

## TUBING DATA

### Cold Drawn Seamless Mechanical Steel Tubing

**Cold Drawn Seamless Mechanical Steel Tubing** is round and concentric. It is clean and it is accurately finished to close tolerances. It can readily be machined, bent and formed, threaded and welded. It can be satisfactorily carburized.

This tubing is produced by piercing a hot billet and swaging or rolling it to reduce diameter and to elongate. Next, it is finished to accurate size and gauge by cold drawing through a die and over a mandrel. The cold drawing operation produces tubing of great accuracy as to size, a superior, smooth finish, increased physical properties and better grain structure which result in excellent machinability.

Ordinarily, open hearth steel of medium carbon is the grade used. Great care is exercised in selecting steel of the highest quality obtainable due to the severity of the foregoing operations.

#### THE CHEMICAL ANALYSIS, AVERAGE GRADE, IS SUBSTANTIALLY AISI C1015 AS FOLLOWS:

Carbon.....	.10 — .20
Manganese.....	.30 — .60
Phosphorus, maximum.....	.045
Sulphur, maximum.....	.055

#### THE AVERAGE PHYSICAL PROPERTIES, AS COLD DRAWN, ARE AS FOLLOWS:

Properties	Half Hard	Soft Annealed
Yield Point, Lbs. Per Sq. In.....	55,000	30,000
Ultimate strength, Lbs. Per Sq. In.....	75,000	48,000
Elongation, per cent in 2 inches.....	30	50
Elongation, per cent in 8 inches.....	12	30
Brinell Hardness.....	120	90
Rockwell Hardness.....	68B	48B

A few of the many satisfactory applications are machine parts, bushings, bearings, spacers, hollow shafts, structural members, torque rods, mandrels, cylinders, pump stock, furniture, rollers, and the like.

**Seamless Mechanical Steel Tubing** is divided into two general classifications, Mechanical Tubing and Pressure Tubing.

**Mechanical Tubing** means all tubing employed in construction of machinery, tools and accessories which does not have to withstand internal pressures from either liquids or gases. The application, therefore, could be one of a non-moving member such as a brace or spacer, or it could be one of a moving member such as a shaft, bearing, bushing or roller. Mechanical tubing is sometimes referred to as, "a bar with a hole in it".

**Pressure Tubing** is that type of seamless tubing which has the ability to withstand internal pressures and, at the same time, act as a conduit. Thus, boiler tubes, heat transfer tubes, diesel injector tubes, and the like, are typical applications.

Almost all tubing carried in warehouse stock is Mechanical Tubing.

## TUBING DATA

### Weight Computing Formulae for Round, Hot Rolled or Cold Drawn, Seamless Steel Tubing

To determine the average wall weight of a tube:

$$W = 10.68 (D - t) t$$

To determine the minimum wall weight of a tube:

$$W = 10.68 (D - \frac{t}{.875}) \frac{t}{.875}$$

Where W = Weight in pounds per foot (carried to 4 digits)  
D = Outside diameter in inches (to 3 decimal places)  
t = Wall thickness in decimals (to 3 decimal places)

All weights are carried to four digits only, the fifth digit being carried forward if five or over, or dropped if under five.  
Outside diameters and wall thicknesses are carried to three decimal places, the fourth decimal being carried forward if five or over, or dropped if under five.

## TUBING DATA

### Standard Manufacturing Tolerances on Round, Cold Drawn, Seamless Mechanical Steel Tubing

Size Range in Inches	O.D. Tolerance in Inches	I.D. Tolerance in Inches	Wall Tolerances
Up to, but not including 1/4 O.D.....	+ .003 - .000	+ .000 - .003 (See Notes 1 and 2)	± 10% (See Notes 1 and 2)
1/4 O.D. to, but not including 1/2 O.D.....	+ .004 - .004	+ .000 - .004 (See Notes 1 and 2)	± 10% (See Notes 1 and 2)
1/2 O.D. to, but not including 3/4 O.D.....	+ .005 - .000 (See Note 3)	+ .000 - .005 (See Notes 1 and 2)	± 10% (See Note 3)
3/4 O.D. to, but not including 1 O.D.....	+ .010 - .000 (See Note 3)	+ .000 - .010 (See Note 3)	± 10% (See Note 3)
1 O.D. to, but not including 1 1/4 O.D.....	+ .015 - .000 (See Note 3)	+ .005 - .015 (See Note 1)	± 10% (See Note 1)
1 1/4 O.D. to, but not including 1 3/4 O.D. when wall is less than 5% of O.D.....	+ .030 (See Note 3)	+ .035 (See Note 3)	± 10% (See Note 3)
1 1/4 O.D. to, but not including 1 3/4 O.D. when wall is at least 5% and not over 7 1/2% O.D.....	+ .020	+ .025	± 10%
1 3/4 O.D. to, but not including 2 O.D. when wall is over 7 1/2% of O.D.....	+ .030 - .000 (See Note 1)	+ .015 - .030 (See Note 1)	± 10% (See Note 1)
2 O.D. to 10 1/4 O.D. when wall is less than 5% of O.D.....	+ .045 (See Note 3)	+ .050 (See Note 3)	± 10% (See Note 3)
2 O.D. to 10 1/4 O.D. when wall is at least 5% and not over 7 1/2% of O.D.....	+ .035	+ .040 (See Note 1)	± 10% (See Note 1)
2 O.D. to 10 1/4 O.D. when wall is over 7 1/2% of O.D.....	+ .045 - .000 (See Note 1)	(See Note 1)	± 10% (See Note 1)

