Federal Public Service
Mobility and Transport
Air Accident Investigation Unit

Air Accident Investigation Unit
(Belgium)
City Atrium
Rue du Progrès 56
1210 Brussels

Safety Investigation Report

Ref. AAIU-2016-AII-08
Issue date: 14 November 2018
Status: Final

SYNOPSIS

Classification:	Accident
Level of investigation:	Standard
Date and time:	08 October 2016 at 14:36 UTC
Aircraft:	Fournier RF 47, MSN: 01
Owner:	Private
Accident location:	In a field in Oordegem (Belgium), Geographic coordinates: 50°57'58,29 – 3°53'46,59
Type of operation:	Non-commerical - Cross-Country
Phase:	En route
Persons on board:	One pilot
Injuries:	The pilot was slightly injured

Abstract
During a navigation flight, the engine began to sputter and lose power. The pilot searched for a suitable location for a forced landing and decided to land on a ploughed field. The engine completely stopped operating in final before touch-down. During the landing, the aeroplane flipped over, leaving the pilot slightly injured and the aeroplane significantly damaged.

Cause
The direct cause of the accident (the flip-over) is an improper pitch-up attitude (not enough "holding off") during a forced landing on a soft terrain as a consequence of an engine failure. The engine breakdown (=indirect cause) was due to an insufficient gap between the valve rotators and the rocker arms. This caused an unwanted mechanical contact between these parts followed by a rapid wear of the valve keys ending in the engine failure.

Contributing safety factor:
Performing non-routine maintenance on critical aircraft components without having extensive technical experience.

Other safety factor:
The lack of technical documentation and/or guidance from the engine manufacturer to warn the mechanics about the "valve stem wear phenomenon", possibly causing an insufficient gap between the valve rotators and the rocker arms.

1. FACTUAL INFORMATION

1.1 History of the flight

Shortly before the accident, the engine had been repaired due to a loss of compression. After carrying out the engine repair involving the replacement of the exhaust valves, the owner performed a ground run of the engine and made subsequently a satisfactory local flight in the vicinity of the home base of Grimbergen (EBGB).

In the morning of Sunday 8 October, the pilot performed a first cross-country flight to the aerodrome of Koksijde (EBFN) without any degradation in performance. However, during the return flight in the afternoon, the engine began to sputter and lose power. At the same time, the pilot noticed an unusual oil smell. The pilot searched for a suitable location for a forced landing, lowered the flaps and decided to land on a ploughed field. The engine stopped operating in short final above a row of trees located at the beginning of the chosen field.

The aeroplane touched down approximately at mid-length of the field at 380 meters from the row of threes and rolled between 10 – 15 m before it became airborne again for about 10 meters. Thereafter, the aeroplane touched down again causing the nose wheel to sink into the soft ground causing a rapid deceleration. The nose landing gear strut failed rearwards and the aeroplane flipped over.

The pilot, slightly injured, managed to leave the cabin through the little space between the ground and the airframe structure after having somewhat dug the ground next to the wreckage.

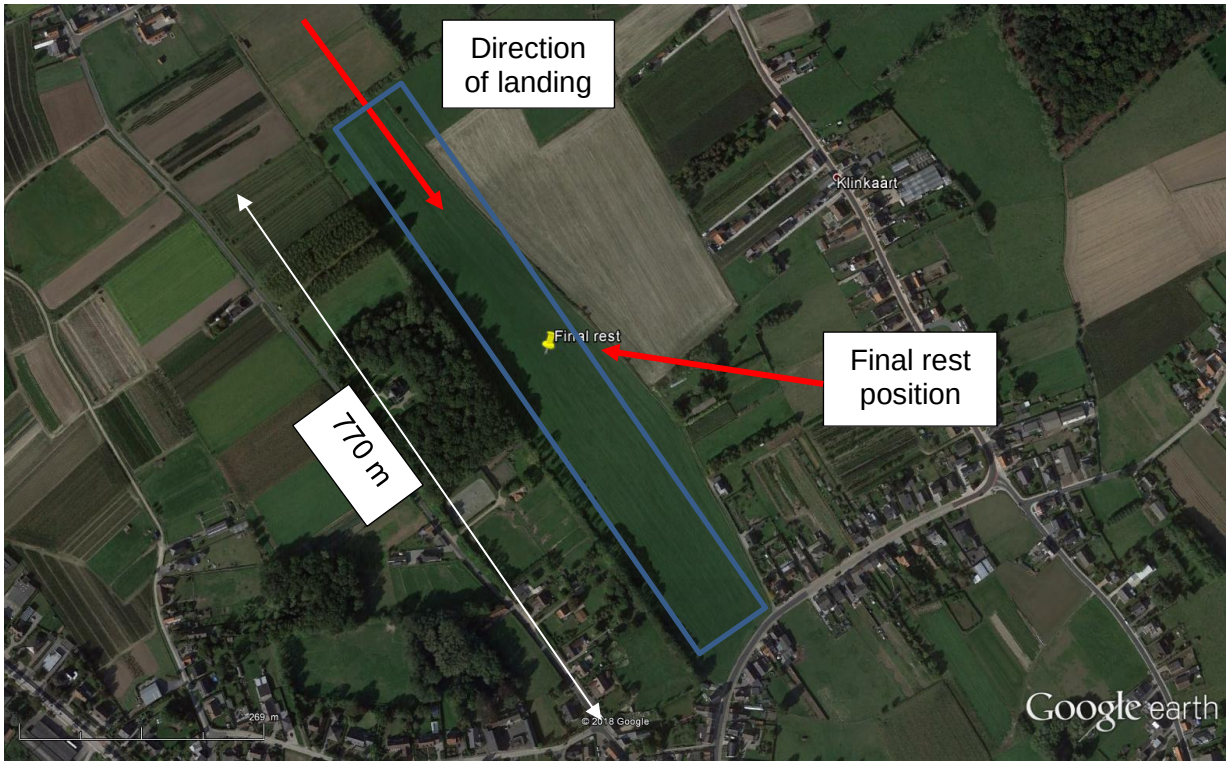

Figure 1: Aerial view of the landing field

Figure 2: Rest position of the wreckage

1.2 Damage

The aeroplane was significantly damaged at the nose landing gear, engine cowlings, engine mount, propeller, canopy, tail section …

Figure 3: Detail of the damage

1.3 Aeroplane

Generalities

The Fournier RF-47 is a French two-seat light aircraft designed and built by 'Avions Fournier' (Mr. René Fournier) in collaboration with Mr. André Daout. The airframe construction is made using a wooden structure with fabric covering. The aeroplane features a low-wing monoplane, a tricycle

landing gear and a fuselage-mounted horizontal stabilizer. The RF-47 has an enclosed cockpit with side-by-side configuration seating for two under a single-piece canopy that hinges at the rear.

