

ASTM B337 / B337M Standard Specification for Seamless and Welded Titanium and Titanium Alloy Pipe

Our main products include titanium tubes, titanium plates, titanium rods, titanium wires, titanium foils, and CNC machined titanium parts.

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1. Standard Overview & Scope

ASTM B337 (inch-pound units) / B337M (SI units) is the primary North American standard governing the manufacture of seamless and welded titanium and titanium alloy pipe intended for critical corrosion-resistant and high-strength-to-weight ratio applications. It covers pipe suitable for high-pressure, high-temperature, and aggressive chemical service.

Key Distinction: This specification covers "pipe" (designated by Nominal Pipe Size - NPS) for pressure-conveying systems, as opposed to "tube" (designated by outside diameter) which is covered under ASTM B338. The manufacturing, dimensions, and pressure ratings differ significantly.

Core Applications: Chemical processing, petrochemical, offshore oil & gas, power generation (condenser tubing, geothermal), marine, aerospace hydraulic lines, and pulp & paper industries.

2. Material (Titanium Grades) and Grades

The standard encompasses both commercially pure (CP) and alloyed titanium grades, each with a unique UNS number and mechanical/corrosion property profile.

2.1 Complete Grade Table with Chemical Composition and Key Properties

UNS Number	Common Name / Grade	Principal Alloying Elements	Key Characteristics & Primary Applications
R50250	Grade 1	Unalloyed Ti (99.5% Ti min.)	Most ductile, lowest strength. Superior corrosion resistance, excellent formability. Chemical processing liners, anodes, marine parts.
R50400	Grade 2	Unalloyed Ti (99.2% Ti min.)	The standard, most widely used CP grade. Excellent balance of strength, ductility, weldability, and corrosion resistance. Standard for chemical process pipe, heat exchangers, seawater systems.
R50550	Grade 3	Unalloyed Ti (99.1% Ti min.)	Higher strength than Grades 1 & 2 while maintaining good ductility. Pressure vessels, aircraft components requiring moderate strength.
R50700	Grade 4	Unalloyed Ti (99.0% Ti min.)	Strongest unalloyed grade. Good cold formability, excellent corrosion resistance. Used where higher strength is needed: airframe components, cryogenic vessels.
R52400	Grade 5 (Ti-6Al-4V)	6% Al, 4% V	The most common titanium alloy. High strength-to-weight ratio, good creep resistance up to 300°C (572°F). Aerospace structural components, engine parts, high-performance automotive, biomedical implants.

UNS Number	Common Name / Grade	Principal Alloying Elements	Key Characteristics & Primary Applications
R53400	Grade 7	Ti-0.15% Pd (Grade 2 + Pd)	Grade 2 with 0.12-0.25% Palladium. Dramatically improved corrosion resistance in reducing acids (e.g., HCl, H ₂ SO ₄) and crevice conditions. Chemical processing with severe conditions.
R56320	Grade 9 (Ti-3Al-2.5V)	3% Al, 2.5% V	Moderate strength alloy with excellent cold formability and higher strength than CP grades. Aerospace hydraulic tubing, sports equipment, marine applications.
R56400	Grade 12 (Ti-0.3Mo-0.8Ni)	0.3% Mo, 0.8% Ni	Enhanced corrosion resistance in crevice and high-temperature reducing environments. Similar to Grade 7 but lower cost than Pd-alloyed grades. Heat exchangers in chemical and seawater service.
R52402	Grade 23 (Ti-6Al-4V ELI)	6% Al, 4% V (Extra Low Interstitial)	Higher purity, lower oxygen version of Grade 5. Superior fracture toughness and ductility. Primary grade for biomedical implants (joint replacements, spinal rods) and critical aerospace weldments.

2.2 Manufacturing Processes

Seamless Pipe: Manufactured by extrusion, rotary piercing (Mannesmann process), or pilgering. Preferred for high-pressure, critical service.

