

ASTM B163

Standard Specification for Seamless Nickel and Nickel Alloy
Condenser and Heat-Exchanger Tubes

Seamless Only

≤ 3" OD

15 Alloy Groups

Condenser & HX

Ni · Monel · Inconel · Incoloy

ASTM B163 standard covers grades such as Nickel 200/201, Monel 400, Inconel 600/601, and Incoloy 800/825, specifying both outside diameter (OD) and wall thickness (average or minimum wall thickness). Dimensional limits: it generally applies to specifications with an outside diameter of 3 inches (76.2 mm) and under. Mechanical property tests (tensile, hardness, and flaring tests) along with chemical composition analysis are required to verify material integrity.

If you have project requirements, feel free to click the link below to view our products!

<https://www.chinastainless-steel.com/nickel-alloy-steel/>



1. Scope & Application

PRODUCT

Seamless Tubes Only

Cold-drawn seamless nickel and nickel-alloy tubes. No welded product — 100% seamless construction for maximum reliability in critical heat transfer service.

SERVICE

Condenser & Heat Exchanger

Specifically designed for shell-and-tube heat exchangers, condensers, and similar heat transfer equipment. ASME Boiler Code equivalent: SB-163 (Section II).

SIZE RANGE

≤ 3" OD · Wall ≤ 0.148"

Maximum 3 inch (76.2 mm) outside diameter. Minimum wall up to 0.148 in. (3.76 mm); average wall up to 0.165 in. (4.19 mm). Smaller converter sizes covered in Appendix X2.

WALL TYPES

Average Wall or Min Wall

Order to either average wall thickness or minimum wall thickness. Tolerances differ by choice — select based on design code requirements.

CONDITIONS

Annealed · Stress-Relieved · Cold-Worked

Multiple temper options: annealed (soft), stress-relieved (higher strength), stress-relieved with annealed ends (for expansion into tubesheets), and cold-worked N08800/N08120.

ALLOY FAMILIES

Pure Ni • Monel • Inconel • Incoloy

Covers nickel (200/201), nickel-copper (Monel 400), nickel-chromium-iron (Inconel 600/601/690), and nickel-iron-chromium (Incoloy 800/800H/800HT/825) families.

2. Alloy Grade Overview

Pure Nickel — N02200 / N02201

Most Used

Nickel 200

UNS N02200

TS: 55 ksi (annealed)

YS: 15 ksi

Elong: 40%

Ni ≥99.0%

Commercially pure wrought nickel. Excellent caustic alkali resistance. Low carbon for service ≤600°F.

Nickel 201

UNS N02201

TS: 50 ksi (annealed)

YS: 12 ksi

Elong: 40%

C ≤0.02%

Low-carbon variant of Nickel 200. Prevents graphite embrittlement above 600°F (315°C).

Nickel-Copper — Monel 400

Most Used

Monel 400

UNS N04400

TS: 70 ksi (annealed)

YS: 28 ksi

Elong: 35%

Ni 63% · Cu 28–34%

Excellent seawater and hydrofluoric acid resistance. Marine heat exchangers, salt plant evaporator tubing.

Nickel-Chromium-Iron — Inconel Series

Most Used

Inconel 600

UNS N06600

TS: 80 ksi

YS: 35 ksi

Elong: 30%

Cr 14–17% · Fe 6–10%

Industry standard for high-temperature corrosion resistance. Oxidation resistant to 2000°F. Stress corrosion cracking resistant in chloride environments.

Inconel 601

UNS N06601

TS: 80 ksi

YS: 30 ksi

Elong: 30%

Cr 21–25% · Al 1.0–1.7%

Higher Cr + Al for improved oxidation resistance. Ideal for furnace components and thermal processing.

Inconel 690

UNS N06690

TS: 85 ksi

YS: 35 ksi

Elong: 30%

Cr 27–31% · Fe 7–11%

High chromium for superior stress corrosion cracking resistance. Nuclear steam generator tubing standard.

Premium

N06045

UNS N06045

TS: 90 ksi

YS: 35 ksi

Elong: 35%

Cr 26–29% · Ce 0.03–0.09%

Rare-earth addition (Ce) for exceptional oxidation and carburization resistance. Waste incineration and petrochemical.

Premium

N06025

UNS N06025

TS: 98 ksi

YS: 39 ksi

Elong: 30%

Cr 24–26% · Al 1.8–2.4%

Ultra-high oxidation resistance. Alumina-forming capability for extreme temperature applications.