The Fournier RF-47 was type-certificated in France on 4 October 1995 and holds the Type Certificate data Sheet Nr 187 edition 1 (10.95). The RF-47 is classified in the EASA product list for Small Aeroplanes as “VLA Powered Sailplanes”.

However, only 5 pre-series RF-47 were manufactured before the manufacturer stopped production. The prototype first flew on 9 April 1993 with a 90 hp (67 kW) Sauer engine. The certified version of the RF-47 was equipped with a Limbach L 2400 EB1 AA engine.

Characteristics

- Crew: 2
- Length: 6.25 m
- Wingspan: 10.00 m
- Height: 2.10 m
- Wing area: 10.60 m²

Performance

- Maximum speed: 270 km/h
- Cruising speed: 190 km/h
- Stall speed: 72 km/h
- Service ceiling: 4000 m
- G limits: +4.4 / -2.2

The accident aeroplane

- Manufacturer: Fournier René and Daout André
- Model: RF-47
- SN: 01
- Year of manufacture: 1993
- Category: Non-EASA home-built aircraft (Also known as "Annex II" aircraft)
- Total time A/C: 1246h6/10 flight hours (1243h9/10 at engine repair)
- Registration: Registered in France (Restricted Registration Certificate) in the name of the current owner since 18 July 2006.
- Airworthiness certificate: Restricted Airworthiness Certificate[1] delivered on 17 September 1996.
- CNRA Validity: Renewed on 13 February 2016 – Valid until 13 February 2019
- Registration Certificate: Delivered by DGAC to the current owner on 18 July 2006.
- Empty weight: 472,5 kg
- Max take-off weight: 680 kg

This aeroplane bears the serial number 01, indicating it is the first RF-47 manufactured. Reportedly, this aeroplane would be the prototype of the RF-47. Upon its registration, DGAC France determined that the airplane did not comply with the “Fiche de Navigabilité N°187”, due to among others the installation of a different engine. DGAC therefore saw this airplane as a homebuilt construction and it was registered with this status as an “Annex II” aircraft.

Permission to Fly over Belgian territory was not granted because this was never requested by the owner.

[1] This Restricted Airworthiness Certificate (“CNRA” = Certificat de Navigabilité Restreint d’Aéronef) is valid only when associated with the “Dossier C.N.R.A. Nr 4169”.

Engine identification

- Manufacturer: Sauer
- Model: ST-2500-H2S
- SN: X1021
- Engine total time: About 1030 flight hours
- Certification document: JAR-22(H) Geräte-Kennblatt Nr 4580 Ausgabe 4 dated 18 September 2003. The engine was type-certificated by the LBA (the German aviation authority) in 1995 (see "Geräte-Kennblatt Nr 4580 Ausgabe 4 dated 18.09.2003").

Main engine cylinder, cylinder heads and valve problems history

17 October 2002	Installation of 4 new cylinders, 2 new cylinder heads, new push rods and new rocker valves. Engine TT: +/- 140 H. Repair performed by Avialaval (France) when the aeroplane was still owned by the previous owner.
10 January 2007	Leak test 1:74/80, 2: 70/80, 3: 79/80, 4: 50/80. Both cylinder heads were removed and replaced by new original parts delivered by the engine manufacturer (Sauer Engine). Engine TT: +/- 353 H. Repair performed by the owner.
22 July 2008	Cylinder Nr 4, piston and rings removed and replaced. Engine TT: +/-450 flight hours due to broken rings + scratches in the cylinder wall. Repair performed by the owner using parts purchased from the engine manufacturer.
September 2016	The engine showed some cylinder low compression. The pilot, assisted by a friend, removed both cylinder heads and found that one exhaust valve was burnt. Four new exhaust valves were purchased from the engine manufacturer and installed. No log book entry found. Engine TT: +/-1025 flight hours.

Maintenance documentation used by the pilot-owner

The engine valve train system of the S 2500 is quite uncommon. Usually, valve trains are either manually adjusted (during periodical maintenance) or feature a hydraulic compensation for the valve lash (hydraulic tappets), where adjustment is automatic.

The S 2500 engine valve train used a hybrid system incorporating at the same time a hydraulic compensation and a mechanical adjustment system where a mechanical pre-adjustment needs to be performed only in specific circumstances (Valve replacement …).

The owner used, for the maintenance of the engine, an operator manual dated 01 November 1995, written in French and entitled '*MANUEL D'UTILISATION pour Moteur Sauer ST2500H1S*'.

The owner stated that, during the last engine repair, the mechanical pre-adjustment of the valves was performed according to a handwritten addendum found in the operator manual 'Chapter 7. Maintenance'.

7.4b Réglage soupape.	7.4b Valve adjustment (Translation)
• Tourner la vis de réglage de sorte qu'un jeu nul soit atteint • Ajouter 2 tours et serrer le contre-écrou	• Turn the adjustment screw in order to obtain zero play • Add 2 turns and tighten the locknut

Official technical documentation

As stated in the type certification document "Geräte-Kennblatt Nr 4580 Ausgabe 4 dated 18.09.2003", the technical documentation available for the maintenance of the engine is:

- Maintenance manual and Parts catalog (written in German language): *Reparaturbuch und Ersatzteilkatalog für Motor S 2500, Ausgabe 01.03.2003*
- Operator Manual (written in German language): *Betriebshandbuch für Motor S 2500, Ausgabe 01.03.2003.*

The maintenance manual details the procedure to be followed to set the valves of an engine equipped with hydraulic compensation (hydraulic tappets) of the valve lash (clearance/play).

However, reference is made to a "distribution housing" and "distributor rotor" that are not installed on this engine. "Distribution housing" and "distributor rotor" are typical parts of a car ignition system, suggesting that the text is copied from a car maintenance manual without the necessary changes.

