



Designation: A 519 – 96 (Reapproved 2001)

Standard Specification for Seamless Carbon and Alloy Steel Mechanical Tubing¹

This standard is issued under the fixed designation A 519; 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. This standard replaces QQ-T-00825 and QQ-T-830.

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 3/4 in. (323.8 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 inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 ASTM Standards:

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products²

E 59 Practice for Sampling Steel and Iron for Determination of Chemical Composition³

2.2 Military Standards:

MIL-STD-129 Marking for Shipment and Storage⁴

MIL-STD-163 Steel Mill Products Preparation for Shipment and Storage⁴

2.3 Federal Standard:

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)⁴

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 Annual Book of ASTM Standards, Vol 01.03.

³ Annual Book of ASTM Standards, Vol 03.05.

⁴ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

TABLE 1 Chemical Requirements of Low-Carbon Steels

Grade Designation	Chemical Composition Limits, %			
	Carbon ^A	Manganese ^B	Phosphorus, ^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 6.1, product analyses are subject to the applicable additional tolerances given in Table 5.


3. Ordering Information

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

TABLE 2 Chemical Requirements of Other Carbon Steels

Grade Designation	Chemical Composition Limits, % ^A			
	Carbon	Manganese	Phosphorus, 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 6.1, product analyses are subject to the applicable additional tolerances given in Table Number 5.

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- 3.1.1 Quantity (feet, weight, or number of pieces),
- 3.1.2 Name of material (seamless carbon or alloy steel mechanical tubing),
- 3.1.3 Form (round, square, rectangular or special shapes, Section 1),
- 3.1.4 Dimensions (round, outside diameters and wall thickness, Section 8; square and rectangular, outside dimensions and wall thickness, Section 9; other, specify),
- 3.1.5 Length (specific or random, mill lengths, see 8.5 and 9.5),
- 3.1.6 Manufacture (hot finished or cold finished, 4.5 and 4.6),
- 3.1.7 Grade (Section 5),
- 3.1.8 Condition (sizing method and thermal treatment, Section 12),
- 3.1.9 Surface finish (special pickling, shot blasting, or ground outside surface, if required),
- 3.1.10 Specification designation,
- 3.1.11 Individual supplementary requirements, if required,
- 3.1.12 End use, if known,
- 3.1.13 Packaging,
- 3.1.14 Product analysis and chemical analysis, if required (Section 6 and Section 7),
- 3.1.15 Specific requirements, or exceptions to this specification,
- 3.1.16 Special marking (Section 15), and
- 3.1.17 Special packing (Section 16).

TABLE 3 Chemical Requirements for Alloy Steels

NOTE 1—The ranges and limits in this table apply to steel not exceeding 200 in.²(1290 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 6.1, product analyses are subject to the applicable additional tolerances given in Table Number 5.

Grade ^{A,B} Designation	Chemical Composition Limits, %							
	Carbon	Manganese	Phosphorus, <i>c</i> _{max}	Sulfur, ^{C,D} <i>c</i> _{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	0.33–0.38	0.70–0.90	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


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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
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	0.45–0.52	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	0.50–0.60	0.70–0.90	0.040	0.040	0.15–0.35	...	0.70–0.90	...
5160	0.55–0.65	0.75–1.00	0.040	0.040	0.15–0.35	...	0.70–0.90	...
E50100	0.95–1.10	0.25–0.45	0.025	0.025	0.15–0.35	...	0.40–0.60	...
E51100	0.95–1.10	0.25–0.45	0.025	0.025	0.15–0.35	...	0.90–1.15	...
E52100	0.95–1.10	0.25–0.45	0.025	0.025	0.15–0.35	...	1.30–1.60	...
								Vanadium
6118	0.16–0.21	0.50–0.70	0.040	0.040	0.15–0.35	...	0.50–0.70	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	1.40–1.80	0.30–0.40
						Nickel		
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	0.50–0.60	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	0.50–0.60	0.70–0.95	0.040	0.040	1.80–2.20	...	...	...
9260	0.55–0.65	0.70–1.00	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	0.38–0.43	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	...


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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
51B60	0.55–0.65	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 are normally manufactured by the basic-open-hearth process but may be manufactured 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 %
Basic open hearth	0.040 max %	Acid open hearth	0.050 max %

^D Minimum and maximum sulfur content indicates resulfurized steels.

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 a seamless process and shall be either hot finished or cold finished, as specified.

4.6 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.

