sup>⑰</sup>	0.05	Remainder

For numbered footnotes, see next page.

# Chemical Analysis

**TABLE 6.2 Chemical Composition Limits of Wrought Aluminum Alloys <sup>① ②</sup> (concluded)**

AA DESIGNATION	SILICON	IRON	COPPER	MANGANESE	MAGNESIUM	CHROMIUM	NICKEL	ZINC	TITANIUM	OTHERS <sup>②</sup>		ALUMINUM Min. <sup>④</sup>
										Each <sup>②</sup>	Total <sup>③</sup>	
6003 <sup>⑦</sup>	0.35-1.0	0.6	0.10	0.8	0.8-1.5	0.35	..	0.20	0.10	0.05	0.15	Remainder
6005	0.6-0.9	0.35	0.10	0.10	0.40-0.6	0.10	..	0.10	0.10	0.05	0.15	Remainder
6005A	0.50-0.9	0.35	0.30	0.50 <sup>⑧</sup>	0.40-0.7	0.30	..	0.20	0.10	0.05	0.15	Remainder
6053	<sup>⑨</sup>	0.35	0.10	..	1.1-1.4	0.15-0.35	..	0.10	..	0.05	0.15	Remainder
6061	0.40-0.8	0.7	0.15-0.40	0.15	0.8-1.2	0.04-0.35	..	0.25	0.15	0.05	0.15	Remainder
6063	0.20-0.6	0.35	0.10	0.10	0.45-0.9	0.10	..	0.10	0.10	0.05	0.15	Remainder
6066	0.9-1.8	0.50	0.7-1.2	0.6-1.1	0.8-1.4	0.40	..	0.25	0.20	0.05	0.15	Remainder
6070	1.0-1.7	0.50	0.15-0.40	0.40-1.0	0.50-1.2	0.10	..	0.25	0.15	0.05	0.15	Remainder
6082	0.7-1.3	0.50	0.10	0.40-1.0	0.6-1.2	0.25	..	0.20	0.10	0.05	0.15	Remainder
6101 <sup>⑩</sup>	0.30-0.7	0.50	0.10	0.03	0.35-0.8	0.03	..	0.10	..	0.03 <sup>⑪</sup>	0.10	Remainder
6105	0.6-1.0	0.35	0.10	0.15	0.45-0.8	0.10	..	0.10	0.10	0.05	0.15	Remainder
6151	0.6-1.2	1.0	0.35	0.20	0.45-0.8	0.15-0.35	..	0.25	0.15	0.05	0.15	Remainder
6162	0.40-0.8	0.50	0.20	0.10	0.7-1.1	0.10	..	0.25	0.10	0.05	0.15	Remainder
6201	0.50-0.9	0.50	0.10	0.03	0.6-0.9	0.03	..	0.10	..	0.03 <sup>⑫</sup>	0.10	Remainder
6262	0.40-0.8	0.7	0.15-0.40	0.15	0.8-1.2	0.04-0.14	..	0.25	0.15	0.05 <sup>⑬</sup>	0.15	Remainder
6351	0.7-1.3	0.50	0.10	0.40-0.8	0.40-0.8	..	..	0.20	0.20	0.05	0.15	Remainder
6463	0.20-0.6	0.15	0.20	0.05	0.45-0.9	..	..	0.05	..	0.05	0.15	Remainder
6951	0.20-0.50	0.8	0.15-0.40	0.10	0.40-0.8	..	..	0.20	..	0.05	0.15	Remainder
7005	0.35	0.40	0.10	0.20-0.7	1.0-1.8	0.06-0.20	..	4.0-5.0	0.01-0.06	0.05 <sup>⑭</sup>	0.15	Remainder
7008 <sup>⑦</sup>	0.10	0.10	0.05	0.05	0.7-1.4	0.12-0.25	..	4.5-5.5	0.05	0.05	0.10	Remainder
7049	0.25	0.35	1.2-1.9	0.20	2.0-2.9	0.10-0.22	..	7.2-8.2	0.10	0.05	0.15	Remainder
7050	0.12	0.15	2.0-2.6	0.10	1.9-2.6	0.04	..	5.7-6.7	0.06	0.05 <sup>⑮</sup>	0.15	Remainder
7072 <sup>⑦</sup>	0.7 Si + Fe	..	0.10	0.10	0.10	..	..	0.8-1.3	..	0.05	0.15	Remainder
7075	0.40	0.50	1.2-2.0	0.30	2.1-2.9	0.18-0.28	..	5.1-6.1	0.20	0.05	0.15	Remainder
7175	0.15	0.20	1.2-2.0	0.10	2.1-2.9	0.18-0.28	..	5.1-6.1	0.10	0.05	0.15	Remainder
7178	0.40	0.50	1.6-2.4	0.30	2.4-3.1	0.18-0.28	..	6.3-7.3	0.20	0.05	0.15	Remainder
7475	0.10	0.12	1.2-1.9	0.06	1.9-2.6	0.18-0.25	..	5.2-6.2	0.06	0.05	0.15	Remainder
8017	0.10	0.55-0.8	0.10-0.20	..	0.01-0.05	..	..	0.05	..	0.03 <sup>⑯</sup>	0.10	Remainder
8030	0.10	0.30-0.8	0.15-0.30	..	0.05	..	..	0.05	..	0.03 <sup>⑰</sup>	0.10	Remainder
8176	0.03-0.15	0.40-1.0	..	..	..	..	..	0.10	..	0.05 <sup>⑱</sup>	0.15	Remainder

Note: Listed herein are designations and chemical composition limits for some wrought unalloyed aluminum and for wrought aluminum alloys registered with The Aluminum Association. This list does not include all alloys registered with The Aluminum Association. A complete list of registered designations is contained in the "Registration Record of International Alloy Designations and Chemical Composition Limits for Wrought Aluminum and Wrought Aluminum Alloys." These lists are maintained by the Technical Committee on Product Standards of the Aluminum Association.

① Composition in percent by weight maximum unless shown as a range or a minimum.

② Except for "Aluminum" and "Others," analysis normally is made for elements for which specific limits are shown. For purposes of determining conformance to these limits, an observed value or a calculated value obtained from analysis is rounded off to the nearest unit in the last right-hand place of figures used in expressing the specified limit, in accordance with ASTM Recommended Practice E 29.

③ The sum of those "Other" metallic elements 0.010 percent or more each, expressed to the second decimal before determining the sum.

④ The aluminum content for unalloyed aluminum not made by a refining process is the difference between 100.00 percent and the sum of all other analyzed metallic elements present in amounts of 0.010 percent or more each, expressed to the second decimal before determining the sum. For alloys and unalloyed aluminum not made by a refining process, when the specified maximum is 0.XX, an observed value or a calculated value greater than 0.005 but less than 0.010% is rounded off and shown as "less than 0.01".

⑤ Also contains 0.40-0.7 percent each of lead and bismuth.

⑥ Electric conductor. Formerly designated EC.

⑦ Cladding Alloy. See Table 6.1.

⑧ Foil.

⑨ Vanadium 0.05 percent maximum.

⑩ Also contains 0.20-0.6 percent each of lead and bismuth.

⑪ Brazing alloy.