Einstellen des Ventilspieles bei Hydraulischen Stößeln – Einstellschrauben in den Kipphebeln zurückdrehen, bis sie bündig mit den Kipphebeln abschließen. – Kurbelwelle auf OT Zylinder 1 stellen (Verteilerläufer muß zur Markierung für Zylinder 1 am Verteilergehäuse zeigen). – Einstellschrauben beider Kipphebel leicht gegen die Ventile drehen (Ventiltriebstelle spielfrei). – Einstellschrauben von diesem Punkt aus ein bis zwei Umdrehungen weiter hineindrehen und kontern. – Zum weiteren Zusammenbau am 2., 3., 4. Zylinder Kurbelwelle links herum weiterdrehen, bis der Verteilerläufer jeweils um 90° versetzt steht.	Translation: **Adjustment of the valve lash when equipped with hydraulic valve lifters** • Turn back the setting screws of the rocker arms until they are flush with the rocker arms. • Set the crankshaft to the TDC of cylinder 1 (the distributor rotor must point to Nr 1 cylinder marking at distributor housing) • Turn the setting screws of both rocker arms until they are slightly in contact with the valves (Without clearance at the valve train). • From this point, turn the setting screws one to two turns further and lock them. To proceed on cylinders 2, 3 and 4, turn the crankshaft further to the left until the distributor rotor is each time at an angle of 90°.

Figure 4: Extract of the maintenance manual

1.4 Engine inspection

An external inspection of the engine showed that two ignition cables were damaged by an abnormal contact with an exhaust pipe, likely due to a wrong cable routing.
Traces of engine oil were present inside the exhaust pipe common to cylinder Nr 2 and Nr 4 (Exhaust of the cylinders located at the right side).

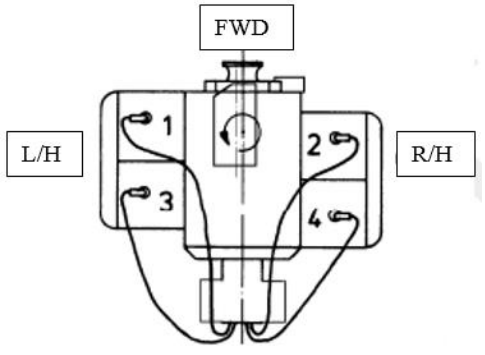

Figure 5: Cylinder sequence numbering

Figure 6: chafing of a high-tension ignition cable on an exhaust pipe.

During the removal of the upper spark plugs, the cylinder Nr 2 spark plug was very hard to unscrew and showed extensive hammering damage after removal.

After removal of the Nr 2 and Nr 4 common cylinder head cover, the inspection of the valve trains showed that the intake valve of cylinder Nr 2 was missing (no longer present inside its guide) and the push rod of the cylinder 4 intake valve was no longer in place against its rocker arm. A worn valve key was found lying under the rocker arm as well as several small damaged pieces of metal.

After disassembly of the rocker arm shaft, all rocker arms could be thoroughly examined. Close examination of the rocker arm of the failed valve (Nr 2 intake) showed an abnormal chafing of the rocker arm. This rocker arm was locally damaged by an abnormal contact with its rotator[2] (generally known as its trademark Rotocap).

Extreme damage to both combustion chambers and pistons was found after removal of Nr 2 and Nr 4 cylinders. The remains of the Nr 2 intake valve were found pressed into the aluminium casing of the combustion chamber.

Figure 5: Cylinders and pistons Nr 2 and Nr 4

The inspection after removal of the Nr 1 and Nr 3 cylinder head cover (left-side cylinders) also showed evidence of an abnormal contact between the rotators and the intake valve rocker arms.

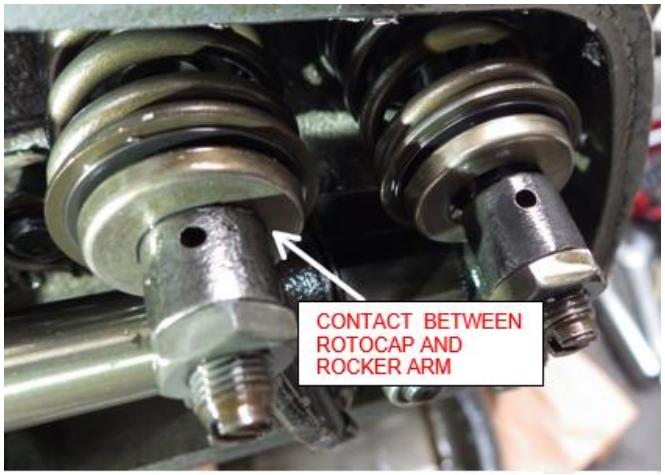

Figure 6: Cylinder Nr 3 lack of gap at intake valve train.

[2] A rotator turns the valve slightly every time it opens or closes, preventing the valve sticking or burning

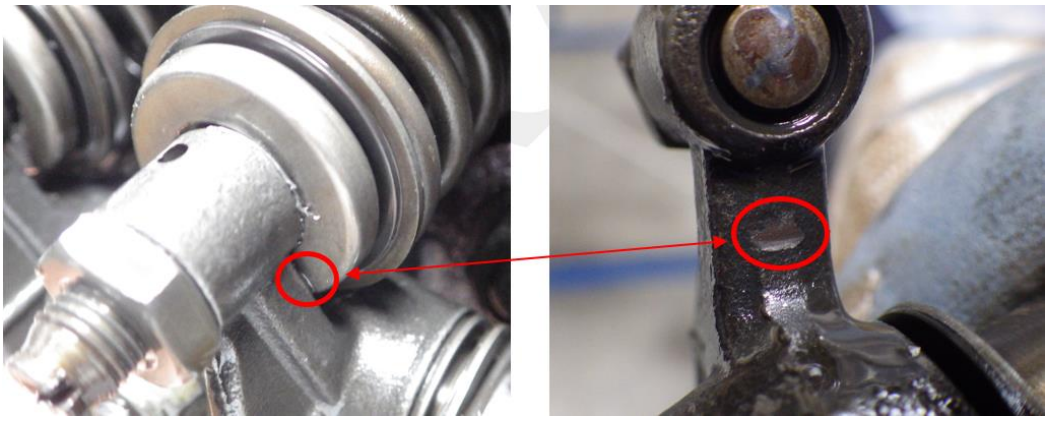

Figure 7: Contact areas between the rocker arm and the rotator

1.5 Pilot information

Sex:	Male
Age:	69 years old
Nationality:	Belgian
License:	EASA PART-FCL PPL (land) license. First delivered on 03 October 1984.
Ratings:	Class rating: SEP (land) valid until 31 May 2017 (training flight with the accident aeroplane completed on 9 May 2015).
Language Proficiency:	English level 4 expired since 25 February 2016
Medical certificate:	Valid until 19 December 2016
Flight experience:	Total flight hours: 1546:26FH

Last 6 months flight experience with the accident aeroplane:

Date	Duration of the flight	Take-offs and landings	Remark
16 April 2016	1:42	3	
30 April 2016	2:06	2	
06 May 2016	3:24	2	
08 May 2016	3:42	2	
30 May 2016	2:12	3	
Begin October 2016 (Local test flight)	2:42	1	Date and duration of test flight unknown. Total hours of test flight + flights on 08 October 2016 = 2:42FH
08 October 2016 (Accident flight)		2	
Total	15:48	15 (Including the crash landing)	

The pilot owner held a fitness certificate for the maintenance of his own aircraft delivered by DGAC on 5 November 2012.

