CIAIAC

COMISIÓN DE
INVESTIGACIÓN
DE ACCIDENTES
E INCIDENTES DE
AVIACIÓN CIVIL

Report
ULM A–007/2016

Accident involving an amateur-built YUMA ULM aircraft, registration EC-XGB, in the vicinity of the ULM airfield in Camarenilla (Toledo, Spain) on 5 March 2016

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DE ESPAÑA

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Foreword

This report is a technical document that reflects the point of view of the Civil Aviation Accident and Incident Investigation Commission (CIAIAC) regarding the circumstances of the accident object of the investigation, and its probable causes and consequences.

In accordance with the provisions in Article 5.4.1 of Annex 13 of the International Civil Aviation Convention; and with articles 5.5 of Regulation (UE) nº 996/2010, of the European Parliament and the Council, of 20 October 2010; Article 15 of Law 21/2003 on Air Safety and articles 1., 4. and 21.2 of Regulation 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future civil aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent from their reoccurrence. The investigation is not pointed to establish blame or liability whatsoever, and it's not prejudging the possible decision taken by the judicial authorities. Therefore, and according to above norms and regulations, the investigation was carried out using procedures not necessarily subject to the guarantees and rights usually used for the evidences in a judicial process.

Consequently, any use of this report for purposes other than that of preventing future accidents may lead to erroneous conclusions or interpretations.

This report was originally issued in Spanish. This English translation is provided for information purposes only.

Contents

Abbreviations

° ′ ″	Sexagesimal degrees, minutes and seconds
° C	Degrees centigrade
AESA	Spain’s National Aviation Safety Agency
CIAIAC	Spain’s Civil Aviation Accident and Incident Investigation Commission
g	Acceleration due to gravity
hPa	Hectopascals
Hp	Horsepower
kg	Kilograms
km	Kilometers
km/h	Kilometers/hour
m	Meters
m^2	Square meters
mm	Millimeters
m/s	Meters/second
N/A	Not affected
Nº.	Number
P/N	Part number
QNH	Altimeter subscale setting to obtain elevation when on the ground
s	Seconds
SE	Southeast
S/N	Serial number
TULM	Ultralight pilot license
ULM	Ultralight
V_A	Maneuvering speed
V_{NE}	Never-exceed speed
W	West

Synopsis

Owner and Operator:	Private
Aircraft:	YUMA (amateur-built)
Date and time of accident:	Saturday, 5 March 2016 at 10:15 local time
Site of accident:	Vicinity of the Camarenilla ULM airfield (Toledo, Spain)
Persons onboard:	One crew, not injured
Type of flight:	General aviation - Private
Phase of flight:	Takeoff – Initial climb
Date of approval:	2 November 2016

Summary of the event:

Shortly after taking off from the Camarenilla ULM airfield, the aircraft's engine failed, as a result of which the pilot decided to land immediately. He found a nearby crop field and landed on it without causing any damage.

He initially decided to move the aircraft over ground to the Camarenilla ULM airfield, but this would have involved traveling on a section of road, which would require permission from the traffic authority.

While waiting for said permission, he decided to try starting the engine, which turned over without any problem. He kept it running for 10 to 15 minutes at different speeds, and the engine responded satisfactorily.

In light of the problems with transporting it on land, and since the engine was running normally, he decided to fly to the Camarenilla airfield.

As soon as he took off, he again felt something wrong with the engine, though it recovered quickly. About 15 seconds later, the engine started to fail again. He moved the throttle lever without sensing any change in the engine's behavior, which stopped some seconds later.

At that point he was over an area with pine trees. He moved the controls in an effort to exit the wooded area, which he almost did, but he could not keep the right landing gear leg from striking one of the last pine trees, which destabilized the aircraft.

He landed immediately afterwards in the field adjacent to the wooded area. The landing was hard, and resulted in the nose leg breaking and in the right gear leg bending backwards. The front end of the aircraft impacted the ground, damaging the propeller and the underside of the front of the aircraft.

The pilot was not injured and was able to exit the aircraft under his own power.

The investigation revealed that this accident occurred when the engine failed during takeoff as the aircraft was flying at a low altitude over a pine forest.

The cause for the engine failure was the partial clogging of the fuel system, which limited the fuel flow to the carburetors.

The following contributed to this accident:

- The decision to fly the aircraft to the Camarenilla ULM airfield after having made a forced landing due to an in-flight engine failure.
- The lack of a bypass line in the electric auxiliary fuel pump system, contrary to the engine manufacturer's recommendation.
- The improper and repeated practice that the aircraft's owners had of never turning on the auxiliary electric fuel pump.

1. FACTUAL INFORMATION

1.1. History of the flight

The pilot took off from the Camarenilla (Toledo) ULM airfield, planning to go on a local flight. Shortly after takeoff, while still climbing, the engine started to fail. The pilot actuated the throttle lever, moving it back and forth, without noticing any change in the engine's operation.

Since the aircraft was unable to maintain altitude, he decided to land immediately in a nearby crop field and landed on it without causing any damage.

Figure 1. Front end of the aircraft

Since he was very close to the Camarenilla airfield, he decided it would be best to move the aircraft over ground, but the route to the airfield would entail traveling on a public road, which required permission from traffic officials.

He decided to try starting the engine, which turned over without any problem. He kept it running for 10 to 15 minutes at different speeds, and the engine responded satisfactorily.

