



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

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

1. Scope*

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

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

1.3 The following precautionary caveat pertains only to the test methods portion, Section 12, 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) 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 166 Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, N06045, and N06696) and Nickel-Chromium-Cobalt-Molybdenum Alloy (UNS N06617) Rod, Bar, and Wire
- 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 10 Test Method for Brinell Hardness of Metallic Materials
- E 18 Test Methods for Rockwell Hardness of Metallic Materials
- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- E 38 Methods for Chemical Analysis of Nickel-Chromium and Nickel-Chromium-Iron Alloys⁴
- E 112 Test Methods for Determining Average Grain Size
- E 140 Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, and Scleroscope Hardness
- E 527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)
- E 1473 Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys
- F 155 Test Method for Temper of Strip and Sheet Metals for Electronic Devices (Spring-Back Method)⁰

2.2 Federal Standards:⁵

- 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

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.

* 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.

⁴ Withdrawn.

⁵ Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, <http://www.dodssp.daps.mil>.

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

2.3 *Military Standard*.⁵

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 6.1 and 6.2 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 7.7.2); also how plate is to be cut (see 7.2.1 and 7.3.2),
- 4.1.8 *Certification*— State if certification or a report of test results is required (Section 15),
- 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 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 Specification B 880.

<https://standards.iteh.ai/catalog/standards/sist/b240ec0e-c22b-4a71-8312-bbf8394e5462/astm-b168-08>

6. Mechanical Properties and Other Requirements

6.1 *Mechanical Properties*—The material shall conform to the mechanical properties prescribed in Table 3:

TABLE 1 Product Description

Product	Thickness, in. (mm)	Width, in. (mm)
Hot-rolled plate ^A	$\frac{3}{16}$ 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)

^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 B 166, 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 1 2 Permissible Variations from Flatness of Rectangular, Circular, and Sketch Plates Note 1—Permissible variations apply to plates up to 12 ft (3660 mm) in length Ch, or to any 12 ft (3660 mm) of longer plates.

NOTE 2—If the longer dimension is under 36 in. (914 mm), the permissible variation is not greater than 1/4 in. (6.4 mm).
 NOTE 3—The shorter dimension specified is considered the width, and the permissible variation in flatness across the width does not exceed the tabular amount of that dimension.
 NOTE 4—The maximum deviation from a flat surface does not customarily exceed the tabular tolerance for the longer dimension specified.

