



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, 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, 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. Table 1

2. Referenced Documents

2.1 ASTM Standards:

E 8 Test Methods for Tension Testing of Metallic Materials²

E 10 Test Method for Brinell Hardness of Metallic Materials²

E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials²

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications³

E 38 Methods for Chemical Analysis of Nickel-Chromium and Nickel-Chromium-Iron Alloys⁴

E 55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition⁵

E 140 Hardness Conversion Tables for Metals²

F 155 Test Method for Temper of Strip and Sheet Metals for Electronic Devices (Spring-Back Method)⁶

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

¹ This specification is under the jurisdiction of ASTM Committee B-2 on Nonferrous Metals and Alloys and is the direct responsibility of Subcommittee B02.07 on Refined Nickel and Cobalt, and Alloys Containing Nickel or Cobalt or Both as Principal Constituents.

Current edition approved Oct. 10, 1995. Published December 1995. Originally published as B 649 – 81. Last previous edition B 649 – 93.

* New designation established in accordance with ASTM E527 and SAE J1086, Practice for Numbering Metals and Alloys (UNS).

² Annual Book of ASTM Standards, Vol 03.01.

³ Annual Book of ASTM Standards, Vol 14.02.

⁴ Discontinued—see 1989 Annual Book of ASTM Standards, Vol 03.05.

⁵ Annual Book of ASTM Standards, Vol 03.05.

⁶ Discontinued—see 1983 Annual Book of ASTM Standards, Vol 10.04.

TABLE 1 Referee Analysis Methods^A

Element	ASTM Method
Carbon	E 98
Manganese	E 38
Silicon	E 38
Phosphorus	E 30—Photometric method
Sulfur	E 30—Direct combustion for stainless steels
Chromium	E 38—Potentiometric titration
Nickel	E 38—Gravimetric method (reprecipitate)
Molybdenum	E 30—Molybdenum by the alphanitrosoxime method. Use 5 mL of H ₃ PO ₄ in starting acid to hold columbium in solution. Reprecipitate
Copper	E 30—Electrolytic method
Columbium	E 30

^ACommittee E-3 on Chemical Analysis of Metals is currently regrouping methods of analysis for various alloys and preparing new scopes for standards covering methods of analysis which appear in Vol 03.05 of the Annual Book of ASTM Standards.

3.1.1 *bars*—hot-finished rounds, squares, octagons, and hexagons: ¼ in. (6.35 mm) and over in diameter or size. Hot-finished flats: ¼ in. to 10 in. (254 mm) inclusive in width, ⅛ in. (3.18 mm) and over in thickness. Cold-finished rounds, squares, octagons, hexagons, and shapes: over ½ in. (12.70 mm) in diameter or size. Cold-finished flats: ⅜ in. (9.52 mm) and over in width (see 3.1.1.1) and ⅛ in. and over in thickness (see 3.1.1.2).

3.1.1.1 *Discussion*—Widths less than ⅜ in. (9.52 mm) and thicknesses less than ⅜ in. (4.76 mm) are described generally as flat wire.

3.1.1.2 *Discussion*—Thickness ⅛ in. to under ⅜ in. (3.18 mm to under 4.76 mm) can be cold-rolled strip as well as bar.

3.1.2 *wire*—cold-finished only: round, square, octagon, hexagon, and shape wire, ½ in. (12.70 mm) and under in diameter or size. Cold-finished only: flat wire, ⅜ in. to under ⅜ in. (4.76 mm to under 9.52 mm) in width, 0.010 to under ⅜ in. (0.25 to under 4.76 mm) in thickness.

4. Ordering Information

4.1 Orders for material to this specification shall include the following information:

- 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

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 (1100–1150°C) followed by water quenching for UNS N08925, UNS N08031, 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 2.

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 requirements as to the composition limits with the product analysis variation prescribed in Table 3.

