



Standard Specification for Low-Carbon Nickel-Chromium-Molybdenum, Low-Carbon Nickel-Molybdenum-Chromium-Tantalum, Low-Carbon Nickel-Chromium-Molybdenum-Copper, and Low-Carbon Nickel-Chromium-Molybdenum-Tungsten Alloy Rod¹

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^{e1} NOTE—Editorial changes were made in 6.1, 7.1, and 7.2 in October 2006.

1. Scope

1.1 This specification² covers rod of low-carbon nickel-chromium-molybdenum alloys (UNS N10276, N06022, N06035, N06455, N06058, and N06059)*, low-carbon nickel-molybdenum-chromium-tantalum (UNS N06210), low-carbon nickel-chromium-molybdenum-copper alloy (UNS N06200), and low-carbon nickel-chromium-molybdenum-tungsten (UNS N06686) as shown in Table 1, for use in general corrosive service.

1.2 The following products are covered under this specification:

1.2.1 Rods $\frac{5}{16}$ to $\frac{3}{4}$ in. (7.94 to 19.05 mm), exclusive, in diameter, hot or cold finished, solution annealed and pickled, or mechanically descaled.

1.2.2 Rods $\frac{3}{4}$ to $3\frac{1}{2}$ in. (19.05 to 88.9 mm), inclusive, in diameter, hot or cold finished, solution annealed, ground or turned.

1.2.3 Rods $\frac{1}{4}$ to $3\frac{1}{2}$ in. (6.35 to 88.9 mm), inclusive, in diameter, solution annealed, cold finished, as cold finished, ground or turned (N06059 and N06686 only, see Table 2 and Table 3).

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

1.4 *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

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 *rod, n*—a product of round solid section furnished in straight lengths.

4. Ordering Information

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

4.1.1 *Alloy*—Table 1.

4.1.2 *Dimensions*—Nominal diameter and length. The shortest useable multiple length should be specified (Table 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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² For ASME Boiler and Pressure Vessel Code applications see related Specification SB-574 in Section II of that Code.

* New designation established in accordance with Practice E 527 and SAE J1086, Practice for Numbering Metals and Alloys (UNS).

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.

TABLE 1 Chemical Requirements

Element	Composition Limits, %								
	Alloy N06035	Alloy N10276	Alloy N06022	Alloy N06455	Alloy N06059	Alloy N06058	Alloy N06200	Alloy N06210	Alloy N06686
Molybdenum	7.60–9.00	15.0–17.0	12.5–14.5	14.0–17.0	15.0–16.5	19.0 - 21.0	15.0–17.0	18.0–20.0	15.0–17.0
Chromium	32.25–34.25	14.5–16.5	20.0–22.5	14.0–18.0	22.0–24.0	20.0- 23.0	22.0–24.0	18.0–20.0	19.0–23.0
Iron	2.00 max	4.0–7.0	2.0–6.0	3.0 max	1.5, max	1.5, max	3.0 max	1.0 max	5.0 max
Tungsten	0.60 max	3.0–4.5	2.5–3.5	...	...	0.3 max	...	...	3.0–4.4
Cobalt, max	1.00	2.5	2.5	2.0	0.3	0.3 max	2.0 max	1.0	...
Carbon, max	0.050	0.010	0.015	0.015	0.010	0.010	0.010	0.015	0.010
Silicon, max	0.60	0.08	0.08	0.08	0.10	0.10	0.08	0.08	0.08
Manganese, max	0.50	1.0	0.50	1.0	0.5	0.5	0.5	0.5	0.75
Vanadium, max	0.20	0.35	0.35	...	...	...	...	0.35	...
Phosphorus, max	0.030	0.04	0.02	0.04	0.015	0.015	0.025	0.02	0.04
Sulfur, max	0.015	0.03	0.02	0.03	0.010	0.010	0.010	0.02	0.02
Titanium	...	...	...	0.7 max	...	...	...	...	0.02–0.25
Nickel	remainder ^A	remainder ^A	remainder ^A	remainder ^A	Bal	Bal	remainder ^A	remainder ^A	remainder ^A
Aluminum	0.40 max	...	...	...	0.1–0.4	0.40 max	0.50 max	...	...
Copper	0.30 max	...	...	...	0.50 max	0.50 max	1.3–1.9	...	...
Tantalum	...	...	...	...	...	...	...	1.5–2.2	...

^ASee 12.1.1.

