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Standard Specification for Precipitation-Hardening Nickel Alloys Plate, Sheet, and Strip¹

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1. Scope

1.1 This specification covers rolled precipitation hardenable nickel-iron-chromium-columbium (Nb)-titanium-aluminum alloy (N09908) plate, sheet, and strip in the annealed condition (temper). This alloy is used as sheathing for super conductor cables, as tooling for fabrication of such cables, and for other applications requiring a material with low coefficient-of-expansion properties.

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 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:*²

- E8 Test Methods for Tension Testing of Metallic Materials
- E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- E228 Test Method for Linear Thermal Expansion of Solid Materials With a Push-Rod Dilatometer
- E1473 Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature 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.

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 The terms given in **Table 1** shall apply.

4. Ordering Information

4.1 Orders for material under this specification should include the following information:

4.1.1 *Alloy*—Name or UNS number (see **Table 2**).

4.1.2 *ASTM designation and year of issue.*

4.1.3 *Condition*—See **6.1** and **Appendix X1**.

4.1.4 *Finish*—See **Appendix X1**.

4.1.5 *Dimensions*—Thickness, width, and length.

4.1.6 *Quantity.*

4.1.7 *Optional Requirements:*

4.1.7.1 *Sheet and Strip*—Whether to be furnished in coil, in cut straight lengths, or in random straight lengths.

4.1.7.2 *Strip*—Whether to be furnished with commercial slit edge, square edge, or round edge.

4.1.7.3 *Plate*—Whether to be furnished specially flattened (see **7.7**); also how plate is to be cut (see **7.2.1** and **7.3.2**).

4.1.8 *Fabrication Details*—Not mandatory but helpful to the manufacturer:

4.1.8.1 *Welding or Brazing*—Process to be employed.

4.1.8.2 *Plate*—Whether material is to be hot-formed.

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

4.1.10 *Samples for Product (Check) Analysis*—Whether samples should be furnished (see **5.2**).

4.1.11 *Purchaser Inspection*—If the purchaser wishes to witness the tests or inspection of material at the place of manufacture, the purchase order must so state indicating which tests or inspections are to be witnessed (see **Section 13**).

5. Chemical Composition

5.1 The material shall conform to the requirements as to chemical composition prescribed in **Table 2**.

5.2 If a product (check) analysis is performed by the purchaser, the material shall conform to the product (check) analysis variations prescribed in **Table 2**.



TABLE 1 Product Description

Product	Thickness, in. (mm)	Width
Hot-rolled plate ^A	3/16 to 2 1/4 (4.8 to 57.2) (Table 4)	Table 6 ^B and Table 7
Cold-rolled sheet ^C	0.010 to 0.250 (0.25 to 6.4), incl (Table 5)	Table 8
Cold-rolled strip ^C	0.005 to 0.250 (0.13 to 6.4), incl (Table 5)	Table 8

^A Material 3/16 to 1/4 in. (4.8 to 6.4 mm), incl, in thickness may be furnished as sheet or plate provided the material meets the specification requirements for the condition ordered.

^B Hot-rolled plate, in widths 10 in. (250 mm) and under, may be furnished as hot-finished rectangles with sheared or cut edges provided the mechanical property requirements of this specification are met.

^C Material under 48 in. (1219 mm) in width may be furnished as sheet or strip provided the material meets the specification requirements for the condition ordered.

6. Mechanical and Other Requirements

6.1 *Tensile Properties*—The material after precipitation hardening shall conform to the tensile properties prescribed in Table 3.

6.2 Coefficient of Thermal Expansion:

6.2.1 The mean coefficient of thermal expansion from 77°F (25°C) to 1292°F (700°C) shall not exceed 7.8×10^{-6} in./in./°F (14.0×10^{-6} cm/cm/°C).

6.2.2 The inflection temperature shall not exceed 572°F (300°C).

7. Dimensions and Permissible Variations

7.1 Thickness and Weight:

7.1.1 *Plate*—The permissible variation under the specified thickness and permissible excess in overweight shall not exceed the amounts prescribed in Table 4.

