ASTM B166 / ASME SB166

SPECIFICATION FOR NICKEL-CHROMIUM-IRON ALLOYS (UNS N06600, N06601, N06603, N06690, N06693, N06025, N06045, AND N06696) AND NICKELCHROMIUM-COBALT-MOLYBDENUM ALLOY (UNS N06617) ROD, BAR, AND WIRE

This specification covers nickel-chromium- iron alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, N06045, and N06696) and nickel-chromium-cobalt-molybdenum alloy (UNS N06617) in the form of hot-finished and cold-worked rounds, squares, hexagons, rectangles, and cold worked wire.

A. Chemical Composition :-

The material shall conform to the composition limits specified in Table 1.

Table 1

Element	Alloy N06600	Alloy N06601	Alloy N06617	Alloy N06690	Alloy N06693	Alloy N06025	Alloy N06045	Alloy N06603	Alloy N06696
Nickel	72.0 min	58.0–63.0	44.5 min	58.0 min	remainder[A]	remainder[A]	45.0 min	remainder[A]	remainder[A]
Chromium	14.0–17.0	21.0–25.0	20.0–24.0	27.0–31.0	27.0–31.0	24.0–26.0	26.0–29.0	24.0–26.0	28.0–32.0
Cobalt	...	...	10.0–15.0	...	...	...	...	...	...
Molybdenum	...	...	8.0–10.0	...	...	...	...	...	1.0–3.0
Iron	6.0–10.0	remainder[A]	3.0 max	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	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	0.05 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	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	0.01 max	0.010 max	0.010 max	0.010 max	0.010 max
Titanium	...	...	0.6 max	...	1.0 max	0.1–0.2	...	0.01–0.25	1.0 max
Phosphorus	...	...	...	...	...	0.020 max	0.020 max	0.20 max	...
Zirconium	...	...	...	...	...	0.01–0.10	...	0.01–0.10	...
Yttrium	...	...	...	...	...	0.05–0.12	...	0.01–0.15	...
Boron	...	...	0.006 max	...	...	...	...	...	...
Nitrogen	...	...	...	...	...	...	...	...	...
Niobium	...	...	...	...	0.5–2.5	...	...	...	...
Cerium	...	...	...	...	...	...	0.03–0.09	...	...

[A] *Element shall be determined arithmetically by difference.*

B. Mechanical Properties :-

The material shall conform to the mechanical properties specified in Table 2 for rod and bar and Table 3 (UNS N06600 and N06690 only) for wire.

C. Length :-

The permissible variations in length of cold-worked and hot-worked rod and bar shall be as prescribed in Table 4.

Table 2

Condition and Diameter or Distance Between Parallel Surfaces, in. (mm)	Tensile Strength, min, psi (MPa)	Yield Strength (0.2% offset), min, psi (MPa)	Elongation in 2 in. or 50 mm or 4D, min, %
UNS N06600:			
Cold-worked (as worked) :			
Rounds:			
Under 1⁄2 (12.7)	120000 (825)	90000 (620)	7[A]
1⁄2 to 1 (12.7 to 25.4), incl	110000 (760)	85000 (585)	10
Over 1 to 21⁄2 (25.4 to 63.5), incl	105000 (725)	80000 (550)	12
Squares, hexagons, and rectangles:			
1⁄4 (6.4) and under	100000 (690)	80000 (550)	5[A]
Over 1⁄4 to 1⁄2 (6.4 to 12.7), excl	95000 (655)	70000 (480)	7
Hot worked (as worked) :			
Rounds:			
1⁄4 to 1⁄2 (6.4 to 12.7), incl	95000 (655)	45000 (310)	20
Over 1⁄2 to 3 (12.7 to 76.2), incl	90000 (620)	40000 (275)	25
Over 3 (76.2)	85000 (585)	35000 (240)	30
Squares, hexagons, and rectangles:			
all sizes	85000 (585)	35000 (240)	20
Rings and disks[B]	—	—	—
Cold-worked (annealed) or hot-worked (annealed) :			
Rods and bars, all sizes	80000 (550)	35000 (240)	30[A]
Rings and disks[C]	—	—	—
Forging Quality:			
all sizes	D	D	D
UNS N06601:			
Cold-worked (annealed) or hot-worked (annealed) :			
all products, all sizes	80000 (550)	30000 (205)	30
Forging Quality:	D	D	D
UNS N06617:			
Cold-worked (annealed)F or hot-worked (annealed)[F]:			
all products, all sizes	95000 (655)	35000 (240)	35
Forging Quality:	D	D	D
UNS N06690:			
Cold-worked (as worked) :			
Rounds:			
Under 1⁄2 (12.7)	120000 (825)	90000 (620)	7[A]
1⁄2 to 1 (12.7 to 25.4), incl	110000 (760)	85000 (585)	10
Over 1 to 21⁄2 (25.4 to 63.5), incl	105000 (725)	80000 (550)	12
Squares, hexagons, and rectangles:			

