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Standard Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing[1]

This standard is issued under the fixed designation A513/A513M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This specification covers electric-resistance-welded carbon and alloy steel tubing for use as mechanical tubing.

1.2 This specification covers mechanical tubing made from hot- or cold-rolled steel.

1.3 This specification covers round, square, rectangular, and special shape tubing.

Type	Size Range (Round Tubing)
~~Electric-Resistance-Welded Tubing from Hot-Rolled Steel~~	~~outside diameter from ½ to 15 in. (19.0 to 381.0 mm)~~
Electric-Resistance-Welded Tubing from Hot-Rolled Steel	outside diameter from ½ to 15 in. [10 to 380 mm]
	~~wall from 0.065 to 0.650 in. (1.65 to 16.50 mm)~~
	wall from 0.065 to 0.650 in. [1.65 to 16.50 mm]
~~Electric-Resistance-Welded Tubing from Cold-Rolled Steel~~	~~outside diameter from ⅜ to 12 in. (9.92 to 304.8 mm)~~
Electric-Resistance-Welded Tubing from Cold-Rolled Steel	outside diameter from ⅜ to 12 in. [9.5 to 305 mm]
	~~wall from 0.022 to 0.134 in. (0.71 to 3.40 mm)~~
	wall from 0.022 to 0.134 in. [0.56 to 3.40 mm]

1.4 Optional supplementary requirements are provided and when desired, shall be so stated in the order.

~~1.5The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.~~

1.5 The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text the SI units are shown in brackets or parenthesis. The values stated in each system may not be exact equivalents; therefore each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard. The inch-pound unts shall apply unless the "M" designation of this specification is specified in the order. In this specification hard or rationalized conversions apply to diameters, lengths and tensile properties. Soft conversion applies to other SI measurements.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment

A1008/A1008M Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable

A1011/A1011M Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength

A1039/A1039M Specification for Steel, Sheet, Hot Rolled, Carbon, Commercial, Structural, and High-Strength Low-Alloy, Produced by Twin-Roll Casting Process

[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.09 on Carbon Steel Tubular Products.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

A1040 Guide for Specifying Harmonized Standard Grade Compositions for Wrought Carbon, Low-Alloy, and Alloy Steels
E1806 Practice for Sampling Steel and Iron for Determination of Chemical Composition
E213 Practice for Ultrasonic Testing of Metal Pipe and Tubing
E273 Practice for Ultrasonic Testing of the Weld Zone of Welded Pipe and Tubing
E309 Practice for Eddy-Current Examination of Steel Tubular Products Using Magnetic Saturation
E570 Practice for Flux Leakage Examination of Ferromagnetic Steel Tubular Products
2.2 *ANSI Standard:*[3]
B 46.1 Surface Texture
2.3 *Military Standards:*[4]
MIL-STD-129 Marking for Shipment and Storage
2.4 *Federal Standard:*[4]
Fed. Std. No. 123 Marking for Shipments (Civil Agencies)

3. Ordering Information

3.1 Orders for material under this specification should include the following as required to adequately describe the desired material:

3.1.1 Quantity (feet, metres, or number of lengths),
3.1.2 Name of material (electric resistance-welded carbon or alloy steel mechanical tubing),
3.1.3 Types, conditions and code letters, (See Sections 1 and 12),
3.1.4 Thermal condition, (See 12.2),
3.1.5 Flash condition, (See 12.3),
3.1.6 Grade designation, if required, (See Section 5),
3.1.7 Report chemical analysis and product analysis, if required (See Sections 6 and 7),
3.1.8 Individual supplementary requirements, if required (S1 to S10, inclusive),
3.1.9 Cross section (round, square, rectangular and special shapes),
3.1.10 Dimensions, round, outside and inside and wall thickness (See 8.1 and 8.2) or square and rectangular, outside dimension and wall thickness and corner radii, if required (See 9.1 and 9.2),
3.1.11 Length, round, mill lengths or definite cut length (See 8.3), square and rectangular, specified length (See 9.4),
3.1.12 Squareness of cut, round tubing, if required, (See 8.4),
3.1.13 Burrs removed, if required (See 11.2),
3.1.14 Protective coating (See 14.1),
3.1.15 Special packaging (See 17.1),
3.1.16 Specification designation,
3.1.17 End use,
3.1.18 Special requirements,
3.1.19 Special marking (See Section 16), and
3.1.20 Straightness Test Method (See 8.5 and 9.6).

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
[4] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

TABLE 1 Chemical Requirements for Standard Low-Carbon Steels[A]

NOTE 1— Chemistry represents heat analysis. Product analysis, except for rimmed or capped steel, is to be in accordance with usual practice as shown in Table 3.

Grade Designation	Chemical Composition Limits, %			
	Carbon	Manganese	Phosphorus, max	Sulfur, max
MT[B] 1010	0.02–0.15	0.30–0.60	0.035	0.035
MT 1015	0.10–0.20	0.30–0.60	0.035	0.035
MT X 1015	0.10–0.20	0.60–0.90	0.035	0.035
MT 1020	0.15–0.25	0.30–0.60	0.035	0.035
MT X 1020	0.15–0.25	0.70–1.00	0.035	0.035

[A] Rimmed or capped steels which may be used for the above grades are characterized by a lack of uniformity in their chemical composition, and for this reason product analysis is not technologically appropriate unless misapplication is clearly indicated.
[B] The letters MT under grade designation indicate Mechanical Tubing.

4. Materials and Manufacture

4.1 The steel may be made by any process.

4.2 If a specific type of melting is required by the purchaser, it shall be as stated on the purchase order.

4.3 The primary melting may incorporate separate degassing or refining, and may be followed by secondary melting, such as electroslag or vacuum-arc remelting. If secondary melting is employed, the heat shall be defined as all of the ingots remelted from a single primary heat.

4.4 Steel may be cast in ingots or may be strand cast. When steel of different grades is sequentially strand cast, identification of the resultant transition material is required. The producer shall remove the transition material by an established procedure that positively separates the grades.

4.5 Tubes shall be made by the electric-resistance-welded process and shall be made from hot- or cold-rolled steel as specified.

