TiTAL®

THE VERY BEST IN CASTINGS

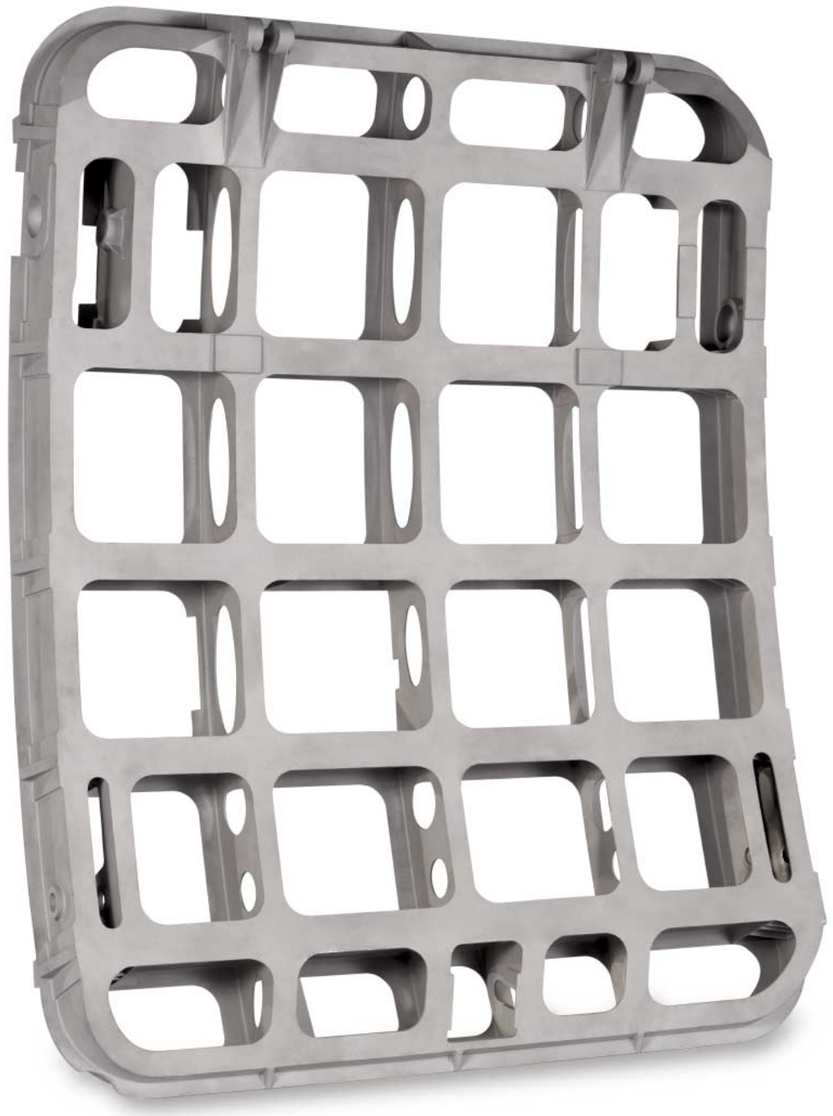
INVESTMENT CASTINGS FOR AEROSPACE

Meeting and exceeding the most complex casting requirements

We are industry leader in the manufacture of titanium and aluminium investment casting products. From our headquarters in Bestwig, Germany, we supply customers around the world in the fields of aerospace, electronics, optics, industrial and medical systems, Formula 1 racing and general motor sports.

Our core competencies and technical capabilities enable us to supply our customers with assembly-ready investment casting components. We concentrate on high growth market segments where demands for quality, complexity and product integrity are critical. Our continued success is driven by our goal to meet and exceed our customer demands throughout the supply chain. This customer focus, combined with our exceptional technical capabilities makes us an ideal development and production partner for global industry leaders. For many years we have accepted the challenge of thinking beyond the boundaries of the possible. Our company culture thrives on the continuous improvement of our products, processes and our relationships with customers, suppliers and staff.

We concentrate on high complexity titanium and aluminium investment casting products with dimensions of up to 60 inches. Our patented HERO Premium Casting® process allows us to achieve consistent above-average mechanical properties throughout every aluminium component. You, the customer, are the focus of all our activities.



Investment casting components for aerospace

The aerospace industry is a dynamic marketplace where the highest demands for precision and quality are commonplace. TITAL® understands these demands and has focused all processes and procedures to meet and exceed these important criteria. Our certifications to EN 9100 and PRI NADCAP (National Aerospace and Defence Contractors Accreditation Program) clearly underline this. In addition, TITAL® has been qualified by Airbus as the world's only investment casting component producer for supply of critical components to Casting Factor 1.0 in accordance with FAR 25.621 and JAR 25.621.

Our customer service starts at the conception phase, in the form of design workshops where our customers receive real-time product consulting. These design sessions allow an open forum for material selection, design and manufacturability discussions well in advance of final designs. Special attention is also devoted to the design-to-cost strategy to achieve specific component requirements at the minimum weight and lowest cost possible. Together with our customers we are able to achieve key program targets in design, development and part cost.

