

c. Special Testing

1) Hardness Testing. The Rockwell hardness test is commonly used as an indication of tensile strength or temper. The test is usually conducted on the ID of a section cut from a ring of the tube. In general, Rockwell B tests may be performed on unannealed tubing with a wall thickness of .049" min. and ID of ¼". One of the superficial Rockwell ranges should be used for thinner walled tubing. For additional information refer to "Standard Methods of Test For Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials," ASTM designation E 18.

2) Tension Testing. The tension test subjects a specimen of tube (either a full section or a longitudinal strip machined from a tube) to a measured load sufficient to cause rupture. For additional information see "Mechanical Testing of Steel Products," ASTM designation A 370, sections 5 to 13.

3) Surface Finish Measurement. Drawn over mandrel tubing can be furnished to known surface smoothness in accordance with the following table. This table lists the ID surface microinch readings shown as supplementary requirements in ASTM A 513 for "special smooth" inside surface tubing. This consideration would be of value for such applications as hydraulic cylinder tubing. For other microinch determinations consult a tubing source.

**Table 1
Microinch Readings — I.D. Surface**

Outside Diameter, in ^A	Tubing Wall Thickness, in. ^A				
	0.065 and Under	Over 0.065 to 0.150, incl	Over 0.150 to 0.187, incl	Over 0.187 to 0.225, incl	Over 0.225 to 0.312, incl
1 to 2½, incl	40	45	50	55	70
Over 2½ to 4½, incl	40	50	60	70	80
Over 4½ to 5½, incl	...	55	70	80	90
Over 5½ to 7, incl	...	55	70	80	90

^A1 in. = 25.4 mm.

Measuring Microinch Finish

X1.1 The procedure for making microinch readings on interior surfaces of cold worked tubing (not polished or ground) ½ in. (12.7 mm) inside diameter and larger is as follows:

X1.1.1 Measurements on tubing with longitudinal or no predominant lay should be circumferential on the inside surface of the straight tube, prior to any fabrication, on a plane approximately perpendicular to the tube axis. Measurements on tubing with circumferential lay should be longitudinal.

X1.1.2 Measurements should be made not less than 1 in. (25.4 mm) from the end.

X1.1.3 Measurements should be made at four positions approximately 90 deg apart or over a complete circumference if the trace should otherwise overlap.

X1.1.4 The length of trace should be in accordance with Section 4.5 of American National Standard B46.1, latest revision (not less than 0.600 in. (15.24 mm) long).

X1.1.5 A minimum of three such measurements should be made spaced not less than ¼ in. (6.4 mm) apart along the longitudinal axis.

X1.1.6 The numerical rating shall be the arithmetical average microinch of all readings taken. Each reading to be averaged should be the mean position of the indicator during the trace; any momentary meter excursions occupying less than 10% of the total trace should be ignored.

X1.1.7 A deviation in numerical rating in various parts of a tube may be expected. Experience to date indicates that a variation of about ± 35% is normal.

X1.2 Instruments should meet the specifications given in American National Standard B46.1 latest revision.

X1.3 Mechanical tracing is preferred. If hand tracing is used, the speed of trace should not vary by more than ± 20% from the required to give the appropriate cutoff. The 0.030-in. roughness width cutoff should be used.

X1.4 Microinch determinations only refer to roughness of areas that do not contain a defect, injurious or otherwise. Such defects as seams, slivers, pits, laps, etc., are subject to ordinary visual inspection in accordance with applicable specifications or trade customs, and have no relationship to roughness.

Ref.: ASTM A 513-85

SECTION III — Data on Commonly Produced Sizes of Round, Square, Rectangular and Shaped Tubing

The American Society for Testing and Materials has issued ASTM A 513 "Standard Specification for Electric Resistance Welded Carbon and Alloy Steel Mechanical Tubing." This specification covers round, square, rectangular and special shaped tubing and contains all the requirements applicable to mechanical tubing. The major requirements of A 513 are included in this Handbook as a service to the reader.

1. Round Tubing

The following tables, pages 8 to 17 cover specifications and data on round tubing. Data on cylinder and special surface tubing which apply to these grades only and which are included in A 513 as Supplementary Requirements are listed on pages 7 and 22.

Table 2
Available Sizes, Round Tubing

Size of Tube	24ga .022"	22ga .028"	21ga .032"	20ga .035"	19ga .042"	18ga .049"	17ga .058"	16ga .065"	15ga .072"	14ga .083"	13ga .095"	12ga .109"	11ga .120"	10ga .134"	9ga .148"	.156"	8ga .165"	7ga .180"	6ga .203"	5ga .220"
.375"	○	○																		
.500"	○	○	○	○	○	○	○	○												
.625"	○	○	○	○	○	○	○	○	○	○										
.750"	○	○	○	○	○	○	○	○	○	○	○	○	○							
.875"	○	○	○	○	○	○	○	○	○	○	○	○	○							
1.000"	○	○	○	○	○	○	○	○	○	○	○	○	○	○						
1.125"	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○					
1.250"		○	○	○	○	○	○	○	○	○	○	○	○	○	○					
1.375"		○	○	○	○	○	○	○	○	○	○	○	○	○	○					
1.500"		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
1.625"		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
1.750"		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
1.875"		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
2.000"		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
2.125"			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
2.250"			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
2.375"			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
2.500"			○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
2.625"				○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
2.750"				○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
2.875"				○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
3.000"				○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
3.125"					○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
3.250"						○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
3.500"					○	○		○	○	○	○	○	○	○	○	○	○	○	○	○
3.750"						○		○		○	○	○	○	○	○	○	○	○	○	○
4.000"					○	○		○	○	○	○	○	○	○	○	○	○	○	○	○
4.250"								○		○	○	○	○	○	○	○	○	○	○	○
4.500"										○	○	○	○	○	○	○	○	○	○	○
4.625"										○	○	○	○	○	○	○	○	○	○	○
4.750"										○	○	○	○	○	○	○	○	○	○	○
5.000"						○		○		○	○	○	○	○	○	○	○	○	○	○
5.500"								○		○	○	○	○	○	○	○	○	○	○	○
5.750"										○	○	○	○	○	○	○	○	○	○	○
6.000"										○	○	○	○	○	○	○	○	○	○	○
6.125"																				
6.500"														○	○	○	○	○	○	○
6.625"															○		○	○	○	○
6.875"																				
7.000"										○	○	○	○	○	○	○	○	○	○	○
7.500"																	○	○	○	○
8.000"										○	○	○	○	○	○	○	○	○	○	○
8.625"																			○	○
8.750"																				
10.000"																			○	○
10.750"																				○
11.250"																				
12.500"																				

