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Commission fédérale sur les accidents d'aviation
Commissione federale sugli infortuni aeronautici
Federal Aircraft Accident Board

Final Report No. 1987

by the

Federal Aircraft Accident Board

concerning the accident

to the aircraft model VAN'S RV-9, HB-YML

on 10 October 2007

Kreuzstrasse, Kägiswil, municipality of Sarnen/OW

18 km south-south-west of Lucerne

This final report has been prepared of the Federal Aircraft Accident Board according to art. 22 – 24 of the Ordinance relating to the Investigation of Aircraft Accidents and Serious Incidents (VFU/SR 748.126.3), based on the Investigation Report by the Air Accident Investigation Bureau on 6 May 2008.

General information on this report

In accordance with Annex 13 of the Convention on International Civil Aviation of 7 December 1944 and article 24 of the Federal Air Navigation Law, the sole purpose of the investigation of an aircraft accident or serious incident is to prevent future accidents or serious incidents. The legal assessment of accident/incident causes and circumstances is expressly no concern of the accident investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability.

If this report is used for purposes other than accident prevention, due consideration shall be given to this circumstance.

The definitive version of this report is the original in the German language.

All times in this report unless otherwise indicated, are indicated in the standard time applicable to the area of Switzerland (local time – LT), corresponding at the time of the accident to Central European Summer Time (CEST). The relationship between LT, CEST and coordinated universal time (UTC) is: $LT = CEST = UTC + 2 \text{ h}$.

For reasons of protection of privacy, the masculine form is used in this report for all natural persons, regardless of their gender.

Final Report

Aircraft type	VAN'S RV-9, homebuilt		HB-YML	
Keeper	Private			
Owner	Private			
Pilot	Swiss citizen, born 1932			
Licence	Private Pilot's Licence PPL (A)			
Flying hours	total	15 172:00 h	during the last 90 days	2:57 h
	on the accident type	11:20 h	during the last 90 days	2:57 h
Location	Kreuzstrasse, Kägiswil, municipality of Sarnen/OW			
Coordinates	662 450 / 196 100 E 008° 15' 30.31" N 46° 54' 47.04"		Elevation	466 m AMSL 1529 ft AMSL
Date and time	10 October 2007, approx. 14:20 LT			
Type of operation	VFR private			
Flight phase	Initial climb			
Accident type	Emergency landing after engine failure			
Injuries to persons				
Injuries	Crew	Passengers	Total number of occupants	Others
Fatal	---	---	---	---
Serious	---	---	---	---
Minor	1	---	1	---
None	---	---	---	---
Total	1	---	1	---
Damage to aircraft	Destroyed			
Other damage	Serious damage to buildings and material			

1 Factual information

1.1 History of the flight

1.1.1 General

The statements of the pilot and of witnesses, as well as the documents which the constructor of the aircraft (self-builder) made available to the investigation authorities, were used to produce the following description of the pre-flight history and flight history.

1.1.2 Pre-flight history

1.1.2.1 Construction and test flight phase of aircraft HB-YML

The homebuilder reported his construction project on 18.12.2004 on the notification form to *Experimental Aviation of Switzerland* – EAS. The so-called kick off report for the commencement of construction of the self-build aircraft HB-YML was produced on 05.04.2005. A construction adviser was allocated to the homebuilder by the EAS.

The investigating authorities were in possession of two construction reports dated 20.12.2005 and 25.11.2006 for the evaluation of the assembly of the aircraft.

The final check of the completed aircraft took place on 08.01.2007.

The type inspection report was issued on 27.01.2007.

The test report of the Federal Office of Civil Aviation (FOCA) was issued on 24.02.2007, with the remark: "*Das Flugzeug ist sauber gebaut*" – "The aircraft is cleanly built".

The permit for flight testing was issued as a provisional airworthiness certificate (red) on 05.03.2007 and was valid until 31.03.2008.

The initial flight was made by the constructor; it took place on 12.03.2007.

