~~Designation:B407–04~~ Designation: B 407 – 08

Standard Specification for Nickel-Iron-Chromium Alloy Seamless Pipe and Tube[1]

This standard is issued under the fixed designation B 407; 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[2] covers UNS N08120, UNS N08800, UNS N08801, UNS N08810, UNS N08811, UNS N08890, and UNS N06811 in the form of cold-worked and hot-finished annealed seamless pipe and tube. Alloys UNS N08800 and UNS N06811 are normally employed in service temperatures up to and including 1100°F (593°C). Alloys UNS N08120, UNS N08810, UNS N08811, and UNS N08890 are normally employed in service temperatures above 1100°F (593°C) where resistance to creep and rupture is required, and they are annealed to develop controlled grain size for optimum properties in this temperature range.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 The following safety hazards caveat pertains only to the test method 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.*

2. Referenced Documents

2.1 *ASTM Standards:* [3]

B 880 Specification for General Requirements for Chemical Check Analysis Limits for Nickel, Nickel ~~Alloys,~~Alloys and Cobalt Alloys

E 8 Test Methods for Tension Testing of Metallic Materials

E 18~~Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials~~ Test Methods for Rockwell Hardness of Metallic Materials

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E 112 Test Methods for Determining ~~the~~ Average Grain Size

E 140~~Hardness Conversion Tables for Metals~~ Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, and Scleroscope Hardness

E 426 Practice for Electromagnetic (Eddy-Current) Examination of Seamless and Welded Tubular Products, Austenitic Stainless Steel and Similar Alloys

E 571 Practice for Electromagnetic (Eddy-Current) Examination of Nickel and Nickel Alloy Tubular Products

E 1473 Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys

3. Terminology

3.1 *Definitions:*

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

3.1.2 *pipe*, *n*—seamless tube conforming to the particular dimensions commercially known as standard pipe sizes (see Table X3.1).

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

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[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.

Current edition approved ~~Oct.~~March 1, ~~2004.~~2008. Published ~~November 2004.~~April 2008. Originally approved in 1957. Last previous edition approved in ~~2001~~2004 as B 407 – 0~~1~~4.

[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SB-407 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.

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

4. Ordering Information

4.1 Orders for material to this specification should include information with respect to the following:

4.1.1 Alloy (Table 1).

4.1.2 Condition Temper (Table 2 and Table X3.1, and Appendix X2 and Appendix X3).

4.1.3 Finish (Table X1.1 and Table X3.2).

4.1.4 *Dimensions*:

4.1.4.1 *Tube*—May be specified in two dimensions only (length excepted) as follows: Outside diameter and average or minimum wall, inside diameter and average wall, or outside diameter and inside diameter.

NOTE 1—Tube produced to outside diameter and minimum wall may be furnished upon agreement between the manufacturer and the purchaser.

4.1.4.2 *Pipe*—Standard pipe size and schedule (Table X3.1).

4.1.5 *Fabrication Details*—Not mandatory but helpful to the manufacturer:

4.1.5.1 Cold Bending or Coiling.

4.1.5.2 Hot Forming.

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

4.1.5.4 *Pressure Requirements*—Test pressure if other than required by 7.3.

4.1.5.5 *Machining*—Indicate finished size and length in which to be machined and whether to be chucked to outside diameter or inside diameter.

4.1.5.6 *Ends*—Plain ends cut and deburred will be furnished. If threaded ends or ends beveled for welding are desired, give details.

4.1.6 *Certification*—State if certification or a report of test results is required (Section 16).

4.1.7 *Samples for Product (Check) Analysis*—State whether samples for product (check) analysis should be furnished (6.2).

4.1.8 *Purchaser Inspection*—If the 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).