Size of Tube	4ga. .238"	.250"	3ga .259"	2ga .284"	1ga .300"	.312"	.320"	.344"	.360"	.375"	.380"	.400"	.425"	.450"	.500"	.525"	.563"	.580"	.625"	
.375"																				
.500"																				
.625"																				
.750"																				
.875"																				
1.000"																				
1.125"																				
1.250"																				
1.375"																				
1.500"																				
1.625"																				
1.750"																				
1.875"																				
2.000"																				
2.125"																				
2.250"																				
2.375"	○																			
2.500"	○	○																		
2.625"																				
2.750"	○	○																		
2.875"	○																			
3.000"	○	○		○	○	○														
3.125"	○																			
3.250"	○	○		○	○	○														
3.500"	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
3.750"	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
4.000"	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
4.250"	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
4.500"	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
4.625"	○	○																		
4.750"	○	○																		
5.000"	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
5.500"	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
5.750"	○	○																		
6.000"	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
6.125"									○	○	○	○	○	○	○	○	○	○	○	○
6.500"	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
6.625"	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
6.875"									○	○	○	○	○	○	○	○	○	○	○	○
7.000"	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
7.500"	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
8.000"	○	○																		
8.625"	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
8.750"				○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
10.000"	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
10.750"	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
11.250"				○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
12.500"								○	○	○	○	○	○	○	○	○	○	○	○	○

Note: Many other sizes and gages are available. Tubing with wall thickness lighter than 15 gage is commonly available only in cold rolled steel. Tubing with wall thickness heavier than 10 gage is commonly available only in hot rolled steel.

Table 3
Tolerances, Diameter — As-Welded, Cold Rolled

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

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

^A 1 in. = 25.4 mm.

^B Flash-In-Tubing is produced to outside diameter tolerances and wall thickness tolerances only, and the height of the inside welding flash does not exceed the wall thickness or $\frac{3}{32}$ in., whichever is less.

^C Flash Controlled to 0.010 in. max tubing consists of tubing over $\frac{5}{8}$ in. outside diameter which is commonly produced to outside diameter tolerances and wall thickness tolerances only, in which the height of the remaining inside welding flash is controlled not to exceed 0.010 in.

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

^E Birmingham Wire Gage.

^F The ovality shall be within the tolerances except when the wall thickness is less than 3 percent of the outside diameter. In such cases the ovality may be 50 per cent greater than the outside tolerances, but the mean outside diameter shall be within the specified tolerance.

Ref.: ASTM A 513-85

Table 4
Tolerances, Diameter — As-Welded, Hot Rolled

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

Outside Diameter Range, in. ^A	Wall Thickness		Flash-in-Tubing ^{B,C}	Flash Controlled to 0.010 in. max Tubing ^{C,E}	Flash Controlled to 0.005 in. max Tubing ^{D,E}	
	Bwg ^F	in. ^A			Outside Diameter Plus and Minus	Outside Diameter Plus and Minus	Inside Diameter Plus and Minus
Tolerances, in. ^{A,G}						
¾ to 1⅛, incl	16 to 10	0.065 to 0.134	0.0035		0.0035	0.020
Over 1⅛ to 2, incl	16 to 14	0.065 to 0.083	0.005	0.005	0.005	0.021
Over 1⅛ to 2, incl	13 to 7	0.095 to 0.180	0.005	0.005	0.005	0.025
Over 1⅛ to 2, incl	6 to 5	0.203 to 0.220	0.005	0.005	0.005	0.029
Over 1⅛ to 2, incl	4 to 3	0.238 to 0.259	0.005	0.005	0.005	0.039
Over 2 to 2½, incl	16 to 14	0.065 to 0.083	0.006	0.006	0.006	0.022
Over 2 to 2½, incl	13 to 5	0.095 to 0.220	0.006	0.006	0.006	0.024
Over 2 to 2½, incl	4 to 3	0.238 to 0.259	0.006	0.006	0.006	0.040
Over 2½ to 3, incl	16 to 14	0.065 to 0.083	0.008	0.008	0.008	0.024
Over 2½ to 3, incl	13 to 5	0.095 to 0.220	0.008	0.008	0.008	0.026
Over 2½ to 3, incl	4 to 3	0.238 to 0.259	0.008	0.008	0.008	0.040
Over 2½ to 3, incl	2 to 0.320	0.284 to 0.320	0.010	0.010	0.010	0.048
Over 3 to 3½, incl	16 to 14	0.065 to 0.083	0.009	0.009	0.009	0.025
Over 3 to 3½, incl	13 to 5	0.095 to 0.220	0.009	0.009	0.009	0.027
Over 3 to 3½, incl	4 to 3	0.238 to 0.259	0.009	0.009	0.009	0.043
Over 3 to 3½, incl	2 to 0.360	0.284 to 0.360	0.012	0.012	0.012	0.050
Over 3½ to 4, incl	16 to 14	0.065 to 0.083	0.010	0.010	0.010	0.026
Over 3½ to 4, incl	13 to 5	0.095 to 0.220	0.010	0.010	0.010	0.028
Over 3½ to 4, incl	4 to 3	0.238 to 0.259	0.010	0.010	0.010	0.044
Over 3½ to 4, incl	2 to 0.500	0.284 to 0.500	0.015	0.015	0.015	0.053
Over 4 to 5, incl	16 to 14	0.065 to 0.083	0.020	0.020	0.020	0.036
Over 4 to 5, incl	13 to 5	0.095 to 0.220	0.020	0.020	0.020	0.045
Over 4 to 5, incl	4 to 3	0.238 to 0.259	0.020	0.020	0.020	0.054
Over 4 to 5, incl	2 to 0.500	0.284 to 0.500	0.020	0.020	0.020	0.058
Over 5 to 6, incl	16 to 10	0.065 to 0.134	0.020	0.020	0.020	0.036
Over 5 to 6, incl	9 to 5	0.148 to 0.220	0.020	0.020	0.020	0.040
Over 5 to 6, incl	4 to 3	0.238 to 0.259	0.020	0.020	0.020	0.054
Over 5 to 6, incl	2 to 0.500	0.284 to 0.500	0.020	0.020	0.020	0.058
Over 6 to 8, incl	11 to 10	0.120 to 0.134	0.025	0.025	0.025	0.043
Over 6 to 8, incl	9 to 5	0.148 to 0.220	0.025	0.025	0.025	0.045
Over 6 to 8, incl	4 to 3	0.238 to 0.259	0.025	0.025	0.025	0.059
Over 6 to 8, incl	2 to 0.500	0.284 to 0.500	0.025	0.025	0.025	0.063