Specified Thickness	48-Alloy 60Y (42Ni-10Cr- 162660); excl 1	60-Alloy 72Y (42Ni-10Cr- 661830); excl 7	72-Alloy 84Y (48Ni-10Cr- 2136690); excl	84-Alloy 96Y (24Ni-10Cr- 2440); excl 6693	96-Alloy 108Y (24Ni-10Cr- 27460); excl 25	108-Alloy 120Y (27Ni-10Cr- 360450); excl	120-Alloy 144Y (3Ni-10Cr- 3660); excl 3	144-Alloy (3Ni-10Cr- and over	
									Inches
Inches 96									
to 1/4, excl	4 1/8	4 1/4	4 1/2	4 3/4	4 3/4	4 3/4	4 3/4	4 3/4	4 3/4
Nickel	72.0 min	44.5 min	58.0 min	remainder ^A	remainder ^A	45.0 min	remainder ^A	remainder ^A	remainder ^A
to 1, excl	14.0-17.0	20.0-24.0	27.0-31.0	27.0-31.0	24.0-26.0	26.0-29.0	24.0-26.0	24.0-26.0	28.0-32.0
Chromium	to 1/2, excl	10.0-15.0	to 3/4, excl	0.5-2.5	0.5-2.5	...	...	...	...
Gebalt	to 1/4	8.0-10.0	to 1/2, excl	2.5-6.0	8.0-11.0	21.0-25.0	8.0-11.0	8.0-11.0	2.0-6.0
Cobalt	...	...	to 3/4	1.0 max	1.0 max	1.0 max	1.0 max	1.0 max	1.0 max
Molybdenum	...	3.0 max	7.0-11.0	2.5-4.0	1.8-2.4	...	2.4-3.0	...	...
Niobium	6.0-10.0	1.0 max	0.5 max	1.0 max	1.5 max	0.05-0.12	0.20-0.40	0.15 max	0.15 max
Iron	to 1, excl	1.5	to 2, excl	0.15 max	0.15 max	...	0.20-0.40	0.15 max	0.15 max
Manganese	to 1, excl	0.8-1.5	...	0.15 max	0.15-0.25	0.05-0.12	0.20-0.40	0.15 max	0.15 max
Manganese	...	...	...	0.5 max	0.1 max	0.3 max	0.50 max	1.5-3.0	1.5-3.0
Aluminum	0.15 max	0.05-0.15	0.5 max	0.5 max	0.1 max	0.3 max	0.50 max	1.5-3.0	1.5-3.0
Carbon	0.5 max	0.5 max	0.5 max	0.5 max	0.1 max	0.3 max	0.50 max	1.5-3.0	1.5-3.0
2 to 4, incl	0.5 max	0.5 max	0.5 max	0.5 max	0.1 max	0.3 max	0.50 max	1.5-3.0	1.5-3.0
Copper	0.5 max	0.5 max	0.5 max	0.5 max	0.1 max	0.3 max	0.50 max	1.5-3.0	1.5-3.0
Silicon	0.5 max	0.5 max	0.5 max	0.5 max	0.1 max	0.3 max	0.50 max	1.5-3.0	1.5-3.0
ax	4.8 to 6.4, excl	19.0	27.0	31.8	1.0-2.5	0.10 max	0.010 max	0.010 max	0.010 max
ax	0.5 max	0.5 max	2.5-3.0	0.50 max	1.0-2.5	0.010 max	0.010 max	0.010 max	0.010 max
Sulfur	0.015 max	0.015 max	0.015 max	0.01 max	0.01 max	0.01 max	0.01 max	0.01 max	0.01 max
6 to 9.5, excl	17-5	23-8	28-6	34-9	36-5	39-7	47-6	44-4	44-4
Titanium	...	0.6 max	...	1.0 max	0.1-0.2	0.1-0.2	0.01-0.25	0.01-0.25	0.01-0.25
9.5 to 12.7, excl	12-7	17-5	...	23-8	28-6	31-8	36-5	34-9	34-9
Phosphorus	...	...	...	20-6	28-6	0.020 max	0.020 max	0.01-0.10	0.01-0.10
12.7 to 19.0, excl	12-7	15-9	15-9	19-9	2-0-6	23-8	25-4	28-6	28-6
Zirconium	12-7	15-9	15-9	19-9	2-0-6	23-8	25-4	28-6	28-6
19.0 to 25.4, excl	12-7	14-3	14-3	14-3	0.05-0.12	17-5	17-5	17-5	17-5
Yttrium	12-7	14-3	14-3	14-3	0.05-0.12	17-5	17-5	17-5	17-5
25.4 to 50.8, excl	12-7	0.006 max	...	...	...	...	...	...	...
Boron	19-0	0.006 max	...	...	...	...	...	...	...

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 As-rolled ^{D,E}	80 000 (550)–85 000 (586)	35 000 (240)–35 000 (240)	30–30	... ..
UNS N06601: Annealed	80 000 (550)	30000 (205)	30	...
UNS N06603: Annealed	94 000 (650)	43 000 (300)	25	...
UNS N06617: Annealed	95 000 (655)	35 000 (240)	35	...
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)	30000 (205)	30	...
UNS N06603: Annealed	94 000 (650)	43 000 (300)	25	...
UNS N06617: Annealed	95 000 (655)	35 000 (240)	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 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 Hard	80 000 (550) ^G –125 000 (860) ^G	35 000 (240)–90 000 (620)	30 ^G –2 ^G	... ..
UNS N06601: Annealed	80 000 (550) ^G	30000 (205)	30 ^G	...
UNS N06603: Annealed	94 000 (650)	43 000 (300)	25 ^G	...
UNS N06617: Annealed	95 000 (655) ^G	35 000 (240)	25 ^G	...
UNS N06690: Annealed Hard	85 000 (586) ^G –125 000 (860) ^G	35 000 (240)–90 000 (620)	30 ^G –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: 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	30000 (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 N06690: Annealed	85 000 (586) ^G	35 000 (240)	30 ^G	...
Skin-hard	...	...	...	B85 to B88
Quarter-hard	...	...	...	B88 to B94

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}
Half-hard	...	...	...	B93 to B98
Three-quarter-hard	...	...	...	B97 to C25
Hard	125 000 (860) ^D	90 000 (620)	— ^D	...
Spring	...	...	...	C30-min
UNS N06693-Annealed	100 000 (690)	60 000 (345)	30	...
UNS N06025-Annealed	98 000 (680)	39 000 (270)	30	...
UNS N06045-Annealed	90 000 (620)	35 000 (240)	35	...

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

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

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

^DAs-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.

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

^FNot applicable for thickness under 0.010 in. (0.25 mm).

6.2 *Deep Drawing and Spinning Quality Sheet and Strip*—The material shall conform to the grain size and hardness requirements as prescribed in Table 4.

6.2.1 The mechanical properties of Table 3 do not apply to deep drawing and spinning quality sheet and strip.

7. Dimensions and Permissible Variations

7.1 Thickness and Weight:

7.1.1 *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.