5. Chemical Composition

5.1 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) and Table 4 (Resulfurized or Rephosphorized, or Both, Carbon Steels).

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

5.3 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.

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

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	0.27–0.34	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	0.70–1.10	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 6.1, product analyses are subject to the applicable additional tolerances given in Table Number 5.

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 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. Product Analysis

7.1 Except as required by 6.1, a product analysis by the manufacturer shall be required only when requested in the order.

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

7.1.2 *Heat Identity Not Maintained*—A product analysis from one tube per 2000 ft (610 m) or less for sizes over 3 in.

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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	0.03	0.03
	over 0.55	0.04	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
	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	...

7.2 Samples for chemical analysis, except for spectrochemical analysis, shall be taken in accordance with Practice E 59. 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.

7.3 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.

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

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.

8. Permissible Variations in Dimensions of Round Tubing

8.1 *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.

8.2 Cold-Worked Mechanical Tubing:

8.2.1 Variations in outside diameter, inside diameter and wall thickness shall not exceed the tolerances shown in Table 8 and Table 9.

8.2.2 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

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	Outside Diameter	Outside Diameter
2.999 in. (76.19 mm) and smaller	3.000 in. (76.20 mm) to 5.999 in. (152.37 mm)	6.000 in. (152.40 mm)	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.

(76.2 mm), and one tube per 5000 ft (1520 m) or less for sizes 3 in. (76.2 mm) and under.


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TABLE 8 Outside and Inside Diameter Tolerances for Round Cold-Worked Tubing^{A,B,C}

Outside Diameter Size Range, in. ^D	Wall Thickness As Percent of Outside Diameter	Thermal Treatment after Final Cold Work Producing Size											
		None, or not exceeding 1100°F Nominal Temperature				Heated Above 1100°F Nominal Temperature Without Accelerated Cooling				Quenched and Tempered			
		OD, in. ^D		ID, in. ^D		OD, in. ^D		ID, in. ^D		OD, in. ^D		ID, in. ^D	
		Over	Under	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under
Up to 0.499	all	0.004	0.000	—	—	0.005	0.002	—	—	0.010	0.010	0.010	0.010
0.500–1.699	all	0.005	0.000	0.000	0.005	0.007	0.002	0.002	0.007	0.015	0.015	0.015	0.015
1.700–2.099	all	0.006	0.000	0.000	0.006	0.006	0.005	0.005	0.006	0.020	0.020	0.020	0.020
2.100–2.499	all	0.007	0.000	0.000	0.007	0.008	0.005	0.005	0.008	0.023	0.023	0.023	0.023
2.500–2.899	all	0.008	0.000	0.000	0.008	0.009	0.005	0.005	0.009	0.025	0.025	0.025	0.025
2.900–3.299	all	0.009	0.000	0.000	0.009	0.011	0.005	0.005	0.011	0.028	0.028	0.028	0.028
3.300–3.699	all	0.010	0.000	0.000	0.010	0.013	0.005	0.005	0.013	0.030	0.030	0.030	0.030
3.700–4.099	all	0.011	0.000	0.000	0.011	0.013	0.007	0.010	0.010	0.033	0.033	0.033	0.033
4.100–4.499	all	0.012	0.000	0.000	0.012	0.014	0.007	0.011	0.011	0.036	0.036	0.036	0.036
4.500–4.899	all	0.013	0.000	0.000	0.013	0.016	0.007	0.012	0.012	0.038	0.038	0.038	0.038
4.900–5.299	all	0.014	0.000	0.000	0.014	0.018	0.007	0.013	0.013	0.041	0.041	0.041	0.041
5.300–5.549	all	0.015	0.000	0.000	0.015	0.020	0.007	0.014	0.014	0.044	0.044	0.044	0.044
5.550–5.559	under 6	0.010	0.010	0.010	0.010	0.018	0.018	0.018	0.018				
	6 to 7½	0.009	0.009	0.009	0.009	0.016	0.016	0.016	0.016				
	over 7½	0.018	0.000	0.009	0.009	0.017	0.015	0.016	0.016				
6.000–6.499	under 6	0.013	0.013	0.013	0.013	0.023	0.023	0.023	0.023				
	6 to 7½	0.010	0.010	0.010	0.010	0.018	0.018	0.018	0.018				
	over 7½	0.020	0.000	0.010	0.010	0.020	0.015	0.018	0.018				
6.500–6.999	under 6	0.015	0.015	0.015	0.015	0.027	0.027	0.027	0.027				
	6 to 7½	0.012	0.012	0.012	0.012	0.021	0.021	0.021	0.021				
	over 7½	0.023	0.000	0.012	0.012	0.026	0.015	0.021	0.021				
7.000–7.499	under 6	0.018	0.018	0.018	0.018	0.032	0.032	0.032	0.032				
	6 to 7½	0.013	0.013	0.013	0.013	0.023	0.023	0.023	0.023				
	over 7½	0.026	0.000	0.013	0.013	0.031	0.015	0.023	0.023				
7.500–7.999	under 6	0.020	0.020	0.020	0.020	0.035	0.035	0.035	0.035				
	6 to 7½	0.015	0.015	0.015	0.015	0.026	0.026	0.026	0.026				
	over 7½	0.029	0.000	0.015	0.015	0.036	0.015	0.026	0.026				
8.000–8.499	under 6	0.023	0.023	0.023	0.023	0.041	0.041	0.041	0.041				
	6 to 7½	0.016	0.016	0.016	0.016	0.028	0.028	0.028	0.028				
	over 7½	0.031	0.000	0.015	0.015	0.033	0.022	0.028	0.028				
8.500–8.999	under 6	0.025	0.025	0.025	0.025	0.044	0.044	0.044	0.044				
	6 to 7½	0.017	0.017	0.017	0.017	0.030	0.030	0.030	0.030				
	over 7½	0.034	0.000	0.015	0.015	0.038	0.022	0.030	0.030				
9.000–9.499	under 6	0.028	0.028	0.028	0.028	0.045	0.045	0.049	0.049				
	6 to 7½	0.019	0.019	0.019	0.019	0.033	0.033	0.033	0.033				
	over 7½	0.037	0.000	0.015	0.022	0.043	0.022	0.033	0.033				
9.500–9.999	under 6	0.030	0.030	0.030	0.030	0.045	0.045	0.053	0.053				
	6 to 7½	0.020	0.020	0.020	0.020	0.035	0.035	0.035	0.035				
	over 7½	0.040	0.000	0.015	0.025	0.048	0.022	0.035	0.035				
10.000–10.999	under 6	0.034	0.034	0.034	0.034	0.045	0.045	0.060	0.060				
	6 to 7½	0.022	0.022	0.022	0.022	0.039	0.039	0.039	0.039				
	over 7½	0.044	0.000	0.015	0.029	0.055	0.022	0.039	0.039				
11.000–12.000	under 6	0.035	0.035	0.035	0.035	0.050	0.050	0.065	0.065				
	6 to 7½	0.025	0.025	0.025	0.025	0.045	0.045	0.045	0.045				
	over 7½	0.045	0.000	0.015	0.035	0.060	0.022	0.045	0.045				

