Designation: A 513 – 08a

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

This standard is issued under the fixed designation A 513; 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) 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) wall from 0.022 to 0.134 in. (0.71 to 3.40 mm)

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

1.5 The 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.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment

A 1040 Guide for Specifying Harmonized Standard Grade Compositions for Wrought Carbon, Low-Alloy, and Alloy Steels

E 1806 Practice for Sampling Steel and Iron for Determination of Chemical Composition

E 213 Practice for Ultrasonic Examination of Metal Pipe and Tubing

E 273 Practice for Ultrasonic Examination of the Weld Zone of Welded Pipe and Tubing

E 309 Practice for Eddy-Current Examination of Steel Tubular Products Using Magnetic Saturation

E 570 Practice for Flux Leakage Examination of Ferromagnetic Steel Tubular Products

2.2 *ANSI Standard:*

B 46.1 Surface Texture[3]

2.3 *Military Standards:*

MIL-STD-129 Marking for Shipment and Storage[4]

2.4 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipments (Civil Agencies)[4]

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 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),

[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.

[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.

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

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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).

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 A 1040). 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.

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.

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, 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) or less for sizes over 3 in. (76.2 mm), and one tube per 5000 ft (150 m) or less for sizes 3 in. and under.

7.2 Samples for product analysis except for spectrochemical analysis shall be taken in accordance with Practice E 1806. The composition thus determined shall correspond to the requirements of Tables 1-3.

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. Permissible variation in outside and inside diameter for tubing

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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.

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.

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.

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. 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. Permissible variations in wall thickness for round tubing, DOM for closer tolerances, are shown in Table 7. 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 11.

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. Measurements are made with use of an "L" square and feeler gage. Side leg of square to be equal to tube diameter except 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) 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)

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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] 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,D]	Flash Controlled to 0.005 in. max Tubing[E,D]	
	Bwg[F]	in.[A]	Outside Diameter, ±	Outside Diameter, ±	Outside Diameter, ±	Inside Diameter, ±
			Tolerances, in.[A,G]			
½ to 1⅛ , incl	16 to 10	0.065 to 0.134	0.0035	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
Over 8 to 10, incl	14 to 12	0.083 to 0.109	0.030	0.030	0.030	0.041
Over 8 to 10, incl	11 to 10	0.120 to 0.134	0.030	0.030	0.030	0.043
Over 8 to 10, incl	9 to 5	0.148 to 0.220	0.030	0.030	0.030	0.045
Over 8 to 10, incl	4 to 3	0.238 to 0.259	0.030	0.030	0.030	0.059
Over 8 to 10, incl	2 to 0.500	0.248 to 0.500	0.030	0.030	0.030	0.063
Over 10 to 12, incl	14 to 12	0.083 to 0.109	0.035	0.035	0.035	0.041
Over 10 to 12, incl	11 to 10	0.120 to 0.134	0.035	0.035	0.035	0.043
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 to 0.259	0.035	0.035	0.035	0.059
Over 10 to 12, incl	2 to 0.500	0.284 to 0.500	0.035	0.035	0.035	0.063
Over 12 to 15, incl	14 to 12	0.083 to 0.109	0.040	0.040	0.040	0.058
Over 12 to 15, incl	11 to 10	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	4 to 3	0.238 to 0.259	0.040	0.040	0.040	0.074
Over 12 to 15, incl	2 to 0.500	0.284 to 0.500	0.040	0.040	0.040	0.086

[A] 1 in. = 25.4 mm.

[B] Flash-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., whichever is less.

[C] Flash Controlled to 0.010 in. maximum tubing consists of tubing 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] 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 0.005 in. maximum tubing is produced 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 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.

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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. from the ends of the tubes.

OD Size Range[A]	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	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 4 and 8.

[B] 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 8.6.2.

[C] Tubing produced to outside diameter and wall thickness, or inside diameter and wall thickness, or outside diameter and inside diameter, by DOM to obtain tolerances closer than those shown in Tables 4 and 8 and no dimensional indication of inside diameter flash.

lengths. For lengths under 1 ft 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:

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)

9. Permissible Variations in Dimensions of Square and Rectangular Tubing

9.1 *Diameter and Wall Thickness*—Permissible variations in outside dimensions for square and rectangular tubing shall be as given in Table 13. The wall thickness tolerance is ±10 % of the nominal wall thickness.

9.2 *Corner Radii*— Unless otherwise specified, the corners of square and rectangular tubing shall be slightly rounded inside and outside, consistent with wall thickness. The outside corners may be slightly flattened. The radii of corners shall be as given in Table 14.

9.3 *Squareness*—Permissible variations for squareness shall be determined by the following equation:

$$\pm b = c \times 0.006 \text{ in.}$$

where:

b = tolerance for out-of-square, and
c = largest external dimension across flats.

The squareness of sides is commonly determined by one of the following methods.

9.3.1 A square with two adjustable contact points on each arm, is placed on two sides. A fixed feeler gage is then used to measure the maximum distance between the free contact point and the surface of the tubing.

9.3.2 A square equipped with a direct reading vernier, may be used to determine the angular deviation which, in turn, may be related to distance in inches.

9.4 *Length*—Variations from the specified length shall not exceed the amount prescribed in Table 15.

9.5 *Twist*—Twist tolerances are shown in Table 16. The twist in square and rectangular tubing may be measured by holding one end of the tubing on a surface plate and noting the height of either corner of the opposite end of same side above the surface plate. Twist may also be measured by the use of a beveled protractor equipped with a level, and noting the angular deviation on opposite ends, or at any point throughout the length.