⑫ Bus conductor.

⑬ Vanadium plus titanium 0.02 percent maximum; boron 0.05 percent maximum; gallium 0.03 percent maximum.

⑭ Zirconium 0.08-0.20.

⑮ Silicon 45 to 65 percent of actual magnesium content.

⑯ Beryllium 0.0003 maximum for welding electrode and welding rod only.

⑰ Boron 0.06 percent maximum.

⑱ Vanadium 0.05-0.15; zirconium 0.10-0.25.

⑲ Gallium 0.03 percent maximum; vanadium 0.05 percent maximum.

⑳ In addition to those alloys referencing footnote ⑮, a 0.0008 weight percent maximum beryllium is applicable to any alloy to be used as welding electrode or welding rod.

㉑ Zirconium 0.08-0.15.

㉒ "Others" includes listed elements for which no specific limit is shown as well as unlisted metallic elements. The producer may analyze samples for trace elements not specified in the registration or specification. However, such analysis is not required and may not cover all metallic "Other" elements. Should any analysis by the producer or the purchaser establish that an "Others" element exceeds the limit of "Each" or that the aggregate of several "others" elements exceeds the limit of "Total," the material shall be considered nonconforming.

㉓ Boron 0.04 percent maximum; lithium 0.003 percent maximum.

㉔ Boron 0.001-0.04.

㉕ Gallium 0.03 percent maximum.

㉖ Boron 0.04 percent maximum.

㉗ 0.12-0.50 Manganese and Chromium.

# Aluminum Specifications

**TABLE 1.3 Aluminum Mill Product Specifications** ① ② ③ ④

ALLOY	PRODUCT	SPECIFICATIONS					
		ASTM	Military	Federal	AMS	ASME	AWS
1060	Sheet and plate	B209	..	..	4000 ⑤	SB-209	..
	Wire, rod, bar, rolled or cold finished	B211	..	..	..	..	..
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	SB-221	..
	Tube; extruded, seamless	B241/B241M	..	..	..	SB-241/SB-241M	..
		B345/B345M	..	..	..	..	..
		B483/B483M	..	..	..	..	..
	Tube; drawn	B210	..	..	..	SB-210	..
	Tube; drawn, seamless	B234	..	..	..	SB-234	..
	Tube; condenser	B345/B345M	..	..	..	..	..
	Pipe; gas and oil transmission	B404/B404M	..	..	..	..	..
Tube; condenser with integral fins	..	..	..	..	..	..	
1100	Sheet and plate	B209	..	..	4001, 4003 AMS-QQ-A-250/1	SB-209	..
	Wire, rod, bar; rolled or cold finished	B211	..	..	..	..	..
		B221	..	..	AMS-QQ-A-225/1	..	..
	Wire, rod, bar; profiles and tube; extruded	B241/B241M	..	..	..	SB-221	..
	Tube; extruded, seamless	B491/B491M	..	..	..	SB-241/SB-241M	..
	Tube; extruded, coiled	B483/B483M	..	..	..	..	..
	Tube; drawn	B210	..	WW-T-700/1	4062	..	..
	Tube; drawn, seamless	B313/B313M	..	..	..	..	..
	Tube; welded	B547/B547M	..	..	..	..	..
	Rivet wire and rod	B316/B316M	..	QQ-A-430	AS7220	..	..
	Spray gun wire	..	..	..	4180	..	C2.25/C2.25M
	Forgings and forging stock	B247	..	..	..	..	..
	Welding rod and electrodes; bare	..	..	..	..	..	A5.10/A5.10M
	Impacts	B221	..	..	..	..	..
	Foil	B479	..	QQ-A-1876	..	..	..
1145	Foil	B373, B479	..	QQ-A-1876	4011	..	..
1235	Foil	B373, B479	..	QQ-A-1876	..	..	..
	Tube; extruded, coiled	B491/B491M	..	..	..	..	..
1350	ACSR	B232/B232M, B401	..	..	..	..	..
	Bus conductors	B236	..	..	..	..	..
	Rolled redraw rod	B233	..	..	..	..	..
	Stranded conductors	B231/B231M, B400	..	..	..	..	..
	Wire; H19 temper	B230/B230M	..	..	..	..	..
	Wire; H14 temper	B609/B609M	..	..	..	..	..
	Wire; rectangular and square	B324	..	..	..	..	..
	Round solid conductor	B609/B609M	..	..	..	..	..
		..	..	..	..	..	..
2011	Tube; drawn, seamless	B210	..	..	..	..	..
	Wire, rod, bar; rolled or cold finished	B211	..	..	AMS-QQ-A-225/3	..	..
2014	Sheet and Plate	B209	..	..	4028, 4029	..	..
	Wire, rod, bar; rolled or cold finished	B211	..	..	4121	SB-211	..
		B221	..	..	AMS-QQ-A-225/4	..	..
	Wire, rod, bar; profiles and tube; extruded	B241/B241M	..	..	4153	..	..
	Tube; extruded, seamless	B210	..	..	AMS-QQ-A-200/2	..	..
	Tube; drawn, seamless	B247	..	..	4133, 4134	..	..
	Forgings and forging stock	..	..	..	AMS-A-22771	..	..
	Rings; forged and rolled	B221	..	..	4314	..	..
Impacts	B209	..	..	..	..	..	
Alclad 2014	Sheet and plate	B209	..	..	AMS-QQ-A-250/3	..	..
2017	Wire, rod, bar; rolled or cold finished	B211	..	..	4118	..	..
	Rivet wire and rod	B316/B316M	..	QQ-A-430	AMS-QQ-A-225/5	..	..
2018	Forgings and forging stock	B247	..	..	4140	..	..
2024	Sheet and plate	B209	..	..	4035, 4037 4193, 4297	..	..
		B211	..	..	AMS-QQ-A-250/4	..	..
	Wire, rod, bar; rolled or cold finished	B221	..	..	4120, 4339	SB-211	..
	Wire, rod, bar; profiles and tube; extruded	B241/B241M	..	..	AMS-QQ-A-225/6	..	..
	Tube; extruded, seamless	B210	..	..	4152, 4164, 4165	SB-221	..
	Tube; drawn, seamless	B210	..	WW-T-700/3	AMS-QQ-A-200/3	..	..
	Tube; hydraulic	..	..	..	4087, 4088	..	..
	Rivet wire and rod	B316/B316M	..	QQ-A-430	4086	..	..
Foil	..	..	..	..	..	..	
	..	..	..	AMS-A-81596	..	..	

For numbered footnotes, see page 44.