TABLE 1 Chemical Requirements‡

Element	Composition Limits, %				
	UNS N08120	UNS N08800, UNS N08810, and UNS N08811	UNS N08801	UNS N08890	UNS N06811
Nickel	35.0 min	30.0 min	30.0 min	40.0 min	38.0 min
	39.0 max	35.0 max	34.0 max	45.0 max	46.0 max
Chromium	23.0 min	19.0 min	19.0 min	23.5 min	27.0 min
	27.0 max	23.0 max	22.0 max	28.5 max	31.0 max
Iron	remainder	39.5 min[A]	39.5 min[A]	remainder	remainder
Manganese, max	1.5	1.5	1.5	1.5	2.0
Carbon	0.02 min	[B]	0.10 max	0.06 min	0.03 max
	0.10 max	...	...	0.14 max	...
~~Copper, max~~	~~0.5~~	~~0.75~~	~~0.5~~	~~0.75~~	~~0.60 max~~
Copper, max	0.5	0.75	0.5	0.75	...
~~Silicon~~	~~1.0~~	~~1.0~~	~~1.0~~	~~1.0 min~~	~~...~~
Silicon	1.0	1.0	1.0	1.0 min	0.60 max
	...	...	...	2.0 max	...
Sulfur, max	0.03	0.015	0.015	0.015	0.010
Aluminum[C]	0.40 max	0.15 min	...	0.05 min	...
	...	0.60 max	...	0.60 max	...
Titanium[C]	0.20 max	0.15 min	0.75 min	0.15 min	...
	...	0.60 max	1.50 max	0.60 max	...
Columbium	0.4 min	...	...	...	...
	0.9 max	...	...	...	...
Molybdenum	2.50 max	...	...	1.0 min	0.50 min
	...	...	...	2.0 max	1.50 max
Niobium	...	...	...	0.2 min	...
	...	...	...	1.0 max	...
Tantalum	...	...	...	0.10 min	...
	~~...~~	~~...~~	~~...~~	~~0.60 max~~	~~0.030 max~~
	...	...	...	0.60 max	...
~~Phosphorus~~	~~0.040 max~~	~~...~~	~~...~~	~~...~~	~~...~~
Phosphorus	0.040 max	...	...	...	0.030 max
Tungsten	2.50 max	...	...	...	...
Cobalt, max	3.0	...	...	...	...
Nitrogen	0.15 min	...	...	...	0.10 min
	0.30 max	...	...	...	0.20 max
Boron	0.010 max	...	...	...	...

[A] Iron shall be determined arithmetically by difference.

[B] Alloy UNS N08800: 0.10 max. Alloy UNS N08810: 0.05–0.10. Alloy UNS N08811: 0.06–0.10.

[C] ~~Alloy UNS N08811: Al+Ti, 0.85–1.20.~~

‡ Editorially corrected.

TABLE 2 Mechanical Properties[A,B] of Pipe and Tube

Alloy	Condition (Temper)	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 N08120	hot-finished annealed or cold-worked annealed	90 000 (621)	40 000 (276)	30
UNS N08800	cold-worked annealed	75 000 (520)	30 000 (205)	30
UNS N08800	hot-finished annealed or hot-finished	65 000 (450)	25 000 (170)	30
UNS N08810 and UNS N08811	hot-finished annealed or cold-worked annealed	65 000 (450)	25 000 (170)	30
UNS N08801	hot-finished annealed or cold-worked annealed	65 000 (450)	25 000 (170)	30
UNS N08890	hot-finished annealed or cold-worked annealed	75 000 (520)	30 000 (205)	35
UNS N06811	hot-finished annealed or cold-worked annealed	85 000 (585)	35 000 (240)	30

[A] For properties of small-diameter and light-wall tubing, see Table X3.1.
[B] See 13.3.

4.1.9 *Small-Diameter and Light-Wall Tube*— (Converter Sizes) (Table X3.2).

4.1.10 *Optional Requirement*—Hydrostatic or Nondestructive Eddy Current Testing (see 7.3.3).

5. Materials and Manufacture

5.1 *Heat Treatment*—The final heat treatment of UNS N08120 shall be 2150°F (1177°C) minimum, UNS N08810, 2050°F (1121°C) minimum, UNS N08811, UNS N08890, 2100°F (1149°C) minimum, and UNS N06811, 1920°F (1050°C) minimum.

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.~~B 880.

