AUBERT&DUVAL

“Our ambition is to be, for our customers,
the worldwide metallurgy reference,
innovative, agile and aware of our responsibilities”

Georges Duval, President

www.aubertduval.com

a member of ERAMET

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Rods, rod-ends, and struts and Ball screws - SKF, *THSA* - Ratier Figeac

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to the choice of the Product and its consequences.

AUBERT&DUVAL

aluminum
titanium
superalloys
alloys

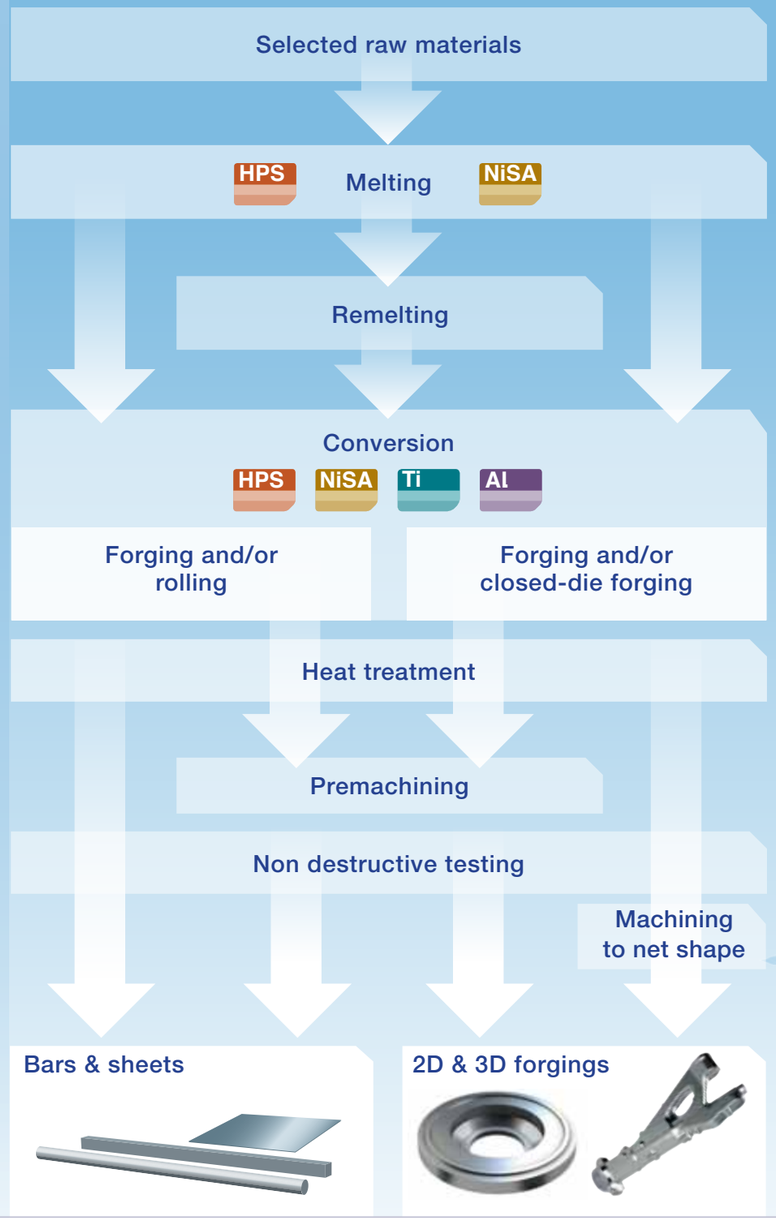
Sustainable solutions for Aerospace high integrity components

Enhancing your performance

Aubert & Duval integrated from nose to tail

Founded in 1907, shortly after the first manned flight, Aubert & Duval has continuously participated in the development of the most challenging programs. Today we partner with OEMs for the development of their newest programs: A350 XWB, A400M, Boeing 787, C 919, Superjet 100, CSeries…

Process flow



HPS
High-Performance Steels:
A range of alloyed steels with tightly controlled characteristics offering optimum value for customers.

NiSA
Nickel-based Superalloys:
A range of alloyed materials with specific resistance to very high temperatures and corrosion, the majority component being nickel.

Ti
Titanium:
Pure or alloyed titanium, combining mechanical properties and corrosion-resistance with light weight.

Al
Aluminum:
Slightly alloyed aluminum, widely used in aircraft structural parts.

Aubert & Duval, the global solution

While earlier aircraft were based on a wooden frame, both aluminum and steel have been extensively used for fuselage and wings, further complemented by composites and titanium.