# Aluminum Specifications

**TABLE 1.3 Aluminum Mill Product Specifications ① ② ③ ④ (continued)**

ALLOY	PRODUCT	SPECIFICATIONS					
		ASTM	Military	Federal	AMS	ASME	AWS
Alclad 2024	Plate and Sheet	B209	..	..	4040, 4041 4194, 4195, 4279 AMS-QQ-A-250/5	..	..
Alclad One Side 2024	Sheet and plate	B209	..	..	4036, 4077	..	..
2025	Forgings and forging stock	B247	..	..	4130	..	..
2117	Rivet Wire and Rod	B316/B316M	..	QQ-A-430	AS 7222	..	..
2124	Plate	B209	..	..	4101, 4221 AMS-QQ-A-250/29	..	..
2218	Forgings and forging stock	B247	..	..	4142	..	..
2219	Sheet and plate	B209	..	..	4031, 4295 AMS-QQ-A-250/30	..	..
	Wire, rod and bar; rolled or cold finished	B211	..	..	..	..	..
	Wire, rod, bar, profiles and tubes; extruded	B221	..	..	4162	..	..
	Tube; extruded, seamless	B241/B241M	..	..	4068	..	..
	Tube; drawn, seamless	B210	..	..	4066	..	..
	Forgings and forging stock	B247	..	..	4143, 4144, AMS-A-22771	..	..
	Armor, Extruded	..	MIL-DTL-46083	..	..	..	..
	Armor, Forgings	..	MIL-DTL-46118	..	..	..	..
	Armor plate	..	MIL-DTL-46118	..	..	..	..
	Rings, rolled or forged	..	..	..	4313	..	..
	Rivet wire and rod	B316/B316M	..	QQ-A-430	..	..	..
Alclad 2219	Sheet and plate	B209	..	..	4094, 4095, 4096	..	..
2319	Welding rod and electrodes; bare	..	..	..	4191	..	A5.10/A5.10M
2519	Armor plate	..	MIL-DTL-46192	..	..	..	..
2618	Forgings and forging stock	B247	..	..	4132, AMS-A-22771	..	..
3003	Sheet and plate	B209	..	..	4006, 4008 AMS-QQ-A-250/2	SB-209	..
	Tread Plate	B632/B632M	..	..	..	..	..
	Wire, rod and bar; rolled or cold finished	B211	..	..	AMS-QQ-A-225/2	..	..
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	AMS-QQ-A-200/1	SB-221	..
	Tube; extruded, seamless	B241/B241M	..	..	..	SB-241/SB-241M	..
	Tube; extruded, coiled	B491/B491M	..	..	..	..	..
	Tube; drawn	B483/B483M	..	..	..	..	..
	Tube, drawn seamless	B210	..	WW-T-700/2	4065, 4067	SB-210	..
	Tube; condenser	B234	..	..	..	SB-234	..
	Tube; condenser with integral fins	B404/B404M	..	..	..	..	..
	Tube; welded	B313/B313M	..	..	..	..	..
	Pipe	B547/B547M	..	..	..	..	..
	Pipe; gas and oil transmission	B241/B241M	MIL-DTL-25995	..	..	SB-241/SB-241M	..
	Rivet wire and rod	B345/B345M	..	..	..	..	..
	Forgings and forging stock	B316/B316M	..	QQ-A-430	..	..	..
	Foil	B247	..	..	..	SB-247	..
		..	..	..	4010 AMS-A-81596	..	..
Alclad 3003	Sheet and plate	B209	..	..	..	SB-209	..
	Brazing Sheet	..	..	..	4063, 4064	..	..
	Tube; drawn, seamless	B210	..	..	..	SB-210	..
	Tube; extruded	B221	..	..	..	..	..
	Tube; extruded, seamless	B241/B241M	..	..	..	SB-241/SB-241M	..
	Tube; condenser	B234	..	..	..	SB-234	..
	Tube; condenser with integral fin	B404/B404M	..	..	..	..	..
	Tube; welded	B547/B547M	..	..	..	..	..
	Pipe; gas and oil transmission	B345/B345M	..	..	..	..	..
3004	Sheet and plate	B209	..	..	..	SB-209	..
	Tube; extruded	B221	..	..	..	..	..
	Tube; welded	B313/B313M	..	..	..	..	..
		B547/B547M	..	..	..	..	..
Alclad 3004	Sheet and plate	B209	..	..	..	SB-209	..
	Tube; welded	B313/B313M	..	..	..	..	..
		B547/B547M	..	..	..	..	..
3005	Sheet	B209	..	..	..	..	..
3102	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	SB-221	..
3105	Sheet	B209	..	..	..	..	..
4032	Rods and Bars; Rolled or Cold Finished	..	..	..	4318, 4319	..	..
	Forgings and forging stock	B247	..	..	..	..	..

For numbered footnotes, see page 44.



# Aluminum Specifications

**TABLE 1.3 Aluminum Mill Product Specifications ① ② ③ ④ (continued)**

ALLOY	PRODUCT	SPECIFICATIONS					
		ASTM	Military	Federal	AMS	ASME	AWS
5154	Sheet and plate	B209	..	..	..	SB-209	..
	Wire, rod and bar; rolled or cold finished	B211	..	..	..	..	..
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	SB-221	..
	Tube; drawn, seamless	B210	..	..	..	SB-210	..
	Tube; welded	B313/B313M B547/B547M	..	..	..	..	..
5183	Welding rod and electrodes; bare	..	..	..	..	..	A5.10/A5.10M
5252	Sheet	B209	..	..	..	..	..
5254	Sheet and plate	B209	..	..	..	SB-209	..
	Tube; extruded, seamless	B241/B241M	..	..	..	..	..
5356	Welding rod and electrodes; bare	..	..	..	..	..	A5.10/A5.10M
5454	Sheet and plate	B209	..	..	AMS-QQ-A-250/10	SB-209	..
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	AMS-QQ-A-200/6	SB-221	..
	Tube; extruded, seamless	B241/B241M	..	..	..	SB-241/SB-241M	..
	Tube; condenser	B234	..	..	..	SB-234	..
	Tube; condenser with integral fins	B404/B404M	..	..	..	..	..
	Tube; welded	B547/B547M	..	..	..	..	..
5456	Sheet and plate	B209	..	..	AMS-QQ-A-250/9 AMS-QQ-A-250/20	SB-209	..
	Marine Sheet and Plate	B928/B928M	..	..	..	..	..
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	AMS-QQ-A-200/7	SB-221	..
	Tube; extruded, seamless	B241/B241M	..	..	..	SB-241/SB-241M	..
	Tube; drawn, seamless	B210	..	..	..	..	..
	Armor plate	..	MIL-DTL-46027	..	..	..	..
	Extruded armor	..	MIL-DTL-46083	..	..	..	..
	Forged armor	..	MIL-DTL-45225	..	..	..	..
5457	Sheet	B209	..	..	..	..	..
5554	Welding rod and electrodes; bare	..	..	..	..	..	A5.10/A5.10M
5556	Welding rod and electrodes; bare	..	..	..	..	..	A5.10/A5.10M
5652	Sheet and plate	B209	..	..	..	SB-209	..
	Tube; extruded, seamless	B241/B241M	..	..	..	..	..
5654	Welding rod and electrodes; bare	..	..	..	..	..	A5.10/A5.10M
5657	Sheet	B209	..	..	..	..	..
6005	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	..	..
6005A	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	SB-221	..
6053	Rivet wire and rod	B316/B316M	..	QQ-A-430	..	..	..
6060	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	..	..
6061	Sheet and plate	B209	..	..	4025, 4026, 4027 AMS-QQ-A-250/11	SB-209	..
	Tread Plate	B632/B632M	..	..	..	..	..
	Wire, rod and bar; rolled or cold finished	B211	..	..	4115, 4116, 4117, 4128	SB-211	..
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	AMS-QQ-A-225/8 4150, 4160, 4161, AMS-QQ-A-200/8 4172, 4173	SB-221	..
	Structural profiles	B308/B308M	..	..	4113 AMS-QQ-A-200/16	SB-308/SB-308M	..
	Tube, drawn	B483/B483M	..	..	..	..	..
	Tube; extruded, seamless	B241/B241M	..	..	..	SB-241/SB-241M	..
	Tube; drawn, seamless	B210	..	WW-T-700/6	4079, 4080, 4082	SB-210	..
	Tube; hydraulic	..	..	..	4081, 4083	..	..
	Tube; condenser	B234	..	..	..	SB-234	..
	Tube; condenser with integral fins	B404/B404M	..	..	..	..	..
	Tube; welded	B313/B313M B547/B547M	..	..	..	..	..
	Pipe	B241/B241M	MIL-DTL-25995	..	..	SB-241/SB-241M	..
	Pipe; gas and oil transmission	B345/B345M	..	..	..	..	..
	Forgings and forging stock	B247	..	..	4127, 4146⑤, 4248 AMS-A-22771	SB-247	..
	Rings; forged or rolled	..	..	..	4312	..	..
	Rivet Wire and Rod	B316/B316M	..	QQ-A-430	..	..	..
Impacts	B221	..	..	..	..	..	
Structural pipe and tube; extruded	B429	..	..	..	..	..	
Foil	..	..	..	4009⑤	..	..	

