



Designation: B 649 – 04

Standard Specification for Ni-Fe-Cr-Mo-Cu Low-Carbon Alloy (UNS N08904), Ni-Fe-Cr-Mo-Cu-N Low-Carbon Alloys (UNS N08925, UNS N08031, UNS N08354, and UNS N08926), and Cr-Ni-Fe-N Low-Carbon Alloy (UNS R20033) Bar and Wire¹

This standard is issued under the fixed designation B 649; 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 covers nickel-iron-chromium-molybdenum-copper low-carbon alloys (UNS N08904)*, nickel-iron-chromium-molybdenum-copper-nitrogen alloys (UNS N08925, UNS N08031, UNS N08354, and UNS N08926), and Cr-Ni-Fe-N low-carbon alloy (UNS R20033) bar and wire.

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 *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 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:²

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

E 8 Test Methods for Tension Testing of Metallic Materials

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

E 55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition

E 527 Practice for Numbering Metals and Alloys (UNS)
E 1473 Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *bars, n*—hot-finished rounds, squares, octagons, and hexagons: $\frac{1}{4}$ in. (6.35 mm) and over in diameter or size. Hot-finished flats: $\frac{1}{4}$ in. to 10 in. (254 mm) inclusive in width, $\frac{1}{8}$ in. (3.18 mm) and over in thickness. Cold-finished rounds, squares, octagons, hexagons, and shapes: over $\frac{1}{2}$ in. (12.70 mm) in diameter or size. Cold-finished flats: $\frac{3}{8}$ in. (9.52 mm) and over in width (see 3.1.1.1) and $\frac{1}{8}$ in. and over in thickness (see 3.1.1.2).

3.1.1.1 *Discussion*—Widths less than $\frac{3}{8}$ in. (9.52 mm) and thicknesses less than $\frac{3}{16}$ in. (4.76 mm) are described generally as flat wire.

3.1.1.2 *Discussion*—Thickness $\frac{1}{8}$ in. to under $\frac{3}{16}$ in. (3.18 mm to under 4.76 mm) can be cold-rolled strip as well as bar.

3.1.2 *wire, n*—cold-finished only: round, square, octagon, hexagon, and shape wire, $\frac{1}{2}$ in. (12.70 mm) and under in diameter or size. Cold-finished only: flat wire, $\frac{3}{16}$ in. to under $\frac{3}{8}$ in. (4.76 mm to under 9.52 mm) in width, 0.010 to under $\frac{3}{16}$ in. (0.25 to under 4.76 mm) in thickness.

4. Ordering Information

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

4.1.1 Quantity (weight or number of pieces),

4.1.2 Alloy name or UNS number,

4.1.3 Form (bar or wire),

4.1.4 Dimensions,

4.1.5 Finish (Section 9),

4.1.6 ASTM designation and year of issue,

4.1.7 Exceptions to the specification or special requirements, and

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 ASTM E 527 and SAE J1086, Practice for Numbering Metals and Alloys (UNS).

² 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.

4.1.8 Certification (Section 16). State if certification is required.

5. Materials and Manufacture

5.1 Heat Treatment—The material shall be supplied in the solution-treated condition except as noted below in 5.2.

NOTE 1—The recommended heat treatment shall consist of heating to a temperature of 1920 to 2100°F (1050 to 1150°C) followed by water quenching for UNS N08904, 2010 to 2100°F (1100 to 1150°C) followed by water quenching for UNS N08925, UNS N08031, 1975 to 2150°F (1080 to 1180°C) followed by water quenching or fast air cool for UNS N08354, and UNS N08926, or 2010 to 2150°F (1100 to 1180°C) followed by water quenching or fast air cool for UNS R20033.

5.2 The heat treatment shall be waived for forging quality material.

6. Chemical Composition

6.1 The material sampled in accordance with 9.2 shall conform to the requirements as to chemical composition prescribed in Table 1.

