FINAL REPORT
of civil aviation safety investigation

CLASSIFICATION
ACCIDENT
Owner
PRIVATE
Operator
PRIVATE
Manufacturer
B&F Technik Vertriebs GmbH
Aircraft
FK 9 MARK IV
Registration country
ROMANIA
Registration:
YR-5228
Location:
Tătăruși commune, Iași County
Date and time:
19.08.2017 / 17:18 LT

No. A 18 – 10
Date: 05.11.2018
Uncontrolled engine shutdown during take-off

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>FK 9 MARK IV / YR-5228</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date and time</td>
<td>19.08.2017 / 17:18 LT (14:18 UTC)</td>
</tr>
<tr>
<td>Operator</td>
<td>PRIVATE</td>
</tr>
<tr>
<td>Flight type</td>
<td>Recreational flight</td>
</tr>
<tr>
<td>Persons onboard</td>
<td>The pilot and one passenger</td>
</tr>
<tr>
<td>Injuries</td>
<td>The pilot died and the passenger was injured, requiring hospitalization</td>
</tr>
<tr>
<td>Pilot</td>
<td>Valid Motorized Ultralight Aircraft Pilot license</td>
</tr>
<tr>
<td>Damages</td>
<td>The aircraft was totally damaged</td>
</tr>
<tr>
<td>Location</td>
<td>Tătăruși commune, Iași County</td>
</tr>
<tr>
<td></td>
<td>Coordinates: Latitude: 47° 21’ 02” N</td>
</tr>
<tr>
<td></td>
<td>Longitude: 26° 37’ 46” E</td>
</tr>
</tbody>
</table>

GENERAL DATA

The Civil Aviation Safety Investigation and Analysis Center – CIAS was notified by phone on 19.08.2017 at 17:18 LT, regarding an aviation occurrence in the area of Tătăruși commune, Iași County. An investigation commission made of two investigators from CIAS went to the accident site.

Note: The history of this accident was elaborated based on the witnesses' statements and on a video recording made by the aircraft's passenger.

1. HISTORY OF OCCURRENCE

On 19.08.2017, the pilot of the aircraft registered YR-5228 started the flight activity around 08:30 LT at Iași Territorial Airclub. The activity consisted in performing a school flight of approximately one hour with a student pilot, in order for this one to obtain a motorized ultralight aircraft pilot license, the pilot acting also as flight instructor.

After completing this activity, the pilot refueled the aircraft with 20 liters of fuel from a personal canister and around 13:00 LT he took-off from Iași Territorial Airclub, together with another aircraft. The two aircraft flew in formation to a flight field situated in the area of Tătăruși locality, Iași County, to perform recreational flights during the events celebrating the "Days of the Forest Reservation".

The flight activity at Tătăruși started around 16:30 LT, but without being also notified to the Air Operations Center – COA. At that moment, the weather condition
was as follows: outside air temperature of about 30° – 32° C, ceiling SKT 050, wind of around 8 kt from the right side relative to take-off direction.

The pilot of YR-5228 aircraft performed a first and short recreational flight with a local person, around 17:00 LT. After the aircraft’s landing and parking, another local got onboard to perform a recreational flight. He occupied the left seat of the aircraft, with the pilot sitting on the right seat.

After a parking of approximate 5 – 10 minutes, while the passenger got onboard, and the pilot adjusted the passenger’s seat belt, the pilot started the engine, set it on full power, and started the take-off roll, without securing his seat belt.

Immediately after lift-off, at a relatively low height, the pilot put the aircraft into a left turn. Just in the first phase of the turn, the aircraft’s engine stopped uncommanded. After the engine’s shutdown, the aircraft continued the turn to the left, with a bank angle which increased progressively, reaching about 30°. Shortly after that, the aircraft lost height and violently impacted the ground, at about 170 m from the northern side of the field it took-off from.

The violent contact with the ground, on the top of an earth bank, determined the aircraft to spin about 180° to the right and its ricochet between two trees in the dell located in the immediate vicinity of the initial contact.

Upon the impact with the ground, the pilot was projected outside the aircraft and died, and the passenger survived, requiring hospitalization. The aircraft was completely damaged.