5. Chemical Composition

5.1 The steel shall conform to the requirements as to chemical composition prescribed in Table 1 or Table 2 (See Specification A1040). If no grade is specified, Grades MT 1010 to MT 1020 may be furnished. Analyses of steels other than those listed are available. To determine their availability, the purchaser should contact the producer.

5.2 When a carbon steel grade is ordered under this specification, supplying an alloy grade that specifically requires the addition of any element other than those listed for the ordered grade in Tables 1 and 2 is not permitted.

5.3 Mechanical tubing with improved ductility may be produced from Drawing Steel (Types A and B), Deep Drawing Steel, or Extra Deep Drawing Steels identified in Specifications A1008/A1008M, A1011/A1011M, or A1039/A1039M. Those Specifications offer guidance in the form of nonmandatory Typical Ranges of Mechanical Properties.

6. Heat Analysis

6.1 An analysis of each heat of steel shall be made by the steel manufacturer to determine the percentages of the elements specified; if secondary melting processes are employed, the heat analysis shall be obtained from one remelted ingot or the product of one remelted ingot of each primary melt. The heat analysis shall conform to the requirements specified, except that where the heat identity has not been maintained or where the analysis is not sufficiently complete to permit conformance to be determined,

TABLE 2 Chemical Requirements for Other Carbon and Alloy Steels[A]

NOTE 1—Chemistry represents heat analysis. Product analysis, except for rimmed or capped steel, is to be in accordance with usual practice as shown in Table 3.

Grade Designation	Chemical Composition Limits, %							
	Carbon	Manganese	Phosphorus, max	Sulfur, max	Silicon	Nickel	Chromium	Molybdenum
1008	0.10 max	0.50 max	0.035	0.035	...	...	...	...
1009	0.15 max	0.60 max	0.035	0.035	...	...	...	...
1010	0.08–0.13	0.30–0.60	0.035	0.035	...	...	...	...
1012	0.10–0.15	0.30–0.60	0.035	0.035	...	...	...	...
1015	0.13–0.18	0.30–0.60	0.035	0.035	...	...	...	...
1016	0.13–0.18	0.60–0.90	0.035	0.035	...	...	...	...
1017	0.15–0.20	0.30–0.60	0.035	0.035	...	...	...	...
1018	0.15–0.20	0.60–0.90	0.035	0.035	...	...	...	...
1019	0.15–0.20	0.70–1.00	0.035	0.035	...	...	...	...
1020	0.18–0.23	0.30–0.60	0.035	0.035	...	...	...	...
1021	0.18–0.23	0.60–0.90	0.035	0.035	...	...	...	...
1022	0.18–0.23	0.70–1.00	0.035	0.035	...	...	...	...
1023	0.20–0.25	0.30–0.60	0.035	0.035	...	...	...	...
1024	0.18–0.25	1.30–1.65	0.035	0.035	...	...	...	...
1025	0.22–0.28	0.30–0.60	0.035	0.035	...	...	...	...
1026	0.22–0.28	0.60–0.90	0.035	0.035	...	...	...	...
1027	0.22–0.29	1.20–1.55	0.035	0.035	...	...	...	...
1030	0.28–0.34	0.60–0.90	0.035	0.035	...	...	...	...
1033	0.30–0.36	0.70–1.00	0.035	0.035	...	...	...	...
1035	0.32–0.38	0.60–0.90	0.035	0.035	...	...	...	...
1040	0.37–0.44	0.60–0.90	0.040	0.050	...	...	...	...
1050	0.48–0.55	0.60–0.90	0.040	0.050	...	...	...	...
1060	0.55–0.65	0.60–0.90	0.040	0.050	...	...	...	...
1340	0.38–0.43	1.60–1.90	0.035	0.040	0.15–0.35	...	...	...
1524	0.19–0.25	1.35–1.65	0.040	0.050	...	...	...	...
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
4140	0.38–0.43	0.75–1.00	0.035	0.040	0.15–0.35	...	0.80–1.10	0.15–0.25
5130	0.28–0.33	0.70–0.90	0.035	0.040	0.15–0.35	...	0.80–1.10	...
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
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

[A] Where the ellipsis (...) appears in this table, there is no requirement.

the chemical composition determined from a product analysis made by the tubular manufacturer shall conform to the requirements specified for heat analysis. When requested in the order or contract, a report of such analysis shall be furnished to the purchaser.

7. Product Analysis

7.1 When requested on the purchase order, a product analysis shall be made by the supplier. The number and source of samples for such product analysis shall be based on the individual heat or lot identity of one of the following forms of material:

7.1.1 *Heat Identity Maintained*—One product analysis per heat shall be made on either the flat-rolled stock or tube.

7.1.2 *Heat Identity Not Maintained* —A product from one tube per 2000 ft ~~(610 m)~~[600 m] or less for sizes over 3 in. ~~(76.2 mm),~~[75 mm], and one tube per 5000 ft ~~(150 m)~~[1500 m] or less for sizes 3 in. [75 mm] and under.

7.2 Samples for product analysis except for spectrochemical analysis shall be taken in accordance with Practice E1806. The composition thus determined shall correspond to the requirements of ~~Tables 1-3~~Tables 1 and 2.

7.3 If the original test for product analysis fails, retests of two additional lengths of flat-rolled stock or tubes shall be made. Both retests for the elements in question shall meet the requirements of the specification; otherwise, all remaining material in the heat or lot shall be rejected or, at the option of the producer, each length of flat-rolled stock or tube may be individually tested for acceptance. Lengths of flat-rolled stock or tubes which do not meet the requirements of the specification shall be rejected.

8. Permissible Variations in Dimensions for Round Tubing

8.1 *Diameter and Wall Thickness (Hot-Rolled Steel)*—Variations from specified outside diameter for "as-welded" and "as-welded and annealed" tubing made from hot-rolled steel shall not exceed the amounts prescribed in Table 4. Permissible variations in outside diameter for tubing that has been sink-drawn for closer tolerance on outside diameter are shown in Table 5. Permissible variations in wall thickness for tubing that has been sink-drawn for closer tolerances on outside diameters are ±10 % of the nominal wall or ±0.010 in. (0.25 mm), whichever is greater. Permissible variations in wall thickness for tubing made from hot-rolled steel are shown in ~~Table 6~~Tables 6 and 7. Permissible variation in outside and inside diameter for tubing made from hot-rolled steel that has been Drawn Over a Mandrel (DOM) for closer tolerances are shown in Table 5 with wall tolerances shown in ~~Table 7~~Tables 8 and 9.