In the same time, engines have also evolved, to withstand higher and higher combustion temperatures, now reaching 800°C / 1,475°F. Hence the development of Nickel-based alloys to meet these stringent requirements. In modern aircraft, Aubert & Duval offering encompasses 90% of potential metallic applications. This is achieved since we process in-house the 4 most critical materials: High-Performance Steels, Nickel, Aluminum and Titanium.

We also master the full range of melting and remelting processes: EAF, VIM, ESR, VAR and gas atomization. We use the most sophisticated open-die and closed-die forging techniques. We forge and roll bars and sheets in all kinds of alloyed steels, Nickel-alloys and Titanium-alloys.

Average split of metallic materials in civil aircraft

40% Aluminum
30% Steel
20% Titanium
10% Others

Contents

For information on the space industry please refer to the dedicated brochure. You can download it on our website.

Providing resistance at key locations

A bird is not only made of feathers! It is built on a relatively resistant, albeit supple assembly of bones and articulations which altogether connect and animate the whole body. A similar role is played by our critical parts, providing maximum safety with minimum surcharge. So, when the 'bird' is 80 m / 262 ft long and weighs 600 t, Aubert & Duval is *the* metallurgy specialist to reckon with.

Body bulkhead frames

Al FORGINGS

Slat tracks

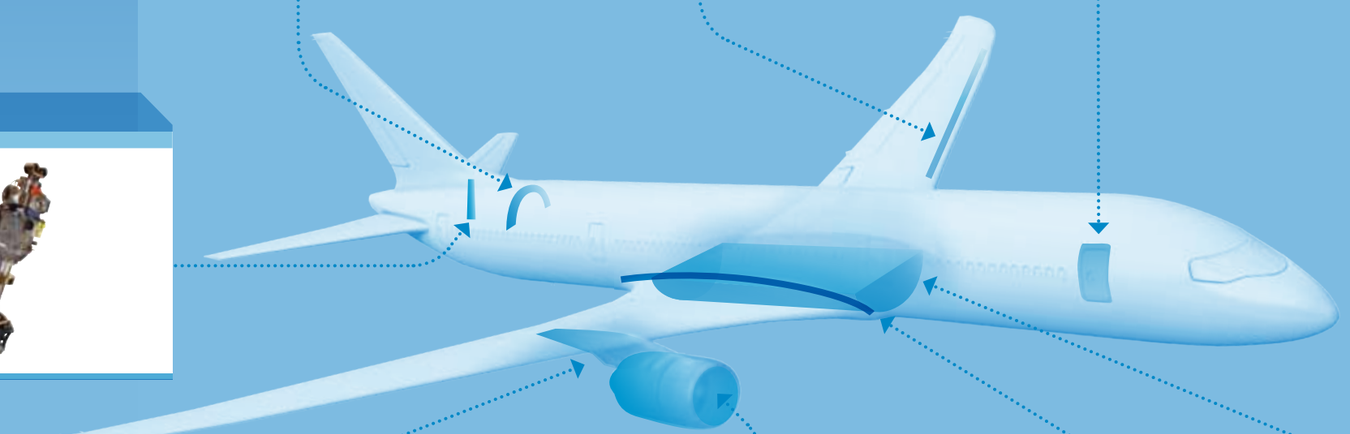
HPS FORGINGS BARS

Door frames

Ti FORGINGS

THSA

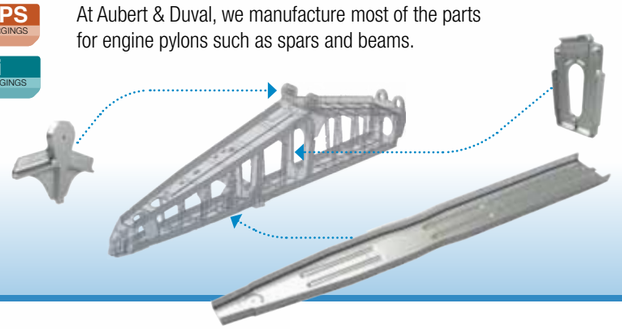
HPS FORGINGS BARS



Engine pylon parts

HPS FORGINGS
Ti FORGINGS

At Aubert & Duval, we manufacture most of the parts for engine pylons such as spars and beams.