Premium

N06603

UNS N06603

TS: 94 ksi

YS: 43 ksi

Elong: 25%

Cr 24–26% · Al 2.4–3.0% · Y

Alumina-forming alloy with Yttrium addition. Best-in-class oxidation resistance. Chemical/petrochemical reformers.

Corrosion

Inconel 686

UNS N06686

TS: 100 ksi

YS: 45 ksi

Elong: 45%

Cr 19–23% · Mo 15–17% · W 3–4.4%

Ni-Cr-Mo-W alloy. Outstanding resistance to pitting, crevice corrosion, and stress cracking in severe chemical environments.

Nickel-Iron-Chromium — Incoloy Series

Most Used

Incoloy 800

UNS N08800

TS: 75 ksi (ann.)

CW: 83 ksi

Elong: 30%

Ni 30–35% · Cr 19–23%

General-purpose Fe-Ni-Cr alloy. Good high-temperature strength and oxidation resistance. Service up to 1100°F (593°C).

High Temp

Incoloy 800H (N08810)

UNS N08810

TS: 65 ksi

YS: 25 ksi

Elong: 30%

ASTM G.S. ≥5 (coarse)

Controlled coarse grain for improved creep/rupture above 1100°F (593°C). C 0.05–0.10% + grain size control.

High Temp

Incoloy 800HT (N08811)

UNS N08811

TS: 65 ksi

YS: 25 ksi

Elong: 30%

C 0.06–0.10% · Al+Ti 0.85–1.20%

Higher Al+Ti than 800H. Optimized for maximum creep-rupture strength at extreme temperatures. Controlled grain size.

Incoloy 801 (N08801)

UNS N08801

TS: 65 ksi

YS: 25 ksi

Elong: 30%

Ti 0.75–1.5% · Al ≤0.3%

Titanium-strengthened variant with increased high-temperature tensile properties.

Corrosion

Incoloy 825

UNS N08825

TS: 85 ksi

YS: 35 ksi

Elong: 30%

Ni 38–46% · Mo 2.5–3.5% · Cu 1.5–3%

Ni-Fe-Cr-Mo-Cu alloy with exceptional resistance to sulfuric and phosphoric acids and chloride stress cracking.

N08120

UNS N08120

TS: 90 ksi (ann.)

YS: 40 ksi

Elong: 30%

Ni 35–39% · Cr 23–27%

High-temperature Fe-Ni-Cr alloy with excellent carburization and oxidation resistance. Cold-worked option available.

3. Chemical Composition (Table 1)

3.1 Pure Nickel & Nickel-Copper Alloys

Element (wt%)	N02200 Nickel 200	N02201 Ni 201	N04400 Monel 400
Ni	≥99.0	≥99.0	≥63.0
Cu	≤0.25	≤0.25	28.0–34.0
Fe	≤0.40	≤0.40	≤2.5
Mn	≤0.35	≤0.35	≤2.0
C	≤0.15	≤0.02	≤0.3
Si	≤0.35	≤0.35	≤0.5
S	≤0.010	≤0.010	≤0.024

3.2 Nickel-Chromium-Iron Alloys (Inconel)

Element (wt%)	N06600	N06601	N06690	N06045	N06025	N06603	N06686
Ni	≥72.0	58.0–63.0	≥58.0	≥45.0	Balance	Balance	Balance
Cr	14.0–17.0	21.0–25.0	27.0–31.0	26.0–29.0	24.0–26.0	24.0–26.0	19.0–23.0
Fe	6.0–10.0	Balance	7.0–11.0	21.0–25.0	8.0–11.0	8.0–11.0	≤5.0
Mo	–	–	–	–	–	–	15.0–17.0
W	–	–	–	–	–	–	3.0–4.4
Al	–	1.0–1.7	–	–	1.8–2.4	2.4–3.0	–
C	≤0.15	≤0.10	≤0.05	≤0.10	≤0.20	0.20–0.40	≤0.010
Mn	≤1.0	≤1.0	≤0.5	≤1.0	≤0.5	≤0.25	≤0.75
Si	≤0.5	≤0.5	≤0.5	≤2.5	≤0.5	≤0.25	≤0.08