Welded Pipe: Manufactured from flat-rolled sheet or strip (coil) that is formed and longitudinally welded, typically using automated Gas Tungsten Arc Welding (GTAW/TIG) or Plasma Arc Welding (PAW) with full inert gas shielding. May be cold-worked after welding ("welded and cold-worked") to improve properties near the weld.

3. Dimensions, Tolerances, and Schedules

3.1 Size Ranges

ASTM B337 pipe is designated by Nominal Pipe Size (NPS) and schedule number (wall thickness), conforming to ASME B36.19M (Titanium Pipe) for dimensions.

NPS Range: Typically covers NPS 1/8 to NPS 24 and larger.

Schedule/Wall Thickness: Common schedules include Schedule 5S, 10S, 40S, 80S, and 160S. The "S" suffix denotes a thickness series that may differ from standard carbon steel pipe schedules for optimized use of titanium.

3.2 Dimensional Tolerances (Key Excerpts for NPS 1/8 to 12)

Tolerances are per ASME B36.19M. Representative values:

Dimension	Tolerance
Outside Diameter (OD)	NPS 1/8 to 1-1/2: ± 0.010 in (± 0.25 mm) NPS 2 to 8: ± 0.015 in (± 0.38 mm) NPS 10 to 12: ± 0.030 in (± 0.76 mm)
Wall Thickness	$\pm 12.5\%$ of nominal wall for seamless pipe. $\pm 10\%$ of nominal wall for welded pipe.
Length	Random: $+3/8$ in, -0 in ($+10$ mm, -0 mm) Cut Length: $+1/8$ in, -0 in ($+3$ mm, -0 mm) for lengths ≤ 20 ft.
Straightness	0.050 in/ft (4.2 mm/m) max. deviation.

3.3 Standard Dimension Ratio (SDR) Pipe

For lower pressure applications (e.g., seawater, geothermal), B337 also covers pipe manufactured to a Standard Dimension Ratio (SDR), where $SDR = (\text{Average OD}) / (\text{Minimum Wall Thickness})$. Common SDRs are 17, 26, and 32.5. This system provides constant pressure ratings across different diameters.

4. Mechanical and Physical Properties

Properties vary significantly by grade. The following table shows minimum required values for annealed condition.

Grade	Tensile Strength Min (ksi / MPa)	Yield Strength (0.2% Offset) Min (ksi / MPa)	Elongation Min (% in 2 in / 50 mm)	Typical Density (lb/in ³ / g/cm ³)
Grade 1	35 / 240	25 / 170	24	0.163 / 4.51
Grade 2	50 / 345	40 / 275	20	0.163 / 4.51
Grade 3	65 / 450	55 / 380	18	0.163 / 4.51
Grade 4	80 / 550	70 / 483	15	0.163 / 4.51
Grade 5	130 / 895	120 / 828	10	0.160 / 4.43
Grade 7	50 / 345	40 / 275	20	0.163 / 4.51
Grade 9	90 / 620	70 / 483	15	0.162 / 4.48
Grade 12	70 / 483	50 / 345	18	0.163 / 4.51
Grade 23	120 / 828	110 / 759	10	0.160 / 4.43

Modulus of Elasticity: $\sim 15 \times 10^6$ psi (103 GPa) for most grades ($\sim 50\%$ of steel).

Maximum Service Temperature: CP Grades up to $\sim 300^\circ\text{C}$ (572°F); Grade 5 up to $\sim 425^\circ\text{C}$ (797°F) for short-term.

5. Testing and Inspection (Mandatory and Optional)

Chemical Analysis: Performed on each heat of material. Strict adherence to grade composition is critical for corrosion performance.

Tension Tests: Two tests per lot (seamless) or one per 500 ft (welded).

Flattening Test (for welded pipe): Mandatory for as-welded pipe to demonstrate weld ductility.

Flare Test, Reverse Flattening Test, or Bend Test: Alternative tests to demonstrate formability and weld quality.

