

WELDED AUSTENITIC STEEL TUBES

ASTM A249/A249M

Standard Specification for Welded Austenitic Steel Boiler, Superheater, Heat-Exchanger, and Condenser Tubes

1. Scope & Application

This specification covers nominal-wall-thickness welded tubes and heavily cold-worked (HCW) welded tubes made from austenitic stainless steels, intended for boiler, superheater, heat-exchanger, and condenser service.



Product Types

Two types: **WLD** (standard welded, cold-worked post-weld) and **HCW** (heavily cold-worked, $\geq 35\%$ reduction in wall & weld, 100% RT of weld before cold work).



Size Range

From $\frac{1}{8}$ in. (3.2 mm) inside diameter to 12 in. (304.8 mm) outside diameter. Wall thickness: 0.015 to 0.320 in. (0.4 to 8.1 mm).



High-Temperature Grades

Grades TP304H through TP348H are "**H**" **modifications** with controlled carbon content (0.04–0.10%) for superior high-temperature creep strength.



Mechanical Note

Mechanical property requirements do not apply to tubes smaller than **1/8 in. ID (3.2 mm)** or thinner than **0.015 in. (0.4 mm)** wall.



Welding Method

Automatic welding process **without filler metal**. Post-weld cold working is mandatory prior to final heat treatment.



Dual Units

Values in inch-pound or SI units are separate standards. Use one system consistently — do not mix.

2. Grade Overview

ASTM A249 covers over 40 austenitic stainless steel grades. Below are the most commonly specified grades organized by alloy family.

Standard 300-Series (18Cr-8Ni Base)

Most Popular

TP304

S30400

The workhorse grade. 18Cr-8Ni for general corrosion resistance. Standard for most heat-exchanger and condenser applications.

Top Pick

TP304L

S30403

Low-carbon variant ($C \leq 0.03$) for improved weldability. Resists intergranular corrosion in as-welded condition.

TP304H

S30409

High-carbon for boiler/superheater high-temperature service. Grain size No. 7 or coarser.

TP304N

S30451

Nitrogen-strengthened 304. Higher yield (35 ksi min vs 30 ksi).

TP304LN

S30453

Low carbon + nitrogen. Best of both: weldability of L-grade with strength of N-grade.

316-Series (Mo-Alloyed for Pitting Resistance)

Top Pick

TP316L

S31603

2–3% Mo for enhanced pitting/crevice resistance. The go-to for chloride-containing environments.

Popular

TP316

S31600

Standard 316. Good all-around corrosion resistance with molybdenum addition.

TP316H

S31609

High-carbon 316 for elevated-temperature superheater/reheater service.

TP317L

S31703

3–4% Mo — superior pitting resistance for aggressive chemical environments.

Stabilized & 321/347-Series

Welding**TP321**

S32100

Ti-stabilized ($Ti \geq 5 \times (C+N)$). Eliminates sensitization risk. Ideal for welded fabrications operating at 800–1500°F.

High-Temp**TP321H**

S32109

High-carbon stabilized grade. Superior creep strength for superheater applications. Grain size $\geq$ No. 7.

TP347

S34700

Nb-stabilized ($Nb \geq 10 \times C$). Alternative to 321 for welded components in the sensitization range.

TP347H

S34709

Stabilized high-temperature variant. Excellent creep properties for superheater tubes.

Super-Austenitic & High-Alloy**Premium****S31254**

S31254

254 SMO®. 6% Mo super-austenitic. Outstanding pitting resistance ($PREN \geq 43$). Seawater-tolerant.

N08367

N08367

AL-6XN®. 6% Mo, 20Cr-24Ni. Exceptional chloride resistance for seawater-cooled heat exchangers.

N08904

N08904

904L. 20Cr-25Ni-4.5Mo. Excellent general corrosion + pitting resistance. Widely used in chemical processing.

N08926

N08926

1925hMo. 20Cr-25Ni-6.5Mo + N. Higher PREN than 904L. Seawater and FGD applications.

3. Chemical Composition

Heat analysis shall conform to the requirements below (all values are max unless range is shown). See Table 1 of ASTM A249.