^A 1 in. = 25.4 mm.

^B Flash-In-Tubing is produced only to outside diameter tolerances and wall thickness tolerances and inside diameter welding flash does not exceed the wall thickness or ⅜ in., whichever is less.

^C Flash Controlled to 0.010 in. max tubing consists of tubing over 1⅛ in. outside diameter which is commonly produced only to outside diameter tolerances and wall thickness tolerances, in which the height of the remaining welding flash is controlled not to exceed 0.010 in.

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

^E No Flash tubing is further processed for closer tolerances with mandrel-tubing produced to outside diameter and wall, inside diameter and wall, or outside diameter and inside diameter to tolerances with no dimensional indication of inside diameter flash. This condition is available in mandrel drawn and special smooth inside diameter tubing.

^F Birmingham Wire Gage.

^G The ovality shall be within the tolerances except when the wall thickness is less than 3 percent of the outside diameter. In such cases the ovality may be 50 per cent greater than the outside tolerances, but the mean outside diameter shall be within the specified tolerance.

Ref.: ASTM A 513-85

Table 5
Tolerances, Wall Thickness — As-Welded, Cold Rolled

Wall Thickness		Outside Diameter, in. ^A											
in. ^A	Bwg ^B	¾ to 7/8, incl		Over 7/8 to 1 1/8, incl		Over 1 1/8 to 3 3/4, incl		Over 3 3/4 to 5, incl		Over 5 to 6, incl		Over 6 to 8, incl	
Wall Thickness Tolerances, in., ^A Plus and Minus													
		Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus
0.028	22	0.001	0.005	0.001	0.005	...	...	...	...	...	...	...	...
0.035	20	0.002	0.005	0.001	0.005	0.001	0.005	...	...	...	...	...	...
0.049	18	0.003	0.006	0.002	0.006	0.002	0.006	...	...	...	...	...	...
0.065	16	0.005	0.007	0.004	0.007	0.004	0.007	0.004	0.007	0.004	0.007	...	...
0.083	14	0.006	0.007	0.005	0.007	0.004	0.007	0.004	0.007	0.004	0.008	0.004	0.008
0.095	13	0.006	0.007	0.005	0.007	0.004	0.007	0.004	0.007	0.004	0.008	0.004	0.008
0.109	12	...	...	0.006	0.008	0.005	0.008	0.005	0.008	0.005	0.009	0.005	0.009
0.120	11	...	...	0.007	0.008	0.006	0.008	0.005	0.008	0.005	0.009	0.005	0.009
0.134	10	...	...	0.007	0.008	0.006	0.008	0.005	0.008	0.005	0.009	0.005	0.009

^A 1 in. = 25.4 mm.

^B Birmingham Wire Gage.

Ref.: ASTM A 513-85

Table 6
Tolerances, Wall Thickness — As-Welded, Hot Rolled

Wall Thickness		Outside Diameter, in. ^A											
in. ^A	Bwg ^B	¾ to 1, incl		Over 1 to 1 1/8, incl		Over 1 1/8 to 3 3/4, incl		Over 3 3/4 to 4 1/2, incl		Over 4 1/2 to 6, incl		Over 6 to 8, incl	
Wall Thickness Tolerances, in., Plus and Minus													
		Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus
0.065	16	0.005	0.009	0.004	0.010	0.003	0.011	0.002	0.012	0.002	0.012	...	...
0.072	15	0.005	0.009	0.004	0.010	0.003	0.011	0.002	0.012	0.002	0.012	...	...
0.083	14	0.006	0.010	0.005	0.011	0.004	0.012	0.003	0.013	0.003	0.013	...	...
0.095	13	0.006	0.010	0.005	0.011	0.004	0.012	0.003	0.013	0.003	0.013	...	...
0.109	12	0.006	0.010	0.005	0.011	0.004	0.012	0.003	0.013	0.003	0.013	0.003	0.013
0.120	11	0.006	0.010	0.005	0.011	0.004	0.012	0.003	0.013	0.003	0.013	0.003	0.013
0.134	10	0.006	0.010	0.005	0.011	0.004	0.012	0.003	0.013	0.003	0.013	0.003	0.013
0.148	9	...	...	0.006	0.012	0.005	0.013	0.004	0.014	0.004	0.014	0.004	0.014
0.165	8	...	...	0.006	0.012	0.005	0.013	0.004	0.014	0.004	0.014	0.004	0.014
0.180	7	...	...	0.006	0.012	0.005	0.013	0.004	0.014	0.004	0.014	0.004	0.014
0.203	6	...	...	...	...	0.007	0.015	0.006	0.016	0.005	0.017	0.005	0.017
0.220	5	...	...	...	...	0.007	0.015	0.006	0.016	0.005	0.017	0.005	0.017
0.238	4	...	...	...	...	0.012	0.020	0.011	0.021	0.010	0.022	0.010	0.022
0.259	3	...	...	...	...	0.013	0.021	0.012	0.022	0.011	0.023	0.011	0.023
0.284	1	...	...	...	...	0.014	0.022	0.013	0.023	0.012	0.024	0.012	0.024
0.300	1	...	...	...	...	0.015	0.023	0.014	0.024	0.013	0.025	0.013	0.025
0.320	...	...	...	...	...	0.016	0.024	0.015	0.025	0.014	0.026	0.014	0.026
0.344	...	...	...	...	...	0.017	0.025	0.016	0.026	0.015	0.027	0.015	0.027
0.360	...	...	...	...	...	0.017	0.025	0.016	0.026	0.015	0.027	0.015	0.027
0.375	...	...	...	...	...	...	...	0.016	0.026	0.015	0.027	0.015	0.027
0.406	...	...	...	...	...	...	...	0.017	0.027	0.016	0.028	0.016	0.028
0.438	...	...	...	...	...	...	...	0.017	0.027	0.016	0.028	0.016	0.028
0.469	...	...	...	...	...	...	...	...	...	0.016	0.028	0.016	0.028
0.500	...	...	...	...	...	...	...	...	...	0.016	0.028	0.016	0.028

^A 1 in. = 25.4 mm.

