

ASTM B111 · ASME SB-111 · 2017 Edition

Copper & Copper-Alloy Seamless Condenser Tubes & Ferrule Stock

A customer-focused quick reference guide covering alloy selection, chemical composition, mechanical properties, testing requirements, dimensional tolerances, and key ordering information.

 Identical to B111/B111M-11  Certification & Test Reports Mandatory

If your project requires UNS C10100, C23000, C44300, C68700, C70600, or C71500 materials, please click the link below to view the relevant products. We offer seamless tubes and casing stock made from these ASTM B111 copper alloys, with diameters up to 3 1/8 inches. These materials are used in surface condensers, evaporators, and heat exchangers.

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

1 Scope & Application

What this standard covers and where these tubes are used.

26

ALLOY GRADES

$\leq 3\frac{1}{8}"$

MAX OD (80 MM)

3

CORE APPLICATIONS

SI + IP

DUAL UNIT SYSTEM

This specification establishes the requirements for **seamless tube and ferrule stock** of copper and various copper alloys up to **3 $\frac{1}{8}$ inches [80 mm]** inclusive in outside diameter, for use in **surface condensers, evaporators, and heat exchangers**.

Surface Condensers

Evaporators

Heat Exchangers

Ferrule Stock

⚠ Important Notes

Dual Units: Values stated in either SI or inch-pound units are to be regarded separately as standard. Mixing values from the two systems may result in non-conformance.

Safety: Mercury is a health hazard (see Residual Stress Test section). This guide is a summary; refer to the full standard for complete requirements.

Alloy Grade Overview

All 26 copper and copper-alloy grades covered by ASTM B111, with density and typical applications. Popular heat exchanger grades are highlighted.

C10100

Oxygen-Free Electronic (OFE)
Density: 8.94 g/cm³

High-conductivity electronic applications

C10200

Oxygen-Free (OFA)
Density: 8.94 g/cm³

Electronic / vacuum devices

C10300

Oxygen-Free, Extra Low Phosphorus
Density: 8.94 g/cm³

High-purity applications

C10800

Oxygen-Free, Low Phosphorus
Density: 8.94 g/cm³

Welding applications

C12000 COMMON

Phosphorized, Low Residual P (DLPA)
Density: 8.94 g/cm³

General heat exchanger tubing

C12200 MOST USED

Phosphorized, High Residual P (DHPA)
Density: 8.94 g/cm³

General-purpose condenser & heat exchanger tube

C14200

Phosphorized, Arsenical (DPAA)
Density: 8.94 g/cm³

Corrosion-resistant heat exchanger tube

C19200

Phosphorized, 1% Iron
Density: 8.86 g/cm³

High-strength heat exchanger tube

C23000

Red Brass (85% Cu)
Density: 8.75 g/cm³

General condenser tubing

C28000

Muntz Metal (60% Cu)
Density: 8.39 g/cm³

Ferrule stock

C44300 MARINE

Admiralty Metal, Type B
Density: 8.53 g/cm³

Marine / seawater condensers

C44400

Admiralty Metal, Type C
Density: 8.53 g/cm³

Marine / seawater condensers

C44500

Admiralty Metal, Type D
Density: 8.53 g/cm³

Marine / seawater condensers

C60800

Aluminum Bronze (5% Al)
Density: 8.17 g/cm³

High-strength corrosion-resistant

C61300

Aluminum Bronze, Type D
Density: 7.89 g/cm³

High-strength seawater service

C61400

Aluminum Bronze (6–8% Al)

Density: 7.89 g/cm³

High-strength seawater service

C68700 MARINE

Aluminum Brass, Type B

Density: 8.33 g/cm³

Seawater condensers — widely used

C70400

95-5 Copper-Nickel

Density: 8.94 g/cm³

Seawater heat exchangers

C70600 TOP PICK

90-10 Copper-Nickel

Density: 8.94 g/cm³

Seawater piping & heat exchangers — most popular Cu-Ni

C70620 WELDING

90-10 Copper-Nickel —
Welding Grade

Density: 8.94 g/cm³

Welded seawater piping systems

C71000

80-20 Copper-Nickel

Density: 8.94 g/cm³

High-velocity seawater applications

C71500 PREMIUM

70-30 Copper-Nickel

Density: 8.94 g/cm³

Seawater / chemical — highest corrosion resistance

C71520 WELDING

70-30 Copper-Nickel —
Welding Grade

Density: 8.94 g/cm³

Welded seawater / chemical piping

C71640

Copper-Nickel-Iron-
Manganese

Density: 8.94 g/cm³

High-strength seawater service

C72200

Copper-Nickel-Chromium

Density: 8.94 g/cm³

High-velocity seawater applications

Chemical Composition — Key Alloys

Chemical requirements for the most commonly ordered heat exchanger tube alloys. For complete data, refer to Table 1 of the original standard.