The accident occurred in the location, having the following coordinates:

Latitude: 47° 21’ 02” N
Longitude: 26° 37’ 46” E

Fig. 1 – Accident site
2. **ADDITIONAL INFORMATION**

2.1 **Pilot information**

<table>
<thead>
<tr>
<th>Pilot</th>
<th>Male, 62 years old</th>
</tr>
</thead>
<tbody>
<tr>
<td>License</td>
<td>ULM pilot license, valid</td>
</tr>
<tr>
<td>Medical certificate</td>
<td>Class 2, valid</td>
</tr>
<tr>
<td>Flight experience</td>
<td>Over 6000 FH- total. The number of flight hours on this type of aircraft could not be determined</td>
</tr>
</tbody>
</table>

The aircraft’s pilot also had the qualifications for flight instructor.

2.2 **Aircraft information**

<table>
<thead>
<tr>
<th>Manufacturer and aircraft type</th>
<th>B&amp;F Technik Vertriebs GmbH / FK 9 MK IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial number and manufacturing year</td>
<td>09-04 SW-393 / 2009</td>
</tr>
<tr>
<td>Engine</td>
<td>Rotax 912 UL</td>
</tr>
<tr>
<td>Registration state and mark</td>
<td>Romania – YR-5228</td>
</tr>
<tr>
<td>Owner</td>
<td>PRIVATE</td>
</tr>
<tr>
<td>Total number of hours</td>
<td>1805 hours and 549 landings as of 14.07.2016</td>
</tr>
</tbody>
</table>

The aircraft is a German production, manufactured by B&F Technik Vertriebs GmbH, equipped with ROTAX 912 UL engine, having the wing positioned upwards. The cockpit is provided with two pilot positions placed “cote a cote”.

2.2.1 **Fuel supply system**

On the aircraft there were installed two fuel tanks with a total capacity of 60 liters, mounted behind the pilots’ seats. The fuel valve (only for the ROTAX engine version) is placed on the center console, with ON and OFF positions. A fuel purge valve is located on the lower fuselage behind the main landing gear. The aircraft is equipped with an electric fuel supply pump which, according to the aircraft’s flight manual, must be turned on during take-off and landing. A fuel pressure warning lamp indicates the fuel pressure below the minimum operational value.
The CIAS investigators, who arrived at the accident site, found that the switch of the electric fuel supply pump was in „off“ position.

In the aircraft’s manual, in chapter 2.4 Engine limitations there are mentioned the fuel types that can be used for engine operation. Therefore, for Rotax 912 UL engine it is recommended to use the following fuel type: car fuel without bioethanol (min 95 ROZ), MOGAS and AVGAS 100 LL.
The aircraft manufacturer issued in 2011 a technical information bulletin (FK#02-2011) regarding a modification of the fuel system to ensure a proper fuel supply even if the additional (electrical) pump is blocked.

This technical information bulletin was not applied on YR-5228.

Fig. 4 – Rotax 912 engine limitations

<table>
<thead>
<tr>
<th>ROTAX 912 UL</th>
<th>ROTAX 912 ULS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>automobile - oil (API SF or SG)</td>
</tr>
<tr>
<td>Oil capacity</td>
<td>2,6 Ltr (min) to 3,05 Ltr (max)</td>
</tr>
<tr>
<td>Oil temperature</td>
<td>min 50°C, max. 140°C min 50°C, max. 130°C</td>
</tr>
<tr>
<td>Oil pressure</td>
<td>1,5 bar to 5 bar (engine start 7 bar)</td>
</tr>
<tr>
<td>Fuel</td>
<td>car fuel without bioethanol (min 95 ROZ) MOGAS, AVGAS 100LL</td>
</tr>
<tr>
<td>Fuel pressure</td>
<td>0,15 bar to 0,4 bar</td>
</tr>
<tr>
<td>CHT</td>
<td>max. 120°C when using water / glycol mixture</td>
</tr>
<tr>
<td>Magneto check</td>
<td>min. 2800 U/min</td>
</tr>
<tr>
<td>Max. drop</td>
<td>300 U/min</td>
</tr>
</tbody>
</table>

Fig. 5 – Technical information bulletin FK#02 - 2011

If the electrical fuel pump is blocked the fuel can flow via the return valve in direction to the mechanical fuel pump.
During the investigation, the investigation commission did not manage to obtain the aircraft logbook to check the maintenance works performed over time. The aircraft’s owner stated that the aircraft logbook was onboard of it, but the AIAS investigators arrived at the accident site did not find it.

