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Standard Specification for Precipitation-Hardening Nickel Alloys Plate, Sheet, and Strip[1]

This standard is issued under the fixed designation B872; 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 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)~~(SDS) 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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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.

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[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~~standard's Document Summary page on the ASTM website.

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TABLE 1 Product Description

Product	Thickness, in. (mm)	Width
Hot-rolled plate[A]	3⁄16 to 2¼ (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 ¼ 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.

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.

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/cm^3).
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.

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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	42.0 min	55.0 min	0.35
	51.0 max	46.0 max	59.0 max	0.35
Chromium	3.75 min	19.5 min	19.0 min	0.10
	4.5 max	22.5 max	22.5 max	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	0.1 min	...	0.10
	1.25 max	0.5 max	0.35 max	0.10
Titanium	1.20 min	1.9 min	1.00 min	0.05
	1.80 max	2.40 max	1.70 max	0.05
Columbium (Nb)	2.7 min	...	2.75 min	0.10
	3.3 max	0.5 max	4.00 max	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	7.00 min	0.15
	...	3.5 max	9.50 max	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.

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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 ± 0.15° (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.

TABLE 4 Permissible Variations in Thickness and Overweight of Rectangular Plates

NOTE 1—All plates shall be ordered to thickness and not to weight per square foot (centimetre). No plates shall vary more than 0.01 in. (0.25 mm) under the thickness ordered, and the overweight of each lot[A] in each shipment shall not exceed the amount in the table. Spot grinding is permitted to remove surface imperfections, such spots not to exceed 0.01 in. (0.25 mm) under the specified thickness.

Specified Thickness, in. (mm)	Permissible Excess in Average Weight[B,C] per Square Foot of Plates for Widths Given in Inches (Millimetres) Expressed in Percentage of Nominal Weights									
	Under 48 (1220)	48 to 60 (1220 to 1520), excl	60 to 72 (1520 to 1830), excl	72 to 84 (1830 to 2130), excl	84 to 96 (2130 to 2440), excl	96 to 108 (2440 to 2740), excl	108 to 120 (2740 to 3050), excl	120 to 132 (3050 to 3350), excl	132 to 144 (3350 to 3660), excl	144 to 160 (3660 to 4070), incl
3/16 to 5/16 (4.8 to 7.9), excl	9.0	10.5	12.0	13.5	15.0	16.5	18.0	...	...	...
5/16 to 3/8 (7.9 to 9.5), excl	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0	...	...
3/8 to 7/16 (9.5 to 11.1), excl	7.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0	19.5
7/16 to 1/2 (11.1 to 12.7), excl	6.0	7.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0
1/2 to 5/8 (12.7 to 15.9), excl	5.0	6.0	7.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5
5/8 to 3/4 (15.9 to 19.1), excl	4.5	5.5	6.0	7.0	7.5	9.0	10.5	12.0	13.5	15.0
3/4 to 1 (19.1 to 25.4), excl	4.0	4.5	5.5	6.0	7.0	7.5	9.0	10.5	12.0	13.5
1 to 2 1/4 (25.4 to 57.2), incl	5.0	5.0	5.5	6.5	7.0	8.0	8.5	10.0	11.5	13.0

[A] The term "lot" applied to this table means all of the plates of each group width and each group thickness.
[B] The permissible overweight for lots of circular and sketch plates shall be 25 % greater than the amounts given in this table.
[C] The weight of individual plates shall not exceed the nominal weight by more than 1 1/4 times the amount given in this table and Table Footnote B.

TABLE 5 Permissible Variations in Thickness of Sheet and Strip

NOTE 1—Permissible variations, plus and minus, in thickness, in. (mm), for widths given in in. (mm).

Specified Thickness, in. (mm)	Sheet			
	Hot-Rolled		Cold-Rolled	
	48 (1220) and Under[A]	Over 48 to 60 (1220 to 1520), incl[A]	48 (1220) and Under[A]	Over 48 to 60 (1220 to 1520), incl[A]
0.018 to 0.025 (0.46 to 0.64), incl	0.003 (0.08)	0.004 (0.10)	0.002 (0.05)	0.003 (0.08)
Over 0.025 to 0.034 (0.64 to 0.86), incl	0.004 (0.10)	0.005 (0.13)	0.003 (0.08)	0.004 (0.10)
Over 0.034 to 0.043 (0.86 to 1.1), incl	0.005 (0.13)	0.006 (0.15)	0.004 (0.10)	0.005 (0.13)
Over 0.043 to 0.056 (1.1 to 1.4), incl	0.005 (0.13)	0.006 (0.15)	0.004 (0.10)	0.005 (0.13)
Over 0.056 to 0.070 (1.4 to 1.8), incl	0.006 (0.15)	0.007 (0.18)	0.005 (0.13)	0.006 (0.15)
Over 0.070 to 0.078 (1.8 to 2.0), incl	0.007 (0.18)	0.008 (0.20)	0.006 (0.15)	0.007 (0.18)
Over 0.078 to 0.093 (2.0 to 2.4), incl	0.008 (0.20)	0.009 (0.23)	0.007 (0.18)	0.008 (0.20)
Over 0.093 to 0.109 (2.4 to 2.8), incl	0.009 (0.23)	0.010 (0.25)	0.007 (0.18)	0.009 (0.23)
Over 0.109 to 0.125 (2.8 to 3.2), incl	0.010 (0.25)	0.012 (0.31)	0.008 (0.20)	0.010 (0.25)
Over 0.125 to 0.140 (3.2 to 3.6), incl	0.012 (0.31)	0.014 (0.36)	0.008 (0.20)	0.010 (0.25)
Over 0.140 to 0.171 (3.6 to 4.3), incl	0.014 (0.36)	0.016 (0.41)	0.009 (0.23)	0.012 (0.31)
Over 0.171 to 0.187 (4.3 to 4.8), incl	0.015 (0.38)	0.017 (0.43)	0.010 (0.25)	0.013 (0.33)
Over 0.187 to 0.218 (4.8 to 5.5), incl	0.017 (0.43)	0.019 (0.48)	0.011 (0.28)	0.015 (0.38)
Over 0.218 to 0.234 (5.5 to 5.9), incl	0.018 (0.46)	0.020 (0.51)	0.012 (0.31)	0.016 (0.41)
Over 0.234 to 0.250 (5.9 to 6.4), incl	0.020 (0.51)	0.022 (0.56)	0.013 (0.33)	0.018 (0.46)

Cold-Rolled Strip	
Specified Thickness, in. (mm)	Widths 12 in. (305 mm) and Under, ±[A]
Up to 0.050 (1.3), incl	0.0015 (0.04)
Over 0.050 to 0.093 (1.3 to 2.4), incl	0.0025 (0.06)
Over 0.093 to 0.125 (2.4 to 3.2), incl[B]	0.004 (0.11)

[A] Measured 3/8 in. (9.5 mm) or more from either edge except for strip under 1 in. (25.4 mm) in width, which is measured at any place.
[B] Standard sheet tolerances apply for thicknesses over 0.125 in. (3.2 mm) and for all thicknesses of strip over 12 in. (305 mm) wide.

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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.