Hydrostatic Test: Mandatory for all pipe. Test pressure calculated by: $P = 2St / D$, where S is 50% of specified min yield strength, t is min wall, D is OD. Held for ≥ 5 seconds. OR Nondestructive Electric Test (eddy current or ultrasonic) may substitute by agreement.

Nondestructive Examination (NDE):

Seamless Pipe: Ultrasonic testing (UT) is common for detecting internal imperfections.

Welded Pipe: Full-length radiographic (RT) or automated ultrasonic testing (AUT) of the weld seam is mandatory to ensure weld integrity.

Visual Examination: Both inside and outside surfaces shall be free of scale, cracks, seams, and other injurious defects.

6. Purchasing Information, Pricing Factors, and Applications

6.1 How to Order/Specify:

A precise purchase order must include:

Standard: ASTM B337 or B337M (units).

Material: Titanium UNS Number and Common Name (e.g., R50400, Grade 2).

Manufacturing Process: Seamless or Welded. If welded, specify "as-welded" or "welded and cold-worked."

Dimensions: NPS and Schedule (e.g., NPS 6, Schedule 40S) OR NPS and SDR (e.g., NPS 8, SDR 17).

Length: Random or specific cut lengths.

End Finish: Plain end, beveled end (for welding), or threaded.

Test Requirements: Special NDE (e.g., 100% RT, PMI), hydrotest pressure, certification requirements (MTR to EN 10204 3.1 or equivalent).

Condition: Annealed (standard).

6.2 Major Price Determinants:

Titanium pipe is a high-value product. Cost drivers include:

Raw Material (Sponge & Mill Products): ~50-70% of cost. Highly volatile, tied to aerospace demand and production capacity. Grade 2 is baseline; Grade 5/23 and Pd-alloyed grades (7, 16) command significant premiums.

Manufacturing Process: Seamless pipe is substantially more expensive than welded pipe due to complex extrusion/pilgering processes and lower yields.

Size and Wall Thickness: Larger diameters and heavier walls use more material and are more challenging to process.

Testing and Certification: Extensive NDE (RT, UT, PMI) and special certifications (NADCAP, Norsok M650) add cost.

Quantity and Market: Aerospace/military contracts vs. industrial chemical projects.

6.3 Application-Specific Grade Selection Guide

Industry	Typical Grade(s)	Reason for Selection
Chemical Processing	Grade 2 (Standard), Grade 7/12 (Severe), Grade 5 (Strength)	Corrosion resistance in chlorides, wet chlorine, oxidizing acids.
Offshore Oil & Gas	Grade 2, Grade 29 (Ti-6Al-4V-Ru)	Seawater corrosion resistance, high strength for risers, Ru addition for crevice corrosion resistance.
Power Generation	Grade 2, Grade 12	Condenser and heat exchanger tubing (freshwater, seawater, brackish).
Aerospace (Hydraulic)	Grade 9 (Ti-3Al-2.5V)	High strength, excellent fatigue life, good bendability for lines.
Biomedical Implants	Grade 23 (Ti-6Al-4V ELI)	Biocompatibility, excellent fatigue strength, superior fracture toughness.
Marine & Naval	Grade 2, Grade 5	Immunity to seawater corrosion, high strength-to-weight for hull components.

7. Related Standards

ASTM B338: Specification for Seamless and Welded Titanium and Titanium Alloy Tubes for Condensers and Heat Exchangers.

ASTM B861 / B862: Specifications for Seamless and Welded Titanium Pipe (alternative product specifications).

ASME SB337: ASME Boiler and Pressure Vessel Code version of this specification.

ASME B36.19M: Standard for Stainless Steel and Titanium Pipe Dimensions.

NACE MR0175/ISO 15156: Standard for metallic materials in H₂S-containing environments (some titanium grades are approved).

ASTM F67, F136: Specifications for Titanium for surgical implant applications (more restrictive than B337).