1⁄4 (6.4) and under	100000 (690)	80000 (550)	5[A]
Over 1⁄4 to 1⁄2 (6.4 to 12.7), excl	95000 (655)	70000 (480)	7
Hot worked (as worked) :			
Rounds:			
1⁄4 to 1⁄2 (6.4 to 12.7), incl	95000 (655)	45000 (310)	20
Over 1⁄2 to 3 (12.7 to 76.2), incl	90000 (620)	40000 (275)	25
Over 3 (76.2)	85000 (585)	35000 (240)	30
Squares, hexagons, and rectangles:			
all sizes	85000 (585)	35000 (240)	20
Rings and disks[B]	—	—	—
Cold-worked (annealed) or hot-worked (annealed) :			
Rods and bars, all sizes	85000 (585)	35000 (240)	30[A]
Rings and disks[C]	—	—	—
Forging Quality:			
all sizes	D	D	D
UNS N06693:			
Cold-worked (annealed) or hot-worked (annealed) :			
Rods and bars, all sizes	100000 (690)	50000 (345)	30
Forging Quality:			
all sizes	D	D	D
UNS N06603:			
Cold-worked (annealed) or hot-worked (annealed) :			
all products, all sizes	94000 (650)	43000 (300)	25
Forging Quality:			
all sizes	D	D	D
UNS N06025:			
Cold-worked (annealed) or hot-worked (annealed) :			
all products, all sizes	98000 (680)	39000 (270)	30
Forging Quality:			
all sizes	D	D	D
UNS N06045:			
Cold-worked (annealed) or hot-worked (annealed) :			
all products, all sizes	90000 (620)	35000 (240)	35
Hot-worked (annealed) :[E]			
Rods and bars, all sizes	75000 (517)	30000 (207)	30
Forging Quality:			
all sizes	D	D	D
UNS N06696:			
Cold-worked (annealed and water quenched) or hot-worked (annealed and water quenched) all products, all sizes	85000 (586)	35000 (240)	30

[A] *Not applicable to diameters or cross sections under 3⁄32 in. (2.4 mm).*
[B] *Hardness B75 to B100, or equivalent.*

[C] *Hardness B75 to B95, or equivalent.*
[D] *Forging quality is furnished to chemical requirements and surface inspection only. No mechanical properties are required.*
[E] *High-temperature annealed condition.*
[F] *Solution anneal is done at 2100°F–2250°F and quenched in water or rapidly cooled by other means.*

TABLE 3[A]

Condition and Size, in.(mm)	Tensi le Strength, psi(MPa)		Wrapping Test
	Min.	Max.	
Annealed			The wire shall be wrapped eight consecutive turns in a closed helix (pitch approximately equal to the diameter of the wire) around a mandrel as follows: (1) For all annealed and regular temper wire and for spring temper wire0.229 in. (5.82 mm) and less: Same as diameter of wire. (2) For spring temper wire over 0.229 in (5.82 mm): Twice the diameter of wire. The wire shall withstand the wrapping test without fracture or development of a pebbled or orange-peel surface.
Under0.032(0.81)	80000(552)	115000(793)	
0.032(0.81) and over	80000(552)	105000(724)	
Cold-worked, regular temper, all sizes	120000(827)		
Cold-worked, spring temper		165000(1138)	
Up to0.057(1.45), incl	185000(1276)	...	
Over0.057(1.45) to0.114(2.90), incl	175000(1207)	. . .	
Over0.114(2.90) to0.229(5.82), incl	170000(1172)	. . .	
Over0.229(5.82) to0.329(8.36), incl	165000(1138)	...	
Over0.329(8.36) to0.375(9.53), incl	160000(1103)	. . .	
Over0.375(9.53) to0.500(12.7), incl	155000(1069)	. . .	
Over0.500(12.7) to0.563(14.3), incl	140000(965)	...	

[A] *Properties are not applicable to wire after straightening and cutting.*

Table 4

Random mill lengths:	
Hot-worked	6 to 24 ft (1.83 to 7.31 m) long with not more than 25 weight % between 6 and 9 ft (1.83 and 2.74 m)[A]
Cold-worked	6 to 20 ft (1.83 to 6.1 m) long with not more than 25 weight % between 6 and 10 ft (1.83 and 3.05 m).
Multiple lengths	Furnished in multiples of a specified unit length, within the length limits indicated above. For each multiple, an allowance of 1⁄4 in. (6.4 mm) will be made for cutting, unless otherwise specified. At the manufacturer's option, individual specified unit lengths may be furnished.
Nominal lengths	Specified nominal lengths having a range of not less than 2 ft (610 mm) with no short lengths allowed[B]
Cut lengths	A specified length to which all rods and bars will be cut with a permissible variation of plus 1⁄8 in. (3.2 mm), minus 0 for sizes 8 in. (203 mm) and less in diameter or distance between parallel surfaces. For larger sizes, the permissible variation shall be +1⁄4 in. (6.4 mm), −0.

[A] *For hot-worked sections weighing over 25 lb/ft (37 kg/m) and for smooth-forged products, al l sections, short lengths down to 2 ft (610 mm) may be furnished.*
[B] *For col d-worked rods and bars under 1/2 in. (12.7 mm) in diameter or di stance between parallel surfaces ordered to nominal or stock lengths with a 2-ft (610-mm) range, at least 93% of such material shall be within the range specified; the balance may be in shorter lengths but in no case shall lengths less than 4 ft (1220 mm) be furnished.*

D. <u>Test Methods :-</u>

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	E 38[A], E 1473
Tension	E 8
Rockwell hardness	E 18
Hardness conversion	E 140
Rounding procedure	E 29

[A] *Methods E 38 are to be used only for elements not covered by Test Methods E 1473.*

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