2.2.2 Aircraft certification

The aircraft YR-5228 obtained the Permit to Fly in April 2009, meeting the applicable airworthiness requirements in force, according to RACR - CCO ULM. As certified aircraft, by recognizing the Type Certificate issued by the German authorities, it had the right to perform the following types of flights according to the Permit to Fly:

- flights in its owner interest;
- private flights;
- school flights;
- any other flight categories for which the operator holds the authorizations and / or specific certificates, according with aeronautical regulations and applicable law for such flights or civilian air operations.

![FK 9 Mark IV aircraft registered YR-5228](image)

In 2016, the aircraft was involved in another accident, occurrence which was not reported to the Civil Aviation Safety Investigation and Analysis Center (CIAS). After that accident, the aircraft was substantially damaged:

- main pillars with residual plastic deformation;
- nose wheel fork deformed, with obvious geometric deviations;
- right wing grip fitting with visible deformations and displaced wing;
- cracks at the forward fuselage structure;
- right wing flap deformed in the framing area.
During a following inspection performed by an authorized inspector of the Romanian Air Club, after the repair works were performed, there were found the following:

- the owner did not provide the proofing documents of origin of the replaced components (wing pillars, nose wheel shipper); qualitatively guaranteed by the manufacturer,
- some repairs were not performed according to the maintenance and repair manual, these being assumed only by the owner;
- new installed propeller, different from the original one.

Due to these findings, the Romanian Airclub issued on 10.08.2016 an Annex to the Identification Certificate for YR-5228 aircraft, according which, it could only be operated as an uncertified aircraft. In this case, the aircraft could only perform the following flight types, according to RACR-CCO ULM 1200:

1) flights in its owner interest;
2) private flights;
3) technical flights in order to obtain the certification;
4) technical flights in order to elaborate the operation and maintenance manual (if it doesn’t exist or if its content is not provided in Annex 2);
5) notwithstanding those mentioned above, an unapproved ULM aircraft may be used / operated for school flights in order to obtain the qualification for that class of aircraft, but only if the student is also the owner of this aircraft.

Note:

(1) The uncertified aircraft shall be used / operated only by pilots qualified for that aircraft class.
(2) Passenger transport is forbidden.
(3) Any other person, onboard of the aircraft, besides the qualified pilot and the student pilot for that aircraft class, is considered, in the context of this regulation, passenger and then Note (2) is applied.
(4) The uncertified aircraft shall wear an inscription mentioning that “This aircraft is uncertified”, which shall be placed in a visible place so that it can be read.

2.3 Flight field information

The flight from 19.08.2017 was performed on a flight field near Tătăruși locality which, according to the provisions of the Romanian Government Decision No. 912/25.08.2010, falls under other fields than certified aerodromes from/on which take-offs and landings of civil aircraft can be performed.

The flight field has an earth runway arranged on heading 06 / 24, having the coordinates: 47°20’52.09” N and 26°37’41.01” E.
2.4 Tests and research

2.4.1 Video recording

The investigation commission analyzed the accident’s video recording, performed by the passenger. The following facts were determined:

- 22 seconds after the aircraft started the take-off roll, almost immediately after lift-off, the pilot put the aircraft into a left turn;
- 4 seconds later, the engine stopped uncommanded;
- 7 seconds after the engine stop, the aircraft crashes into an earth bank located in the immediate proximity of the runway.

Fig. 8 – Moment of engine shutdown

At the moment of the engine shutdown, the aircraft was inclined to the left at an angle of about 15°-20°, at a height of approximately 10 - 15 m, in a slight climbing slope with Vv = 2 m/s and an airspeed of 120 km/h. After the engine shutdown, the aircraft continued the turn to the left, shortly maintaining the flight height, but the bank angle increased, which led to a speed decrease to 80 km/h, value close to the stall speed (75 km/h).

