Titanium Grade 5 (Ti-6Al-4V) Material Specifications

1. Overview

Titanium Grade 5, also known as Ti-6Al-4V or Ti64, is the most widely used titanium alloy, accounting for approximately 50% of total titanium usage worldwide. It is an alpha-beta alloy containing 6% aluminum and 4% vanadium. This alloy is renowned for its exceptional combination of high strength, light weight, and excellent corrosion resistance.

Grade 5 titanium was originally developed for aerospace applications but has since expanded into numerous industries due to its superior mechanical properties and biocompatibility.

2. Chemical Composition

Element	Content (%)
Titanium (Ti)	Balance (approximately 90%)
Aluminum (Al)	5.5 - 6.75%
Vanadium (V)	3.5 - 4.5%
Iron (Fe)	<= 0.40%
Oxygen (O)	<= 0.20%
Carbon (C)	<= 0.08%
Nitrogen (N)	<= 0.05%
Hydrogen (H)	<= 0.015%

3. Mechanical Properties

Property	Value

Tensile Strength	895 - 1000 MPa (130 - 145 ksi)
Yield Strength (0.2%)	828 - 910 MPa (120 - 132 ksi)
Elongation at Break	10 - 14%
Reduction of Area	25 - 40%
Elastic Modulus	110 - 114 GPa (16 - 16.5 x 10^6 psi)
Hardness (Rockwell C)	30 - 36 HRC
Poisson's Ratio	0.31 - 0.34
Fatigue Strength	510 MPa (74 ksi) at 10^7 cycles

4. Physical Properties

Property	Value
Density	4.43 g/cm^3 (0.160 lb/in^3)
Melting Point	1604 - 1660°C (2920 - 3020°F)
Beta Transus Temperature	995°C (1820°F)
Thermal Conductivity	6.7 W/m.K at 20°C
Specific Heat Capacity	526 J/kg.K
Thermal Expansion Coefficient	8.6 x 10^{-6} /°C (20-100°C)
Electrical Resistivity	1.78 uΩ.m

5. Key Characteristics

5.1 Strength-to-Weight Ratio

Grade 5 titanium offers one of the highest strength-to-weight ratios of any metal. It is approximately 40% lighter than steel while maintaining comparable or superior strength. This makes it ideal for applications where weight

reduction is critical without compromising structural integrity.

5.2 Corrosion Resistance

This alloy exhibits excellent resistance to corrosion in various environments including seawater, chloride solutions, and many acids. The protective oxide layer (TiO_2) that forms naturally on the surface provides outstanding protection against oxidation and chemical attack.

5.3 Temperature Performance

Grade 5 titanium maintains good mechanical properties at elevated temperatures up to approximately 400°C (750°F). It also performs well at cryogenic temperatures, making it suitable for both high and low-temperature applications.

5.4 Biocompatibility

Ti-6Al-4V is highly biocompatible and non-toxic to human tissue. It does not cause allergic reactions and promotes osseointegration (bone growth onto the implant surface), making it the preferred choice for medical implants.

6. Heat Treatment Options

- Annealing: 700-785°C (1290-1445°F), air cool or furnace cool
- Solution Treatment: 955-970°C (1750-1780°F), water quench
- Aging: 480-595°C (900-1100°F), 4-8 hours, air cool
- Stress Relief: 480-650°C (900-1200°F), 1-4 hours, air cool

7. Common Applications

- Aerospace: Aircraft structural components, engine parts, fasteners, landing gear
- Medical: Orthopedic implants (hip/knee replacements), dental implants, surgical instruments
- Marine: Propeller shafts, heat exchangers, submarine components
- Automotive: High-performance racing components, exhaust systems, connecting rods
- Sports Equipment: Golf club heads, bicycle frames, tennis rackets
- Industrial: Chemical processing equipment, pressure vessels, heat exchangers
- Military: Armor plating, missile components, naval applications

8. Machining Considerations

Grade 5 titanium requires careful machining due to its low thermal conductivity and tendency to work harden. Recommended practices include:

- Use sharp carbide or ceramic cutting tools
- Maintain low cutting speeds (30-60 m/min)
- Apply high-pressure coolant flood cooling
- Use positive rake angles to reduce cutting forces
- Avoid dwelling or interrupted cuts when possible

- Maintain rigid setups to minimize vibration

9. Welding Information

Grade 5 titanium is weldable using GTAW (TIG), electron beam, or laser welding methods. Proper shielding with inert gas (argon or helium) is essential to prevent contamination. Filler metal should match the base metal composition (typically ERTi-5 wire).

10. Available Forms

- Sheet and plate
- Bar and rod (round, square, hexagonal)
- Wire
- Tube and pipe
- Forgings
- Fasteners
- Powder (for additive manufacturing)

11. Applicable Standards

- ASTM B265 (Sheet, Strip, and Plate)
- ASTM B348 (Bars and Billets)
- ASTM B381 (Forgings)
- ASTM F1472 (Medical Implants)
- AMS 4911 (Aerospace Sheet)
- AMS 4928 (Aerospace Bars)
- ISO 5832-3 (Medical)