A second provisional airworthiness certificate (white) was issued on 29.08.2007 and was valid until 31.12.2007. This permit was valid for flights according to the AFM.

1.1.2.2 Work on the fuel system during the test flight phase

The naming of the fuel system devices is taken from the diagram in fig. 4.

At the beginning of the flight testing phase, the locknuts on the fuel line system were tightened because of a smell of fuel in the cabin.

During the flight testing phase, the constructor worked several times on the area of the fuel selector, fuel filter, booster pump and the corresponding fuel line system.

On 18.09.2007, at 28:21 hours flying time, the constructor dismantled the purge valve and deactivated the respective fuel return line. It cannot be excluded that in order to accomplish this locknut of the fuel supply line to the fuel selector had to be loosened and re-tightened.

After 28.04.2007, the fuel filter was removed and refitted at least once to check that it was clean. In order to remove the fuel filter, two locknuts had to be loosened and re-tightened after the re-fitting of the fuel filter.

1.1.2.3 Flights by the flight adviser

At the time of the accident, the aircraft was licensed for flights according to the AFM.

The pilot of the flight involved in the accident was the flight adviser assigned to the constructor of aircraft HB-YML by the EAS. On the majority of test flights made by the constructor, he flew with him as his passenger. He had been assigned to the homebuilder as a construction adviser during the construction phase.

Up to the accident flight, he had completed 1:03 hours as pilot on aircraft HB-YML and had made 3 landings. Thus for example, on 02.10.2007 he completed a training flight from Kägiswil aerodrome as solo pilot on HB-YML. Approximately 14 minutes after take-off, at 3900 ft above Lake of Sarnen, the pilot noticed rough, irregular engine running. The ignition check subsequently carried out by the pilot and adjustments to the power lever position, mixture setting and propeller speed did not result in any improvement in engine running. With power set to idle, he flew back to the take-off aerodrome and landed immediately.

The static test run immediately after the landing, at a power setting of 20 in-Hg and 2000 rpm generated rough, irregular engine running.

1.1.2.4 Work on the aircraft before the accident flight

On 06.10.2007 the constructor of HB-YML carried out a cleanliness check on the fuel filter. In his assessment, it was clean. When asked, the constructor stated that this task was very laborious. He said he had already dismantled this filter more than once and checked it for contamination. He then carried out a static test run, which produced normal engine values.

On the advice of an expert on the electronic ignition system fitted to aircraft HB-YML, on the morning of 10.10.2007 (the day of the accident), the constructor changed the spark plug gap from 0.75 to 0.6 mm. After fitting the spark plugs, he carried out two static test runs, which produced normal engine values.

1.1.3 History of the flight

The pilot took off from runway 03 of Kägiswil aerodrome on 10.10.2007 at approximately 14:20 LT. According to the pilot's statement, the wind information transmitted from Alpnach aerodrome, 5 km to the north, was: "*16 kt aus Richtung Nord*" – "16 kt from the north".

According to the pilot's assessment, during the take-off phase the engine was running well at 2600 rpm and 26.5 in-Hg boost pressure.

Two pilots who were in the vicinity of the beginning of runway 03 and who observed the take-off phase independently noticed unusual engine noises. They had the impression that the engine was not running well.

Statement by the pilot on the flight history (translated from German): "I took off completely normally and after lift-off I left the power lever in the full power position and the propeller setting at maximum (2600 rpm). Without any warning, between 50 and 100 m above ground, I felt a power drop with simultaneous high-frequency engine vibrations. I brought the mixer back by about half and pushed it forward again, without any change in the situation. My V_a (indicated airspeed) was between 70 and 80 kt.

