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Aircraft Accident Investigation Bureau AAIB

Summary Report No. 1970 by the Aircraft Accident Investigation Bureau

concerning the Marvel Schebler / Precision Airmotive carburettor respectively float system faults in Switzerland

Bundeshaus Nord, CH-3003 Berne

General information on this report

This report contains the AAIB's conclusions on the circumstances and causes of the accidents and serious incidents which are the subject of the investigation.

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.

This report is being sent to:

- National Transportation Safety Board NTSB USA

And for information to:

- Air Accident Investigation Branch AAIB England
- Bureau d'Enquêtes et d'Analyses BEA France
- Bundesstelle für Flugunfalluntersuchung BFU Deutschland
- Swiss Federal Office for Civil Aviation FOCA

Contents

1 Factual information

1.1 Previous history

In 2006, several incidents and aircraft accidents occurred in Switzerland due to insufficient engine power which involved small single-engined aircraft equipped with Marvel Schebler / Precision Airmotive carburettors. One accident resulted in the death of the pilot.

1.2 Information on the incidents and accidents

The initial results of the ongoing investigations into a total of eight incidents or accidents with engine faults, seven of which occurred in 2006, indicate that the causes of all the faults lay with the carburettor. In the case of six faults, a malfunction of the float system and of the float in particular, contributed to the fault.

In the case of the fatal accident involving aircraft HB-KOC on 03.05.2006, the correct operation of the float system and of the float, which was made of plastic, could not be investigated because of destruction due to a fire.

The annex lists the eight incidents or accidents individually.

1.3 Principle of operation of fuel feed

Most carburettor designs do not allow the fuel to be drawn into the carburettor from the tank via hoses. The partial vacuum created in the venturi is not sufficient to draw the fuel through the fine holes of the fuel nozzle directly from the fuel tank. For this reason, a “storage bowl” is needed for the required fuel to be combusted. This storage bowl is termed the carburettor bowl.

In order to avoid pressure fluctuations which might result in an incorrect mixture generation, the fuel level in the carburettor bowl must be kept as constant as possible. To control the level, a buoyancy device, known as a float, controls a needle valve. When the level in the carburettor bowl drops, the float opens the needle valve and allows the fuel to flow in. When the desired fluid level is reached, the valve seals the fuel feed. The desired fluid level is permanently set by the float and the needle valve. If the needle valve does not close when the fluid level is reached, this causes the carburettor bowl to overflow (see Fig. 1).

The supply of fuel from the fuel tank to the carburettor bowl is assured by a fuel pump driven by the engine. Some engines also have an additional electrically driven fuel pump.