This is made possible by our staff's commitment and motivation to continuous process improvement.

Designed by Techspace Aero

Technology driving innovation

Aluminium and titanium investment castings can be found in virtually all commercial airplanes and helicopters as well as in defence projects like the Eurofighter, A400M, NH90 and the guided missiles, Meteor and Taurus. TITAL® has long participated in the industry trend where engine and air frame manufacturers request assembly-ready components. We have also developed our production system to adapt to larger and more complex investment castings. Investment castings exceeding 40" are commonplace in today's aerospace industry.

In addition, TITAL® has been very successful in positioning aluminium investment products ahead of traditional sand casting competitors. This has been achieved by making larger components with superior quality, lighter weight, reliable and repeatable processes at significantly lower costs.

Cast Frame · TiAl6V4
40.6 x 4.3 x 7.1 inches · 13.2 lbs

A400M

AFT Canopy Casting · A357
49.21 x 33.46 x 13.78 inches · 46 lbs

Eurofighter

Track A357
23.43 x 19.88 x 10.04 inches · 21 lbs

Airbus

Intermediate Casting · A357
37.8 x 37.8 x 12.2 inches · 174 lbs

GP7000

Tail rotor gearbox · A357
20.5 x 11.8 x 18.1 inches · 57.7 lbs

NH90

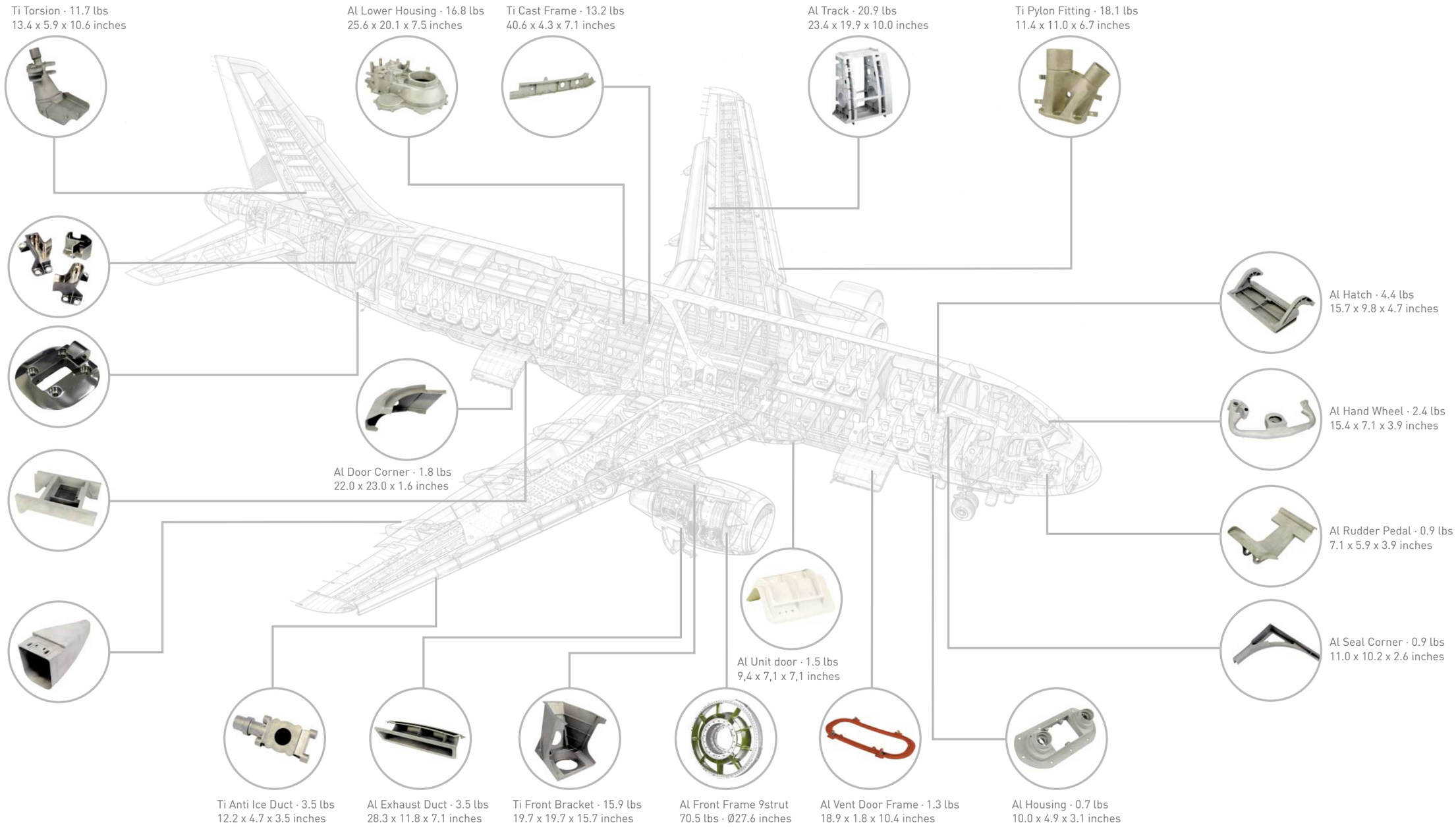
Rear Main Frame · A357
33.9 x 18.1 x 26.8 inches · 51.8 lbs

