



Standard Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, N06045, and N06696), Nickel- Chromium-Cobalt-Molybdenum Alloy (UNS N06617), and Nickel-Iron-Chromium-Tungsten Alloy (UNS N06674) Plate, Sheet, and Strip¹

This standard is issued under the fixed designation B168; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*Scope

1.1 This specification² covers rolled nickel-chromium-iron alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, N06045, and ~~N06696~~),³ nickel-chromium-cobalt-molybdenum alloy (UNS N06617), and nickel-iron-chromium-tungsten alloy (UNS N06674) plate, sheet, and strip.

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 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:⁴

B166 Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, N06045, and N06696), Nickel-Chromium-Cobalt-Molybdenum Alloy (UNS N06617), and Nickel-Iron-Chromium-Tungsten Alloy (UNS N06674) Rod, Bar, and Wire

B880 Specification for General Requirements for Chemical Check Analysis Limits for Nickel, Nickel Alloys and Cobalt Alloys

E8 Test Methods for Tension Testing of Metallic Materials

E10 Test Method for Brinell Hardness of Metallic Materials

E18 Test Methods for Rockwell Hardness of Metallic Materials

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E38 Methods for Chemical Analysis of Nickel-Chromium and Nickel-Chromium-Iron Alloys (Withdrawn 1989)⁵

E112 Test Methods for Determining Average Grain Size

E140 Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness

E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

E1473 Test Methods for Chemical Analysis of Nickel, Cobalt and High-Temperature 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 ASME Boiler and Pressure Code applications, see related Specification SB-168 in Section II of that Code.

³ For ASME Boiler and Pressure Code applications, see related Specification SB-168 in Section II of that Code.

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

⁴ 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.

⁵ The last approved version of this historical standard is referenced on www.astm.org.

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

F155 Method of Test for Temper of Strip and Sheet Metals for Electronic Devices (Spring-Back Method) (Withdrawn 1982)⁵

2.2 Federal Standards:⁶

Fed. Std. No. 102 Preservation, Packaging and Packing Levels

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

Fed. Std. No. 182 Continuous Identification Marking of Nickel and Nickel-Base Alloys

2.3 Military Standard:⁶

MIL-STD-129 Marking for Shipment and Storage

3. Terminology

3.1 Descriptions of Terms Specific to This Standard—The terms given in Table 1 shall apply.

4. Ordering Information

4.1 It is the responsibility of the purchaser to specify all requirements that are necessary for the safe and satisfactory performance of 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 (see Table 2),

4.1.2 ASTM designation, including year of issue,

4.1.3 Condition—See 7.1 and 7.2 and Appendix X1,

4.1.4 Finish—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 8.7.2); also how plate is to be cut (see 8.2.1 and 8.3.2),

4.1.8 Certification—State if certification or a report of test results is required (Section 16),

4.1.9 Samples for Product (Check) Analysis—Whether samples for product (check) analysis should be furnished (see 5.2), and

4.1.10 Purchaser Inspection—If the purchaser wishes to witness 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 (Section 14).

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 Specification B880.

6. Heat Treatment

6.1 Material of N06674 shall be solution annealed after cold-working or hot-working by heating to 2150°F (1175°C) minimum, followed by quenching in water or rapidly cooling by other means.

⁶ Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5098, <http://www.dodssp.daps.mil>; 19111-5094, <http://quicksearch.dla.mil>.

TABLE 1 Product Description

Product	Thickness, in. (mm)	Width, in. (mm)
Hot-rolled plate ^A	$\geq \frac{3}{16}$ and over (Table 5 and Table 6)	(Table 8) ^B
Hot-rolled sheet ^A	0.018 to 0.250 (0.46 to 6.4), incl (Table 7)	(Table 10)
Cold-rolled sheet ^C	0.018 to 0.250 (0.46 to 6.4), incl (Table 7)	(Table 10)
Cold-rolled strip ^C	0.005 to 0.250 (0.13 to 6.4), incl (Table 7)	(Table 10)

TABLE 1 Product Description

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Cold-rolled sheet ^C	0.018 to 0.250 (0.46 to 6.4), incl (Table 7)	(Table 10)
Cold-rolled strip ^C	0.005 to 0.250 (0.13 to 6.4), incl (Table 7)	(Table 10)

^A Material $\frac{3}{16}$ to $\frac{1}{4}$ 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. (254 mm) and under, may be furnished as hot-finished rectangles with sheared or cut edges in accordance with Specification B166, 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.