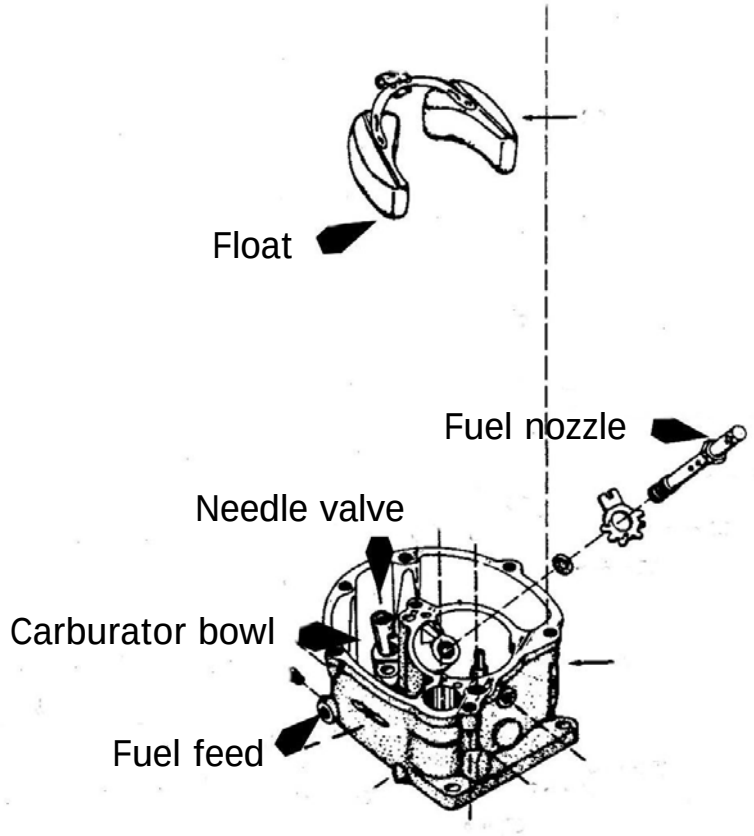

Fig. 1: Partial view of the Marvel Schebler/Precision Airmotive carburettor

1.4 Plastic float

Of the seven Marvel Schebler / Precision Airmotive MA-4-5 or MA-4SPA carburettors involved, five were equipped with a plastic float. In four cases, a considerable amount of AVGAS was found in one of the two elements of the plastic float.

Of the two plastic float types some 17 000 have been manufactured to date.

Fig. 2

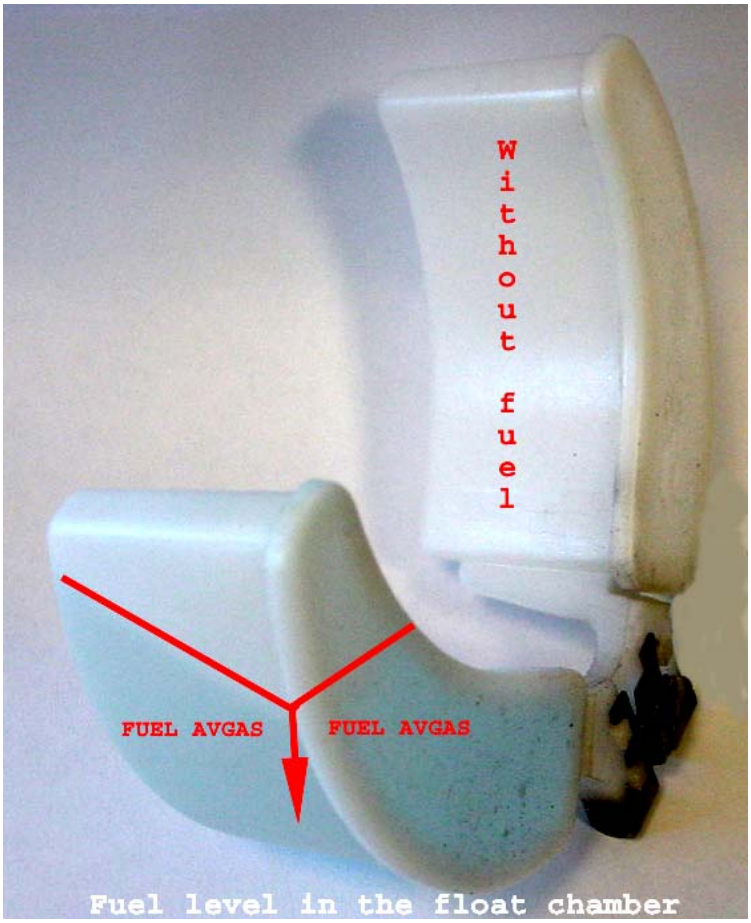

Fig. 3

Fig. 2 and 3: Marvel Schebler/Precision Airmotive carburettor MA-4SPA, p/n 10-5217, s/n CK817178, aircraft HB-HEZ (Annex case 7). Float where one of the two plastic float chambers was filled to 80% with AVGAS fuel.