1.6 Meteorological information

METAR EBBR & EBAW valid 8/10/2016 14h30

METAR EBBR 081420Z 04008KT 010V090 9999 SCT048 14/03 Q1024 NOSIG=
METAR EBAW 081420Z 06007KT 020V090 9999 SCT046 15/02 Q1025 NOSIG=

Based on METARs from EBBR and EBAW, the meteorological conditions at the crash site were approximately as follows:

Wind direction:	50° (variable from 10° to 90°),
Windspeed:	8 kt,
Prevailing visibility:	more than 10 km,
Ceiling:	Scattered clouds at 4600 ft,
QNH:	1024 hPa

2. ANALYSIS

2.1 The forced landing

The pilot stated that, several years before, he already experienced an engine failure when in command of another aeroplane. In this case, he performed a successful forced landing without any damage. Since this event, when in flight, aware that an engine failure can occur at any time, he scans the surroundings regularly for available fields to perform a forced landing. The pilot performed a satisfactory training flight with an instructor 7 months before the accident and had a large experience flying single engine aeroplane. All of this indicates that he was adequately prepared to perform a satisfactory forced landing, if necessary.

The prevailing wind (50° - 8 kt) and the field orientation (143°) determined that the aeroplane probably landed in left crosswind conditions. However, based on the interview of the pilot, this does not seem to have caused particular difficulties.

The traces left on the ground by the landing gear show that the aeroplane touched down on its 3 wheels, rolled for 10 metres, went airborne before touching down again in a flat attitude, on its 3 wheels.

The owner stated that the cause of the flip over was an insufficient pitch-up attitude (not enough back pressure on the stick or “holding off”) during the second touchdown on a soft soil, causing the nose wheel landing gear strut to collapse and the aeroplane to flip over.

It is likely that if an appropriate landing technique would have been adhered to, the accident could have been prevented. However the pilot had no means, when in flight, to realize that the soil was very soft.

2.2 The engine failure

As seen in chapter 1.3., the valve train system is uncommon and requires specific knowledge and/or guidance for a proper maintenance. The owner stated that as he didn’t have the maintenance manual of the engine, he used a short handwritten procedure found in the flight manual to adjust the lash of all valves; i.e. he turned counter clockwise the adjustment screw in order to obtain zero play and thereafter added 2 clockwise turns and tightened the locknut. This unofficial procedure is less detailed but is rather similar to the one recommended in the maintenance manual. Thus, according to his statement, the owner adjusted all intake and exhaust valves in the same way.

The examination of the failed engine determined that, for the intake valves only, there was a dramatic reduction of the gap between the rocker arms and the rotators. Several rocker arms and their respective rotator were even in contact when the valves were closed.
However, the exhaust valves showed a sufficient clearance between the rocker arms and the rotators.

The investigation could not positively determine the cause of a different situation between the intake and exhaust valves. However, as the owner stated that he adjusted all intake and exhaust valves using the same procedure, it is likely that the stems of the used intake valves were worn. This wear, undetected during the adjustment of the valves, reduced the gap between the rocker arms and the rotators.

When the valve system is operating normally, the rocker arm rotates around its axis in a tilting movement and pushes the end of the valve stem to activate the opening of the valve. The tilting movement of the rocker arm is thus changed in a simple rectilinear movement.

Because of the lack of gap between the rocker arm and the valve rotator, a chafing occurred between the rocker arm and the rotator, in particular when the valve was in the closed position. This caused on its turn a rapid wear of the valve keys. After a while, the worn valve keys failed to hold the valve train assembly causing the valve to be sucked inside the combustion chamber. The engine failure occurred only 2h42 after the repair.

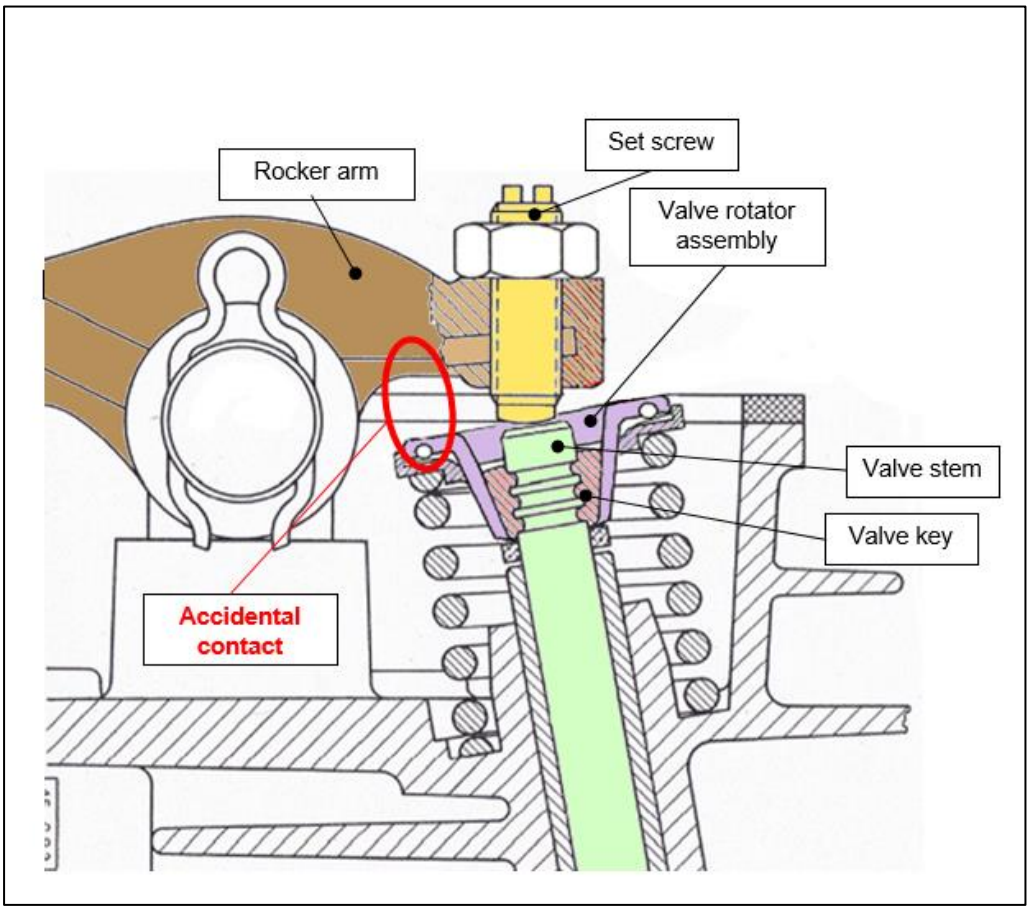

Figure 8: components of the valve train showing the location of unwanted contacts between the rotator and the rocker arm

Beyond the cause of the engine failure, the investigation determined that one high tension (HT) cable was significantly damaged by chafing onto an exhaust pipe. Guidance to avoid the chafing of high tension cables, electrical wires, flexible lines etc. is not always available in the manufacturer technical documentation in general aviation. It is common sense, experience, capacity for observation and skill that show the mechanics how to adequately organize the routing of these components.

