



Designation: A519/A519M – 23

Standard Specification for Seamless Carbon and Alloy Steel Mechanical Tubing¹

This standard is issued under the fixed designation A519/A519M; 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.

1. Scope*

1.1 This specification covers several grades of carbon and alloy steel seamless mechanical tubing. The grades are listed in **Tables 1-3**. When welding is used for joining the weldable mechanical tube grades, the welding procedure shall be suitable for the grade, the condition of the components, and the intended service.

1.2 This specification covers both seamless hot-finished mechanical tubing and seamless cold-finished mechanical tubing in sizes up to and including 12 $\frac{3}{4}$ in. [325 mm] outside diameter for round tubes with wall thicknesses as required.

1.3 The tubes shall be furnished in the following shapes, as specified by the purchaser: round, square, rectangular, and special sections.

1.4 Supplementary requirements of an optional nature are provided and when desired shall be so stated in the order.

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

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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. Referenced Documents

2.1 ASTM Standards:²

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A751 Test Methods and Practices for Chemical Analysis of Steel Products

A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys

A1040 Guide for Specifying Harmonized Standard Grade Compositions for Wrought Carbon, Low-Alloy, and Alloy Steels

A1058 Test Methods for Mechanical Testing of Steel Products—Metric

2.2 Military Standards:

MIL-STD-129 Marking for Shipment and Storage³

MIL-STD-163 Steel Mill Products Preparation for Shipment and Storage³

2.3 Federal Standard:

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)³

3. Terminology

3.1 *Definitions of Terms*—For definitions of terms used in this standard refer to:

3.1.1 Terminology **A941** for general steel terminology,

3.1.2 Test Methods and Definitions **A370** or Test Methods **A1058** for mechanical testing of steel products terminology, and

3.1.3 Test Methods and Practices **A751** for chemical analysis of steel products terminology.

4. Ordering Information

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

4.1.1 Quantity (feet, weight, or number of pieces),

4.1.2 Name of material (seamless carbon or alloy steel mechanical tubing),

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 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

TABLE 1 Chemical Requirements of Low-Carbon Steels

Grade Designation	Chemical Composition Limits, %			
	Carbon ^A	Manganese ^B	Phosphorous, ^B max	Sulfur, ^B max
MT 1010	0.05–0.15	0.30–0.60	0.040	0.050
MT 1015	0.10–0.20	0.30–0.60	0.040	0.050
MT X 1015	0.10–0.20	0.60–0.90	0.040	0.050
MT 1020	0.15–0.25	0.30–0.60	0.040	0.050
MT X 1020	0.15–0.25	0.70–1.00	0.040	0.050

^A Limits apply to heat and product analyses.

^B Limits apply to heat analysis; except as required by 7.1, product analyses are subject to the applicable additional tolerances given in Table 5.

TABLE 2 Chemical Requirements of Other Carbon Steels

Grade Designation	Chemical Composition Limits, % ^A			
	Carbon	Manganese	Phosphorous, max	Sulfur, max
1008	0.10 max	0.30–0.50	0.040	0.050
1010	0.08–0.13	0.30–0.60	0.040	0.050
1012	0.10–0.15	0.30–0.60	0.040	0.050
1015	0.13–0.18	0.30–0.60	0.040	0.050
1016	0.13–0.18	0.60–0.90	0.040	0.050
1017	0.15–0.20	0.30–0.60	0.040	0.050
1018	0.15–0.20	0.60–0.90	0.040	0.050
1019	0.15–0.20	0.70–1.00	0.040	0.050
1020	0.18–0.23	0.30–0.60	0.040	0.050
1021	0.18–0.23	0.60–0.90	0.040	0.050
1022	0.18–0.23	0.70–1.00	0.040	0.050
1025	0.22–0.28	0.30–0.60	0.040	0.050
1026	0.22–0.28	0.60–0.90	0.040	0.050
1030	0.28–0.34	0.60–0.90	0.040	0.050
1035	0.32–0.38	0.60–0.90	0.040	0.050
1040	0.37–0.44	0.60–0.90	0.040	0.050
1045	0.43–0.50	0.60–0.90	0.040	0.050
1050	0.48–0.55	0.60–0.90	0.040	0.050
1518	0.15–0.21	1.10–1.40	0.040	0.050
1524	0.19–0.25	1.35–1.65	0.040	0.050
1541	0.36–0.44	1.35–1.65	0.040	0.050