2 Analysis

2.1 Technical aspects

2.1.1 Leaks in the plastic float

The investigative work in connection with the above-mentioned incidents and accidents was still in progress at the time this report was being produced. In seven of eight cases, the investigation results available today indicate problems with the float chambers of Marvel Schebler/Precision Airmotive MA-4-5 und MA-4SPA carburettors. It is very striking that the floats of five of the carburettors involved are made of plastic. In four cases, a considerable amount of AVGAS fuel was found in one of the two plastic float chambers.

As investigations of previous accidents or incidents due to engine faults in the air and on the ground and the experience of licensed carburettor servicing companies have shown, the freedom of movement of a float with one side filled with AVGAS is very badly affected by the asymmetrical forces acting on the float linkage. The resulting defective operation of the needle valve prevents the generation of a correct fuel-air mix. As a rule, too much fuel is therefore added to the mixture, leading to a loss of power.

The plastic floats consist of two banana-shaped float chambers, whose cavity is sealed by a flat lid (see Fig. 2 and 3). It seems that leaks can occur at the weld points. These may be caused by

- defective welding
- fatigue of the welded seam as a result of intense vibrations
- brittleness of the welded seam due to ageing
- formation of stress cracks due to additives found in fuel, such as alcohol, oil or aromatic hydrocarbons, etc.
- the effects of temperature and pressure.

The float is located inside the airtight carburettor bowl. This may be opened only by the aircraft maintenance company which is licensed to overhaul carburettors. Thus leaks are discovered only when faults are rectified or when carburettors are overhauled. The maintenance interval (time between overhaul – TBO) for Marvel Schebler/Precision Airmotive carburettors corresponds to the engine's TBO and, depending on the engine type, is between 1800 and 2000 hours.

Leaking plastic floats as the cause of engine faults have also led to detailed investigations by the Bureau d'Enquêtes et d'Analyses BEA in France and the Air Accident Investigation Branch AAIB in England. They have shown that this type of float is unsuitable for safe operation in powered flight.

2.1.2 Measures taken to date by the manufacturer and the authorities

The designer and manufacturer of the Marvel Schebler / Precision Airmotive carburettor types is aware of the leaks in the plastic floats and their consequences.

Therefore, in several publications and in:

- SIL MS-11 Rev.1 dated 29.09.2005
- SIL MS-12 dated 24.02.2006

it has proposed replacement of the plastic floats with an air-filled chamber by a new model made from foam plastic.

The FAA noted this information and published it in a Special Airworthiness Information Bulletin "SAIB CE-06-33“, dated 17.03.2006. The SAIB CE-06-33 does not require mandatory replacement of the plastic float within a specified period.

The Federal Office of Civil Aviation (FOCA) transmitted the above-mentioned documents

- SIL MS- MS-11 Rev.1 dated 29.09.2005
- SIL MS-12 dated 24.02.2006
- Special Airworthiness Information Bulletin SAIB CE-06-33 dated 17.03.2006

to Swiss aircraft owners and individual air operators as a recommendation.

3 Conclusions

3.1 Findings

- In 2006 several incidents and aircraft accidents occurred in Switzerland due to insufficient engine power which involved small single-engined aircraft equipped with Marvel Schebler / Precision Airmotive carburettors. One accident resulted in the death of the pilot.
- Of the seven Marvel Schebler / Precision Airmotive MA-4-5 or MA-4SPA carburettors involved, five were equipped with a plastic float.
- In four cases, a considerable amount of AVGAS fuel was found in one of the two plastic float chambers.
- The several ways in which leaks can occur in the welded joint between the cavity and the lid which were detected permit the conclusion that this float design is not adequate for safe flying operations.
- Of the plastic float types found to be defective in Switzerland, some 17 000 have been manufactured to date.
- The relatively high incidence of leaks in plastic float chambers is known to the designer and manufacturer of the MA-4-5 and MA-4SPA carburettors.
- A leaking float can be detected only when the carburettor bowl is opened up on the occasion of a repair or overhaul by a licensed carburettor servicing company.
- The effectiveness of the manufacturer's and relevant authorities' provisions to date with a view to preventing future engine failures due to faults in the float system is considered by the AAIB as inadequate.