UNS No.	Cu (%)	Sn	Al	Ni+Co	Fe	Zn	Mn	As / Sb / P	Other Limits
C12200	≥99.9	—	—	—	—	—	—	P 0.015–0.040	—
C44300	70.0–73.0	0.9–1.2	—	—	≤0.06	Rem.	—	As 0.02–0.06	Pb ≤0.07
C68700	76.0–79.0	—	1.8–2.5	—	≤0.06	Rem.	—	As 0.02–0.06	Pb ≤0.07
C70400	Rem.	—	—	4.8–6.2	1.3–1.7	≤1.0	0.30–0.80	—	Pb ≤0.05
C70600	Rem.	—	—	9.0–11.0	1.0–1.8	≤1.0	≤1.0	—	Pb ≤0.05
C70620	≥86.5	—	—	9.0–11.0	1.0–1.8	≤0.50	≤1.0	P ≤0.02	Pb ≤0.02, S ≤0.02, C ≤0.05
C71500	Rem.	—	—	29.0–33.0	0.40–1.0	≤1.0	≤1.0	—	Pb ≤0.05
C71520	≥65.0	—	—	29.0–33.0	0.40–1.0	≤0.50	≤1.0	P ≤0.02	Pb ≤0.02, S ≤0.02, C ≤0.05
C71640	Rem.	—	—	29.0–32.0	1.7–2.3	≤1.0	1.5–2.5	—	Pb ≤0.05, C ≤0.06
C72200	Rem.	—	—	15.0–18.0	0.50–1.0	≤1.0	≤1.0	Cr 0.30–0.70	Pb ≤0.05, Si ≤0.03

Note on Zinc-Containing Alloys

For alloys where zinc is specified as the remainder (C23000, C28000, C44300, C44400, C44500, C68700), either copper or zinc may be taken as the difference between the sum of all analyzed elements and 100%.

4 Mechanical Properties

Tensile requirements by alloy and temper condition. Both inch-pound and SI values are provided.

INCH-POUND UNITS (KSI)

UNS No.	Temper	Tensile Strength min (ksi)	Yield Strength ¹ min (ksi)	Elongation min (%)
C12200	H55 Light-Drawn	36	30	—
C12200	H80 Hard-Drawn	45	40	—
C44300 / C44400 / C44500	O61 Annealed	45	15	—
C68700	O61 Annealed	50	18	—
C70400	O61 Annealed	38	12	—
C70400	H55 Light-Drawn	40	30	—
C70600 / C70620	O61 Annealed	40	15	—
C70600 / C70620	H55 Light-Drawn	45	35	—
C71000	O61 Annealed	45	16	—
C71500 / C71520	O61 Annealed	52	18	—
C71500 / C71520 (t ≤0.048")	HR50 Stress- Relieved	72	50	12
C71500 / C71520 (t >0.048")	HR50 Stress- Relieved	72	50	15
C71640	O61 Annealed	63	25	—
C71640	HR50 Stress- Relieved	81	58	—

UNS No.	Temper	Tensile Strength min (ksi)	Yield Strength ¹ min (ksi)	Elongation min (%)
C72200	O61 Annealed	45	16	—
C72200	H55 Light- Drawn	50	45	—

¹ At 0.5% extension under load. | ksi = 1,000 psi.