6.2 Product Analysis (Formerly Check Analysis)—Product analysis may be made by the purchaser to verify the identity of the finished material representing each heat or lot. Such analysis may be made by any of the commonly accepted methods that will positively identify the material.

6.2.1 If a product analysis is made, the material shall conform to the product check analysis variation per Specification B 880.

7. Mechanical and Other Requirements

7.1 Tensile Requirements—The material shall conform to the requirements as to the mechanical property prescribed in Table 2.

8. Dimensions, Weights, and Permissible Variations

8.1 Bar—The material referred to as bar shall conform to the variations in dimensions prescribed in Tables 3-11 inclusive, as applicable.

8.2 Wire—The material referred to as wire shall conform to the permissible variations in dimensions prescribed in Tables 12-16 inclusive, as applicable.

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 defects.

TABLE 2 Mechanical Property Requirements^A

Alloy	Cold Finished and Hot Finished Annealed, All Sizes			
	Tensile Strength, min, psi (MPa)	Yield Strength min, psi (MPa)	Elongation in 2 in. (50.8 mm), min, %	Forging Quality, All Sizes
UNS N08904	71 000 (490)	31 000 (220)	35	^B
UNS N08925	87 000 (600)	43 000 (300)	40	^B
UNS N08031	94 000 (650)	40 000 (270)	40	^B
UNS N08926	94 000 (650)	43 000 (295)	35	^B
UNS N08354	93 000 (640)	43 000 (295)	40	^B
UNS R20033	109 000 (750)	55 000 (380)	40	^B

^AFor wire only, tensile strength 90 000 to 120 000 psi (620 to 830 MPa).
^BNo tensile properties are required on forging quality.

9.2 Bars in the hot-finished condition may be furnished with one of the following finishes:

- 9.2.1 Scale not removed,
- 9.2.2 Pickled or descaled, or
- 9.2.3 Turned (rounds only).

9.3 Bars in the cold-finished condition may be furnished with one of the following finishes:

- 9.3.1 Cold-drawn,
- 9.3.2 Centerless ground (rounds only), or
- 9.3.3 Polished (rounds only).

9.4 Wire in the cold-finished condition may be furnished with one of the following finishes:

- 9.4.1 Cold-drawn,
- 9.4.2 Centerless ground (rounds only),
- 9.4.3 Polished (rounds only), or
- 9.4.4 Pickled.

10. Sampling

10.1 Lots for Chemical Analysis and Mechanical Testing:

- 10.1.1 A lot for chemical analysis shall consist of one heat.
- 10.1.2 A lot for testing and inspection purposes shall consist of material from one heat of the same condition (temper), finish, and cross section, and in no case more than 30 000 lb (13 600 kg) in mass.

NOTE 2—Where material cannot be identified by heat, a lot shall consist of not more than 500 lb (227 kg) of material in the same thickness and condition, except that for pieces weighing over 500 lb, only one specimen shall be taken.

10.2 Sampling for Chemical Analysis:

- 10.2.1 A representative sample shall be taken from each heat during pouring or subsequent processing.

TABLE 1 Chemical Requirements

Element	Composition, %					
	UNS N08904	UNS N08925	UNS N08031	UNS N08354	UNS N08926	UNS R20033
Carbon, max	0.020	0.020	0.015	0.030	0.020	0.015
Manganese, max	2.00	1.00	2.0	1.00	2.00	2.0
Phosphorus, max	0.045	0.045	0.020	0.030	0.03	0.02
Sulfur, max	0.035	0.030	0.010	0.010	0.01	0.01
Silicon, max	1.00	0.50	0.3	1.00	0.5	0.50
Nickel	23.00–28.00	24.00–26.00	30.0–32.0	34.0–36.0	24.00–26.00	30.0–33.0
Chromium	19.00–23.00	19.00–21.00	26.0–28.0	22.0–24.0	19.00–21.00	31.0–35.0
Molybdenum	4.0–5.0	6.0–7.0	6.0–7.0	7.0–8.0	6.0–7.0	0.50–2.0
Copper	1.0–2.0	0.8–1.5	1.0–1.4	...	0.5–1.5	0.30–1.20
Nitrogen	...	0.1–0.2	0.15–0.25	0.17–0.24	0.15–0.25	0.35–0.60
Iron	balance	balance	balance	balance	balance	balance