4 Safety recommendations and measures for improving flight safety

4.1 Safety recommendations

4.1.1 Safety deficit

The plastic float construction of the MA carburettor types caused engine faults and in these cases did not meet the requirements of safe flying operations.

The issued recommendations of the manufacturer and authorities in this respect are not mandatory.

4.1.2 Safety recommendation No. 398

Die Kunststoff-Schwimmer Schwimmerkammer der Vergasertypen Marvel Schebler/Precision Airmotive MA-4-5 und MA-4SPA mit einer Luftkammer sind innerhalb eines befristeten Zeitraumes durch ein geeignetes Produkt zu ersetzen.

The plastic floats with an air-filled float chamber of the Marvel Schebler/Precision Airmotive MA-4-5 und MA-4SPA carburettors must be replaced by an appropriate product within a limited period.

4.2 Further cases of discovered fuel residuals in plastic float chambers

On the occasion of investigating the carburettors of aircraft HB-PPQ and HB-CFB which took place after writing the report in hand, a considerable amount of AVGAS was found in one of the two elements of each plastic float. With that the number of leaking floats raised up to six. The two incidents are described in Annexes nine and ten.

Berne, 22 August 2007 Aircraft Accident Investigation Bureau

Annexes

Detailed presentation of the ten incidents and accidents

Case No. 1

Aircraft registration		**HB-KFY**
Date		17.12.2003
Aircraft	Type	Robin DR 400/180R
Engine	Type	Lycoming O-360-A1P
	Serial No.	L-39239-36A
Carburettor	Type	Precision Airmotive Corporation MA-4-5
	Part No.	10-6054
	Serial No.	75139704
	TSN	New
	TSO	N/A
Fuel used		AVGAS 100LL
Float	Manufacture	Plastic

During the factory acceptance flights carried out by the manufacturer after production of the Robin DR 400/180R (HB-KFY) aircraft on 17.12.2003, fuel flow and mixer problems were found on the carburettor of the brand-new engine. The engine of aircraft HB-KFY was equipped with another carburettor, eliminating the fault.

The defective Marvel Schebler/Precision Airmotive M-4-5 carburettor, P/N 10-6054; S/N 75139704 was subsequently repaired. The company which carried out the repair work found an anomaly in the fuel level setting in the carburettor bowl. As a corrective measure, the fuel level had to be re-adjusted on the fuel level needle valve.

The repaired carburettor was later installed on the engine of the brand-new Robin DR 400/180R aircraft, HB-KOC, and the aircraft was imported into Switzerland (see case No. 4).

Case No. 2

Aircraft registration		**HB-KEO**
Date		06.10.2005
Aircraft	Type	Robin DR400/180
Engine	Type	Lycoming O-360-A1P
	Serial No.	L-27913-36A
Carburettor	Type	Precision Airmotive Corporation MA-4-5
	Part No.	10-3878
	Serial No.	G509105
	TSN	6490 hours
	TSO	2350 hours
Fuel used		AVGAS 100LL
Float	Manufacture	Plastic

The carburettor was removed and examined by a licensed company because of an engine fault in flight. It was found that there was AVGAS fuel in one chamber of the plastic float.

Case No. 3

Aircraft registration		**HB-KFP**
Date		02.05.2006
Aircraft	Type	Robin DR400/140B
Engine	Type	Lycoming O-320-D2A
	Serial No.	L-19227-39A
Carburettor	Type	Precision Airmotive Corporation MA-4SPA
	Part No.	10-5217
	Serial No.	DC 46546
	TSN	2161 hours
	TSO	53 hours
Fuel used		AVGAS 100LL
Float	Manufacture	Metal

During a cross country flight, the pilot experienced an engine fault with loss of power. The pilot made a successful emergency landing with the engine shut down at a nearby aerodrome. After the landing, when the engine was examined, fuel leaked out of the engine.

