

## 12. Tube and Pipe

### Introduction

Section 12. of Aluminum Standards and Data covers the mechanical property limits and product dimensional tolerance limits for aluminum alloy tube and pipe. These limits are statistically based guaranteed limits, and may be used as the basis of design. Note that the limits applicable in any specific situation are those for the specific size of product ordered.

### Mechanical Property Limits For Aluminum Alloy Tube and Pipe

The specified aluminum industry mechanical property limits for aluminum alloy tube and pipe are provided in the following tables:

- Table 12.1 - Mechanical Property Limits - Extruded Tube
- Table 12.15 - Mechanical Property Limits - Extruded Coiled Tube
- Table 12.19 - Mechanical Property Limits - Drawn Tube
- Table 12.33 - Mechanical Property Limits - Heat Exchanger Tube
- Table 12.48 - Mechanical Property Limits - Pipe, Extruded and Drawn
- Table 7.1 - Mechanical Property Limits - Non-Heat-Treatable Alloys (applicable to Sheet for Welded Tube)

Note that the limits shown are statistically-based guaranteed limits, and are thus suitable for design.

**Special Note: The applicable limits for any individual product are those that apply to the specified (ordered) dimension.**

### Dimensional Tolerance Limits for Aluminum Alloy Tube and Pipe

Specific aluminum industry guaranteed tolerance limits for aluminum alloy tube and pipe are shown in the following tables:

#### Extruded Tube

- Table 12.2 - Diameter - Round Tube
- Table 12.3 - Width and Depth - Square, Rectangular, Hexagonal, Octagonal Tube
- Table 12.4 - Wall Thickness - Round Extruded Tube
- Table 12.5 - Wall Thickness - Other-Than-Round Extruded Tube
- Table 12.6 - Length - Extruded Tube
- Table 12.7 - Length - Other-than-Round Extruded Tube
- Table 12.8 - Straightness - Tube in Straight Lengths
- Table 12.9 - Flatness (Flat Surfaces)
- Table 12.10 - Squareness of Cut Ends
- Table 12.11 - Corner and Fillet Radii
- Table 12.12 - Angularity
- Table 12.13 - Surface Roughness
- Table 12.14 - Dents

#### Extruded Coiled Tube

- Table 12.16 - Outside Diameter
- Table 12.17 - Wall Thickness
- Table 12.18 - Coil Length

#### Drawn Tube

- Table 12.20 - Diameter - Drawn Round Tube
- Table 12.21 - Width and Depth - Drawn Square, Rectangular, Hexagonal, Octagonal Tube
- Table 12.22 - Diameter - Drawn Oval, Elliptical and Streamline Tube
- Table 12.23 - Corner Radii - Drawn Tube
- Table 12.24 - Wall Thickness - Drawn Round and Other-Than-Round Tube
- Table 12.25 - Straightness - Drawn Tube
- Table 12.26 - Twist - Drawn Tube
- Table 12.27 - Length - Drawn Tube
- Table 12.28 - Flatness (Flat Surfaces) - Drawn Tube
- Table 12.29 - Squareness of Cut Ends - Drawn Tube
- Table 12.30 - Angularity - Drawn Tube
- Table 12.31 - Surface Roughness - Drawn Tube
- Table 12.32 - Dents - Drawn Tube

#### Heat Exchanger Tube

- Table 12.33 - Mechanical Property Limits - Heat Exchanger Tube
- Table 12.34 - Outside Diameter Tolerances - Heat-Treatable Tube
- Table 12.35 - Outside Diameter Tolerances - Non-Heat-Treatable Tube
- Table 12.36 - Wall Thickness Tolerances
- Table 12.37 - Length Tolerances
- Table 12.38 - Straightness Tolerances
- Table 12.39 - Squareness of Cut Ends
- Table 12.40 - (unassigned)

#### Welded Tube

- Table 12.41 - Diameter Tolerances - Round Tube
- Table 12.42 - Width and Depth Tolerances - Square Tube
- Table 12.43 - Wall Thickness Tolerances - Round and Square Tube
- Table 12.44 - Length Tolerances
- Table 12.45 - Straightness Tolerances
- Table 12.46 - Twist Tolerances
- Table 12.47 - Squareness of Cut Ends