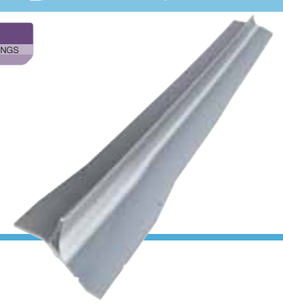


Nacelle parts

Al FORGINGS

Wing mount parts

Al FORGINGS



Wing box parts

Al FORGINGS
Ti FORGINGS

The largest closed-die forging press in the Western World

- **A powerful press…**
  - **65 KT capacity**
  - **Weighing twice the Eiffel Tower**
- **… with a high degree of precision:**
  - **Speed control to the mm per second**
  - **Centering to the mm**

Main materials

High performance steels

HPS	
A&D grade	**Common name**
MARVALX12	AMS 5928
MARVALX12H	AMS 5935
MARVAL13X	PH13-8Mo
MLX17 New	AMS 5937
CX13VDW	AMS 5719
X15U5W	15-5PH
X17U4	17-4PH
819AW	E35NCD16H
819B	35NCD16
FDMA	30NiCrMo16
MARVAL18	Maraging 250
MY19	Maraging 300
NC40M	4330
NC40SW	300M
NC310YW New	AMS 6499

Aluminum Alloys

Al
7175
7010
7050
Airware 2050 (Al-Cu-Li) New
2214
2219
2618
6061

Titanium Alloys

Ti
TA6V
Ti555.3
Ti17
Ti10.2.3
Ti6.2.4.2

Main data

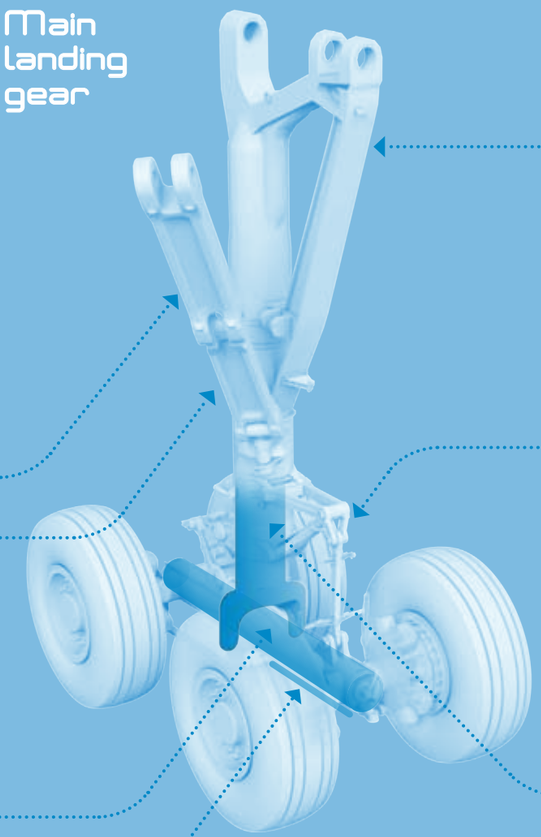
Closed-die forging parts:

- From 50 kgs / 110 lbs to 20 t
- Up to 8 m / 314 in

Utmost confidence for repeated landings

Always trying to land as softly as birds, aircraft are built to withstand exceptional situations such as wind gusts where the impact pressure can be compared to a car crashing at 160 km/h - 100 mph, this without getting damaged, and still with only 2 main landing gear. The largest part now reaches 3.5 m / 118 in, twice the size of a human being. Material choice and quality are therefore of utmost importance to meet these requirements. With the understanding that, every second, a large passenger aircraft lands somewhere in the world.

Main landing gear



Arms

Al FORGINGS
HPS FORGINGS
Ti FORGINGS

Bogie beams

HPS FORGINGS
Ti FORGINGS

Brake rods

HPS BARS

Main fittings

HPS FORGINGS
Al FORGINGS

Torque links

Al FORGINGS
Ti FORGINGS

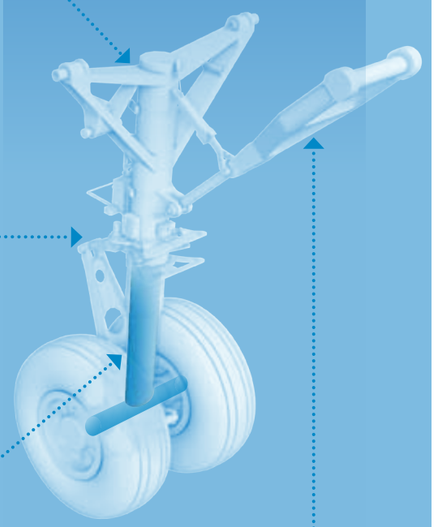
Sliding tubes

HPS FORGINGS
Al FORGINGS

Large and smaller round bars used in landing gears

We provide various types of semi-finished products for hydraulic and electric actuators, braking pads and related fittings. Namely for landing gear locking, retractation and steering, or braking torque systems.

