Designation: ~~B408 – 06 (Reapproved 2016)~~ B408 – 22

Standard Specification for Nickel-Iron-Chromium Alloy Rod and Bar[1]

This standard is issued under the fixed designation B408; 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~~ Scope*

1.1 This specification[2] covers UNS N08120, UNS N08800, UNS N08810, UNS N08811,[3] and UNS N08890 in the form of hot-worked and cold-worked rod and bar. Alloy UNS N08800 is normally employed in service temperatures up to and including ~~1100°F (593°C).~~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)~~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 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 *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~~ safety, health, and ~~health~~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.*

2. Referenced Documents

2.1 *ASTM Standards:*[4]

B880 Specification for General Requirements for Chemical Check Analysis Limits for Nickel, Nickel Alloys and Cobalt Alloys
B899 Terminology Relating to Non-ferrous Metals and Alloys
~~E8~~E8/E8M Test Methods for Tension Testing of Metallic Materials ~~[Metric] E0008_E0008M~~
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E112 Test Methods for Determining Average Grain Size
E1473 Test Methods for Chemical Analysis of Nickel, Cobalt and High-Temperature Alloys

3. Terminology

3.1 *Definitions of Terms:*

[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-408 in Section II of that Code.

[3] New designations established in accordance with Practice E527 and SAE J1086, Practice for Numbering Metals and Alloys (UNS).

[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.

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

3.1.1 The terms and definitions of Terminology B899 are applicable to this specification.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *bar, n*—material of rectangular (flats), hexagonal, or square solid section up to and including 10 in. (254 mm) in width and ⅛ in. (3.2 mm) and over in thickness in straight lengths.

3.2.1.1 *Discussion*—

Hot-worked rectangular bar in widths 10 in. (254 mm) and under may be furnished as hot-rolled plate with sheared or cut edges in accordance with Specification B408, provided the mechanical property requirements of Specification B408 are met.

~~3.1.2 *rod, n*—material of round solid section furnished in straight lengths.~~

4. Ordering Information

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

4.1.1 ASTM designation, and year of issue.

4.1.2 Alloy designation or UNS number.

4.1.3 *Section*—Rod (round) or bar (square, hexagonal, or rectangular).

4.1.4 *Dimensions*—Dimensions including length (Section 8, Tables 1-4 incl).

4.1.5 *Condition* (Table 5 and Appendix X1).

4.1.6 *Finish* (Appendix X1).

4.1.7 *Quantity* (feet or number of pieces).

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

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

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 test or inspections are to be witnessed.

5. Materials and Manufacture

5.1 *Heat Treatment*—The minimum temperature of the final heat treatment ~~of UNS N08120 shall be 2150°F (1177°C) minimum, UNS N08810, 2050°F (1121°C) minimum, UNS N08811, and UNS N08890, 2100°F (1149°C) minimum.~~for each alloy shall be as follows:

TABLE 1 Permissible Variations in Diameter or Distance Between Parallel Surfaces of Cold-Worked Rod and Bar

Specified Dimension, ~~in.~~ in. (mm)[A]	Permissible Variations from Specified Dimension, in. (mm)	
	+	−
Rounds:		
1/16 (1.6) to 3/16 (4.8), excl	0	0.002 (0.05)
3/16 (4.8) to ½ (12.7), excl	0	0.003 (0.08)
½ (12.7) to 15/16 (23.8), incl	0.001 (0.03)	0.002 (0.05)
Over 15/16 (23.8) to 1 15/16 (49.2), incl	0.0015 (0.04)	0.003 (0.08)
Over 1 15/16 (49.2) to 2½ (63.5), incl	0.002 (0.05)	0.004 (0.10)
Hexagons, squares, rectangles:		
½ (12.7) and less	0	0.004 (0.10)
Over ½ (12.7) to ⅞ (22.2), incl	0	0.005 (0.13)
Over ⅞ (22.2) to 1¼ (31.8), incl	0	0.007 (0.18)
Over 1¼ (31.8) to 2 (50.8), incl	0	0.009 (0.23)

[A] Dimensions apply to diameter of rounds, to distance between parallel surfaces of hexagons and squares, and separately to width and thickness of rectangles.

