Ti / Ti Alloys Aerospace Application Bulletin

Takeaway: Titanium and its alloys enable lightweight, high-strength, corrosion-resistant, and high-temperature-capable aerospace structures. Each alloy family offers a distinct balance of strength, ductility, fatigue resistance, and temperature capability, allowing engineers to tailor materials to specific aircraft and engine demands.

1. Commercially Pure (CP) Titanium — Grades 1–4

Role in Aerospace: Corrosion-resistant, weldable materials for non-critical or moderate-strength structures.

Grade 1 (≈240 MPa): Ductwork, ECS tubing, and non-load-bearing parts
Grade 2 (≈345 MPa): Airframe components, hydraulic lines, non-critical engine parts
Grade 3 (450–500 MPa): Structural airframe parts, engine supports
Grade 4 (≈550 MPa): Load-bearing frames, pressure vessels

Why used: Excellent corrosion resistance and formability; strength increases with oxygen content.

2. Alpha (α) & Near-Alpha Alloys

Role in Aerospace: High-temperature and cryogenic performance with excellent creep resistance.

Ti-5Al-2.5Sn: Cryogenic components, turbine blades, space systems
Ti-5Al-2.5Sn ELI: Cryogenic tanks, valves, pressure vessels
Ti-8Al-1Mo-1V: High-temperature fan blades in military jet engines

Why used: Stable α-phase provides toughness and creep resistance; not heat-treatable.

3. Alpha-Beta (α+β) Alloys

Role in Aerospace: The workhorse class—high strength, fatigue resistance, and heat-treatability.

Grade 5 (Ti-6Al-4V): 895–1000 MPa; airframes, engines, landing gear, turbine blades
Grade 5 ELI: ~860 MPa; fracture-critical components
Ti-6Al-2Sn-4Zr-2Mo-0.1Si: 950–1000 MPa; high-strength engine and structural parts
Ti-6Al-6V-2Sn: High-strength, high-temperature engine sections

Why used: Balanced α/β microstructure enables high strength, good ductility, and heat treatment flexibility.

4. Beta (β) & Near-Beta Alloys

Role in Aerospace: Ultra-high-strength alloys for heavily loaded structures.

Ti-10V-2Fe-3Al (Ti-10-2-3): Landing gear, high-load structures
Ti-15V-3Cr-3Sn-3Al (Ti-15-3): Rotors, springs, high-load components
Ti-3Al-8V-6Cr-4Zr-4Mo (Beta-C): Deep-section hardenable alloy for high-stress structures

Why used: Solution-treatable and age-hardenable; excellent cold formability and fatigue strength.

5. Titanium-Aluminum Intermetallic (TiAl)

Role in Aerospace: High-temperature turbine materials (up to ~725 °C).

Applications: Low-pressure turbine blades in commercial and military engines

Benefits: Lower density than nickel super alloys, enabling improved engine efficiency

Summary Table

Grade / Alloy	Type	Tensile Strength (MPa)	Aerospace Use
Grade 1	CP	~240	Ducts, non-structural parts
Grade 2	CP	~345	Airframe, hydraulic tubing
Grade 3	CP	450–500	Airframe supports
Grade 4	CP	~550	Load-bearing frames
Grade 5 (Ti-6Al-4V)	α+β	895–1000	Airframes, engines, landing gear
Grade 5 ELI	α+β	~860	Fracture-critical components
Ti-6Al-2Sn-4Zr-2Mo-0.1Si	α+β	950–1000	Engine & structural parts
Ti-6Al-6V-2Sn	α+β	High	High-strength engine sections
Ti-10-2-3	β	Very High	Landing gear, high-stress parts
Ti-15-3	β	Very High	Rotors, springs
Beta-C	β	High	High-stress structural components

Key Engineering Takeaways

CP Titanium: Best for corrosion resistance and formability; used in low-to-moderate strength applications.

Alpha / Near-Alpha: Superior creep resistance; ideal for cryogenic and high-temperature environments.

Alpha-Beta (Ti-6Al-4V family): Dominant aerospace alloys due to strength, ductility, and heat-treatability.

Beta Alloys: Highest strength and fatigue resistance; used in landing gear and high-load structures.

TiAl Intermetallic: Enable lighter, hotter-running turbine engines.