The speed decrease determined the pilot to put the aircraft in a descending slope of 3 m/s, the speed increasing to a value of 100 km/h. Just before the impact with the ground, the pilot took the aircraft almost completely out of the inclination, but without being able to completely recover, which determined the impact toughness.

The very low height, as well as the high bank angle in which the aircraft was flying during the engine shutdown, have limited in terms of time and space, in a determinant way, the possibility of the pilot's performing a safe emergency landing.
In the Aircraft’s Operation Manual issued by the manufacturer, in Chapter 3 - “Emergency Procedures” the engine shutdown and emergency landing are presented as follows:

### Engine Failure

<table>
<thead>
<tr>
<th>Action</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glide speed</td>
<td>100 km/h flaps pos. 1</td>
</tr>
<tr>
<td>Electrical fuel pump</td>
<td>ON ( ROTAX only)</td>
</tr>
<tr>
<td>Fuel selector</td>
<td>check ON</td>
</tr>
<tr>
<td>Fuel remaining</td>
<td>check</td>
</tr>
<tr>
<td>Ignition ( SMART only )</td>
<td>OFF then ON ( electronic reset )</td>
</tr>
<tr>
<td>Engine</td>
<td>start</td>
</tr>
<tr>
<td><strong>No restart possible</strong></td>
<td></td>
</tr>
<tr>
<td>Emergency landing</td>
<td>Perform respective procedure</td>
</tr>
</tbody>
</table>

### Emergency landing

<table>
<thead>
<tr>
<th>Action</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glide speed</td>
<td>100 km/h flaps pos. 1</td>
</tr>
<tr>
<td>Emergency field</td>
<td>select</td>
</tr>
<tr>
<td>Emergency call ( 121,5 )</td>
<td>perform</td>
</tr>
<tr>
<td>Throttle</td>
<td>close</td>
</tr>
<tr>
<td>Electrical fuel pump</td>
<td>OFF ( ROTAX only )</td>
</tr>
<tr>
<td>Fuel selector</td>
<td>OFF ( ROTAX only )</td>
</tr>
<tr>
<td>Ignition / Battery switch</td>
<td>OFF</td>
</tr>
<tr>
<td>Safety belts</td>
<td>Pull tight</td>
</tr>
<tr>
<td><strong>Final, landing assured</strong></td>
<td></td>
</tr>
<tr>
<td>Flaps</td>
<td>Full down</td>
</tr>
<tr>
<td>Approach speed</td>
<td>90 km/h</td>
</tr>
</tbody>
</table>
The emergency cases are generally dealt with in the Aircraft’s Operation Manual, without providing indications on the pilotage technique. Also, the manual does not make any reference on appropriate procedures in case of the engine’s uncontrolled shutdown during a critical flight phase, such as the take-off.

2.4.2 Fuel

There were taken fuel samples from the two tanks of the aircraft, for the expertise. The analysis bulletins corresponding to the two samples showed that gasoline was not in compliance with the provisions of SR EN 228 norm – Vehicle fuels - Unleaded petrol.

Fig. 10 – Fuel samples taken for the expertise

2.4.3 Engine

In order to find the causes of the engine’s uncommanded shutdown while performing the turn shortly after take-off, the investigation commission decided to perform an expertise in an authorized Rotax workshop (Franz Aircraft Engines GmbH).

During dismantling the engine for the expertise, the commission also inspected the engine’s fuel supply system. It was found that the aircraft was not equipped with a fuel return pipe, as recommended by the manufacturer of Rotax engine.
As one can see, the fuel distributor (Fig. 13) mounted on this engine has an entrance way (from the pump) and two exits (to the carburetors), the exit way for the return pipe is not provided.
In Fig. 14 is presented, for example, a supply installation that complies with ROTAX requirements.

Fig. 14 – Supply installation complying with ROTAX requirements

Also, the fuel supply pipes of the engine installed on YR-5228 don’t comply either with the manufacturer’s requirements (Rotax) in terms of quality requirements for a safe operation and for avoiding the vapor lock phenomenon. They should have had a thermal protection.