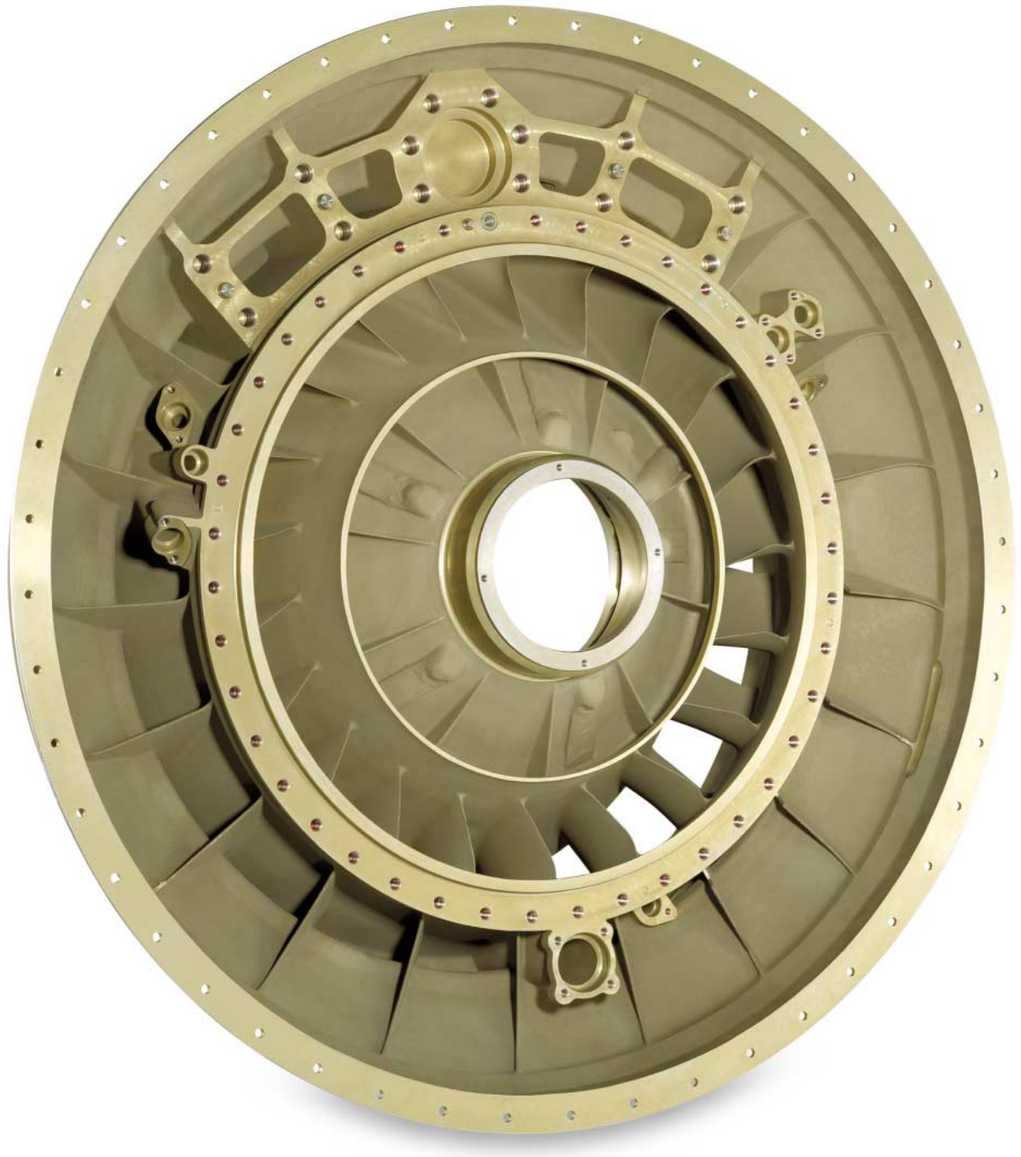
TAURUS KEPD 350

Aluminium and titanium in every aerospace platform

Titanium and aluminium investment components manufactured by TITAL® are used in virtually all areas of the aircraft's primary and secondary structures. Titanium is used for structural engine components where high temperature and strength-to-weight ratios are critical. Titanium castings are also used in the aircraft pylon where thin walls of less than 0.08 inches are important for proper weight distribution. Smaller titanium castings are used in the door frame and latch assemblies.

Pipe connections are another area for aluminium and titanium casting products and can also be found in the air conditioning system and cabin air management systems as well as in all actuation areas, e.g. in the area of airbrakes.