In order to maintain V_a , I had to go over to horizontal flight. I was able to maintain horizontal flight for about 20 seconds and then initiated a left turn, in order to land again on 03 via low circuit. In this phase, at the end of the 90° turn, engine power dropped to zero. The engine was windmilling. I didn't try to re-start it again but concentrated on an emergency landing. In this phase I switched off the master, alternator and ignition. I turned the aircraft further to the left and had to adjust my rate of descent to the tailwind in this phase. When I was again flying in the direction of the aerodrome, I was already close to the ground. In order not to fly into a large building which was across my direction of flight, I brought the aircraft immediately to the ground."

The aircraft collided with the terrain approximately 75 m in front of the large building. At a speed which was still considerably above landing speed, the aircraft crashed into several parked cars and a garage building; in the process the landing gear, wingtips and tail were torn off. Fire did not break out, even though a large quantity of fuel leaked out.

The pilot was wearing his belt.

He was taken to hospital for control and observation reasons, where minor injuries were determined.

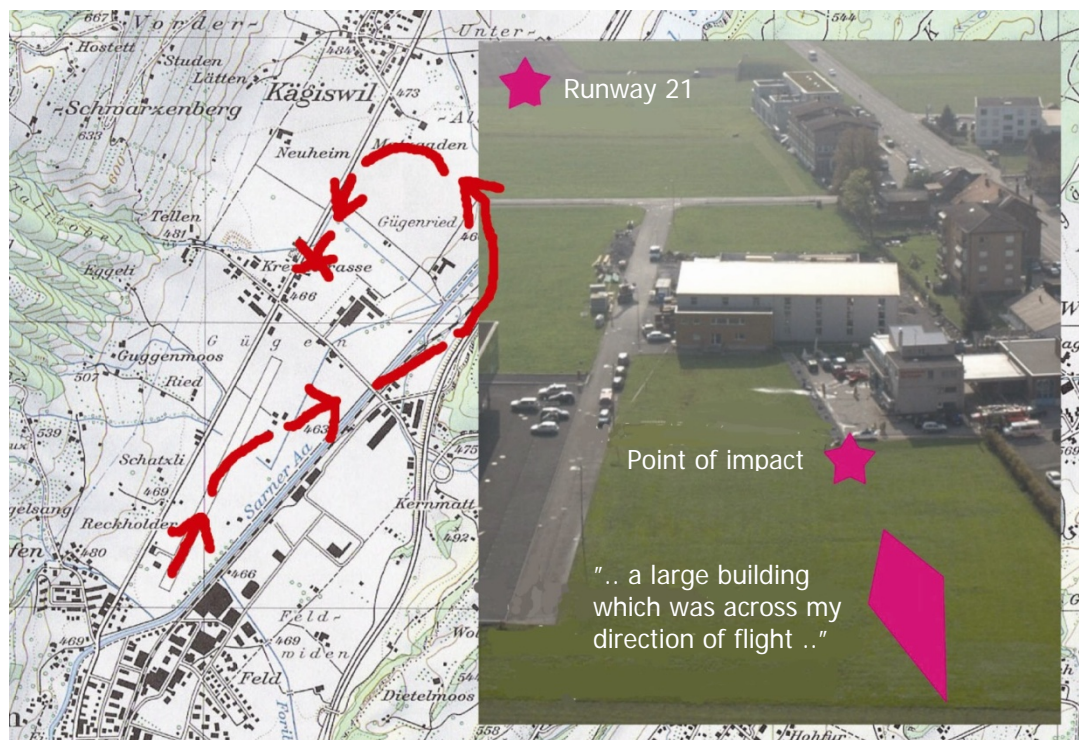


Fig. 1: Approximate flight path, view of runway 21 and point of impact

1.2 Meteorological information

According to information from MeteoSwiss, the METAR reports from Alpnach aerodrome in the time frame of the accident were as follows:

LSMA 101150Z 06010KT 030V100 3000 HZ FEW055 16/09 Q1019 RMK GREEN

LSMA 101250Z NIL=

LSMA 101350Z 05013KT 010V080 3000 HZ SCT050 16/10 Q1019 RMK GREEN

At 14:25 LT, the Alpnach aerodrome air traffic controller reported the following wind information for Alpnach aerodrome by radio: *"Windstärke 16 kt aus Richtung Nord [Wind strength 16 kt from direction north]"*.