When the carburettor was examined, it was found that the metal float had come into contact with the wall of the housing and that the needle valve was jammed as a result. The carburettor had been overhauled 53 hours before the incident.

Case No. 4

Aircraft registration		**HB-KOC**
Date		03.05.2006
Aircraft	Type	Robin DR 400/180R
Engine	Type	Lycoming O-360-A1P
	Serial No.	L-39501-36A
Carburettor	Type	Precision Airmotive Corporation MA-4-5
	Part No.	10-6054
	Serial No.	75139704
	TSN	314 hours
	TSO	N/A
Fuel used		AVGAS 100LL
Float	Manufacture	Plastic

On 03.05.2006 the pilot attempted an emergency landing at the aerodrome from which he had taken off, because of an engine fault. The aircraft crashed onto a field and immediately caught fire. The pilot suffered fatal injuries in this accident.

During the currently ongoing investigation into the accident it was found that the carburettor was equipped with a plastic float. This was destroyed by the aircraft fire. The hypothesis of a carburettor fault could not be confirmed because of the extensive destruction.

The engine of the Robin DR 400/180R aircraft, HB-KOC, was equipped before export to Switzerland on 17.06.2004 with the Marvel Schebler/Precision Airmotive M-4-5 carburettor, P/N 10-6054; S/N 75139704. Since the time the brand-new aircraft was imported into Switzerland, aircraft HB-KOC had flown 314 hours.

The carburettor S/N 75139704 had previously been fitted to the engine of aircraft HB-KFY, which was brand new at the time, and was removed from it on 17.12.2003 because of fuel flow and mixer problems. It was then repaired and subsequently fitted by the aircraft manufacturer to the engine of aircraft HB-KOC (see case No. 1 HB-KFY).

Case No. 5

Aircraft registration		**HB-EPG**
Date		04.07.2006
Aircraft	Type	Robin DR 300/180R
Engine	Type	Lycoming O-360-A3A
	Serial No.	L-22559-36A
Carburettor	Type	Precision Airmotive Corporation MA-4-5
	Part No.	10-3878
	Serial No.	G182565
	TSN	1077 hours
	TSO	N/A
Fuel used		AVGAS 100LL
Float	Manufacture	Metal

The aircraft was mainly used to tow glider aircraft. The carburettor was removed on 05.09.2005 due to an engine fault on the ground and repaired by a licensed company.

When the engine was started on 26.06.2006, fuel leaked from the air filter. An overflow from the carburettor bowl was found to be the cause. After a visual inspection of the engine, during which no fault was found, the aircraft was back in service the next day. During the second flight, the engine stopped in flight. The subsequent emergency landing, with the engine shut down, at the take-off aerodrome was successful. The carburettor was removed again and repaired by the same company.

After it had been refitted on 30.06.2006, the aircraft was used for towing without any complaints. During the third flight on 04.07.2006, the engine again stopped in flight. The subsequent emergency landing, with the engine shut down, at the take-off aerodrome was successful. When the aircraft was at a standstill on the runway, the pilot tried several times to re-start the engine using the starter. In the process, fuel leaked out from the air filter and ignited. The aircraft caught fire and was completely burnt out. The pilot was able to escape unharmed.

During the investigation into the cause of the accident it was found that the carburettor was equipped with a metal float. The float linkage exhibited abnormally large play. The hypothesis of the cause of the fault is that the float came into contact with the wall of the carburettor bowl as a result of the large amount of play, temporarily impeding the correct operation of the float. Proof of the cause could not be fully provided because of the extensive destruction due to the effects of the fire.

Case No. 6

Aircraft registration		**HB-POE**
Date		27.07.2006
Aircraft	Type	Piper PA-28-161
Engine	Type	Lycoming O-320-D3G
	Serial No.	L-15672-39A
Carburettor	Type	Precision Airmotive Corporation MA-4SPA
	Part No.	10-5135
	Serial No.	CK612923
	TSN	Inc.
	TSO	1959 hours
Fuel used		AVGAS 100LL
Float	Manufacture	Plastic

During the flight preceding the incident flight, the engine had stopped unexpectedly after landing on the runway. The pilot re-started the engine and taxied to the parking stand, where he shut down the engine normally. He reported the incident to the aircraft leasing company and also made a corresponding entry into the logbook.

