

ASTM B163 / ASME SB163

SPECIFICATION FOR SEAMLESS NICKEL AND NICKEL ALLOY CONDENSER AND HEAT-EXCHANGER TUBES

This specification covers seamless tubes of nickel and nickel alloys, as shown in Table 1, for use in condenser and heat-exchanger service.

The sizes covered by this specification are 3 in. (76.2 mm) and under in outside diameter with minimum wall thicknesses of 0.148 in. (3.76 mm) and under, and with average wall thicknesses of 0.165 in. (4.19 mm) and under.

Tube shall be furnished in the alloys and conditions as shown in Table 2.

A. Chemical Composition :-

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

Table 1

Alloy	Ni	Cu	Mo	Fe	Mn, max	C (A)	Si (A)	S, max	Cr	Al	Other element
Nickel UNS N02200	99.0 min(B)	0.25 max	...	0.40 max	0.35	0.15 max	0.35	0.01	...	...	...
Low-carbon Nickel UNS N02201	99.0 min(B)	0.25 max	...	0.40 max	0.35	0.02 max	0.35	0.01	...	...	...
Nickel-copper alloy UNS N04400	63.0 min(B)	28.0-34.0	...	2.5 max	2	0.3 max	0.5	0.024	...	...	...
Nickel-chromium-iron alloy UNS N06600	72.0 min(B)	0.5 max	...	6.0-10.0	1	0.15 max	0.5	0.015	14.0-17.0	...	...
Nickel-chromium-iron alloy UNS N06601	58.0-63.0	1.0 max	...	remainder(A)	1	0.1	0.5	0.015	21.0-25.0	1.0-1.7	...
Nickel-chromium-iron alloy UNS N06690	58.0 min(B)	0.5 max	...	7.0-11.0	0.5	0.05 max	0.5	0.015	27.0-31.0	...	...
Nickel-chromium-iron alloy UNS N06025	remainder(B)	0.1 max	...	8.0-11.0	0.15	0.15-0.25	0.5	0.01	24.0-26.0	1.8-2.4	P [0.020 max], Zr [0.01-0.10], Y [0.05-0.12], Ti [0.1-0.2]
Alloy UNS N06045	45.0 min	0.3 max	...	21.0-25.0	1	0.05-0.12	2.5-3.0	0.01	26.0-29.0	...	P [0.020 max], Ce [0.03-0.09]
Nickel-chromium-iron aluminum alloy UNS N06603	remainder(B)	0.5 max	...	8.0-11.0	15	0.20-0.40	0.5 max	0.01	24.0-26.0	2.4-3.0	P [0.02 max], Zr [0.01-0.10], Y [0.01-0.15], Ti [0.01-0.25]

Low-carbon nickel-chromium-molybdenum tungsten alloy UNS N06686	remainder(B)	...	15.0-17.0	5.0 max	0.75	0.01	0.08	0.02	19.0-23.0	...	P [0.04 max], W [3.0-4.4], Ti [0.02-0.25]
Nickel-iron-chromium alloy UNS N08120	35.0-39.0	0.50 max	2.50 max	remainder(B)	1.5 max	0.02-0.10	1.0 max	0.03 max	23.0-27.0	0.40 max	P [0.04 max], B [0.010 max], Co [3.0 max], Cb [0.4-0.9], W [2.50 max], N [0.13-0.30], Ti [0.20 max]
Nickel-iron-chromium alloy UNS N08800	30.0-35.0	0.75 max	...	39.5 min(B)	1.5	0.10 max	1	0.015	19.0-23.0	0.15-0.60	Ti [0.15-0.60]
Nickel-iron-chromium alloy UNS N08810	30.0-35.0	0.75 max	...	39.5 min(B)	1.5	0.05-0.10	1	0.015	19.0-23.0	0.15-0.60	Ti [0.15-0.60]
Nickel-iron-chromium alloy UNS N08811	30.0-35.0	0.75 max	...	39.5 min(B)	1.5	0.06-0.10	1	0.015	19.0-23.0	0.15-0.60(C)	Ti [0.15-0.60 (C)]
Nickel-iron-chromium alloy UNS N08801	30.0-34.0	0.50 max	...	39.5 min(B)	1.5	0.10 max	1	0.015	19.0-22.0	...	Ti [0.75-1.5]
Nickel-iron-chromium molybdenum-copper alloy UNS N08825	38.0-46.0	1.5-3.0	2.5-3.5	22.0 min(B)	1	0.05 max	0.5	0.03	19.5-23.5	0.2 max	Ti [0.6-1.2]

NOTES:

(A) Maximum unless range is given.