3.3 Nickel-Iron-Chromium Alloys (Incoloy)

Element (wt%)	N08800	N08810	N08811	N08801	N08825	N08120
Ni	30.0–35.0	30.0–35.0	30.0–35.0	30.0–34.0	38.0–46.0	35.0–39.0
Cr	19.0–23.0	19.0–23.0	19.0–23.0	19.0–22.0	19.5–23.5	23.0–27.0
Fe	≥39.5	≥39.5	≥39.5	≥39.5	≥22.0	Balance
Mo	–	–	–	–	2.5–3.5	≤2.5
Cu	≤0.75	≤0.75	≤0.75	≤0.50	1.5–3.0	≤0.50
C	≤0.10	0.05–0.10	0.06–0.10	≤0.10	≤0.05	0.02–0.10
Ti	≤0.60	≤0.60	≤0.60	0.75–1.50	0.6–1.2	≤0.20
Al	≤0.60	≤0.60	≤0.60	≤0.30	≤0.2	≤0.40
Mn	≤1.5	≤1.5	≤1.5	≤1.5	≤1.0	≤1.5

Key Chemistry Notes:

- 800H (N08810) & 800HT (N08811) require controlled grain size (ASTM No. 5 or coarser) for creep resistance above 1100°F.
- 800HT has tighter Al+Ti control (0.85–1.20%) vs. 800H (0.30–1.20%) for optimized creep-rupture.
- N06686 (Inconel 686) is an ultra-low-carbon (≤0.010%) Ni-Cr-Mo-W alloy for severe aqueous corrosion service.
- N06603 is an alumina-former with yttrium/cerium additions for exceptional oxidation resistance.

4. Mechanical Properties (Table 3)

Alloy & Condition	Tensile Strength min, ksi (MPa)	Yield Strength 0.2% Offset, ksi (MPa)	Elongation min, %	Hardness (Stress-Relieved)
Pure Nickel				
N02200 Annealed	55 (379)	15 (103)	40	—
N02200 Stress-Relieved	65 (448)	40 (276)	15	HRB 65 max
N02201 Annealed	50 (345)	12 (83)	40	—
N02201 Stress-Relieved	60 (414)	30 (207)	15	HRB 62 max
Nickel-Copper				
N04400 Annealed	70 (483)	28 (193)	35	—
N04400 Stress-Relieved	85 (586)	55 (379)	15	HRB 75 max
Nickel-Chromium-Iron (Inconel) — All Annealed				
N06600	80 (552)	35 (241)	30	—
N06601	80 (552)	30 (207)	30	—
N06690	85 (586)	35 (241)	30	—
N06045	90 (620)	35 (240)	35	—
N06025	98 (680)	39 (270)	30	—
N06603	94 (650)	43 (300)	25	—
N06686 Solution Annealed	100 (690)	45 (310)	45	—
Nickel-Iron-Chromium (Incoloy) — Annealed Unless Noted				
N08120 Annealed	90 (620)	40 (276)	30	—
N08800 Annealed	75 (517)	30 (207)	30	—
N08800 Cold-Worked	83 (572)	47 (324)	30	—
N08801 Annealed	65 (448)	25 (172)	30	—
N08810 Annealed	65 (448)	25 (172)	30	—
N08811 Annealed	65 (448)	25 (172)	30	—

Alloy & Condition	Tensile Strength min, ksi (MPa)	Yield Strength 0.2% Offset, ksi (MPa)	Elongation min, %	Hardness (Stress-Relieved)
N08825 Annealed	85 (586)	35 (241)	30	—

Hydrostatic Test Fiber Stress Limits (Table 3 supplemental):

Each tube must withstand internal hydrostatic pressure of 1000 psi (6.9 MPa) provided calculated fiber stress does not exceed the values below. $P = 2St/D$ formula applies.

Alloy & Condition	Allowable Fiber Stress S, psi	Allowable Fiber Stress S, MPa
N02201 Annealed	8 000	55.2
N02200 Annealed	10 000	68.9
N02201 Stress-Relieved	15 000	103.4
N02200 Stress-Relieved	16 200	111.7
N08810 / N08811 / N08801 Annealed	16 600	114.4
N04400 Annealed	17 500	120.6
N08800 Annealed	18 700	128.9
N06600 / N06601 Annealed	20 000	137.9
N08800 Cold-Worked	20 700	142.7
N08825 Annealed	21 000	144.8
N06690 / N04400 Stress-Relieved	21 200	146.2
N08120 / N06045 Annealed	22 500	155.1
N06603 Annealed	24 000	165.5
N06025 Annealed	24 500	168.9
N06686 Solution Annealed	25 000	172.4

Hardness Note: Rockwell hardness values apply only to the annealed ends of stress-relieved tubing. For wall thickness <0.050 in. (1.27 mm), use Rockwell superficial or Vickers test. Cautions: results may be affected by thin material.

5. Testing & Inspection Requirements

REQUIRED

Tensile Test

One per lot. Full tubular size preferred; longitudinal strip specimen when full-tube testing not possible. Test in direction of fabrication. For stress-relieved tubes with annealed ends: test prior to annealing ends.