#### Pipe

- Table 12.49 - Outside Diameter
- Table 12.50 - Wall Thickness
- Table 12.51 - Weight
- Table 12.52 - Length
- Table 12.53 - Straightness
- Table 12.54 - Standard Welding Bevels
- Table 12.55 - Diameters, Wall Thickness, Weights

**tube and pipe/introduction**

**Rigid Electrical Conduit**

- Table 12.56 - Designed Dimensions and Weights
- Table 12.57 - Dimensions of Threads
- Table 12.58 - Designed Dimensions and Weights of Couplings
- Table 12.59 - Dimensions of 90-Degree Elbows and Weights of Nipples per Hundred
- Table 12.60 - Standard Tolerances
- Table 12.61 - Identification

Some general comments on the applicability and methods for calculating tolerances from these tables are given on p. 4-16 of Aluminum Standards and Data. For pipe, it is appropriate to note that these published tolerance limits represent industry standards that are agreed to and capable of being met by all members of the industry. Thus they represent the maximum tolerances that can be provided by any producer; in no case should tolerance ranges larger than these values be provided.

In some cases, substantially tighter limits (i.e., smaller ranges of thickness, width and/or length) may be obtained from individual producers upon special order. In this regard, for example, it is broadly understood in the industry that it may be possible to order product from many suppliers to dimensional tolerances that are one-half those in the limit tables.

For additional information of specific tolerance ranges available, contact producers directly.

**References to Other Tube and Pipe Information in Aluminum Standards and Data**

**Alloy and Temper Designation**

- System . . . . . Blue Pages, p. 1-3
- Specifications for Aluminum Alloy
- Tube and Pipe . . . . . Table 1.3, p. 1-15
- Available Alloys and Tempers . . . . . Table 3.1, p. 3-1

**Comparative Characteristics and**

- Applications . . . . . Table 3.3, p. 3-8
- Typical Heat Treatments . . . . . Table 3.4, p. 3-12
- Typical Annealing Treatments . . . . . Table 3.5, p. 3-17
- Quality Control . . . . . p. 4-1
- Sampling and Testing . . . . . p. 4-2
- Mechanical Test Specimens . . . . . p. 4-2
- Visual Quality Inspection . . . . . p. 4-5
- Ultrasonic Testing . . . . . p. 4-6
- Identification Marking . . . . . p. 4-7
- Color Code for Alloys . . . . . p. 4-11
- Handling and Storage . . . . . p. 4-12
- Protective Oil . . . . . p. 4-13
- Certification Requirements . . . . . p. 4-13
- Dimensional Tolerances . . . . . p. 4-17

**Terminology . . . . . p. 5-1**

- Limits Definitions . . . . . p. 6-1
- Standard Limits . . . . . p. 6-1
- Applicable Limits . . . . . p. 6-2
- Conformance Limits . . . . . p. 6-3

- Chemical Composition Limits . . . . . p. 6-1
- Chemical Composition Limits
- Listings . . . . . Table 6.2, p. 6-5

**Ultrasonic Discontinuity Limits . . . . . Table 6.3, p. 6-7**

**Lot Acceptance Criteria for Corrosion**

- Resistant Tempers . . . . . Table 6.4, p. 6-7
- Location for Electrical Conductivity
- Measurements . . . . . Table 6.5, p. 6-9
- Corrosion resistance Test Criteria . . . . . Table 6.7, p. 6-10

**TABLE 12.1 Mechanical Property Limits—Extruded Tube**

ALLOY AND TEMPER	SPECIFIED WALL THICKNESS ① in.	AREA sq. in.	TENSILE STRENGTH—ksi				ELONGATION percent min. in 2 in. or 4D ②
			ULTIMATE		YIELD		
			min.	max.	min.	max.	
<b>1060</b>							
1060-O	All	All	8.5	14.0	2.5	..	25
1060-H112	All	All	8.5	..	2.5	..	25
<b>1100</b>							
1100-O	All	All	11.0	15.5	3.0	..	25
1100-H112	All	All	11.0	..	3.0	..	25
<b>2014</b>							
2014-O	All	All	..	30.0	..	18.0	12
2014-T4, T4510 ④ and T4511 ④	All	All	50.0	..	35.0	..	12
2014-T42 ③ ⑤	All	All	50.0	..	29.0	..	12
2014-T6, T6510 ④ and T6511 ④	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 ③ ⑤	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 ④ and T3511 ④	Up thru 0.249	All	57.0	..	42.0	..	10
	0.250–0.749	All	60.0	..	44.0	..	10
	0.750–1.499	All	65.0	..	46.0	..	10
	1.500 and over	Up thru 25	70.0	..	48.0	..	10
	1.500 and over	Over 25 thru 32	68.0	..	46.0	..	8
2024-T42 ③ ⑤	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 ④ and T8511 ④	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 ④ and T3511 ④	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 ③ ⑤	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 ④, and T8511 ④	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	..	25
<b>ALCLAD 3003</b>							
ALCLAD 3003-O	All	All	13.0	18.0	4.5	..	25
ALCLAD 3003-H112	All	All	13.0	..	4.5	..	25
<b>3004</b>							
3004-O	All	All	23.0	29.0	8.5	..	..