**IMPORTANT**—The above O.D., I.D. and wall tolerances apply only to normal sizes, and to unannealed and finished annealed tubing. Tubing having relatively heavy or light wall in relation to the O.D. is covered by special tolerances, reference to which is made in Footnotes 1 to 3 of this table.

Finished and unannealed tubing constitute the bulk of cold drawn mechanical tubing. Tubes which have been given a softer anneal are apt to possess more or less ovality due to warpage in annealing, or to straightening operations. The greater degree of heat used in the softer anneals, with the attendant increase in scale, also affects the accuracy of diameter. Therefore, medium or soft annealed tubes will not be as close to size as the table indicates.

**NOTE 1**—For tubes with I.D. less than 50 per cent of O.D. or with Wall more than 25 per cent of O.D. or with Wall more than 1 1/4 inch thick or weighing more than 90 pounds per foot, which cannot be successfully drawn over a mandrel, the I.D. may vary over or under by an amount equal to 10 per cent of the wall thickness. The wall thickness may vary 12 1/2 per cent over or under the thickness specified.

**NOTE 2**—For tubes with I.D. less than 1/2 inch, or less than 1/2 per cent of the wall thickness is more than 20 per cent of the O.D., which cannot be successfully drawn over a mandrel, the wall thickness may vary 15 per cent over or under that specified and the I.D. will be governed by the O.D. and wall thickness variations.

## TUBING DATA

### Standard Manufacturing Tolerances on Round, Cold Drawn, Seamless Mechanical Steel Tubing

Continued from preceding page.

**NOTE 3**—Tubing having a wall thickness less than 3 per cent of the O.D. cannot be straightened properly without a certain amount of distortion. Consequently such tubes, while having an average O.D. and I.D. within the tolerances shown in the table, will require an ovality tolerance over and under 1/2 per cent of the nominal O.D. and I.D., this being in addition to the tolerances indicated in the table.

**SPECIAL NOTE**—Tolerances are applicable only to two dimensions (length excepted). Thus, if O.D. and wall are specified, the theoretical I.D. may not conform to published tolerances. If O.D. and I.D. are specified, the wall may not conform to published tolerances except that the mean or average wall (taking into account the permissible O.D. and I.D. tolerances) will not vary more than indicated under "Wall Tolerances." Stock material is generally ordered to O.D. and wall.

#### EXAMPLE

If a cold drawn tube is specified 1 1/2 inch O.D. x 1 1/4 inch I.D., one might expect the theoretical wall of 1/8 inch to be held to a variation of plus-minus 10 per cent or within the limits of .1125/.1375 inch.

However, for a nominal O.D. of 1.500 inch, the O.D. may vary between 1.500 inch and 1.510 inch, and the I.D. may vary between 1.240 inch and 1.250 inch, which may result in an average or mean wall of .130 inch instead of 1/8 inch. Consequently, the wall may vary plus-minus 10 per cent from the mean of .130 inch, or within limits of .1215/.1485 inch. If, however, the average wall were 1/8 inch (.125) reflecting 1.500 inch O.D. and 1.250 inch I.D., the wall limits would be plus-minus 10 per cent of 1/8 or .1125/.1375 inch. Hence, any order of tubes might vary in the entire lot as low as .1125 inch on some and as high as .1430 inch on others.

Therefore, if a buyer specifies the three dimensions of O.D., I.D. and wall, it would be impracticable to meet all three of these tolerances. If, in the case above, the size were specified 1 1/2 inch O.D. x 1 1/4 inch I.D. x 1/8 inch wall, this would entail a wall limitation of .1125/.1375 inch, which is obviously inconsistent with actual average wall resulting from standard O.D. and I.D. tolerances.