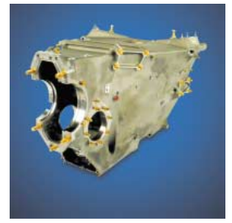




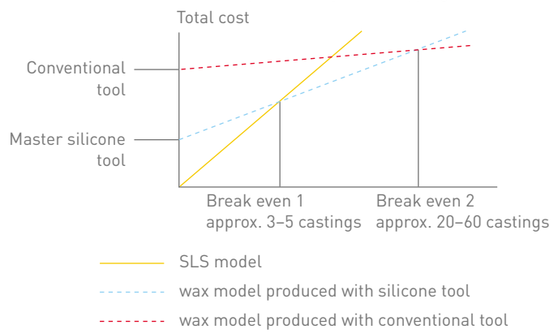
Design of a casting part using the Rapid Prototyping process

Batch sizes of one are no longer just a dream. We provide our customers with a convenient, high-speed solution for prototype and small lot production of titanium or aluminium investment castings.

The wax model needed for the casting process is replaced by a laser generated stereolithography or SLS pattern that allows our customers to significantly reduce the development time and associated costs. The rapid prototype casting goes through the same production process with no sacrifice in product quality. In addition, we have a separate production line for rapid prototype castings that allows for maximum speed and flexibility to meet the customers aggressive development timelines.

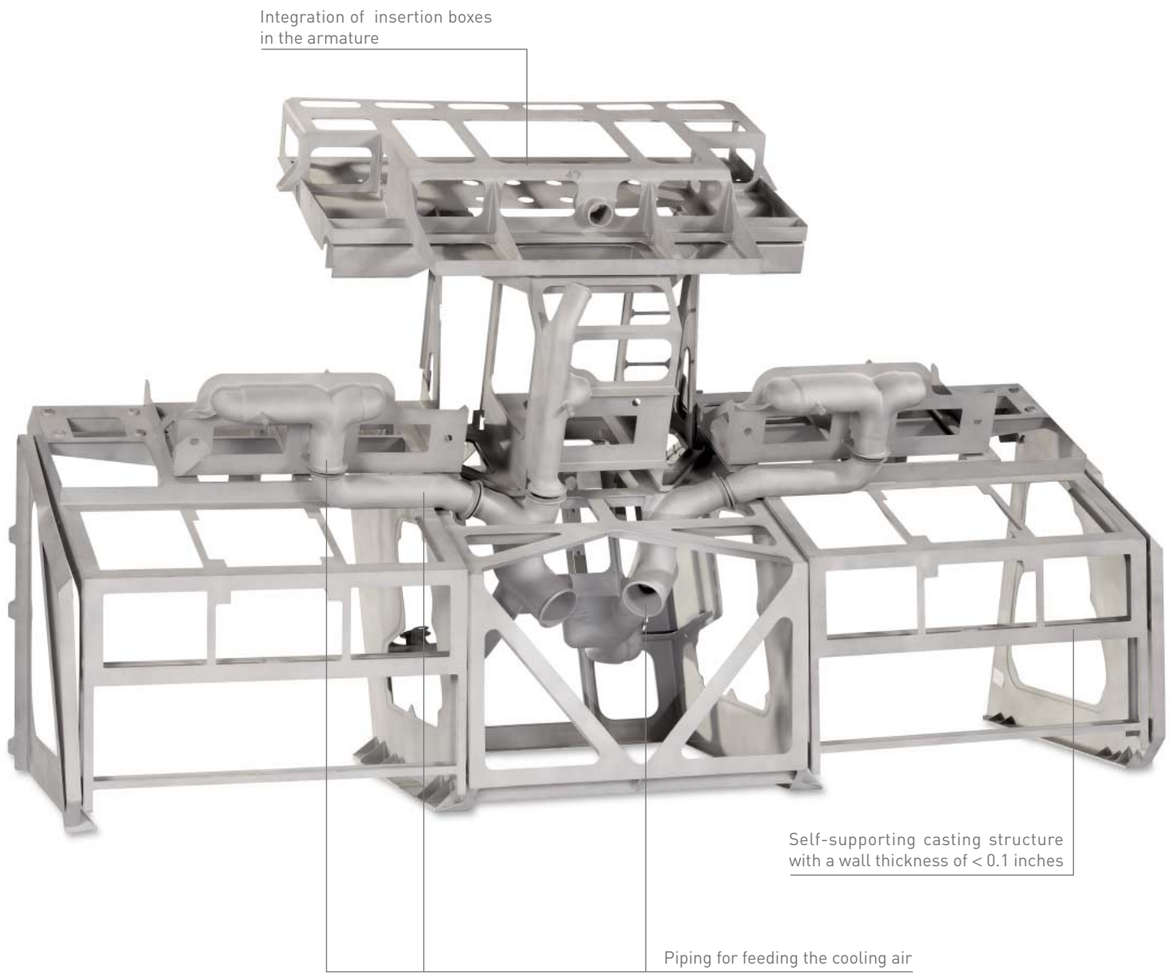


Cost comparison Rapid Prototyping / Series



Engine gearbox with turbine bearing and seven integrated feeders and waste disposal lines (Ø 0.47 inches)

Dimensions: 37.8 x 12.2 in
Weight: 174 lbs
Alloy: GF-ALSi7Mg0,6



Design to Cost - our solution in search of cost savings

Due to the wide array of product configurations and complexities available using the investment casting process, castings are truly an economical alternative to other manufacturing methods. Significant savings are available when several structural components that are either welded or mechanically connected are replaced by a single investment casting.