^A The ranges and limits given in this table apply to heat analysis; except as required by 7.1, product analyses are subject to the applicable additional tolerances given in Table 5.

4.1.3 Form (round, square, rectangular or special shapes, Section 1),

4.1.4 Dimensions (round, outside diameters and wall thickness, Section 9; square and rectangular, outside dimensions and wall thickness, Section 10; other, specify),

4.1.5 Length (specific or random, mill lengths, see 9.5 and 10.5),

4.1.6 Manufacture (hot finished or cold finished, 5.5 and 5.6),

4.1.7 Grade (Section 6),

4.1.8 Condition (sizing method and thermal treatment, Section 13),

4.1.9 Surface finish (special pickling, shot blasting, or ground outside surface, if required),

4.1.10 ASTM Specification designation, and year of issue.

4.1.11 Individual supplementary requirements, if required,

4.1.12 End use, if known,

4.1.13 Packaging,

4.1.14 Product analysis and chemical analysis, if required (Section 7 and Section 8),

4.1.15 Specific requirements, or exceptions to this specification,

4.1.16 Special marking (Section 16), and

4.1.17 Special packing (Section 17).

5. Materials and Manufacture

5.1 The steel may be made by any process.

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

5.3 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.

5.4 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.

5.5 Tubes shall be made by a seamless process and shall be either hot finished or cold finished, as specified.

5.6 Seamless tubing is a tubular product made without a welded seam. It is manufactured usually by hot working steel and, if necessary, by subsequently cold finishing the hot-worked tubular product to produce the desired shape, dimensions and properties.

6. Chemical Composition

6.1 The steel shall conform to the requirements as to chemical composition prescribed in Table 1 (Low Carbon MT Grades), Table 2 (Higher Carbon Steels), Table 3 (Alloy Standard Steels (see Guide A1040)) and Table 4 (Resulfurized or Rephosphorized, or Both, Carbon Steels (see Guide A1040)).

6.2 Grade MT1015 or MTX1020 will be supplied at the producer's option, when no grade is specified.

6.3 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 Table 1 and Table 2 is not permitted.

6.4 Analyses of steels other than those listed are available. To determine their availability, the purchaser should contact the producer.

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.

TABLE 3 Chemical Requirements for Alloy Steels

NOTE 1—The ranges and limits in this table apply to steel not exceeding 200 in.² [1300 cm²] in cross-sectional area.

NOTE 2—Small quantities of certain elements are present in alloy steels which are not specified or required. These elements are considered as incidental and may be present to the following maximum amounts: copper, 0.35 %; nickel, 0.25 %; chromium, 0.20 %; molybdenum, 0.10 %.

NOTE 3—The ranges and limits given in this table apply to heat analysis; except as required by 7.1, product analyses are subject to the applicable additional tolerances given in Table 5.