REQUIRED

Flare Test

60° expanding tool, expand OD by 30%. No cracking through the wall. Test 1% of finished tubes (min. 1 per lot). Sample from each lot; for stress-relieved with annealed ends, test before or after end-annealing.

REQUIRED

Hydrostatic or NDT

100% of tubes. 1000 psi internal hydrostatic ($\geq \frac{1}{8}$ " OD, ≥ 0.015 " wall) OR nondestructive electric test per B829. Type at manufacturer's option unless specified. Allowable fiber stress S per grade.

REQUIRED

Hardness (Annealed Ends)

3% of each lot. Required only when stress-relieved with annealed ends is ordered. Per Table 3: HRB 62 max (N02201), HRB 65 max (N02200), HRB 75 max (N04400).

REQUIRED

Grain Size

One per lot. Required for N08120, N08810, N08811 only: ASTM No. 5 or coarser. Planimetric (referee), comparison, or intercept method per ASTM E112.

REQUIRED

Chemical Analysis

One test per heat/lot. Per ASTM E76 or E1473. Product (check) analysis is purchaser's responsibility, per B880.

Test Methods Reference: Chemical (E76, E1473) · Tension (E8) · Hardness (E18) · Grain Size (E112) · Rounding (E29) · Hardness Conversion (E140)

6. Dimensions & Permissible Variations (Table 4)

Material Group	OD Range, in. (mm)	OD Tolerances, in. (mm)	Wall Thickness Tolerance, %	
		+	Avg Wall ±	Min Wall + / -
Nickel & Monel (N02200, N02201, N04400)				
	1/2–5/8 (12.7–15.9)	0.005 (0.13) / -0	12.5	25.0 / 0
	5/8–1 1/2 (15.9–38.1)	0.005 (0.13) / -0.005 (0.13)	10.0	20.0 / 0
	Over 1 1/2–3 (38.1–76.2)	0.010 (0.25) / -0.010 (0.25)	10.0	22.0 / 0
Inconel, Incoloy & All Other Alloys				
	1/2–5/8 (12.7–15.9)	0.005 (0.13) / -0.005 (0.13)	12.5	25.0 / 0
N06686	5/8–1 1/2 (15.9–38.1)	0.0075 (0.19) / -0.0075 (0.19)	10.0	20.0 / 0
All other alloys	5/8–1 1/2 (15.9–38.1)	0.005 (0.13) / -0.005 (0.13)	10.0	20.0 / 0
	Over 1 1/2–3 (38.1–76.2)	0.010 (0.25) / -0.010 (0.25)	10.0	22.0 / 0

Eccentricity: Wall variation in any one cross section shall not exceed $\pm 10\%$ of the actual (measured) average wall.

Ovality (thin wall $\leq 3\%$ OD): Mean OD must comply with table tolerances. Individual measurements: add 1/2% of nominal OD to table values.

Length Tolerance: Cut-to-length: $+\frac{1}{8}$ in. (3.2 mm) for lengths ≤ 30 ft; $+\frac{1}{4}$ in. (6.4 mm) over 30 ft (9.1 m).

Straightness: Material shall be reasonably straight and free of bends or kinks.

7. Supplementary Requirements

S1 · WHEN SPECIFIED

U-Bent Tubes

For U-bent condenser/HX tubes. Covers leg spacing, diameter in bend section (max 10% deviation), wall thinning at apex ($T_F = T \times 2R/(2R+D)$), leg length tolerances, and end squareness. Separate hydrostatic test after bending (5 sec hold). Bend radii per Table 5.

S2 · WHEN SPECIFIED

High Yield Strength Tubes (HYS)

Limited to N06600, N06601, N08800, N06690. OD $\frac{1}{4}$ – $\frac{7}{8}$ in., wall ≤ 0.100 in. YS 40–65 ksi (276–448 MPa). No additional cold work beyond normal processing. Furnished annealed with controlled grain size. Marked "HYS".

S3 · WHEN SPECIFIED

Coiled / Unstraightened Tubing

After final heat treatment, tensile specimens may be machine-straightened before testing. Grade designation suffix "U" (e.g. N06600-U) on certification and marking.

S4 · WHEN SPECIFIED

U.S. Government Requirements

Fed. Std. No. 182 continuous ID marking. Quality assurance inspection rights. Packaging/preservation per Fed. Std. 102 (civil) or MIL-STD-129 (military).