^B Birmingham Wire Gage.

Ref.: ASTM A 513-85

Table 7
Tolerances, Diameter, Mandrel Drawn, Sink Drawn, Special Smooth ID

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

Outside Diameter Range, in. ^A	Wall % of OD	Types 3, 4, Sink Drawn ^{A,B} and 5, 6, Mandrel Drawn ^{B,C} OD, in.		Types 5 and 6 Mandrel Drawn ^{B,C} ID in.	
		Over	Under	Over	Under
Up to 0.499	all	0.004	0.000	...	...
0.500 to 1.699	all	0.005	0.000	0.000	0.005
1.700 to 2.099	all	0.006	0.000	0.000	0.006
2.100 to 2.499	all	0.007	0.000	0.000	0.007
2.500 to 2.899	all	0.008	0.000	0.000	0.008
2.900 to 3.299	all	0.009	0.000	0.000	0.009
3.300 to 3.699	all	0.010	0.000	0.000	0.010
3.700 to 4.099	all	0.011	0.000	0.000	0.011
4.100 to 4.499	all	0.012	0.000	0.000	0.012
4.500 to 4.899	all	0.013	0.000	0.000	0.013
4.900 to 5.299	all	0.014	0.000	0.000	0.014
5.300 to 5.549	all	0.015	0.000	0.000	0.015
5.550 to 5.999	under 6	0.010	0.010	0.010	0.010
	6 and over	0.009	0.009	0.009	0.009
6.000 to 6.499	under 6	0.013	0.013	0.013	0.013
	6 and over	0.010	0.010	0.010	0.010
6.500 to 6.999	under 6	0.015	0.015	0.015	0.015
	6 and over	0.012	0.012	0.012	0.012
7.000 to 7.499	under 6	0.018	0.018	0.018	0.018
	6 and over	0.013	0.013	0.013	0.013
7.500 to 7.999	under 6	0.020	0.020	0.020	0.020
	6 and over	0.015	0.015	0.015	0.015
8.000 to 8.499	under 6	0.023	0.023	0.023	0.023
	6 and over	0.016	0.016	0.016	0.016
8.500 to 8.999	under 6	0.025	0.025	0.025	0.025
	6 and over	0.017	0.017	0.017	0.017
9.000 to 9.499	under 6	0.028	0.028	0.028	0.028
	6 and over	0.019	0.019	0.019	0.019
9.500 to 9.999	under 6	0.030	0.030	0.030	0.030
	6 and over	0.020	0.020	0.020	0.020
10.000 to 10.999	all	0.034	0.034	0.034	0.034
11.000 to 11.999	all	0.035	0.035	0.035	0.035
12.000 to 12.999	all	0.036	0.036	0.036	0.036
13.000 to 13.999	all	0.037	0.037	0.037	0.037
14.000 to 14.999	all	0.038	0.038	0.038	0.038

^A Tubing, flash in or flash controlled which is further processed without mandrel to obtain tolerances closer than those shown in Tables 3 and 4.

^B The ovality shall be within the above tolerances except when the wall thickness is less than 3 per cent of the outside diameter. In such cases the additional ovality shall be as follows but the mean outside diameter shall be within the specified tolerance:

Outside Diameter, in. (mm)	Additional Ovality Tolerance, in. (mm)
Up to 2 (50.8), incl	0.010 (0.25)
Over 2 to 3 (50.8 to 76.2), incl	0.015 (0.38)
Over 3 to 4 (76.2 to 101.6), incl	0.020 (0.51)
Over 4 to 5 (101.6 to 127.0), incl	0.025 (0.64)
Over 5 to 6 (127.0 to 152.4), incl	0.030 (0.76)
Over 6 to 7 (152.4 to 177.8), incl	0.035 (0.89)
Over 7 to 8 (177.8 to 203.2), incl	0.040 (1.02)
Over 8 to 9 (203.2 to 228.6), incl	0.045 (1.14)
Over 9 to 10 (228.6 to 254.0), incl	0.050 (1.27)
Over 10 to 11 (254.0 to 279.4), incl	0.055 (1.40)
Over 11 to 12 (279.4 to 304.8), incl	0.060 (1.52)
Over 12 to 12.500 (304.8 to 317.5), incl	0.065 (1.65)

^C Tubing produced to outside diameter and wall thickness, or inside diameter and wall thickness, or outside diameter and inside diameter, with mandrel to obtain tolerances closer than those shown in Tables 3 and 4 and no dimensional indication of inside diameter flash.