2.3 Maintenance performed by the pilot owner

Regulation ((EU) 1321/2014[3]) is not applicable to annex II (homebuilt) aircraft. The regulation applicable to French registered home-built aircraft is the Decree of 15 March 2005 of the French Republic regarding the "Restricted Airworthiness Certificate (CNRA). This French regulation allows the owner to perform all maintenance tasks to the aircraft, including engine heavy maintenance. On 5 November 2012, DGAC officially allowed the owner to perform maintenance on his aircraft (Certificat pour l'entretien d'un aéronef de construction amateur).

The maintenance tasks on the engine were performed by the owner assisted by a friend. Both have a limited experience and qualification in aviation maintenance. The inadequate routing of the ignition lead found during the investigation and visible before the accident would normally not have been performed by an experienced qualified aviation mechanic. However, the valve anomalies were more difficult to detect.

2.4 Technical documentation

A few days after the accident, the engine manufacturer was notified by AAIU(Be) via, the German Federal Bureau of Aircraft Accident Investigation (BFU), and a preliminary report was provided on 19 October 2016 describing the factual information collected during the inspection of the engine.

This prompted the engine manufacturer to issue on 14 December 2016 two technical bulletins ('Technische Mitteilung' or TM) regarding the adjustment of the valves and the testing of the geometry of the rocker arms of different engine types.

Technische Mitteilung Nr. 25 Datum: 14 Dec. 2016	Gegenstand: Kontrolle der Kipphebelgeometrie und der Kontaktflächen zwischen Ventilschaft und Ventileinstellschraube	Subject: Testing of the geometry of the valve-rocker and the contact surface between the valve stem and the set screw.

Technische Mitteilung Nr. 26 Datum: 14 Dec 2016	Gegenstand: Ventileinstellung und Kontrolle der Kipphebelgeometrie von Motoren mit und ohne hydraulischem Ventilspielausgleich (Hydrostößel).	Subject: Adjustment of the valve and testing of the geometry of the rocker for motors with or without hydraulic compensation for the valve lash (hydraulic tappet).

These technical bulletins, only released in German language, are enclosed at the end of this report as well as a non-official translation in English made for the purpose of the investigation.

[3] Regulation ((EU) 1321/2014 : Commission Regulation of 26 November 2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks

In summary:

Technical bulletin Nr 25 requests:

1) To check visually the damage through wear and tear of materials on the contact surface between the set screw and the valve stem.
2) To verify periodically the presence of at least 1 mm gap between the rotator and the valve-rocker when the valve is pushed in.

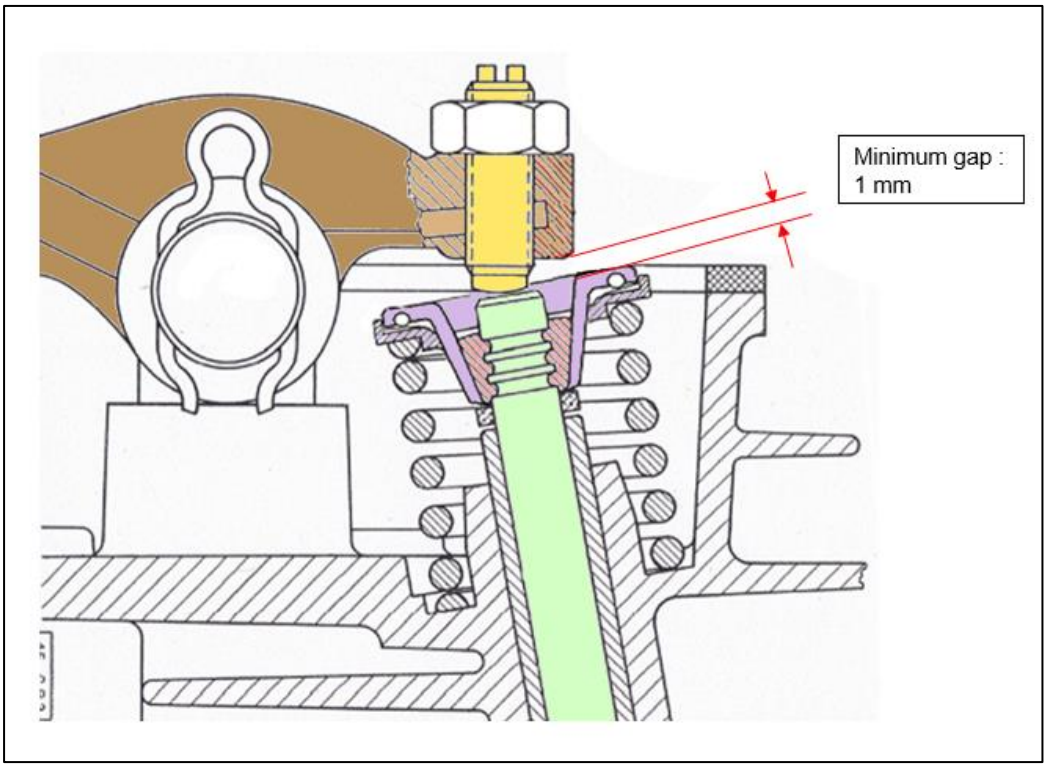

Figure 9: Minimum gap between the rocker arm and the rotator (When valve fully pushed in)

Technical bulletin Nr 26:

1) Reminds that some engine models can be equipped with or without hydraulic tappets implying that a different procedure must be applied for the valve lash adjustments.
2) Describes the two different adjustment procedures to be used depending on the installed mechanical tappets or hydraulic tappets.
3) Reminds that the minimum gap between the rotator and the rocker arm must be verified in accordance with “Technical bulletin Nr 25”.