TABLE 2 Permissible Variations in Diameter or Distance

Specified Dimension, in. (mm)[A]	Permissible Variations from Specified Dimensions, in. (mm)	
	+	–
Rod and bar, hot-worked:		
1 (25.4) and under	0.016 (0.41)	0.016 (0.41)
Over 1 (25.4) to 2 (50.8), incl	0.031 (0.79)	0.016 (0.41)
Over 2 (50.8) to 4 (101.6), incl	0.047 (1.19)	0.031 (0.79)
Over 4 (101.6)	0.125 (3.18)	0.063 (1.60)
Rod, rough turned or ground:		
Under 1 (25.4)	0.005 (0.13)	0.005 (0.13)
1 (25.4) and over	0.031 (0.79)	0
~~Forging quality rod:~~[B]		
Forging quality rod[B]		
Under 1 (25.4)	0.005 (0.13)	0.005 (0.13)
1 (25.4) and over	0.031 (0.79)	0

[A] Dimensions apply to diameter of rods, to distance between parallel surfaces of hexagons and squares, and separately to width and thickness of rectangles.
[B] ~~Spot~~ Spot grinding is permitted to remove minor surface imperfections. The depth of these spot ground areas shall not exceed 3 % of the diameter of the rod.

5.1.1 *UNS N08120*—2150 °F (1177 °C);

5.1.2 *UNS N08810*—2050 °F (1121 °C);

5.1.3 *UNS N08811 and UNS N08890*—2100 °F (1149 °C).

6. Chemical Composition

6.1 The material shall conform to the composition limits specified in Table 6.

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.

7. Mechanical Properties and Other Requirements

7.1 *Mechanical Properties*—The material shall conform to the mechanical properties specified in Table 5.

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

8. Dimensions and Permissible Variations

8.1 *Diameter, Thickness, or Width*—The permissible variations from the specified dimensions as measured on the diameter or between parallel surfaces of cold-worked rod and bar shall be as prescribed in Table 1, and of hot-worked rod and bar as prescribed in Table 2.

8.2 *Out-of-Round*—Hot-worked rods and cold-worked rods (except "forging quality") all sizes, in straight lengths, shall not be out-of-round by more than one half the total permissible variations in diameter shown in Table 1 and Table 2, except for hot-worked rods ½ in. (12.7 mm) in diameter and under, which may be out-of-round by the total permissible variations in diameter shown in Table 2.

8.3 *Corners*—Cold-worked bars will have practically exact angles and sharp corners.

8.4 *Machining Allowances for Hot-Worked Materials*—When the surfaces of hot-worked products are to be machined, the allowances prescribed in Table 3 are recommended for normal machining operations.

8.5 *Length*—The permissible variations in length of cold-worked and hot-worked rod and bar shall be as prescribed in Table 4.

TABLE 3 Normal Machining Allowances for Hot-worked Material

Finished-Machined Dimensions for Finishes as Indicated Below, in. (mm)[A]	Normal Machining Allowance, in. (mm)			
	On Diameter, for Rods	Distance Between Parallel Surfaces, for Hexagonal and Square Bar	For Rectangular Bar	
			On Thickness	On Width
Hot-worked:[B]				
Up to 7/8 (22.2), incl	1/8 (3.2)	1/8 (3.2)	1/8 (3.2)	3/16 (4.8)
Over 7/8 to 1 7/8 (22.2 to 47.6), incl	1/8 (3.2)	3/16 (4.8)	1/8 (3.2)	3/16 (4.8)
Over 1 7/8 to 2 7/8 (47.6 to 73.0), incl	3/16 (4.8)	1/4 (6.4)	...	3/16 (4.8)
Over 2 7/8 to 3 13/16 (73.0 to 96.8), incl	1/4 (6.4)	...	...	3/16 (4.8)
Over 3 13/16 (96.8)	1/4 (6.4)	...	...	3/8 (9.5)
Hot-worked rods:				
Rough-turned or Rough Ground:[C]				
15/16 to 4 (23.8 to 101.6), incl in diameter	1/16 (1.6)	...	...	...
~~Over 4 to 12 (101.6 to 304.8), incl in diameter~~	~~1/8 (3.2)~~	~~...~~	~~...~~	~~...~~
Over 4 to 12 (101.6 to 304.8), incl in diameter	1/8 (3.2)	...	...	...

[A] Dimensions apply to diameter of rods, to distance between parallel surfaces of hexagonal and square bar, and separately to width and thickness of rectangular bar.
[B] The allowances for hot-worked material in Table 5 are recommended for rods machined in lengths of 3 ft (0.91 m) or less and for bars machined in lengths of ~~2 ft (0.61 m)~~ 2 ft (0.61 m) or less. Hot-worked material to be machined in longer lengths should be specified showing the finished cross-sectional dimension and the length in which the material will be machined in order that the manufacturer may supply material with sufficient oversize, including allowance for out-of-straightness.
[C] Applicable to 3 ft (0.91 m) max length.