9.6 *Straightness*— The straightness tolerance is 1/16 in./3 ft (1.7 mm/1 m). The test method for straightness measurement is at the manufacturer's option, unless a specific test method is specified in the purchase order.

10. Tubing Sections Other Than Square and Rectangular

10.1 In addition to square and rectangular tubing, many producers supply a variety of special sections, such as oval, streamlined, hexagonal, octagonal, round inside and hexagonal or octagonal outside, ribbed inside or out, triangular, rounded

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

Wall 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]	Wall Thickness Tolerances, in., ±[C]																	
		+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−
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 in. = 25.4 mm.
[B] Birmingham Wire Gage.
[C] Where the ellipsis (...) appears in this table, the tolerance is not addressed.

TABLE 7 Wall Thickness Tolerances of Types 5 and 6 (DOM and S.S.I.D.) Round Tubing

Wall Thickness		Outside Diameter, in.[A]							
		⅜ to ⅞, incl		Over ⅞ to 1⅞, incl		Over 1⅞ to 3¾, incl		Over 3¾ to 15, incl	
in.[A]	Bwg[B]	Wall Thickness Tolerances, in.,[A,C] ±							
		+	−	+	−	+	−	+	−
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.
[C] Where the ellipsis (...) appears in this table, the tolerance is not addressed.

rectangular and D shapes. Manufacturing practices limit the size range and section available from the various producers. These special sections may be made through turkshead rolls or through a die with or without use of a mandrel. Since the sections are special, dies and other tools are not held available. Therefore, when inquiring for shapes other than square and rectangular, it is essential to give full details as to dimensions and finish.

11. Workmanship, Finish, and Appearance

11.1 The tubing shall be free of injurious defects and shall have a workmanlike finish.

11.2 When burrs must be removed from one or both ends, it shall be specified in the purchase order.

12. Types and Conditions

12.1 The types of tubing covered by this specification are:

Type Number	Code Letters	Description
1a	A.W.H.R.	"as-welded" from hot-rolled steel (with mill scale)
1b	A.W.P.O.	"as-welded" from hot-rolled pickled and oiled steel (mill scale removed)
2	A.W.C.R.	"as-welded" from cold-rolled steel
3	S.D.H.R.	"sink-drawn" hot-rolled steel
4	S.D.C.R.	"sink-drawn," cold-rolled steel
5	DOM	Drawn Over a Mandrel
6	S.S.I.D.	special smooth inside diameter

12.2 The thermal conditions under which tubing may be furnished are:

Code	Description
NA	Not Annealed; in the as-welded or as-drawn condition
SRA	Stress Relieved Annealed (at a temperature below the lower critical temperature)
N	Normalized or Annealed (at a temperature above the upper critical temperature)

12.2.1 When the thermal condition is not specified, the tube may be supplied in the NA condition.

12.2.2 When a final thermal treatment is specified, a tight oxide is normal. When an oxide-free surface is specified, the tube may be bright annealed or pickled at the manufacturer's option.

12.3 Flash conditions under which tubing may be furnished are as follows. The flash shall be removed from the outside diameter of tubing covered by this specification. Tubing furnished to this specification may have the following conditions of welding flash on the inside diameter.

12.3.1 *Flash-In*—Tubing in which the inside diameter welding flash does not exceed the wall thickness or 3⁄32 in. (2.4 mm), whichever is less. This condition is available in Types 1a, 1b, 2, 3, and 4.

12.3.2 *Flash Controlled to 0.010 in. (0.25 mm), maximum*—Tubing in which the height of the remaining welding flash is controlled so as not to exceed 0.010 in. This condition is available in Types 1a, 1b, and 2 over 1⅛-in. (28.5-mm) outside diameter and Types 3 and 4.

12.3.3 *Flash Controlled to 0.005 in. (0.13 mm), maximum*—Tubing produced to outside diameter and wall thickness, inside diameter and wall thickness, or outside diameter and inside diameter tolerances which are so controlled that the height of the remaining inside diameter flash does not exceed 0.005 in. Any remaining inside diameter flash is part of the applicable inside diameter tolerance. This condition is available in Types 1a, 1b, 2, 3, and 4.

12.3.4 *No Flash*—Tubing further processed by DOM for closer tolerances, produced to outside diameter and wall

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TABLE 8 Diameter Tolerances for Type 2 (A.W.C.R.) Round Tubing