1.3 Aircraft information

1.3.1 Aircraft HB-YML

Aircraft type	RV-9 "Experimental"
Characteristics	The Vans RV-9 is a two-seater low-wing aircraft entirely of metal construction with flaps and fixed landing gear in the tail wheel configuration.
Manufacturer	Vans Aircraft, Aurora OR 97002, USA The aircraft can be purchased from the manufacturer only as a kit and then assembled in a homebuild process.
Serial No.	91100
Year of construction	2006
Empty weight	515.1 kg
Maximum take-off mass	795.0 kg
Wingspan	8.52 m
Length	6.20 m
Airworthiness certificate	Provisional airworthiness certificate dated 29.08.2007 / No. 2
Operating hours	33:02 hours

1.3.2 Engine

Type	IO-320-D1A
Manufacturer	Aero Sport Power, Kamloops BC Canada
Year of construction	2005
Airworthiness certificate	Uncertified engine
Power	156 HP at 2600 rpm
Operating hours	33:02 hours
Propeller	Hartzell Propellers, USA
Type	HC-C2YL-1BF "Experimental", variable pitch propeller
Serial No.	AX119B

1.4 Information on the condition of the aircraft after the emergency landing

1.4.1 Aircraft

The aircraft was destroyed.

The damage to the propeller indicated low rpm at the time of impact.

The engine and ignition system suffered minor damage.



Fig. 2: The wreck of the aircraft

1.5 Dismantling work and findings after the accident

1.5.1 Fuel tests

Fairly large amounts of fuel leaked out at the accident site after the aircraft came to a standstill as a result of major damage to the airframe. The fire brigade pumped the fuel remaining in the wing tanks (approximately 30 litres) into containers. One litre of this fuel was tested in a laboratory. The analysis showed that the fuel quality, with the exception of the evaporation residue, complied with the AVGAS 100LL specification. The high measured values of the evaporation residue are probably attributable to the fire brigade's use of containers which had not been cleaned.

In addition, fuel still present in the filter housing of the Andair Gascolator (10 cm³) and in the injector (3 cm³) of the engine, was tested for alcohol content, with the result that this was below 1%.

1.5.2 Ignition system

The Plasma III electronic ignition system by Light Speed Electronics and the two batteries were removed. The ignition system was not subsequently examined.

The analysis of the state of charge of the two batteries showed:

- main battery 12 V; charge state 68 %
- emergency battery 12 V; charge state 40 %

1.5.3 Fuel system

The fuel selector, fuel filter and booster pump with the corresponding fuel line system were fitted as a compact unit enclosed by a casing on the cockpit floor in front of and between the two pilots' seats.

Once the only slightly damaged casing had been opened, it was found that the booster pump return line to the fuel selector was separated.

