Designation: A 512 – 06

# Standard Specification for Cold-Drawn Buttweld Carbon Steel Mechanical Tubing[1]

This standard is issued under the fixed designation A 512; 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 cold-drawn buttweld carbon steel tubes for use as mechanical tubing.

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

1.3 Round tube size ranges covered are outside diameters up to 3 ½ in. (88.9 mm) and wall thickness from 0.035 to 0.500 in. (0.89 to 12.70 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 1040 Guide for Specifying Harmonized Standard Grade Compositions for Wrought Carbon, Low-Alloy, and Alloy Steels

E 59 Practice for Sampling Steel and Iron for Determination of Chemical Composition[3]

2.2 *Military Standards:*[4]

MIL-STD-129 Marking for Shipment and Storage

MIL-STD-163 Steel Mill Products Preparation for Shipment and Storage

2.3 *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 describe the required material adequately:

3.1.1 Quantity (feet, weight (Note 1), or number of lengths),

NOTE 1—The term "weight" is temporarily used in this specification because of established trade usage. The word is used to mean both "force" and "mass," and care must be taken to determine which is meant in each case (SI unit for force = newton and for mass = kilogram).

3.1.2 Name of material (buttweld carbon steel mechanical tubing),

3.1.3 Form (round, square, rectangular, special shape),

3.1.4 Condition, description and code letters (Section 5),

3.1.5 Grade, if required (Section 6),

3.1.6 Dimensions (round, Section 9 or square and rectangular, Section 10),

3.1.7 Length (round length, 9.2; square and rectangular length, 10.5),

3.1.8 Burr removal (Section 11),

3.1.9 Report of chemical analysis and products analysis, if required,

3.1.10 Individual supplementary requirements if required (S1 through S5),

3.1.11 Special requirements,

3.1.12 End use,

3.1.13 Specification designation,

3.1.14 Special marking (Section 15), and

3.1.15 Special packaging (Section 16).

## 4. Materials and Manufacture

4.1 The steel shall 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

[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] Withdrawn.

[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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producer shall remove the transition material by an established procedure that positively separates the grades.

4.5 Tubes shall be made by the furnace buttweld process.

4.6 Tubes shall be cold finished, either externally only (sunk) or externally and internally (mandrel drawn).

## 5. Condition

5.1 The purchaser shall specify in the order one of the following conditions:

MD (Mandrel Drawn)—No final thermal treatment

SD (Sink Drawn)—No final thermal treatment

MDSR—Mandrel Drawn and Stress Relieved

SDSR—Sink Drawn and Stress Relieved

MDSA—Mandrel Drawn and Soft Annealed or normalized

SDSA—Sink Drawn and Soft Annealed or normalized

NORM-MD-SR—Normalized, Mandrel Drawn, and Stress Relieved

NORM-SD-SR—Normalized, Sink Drawn, and Stress Relieved

## 6. Chemical Composition

6.1 The steel shall conform to the requirements as to chemical composition prescribed in Table 1 or Table 2 (see Specification A 1040) and Table 3.

6.2 When a 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 Table 1 or Table 2 is not permitted.

## 7. Heat Analysis

7.1 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 used, 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 analyses shall be furnished to the purchaser.

7.2 A report of this analysis shall be furnished only when requested on the order.

**TABLE 1 Chemical Requirements**[A]

| Grade Designation | | Chemical Composition Limits, % | | | |
|---|---|---|---|---|---|
| | | Carbon | Manganese | Phosphorus, max | Sulfur, max |
| MT | 1010 | 0.05–0.15 | 0.30–0.60 | 0.04 | 0.045 |
| MT | 1015 | 0.10–0.20 | 0.30–0.60 | 0.04 | 0.045 |
| MT X | 1015 | 0.10–0.20 | 0.60–0.90 | 0.04 | 0.045 |
| MT | 1020 | 0.15–0.25 | 0.30–0.60 | 0.04 | 0.045 |
| MT X | 1020 | 0.15–0.25 | 0.70–1.00 | 0.04 | 0.045 |

[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.