In light of the problems with transporting it on land, and since the engine was running normally, he decided to fly to the Camarenilla airfield.

As soon as he took off, he again felt something wrong with the engine, though it recovered quickly. About 15 seconds later, the engine started to fail again. He moved the throttle lever without sensing any change in the engine's behavior, which stopped some seconds later.

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1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal				
Serious				
Minor				N/A
None	1		1	N/A
TOTAL	1		1	

1.3. Damage to aircraft

During the landing, the nose leg broke and the right main landing gear leg bent backwards.

The broken front leg allowed the front end of the fuselage to strike the ground. This impact caused one of the three propeller blades to break and damaged the underside of the fuselage, which affected the oil radiator and the exhaust system.

1.4. Other damage

There was no additional damage, except for that caused to the pine tree that was struck by one of the landing gear legs, though it was very minor.

1.5. Personnel information

The pilot, a 60-year old Spanish national, had an ultralight pilot license (TULM) issued by Spain's National Aviation Safety Agency (AESA), which was valid until 13 May 2016.

He also had a class-2 medical certificate that was valid until 29 October 2016.

According to the pilot's statement, he had approximately 300 hours of experience flying ultralights, of which 150 had been on the accident aircraft.

1.6. Aircraft information

1.6.1. General information

The accident aircraft is a single-engine ultralight called Yuma. The amateur-built aircraft was assembled from a kit based on an Italian design. It had serial number 10006-2477.

It has a tubular structure and aluminum skin. It has a tricycle landing gear.

Its general characteristics are as follows:

- Wingspan: 9.75 m
- Length: 6.45 m
- Wing surface area: 13.40 m^2
- Empty weight: 282 kg
- Maximum takeoff weight: 450 kg
- Fuel capacity: 85 liters
- Engine: Rotax 912UL (80 hp)
- Propeller: three blades
- Cruise speed: 150 km/h
- Never-exceed speed (V_{NE}): 210 km/h
- Maneuvering speed (V_A): 110 km/h
- Maximum speed with flaps extended: 100 km/h
- Stall speed (with flaps): 50 km/h
- Stall speed (without flaps): 55 km/h
- Maximum climb rate: 6 m/s
- Load factor: +4 g, -1.5 g

The aircraft's current owners had purchased it from the previous owner, who had also built it, in 2014.

They had no information on the assembly instructions provided by the kit manufacturer.

Days before the accident the aircraft had been weighed to determine its weight and balance. To do so, all of the fuel was removed from the tanks via the drain valve on the gascolator.

The accident flight was the aircraft's first after being weighed.

1.6.2. Maintenance records

The last maintenance inspection of the aircraft had been on 1 October 2015, at which time the aircraft had 685 hours. The following components were checked:

- Airframe.
- Structure.
- Flight controls.
- Electrical system.
- Fuel system.
- Landing gear.
- Brakes.

1.6.3. Engine

On 15 July 2015, the engine underwent a 100-hr inspection, at which time it had 671 hours. The following tasks were performed:

- Overhaul of the engine
- Oil and filter change
- Spark plug replacement
- Hose replacement
- Clamp replacement
- Replacement of springs in the exhaust system
- Cleaning and adjustment of carburetors

1.6.4. Airworthiness condition

The aircraft had a special restricted certificate of airworthiness in the private-3-normal[1] ULM category, issued on 6 July 2011.

The certificate had been renewed on 3 January 2016 by Flight Safety Office no. 6 and was valid until 2 January 2018.

1.6.5. Description of the fuel system installed on the aircraft

The fuel system on the aircraft has two wing tanks, each with a 41-liter capacity and a vent line.

Each tank has a line that goes to an auxiliary tank that is located inside the cockpit and attached to the firewall.

Each line has its own cutoff valve, which is located on either side of the cockpit, just above the doors.

Leaving the auxiliary tank is a line that crosses the firewall and goes to the gascolator. The line has a cutoff valve at the outlet of the auxiliary tank. Inside the gascolator is a filter, which has a drain valve.

At the top of the auxiliary tank is a vent line that connects the tank to the tank in the right wing (in blue in the diagram in Figure 2).

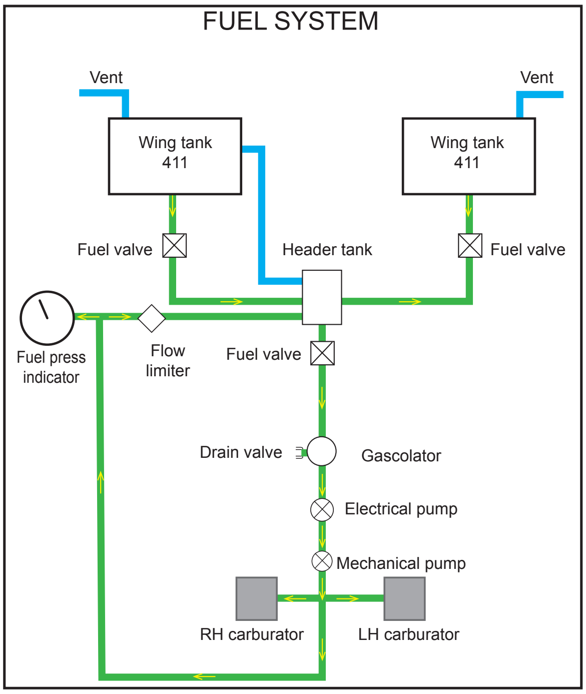


Figure 2. Diagram of the fuel system

From the gascolator, the fuel is routed through a line to the electric pump. Another line channels it from the electric pump to the mechanical pump.