Grade ^{A,B} Designation	Chemical Composition Limits, %							
	Carbon	Manganese	Phosphorus, ^C max	Sulfur, ^{C,D} max	Silicon	Nickel	Chromium	Molybdenum
1330	0.28–0.33	1.60–1.90	0.040	0.040	0.15–0.35	...	...	...
1335	0.33–0.38	1.60–1.90	0.040	0.040	0.15–0.35	...	...	...
1340	0.38–0.43	1.60–1.90	0.040	0.040	0.15–0.35	...	...	...
1345	0.43–0.48	1.60–1.90	0.040	0.040	0.15–0.35	...	...	...
3140	0.38–0.43	0.70–0.90	0.040	0.040	0.15–0.35	1.10–1.40	0.55–0.75	...
E3310	0.08–0.13	0.45–0.60	0.025	0.025	0.15–0.35	3.25–3.75	1.40–1.75	...
4012	0.09–0.14	0.75–1.00	0.040	0.040	0.15–0.35	...	...	0.15–0.25
4023	0.20–0.25	0.70–0.90	0.040	0.040	0.15–0.35	...	...	0.20–0.30
4024	0.20–0.25	0.70–0.90	0.040	0.035–0.050	0.15–0.35	...	...	0.20–0.30
4027	0.25–0.30	0.70–0.90	0.040	0.040	0.15–0.35	...	...	0.20–0.30
4028	0.25–0.30	0.70–0.90	0.040	0.035–0.050	0.15–0.35	...	...	0.20–0.30
4037	0.35–0.40	0.70–0.90	0.040	0.040	0.15–0.35	...	...	0.20–0.30
4042	0.40–0.45	0.70–0.90	0.040	0.040	0.15–0.35	...	...	0.20–0.30
4047	0.45–0.50	0.70–0.90	0.040	0.040	0.15–0.35	...	...	0.20–0.30
4063	0.60–0.67	0.75–1.00	0.040	0.040	0.15–0.35	...	...	0.20–0.30
4118	0.18–0.23	0.70–0.90	0.040	0.040	0.15–0.35	...	0.40–0.60	0.08–0.15
4130	0.28–0.33	0.40–0.60	0.040	0.040	0.15–0.35	...	0.80–1.10	0.15–0.25
4135	0.32–0.39	0.65–0.95	0.040	0.040	0.15–0.35	...	0.80–1.10	0.15–0.25
4137	0.35–0.40	0.70–0.90	0.040	0.040	0.15–0.35	...	0.80–1.10	0.15–0.25
4140	0.38–0.43	0.75–1.00	0.040	0.040	0.15–0.35	...	0.80–1.10	0.15–0.25
4142	0.40–0.45	0.75–1.00	0.040	0.040	0.15–0.35	...	0.80–1.10	0.15–0.25
4145	0.43–0.48	0.75–1.00	0.040	0.040	0.15–0.35	...	0.80–1.10	0.15–0.25
4147	0.45–0.50	0.75–1.00	0.040	0.040	0.15–0.35	...	0.80–1.10	0.15–0.25
4150	0.48–0.53	0.75–1.00	0.040	0.040	0.15–0.35	...	0.80–1.10	0.15–0.25
4320	0.17–0.22	0.45–0.65	0.040	0.040	0.15–0.35	1.65–2.00	0.40–0.60	0.20–0.30
4337	0.35–0.40	0.60–0.80	0.040	0.040	0.15–0.35	1.65–2.00	0.70–0.90	0.20–0.30
E4337	0.35–0.40	0.65–0.85	0.025	0.025	0.15–0.35	1.65–2.00	0.70–0.90	0.20–0.30