The component size, weight and cost can also be optimized by integrating several components into one investment casting. Savings can be achieved by the reduction of part drawings, CAD models and associated inspection costs.

With TITAL's HERO Premium Casting® process for aluminium investment castings, circuit board slots can be cast with such precision that no subsequent machining is required.

Significant savings can be achieved when castings replace large component assemblies. For example, TITAL in conjunction with the customer converted an extremely complex cockpit instrument panel assembly into a fully integrated cast component. Historically, the instrument panel was assembled from 300 single components with more than 600 rivet connections. The concurrent engineering effort reduced the 300 single components into 11 investment castings which reduced the assembly time by 90% and the product cost by 50%.

TITAL® stays in close communication with the industry through customer design and manufacturing engineers. Concurrent engineering workshops with the customers' design and engineering professionals are held on a regular basis. The TITAL® hosted "Investment Casting Seminar" is an in depth look at the titanium and aluminium casting process from start to finish with special emphasis on design-to-cost issues and solutions. Dates for the next "Investment Casting Seminar" can be found on www.tital.de.

Cost savings of the electronic circuit housing

	Sheet Metal Assembly	Investment Casting
Concept	9 Plates/Bent Components 8 Milled Parts 42 Plastic Guides	1 Casting
Weight	7.9 lbs	4.9 lbs
Elimination of Fasteners		Approx. 184 Fasteners
Overall Cost	100 %	65 %

HERO Premium Casting® - for lightweight, high-strength, complex aluminium casting parts with casting factor 1.0

The HERO Premium Casting® process for aluminium investment castings is a combination of an innovative casting process with intelligent process-engineering. The results are light-weight, high-strength complex components that successfully meet tomorrow's design demands today.

The patented HERO Premium Casting® process differs from conventional casting methods with its computer assisted control of component solidification. In the casting process, the required solidification parameters are programmed on a process computer which translates them to repeatable mechanical properties.

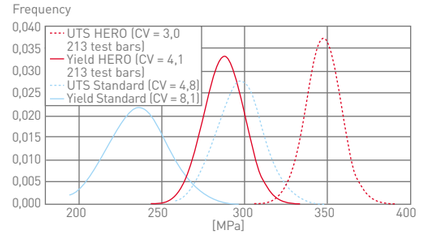
The HERO® aluminium casting process was developed at TITAL® in 1990 by a five member engineering team and is a combination of an innovative casting process with intelligent process engineering. The HERO® casting process differs from conventional casting methods by using computer-assisted component solidification. The rapid, controlled solidification achieved with the HERO® casting process produces an extremely fine metallurgical structured component that is virtually defect-free with superior mechanical properties.

The patented HERO Premium Casting® process also leads to stable and predictable shrinkage which allows TITAL® to meet our customers toughest dimensional requirements.

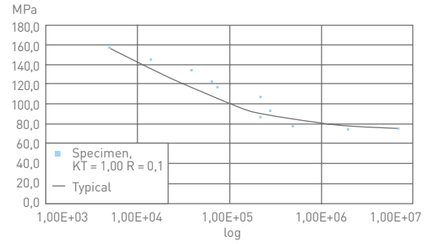
Cost-savings throughout the value added chain by:

- Weight reduction by the use of Casting factor 1.0
- Minimum variation of shape and positional tolerances
- High casting quality
- Reduced risk of latent defects
- Automated processes
- Monitored preventative quality assurance
- Reduction of inspection costs
- Reduction of machining costs.

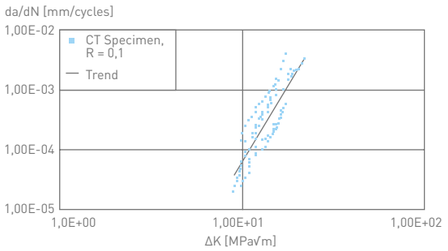
TITAL® A357 Gaussian Distribution of Static Properties, HERO Premium Casting® and Standard Casting



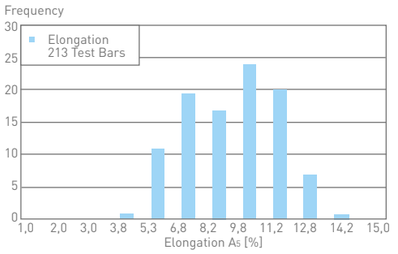
TITAL® A357 HERO Premium Casting® Fatigue Properties



TITAL® A357 HERO Premium Casting® Crack Propagation



TITAL® A357 HERO Premium Casting® Elongation



Highest customer demands are met with titanium investment castings

TITAL® produces titanium investment casting parts with a component size of up to 60 inches and part weight up to 661 pounds for all industry leaders in the European aerospace industry. TITAL® specialized in casting the titanium alloys TiAl6V4 and TiAl6Sn2Zr4Mo2 and produces cast parts using centrifugal or gravity pouring processes depending on the size.