At the outlet of the mechanical pump is a line that divides into three segments. Two of these branches go to the carburetors, while the third, with the excess fuel, goes to the rear of the engine housing. Before it reaches the firewall it divides in two. Both branches cross the firewall, after which one of the lines goes to the fuel

[1] Private (type of flight flown by the aircraft)-3- (aircraft used for visual flight only) normal (does not allow acrobatic flights or spins).

pressure gauge and the other to the auxiliary tank. The latter of these lines has a flow limiter at the outlet of the branch.

1.6.6. Instructions from the kit manufacturer and the engine manufacturer for the fuel system

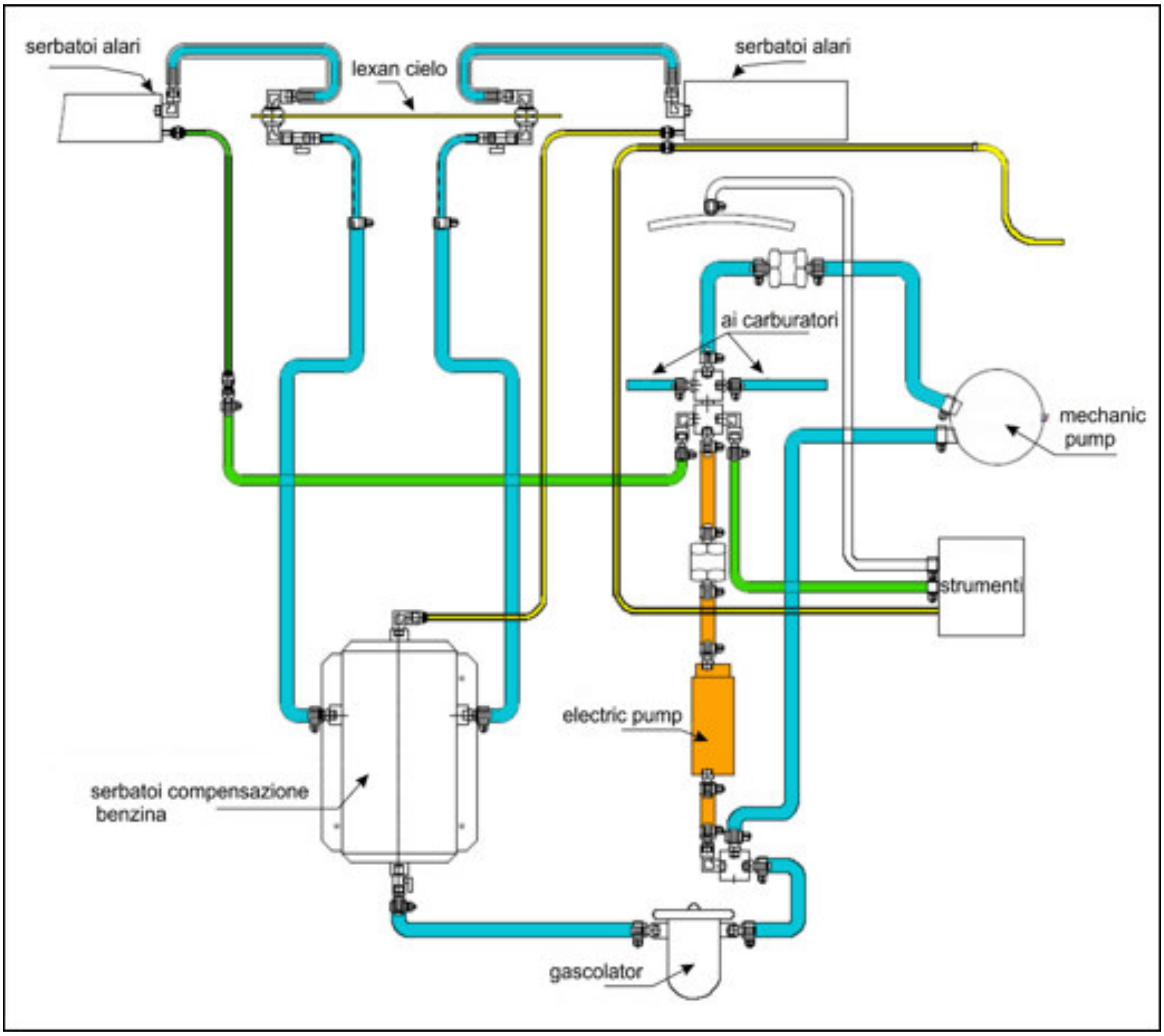
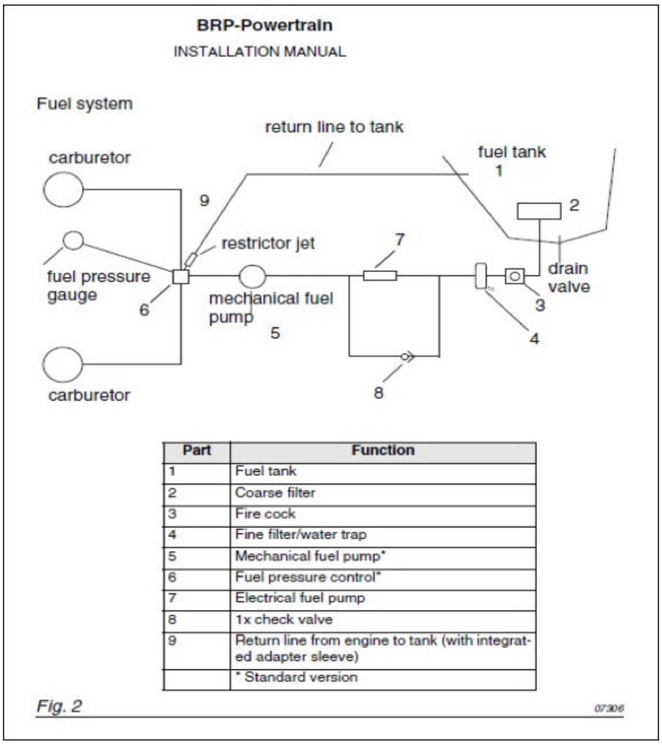