For all numbered footnotes, see page 12-5.

extruded tube/mechanical properties

TABLE 12.1 Mechanical Property Limits—Extruded Tube (continued)

ALLOY AND TEMPER	SPECIFIED WALL THICKNESS ① in.	AREA sq. in.	TENSILE STRENGTH—ksi				ELONGATION percent min. in 2 in. or 4D ②
			ULTIMATE		YIELD		
			min.	max.	min.	max.	
<b>5083</b>							
5083-O	All	Up thru 32	39.0	51.0	16.0	..	14
5083-H111	All	Up thru 32	40.0	..	24.0	..	12
5083-H112	All	Up thru 32	39.0	..	16.0	..	12
<b>5086</b>							
5086-O	All	Up thru 32	35.0	46.0	14.0	..	14
5086-H111	All	Up thru 32	36.0	..	21.0	..	12
5086-H112	All	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	All	Up thru 32	31.0	41.0	12.0	..	14
5454-H111	All	Up thru 32	33.0	..	19.0	..	12
5454-H112	All	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
<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 ④ and T4511 ④	All	All	26.0	..	16.0	..	16
6061-T42 ③ ⑤	All	All	26.0	..	12.0	..	16
6061-T51	Up thru 0.625	All	35.0	..	30.0	..	8
6061-T6, T62 ③ ⑤, T6510 ④ and T6511 ④	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 ③ ⑤	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 ⑦	Up thru 1.000	All	22.0	30.0	16.0	25.0	8
6063-T6 and T62 ③ ⑤	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 ④, and T4511 ④	All	All	40.0	..	25.0	..	14
6066-T42 ③ ⑤	All	All	40.0	..	24.0	..	14
6066-T6, T6510 ④ and T6511 ④	All	All	50.0	..	45.0	..	8
6066-T62 ③ ⑤	All	All	50.0	..	42.0	..	8
<b>6070</b>							
6070-T6 and T62 ③ ⑤	Up thru 2.999	Up thru 32	48.0	..	45.0	..	6

For all numbered footnotes, see page 12-5.

**TABLE 12.1 Mechanical Property Limits—Extruded Tube (concluded)**

ALLOY AND TEMPER	SPECIFIED WALL THICKNESS ① in.	AREA sq. in.	TENSILE STRENGTH—ksi				ELONGATION percent min. in 2 in. or 4D ②
			ULTIMATE		YIELD		
			min.	max.	min.	max.	
<b>6082</b>							
6082-T6	0.200–1.000	All	45.0	..	38.0	..	8
<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 ④ and T5511 ④	Up thru 1.000	All	37.0	..	34.0	..	7
6162-T6, T6510 ④ and T6511 ④	Up thru 0.249 0.250–0.499	All	38.0	..	35.0	..	8
		All	38.0	..	35.0	..	10
<b>6262</b>							
6262-T6, T62 ③ ⑤, T6510 ④ and T6511 ④	All	All	38.0	..	35.0	..	10
<b>6351</b>							
6351-T4 6351-T6	Up thru 0.749 Up thru 0.124 0.125–0.749	All	32.0	..	19.0	..	16
		All	42.0	..	37.0	..	8
		All	42.0	..	37.0	..	10
<b>7075</b>							
7075-O	All	All	..	40.0	..	24.0	10
7075-T6, T62 ③ ⑤, T6510 ④ and T6511 ④	Up thru 0.249 0.250–0.499 0.500–1.499 1.500–2.999	All	78.0	..	70.0	..	7
		All	81.0	..	73.0	..	7
		All	81.0	..	72.0	..	7
		All	81.0	..	72.0	..	7
7075-T73 ⑥, T73510 ④ ⑥ and T73511 ④ ⑥	0.062–0.249 0.250–1.499 1.500–2.999	All	68.0	..	58.0	..	7
		Up thru 25 Up thru 25	70.0	..	61.0	..	8
			69.0	..	59.0	..	8

**Footnotes for Table 12.1**

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 D represents specimen diameter.