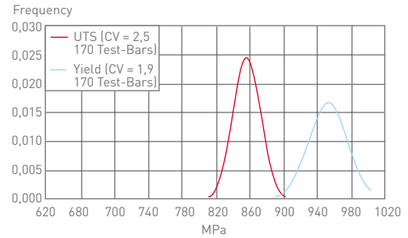
In 2008, Airbus Germany approved TITAL® to manufacture titanium cast parts with a Casting Factor of 1.0 for the A380 aircraft. This approval has been preceded by component tests in order to determine the coefficients of variation on TiAl6V4 casting parts. This included the investigation of the influence of chemistry, weld repair, as well as the level of discontinuities with regard to the variability of static and mechanical properties.

TITAL® verifies the compliance to required mechanical properties through regularly scheduled customer specific component testing. Dynamic properties like fatigue resistance and crack propagation are being monitored in addition to static properties like yield strength, tensile strength and elongation.

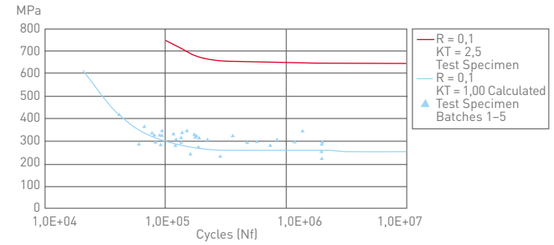
The casting process is a superior alternative to machining and saves precious raw materials and the final result particularly with titanium components is more cost efficient than components machined from raw material. The cost savings achieved when using the near-net-shape investment casting for titanium components are so substantial that the conversion costs from machining to castings are quickly amortized. In addition, for big and complex assemblies many functions can be integrated into one single casting which saves additional weight and assembly costs.

In 2008 TITAL® became involved in the development of state-of-the-art titanium casting technology. Together with renowned universities and research institutes TITAL® investigates production technologies for more efficient casting processes of the intermetallic alloy γ-TiAl. γ-TiAl has a density of 0.14 lbs/inches^3 and is 10 % lighter than conventional titanium alloys. Besides the advantage in weight γ-TiAl is heat-resistant and perfectly suited for use in turbine blades in aircraft engines.

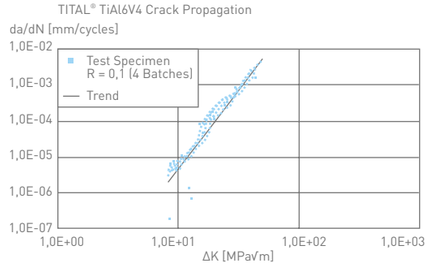
TITAL® TiAl6V4 Gaussian Distribution Static Properties



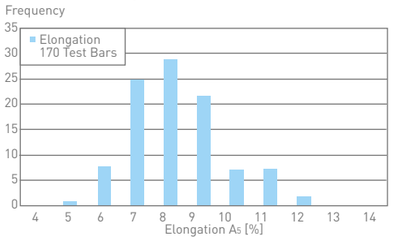
TITAL® TiAl6V4 Open Hole Fatigue Properties

