



Designation: B163 – 19

Standard Specification for Seamless Nickel and Nickel Alloy Condenser and Heat-Exchanger Tubes¹

This standard is issued under the fixed designation B163; 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 U.S. Department of Defense.

1. Scope*

1.1 This specification² covers seamless tubes of nickel and nickel alloys, as shown in **Table 1**, for use in condenser and heat-exchanger service.

1.2 This specification covers outside diameter and average wall, or outside diameter and minimum wall tube.

1.2.1 The sizes covered by this specification are 3 in. (76.2 mm) and under in outside diameter with minimum wall thicknesses of 0.148 in. (3.76 mm) and under, and with average wall thicknesses of 0.165 in. (4.19 mm) and under.

1.3 Tube shall be furnished in the alloys and conditions as shown in **Table 2**. For small diameter and light wall tube (converter sizes), see **Appendix X2**.

1.4 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.

1.5 The following safety hazards caveat pertains only to the test method portion, Section 12, of this specification. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to become familiar with all hazards including those identified in the appropriate Safety Data Sheet (SDS) for this product/material as provided by the manufacturer, to establish appropriate safety, health, and environmental practices, and determine the applicability of regulatory limitations prior to use.*

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 Recom-*

mendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

2. Referenced Documents

2.1 ASTM Standards:³

B829 Specification for General Requirements for Nickel and Nickel Alloys Seamless Pipe and Tube

B880 Specification for General Requirements for Chemical Check Analysis Limits for Nickel, Nickel Alloys and Cobalt Alloys

E8/E8M Test Methods for Tension Testing of Metallic Materials

E18 Test Methods for Rockwell Hardness of Metallic Materials

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E76 Test Methods for Chemical Analysis of Nickel-Copper Alloys (Withdrawn 2003)⁴

E112 Test Methods for Determining Average Grain Size

E140 Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness

E1473 Test Methods for Chemical Analysis of Nickel, Cobalt and High-Temperature Alloys

2.2 Federal Standards:⁵

Fed. Std. No. 102 Preservation, Packaging and Packing Levels

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

Fed. Std. No. 182 Continuous Identification Marking of Nickel and Nickel-Base Alloys

2.3 Military Standard:⁵

MIL-STD-129 Marking for Shipment and Storage

¹ This specification is under the jurisdiction of ASTM Committee B02 on Nonferrous Metals and Alloys and is the direct responsibility of Subcommittee B02.07 on Refined Nickel and Cobalt and Their Alloys.

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² For ASME Boiler and Pressure Vessel Code applications see related Specification SB-163 in Section II of that Code.

³ 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.

⁴ The last approved version of this historical standard is referenced on www.astm.org.

⁵ Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, <http://quicksearch.dla.mil>.

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

TABLE 1 Chemical Requirements^A

	Composition, %									
	N02200	N02201	N04400	N06025	N06045	N06600	N06601	N06603	N06686	N06690
Nickel	99.0 min ^B 0.25	99.0 min ^B 0.25	63.0 min ^B 28.0–34.0	remainder ^B 0.1	45.0 min ^B 0.3	72.0 min ^B 0.5	58.0–63.0 1.0	remainder ^B 0.5	remainder ^B ...	58.0 min ^B 0.5
Copper	...	...	...	...	...	...	...	...	...	...
Molybdenum	0.40	0.40	2.5	8.0–11.0	21.0–25.0	6.0–10.0	remainder ^B	8.0–11.0	15.0–17.0	...
Iron	0.35	0.35	2.0	0.15	1.0	1.0	1.0	0.15	5.0	7.0–11.0
Manganese	0.15	0.02	0.3	0.15–0.25	0.05–0.12	0.15	0.10	0.20–0.40	0.75	0.5
Carbon	0.35	0.35	0.5	0.5	2.5–3.0	0.5	0.5	0.5	0.010	0.05
Silicon	0.01	0.01	0.024	0.010	0.010	0.015	0.015	0.010	0.08	0.5
Sulfur	...	...	...	24.0–26.0	26.0–29.0	14.0–17.0	21.0–25.0	0.02	0.02	0.015
Chromium	...	...	...	1.8–2.4	...	...	1.0–1.7	2.4–3.0	19.0–23.0	27.0–31.0
Aluminum	...	...	...	0.1–0.2	...	...	...	0.01–0.25	...	...
Titanium	...	...	...	0.020	0.020	...	...	0.02	0.02–0.25	...
Phosphorus	...	...	...	...	0.03–0.09	...	...	...	0.04	...
Cerium	...	...	...	...	...	...	...	...	...	...
Zirconium	...	...	...	0.01–0.10	...	...	...	0.01–0.10	...	...
Yttrium	...	...	...	0.05–0.12	...	...	...	0.01–0.15	...	...
Boron	...	...	...	...	...	...	...	...	...	...
Cobalt	...	...	...	...	...	...	...	...	...	...
Columbium	...	...	...	...	...	...	...	...	...	...
(Nb)	...	...	...	...	...	...	...	...	...	...
Tungsten	...	...	...	...	...	...	...	...	3.0–4.4	...
Nitrogen	...	...	...	...	...	...	...	...	...	...