8.2 *Diameter and Wall Thickness (Cold-Rolled Steel)*—Variations in outside diameter and inside diameter of "as-welded" and "as-welded and annealed" tubing made from cold-rolled steel are shown in ~~Table 8~~Table 10. Outside diameter tolerances for cold-rolled steel tubing, sink drawn and DOM, are shown in Table 5. Wall thickness tolerances for" as-welded" tubing made from cold-rolled steel are shown in ~~Table 9~~Tables 11 and 12. Permissible variations in wall thickness for round tubing, DOM for closer tolerances, are shown in ~~Table 7~~Tables 8 and 9. Permissible variations in wall thickness for tubing that has been sink-drawn for closer tolerances on outside diameter are ±10 % of the nominal wall or ±0.010 in. (0.25 mm), whichever is greater.

8.3 *Length (Hot- and Cold-Rolled Steel)*—Mechanical tubing is commonly furnished in mill lengths 5 ft (1.5 m) and over. Definite cut lengths are furnished when specified by the purchaser. Tolerances for definite cut lengths round tubing shall be as given in ~~Tables 10 and~~ Tables 13 and ~~11~~14.

8.4 *Squareness of Cut (Hot- and Cold-Rolled Steel)*—When specified, tolerance for squareness of cut of round tubing shall be as given in ~~Table 12~~Table 15. Measurements are made with use of an "L" square and feeler ~~gage. Side~~ gauge. The long leg (blade)

TABLE 3 Tolerances for Product Analysis for Steels Shown in Tables 1 and 2[A,B]

Element	Limit, or Maximum of Specified Range, %	Variation, Over the Maximum Limit or Under the Minimum Limit	
		Under min, %	Over max, %
Carbon	to 0.15, incl	0.02	0.03
	over 0.15 to 0.40, incl	0.03	0.04
	over 0.40 to 0.55, incl	0.03	0.05
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
Nickel	to 1.00, incl	0.03	0.03
Chromium	to 0.90, incl	0.03	0.03
	over 0.90 to 2.10, incl	0.05	0.05
Molybdenum	to 0.20, incl	0.01	0.01
	over 0.20 to 0.40, incl	0.02	0.02

[A] Individual determinations may vary from the specified heat limits or ranges to the extent shown in this table, except that any element in a heat may not vary both above and below a specified range.

[B] Where the ellipsis (...) appears in this table, there is no requirement.

TABLE 4 Diameter Tolerances for Type I (A.W.H.R.) Round Tubing

NOTE 1—Measurements for diameter are to be taken at least 2 in.A [50 mm] from the ends of the tubes.