**TABLE 2 Chemical Requirements for Other Carbon Grades**[A]

| Grade Designation[B] | Chemical Composition Limits, % | | | |
|---|---|---|---|---|
| | Carbon | Manganese | Phosphorus, max | Sulfur, max |
| 1008 | 0.10 max | 0.30–0.50 | 0.040 | 0.045 |
| 1010 | 0.08–0.13 | 0.30–0.60 | 0.040 | 0.045 |
| 1012 | 0.10–0.15 | 0.30–0.60 | 0.040 | 0.045 |
| 1015 | 0.13–0.18 | 0.30–0.60 | 0.040 | 0.045 |
| 1016 | 0.13–0.18 | 0.60–0.90 | 0.040 | 0.045 |
| 1018 | 0.15–0.20 | 0.60–0.90 | 0.040 | 0.045 |
| 1019 | 0.15–0.20 | 0.70–1.00 | 0.040 | 0.045 |
| 1020 | 0.18–0.23 | 0.30–0.60 | 0.040 | 0.045 |
| 1021 | 0.18–0.23 | 0.60–0.90 | 0.040 | 0.045 |
| 1025 | 0.22–0.28 | 0.30–0.60 | 0.040 | 0.045 |
| 1026 | 0.22–0.28 | 0.60–0.90 | 0.040 | 0.045 |
| 1030 | 0.28–0.34 | 0.60–0.90 | 0.040 | 0.045 |
| 1035 | 0.32–0.38 | 0.60–0.90 | 0.040 | 0.045 |
| 1110 | 0.08–0.13 | 0.30–0.60 | 0.040 | 0.130[C] |
| 1115 | 0.13–0.20 | 0.60–0.90 | 0.040 | 0.130[C] |
| 1117 | 0.14–0.20 | 1.00–1.30 | 0.040 | 0.130[C] |

[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] Other analyses are available.

[C] Grades 1110, 1115, and 1117 shall contain 0.08 min % sulfur.

**TABLE 3 Tolerances for Product Analysis for Steels Shown in Table 1**

| Element | Limit, or Maximum of Specified Range, % | Variation, Over Maximum Limit or Under Minimum Limit | |
|---|---|---|---|
| | | Under min, % | Over max, % |
| Carbon | To 0.15, incl | 0.02 | 0.03 |
| | Over 01.5 | 0.03 | 0.04 |
| Manganeses | To 0.60, incl | 0.03 | 0.03 |
| | Over 0.60 | 0.04 | 0.04 |
| Phosphorus | . . . | . . . | 0.01 |
| Sulfur | . . . | . . . | 0.01 |

## 8. Product Analysis

8.1 When requested on the purchase order, a product analysis shall be made by the manufacturer. The chemical composition thus determined shall conform to the requirements prescribed in Table 1 or Table 2 as modified by Table 3.

8.2 The product analysis limits shown for carbon are not normally applicable to the MT grades.

8.3 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.

8.3.1 *Heat Identity Maintained*—One product analysis per heat on either a billet, a length of flat rolled stock, or a tube.

8.3.2 *Heat Identity Not Maintained*—One product analysis from one tube per 2000 ft (610 m) or less for sizes over 3 in. (76.2 mm), or one product analysis from one tube per 5000 ft (1524 m) or less for sizes under 3 in. (76.2 mm).

8.4 If the original test for product analysis fails, retests of 2 additional billets, 2 lengths of flat rolled stock, or 2 tubes shall be made. Both retests for the elements in question shall meet the requirements of this specification; otherwise all remaining material in the heat or lot shall be rejected, or at the option of the producer, each billet, length, flat rolled stock, or tube may be individually tested for acceptance.

8.5 Samples for product analysis, except for spectrochemical analysis, shall be taken in accordance with Practice E 59,



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and the composition thus determined shall correspond to the requirements in applicable section or table.

## 9. Permissible Variations in Dimensions of Round Tubing

9.1 *Diameter and Wall Thickness*:

9.1.1 Variations in outside diameter, inside diameter, and wall thickness shall not exceed the amounts prescribed in Table 4.