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

7.1.2 *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.

7.1.3 *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.

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 8 and Table 9.

7.2.2 *Sheet and Strip*—The permissible variations in width for sheet and strip shall be as prescribed in Table 10.

7.3 Length:

7.3.1 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.

7.3.2 Permissible variations in length of rectangular plate shall be as prescribed in Table 11.

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 in feet (0.04 mm multiplied by the length in centimetres).

7.4.2 Straightness for coiled 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 order, the following descriptions shall apply:

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

7.5.1.2 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.

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 $90 \pm 0.15^\circ$ ($\frac{1}{16}$ in. in 24 in. (1.6 mm in 610 mm)).

7.7 Flatness:

7.7.1 There shall be no flatness requirements for "deep-drawing quality," "spinning quality," or "as rolled" sheet and strip (see X1.4).

7.7.2 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.

TABLE 2 3 Chemical Requirements

Alloy Condition (Temper)	Element				Composition
	Tensile Strength, min, psi (MPa)	Yield Strength ^A (0.2% offset), min, psi (MPa)	Elongation in 2 in. or 50.8 mm (or 4D), min, %	Rockwell Hardness	
UNS N066025					UNS N066025
Nickel	72.0 min	58.0–63.0	44.5 min	58.0 min	...
UNS N06600: remainder ^A	remainder ^A	4 5.0 min	remainder ^A 35 000 (240)	30	...
Annealed	remainder ^E	80 000 (550)	35 000 (240)	30	...
As-rolled ^D		85 000 (586)	35 000 (240)	30	...
Chromium	14.0–17.0	21.0–25.0			...
UNS N06601: Annealed	2.0–0–24.0	27.0–31.0	30	...	...
Annealed	80 000 (550)	30 000 (205)	30	...	...
UNS N06603: Annealed	27.0–31.0	24.0–26.0			...
UNS N06603: Annealed	26.0–2–9.0	24.0–00 (300)	265	0	...
Annealed	94 000 (650)	43 000 (300)	25	...	...
Cobalt	...	...			...
UNS N06617: ...	1–0–0–15.0	...	35	...	...
...	95 000 (655)	35 000 (240)	35	...	...
UNS N06690: ...	...	0–00 (240)	30	...	...
...	...	35 000 (240)	30	...	...
Molybdenum	...	35–000 (240)	30	...	...
As-rolled ^{D,E}	...	35 000 (240)	30	...	...
...	8.0–10.0	30–000 (206)	30	...	...
...	8.0–10.0	30 000 (206)	30	...	...
UNS N06693	...	...	...	...	...
UNS N06693	...	...	...	...	...
...	100 000 (690)	50 000 (345)	30	...	...
Niobium	...	...	...	...	...
UNS N06025	...	...	...	...	...
Annealed	98 000 (680)	39 000 (270)	30	...	...
UNS N06045	0.5–2.5	...	...	...	...
Annealed	...	...	...	...	...
UNS N06045	0.5–2.5	...	...	...	...
Annealed	90 000 (620)	35 000 (240)	35	...	...
Hot-Rolled Sheet					
Iron	–6.0–10.0	remainder ^A			...
UNS N06600: –3.0 max	–7.0–11.0	–2.5–6.0	30	...	...
3.0 max	7.0–11.0	35 000 (240)	30	...	...
UNS N06601: –8.0–11.0	–8.0–11.0	21.0–25.0			...
UNS N06601: Annealed	8.0–11.0	30 000 (205)	30	...	...
Manganese	–1.0 max	...			...
UNS N06603: –1.0 max	–1.0 max	–0.5 max	25	...	...
1.0 max	1.0 max	43 000 (300)	25	...	...
UNS N06617: –1.0 max	–1.0 max	...			...
UNS N06617: –0.15 max	–1.0 max	0–00 (240)	30	...	...
0.15 max	1.0 max	35 000 (240)	30	...	...
Aluminum	...	...			...
UNS N06690: 1.0–1.7	0.8–1.5	35 000 (240)	30	...	...
UNS N06693	–2.5–4.0	–1.8–2.4	...	–2.4–3.0	...
UNS N06693	2.5–4.0	1.8–2.4	...	2.4–3.0	...
...	100 000 (690)	50 000 (345)	30	...	...
Carbon	–0.15 max	–0.10 max	–0.05–0.15	–0.05 max	...
UNS N06025	0.15 max	0.10 max	0.05–0.15	0.05 max	...
Annealed	98 000 (680)	39 000 (270)	30	...	...
UNS N06045	–0.15 max	–0.15–0.25	–0.05–0.12	–0.20–0.40	...
Annealed	...	...	...	...	...