For numbered footnotes, see page 44.

# Aluminum Specifications

**TABLE 1.3 Aluminum Mill Product Specifications ① ② ③ ④ (continued)**

ALLOY	PRODUCT	SPECIFICATIONS						
		ASTM	Military	Federal	AMS	ASME	AWS	
Alclad 6061	Sheet and plate	B209	..	..	4021⑤	SB-209	..	
6063	Wire, rod, bar, profiles and tube; extruded	B221	..	..	4156 AMS-QQ-A-200/9	SB-221	..	
	Tube; extruded, seamless	B241/B241M	..	..	..	SB-241/SB-241M	..	
	Tube; extruded, coiled	B491/B491M	..	..	..	..	..	
	Tube; drawn	B483/B483M	..	..	..	..	..	
	Pipe	B241/B241M	MIL-DTL-25995	..	..	..	SB-241/SB-241M	..
	Pipe; gas and oil transmission, seamless Structural pipe and tube; extruded	B345/B345M B429	..	..	..	..	..	..
6066	Wire, rod, bar, profiles and tube; extruded	B221	..	..	AMS-QQ-A-200/10	..	..	
	Forgings and forging stock	B247	..	..	..	..	..	
6070	Rod, bar, profiles and tube; extruded	B221	..	..	..	..	..	
	Impacts	B221	..	..	..	..	..	
	Pipe; gas and oil transmission	B345/B345M	..	..	..	..	..	
6082	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	SB-221	..	
6101	Bus conductor	B317/B317M	..	..	..	..	..	
6105	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	..	..	
6151	Forgings and forging stock	B247	..	..	4125, AMS-A-22771	..	..	
6201	Wire ; T81 temper	B398/B398M	..	..	..	..	..	
	Standard conductor; T81 temper	B399/B399M	..	..	..	..	..	
6162	Wire, rod, bar, profiles and tube; extruded	B211	..	..	..	..	..	
6262	Wire, rod and bar; rolled or cold finished	B211	..	..	AMS-QQ-A-225/10	..	..	
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	..	..	
	Tube, drawn seamless	B210	..	..	..	..	..	
		B483/B483M	..	..	..	..	..	
6351	Pipe; gas and oil transmission	B345/B345M	..	..	..	..	..	
	Seamless pipe and tube, extruded,	B241/B241M	..	..	..	..	..	
	Wire, rod, bar, profiles and tube; extruded	B345/B345M B221	..	..	..	..	..	
6463	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	..	..	
7005	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	..	..	
7039	Armor plate	..	MIL-DTL-46063	..	..	..	..	
	Armor, Extruded	..	MIL-DTL-46083	..	..	..	..	
	Armor, Forgings	..	MIL-DTL-45225	..	..	..	..	
7049	Forgings	B247	..	..	4111, AMS-A-22771	..	..	
	Extrusions	..	..	..	4157, 4159	..	..	
	Hand forgings	..	..	..	4247	..	..	
	Forging	..	..	..	4321	..	..	
	Plate	..	..	..	4200	..	..	
7050	Plate	..	..	..	4050, 4201	..	..	
	Wire, rod, bar; extruded	..	..	..	4340, 4341, 4342	..	..	
	Forgings	B247	..	..	4107, 4108, AMS-A-22771	..	..	
	Die forgings	B247	..	..	4333	..	..	
	Rivet Wire and Rod	B316/B316M	..	QQ-A-430	..	..	..	
Alclad 7050	Sheet	..	..	..	4243	..	..	
7075	Sheet and plate	B209	..	..	4044, 4045, 4078 AMS-QQ-A-250/12 AMS-QQ-A-250/24	..	..	
	Sheet; fine grained	..	..	..	4277	..	..	
	Wire, rod and bar; rolled or cold finished	B211	..	..	4122, 4123, 4124, 4186, 4187 ⑤	..	..	
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	AMS-QQ-A-225/9 4154, 4166, 4167, 4168, 4169	..	..	
	Wire, rod, bar, profiles and tube; extruded (Exfoliation Resistant)	..	..	..	AMS-QQ-A-200/11 AMS-QQ-A-200/15	..	..	
	Tube; extruded	B241/B241M	..	..	..	..	..	
	Tube; drawn, seamless	B210	..	WW-T-700/7	..	..	..	
	Forgings and forging stock	B247	..	..	4126, 4131, 4141, 4147, AMS-A-22771	..	..	
	Hand forging	B247	..	..	4323	..	..	
	Rings, forged or rolled	B247	..	..	4310, 4311	..	..	
	Impacts	B221	..	..	..	..	..	
	Rivet Wire	B316/B316M	..	QQ-A-430	..	..	..	

For numbered footnotes, see page 44.

# Aluminum Specifications

**TABLE 1.3 Aluminum Mill Product Specifications ① ② ③ ④ (concluded)**

ALLOY	PRODUCT	SPECIFICATIONS					
		ASTM	Military	Federal	AMS	ASME	AWS
Alclad 7075	Sheet and plate	B209	..	..	4048, 4049 AMS-QQ-A-250/13 AMS-QQ-A-250/25 AMS-QQ-A-250/26 4278	..	..
	Sheet; fine grained						
Alclad One Side 7075	Sheet and plate	B209	..	..	4046 AMS-QQ-A-250/18	..	..
7116	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	..	..
7129	Wire, rod, bar, profiles and tube; extruded	B221	..	..	..	..	..
7175	Extruded	..	..	..	4344	..	..
	Forgings and forging stock	B247	..	..	4148, 4149, 4179, AMS-A-2271	..	..
7178	Sheet and plate	B209	..	..	AMS-QQ-A-250/14 AMS-QQ-A-250/21	..	..
	Wire, rod, bar, profiles and tube; extruded	B221	..	..	AMS-QQ-A-200/13 AMS-QQ-A-200/14	..	..
	Rivet Wire	B316/B316M	..	..	..	..	..
	Tube; extruded, seamless	B241/B241M	..	..	..	..	..
Alclad 7178	Sheet and plate	B209	..	..	.. AMS-QQ-A-250/15 AMS-QQ-A-250/22 AMS-QQ-A-250/28	..	..
7475	Sheet and plate	..	..	..	4084, 4085, 4089, 4090, 4202	..	..
Alclad 7475	Sheet	..	..	..	4100, 4207	..	..