9.1.2 These variations apply to round, unannealed, and stress-relieved tubing.

9.1.3 Diameter tolerance includes ovality.

9.1.4 Sink tubing is normally ordered by outside diameter and nominal wall. Mandrel-drawn tubing is normally ordered by outside diameter and inside diameter and may be ordered by outside diameter or inside diameter and wall thickness but not by all three dimensions.

9.2 *Length*—Random lengths between acceptable limits will be furnished, utilizing the full mill length. Tubing will be cut in half if specified. Full length random tubing will have a spread not exceeding 7 ft (2.1 m). Half-length random tubing will have a spread not exceeding 4 ft (1.2 m). Not more than 10 % of the total footage of a shipment may be furnished in lengths shorter than the minimum specified but not less than 6 ft (1.8 m).

9.2.1 When specified, multiple lengths will be furnished and should include allowances made for the customer's cutting tool width and grippage. Maximum and minimum lengths may be specified with the understanding that not more than 10 % of the total footage in a shipment may be furnished in individual multiples cut to the customer's specifications.

9.2.2 Variations from the specified length shall not exceed the amounts prescribed in Table 5.

9.3 *Straightness*:

9.3.1 A round tube shall be considered straight provided that no 3-ft (0.9-m) section departs from a straight line by more than 0.030 in. (0.76 mm).

9.3.2 The straightness of round tubes shorter than 3 ft (0.9 m) shall be proportionate to 0.010 in./ft (0.8 mm/m).

9.3.3 These straightness tolerances do not apply to soft-annealed tubing nor to long lengths of small diameter tubing.

**TABLE 5 Permissible Variations in Length—Round Tubing**

| | |
|---|---|
| Lengths 4 ft (1.2 m) and under—up to 2 in. (50.8 mm) diameter | ± 1/32 in. (0.8 mm) |
| Lengths 4 ft (1.2 m) and under—over 2 in. (50.8 mm) diameter | ±3/64 in. (1.2 mm) |
| Lengths 4 ft to 10 ft (1.2 to 3.0 m), incl—up to 2 in. (50.8 mm) diameter | ±3/64 in. (1.2 mm) |
| Lengths 4 ft to 10 ft (1.2 to 3.0 m), incl—over 2 in. (50.8 mm) diameter | ±1/16 in. (1.6 mm) |
| Lengths 10 ft to 24 ft (3.0 to 7.3 m), incl—all diameters | ±1/8 in. (3.2 mm) |
| Lengths over 24 ft (7.3 m)—all diameters | ±1/8 in. (3.2 mm)[A] |

[A] Plus an additional tolerance of ±1/16 (1.6 mm) for each 10 ft (3.0 m) or fraction over 24 ft (7.3 m).

## 10. Permissible Variations in Dimensions of Square and Rectangular Tubing

10.1 *Outside Dimensions and Wall Thickness*—Variations in largest outside dimensions across flats and wall thickness shall not exceed the amounts prescribed in Table 6.

10.2 *Corner Radii*—The corners of square and rectangular tubes shall be slightly rounded inside and slightly rounded outside consistent with wall thickness. The outside corners may be slightly flattened. The radii of corners for square and rectangular cold-finished buttweld tubes shall be in accordance with Table 7. Special radii may be obtained.

10.3 *Squareness Tolerance*—Permissible variations for the side of square and rectangular tube shall be determined by the following equation:

$$\pm b = c \times 0.006, \text{ in. (mm)}$$

where:

$b$ = tolerance for out-of-square, and
$c$ = largest external dimensions across flats, in. (mm).

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

10.3.1 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.