Ref: ASTM A 513-85

Table 8
Tolerances, Wall Thickness — Cold Drawn Over Mandrel

Wall Thickness		Outside Diameter, in. ^A							
in. ^A	Bwg ^B	³ / ₈ to ⁷ / ₈ , incl		Over ⁷ / ₈ to 1 ⁷ / ₈ , incl		Over 1 ⁷ / ₈ to 3 ³ / ₄ , incl		Over 3 ³ / ₄ to 15, incl	
Wall Thickness Tolerances, in., ^A Plus and Minus									
		Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus
0.035	20	0.002	0.002	0.002	0.002	0.002	0.002	...	...
0.049	18	0.002	0.002	0.002	0.003	0.002	0.003	...	...
0.065	16	0.002	0.002	0.002	0.003	0.002	0.003	0.004	0.004
0.083	14	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.005
0.095	13	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.005
0.109	12	0.002	0.003	0.002	0.004	0.003	0.003	0.005	0.005
0.120	11	0.003	0.003	0.002	0.004	0.003	0.003	0.005	0.005
0.134	10	...	...	0.002	0.004	0.003	0.003	0.005	0.005
0.148	9	...	...	0.002	0.004	0.003	0.003	0.005	0.005
0.165	8	...	...	0.003	0.004	0.003	0.004	0.005	0.006
0.180	7	...	...	0.004	0.004	0.003	0.005	0.006	0.006
0.203	6	...	...	0.004	0.005	0.004	0.005	0.006	0.007
0.220	5	...	...	0.004	0.006	0.004	0.006	0.007	0.007
0.238	4	...	...	0.005	0.006	0.005	0.006	0.007	0.007
0.259	3	...	...	0.005	0.006	0.005	0.006	0.007	0.007
0.284	2	...	...	0.005	0.006	0.005	0.006	0.007	0.007
0.300	1	...	...	0.006	0.006	0.006	0.006	0.008	0.008
0.320	...	...	...	0.007	0.007	0.007	0.007	0.008	0.008
0.344	...	...	...	0.008	0.008	0.008	0.008	0.009	0.009
0.375	...	...	...	...	...	0.009	0.009	0.009	0.009
0.400	...	...	...	...	...	0.010	0.010	0.010	0.010
0.438	...	...	...	...	...	0.011	0.011	0.011	0.011
0.460	...	...	...	...	...	0.012	0.012	0.012	0.012
0.480	...	...	...	...	...	0.012	0.012	0.012	0.012
0.531	...	...	...	...	...	0.013	0.013	0.013	0.013
0.563	...	...	...	...	...	0.013	0.013	0.013	0.013
0.580	...	...	...	...	...	0.014	0.014	0.014	0.014
0.600	...	...	...	...	...	0.015	0.015	0.015	0.015
0.625	...	...	...	...	...	0.016	0.016	0.016	0.016
0.650	...	...	...	...	...	0.017	0.017	0.017	0.017

^A 1 in. = 25.4 mm.

^B Birmingham Wire Gage.

Ref: ASTM A 513-85

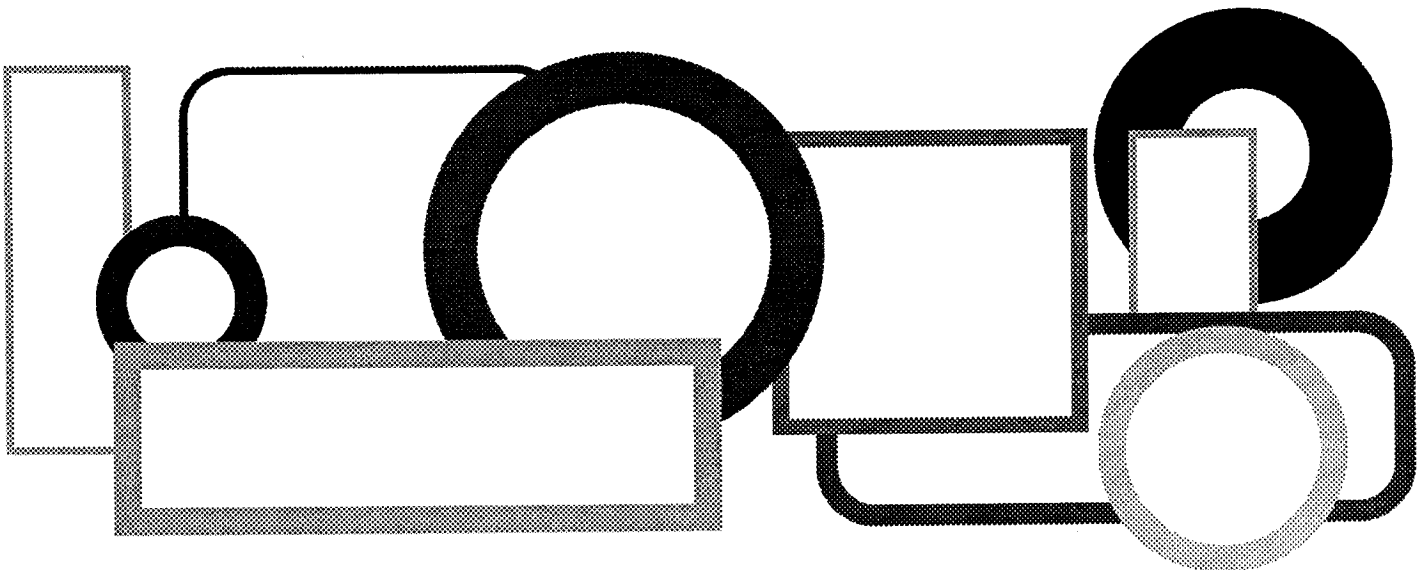


Table 9
Diameter Tolerances for Metallic-Coated Round Tubing

Outside Diameter Range, in. ^A	Wall Thickness		Tubing with Any Inside Flash Condition	Flash-Controlled to 0.005 in. Tubing Only ^E
	Bwg ^B	in. ^A	Outside ^{C,D} Diameter, Plus and Minus	Inside Diameter, Plus and Minus
1/2 to 1 1/8, incl	22 to 16	0.028/0.065	0.0035	0.019
1 1/8 to 2, incl	22 to 14	0.028/0.083	0.005	0.021
1 1/8 to 2, incl	13 to 10	0.095/0.134	0.005	0.027
2 to 2 1/2, incl	20 to 14	0.035/0.083	0.006	0.023
2 to 2 1/2, incl	13 to 10	0.095/0.134	0.006	0.029
2 1/2 to 3, incl	20 to 14	0.035/0.083	0.008	0.025
2 1/2 to 3, incl	13 to 10	0.095/0.134	0.008	0.031
3 to 3 1/2, incl	20 to 14	0.035/0.083	0.009	0.026
3 to 3 1/2, incl	13 to 10	0.095/0.134	0.009	0.032
3 1/2 to 4, incl	20 to 14	0.035/0.083	0.010	0.027
3 1/2 to 4, incl	13 to 10	0.095/0.134	0.010	0.033
4 to 5, incl	16 to 14	0.065/0.083	0.020	0.037
4 to 5, incl	13 to 10	0.095/0.134	0.020	0.043
5 to 6, incl	16 to 14	0.065/0.083	0.020	0.037
5 to 6, incl	13 to 10	0.095/0.134	0.020	0.043
6 to 8, incl	14 to 10	0.083/0.134	0.025	0.048

^A 1 in. = 25.4 mm.