TABLE 3 Permissible Variations in Size of Hot-Finished Round and Square Bars

	Permissible Variations from Specified Size, in. (mm)		Out-of-Round ^A or Out-of-Square, ^B in. (mm)
	Over	Under	
1/4 (6.35) to 5/16 (7.94), incl ^{CD}	<i>E</i>	<i>E</i>	<i>E</i>
Over 5/16 (7.94) to 7/16 (11.11), incl ^{CD}	0.006 (0.15)	0.006 (0.15)	0.009 (0.23)
Over 7/16 (11.11) to 5/8 (15.88), incl ^{CD}	0.007 (0.18)	0.007 (0.18)	0.010 (0.25)
Over 5/8 (15.88) to 7/8 (22.22), incl	0.008 (0.20)	0.008 (0.20)	0.012 (0.30)
Over 7/8 (22.22) to 1 (25.40), incl	0.009 (0.23)	0.009 (0.23)	0.013 (0.33)
Over 1 (25.40) to 1 1/8 (28.58), incl.	0.010 (0.25)	0.010 (0.25)	0.015 (0.38)
Over 1 1/8 (28.58) to 1 1/4 (31.75), incl	0.011 (0.28)	0.011 (0.28)	0.016 (0.41)
Over 1 1/4 (31.75) to 1 3/8 (34.92), incl	0.012 (0.30)	0.012 (0.30)	0.018 (0.46)
Over 1 3/8 (34.92) to 1 1/2 (38.10), incl	0.014 (0.36)	0.014 (0.36)	0.021 (0.53)
Over 1 1/2 (38.10) to 2 (50.80), incl	1/64 (0.40)	1/64 (0.40)	0.023 (0.58)
Over 2 (50.80) to 2 1/2 (63.50), incl	1/32 (0.79)	0	0.023 (0.58)
Over 2 1/2 (63.50) to 3 1/2 (88.90), incl	3/64 (1.19)	0	0.035 (0.89)
Over 3 1/2 (88.90) to 4 1/2 (114.30), incl	1/16 (1.59)	0	0.046 (1.17)
Over 4 1/2 (114.30) to 5 1/2 (139.70), incl	5/64 (1.98)	0	0.058 (1.47)
Over 5 1/2 (139.70) to 6 1/2 (165.10), incl	1/8 (3.18)	0	0.070 (1.78)
Over 6 1/2 (165.10) to 8 (203.20), incl	5/32 (3.97)	0	0.085 (2.18)

^AOut-of-round is the difference between the maximum and minimum diameters of the bar, measured at the same cross section.

^BOut-of-square section is the difference in the two dimensions at the same cross section of a square bar, each dimension being the distance between opposite faces.

^CSize tolerances have not been evolved for rounds in the size range from 1/4 to 5/16 in. (6.35 to 7.94 mm), incl. Size tolerances have not been evolved for round sections in the size range from 1/4 (6.35 mm) to approximately 5/8 in. (15.88 mm) in diameter which are produced on rod mills in coils.

^DSquares in this size are not produced as hot-rolled products.

^EVariations in size of coiled product made on rod mills are greater than size tolerances for product made on bar mills.