**TABLE 4 Diameter and Wall Thickness Tolerances for Round Tubing**

| Outside Diameter Range, in. (mm) | Outside Diameter, in. (mm) | | Inside Diameter, in. (mm) | | Wall Thickness, % | |
|---|---|---|---|---|---|---|
| | Over | Under | Over | Under | Over | Under |
| **Sunk** | | | | | | |
| Up to ½ (12.7), excl | 0.004 (0.10) | 0 | . . . | . . . | 15[A] | 15 |
| ½ to 1½ (12.7 to 38.1), excl | 0.005 (0.13) | 0 | . . . | . . . | 10[A] | 10 |
| 1½ to 3 (38.1 to 76.2), incl | 0.010 (0.25) | 0 | . . . | . . . | 10[A] | 10 |
| **Mandrel Drawn** | | | | | | |
| Less than 0.156 (3.96) wall: | | | | | | |
| Up to ½ (12.7), excl | 0.004 (0.10) | 0 | 0 | 0.010 (0.25) | 12½ | 12½ |
| ½ to 1½ (12.7 to 38.1), excl | 0.005 (0.13) | 0 | 0 | 0.005 (0.13)[B] | 10 | 10 |
| 0.156 (3.96) wall and over: | | | | | | |
| ½ to 1½ (12.7 to 38.1), excl | 0.005 (0.13) | 0 | 0 | 0.005 (0.13)[B] | 7 | 7 |
| Under 0.156 (3.96) wall: | | | | | | |
| 1½ (38.1) and over | 0.010 (0.25) | 0 | . . . | 0.010 (0.25) | 10 | 10 |
| 0.156 (3.96) wall and over: | | | | | | |
| 1½ (38.1) and over | 0.010 (0.25) | 0 | 0 | 0.010 (0.25) | 7 | 7 |

[A] Except at the weld line, where the weld pad may exceed this figure.
[B] Tubes with an inside diameter under ½ in. (12.7 mm) may require more than 0.005 in. (0.13 mm) inside diameter tolerance and the producer should be consulted.



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**TABLE 6 Outside Dimension and Wall Thickness Tolerances for Square and Rectangular Tubing**

| Largest Outside Dimension Across Flats | Wall Thickness | Outside Dimension, Including Convexity or Concavity | | Wall Thickness Tolerance, ±, % | |
|---|---|---|---|---|---|
| | | Over | Under | Sink[A] | Mandrel |
| Inch-Pound Units | | | | | |
| in. | in. | in. | in. | | |
| To ¾ | over 0.065 | 0.010 | 0.010 | 15 | 12½ |
| Over ¾ to 1¼ | under 0.156 | 0.015 | 0.015 | 10 | 10 |
| Over ¾ to 1¼ | 0.156 and over | 0.015 | 0.015 | 10 | 7 |
| Over 1¼ to 2½ | under 0.156 | 0.020 | 0.020 | 10 | 10 |
| Over 1¼ to 2½ | 0.156 and over | 0.020 | 0.020 | 10 | 7 |
| SI Units | | | | | |
| mm | mm | mm | mm | | |
| To 19.0 | over 1.65 | 0.25 | 0.25 | 15 | 12½ |
| Over 19.0 to 31.8 | under 3.96 | 0.38 | 0.38 | 10 | 10 |
| Over 19.0 to 31.8 | 3.96 and over | 0.38 | 0.38 | 10 | 7 |
| Over 31.8 to 63.5 | under 3.96 | 0.51 | 0.51 | 10 | 10 |
| Over 31.8 to 63.5 | 3.96 and over | 0.51 | 0.51 | 10 | 7 |

[A] Except at the weld line where the weld pad may exceed this figure.

**TABLE 7 Radii of Corners of Butt-Weld Square and Rectangular Tubing**

| Wall Thickness, in. (mm) | Maximum Radii of Corners, in. (mm)[A] |
|---|---|
| 0.065 to 0.083 (1.65 to 2.11), incl | 9/64 (3.6) |
| Over 0.083 to 0.095 (2.11 to 2.41), incl | 3/16 (4.8) |
| Over 0.095 to 0.109 (2.41 to 2.76), incl | 13/64 (5.2) |
| Over 0.109 to 0.134 (2.76 to 3.40), incl | 7/32 (5.6) |
| Over 0.134 to 0.156 (3.40 to 3.96), incl | 1/4 (6.4) |
| Over 0.156 to 0.188 (3.96 to 4.78), incl | 9/32 (7.1) |
| Over 0.188 to 0.250 (4.78 to 6.35), incl | 11/32 (8.7) |
| Over 0.250 to 0.313 (6.35 to 7.95), incl | 7/16 (11.1) |
| Over 0.313 to 0.375 (7.95 to 9.52), incl | ½ (12.7) |
| Over 0.375 to 0.500 (9.52 to 12.70), incl | 11/16 (17.5) |

[A] These tolerances apply to grades MT 1010 and MT 1015 steel only. Tolerances on other grades shall be established between the manufacturer and the purchaser.