^B Birmingham Wire Gage.

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

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

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

^F The ovality shall be within the above tolerances except when the wall thickness is less than 3% of the outside diameter. When the tube wall thickness is less than 3% of the tube outside diameter the ovality may be 50% greater than the outside diameter tolerances, but the mean diameter (average of maximum outside diameter and minimum outside diameter) shall be within the specified tolerance.

Ref.: ASTM A 787-84b

Table 10
Wall Thickness Tolerance for Premetallic Coated As-welded Tubing^A

Wall Thickness		Outside Diameter, in.											
		1/2 to 1 Incl		Over 1 to 1 1/8, Incl		Over 1 1/8 to 3 3/4, Incl		Over 3 3/4 to 4 1/2, Incl		Over 4 1/2 to 6, Incl		Over 6 to 8, Incl	
In.	Bwg	Wall Thickness Tolerances, Inches, Plus and Minus											
		Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus
.028	22	.002	.006	.002	.006	...	...	...	...	...	...	...	...
.035	20	.003	.006	.002	.006	.002	.006	...	...	...	...	...	...
.049	18	.004	.007	.003	.008	.003	.008	...	...	...	...	...	...
.065	16	.005	.007	.004	.008	.003	.009	.003	.009	.002	.010	...	...
.083	14	.006	.008	.006	.008	.005	.009	.005	.009	.004	.010	.004	.010
.095	13	.008	.010	.008	.010	.007	.011	.007	.011	.006	.012	.006	.012
.109	12	.008	.010	.008	.010	.007	.011	.007	.011	.006	.012	.006	.012
.120	11	.009	.011	.009	.011	.008	.012	.008	.012	.007	.013	.007	.013
.134	10	.009	.011	.009	.011	.008	.012	.008	.012	.007	.013	.007	.013

^A Special manufacturing practices allow for post-hot dipped galvanizing of welded tubing. If this product is desired, wall thickness tolerances shall be determined by agreement between the producer and purchaser.

^B Birmingham Wire Gage

^C 1 in. = 25.4 mm.

Ref.: ASTM A 787-84b

Table 11
Tolerances, Cut Length — Lathe Cut

Outside Diameter Size, in. ^A	Length			
	6 in. and under 12 in.	12 in. and under 48 in.	48 in. and under 10 ft.	10 ft. to 24 ft. incl. ^B
3/8 to 3 incl	± 1/64 in.	± 1/32 in.	± 3/64 in.	± 1/8 in.
Over 3 to 6, incl	± 1/32 in.	± 3/64 in.	± 1/16 in.	± 1/8 in.
Over 6 to 9, incl	± 1/16 in.	± 1/16 in.	± 1/8 in.	± 1/8 in.
Over 9 to 12, incl	± 3/32 in.	± 3/32 in.	± 1/8 in.	± 1/8 in.

^A 1 in. = 25.4 mm.

^B For each additional 10 ft. or fraction thereof over 24 ft., an additional allowance should be made of plus or minus 1/16 in.

Ref.: ASTM A 513-85

Punch, Saw, or Disc Cut

Length of Tube	Cut Length Tolerance
1 to 3 ft, incl	± 1/16 in.
Over 3 to 12 ft, incl	± 3/32 in.
Over 12 to 20 ft, incl	± 1/8 in.
Over 20 to 30 ft, incl	± 3/16 in.

Table 12
Tolerance (Inch), for Squareness of Cut (Either End)
When Specified for Round Tubing^{A,B}

Length of Tube, ft ^C	Outside Diameter, in. ^D				
	Under 1	1 to 2, incl	Over 2 to 3, incl	Over 3 to 4, incl	Over 4
Under 1	0.006	0.008	0.010	0.015	0.020
1 to 3, incl	0.008	0.010	0.015	0.020	0.030
Over 3 to 6, incl	0.010	0.015	0.020	0.025	0.040
Over 6 to 9, incl	0.015	0.020	0.025	0.030	0.040

^A Actual squareness normal to length of tube, not parallelness of both ends.

^B Values given are "go" value of feeler gage. "No go" value is 0.001 in. greater in each case.

^C 1 ft. = 0.3 m.

^D 1 in. = 25.4 mm.

Ref.: ASTM A 513-85

Table 13
Tolerance, Straightness

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

Ref.: ASTM A 513-85

a. Methods of Checking Tolerances on Round Tubing

Experience in checking tolerances of round tubing indicates that the methods described below can be expected to obtain the most accurate and consistent results.

1) Measuring O.D.

Normal method for measuring the outside diameter of tubing is by use of a micrometer with flat anvils. Measurements should be taken at least 2" from either end of the tube.

2) Measuring I.D.

The inside diameter is ordinarily measured with plug gauges. Methods other than plug gauging can be used; consult a tubing source.

3) Measuring Wall Thickness or Gauge

Gauge measurement is usually made with ball pointed gauge micrometers having a radius of the anvil of 3/32" (± 1/64") to insure correct registering of the thickness.

4) Measuring Height of Inside Weld Flash

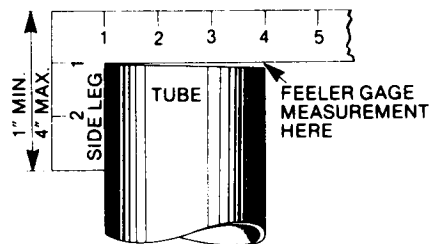
The height of the inside weld flash is the difference between the thickness of the tube wall at the point of the flash and the thickness of the tube wall at a point near the flash, using a ball micrometer having a radius of the anvil or ball point of 3/32" (± 1/64").

5) Measuring Straightness

Straightness tolerance is checked by placing a 3' straight-edge against the tube on a neutral axis. The point of maximum deflection of the tube from the straightedge should not be more than allowed in Table 13 when measured with a feeler gage.