(B) Element shall be determined arithmetically by difference.

(C) Alloy UNS N08811: (Al+Ti) [0.85-1.20].

Table 2: Alloy And Conditions

Alloy	Condition
Nickel UNS N02200 and low-carbon nickel UNS N02201	annealed or stress-relieved
Nickel-copper alloy UNS N04400	annealed or stress-relieved
Nickel-chromium-iron-aluminum alloy UNS N06603	annealed
Nickel-chromium-iron-aluminum alloy UNS N06601	annealed
Nickel-chromium-iron alloy UNS N06600	annealed

Low-carbon nickel-chromium-molybdenum-tungsten alloy UNS N06686	annealed
Nickel-chromium-iron alloy UNS N06690	annealed
Nickel-chromium-iron alloy UNS N06045	annealed
Nickel-iron-chromium alloy UNS N08120 (A)	annealed or cold-worked
Nickel-iron-chromium alloy UNS N08800 (A)	annealed or cold-worked
Nickel-iron-chromium alloy UNS N08810 (A)	annealed
Nickel-iron-chromium alloy UNS N08811 (A)	annealed
Nickel-iron-chromium alloy UNS N08801	annealed
Nickel-iron-chromium-molybdenum-copper alloy UNS N08825	annealed
<i>Nickel-chromium-iron alloy UNS N06025</i>	<i>annealed</i>

NOTE:

(A) Alloy UNS N08800 is normally employed in service temperatures up to and including 1100°F (593°C). Alloys UNS N08810, UNS N08811, and UNS N08120 are normally employed in service temperatures above 1100°F (539°C) where resistance to creep and rupture is required, and it is annealed to develop controlled grain size for optimum properties in this temperature range.

B. Mechanical Properties and Other Requirements :-

1. Mechanical Properties—

- i. The material shall conform to the mechanical properties specified in Table 3.

Table 3

Material and Condition	Tensile Strength, min, ksi (MPa)	Yield Strength (0.2% Offset), min, psi (MPa)	Elongation in 2 in. or 50 mm (or 4 D) min, %	Rockwell Hardness (or equivalent) for annealed ends (A)
Nickel UNS N02200:				
Annealed	55 (379)	15 (103)	40	...
Stress-relieved	65 (448)	40 (276)	15	B65 max
Low-carbon nickel UNS N02201:				
Annealed	50 (345)	12 (83)	40	...
Stress-relieved	60 (414)	30 (207)	15	B62 max
Nickel-copper alloy UNS N04400:				
Annealed	70 (483)	28 (193)	35	...
Stress-relieved	85 (586)	55 (379)	15	B75 max
Nickel-chromium-iron alloys:				
Annealed alloy UNS N06600	80 (552)	35 (241)	30	...

Annealed alloy UNS N06601	80 (552)	30 (207)	30	...
Annealed alloy UNS N06690	85 (586)	35 (241)	30	...
Annealed alloy UNS N06045	90 (620)	35 (240)	35	...
Annealed alloy UNS N06025	98 (680)	39 (270)	30	...
Annealed alloy UNS N06603	94 (650)	43 (300)	25	...
Low-carbon nickel-chromium-molybdenum-tungsten alloy:				
Annealed UNS N06686	100 (690)	45 (310)	45	...
Nickel-iron-chromium alloys:				
Annealed alloy UNS N08120	90 (620)	40 (276)	30	...
Annealed alloy UNS N08800	75 (517)	30 (207)	30	...
Annealed alloy UNS N08801	65 (448)	25 (172)	30	...
Cold-worked alloy UNS N08800	83 (572)	47 (324)	30	...
Annealed alloy UNS N08810	65 (448)	25 (172)	30	...
Annealed alloy UNS N08811	65 (448)	25 (172)	30	...
Nickel-iron-chromium-molybdenum-copper-alloy:				
Annealed UNS N08825	85 (586)	35 (241)	30	...