① The Aluminum Association and its members assume no responsibility for use of this index, for errors, for omissions, or for failure to advise of subsequent revisions or amendments.

② This cross-reference index lists the basic specification or standard number and no attempt is made to reflect the latest revision or amendment to any particular document. The appropriate specification index published by the specification issuing body should be consulted to determine the latest issue of any particular specification or standard. The aluminum industry generally prefers to use the latest issue of any given specification or standard.

③ Different organizations' specifications for the same alloy and product may contain different requirements.

④ Copies of specifications can be obtained from:

(Aerospace Material Specifications) (AMS) ASTM  
SAE, Inc.  
400 Commonwealth Drive  
Warrendale, PA 15096-0001  
100 Barr Harbor Drive  
West Conshohocken, PA  
19428-2959

(Military and Federal) (AWS)  
Standardization Documents Order Desk American Welding Society  
Building 4D, 700 Robins Avenue  
Philadelphia, PA 19111-5094  
550 N.W. LeJeune Road  
Miami, FL 33126

(ASME)  
American Society of Mechanical Engineers  
345 East 47<sup>th</sup> Street  
New York, NY 10017

⑤ Noncurrent

# Aluminum Specifications

**TABLE 1.4 Specifications Covering Aluminum Mill Products** ① ②

SPECIFICATION NUMBER	ALLOYS AND PRODUCT OR PROCESS COVERED	SPECIFICATION NUMBER	ALLOYS AND PRODUCT OR PROCESS COVERED	
<b>FEDERAL SPECIFICATIONS</b>		<b>AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)</b>		
FED-STD-123	Marking for domestic shipment (civilian agencies)	B209	1060, 1100, 2014, Alclad 2014, 2024, Alclad 2024, Alclad one side 2024, 2124, 2219, Alclad 2219, 3003, Alclad 3003, 3004, Alclad 3004, 3005, 3105, 5005, 5050, 5052, 5083, 5086, 5154, 5252, 5254, 5454, 5456, 5457, 5652, 5657, 6061, Alclad 6061, 7075, Alclad 7075, Alclad one side 7075, 7178, and Alclad 7178 sheet and plate	
FED-STD-184	Item identification marking for aluminum products			
FED-STD-245	Tolerances for aluminum wrought products finished wire, rod, bar and special shapes			
QQ-A-430	1100, 2017, 2024, 2117, 2219, 3003, 5005, 5052, 5056, 6053, 6061, 7050, and 7075 wire and rod for rivets and cold heading			
QQ-A-1876	Aluminum Foil; 1100, 1145, 1235			
WW-T-700	General specification for drawn tube, seamless		B210	1060, 1100, 2011, 2014, 2024, 3003, Alclad 3003, 5005, 5050, 5052, 5083, 5086, 5154, 5456, 6061, 6063, 6262 and 7075 drawn seamless tube
WW-T-700/1	1100 drawn tube, seamless		B211	1060, 1100, 2011, 2014, 2017, 2024, 2219, 3003, 5052, 5056, 5154, 6061, 6063, 6262 and 7075 rolled, drawn or cold finished wire, rod and bar
WW-T-700/2	3003 drawn tube, seamless		B221	1060, 1100, 2014, 2024, 2219, 3003, Alclad 3003, 3004, 3102, 5052, 5083, 5086, 5154, 5454, 5456, 6005, 6005A, 6060, 6061, 6063, 6066, 6070, 6105, 6162, 6262, 6351, 6463, 7005, 7072, 7075, 7116, 7129 and 7178 extruded wire, rod, bar, shapes and tube
WW-T-700/3	2024 drawn tube, seamless		B230/B230M	1350-H19 wire
WW-T-700/4	5052 drawn tube, seamless		B231/B231M	Aluminum conductors, concentric-lay-stranded
WW-T-700/5	5086 drawn tube, seamless	B232/B232M	1350 Aluminum conductors, steel reinforced, concentric-lay-stranded (ACSR)	
WW-T-700/6	6061 drawn tube, seamless	B233	1350 drawing stock for electrical purposes	
WW-T-700/7	7075 drawn tube, seamless	B234	1060, 3003, Alclad 3003, 5052, 5454, and 6061 drawn, seamless tube for condensers and heat exchangers	
<b>MILITARY SPECIFICATIONS</b>		B236	1350 bus conductor	
MIL-STD-129	Marking for shipment and storage	B241/B241M	3003, 6061, 6063, and 6351 seamless pipe; 1060, 1100, 2014, 2024, 2219, 3003, Alclad 3003, 5052, 5083, 5086, 5254, 5454, 5456, 5652, 6061, 6063, 6351, 7075, and 7178 seamless extruded tube	
MIL-C-5541	Chemical films for aluminum and aluminum alloys	B247	2014, 2219, 2618, 5083, 6061, 7049, 7050, 7075, and 7175 hand forgings; 1100, 2014, 2018, 2025, 2218, 2219, 2618, 3003, 4032, 5083, 6061, 6066, 6151, 7049, 7050, 7075, 7076 and 7175 die forgings; 2014, 2219, 2618, 6061, 6151, and 7075 rolled ring forgings	
MIL-A-8625	Anodic coatings for aluminum alloys	B308/B308M	6061 rolled or extruded standard structural shapes	
MIL-DTL-25995	3003, 6061 and 6063 pipe	B313/B313M	1100, 3003, 3004, Alclad 3004, 5050, 5052, 5086, 5154, and 6061 round welded tube	
MIL-DTL-45225	5083, 5456 and 7039 forged armor	B316/B316M	1100, 2017, 2024, 2117, 2219, 3003, 5005, 5052, 5056, 6053, 6061, 7050, 7075 and 7178 rivet and cold heading wire and rod	
MIL-DTL-46027	5083 and 5456 armor plate	B317/B317M	6101 extruded rod, bar, structural shapes and pipe for electrical purposes	
MIL-DTL-46063	7039 armor plate	B324	1350 rectangular and square wire	
MIL-DTL-46083	5083, 5456, 2219 and 7039 extruded armor	B345/B345M	3003, 6061, 6063, and 6351 seamless pipe; 1060, 3003, Alclad 3003, 5083, 5086, 6061, 6063, 6070, and 6351 seamless extruded tube	
MIL-DTL-46118	2219 armor plate and forgings	B373	1145 and 1235 foil for capacitors	
MIL-DTL-46192	2519 armor plate	B398/B398M	6201-T81 wire for electrical purposes	
<b>THE AMERICAN WELDING SOCIETY (AWS)</b>		B399/B399M	Concentric-lay-stranded, 6201-T81 conductors	
A5.3/A5.3M	Specification for Aluminum and Aluminum Alloy Electrodes for Shielded Gas Metal Arc Welding	B400	Compact round concentric-lay-stranded, 1350 conductors, hard-drawn	
A5.10/A5.10M	Specification for Bare Aluminum and Aluminum Welding Electrodes and Rods, 1100, 2319, 4043, 4047, 4145, 4643, 5183, 5356, 5554, 5556, 5654	B401	1350 Compact round concentric-lay-stranded aluminum conductors, steel reinforced (ACSR)	
C2.25/C2.25M	Thermal Spray - Solid and Composite Wire and Ceramic Rods	B404/B404M	1060, 3003, Alclad 3003, 5052, 5454, and 6061 seamless condenser and heat exchanger tube with integral fins	
<b>AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)</b>		B429	6061 and 6063 extruded structural pipe and tube	
B36.10M	Standard dimensions for welded and seamless (steel) pipe	B479	1100, 1145, and 1235 foil for flexible barrier	
B36.19M	Standard dimensions for (stainless steel) pipe	B483/B483M	1060, 1100, 1435, 3003, 5005, 5050, 5052, 6061, 6063 and 6262 drawn tube	
SB-209	1060, 1100, 3003, Alclad 3003, 3004, Alclad 3004, 5052, 5083, 5086, 5154, 5254, 5454, 5456, 5652, 6061, and Alclad 6061 sheet and plate	B491/B491M	1050, 1100, 1200, 1235, 3003 and 6063 extruded round coiled tube	
SB-210	1060, 3003, Alclad 3003, 5052, 5154, 6061, and 6063 drawn seamless tube	B547/B547M	1100, 3003, Alclad 3003, 3004 Alclad 3004, 5050, 5052, 5083, 5086, 5154, 5454 and 6061 formed and arc welded round tube	
SB-211	2014, 2024, and 6061 rolled, drawn, or cold finished wire, rod and bar			
SB-221	1060, 1100, 2024, 3003, 5083, 5086, 5154, 5454, 5456, 6005A, 6061 and 6063 extruded rod, bar and shapes			
SB-234	1060, 3003, Alclad 3003, 5052, 5454, and 6061 drawn, seamless tube for condensers and heat exchangers			
SB-241/SB-241M	3003, 6061 and 6063 seamless pipe; 1060, 1100, 3003, Alclad 3003, 5052, 5083, 5086, 5454, 5456, 6061 and 6063 seamless extruded tube			
SB-247	5083 and 6061 hand forgings; 2014, 3003, 5083 and 6061 die forgings			
SB-308/SB-308M	6061 rolled or extruded standard structural shapes			