6) Measuring Squareness of End Cut

Experience indicates measurements should be made with use of an "L" square and feeler gauge, side leg of square to be equal to tube diameter except minimum length of 1" and maximum length of 4". Outside diameter burr to be removed for measurement.



b. Tensile Properties

Welded tubing is available in a wide range of diameters and wall thicknesses. Tensile properties of the as-welded tube will vary somewhat with grade and size. These properties are shown in the following tables taken from ASTM A 513.

When hardness properties are specified on the order the tubing shall conform to the hardness limits specified in Tables 14-18 unless "Tensile Properties Required" is specified in the purchase order. When "Tensile Properties Required" is specified in the purchase order, the tubing shall conform to the tensile requirements and not necessarily the hardness limits shown in Tables 14-18. For grades not shown in Tables 14-18, tensile or hardness limits shall be upon agreement between the manufacturer and the purchaser.

Table 14
Mechanical Properties, As-Welded Tubing^A

Type of Steel	Yield Strength, ksi (MPa), min	Ultimate Strength, ksi (MPa), min	Elongation in 2 in. or 50 mm, %, min	RB min	RB max
1010	32 (221)	45 (310)	15	55	...
1015	35 (241)	48 (331)	15	58	...
1020	38 (262)	52 (359)	12	62	...
1025	40 (276)	56 (386)	12	65	...
1030	45 (310)	62 (427)	10	70	...
1035	50 (345)	66 (455)	10	75	...

Ref.: ASTM A 513-85

Table 15
Mechanical Properties, Normalized Tubing^A

Type of Steel	Yield Strength, ksi (MPa), min	Ultimate Strength, ksi (MPa), min	Elongation in 2 in. or 50 mm, %, min	RB min	RB max
1010	25 (172)	40 (276)	30	...	65
1015	30 (207)	45 (310)	30	...	70
1020	35 (241)	50 (345)	25	...	75
1025	37 (255)	55 (379)	25	...	80
1030	40 (276)	60 (414)	25	...	85
1035	45 (310)	65 (448)	20	...	88

Table 16
Mechanical Properties, Sink Drawn Tubing^A

Type of Steel	Yield Strength, ksi (MPa), min	Ultimate Strength, ksi (MPa), min	Elongation in 2 in. or 50 mm, %, min	RB min	RB max
1010	40 (276)	50 (345)	8	65	...
1015	45 (310)	55 (379)	8	67	...
1020	50 (345)	60 (414)	8	70	...
1025	55 (379)	65 (448)	7	72	...
1030	62 (427)	70 (483)	7	78	...
1035	70 (483)	80 (552)	7	82	...

Table 19
Chemical Composition of Carbon Steels

Type of Steel	Cast or Heat Chemical Composition ^A Limits, %			
	C	Mn	P, max.	S, max.
1006	0.08 max.	0.45 max.	0.040	0.050
1008	0.10 max.	0.50 max.	0.040	0.050
1009	0.15 max.	0.60 max.	0.040	0.050
1010	0.08-0.13	0.30-0.60	0.040	0.050
1012	0.10-0.15	0.30-0.60	0.040	0.050
1015	0.12-0.18	0.30-0.60	0.040	0.050
1016	0.12-0.18	0.60-0.90	0.040	0.050
1017	0.14-0.20	0.30-0.60	0.040	0.050
1018	0.14-0.20	0.60-0.90	0.040	0.050
1019	0.14-0.20	0.70-1.00	0.040	0.050
1020	0.17-0.23	0.30-0.60	0.040	0.050
1021	0.17-0.23	0.60-0.90	0.040	0.050
1022	0.17-0.23	0.70-1.00	0.040	0.050
1023	0.19-0.25	0.30-0.60	0.040	0.050
1025	0.22-0.28	0.30-0.60	0.040	0.050
1026	0.22-0.28	0.60-0.90	0.040	0.050
1030	0.27-0.34	0.60-0.90	0.040	0.050
1033	0.29-0.36	0.70-1.00	0.040	0.050
1035	0.31-0.38	0.60-0.90	0.040	0.050
1040	0.36-0.44	0.60-0.90	0.040	0.050

Table 17
Mechanical Properties, Mandrel Drawn Tubing^A

Type of Steel	Yield Strength, ksi (MPa), min	Ultimate Strength, ksi (MPa), min	Elongation in 2 in. or 50 mm, %, min	RB min	RB max
1010	50 (345)	60 (414)	5	73	...
1015	55 (379)	65 (448)	5	77	...
1020	60 (414)	70 (483)	5	80	...
1025	65 (448)	75 (517)	5	82	...
1030	75 (517)	85 (586)	5	87	...
1035	80 (552)	90 (621)	5	90	...

Table 18
Mechanical Properties, Mandrel Drawn Stress Relieved Tubing^{A,B}

Type of Steel	Yield Strength, ksi (MPa), min	Ultimate Strength, ksi (MPa), min	Elongation in 2 in. or 50 mm, %, min	RB min	RB max
1010	45 (310)	55 (379)	12	68	...
1015	50 (345)	60 (414)	12	72	...
1020	55 (379)	65 (448)	10	75	...
1025	60 (414)	70 (483)	10	77	...
1030	70 (483)	80 (552)	10	81	...
1035	75 (517)	85 (586)	10	85	...

Notes: Tables 14-18^A For longitudinal strip tests, the width of the gage section shall be 1 in. (25.4 mm) and a deduction of 0.5 percentage points from the basic minimum elongation for each 1/2 in. (0.8 mm) decrease in wall thickness under 3/8 in. (7.9 mm) in wall thickness shall be permitted.

^B These values are based on normal mill stress relieving temperatures. For particular applications, properties may be adjusted by negotiation between purchaser and producer.

Ref.: ASTM A 513-85

^AThese steels may be produced by the basic open hearth, the basic oxygen, or the basic electric steelmaking process (see SAE J411, Carbon and Alloy Steels). Where silicon is required, the following limits and ranges are commonly used: for steel designations up to and including SAE 1025: 0.10% max, or ranges of 0.10 to 0.25% or 0.15 to 0.35%; for over SAE 1025: ranges of 0.10 to 0.25% or 0.15 to 0.35%. Rimmed or capped steels are characterized by a lack of uniformity in their chemical composition, especially for the elements carbon, phosphorus, and sulfur, and for this reason product analysis is not considered appropriate for these elements unless misapplication is clearly indicated.