7.1.1.1 For use with Table 4, plate shall be assumed to weigh 0.292 lb/in.³ (8.08 g/cm³).

7.1.2 *Sheet and Strip*—The permissible variations in thickness of sheet and strip shall be as prescribed in Table 5. The thickness of strip and sheet shall be measured with the micrometer spindle 3/8 in. (9.5 mm) or more from either edge for material 1 in. (25.4 mm) or over in width and at any place on the strip under 1 in. in width.

7.2 Width or Diameter:

7.2.1 *Plate*—The permissible variations in width of rectangular plates and diameter of circular plates shall be as prescribed in Table 6 and Table 7.

7.2.2 *Sheet and Strip*—The permissible variations in width for sheet and strip shall be as prescribed in Table 8.

7.3 Length:

7.3.1 Sheet and strip of all sizes may be ordered to cut lengths, in which case a variation of 1/8 in. (3.2 mm) over the specified length shall be permitted.

7.3.2 Permissible variations in length of rectangular plate shall be as prescribed in Table 9.

7.4 Straightness:

7.4.1 The edgewise curvature (depth of chord) of flat sheet, strip, and plate shall not exceed 0.05 in. multiplied by the length of the product in feet (0.04 mm multiplied by the length of the product in centimetres).

7.4.2 Straightness for coiled strip material is subject to agreement between the manufacturer and the purchaser.

7.5 Edges:

7.5.1 When finished edges of strip are specified in the contract or purchase order, the following descriptions shall apply:

7.5.1.1 Square-edge strip shall be supplied with finished edges, with sharp, square corners, and without bevel or rounding.

7.5.1.2 Round-edge strip shall be supplied with finished edges, semicircular in form, and the diameter of the circle forming the edge being equal to the strip thickness.

7.5.1.3 When no description of any required form of strip edge is given, it shall be understood that edges such as those resulting from slitting or shearing will be acceptable.

7.5.1.4 Sheet shall have sheared or slit edges.

7.5.1.5 Plate shall have sheared or cut (machined, abrasive-cut, powder-cut, or inert-arc-cut) edges, as specified.

7.6 *Squareness (Sheet)*—For sheets of all thicknesses, the angle between adjacent sides shall be $90 \pm 0.15^\circ$ (1/16 in. in 24 in.) (1.6 mm in 610 mm).

7.7 *Flatness*—Standard flatness tolerances for plate shall conform to the requirements prescribed in Table 10. “Specially flattened” plate, when so specified, shall have permissible variations in flatness as agreed upon between the manufacturer and purchaser.

8. Workmanship, Finish, and Appearance

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

9. Sampling

9.1 Lot—Definition:

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

9.1.2 A lot for tension testing shall consist of all material from the same heat, nominal thickness, and condition.

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

9.2 Test Material Selection:

9.2.1 *Chemical Analysis*—Representative samples shall be taken during pouring or subsequent processing.

9.2.1.1 Product (Check) Analysis shall be wholly the responsibility of the purchaser.

9.2.2 *Tension and Coefficient of Thermal Expansion Testing*—Samples of the material to provide test specimens for tension and coefficient of thermal expansion testing shall be taken from such locations in each lot as to be representative of that lot.

10. Number of Tests

10.1 *Chemical Analysis*—One test per lot.

10.2 *Tension*—One test per lot.

10.3 *Coefficient of Thermal Expansion*—One test per lot.