Outside Diameter Range, in.A in. [mm]	Wall Thickness		–	Flash-in-Tubing BA,CB	Flash Controlled to Co 0.010 in. maxtrolled to 0.010 in. (0.26 mm) max Tubing CB,DC	Flash Controlled to 0.005 in. max (0.13 mm). max Tubing EC,D		
	Bwg FE	in.A	– (mm)	Outside Diameter, ±	Outside Diameter, ±	Outside Diameter, ±	Inside Diameter, ±	
			Tolerances, in.AF,G					
			in. (mm)	in. (mm)	in. (mm)	in. (mm)		
½ to 1⅛, incl	16	to 1 0	0.065 to0.134	–	–0.0035	–0.0035	–0.00350.020	
½ to 1⅛, incl [15 to 30]	16 to 10	0.065 to 0.134 (1.7 to 3.4)	0.0035 (0.09)	0.0035 (0.09)	0.0035 (0.09)	0.02035	– (0.51)	
Over 1⅛ to 2, incl	16	to14	0.065 to0.083		0.005	0.005	0.0050.021	
Over 1⅛ to 2, incl [30 to 50]	16 to 14	0.065 to 0.083 (1.7 to 2.1)	0.005 (0.13)	0.005 (0.13)	0.005 (0.13)	0.021 (05	0.53)	
Over 1⅛ to 2, incl	13	to 7	0.095 to0.180		0.005	0.0050.005	0.025	
Over 1⅛ to 2, incl [30 to 50]	13 to 7	0.095 to 0.180 (2.4 to 4.6)	0.005 (0.13)	0.005 (0.13)	0.005 (0.13)	0.025 (0.005	0.02564)	
Over 1⅛ to 2, incl	6	to5	0.203 to0.220		0.005	0.005	0.005	0.029
Over 1⅛ to 2, incl [30 to 50]	6 to 5	0.203 to 0.220 (5.2 to 5.6)	0.005 (0.13)	0.005 (0.13)	0.005 (0.13)	0.005	0.005	0.029 (0.74)
Over 1⅛ to 2, incl	4	to 3	0.238 to0.259		0.005	0.005.99)		
Over 1⅛ to 2, incl [30 to 50]	4 to 3	0.238 to 0.259 (6.0 to 6.6)	0.005 (0.13)	0.005 (0.13)	0.005 (0.13)	0.039 (0.99)		
	0.005	0.039 0.039						
Over 2 to 2½, incl	16	to14	0.065 to0.083	–	0.006	0.006	0.0060.022	
Over 2 to 2½, incl [50 to 65]	16 to 14	0.065 to 0.083 (1.7 to 2.1)	0.006 (0.15)	0.006 (0.15)	0.006 (0.15)	0.022 (06	0.56)	
Over 2 to 2½, incl	13	to 5	0.095 to0.220		0.006	0.006	0.0060.024	
Over 2 to 2½, incl [50 to 65]	13 to 5	0.095 to 0.220 (2.4 to 5.6)	0.006 (0.15)	0.006 (0.15)	0.006 (0.15)	0.024 (06	0.61)	
Over 2 to 2½, incl	4	to 3	0.238 to0.259		0.006	0.006	0.006	0.040
Over 2 to 2½, incl [50 to 65]	4 to 3	0.238 to 0.259 (6.0 to 6.6)	0.006 (0.15)	0.006 (0.15)	0.006 (0.15)	0.0406	0 (1.006	0.0402)
Over 2½ to 3, incl	16	to14	0.065 to0.083		0.008	0.008	0.008	0.024
Over 2½ to 3, incl [65 to 75]	16 to 14	0.065 to 0.083 (1.7 to 2.1)	0.008 (0.20)	0.008 (0.20)	0.008 (0.20)	0.008	0.008	0.024 (0.61)
Over 2½ to 3, incl	13	to 5	0.095 to0.220		0.008	0.008	0.008	0.026
Over 2½ to 3, incl [65 to 75]	13 to 5	0.095 to 0.220 (2.4 to 5.6)	0.008 (0.20)	0.008 (0.20)	0.008 (0.20)	0.026 (08	0.008	0.0266)
Over 2½ to 3, incl	4	to 3	0.238 to0.259		0.008	0.008	0.008	0.040
Over 2½ to 3, incl [65 to 75]	4 to 3	0.238 to 0.259 (6.0 to 6.6)	0.008 (0.20)	0.008 (0.20)	0.008 (0.20)	0.0408	0 (1.008	0.0402)
Over 2½ to 3, incl	2	to 0.320	0.284 to0.320		0.010	0.010.22)		
Over 2½ to 3, incl [65 to 75]	2 to 0.320 [8.1]	0.284 to 0.320 (7.2 to 8.1)	0.010 (0.25)	0.010 (0.25)	0.010 (0.25)	0.048 (1.22)		
	0.010	0.048 0.048						
Over 3 to 3½, incl	16	to14	0.065 to0.083	–	0.009	0.009	0.009	0.025
Over 3 to 3½, incl [75 to 90]	16 to 14	0.065 to 0.083 (1.7 to 2.1)	0.009 (0.23)	0.009 (0.23)	0.009 (0.23)	0.009	0.009	0.025 (0.64)
Over 3 to 3½, incl	13	to 5	0.095 to0.220		0.009	0.009	0.0090.027	
Over 3 to 3½, incl [75 to 90]	13 to 5	0.095 to 0.220 (2.4 to 5.6)	0.009 (0.23)	0.009 (0.23)	0.009 (0.23)	0.027 (09	0.69)	
Over 3 to 3½, incl	4	to 3	0.238 to0.259		0.009	0.009	0.0090.043	
Over 3 to 3½, incl [75 to 90]	4 to 3	0.238 to 0.259 (6.0 to 6.6)	0.009 (0.23)	0.009 (0.23)	0.009 (0.23)	0.009	043 (1.09)	
Over 3 to 3½, incl	2	to 0.360	0.284 to0.360		0.012	0.0127)		
Over 3 to 3½, incl [75 to 90]	2 to 0.360 [9.1]	0.284 to 0.360 (7.2 to 9.1)	0.012 (0.30)	0.012 (0.30)	0.012 (0.30)	0.050 (1.27)		
	0.012	0.050 0.050						
Over 3½ to 4, incl	16	to14	0.065 to0.083	–	0.010	0.0100.010	0.026	
Over 3½ to 4, incl [90 to 100]	16 to 14	0.065 to 0.083 (1.7 to 2.1)	0.010 (0.25)	0.010 (0.25)	0.010 (0.25)	0.026 (0.010	0.0266)	
Over 3½ to 4, incl	13	to 5	0.095 to0.220		0.010	0.0100.010	0.028	
Over 3½ to 4, incl [90 to 100]	13 to 5	0.095 to 0.220 (2.4 to 5.6)	0.010 (0.25)	0.010 (0.25)	0.010 (0.25)	0.028 (0.010	0.072)	
Over 3½ to 4, incl	4	to 3	0.238 to0.259		0.010	0.010	0.010	0.044
Over 3½ to 4, incl [90 to 100]	4 to 3	0.238 to 0.259 (6.0 to 6.6)	0.010 (0.25)	0.010 (0.25)	0.010 (0.25)	0.044 (10	0.10	0.0442)
Over 3½ to 4, incl	2	to 0.500	0.284 to0.500		0.015	0.015)		
Over 3½ to 4, incl [90 to 100]	2 to 0.500 [12.7]	0.284 to 0.500 (7.2 to 12.7)	0.015 (0.38)	0.015 (0.38)	0.015 (0.38)	0.053 (1.35)		
	0.015	0.053 0.053						
Over 4 to 5, incl	16	-						
to14	0.065 to 0.083	–	0.020	0.020	0.020	0.036		
Over 4 to 5, incl [100 to 130]	16 to 14	0.065 to 0.083 (1.7 to 2.1)	0.020 (0.51)	0.020 (0.51)	0.020 (0.51)	0.036 (0.91)		
Over 4 to 5, incl	13	to 5	0.095 to 0.220		0.020	0.0245 (1.14)		
Over 4 to 5, incl [100 to 130]	13 to 5	0.095 to 0.220 (2.4 to 5.6)	0.020 (0.51)	0.020 (0.51)	0.020 (0.51)	0.045 (1.14)		
Over 4 to 5, incl [10	0.020	0. 045Over 4 to 5, incl	4	to 3	0.238 to0.259	0.054 (1.37)		
Over 4 to 5, incl [100 to130]	4 to 3	0.238 to 0.259 (6.0 to 6.6)	0.020 (0.51)	0.020 (0.51)	0.020 (0.51)	0.054 (1.37)		
Over 4 to 5, incl [100 to 130]	0.020	0.02 0	0.020	0.054				
Over 4 to 5, incl [100 to 130]	2 to 0.500 [12.7]	0.284 to 0.500 (7.2 to 12.7)	0.020 (0.51)	0.020 (0.54				
Over 4 to 5, incl	2	to0.50058 (1.47)						