TABLE 2 Chemical Requirements^A

Element	Composition Limits, %									
	Alloy N06600	Alloy N06601	Alloy N06617	Alloy N06674	Alloy N06690	Alloy N06693	Alloy N06025	Alloy N06045	Alloy N06603	Alloy N06696
Nickel	72.0 min	58.0–63.0	44.5 min	remainder ^B	58.0 min	remainder ^B	remainder ^B	45.0 min	remainder ^B	remainder ^B
Chromium	14.0–17.0	21.0–25.0	20.0–24.0	21.5–24.5	27.0–31.0	27.0–31.0	24.0–26.0	26.0–29.0	24.0–26.0	28.0–32.0
Cobalt	...	...	10.0–15.0	...	...	...	...	...	...	...
Molybdenum	...	...	8.0–10.0	...	...	...	...	...	...	1.0–3.0
Niobium	...	...	...	0.10–0.35	...	0.5–2.5	...	...	...	...
Iron	6.0–10.0	remainder ^B	3.0 max	20.0–27.0	7.0–11.0	2.5–6.0	8.0–11.0	21.0–25.0	8.0–11.0	2.0–6.0
Manganese	1.0 max	1.0 max	1.0 max	1.50 max	0.5 max	1.0 max	0.15 max	1.0 max	0.15 max	1.0 max
Aluminum	...	1.0–1.7	0.8–1.5	...	...	2.5–4.0	1.8–2.4	...	2.4–3.0	...
Carbon	0.15 max	0.10 max	0.05–0.15	0.10 max	0.05 max	0.15 max	0.15–0.25	0.05–0.12	0.20–0.40	0.15 max
Copper	0.5 max	1.0 max	0.5 max	...	0.5 max	0.5 max	0.1 max	0.3 max	0.50 max	1.5–3.0
Silicon	0.5 max	0.5 max	1.0 max	1.0 max	0.5 max	0.5 max	0.5 max	2.5–3.0	0.50 max	1.0–2.5
Sulfur	0.015 max	0.015 max	0.015 max	0.015 max	0.015 max	0.01 max	0.010 max	0.010 max	0.010 max	0.010 max
Titanium	...	...	0.6 max	0.05–0.20	...	1.0 max	0.1–0.2	...	0.01–0.25	1.0 max
Phosphorus	...	...	...	0.030 max	...	...	0.020 max	0.020 max	0.020 max	...
Zirconium	...	...	...	...	...	...	0.01–0.10	...	0.01–0.10	...
Yttrium	...	...	...	...	...	...	0.05–0.12	...	0.01–0.15	...
Boron	...	...	0.006 max	0.0005–0.006	...	...	...	...	...	...
Nitrogen	...	...	...	0.02 max	...	...	...	...	...	...
Cerium	...	...	...	...	...	...	...	0.03–0.09	...	...
Tungsten	...	...	...	6.0–8.0	...	...	...	...	...	...

^A Where ellipses (...) appear in this table there is no requirement and the element need neither be analyzed for nor reported.

^B Element shall be determined arithmetically by difference.

7. Mechanical Properties and Other Requirements

7.1 *Mechanical Properties*—The material shall conform to the mechanical properties prescribed in [Table 3](#).

7.2 *Deep Drawing and Spinning Quality Sheet and Strip*—The material shall conform to the grain size and hardness requirements as prescribed in [Table 4](#).

7.2.1 The mechanical properties of [Table 3](#) do not apply to deep drawing and spinning quality sheet and strip.

7.3 *Grain Size*—Except as prescribed in [7.2](#), the grain size for N06674 shall be 7 or coarser, as determined in accordance with Test Methods [E112](#).

8. Dimensions and Permissible Variations

8.1 *Thickness and Weight:*

8.1.1 *Plate*—For plate up to 2 in. (50.8 mm), inclusive, in thickness, the permissible variation under the specified thickness and permissible excess in overweight shall not exceed the amounts prescribed in [Table 5](#).

8.1.1.1 For use with [Table 5](#), plate shall be assumed to weigh 0.304 lb/in.³ (8.415 g/cm³).

8.1.2 *Plate*—For plate over 2 in. (50.8 mm) in thickness, the permissible variations over the specified thickness shall not exceed the amounts prescribed in [Table 6](#).

8.1.3 *Sheet and Strip*—The permissible variations in thickness of sheet and strip shall be as prescribed in [Table 7](#). The thickness of strip and sheet shall be measured with the micrometer spindle $\frac{3}{8}$ 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.