TABLE 4 Permissible Variations in Length of Rods and Bars

Random mill lengths:	
~~Hot-worked~~	~~6 to 24 ft (1.83 to 7.31 m) long with not more than 25 weight % between 6 and 9 ft (1.83 and 2.74 m)[A]~~
Hot-worked	6 to 24 ft (1.83 to 7.31 m) long with not more than 25 weight % between 6 and 9 ft (1.83 and 2.74 m) [A]
Cold-worked	6 to 20 ft (1.83 to 6.1 m) long with not more than 25 weight % between 6 and 10 ft (1.83 and 3.05 m).
~~Multiple lengths~~	~~furnished in multiples of a specified unit length, within the length limits indicated above. For each multiple, an allowance of 1/4 in. (6.4 mm) will be made for cutting, unless otherwise specified. At the manufacturer's option, individual specified unit lengths may be furnished.~~
Multiple lengths	Furnished in multiples of a specified unit length, within the length limits indicated above. For each multiple, an allowance of 1/4 in. (6.4 mm) will be made for cutting, unless otherwise specified. At the manufacturer's option, individual specified unit lengths may be furnished.
~~Nominal lengths~~	~~specified nominal lengths having a range of not less than 2 ft (610 mm) with no short lengths allowed[B]~~
Nominal lengths	Specified nominal lengths having a range of not less than 2 ft (610 mm) with no short lengths allowed [B]
~~Cut lengths~~	~~a specified length to which all rods and bars will be cut with a permissible variation of plus 1/8 in. (3.2 mm), minus 0 for sizes 8 in. (203 mm) and less in diameter or distance between parallel surfaces. For larger sizes, the permissible variation shall be + 1/4 in. (6.4 mm), – 0.~~
Cut lengths	A specified length to which all rods and bars will be cut with a permissible variation of plus 1/8 in. (3.2 mm), minus 0 for sizes 8 in. (203 mm) and less in diameter or distance between parallel surfaces. For larger sizes, the permissible variation shall be + 1/4 in. (6.4 mm), – 0.

[A] For hot-worked sections weighing over ~~25~~25 lb ~~lb/ft~~/ft (37 kg/m) and for smooth forged products, all sections, short lengths down to 2 ft (610 mm) may be furnished.
[B] ~~For~~ For cold-worked rods and bars under 1/2 in. (12.7 mm) in diameter or distance between parallel surfaces ordered to nominal or stock lengths with a 2-ft ~~(610 mm)~~(610 mm) range, at least 93 % of such material shall be within the range specified; the balance may be in shorter lengths but in no case shall lengths less than 4 ft (1220 mm) be furnished.

8.5.1 Rods and bars ordered to random or nominal lengths will be furnished with either cropped or saw-cut ends; material ordered to cut lengths will be furnished with square saw-cut or machined ends.

8.6 *Straightness:*

8.6.1 The permissible variations in straightness of cold-worked rod and bar as determined by the departure from straightness shall be as prescribed in Table 7.

8.6.2 The permissible variations in straightness of hot-worked rod and bar as determined by the departure from straightness shall be as specified in Table 8.

9. Workmanship, Finish, and Appearance

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

TABLE 5 Mechanical Properties of Rods and Bars[A]

Alloy	Condition	Tensile Strength, ~~min,~~ psi (MPa)	Yield Strength (0.2 % offset) ~~min,~~ psi (MPa)	Elongation in 2 in. or 50 mm ~~(or~~ (or 4*D*)~~, min, %~~), %
UNS N08120	Cold-worked and hot-worked, annealed	90 000 (621)	40 000 (276)	30
~~UNS N08800~~	~~Hot worked, as-hot-worked~~	~~80 000 (550)~~	~~35 000 (240)~~	~~25[A]~~
UNS N08800	Hot worked, as-hot-worked	80 000 (550)	35 000 (240)	25[B]
	Cold-worked and hot-worked, annealed	75 000 (515)	30 000 (205)	30
UNS N08810 and UNS N08811	Cold-worked and hot-worked, annealed	65 000 (450)	25 000 (170)	30
UNS N08890	Cold-worked and hot-worked, annealed	75 000 (520)	30 000 (205)	35
~~UNS N08800, UNS N08810 and UNS N08811~~	~~Forging quality~~	[B]	[B]	[B]
UNS N08800, UNS N08810 and UNS N08811	Forging quality	[C]	[C]	[C]

[A] All values are minimums.
[B] For hot-worked as-hot-worked rectangular bar 5⁄16 in. (7.94 mm) and under in thickness the elongation shall be 20 % min.
[C] Forging quality is furnished to chemical requirements and surface inspection only. No tensile properties are required.

10. Sampling

10.1 *Lot:*

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

10.1.2 A lot for mechanical properties and grain size testing shall consist of all material from the same heat, nominal diameter or thickness, 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 size and condition except that a single piece weighing over 500 lb shall be considered as one lot.