TABLE 4 *Continued*

Outside Diameter Range, in.[A] in. [mm]	Wall Thickness Bwg[FE]	in.A	– (mm)	Flash-in-Tubing[BA,CB] Outside Diameter, ±	Flash Controlled t Co 0.010 in. maxtrolled to 0.010 in. (0.26 mm) max Tubing[CB,DC] Outside Diameter, ±	Flash Controlled to 0.005 in. max (0.13 mm). max Tubing[EC,D] Outside Diameter, ±	Inside Diameter, ±	
			Tolerances, in.[AF,G] in. (mm)	in. (mm)	in. (mm)	in. (mm)		
Over 4 to 5, incl1)	0.020 (0.51)	0.058 (1.47)						
	0.284 to 0.500		0.020	0.020	0.020	0.058		
Over 5 to 6, incl [130 to 150]	16 to 10	0.065 to 0.134 (1.7 to 3.4)	0.020 (0.51)					
Over5 to 6, incl	16	0.036 (0.91)						
0.020 (0.51)	0.020 (0.51)	0.036 (0.91)						
Over 5 to10	0.065 to 0.134	–	0.020	0.020	0.020	0.036		
Over 5 to 6, incl [130 to 150]	9 to 5	0.148 to 0.220 (3.8 to 5.6)	0.020 (0.51)	0.020 (0.51)	0.020 (0.51)	0.040 (10.02)		
Over 5 to 6, incl	9	to5	0.148 to0.220		0.020	0.0254 (1.37)		
Over 5 to 6 incl [130 to 150]	4 to 3	0.238 to 0.259 (6.0 to 6.6)	0.020 (0.51)	0.020 (0.51)	0.020 (0.51)	0.054 (1.37)		
Over 5 to 6, incl [130	0.020	0.04 0Over5 to 6 incl	4	to 3	0.238 to0.259			
Over 5 to 6, incl [130 to 150]	2 to 0.500 [12.7]	0.284 to 0.500 (7.2 to 12.7)	0.020 (0.51)	0.020 (0.51)	0.020 (0.51)	0.058 (1.47)		
	0.020	0.020	0.020	0.054				
				0.054				
Over 5 to 6, incl	2	-						
Over 5 to 6, incl								
to 0.500	0.284 to 0.500		0.020	0.020	0.020	0.058		
Over 6 to 8, incl [150 to 200]	11 to 10	0.120 to 0.134 (3.0 to 3.4)	0.025 (0.64)	0.025 (0.64)	0.025 (0.64)	0.043 (1.09)		
Over 6 to 8, incl [150 to 200]	9 to 5	0.148 to 0.220 (3.8 to 5.6)	0.025 (0.64)					
Over6 to 8, incl	11	0.045 (1.14)						
0.025 (0.64)	0.025 (0.64)	0.045 (1.14)						
Over 6 to10	0.120 to 0.1 34	–	0.025	0.025	0.025	0.043		
Over 6 to 8, incl [150 to 200]	4 to 3	0.238 to 0.259 (6.0 to 6.6)	0.025 (0.64)	0.025 (0.64)	0.025 (0.64)	0.059 (1.50)		
Over 6 to 8, incl	9	to5	0.148 to0.220		0.025	0.02563 (1.60)		
Over 6 to 8, incl [150 to 200]	2 to 0.500 [12.7]	0.284 to 0.500 (7.2 to 12.7)	0.025 (0.64)	0.025 (0.64)	0.025 (0.64)	0.063 (1.60)		
	0.025	0.045						
		0.045						
Over 6 to 8, incl	4	to 3	0.238 to 0.259					
Over 6 to 8, incl								
Over 8 to 10, incl [200 to 250]	0.025	0.025	0.025	0.059				
Over 8 to 10, incl [200 to 250]	14 to 12	0.083 to 0.109 (2.1 to 2.8)	0.030 (0.76)	0.059				
Over6 to 8, incl	2	0.041 (1.04)						
Over30 (0.76)	0.030 (0.76)	0.041 (1.04)						
Over 8 to0.500	0.284 to 0.500		0.025	0.025	0.025	0.063		
Over 8 to 10, incl [200 to 250]	11 to 10	0.120 to 0.134 (3.0 to 3.4)	0.030 (0.76)	0.030 (0.76)	0.030 (0.76)	0.043 (1.09)		
Over 8 to 10, incl [200 to 250]	9 to 5	0.148 to 0.220 (3.8 to 5.6)	0.030 (0.76)	0.030 (0.76)	0.030 (0.76)	0.045 (1.14)		
Over 8 to 10, incl	14	to 12	0.083 to0.109		0.030	0.030	0.030	0.041
Over 8 to 10, incl [200 to 250]	4 to 3	0.238 to 0.259 (6.0 to 6.6)	0.030 (0.76)		0.030 (0.76)	0.030 (0.76)	0.0300	059 (1.50)
Over 8 to 10, incl	11	to 1 0	0.120 to0.134		0.030	0.030	0.030	0.043
Over 8 to 10, incl [200 to 250]	2 to 0.500 [12.7]	0.248 to 0.500 (7.2 to 12.7)	0.030 (0.76)		0.030 (0.76)	0.030 (0.76)	0.0630	0 (1.60)
Over 8 to 10, incl	9	to 5	0.148 to 0.220		0.030	0.030	0.030	0.045
							0.030	0.045
Over 8 to 10, incl	4	to 3	0.238 to0.259		0.030	0.030	0.030	0.059
Over 10 to 12, incl [250 to 300]	14 to 12	0.083 to 0.109 (2.1 to 2.8)	0.035 (0.89)		0.035 (0.89)	0.035 (0.89)	0.0300	041 (1.04)
Over 8 to 10, incl	2	to 0.500	0.248 to0.500		0.030	0.030	0.030	0.063
Over 10 to 12, incl [250 to 300]	11 to 10	0.120 to 0.134 (3.0 to 3.4)	0.035 (0.89)		0.035 (0.89)	0.035 (0.89)	0.0430	0 (1.09)
Over 10 to 12, incl [250 to 300]	9 to 5	0.148 to 0.220 (3.8 to 5.6)	0.035 (0.89)	0.035 (0.89)	0.035 (0.89)	0.045 (1.14)		
Over 10 to 12, incl	14	to 12	0.083 to0.109		0.035	0.035	0.0350.041	
Over 10 to 12, incl [250 to 300]	4 to 3	0.238 to 0.259 (6.0 to 6.6)	0.035 (0.89)		0.035 (0.89)	0.035 (0.89)	0.059 (1.50)	
Over 10 to 12, incl	11	to 1 0	0.120 to0.134		0.035	0.035	0.035	0.043

