# Titanium Grade 1 (Commercially Pure - Softest) Material Specifications

## 1. Overview

Titanium Grade 1 is the softest and most ductile of all commercially pure titanium grades. It has the lowest strength but offers the highest formability, corrosion resistance, and impact toughness. Grade 1 is often chosen when maximum workability and superior corrosion resistance are more important than strength.

This grade contains the lowest levels of interstitial elements (oxygen, nitrogen, carbon, and iron) among the four commercially pure titanium grades (Grades 1-4), which accounts for its excellent ductility and formability characteristics.

## 2. Chemical Composition

| Element | Content (%) |
|---|---|
| Titanium (Ti) | Balance (>= 99.5%) |
| Iron (Fe) | <= 0.20% |
| Oxygen (O) | <= 0.18% |
| Carbon (C) | <= 0.08% |
| Nitrogen (N) | <= 0.03% |
| Hydrogen (H) | <= 0.015% |
| Other Elements (each) | <= 0.10% |
| Other Elements (total) | <= 0.40% |

## 3. Mechanical Properties

| Property | Value |
|---|---|

| | |
|---|---|
| Tensile Strength | 240 - 345 MPa (35 - 50 ksi) |
| Yield Strength (0.2%) | 170 - 240 MPa (25 - 35 ksi) |
| Elongation at Break | 24 - 30% |
| Reduction of Area | 30 - 55% |
| Elastic Modulus | 102 - 105 GPa (14.8 x $10^6$ psi) |
| Hardness (Brinell) | 120 - 160 HB |
| Hardness (Rockwell B) | 60 - 75 HRB |
| Poisson's Ratio | 0.34 |
| Impact Strength (Charpy) | 45 - 60 J |

## 4. Physical Properties

| Property | Value |
|---|---|
| Density | 4.51 g/$cm^3$ (0.163 lb/$in^3$) |
| Melting Point | 1670°C (3038°F) |
| Thermal Conductivity | 16.0 W/m.K at 20°C |
| Specific Heat Capacity | 520 J/kg.K |
| Thermal Expansion Coefficient | 8.6 x $10^{-6}$ /°C (20-100°C) |
| Electrical Resistivity | 0.54 uΩ.m |
| Magnetic Permeability | 1.00005 (non-magnetic) |

## 5. Key Characteristics

### 5.1 Superior Formability

Grade 1 titanium offers the best formability among all titanium grades. It can be easily cold formed, drawn, spun, and bent without cracking. This makes it ideal for complex shapes requiring extensive forming operations, such as deep-drawn parts and intricate architectural components.

### 5.2 Highest Corrosion Resistance

With the lowest interstitial content, Grade 1 provides marginally better corrosion resistance than other CP grades. It is completely immune to stress corrosion cracking in most environments and maintains its corrosion resistance even under severe conditions.

### 5.3 Excellent Ductility and Toughness

Grade 1 exhibits the highest ductility and impact toughness of all titanium grades. It retains excellent toughness at sub-zero temperatures, making it suitable for cryogenic applications down to -253°C (-423°F).

### 5.4 Outstanding Weldability

This grade welds easily with no loss of ductility or corrosion resistance in the weld zone. The welded joints maintain properties similar to the base metal without requiring post-weld heat treatment.

## 6. Comparison with Other CP Grades

| Property | Grade 1 vs Other CP Grades |
|---|---|
| Oxygen Content | Lowest (<=0.18%) - Grades 2-4 have higher $O_2$ |
| Strength | Lowest - Best for non-structural applications |
| Ductility | Highest - Superior forming capability |
| Formability | Best - Ideal for complex shapes |
| Corrosion Resistance | Marginally highest |
| Cost | Similar to Grade 2 |

## 7. Corrosion Resistance Details

Grade 1 titanium demonstrates excellent resistance in numerous aggressive environments:

- Seawater: Complete immunity, no pitting even in stagnant conditions
- Chlorine compounds: Resistant to wet chlorine gas and hypochlorites
- Nitric acid: Resistant at all concentrations up to boiling
- Organic acids: Excellent resistance to acetic, citric, lactic acids
- Alkaline solutions: Good resistance to sodium and potassium hydroxides

- Hydrogen peroxide: Excellent resistance at all concentrations
- Body fluids: Non-reactive, ideal biocompatibility
- Atmospheric: Outstanding resistance in industrial and marine atmospheres

## 8. Common Applications

- Architecture: Building facades, decorative panels, roofing, monuments, sculptures
- Chemical Processing: Plate heat exchangers, expansion joints, gasket-faced flanges
- Marine: Seawater piping, desalination equipment, heat exchangers
- Medical/Dental: Surgical implants, dental posts, medical devices
- Electrochemical: Anodes, cathodes, electroplating equipment
- Food Processing: Dairy equipment, brewing vessels, food-grade containers
- Jewelry: Rings, watches, body jewelry, artistic pieces
- Consumer Products: Eyeglass frames, sporting goods, premium cookware
- Cryogenic: LNG tanks, low-temperature piping systems

## 9. Fabrication Guidelines

### 9.1 Cold Forming

- Excellent cold forming characteristics
- Minimum bend radius: 1.5-2T (tighter than other grades)
- Drawing reduction: Up to 50% per pass possible
- Springback: Approximately 10-15 degrees
- Lubricants: Use appropriate titanium-compatible lubricants

### 9.2 Hot Forming

- Temperature range: 400-600°C (750-1110°F)
- Provides even better formability for complex shapes
- Heating atmosphere should be oxidizing or inert
- Scale removal required after hot forming

### 9.3 Machining

- Use sharp tools (carbide preferred)
- Cutting speeds: 50-100 m/min (160-330 ft/min)
- Maintain continuous cuts; avoid dwelling
- Apply generous coolant flow
- Positive rake angles (6-8° face, 8-10° side)

### 9.4 Welding

- All common methods: GTAW, GMAW, PAW, EBW, laser
- Filler metal: ERTi-1 or ERTi-2
- Shielding: High-purity argon (99.995%+)

- Back purging essential until below 315°C (600°F)
- Surface preparation critical - remove all contaminants

## 10. Heat Treatment

Grade 1 titanium cannot be strengthened by heat treatment. The following processes may be applied for stress relief:

- Stress Relief Anneal: 480-540°C (900-1000°F), 30-60 minutes, air cool
- Full Anneal: 650-700°C (1200-1290°F), 1-2 hours, air cool
- Note: Avoid temperatures above 870°C (1600°F) to prevent excessive grain growth

## 11. Available Forms

- Sheet and plate (0.4mm to 100mm thickness)
- Strip and foil (down to 0.025mm)
- Bar and billet (round, square, hex)
- Wire (down to 0.1mm diameter)
- Seamless and welded tubing
- Pipe (NPS sizes)
- Forgings
- Expanded mesh

## 12. Applicable Standards

- ASTM B265 - Sheet, Strip, and Plate
- ASTM B348 - Bars and Billets
- ASTM B337 - Seamless and Welded Pipe
- ASTM B338 - Seamless and Welded Tube
- ASTM B381 - Forgings
- ASTM F67 - Surgical Implant Applications
- AMS 4901 - Commercially Pure Ti Sheet
- ISO 5832-2 - Implants for Surgery
- DIN 17850 - Titanium and Titanium Alloys