Titanium Grade 2 (Commercially Pure) Material Specifications

1. Overview

Titanium Grade 2 is a commercially pure (CP) titanium that offers an excellent balance of moderate strength and superior formability. It is the most widely used grade of commercially pure titanium, often referred to as the "workhorse" of the titanium industry.

Grade 2 is unalloyed titanium with controlled amounts of oxygen and iron to achieve specific mechanical properties. It combines good corrosion resistance with reasonable strength, making it suitable for a wide range of industrial applications.

2. Chemical Composition

Element	Content (%)
Titanium (Ti)	Balance (>= 99.0%)
Iron (Fe)	<= 0.30%
Oxygen (O)	<= 0.25%
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	345 - 450 MPa (50 - 65 ksi)
Yield Strength (0.2%)	275 - 345 MPa (40 - 50 ksi)
Elongation at Break	20 - 28%
Reduction of Area	30 - 50%
Elastic Modulus	103 - 107 GPa (15 x 10^6 psi)
Hardness (Brinell)	145 - 200 HB
Hardness (Rockwell B)	70 - 85 HRB
Poisson's Ratio	0.34
Fatigue Strength	240 MPa (35 ksi) at 10^7 cycles

4. Physical Properties

Property	Value
Density	4.51 g/cm^3 (0.163 lb/in^3)
Melting Point	1665°C (3030°F)
Thermal Conductivity	16.4 W/m.K at 20°C
Specific Heat Capacity	522 J/kg.K
Thermal Expansion Coefficient	8.6 x 10^{-6} /°C (20-100°C)
Electrical Resistivity	0.56 uΩ.m
Magnetic Permeability	1.00005 (non-magnetic)

5. Key Characteristics

5.1 Corrosion Resistance

Grade 2 titanium offers outstanding corrosion resistance in a wide variety of aggressive environments. It is highly resistant to oxidizing acids, chlorides, seawater, and many organic media. The naturally forming titanium dioxide (TiO_2) passive film provides excellent protection and has the ability to self-heal if damaged.

5.2 Formability and Workability

This grade exhibits excellent cold and hot formability, making it ideal for forming, drawing, and spinning operations. It can be cold worked more easily than higher-strength titanium grades, allowing for complex shapes to be produced economically.

5.3 Weldability

Grade 2 titanium has excellent weldability using all common fusion welding methods. The weld metal and heat-affected zone retain full corrosion resistance when proper shielding procedures are followed. No post-weld heat treatment is typically required.

5.4 Biocompatibility

As a commercially pure titanium, Grade 2 is highly biocompatible and suitable for medical and dental applications. It is non-toxic, non-allergenic, and promotes excellent tissue integration.

6. Corrosion Resistance Performance

Grade 2 titanium demonstrates exceptional resistance to the following environments:

- Seawater and marine atmospheres - immune to pitting and crevice corrosion
- Chlorine gas (wet or dry) and chloride solutions
- Nitric acid (all concentrations)
- Oxidizing acids (chromic, perchloric)
- Organic acids (acetic, citric, tartaric)
- Alkaline solutions including sodium hydroxide
- Hydrogen sulfide environments
- Body fluids and biological environments

7. Common Applications

- Chemical Processing: Heat exchangers, pressure vessels, piping systems, reactor vessels, tanks
- Marine: Desalination plants, offshore platforms, shipboard cooling systems, propellers
- Power Generation: Condenser tubing, steam turbine blades, cooling systems
- Medical: Dental implants, pacemaker cases, surgical instruments, prosthetics
- Architecture: Building facades, roofing, decorative panels, sculptures
- Food Processing: Equipment for dairy, brewing, and pharmaceutical industries
- Pulp and Paper: Bleaching equipment, washers, storage tanks
- Automotive: Exhaust systems, mufflers, catalytic converter housings

8. Fabrication Guidelines

8.1 Forming

- Cold forming is possible with proper tooling and lubrication
- Hot forming recommended for severe bends (400-600°C / 750-1110°F)
- Minimum bend radius: 2.5-3T for cold forming, 1.5-2T for hot forming
- Springback is approximately 15-25 degrees

8.2 Machining

- Use sharp carbide tools with positive rake angles
- Cutting speeds: 45-90 m/min (150-300 ft/min)
- Feed rates: 0.1-0.4 mm/rev (0.004-0.016 in/rev)
- Abundant coolant flow is essential
- Avoid stops during cutting to prevent work hardening

8.3 Welding

- GTAW (TIG), PAW, and EBW are preferred methods
- Use argon or helium shielding (99.995% purity minimum)
- Filler metal: ERTi-2 or matching base metal
- Back purge all welds until cooled below 315°C (600°F)
- Clean surfaces thoroughly before welding (acetone, alcohol)

9. Heat Treatment

Grade 2 titanium is not heat treatable for strength increases. However, stress relief annealing may be performed when needed:

- Stress Relief: 480-595°C (900-1100°F), 30-60 minutes, air cool
- Full Anneal: 650-760°C (1200-1400°F), 1-2 hours, air cool or slow cool

10. Available Forms

- Sheet and plate (ASTM B265)
- Bar and billet (ASTM B348)
- Seamless and welded tubing (ASTM B337, B338)
- Pipe (ASTM B861, B862)
- Wire (ASTM B863)
- Forgings (ASTM B381)
- Castings (ASTM B367)

11. Applicable Standards

- ASTM B265 - Titanium Sheet, Strip, and Plate
- ASTM B348 - Titanium Bars and Billets
- ASTM B338 - Seamless and Welded Titanium Tube

- ASTM B861 - Titanium Seamless Pipe
- ASTM B862 - Titanium Welded Pipe
- ASTM F67 - Unalloyed Titanium for Surgical Implants
- AMS 4902 - Commercially Pure Titanium Sheet
- ISO 5832-2 - Implants for Surgery