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

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	
			Outside Diameter, ±	Outside Diameter,±	Outside Diameter, ±	Inside Diameter, ±
	Bwg[A]	in.[E]	Tolerances, in.[F,G]			
⅜ to ⅝ , incl	24 to 16	0.022 to 0.065	0.003	...	...	...
Over ⅝ to 1⅛ , incl	24 to 19	0.022 to 0.042	0.0035	0.0035	0.0035	0.013
Over ⅝ to 1⅛ , incl	18	0.049	0.0035	0.0035	0.0035	0.015
Over ⅝ to 1⅛ , incl	16 to 14	0.065 to 0.083	0.0035	0.0035	0.0035	0.019
Over ¾ to 1⅛ , incl	13	0.095	0.0035	0.0035	0.0035	0.019
Over ⅞ to 1⅛ , incl	12 to 11	0.109 to 0.120	0.0035	0.0035	0.0035	0.021
Over 1⅛ to 2, incl	22 to 18	0.028 to 0.049	0.005	0.005	0.005	0.015
Over 1⅛ to 2, incl	16 to 13	0.065 to 0.095	0.005	0.005	0.005	0.019
Over 1⅛ to 2, incl	12 to 10	0.109 to 0.134	0.005	0.005	0.005	0.022
Over 2 to 2½ , incl	20 to 18	0.035 to 0.049	0.006	0.006	0.006	0.016
Over 2 to 2½ , incl	16 to 13	0.065 to 0.095	0.006	0.006	0.006	0.020
Over 2 to 2½ , incl	12 to 10	0.109 to 0.134	0.006	0.006	0.006	0.023
Over 2½ to 3, incl	20 to 18	0.035 to 0.049	0.008	0.008	0.008	0.018
Over 2½ to 3, incl	16 to 13	0.065 to 0.095	0.008	0.008	0.008	0.022
Over 2½ to 3, incl	12 to 10	0.109 to 0.134	0.008	0.008	0.008	0.025
Over 3 to 3½ , incl	20 to 18	0.035 to 0.049	0.009	0.009	0.009	0.019
Over 3 to 3½ , incl	16 to 13	0.065 to 0.095	0.009	0.009	0.009	0.023
Over 3 to 3½ , incl	12 to 10	0.109 to 0.134	0.009	0.009	0.009	0.026
Over 3½ to 4, incl	20 to 18	0.035 to 0.049	0.010	0.010	0.010	0.020
Over 3½ to 4, incl	16 to 13	0.065 to 0.095	0.010	0.010	0.010	0.024
Over 3½ 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
Over 8 to 10, incl	16 to 13	0.065 to 0.095	0.030	0.030	0.030	0.044
Over 8 to 10, incl	12 to 10	1.109 to 0.134	0.030	0.030	0.030	0.049
Over 10 to 12, incl	14 to 13	0.083 to 0.095	0.035	0.035	0.035	0.049
Over 10 to 12, incl	12 to 10	0.109 to 0.134	0.035	0.035	0.035	0.054

[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 3⁄32 in., whichever is less.

[C] Flash Controlled to 0.010 in. maximum tubing consists of tubing over ⅝ 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. 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.

[E] Birmingham Wire Gage.

[F] 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.

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

thickness, inside diameter and wall thickness, or outside diameter and inside diameter to tolerances, with no dimensional indication of inside diameter flash, is available in Types 5 and 6.

12.4 Tubes shall be furnished in the following shapes, as specified by the purchaser: round, square, rectangular, or special shapes (as negotiated).

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TABLE 9 Wall Thickness Tolerances for Type 2 (A.W.C.R.) Round Tubing

Wall Thickness		Outside Diameter, in.[A]															
		⅜ to ⅞, incl		Over ⅞ to 1⅞, incl		Over 1⅞ to 3¾, incl		Over 3¾ to 5, incl		Over 5 to 6, incl		Over 6 to 8, incl		Over 8 to 10, incl		Over 10 to 12, incl	
in.[A]	Bwg[B]	Wall Thickness Tolerances, in.,[A,C] ±															
		+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−
0.022	24	0.001	0.005	0.001	0.005	...	...	...	...	...	...	...	...				
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	...	...	...	...	...	...	...	...	...	...
0.042	19	0.002	0.006	0.001	0.006	0.001	0.006	...	...	...	...	...	...	...	...	...	...
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	...	...	0.004	0.008	...	...
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	0.004	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	0.004	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	0.005	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	0.005	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	0.005	0.009	0.005	0.009

[A] 1 in. = 25.4 mm.
[B] Birmingham Wire Gage.
[C] Where the ellipsis appears in this table, the tolerance is not addressed.

TABLE 10 Cut-Length Tolerances for Lathe-Cut Round Tubing

Outside Diameter Size, in.[A]	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]
⅜ to 3 incl	±1/64 in.	±1/32 in.	±3/64 in.	±⅛ in.
Over 3 to 6, incl	±1/32 in.	±3/64 in.	±1/16 in.	±⅛ in.
Over 6 to 9, incl	±1/16 in.	±1/16 in.	±⅛ in.	±⅛ in.
Over 9 to 12, incl	±3/32 in.	±3/32 in.	±⅛ in.	±⅛ in.
Over 12 to 15, incl	±3/32 in.	±3/32 in.	±⅛ in.	±⅛ 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.

TABLE 11 Length Tolerances for Punch-, Saw-, or Disc-Cut Round Tubing

Outside Diameter Size, in.[A]	6 in. and under 12 in.	12 in. and under 48 in.	48 in. and under 10 ft	10 ft and 24 ft incl.
⅜ to 3, incl	±1/16 in.	±1/16 in.	±⅛ in.	±¼ in.
Over 3 to 6, incl	±1/16 in.	±1/16 in.	±⅛ in.	±¼ in.
Over 6 to 9, incl	±1/16 in.	±1/16 in.	±⅛ in.	±¼ in.
Over 9 to 12, incl	±1/16 in.	±1/16 in.	±⅛ in.	±¼ in.
Over 12 to 15, incl	±1/16 in.	±1/16 in.	±⅛ in.	±¼ in.

[A] 1 in. = 25.4 mm

13. Surface Finish

13.1 Tubes shall have a surface finish compatible with the conditions (See Section 12) to which they are ordered (See Appendix X1).

14. Coating

14.1 When specified, tubing shall be coated with a film of oil before shipping to retard rust. Should the order specify that tubing be shipped without rust retarding oil, the film of oils incidental to manufacture will remain on the surface. If the order specifies no oil, the purchaser assumes responsibility for rust in transit.

14.2 Special surface preparations as may be required for specific applications are not within the scope of this section. Such requirements shall be considered under the supplementary or basis of purchase provisions of this specification and details shall be provided in the purchase order.