Nose landing gear



Panels

Al FORGINGS

Main materials

Titanium Alloys

Ti
TA6V
Ti662
Ti10.2.3

Aluminum Alloys

Al
7010
7175

High performance steels

HPS	
A&D grade	**Common name**
NC40SW	300M
819AW	E35NCD16H
819B	35NCD16
MLX17 New	AMS 5937
MLX19 New	AMS 5938
MARVAL13X	PH13-8Mo
NC40M	4330
X15U5W	15-5PH

Main data

Closed-die forging parts:

- From 50 kgs / 110 lbs to 20 t
- Up to 8 m / 314 in

Meeting the most arduous requirements

No parts in the engine face as many stress challenges as rotating parts: temperatures close to 800°C / 1,475°F, corrosion from gas and humidity, resistance to shock and crack propagation, to name a few. And this for hours and hours… with minimized fuel consumption. Hence the necessity for the most advanced materials such as Nickel-based Superalloys and Titanium, and for the most demanding techniques such as open and closed-die forging.

LPC/IPC disks

Ti FORGINGS

HPC disks

NiSA FORGINGS
PM FORGINGS
Ti FORGINGS

Cone shafts

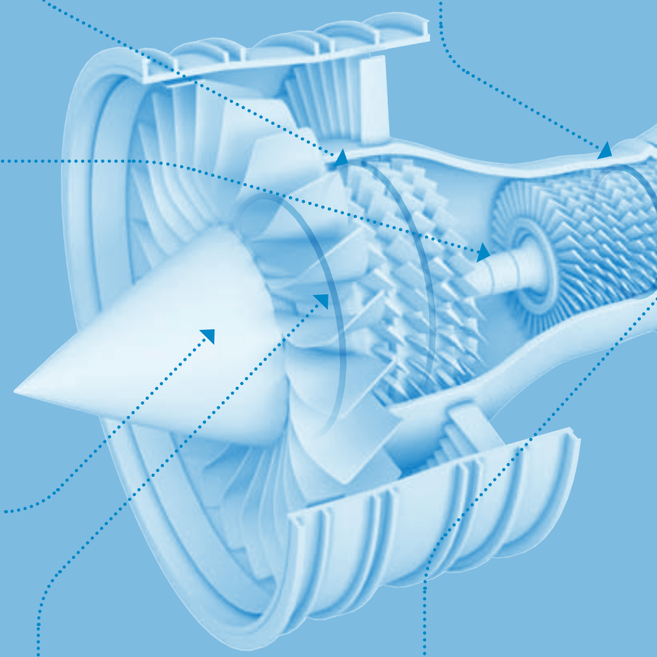
HPS FORGINGS

Compressor shafts

HPS FORGINGS BARS
NiSA FORGINGS BARS

Spinners

Al FORGINGS



Fan disks

Ti FORGINGS

Turbine shafts

HPS FORGINGS BARS
NiSA FORGINGS BARS

HPT disks

NiSA FORGINGS
PM FORGINGS

LPT disks

NiSA FORGINGS

A 100M€ investment for disks

- **The newly built 40 KT closed-die forging press is the center piece of our fully-automated EDPL (Engine Disk Production Line).**
- **Lean workshop integrating all steps from the preparation of our own billets to final ultrasonic tests.**

Main materials

High performance steels

HPS

A&D grade	Common name
GH4W	40CrMoV12
MARVAL 18	Maraging 250
ML1014	GE1014
ML340 New	X23NiCoCrMoAl13-6-3
X17U4	17-4PH
X13VDW	X12CrNiMoV12
XN26TW	A286

Superalloys

NiSA

A&D grade	Common name
PER718	INCO 718
PER72	Udimet720
PER3	Waspaloy
-	Gatorized Waspaloy
PER901	INCO 901
AD730 New	-

Aluminum Alloys

Al

2618
7050

Titanium Alloys

Ti

TA6V
Ti6.2.4.6
Ti17
Ti6.2.4.2

Powder metallurgy

PM

Powder metallurgy:
Gas-atomized alloyed steels, superalloys, or titanium powders, further hipped into semi-finished or near net-shaped products.

Main data

Closed-die forging parts:

- From 20 kgs / 44 lbs to 20 t
- **Max diameter for disks:** 1,200 mm / 47 in
- **Max length for shafts:** 4 m / 157 in

Safety, flexibility and speed

Over the decades, helicopters have become an irreplaceable transportation means. Not only for traditional military, offshore or business requirements, but more and more for police, anti-terrorism, border protection, health care and other emergency issues. For the next decade, it is predicted that approximately 16,000 turbine helicopters will be needed, the vast majority consisting of new rotorcraft for fast growing countries such as China.