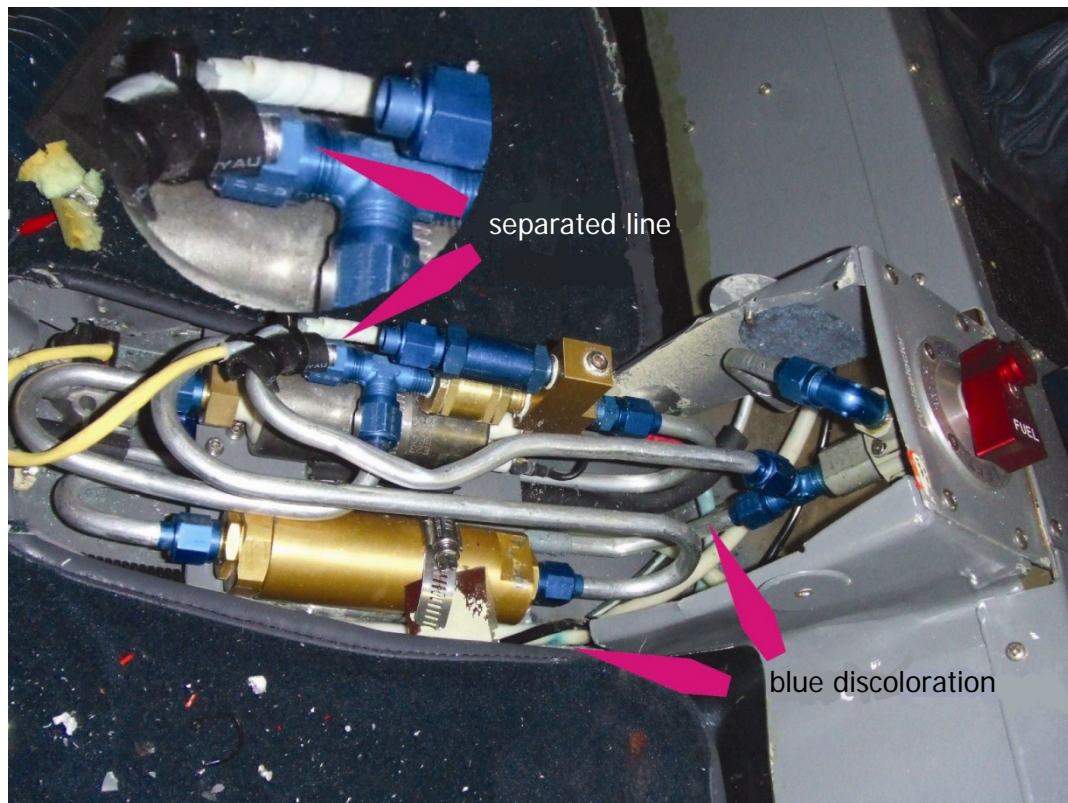


Fig. 3: Separated return line

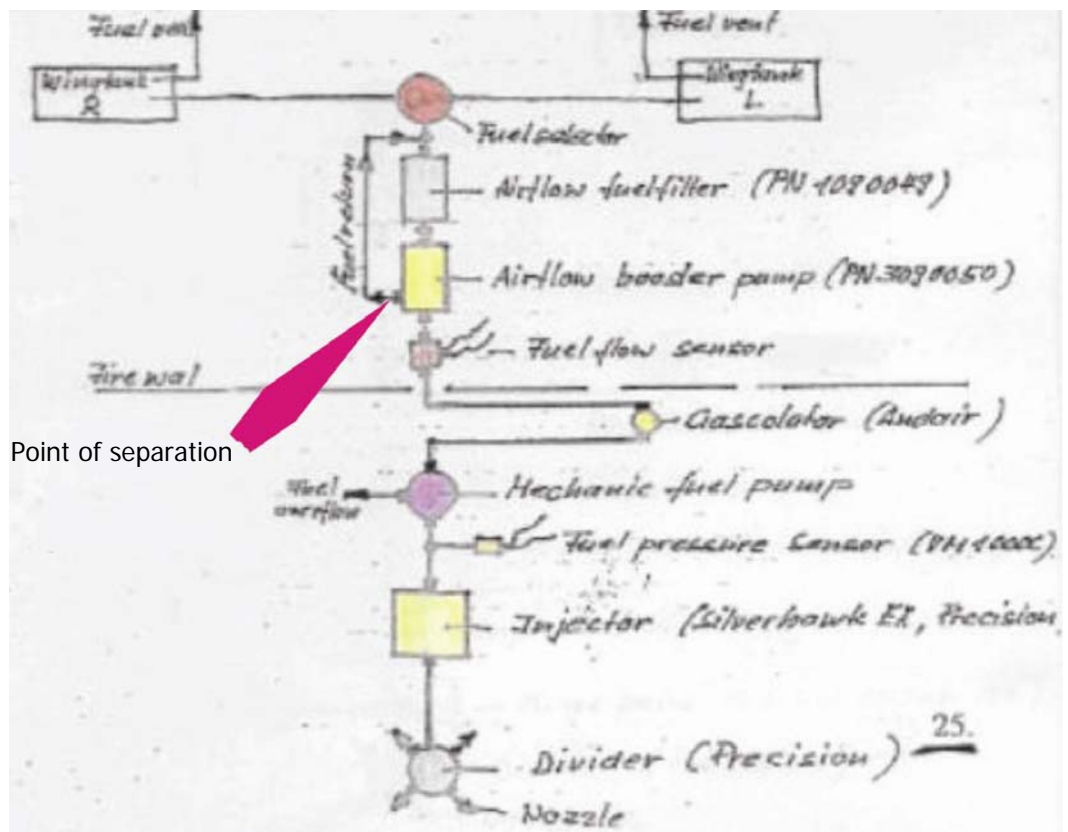


Fig. 4: Diagram of fuel system according to AFM HB-YML

No traces of an external violent force could be found either on the fuel selector casing or on the separated line.

Abnormal force had to be applied to separate the other fuel lines in this area when the locknuts were loosened. Individual ends of lines were jammed firmly in the locknuts; this was attributable to excessive tightening of the unions. Examination of the torn-out end of the return line and the corresponding locknut showed that the wall thickness of the tube at the flare was greatly reduced and as a result had torn around its circumference. This damage, as well as the end of the fuel line jammed in the locknut, indicated that the lines had been fabricated incorrectly. Upon examination it was found that the fissured line had been pushed out of the locknut. This condition can be explained as the result of the high deceleration forces on impact.

Several areas with blue discoloration were found in the whole area of the fuel selector. This discoloration was caused by fuel residue at tube unions. The largest areas of discoloration were behind a panel which covered the lines between the two wing tanks and the fuel selector. The locknut on one fuel line to the left wing tank was insufficiently tightened.