For numbered footnotes, see page 48.

# Aluminum Specifications

**TABLE 1.4 Specifications Covering Aluminum Mill Products** ① ②

SPECIFICATION NUMBER	ALLOYS AND PRODUCT OR PROCESS COVERED	SPECIFICATION NUMBER	ALLOYS AND PRODUCT OR PROCESS COVERED
B609/B609M	Aluminum 1350 round wire, annealed and intermediate tempers, for electrical purposes	4085	7475-T761 Sheet
B632/B632M	Aluminum-alloy 6061 rolled tread plate	4086	2024-T3 Drawn, Seamless Hydraulic Tube
B660	Packaging/Packing of Aluminum and Magnesium Products	4087	2024-O Drawn Seamless Tube
B666/B666M	Practice for Identification Marking of Aluminum Products	4088	2024-T3 Drawn Seamless Tube
B928/B928M	High Magnesium Aluminum Alloy Sheet and Plate for Marine Service	4089	7475-T7651 Plate
		4090	7475-T651 Plate
		4094	Alclad 2219-T81 Sheet and T851 Plate
		4095	Alclad 2219-T31 Sheet and T351 Plate
<b>SAE — AEROSPACE MATERIAL SPECIFICATIONS (AMS)</b>			
2469	Process and Performance Requirement for Hard-Anodic Coating Treatment of Aluminum Alloys	4096	Alclad 2219-O Sheet and Plate
2470	Chromic-Acid Anodizing of Aluminum Alloys	4100	Alclad 7475-T761 Sheet
2471	Undyed Coating Sulfuric-Acid Process, Anodizing of Aluminum Alloys	4101	2124-T851 Plate
2472	Dyed Coating Sulfuric-Acid Anodizing of Aluminum Alloys	4107	7050-T74 (formerly T736) Die Forgings
2473	Chemical Film Treatment for Aluminum Alloys, General Purpose Coating	4108	7050-T7452 (formerly T73652) Hand Forgings
2474	Low Electrical Resistant Coating, Chemical Treatments for Aluminum Alloys	4111	7049-T73 Forgings and Forging Stock
2808	Identification Markings for Forgings	4113	6061-T6 Extruded Profiles
2816	Color Code identification Marking of Welding Wire	4114	5052-F Rolled or Cold Finished, Rods and Bars
4000 ③	1060-O Sheet and Plate	4115	6061-O Rolled, Drawn or Cold Finished Wire, Rod, Bar and Flash Welded Rings
4001	1100-O Sheet and Plate	4116	6061-T4 Cold Finished Wire, Rod and Bar
4003	1100-H14 Sheet and Plate	4117	6061-T6 and T651 Rolled or Cold Finished Wire, Rod, Bar and Flash Welded Rings
4004	5052-H191 Foil	4118	2017-T4 and T451 Rolled Cold Finished Wire, Rod and Bar
4005 ③	5056-H191 Foil	4120	2024-T4 and T351 Rolled or Cold Finished Wire, Rod and Bar
4006	3003-O Sheet and Plate	4121	2014-T6 Rolled or Cold Finished Wire, Rod and Bar
4008	3003-H14 Sheet and Plate	4122	7075-T6 Rolled or Cold Finished Wire, Rod, Bar and Rings
4009 ③	6061-O Foil	4123	7075-T651 Rolled or Cold Finished Rod and Bar
4010	3003-H18 Foil	4124	7075-T7351 Rolled or Cold Finished Bars, Rods and Wire
4011	1145-O Foil	4125	6151-T6 Die Forgings and Rolled or Forged Rings
4013	Laminated Shim Stock, Surface Bonded	4126	7075-T6 Die and Hand Forgings and Rolled Rings
4015	5052-O Sheet and Plate	4127	6061-T6 Forgings and Rolled or Forged Rings
4016	5052-H32 Sheet and Plate	4128	6061-T451 Bars, Rolled or Cold Finished
4017	5052-H34 Sheet and Plate	4130	2025-T6 Die Forgings
4021 ③	Alclad 6061-O Sheet and Plate	4131	7075-T74 Die and Hand Forgings
4025	6061-O Sheet and Plate	4132	2618-T61 Die and Hand Forgings, Rolled Rings and Forging Stock
4026	6061-T4 and T451 Sheet and Plate	4133	2014-T6 Forgings and Rolled Rings
4027	6061-T6 and T651 Sheet and Plate	4134	2014-T4 Die Forgings
4028	2014-O Sheet and Plate	4140	2018-T61 Die Forgings
4029	2014-T6 Sheet and 2014-T651 Plate	4141	7075-T73 Die Forgings
4031	2219-O Sheet and Plate	4143	2219-T6 Forgings and Rolled or Forged Rings
4035	2024-O Sheet and Plate	4144	2219-T852 and -T851 Hand Forgings and Rings
4036	Alclad one side 2024-T3 Sheet and T351 Plate	4146 ③	6061-T4 Forgings and Rolled or Forged Rings
4037	2024-T3 Sheet and T351 Plate	4147	7075-T7352 Forgings
4040	Alclad 2024-O and 1½% Alclad 2024-O Sheet and Plate	4148	7175-T66 Die Forgings
4041	Alclad 2024 and 1½% Alclad 2024-T3 Flat Sheet; Alclad 2024-T351 Plate	4149	7175-T74 Die and Hand Forgings
4044	7075-O Sheet and Plate	4150	6061-T6 Extrusions and Rings
4045	7075-T6 Sheet and T651 Plate	4152	2024-T3 Extrusions
4046	Alclad One Side 7075-T6 Sheet and Alclad One Side, 7075-T651 Plate	4153	2014-T6 Extrusions
4048	Alclad 7075-O Sheet and Plate	4154	7075-T6 Extrusions
4049	Alclad 7075-T6 Sheet and Alclad 7075-T651 Plate	4156	6063-T6 Extrusions
4050	7050-T7451 (formerly T73651) Plate	4157	7049-T7351 Extrusions
4056	5083-O Sheet and Plate	4159	7049-T7651 Extrusions
4062	1100-H14 Drawn Seamless Tube	4160	6061-O Extrusions
4063	Clad One Side 3003 Sheet (Brazing Sheet No. 11-O)	4161	6061-T4 Extrusions
4064	Clad Two Sides 3003 Sheet (Brazing Sheet No. 12-O)	4162	2219-T8511 Extrusions
4065	3003-O Drawn Tube, Seamless	4163	2219-T3511 Extrusions
4066	2219-T851 Drawn Tube, Seamless	4164	2024-T3510 Extrusions
4067	3003-H14 Drawn Tube, Seamless	4165	2024-T3511 Extrusions
4068	2219-T351 Drawn Tube, Seamless	4166	7075-T73 Extrusions
4069	5052-O Drawn Tube, Special Tolerances, Seamless	4167	7075-T73511 Extrusions
4070	5052-O Drawn Tube, Seamless	4168	7075-T6510 Extrusions
4071	5052-O Drawn, Hydraulic Tube, Seamless	4169	7075-T6511 Extrusions
4077	Alclad one side 2024-O Sheet and Plate	4172	6061-T4511 Extrusions
4078	7075-T7351 Plate	4173	6061-T6511 Extrusions
4079	6061-O Drawn Seamless Tube, Special Tolerances	4179	7175-T7452 Forgings
4080	6061-O Drawn Seamless Tube	4180	1100-H18 Wire for Metal Spraying
4081	6061-T4 Drawn, Seamless Hydraulic Tube	4184	4145 Brazing Filler Metal
4082	6061-T6 Seamless Drawn Tube	4185	4047 Brazing Filler Metal
4083	6061-T6 Drawn, Seamless Hydraulic Tube	4186	7075-F Wire, Rod and Bar ; Rolled or Cold Finished
4084	7475-T61 Sheet	4187 ③	7075-O Wire, Rod and Bar ; Rolled, Drawn or Cold Finished
		4189	4643 Welding Wire