③ 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 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.

④ 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.

⑤ This temper is not available from the material producer.

⑥ 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 through 6-10.

⑦ 6063-T52 is a producer temper and is an exception to ANSI H35.1/H35.1(M) paragraphs A2.2 Temper Designation for Purchaser/User Heat Treatment, A2.3 Temper Designations for Producer/Supplier Demonstration of Response to Temper Conversion and A2.4 Temper Designation for Purchaser/User Heat Treatment.

extruded tube/standard tolerances

TABLE 12.2 Diameter—Round Tube

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

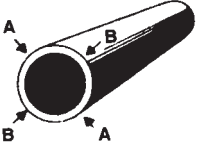
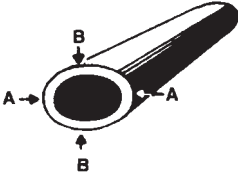
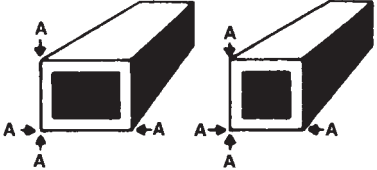

SPECIFIED DIAMETER <sup>①</sup>  in.	TOLERANCE <sup>②</sup> —in. plus and minus			
	ALLOWABLE DEVIATION OF MEAN DIAMETER <sup>③</sup> FROM SPECIFIED DIAMETER (Size)		ALLOWABLE DEVIATION OF DIAMETER AT ANY POINT FROM SPECIFIED DIAMETER <sup>④</sup>	
	 Difference between ½ (AA+BB) and specified diameter		 Difference between AA or BB and specified diameter	
Col. 1	Col. 2		Col. 3	
	5xxx 4.0 nominal Mg <sup>⑥</sup>	Other Alloys	5xxx 4.0 nominal Mg <sup>⑥</sup>	Other Alloys
0.500–0.999	.015	.010	.030	.020
1.000–1.999	.018	.012	.038	.025
2.000–3.999	.023	.015	.045	.030
4.000–5.999	.038	.025	.075	.050
6.000–7.999	.053	.035	.113	.075
8.000–9.999	.068	.045	.150	.100
10.000–11.999	.083	.055	.188	.125
12.000–13.999	.098	.065	.225	.150
14.000–15.999	.113	.075	.263	.175
16.000–17.999	.128	.085	.300	.200
18.000–19.999	.143	.095	.338	.225
20.000–21.999	.158	.105	.375	.250
22.000–23.999	.173	.115	.413	.275

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

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

SPECIFIED WIDTH OR DEPTH  in.	TOLERANCE <sup>②</sup> —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 <sup>④</sup>		
	 Difference between AA and specified width or depth		 Difference between AA and specified width, depth, or distance across flats		
Col. 1	Col. 2		Col. 3		Col. 4
	5xxx 4.0 nominal Mg <sup>⑥</sup>	Other Alloys	5xxx 4.0 nominal Mg <sup>⑥</sup>	Other Alloys	All Alloys
0.500–0.749	.018	.012	.030	.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 3/8 inch alloy 6061 rectangular tube is ±0.025 inch and the depth tolerance ±0.035 inch.
0.750–0.999	.021	.014	.030	.020	
1.000–1.999	.027	.018	.038	.025	
2.000–3.999	.038	.025	.053	.035	
4.000–4.999	.053	.035	.068	.045	
5.000–5.999	.068	.045	.083	.055	
6.000–6.999	.083	.055	.098	.065	
7.000–7.999	.098	.065	.108	.075	
8.000–8.999	.113	.075	.123	.085	
9.000–9.999	.128	.085	.143	.095	
10.000–10.999	.143	.095	.158	.105	
11.000–12.999	.158	.105	.173	.115	

For all numbered footnotes, see page 12-9.