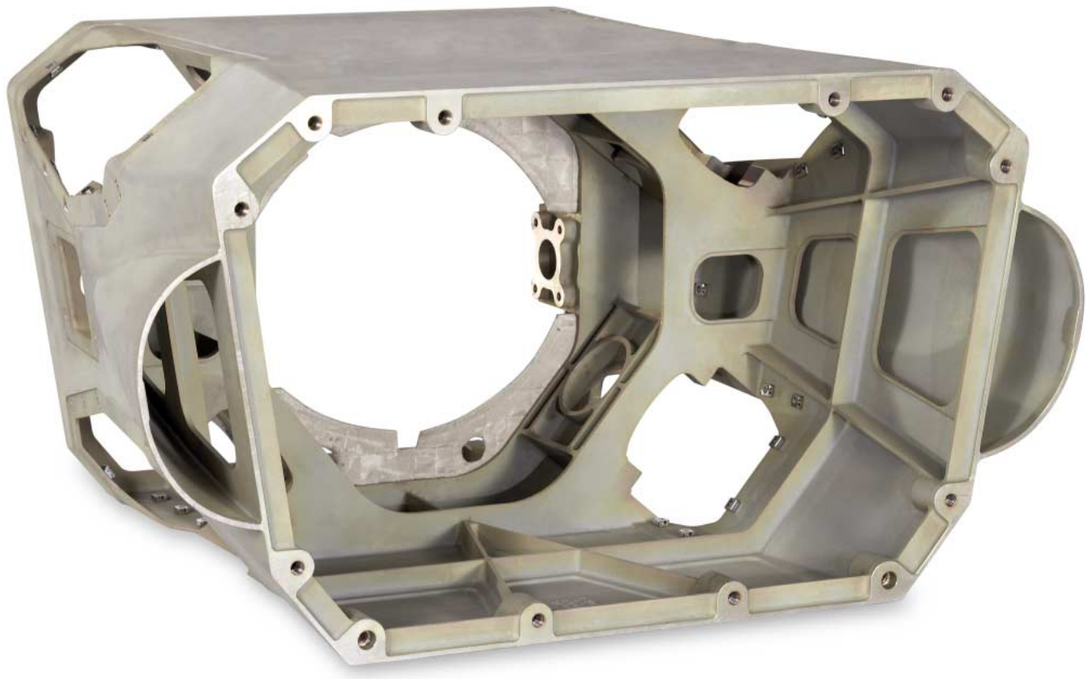


TITAL® TiAl6V4 Crack Propagation



TITAL® TiAl6V4 Elongation 170 Test Bars

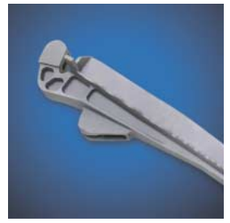




Ready for Assembly: Cost savings with ready for assembly casting components

For many years TITAL® has offered its clients the delivery of casting parts ready for assembly. Depending on the customer's requirements the casting parts are delivered directly to the production line including mechanical finishing, surface treatment and, if necessary, mounted purchased parts like rivet nuts, linkages or bolts.

When purchasing machined complete and ready for assembly products our customers avoid costly management of parts and supplies and administrative costs are reduced along with supplier base reductions. The share of castings ready for installation at TITAL® has grown strongly and will prevail as the norm in the future. TITAL® has laid the foundations to continue supporting this trend.



Concurrent Engineering: Cost advantages from conception to production

The TITAL® engineering team makes 100% of it's casting technology expertise available to our customers to find the best engineering and cost effective solutions. The concurrent engineering and joint product development process is key to maximum cost savings along the entire product value chain.

As a project moves from development into production, TITAL® assembles a cross-functional team from Sales, Engineering, Quality and Manufacturing to ensure a smooth and seamless product transition. Customer communication is a constant priority through-out the transition and becomes permanent in the production manufacturing environment.

As an example of the concurrent engineering process, a tail rotor gearbox was converted from an aluminium sand casting to an aluminium investment casting. This project resulted in significant cost savings and a weight reduction of more than 20%.

Contact us – we are looking forward to your challenges!

Materials

Aluminium-Casting-Alloys

Alloy	Material designation	Chemical composition in %											Quality-grade	Mechanical characteristics at 20 °C				Wall thickness	Heat treatment condition	Limits for technical use**	Corrosion resistance	Resistance to		Machin-ability	Electrical conductivity	Thermal conducti-vity	Coefficient of thermal expansion	max. dimension of parts l x b x h other dimensions on request	max. Weight
									Other													Climatic influence	Sea water						
		Si	Fe	Cu	Mn	Mg	Zn	Ti	Be	each	total	Al		Rp0,2 MPa min.	Rm MPa min.	A5 % min.	hardness HB min.	mm		°C					m/(Ω · mm²)	W/(K · cm)	10^{-6} · mm/(mm · K) 20 °C – 100 °C	mm	kg
GF-AlSi7Mg0,6 A357	EN-AC-42200 DIN EN 1706	6,5 7,5	0,20	0,20	0,10	0,40 0,70	0,10	0,04 0,20	0,07	0,05	0,15	rest		240	290	2	80	general	T6									
	Al-C-42201 EN 3125*												critical areas	250	310	5	85	< 3	T6									
														240	300	4	85	3-6	T6									
	WL 3.2384 Teil 3	6,5 7,5	0,20	0,20	0,10	0,40 0,70	0,10	0,04 0,20	0,07	0,05	0,15	rest		240	300	3	85	6-12	T6									
	AMS-A-21180													240	290	2	85	12-18	T6									
	DAN 2000 Teil 4												other areas	230	290	3	85	< 3	T6	max. 100	B	A	B	B	21-32	1,5-1,8	22	1000 x 1000 x 600	50
														220	280	3	85	3-6	T6									
														220	270	3	85	6-12	T6									
														220	260	2	85	12-18	T6									
	***Hero Premium Casting®	6,5 7,5	0,20	0,20	0,10	0,40 0,70	0,10	0,04 0,20	0,07	0,05	0,15	rest	all areas	270	330	3	85	low effect	T6									
GF-AlSi5Cu1,2Mg C355	AMS 4215	4,5 5,5	0,20	1,0 1,5	0,10	0,40 0,60	0,10	0,20	-	0,08	0,15	rest	general	193	241	2	80	up to max. 10	T6	max. 150	C	C	C	B	19-22	1,5-1,6	22,4	500 x 300 x 250	20
GF-AlCu5Ni1,5 MnSbCoTiZr	WL 3.1754 Teil 1	0,30	0,50	4,5 5,5	0,20 0,30	-	-	0,15 0,25	-	Ni 1,3 1,8			critical areas	160	200	1	80	up to max.10	T6									
RR350										Zr 0,10 0,30			other areas	150	190	1	80		T6									
										Co 0,10 0,40			critical areas	130	185	1	-	up to max. 10	T9	max. 180	D	D	F	B	19-23	1,4-1,6	22,5	300 x 300 x 300	15
										Sb 0,10 0,40																		
										0,05	0,15	rest	other areas	130	180	1		up to max. 10	T9									
GF-AlCu4TiMg(Ag) A201	AMS 4229	0,05	0,10	4 5	0,20 0,40	0,15 0,35	-	0,15 0,35	-	Ag 0,4 1,0			critical	345	415	3	90	up to max. 10	T7	max 150	D	D	F	B	27-32	1,5-1,8	19,3	150 x 150 x 150	5
										0,03	0,1	rest	uncritical	330	385	1,5												

