Titanium Grade 5 (Ti 6Al-4V) – Technical Material Specification

1.0 Material Overview & Common Uses

Titanium Grade 5, also known as Ti 6Al-4V, is an alpha-beta titanium alloy containing 6% aluminum and 4% vanadium. It is the most widely used titanium alloy, accounting for approximately 50% of all titanium usage globally. This material offers an exceptional strength-to-weight ratio, excellent corrosion resistance, and good fatigue properties, making it a staple in aerospace, medical implants, marine hardware, and high-performance automotive components.

Common industrial applications include aircraft structural components (landing gear, airframes), gas turbine engine parts (compressor blades, discs), orthopedic implants (hip stems, bone plates), chemical processing equipment (heat exchangers, valves), and sporting goods (bicycle frames, golf club heads). Its biocompatibility and resistance to bodily fluids make it the gold standard for surgical implants.

2.0 Core Technical Properties & Sizing

- Density: 4.43 g/cm³ (0.160 lb/in³)
- Melting Point: 1660°C (3020°F)
- Tensile Strength (Ultimate): 950 MPa (138 ksi) minimum
- Yield Strength (0.2% offset): 880 MPa (128 ksi) minimum
- Elongation at Break: 10% minimum (in 2 inches)
- Modulus of Elasticity: 114 GPa (16.5 Msi)
- Hardness: 36 HRC (Rockwell C) typical
- Thermal Conductivity: 6.7 W/m·K at 20°C
- Electrical Resistivity: 1.7 µΩ·m at 20°C
- Standard Stock Forms: Round bar (diameter 1/4" to 12"), plate (thickness 0.125" to 4"), sheet (thickness 0.016" to 0.187"), and forging billet.
- Diameter Tolerance for round bar (ground): ±0.002" up to 1" diameter, ±0.003" for 1" to 3" diameter.
- Thickness Tolerance for plate (hot rolled): ±0.010" for thicknesses up to 0.250", ±0.015" for 0.250" to 0.500".
- Flatness Tolerance for plate: 0.005" per foot of length, maximum 0.030" overall.

3.0 Processing, Machinability & Application

Ti 6Al-4V is classified as difficult to machine due to its low thermal conductivity, high chemical reactivity, and tendency to work-harden. Successful machining requires rigid setups, sharp tooling, and aggressive coolant application. The material's low modulus of elasticity can cause deflection and chatter, so minimal overhang and robust fixturing are essential.

- Cutting Tool Material: Use carbide inserts with TiAlN or AlTiN coatings. For finishing, CBN (cubic boron nitride) tools provide superior wear resistance.
- Turning Speeds: Roughing at 30-60 SFM (surface feet per minute), finishing at 60-100 SFM. Feed rates: 0.005-0.015 in/rev for roughing, 0.002-0.005 in/rev for finishing.

- Milling Speeds: Use 30-50 SFM for roughing, 50-80 SFM for finishing. Chip load: 0.002-0.005 in/tooth. Climb milling is preferred to reduce work hardening.
- Drilling: Use split-point carbide drills with 118-135° point angle. Peck drilling cycle recommended (0.010-0.020" per peck). Speeds: 20-40 SFM, feed: 0.001-0.003 in/rev.
- Coolant: Flood coolant with high-pressure (1000+ psi) through-spindle delivery is critical. Use water-soluble oil at 5-8% concentration. Avoid chlorine-based cutting fluids due to stress corrosion cracking risk.
- Welding: Requires inert gas shielding (argon or helium) to prevent embrittlement. Use ERTi-5 filler wire. Pre-heat not required but interpass temperature must stay below 300°F. Post-weld stress relief at 540°C (1000°F) for 2 hours recommended.
- Forming: Hot forming at 700-800°C (1300-1470°F) is typical. Cold forming possible but limited to small bends due to low ductility. Springback allowance: 2-3 times that of steel.

4.0 Common Defects & Quality Control

- Reject if surface cracks or laps are visible under 10x magnification on any surface.
- Reject if surface pitting exceeds 0.005" (0.13 mm) in depth or 0.020" (0.5 mm) in diameter.
- Reject if alpha-case layer (oxygen-enriched brittle surface) is present deeper than 0.003" (0.08 mm) after heat treatment.
- Reject if ultrasonic inspection reveals any indications larger than 0.040" (1.0 mm) flat-bottom hole equivalent.
- Reject if chemical composition deviates from ASTM B348 Grade 5 limits: Al 5.5-6.75%, V 3.5-4.5%, Fe max 0.40%, O max 0.20%, C max 0.08%, N max 0.05%, H max 0.015%.
- Reject if tensile strength is below 950 MPa or yield strength below 880 MPa per ASTM E8.
- Reject if elongation is less than 10% in 2 inches.
- Reject if hardness exceeds 38 HRC (indicating oxygen contamination or improper heat treatment).
- Reject if dimensional tolerances exceed ±0.005" on critical features or ±0.010" on non-critical features.
- Reject if flatness exceeds 0.005" per foot of length or 0.030" overall on plate stock.

5.0 Storage, Handling & WHMIS Guidelines

- Store in a clean, dry environment with relative humidity below 60% to prevent surface contamination. No special temperature control required.
- Shelf life is indefinite under proper storage conditions. Use FIFO (First-In, First-Out) protocol to ensure traceability of heat numbers and certifications.
- Avoid contact with carbon steel tools or fixtures to prevent iron contamination, which can cause localized corrosion. Use dedicated titanium handling tools or stainless steel fixtures.
- WHMIS Classification: Not classified as a hazardous material in solid form. However, fine dust and machining chips are combustible and may present a fire or explosion hazard.
- WHMIS Hazard Statements: H228 (Combustible dust), H315 (Causes skin irritation from prolonged contact with fines), H319 (Causes serious eye irritation from dust).
- Mandatory PPE: Safety glasses with side shields, cut-resistant gloves (Kevlar or Dyneema) when handling sharp edges, and leather or nitrile gloves for general handling. For machining: full face shield, hearing protection, and flame-resistant clothing.
- Fire Safety: Titanium dust fires require Class D extinguishing agents (dry powder, sand, or special metal fire extinguishers). Do not use water, CO2, or halon as they can cause explosive reactions.
- Ventilation: Use local exhaust ventilation (LEV) when machining or grinding to capture airborne dust and chips. Maintain air velocity of at least 100 ft/min at the source.
- Spill Procedure: Sweep up dry dust carefully to avoid creating airborne clouds. Place in a sealed metal container labeled for titanium waste. Do not use vacuum cleaners unless they are explosion-proof rated.

Regulatory Disclaimer: This document is a generic technical material specification provided for educational purposes. The end-user assumes all liability for reviewing, adapting, and validating all tolerances, properties, and safety protocols against specific OEM data sheets and local regulations before deployment.