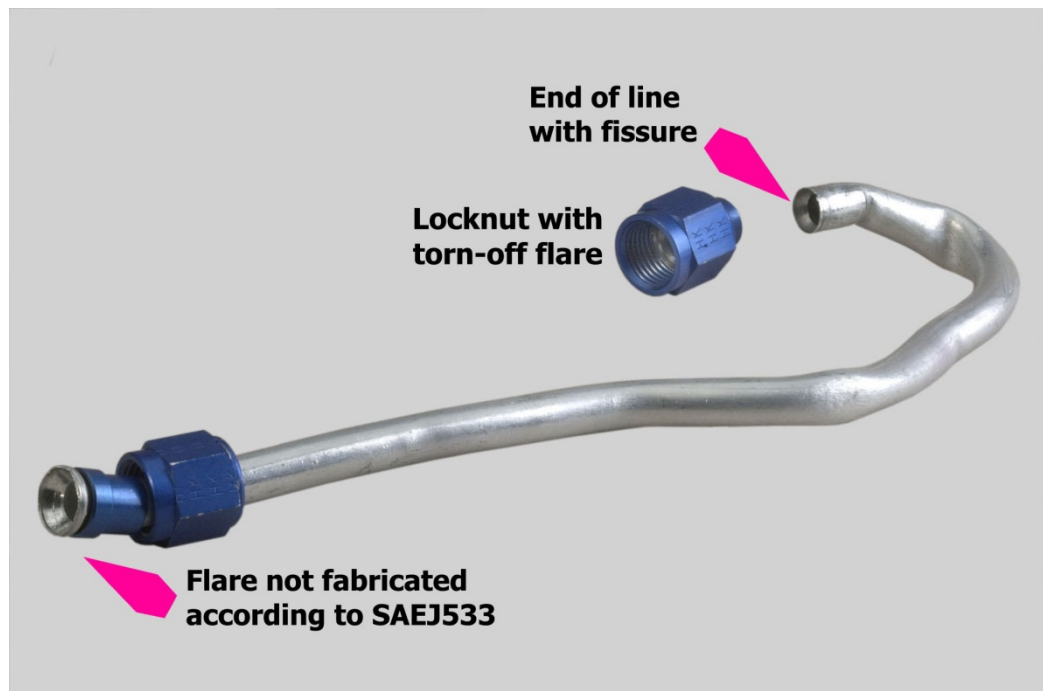


Fig. 5: Fissured fuel line

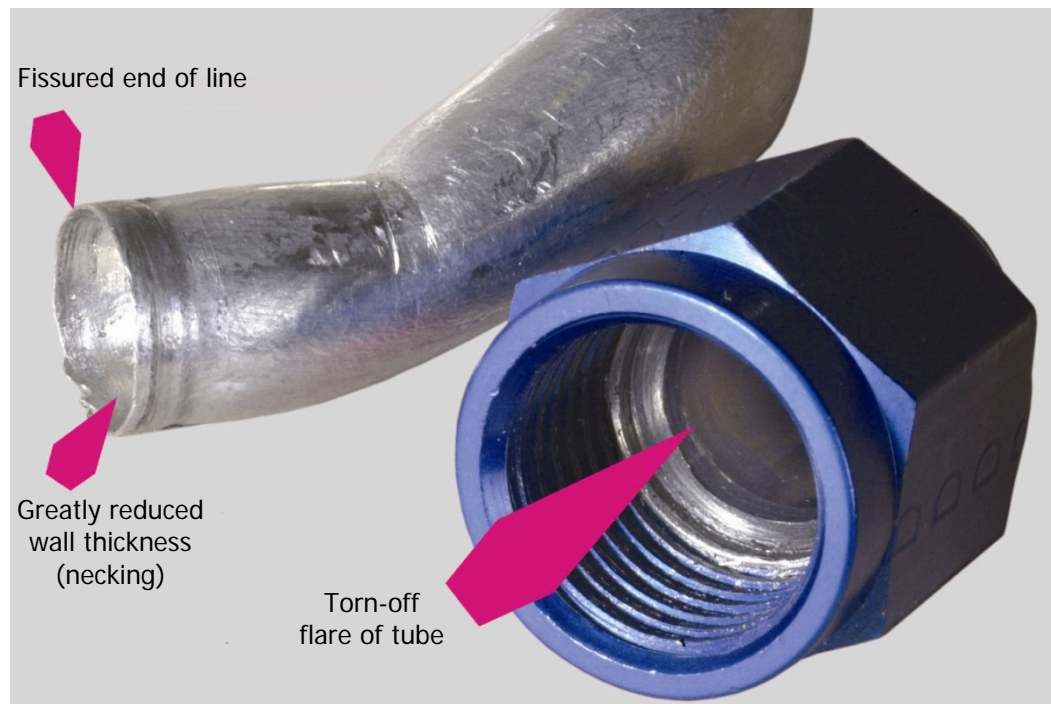


Fig. 6: Details of the fissure in the line and the torn-off flare in the locknut



Fig. 7: Left: line with correctly fabricated flare, right: line from aircraft HB-YML with a flare not fabricated according to norm SAEJ533

The results of a leak in the return line from the booster pump to the fuel selector were investigated by performing static test runs on a comparison engine with the booster pump switched on. Depending on the magnitude of the simulated leak, the engine shut down after 10 seconds to 3 minutes. The engine stoppage was in each case preceded by a reduction in rpm, with pronounced fluctuations in speed. The test during which the engine shut down after 3 minutes was one with a small simulated leak. At full power, the reduction in speed before shutting down was approximately 600 rpm, accompanied by heavy vibrations. The time from the reduction in speed to the engine shut down was about 15 seconds.

1.5.4 The injection system

The injection system of the aircraft involved in the accident was removed and examined by a licensed maintenance company. The investigation showed that the injection nozzle of cylinder No. 1 was partially blocked. The resulting reduced flow to cylinder No. 1 was 50% at full engine power. This certainly affected flawless engine running at full power, but not sufficiently to cause the engine to lose much power or to shut down all together.