^A Maximum unless range or minimum is given. Where ellipses (...) appear in this table, there is no requirement and analysis for the element need not be determined or reported.

^B Element shall be determined arithmetically by difference.

TABLE 1 Chemical Requirements^A (continued)

	N06696	N06699	N06845	N08120	N08800	N08801	N08810	N08811	N08825	N08935
Nickel	remainder ^B	remainder ^B	44.0–50.0	35.0–39.0	30.0–35.0	30.0–34.0	30.0–35.0	30.0–35.0	38.0–46.0	34.0–36.0
Copper	1.5–3.0	0.50	2.0–4.0	0.50	0.75	0.50	0.75	0.75	1.5–3.0	0.4
Molybdenum	1.0–3.0	...	5.0–7.0	2.50	...	...	...	...	2.5–3.5	6.1–7.1
Iron	2.0–6.0	2.5	remainder ^B	remainder ^B	39.5 min ^B	39.5 min ^B	39.5 min ^B	39.5 min ^B	22.0 min ^B	remainder ^B
Manganese	1.0	0.50	0.5	1.5	1.5	1.50	1.5	1.5	1.0	1.2
Carbon	0.15	0.005–0.10	0.05	0.02–0.10	0.10	0.10	0.05–0.10	0.06–0.10	0.05	0.030
Silicon	1.0–2.5	0.50	0.5	1.0	1.0	1.00	1.0	1.0	0.5	0.5
Sulfur	0.010	0.01	0.010	0.03	0.015	0.015	0.015	0.015	0.03	0.020
Chromium	28.0–32.0	26.0–30.0	20.0–25.0	23.0–27.0	19.0–23.0	19.0–22.0	19.0–23.0	19.0–23.0	19.5–23.5	26.0–28.0
Aluminum	...	1.9–3.0	...	0.40	0.15–0.60	...	0.15–0.60	0.15–0.60 ^C	0.2	...
Titanium	1.0	0.60	...	0.20	0.15–0.60	0.75–1.5	0.15–0.60	0.15–0.60 ^C	0.6–1.2	...
Phosphorus	...	0.02	...	0.04	...	...	...	...	...	0.030
Cerium	...	...	...	...	...	...	...	...	...	...
Zirconium	...	0.10	...	...	...	...	...	...	...	...
Yttrium	...	...	...	...	...	...	...	...	...	...
Boron	...	0.008	...	0.010	...	...	...	...	...	...
Cobalt	...	...	...	3.0	...	...	...	...	...	...
Niobium	...	...	...	0.4–0.9	...	...	...	...	...	...
(Nb)	...	0.50	...	...	...	...	...	...	...	...
Tungsten	...	...	2.0–5.0	2.50	...	...	...	...	...	...
Nitrogen	...	0.05	...	0.13–0.30	...	...	...	...	...	0.25–0.36

^A Maximum unless range or minimum is given. Where ellipses (...) appear in this table, there is no requirement and analysis for the element need not be determined or reported.^B Element shall be determined arithmetically by difference.^C Alloy UNS N08811: Al + Ti, 0.85 – 1.20.