TABLE 2 Permissible Variations in Diameter and Out-of-Roundness of As Cold Finished Rods

Specified Diameter, in. (mm)	Permissible Variations, in. (mm)		
	Diameter		Out of Roundness, max
	+	-	
1/4 –7/16 (6.35–11.11), incl	0.012 (0.30)	0.012 (0.30)	0.018 (0.46)
Over 7/16 –5/8 (11.11–15.87), incl	0.014 (0.36)	0.014 (0.36)	0.020 (0.51)
Over 5/8 –3/4 (15.87–19.05), excl	0.016 (0.41)	0.016 (0.41)	0.024 (0.61)
3/4 –3 1/2 (19.05–88.9), incl	0.010 (0.25)	0.010 (0.25)	0.010 (0.25)

TABLE 3 Mechanical Property Requirements for As Cold Finished Rods

Alloy	Grade	Tensile Strength, min, psi (MPa)	Yield Strength (0.2 % Offset), min, psi (MPa)	Elongation in 2 in. (50.8 mm) or 4D ^A min, %
N06059	1	120 (827)	85 (586)	20
	2	135 (931)	125 (862)	20
	3	160 (1103)	150 (1034)	15
N06686	1	120 (827)	85 (586)	20
	2	135 (931)	125 (862)	20
	3	160 (1103)	150 (1034)	20

^A D refers to the diameter of the tension specimen.

TABLE 4 Permissible Variations in Diameter and Out-of-Roundness of Hot or Cold Finished, Solution Annealed Rods

Specified Diameter, in. (mm)	Permissible Variations, in. (mm)		
	Diameter		Out of Roundness, max
	+	-	
5/16 Hot-Finished, Annealed, and Descaled Rods			
5/16 –7/16 (7.94–11.11), incl	0.012 (0.30)	0.012 (0.30)	0.018 (0.46)
Over 7/16 –5/8 (11.11–15.87), incl	0.014 (0.36)	0.014 (0.36)	0.020 (0.51)
Over 5/8 –3/4 (15.87–19.05), excl	0.016 (0.41)	0.016 (0.41)	0.024 (0.61)
Hot-Finished, Annealed, and Ground or Turned Rods			
3/4 –3 1/2 (19.05–88.9), incl	0.010 (0.25)	0	0.008 (0.20)

4.1.3 *Certification*— State if certification or a report of test results is required (Section 15).

4.1.4 *Purchaser Inspection*—State which tests or inspections are to be witnessed (Section 13).

4.1.5 *Samples for Product (Check) Analysis*—State whether samples should be furnished (9.2.2).

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 made by the purchaser, the material shall conform to the product (check) analysis variations per Specification B 880.

6. Mechanical Properties and Other Requirements

6.1 The mechanical properties of the material at room temperature shall conform to those shown in [Table 3](#) and [Table 5](#).

7. Dimensions and Permissible Variations

7.1 *Diameter*—The permissible variations from the specified diameter shall be as prescribed in [Table 2](#) and [Table 4](#).

7.2 *Out of Roundness*—The permissible variation in roundness shall be as prescribed in [Table 2](#) and [Table 4](#).

7.3 *Machining Allowances*—When the surfaces of finished material are to be machined, the following allowances are suggested for normal machining operations.

7.3.1 *As-finished (Annealed and Descaled)*—For diameters of $\frac{5}{16}$ to $\frac{1}{4}$ in. (7.94 to 17.46 mm) inclusive, an allowance of $\frac{1}{16}$ in. (1.59 mm) on the diameter should be made for finish machining.

7.4 Length:

7.4.1 Unless multiple, nominal, or cut lengths are specified, random mill lengths shall be furnished.

7.4.2 The permissible variations in length of multiple, nominal, or cut length rod shall be as prescribed in [Table 6](#). Where rods are ordered in multiple lengths, a $\frac{1}{4}$ -in. (6.35-mm) length addition shall be allowed for each uncut multiple length.

7.5 Ends:

7.5.1 Rods ordered to random or nominal lengths shall be furnished with either cropped or sawed ends.

7.5.2 Rods ordered to cut lengths shall be furnished with square sawcut or machined ends.

7.6 *Weight*—For calculations of mass or weight, the following densities shall be used:

Alloy	Density	
	lb/in. ³	g/cm ³
N10276	0.321	8.87
N06022	0.314	8.69
N06035	0.296	8.18
N06455	0.312	8.64
N06058	0.318	8.80
N06059	0.311	8.60
N06200	0.307	8.50
N06686	0.315	8.73
N06210	0.316	8.76

7.7 *Straightness*—The maximum curvature (depth of chord) shall not exceed 0.050 in. multiplied by the length of the chord in feet (0.04 mm multiplied by the length in centimetres).