Figure 3. Diagram of the fuel system provided by the kit manufacturer, Alisport

The company that made the aircraft, Alisport, offers the option to purchase the aircraft either fully assembled or as a semi-finished kit. The kit contains some components of the fuel system, such as the fuel and auxiliary fuel tanks, drain vale, and so on, but it does not include the engine, propeller, instruments or paint.

The kit manufacturer provided the diagram for assembling the fuel system used in the fully finished aircraft it sells. This diagram is also included with the kits for buyers to use as a reference when installing the fuel system (see Figure 3).



Part	Function
1	Fuel tank
2	Coarse filter
3	Fire cock
4	Fine filter/water trap
5	Mechanical fuel pump*
6	Fuel pressure control*
7	Electrical fuel pump
8	1x check valve
9	Return line from engine to tank (with integrated adapter sleeve)
	* Standard version

Figure 4. Fuel system diagram in the Rotax 912 engine installation manual

The engine installation manual that is published by the engine manufacturer, Rotax, specifies that the part of the fuel system that goes from, and includes, the tanks and the inlet to the mechanical fuel pump is the responsibility of the aircraft manufacturer, both in terms of its design and its assembly. It adds that the fuel system must be designed in a way that ensures that the engine is supplied with sufficient fuel at adequate pressure under any operating conditions.

This same chapter, however, does include a simple diagram of a complete fuel system (see figure 4).

1.7. Meteorological information

1.7.1. General conditions

A strong low-pressure area centered over western France dominated large-scale conditions in the Iberian Peninsula. The clouds associated with the cold front, however, had stopped mainly along the coasts of Cantabria and Galicia. A small cold front associated with a secondary low-pressure zone inside the main area brought cloud cover to Spain’s Central system, but skies in the rest of the peninsula were clear. The surface chart showed cold and moderate winds from the north throughout the peninsula.

1.7.2. Conditions in the area of the accident

Though weather data for Camarenilla are not available, the information from the automatic station in Toledo, some 20 km away from Camarenilla, along with satellite and radar images and adverse weather warnings, were used to estimate the most likely weather conditions at the accident site, which were as follows:

- Wind
  - o Direction: W (270°).

   - o Speed: moderate to high, at 30 km/h.
   - o Maximum gusts: around 45 km/h.
   - o Higher instantaneous wind speeds (up to 50 or 60 km/h) and moderate low-level turbulence cannot be ruled out. The readings indicated above are average values over ten minutes.

- Visibility: Good on the surface.
- Clouds: None.
- Temperature: around 9° C.
- QNH: around 1012 hPa.
- Relative humidity: around 55%.
- Significant weather phenomena: There was no significant precipitation or adverse weather phenomena.

1.8. Aids to navigation

Not applicable.

1.9. Communications

There is no record of any messages sent by the pilot.

1.10. Aerodrome information

The aircraft took off from the Camarenilla (Toledo) ULM airfield, which is located north of the town by the same name.

It has one 500-m long, 20-m wide runway in a 05/23 orientation. The runway is made of natural compacted soil and it slopes downward from northeast to southwest.

The aerodrome's traffic circuit is to the north of the field.

1.11. Flight recorders

The aircraft was not equipped with a flight data recorder or a cockpit voice recorder, since neither was required to be installed on this type of aircraft by the applicable aviation regulations.

1.12. Wreckage and impact information

The aircraft's nose leg broke just above the fork, which allowed the nose of the aircraft to fall and impact the ground, damaging some of the engine components.

This impact also broke one of the engine's three blades. The other two were practically unaffected and had no marks indicative of rotation.

1.13. Medical and pathological information

Not applicable.

1.14. Fire

There was no fire.

1.15. Survival aspects

Not applicable.

1.16. Tests and research

1.16.1. Pilot's statement

The pilot stated that after doing the pre-flight check, he started the engine. The warm-up process lasted about five minutes, after which he started taxiing to the runway 23 threshold.

He took off from runway 23 and as he was preparing to turn into the crosswind, he felt the engine starting to fail. After moving the throttle several times and not noticing any change in the operation of the engine, he decided to land immediately, which he did on a crop field.

As for the time that elapsed between starting the engine and when it began to fail, he estimated that it was around eight to ten minutes.

Since he was very close to the Camarenilla ULM airfield, he decided to taxi there along the ground, but this would have required traveling on a short stretch of road.

He decided to try starting the engine, since if it worked he could use it to taxi. The engine started without any problem.