15. Rejection

15.1 Tubes that fail to meet the requirements of this specification shall be set aside and the producer shall be notified.

16. Product and Package Marking

16.1 *Civilian Procurement*—Each box, bundle, lift, or piece shall be identified by a tag or stencil with manufacturers name or brand, specified size, type, purchaser's order number, and this specification number. Bar coding is acceptable as a supplementary identification method. Bar coding should be consistent with the Automotive Industry Action Group [AIAG] standard prepared by the Primary Metals Subcommittee of the AIAG Bar Code Project Team.

16.2 *Government Procurement*—When specified in the contract or order, and for direct procurement by or direct shipment to the Government, marking for shipment, in addition to requirements specified in the contract or order, shall be in accordance with MIL-STD-129 for Military agencies and in accordance with Fed. Std. No. 123 for civil agencies.

16.3 *Bar Coding*—In addition to the requirements in 16.1 and 16.2, bar coding is acceptable as a supplemental identification method. The purchaser may specify in the order a specific bar coding system to be used.

17. Packaging

17.1 *Civilian Procurement*—On tubing 16 gage (1.29 mm) and lighter, the producer will determine whether or not the tubing will be boxed, crated, cartoned, packaged in secured lifts, or bundled to ensure safe delivery unless otherwise instructed. Tubing heavier than 16 gage will normally be shipped loose, bundled, or in secured lifts. Special packaging requiring extra operations other than those normally used by a producer must be specified on the order.

17.2 *Government Procurement*—When specified in the contract or order, and for direct procurement by or direct shipment to the Government when Section 10, Tubular Products is specified, preservation, packaging, and packing shall be in accordance with the Practices A 700.

18. Keywords

18.1 alloy steel tube; carbon steel tube; mechanical tubing; resistance welded steel tube; steel tube; welded steel tube

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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 to 6, incl	Over 6 to 10, incl	Over 10 to 15, incl
Under 1	0.006	0.008	0.010	0.015	0.020	0.060	0.080
1 to 3, incl	0.008	0.010	0.015	0.020	0.030	0.060	0.080
Over 3 to 6, incl	0.010	0.015	0.020	0.025	0.040	0.070	0.090
Over 6 to 9, incl	0.015	0.020	0.025	0.030	0.040	0.070	0.090

[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.

TABLE 13 Tolerances, Outside Dimensions[A] Square and Rectangular Tubing

Largest Nominal Outside Dimension, in.[B]	Wall Thickness, in.[B]	Outside Tolerance at All Sides at Corners ± in.[B]
3/16 to 5/8 , incl	0.020 to 0.083, incl	0.004
Over 5/8 to 1 1/8 , incl	0.022 to 0.156, incl	0.005
Over 1 1/8 to 1 1/2 , incl	0.025 to 0.192, incl	0.006
Over 1 1/2 to 2, incl	0.032 to 0.192, incl	0.008
Over 2 to 3, incl	0.035 to 0.259, incl	0.010
Over 3 to 4, incl	0.049 to 0.259, incl	0.020
Over 4 to 6, incl	0.065 to 0.259, incl	0.020
Over 6 to 8, incl	0.185 to 0.259, incl	0.025

[A] Measured at corners at least 2 in. from the cut end of the tubing.

Convexity and concavity: Tubes having two parallel sides are also measured in the center of the flat sides for convexity and concavity. This tolerance applies to the specific size determined at the corners, and is measured on the following basis:

Largest Nominal Outside Dimension, in.	Tolerance ±, in.
2 1/2 and under	0.010
Over 2 1/2 to 4	0.015
Over 4 to 8	0.025

[B] 1 in. = 25.4 mm.

TABLE 14 Radii of Corners of Electric-Resistance-Welded Square and Rectangular Tubing[A]

Squares and Rectangles Made from Tubes of the Following Diameter Ranges, in.[B]	Wall Thickness in Bwg and in.[B]	Radius Tolerances, in.[C]
1/2 to 1 1/2 , incl	24 (0.022)	1/64 to 3/64
1/2 to 1 1/2 , incl	22 (0.028)	1/32 to 1/16
1/2 to 2 1/2 , incl	20 (0.035)	1/32 to 1/16
1/2 to 2 1/2 , incl	19 (0.042)	3/64 to 5/64
1/2 to 4, incl	18 (0.049)	3/64 to 5/64
1/2 to 4 1/8 , incl	16 (0.065)	1/16 to 7/64
3/4 to 4 1/8 , incl	14 (0.083)	5/64 to 1/8
Over 4 1/8 to 6, incl	14 (0.083)	3/16 to 5/16
1 to 4 1/8 , incl	13 (0.095)	3/32 to 5/32
Over 4 1/8 to 6, incl	13 (0.095)	3/16 to 5/16
1 1/4 to 4, incl	12 (0.109)	1/8 to 13/64
Over 4 to 6, incl	12 (0.109)	3/16 to 5/16
1 1/4 to 4, incl	11 (0.120)	1/8 to 7/32
Over 4 to 6, incl	11 (0.120)	7/32 to 7/16
2 to 4, incl	10 (0.134)	5/32 to 9/32
Over 4 to 6, incl	10 (0.134)	7/32 to 7/16
2 to 4, incl	9 (0.148)	3/16 to 5/16
Over 4 to 8, incl	9 (0.148)	7/32 to 7/16
2 to 8, incl	8 (0.165)	1/4 to 1/2
2 to 8, incl	7 (0.180)	1/4 to 1/2
2 1/2 to 4, incl	6 (0.203)	5/16 to 9/16
Over 4 to 8, incl	6 (0.203)	5/16 to 9/16
2 1/2 to 8, incl	5 (0.220)	3/8 to 5/8
2 1/2 to 8, incl	4 (0.238)	3/8 to 5/8
2 1/2 to 8, incl	3 (0.259)	3/8 to 5/8

[A] This table establishes a standard radius. The purchaser and producer may negotiate special radii. Slight radius flattening is more pronounced in heavier wall tubing.
[B] 1 in. = 25 mm.
[C] These radius tolerances apply to grades of steel covered in Table 1. The purchaser and producer may negotiate tolerances on other grades of steel.