TABLE 4 *Continued*

Outside Diameter Range, in.[A] in. [mm]	Wall Thickness		–	Flash-in-Tubing[B,A,C,B]	Flash Controlled to 0.010 in. (0.26 mm) max Tubing[C,B,D,C]	Flash Controlled to 0.005 in. (0.13 mm). max Tubing[E,C,D]		
	Bwg[F,E]	in.[A]	– (mm)	Outside Diameter, ±	Outside Diameter, ±	Outside Diameter, ±	Inside Diameter, ±	
				Tolerances, in.[A,F,G]				
			in. (mm)	in. (mm)	in. (mm)	in. (mm)		
Over 10 to 12, incl [250 to 300]	2 to 0.500 [12.7]	0.284 to 0.500 (7.2 to 12.7)	0.035 (0.89)		0.035 (0.89)	0.035 (0.89)	0.0635	0 (1.60)
Over 10 to 12, incl	9	to 5	0.148 to 0.220		0.035	0.035	0.035	0.045
Over 10 to 12, incl	4	to 3	0.238 to0.259		0.035	0.035	0.035 0.059	0.045
Over 12 to 15, incl [300 to 380]	14 to 12	0.083 to 0.109 (2.1 to 2.8)	0.040 (1.02)		0.040 (1.02)	0.040 (1.02)	0.058 (1.47)	
Over 10 to 12, incl	2	to 0.500	0.284 to0.500		0.035	0.0358 (1.47)		
Over 12 to 15, incl [300 to 380]	11 to 10	0.120 to 0.134 (3.0 to 3.4)	0.040 (1.02)	0.040 (1.02)	0.040 (1.02)	0.058 (1.47)		
Over 12 to 15, incl [300 to 380]	0.03 5	0. 063						
Over 12 to 15, incl [300 to 380]	9 to 5	0.148 to 0.220 (3.8 to 5.6)	0.040 (1.02)	0.040 (1.02)	0.040 (1.02)	0.060 (1.52)		
Over 12 to 15, incl	14	to 12	0.083 to0.109		0.040	0.040	0.040	0.058
Over 12 to 15, incl [300 to 380]	4 to 3	0.238 to 0.259 (6.0 to 6.6)	0.040 (1.02)	0.040 (1.02)	0.040 (1.02)	0.0740	0 (1.040	0.0588)
Over 12 to 15, incl	11	to 1 0	0.120 to 0.134		0.040	0.040	0.040	0.058
Over 12 to 15, incl [300 to 380]	2 to 0.500 [12.7]	0.284 to 0.500 (7.2 to 12.7)	0.120 to 0.134		0.040	0.040	0.040	0.058
Over 12 to 15, incl		9 to 5	0.148 to 0.220		0.040	0.040	0.040	0.060
Over 12 to 15, incl		90.040 (1.02)	0.148 to 0.220		0.040	0.040	0.040	0.060
Over 12 to 15, incl		4 to 3	0.238 to 0.259		0.040	0.040	0.040	0.074
Over 12 to 15, incl		40.040 (1.02)	0.238 to 0.259		0.040	0.040	0.040	0.074
Over 12 to 15, incl		2 to0.500	0.284 to0.500		0.040	0.040	0.040	0.086
Over 12 to 15, incl		20.040 (1.02)	0.0.500		0.040	0.040	0.040	0.086 (2.18)

[A] 1Flash-In-Tubing is produced only to outside diameter tolerances and wall thickness tolerances and the inside diameter welding flash does not exceed the wall thickness or 3⁄32 in.= (25.4 mm), whichever is less.

[B] Flash-I Con-Ttrolled to 0.010 in. (0.25 mm) maximum tubing consists of tubing which is commonly produced only to outside diameter tolerances and wall thickness tolerances a, ind which the insid he diameght of the remaining welding flash d is controlled not to exceed the wall thickness or 3⁄32 in 0., wh010 ichever is lessn.

[C] Flash Controlled to 0.0105 in. (0.13 mm) maximum tubing cons ists of tubing which is commonly produced only to outside diameters and wall thickness tolerance, inside diameter and wall thickness tolerances, or outside diameters and inside diameter tolerances, in which the height of the remaining welding flash is controlled not to exceed 0.0105 in. Any remaining flash is considered to be part of the applicable inside diameter tolerances.

[D] No Flash tubing is further processed by DOM for closer tolerances, produced to outside diameter and wall, inside diameter and wall, or outside diameter and inside diameter, with no dimensional indication of inside diameter flash, and is available in Types 5 and 6.

[E] Flash Controlled to 0.005Bin.rmaximum tubing is produced to outside diameters and wall thickness tolerance, inside diameter and wall th Wickness tolerances, or outside di Gameters and inside diameter tolerances, in which the heiught 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.

[F] Birmingham Wire Gage.

[G] The ovality shall be within the above tolerances except when the wall thickness is less than 3 % of the outside diameter, in such cases see 8.6.1.

of the square to be equal to tube diameter except plus a minimum length of 1 in. (25.4 mm) and maximum length of 4 in. (101.6 mm). Outside diameter burr to be removed for measurement.

8.5 *Straightness*— The straightness tolerance for round tubing is 0.030 in./3 ft (0.76 mm/1m)[0.75 mm/1m] lengths to 8.000 in. (203 mm)[200 mm] outside diameter. For 8.000 in. [200 mm] outside diameter and above, straightness tolerance is 0.060 in./3 ft (1.52[1.5 mm/1 m)m] lengths. For lengths under 1 ft [305 mm] the straightness tolerance shall be agreed upon between the purchaser and producer. The test method for straightness measurement is at the manufacturer's option, unless a specific test method is specified in the purchase order.

8.6 *Ovality (Hot- and Cold-Rolled Steel)*—The ovality shall be within the tolerances except when the wall thickness is less than 3 % of the outside diameter.

8.6.1 In such cases for Types 1 and 2 (A.W.H.R. and A.W.C.R.) the ovality may be 50 % greater than the outside tolerances but the mean outside diameter shall be within the specified tolerance.