SI UNITS (MPa)

UNS No.	Temper	Tensile Strength min (MPa)	Yield Strength ¹ min (MPa)	Elong. in 50 mm min (%)
C12200	H55 Light- Drawn	250	205	—
C12200	H80 Hard- Drawn	310	275	—
C44300 / C44400 / C44500	O61 Annealed	310	105	—
C68700	O61 Annealed	345	125	—
C70400	O61 Annealed	260	85	—
C70400	H55 Light- Drawn	275	205	—
C70600 / C70620	O61 Annealed	275	105	—
C70600 / C70620	H55 Light- Drawn	310	240	—
C71000	O61 Annealed	310	110	—
C71500 / C71520	O61 Annealed	360	125	—
C71500 / C71520 (t ≤1.2mm)	HR50 Stress- Relieved	495	345	12

UNS No.	Temper	Tensile Strength min (MPa)	Yield Strength ¹ min (MPa)	Elong. in 50 mm min (%)
C71500 / C71520 (t >1.2mm)	HR50 Stress- Relieved	495	345	15
C71640	O61 Annealed	435	170	—
C71640	HR50 Stress- Relieved	560	400	—
C72200	O61 Annealed	310	110	—
C72200	H55 Light- Drawn	345	310	—

5 Temper Designation Guide

Understanding the five temper conditions available under ASTM B111. The temper must be specified when placing an order.

061

Annealed
Fully recrystallized, softest

H55

Light-Drawn
Light cold work, moderate strength

H80

Hard-Drawn
Higher cold work, maximum strength

HR50

Drawn & Stress-Relieved
Balance of strength + SCC resistance

HE80

Hard-Drawn, End-Annealed
Annealed ends for rolling-in; body retains strength

Alloy Group	Available Tempers	Notes
C23000, C28000, C44300–C44500, C60800, C61300, C61400, C68700, C71000	O61 (Annealed) only	Furnished annealed unless otherwise specified
C71500, C71520, C71640	O61 or HR50	Must specify which temper is required
C10100–C10800, C12000, C12200, C14200	H55, H80, or HE80	Pure copper grades
C19200	O61, H55, H80, or HE80	All four tempers available
C70400, C70600, C70620, C72200	O61 or H55	Most common Cu-Ni grades

⚠ Stress-Corrosion Cracking Advisory

For tubes used in aggressive environments, alloys C23000, C28000, C44300, C44400, C44500, C60800, C61300, C61400, and C68700 may benefit from a post-straightening thermal stress relief. This must be specified in the purchase order.

Testing & Inspection Requirements

Mandatory and optional tests applied to every tube, along with key acceptance criteria.

6.1 Nondestructive Testing — Eddy-Current (Mandatory)

Every tube must pass an eddy-current examination per **ASTM E243**. Testing may be performed in the final drawn, annealed, or heat-treated temper.

ALTERNATIVE TESTS (PURCHASER OPTION)

Hydrostatic Test
Internal pressure to produce fiber stress of **7,000 psi [48 MPa]**. Not to exceed 1,000 psi [7.0 MPa].

Pneumatic Test
Internal air pressure of **60 psig [400 kPa]** minimum for **5 seconds** minimum. Any leakage is cause for rejection.

6.2 Expansion Test

Tube specimens must withstand expansion per **ASTM B153** without cracking or rupture visible to the unaided eye. Hard-drawn tubes not end-annealed are exempt. Ferrule stock is exempt.

EXPANSION REQUIREMENTS (% OF ORIGINAL OD)

Temper	Alloy	Expansion %	Temper	Alloy	Expansion %
O61	C70600, C70620	30	O61	C71500, C71520	30
O61	C44300, C44400, C44500	20	O61	C68700	20
O61	C70400	30	O61	C71640	30
H55	C70600, C70620	20	H55	C70400	20
HR50	C71500, C71520	20	HR50	C71640	20

6.3 Flattening Test

Specimen flattened at **3 places** along its length, each rotated ~120°. A micrometer set at **3× wall thickness** must pass freely over the flattened area. Ferrule stock is exempt from this test.

6.4 Residual Stress Test (Optional)

Required only when specified, and only for non-annealed tempers of: **C23000, C28000, C44300, C44400, C44500, C60800, C61300, C61400, C68700**. Producer may choose either:

- **Mercurous Nitrate Test** (ASTM B154) — 6" [150 mm] specimen, no cracking after immersion
- **Ammonia Vapor Test** (ASTM B858) — Default risk level pH = 10

6.5 Grain Size — Annealed Tempers

All O61 annealed product must show uniform and complete recrystallization at 75× magnification (ASTM E112). Average grain size: **0.010 – 0.045 mm** (excludes C19200 and C28000).

7 Dimensional Tolerances

Key dimensional tolerance tables for outside diameter, wall thickness, length, and squareness of cut.

