

FS PRECISION



Aerospace



Defense



Long Traditions for Meeting Demanding Needs

Founded in 1953, FS Precision is a leading global manufacturer of components and assemblies for the demanding applications of the aerospace industry. With certified production facilities in the USA and Taiwan, we specialize in the high precision manufacturing of Titanium investment castings. Our strength, longevity, and commitment to long-term customer value enable us to deliver quantifiable value for the highly-specialized needs of our aerospace customers.

FS Precision Advantages for Aerospace From Nose to Tail

FS Precision stands with our aerospace customers to offer them leading-edge advantages. Our commitment to quality involves more than detailed review of drawings. Our qualified Application Engineers work with our customers' Engineers early in the process to thoroughly diagnose all application requirements. Through this collaborative process, we maximize the benefits of our unique combination of capabilities:

- ▶ Turnkey Parts Supply: Machining, finishing, and assembling
- ▶ Solution-centric Service: Fast response with technical personnel
- ▶ Global Strength: U.S., Asian, and European Supply Chains
- ▶ Quality: Aerospace and ISO certifications
- ▶ Cost Savings: Melting and recycling efficiencies

FS Precision's impressive Titanium castings are used in all facets of structural aircraft and military system components including:

- ▶ Airfoils
- ▶ Engine components
- ▶ Braking systems
- ▶ Optical-sensor housings
- ▶ Rotor hubs (Helicopters)
- ▶ Flap tracks (Fighter jets)
- ▶ Ordnance and other parts (Military aircraft and missiles)



Value-Added Technologies and Services

- ▶ Rapid Prototyping
- ▶ Vacuum Arc Remelting (VAR) — Titanium
- ▶ Induction Air Melt
- ▶ Vacuum Induction Melting (VIM)
- ▶ In-house 3- and 5-Axis Computer Numerical Control (CNC) Machining
- ▶ In-house Radiographic Inspection
- ▶ Hot Isostatic Pressing (HIP)
- ▶ In-house Welding — Nadcap
- ▶ In-house Chemical Milling
- ▶ Liquid Argon SPAL™ process
- ▶ In-house Fluorescent Penetrant Inspection (FPI)

Casting makes Aerospace Better

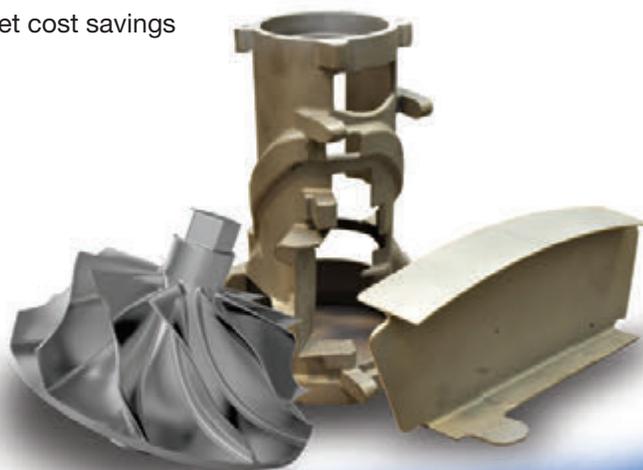
From commercial to military, FS Precision delivers First-Class castings that provide the aerospace industry with improved production rates, increased durability, and cost savings. The adaptation of HIP with investment casting allows for advancements in:

- ▶ Design complexity
- ▶ Tolerance
- ▶ Surface-finish control

The Titanium Touch

Unlike many other metals, FS Precision Titanium castings are often equal in strength to their cold-worked counterparts. Additionally, fracture toughness and resistance to crack-propagation for FS Precision's Ti castings can frequently exceed that of wrought materials. The fatigue strength of cast Titanium can be further enhanced by special processing and heat treatment. The most significant advantages to using FS Precision Titanium casting over conventional wrought Titanium are:

- ▶ Reduction of component delivery lead time
- ▶ Production of complex near-net shapes with limited machining costs
- ▶ Ability to produce early-stage development components via rapid prototyping
- ▶ Higher throughput and delivery capacity than machined components
- ▶ Overall net cost savings





Making a Good Design

In aerospace, intricate component details are critical for reliable performance. FS Precision helps you to optimize your designs through:

- ▶ Collaborating with customer Engineering and Development Teams to optimize the desired properties and intended shape
- ▶ Filling the mold as completely as possible; Weld repairs are minimized
- ▶ Avoiding unnecessary tooling complexity and cost
- ▶ Developing the casting envelope with:
 - Smooth transition from thick to thin areas
 - Generous radii and fillets

The Essential Step: Prototyping

FS Precision rapid prototyping enables designers to optimize Titanium component design in a fraction of the time and cost required for conventional wrought processing techniques. Using 3D CAD services (Unigraphics platform), we create a 3D wax pattern through:

