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Standard Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, N06045, and N06696),* Nickel- Chromium-Cobalt-Molybdenum Alloy (UNS N06617), and Nickel-Chromium-Cobalt-MolybdenumNickel-Iron-Chromium- Tungsten Alloy (UNS N06617)N06674) Seamless Pipe and Tube¹

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 Department of Defense.

1. Scope*

1.1 This specification² covers nickel-chromium-iron alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, N06045, and ~~N06696)* and N06696)*~~ nickel-chromium-cobalt-molybdenum alloy (UNS N06617), and nickel-iron-chromium-tungsten alloy UNS N06674), 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 ~~the 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 Material Safety Data Sheet (MSDS) for this product/material as provided by the manufacturer; to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.*

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 [Test Methods for Tension Testing of Metallic Materials](#)

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](#)

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:⁴

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:⁴

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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* New designation established in accordance with Practice E527 and SAE J 1086, Practice for Numbering Metals and Alloys (UNS).

² For ASME Boiler and Pressure Vessel Code applications see related Specification SB-167 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 Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, <http://www.dodssp.daps.mil>.

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

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.

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),

4.1.4 *Finish* (see Appendix X3),

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,

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 ~~6.27.2~~).

4.1.8 *Hydrostatic Pressure Requirements*—Specify test pressure if other than required by ~~42.3.4~~13.3.1,

4.1.9 *Certification*—State if certification is required (Section ~~1516~~),

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

4.1.11 *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 ~~1314~~), and

4.1.12 *Small-Diameter and Light-Wall Tube (Converter Sizes)*—See Appendix X1.

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 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

~~6.1~~

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

67.1.1 Tensile properties for material specified as small-diameter and light-wall tube (converter sizes) shall be as prescribed in Table X1.1.

~~6.2~~

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.~~

7.3 Grain Size:

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

8. Dimensions and Permissible Variations

~~7.1~~

8.1 Diameter, Wall Thickness, and Length—The permissible variations in the outside diameter and wall thickness shall conform to the permissible variations prescribed in the Permissible Variations for Outside Diameter and Wall Thickness of Seamless Cold-Worked Pipe and Tube, Permissible Variations for Outside Diameter and Wall Thickness of Hot-Finished Tube, and

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
Nickel	remainder ^A	45.0 min	72.0 min	58.0-63.0	remainder ^A	44.5 min	remainder ^B	58.0 min	remainder ^A	remainder ^A
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
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
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
Iron	8.0-11.0	21.0-25.0	6.0-10.0	remainder ^A	8.0-11.0	3.0 max	20.0-27.0	7.0-11.0	2.5-6.0	2.0-6.0
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
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
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
Molybdenum	...	...	...	...	...	...	...	...	...	...
Molybdenum	...	...	...	...	...	...	...	...	...	...
Cobalt	...	...	...	...	...	...	...	...	...	...
Cobalt	...	...	...	...	...	...	...	...	...	...
Aluminum	1.8-2.4	...	...	1.0-1.7	2.4-3.0	8.0-10.0	...	...	...	...
Aluminum	1.8-2.4	...	...	1.0-1.7	2.4-3.0	8.0-10.0	...	...	...	...
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
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
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
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
Boron	...	...	...	...	...	0.006 max	...	...	...	...
Boron	...	...	...	...	...	0.006 max	0.0005-0.006	...	...	...
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
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
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
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
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
Titanium	0.1-0.2	...	...	...	0.1-0.25	0.6 max	0.05-0.20	...	1.0 max	1.0 max
Titanium	0.1-0.2	...	...	...	0.1-0.25	0.6 max	0.05-0.20	...	1.0 max	1.0 max
Niobium	...	...	...	...	...	...	0.10-0.35	...	0.5-2.5	...
Niobium	...	...	...	...	...	...	0.10-0.35	...	0.5-2.5	...
Phosphorus	0.020 max	0.020 max	...	...	0.020 max	...	0.030 max	...	...	...
Phosphorus	0.020 max	0.020 max	...	...	0.020 max	...	0.030 max	...	...	...
Zirconium	0.01-0.10	...	...	...	0.01-0.10	...	...	...	...	...
Zirconium	0.01-0.10	...	...	...	0.01-0.10	...	...	...	...	...
Yttrium	0.05-0.12	...	...	...	0.01-0.15	...	...	...	...	...
Yttrium	0.05-0.12	...	...	...	0.01-0.15	...	...	...	...	...
Yttrium	0.05-0.12	...	...	...	0.01-0.15	...	...	...	...	...
Cerium	...	0.03-0.09	...	...	...	...	...	...	...	...
Cerium	...	0.03-0.09	...	...	...	...	0.02 max	...	...	...
Nitrogen	...	...	...	...	...	...	6.0-8.0	...	...	...
Nitrogen	...	...	...	...	...	...	6.0-8.0	...	...	...
Tungsten	...	...	...	...	...	...	...	...	...	...
Tungsten	...	...	...	...	...	...	...	...	...	...

^A 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.