Grade	UNS	C	Mn	P	S	Si	Cr	Ni	Mo	N	Other
TP304	S30400	0.08	2.00	0.045	0.030	1.00	18.0–20.0	8.0–11.0	—	—	—
TP304L	S30403	0.030	2.00	0.045	0.030	1.00	18.0–20.0	8.0–12.0	—	—	—
TP304H	S30409	0.04–0.10	2.00	0.045	0.030	1.00	18.0–20.0	8.0–11.0	—	—	—
TP304N	S30451	0.08	2.00	0.045	0.030	1.00	18.0–20.0	8.0–11.0	—	0.10–0.16	—
S30415	S30415	0.04–0.06	0.80	0.045	0.030	1.00–2.00	18.0–19.0	9.0–10.0	—	0.12–0.18	Ce 0.03–0
TP316	S31600	0.08	2.00	0.045	0.030	1.00	16.0–18.0	10.0–14.0	2.00–3.00	—	—
TP316L	S31603	0.030	2.00	0.045	0.030	1.00	16.0–18.0	10.0–14.0	2.00–3.00	—	—
TP316H	S31609	0.04–0.10	2.00	0.045	0.030	1.00	16.0–18.0	10.0–14.0	2.00–3.00	—	—
TP317L	S31703	0.030	2.00	0.045	0.030	1.00	18.0–20.0	11.0–15.0	3.0–4.0	—	—
TP321	S32100	0.08	2.00	0.045	0.030	1.00	17.0–19.0	9.0–12.0	—	0.10	Ti≥5×(C+N)
TP321H	S32109	0.04–0.10	2.00	0.045	0.030	1.00	17.0–19.0	9.0–12.0	—	0.10	Ti≥5×(C+N)
TP347	S34700	0.08	2.00	0.045	0.030	1.00	17.0–19.0	9.0–12.0	—	—	Nb≥10×(C+N)
TP347H	S34709	0.04–0.10	2.00	0.045	0.030	1.00	17.0–19.0	9.0–12.0	—	—	Nb≥10×(C+N)
S31254	S31254	0.020	1.00	0.030	0.010	0.80	19.5–20.5	17.5–18.5	6.0–6.5	0.18–0.25	Cu 0.50–1.00
N08367	N08367	0.030	2.00	0.040	0.030	1.00	20.0–22.0	23.5–25.5	6.0–7.0	0.18–0.25	Cu 0.75
N08904	N08904	0.020	2.00	0.040	0.030	1.00	19.0–23.0	23.0–28.0	4.0–5.0	0.10	Cu 1.0–2.0

Grade	UNS	C	Mn	P	S	Si	Cr	Ni	Mo	N	Other
TPXM-19	S20910	0.06	4.0–6.0	0.045	0.030	1.00	20.5–23.5	11.5–13.5	1.50–3.00	0.20–0.40	Nb 0.10–0.30, V 0.1–0.30
S30815	S30815	0.05–0.10	0.80	0.040	0.030	1.40–2.00	20.0–22.0	10.0–12.0	—	0.14–0.20	Ce 0.03–0
TP310S	S31008	0.08	2.00	0.045	0.030	1.00	24.0–26.0	19.0–22.0	—	—	—

Key Chemical Notes

- **L-Grade Carbon:** TP304L and TP316L have C ≤ 0.030% (improved weldability and IGC resistance).
- **H-Grade Carbon:** TP304H, TP321H, etc. have C 0.04–0.10% for optimal high-temperature creep strength.
- **Stabilized Grades:** TP321 requires Ti ≥ 5×(C+N); TP347 requires Nb ≥ 10×C (prevents sensitization).
- Full chemistry for all ~40 grades is available in Table 1 of ASTM A249/A249M.

4. Mechanical Properties

Room-temperature tensile and hardness requirements per Table 4 of ASTM A249. Not applicable to tubes < 1/8 in. OD or < 0.015 in. wall.

Grade	UNS	Tensile Strength min, ksi [MPa]	Yield Strength min, ksi [MPa]	Elongation min, %	Rockwell Hardness max
TP304	S30400	75 [515]	30 [205]	35	HRB 90
TP304L	S30403	70 [485]	25 [170]	35	HRB 90
TP304H	S30409	75 [515]	30 [205]	35	HRB 90
TP304N	S30451	80 [550]	35 [240]	35	HRB 90
TP316	S31600	75 [515]	30 [205]	35	HRB 90
TP316L	S31603	70 [485]	25 [170]	35	HRB 90
TP316H	S31609	75 [515]	30 [205]	35	HRB 90
TP317L	S31703	75 [515]	30 [205]	35	HRB 90
TP321	S32100	75 [515]	30 [205]	35	HRB 90
TP321H	S32109	75 [515]	30 [205]	35	HRB 90
TP347	S34700	75 [515]	30 [205]	35	HRB 90
TP347H	S34709	75 [515]	30 [205]	35	HRB 90
S31254	S31254	98/95 [675/655] [†]	45 [310/300] [†]	35	HRB 100
N08367	N08367	100/95 [690/655] [†]	45 [310] [†]	30	HRB 100
N08904	N08904	71 [490]	31 [215]	35	HRB 90
N08926	N08926	94 [650]	43 [295]	35	HRB 100
TPXM-19	S20910	100 [690]	55 [380]	35	HRC 25
S24565	S24565	115 [795]	60 [415]	35	HRB 100
TP310S	S31008	75 [515]	30 [205]	35	HRB 90

[†] Dual values: t ≤ 0.187 in. [5.00 mm] / t > 0.187 in.

