Designation: ~~B167 – 18~~ B167 – 23

Standard Specification for Nickel-Chromium-Aluminum ~~Alloys (UNS N06699), Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, N06045, and N06696), Nickel-Chromium-Cobalt-Molybdenum Alloy (UNS N06617), Nickel-Iron-Chromium-Tungsten Alloy (UNS N06674),~~ Alloys, Nickel-Chromium-Iron Alloys, Nickel-Chromium-Cobalt-Molybdenum Alloy, Nickel-Iron-Chromium-Tungsten Alloy, and Nickel-Chromium-Molybdenum-Copper Alloy ~~(UNS N06235)~~ Seamless Pipe and Tube[1]

This standard is issued under the fixed designation B167; 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 specification[2] covers nickel-chromium-aluminum alloys (UNS N06699), nickel-chromium-iron alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, N06045, and N06696),[3] nickel-chromium-cobalt-molybdenum alloy (UNS N06617), nickel-iron-chromium-tungsten alloy (UNS N06674), and nickel-chromium-molybdenum-copper alloy (UNS N06235) in cold-worked annealed, hot-worked annealed, and hot-finished seamless pipe and tube intended for general corrosion resistant and heat resistant applications.

1.2 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.

1.3 The following safety hazards caveat pertains only to the test methods portion, Section 13, 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.*

1.4 *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 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-167 in Section II of that Code.

[3] Designation established in accordance with Practice E527 and SAE J 1086, Practice for Numbering Metals and Alloys (UNS).

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

2. Referenced Documents

2.1 *ASTM Standards:*[4]

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~~B899 ~~Test Methods for Tension Testing of Metallic Materials~~Terminology Relating to Non-ferrous Metals and Alloys

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

~~E38 Methods for Chemical Analysis of Nickel-Chromium and Nickel-Chromium-Iron Alloys (Withdrawn 1989)~~[5]

E112 Test Methods for Determining Average Grain Size

E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

~~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

3. Terminology

~~3.1 *Definitions of Terms Specific to This Standard:*~~

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

~~3.1.2 *pipe, n*—tube conforming to the particular dimensions commercially known as pipe sizes. See Table X2.1.~~

~~3.1.3 *seamless pipe or tube, n*—a pipe or tube produced with a continuous periphery in all stages of the operations.~~

~~3.1.4 *tube, n*—a hollow product of round or any other cross section having a continuous periphery.~~

3.1 *Definitions:*

3.1.1 The terms and definitions of Terminology B899 apply.

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 Name or UNS Number*—see Table 1,

4.1.2 *ASTM Designation,* including year of issue,

4.1.3 *Condition* (see Appendix ~~X3~~X2),

4.1.4 *Finish* (see Appendix ~~X3~~X2),

4.1.5 *Dimensions:*

4.1.5.1 *Tube*—Specify outside diameter and nominal or minimum wall,

4.1.5.2 *Pipe*—Specify standard pipe size and ~~schedule,~~schedule (see Appendix X1),

[4] 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.

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

TABLE 1 Chemical Requirements[A]

