

# Grades for Medical and Cryogenic Applications: Grade 23 (Ti-6Al-4V ELI)

## Grade 23 (Ti-6Al-4V ELI)

### Properties

Grade 23, also known as Ti-6Al-4V ELI (Extra Low Interstitials), is a specialized version of Grade 5 titanium. It has been refined for superior biocompatibility and fracture toughness, making it ideal for sensitive applications like medical implants and cryogenic vessels. With a tensile strength of approximately 860–950 MPa and excellent resistance to fatigue and corrosion, Grade 23 ensures long-term reliability. Its low interstitial element content enhances ductility and toughness at extremely cold temperatures, making it suitable for cryogenic environments.

### Machining Considerations

Grade 23 presents moderate challenges during machining, similar to Grade 5. However, the following strategies can help achieve optimal results:

- **Tooling:** Use sharp carbide tools with TiAlN (Titanium Aluminum Nitride) or TiCN (Titanium Carbonitride) coatings, as these coatings enhance wear resistance and heat minimization.
- **Cutting Parameters:**
  - Cutting speeds should be kept moderate at around 30–70 m/min to manage heat buildup.
  - Low feed rates help achieve smooth finishes while maintaining tool life.
- **Coolant:** Flood cooling is essential during machining to prevent overheating and material smearing. High-pressure coolant systems can further enhance performance.
- **Chip Control:** Employ chip breakers for efficient chip evacuation, as titanium tends to produce long, stringy chips.
- **Finishing Passes:** Conduct final passes with fine tools to achieve the precision and surface finish required for medical and cryogenic applications.

## Applications

The unique properties of Grade 23 make it highly sought after for both medical and industrial applications requiring exceptional toughness, reliability, and biocompatibility:

- **Medical Implants:**
  - Orthopedic devices, such as joint replacements and bone screws.
  - Dental implants due to its compatibility with human tissue.
- **Cryogenic Equipment:**
  - Storage tanks and pressure vessels designed for extremely low temperatures.
- **Aerospace:**
  - Components exposed to high stress and variable temperatures, while requiring lightweight and durable materials.
- **Chemical Processing:**
  - Environments where corrosion resistance and fracture toughness are paramount.

## Summary Table

Characteristic	Details
Tensile Strength	860 - 950 MPa
Key Features	Superior biocompatibility, excellent fracture toughness, high durability at cryogenic temperatures
Machining Challenges	Heat management, chip control, and achieving smooth finishes
Recommended Tools	Carbide tools with TiAlN or TiCN coatings; high sharpness
Cutting Speed	Moderate (30 - 70 m/min)
Primary Applications	Medical implants, cryogenic storage vessels, aerospace components, chemical processing equipment

Grade 23's unique combination of strength, biocompatibility, and durability makes it an indispensable material for high-performance and precision-demanding industries. By following optimized machining strategies, manufacturers can confidently produce components that meet the rigorous standards of medical, aerospace, and cryogenic applications.