8.2 *Width or Diameter:*

8.2.1 *Plate*—The permissible variations in width of rectangular plates and diameter of circular plates shall be as prescribed in [Table 8](#) and [Table 9](#).

8.2.2 *Sheet and Strip*—The permissible variations in width for sheet and strip shall be as prescribed in [Table 10](#).

8.3 *Length:*

8.3.1 Sheet and strip of all sizes may be ordered to cut lengths, in which case a variation of $\frac{1}{8}$ in. (3.2 mm) over the specified length shall be permitted.

8.3.2 Permissible variations in length of rectangular plate shall be as prescribed in [Table 11](#).

8.4 *Straightness:*

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

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

8.5 *Edges:*

8.5.1 When finished edges of strip are specified in the contract or order, the following descriptions shall apply: -112016

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

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

8.5.1.3 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.

8.5.1.4 Sheet shall have sheared or slit edges.

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

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

8.7 *Flatness:*

8.7.1 There shall be no flatness requirements for “deep-drawing quality,” “spinning quality,” or “as rolled” sheet and strip (see [X1.4](#)).

8.7.2 Standard flatness tolerances for plate shall conform to the requirements of [Table 12](#). “Specially flattened” plate, when so specified, shall have permissible variations in flatness as agreed upon between the manufacturer and the purchaser.

9. Workmanship, Finish, and Appearance

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

9.2 *Sheet, Strip, and Plate*—Sheet, strip, and plate supplied in the conditions and finishes as listed in the appendix may be ground or machined to remove surface imperfections, provided such removal does not reduce the material below the minimum specified dimensions. Surface eliminated depressions shall be faired smoothly into the surrounding material. The removal of a surface imperfection shall be verified by the method originally used to detect the imperfection.

TABLE 3 Mechanical Properties for Plate, Sheet, and Strip (All Thicknesses and Sizes Unless Otherwise Indicated)

Condition (Temper)	Tensile Strength, min, psi (MPa)	Yield Strength ^A (0.2 % offset), min, psi (MPa)	Elongation in 2 in. or 50 mm (or 4D), min, %	Rockwell Hardness ^{B,C}
Hot-Rolled Plate				
UNS N06600:				
Annealed	80 000 (550)	35 000 (240)	30	...
As-rolled ^{D,E}	85 000 (586)	35 000 (240)	30	...
UNS N06601:				
Annealed	80 000 (550)	30 000 (205)	30	...
UNS N06603:				
Annealed	94 000 (650)	43 000 (300)	25	...
UNS N06617:				
Annealed	95 000 (655)	35 000 (240)	35	...
UNS N06674:				
Annealed	86 000 (590)	34 000 (235)	30	...
UNS N06690:				
Annealed	85 000 (586)	35 000 (240)	30	...
As-rolled ^{D,E}	85 000 (586)	35 000 (240)	30	...
Annealed ^F	75 000 (514)	30 000 (206)	30	...
UNS N06693:				
Annealed	100 000 (690)	50 000 (345)	30	...
UNS N06025:				
Annealed	98 000 (680)	39 000 (270)	30	...
UNS N06045:				
Annealed	90 000 (620)	35 000 (240)	35	...
Hot-Rolled Sheet				
UNS N06600:				
Annealed	80 000 (550)	35 000 (240)	30	...
UNS N06601:				
Annealed	80 000 (550)	30 000 (205)	30	...
UNS N06603:				
Annealed	94 000 (650)	43 000 (300)	25	...
UNS N06617:				
Annealed	95 000 (655)	35 000 (240)	30	...
UNS N06674:				
Annealed	86 000 (590)	34 000 (235)	30	...
UNS N06690:				
Annealed	85 000 (586)	35 000 (240)	30	...
UNS N06693:				
Annealed	100 000 (690)	50 000 (345)	30	...
UNS N06025:				
Annealed	98 000 (680)	39 000 (270)	30	...
UNS N06045:				
Annealed	90 000 (620)	35 000 (240)	35	...
Cold-Rolled Plate				
UNS N06603:				
Annealed	94 000 (650)	43 000 (300)	25	...
UNS N06674:				
Annealed	86 000 (590)	34 000 (235)	30	...
UNS N06025:				
Annealed	98 000 (680)	39 000 (270)	30	...
UNS N06045:				
Annealed	90 000 (620)	35 000 (240)	35	...
Cold-Rolled Sheet				
UNS N06600:				
Annealed	80 000 (550) ^G	35 000 (240)	30 ^G	...
Hard	125 000 (860) ^G	90 000 (620)	2 ^G	...
UNS N06601:				
Annealed	80 000 (550) ^G	30 000 (205)	30 ^G	...
UNS N06603:				
Annealed	94 000 (650)	43 000 (300)	25 ^G	...
UNS N06674:				
Annealed	86 000 (590)	34 000 (235)	30	...
UNS N06617:				
Annealed	95 000 (655) ^G	35 000 (240)	25 ^G	...
UNS N06690:				
Annealed	85 000 (586) ^G	35 000 (240)	30 ^G	...
Hard	125 000 (860) ^G	90 000 (620)	2 ^G	...
UNS N06693:				
Annealed	100 000 (690)	50 000 (345)	30	...
UNS N06025:				
Annealed	98 000 (680)	39 000 (270)	30	...
UNS N06045:				
Annealed	90 000 (620)	35 000 (240)	35	...
Cold-Rolled Strip				
UNS N06600:				