2. Hardness—

- i. When annealed ends are specified for tubing in the stress-relieved condition (see Table 3), the hardness of the ends after annealing shall not exceed the values specified in Table 3.

3. Flare —

- i. The flare test shall consist of flaring a test specimen with an expanding tool having an included angle of 60° until the specified outside diameter has been increased by 30%. The flared specimen shall not exhibit cracking through the wall.

4. Grain Size—

- i. A transverse sample representing full wall thickness of annealed alloys UNS N08120, UNS N08810 and UNS N08811 shall conform to an average grain size of ASTM No. 5 or coarser.

5. Hydrostatic or Non-destructive Electric Test —

- i. The type of test to be used shall be at the option of the manufacturer, unless otherwise specified in the purchase order.
- ii. Hydrostatic Test— Each tube with an outside diameter 1/8 in. (3.2 mm) and larger and tubes with wall thickness of 0.015 in. (0.38 mm) and over shall be tested by the manufacturer to an internal hydrostatic pressure of 1000 psi (6.9 MPa) provided that the fiber stress calculated in accordance with the following equation does not exceed the allowable fiber stress, S, indicated below. The tube shall show no evidence of leakage.

$$P = 2St/D$$

where: P = hydrostatic test pressure, psi (MPa),

S = allowable fiber stress for material in the condition furnished, as follows:

	psi	MPa
Annealed low-carbon nickel UNS N02201	8000	55.2
Stress-relieved low-carbon nickel UNS N02201	15000	103.4
Annealed nickel UNS N02200	10000	68.9
Stress-relieved nickel UNS N02200	16200	111.7
Annealed nickel-copper alloy UNS N04400	17500	120.6
Stress-relieved nickel-copper alloy UNS N04400	21200	146.2
Annealed nickel-chromium-iron alloy UNS N06600	20000	137.9
Annealed nickel-chromium-iron alloy UNS N06601	20000	137.9
Annealed nickel-chromium-iron alloy UNS N06690	21200	146
Annealed nickel-chromium-iron alloy UNS N06045	22500	155
Annealed nickel-chromium-iron alloy UNS N06025	24500	169
Solution annealed low-carbon nickel-chromium-molybdenum-tungsten alloy UNS N06686	25000	172
Annealed nickel-chromium-iron-aluminum alloy UNS N06603	24000	165
Annealed nickel-iron-chromium alloy UNS N08120	22500	155
Annealed nickel-iron-chromium alloy UNS N08800	18700	128.9
Annealed nickel-iron-chromium alloy UNS N08810	16600	114.4
Annealed nickel-iron-chromium alloy UNS N08811	16600	114.4
Annealed nickel-iron-chromium alloy UNS N08801	16600	114.4
Annealed nickel-iron-chromium-molybdenum copper alloy UNS N08825	21000	144.8
Cold-worked nickel-iron-chromium alloy UNS N08800	20700	142.7

t = minimum wall thickness, in. (mm); equal to the specified average wall minus the permissible “minus” wall tolerance, Table 4, or the specified minimum wall thickness, and
D = outside diameter of the tube, in. (mm).

- iii. Non-destructive Electric Test—Each tube shall be examined with a non-destructive electric test as prescribed in Specification B 829.

C. Length :-

- i. When tube is ordered cut-to-length, the length shall not be less than that specified, but a variation of plus 1/8 in. (3.2 mm) will be permitted, except that for lengths over 30 ft (9.1 m), a variation of plus 1/4 in. (6.4 mm) will be permitted.

D. Test Methods :-

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:

<u>Test</u>	<u>ASTM Designation</u>
Chemical Analysis	E76, E1473
Tension	E8
Rounding Procedure	E29
Rockwell Hardness	E18
Grain Size	E 112
Hardness Conversion	E 140

E. Supplementary Requirements :-

1. U-BENT Tubes.
2. High Yield Strength Tubes.
3. Coiled or Unstraightened Tubing.

Related Keywords

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