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Standard Specification for Precipitation Hardening Nickel Alloys Bar and Wire¹

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1. Scope*

1.1 This specification covers nickel alloys UNS N07716, N07725, N07773, N07776, N09777, and N09925 in the form of hot or cold finished rounds, squares, hexagons, rectangles, and cold finished wire.

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 The following precautionary caveat pertains only to the test methods, 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 Safety Data Sheet (SDS) for this product/material as provided by the manufacturer, to establish appropriate safety, health, and 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*:²

[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](#)

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 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.

[E8/E8M Test Methods for Tension Testing of Metallic Materials](#)

[E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications](#)

[E1473 Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys](#)

3. Terminology

3.1 *Definitions*—Definitions for terms defined in Terminology [B899](#) shall apply unless otherwise defined by the requirements of this document.

3.2 *Definitions of Terms Specific to This Standard*:

3.2.1 *bar, n*—material of round, rectangular (flats), hexagonal, square, or other solid section up to and including 10 in. (254 mm) in width and 1/8 in. (3.2 mm) or over in thickness in straight lengths.

3.2.2 *wire, n*—a cold-worked solid product of uniform cross section along its whole length, usually supplied in coil form.

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 name or UNS number,

4.1.2 ASTM designation and date of issue,

4.1.3 Quantity,

4.1.4 Form (bar or wire),

4.1.5 Dimensions,

4.1.6 Condition,

4.1.7 Finish,

4.1.8 *Certification*—State if certification is required,

4.1.9 *Samples for Product Analysis*—State if samples for product analysis are to be furnished, and

4.1.10 *Purchaser Inspection*—State if purchaser inspection is required and which tests or inspections are to be witnessed.

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 performed, the material shall conform to the tolerances provided in Specification [B880](#).

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

TABLE 1 Chemical Requirements^A

Element	Composition, Weight %					
	Alloy N07716	Alloy N07725	Alloy N07773	Alloy N07776	Alloy N09777	Alloy N09925
Carbon	0.03	0.03	0.03	0.03	0.03	0.03
Manganese	0.20	0.35	1.00	1.00	1.00	1.0
Phosphorous	0.015	0.015	0.030	0.030	0.030	0.03
Sulfur	0.010	0.010	0.010	0.010	0.010	0.03
Silicon	0.20		0.50	0.50	0.50	0.5
Chromium	19.00–22.00	19.00–22.50	18.0–27.0	12.0–22.0	14.0–19.0	19.5–22.5
Nickel	59.00–63.00	55.00–59.00	45.0–60.0	50.0–60.0	34.0–42.0	42.0–46.0
Molybdenum	7.00–9.50	7.00–9.50	2.5–5.5	9.0–15.0	2.5–5.5	2.5–3.5
Niobium ^C	2.75–4.00	2.75–4.00	2.5–6.0	4.0–6.0	0.10	0.5
Titanium	1.00–1.60	1.00–1.70	2.0	1.00	2.0–3.0	1.9–2.40
Aluminum		0.35	2.0	2.00	0.35	0.1–0.5
Iron	rem ^B	rem ^B	rem ^B	rem ^B	rem ^B	22.0 ^D
Other	...	...	Mo + 0.5 W = 2.5–5.5	...	...	Cu 1.5–3.0
Tungsten	...	...	6.0	0.5–2.5	...	...

^A All values are maximums unless a range is provided or is a minimum.

^B Iron or nickel shall be determined arithmetically by difference, "rem" means remainder.

^C Columbium and Niobium are interchangeable names for the same element and both names are acceptable for use in B02.07 specifications.

^D Minimum.

6. Condition

6.1 Bar shall be supplied in the solution treated conditions.

NOTE 1—The recommended solution treatment shall consist of heating the material to temperature in the range from 1850 °F to 1950 °F (1010 °C to 1065 °C), followed by rapid cooling. For alloy N09925, the recommended solution treatment shall consist of heating the material to temperature of 1875 °F (1024 °C), followed by air cooling or faster for 1 in. (25.4 mm) diameter or less and water quenching or faster for greater than 1 in. (25.4 mm) diameter. For alloy N07725, the recommended solution treatment shall consist of heating the material to temperature of 1900 °F (1038 °C), followed by air cooling.