3. CONCLUSION

3.1 Findings

- The aeroplane was registered in France and was flying under a French Restricted Airworthiness Certificate (CNRA) valid until 13 February 2019.
- The Restricted Airworthiness Certificate (CNRA) is only valid above the French territories unless a written overflight permission is granted by the authority of the overflown foreign country.
- Although the aeroplane was based on the EBGB (Grimbergen) airfield, Permission to Fly over Belgian territory was not granted because this was never requested by the owner.
- The pilot owner held a fitness certificate for the maintenance of his own aircraft delivered by DGAC on 5 November 2012. He regularly performed the routine maintenance of his aeroplane, but lacked experience for the heavy maintenance of the engine and components.
- The pilot-owner did not hold adequate documentation (MM, IPC) for the maintenance and repair of the engine.
- The engine breakdown occurred during the third flight after the replacement of all exhaust valves, 2,7 flight hours after the repair.
- There are indications that the correct adjustment procedure was applied for the adjustment of the valves but an abnormal wear at the stems of the intake valves was not detected.
- The engine failed due to the ingestion of one intake valve inside the combustion chamber of its cylinder. This occurred after an abnormal mechanical contact between the valve rotator and the rocker arm causing the failure of the valve keys.
- The pilot held a valid PPL(A) with a valid SEP(land) class rating.
- During the forced landing, the aeroplane touched down, rebounded and landed again causing the nose landing gear to collapse and the aeroplane to flip over.

3.2 Cause

The direct cause of the accident (the flip-over) is an improper pitch-up attitude (not enough “holding off”) during a forced landing on a soft terrain as a consequence of an engine failure. The engine breakdown (=indirect cause) was due to an insufficient gap between the valve rotators and the rocker arms. This caused an unwanted mechanical contact between these parts followed by a rapid wear of the valve keys ending in the engine failure.

Contributing safety factor:

Performing non-routine maintenance on critical aircraft components without having extensive technical experience.

Other safety factor:

The lack of technical documentation and/or guidance from the engine manufacturer to warn the mechanics about the “valve stem wear phenomenon”, possibly causing an insufficient gap between the valve rotators and the rocker arms.

4. SAFETY ACTIONS AND RECOMMENDATIONS

4.1 Safety issue: lack of technical documentation

At the time of the accident, no technical documentation and/or guidance from the engine manufacturer existed to warn the mechanics about the valve stem wear phenomenon, possibly causing an insufficient gap between the valve rotators and the rocker arms.

Safety action by the engine manufacturer:

On 14 December 2016, two months after the accident, the engine manufacturer issued two Technical Bulletins regarding the adjustment procedure of the valves and the checking of the geometry of the rocker arms.
These bulletins adequately describe the possible issues that led to this engine failure and the appropriate mitigation measures to avoid the reoccurrence of such an engine failure.

AAIU(Be) supports this initiative but encourages the manufacturer to release an English translation of its Technical Bulletins in order to inform as many mechanics as possible.

4.2 Safety factor: Performing an engine repair without having sufficient knowledge/training.

The engine failure occurred soon after an engine repair performed without the support of an appropriate technical documentation. This underlines the importance to have comprehensive data on all kinds of works to be done on an aircraft. Therefore:

Safety message[4] to owners performing the maintenance of their aircraft:

Beside the fact that an appropriate skill is required, before deciding to perform maintenance or a repair on your aircraft:

- Make sure that you understand the system of documentation developed by the manufacturer.
- Make sure that you have the most suitable technical documentation for the intended work. As a matter of fact, the manufacturer documentation can be available in several versions depending on the depth of the work to be done (Routine maintenance, overhaul, repair etc).
- Make sure that your technical documentation is up-to-date.
- Check that your technical documentation is complete: the aircraft manufacturer and engine and accessories manufacturers regularly release technical bulletins that focus on specific problems.
- When reading the technical documentation, make sure that you understand it thoroughly. Ask yourself “Do I understand in detail the procedure described in the documentation?”, “Do I understand the reason of the procedure?”, “Does the procedure apply to my case?” etc.

[4] **Safety message:** A message focussing on the existence of a safety factor and the lessons learned. AAIU(Be) can disseminate a safety message to a community (of pilots, instructors, examiners, ATC officers), an organization or an industry sector for it to consider a safety factor and take action where it believes it appropriate. There is no requirement for a formal response to a safety message, although AAIU(Be) will publish any response it receives.

About this report

As per Annex 13 and Regulation EU 996/2010, each safety investigation shall be concluded with a report in a form appropriate to the type and seriousness of the accident and serious incident. For this occurrence, a limited-scope, fact-gathering investigation and analysis was conducted in order to produce a short summary report.
It is not the purpose of the Air Accident Investigation Unit to apportion blame or liability. The sole objective of the investigation and the reports produced is the determination of the causes, and, where appropriate define recommendations in order to prevent future accidents and incidents.

5. APPENDICES

5.1 Technische Mitteillung NR.25

SAUER FLUGMOTORENBAU GMBH

55270 Ober-Olm • Nieder-Olmer-Str. 16 • Telefon 06136/89377 • Telefax 06136/85466

TECHNISCHE MITTEILUNG NR. 25

Datum 14.Dezember 2016

Gegenstand

Kontrolle der Kipphebelgeometrie und der Kontaktflächen zwischen Ventilschaft und Ventileinstellschraube.

betroffene Geräte

Motor S1800 ( ), LBA Geräte-Nr. 4590

Motor S2100 ( ), LBA Geräte-Nr. 4608

Motor S2500 ( ), LBA Geräte-Nr. 4580

Anlass

In der Vergangenheit kam es vereinzelt, bedingt durch Mangelschmierung an den Kontaktflächen zwischen Ventilschaft und Ventileinstellschraube, zur Beschädigung des Ventilschaftes.
An den hoch belasteten Kontaktflächen zwischen Ventilschaft und Ventileinstellschraube kann es bei Abriss des Schmierfilmes in Folge eines direkten Kontaktes zwischen Ventileinstellschraube und Ventilschaft zu erhöhtem Verschleiß kommen.
Im Laufe der Zeit vergrößert sich dadurch die Eindringtiefe des Kipphebels in den Ventiltrieb dermaßen, dass im Extremfall ein Kipphebel auf einen Rotocap einzuwirken beginnt. Mit fortschreitendem Verschleiß kann dies zum Verlust der Sicherungskeile eines Ventils und damit zu einem kapitalen Motorschaden führen. Aus diesem Grund ist der Abstand zwischen Kipphebel und Rotocap in regelmäßigen Zeitabständen einer Sichtkontrolle zu unterziehen.
Der Abstand zwischen Kipphebel und Rotocap muss bei voll gedrücktem Ventil mindestens **1 mm** oder größer betragen.