Element	Composition Limits, %											
	Alloy N06025	Alloy N06045	Alloy N06600	Alloy N06601	Alloy N06603	Alloy N06617	Alloy N06674	Alloy N06690	Alloy N06693	Alloy N06696	Alloy N06699	Alloy N06235
Nickel	remainder[B]	45.0 min	72.0 min	58.0–63.0	remainder[B]	44.5 min	remainder[B]	58.0 min	remainder[B]	remainder[B]	remainder[B]	remainder[B]
Chromium	24.0–26.0	26.0–29.0	14.0–17.0	21.0–25.0	24.0–26.0	20.0-24.0	21.5–24.5	27.0–31.0	27.0–31.0	28.0–32.0	26.0-30.0	30.0-32.5
~~Iron~~	~~8.0–11.0~~	~~21.0–25.0~~	~~6.0–10.0~~	~~remainder[B]~~	~~8.0–11.0~~	~~3.0 max~~	~~20.0–27.0~~	~~7.0–11.0~~	~~2.5–6.0~~	~~2.0–6.0~~	~~2.5 max~~	~~1.5 max~~
Iron	8.0–11.0	21.0–25.0	6.0–10.0	remainder[B]	8.0–11.0	3.0	20.0–27.0	7.0–11.0	2.5–6.0	2.0–6.0	2.5	1.5
~~Manganese~~	~~0.15 max~~	~~1.0 max~~	~~1.0 max~~	~~1.5 max~~	~~0.15 max~~	~~1.0 max~~	~~1.50 max~~	~~0.5 max~~	~~1.0 max~~	~~1.0 max~~	~~0.50 max~~	~~0.3-0.65~~
Manganese	0.15	1.0	1.0	1.5	0.15	1.0	1.50	0.5	1.0	1.0	0.50	0.3-0.65
Molybdenum	...	...	...	...	...	8.0–10.0	...	...	...	1.0–3.0	...	5.0-6.2
~~Cobalt~~	~~...~~	~~...~~	~~...~~	~~...~~	~~...~~	~~10.0–15.0~~	~~...~~	~~...~~	~~...~~	~~...~~	~~...~~	~~1.0 max~~
Cobalt	...	...	...	...	...	10.0–15.0	...	...	...	...	...	1.0
Aluminum	1.8–2.4	...	...	1.0–1.7	2.4-3.0	0.8-1.5	...	...	2.5–4.0	...	1.9-3.0	0.2-0.4
~~Carbon~~	~~0.15–0.25~~	~~0.05–0.12~~	~~0.15 max~~	~~0.10 max~~	~~0.20-0.40~~	~~0.05-0.15~~	~~0.10 max~~	~~0.05 max~~	~~0.15 max~~	~~0.15 max~~	~~0.005-0.10~~	~~0.02-0.06~~
Carbon	0.15–0.25	0.05–0.12	0.15	0.10	0.20-0.40	0.05-0.15	0.10	0.05	0.15	0.15	0.005-0.10	0.02-0.06
~~Copper~~	~~0.1 max~~	~~0.3 max~~	~~0.5 max~~	~~1.0 max~~	~~0.50 max~~	~~0.5 max~~	~~...~~	~~0.5 max~~	~~0.5 max~~	~~1.5–3.0~~	~~0.50 max~~	~~3.5-4.0~~
Copper	0.1	0.3	0.5	1.0	0.50	0.5	...	0.5	0.5	1.5–3.0	0.50	3.5-4.0
~~Boron~~	~~...~~	~~...~~	~~...~~	~~...~~	~~...~~	~~0.006 max~~	~~0.0005–0.006~~	~~...~~	~~...~~	~~...~~	~~0.008 max~~	~~...~~
Boron	...	...	...	...	...	0.006	0.0005–0.006	...	...	...	0.008	...
~~Silicon~~	~~0.5 max~~	~~2.5–3.0~~	~~0.5 max~~	~~0.5 max~~	~~0.50 max~~	~~1.0 max~~	~~1.0 max~~	~~0.5 max~~	~~0.5 max~~	~~1.0–2.5~~	~~0.50 max~~	~~0.2-0.6~~
Silicon	0.5	2.5–3.0	0.5	0.5	0.50	1.0	1.0	0.5	0.5	1.0–2.5	0.50	0.2-0.6
~~Sulfur~~	~~0.010 max~~	~~0.010 max~~	~~0.015 max~~	~~0.015 max~~	~~0.010 max~~	~~0.015 max~~	~~0.015 max~~	~~0.015 max~~	~~0.01 max~~	~~0.010 max~~	~~0.01 max~~	~~0.015 max~~
Sulfur	0.010	0.010	0.015	0.015	0.010	0.015	0.015	0.015	0.01	0.010	0.01	0.015
~~Titanium~~	~~0.1–0.2~~	~~...~~	~~...~~	~~...~~	~~0.1–0.25~~	~~0.6 max~~	~~0.05–0.20~~	~~...~~	~~1.0 max~~	~~1.0 max~~	~~0.60 max~~	~~0.5 max~~
Titanium	0.1–0.2	...	...	...	0.1–0.25	0.6	0.05–0.20	...	1.0	1.0	0.60	0.5
~~Niobium~~	~~...~~	~~...~~	~~...~~	~~...~~	~~...~~	~~...~~	~~0.10–0.35~~	~~...~~	~~0.5–2.5~~	~~...~~	~~0.50 max~~	~~1.0 max~~
Niobium[C]	...	...	...	...	...	...	0.10–0.35	...	0.5–2.5	...	0.50	1.0
~~Phosphorous~~	~~0.020 max~~	~~0.020 max~~	~~...~~	~~...~~	~~0.020 max~~	~~...~~	~~0.030 max~~	~~...~~	~~...~~	~~...~~	~~0.02 max~~	~~0.03 max~~
Phosphorous	0.020	0.020	...	...	0.020	...	0.030	...	...	...	0.02	0.03
~~Zirconium~~	~~0.01–0.10~~	~~...~~	~~...~~	~~...~~	~~0.01–0.10~~	~~...~~	~~...~~	~~...~~	~~...~~	~~...~~	~~0.10 max~~	~~...~~
Zirconium	0.01–0.10	...	...	...	0.01–0.10	...	...	...	...	...	0.10	...
Yttrium	0.05–0.12	...	...	...	0.01–0.15	...	...	...	...	...	...	...
Cerium	...	0.03–0.09	...	...	...	...	...	...	...	...	...	...
~~Nitrogen~~	~~...~~	~~...~~	~~...~~	~~...~~	~~...~~	~~...~~	~~0.02 max~~	~~...~~	~~...~~	~~...~~	~~0.05 max~~	~~...~~
Nitrogen	...	...	...	...	...	...	0.02	...	...	...	0.05	...
~~Tungsten~~	~~...~~	~~...~~	~~...~~	~~...~~	~~...~~	~~...~~	~~6.0–8.0~~	~~...~~	~~...~~	~~...~~	~~...~~	~~0.60 max~~
Tungsten	...	...	...	...	...	...	6.0–8.0	...	...	...	...	0.60