TABLE 15 Length Tolerances—Square and Rectangular Tubing

Lengths, ft[A]	Tolerances, in.[B]
1 to 3, incl	±1/16
Over 3 to 12, incl	±3/32
Over 12 to 20, incl	±1/8
Over 20 to 30, incl	±3/16
Over 30 to 40, incl	±3/8

[A] 1 ft = 0.3 m.
[B] 1 in. = 25.4 mm.

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TABLE 16 Twist Tolerances Electric-Resistance-Welded for Square and Rectangular-Mechanical Tubing

Largest Dimension, in.[A]	Twist Tolerance in 3 ft[B], in.[A]
½ and under	0.032
Over ½ to 1½ , incl	0.050
Over 1½ to 2½ , incl	0.062
Over 2½ to 4, incl	0.075
Over 4 to 6, incl	0.087
Over 6 to 8, incl	0.100

[A] 1 in. = 25.4 mm.
[B] 1 ft = 0.3 m.

SUPPLEMENTARY REQUIREMENTS

One or more of the following supplementary requirements may become a part of the specification when specified in the inquiry or invitation to bid, and purchase order or contract. These requirements shall not be considered, unless specified in the order and the necessary tests shall be made at the mill. Mechanical tests shall be performed in accordance with the applicable portions of Test Methods and Definitions A 370.

S1. Tubes for Cylinders

S1.1 Round tubing, DOM for cylinder applications with inside diameter cleanup allowances is considered to be cylinder tubing. Table S1.1 shows the minimum inside diameter allowance for removal of inside surface imperfections by a honing operation.

S2. Cleanup by Centerless Grinding

S2.1 Round tubing, DOM for applications with outside diameter allowances is considered to be special smooth outside surface tubing. Table S2.1 shows the minimum outside diameter stock allowance for removal of outside surface imperfections by centerless grinding.

S3. Cleanup by Machining

S3.1 Cleanup is permitted on round tubing, DOM for applications where machining is required to remove surface imperfections. Table S3.1 shows the minimum stock allowance for removal of surface imperfections from either or both the outside and inside surfaces by machining.

S4. Special Smooth Inside Surface

S4.1 Round tubing, special smooth inside diameter for cylinder applications with microinch finish and inside diameter cleanup allowances is considered to be special smooth inside surface tubing. Table S4.1 shows the maximum average microinch readings on the inside surface. Table S4.2 shows the minimum wall depth allowance for inside surface imperfections.

S5. Hardness and Tensile Requirements

S5.1 When hardness properties are specified on the order, round tubing shall conform to the hardness limits specified in Table S5.1 unless "Tensile Properties Required" is specified in the purchase order. When "Tensile Properties Required" is specified in the purchase order, round tubing shall conform to the tensile requirements and not necessarily the hardness limits shown in Table S5.1. For grades of round tubing not shown in Table S5.1, and for all square and rectangular tubing, tensile or hardness limits shall be upon agreement between the manufacturer and the purchaser.

TABLE S1.1 Minimum Inside Diameter Stock Allowance on Diameter[A] for Removal of Inside-Surface Imperfections by Honing Operation (DOM Tubing)

Outside Diameter, in.[B]	Wall Thickness, in.[B,C]							
	0.065 and under	Over 0.065 to 0.125, incl	Over 0.125 to 0.180, incl	Over 0.180 to 0.230, incl	Over 0.230 to 0.360, incl	Over 0.360 to 0.460, incl	Over 0.460 to 0.563, incl	Over 0.563
Up to and incl 1½	0.010	0.011	0.013	0.015	0.018	...	...	...
Over 1½ to 3 incl	0.010	0.012	0.014	0.016	0.018	0.021	0.023	...
Over 3 to 4 incl	0.011	0.013	0.015	0.017	0.019	0.021	0.023	0.025
Over 4 to 4¾ incl	...	0.014	0.016	0.018	0.020	0.022	0.024	0.026
Over 4¾ to 6 incl	...	0.015	0.017	0.019	0.021	0.023	0.025	0.027
Over 6 to 8 incl	...	0.016	0.018	0.020	0.022	0.024	0.026	0.028
Over 8 to 10½ incl	...	...	...	0.021	0.023	0.025	0.027	0.029
Over 10½ to 12½ incl	...	...	...	0.022	0.024	0.026	0.028	0.030
Over 12½ to 14 incl	...	...	...	0.024	0.025	0.027	0.029	0.031
Over 14 to 15 incl	...	...	...	0.025	0.026	0.028	0.030	0.032

[A] If a specific size is desired, these allowances plus normal size tolerances must be considered in calculating size to be ordered.
[B] 1 in. = 25.4 mm.
[C] Where the ellipsis (...) appears in this table, no allowances have been established.

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S5.2 Number of tests and retests shall be as follows: one tension test per lot shall be made (See Note S1) and 1 % of all tubes per lot but in no case less than 5 tubes shall be tested for hardness. If the results of the mechanical tests do not conform to the requirements shown in the table, retests shall be made on additional tubes double the original number selected, each of which shall conform to the specified requirements.