Dringlichkeit

Innerhalb der nächsten 20 Betriebsstunden. Danach im Rahmen jeder 100h Kontrolle.

Maßnahmen

1. Stellen Sie sicher, dass die Zündung ausgeschaltet ist.
2. Ventildeckel abnehmen. Beschädigen Sie nicht die Stößelschutzrohre beim Abhebeln der Ventildeckelklammern.
3. Motor von Hand am Propeller durchdrehen.
4. Sichtkontrolle der Kontaktflächen zwischen Ventileinstellschraube und Ventilschaft auf Beschädigung durch Materialabtragung.

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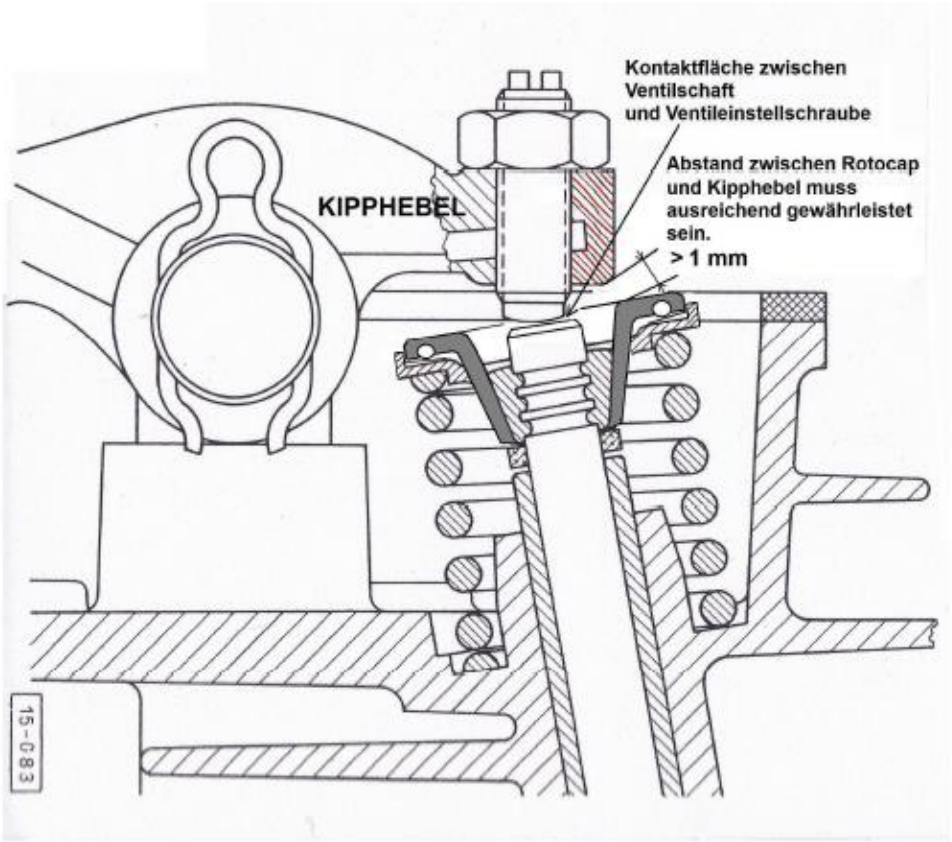
5. Motor von Hand durchdrehen und die Kipphebelgeometrie prüfen.
Bei halb gedrücktem Ventil sollte die Ventileinstellschraube senkrecht zum Ventilschaft stehen.
Bei vollständig gedrücktem Ventil muss mindestens 1 **mm** Spiel zwischen Rotocap und Kipphebel vorhanden sein.
Sollte weniger als 1mm Spiel zwischen Rotocap und Ventilschaft vorhanden sein und oder die Kontaktflächen zwischen Ventileinstellschraube und Ventilschaft derart eingelaufen sein, dass ein Verdacht auf Mangelschmierung besteht, ist die Firma Sauer Flugmotorenbau GmbH zu informieren.
Die entsprechenden Informationen zur Instandsetzung werden von der Firma Sauer Flugmotorenbau GmbH bereitgestellt.



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5.2 Technical Bulletin Nr 25 (Non official translation in English)

TECHNICAL BULLETIN N° 25

Date 14 December 2016

Subject

Testing of the geometry of the valve-rocker and the contact surface between the valve stem and the set screw.

Equipment in question

Motor S1800 ( ), No of air navigation equipment 4590 Motor S2100 ( ), No of air navigation equipment 4608

Motor S2500 ( ), No of air navigation equipment 4580

Issue

In the past, valve stems were occasionally damaged due to insufficient lubrication of the contact surfaces between the valve stem and the set screw.
These contact surfaces were subject to major mechanical constraints between the valve stem and the set screw and, in case of disappearance of the layer of lubricant, direct contact risked occurring between the set screw and the valve stem, thus producing premature wear.
Due to this, the penetration depth of the valve-rocker in the valve gear ends up increasing so much that in extreme cases, the valve-rocker could enter into contact with the rotocap (pressure cup on the rotary spring). Heavy wear on the keys can lead to the loss of a valve with a risk of breakdown of the motor. It is for this reason that the spacing between the valve-rocker and the rotocap should be regularly subject to visual inspection.
The spacing between the valve-rocker and the rotocap should be at least **1 mm** when the valve is completely pushed in.

Urgency

Within the next 20 flight hours. Then during every inspection at 100 hours.