TABLE 6 Permissible Variations in Length of Rods

Random mill lengths	2 to 12 ft (610 to 3660 mm) long with not more than 25 weight % under 4 ft (1.22 m).
Multiple lengths	Furnished in multiples of a specified unit length, within the length limits indicated above. For each multiple, an allowance of $\frac{1}{4}$ in. (6.35 mm) shall 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.
Cut lengths	A specified length to which all rods shall be cut with a permissible variation of $\pm\frac{1}{8}$ in. (3.17 mm) – 0.

8. Workmanship, Finish, and Appearance

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

9. Sampling

9.1 Lots for Chemical Analysis and Mechanical Testing:

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

9.1.2 A lot of bar for mechanical testing shall be defined as the material from one heat in the same condition and specified diameter.

9.2 Sampling for Chemical Analysis:

9.2.1 A representative sample shall be obtained from each heat during pouring or subsequent processing.

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

9.3 *Sampling for Mechanical Testing*—A representative sample shall be taken from each lot of finished material.

10. Number of Tests and Retests

10.1 *Chemical Analysis*—One test per heat.

10.2 *Tension Tests*—One test per lot.

10.3 *Retests*—If the specimen used in the mechanical test of any lot fails to meet the specified requirements, two additional specimens shall be taken from different sample pieces and tested. The results of the tests on both of these specimens shall meet the specified requirements.

TABLE 5 Mechanical Property Requirements for Hot or Cold Finished, Solution Annealed Rods

Alloy	Tensile Strength, min, psi (MPa)	Yield Strength (0.2 % Offset), min, psi (MPa)	Elongation in 2 in. (50.8 mm) or 4D ^A min, %
N10276	100 000 (690)	41 000 (283)	40
N06022	100 000 (690)	45 000 (310)	45
N06035	85 000 (586)	35 000 (241)	30
N06455	100 000 (690)	40 000 (276)	40
N06058	110 000 (760)	52 000 (360)	40
N06059	100 000 (690)	45 000 (310)	45
N06200	100 000 (690)	45 000 (310)	45
N06686	100 000 (690)	45 000 (310)	45
N06210	100 000 (690)	45 000 (310)	45

^A D refers to the diameter of the tension specimen.

11. Specimen Preparation

11.1 Tension test specimens shall be taken from material after final heat-treatment and tested in the direction of fabrication.

11.2 Tension test specimens shall be any of the standard or subsized specimens shown in Test Methods E 8.

11.3 In the event of disagreement, the referee specimen shall be the largest possible round specimen shown in Test Methods E 8.

12. Test Methods

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

12.1.1 *Chemical Analysis*—Test Methods E 1473, For elements not covered by Test Methods E 1473, the referee method shall be as agreed upon between the manufacturer and the purchaser. The nickel composition shall be determined arithmetically by difference.

12.1.2 *Tension Test*—Test Methods E 8.

12.1.3 *Method of Sampling*—Practice E 55.

12.1.4 *Determining Significant Places*—Practice E 29.

12.2 For purposes of determining compliance with the limits in this specification, an observed value or a calculated value shall be rounded in accordance with the rounding method of Practice E 29:

Requirements	Rounded Unit for Observed or Calculated Value
Chemical composition and tolerances	nearest unit in the last right-hand place of figures of the specified limit
Tensile strength and yield strength	nearest 1000 psi (7 MPa)
Elongation	nearest 1 %

13. Inspection

13.1 Inspection of the material shall be made as agreed upon by the manufacturer and the purchaser 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.

15. Certification

15.1 When specified in the purchase order or contract, a manufacturer's certification shall be furnished to the purchaser stating that material has been manufactured, tested, and inspected in accordance with this specification, and that the test results on representative samples meet specification requirements. When specified in the purchase order or contract, a report of the test results shall be furnished.

16. Product Marking

16.1 Each piece of material ½ in. (12.7 mm) and over in diameter shall be marked with the specification number, alloy, heat number, manufacturer's identification, and size. The markings shall have no deleterious effect on the material or its performance and shall be sufficiently stable to withstand normal handling.

16.2 Each bundle or shipping container shall be marked with the name of the material; this specification number; alloy; the size; gross, tare and net weight; consignor and consignee address; contract or order number; and such other information as may be defined in the contract or order.

17. Keywords

17.1 N06022; N06035; N06058; N06059; N06200; N06210; N06455; N06686; N10276; rod

APPENDIX

(Nonmandatory Information)

X1. HEAT TREATMENT

X1.1 Proper heat treatment during or subsequent to fabrication is necessary for optimum performance and the manu-

facturer shall be consulted for details.

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