7. Mechanical and Other Requirements

7.1 *Tensile and Hardness Requirements*—The material shall conform to the requirements as to the mechanical property prescribed in Table 4.

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 5-13 inclusive, as applicable.

8.2 *Wire*—The material referred to as wire shall conform to the permissible variations in dimensions prescribed in Tables 14-18 inclusive, as applicable.

9. Workmanship, Finish, and Appearance

9.1 The material shall be uniform in quality and condition,

TABLE 3 Product Analysis Tolerances

Element	Tolerances Over the Max Limit or Under the Min Limit, %			
	UNS N08904 UNS N08925	UNS N08031	UNS N08926	UNS R20033
Carbon	0.005	0.005	0.005	0.005
Manganese	0.04	0.04	0.04	0.04
Phosphorus	0.005	0.005	0.005	0.005
Sulfur	0.005	0.003	0.003	0.003
Silicon	0.05	0.03	0.03	0.03
Chromium	0.20	0.30	0.25	0.30
Nickel	0.20	0.30	0.25	0.30
Molybdenum	0.10	0.15	0.15	0.05
Copper	0.10	0.04	0.04	0.04
Nitrogen	...	0.01	0.01	0.03

TABLE 4 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	<i>B</i>
UNS N08925	87 000 (600)	43 000 (300)	40	<i>B</i>
UNS N08031	94 000 (650)	40 000 (270)	40	<i>B</i>
UNS N08926	94 000 (650)	43 000 (295)	35	<i>B</i>
UNS R20033	109 000 (750)	55 000 (380)	40	<i>B</i>

^AFor wire only, tensile strength 90 000 to 120 000 psi (620 to 830 MPa).

^BNo tensile properties are required on forging quality.

smooth, commercially straight or flat, and free of injurious defects.

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, 733-16c7ea4e9fe/astm-b649-95

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:*

TABLE 2 Chemical Requirements

Element	Composition, %				
	UNS N08904	UNS N08925	UNS N08031	UNS N08926	UNS R20033
Carbon, max	0.020	0.020	0.015	0.020	0.015
Manganese, max	2.00	1.00	2.0	2.00	2.0
Phosphorus, max	0.045	0.045	0.020	0.03	0.02
Sulfur, max	0.035	0.030	0.010	0.01	0.01
Silicon, max	1.00	0.50	0.3	0.5	0.50
Nickel	23.00–28.00	24.00–26.00	30.0–32.0	24.00–26.00	30.0–33.0
Chromium	19.00–23.00	19.00–21.00	26.0–28.0	19.00–21.00	31.0–35.0
Molybdenum	4.0–5.0	6.0–7.0	6.0–7.0	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	0.15–0.25	0.35–0.60
Iron	balance	balance	balance	balance	balance

TABLE 5 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 6 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)

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.

10.2.2 If the manufacturer determines that the material meets the chemical requirements during pouring or subsequent processing, he shall not be required to sample and analyze the finished product.

10.2.3 Product analysis, if performed, shall be wholly the responsibility of the purchaser.

10.3 Sampling for Mechanical Tests:

10.3.1 A sample of the material to provide test specimens for mechanical tests shall be taken from such a location in each lot as to be representative of that lot.

10.3.2 When samples are to be taken after delivery, the

purchaser of material ordered to cut lengths may request on the purchase order additional material of adequate size to provide sample coupons for inspection purposes.

11. Number of Tests

11.1 One chemical analysis shall be made on each lot in accordance with 10.1.1.

11.2 One tension test shall be made on each lot in accordance with 10.1.2.

11.2.1 If any specimens selected to represent any heat fail to meet any of the test requirements, the material represented by such specimens may be reheat-treated and resubmitted for test.

12. Specimen Preparation

12.1 Tension test specimens shall be taken from material after final heat treatment and shall be selected in the longitudinal direction. The tension test specimens shall conform to the appropriate sections of Test Methods E 8.

13. Test Methods

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