TABLE 2 Alloy and Conditions

Alloy	Condition
Nickel UNS N02200 and low-carbon nickel UNS N02201	annealed or stress-relieved
Nickel-copper alloy UNS N04400	annealed or stress-relieved
Nickel-chromium-iron-aluminum alloy UNS N06603	annealed
Nickel-chromium-iron-copper alloy UNS N06696	annealed
Nickel-chromium-iron-aluminum alloy UNS N06601	annealed
Nickel-chromium-iron alloy UNS N06600	annealed
Low-carbon nickel-chromium-molybdenum-tungsten alloy UNS N06686	annealed
Nickel-chromium-iron alloy UNS N06690	annealed
Nickel-chromium-iron alloy UNS N06045	annealed
Nickel-iron-chromium alloy UNS N08120 ^A	annealed or cold-worked
Nickel-iron-chromium alloy UNS N08800 ^A	annealed or cold-worked
Nickel-iron-chromium alloy UNS N08810 ^A	annealed
Nickel-iron-chromium alloy UNS N08811 ^A	annealed
Nickel-iron-chromium alloy UNS N08801	annealed
Nickel-iron-chromium-molybdenum alloy UNS N08935	annealed
Nickel-iron-chromium-molybdenum-copper alloy UNS N08825	annealed
Nickel-chromium-iron alloy UNS N06025	annealed
Nickel-iron-chromium-molybdenum-copper alloy UNS N06845	annealed
Nickel-chromium-aluminum alloy UNS N06699	annealed

^A Alloy UNS N08800 is normally employed in service temperatures up to and including 1100°F (593°C). Alloys UNS N08810, UNS N08811, and UNS N08120 are normally employed in service temperatures above 1100°F (539°C) where resistance to creep and rupture is required, and it is annealed to develop controlled grain size for optimum properties in this temperature range.

3. Terminology

3.1 Definitions:

3.1.1 *average diameter, n*—average of the maximum and minimum outside diameters, as determined at any one cross section of the tube.

3.1.2 *tube, n*—hollow product of round or any other cross section having a continuous periphery.

4. Ordering Information

4.1 It is the responsibility of the purchaser to specify all requirements that are necessary for the safe and satisfactory performance of material ordered under this specification. Examples of such requirements include, but are not limited to, the following:

4.1.1 *Alloy* (Table 1).

4.1.2 *Condition (Temper)* Table 3 and Appendix X1 and Appendix X2.

4.1.2.1 If annealed ends for stress relieved tubing are desired, state length of end to be annealed and whether or not one end or both ends are to be annealed.

4.1.3 *Finish*.

4.1.4 *Dimensions*—Outside diameter, minimum or average wall thickness (in inches, not gage number), and length.

4.1.5 *Fabrication Operations*:

4.1.5.1 *Cold Bending or Coiling*.

4.1.5.2 *Packing*.

4.1.5.3 *Rolling or Expanding into Tube Sheets*.

4.1.5.4 *Welding or Brazing*—Process to be employed.

4.1.5.5 *Hydrostatic Test or Nondestructive Electric Test*—Specify type of test (6.5).

4.1.5.6 *Pressure Requirements*—If other than required by 6.5.

4.1.5.7 *Ends*—Plain ends cut and deburred will be furnished.

4.1.6 *Supplementary Requirements*—State nature and details.

4.1.7 *Certification*—State if certification is required (Section 15).

4.1.8 *Samples for Product (Check) Analysis*—Whether samples for product (check) analysis shall be furnished.

4.1.9 *Purchaser Inspection*—If purchaser wishes to witness tests or inspection of material at place of manufacture, the purchase order must so state indicating which tests or inspections are to be witnessed (Section 13).

4.1.10 *Small-Diameter and Light-Wall Tube (Converter Sizes)*—See Appendix X2.

5. Chemical Composition

5.1 The material shall conform to the composition limits specified in Table 1.

5.2 If a product (check) analysis is performed by the purchaser, the material shall conform to the product (check) analysis per Specification B880.

6. Mechanical Properties and Other Requirements

6.1 *Mechanical Properties*—The material shall conform to the mechanical properties specified in Table 3.

6.2 *Hardness*—When annealed ends are specified for tubing in the stress-relieved condition (see Table 3), the hardness of the ends after annealing shall not exceed the values specified in Table 3.

6.3 *Flare*—A flare test shall be made on one end of 1 % of the number of finished tube lengths from each lot. For less than 100 tubes in a lot, a flare test shall be made on one end of one tube length in the lot. In the case of stress relieved tubing with annealed ends, the test shall be made prior to, or subsequent to, annealing of the ends at the option of the manufacturer.

6.3.1 The flare test shall consist of flaring a test specimen with an expanding tool having an included angle of 60° until the specified outside diameter has been increased by 30 %. The flared specimen shall not exhibit cracking through the wall.

6.4 *Grain Size*—A transverse sample representing full-wall thickness of annealed alloys UNS N08120, UNS N08810 and UNS N08811 shall conform to an average grain size of ASTM No. 5 or coarser.