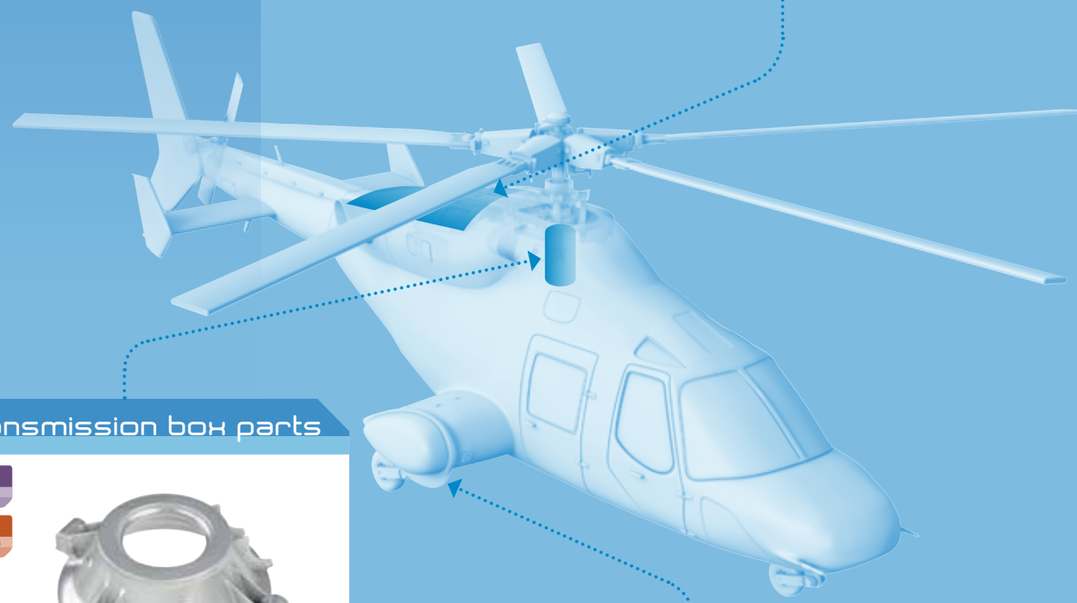
When incompatible becomes feasible

Helicopters must endure a very high torque effect in the main gear box, as well as many vibrations.

At the same time, to avoid fatigue, the same parts must offer very high hardness characteristics. This is made possible with Aubert & Duval nitriding or carburizing proprietary grades such as GKP, FND and FDG which allow to combine flexible core and hard surface.

Engine parts

HPS FORGINGS BARS



Transmission box parts

Al FORGINGS

HPS FORGINGS BARS

Main fitting

Al FORGINGS

Ti FORGINGS

High Performance Steel Bars

Available in small or larger diameters and cut-to-size, these bars are machined, then used in the main rotor, 42- and 90-degree transmission systems, main frame, and other demanding applications.

Rotor parts

Ti FORGINGS

HPS FORGINGS BARS

Al FORGINGS

Main materials

High performance steels

HPS

A&D grade	Common name
MARVALX12	AMS 5928
MLX17 New	AMS 5937
MLX19 New	AMS 5938
CX13VDW	AMS 5719
X15U5W	15-5PH
X17U4	17-4PH
819AW	E35NCD16H
GKP	AMS 6497
FND	AMS 6495
FDG	AMS 6493
GKH	32CDV13

Aluminum Alloys

Al

7175
Airware 2050 (Al-Cu-Li) New

Titanium Alloys

Ti

Ti10.2.3
TA6V

Main data

Closed-die forging parts:
- From 50 kgs / 110 lbs to 20 t
- Up to 8 m / 314 in

Max diameter for disks:
1,200 mm / 47 in

Setting the bars at their highest

Whether used in transmission, in engines or as fittings, the millions of small parts play a role as important as that of larger parts. They are generally machined from bars which can be forged, rolled or drawn. The initial quality of the selected materials is therefore key to the overall performance and safety of the aircraft. This is why our bars – round or flat – billets and sheets are designed, manufactured and tested with the same rigorous care as larger parts.

New! Titanium bars

Through its UKAD investment in a new 4,500-ton forging press, Aubert & Duval has made the first step towards the manufacturing and sales of bars made of commercially pure and alloyed titanium.