[A] ~~Where~~ Maximum, unless a range or minimum is indicated. Where ellipses (...) appear in this table, there is no requirement and the element need neither be analyzed for nor reported.
[B] Element shall be determined arithmetically by difference.
[C] The terms columbium (Cb) and niobium (Nb) both refer to the same element.

4.1.5.3 *Length*—Cut to length or random,

4.1.6 *Quantity*—Feet or number of pieces,

4.1.7 *Hydrostatic Test or Nondestructive Electric Test*—Specify type of test (see ~~7.2~~8.1).

4.1.8 *Hydrostatic Pressure Requirements*—Specify test pressure if other than required by ~~13.3.1~~8.2.1,

4.1.9 *Samples for Product (Check) Analysis*—State whether samples for product (check) analysis should be furnished (see ~~5.2~~6.2),

4.1.10 *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 14), and

4.1.11 *Small-Diameter Tube and Tube with Specified Wall Thickness 3 % or Less of the Specified Outside Diameter (Converter Sizes)*—See ~~Appendix X1~~A1.

5. Materials and Manufacture

5.1 Material furnished under this specification shall conform to the applicable requirements of Specification B829 unless otherwise provided herein.

5.2 Heat treatment of N06674 after cold-working or hot-working shall be solution annealing by heating to 2150 °F (1175 °C) minimum, followed by quenching in water or rapidly cooling by other means.

6. Chemical Composition

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

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

~~**6. Heat Treatment**~~

~~6.1 Heat treatment of N06674 after cold-working or hot-working shall be solution annealing by heating to 2150°F (1175°C) minimum, followed by quenching in water or rapidly cooling by other means.~~

7. Mechanical Properties and Other Requirements

7.1 *Tensile Test*—The material shall conform to the tensile properties specified in Table 2.

~~7.1.1 Tensile properties for material specified as small-diameter tube and tube with specified wall thickness 3 % or less of the specified outside diameter (converter sizes) shall be as prescribed in Table X1.1.~~

~~7.2 *Hydrostatic or Nondestructive Electric Test*—Each pipe or tube shall be subjected to either the hydrostatic test or the nondestructive electric test. The type of test to be used shall be at the option of the manufacturer, unless otherwise specified in the purchase order.~~

7.2 *Grain Size:*

7.2.1 Grain size for N06674 shall be 7 or coarser, as determined in accordance with Test Methods E112.

7.2.2 Grain size determinations, to demonstrate compliance with 7.2.1, shall be made on one end of one finished tube from each lot. See 11.1.2.