TABLE 12.4 Wall Thickness—Round Extruded Tube

SPECIFIED WALL THICKNESS <sup>⑥</sup> in.	TOLERANCE <sup>①</sup> <sup>②</sup> —in. plus and minus								
	ALLOWABLE DEVIATION OF MEAN WALL THICKNESS <sup>⑤</sup> FROM SPECIFIED WALL THICKNESS								ALLOWABLE DEVIATION OF WALL THICKNESS AT ANY POINT FROM MEAN WALL THICKNESS <sup>⑤</sup> (Eccentricity)
	Difference between $\frac{1}{2}(AA + BB)$ and specified wall thickness								
	OUTSIDE DIAMETER—IN.								
Col. 1	Under 1.250		1.250–2.999		3.000–4.999		5.000 and over		Col. 6
	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6				
	5xxx 4.0 nominal Mg <sup>⑬</sup>	Other Alloys	5xxx 4.0 nominal Mg <sup>⑬</sup>	Other Alloys	5xxx 4.0 nominal Mg <sup>⑬</sup>	Other Alloys	5xxx 4.0 nominal Mg <sup>⑬</sup>	Other Alloys	All Alloys
Under 0.047	.009	.006	..	..	..	..	..	..	Plus and minus 10% of mean wall thickness
0.047–0.061	.011	.007	.012	.008	.012	.008	.015	.010	
0.062–0.077	.012	.008	.012	.008	.014	.009	.018	.012	
0.078–0.124	.014	.009	.014	.009	.015	.010	.023	.015	
0.125–0.249	.014	.009	.014	.009	.020	.013	.030	.020	
0.250–0.374	.017	.011	.017	.011	.024	.016	.038	.025	
0.375–0.499	..	..	.023	.015	.032	.021	.053	.035	max ±0.060 min ±0.010
0.500–0.749	..	..	.030	.020	.042	.028	.068	.045	
0.750–0.999	..	..	..	..	.053	.035	.083	.055	
1.000–1.499	..	..	..	..	.068	.045	.098	.065	
1.500–2.000	..	..	..	..	..	..	.113	.075	
2.001–2.499	..	..	..	..	..	..	.128	.085	±0.120
2.500–2.999	..	..	..	..	..	..	.143	.095	
3.000–3.499	..	..	..	..	..	..	.158	.105	
3.500–4.000	..	..	..	..	..	..	.173	.115	

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

SPECIFIED WALL THICKNESS <sup>⑥</sup> in.	TOLERANCE <sup>①</sup> <sup>②</sup> —in. plus and minus					
	ALLOWABLE DEVIATION OF MEAN WALL THICKNESS <sup>⑤</sup> FROM SPECIFIED WALL THICKNESS				ALLOWABLE DEVIATION OF WALL THICKNESS AT ANY POINT FROM MEAN WALL THICKNESS <sup>⑤</sup> (Eccentricity)	
	Difference between $\frac{1}{2}(AA + BB)$ and specified wall thickness				Difference between AA and mean wall thickness	
	CIRCUMSCRIBING CIRCLE DIAMETER <sup>⑩</sup> —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		
	5xxx4.0 nominal Mg <sup>⑬</sup>	Other Alloys	5xxx4.0 nominal Mg <sup>⑬</sup>	Other Alloys	All Alloys	All Alloys
Under 0.047	.008	.005	.012	.008	.005	Plus and minus 10% of mean wall thickness
0.047–0.061	.009	.006	.014	.009	.007	
0.062–0.124	.011	.007	.015	.010	.010	
0.125–0.249	.012	.008	.023	.015	.015	
0.250–0.374	.017	.011	.030	.020	.025	
0.375–0.499	.021	.014	.045	.030	.030	
0.500–0.749	.038	.025	.060	.040	.040	
0.750–0.999	.053	.035	.075	.050	.050	
1.000–1.499	.068	.045	.090	.060	.060	
1.500–2.000	..	..	.105	.070	..	