Our customers transform our bars

Rods, rod-ends and struts

These are generally fabricated out of round bars, and potentially used all across the aircraft or helicopter.

Structural fasteners and assembly components

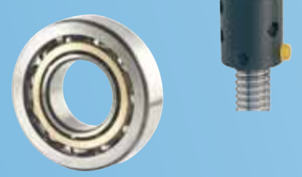
Round bars or wire for bolts, nuts, studs, pins, clamps, hinges, all kinds of fittings, and other safety parts.

Gears and shafts

While shafts are essential parts of aircraft engines, 42- and 90-degree transmissions are key to helicopters integrity. Other gears and shafts can be found in several other devices: APU, wing flaps, landing gear, pumps, etc.

Bearings and ball screws

Ball bearings, roller bearings, flange bearings are used in numerous areas, such as engines and hydraulic or electric actuators.



Main sizes

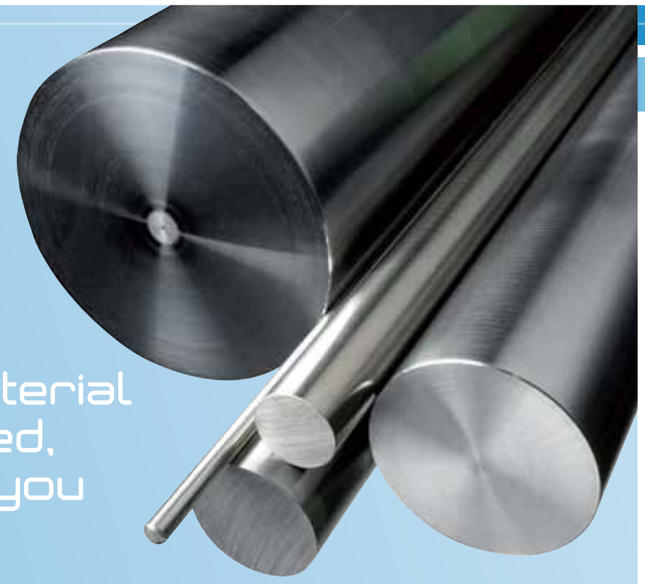
	mm	inches
Round Bars	Ø 7.5-500	Ø 0.30-20
Flat & Square Bars	T ≤ 310	T ≤ 12
Sheets	0.6 ≤ T ≤ 150	0.2 ≤ T ≤ 6

Surface conditions

- Black
- Peeled
- Ground
- Others

Heat treatment conditions

- Annealed
- Hyperquenched
- Normalized
- Heat solution treated
- Heat treated
- Aged



The material you need, where you need it

Offering state-of-the-art products would be of no use if not supported by a first-class logistics service. Aubert & Duval is constantly adapting its service offer to meet changing logistical requirements.
We are therefore able to deliver medium or small-size orders on a regular basis for call-off supplies, or rapidly when it comes to emergency shortages.

Certifications and specifications

In addition to general certifications (ISO 9001, ISO 14001, ISO 18001), our Lyon Service Center is certified to the most stringent industry specific standards: ISO 9100 (aero design and manufacturing), ISO 9120 (aero distribution) and AQAP 2110 (NATO). Also, our products are AMS, ABS and ASNA specified.

For more information on bars, please refer to our dedicated brochures.
You can download them on our website

Main materials

High performance steels

HPS

A&D grade	Common name
SCV	15CDV6
819B	35NICrMo16
NC40SW	300M
NC310YW New	AMS 6499
FADC	9310
FADH	16NICrMo13
FDG New	AMS 6493
GH4	40CrMoV12
GKH	32CrMoV13
GKP New	AMS 6497
RA50YW	M50
MARVAL18	Maraging 250
APX	431
X17U4	17-4PH
X15U5W	15-5PH
MARVAL13X	PH13-8Mo
MLX17 New	AMS 5937
MLX19 New	AMS 5938
X13VD	JETHETE M152
CX13VDW	AMS 5719
XDBD	440C
XD15NW	AMS 5925
XN26TW	A286

STAINLESS STEELS

Superalloys

NiSA

A&D grade	Common name
PER3	Waspaloy
PER75	NIMONIC 75
PER625	INCO 625
PER718	INCO 718
XSH	KC20WN