TABLE 2 Chemical Requirements

Element	Composition Limits, % N09908	Composition Limits, % N09925	Composition Limits, % N07725	Product (Check) Analysis Variations, Under min or Over max, of the Specified Limit of Element
Nickel	47.0 min 51.0 max	42.0 min 46.0 max	55.0 min 59.0 max	0.35 0.35
Chromium	3.75 min 4.5 max	19.5 min 22.5 max	19.0 min 22.5 max	0.10 0.10
Iron	remainder ^A	22.0 min	remainder ^A	...
Manganese, max	1.0	1.0	0.35	0.03
Carbon, max	0.03	0.03	0.03	0.01
Copper	...	1.5 min	...	0.03
	0.5 max	3.0 max	...	
Silicon, max	0.5	0.5	0.20	0.03
Sulfur, max	0.005	0.03	0.010	0.003
Aluminum	0.75 min 1.25 max	0.1 min 0.5 max	...	0.10 0.10
Titanium	1.20 min 1.80 max	1.9 min 2.40 max	1.00 min 1.70 max	0.05 0.05
Columbium (Nb)	2.7 min 3.3 max	...	2.75 min 4.00 max	0.10 0.15
Phosphorus	0.015 max	0.03	0.015	0.005
Boron	0.012 max	0.005
Cobalt	0.5 max	0.03
Molybdenum	...	2.5 min 3.5 max	7.00 min 9.50 max	0.15 0.15

^A Iron shall be determined arithmetically by difference.

TABLE 3 Tensile Properties for Plate, Sheet, and Strip^A

Nominal Thickness, in. (mm)	Tensile Strength, min, ksi (MPa)	Yield Strength (0.2 % offset), min, ksi (MPa)	Elongation in 2 in. or 50 mm (or 4D), min %
N09908^B			
Up to 1.0 (25.4), incl	170 (1172)	120 (827)	12
Over 1.0 to 2.25 (25.4 to 57.2), incl	170 (1172)	120 (827)	10
N09925^C			
Up to 1.0 (25.4), incl	140 (965)	105 (724)	18
Over 1.0 to 2.25 (25.4 to 57.2), incl	140 (965)	105 (724)	18
N07725^D			
Up to 1.0 (25.4), incl	150 (1034)	120 (827)	20
Over 1.0 to 2.25 (25.4 to 57.2), incl	150 (1034)	120 (827)	20

^A Material shall be supplied in the annealed condition (temper). The manufacturer shall demonstrate that annealed material is capable of meeting the properties prescribed in **Table 3** after precipitation heat treatment.

^B Precipitation heat treatment for N09908 shall consist of heating to 1292°F (700°C), holding at temperature for 50 h, and then air cooling.

^C Precipitation heat treatment for N09925 consists of 1365°F (740°C), hold at temperature for 6 to 9 h, furnace cool to 1150°F (621°C), hold until total precipitation heat treatment time has reached 18 h, air cool or faster.

^D Precipitation heat treatment for N07725 consists of 1350°F (732°C) for 8 h followed by furnace cooling to 1500 to 1200°F (621 to 649°C), holding 8 h, and air cooling.

11. Specimen Preparation

11.1 Tension test specimens shall be taken from material in the annealed condition (temper). The specimen shall be transverse to the direction of rolling when width will permit. The test specimen shall be precipitation heat treated (see **Table 3**) prior to testing.

11.2 Tension test specimens shall be any of the standard or subsized specimens shown in Test Methods **E8**.

11.3 In the event of disagreement, referee specimens shall be as follows:

11.3.1 Full thickness of the material machined to the form and dimensions shown for the sheet-type specimen in Test Methods **E8** for material under ½ in. (12.7 mm) in thickness.

11.3.2 The largest possible round specimen shown in Test Methods **E8** for material ½ in. (12.7 mm) and over.

11.4 Coefficient of thermal expansion test specimens may be taken from material in the annealed condition following the final hot rolling, or in the annealed condition following any subsequent cold rolling. The coefficient of thermal expansion test specimens shall be given the age hardening heat treatment prescribed in **Table 3** prior to testing.

12. Test Methods

12.1 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
Rounding procedure	E29
Coefficient of Thermal Expansion	E228

12.2 For purposes of determining compliance with the specified limits for requirements of the properties listed in the following table, an observed value or a calculated value shall