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

10.4 *Twist Tolerance*—Variation in twist for square and rectangular tubing shall not exceed the amounts prescribed in Table 8. 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 means of a beveled protractor equipped with a level. The angular deviation is measured on opposite ends or at any point throughout the length.

10.5 *Length*—Random lengths between acceptable limits will be furnished, utilizing the full mill length. Tubing will be cut in half if specified. Full length random tubing will have a spread not exceeding 7 ft (2.1 m). Half-length random tubing will have a spread not exceeding 4 ft (1.2 m). Not more than 10 % of the total footage of a shipment may be furnished in lengths shorter than the minimum specified, but not less than 6 ft (1.8 m).

10.5.1 When specified, multiple lengths will be furnished and should include allowances made for the customer's cutting tool width and grippage. Maximum and minimum lengths may be specified with the understanding that not more than 10 % of the total footage in a shipment may be furnished in individual multiples cut to the customer's specifications.

10.5.2 Variations from the specified length shall not exceed the amounts prescribed in Table 9.

10.6 *Straightness*—The straightness tolerance for square and rectangular tubing shall be 1/16 in. in 3 ft (1:576).

**TABLE 8 Twist Tolerance, Square and Rectangular Mechanical Tubing**

| Largest Dimension, in. (mm) | Twist Tolerance in 3 ft, in. (in 1 m, mm) |
|---|---|
| Under ½ (12.7) | 0.050 (0.014) |
| ½ to 1½ (12.7 to 38.1), incl | 0.075 (0.020) |
| Over 1½ to 2½ (38.1 to 63.5), incl | 0.095 (0.026) |
| Over 2½ (63.5) | 0.125 (0.035) |

## 11. Workmanship, Finish, and Appearance

11.1 Tubes shall have a surface finish compatible with the conditions (Section 5) to which the tubes are ordered.

11.2 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.

11.3 The tubing shall be free of injurious defects and shall have a workmanlike finish. Surface imperfections such as handling marks, straightening marks, light die marks, or shallow pits are not considered injurious.

11.4 The tubing shall be free of scale. In the case of thermally treated tubing, a slight amount of color will not be considered cause for rejection.

**TABLE 9 Permissible Variation in Length—Square and Rectangular Tubing**

| | |
|---|---|
| Lengths 3 ft (0.9 m) and under | ±1/16 in. (1.,6 mm) |
| Lengths over 3 to 12 ft (0.9 to 3.7 m), incl | ±1/32 in. (2.4 mm) |
| Lengths over 12 to 20 ft (3.7 to 6.1 m), incl | ±1/8 in. (3.2 mm) |
| Lengths over 20 to 30 ft (6.1 to 9.1 m), incl | ±3/16 in. (4.8 mm) |
| Lengths over 30 to 40 ft (9.1 to 12.2 m), incl | ±3/8 in. (9.5 mm) |



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11.5 Saw cut tubes will be furnished without removing outside diameter and inside diameter burrs.

11.6 Lathe cut tubes will be furnished with outside diameter burr only removed.

11.7 Burr removal may be obtained by so specifying in the purchase order.

## 12. Machining Allowance—Round Tubing

12.1 For the method of calculating the tube size required to clean up machining to a particular finished part, see Appendix X1.

## 13. Coating

13.1 Unless otherwise specified, the outside surface of the tubing shall be coated, before shipping, with a film of rust-retarding oil. Unless otherwise specified, the inside surface of the tubing may also be coated with a film of rust-retarding oil at the option of the manufacturer. When the order specifies that the tubing be shipped without rust-retarding oil, the film of oils incidental to manufacturing will remain on the surfaces. If the order specifies no oil, the purchaser assumes responsibility for rust in transit.