In light of the problems obtaining permission from traffic authorities to taxi on the road, since traffic would have to be cut off on that section of the road, he decided to keep the engine running and to try it at different speeds. Since the engine was still operating normally after running for ten minutes, he decided to try to fly back to the airfield.

The takeoff run was normal and just as he was starting the rotation, he felt something go wrong with the engine. He continued with the takeoff, and shortly afterward the engine stopped.

He was asked if he checked the fuel pressure reading, to which he replied that he had not done so on either of the two engine failures and did not know what the reading might have been.

As for the electric fuel pump, he stated that he never used it since the mechanical pump kept the fuel pressure in the green zone, and when he turned the electric pump on the pressure climbed to the high part of the green zone.

He added that he did not think to turn on the electric pump during either of the two engine failure events.

1.16.2. Inspection of the aircraft

In light of the engine failure that this aircraft had experienced before (see Section 1.18 for details), it was decided to conduct a thorough check of the fuel, air intake and ignition systems.

Although the accident had damaged the propeller and some engine components, like the oil radiator and the left exhaust, the engine proper seemed to be in good condition.

It turned freely, with no apparent resistance or abnormal noise.

Investigators were unable to do an operational test of the engine due to the damage to the oil system (oil radiator) and the exhaust. Before starting the engine, some of the engine component dimensions would also have had to be checked to ensure that the impact with the ground had not caused any internal deformations.

1.16.2.1. Fuel system

The fuel cutoff valves located above the doors were closed. The pilot stated that he closed them after the accident, adding that after the engine failure in 2014, they decided to keep these valves open at all times.

The cutoff valve located at the outlet to the auxiliary tank was open.

There was gasoline in the fuel tanks. The vents were verified to be unobstructed and performing their function correctly.

The gascolator was full of fuel, which was clean except for a small drop of water. There was some sediment at the bottom of the tank. The filter was clean.

The BING carburetor was of the constant-depression variety. The tanks in both carburetors were full of fuel, which was clean. The float valves were working properly and were actuating the stop valves.

Small particles of dirt were found in the fuel intake on the left carburetor.

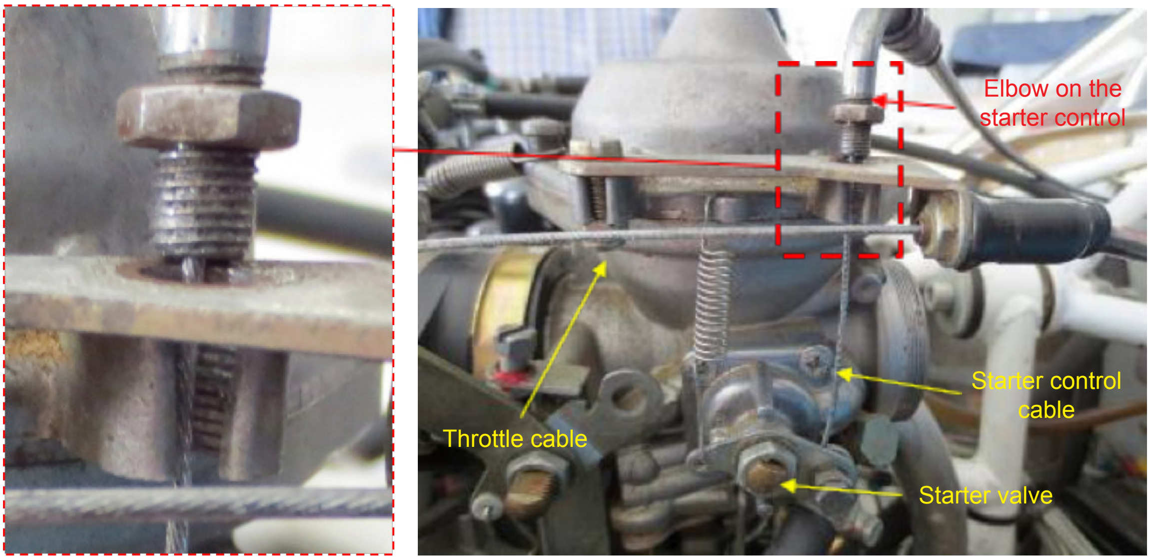


Figure 5. Photograph of the left carburetor (right). The elbow on the starter control was removed from its housing for a clearer view. See close-up in the photograph on the left.

The membranes were in good condition, with no cracks, and properly attached to their respective pistons. There was nothing to impede the movement of the pistons. The needle valve that controls fuel flow was in good condition and in its proper position. The jet was clean.

The throttle cables properly actuated the butterfly valves.

The starter valve on the left carburetor did not return to its position when the lever was released in the cockpit. An inspection of this control cable, its sheath and sleeves revealed that the elbow sleeve in the carburetor, despite being in its housing, was loose due to wear on the thread (see Figure 5), allowing it to come loose easily.

All of the fuel lines were loosened, and all were found to contain fuel. No sign was found that any of the lines was clogged.

Both the electric and mechanical pumps were verified to be operating correctly.

The fuel pressure gauge worked correctly.

Also, since the electric pump was not on during the event, a test was carried out to see if in a non-operational state it allowed fuel to flow through. This test revealed that in this condition, only a reduced amount of fuel passed through the pump.

A longer test was repeated with the pump running, during which the fuel was collected in a container. After a few seconds, sludge started issuing from the line, then a small amount of water and shortly afterwards a solid, irregularly shaped fragment some 5 mm thick emerged from the line, after which the fuel flow increased.