4340	0.38–0.43	0.60–0.80	0.040	0.040	0.15–0.35	1.65–2.00	0.70–0.90	0.20–0.30
E4340	0.38–0.43	0.65–0.85	0.025	0.025	0.15–0.35	1.65–2.00	0.70–0.90	0.20–0.30
4422	0.20–0.25	0.70–0.90	0.040	0.040	0.15–0.35	...	...	0.35–0.45
4427	0.24–0.29	0.70–0.90	0.040	0.040	0.15–0.35	...	...	0.35–0.45
4520	0.18–0.23	0.45–0.65	0.040	0.040	0.15–0.35	...	...	0.45–0.60
4615	0.13–0.18	0.45–0.65	0.040	0.040	0.15–0.35	1.65–2.00	...	0.20–0.30
4617	0.15–0.20	0.45–0.65	0.040	0.040	0.15–0.35	1.65–2.00	...	0.20–0.30
4620	0.17–0.22	0.45–0.65	0.040	0.040	0.15–0.35	1.65–2.00	...	0.20–0.30
4621	0.18–0.23	0.70–0.90	0.040	0.040	0.15–0.35	1.65–2.00	...	0.20–0.30
4718	0.16–0.21	0.70–0.90	0.040	0.040	0.15–0.35	0.90–1.20	0.35–0.55	0.30–0.40
4720	0.17–0.22	0.50–0.70	0.040	0.040	0.15–0.35	0.90–1.20	0.35–0.55	0.15–0.25
4815	0.13–0.18	0.40–0.60	0.040	0.040	0.15–0.35	3.25–3.75	...	0.20–0.30
4817	0.15–0.20	0.40–0.60	0.040	0.040	0.15–0.35	3.25–3.75	...	0.20–0.30
4820	0.18–0.23	0.50–0.70	0.040	0.040	0.15–0.35	3.25–3.75	...	0.20–0.30
5015	0.12–0.17	0.30–0.50	0.040	0.040	0.15–0.35	...	0.30–0.50	...
5046	0.43–0.50	0.75–1.00	0.040	0.040	0.15–0.35	...	0.20–0.35	...
5115	0.13–0.18	0.70–0.90	0.040	0.040	0.15–0.35	...	0.70–0.90	...
5120	0.17–0.22	0.70–0.90	0.040	0.040	0.15–0.35	...	0.70–0.90	...
5130	0.28–0.33	0.70–0.90	0.040	0.040	0.15–0.35	...	0.80–1.10	...
5132	0.30–0.35	0.60–0.80	0.040	0.040	0.15–0.35	...	0.75–1.00	...
5135	0.33–0.38	0.60–0.80	0.040	0.040	0.15–0.35	...	0.80–1.05	...
5140	0.38–0.43	0.70–0.90	0.040	0.040	0.15–0.35	...	0.70–0.90	...
5145	0.43–0.48	0.70–0.90	0.040	0.040	0.15–0.35	...	0.70–0.90	...
5147	0.46–0.51	0.70–0.95	0.040	0.040	0.15–0.35	...	0.85–1.15	...
5150	0.48–0.53	0.70–0.90	0.040	0.040	0.15–0.35	...	0.70–0.90	...
5155	0.51–0.59	0.70–0.90	0.040	0.040	0.15–0.35	...	0.70–0.90	...
5160	0.56–0.64	0.75–1.00	0.040	0.040	0.15–0.35	...	0.70–0.90	...
52100 ^F	0.93–1.05	0.25–0.45	0.025	0.015	0.15–0.35	0.25 max	1.35–1.60	0.10 max
E50100	0.98–1.10	0.25–0.45	0.025	0.025	0.15–0.35	...	0.40–0.60	...
E51100	0.98–1.10	0.25–0.45	0.025	0.025	0.15–0.35	...	0.90–1.15	...