## Standard Manufacturing Tolerances for Round, Soft Annealed Steel Tubing

Group No.	Size in Inches	Outside Diameter		Inside Diameter		Wall Thickness		Ovality Deviates O.D. and I.D. Tolerances when Wall is:
		Over	Under	Over	Under	Over	Under	
1	Less than 1/2 I.D.....	.010	.000	†	†	15%	15%	
2	1/2 I.D. to, but not including 1 1/4 O.D.....	.010	.000	.000	.010	10%	10%	Lighter than 16 gauge (.065)
3	1 1/4 O.D. to, but not including 3 1/2 O.D.....	.010	.010	.010	.010	10%	10%	Lighter than 13 gauge (.095)
4	3 1/2 O.D. to, but not including 5 1/2 O.D.....	.015	.015	.015	.015	10%	10%	Lighter than 9 gauge (.148)
5	5 1/2 O.D. to 9 O.D.....	1/2 %	1/2 %	1/2 %	1/2 %	10%	10%	Information on request
		of O.D.	of O.D.	of I.D.	of I.D.			

\*Tubes having an I.D. less than 60 per cent of the O.D., or having a wall 1/4 inch and heavier, cannot be successfully drawn over a mandrel. The I.D. of such sizes may vary 10 per cent over or under the wall thickness. The wall of such sizes may vary 12 1/2 per cent over or under.

†Tubes less than 1/2 inch I.D. cannot be successfully drawn over a mandrel. This wall may vary 15 per cent over or under and the I.D. will be governed by the O.D. and wall variations. The actual weight limit may be the theoretical weight plus 10 per cent.

## TUBING DATA

### Straightness Tolerances for Round, Cold Drawn, Seamless Mechanical Steel Tubing

Under standard practice, out-of-straightness tolerances should not exceed the amounts shown in tabular form below. The tolerance for any 3 feet of length is measured with a 3 foot straightedge and the use of a feeler gauge. The total tolerance, that is the maximum curvature of any point in the total length of the tube, is determined by rolling the tube on a surface plate and measuring the curvature with a feeler gauge. The table applies to lengths not over 22 feet.

Size Limits in Inches	Maximum Curvature in any 3 Feet	Maximum Curvature in Total Lengths	Maximum Curvature for Lengths under 3 Feet
O.D. 5 and smaller. Wall thickness over 3% of O.D., but not over .5	.030	.030 x $\frac{\text{Number of feet of length}}{3}$	Ratio of .01 per Ft.
O.D. over 5 to 8, Incl. Wall thickness over 4% of O.D., but not over .75	.045	.045 x $\frac{\text{Number of feet of length}}{3}$	Ratio of .015 per Ft.
O.D. over 8 to 10 1/4, Incl. Wall thickness over 4% of O.D., but not over 1	.060	.060 x $\frac{\text{Number of feet of length}}{3}$	Ratio of .020 per Ft.

The tolerances apply generally to unannealed, finish annealed and medium annealed cold finished or hot finished tubes of carbon steel up to a maximum of .45 per cent carbon and to alloy steel tubes up to a maximum of .25 per cent carbon. Tubes having lighter or heavier walls and soft annealed or hardened tubes present straightening difficulties in varying degrees beyond normal, and the tolerance requirements of such tubes should be agreed upon at the time of ordering.

Tubes for special purposes such as conveyor rolls, etc., requiring straightness tolerances closer than above, demand special straightening operations and inspection which should also be agreed upon at the time of ordering.

## Standard Length Tolerances—Lathe Cut

Standard tolerances in inches on commercially exact cut lengths are:			
4' and under.....	Up to 2, Incl.....	+ 1/16	-.00
	Over 2 to 4, Incl.....	+ 1/32	-.00
	Over 4 to 10', Incl.....	+ 1/16	-.00
	Over 10' to 24', Incl.....	+ 1/8	-.00
	Over 24'.....	+ 1/4	-.00
	All sizes.....	*	-.00

\*Plus 1/16 inch plus 1/8 inch for each 10 feet or fraction over 24 feet.

## Standard Ovality Tolerances

Amount by which Cold Drawn Seamless Mechanical Tubing is out of round, primarily caused by annealing or straightening operations. Ovality of normal sizes will be within O.D. tolerance. Ovality of abnormal sizes is covered by Footnote D of Tolerance Table. Ovality does not affect wall tolerance.

**TUBING DATA**  
Standard Diameter Tolerances for Square and Rectangular, Welded Steel Tubing

**TOLERANCE ON SIZE**—The O.D. tolerance of square and rectangular tube as measured at the corners, disregarding tolerance on convexity or concavity of side, is the same as that of the round tube size "Flash-in Tube" used to form the square or rectangular section.