Mechanical Property Notes

- Most standard 300-series austenitic grades share the baseline: **75 ksi tensile / 30 ksi yield / 35% elongation**.
- L-grade variants (304L, 316L) have slightly lower minimum strength: 70 ksi / 25 ksi.
- For super-austenitic grades (S31254, N08367), strength values are **wall-thickness-dependent** — thinner walls have higher minima.
- Tubes < 1/8 in. OD or < 0.015 in. wall: mechanical properties are by **agreement between manufacturer and purchaser**.

5. Heat Treatment

All material shall be furnished in solution-annealed condition. Quench method: water or rapidly cooled by other methods unless noted.

Grade	UNS	Solution Annealing Temp °F [°C] (min)
Standard grades (304/304L/316/316L/317/317L/310S/321/347)	—	1900 [1040]
S30815 (253 MA®)	S30815	1920 [1050]
S31254 (254 SMO®)	S31254	2100 [1150]
TP316H	S31609	1900 [1040]
TP321	S32100	1900 [1040]
TP321H	S32109	2000 [1100]
S32654	S32654	2100 [1150]
S33228	S33228	2050 [1120]
S34565	S34565	2050–2140 [1120–1170]
TP347	S34700	1900 [1040]
TP347H	S34709	2000 [1100]
S35045	S35045	2000 [1100]
S38815	S38815	1950 [1065]
N08367 (AL-6XN®)	N08367	2025 [1110]

Grade	UNS	Solution Annealing Temp °F [°C] (r
N08904 (904L)	N08904	2000 [1100]
N08926	N08926	2010 [1105]
TP310H / TP310HCb	S31009 / S31041	1900 [1040]

Important Heat Treatment Notes

- **Note A:** For grades $\leq 3\%$ Mo: quench rapidly enough to prevent carbide reprecipitation, verifiable by Practice E of ASTM A262 (only if specified in purchase order).
- **Note C:** For TP309HCb, TP310HCb, TP321, TP321H, TP347, TP347H, TP348, TP348H: solution annealing **above 1950°F [1065°C] may impair IGC resistance** after subsequent sensitizing exposure. A lower-temperature stabilization re-anneal may be specified (see Supplementary S4).
- **H-Grade heat treatment:** H grades use higher solution temperatures than their non-H counterparts to achieve the required grain size for creep strength.

6. Testing & Inspection Requirements

Mandatory mechanical tests and inspections per ASTM A249. The standard also provides 9 optional supplementary requirements (S1–S9).

Test / Inspection	Frequency	Notes
Tension Test	1 per lot $\leq$ 50 tubes; 2 per lot $>$ 50 tubes	Per Table 4 requirements
Hardness Test	2 tubes per lot	Rockwell; see Table 4 max values
Flattening Test	1 specimen per each end of 1 tube per lot	Per A1016/A1016M; different tube than flange test
Flange Test	1 specimen per each end of 1 tube per lot	Per A1016/A1016M; different tube than flattening test
Reverse-Bend Test	1 per 1500 ft [450 m] of finished tubing	Weld at point of max bend. Not required if wall $\geq$ 10% of OD, or wall $\geq$ 0.134 in., or OD $<$ 0.375 in.
Hydrostatic or NDT Electric Test	Each tube (100%)	Purchaser to specify which test is preferred
Grain Size (H grades only)	Same frequency as flattening test	TP304H/316H/321H/347H/348H: $\geq$ No. 7 TP309H/309HCB/310H/310HCB: $\geq$ No. 6
Product Analysis	1 per heat	Per A480/A480M tolerance. Re-test 2 additional lengths if initial fails.

7. Supplementary Requirements

These apply **only when specified on the purchase order**. The most commonly requested are S4 (stabilization), S6 (IGC test), and S7 (weld decay for HCW).

S1

Stress-Relieved Annealed Tubes

For chlorides/stress-corrosion environments. Heat treat 1550–1650°F [845–900°C] after roll straightening. Air or slow cool. No mechanical straightening after stress relief. (TP304L, TP316L, TP321, TP347, TP348)

S2

Minimum Wall Tubes

Tubes furnished on a minimum wall basis (per A1016/A1016M) rather than nominal wall. Marking includes "S2".