8.6.2 For Types 3, 4, 5, and 6 (S.D.H.R., S.D.C.R., DOM, and S.S.I.D.) the additional ovality shall be as follows but the mean outside diameter shall be within the specified tolerance:

TABLE 5 Diameter Tolerances for Types 3, 4, 5, and 6 (S.D.H.R., S.D.C.R., DOM, and S.S.I.D) Round Tubing

NOTE 1—Measurements for diameter are to be taken at least 2 in. [50 mm] from the ends of the tubes.

OD Size Range[A] in. (mm)	Wall- % of OD	Types 3, 4, (Sink Drawn)[A,B] and 5, 6, (DOM)[B,C] OD, in.		Types 5 and 6 (DOM)[B,C], ID in.	
		Over in. (mm)	Under in. (mm)	Over in. (mm)	Under in. (mm)
Up to 0.499 (12.67)	all	0.004 (0.10)	0.000 (0.00)	. . .	. . .
0.500 to 1.699 (12.70 to 43.15)	all	0.005 (0.13)	0.000 (0.00)	0.000 (0.00)	0.005 (0.13)
1.700 to 2.099 (43.18 to 53.31)	all	0.006 (0.15)	0.000 (0.00)	0.000 (0.00)	0.006 (0.15)
2.100 to 2.499 (53.34 to 63.47)	all	0.007 (0.18)	0.000 (0.00)	0.000 (0.00)	0.007 (0.18)
2.500 to 2.899 (63.50 to 73.63)	all	0.008 (0.20)	0.000 (0.00)	0.000 (0.00)	0.008 (0.20)
2.900 to 3.299 (73.66 to 83.79)	all	0.009 (0.23)	0.000 (0.00)	0.000 (0.00)	0.009 (0.23)
3.300 to 3.699 (83.82 to 93.95)	all	0.010 (0.25)	0.000 (0.00)	0.000 (0.00)	0.010 (0.25)
3.700 to 4.099 (93.98 to 104.11)	all	0.011 (0.28)	0.000 (0.00)	0.000 (0.00)	0.011 (0.28)
4.100 to 4.499 (104.14 to 114.27)	all	0.012 (0.30)	0.000 (0.00)	0.000 (0.00)	0.012 (0.30)
4.500 to 4.899 (114.30 to 124.43)	all	0.013 (0.33)	0.000 (0.00)	0.000 (0.00)	0.013 (0.33)
4.900 to 5.299 (124.46 to 134.59)	all	0.014 (0.36)	0.000 (0.00)	0.000 (0.00)	0.014 (0.36)
5.300 to 5.549 (134.62 to 140.94)	all	0.015 (0.38)	0.000 (0.00)	0.000 (0.00)	0.015 (0.38)
5.550 to 5.999 (140.97 to 152.37)	under 6	0.010 (0.25)	0.010 (0.25)	0.010 (0.25)	0.010 (0.25)
—	6 and over	0.009	0.009	0.009	0.009
—	6 and over	0.009 (0.23)	0.009 (0.23)	0.009 (0.23)	0.009 (0.23)
6.000 to 6.499 (152.40 to 165.07)	under 6	0.013 (0.33)	0.013 (0.33)	0.013 (0.33)	0.013 (0.33)
—	6 and over	0.010	0.010	0.010	0.010
—	6 and over	0.010 (0.25)	0.010 (0.25)	0.010 (0.25)	0.010 (0.25)
6.500 to 6.999 (165.10 to 177.77)	under 6	0.015 (0.38)	0.015 (0.38)	0.015 (0.38)	0.015 (0.38)
—	6 and over	0.012	0.012	0.012	0.012
—	6 and over	0.012 (0.30)	0.012 (0.30)	0.012 (0.30)	0.012 (0.30)
7.000 to 7.499 (177.80 to 190.47)	under 6	0.018 (0.46)	0.018 (0.46)	0.018 (0.46)	0.018 (0.46)
—	6 and over	0.013	0.013	0.013	0.013
—	6 and over	0.013 (0.33)	0.013 (0.33)	0.013 (0.33)	0.013 (0.33)
7.500 to 7.999 (190.50 to 203.17)	under 6	0.020 (0.51)	0.020 (0.51)	0.020 (0.51)	0.020 (0.51)
—	6 and over	0.015	0.015	0.015	0.015
—	6 and over	0.015 (0.38)	0.015 (0.38)	0.015 (0.38)	0.015 (0.38)
8.000 to 8.499 (203.20 to 215.87)	under 6	0.023 (0.58)	0.023 (0.58)	0.023 (0.58)	0.023 (0.58)
—	6 and over	0.016	0.016	0.016	0.016
—	6 and over	0.016 (0.41)	0.016 (0.41)	0.016 (0.41)	0.016 (0.41)
8.500 to 8.999 (215.90 to 228.57}	under 6	0.025 (0.64)	0.025 (0.66)	0.025 (0.66)	0.025 (0.64)
—	6 and over	0.017	0.017	0.017	0.017
	6 and over	0.017	0.017	0.017	0.017

TABLE 6 Wall Thickness Tolerance for Type I (A.W.H.R.) Round Tubing (Inch Units)