7.1 U-Bend Table 5 — Bend Radii by Size

Tube OD, in.	Wall Range, in.	Min Bend Radius, in. (mm)	
		Annealed	Stress-Relieved
$\leq \frac{1}{2}$	0.046–0.057	$1\frac{3}{16}$ (30.2)	$1\frac{1}{4}$ (31.8)

Tube OD, in.	Wall Range, in.	Min Bend Radius, in. (mm)	
$\leq \frac{1}{2}$	0.057–0.120	1 (25.4)	$1\frac{1}{8}$ (28.6)
$\frac{1}{2}$ – $\frac{5}{8}$	0.037–0.057	$1\frac{3}{16}$ (30.2)	$1\frac{1}{4}$ (31.8)
$\frac{1}{2}$ – $\frac{5}{8}$	0.057–0.120	1 (25.4)	$1\frac{3}{16}$ (30.2)
$\frac{5}{8}$ – $\frac{3}{4}$	0.049–0.057	$1\frac{1}{4}$ (31.8)	$1\frac{1}{2}$ (38.1)
$\frac{5}{8}$ – $\frac{3}{4}$	0.057–0.109	$1\frac{3}{16}$ (30.2)	$1\frac{1}{4}$ (31.8)
$\frac{3}{4}$ –1	0.049–0.058	2 (50.8)	4 (101.6)
$\frac{3}{4}$ –1	0.058–0.109	$1\frac{3}{4}$ (44.5)	2 $\frac{1}{4}$ (57.2)

Note: Not applicable to N08810, N08801, and N08811.

8. Ordering Information

Mandatory (Specify)

1. Alloy — UNS number from Table 1
2. Condition (Temper) — Annealed, stress-relieved, or cold-worked. If annealed ends: state length and one/both ends
3. Finish — Per Appendix X1
4. Dimensions — OD, wall (min or avg, in inches, not gage), and length
5. Fabrication — Cold bending/coiling, packing, rolling/expanding, welding/brazing process
6. Hydrostatic or NDT test type (if specific)
7. Pressure requirements (if other than standard)
8. Ends — Plain ends cut and deburred (standard)

Optional (If Required)

9. **Optional** Supplementary requirements (S1–S4)
10. **Optional** Certification (Section 15)
11. **Optional** Product (check) analysis samples
12. **Optional** Purchaser inspection at manufacture
13. **Optional** Small-diameter/light-wall (converter sizes) — Appendix X2
14. **Optional** U-bent tubes (S1) — Specify bend radius, leg lengths
15. **Optional** High yield strength tubes (S2)

16. Optional Coiled/unstraightened (S3)

Example Order Description

Example 1 (Standard):

Seamless nickel-chromium-iron alloy UNS N06600 tube, annealed, $\frac{3}{4}$ in. OD $\times$ 0.065 in. average wall $\times$ 20 ft, per ASTM B163.

Example 2 (U-Bent + Hydrostatic):

Seamless nickel-copper alloy UNS N04400 tube, stress-relieved with annealed ends (anneal 6 in. both ends), $\frac{3}{4}$ in. OD $\times$ 0.065 in. average wall, U-bent with 1 $\frac{1}{2}$ in. centerline radius, 20 ft legs, hydrostatic test after bending per S1.3, ASTM B163.

9. Key Takeaways

1

15 Alloys, One Standard

B163 covers pure nickel, Monel, Inconel, and Incoloy families — all seamless — in a single specification. From commodity Ni 200 to premium Ni-Cr-Mo-W 686.

2

Stress-Relieved + Annealed Ends

Unique feature: stress-relieved body for higher strength + locally annealed ends for safe rolling/expansion into tubesheets. Requires hardness verification on annealed ends.

3

800H/800HT Grain Size Matters

Incoloy 800H and 800HT require ASTM grain size ≥ 5 (coarse grain) for creep-rupture resistance above 1100°F. This must be verified in testing.

4

U-Bent Tubes — S1

When ordering U-bent tubes, specify bend radius, leg lengths, and whether hydrostatic testing after bending is required. Wall thinning at apex follows $T_F = T \times 2R/(2R+D)$.

5

NDT Option Reduces Cost

Nondestructive electric test (per B829) is a manufacturer option. Specify hydrostatic if your design code requires it, or accept NDT for faster turnaround.

Alumina-Formers for Oxidation

N06603 (with Y and Ce) and N06025 form protective alumina scales. Best-in-class oxidation resistance for extreme-temperature chemical processing.

This customer guide is based on **ASTM B163 – 04** and is provided for informational purposes only. For complete requirements, refer to the official ASTM standard. Key alloys: N02200, N02201, N04400, N06600, N06601, N06690, N06045, N06025, N06603, N06686, N08120, N08800, N08810, N08811, N08801, N08825.