NOTE S1—A lot shall consist of all tubes, before cutting to length, of the same size and wall thickness which are produced from the same heat of steel and, when heat treated, subjected to the same finishing treatment in a continuous furnace. When final heat treatment is done in a batch-type furnace, the lot shall include all those tubes which are heat treated in the same furnace charge.

S5.3 The yield strength corresponding to a permanent offset of 0.2 % of the gage length of the specimen or to a total extension of 0.5 % of the gage length under load shall be determined.

S6. Destructive Weld Tests

S6.1 Round tubing and tubing to be formed into other shapes when in the round form shall meet the following destructive weld tests.

S6.2 *Flattening Test*—A test 4 to 6 in. (101.6 to 152.4 mm) in length shall be flattened between parallel plates with the weld 90 ° from the direction of applied force (at the point of maximum bending) until opposite walls of the tubing meet. Except as allowed in S6.2.1, no opening in the weld shall take place until the distance between the plates is less than two thirds of the original outside diameter of the tubing. No cracks or breaks in the base metal shall occur until the distance between the plates is less than one third of the original outside diameter of the tubing, but in no case less than five times the thickness of the tubing wall. Evidence of lamination or burnt material shall not develop during the flattening process, and the weld shall not show injurious defects.

S6.2.1 When low D-to-t ratio tubing is tested, because the strain imposed due to geometry is unreasonably high on the inside surface at the six and twelve o'clock locations, cracks at these locations shall not be cause for rejection if the D-to-t ratio is less than 10.

S6.3 *Flaring Test*—A section of tube approximately 4 in. (101.6 mm) in length shall stand being flared with a tool having a 60° included angle until the tube at the mouth of the flare has been expanded 15 % of the inside diameter, without cracking or showing flaws.

S6.4 In order to properly evaluate weld quality, the producer at his option may normalize the test specimen prior to testing.

S6.5 Number of tests and retests:

S6.5.1 Two flattening and two flaring tests shall be made from each lot as specified. Each tested specimen shall conform to the respective requirement (See Note S1).

S6.5.2 If the results of the testing do not conform to the requirements, retests shall be made on four additional specimens, each of which shall conform to the respective requirement.

TABLE S2.1 Minimum Outside Diameter Stock Allowance on Diameter[A] for Removal of Outside-Surface Imperfections by Centerless Grinding (DOM Tubing)

Outside Diameter, in.[B]	Tubing Wall Thickness, in.[B,C]					
	Up to 0.125, incl	Over 0.125 to 0.180, incl	Over 0.180 to 0.230, incl	Over 0.230 to 0.360, incl	Over 0.360 to 0.460, incl	Over 0.460
Up to 3, incl	0.012	0.014	0.016	0.020	0.024	0.026
Over 3 to 4¾ , incl	0.016	0.018	0.020	0.022	0.024	0.026
Over 4¾ to 6, incl	0.018	0.020	0.022	0.024	0.026	0.028
Over 6 to 7, incl	0.020	0.022	0.024	0.026	0.028	0.030
Over 7 to 8, incl	...	...	0.026	0.027	0.029	0.031
Over 8 to 10½ , incl	...	...	0.027	0.028	0.030	0.032
Over 10½ to 12½ , incl	...	...	0.028	0.030	0.032	0.034
Over 12½ to 14 incl	...	...	0.030	0.032	0.034	0.036
Over 14	...	...	0.033	0.035	0.036	0.037

[A] If a specific size is desired, these allowances plus normal size tolerances must be considered in calculating size to be ordered.
[B] 1 in. = 25.4 mm.
[C] Where the ellipsis (...) appears in this table, no allowances have been established.

TABLE S3.1 Minimum Diameter Stock Allowance for Outside Diameter and Inside Diameter for Removal of Imperfections by Machining (DOM Tubing)[A]

NOTE 1—*Camber*—For every foot or fraction thereof over one foot of length, add 0.010 in.[B] for camber.

Outside Diameter, in.[B]	Wall Thickness, in.[B,C]				
	Up to 0.187	0.187 to 0.230, incl	Over 0.230 to 0.360, incl	Over 0.360 to 0.460, incl	Over 0.460
Up to 1½ incl	0.015	0.020	0.025	...	...
Over 1½ to 3 incl	0.020	0.025	0.030	0.030	0.035
Over 3 to 4¾ incl	0.025	0.030	0.035	0.035	0.040
Over 4¾ to 6 incl	0.030	0.035	0.040	0.040	0.045
Over 6 to 7 incl	0.035	0.040	0.045	0.045	0.050
Over 7 to 8 incl	...	0.045	0.048	0.048	0.053
Over 8 to 10½ incl	...	0.048	0.050	0.050	0.055
Over 10½ to 15 incl	...	0.050	0.055	0.055	0.060

[A] If a specific size is desired, those allowances plus normal size tolerances must be considered in calculating size to be ordered.
[B] 1 in. = 25.4 mm.
[C] Where the ellipsis (...) appears in this table, no allowances have been established.

TABLE S4.1 Maximum Average Microinch Readings on Inside Surface (Special Smooth Inside Diameter Tubing)

Outside Diameter, in.[A]	Tubing Wall Thickness, in.[A,B]				
	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

[A] 1 in. = 25.4 mm.
[B] Where the ellipsis (...) appears in this table, there is no requirement.