Fig. 15 – Extracted from the installation manual of Rotax 912 engine

The engine’s expertise activity started by checking the packing box condition and the engine’s integrity. Both the box, but also its content did not suffer due to transport.

Fig. 16 – Box and engine inspection for integrity

A visual inspection of the engine was performed. It was inspected both the oil filter for any metal particles, but also the metal chip detector in the engine’s oil.
No metal particles were found in the oil filter. The filter mounted on the engine was not an original part, this being one of a smaller dimension used on Renault car engines.

![Oil filter inspection](image1)

Fig. 17 – Oil filter inspection

On the surface of the chip detector there were found metal particles in a higher quantity than usual; most probably it wasn’t checked and cleaned during the maintenance works performed to this engine.

![Metal chip detector inspection](image2)

Fig. 18 – Metal chip detector inspection

Compression value was measured on each engine’s cylinder – this was found within the limits recommended by the manufacturer.
It was measured the propeller flange deviation. Its value was 0.15 mm, the maximum admissible value being 0.6 mm.

It was made a visual inspection of the spark plugs fitted on the engine. No nonconformities were found.

Further, the condition of the carburetors was checked. There were inspected the constant level chambers and the mounted floats. No nonconformities were found.
The engine was mounted on the test bench and after making all the necessary connections and adjustments, it was started and tested. A full run-up to its maximum speed of 5800 rpm was performed and there was monitored all the operation parameters (oil pressure and temperature, exhaust gas temperature, fuel supply pressure). The engine operated within the parameters recommended by the manufacturer.

After this testing, it was decided to mount on the supply circuit of the fuel filter installed on the aircraft at the moment of the accident occurrence, the electric fuel supply pump, the supply opening valve along with the fuel pipes which have been removed from the aircraft.

The engine was restarted on the testing bench and tested again at the maximum admissible speed of 5800 rpm, monitoring the operation parameters. In this configuration of the fuel supply circuit the engine also performed within the parameters recommended by the manufacturer.
Fig. 23 – Engine testing along with the aircraft’s supply circuit (supply pipes, fuel filter, valve and electric fuel supply pump)
The engine operated in the parameters recommended by the manufacturer.
After finishing/completing the tests, the engine was teared apart and the oil filter was inspected. No nonconformities were found.

![Oil filter inspection after testing the engine on the bench](image)

Fig. 25 – Oil filter inspection after testing the engine on the bench

The investigation commission considered and analyzed the tests and expertise results, the finding and consequently, the hypothesis considered the most likely on the engine uncontrolled shutdown is the occurrence of the Vapor Lock phenomenon.

The Vapor Lock phenomenon appears when the fuel state condition changes from liquid to gas, while it is in the supply system. This prevents the fuel pump to operate within its nominal parameters, causing the loss of supply pressure, resulting in the temporary loss of power or the complete engine shutdown.

Vapor lock can occur when the engine is turned off without its prior cooling, the ambient temperature is high and the aircraft is parked for a short period of time (approximately 10 – 15 minutes). The fuel from the supply pipe near the engine doesn’t move and therefore it can heat enough to vaporize and form the vapor lock.

This phenomenon is more frequent at gasoline fuel systems which are provided with a mechanical fuel pump of low pressure, operated by the engine, situated in the engine’s compartment.

On this aircraft, the mechanical supply pump is situated higher than the fuel tank. When the fuel is sucked under negative pressure from the fuel tank through the supply pipe, the risk of the supply pipe blocking with fuel vapors between the tank and the pump, increases.
The main factors that led to the \textit{vapour lock} phenomenon and to the subsequent engine’s shutdown, identified by the investigation commission are the following:

- high ambient temperature: $30^\circ – 32^\circ$ C;
- the gasoline used was not compliant with the aircraft’s manufacturer recommendations in the Pilot’s Manual;
- lack of thermal protection on the fuel supply pipes throughout the engine’s compartment;
- short time of parking before performing the accident’s flight.