10.2 *Test Material Selection:*

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 Properties and Grain Size*—Samples of the material to provide test specimens for mechanical properties and grain size shall be taken from such locations in each lot as to be representative of that lot.

TABLE 6 Chemical Requirements

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

TABLE 6 Chemical Requirements[A]

Element	Composition Limits, %				
	Alloy N08120	Alloy N08800	Alloy N08810	Alloy N08811	Alloy N08890
Nickel	35.0 – 39.0	30.0 – 35.0	30.0 – 35.0	30.0 – 35.0	40.0 – 45.0
Chromium	23.0 – 27.0	19.0 – 23.0	19.0 – 23.0	19.0 – 23.0	23.5 – 28.5
Iron	remainder	39.5 min [B]	39.5 min [B]	39.5 min [B]	remainder
Manganese	1.5	1.5	1.5	1.5	1.5
Carbon	0.02 – 0.10	0.10	0.05 – 0.10	0.06 – 0.10	0.06 – 0.14
Copper	0.50	0.75	0.75	0.75	0.75
Silicon	1.0	1.0	1.0	1.0	1.0 – 2.0
Sulfur	0.03	0.015	0.015	0.015	0.015
Aluminum	0.40	0.15 – 0.60	0.15 – 0.60	0.25 – 0.60[C]	0.05 – 0.60
Titanium	0.20	0.15 – 0.60	0.15 – 0.60	0.25 – 0.60[C]	0.15 – 0.60
Molybdenum	2.50	...	...	...	1.0 – 2.0
Niobium[D]	0.4 – 0.9	...	...	...	0.2 – 1.0
Tantalum	...	...	...	...	0.10 – 0.60
Phosphorus	0.040	0.045	0.045	0.045	...
Tungsten	2.50	...	...	...	...
Cobalt	3.0	...	...	...	...
Nitrogen	0.15 – 0.30	...	...	...	...
Boron	0.010	...	...	...	...

[A] All values are maximums unless specified as a minimum or a range is provided.
[B] Iron shall be determined arithmetically by difference.
[C] Alloy ~~UNS N08811: Al + Ti, 0.85–1.20.~~N08811: Al + Ti = 0.85 – 1.20.
[D] Columbium and niobium are interchangeable names for the same element and both names are acceptable for use in B02.07 specifications.

11. Number of Tests

11.1 *Chemical Analysis*—One test per lot.

11.2 *Tension*—One test per lot.

TABLE 7 Permissible Variations in Straightness of Cold-Worked Rods and Bars

Specified Diameter or Distance Between Parallel Surfaces, in. (mm)[A]	Depth of Chord, Permissible Variations in Lengths Indicated, ~~in.~~ in. (mm)
Rounds:	
½ (12.7) to 2½ (63.5), incl	0.030 (0.76) per ft (305 mm) of length
Hexagons, squares, rectangles:	
½ (12.7) to 2 (50.8), incl	0.030 (0.76) per ft (305 mm) of length

[A] Material under ½ in. (12.7 mm) shall be reasonably straight and free of sharp bends and kinks.

TABLE 8 Permissible Variations in Straightness of Hot-Worked Rods and Bars[A]

Finish	Permissible Variations, ~~in./ft (mm/m)~~in./ft (mm/m)[B]
Rods and bars, hot-worked	0.050 (4.2)[C]
Rounds: hot-worked, rough ground, or rough turned	0.050 (4.2)[C]

[A] Not applicable to forging quality.
[B] Material under ½ in. (12.7 mm) shall be reasonably straight and free of sharp bends and kinks.
[C] The maximum curvature (depth of chord) shall not exceed the values indicated multiplied by the length in feet.

11.3 *Grain Size*—One test per lot.

12. Specimen Preparation

12.1 Tension test specimens shall be taken from material in the final condition and tested in the direction of fabrication.

12.1.1 All rod and bar shall be tested in full cross-section size when possible. When a full cross-section size test cannot be performed, the largest possible round specimen shown in Test Methods ~~E8~~E8/E8M shall be used. Longitudinal strip specimens shall be prepared in accordance with Test Methods ~~E8~~E8/E8M for rectangular bar up to ½ in. (12.7 mm), inclusive, in thicknesses which are too wide to be pulled full size.

13. Test Method

13.1 The chemical composition, mechanical, and other properties of the material as enumerated in this specification shall be determined, in case of disagreement, in accordance with the following methods:

Test	ASTM Designation
Chemical Analysis	E1473
~~Tension~~	~~E8~~
Tension	E8/E8M
Rounding Procedure	E29
Grain Size	E112