Titanium Alloys

Ti

TA6V
Ti555.3
Ti17
Ti10.2.3
Ti6.2.4.2
Ti662
TA6VEli

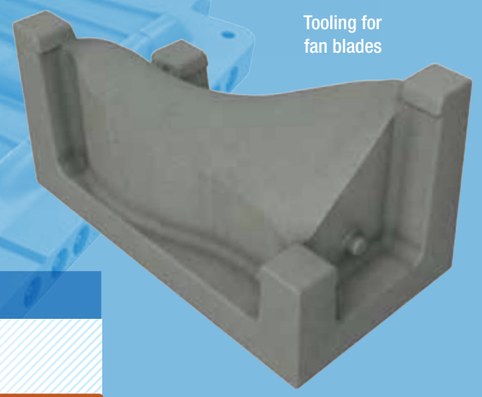
High-resistance molds for Composites and Titanium

Titanium and Composites are becoming widely used for their mechanical properties due to their weight advantage. SuperPlastic Forming (SPF) is a well known solution for titanium hollow fan blades. Molded or injected composites can be found in nearly all aerospace sectors: civil and military fixed wings, helicopters, launchers, UAVs... When it comes to the corresponding tools, their design simplicity, life expectancy and heating/cooling speed are key parameters to optimizing manufacturing costs.

Molds for SuperPlastic Forming and Hot Forming of Titanium

SuperPlastic Forming, with or without Diffusion Bonding, Hot Forming and Twist and Camber technologies are used for complex shapes in titanium such as fan blades, aircraft wing access panels, cockpit frames, nozzles, doors, engine casings... Aubert & Duval supplies the upper and lower dies, and heating press platens that endure high temperature and pressure.

Tooling for engine exhaust outlet



Tooling for fan blades

The Aubert & Duval Foundry is a dedicated high-tech and flexible workshop, integrated in a state-of-the-art steel mill. Thanks to its long experience, Aubert & Duval Foundry offers a wide range and cost efficient solutions:

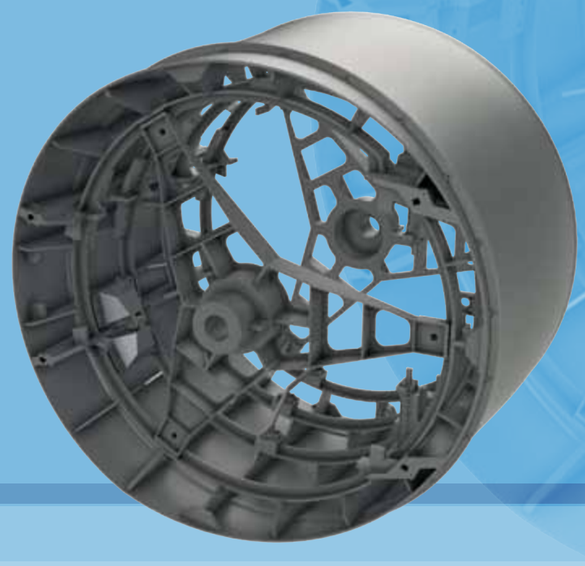
- **Large choice of high-performance steels (heat creep resistant, low thermal expansion) and nickel alloys.**
- **Single-block tools for large or extra-long dimensions: molded parts up to 12 m, with a maximum weight of 20 t.**
- **Complex designed and multi-part molds.**
- **Aerospace-level service in terms of quality, dependency and delivery.**

Molds for Composites

Aubert & Duval provides mold parts for processes such as RTM, Infusion, Vacuum Bagging…, with or without Autoclave curing… adapted for CFRP- Carbon Fiber Reinforced Polymers, honeycomb and prepreg. Our markets are structure and engine components, and helicopter blades.

Mold for helicopter blades
9 m / 12 t
354 in

Four-part mold for acoustic panel - no welding (Vacuum Bagging)
Weight: 10 t



Refractory alloys

High performance steels

HPS	
A&D grade	**Common name**
X25SPF	G-X30CrNi25-21

Superalloys

NiSA	
A&D grade	**Common name**
XN40F	G-X35NiCr40-20
XN50TF	G-NiCr27Fe16W5
XN52F	G-NiFe28Cr18
XN37TF	G-X30NiCrW36-25-4
PER101F	G-NiCo14Cr10AlTiMo

Alloys with low thermal expansion coefficient

High performance steels

HPS	
A&D grade	**Common name**
EXL036F	FeNi36
T7016	Iron-Nickel alloy casting
T7236 (37%Ni+Co)	Iron-Nickel alloy casting

Meeting our customers ever more demanding requirements

Aubert & Duval contributes to the global sustainability challenge. We work exclusively on fully and easily recyclable materials. By developing enhanced materials solutions, we allow our customers to build ever more fuel-saving aircraft. In addition, our production and warehousing sites are ISO 14001 certified.