TABLE 2 Mechanical Properties

Condition and Size	Tensile Strength, min psi (MPa)	Yield Strength (0.2 % offset), min, psi (MPa)	Elongation in 2 in. or 50 mm or 4*D* min,%
UNS N06025:			
Hot-worked annealed or cold worked annealed (all sizes)	98 000 (680)	39 000 (270)	30
UNS N06045:			
Hot-worked annealed or cold-worked annealed (all sizes)	90 000 (620)	35 000 (240)	35
UNS N06600:			
Hot-worked or hot-worked annealed:			
5 in. (127 mm) in outside diameter and under	80 000 (550)	30 000 (205)	35
Over 5 in. (127 mm) in outside diameter	75 000 (515)	25 000 (170)	35
Cold-worked annealed:			
5 in. (127 mm) in outside diameter and under	80 000 (550)	35 000 (240)	30
Over 5 in. (127 mm) in outside diameter	80 000 (550)	30 000 (205)	35
UNS N06601:			
Cold-worked annealed or hot-worked annealed:			
All sizes	80 000 (550)	30 000 (205)	30
UNS N06603:			
Hot-worked annealed or cold worked annealed (all sizes)	94 000 (650)	43 000 (300)	25
UNS N06617:			
Cold-worked annealed or hot-worked annealed: All sizes	95 000 (665)	35 000 (240)	35
UNS N06674:			
Cold-worked annealed or hot-worked annealed: All sizes	86 000 (590)	34 000 (235)	30
UNS N06690:			
Hot-worked or hot-worked annealed:			
5 in. (127 mm) in outside diameter and under	85 000 (586)	30 000 (205)	35
Over 5 in. (127 mm) in outside diameter	75 000 (515)	25 000 (170)	35
Cold-worked annealed:			
5 in. (127 mm) in outside diameter and under	85 000 (586)	35 000 (240)	30
Over 5 in. (127 mm) in outside diameter	85 000 (586)	30 000 (205)	35
UNS N06693:			
Cold-worked annealed or hot- worked annealed: 5 in. (127 mm) in outside diameter and under	100 000 (690)	50 000 (345)	30
UNS N06696			
Cold-worked annealed (all sizes)	85 000 (586)	35 000 (240)	30
UNS N06235			
Hot-worked annealed or cold worked annealed (all sizes)	90 000 (620)	35 000 (240)	35
UNS N06699			

TABLE 2 *Continued*

Condition and Size	Tensile Strength, min psi (MPa)	Yield Strength (0.2 % offset), min, psi (MPa)	Elongation in 2 in. or 50 mm or 4*D* min,%
Hot-worked annealed or cold worked annealed (all sizes)	89 000 (610)	35 000 (240)	40

8. Nondestructive Testing and Examination

8.1 *Hydrostatic or Nondestructive Electric Test*—Each pipe or tube shall be subjected to either the hydrostatic test or the nondestructive electric test. The type of test to be used shall be at the option of the manufacturer, unless otherwise specified in the purchase order.

8.2 *Hydrostatic Test*—Each pipe or tube with an outside diameter ⅛ in. (3 mm) and larger and with wall thickness of 0.015 in. (0.38 mm) and over shall be tested by the manufacturer to an internal hydrostatic pressure of 1000 psi (6.9 MPa) provided that the fiber stress calculated in accordance with the following equation does not exceed the allowable fiber stress, *S*, indicated as follows:

$$P = 2St/D \quad (1)$$

where:

P = hydrostatic test pressure, psi (or MPa),
t = minimum wall thickness, in. (or mm), equal to the specified nominal wall minus the permissible minus wall tolerance, or the specified minimum wall thickness,
D = outside diameter of the pipe or tube, in. (or mm), and
S = allowable fiber stress, for material in the condition (temper) furnished as follows:

Hot-worked or hot-worked annealed:	—
UNS N06025	24 000 (165 MPa)
UNS N06045	22 500 (155 MPa)
UNS N06600	20 000 (140 MPa)
UNS N06601	20 000 (140 MPa)
UNS N06603	24 000 (165 MPa)
UNS N06617	23 700 (163 MPa)
UNS N06690	21 200 (146 MPa)
UNS N06674	21 500 (148 MPa)
UNS N06693	25 000 (172 MPa)
UNS N06235	22 500 (155 MPa)
UNS N06699	22 100 (152 MPa)
Over 5 in. outside diameter:	—
UNS N06600	16 700 (115 MPa)
UNS N06690	16 700 (115 MPa)
Cold-worked annealed—All sizes:	—
UNS N06025	24 500 (169 MPa)
UNS N06045	22 500 (155 MPa)
UNS N06600	20 000 (140 MPa)
UNS N06601	20 000 (140 MPa)
UNS N06674	21 500 (148 MPa)
UNS N06690	21 200 (146 MPa)
UNS N06693	21 200 (146 MPa)
UNS N06696	21 200 (146 MPa)
UNS N06235	22 500 (155 MPa)
UNS N06699	22 100 (152 MPa)

8.2.1 When so agreed upon between the manufacturer and purchaser, pipe or tube may be tested to 1½ times the allowable fiber stress given above.

8.2.2 If any pipe or tube shows leaks during hydrostatic testing, it shall be rejected.

8.3 *Nondestructive Electric Test*—Each pipe or tube shall be examined with a nondestructive electric test in accordance with Specification B829.