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TABLE 3 Continued

Grade ^{A,B} Designation	Chemical Composition Limits, %							
	Carbon	Manganese	Phosphorus, ^C max	Sulfur, ^{C,D} max	Silicon	Nickel	Chromium	Molybdenum
E52100	0.98–1.10	0.25–0.45	0.025	0.025	0.15–0.35	...	1.30–1.60	...
6118	0.16–0.21	0.50–0.70	0.040	0.040	0.15–0.35	...	0.50–0.70	Vanadium 0.10–0.15
6120	0.17–0.22	0.70–0.90	0.040	0.040	0.15–0.35	...	0.70–0.90	0.10 min
6150	0.48–0.53	0.70–0.90	0.040	0.040	0.15–0.35	...	0.80–1.10	0.15 min
						Aluminum		Molybdenum
E7140	0.38–0.43	0.50–0.70	0.025	0.025	0.15–0.40	0.95–1.30 Nickel	1.40–1.80	0.30–0.40
8115	0.13–0.18	0.70–0.90	0.040	0.040	0.15–0.35	0.20–0.40	0.30–0.50	0.08–0.15
8615	0.13–0.18	0.70–0.90	0.040	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.15–0.25
8617	0.15–0.20	0.70–0.90	0.040	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.15–0.25
8620	0.18–0.23	0.70–0.90	0.040	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.15–0.25
8622	0.20–0.25	0.70–0.90	0.040	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.15–0.25
8625	0.23–0.28	0.70–0.90	0.040	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.15–0.25
8627	0.25–0.30	0.70–0.90	0.040	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	0.040	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.15–0.25
8637	0.35–0.40	0.75–1.00	0.040	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.15–0.25
8640	0.38–0.43	0.75–1.00	0.040	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.15–0.25
8642	0.40–0.45	0.75–1.00	0.040	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.15–0.25
8645	0.43–0.48	0.75–1.00	0.040	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.15–0.25
8650	0.48–0.53	0.75–1.00	0.040	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.15–0.25
8655	0.51–0.59	0.75–1.00	0.040	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.15–0.25
8660	0.55–0.65	0.75–1.00	0.040	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.15–0.25
8720	0.18–0.23	0.70–0.90	0.040	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.20–0.30
8735	0.33–0.38	0.75–1.00	0.040	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.20–0.30
8740	0.38–0.43	0.75–1.00	0.040	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.20–0.30
8742	0.40–0.45	0.75–1.00	0.040	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.20–0.30
8822	0.20–0.25	0.75–1.00	0.040	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.30–0.40
9255	0.51–0.59	0.60–0.80	0.040	0.040	1.80–2.20	...	0.60–0.80	...
9260	0.56–0.64	0.75–1.00	0.040	0.040	1.80–2.20	...	...	...
9262	0.55–0.65	0.75–1.00	0.040	0.040	1.80–2.20	...	0.25–0.40	...
E9310	0.08–0.13	0.45–0.65	0.025	0.025	0.15–0.35	3.00–3.50	1.00–1.40	0.08–0.15
9840	0.38–0.42	0.70–0.90	0.040	0.040	0.15–0.35	0.85–1.15	0.70–0.90	0.20–0.30
9850	0.48–0.53	0.70–0.90	0.040	0.040	0.15–0.35	0.85–1.15	0.70–0.90	0.20–0.30
50B40	0.38–0.42	0.75–1.00	0.040	0.040	0.15–0.35	...	0.40–0.60	...
50B44	0.43–0.48	0.75–1.00	0.040	0.040	0.15–0.35	...	0.40–0.60	...
50B46	0.43–0.50	0.75–1.00	0.040	0.040	0.15–0.35	...	0.20–0.35	...
50B50	0.48–0.53	0.74–1.00	0.040	0.040	0.15–0.35	...	0.40–0.60	...
50B60	0.55–0.65	0.75–1.00	0.040	0.040	0.15–0.35	...	0.40–0.60	...
51B60	0.56–0.64	0.75–1.00	0.040	0.040	0.15–0.35	...	0.70–0.90	...
81B45	0.43–0.48	0.75–1.00	0.040	0.040	0.15–0.35	0.20–0.40	0.35–0.55	0.08–0.15
86B45	0.43–0.48	0.75–1.00	0.040	0.040	0.15–0.35	0.40–0.70	0.40–0.60	0.15–0.25
94B15	0.13–0.18	0.75–1.00	0.040	0.040	0.15–0.35	0.30–0.60	0.30–0.50	0.08–0.15
94B17	0.15–0.20	0.75–1.00	0.040	0.040	0.15–0.35	0.30–0.60	0.30–0.50	0.08–0.15
94B30	0.28–0.33	0.75–1.00	0.040	0.040	0.15–0.35	0.30–0.60	0.30–0.50	0.08–0.15
94B40	0.38–0.43	0.75–1.00	0.040	0.040	0.15–0.35	0.30–0.60	0.30–0.50	0.08–0.15

^A Grades shown in this table with prefix letter E generally are manufactured by the basic-electric-furnace process. All others may be manufactured by any commercially viable steel making process or by the basic-electric-furnace process with adjustments in phosphorus and sulfur.