TABLE 3 *Continued*

Condition (Temper)	Tensile Strength, min, psi (MPa)	Yield Strength ^A (0.2 % offset), min, psi (MPa)	Elongation in 2 in. or 50 mm (or 4D), min, %	Rockwell Hardness ^{B,C}
Annealed	80 000 (550) ^G	35 000 (240)	30 ^G	...
Skin-hard	...	...	...	B85 to B88
Quarter-hard	...	...	...	B88 to B94
Half-hard	...	...	...	B93 to B98
Three-quarter-hard	...	...	...	B97 to C25
Hard	125 000 (860) ^G	90 000 (620)	2 ^G	...
Spring	...	...	...	C30 min
UNS N06601: Annealed	80 000 (550) ^G	30 000 (205)	30 ^G	...
UNS N06603: Annealed	94 000 (650)	43 000 (300)	25 ^G	...
UNS N06617: Annealed	95 000 (655) ^G	35 000 (240)	30 ^G	...
UNS N06674: Annealed	86 000 (590)	34 000 (235)	30	...
UNS N06690: Annealed	85 000 (586) ^G	35 000 (240)	30 ^G	...
Skin-hard	...	...	...	B85 to B88
Quarter-hard	...	...	...	B88 to B94
Half-hard	...	...	...	B93 to B98
Three-quarter-hard	...	...	...	B97 to C25
Hard	125 000 (860) ^G	90 000 (620)	2 ^G	...
Spring	...	...	...	C30 min
UNS N06693: Annealed	100 000 (690)	50 000 (345)	30	...
UNS N06025: Annealed	98 000 (680)	39 000 (270)	30	...
UNS N06045: Annealed	90 000 (620)	35 000 (240)	35	...
UNS N06696: Annealed	85 000 (586)	35 000 (240)	30	...

^A Yield strength requirements do not apply to material under 0.020 in. (0.51 mm) in thickness.

^B For Rockwell or equivalent hardness conversions, see Hardness Conversion Tables E140.

^C Caution should be served in using the Rockwell test on thin material, as the results may be affected by specimen thickness. For thicknesses under 0.050 in. (1.3 mm), the use of the Rockwell superficial or the Vickers hardness test is suggested.

^D As-rolled plate may be given a stress relieving heat treatment subsequent to final rolling.

^E As-rolled plate specified "suitable for hot forming" shall be furnished from heats of known good hot-malleability characteristics (see X1.2.2). There are no applicable tensile or hardness requirements for such material.

^F Annealed at 1850°F (1010°C) minimum.

^G Not applicable for thickness under 0.010 in. (0.25 mm).

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<https://standards.iteh.ai/catalog/standards/sist/bf730bea-0bf4b31-b1ca-34225c2c57d9/astm-b168-112016>

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, hardness, and grain size testing shall consist of all material from the same heat, nominal thickness, and condition.

10.1.2.1 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.

10.2 Test Material Selection:

10.2.1 *Chemical Analysis*—Representative samples from each lot shall be taken during pouring or subsequent processing.

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

10.2.2 *Mechanical Properties, Hardness, and Grain Size*—Samples of the material to provide test specimens for mechanical properties, hardness, and grain size shall be taken from such 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.

11.3 *Hardness*—One test per lot. (Required only as specified in Table 3 and Table 4.)

11.4 *Grain Size*—One test per lot. (Required only as specified in 7.3 or Table 4.)

12. Specimen Preparation

12.1 Tension test specimens shall be taken from material in the final condition (temper) and tested transverse to the direction of rolling when width will permit.