After the formation of fuel vapors in the fuel supply circuit, the lack of return pipe led to the impossibility of the supply system’s ventilation even if the electric pump would have been switched ON.

3. **CONCLUSIONS**

3.1 **Findings**

1. The pilot held a motorized ultralight aircraft license and medical certificate, both valid;
2. The pilot did not perform the flights from the aircraft’s main pilotage seat;
3. During the flight the pilot did not wear the seat belt;
4. The aircraft was not certified, the passenger flight being forbidden according to RACR-CCO ULM 1200;
5. The aircraft’s logbook was not found to evaluate the maintenance works performed on the aircraft;
6. The gasoline used was not compliant with the aircraft’s manufacturer recommendations in the Pilot’s Manual;
7. The fuel supply pipes within the engine’s compartment were not provided with thermal protection;
8. The aircraft’s engine was not equipped with a return pipe, according to the engine manufacturer recommendations;
9. Aircraft manufacture’s technical information FK#02-2011 regarding modification of the fuel supply system using a bypass system of the fuel electrical pump was not applied on YR-5228;
10. The ambient temperature was around $30^\circ – 32^\circ$ C;
11. The Aircraft’s Manual does not specify in Chapter 3 – *Emergency Procedures* any procedure to be followed in case of engine’s uncommanded shutdown immediately after take-off;

12. The flight activity on Tătăruşi flight field was not declared at the Air Operations Center;

13. The very low height, as well as the bank angle position in which the aircraft was flying at the moment of the engine’s shutdown, limited in terms of time and space, in a determinant way, the possibility of the pilot’s performing a safe emergency landing.

3.2 Cause of accident occurrence

The cause of the accident occurrence is the impossibility to manage an emergency situation, namely the engine’s uncommanded shutdown, during a left turn performed at low height, immediately after take-off.

The engine’s uncommanded shutdown occurred most probably by the *vapour lock* phenomenon in the fuel supply system caused by:

- a high outside air temperature;
- the use of improper fuel type;
- the lack of thermal protection of the fuel pipe within the area of engine’s compartment;
- the lack of a return (pipe) system for the fuel supply installation

4. Safety recommendations

The investigation commission issues the following safety recommendations:

1. It is recommended to the aircraft’s manufacturer - B&F Technik Vertriebs GmbH, for the aircraft type FK 9 Mark IV equipped with Rotax 912 UL/ULS engine, to develop an installation kit for the fuel return pipe from the engine to the aircraft’s fuel tank, in order to eliminate the effects of *vapour lock* formation, according to the requirements in the installation manual of Rotax 912 UL/ULS engine.

2. It is recommended to the aircraft’s manufacturer - B&F Technik Vertriebs GmbH, to complete the Aircraft’s Manual for FK 9 Mark IV model, in Chapter 3 – *Emergency Procedures*, by adding a procedure to follow in case of the engine’s uncommanded shutdown immediately after take-off.
3. It is recommended to the Romanian Airclub, as the Certifying Authority in the field of motorized ultralight aircraft, to inform the owners of motorized ultralight aircraft on the necessity of complying with the installation requirements of Rotax 912 UL/ULS engine provided by the manufacturer, especially the installation of the return pipe from the engine to the aircraft’s tank, which aims to eliminate the effects of vapour lock phenomenon.

4. It is recommended to the Romanian Airclub, as the Certifying Authority in the field of motorized ultralight aircraft, to take all the adequate measures to check the compliance of installation requirements provided by the manufacturer, for Rotax 912 UL/ULS engine while issuing/prolonging the validity of identification certificates/annex to the Identification certificate and/or Permits to fly.

5. It is recommended to the Romanian Airclub, as the Certifying Authority in the field of motorized ultralight aircraft, to publish on their website a list of the aircraft holding Permit to Fly documents, as well as their validity term, aiming to offer the public the possibility to check if the motorized ultralight aircraft participating in different aviation manifestations are allowed to perform flights with passengers.

Note: The documents and analysis objects used for the issuance of the flight safety investigation Report are confidential and are archived at the Civil Aviation Safety Investigation and Analysis Authority (AIAS), according to legal provisions.