TABLE 4 Permissible Variations in Size of Hot-Finished Hexagonal and Octagonal Bars

Specified Sizes Measured Between Opposite Sides, in. (mm)	Permissible Variations from Specified Size, in. (mm)		Maximum Difference in 3 Measurements for Hexagons only, in. (mm)
	Over	Under	
1/4 (6.35) to 1/2 (12.70), incl	0.007 (0.18)	0.007 (0.18)	0.011 (0.28)
Over 1/2 (12.70) to 1 (25.40), incl	0.010 (0.25)	0.010 (0.25)	0.015 (0.38)
Over 1 (25.40) to 1 1/2 (38.10), incl	0.021 (0.53)	0.021 (0.53)	0.025 (0.64)
Over 1 1/2 (38.10) to 2 (50.80), incl	1/32 (0.79)	1/32 (0.79)	1/32 (0.79)
Over 2 (50.80) to 2 1/2 (63.50), incl.	3/64 (1.19)	3/64 (1.19)	3/64 (1.19)
Over 2 1/2 (63.50) to 3 1/2 (88.90), incl	1/16 (1.59)	1/16 (1.59)	1/16 (1.59)

TABLE 5 Permissible Variations in Thickness and Width for Hot-Finished Flat Bars

Specified Width, in. (mm)	Permissible Variations in Thickness for Thicknesses Given, in. (mm)					
	1/8 (3.18) to 1/2 (12.70), incl		Over 1/2 (12.70) to 1 (25.40), incl		Over 1 (25.40) to 2 (50.80), incl	
	Over	Under	Over	Under	Over	Under
To 1 (25.40), incl	0.008 (0.20)	0.008 (0.20)	0.010 (0.25)	0.010 (0.25)	...	...
Over 1 (25.40) to 2 (50.80), incl	0.012 (0.30)	0.012 (0.30)	0.015 (0.38)	0.015 (0.38)	0.031 (0.79)	0.031 (0.79)
Over 2 (50.80) to 4 (101.60), incl	0.015 (0.38)	0.015 (0.38)	0.020 (0.51)	0.020 (0.51)	0.031 (0.79)	0.031 (0.79)
Over 4 (101.60) to 6 (152.40), incl	0.015 (0.38)	0.015 (0.38)	0.020 (0.51)	0.020 (0.51)	0.031 (0.79)	0.031 (0.79)
Over 6 (152.40) to 8 (203.20), incl	0.016 (0.41)	0.016 (0.41)	0.025 (0.64)	0.025 (0.64)	0.031 (0.79)	0.031 (0.79)
Over 8 (203.20) to 10 (254.00), incl	0.021 (0.53)	0.021 (0.53)	0.031 (0.79)	0.031 (0.79)	0.031 (0.79)	0.031 (0.79)
	Over 2 (50.80) to 4 (101.60), incl		Over 4 (101.60) to 6 (152.40), incl		Over 6 (152.40) to 8 (203.20), incl	
	Over	Under	Over	Under	Over	Under
To 1 (25.40), incl	...	...	...	...	...	...
Over 1 (25.40) to 2 (50.80), incl	...	...	...	...	...	...
Over 2 (50.80) to 4 (101.60), incl	0.062 (1.57)	0.031 (0.79)	...	...	...	...
Over 4 (101.60) to 6 (152.40), incl	0.062 (1.57)	0.031 (0.79)	0.093 (2.36)	0.062 (1.57)	...	...
Over 6 (152.40) to 8 (203.20), incl	0.062 (1.57)	0.031 (0.79)	0.093 (2.36)	0.062 (1.57)	0.125 (3.18)	0.156 (3.96)
Over 8 (203.20) to 10 (254.00), incl	0.062 (1.57)	0.031 (0.79)	0.093 (2.36)	0.062 (1.57)	0.125 (3.18)	0.156 (3.96)
Specified Width, in. (mm)	Permissible Variations in Width, in. (mm)					
	Over			Under		
To 1 (25.40), incl	0.015 (0.38)			0.015 (0.38)		
Over 1 (25.40) to 2 (50.80), incl	0.031 (0.79)			0.031 (0.79)		
Over 2 (50.80) to 4 (101.60), incl	0.062 (1.57)			0.031 (0.79)		
Over 4 (101.60) to 6 (152.40), incl	0.093 (2.36)			0.062 (1.57)		
Over 6 (152.40) to 8 (203.20), incl	0.125 (3.18)			0.156 (3.96)		
Over 8 (203.20) to 10 (254.00), incl	0.156 (3.96)			0.187 (4.75)		