For numbered footnotes, see page 48.

# Aluminum Specifications

**TABLE 1.4 Specifications Covering Aluminum Mill Products** ① ②

SPECIFICATION NUMBER	ALLOYS AND PRODUCT OR PROCESS COVERED	SPECIFICATION NUMBER	ALLOYS AND PRODUCT OR PROCESS COVERED
4190	4043 Welding Wire	AMS-QQ-A-200/14	7178-T76, Bar, Rod, Shapes and Wire, Extruded (Exfoliation Resistant)
4191	2319 Welding Wire	AMS-QQ-A-200/15	7075-T76, Bar, Rod and Shapes, Extruded (Exfoliation Resistant)
4193	2024-T861 Sheet and Plate	AMS-QQ-A-200/16	6061, Structural Shapes, Extruded
4194 ③	Alclad 2024-T361 Sheet and Plate	AMS-QQ-A-200/17	6162, Bar, Rod, Shapes, Tube and Wire, Extruded
4195	Alclad 2024-T861 Sheet and Plate	AMS-QQ-A-225	Aluminum and Aluminum Alloy, Bar, Rod, Wire, or Special Shapes; Rolled, Drawn or Cold Finished; General Specification for
4200	7049-T7351 Plate	AMS-QQ-A-225/1	1100 Aluminum Alloy, Bar, Rod, Wire; Rolled, Drawn or Cold Finished
4201	7050-T7651 Plate	AMS-QQ-A-225/2	3003 Aluminum Alloy, Bar, Rod, Wire; Rolled, Drawn or Cold Finished
4202	7475-T7351 Plate	AMS-QQ-A-225/3	2011 Aluminum Alloy, Bar, Rod, Wire; Rolled, Drawn or Cold Finished
4203	7010-T7351 Plate	AMS-QQ-A-225/4	2014 Aluminum Alloy, Bar, Rod, Wire, and Special Shapes; Rolled, Drawn or Cold Finished
4204	7010-T7651 Plate	AMS-QQ-A-225/5	2017 Aluminum Alloy, Bar, Rod, Wire; Rolled, Drawn or Cold Finished
4205	7010-T7451 (formerly T73651) Plate	AMS-QQ-A-225/6	2024 Aluminum Alloy, Bar, Rod, Wire; Rolled, Drawn or Cold Finished
4206	7055-T7751 Plate	AMS-QQ-A-225/7	5052 Aluminum Alloy, Bar, Rod, Wire; Rolled, Drawn or Cold Finished
4207	Alclad 7475-T61 Sheet	AMS-QQ-A-225/8	6061 Aluminum Alloy, Bar, Rod, Wire, and Special Shapes; Rolled, Drawn or Cold Finished
4208	2004-F Sheet	AMS-QQ-A-225/9	7075 Aluminum Alloy, Bar, Rod, Wire, and Special Shapes; Rolled, Drawn or Cold Finished
4209	Alclad 2004-F Sheet	AMS-QQ-A-225/10	6262 Aluminum Alloy, Bar, Rod, Wire; Rolled, Drawn or Cold Finished
4221	2124-T8151 Plate	AMS-QQ-A-250	Aluminum and Aluminum Alloy, Plate and Sheet, General Specification for
4232	2090-T86 Extrusions	AMS-QQ-A-250/1	1100 Aluminum Sheet and Plate
4243	Alclad 7050-T76 Sheet	AMS-QQ-A-250/2	3003 Aluminum Alloy Plate and Sheet
4247	7049-T7352 Hand Forgings	AMS-QQ-A-250/3	Alclad 2014 Aluminum Alloy Plate and Sheet
4248	6061-T652 Hand Forgings and Rolled Rings	AMS-QQ-A-250/4	2024 Aluminum Alloy Plate and Sheet
4251	2090-T83 Sheet	AMS-QQ-A-250/5	Alclad 2024 Aluminum Alloy Plate and Sheet
4252	7150-T7751 Plate	AMS-QQ-A-250/6	5083 Aluminum Alloy Plate and Sheet
4255	Clad One Side 6951 Sheet (No. 21 Brazing Sheet) As Fabricated	AMS-QQ-A-250/7	5086 Aluminum Alloy Plate and Sheet
4256	Clad Two Sides 6951 Sheet (No. 22 Brazing Sheet) As Fabricated	AMS-QQ-A-250/8	5052 Aluminum Alloy Plate and Sheet
4259 ③	8090-T6 Sheet (Unrecrystallized)	AMS-QQ-A-250/9	5456 Aluminum Alloy Plate and Sheet
4270	Alclad 2424-T3 Sheet	AMS-QQ-A-250/10	5454 Aluminum Alloy Plate and Sheet
4273	2424-T3 Sheet and Plate	AMS-QQ-A-250/11	6061 Aluminum Alloy Plate and Sheet
4274	Alclad 2424-O Sheet, Fine Grained	AMS-QQ-A-250/12	7075 Aluminum Alloy Plate and Sheet
4276	2424-O Sheet, Fine Grained	AMS-QQ-A-250/13	Alclad 7075 Aluminum Alloy Plate and Sheet
4277	7075-O Sheet, Fine Grained	AMS-QQ-A-250/14	7178 Aluminum Alloy Plate and Sheet
4278	Alclad 7075-O Sheet, Fine Grained	AMS-QQ-A-250/15	Alclad 7178 Aluminum Alloy Plate and Sheet
4279	Alclad 2024-T4 Sheet	AMS-QQ-A-250/18	Alclad One Side 7075 Aluminum Alloy Plate and Sheet
4295	2219 Sheet and Plate	AMS-QQ-A-250/19	5086 Aluminum Alloy Plate and Sheet for Seawater Applications
4296	Alclad 2524-T3 Sheet and Plate	AMS-QQ-A-250/20	5456 Aluminum Alloy Plate and Sheet for Seawater Applications
4297	2024-T4 Sheet	AMS-QQ-A-250/21	7178-T76 Aluminum Alloy Plate and Sheet (Exfoliation Resistant)