7.1 Outside Diameter Tolerance

OD Range (in)	Wall $\geq 0.049" \pm in$	OD Range (mm)	Wall $\geq 1.24mm \pm mm$
≤ 0.500	0.0025	≤ 12	0.064
0.500 – 0.740	0.003	12 – 18	0.076
0.740 – 1.000	0.004	18 – 25	0.10
1.000 – 1.250	0.0045	25 – 35	0.13
1.375 – 2.000	0.006	35 – 50	0.15
2.000 – 3.125	0.0065	50 – 79	0.17

7.2 Wall Thickness Tolerance (Nominal Wall)

Wall Range (in)	OD $\frac{1}{8}$ – $\frac{5}{8}" \pm in$	OD $\frac{5}{8}$ –1"	OD 1–2"	OD 2– $3\frac{1}{8}"$
0.020 – 0.032	0.003	0.003	—	—
0.035 – 0.058	0.004	0.0045	0.0045	0.005
0.058 – 0.083	0.0045	0.005	0.005	0.0055
0.083 – 0.120	0.005	0.0065	0.0065	0.0065
0.120 – 0.134	0.007	0.007	0.0075	0.008

Minimum Wall vs. Nominal Wall

Minimum Wall: No point shall be less than specified. Maximum plus deviation $\leq 2 \times$ table values.

Nominal Wall: Plus and minus deviations per tables above.

7.3 Length Tolerance (All Plus)

Specified Length (ft)	Plus (in)	Specified Length (mm)	Plus (mm)
≤ 15	3/32 (2.4)	$\leq 4,500$	2.4
15 – 20	1/8 (3.2)	4,500 – 6,000	3.2
20 – 30	5/32 (4.0)	6,000 – 10,000	4.0

Specified Length (ft)	Plus (in)	Specified Length (mm)	Plus (mm)
30 – 60	3/8 (9.5)	10,000 – 18,000	9.5
60 – 100	1/2 (13.0)	18,000 – 30,000	13.0

7.4 Squareness of Cut

- **OD ≤ 5/8" [16 mm]:** ≤ 0.010" [0.25 mm] departure from squareness
- **OD > 5/8" [16 mm]:** ≤ 0.016"/inch [mm/mm] of diameter

Ordering Information

What to specify when placing an order to ensure full compliance with ASTM B111 and your project requirements.

MANDATORY INFORMATION

- 1 **Quantity** — total number of pieces or total weight
- 2 **Material designation** — UNS number (e.g., C70600, C71500)
- 3 **Temper** — O61, H55, H80, HR50, or HE80
- 4 **Dimensions** — outside diameter × wall thickness × length
- 5 **ASME Code tensile test** — if required per ASME Boiler & Pressure Vessel Code

OPTIONAL REQUIREMENTS (SPECIFY IF NEEDED)

- Hydrostatic or pneumatic test as alternative to eddy-current test
- Whether cut ends do **not** need deburring (deburring is default)
- Product intended for subsequent welding (use welding-grade alloys C70620 / C71520)
- Residual stress test — ammonia vapor or mercurous nitrate
- Ammonia vapor test risk level (pH value) if other than default 10
- Heat identification or traceability requirements
- Certification (mandatory per this edition)
- Mill test report (mandatory per this edition)
- Post-straightening thermal stress relief (see Temper section advisory)

PACKAGING & MARKING

Each shipping unit shall be legibly marked with: purchase order number, alloy designation, temper, size, total length or piece count, supplier name, and specification number.

CERTIFICATION & REPORTS

Certification and mill test reports are **mandatory** under this edition. Samples representing each lot must be tested or inspected as directed.

REJECTION & RETEST

Product failing to conform when tested by the purchaser may be rejected. Manufacturer may request a retest with twice the number of specimens.

SURFACE CONDITION

Annealed tubes may have a superficial dull iridescent film. Drawn-temper tubes may have a superficial drawing lubricant film. Cut ends are deburred by default.

UNIT SYSTEM

Inch-pound and SI values are separate standard systems. **Do not mix** values from the two systems in a single order.

LOT DEFINITION

600 tubes or 10,000 lb [4,550 kg], whichever constitutes the greater weight. Sample pieces from two individual lengths of finished product.

Disclaimer: This guide is a condensed summary of ASTM B111 / ASME SB-111 (2017 Edition) and is provided for quick reference only. All technical requirements are governed by the full standard. For the complete specification text, or for technical support regarding your specific application, please contact your supplier.