S4

Stabilizing Heat Treatment

For stabilized grades: a second lower-temperature heat treatment after the solution anneal to restore IGC resistance. Temperature agreed between purchaser and vendor.

S6

Intergranular Corrosion (IGC) Test

Per ASTM A262 Practice E. Testing on sensitized specimens for L/stabilized grades, as-shipped for others. Stabilization anneal (S4) may be required to pass.

S7

Weld Decay Test (HCW Tubes)

Boiling 50% HCl test. Corrosion ratio $R \leq 1.25$ required for HCW tubes. Not applicable to $Ni \geq 19\%$ or $Mo \geq 4\%$ alloys.

S8

Special Applications (Hydraulic Expansion)

No dimensional indication of the weld allowed. Tubes marked "NB" (No Bead). For hydraulic expansion into tube sheets.

S9

Additional UT + NDT Testing (ASME)

Each tube: 100% UT per E273 or E213 + NDT electric test. End-effect portions removed. Marked "S9".

8. Dimensions & Tolerances

Dimensional tolerances per A1016/A1016M except wall thickness. Weld geometry has specific additional requirements.

Dimension	Tolerance	Notes
Wall Thickness	±10% of nominal wall	A249-specific; all sizes
Weld Bead Excess	≤ nominal wall + 6% of nominal wall, or ≤ nominal wall + 0.004 in. [0.1 mm], whichever is greater	Measured at weld vs. 90° from weld
OD & ID	Per A1016/A1016M	Standard tubular product tolerances
Length	Per A1016/A1016M	Specific or random lengths
Straightness	Max deviation 0.030 in. [0.8 mm] per 3 ft [900 mm] of length	After final heat treatment

Weld Bead Note — Exceptions

The weld bead excess limit (14.2) does **not** apply when any of the following conditions are met:

- Specified wall thickness exceeds 12% of specified OD;
- Specified wall thickness exceeds 0.165 in. [4.2 mm];
- Specified OD exceeds 3 in. [76.2 mm]; **or**
- Specified minimum yield strength for the grade is 35 ksi [240 MPa] or greater.

9. Ordering Information

The purchaser must specify all requirements needed for material ordered under this specification.

✓ Required Information

1. Quantity (feet, metres, or number of lengths)
2. Material type: **WLD** (welded) or **HCW** (heavily cold worked)
3. Grade (e.g., TP304, TP304L, TP316L, TP321, etc.)
4. Size: outside diameter and nominal wall thickness
5. Length (specific cut lengths or random)
6. Hydrostatic or NDT electric test preference (13.6)
7. Test report required (certification)
8. Specification designation: A249 or A249M

Optional Requirements

- Cold working method (weld-only or weld + base metal)
- Minimum reduction % for cold-drawn tubes
- Metric units (A249M)
- Supplementary requirements S1–S9 (as applicable)
- Special packaging / marking
- Intergranular corrosion test (S6)
- Stabilization heat treatment (S4)
- Weld decay test for HCW tubes (S7)

Example Order:

2,000 ft of welded (WLD) TP316L stainless steel tubes,
1.000 in. OD × 0.065 in. nominal wall, cut to 20 ft lengths,
hydrostatic test, with certification, per ASTM A249.

HCW Example:

500 pcs heavily cold worked (HCW) TP304L tubes,
25.4 mm OD × 1.65 mm wall, random lengths 6–8 m,
NDT electric test, weld decay test (S7), per ASTM A249M.

10. Key Takeaways for Buyers

WLD vs. HCW

WLD = standard welded (cold-worked after weld). **HCW** = heavily cold worked (≥35% reduction, 100% RT, superior uniformity). Choose HCW for critical service.

H-Grades for High Temp

If your application exceeds 1000°F (540°C), specify an **H-grade** (TP304H, TP316H, TP321H, TP347H). The controlled carbon range (0.04–0.10%) provides essential creep strength.

 L-Grades for Welding

When welded tubes will be used without post-weld heat treatment, **L-grades (304L, 316L)** prevent weld-decay intergranular attack without requiring stabilization.

 Always Specify the Test

Your order must state whether you want **hydrostatic** or **NDT electric** testing. If you need IGC testing, corrosion resistance verification, or UT, use the **supplementary requirements S1–S9**.

This guide is a simplified summary of ASTM A249/A249M – 04 for customer reference.
For the complete standard, refer to the official ASTM International publication at www.astm.org.

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