7. Mechanical Properties and Other Requirements

7.1 *Mechanical Properties*—The material shall conform to the mechanical properties specified in Table 2.

7.2 *Grain Size*—Annealed UNS Alloys N08120, N08810, N08811, and UNS N08890 shall conform to an average grain size of ASTM No. 5 or coarser.

7.3 *Hydrostatic Test*:

7.3.1 Each pipe or tube with an outside diameter ⅛ in. (3.2 mm) and larger, and tubes 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 below. The pipe or tube shall show no evidence of leakage.

$$P = 2St/D$$

where:

P = hydrostatic test pressure, psi (MPa),

S = allowable fiber stresses, for material in the condition, as follows:

Cold-drawn annealed or hot-finished annealed alloy UNS N08120	22 500 psi 155 (MPa)
Cold-drawn annealed alloy UNS N08800 and all alloy UNS N08890	18 700 psi (130 MPa)
Hot-finished as hot-finished, or hot-finished annealed, alloy UNS N08800	16 600 psi (115 MPa)
Cold-drawn annealed or hot-finished annealed alloys UNS N08810, UNS N08811, and UNS N08801	16 600 psi (115 MPa)
Cold-drawn annealed or hot-finished annealed alloy UNS N06811	21 200 psi (145 MPa)

t = minimum wall thickness, in. (mm), equal to the specified average wall minus the permissible minus wall tolerance, Table 3, or the specified minimum wall thickness, and

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

7.3.2 When so agreed upon between the manufacturer and purchaser, pipe or tube may be tested to 1½ times the allowable fiber stress given in 7.3.1.

7.3.3 Each pipe or tube shall be subjected to the hydrostatic test, or, in lieu of this test, a nondestructive eddy current test may be used at the manufacturer's option. If eddy current testing is used, the following test method would apply:

7.3.3.1 *Eddy-Current Testing*—Testing shall be conducted in accordance with Practices E 426 or E 571. The eddy-current examination referenced in this specification has the capability of detecting significant discontinuities, especially of the short abrupt type.

(1) Unless otherwise specified the calibration standard shall contain, at the option of the manufacturer, any one of the following discontinuities to establish a minimum sensitivity level for rejection. The discontinuity shall be placed in the weld if visible.

TABLE 3 Permissible Variations in Outside and Inside Diameter and Wall Thickness (Average Wall)

Specified Outside Diameter or Calculated Nominal Outside Diameter (When Ordered to Inside Diameter and Average Wall)	Permissible Variations			
	Outside Diameter or Inside Diameter		Wall Thickness,%	
	+	−	+	−
Cold-Finished[A,B,C,D] Pipe and Tube				
Inches				
0.500 to ⅝ , excl	0.005	0.005	15.0	15.0
⅝ to 1½ , incl	0.0075	0.0075	10.0	10.0
Over 1½ to 3½ , incl	0.010	0.010	10.0	10.0
Over 3½ to 4½ , incl	0.015	0.015	10.0	10.0
Over 4½ to 6, incl	0.020	0.020	12.5	12.5
Over 6 to 6⅝ , incl	0.025	0.025	12.5	12.5
Millimetres				
12.7 to 15.8, excl	0.127	0.127	15.0	15.0
15.8 to 38.1, incl	0.190	0.190	10.0	10.0
Over 38.1 to 88.9, incl	0.254	0.254	10.0	10.0
Over 88.9 to 114.3, incl	0.381	0.381	10.0	10.0
Over 114.3 to 152.4, incl	0.508	0.508	12.5	12.5
Over 152.4 to 168.3, incl	0.635	0.635	12.5	12.5
Hot-Finished Tube[E,F,G,H]				
Inches				
2½ to 5½ , excl	0.031	0.031	12.5	12.5
5½ to 9¼ , incl	0.047	0.047	12.5	12.5
Millimetres				
63.5 to 139.7, excl	0.787	0.787	12.5	12.5
139.7 to 234.9, incl	1.19	1.19	12.5	12.5

[A] The permissible variations in this table apply to individual measurements, including out-of-roundness (ovality), except for the following conditions.