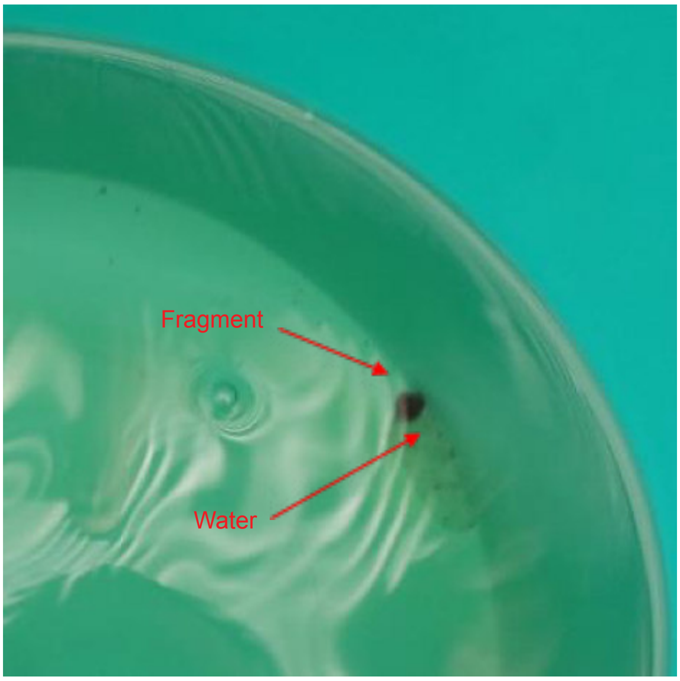


Figure 6. Fuel with a solid fragment and water

The electric pump installed in the aircraft was a Pierburg pump, P/N 7.21440.01 and S/N 98T146.

This pump model cannot be disassembled and it is not equipped with a fuel filter.

The pump was opened by cutting off its casing, which revealed this to be a vane pump.

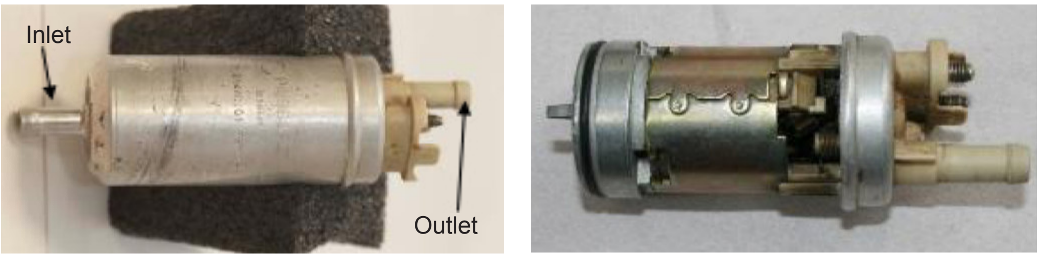


Figure 7. Photograph of the pump in its original state (left) and after part of its casing was cut off and removed (right)

When the motor is energized, the fuel is pushed by the vanes, drawing it into the body of the motor through slots (see Figure 8). The fuel flows both inside the electric motor stator and outside it (through the stator and the outer casing), cooling it. The fuel eventually flows out the pump through a line at the opposite end from the inlet.

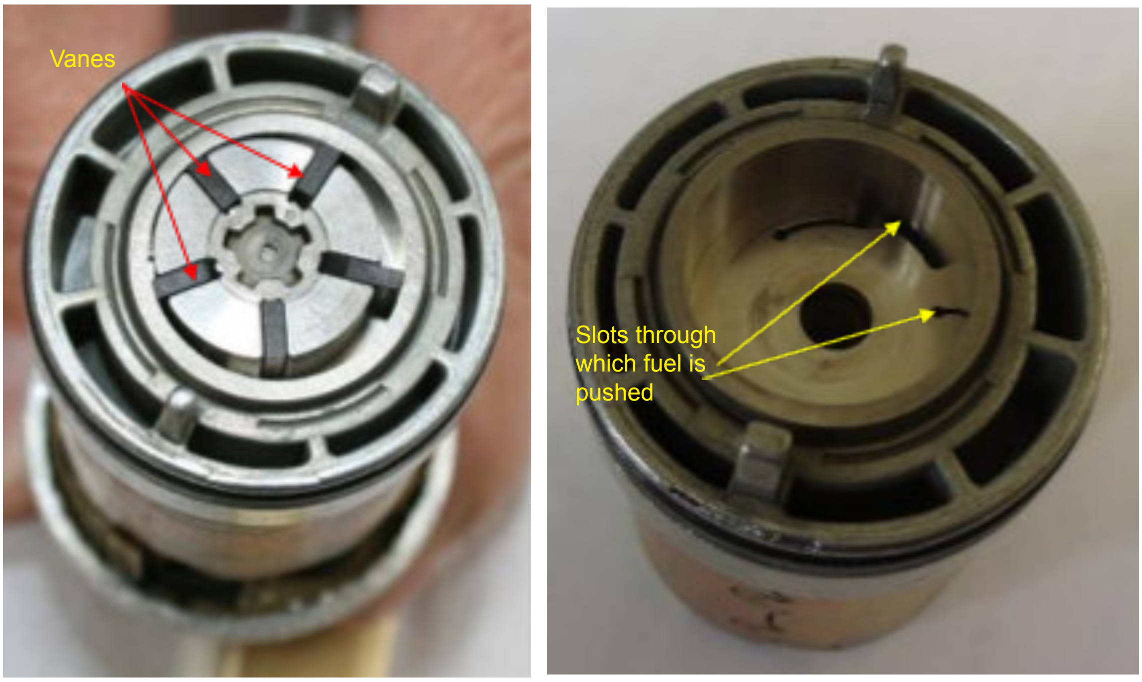


Figure 8. Close-up of the vanes (left) and the slots through which the fuel is pushed (right)

There was no dirt or foreign debris inside the pump and all of the flow passages inside the pump were free from obstructions.