6.2 Wire shall be supplied in the solution treated and cold finished condition.

6.3 Upon agreement between the purchaser and the manufacturer, the material may be supplied in the as-hot worked, solution treated plus aged, or other conditions.

7. Mechanical Properties

7.1 Unless otherwise specified, the material shall be supplied in the solution treated condition, suitable for subsequent age hardening, and shall conform to the minimum room temperature mechanical properties shown in Table 2.

7.2 The solution treated material shall be capable of meeting the mechanical property requirements of Table 3 following the precipitation hardening aging treatment described in Table 3.

7.3 When the material is to be supplied in the solution treated plus aged condition, mechanical property requirements

TABLE 2 Solution Treated Mechanical Properties^A

Alloy	Tensile Strength, min		Yield Strength, min		Elongation in 4D, % min	Reduction of Area, % min
	ksi	MPa	ksi	MPa		
N07716 and N07725	110	758	45	310	30	40
N07773 and N07776	90	621	35	241	35	50
N09777	75	517	30	207	35	50
N09925	75	517	35	241	35	50

TABLE 3 Capability Mechanical Properties^A

Alloy	Tensile Strength, min		Yield Strength, min		Elongation in 4D, % min	Reduction of Area, % min
	ksi	MPa	ksi	MPa		
N07716 and N07725	165	1137	120	827	20	35
N07773 and N07776	140	965	120	827	20	30
N09777	125	862	110	758	25	35
N09925 ^B	140	965	105	724	18	25
N09925 ^C	140	965	110	758	18	25

^A Properties after aging solution treated material.

Aging treatment for UNS N07716 and N07725 consists of 1350 °F (732 °C) for 8 h followed by furnace cooling to 1150 °F to 1200 °F (621 °C to 649 °C), holding 8 h, and air cooling. See Note 2.

Aging treatment for UNS N07773 consists of 1275 °F (690 °C) for 20 h followed by air cooling (see Note 2).

Aging treatment for UNS N07776 consists of 1335 °F (725 °C) for 8 h followed by furnace cooling to 1155 °F (625 °C), holding 8 h, and air cooling (see Note 2).

Aging treatment for UNS N09777 consists of 1330 °F (720 °C) for 8 h followed by furnace cooling to 1150 °F (620 °C), holding 8 h, and air cooling (see Note 2).

Aging treatment for UNS N09925 consists of 1365 °F (740 °C), hold at temperature for 6 h to 9 h, furnace cool to 1150 °F (62 °C), hold until total precipitation heat treatment time has reached 18 h, air cool or faster.

^B Cold worked, solution annealed and aged.

^C Hot worked, solution annealed and aged.

shall be those shown in Table 3, or as agreed upon between the purchaser and the manufacturer as part of the purchase contract.

NOTE 2—An aging treatment other than that described in Table 3 may be used provided the mechanical property and other requirements of this specification or the governing purchase contract are met.

8. Dimensions and Permissible Variations

8.1 Bar—Bar shall conform to the variations in dimensions prescribed in Tables 4-12, inclusive, as applicable.

8.2 Wire—Wire shall conform to the variations in dimensions prescribed in Tables 13-17, inclusive, as applicable.

9. Workmanship, Finish, and Appearance

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

TABLE 4 Permissible Variations in Size of Hot-Rolled 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 ^{C,D}	<i>E</i>	<i>E</i>	<i>E</i>
Over 5/16 (7.94) to 7/16 (11.11), incl ^{C,D}	0.006 (0.15)	0.006 (0.15)	0.009 (0.23)
Over 7/16 (11.11) to 5/8 (15.88), incl ^{C,D}	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)

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

^B Out-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.