4303	2090-T81 Plate	AMS-QQ-A-250/22	Alclad 7178-T76 Aluminum Alloy Plate and Sheet (Exfoliation Resistant)
4306	7150-T6151 Plate	AMS-QQ-A-250/24	7075 Aluminum Alloy Plate and Sheet (Exfoliation Resistant)
4307 ①	7150-T6151 Extrusions	AMS-QQ-A-250/25	Alclad 7075 Aluminum Alloy Plate and Sheet (Exfoliation Resistant)
4308 ③	8009-H112 Sheet	AMS-QQ-A-250/26	7075, Alclad 7011 Aluminum Alloy Plate and Sheet
4309 ③	8009-H112 Extrusions	AMS-QQ-A-250/28	7178, Alclad 7011 Aluminum Alloy Plate and Sheet
4310	7075-T651 and T652 Rings, Forged or Rolled	AMS-QQ-A-250/29	2124 Aluminum Alloy Plate
4311	7075-T7351 and T7352 Rings, Forged or Rolled	AMS-QQ-A-250/30	2219 Aluminum Alloy Plate and Sheet
4312	6061-T651 and T652 Rings, Rolled or Forged	AMS-H-6088	Heat Treatment of Wrought Aluminum Alloys
4313	2219-T351 and T352 Rings, Forged or Rolled	AMS-B-20148	4045 and 4343 Brazing Sheet
4314	2014-T651 and T652 Rings, Forged or Rolled	AMS-A-22771	Aluminum Alloy Forgings, Heat Treated
4319	4032-T651 Rolled or Cold Finished Bars and Rods	AMS-A-81596	2024, 3003, 5052 and 5056 Foil
4320	7149-T73 Forgings		
4321	7049-O1 Forgings		
4323	7075-T7452 Hand Forgings		
4333	7050-T7452 Die Forgings		
4334 ③	7249-T74 and T7452 Forgings		
4337	7055-T7751 Extruded Profiles		
4339	2024-T851 Rolled or Cold Finished Bars and Rods		
4340	7050-T7651 Extrusions		
4341	7050-T7351 Extrusions		
4342	7050-T74511 (formerly T736511) Extrusions		
4343	7149-T7351 Extrusions		
4344	7175-T7351 Extrusions		
4345	7150-T7751 Extrusions		
4347	6013-T4 Sheet		
AMS-QQ-A-200	Aluminum Alloy, Bar, Rod, Shapes, Structural Shapes, Tube and Wire, Extruded, General Specification for		
AMS-QQ-A-200/1	3003, Bar, Rod, Shapes, Tube and Wire, Extruded		
AMS-QQ-A-200/2	2014, Bar, Rod, Shapes, Tube and Wire, Extruded		
AMS-QQ-A-200/3	2024, Bar, Rod, Shapes, Tube and Wire, Extruded		
AMS-QQ-A-200/4	5083, Bar, Rod, Shapes, Tube and Wire, Extruded		
AMS-QQ-A-200/5	5086, Bar, Rod, Shapes, Tube and Wire, Extruded		
AMS-QQ-A-200/6	5454, Bar, Rod, Shapes, Tube and Wire, Extruded		
AMS-QQ-A-200/7	5456, Bar, Rod, Shapes, Tube and Wire, Extruded		
AMS-QQ-A-200/8	6061, Bar, Rod, Shapes, Tube and Wire, Extruded		
AMS-QQ-A-200/9	6063, Bar, Rod, Shapes, Tube and Wire, Extruded		
AMS-QQ-A-200/10	6066, Bar, Rod, Shapes, Tube and Wire, Extruded		
AMS-QQ-A-200/11	7075, Bar, Rod, Shapes, Tube and Wire, Extruded		
AMS-QQ-A-200/13	7178, Bar, Rod, Shapes, Tube and Wire, Extruded		
<b>SAE — AEROSPACE STANDARDS (AS)</b>			
		7220	1100-H14 Rivets
		7222	2117-T4 Rivets
<b>AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)</b>			
	C80.5		Aluminum Alloy Rigid Conduit
	H35.1		Alloy and Temper Designation Systems for Wrought Aluminum
	H35.2		Dimensional Tolerances for Aluminum Mill Products

For numbered footnotes, see page 48.

# Aluminum Specifications

---

- ① The Aluminum Association and its members assume no responsibility for use of this index, for errors, for omissions, or for failure to advise of subsequent revisions or amendments.
- ② This cross-reference index lists the basic specification or standard number, and no attempt is made to reflect the latest revision or amendment to any particular document. The appropriate specification index published by the specification issuing body should be consulted to determine the latest issue of any particular specification or standard. The aluminum industry generally prefers to use the latest issue of any given specification or standard.
- ③ Noncurrent specification

**Notes:**

---

## Notes:

---

**Sapa Industrial Extrusions**

**Cressona Sales Office**

53 Pottsville Street  
Cressona, PA 17929  
Phone: 800-233-3165  
Fax: 800-252-4646

[www.sapagroup.com/us/industrialextrusions](http://www.sapagroup.com/us/industrialextrusions)

**sapa:**

**Shaping** the future