1.16.2.2. Ignition system

The ignition system was checked visually and determined to be in good condition.

The spark plugs were removed. Their color was normal (indicating that the fuel mix was correct). The gap in the electrodes was 0.8 mm, which is slightly wider than normal (between 0.6 and 0.7 mm). The engine was turned manually and all the spark plugs were verified to produce sparks.

1.16.2.3. Air intake system

The air intake system is extremely simple, consisting of an air filter attached to the air inlet on the carburetor.

The filters were removed from both carburetors. They were clean and free from obstructions. The inside of the air intake passage on the carburetor was also clean.

1.17. Organizational and management information

Not applicable.

1.18. Additional information

On 6 April 2014, the aircraft suffered an accident while making an emergency landing caused by an in-flight engine failure.

That event was investigated by the CIAIAC in report ULM A-004/2014. Despite a thorough check of the fuel system and engine, the reason for the failure of the engine could not be determined.

The person piloting the aircraft during the 2014 event was not the same person who was piloting it during the 2016 event investigated in this report.

1.19. Useful or effective investigation techniques

Not applicable.

2. ANALYSIS

2.1. Analysis of the flight

The initial engine failure occurred before the aircraft reached the minimum safe altitude to make the crosswind turn.

The pilot, after seeing that the engine did not respond to any movements of the throttle, decided to land immediately. He chose a suitable field and landed without causing any damage. This indicates that the decision to land was correct.

He initially decided to move the aircraft over ground to the Camarenilla airfield, which was nearby. This decision would have been appropriate, since the aircraft had experienced an in-flight failure whose cause had not been determined, leaving open the possibility that it would reappear, as turned out to be the case.

The problems involved in moving the aircraft over land, combined with the seemingly properly functioning engine, spurred the pilot to change his mind about how to return the aircraft to the Camarenilla airfield.

The failure resurfaced as soon as he took off. The aircraft's condition was now worse than during the previous failure. It was at a lower altitude and it was over an area full of pine trees, with no clearings on which to land.

The pilot was skilled enough to leave the wooded area, though by that time the aircraft had lost most of its altitude, and with it any option to choose an area in which to land. Moreover, one of the landing gear legs struck a branch on one of the last pine trees, which destabilized the aircraft, making it even harder to land.

Although the landing was hard, the pilot was not injured and he was able to exit the aircraft under his own power.

2.2. Analysis of the engine failure

According to the description of the engine failure provided by the pilot, the initial fault resulted in a drop in engine power, without the engine coming to a stop.

The second fault started out the same as the first, though this time the engine came to a full stop.

The drop in power described by the pilot is consistent with a reduction in fuel flow or in air flow in the air intake system, or with a partial failure of the ignition system.

The inspections of the aircraft did not reveal anything unusual in the ignition or air intake systems.

In contrast, the inspection of the fuel system did reveal the presence of a partial obstruction in the electric pump that limited the amount of fuel reaching the carburetors.

The amount of fuel demanded by the engine is highest on takeoff, when the engine is supplying maximum power. It thus seems logical that if a reduction in fuel flow did occur, its effects would be more noticeable during this phase.

The solid fragment that was found in the fuel system must have been lodged inside the electric pump, since its size would not have allowed it to flow through the vanes and slots in the pump. This also indicates that the fragment was created inside the pump itself as smaller particles clumped together.

When the electric pump is turned on, it increases both the fuel pressure and the amount of fuel that flows through the pump. This can help expel the small particles that can build up in stagnant areas when the pump is not running. The fact that none of the individuals who piloted the aircraft normally turned on the electric pump could have helped the fragment found inside the pump to grow in size.

It is also a well-known fact that solid deposits build up in fuel tanks over time. These deposits usually fall to the bottom of the tank, as they are heavier than the fuel. They remain at the bottom of the tank and are not normally entrained in the fuel that leaves the tank. When all of the fuel is drained from a tank, however, this stirs the particles at the bottom, which can then be carried by the fuel.

When the fuel was drained as part of the process to determine the aircraft's weight and balance, the particles at the bottom of the tanks could have moved into the fuel system lines. Even though these lines were also drained, it is possible that some particles remained.

When these particles reached the electric fuel pump, they could have accelerated the clumping process in the pump.

2.3. Fuel system

An auxiliary fuel pump, such as the electric pump installed in the accident aircraft, should only be turned on during the most critical phases of flight: takeoff and landing. During the rest of the flight, it should be turned off.

Such a pump is normally installed in the fuel system in parallel, since this avoids forcing the fuel to have to flow through it when it is not running.

For this reason, both the aircraft manufacturer, Alisport, and the engine manufacturer, Rotax, recommend fuel systems that despite differing in their design (Alisport recommends a parallel system and Rotax a series system), both ensure the continuity of the fuel supply if the electric pump is clogged.