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

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

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

TABLE 5 Permissible Variations in Size of Hot-Rolled 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 6 Permissible Variations in Thickness and Width for Hot-Rolled 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)
	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)			

TABLE 7 Permissible Variations in Size of Cold-Finished Round Bars

Specified Size, in. (mm)	Permissible Variations from Specified Size, in. (mm) ^{A,B}	
	Over	Under
Over ½ (12.70) to 1 (25.40), excl	0.002 (0.05)	0.002 (0.05)
1 (25.40) to 1½ (38.10), incl	0.0025 (0.06)	0.0025 (0.06)
1½ (38.10) to 4 (101.60), incl ^C	0.003 (0.08)	0.003 (0.08)

^A Unless otherwise specified, size tolerances are over and under as shown in the above table. When required, however, they may be specified all over and nothing under, or all under and nothing over, or any combination of over and under, if the total spread in size tolerance for a specified size is not less than the total spread shown in the table.

^B When it is necessary to heat treat or heat treat and pickle after cold finishing, size tolerances are double those shown in the table.

^C Cold-finish bars over 4 in. (101.60 mm) in diameter are produced; size tolerances for such bars have not been evolved.

TABLE 8 Permissible Variations in Size of Cold-Finished Hexagonal, Octagonal, and Square Bars

Specified Size, in. (mm)	Permissible Variations from Specified Size, in. (mm) ^A	
	Over	Under
Over ½ (12.70) to 1 (25.40), incl	0	0.004 (0.10)
Over 1 (25.40) to 2 (50.80), incl	0	0.006 (0.15)
Over 2 (50.80) to 3 (76.20), incl	0	0.008 (0.20)
Over 3 (76.20)	0	0.010 (0.25)

^A When it is necessary to heat treat or heat treat and pickle after cold finishing, size tolerances are double those shown in the table.

TABLE 9 Permissible Variations in Width and Thickness of Cold-Finished Flat Bars

Width, in. (mm)	Permissible Variations in Width, over and under, in. (mm) ^A	
	For Thicknesses ¼ (6.35) and Under	For Thicknesses Over ¼ (6.35)
¾ (9.52) to 1 (25.40), incl	0.004 (0.10)	0.002 (0.05)
Over 1 (25.40) to 2 (50.80), incl	0.006 (0.15)	0.003 (0.08)
Over 2 (50.80) to 3 (76.20), incl	0.008 (0.20)	0.004 (0.10)
Over 3 (76.20) to 4½ (114.30), incl	0.010 (0.25)	0.005 (0.13)

Thickness, in. (mm)	Permissible Variations in Thickness, over and under, in. (mm) ^A	
¾ (3.18) to 1 (25.40), incl	0.002 (0.05)	
Over 1 (25.40) to 2 (50.80), incl	0.003 (0.08)	
Over 2 (50.80) to 3 (76.20), incl	0.004 (0.10)	
Over 3 (76.20) to 4½ (114.30), incl ^B	0.005 (0.13)	

^A When it is necessary to heat treat and pickle cold finishing, size tolerances are double those shown in the table.

^B Cold-finished flat bars over 4½ in. (114.30 mm) wide or thick are produced; width and thickness tolerances for such bars have not been evolved.

10. Sampling

10.1 Lot Definition:

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

10.1.2 A lot for mechanical properties shall consist of all material from the same heat, nominal diameter, or thickness, subjected to the same heat treatment at the same time.

10.2 Test Material Selection:

10.2.1 *Chemical Analysis*—Representative samples shall be taken at the time of final ingot casting or during subsequent processing.

10.2.2 *Product Analysis*—Shall be solely the responsibility of the purchaser.

10.2.3 *Mechanical Properties*—Samples of material to provide test specimens shall be taken from locations in each lot as to be representative of that lot.

11. Number of Tests

11.1 *Chemical Analysis*—One test per lot.

11.2 *Mechanical Properties*—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.