Ranges to left are based on cast or heat analysis. Product analysis may vary over and under in accordance with the limits shown in Table 21 (Tolerances for Product Analysis).

Low-Alloy, High-Strength Steels are available in a wide range of analyses.

Table 20
Chemical Composition of Alloy Steels

Type of Steel	Ladle Chemical Composition ^A Limits, %							
	C	Mn	P Max.	S Max.	Si	Ni	Cr	Mo
1330	0.28-0.33	1.60-1.90	0.035	0.040	0.15-0.35	...	...	...
4012	0.09-0.14	0.75-1.00	0.035	0.040	0.15-0.35	...	...	0.15-0.25
4023	0.20-0.25	0.70-0.90	0.035	0.040	0.15-0.35	...	...	0.20-0.30
4118	0.18-0.23	0.70-0.90	0.035	0.040	0.15-0.35	...	0.40-0.60	0.08-0.15
4130	0.28-0.33	0.40-0.60	0.035	0.040	0.15-0.35	...	0.80-1.10	0.15-0.25
4615	0.13-0.18	0.45-0.65	0.035	0.040	0.15-0.35	1.65-2.00	...	0.20-0.30
4617	0.15-0.20	0.45-0.65	0.035	0.040	0.15-0.35	1.65-2.00	...	0.20-0.30
4620	0.17-0.22	0.45-0.65	0.035	0.040	0.15-0.35	1.65-2.00	...	0.20-0.30
4718	0.16-0.21	0.70-0.90	...	...	...	0.90-1.20	0.35-0.55	0.30-0.40
4720	0.17-0.22	0.50-0.70	0.035	0.040	0.15-0.35	0.90-1.20	0.35-0.55	0.15-0.25
4815	0.13-0.18	0.40-0.60	0.035	0.040	0.15-0.35	3.25-3.75	...	0.20-0.30
4820	0.18-0.23	0.50-0.70	0.035	0.040	0.15-0.35	3.25-3.75	...	0.20-0.30
5015	0.12-0.17	0.30-0.50	0.035	0.040	0.15-0.35	...	0.30-0.50	...
5115	0.13-0.18	0.70-0.90	0.035	0.040	0.15-0.30	...	0.70-0.90	...
6118	0.16-0.21	0.50-0.70	0.035	0.040	0.15-0.35	...	0.50-0.70	0.10-0.15(V) ^B
8115	0.13-0.18	0.70-0.90	0.035	0.040	0.15-0.35	0.20-0.40	0.30-0.50	0.08-0.15
8615	0.13-0.18	0.70-0.90	0.035	0.040	0.15-0.35	0.40-0.70	0.40-0.60	0.15-0.25
8620	0.18-0.23	0.70-0.90	0.035	0.040	0.15-0.35	0.40-0.70	0.40-0.60	0.15-0.25
8625	0.23-0.28	0.70-0.90	0.035	0.040	0.15-0.35	0.40-0.70	0.40-0.60	0.15-0.25
8630	0.28-0.33	0.70-0.90	0.035	0.040	0.15-0.35	0.40-0.70	0.40-0.60	0.15-0.25
8720	0.18-0.23	0.70-0.90	0.035	0.040	0.15-0.35	0.40-0.70	0.40-0.60	0.20-0.30

^AFor standard variations in composition limits, see Table 4 of SAE J409. Small quantities of certain elements which are not specified or required may be found in alloy steels. These elements are to be considered as incidental and are acceptable to the following maximum amount: copper to 0.35%, nickel to 0.25%, chromium to 0.20%, and molybdenum to 0.06%.

^BVanadium.

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Table 21
Product Analysis, Tolerances for Product Analysis, Welded Carbon Steel Tubing

Element	Limit or Max. of Specified Element, %	Variation % over Max. Limit or under Min. Limit	
		Under Min. Limit	Over Max. Limit
Carbon	To 0.15 incl	0.02	0.03
	Over 0.15 to 0.40 incl	0.03	0.04
	Over 0.40 to 0.80 incl	0.03	0.05
	Over 0.80	0.03	0.06
Manganese	To 0.60 incl	0.03	0.03
	Over 0.60 to 1.15 incl	0.04	0.04
	Over 1.15 to 1.65 incl	0.05	0.05
Phosphorus	...	...	0.01
Sulfur	...	...	0.01
Silicon	To 0.30 incl	0.02	0.03
	Over 0.30 to 0.60	0.05	0.05
Copper	For copper bearing steel	0.02	...
Lead ^A	0.15 to 0.35 incl	0.03	0.03

^AProduct analysis tolerance for lead applies both over and under a range of 0.15-0.35% lead.

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c. High Strength Low Alloy Steels

Most steel producers make available many different grades and types of high strength low alloy steels which may be fabricated into tubing to produce a product with higher yield

and tensile strengths than are available with the more common straight low carbon varieties. In some cases, depending on alloy, they show added resistance to atmospheric corrosion. They are not intended to be quenched and tempered as supplied. They achieve these high strengths through the addition of very small amounts of elements such as copper, nickel, chromium, columbium, vanadium, titanium, molybdenum, nitrogen, and zirconium.

These steels are available in minimum yield strengths from 50,000 psi to over 100,000 psi. The tubing producer should be consulted for the proper analysis for a particular application.

2. Squares and Rectangles

Welded tubing is produced in large volume in square and rectangular form. Due to the ease of fabrication, square and rectangular tubing finds wide usage in such items as van bodies, racks and many other mechanical assemblies. It is usually produced directly on the welder by converting the round tube into the desired shape through a section of roll stands (commonly called turksheads) at the exit end of the sizing stands. The tubes are straight as they emerge from the turksheads and normally no further straightening is required.

3. Special Shapes

Electric resistance welded tubing may also be produced in shapes other than squares and rectangles. Normal practice is to weld a round tube and produce the desired shape by forming it with a turkshead or by rolling or drawing it. The figure below shows some typical shapes that have been produced.