Titanium-Casting-Alloys

Alloy	Material designation	Chemical composition in %														Mechanical characteristics at 20 °C			Max. service temperature	Weldingability	Machinability	Electrical conductivity	Thermal conducti-vity	Coefficient of thermal expansion	max. dimension of parts l x b x h other dimensions on request	max. Weight
												Other														
		O_2	N_2	H_2	Fe	C	Al	V	Sn	Zr	Mo	Si	each	total	Ti	Rp0,2 MPa min.	Rm MPa min.	A5 % min.	°C			m/(Ω · mm²)	W/(K · cm)	10^{-6} · mm/(mm · K) 20 °C – 600 °C	mm	kg
GF-TiAl6V4	EN 3352 WL 3.7264 ASTM B 367-83 Grade C5 MIL-T-81915 Type III AMS 4992 BMS 7-310 MSRR 8670 EMS 54914 MTS 1046	0,25	0,05	0,015	0,30	0,10	5,50 6,70	3,5 4,5	-	-	-	-	0,10	0,40	rest	815	880	5	350	A	All reduced cutting speed and cooling, Ti and Ti-alloys can be machined without difficulty	0,58	0,071	9,3	1000 x 1000 x 600	300
GF-TiAl6Sn2Zr4Mo2	MSRR 8688	0,20	0,05	0,015	0,11	0,10	5,5 6,5	-	1,75 2,25	3,5 4,5	1,75 2,25	0,13	0,10	0,40	rest	847	930	8	450	B		-	-	-	750 x 750 x 600	150

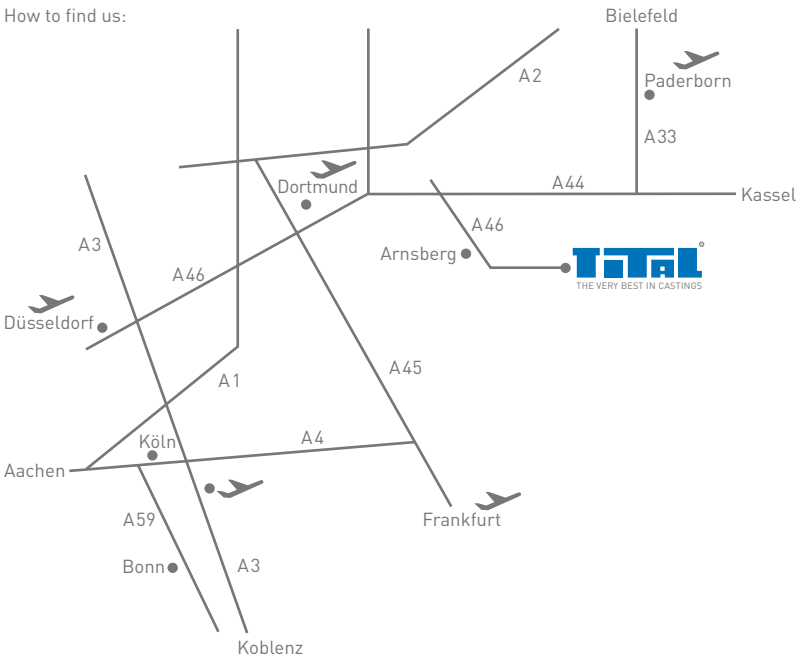
A = excellent
B = good
C = acceptable

D = poor
E = not recommandable
F = unqualified

* Developement stage
** mech. characteristics are depending on temperature and load
*** TITAL® Patent: EP 0571 703B1

AC = Air Cooling
GFQ = Gas Fan Quench

How to find us:



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