^B Grades shown in this table with the letter B, such as 50B40, can be expected to have 0.0005 % minimum boron control.

^C The phosphorus sulfur limitations for each process are as follows:

Basic electric furnace	0.025 max %	Acid electric furnace	0.050 max %
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^D Minimum and maximum sulfur content indicates resulfurized steels.

^E The purchaser may specify the following maximum amounts: copper, 0.30 %; aluminum, 0.050 %; and oxygen, 0.0015 %.

TABLE 4 Chemical Requirements of Resulfurized or Rephosphorized, or Both, Carbon Steels^A

Grade Designation	Chemical Composition Limits, %				
	Carbon	Manganese	Phosphorus	Sulfur	Lead
1118	0.14–0.20	1.30–1.60	0.040 max	0.08–0.13	
11L18	0.14–0.20	1.30–1.60	0.040 max	0.08–0.13	0.15–0.35
1132	0.27–0.32	1.35–1.65	0.040 max	0.08–0.13	
1137	0.32–0.39	1.35–1.65	0.040 max	0.08–0.13	
1141	0.37–0.45	1.35–1.65	0.040 max	0.08–0.13	
1144	0.40–0.48	1.35–1.65	0.040 max	0.24–0.33	
1213	0.13 max	0.70–1.00	0.07–0.12	0.24–0.33	
12L14	0.15 max	0.85–1.15	0.04–0.09	0.26–0.35	0.15–0.35
1215	0.09 max	0.75–1.05	0.04–0.09	0.26–0.35	

^A The ranges and limits given in this table apply to heat analysis; except as required by 7.1, product analyses are subject to the applicable additional tolerances given in Table 5.

8. Product Analysis

8.1 Except as required by 7.1, a product analysis by the manufacturer shall be required only when requested in the order.

8.1.1 *Heat Identity Maintained*—One product analysis per heat on either billet or tube.

8.1.2 *Heat Identity Not Maintained*—A product analysis from one tube per 2000 ft [600 m] or less for sizes over 3 in. [75 mm], and one tube per 5000 ft [1500 m] or less for sizes 3 in. [75 mm] and under.

8.2 Samples for chemical analysis, except for spectrochemical analysis, shall be taken in accordance with Test Methods and Practices A751. The composition thus determined shall correspond to the requirements in the applicable section or Tables 1-5 of this specification and shall be reported to the purchaser or the purchaser’s representative.

8.3 If the original test for check analysis fails, retests of two additional billets 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 billet or tube may be individually tested for acceptance. Billets or tubes which do not meet the requirements of the specification shall be rejected.

9. Permissible Variations in Dimensions of Round Tubing

9.1 *Hot-Finished Mechanical Tubing*—Hot-finished mechanical tubing is produced to outside diameter and wall thickness. Variations in outside diameter and wall thickness shall not exceed the tolerances shown in Table 6 and Table 7. Table 6 and Table 7 cover these tolerances and apply to the specified size.

9.2 Cold-Worked Mechanical Tubing:

9.2.1 Variations in outside diameter, inside diameter and wall thickness shall not exceed the tolerances shown in Tables 8-10.

9.2.2 Cold-worked mechanical tubing is normally produced to outside diameter and wall thickness. If the inside diameter is a more important dimension, then cold-worked tubing should be specified to inside diameter and wall thickness or outside diameter and inside diameter.

TABLE 5 Product Analysis Tolerances Over or Under Specified Range or Limit

NOTE 1—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.

NOTE 2—In all types of steel, because of the degree to which phosphorus and sulfur segregate, product analysis for these elements is not technologically appropriate for rephosphorized or resulfurized steels unless misapplication is clearly indicated.