Wall ~~t~~ Thickness		Outside Diameter, ~~in.~~[A]																		
				¾ to 1, incl		Over 1 to 1 15/16, incl		Over 1 15/16 to 3¾, incl		Over 3¾ to 4½, incl		Over 4½ to 6, incl		Over 6 to 8, incl		Over 8 to 10, incl		Over 10 to 12, incl		Over 12 to 15, incl	
in.[A]	Bwg[B A]	Wall Thickness Tolerances, in., ±[C B]																			
				+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−
0.065	16	0.005	0.009	0.004	0.010	0.003	0.011	0.002	0.012	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	0.002	0.012	0.003	0.013	...	...	...	...		
0.083	14	0.006	0.010	0.005	0.011	0.004	0.012	0.003	0.013	0.003	0.013	0.003	0.013	0.003	0.013	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	0.003	0.013	0.003	0.013	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	0.003	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	0.003	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	0.003	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	0.004	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	0.004	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	0.004	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	0.005	0.017	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	0.005	0.017	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	0.010	0.022	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	0.011	0.023	0.011	0.023	0.011	0.023		
0.284	2	...	...	...	...	0.014	0.022	0.013	0.023	0.012	0.024	0.012	0.024	0.012	0.024	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	0.013	0.025	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	0.014	0.026	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	0.015	0.027	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	0.015	0.027	0.015	0.027	0.015	0.027		
0.375		...	...	...	...	...	...	0.016	0.026	0.015	0.027	0.015	0.027	0.015	0.027	0.015	0.027	0.015	0.027		
0.406		...	...	...	...	...	...	0.017	0.027	0.016	0.028	0.016	0.028	0.016	0.028	0.016	0.028	0.016	0.028		
0.438		...	...	...	...	...	...	0.017	0.027	0.016	0.028	0.016	0.028	0.016	0.028	0.016	0.028	0.016	0.028		
0.469		...	...	...	...	...	...	...	...	0.016	0.028	0.016	0.028	0.016	0.028	0.016	0.028	0.016	0.028		
0.500		...	...	...	...	...	...	...	...	0.016	0.028	0.016	0.028	0.016	0.028	0.016	0.028	0.016	0.028		

[A] ~~1~~ Birmin~~. = 25.4~~gham~~m~~ Wire Gauge.
[B] Birmingham Wire Gage.
[C] Where the ellipsis (...) appears in this table, the tolerance is not addressed.

TABLE 7 Wall Thickness Tolerance for Type I (A.W.H.R.) Round Tubing (SI Units)

Wall Thickness mm	Outside Diameter, mm: 20 to 25 mm, incl		Over 25 to 50 mm, incl		Over 50 to 95 mm, incl		Over 95 to 115 mm incl		Over 115 to 150 mm incl		Over 150 to 200 mm Incl		Over 200 to 250 mm incl		Over 250 to 305 mm Incl		Over 305 to 380 mm, incl	
	Wall Thickness Tolerances, mm, ±[A]																	
	±	−	±	−	±	−	±	−	±	−	±	−	±	−	±	−	±	−
1.65	0.13	0.23	0.10	0.25	0.08	0.28	0.05	0.30	0.05	0.30	0.05	0.30	...	...	...	...	...	...
1.83	0.13	0.23	0.10	0.25	0.08	0.28	0.05	0.30	0.05	0.30	0.05	0.30	0.08	0.33	...	...	...	...
2.11	0.15	0.25	0.13	0.28	0.10	0.30	0.08	0.33	0.08	0.33	0.08	0.33	0.08	0.33	0.08	0.33	0.08	0.33
2.41	0.15	0.25	0.13	0.28	0.10	0.30	0.08	0.33	0.08	0.33	0.08	0.33	0.08	0.33	0.08	0.33	0.08	0.33
2.77	0.15	0.25	0.13	0.28	0.10	0.30	0.08	0.33	0.08	0.33	0.08	0.33	0.08	0.33	0.08	0.33	0.08	0.33
3.05	0.15	0.25	0.13	0.28	0.10	0.30	0.08	0.33	0.08	0.33	0.08	0.33	0.08	0.33	0.08	0.33	0.08	0.33
3.40	0.15	0.01	0.13	0.28	0.10	0.30	0.08	0.33	0.08	0.33	0.08	0.33	0.08	0.33	0.08	0.33	0.08	0.33
3.76	...	...	0.15	0.30	0.13	0.33	0.10	0.36	0.10	0.36	0.10	0.36	0.10	0.36	0.10	0.36	0.10	0.36
4.19	...	...	0.15	0.30	0.13	0.33	0.10	0.36	0.10	0.36	0.10	0.36	0.10	0.36	0.10	0.36	0.10	0.36
4.57	...	...	0.16	0.30	0.13	0.33	0.10	0.36	0.10	0.36	0.10	0.36	0.10	0.36	0.10	0.36	0.10	0.36
5.16	...	...	...	...	0.18	0.38	0.15	0.41	0.13	0.43	0.13	0.43	0.13	0.43	0.13	0.43	0.13	0.43
5.59	...	...	...	...	0.18	0.38	0.15	0.41	0.13	0.43	0.13	0.43	0.13	0.43	0.13	0.43	0.13	0.43
6.05	...	...	...	...	0.30	0.51	0.28	0.53	0.25	0.56	0.25	0.56	0.25	0.56	0.25	0.56	0.25	0.56
6.58	...	...	...	...	0.33	0.53	0.30	0.56	0.28	0.58	0.28	0.58	0.28	0.58	0.28	0.58	0.28	0.58
7.21	...	...	...	...	0.36	0.56	0.33	0.58	0.30	0.61	0.30	0.61	0.30	0.61	0.30	0.61	0.30	0.61
7.62	...	...	...	...	0.38	0.58	0.36	0.61	0.33	0.64	0.33	0.64	0.33	0.64	0.33	0.64	0.33	0.64
8.13	...	...	...	...	0.41	0.61	0.38	0.64	0.36	0.66	0.36	0.66	0.36	0.66	0.36	0.66	0.36	0.66
8.74	...	...	...	...	0.43	0.64	0.41	0.66	0.38	0.69	0.38	0.69	0.38	0.69	0.38	0.69	0.38	0.69
9.14	...	...	...	...	0.43	0.64	0.41	0.66	0.38	0.69	0.38	0.66	0.38	0.66	0.38	0.66	0.38	0.66
9.53	...	...	...	...	...	...	0.41	0.66	0.38	0.69	0.38	0.69	0.38	0.69	0.38	0.69	0.38	0.69
10.31	...	...	...	...	...	...	0.43	0.69	0.41	0.71	0.41	0.71	0.41	0.71	0.41	0.71	0.41	0.71
11.13	...	...	...	...	...	...	0.43	0.69	0.41	0.71	0.41	0.71	0.41	0.71	0.41	0.71	0.41	0.71
11.91	...	...	...	...	...	...	...	...	0.41	0.71	0.41	0.71	0.41	0.71	0.41	0.71	0.41	0.71
12.70	...	...	...	...	...	...	...	...	0.41	0.71	0.41	0.71	0.41	0.71	0.41	0.71	0.41	0.71

[A] Where the ellipsis (...) appears in this table, the tolerance is not addressed.