No measures were taken.

During the next flight on the following day by another pilot, the engine again stopped on the runway after landing. The pilot tried to re-start the engine, but without success. While doing so a carburettor fire occurred. Another pilot, who was in the process of refuelling his aircraft, was the first person to notice that flames were emerging from the engine compartment of the aircraft, which was standing on the runway. He took a fire extinguisher which was available near the refuelling station, hurried to the aircraft and extinguished the fire in the engine compartment.

The carburettor was removed and examined. Friction marks due to contact with the housing wall were found on the plastic float. A considerable amount of AVGAS was found in one of the elements of the plastic float.

Case No. 7

Aircraft registration		**HB-HEZ**
Date		07.08.2006
Aircraft	Type	Bravo AS 202/15
Engine	Type	Lycoming O-320-E2A
	Serial No.	L-33796-27A
Carburettor	Type	Precision Airmotive Corporation MA-4SPA
	Part No.	10-5217
	Serial No.	CK817178
	TSN	Inc.
	TSO	509 hours
Fuel used		AVGAS 100LL
Float	Manufacture	Plastic

On 07.04.2005, the carburettor was removed 93 hours after an engine overhaul by the manufacturer, Textron Lycoming in the USA, because of a leak. It was repaired in Switzerland and re-installed. On 07.08.2006, 416 hours after the repair, the engine stopped in the 'IDLE' position twice after landing on the occasion of a training flight.

When the carburettor was examined, a large amount of AVGAS fuel was found in one of the elements of the plastic float.

Case No. 8

Aircraft registration		**HB-ZEM**
Date		12.02.2007
Aircraft	Type	Helicopter R22 BETA
Engine	Type	Lycoming O-360-J2A
	Serial No.	L-38866-36A
Carburettor	Type	Precision Airmotive Corporation MA-4SPA
	Part No.	10-5217
	Serial No.	75132012
	TSN	1962 hours
	TSO	N/A
Fuel used		AVGAS 100LL
Float	Manufacture	Plastic

When the carburettor was being overhauled, a considerable amount of AVGAS fuel was found in one of the elements of the plastic float. The aircraft operator had not noticed any abnormalities in engine operation before the time of the overhaul.

Case No. 9

Aircraft registration:		**HB-PPQ**
Date		27.04.2007
Aircraft	Type:	Piper PA-28-181
Engine	Type:	Lycoming O-360-A3A
	Serial No.:	L-17691-36A
Carburettor	Type:	Precision Airmotive Corporation MA-4-5
	Part No.:	10-4164-1
	Serial No.:	G0101824
	TSN:	6168 hours
	TSO:	1368 hours
Fuel used		AVGAS 100LL
Float	Manufacture	Plastic

The company who was charged with the total revision of the engine established on the occasion of an examination of the carburettor that one of the elements of the plastic float was filled to approximately 50% with AVGAS fuel.

Case No.10

Aircraft registration:		**HB-CFB**
Date		23.08.2007
Aircraft	Type:	Cessna 172 RG
Engine	Type:	Lycoming O-360-F1A6
	Serial No.:	L-28428-36A
Carburettor	Type:	Precision Airmotive Corporation HA-6
	Part No.:	10-5219
	Serial No.:	75059710
	TSN:	Inc.
	TSO:	~ 500 hours
Fuel used		AVGAS 100LL
Float	Manufacture	Plastic

The engine was running erratically. The operator observed vibrations and the development of smoke. It was not possible to adjust the idle run resulting in the engine to stop. The company who was charged with the overhaul of the carburettor established that one of the elements of the plastic float was filled to approximately 30% with AVGAS fuel.