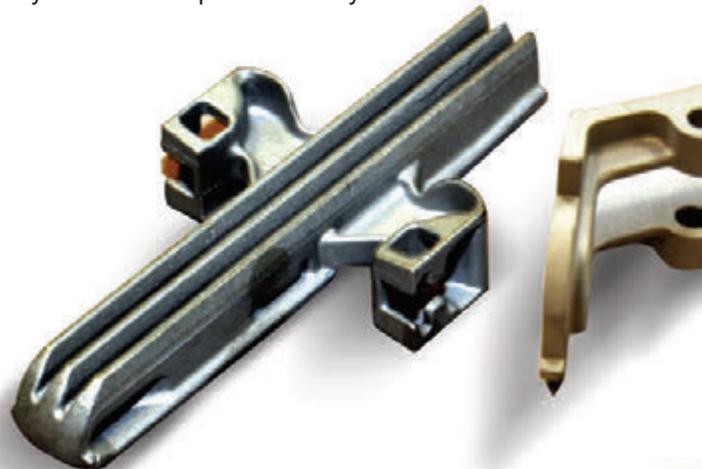
- ▶ Optical scanning
- ▶ Digitization
- ▶ Replication Engineering

Multiple design variations can be easily evaluated to facilitate comprehensive and rapid component optimization.

FS Precision Castings Pay You Dividends

FS Precision investment castings help you to be highly efficient. Our net shape and near-net shape capabilities will substantially reduce — and in many cases eliminate — costly cycle-time-intensive machining operations.

- ▶ Reduced need for post-forming — Save capital equipment and labor costs
- ▶ Less wasted material — Improve your buy-to-fly ratios and be environmentally friendly
- ▶ Reduce your CNC maintenance, repair, and cutting tool costs
- ▶ Reduce your WIP and production cycle times





The Process

Some of the most complex Titanium aerospace components are produced using the investment casting — or “Lost Wax” — process. FS Precision incorporates its own proprietary technologies into its process to ensure the maximum efficiency and repeatability with minimum cycle times repeatability with minimum cycle times:

- ▶ Generate a 3D CAD model that compensates for shrinkage and distortion during solidification. FS Precision’s “Distorting to net” is a casting art with which few others in the industry can compare.
- ▶ Create an injection mold cavity duplication of the part
- ▶ Inject a specialized wax into the cavity
- ▶ Repeat this pattern to replicate the specified number of parts needed
- ▶ Assemble the wax patterns into a cluster or tree-like structure
- ▶ Coat with multiple layers of ceramic slurries to create a shell
- ▶ Melt the wax from the shell
- ▶ Fire the ceramic to create a strong, solid shell with vacant cavities
- ▶ Pour molten Titanium alloy into the shell
- ▶ Cool and remove the ceramic shell
- ▶ Perform post-cast processing, finishing, and inspection



Aerospace Customer Success Story

Situation: Our customer needed to develop a light-weight and geometrically complex component for its Airbus A400M military transport aircraft engine.

Opportunity: Our team proposed that a substantial cost savings could be achieved by converting the engine component from stainless steel to Titanium.

Application: FS Precision’s sophisticated engineering and high-precision process capabilities enabled the formation and production of very complex geometry using Titanium alloy.

Results:

- ▶ Successful casting design and process control
- ▶ Achievement of a weight savings in excess of 40%
- ▶ Improvement of component strength and lifecycle reliability
- ▶ FS Precision helped this customer to save an estimated \$700,000 over the lifetime of this one component program alone.



Vacuum Melt Alloys

Most of the investment castings developed for aerospace applications are based on Ti-6Al-4V, which is an alpha-beta type containing 6 wt% aluminum (Al) and 4 wt% vanadium (V). Ti6-4 alloy combines high strength-to-weight ratio, toughness, and corrosion resistance which all make it an ideal alloy for aerospace castings. FS Precision produces Ti6-4 aerospace castings as well as a variety of other standard and proprietary alloys:

- ▶ Multiple variants of 6Al-4V-Ti (Grade 5)
- ▶ Commercially pure Ti
- ▶ Beta & Near-beta Ti alloys (including Proprietary FS-2S fatigue resistant alloy)
- ▶ Gamma Titanium Aluminide (γ -TiAl) alloy
- ▶ Zirconium (Zr) grades 702 (unalloyed), 704 (Zr-Sn-Cr-Fe alloy), & 705 (Zr-Cb alloy)
- ▶ Custom alloys available upon request

Alloy Advantages

FS Precision seeks the best alloys to give our customers the greatest advantages.