Carbon Steel Seamless Tubes			
Element	Limit, or Maximum of Specified Range, %	Tolerance, Over the Maximum Limit or Under the Minimum Limit, %	
		Under min	Over max
Carbon	to 0.25, incl	0.02	0.02
	over 0.25 to 0.55, incl over 0.55	0.03 0.04	0.03 0.04
Manganese	to 0.90, incl	0.03	0.03
	over 0.90 to 1.65, incl	0.06	0.06
Phosphorus	basic steel to 0.05, incl	...	0.008
	acid-bessemer steel to 0.12, incl	...	0.010
Sulfur	to 0.06, incl	...	0.008
Silicon	to 0.35, incl	0.02	0.02
	over 0.35 to 0.60, incl	0.05	0.05
Copper	...	0.02	0.02
Alloy Steel Seamless Tube			
Elements	Limit, or Maximum of Specified Element, %	Tolerance Over Maximum Limit or Under Minimum Limit for Size Ranges Shown, %	
		100 in. ² [645 cm ²] or less	Over 100 to 200 in. ² [645 to 1290 cm ²], incl
Carbon	to 0.30, incl	0.01	0.02
	over 0.30 to 0.75, incl	0.02	0.03
	over 0.75	0.03	0.04
Manganese	to 0.90, incl	0.03	0.04
	over 0.90 to 2.10, incl	0.04	0.05
Phosphorus	over max, only	0.005	0.010
	Sulfur to 0.060, incl	0.005	0.010
Silicon	to 0.35, incl	0.02	0.02
	over 0.35 to 2.20, incl	0.05	0.06
	Nickel to 1.00, incl	0.03	0.03
Nickel	over 1.00 to 2.00, incl	0.05	0.05
	over 2.00 to 5.30, incl	0.07	0.07
	over 5.30 to 10.00, incl	0.10	0.10
Chromium	to 0.90, incl	0.03	0.04
	over 0.90 to 2.10, incl	0.05	0.06
	over 2.10 to 3.99, incl	0.10	0.10
Molybdenum	to 0.20, incl	0.01	0.01
	over 0.20 to 0.40, incl	0.02	0.03
	over 0.40 to 1.15, incl	0.03	0.04
Vanadium	to 0.10, incl	0.01	0.01
	over 0.10 to 0.25, incl	0.02	0.02
	over 0.25 to 0.50, incl	0.03	0.03
Tungsten	min value specified, check under min limit	0.01	0.01
	to 1.00, incl	0.04	0.05
Aluminum	over 1.00 to 4.00, incl	0.08	0.09
	up to 0.10, incl	0.03	...
	over 0.10 to 0.20, incl	0.04	...
	over 0.20 to 0.30, incl	0.05	...
	over 0.30 to 0.80, incl	0.07	...
	over 0.80 to 1.80, incl	0.10	...

9.3 *Rough-Turned Mechanical Tubing*—Variation in outside diameter and wall thickness shall not exceed the tolerance in

TABLE 6 Outside Diameter Tolerances for Round Hot-Finished Tubing^{A,B,C}

$$\pm b = c \times 0.006$$

Outside Diameter Size Range, in. [mm]	Outside Diameter Tolerance, in. [mm]	
	Over	Under
Up to 2.999 [76.17]	0.020 [0.51]	0.020 [0.51]
3.000–4.499 [76.20–114.27]	0.025 [0.64]	0.025 [0.64]
4.500–5.999 [114.30–152.37]	0.031 [0.79]	0.031 [0.79]
6.000–7.499 [152.40–190.47]	0.037 [0.94]	0.037 [0.94]
7.500–8.999 [190.50–228.57]	0.045 [1.14]	0.045 [1.14]
9.000–10.750 [228.60–273.05]	0.050 [1.27]	0.050 [1.27]

^A Diameter tolerances are not applicable to normalized and tempered or quenched and tempered conditions.