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 4D min,%
<i>UNS N06025:</i> Hot-worked annealed or cold worked annealed (all sizes)	98 000 (680)	39 000 (270)	30
<i>UNS N06045:</i> Hot-worked annealed or cold-worked annealed (all sizes)	90 000 (620)	35 000 (240)	35
<i>UNS N06600:</i> 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
<i>UNS N06601:</i> Cold-worked annealed or hot-worked annealed: All sizes	80 000 (550)	30 000 (205)	30
<i>UNS N06603:</i> Hot-worked annealed or cold worked annealed (all sizes)	94 000 (650)	43 000 (300)	25
<i>UNS N06617:</i> Cold-worked annealed or hot-worked annealed: All sizes	95 000 (665)	35 000 (240)	35
<i>UNS N06674:</i> Cold-worked annealed or hot-worked annealed: All sizes	86 000 (590)	34 000 (235)	30
<i>UNS N06690:</i> 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
<i>UNS N06693:</i> Cold-worked annealed or hot-worked annealed: 5 in. (127 mm) in outside diameter and under	100 000 (690)	50 000 (345)	30
<i>UNS N06696</i> Cold-worked annealed (all sizes)	85 000 (586)	35 000 (240)	30

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Permissible Variations for Outside Diameter and Wall Thickness of Seamless Hot-Worked Pipe tables in Specification B829. The permissible variations in the length shall conform to the permissible variations prescribed in the Permissible Variations in Length table in Specification B829.

8.2 Permissible variations for material specified as small-diameter and light-wall tube (converter size) shall conform to the permissible variations prescribed in Table X1.2.

8. Workmanship, Finish, and Appearance

8.1 The material shall be uniform in quality and temper, smooth, commercially straight, and free of injurious imperfections.

9. Workmanship, Finish and Appearance

9.1 The material shall be uniform in quality and temper, smooth, commercially straight, and free of injurious imperfections.

10. Sampling

10.1

10.1 *Lot Definition:*

10.1.1 A lot for chemical analysis shall consist of one heat.

10.1.2 A lot for all other testing shall consist of all material from the same heat, nominal size (excepting length), and condition.

10.1.2.1 Where material cannot be identified by heat, a lot shall consist of not more than 500 lb (227 kg) of material in the same condition and nominal size (excepting length).

10.2 *Test Material Selection:*

10.2.1

10.2.1 *Chemical Analysis*—Representative samples from each lot shall be taken during pouring or subsequent processing.

10.2.1.1 Product (check) analysis shall be wholly the responsibility of the purchaser.

10.2.2 *Mechanical and Other Properties*—Samples of the material to provide test specimens for mechanical and other properties shall be taken from such locations in each lot as to be representative of that lot. Test specimens shall be taken from material in the final condition.

11.

11. Number of Tests

11.1

11.1 *Chemical Analysis*—One test per lot.

11.2

11.2 *Tension*—One test per lot.

11.3

11.3 *Hydrostatic or Nondestructive Electric Test*—Each piece in each lot.

12.

12. Specimen Preparation

12.1

12.1 *Room-Temperature Tension Specimen*—Material shall be tested in the direction of fabrication. Whenever possible, all pipe and tube shall be tested in full tubular size. When testing in full tubular size is not possible, longitudinal strip specimens, or the largest possible round specimen, shall be used. In the event of disagreement when full tubular testing is not possible, a longitudinal strip specimen with reduced gage length as contained in Test Methods E8 shall be used.

13.

13. Test Methods

13.1

13.1 *Chemical Composition*—In case of disagreement, the chemical composition shall be determined in accordance with Test Methods E1473 or Methods E38. Methods E38 is to be used only for elements not covered by Test Methods E1473.

13.2

13.2 *Tension Test*—Tension testing shall be conducted in accordance with Test Methods E8.

13.3

13.3 *Hydrostatic Test*—Each pipe or tube with an outside diameter $\frac{1}{8}$ 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:

$$P = 2St/D$$

(1)

where:

P = hydrostatic test pressure, psi (or MPa),

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)

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)

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, and,

D = outside diameter of the pipe or tube, in. (or mm).

12.3.1

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

12.3.2 13.3.2 If any pipe or tube shows leaks during hydrostatic testing, it shall be rejected.

12.4 13.4 *Nondestructive Electric Test*—Each pipe or tube shall be examined with a nondestructive electric test in accordance with Specification B829.

12.5

13.5 *Grain Size*—Grain size determinations, to demonstrate compliance with 7.3.1, shall be made on one end of one finished tube from each lot. See 10.1.2.

13.6 *Rounding Method*— For purposes of determining compliance with the specified limits for requirements of the properties listed in the following table, an observed value, or a calculated value, shall be rounded as indicated below, in accordance with the rounding method of Practice E29:

Test	Rounded Unit for Observed or Calculated Value
Chemical composition and tolerances (when expressed in decimals)	nearest unit in the last right-hand place of figures of the specified limit. If two choices are possible, as when the digits dropped are exactly a 5 or a 5 followed only by zeros, choose the one ending in an even digit with zero defined as an even digit.
Tensile strength, yield strength	nearest 1000 psi (6.9 MPa)
Elongation	nearest 1 %

13. Inspection

13.1 Inspection of the material shall be agreed upon between the purchaser and the supplier as part of the purchase contract.

14. Rejection and Rehearing

14.1 Material that fails to conform to the requirements of this specification may be rejected. Rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of the test, the producer or supplier may make claim for a rehearing. Inspection

14.1 Inspection of the material shall be agreed upon between the purchaser and the supplier as part of the purchase contract.

15. Certification

15.1 When specified in the purchase order or contract, a manufacturer's certification shall be furnished to the purchaser stating