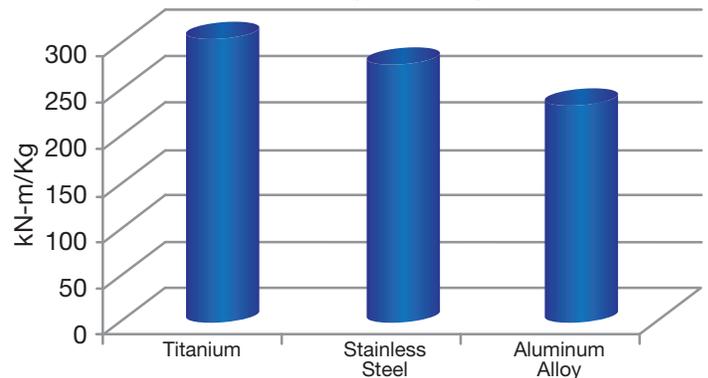
Proprietary FS-2S High Strength Cast Titanium Alloy

- ▶ Superior damping properties
- ▶ Better machinability
- ▶ Fatigue strength greater than 6Al-4V-Ti (Grade 5)

Low Cost γ -TiAl Alloy

- ▶ Lighter than conventional Ti alloys
- ▶ Higher specific strength than Inconel 713C
- ▶ Continuous operations at temperatures up to 1400°F (760°C)

Strength-to-Weight Ratio



Products

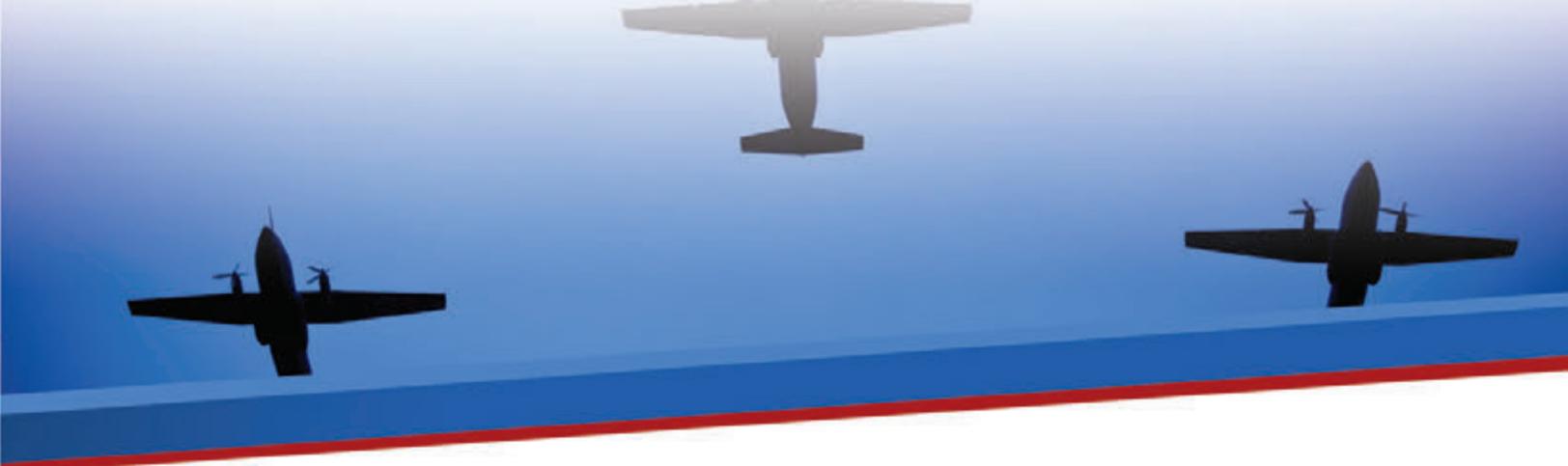
From aft mount brackets to valve bodies, FS Precision can produce the flying and non-flying parts to meet your Aerospace needs.

- ▶ Jet Engine Fan Components
- ▶ Compressor Blades
- ▶ Engine Nacelle Components
- ▶ Airframe Structures
- ▶ Airborne Weapon Systems
- ▶ Missile Components
- ▶ A world of other components that your development engineers might require or envision

Markets

FS Precision Titanium investment castings can be used in both simple and complex aerospace systems from critical structural components weighing as much as 40 kg, to small switch guards weighing less than 30 grams each. The primary aerospace applications that FS Precision serves are:

- ▶ Commercial Transport
- ▶ Regional Jets
- ▶ Military Aircraft
- ▶ Helicopters
- ▶ Launch Vehicles



Delivery Quality that is Sky High

FS Precision delivers more than industry-leading precision castings. Our flexible, friendly, collaborative, and responsive service is a hallmark of our culture that is very different from the other Titanium casting foundries you may have worked with in the past. Our materials meet ASTM, AMS, and MIL-SPEC requirements, and we maintain the following quality certifications:

- ▶ ISO 9001:2008
- ▶ ISO/TS 16949:2009
- ▶ ANSI/ISO/ASQ Q9001-2000
- ▶ AS9100C
- ▶ OHSAS-18001
- ▶ Nadcap Welding

Memberships

To keep current with ever-changing aerospace technologies and regulations, FS Precision is a member of:

- ▶ Aerospace Industries Association
- ▶ Investment Casting Institute (ICI)

Certified to Ensure the Highest Quality



General

ISO 9001:2008

Aerospace

ANSI/ISO/ASQ Q9001-2000

AS9100:2009 Rev. C

Nadcap Welding

Automotive

ISO/TS 16949:2009





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