## 14. Rejection

14.1 Tubes that fail to meet the requirements of the specification shall be set aside, and the manufacturer shall be notified.

## 15. Product Marking

15.1 *Civilian Procurement*—Each box, bundle, lift, or, when individual pieces are shipped, each piece shall be identified by a tag or stencil with the manufacturer's name or brand, grade or material, purchaser's order number, and this specification number (ASTM designation).

15.2 *Bar Coding*—In addition to the requirements in 15.1 and 15.3 bar coding is acceptable as a supplemental identification method. The purchaser may specify in the order a specific bar coding system to be used.

15.3 *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. Packaging

16.1 *Civilian Procurement*—The manufacturer, at his option, will box, crate, carton, package in secured lifts, or bundle to ensure safe delivery. Special packaging requiring extra operations other than those normally used by the manufacturer must be specified on the order.

16.2 *Government Procurement*—When specified in the contract or order, and for direct procurement by or direct shipment to the government when Level A is specified, preservation, packaging, and packing shall be in accordance with the Level A requirements of MIL-STD-163.

## 17. Keywords

17.1 carbon steel tube; mechanical tubing; steel tube

## SUPPLEMENTARY REQUIREMENTS

These requirements shall not be considered unless specified in the order, and the necessary tests shall be made at the mill. Mechanical property tests shall be performed in accordance with applicable portions of Test Methods and Definitions A 370.

## S1. Hardness and Tension Tests—Round Tubing

S1.1 When hardness is specified in the order, the tubing shall conform to the hardness limits specified in Table S1.1 or Table S1.2, unless "Tensile Properties Required" is specified in the purchase order. When "Tensile Properties Required" is specified in the purchase order, the tubing shall conform to the tension test requirements and not necessarily the hardness limits shown in Table S1.1 or Table S1.2.

**TABLE S1.1 Tensile and Hardness Requirements for Stress Relief Annealed Round Tubes**

| Grade | Tensile Strength, ksi (MPa) | | (0.2 % Offset) Yield Strength, min, ksi (MPa) | Elongation in 2 in. or 50 mm, min, % | Rockwell Hardness | |
|---|---|---|---|---|---|---|
| | min | max | | | min | max |
| MT1010 | 63 (434) | 100 (689) | 58 (400) | 15 | B 70 | B 90 |
| 1011 | 65 (448) | 100 (689) | 59 (407) | 13 | B 70 | B 100 |
| MT1015 | 66 (555) | 100 (689) | 60 (414) | 14 | B 70 | B 100 |
| 1016 | 67 (462) | 100 (689) | 61 (421) | 13 | B 70 | B 100 |
| MT1017 | 67 (462) | 100 (689) | 62 (427) | 13 | B 72 | B 100 |
| 1018 | 68 (469) | 100 (689) | 62 (427) | 13 | B 73 | B 100 |
| MT1020 | 71 (490) | 130 (896) | 65 (448) | 11 | B 75 | C 20 |
| 1025 | 72 (496) | 130 (896) | 67 (462) | 11 | B 78 | C 20 |
| 1030 | 80 (552) | 130 (896) | 70 (483) | 10 | B 80 | C 20 |
| 1110 | 63 (434) | 100 (689) | 58 (400) | 15 | B 70 | B 100 |
| 1115 | 68 (469) | 100 (689) | 62 (427) | 13 | B 70 | B 100 |



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**TABLE S1.2 Tensile and Hardness Requirements for Soft Annealed Round Tubes**

| Grade | Tensile Strength, min, ksi (MPa) | Yield Strength, min, ksi (MPa) | Elongation in 2 in. or 50 mm, min, % | Rockwell Hardness |
|---|---|---|---|---|
| MT1010 | 40 (276) | 20 (138) | 35 | B 40 to B 65 |
| MT1015 | 43 (296) | 25 (172) | 34 | B 40 min |
| MT1020 | 50 (345) | 30 (207) | 32 | B 50 min |
| MT1025 | 55 (379) | 35 (241) | 32 | B 55 min |
| MT1030 | 65 (448) | 40 (276) | 30 | B 60 min |

S1.2 *Number of Tests and Retests:*

S1.2.1 *Hardness*—One percent of all tubes per lot (Note S1.1),

S1.2.2 *Tension:*

S1.2.2.1 One test per lot (Note S1.1).