1.5.5 Fuel line unions

An assessment plus geometric measurements of the flares on all aluminium fuel lines showed that they had not been fabricated professionally and that the dimensions did not comply with the norm SAEJ533.

1.6 Mass and centre of gravity

Both the mass and centre of gravity were within the permitted limits.

2 Analysis

2.1 Technical aspects

On the basis of the measurements and tests carried out, it can be assumed that at full power on take-off, with the booster pump switched on, air found its way into the injection system through an opening in the fissured return line and consequently the engine first delivered reduced power and then shut down completely.

The partial blockage of the injection nozzle on cylinder No. 1 could explain the unusual engine behaviour during the flight on 02.10.2007 as well as the unusual engine noise heard by two witnesses during the take-off of the flight involved in the accident.

In the manufacturer's assembly instructions, insufficient reference is made to the problem of a fuel line which is not fabricated professionally. In licensed maintenance companies it is customary for the fabrication of aluminium unions to be performed by trained personnel with appropriate special tooling.

The perceived smell of fuel may have been an indication of incorrectly fabricated fuel lines. The high tightening torques ascertained on the locknuts of the aluminium unions may possibly have been the result of re-tightening by the constructor because of the smell of fuel which he had noticed.

2.2 Human and operational aspects

It must remain an open question whether turning back at low altitude to land on runway 03 was the correct decision.

3 Conclusions

3.1 Findings

- The pilot was in possession of the appropriate pilot's licences.
- In the pilot's assessment, the engine was running flawlessly during the take-off phase.
- Eye-witnesses who were in the vicinity of the beginning of runway 03 and who observed the take-off phase noticed unusual engine noises, as if the engine was not running smoothly.
- Shortly after lift-off, at approximately 50 to 100 m above the ground, the pilot noticed a distinct power drop.
- The engine shut down completely in the left turn of the shortened circuit.
- The damage to the propeller indicated a low rpm at the time of impact.
- The return line from the booster pump to the fuel selector was found separated in the area of the booster pump.
- Examinations of the torn-out end of the return line and the corresponding locknut showed that the wall thickness of the tube at the flare was greatly reduced and as a result had torn around its circumference.
- Geometric measurements of the flares on all aluminium fuel lines showed that they had not been fabricated professionally and that the dimensions did not comply with the norm SAEJ533.
- The results of a leak in the return line from the booster pump to the fuel selector were investigated by carrying out static test runs on a comparison engine with the booster pump switched on. Depending on the magnitude of the simulated leak, the engine shut down after 10 seconds to 3 minutes.
- Both the mass and centre of gravity were within the permitted limits.

3.2 Causes

The accident is attributable to an emergency landing which was necessary because of an engine failure at a low height. In the process, the aircraft collided with obstacles.

The engine failure is attributable to a fuel line which was not fabricated professionally.

4 Safety recommendations and measures taken since the accident

4.1 Measures taken since the accident

The management of the FOCA stated in its comments dated 14 April 2008 on the draft investigation report among other things:

„2. Bemerkungen und Erwägungen

2.1. Unter Ziffer 2.1 „Technische Aspekte“, Seite 14, dritter Abschnitt wird aufgeführt, dass die Treibstoffleitungen nicht fachgerecht hergestellt wurden. Die Bauaufsicht wird von der Firma EAS durchgeführt. Im Lichte dieses Sachverhalts wird das BAZL die Überprüfung der EAS-Bauaufsicht vornehmen.“ (...)

Translation:

„2. Remarks and considerations

2.1. Under point 2.1 „Technical aspects“, page 14, para. 3 it is stated that the fuel lines were not professionally manufactured. The construction supervision is accomplished by the company EAS. In the light of these circumstances the FOCA will examine the construction supervision by EAS.“ (...)

Berne, 28 October 2010

Federal Aircraft Accident Board

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