In the Rotax layout, this condition is achieved by installing a bypass line with a check valve that circumvents the electric pump.

An examination of the fuel system on the accident aircraft revealed that the electric pump was not installed using either of these layouts.

The assembly actually resembles the system proposed by Rotax, since the electric pump is installed in series, but differs from it by not having the bypass line.

In light of this, it may be concluded that the builder of the aircraft, which was its previous owner, installed the fuel system without adhering to the recommendations of either the kit manufacturer or the engine manufacturer.

The regulation that governs the construction of amateur-built aircraft does not contain any instructions concerning the design or assembly of the fuel systems on these aircraft. This implies that the regulation allows builders to install a fuel system that is as recommended by the kit manufacturer, the engine manufacturer, or one based on any other design, be it the builder’s or one belonging to a third party.

2.4. Flight procedures

The accident aircraft is amateur built, and was constructed from a kit that was designed and manufactured in Italy.

The kit manufacturer does not provide any flight manuals or procedures for the aircraft.

The regulation that governs the construction of amateur-built aircraft, published through the Ministry Order of 31/05/1982, also does not require the manufacturer of the aircraft to supply flight procedures. This regulation also allows the aircraft to be transferred to another owner four years after its initial registration.

Operating procedures are intended to standardize, optimize and ensure uniformity, reproducibility and consistency in the way an aircraft handles, and thus contribute to improving operational safety.

The lack of written operating procedures could lead to aircraft not being operated correctly.

This is even more so when ownership of the aircraft is transferred, since the new owner will probably lack the knowledge of the aircraft gained by the original owner, who was also its builder.

Since writing operating procedures is not a burdensome task, and since their use contributes significantly to improving the safety of operations, it seems advisable for this type of aircraft to have written operating procedures.

As a result, two safety recommendations are issued in this report, one for Spain's Civil Aviation General Directorate and the other to Spain's National Aviation Safety Agency, intended to require the manufacturers of these types of aircraft to issue written operating procedures before they are authorized to be built.

As stated by the pilot, none of its owners or pilots used the electric fuel pump, meaning it must have been idle for a long time.

The aircraft engine has an engine-driven mechanical pump, which is thus running whenever the engine is in operation. This pump is sufficient to supply the fuel needed for the engine to run.

However, in an effort to ensure the supply of fuel during critical phases of flight, namely landing and takeoff, manufacturers usually equip aircraft with an electric fuel pump.

As a result, the normal procedures contained in most flight manuals typically require turning this pump on during these critical phases of flight, and leaving it off the rest of the time.

Likewise, one of the first steps required in the vast majority of engine failure procedures is to turn on the electric fuel pump.

It is possible that turning on the electric fuel pump after the engine failure would have allowed the engine to recover.

3. CONCLUSIONS

3.1. Findings

- The pilot had a valid ULM pilot license.
- The pilot had a class-2 medical certificate that was valid until 29 October 2016.
- The pilot was sufficiently experienced in flying ultralights in general, and in particular in flying ultralights like the one involved in the accident.
- The aircraft's documentation was valid and the aircraft was airworthy.
- The aircraft did not have standard operating procedures.
- The pilots who operated the aircraft did not use the electric fuel pump.
- Days before the accident all of the fuel had been drained from the tanks.
- The electric auxiliary fuel pump was installed in series.
- The aircraft's engine failed during takeoff from the Camarenilla ULM airfield.
- The pilot made an emergency landing in a nearby field, during which the aircraft was not damaged.
- The pilot decided to move the aircraft over land to the Camarenilla ULM airfield, where it is based.
- While waiting for the relevant authorization, he started the aircraft's engine, which seemed to be working normally.
- In light of the problems involved in transporting the aircraft over roads, he decided to fly.
- During takeoff, the engine fault reappeared and the engine eventually stopped.
- The pilot did not turn on the electric fuel pump after the engine failure.
- The right main landing gear leg impact the top of a pine tree, destabilizing the aircraft.
- The nose leg broke off during the landing.
- Nothing unusual was detected in the engine's ignition and air intake systems.
- The electric fuel pump was partially clogged by a solid particle.

3.2. Causes/Contributing factors

This accident was caused by the engine failing repeatedly on takeoff at a time when the aircraft was still at a low altitude over a pine forest.

The engine failure was caused by a partial obstruction in the fuel system that restricted the fuel flow to the carburetors.

The following factors contributed to the accident:

- The decision to fly the aircraft to the Camarenilla ULM airfield after having made a forced landing due to an in-flight engine failure.
- The lack of a bypass line in the electric auxiliary fuel pump system, contrary to the engine manufacturer's recommendation.
- The improper and repeated practice that the aircraft's owners had of never turning on the electric auxiliary fuel pump.

4. SAFETY RECOMMENDATIONS

REC. 71/16. It is recommended that Spain's Civil Aviation General Directorate make the suitable changes to the regulation that governs the construction of amateur-built aircraft so as to have it require the manufacturers of these types of aircraft to write a user's manual describing the topics below before authorizing its construction:

- Normal procedures.
- Operating limits.
- Emergency procedures.

REC. 72/16. It is recommended that Spain's National Aviation Safety Agency take the initiative to make the suitable changes to the regulation that governs the construction of amateur-built aircraft so as to have it require the manufacturers of these types of aircraft to write a user's manual describing the topics below before authorizing its construction:

- Normal procedures.
- Operating limits.
- Emergency procedures.