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TABLE S4.2 Allowance for Surface Imperfections on Inside Diameters of Special Smooth Finish Tubes[A]

Outside Diameter Size, in.[B]	Wall Thickness, in.[B]	Wall Depth Allowance for Inside Diameter Surface Imperfections, in.[B]	
		Scores	Pits
Up to 2½ , incl	0.065 to 0.109, incl	0.001	0.0015
	Over 0.109 to 0.250, incl	0.001	0.002
	Over 0.250 to 0.312, incl	0.001	0.0025
Over 2½ to 5½ , incl	0.083 to 0.125, incl	0.0015	0.0025
	Over 0.125 to 0.187, incl	0.0015	0.003
	Over 0.187 to 0.312, incl	0.002	0.004
Over 5½ to 7, incl	0.125 to 0.187, incl	0.0025	0.005
	Over 0.187 to 0.312, incl	0.003	0.006

[A] If a specific size is desired, these allowances plus normal size tolerances must be considered in calculating size to be ordered.
[B] 1 in. = 25.4 mm.

TABLE S5.1 Hardness Limits and Tensile Properties for Round Tubing

NOTE 1—These values are based on normal mill stress relieving temperatures. For particular applications, properties may be adjusted by negotiation between purchaser and producer.

NOTE 2— 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 1/32 in. (0.8 mm) decrease in wall thickness under 5/16 in. (7.9 mm) in wall thickness shall be permitted.

	Yield Strength, ksi (MPa), min	Ultimate Strength, ksi (MPa), min	Elongation in 2 in. or 50 mm, %, min	RB min	RB max
			As-Welded Tubing		
1008	30 (207)	42 (290)	15	50	
1009	30 (207)	42 (290)	15	50	
1010	32 (221)	45 (310)	15	55	
1015	35 (241)	48 (331)	15	58	
1020	38 (262)	52 (359)	12	62	
1021	40 (276)	54 (372)	12	62	
1025	40 (276)	56 (386)	12	65	
1026	45 (310)	62 (427)	12	68	
1030	45 (310)	62 (427)	10	70	
1035	50 (345)	66 (455)	10	75	
1040	50 (345)	66 (645)	10	75	
1340	55 (379)	72 (496)	10	80	
1524	50 (345)	66 (455)	10	75	
4130	55 (379)	72 (496)	10	80	
4140	70 (485)	90 (621)	10	85	
			Normalized Tubing		
1008	23 (159)	38 (262)	30		65
1009	23 (159)	38 (262)	30		65
1010	25 (172)	40 (276)	30		65
1015	30 (207)	45 (310)	30		70
1020	35 (241)	50 (345)	25		75
1021	35 (241)	50 (345)	25		78
1025	37 (255)	55 (379)	25		80
1026	40 (276)	60 (414)	25		85
1030	40 (276)	60 (414)	25		85
1035	45 (310)	65 (448)	20		88
1040	45 (310)	65 (448)	20		90
1340	50 (345)	70 (483)	20		100
1524	45 (310)	65 (448)	20		88
4130	50 (345)	70 (483)	20		100
4140	65 (448)	90 (621)	20		105
			Sink-Drawn Tubing		
1008	38 (262)	48 (331)	8	65	
1009	38 (262)	48 (331)	8	65	
1010	40 (276)	50 (345)	8	65	
1015	45 (310)	55 (379)	8	67	
1020	50 (345)	60 (414)	8	70	
1021	52 (359)	62 (428)	7	70	
1025	55 (379)	65 (448)	7	72	
1026	55 (379)	70 (483)	7	77	
1030	62 (427)	70 (483)	7	78	

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TABLE S5.1 *Continued*

	Yield Strength, ksi (MPa), min	Ultimate Strength, ksi (MPa), min	Elongation in 2 in. or 50 mm, %, min	RB min	RB max
1035	70 (483)	80 (552)	7	82	
		DOM Tubing			
1008	50 (345)	60 (414)	5	73	
1009	50 (345)	60 (414)	5	73	
1010	50 (345)	60 (414)	5	73	
1015	55 (379)	65 (448)	5	77	
1020	60 (414)	70 (483)	5	80	
1021	62 (427)	72 (496)	5	80	
1025	65 (448)	75 (517)	5	82	
1026	70 (483)	80 (552)	5	85	
1030	75 (517)	85 (586)	5	87	
1035	80 (552)	90 (621)	5	90	
1040	80 (552)	90 (621)	5	90	
1340	85 (586)	95 (655)	5	90	
1524	80 (552)	90 (621)	5	90	
4130	85 (586)	95 (655)	5	90	
4140	100 (690)	110 (758)	5	90	
		DOM Stress-Relieved Tubing			
1008	45 (310)	55 (379)	12	68	
1009	45 (310)	55 (379)	12	68	
1010	45 (310)	55 (379)	12	68	
1015	50 (345)	60 (414)	12	72	
1020	55 (379)	65 (448)	10	75	
1021	58 (400)	68 (469)	10	75	
1025	60 (414)	70 (483)	10	77	
1026	65 (448)	75 (517)	10	80	
1030	70 (483)	80 (552)	10	81	
1035	75 (517)	85 (586)	10	85	
1040	75 (517)	85 (586)	10	85	
1340	80 (552)	90 (621)	10	87	
1524	75 (517)	85 (586)	10	85	
4130	80 (552)	90 (621)	10	87	
4140	95 (655)	105 (724)	10	90	

S7. Hydrostatic Test Round Tubing

S7.1 All tubing will be given a hydrostatic test calculated as follows:

$$P = \frac{2St}{D}$$

where:

P = minimum hydrostatic test pressure, psi or MPa,
S = allowable fiber stress of 14 000 psi or 96.5 MPa,
t = specified wall thickness, in. or mm, and
D = specified outside diameter, in. or mm.