1) Thin-Wall Pipe and Tube—For thin-wall pipe and tube having a nominal wall thickness of 3 % or less of the nominal outside diameter, in all conditions (temper), the mean outside diameter or mean inside diameter shall conform to the permissible variations of this table, and individual measurements (including ovality) shall conform to the plus and minus values of this table, with the values increased by 0.5 % of the nominal outside diameter.

2) Annealed Pipe and Tube Over 4½ in. (114.3 mm) in Nominal Outside Diameter—For annealed pipe and tubing over 4½ in. (114.3 mm) in nominal outside diameter with a nominal wall thickness greater than 3 % of the nominal outside diameter, the mean outside diameter or mean inside diameter shall conform to the permissible variations of this table, and individual measurements shall not exceed twice the permissible variations of this table.

[B] For pipe and tube, in all tempers, with an inside diameter of less than ½ in. (12.70 mm) which cannot be successfully drawn over a mandrel, the inside diameter shall be governed by the outside diameter and the wall thickness variations.

[C] For pipe and tube in all tempers with an inside diameter less than 50 % of the outside diameter, which cannot be successfully drawn over a mandrel, the inside diameter may vary over or under by an amount equal to 10 % of the nominal wall thickness and the wall thickness may vary ±15 %.

[D] *Eccentricity*—The variation in wall thickness in any one cross section of any one cold-finished pipe or tube shall not exceed ±10 % of the actual (measured) average wall of that section (defined as the average of the thickest and the thinnest wall in that section).

[E] For tube 5 in. (127.0 mm) and under in outside diameter the tolerance on the outside diameter applies for individual measurements and includes ovality. For tubes over 5 in. (127.0 mm) in outside diameter the mean outside diameter shall conform to the permissible variations of this table and individual measurements shall not exceed twice the permissible variations of this table.

[F] The diameter tolerances for tube with machined outside and inside diameters shall be +0.031 in. (0.787 mm), –0 for the outside diameter and +0, – 0.062 in. (1.57 mm) for the inside diameter.

[G] If tube is specified as minimum wall, the tolerance shall be +28.5 %, –0.

[H] The wall thickness tolerance includes eccentricity tolerance up to ±12.5 %.

(2) Drilled Hole—A hole not larger than 0.031 in. (0.79 mm) in diameter shall be drilled radially and completely through the wall, care being taken to avoid distortion of the material while drilling.

(3) Transverse Tangential Notch—Using a round file or tool with a ¼ in. (6 mm) diameter, a notch shall be filed or milled on the tube outside diameter tangential to the surface and transverse to the longitudinal axis of the material. Said notch shall have a depth not exceeding 12½ % of the specified wall thickness of the material, or 0.004 in. (0.10 mm), whichever is greater.

7.3.3.2 *Calibration Frequency*—The frequency of calibration checks shall be as follows:

(1) At the beginning of each production run or log.

(2) After every 4 h or less during testing.

(3) At the end of each production run or lot.

(4) At any time malfunctioning is suspected, or the equipment has been left unattended.

(5) If, during any check, the equipment fails to pick up the standard defects in the calibration standard, the instrument test must be recalibrated and all material tested since the last check shall be reexamined.

7.3.3.3 *Acceptance and Rejection*—Material producing a signal equal to or greater than the calibration imperfection shall be subject to rejection.

(1) Test signals produced by imperfections that cannot be identified or produced by cracks or crack-like imperfections shall result in rejection of the tube, subject to rework, and retest.

(2) If the imperfection is judged as not fit for use, the tube shall be rejected, but may be reconditioned and retested providing the dimensions requirements are met. To be accepted, retested material shall meet the original electric test requirements.

(3) If the imperfection is explored to the extent that it can be identified and the pipe or tube is determined to be fit for use, the material may be accepted without further test providing the imperfection does not encroach on the minimum wall thickness.

7.4 *Annealing Temperature*—Alloy UNS N08120 shall be annealed at 2150°F (1177°C) minimum, and UNS N08810 at 2050°F (1120°C) minimum.