S1.2.2.2 The yield strength corresponding to a permanent offset of 0.2 % of the gauge length of the specimen or to a total extension of 0.5 % of the gauge length under load shall be determined.

S1.2.3 If the results of the mechanical tests do not conform to the requirements shown in Table S1.1 and Table S1.2, retests shall be made on additional tubes double the original number, each of which shall conform to the specified requirements.

NOTE S1.1—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 in a batch-type furnace, the lot shall include only those tubes which are heat treated in the same furnace charge.

## S2. Flattening Test—Soft-Annealed Round Tubing

S2.1 The weld shall be located 45° from the line of the direction of applied force. No cracks other than superficial surface ruptures shall appear in the weld until the distance between the flattening plates is less than three fourths of the outside diameter of the tube. Likewise, no cracks, other than superficial surface ruptures, shall appear in the metal of the tube other than the weld metal until the distance between the flattening plates is less than three fifths of the outside diameter of the tube.

S2.2 *Number of Tests and Retests:*

S2.2.1 One test per lot (Note S1.1).

S2.2.2 Two retests per lot (Note S1.1).

## S3. Flaring Test—Round Tubing

S3.1 A tapered mandrel having a slope of 1 in 10 shall be driven into one end of a soft-annealed section cut to a suitable length and thus expanding the specimen until the outside diameter has been increased 5 %.

S3.2 *Number of Tests and Retests:*

S3.2.1 One test per lot (Note S1.1).

S3.2.2 Two retests per lot (Note S1.1).

## S4. Nondestructive Electrical Test—Round Tubing

S4.1 The manufacturer shall test the tubing by an electrical method of nondestructive test for detection of harmful faults and soundness of weld. The equipment used shall be capable of indicating and rejecting all defects on the outside diameter or inside diameter greater than 1/16 in. (1.6 mm) in length and to a depth greater than approximately one fourth the wall thickness.

## S5. Certification for Government Orders

S5.1 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.

# APPENDIX

**(Nonmandatory Information)**

## X1. MACHINING ALLOWANCES

X1.1 The minimum diameter stock allowance for removal of imperfections by machining from the outside of the tube when chucked concentrically on the tube outside diameter is given in Table X1.1.

X1.2 *Boring Mandrel Drawn Tubing*—When chucked concentrically with the outside diameter, mandrel drawn tubing will clean up concentrically with the outside diameter on a boring operation at a size derived from the following equation:

Ordered inside diameter = finished inside diameter – (0.075 in. (1.90 mm) × original outside diameter – amount shown in Table X1.1).

**TABLE X1.1 Machining Allowances[A]**

NOTE—1 in. = 25.4 mm.

| Diameter, in. | Wall Thickness, in. | |
|---|---|---|
| | Up to 0.200 | 0.200 and Over |
| *Sink Drawn:* | | |
| Up to 1½ | 0.025 | 0.030 |
| 1½ and over | 0.030 | 0.035 |
| *Mandrel Drawn:* | | |
| Up to 1½ | 0.020 | 0.025 |
| 1½ and over | 0.025 | 0.030 |

[A] If a specific size is desired, these allowances plus normal size tolerances must be considered in calculating the size to be ordered.



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X1.2.1 To this equation, add 0.005 in. (0.13 mm) when the original outside diameter does not exceed 1 ½ in. (38.1 mm); add 0.010 in. (0.25 mm) when the original outside diameter is over 1 ½ in. These equations apply to tubes chucked within 2 in. (50.8 mm) of the end being bored.

## SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this specification since the last issue, A 512 – 96(2005), that may impact the use of this specification. (Approved October 1, 2006)

(*1*) Revised Table 2 to agree with composition requirements contained in Specification A 1040.

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