^B The common range of sizes of hot finished tubes is 1½ in. [38.1 mm] to 10¾ in. [273.0 mm] outside diameter with wall thickness at least 3 % or more of outside diameter, but not less than 0.095 in. [2.41 mm].

^C Larger sizes are available; consult manufacturer for sizes and tolerances.

TABLE 7 Wall Thickness Tolerances for Round Hot-Finished Tubing

Wall Thickness Range as Percent of Outside Diameter	Wall Thickness Tolerance, ^A percent Over and Under Nominal		
	Outside Diameter 2.999 in. [76.19 mm] and smaller	Outside Diameter 3.000 in. [76.20 mm] to 5.999 in. [152.37 mm]	Outside Diameter 6.000 in. [152.40 mm] to 10.750 in. [273.05 mm]
Under 15	12.5	10.0	10.0
15 and over	10.0	7.5	10.0

^A Wall thickness tolerances may not be applicable to walls 0.199 in. [5.05 mm] and less; consult manufacturer for wall tolerances on such tube sizes.

Table 11. Table 11 covers tolerances as applied to outside diameter and wall thickness and applies to the specified size.

9.4 *Ground Mechanical Tubing*—Variation in outside diameter shall not exceed the tolerances in Table 12. This product is normally produced from a cold-worked tube.

9.5 *Lengths*—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. Length tolerances are shown in Table 13.

9.6 *Straightness*—The straightness tolerances for seamless round tubing shall not exceed the amounts shown in Table 14.

10. Permissible Variations in Dimensions of Square and Rectangular Tubing

10.1 Variations in outside dimensions and wall thickness shall not exceed the tolerances shown in Table 15 unless otherwise specified by the manufacturer and the purchaser. The wall thickness dimensions shall not apply at the corners.

10.2 *Corner Radii*—The corners of a square and a rectangular tube will be slightly rounded inside and rounded outside consistent with the wall thickness. The outside corner may be slightly flattened. The radii of corners for square and rectangular cold finished tubing shall be in accordance with Table 16.

10.3 Squareness Tolerance:

10.3.1 Permissible variations for squareness for the side of square and rectangular tubing shall be determined by the following equation:

where:

b = tolerance for out-of-square, in. [mm], and

c = largest external dimension across flats, in. [mm].

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

10.3.2.1 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.

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

10.4 Twist Tolerance:

10.4.1 Twist tolerance for square and rectangular tubing shall be in accordance with Table 17. The twist tolerance in square and rectangular tubing may be measured by holding one end of the square or rectangular tube on a surface plate with the bottom side parallel to the surface plate and noting the height at either corner of the opposite end of the same side above the surface plate.

10.4.2 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.

10.5 *Lengths*—Square and rectangular tubing is commonly furnished in mill lengths 5 ft [1.5 m] and over. Definite cut lengths are furnished when specified by the purchaser. Length tolerances are shown in Table 18 and Table 9.

10.6 *Straightness*—Straightness for square and rectangular tubing shall be 0.060 in. in any 3 ft [1.5 mm in 1 m].

11. Machining Allowances

11.1 For the method of calculating the tube size required to cleanup in machining to a particular finished part, see Appendix X1.

12. Workmanship, Finish, and Appearance

12.1 The tubing shall be free of laps, cracks, seams, and other defects as is consistent with good commercial practice. The surface finish will be compatible with the condition to which it is ordered.

13. Condition

13.1 The purchaser shall specify a sizing method and, if required, a thermal treatment.

13.1.1 Sizing Methods:

13.1.1.1 HF—Hot Finished,

13.1.1.2 CW—Cold Worked,

13.1.1.3 RT—Rough Turned,

13.1.1.4 G—Ground.

13.1.2 Thermal Treatments:

13.1.2.1 A—Annealed,

13.1.2.2 N—Normalized,

13.1.2.3 QT—Quenched and Tempered,

13.1.2.4 SR—Stress Relieved or Finish Anneal.