**TOLERANCE ON SIDE**—The convexity or concavity on the side of a square or rectangle is measured with a micrometer, tolerances being: When the longest side of a rectangle or square does not exceed 2½ inches the tolerance is ± .010 inch.

When the longest side of a rectangle or square exceeds 2½ inches the tolerance is ± .015 inch.

**SQUARENESS OF SIDES**—The squareness tolerance of square and rectangular tubes varies in accordance with the following formula:

$$\pm b = c \times .006 \text{ inch}$$

b = Tolerance for out-of-square  
c = Length of longest side.

Example: Rectangular tubes 2 inch x 1 inch  
c = 2 inch  
± b = 2 x .006 inch = .012 inch.

Thus a 2 inch x 1 inch rectangular tube may have its sides fail to be 90° to each other by ± .012 inch.

**TWIST**—Permissible twist in square and rectangular tubes is ½ inch in 3 feet. This is measured by holding one end of square or rectangular tube on a surface plate with bottom side parallel to the plate, and noting the height that either corner on the opposite end of the same side, is above the surface plate.

**Standard Straightness Tolerances for Round, Welded Steel Tubing**

Commercial tolerance for straightness is .030 inch in a length of 3 feet and is checked by placing the tube on a surface plate with both ends touching the surface plate. The point of maximum deflection of the tube from the surface plate shall not be more than .030 inch for a length of 3 feet when measured with a feeler gauge.

No tube, regardless of length, shall have a deflection greater than .030 inch for any 3 foot length, when checked as outlined above with a 3 foot straight edge.

In lengths greater than 3 feet, the permissible deflection is determined by the following formula:

$$\frac{L}{3} \times .030 \text{ inch}$$

L = Length of tube

**EXAMPLE**—A tube 18 feet long would have a maximum deflection as computed by the above formula of .180 inch, derived as follows:

$$\frac{18}{3} \times .030 = .180 \text{ inch}$$

For length less than three feet, the straightness tolerance is pro-rated on the basis of .030 inch in three feet, down to a length of 12 inches. Below 12 inches, the minimum straightness tolerance is not less than .010 inch.

**Methods of Cutting Tube into Short Lengths**

**LATHE CUT**—The tube is cut by a lathe parting tool, but, in making the cut, a slight burr is thrown up, both on the inside and outside. This cutting burr is usually very slight and can be removed if necessary.

**PUNCH CUT**—The tube is clamped in a die and a pointed knife is forced through the tube, thereby cutting out a slug. The ends are square and flat but there is a slight dent where the knife pierces through the tube.

**DISC CUT**—This type of cut off is similar to the conventional type used by plumbers in cutting pipe except that the operation is performed in a special machine. The end of the tube is rolled over about ½ inch on a side due to the action of the cutting knife.

**SAW CUT**—Saw cutting is done with a high speed saw. In making the cut the tube is sometimes distorted due to the pressure of the saw and a pronounced burr is thrown up on both the outside and inside.

**TUBING DATA**  
Standard Cutting Tolerances-Lathe Cut

Size in Inches	Gauge	Length in Inches	Toler. Plus or Minus	Size in Inches	Gauge	Length in Inches	Toler. Plus or Minus
¾ to 1	14-22	0 to 12	¼	1½ to 2	9-13	60½ to 120	¼
¾ to 1	14-22	12½ to 60	½	2½ to 3	14-20	0 to 12	½
¾ to 1	14-22	60½ to 120	¼	2½ to 3	14-20	12½ to 120	¼
1½ to 2	14-22	0 to 12	¼	3½ to 4	14-18	0 to 12	¼
1½ to 2	14-22	12½ to 60	½	3½ to 4	14-18	12½ to 120	¼
1½ to 2	14-22	60½ to 120	¼	3½ to 4	9-13	0 to 12	¼
1½ to 2	9-13	0 to 12	½	3½ to 4	9-13	12½ to 120	¼
1½ to 2	9-13	12½ to 60	¼				

**Cutting Tolerances-Punch, Disc or Saw Cut**

1 to 3 feet..... ± ¼ inch      13 feet and longer..... ± ½ inch  
4 to 12 feet..... ± ½ inch