^A Many tubes with inside diameter less than 50 % of outside diameter or with wall thickness more than 25 % of outside diameter, or with wall thickness over 1¼ in., or weighing more than 90 lb/ft, are difficult to draw over a mandrel. Therefore, the inside diameter can vary over or under by an amount equal to 10 % of the wall thickness. See also Footnote B.

^B For those tubes with inside diameter less than ½ in. (or less than 5/8 in. when the wall thickness is more than 20 % of the outside diameter), which are not commonly drawn over a mandrel, Footnote A is not applicable. Therefore, for those tubes, the inside diameter is governed by the outside diameter tolerance shown in this table and the wall thickness tolerances shown in Table Number 9.

^C Tubing having a wall thickness less than 3 % of the outside diameter cannot be straightened properly without a certain amount of distortion. Consequently such tubes, while having an average outside diameter and inside diameter within the tolerances shown in this table, require an ovality tolerance of ½ % over and under nominal outside diameter, this being in addition to the tolerances indicated in this table.

^D 1 in. = 25.4 mm.

TABLE 9 Wall Thickness Tolerances for Round Cold-Worked Tubing

Wall Thickness Range as % of Outside Diameter	Wall Thickness Tolerance Over and Under Nominal, %	
	Up to 1.499 in., ID	1.500 in. and Over
25 and Under	10.0	7.5
Over 25	12.5	10.0

be specified to inside diameter and wall thickness or outside diameter and inside diameter.

8.3 Rough-Turned Mechanical Tubing—Variation in outside diameter and wall thickness shall not exceed the tolerance in Table 10. Table 10 covers tolerances as applied to outside diameter and wall thickness and applies to the specified size.