S7.2 The minimum hydrostatic test pressue shall be maintained for not less than 5 s.

S8. Nondestructive Electric Test

S8.1 Each tube shall be tested with a nondestructive electric test in accordance with Practice E 213, Practice E 273, Practice E 309, or Practice E 570. It is the intent of this test to reject tubes containing injurious defects.

S8.2 For eddy-current testing, the calibration tube shall contain, at the option of the producer, any one of the following discontinuities to establish a minimum sensitivity level for rejection. For welded tubing, they shall be placed in the weld if visible.

S8.2.1 *Drilled Hole*—A hole not larger than 0.031 in. (0.79 mm) in diameter shall be drilled radially and completely through the tube wall, care being taken to avoid distortion of the tube while drilling.

S8.2.2 *Transverse Tangential Notch*—Using a round tool or file with a ¼-in. (6.4-mm) diameter, a notch shall be filed or milled tangential to the surface and transverse to the longitudinal axis of the tube. Said notch shall have a depth not exceeding 12½ % of the specified wall thickness of the tube or 0.004 in. (0.102 mm), whichever is greater.

S8.2.3 *Longitudinal Notch*—A notch 0.031 in. (0.79 mm) or less in width shall be machined in a radial plane parallel to the tube axis on the outside surface of the tube, to have a depth not exceeding 12½ % of the specified wall thickness of the tube or 0.004 in. (0.102 mm), whichever is greater. The length of the notch shall be compatible with the testing method.

S8.3 For ultrasonic testing, the longitudinal calibration reference notches shall be at the option of the producer, any one of the three common notch shapes shown in Practice E 213 or Practice E 273. The depth of notch shall not exceed 12½ % of the specified wall thickness of the tube or 0.004 in. (0.102 mm), whichever is greater. For welded tubing the notch shall be placed in the weld, if visible.

S8.4 For flux leakage testing, each of the longitudinal calibration notches shall be a straight sided notch not over 12½ % of the wall thickness in depth and not over 1.0 in. (25 mm) in length. Both outside diameter and inside diameter notches

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shall be placed in the tube located sufficiently apart to enable separation and identification of the signals.

S8.5 Tubing producing a signal equal to or greater than the calibration defect shall be subject to rejection. The area producing the signal may be examined.

S8.5.1 Test signals produced by imperfections which cannot be identified, or produced by cracks or crack-like defects shall result in rejection of the tube subject to rework and retest.

S8.5.2 Test signals produced by imperfections such as those listed below may be judged as injurious or noninjurious depending on visual observation of their severity or the type of signal they produce on the testing equipment used, or both:

S8.5.2.1 Dinges,

S8.5.2.2 Straightener marks,

S8.5.2.3 Loose inside diameter bead and cutting chips,

S8.5.2.4 Scratches,

S8.5.2.5 Steel die stamps,

S8.5.2.6 Chattered flash trim,

S8.5.2.7 Stop marks, or

S8.5.2.8 Tube reducer ripple.

S8.5.3 Any imperfection of the above type exceeding 0.004 in. (0.102 mm) or 12½ % of the specified wall thickness (whichever is greater) in depth shall be considered injurious.

S8.5.3.1 If the imperfection is judged as injurious, the tubes shall be rejected but may be reconditioned and retested providing the dimensional requirements are met.

S8.5.3.2 If the imperfection is explored to the extent that it can be identified as noninjurious, the tubes may be accepted without further test providing the imperfection does not encroach on the minimum wall thickness, after due allowance for cleanup in mandrel drawn tubes.

S9. Certification for Government Orders

S9.1 A producer's or supplier's certification shall be furnished to the Government that the material was manufactured, sampled, tested, and inspected in accordance with this specification and has been found to meet the requirements. This certificate shall include a report of heat analysis (product analysis when requested in the purchase order), and when specified in the purchase order or contract, a report of test results shall be furnished.

S10. Rejection Provisions for Government Orders

S10.1 Each length of tubing received from the manufacturer may be inspected by the purchaser and, if it does not meet the requirements of the specification based on the inspection and test method as outlined in the specification, the tube may be rejected and the manufacturer shall be notified. Disposition of rejected tubing shall be a matter of agreement between the manufacturer and the purchaser.

S10.2 Material that fails in any of the forming operations or in the process of installation and is found to be defective shall be set aside and the manufacturer shall be notified for mutual evaluation of the material's suitability. Disposition of such material shall be a matter for agreement.

APPENDIX

(Nonmandatory Information)

X1. 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° apart or over a complete circumference if the trace should otherwise overlap.

X1.1.4 The length of trace should be in accordance with the latest revision of Section 4.5 of ANSI B 46.1 (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 the latest revision of ANSI B 46.1.

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.

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SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this specification since the last issue, A 513 – 08, that may impact the use of this specification. (Approved October 1, 2008)

(*1*) Revised Supplementary Requirement S6.5.
(*2*) Revised Supplementary Requirement S7.1 and added new S7.2.
(*3*) Revised Table 4, Table 6, Table 10, Table 11, and Table 12 to match the Scope.

Committee A01 has identified the location of selected changes to this specification since the last issue, A 513 – 07, that may impact the use of this specification. (Approved May 1, 2008)

(*1*) Revised Table 2 to change the Mn content for steel grade C-1008 to 0.50 max.

Committee A01 has identified the location of selected changes to this specification since the last issue, A 513 – 06b, that may impact the use of this specification. (Approved March 1, 2007)

(*1*) Replaced "mandrel drawn" and "M.D." with DOM throughout the standard.
(*2*) Cleaned up sentence fragments in 12.3.4 and Table 4 notes.

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