For all numbered footnotes, see page 12-9.

extruded tube/standard tolerances

TABLE 12.6 Length—Extruded Tube

SPECIFIED OUTSIDE DIAMETER OR WIDTH  in.	TOLERANCE—in. plus excepted 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 thru 250	Over 250 thru 500	Over 500
0.500–1.249	1/8	1/4	3/8	1	+5%, -0%	±10%	±15%	±20%
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

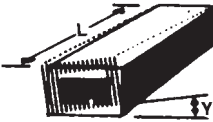
TEMPER	SPECIFIED WIDTH in.	SPECIFIED THICKNESS in.	TOLERANCE <sup>(9)</sup> —Degrees	
			ALLOWABLE DEVIATION FROM STRAIGHT	
			IN TOTAL LENGTH OR IN ANY SEGMENT OF ONE FT. OR MORE OF TOTAL LENGTH	MAXIMUM FOR TOTAL LENGTH
All except O, TX510, TX511 <sup>(8)</sup>	0.500 thru 1.499 1.500–2.999 3.000 and over	All All All	 <p>Y (max.) in degrees</p>	
			O, TX510 <sup>(8)</sup>	0.500 and over
TX511 <sup>(8)</sup>	0.500–1.499 1.500–2.999 3.000 and over	0.095 and over 0.095 and over 0.095 and over	1/2 · Measured length, ft.	5
			1/4 · Measured length, ft.	3
			1 · Measured length, ft.	7
			1/2 · Measured length, ft.	5
			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 6.000 and over	.010 · Measured length, ft.
		.020 · Measured length, ft.
O, TX510 <sup>(8)</sup>	0.500 and over	⑦

For all numbered footnotes, see page 12-9.

TABLE 12.9 Flatness (Flat Surfaces)—Extruded Tube

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

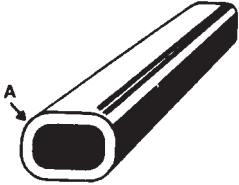
MINIMUM THICKNESS OF METAL FORMING THE SURFACE in.	TOLERANCE—in.	
	Maximum Allowable Deviation Y	
	WIDTHS UP THRU 1 IN. OR ANY 1 IN. INCREMENT OF WIDER SURFACES	WIDTHS OVER 1 IN. THRU 5.999 IN.
Up thru 0.187 0.188 and over	0.006	0.006 · W (inches)
	0.004	0.004 · W (inches)



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

Allowable deviation from square: 1 degree.
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**TABLE 12.11 Corner and Fillet Radii—Extruded  
Tube**

SPECIFIED RADIUS <sup>18</sup> in.	TOLERANCE—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 12.12 Angularity—Extruded Tube**

Allowable deviation from square: ±2 degrees.
--

**TABLE 12.13 Surface Roughness <sup>14</sup> <sup>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	0.012
	Up thru 0.500	0.015
	0.501 and over	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.)

**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 coiled tube/properties and tolerances

### Application

Extruded round coiled tube is produced by bridge or porthole die extrusion methods and is intended for general purpose applications such as refrigeration units, oil lines and instrument lines.

### Internal Cleanliness

The tube shall be capable of meeting an inside cleanliness requirement of no more residue than 0.002 g of residue per square foot ( $0.139 \cdot 10^{-4}$ g per sq. in.) of internal surface when tested in accordance with the following paragraph. Tube ends are sealed by crimping or by other suitable means to maintain cleanliness during shipping and storage.

*Test Method*—A measured quantity of solvent (125 ml minimum of inhibited 1,1,1 trichloroethane, trichloroethylene or equal) is pumped or aspirated through a test sample of tube into the flask. The test sample shall have a minimum internal area of 375 sq. in. except that no more than 50 ft. of length shall be required. The solvent is then transferred to a preweighed container such as a crucible, evaporating dish or beaker, and completely evaporated on a low temperature hot plate. After solvent evaporation the container is dried in a furnace or over for at least 10 minutes at 212–230°F, cooled in a desiccator, then weighed.

A blank determination is made on the measured quantity of solvent, and the gain in weight for the blank is subtracted from the weight of the residue sample. The corrected weight is then calculated in grams of residue per internal area of tube.

*Note:* The quantity of solvent used for the blank run is the same as that used for the actual examination of the tube sample. The sample is prepared so that there is no inclusion of chips, dust, and so forth, resulting from the sample preparation.

### Leak Test

The tube is capable of withstanding an internal air pressure of 250 psi with no evidence of leakage, or pressure loss.

### Formability

The tube ends are capable of being expanded by forcing a steel pin having an included angle of 60 degrees into them until the outside diameter is increased 40 percent. The expansion shall not cause cracks, ruptures or other defects visible to the unaided eye.