**Standard Gauge Tolerances for Cold Rolled, Welded, Carbon Steel Tubing**

Gauge	Size in Inches		Size of Tube in Inches		
	Decimal	3/8 to 7/8	1 to 2	2-1/8 to 3	3-1/8 to 4
22	.028	{ +.000 -.004	+ .000 -.004	—	—
20	.035	{ +.000 -.004	+ .000 -.004	+ .000 -.005	—
18	.049	{ +.000 -.004	+ .000 -.005	+ .000 -.006	—
16	.065	{ +.000 -.004	+ .000 -.006	+ .000 -.006	+ .000 -.006
14	.083	{ +.000 -.004	+ .000 -.006	+ .000 -.006	+ .000 -.006
12	.109	{ — —	+ .000 -.006	+ .000 -.006	+ .000 -.006
11	.120	{ — —	+ .000 -.006	+ .000 -.008	+ .000 -.008
10	.134	{ — —	+ .000 -.006	+ .000 -.008	+ .000 -.008
9	.148	{ — —	+ .000 -.006	+ .000 -.008	+ .000 -.008
8	.165	{ — —	+ .000 -.008	+ .000 -.008	+ .000 -.010

**TUBING DATA**  
Standard Gauge Tolerances for Hot Rolled, Welded, Carbon Steel Tubing

Gauge	Size in Inches		Size of Tube in Inches		
	Decimal	9/8 to 1-1/2	1-5/8 to 3	3-1/8 to 5	
20	.035	{ +.000 -.006	—	—	—
18	.049	{ +.000 -.006	+ .002 -.006	—	—
16	.065	{ +.002 -.006	+ .002 -.008	+ .002 -.010	+ .002 -.010
14	.083	{ +.002 -.006	+ .002 -.008	+ .002 -.010	+ .002 -.010
12	.109	{ +.002 -.006	+ .002 -.008	+ .002 -.010	+ .002 -.010
11	.120	{ +.002 -.008	+ .002 -.010	+ .002 -.012	+ .002 -.012
10	.134	{ — —	+ .002 -.010	+ .002 -.012	+ .002 -.012
9	.148	{ — —	+ .002 -.010	+ .002 -.012	+ .002 -.012
8	.165	{ — —	+ .002 -.010	+ .002 -.012	+ .002 -.012

**Definition of Ovality**

Ovality is the difference between the maximum diameters of any one section of the tube. Tubing in the heavier gauges will have a closer ovality tolerance. The maximum and minimum O.D. tolerances listed in the table should be considered as maximum limits.

As an example, in accordance with the above, 2 inch x 16 gauge standard cold rolled tube has the following tolerance:

Maximum.....O.D. 2.005  
Minimum.....O.D. 1.995  
Ovality......006

Thus, at any section of the tube, there could be a maximum micrometer reading of 2.005, and a minimum reading of 1.999, or a minimum micrometer reading of 1.995, and a maximum reading of 2.001.

**WEIGHTS AND DIMENSIONS OF SEAMLESS AND WELDED PIPE**

Pipe Size	O.D. Inches	A. S. A. PIPE SCHEDULES												Double E.H.		
		5	10	20	30	40	STD.	60	80	E.H.	100	120	140		160	
½	.405	.035	.049	—	—	.068	.068	—	.095	.095	—	—	—	—	—	—
¾	.540	.133	.163	—	—	.247	.247	—	.315	.315	—	—	—	—	—	—
1	.675	.257	.327	—	—	.424	.424	—	.531	.531	—	—	—	—	—	—
1½	.840	.449	.565	—	—	.691	.691	—	.826	.826	—	—	—	—	—	—
2	1.050	.653	.823	—	—	.991	.991	—	1.179	1.179	—	—	—	—	—	—
2½	1.315	.868	1.104	—	—	1.331	1.331	—	1.574	1.574	—	—	—	—	—	—
3	1.660	1.107	1.406	—	—	1.679	1.679	—	1.972	1.972	—	—	—	—	—	—
3½	1.900	1.274	1.638	—	—	1.919	1.919	—	2.236	2.236	—	—	—	—	—	—
4	2.375	1.604	2.038	—	—	2.303	2.303	—	2.676	2.676	—	—	—	—	—	—
4½	2.875	2.075	2.638	—	—	2.931	2.931	—	3.416	3.416	—	—	—	—	—	—
5	3.500	2.475	3.131	—	—	3.516	3.516	—	4.026	4.026	—	—	—	—	—	—
5½	4.000	2.831	3.531	—	—	4.016	4.016	—	4.551	4.551	—	—	—	—	—	—
6	4.500	3.131	3.931	—	—	4.316	4.316	—	4.881	4.881	—	—	—	—	—	—
6½	5.000	3.431	4.331	—	—	4.616	4.616	—	5.226	5.226	—	—	—	—	—	—

LIGHT FIGURES—Wall Thickness in Inches

BOLD FIGURES—Weight Per Foot in Pounds