We make sure we deliver the best product

Components and parts we produce at Aubert & Duval are critical and have to comply with the most stringent specifications. Therefore, our products go through advanced non-destructive tests:

- Magnetic particle inspection
- Fluorescent penetrant testing
- Red dye penetrant testing
- Eddy current testing
- Ultrasonic testing (including phased array)
- Radiographic testing

Many NDT are performed at different steps in the metallurgical process, from melting to the delivered parts. Aubert & Duval is accredited by COFREND to perform certification examination for level 1 and 2 in accordance with COSAC (EN 4179) and CCPA (EN473).

Fully integrated tier 1 supplier

In fine metallurgy, each process step strongly depends on how the upstream ones have been carried out. In the past, a single person would master the whole chain from raw material selection to end-testing, thus ensuring the customer with an optimized flow. Today, thanks to its integration scheme, Aubert & Duval can provide the same kind of benefits, with the volumes, speed and quality corresponding to most modern requirements. We are today able to manage the full chain from raw materials to machining.

Impro ved performance

More reliable

Customer

Cleaner and safer

Sustainability

All our handled materials are systematically recycled. This is particularly necessary while only a part of the weight bought will actually fly. We contribute directly to environmental protection through the development of ever more effective materials. These combine several of the following features:

- Resistance to high-temperature, allowing the highest-yield engines.
- Lower density, to lighten the aircraft weight, hence also decrease fuel consumption.
- High intrinsic mechanical resistance, in order to use less materials.
- Surface immediately resistant to corrosion, to avoid hazardous chemical coatings.

We already work together

- Airbus
- Aircelle
- Asco Industries
- Astrium
- AVIC
- Boeing
- Dassault
- Eurocopter
- General Electric
- Goodrich
- IHI
- ITP
- KHI
- Liebherr
- Messier-Bugatti-Dowty
- MTU
- Pratt & Whitney
- Ratier Figeac
- Rolls-Royce
- SKF
- Snecma
- Spirit
- Techspace Aero
- Turbomeca

... and many others

We invest in new solutions

Based on its own proprietary work as well as on cooperation with customers or other partners, Aubert & Duval continuously develops new processes and new products, able to face technical and economical challenges. In investment, priority has been recently given to capacity extension, so as to be fully ready for the rapid development of the aerospace industry.

New materials

HPS **ML340**

This duplex hardening grade is specifically adapted for turbine shafts operating at high temperature (450°C/840°F), and requiring 2230 MPa/323 Ksi resistance. This allows savings in weight, together with engine efficiency improvement, hence lower gas consumption.

HPS **MLX17 & MLX19**

These new precipitation hardening steels show a strength of 1700/1900 MPa (247/276 Ksi), and simultaneously keep an excellent resistance to stress-corrosion cracking. Eliminating the need for cadmium plating, it is a most environmentally friendly solution.

NiSA **AD730**

Designed to improve engine efficiency and save fuel, AD730 is a fully-innovative nickel-based superalloy. It withstands higher temperatures (700°C/1,350°F) while preserving strength, creep and fatigue resistances at a competitive cost.

Al **Aluminum-lithium alloys**

Aluminum lithium grades (such as Airware 2050) allow weight gain up to 4%. Their static properties are equivalent or higher to 7010/7050 and fatigue and rigidity properties improved more than 10%.

Our R&D expenditure represents

4.7%

of our added economic value

New facilities

Ti UKAD **Coping with Titanium demand**

Due to its density (4.5 vs 7.8 for steel) and high resistance to corrosion, titanium has become a more popular material for a variety of aerospace applications. We invested in a new 4,500 tons state-of-the-art fast forging press in the frame of UKAD*, for an amount of 47 M€. It allows the company to complement its integrated supply chain, and to market new products such as commercially pure and alloyed titanium bars.

* UKAD is a 50/50 joint-venture with UKTMP, the leading Kazakhstan titanium ore-to-ingot producer.

PM **Powder metallurgy**

With its sister-company Erasteel, Aubert & Duval is the world leader in this most promising technology. It offers a large range of grades, from alloyed steels, to Nickel and Cobalt superalloys, and even Titanium. Powders are then hipped and converted through different process routes like closed-die forging or extrusion. The whole Group operates an impressive 7 atomizing furnaces of all sizes, equipped to meet your most stringent cleanliness requirements. The latest addition – Durin™ furnace in Söderfors (Sweden) – guarantees available capacity for further development.

HPS **New VIM furnace for larger ingots**

Aubert & Duval has recently extended its vacuum melting capacity by investing in a new VIDP (Vacuum Induction Degassing & Pouring) furnace. This cutting-edge facility allows the casting of ingots of 20 t.