Measures

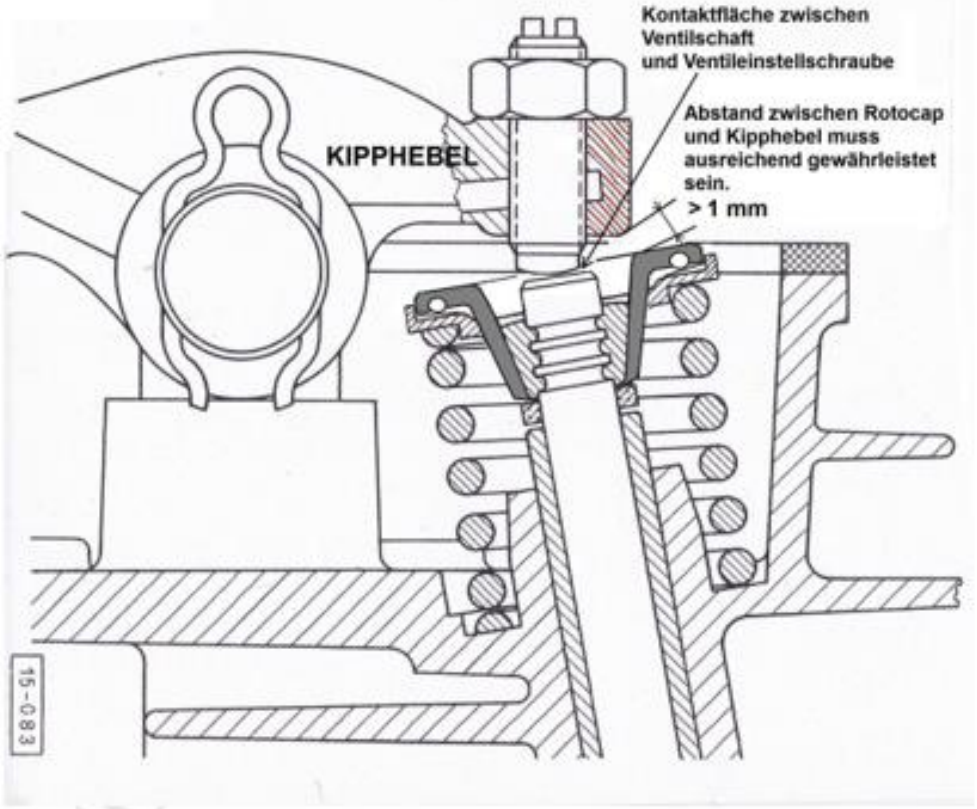
1. Make sure that the ignition is cut.

2. Take off the valve-rocker covers. Do not damage the protection covers on the control rods of the valve-rockers when removing the clips on the valve-rocker covers.

3. Run the engine by manually turning the propeller.

4. Visually check the damage through wear and tear of materials on the contact surface between the set screw and the valve stem.

5. Manually run the motor to check the geometry of the valve-rocker.
When the valve is mid-stroke, the set screw should be perpendicular to the valve stem.
When the valve is pushed in, there should be at least **1 mm** of lash between the rotocap and the valve-rocker.
If there is at least 1 mm of lash between the rotocap and the valve-rocker or if the contact surfaces between the set screw and the valve stem are so reduced that a lack of lubrication can be presumed, the company Sauer Flugmotorenbau GmbH should be informed.
Information on repairs are made available by the company Sauer Flugmotorenbau GmbH.



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5.3 Technische Mitteillung NR.26

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TECHNISCHE MITTEILUNG NR. 26

Datum 14. Dezember 2016

Gegenstand

Ventileinstellung und Kontrolle der Kipphebelgeometrie von Motoren mit und ohne hydraulischem Ventilspielausgleich (Hydrostößel).

betroffene Geräte

Motor S1800 ( ), LBA Geräte-Nr. 4590
Motor S1800 UL

Motor S2100 ( ), LBA Geräte-Nr. 4608
Motor S2100 UL
Motor S2200 UL
Motor S2400UL

Motor S2500 ( ), LBA Geräte-Nr. 4580
Motor S2500 UL

Anlass

Durch unsachgemäße Ventileinstellung, bei Motoren mit hydraulischem Ventilspielausgleich (Hydrostößel), ist es in der Vergangenheit zu Motorstörungen gekommen.

Bei einem Ventiltrieb mit hydraulischem Ventilspielausgleich (Hydrostößel), ist im Normalbetrieb eine wiederholte Einstellung der Ventile in Zeitabständen überflüssig. Lediglich nach Zerlegungsarbeiten im Bereich der Ventilsteuerung (Demontage des Zylinderkopfes, der Kipphebelwelle, der Stößel und Hydrostößel) muss eine "**Grundeinstellung**" der Ventile, wie nachstehend beschrieben, durchgeführt werden.

Bei einem Ventiltrieb mit mechanischen Stößeln (ohne Hydrostößel), ist ein Ventilspiel erforderlich, welches mit 0,2 – 0,25 mm eingestellt wird.

Wenn in Unkenntnis des Vorhandenseins von Hydrostößeln der Ventiltrieb mit vorbezeichnetem Ventilspiel eingestellt wird, kann es dazu kommen, dass zu wenig Platz zwischen Rotocap and Kipphebel vorhanden ist, da in diesem Fall die Eindringtiefe der Ventileinstellschraube in den Ventiltrieb zu gering ist.
Bei gedrücktem Ventil kann dann der Kipphebel den Rotocap berühren. Dadurch können sich die Ventilkeile lockern und im Extremfalle aus ihrem Sitz springen. Das Ventil wird dann nicht mehr gehalten und in den Zylinder gesaugt, was zwangsläufig einen kapitalen Motorschaden zur Folge hat.

Vergewissern Sie sich daher im Betriebshandbuch Ihres Motors vorab, ob Ihr Motor mit Hydrostößeln ausgestattet ist. Im Zweifelsfall fragen sie den Hersteller.

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Dringlichkeit der Maßnahmen:

Für Motore mit Hydrostößeln:
Die Maßnahmen 1.1 bis 1.4 innerhalb der nächsten 20 Flugstunden.
Die Maßnahme 1.5. in allen weiteren 100h Kontrollen.

Für Motore ohne Hydrostößel:
Die Maßnahme 2.1 bei der nächstfälligen 50h Kontrolle sowie in allen weiteren 100h Kontrollen.

Maßnahmen und Ventileinstellung

1. **Motore mit Hydrostößel:**

   Stellen Sie sicher, dass die Zündung ausgeschaltet ist.

1.1. Es ist eine Grundeinstellung des Ventiltriebes durchzuführen, wie folgt:

1.2. Öffnen Sie den Federbügel des Zylinderkopfdeckels vorsichtig, ohne die Stößelrohre zu beschädigen.

1.3. Suchen Sie den oberen Totpunkt des einzustellenden Zylinders durch Drehen am Propeller. Das Einstellen des Ventiltriebes erfolgt immer wenn der jeweilige Zylinder im Arbeitstakt auf OT steht.

1.4. Lösen Sie die Kontermutter des jeweiligen Ventiles, welches Sie einstellen wollen und drehen Sie die Ventileinstellschraube soweit heraus, bis diese den Ventilschaft sicher nicht mehr berührt und Spiel zwischen Ventileinstellschraube und Ventilschaft entsteht.
Drehen Sie dann die Ventileinstellschraube gerade so weit wieder ein, bis diese am Ventilschaft anliegt.
Von dieser Stellung aus drehen Sie die Ventileinstellschraube 1- 2 Umdrehungen nach rechts weiter ein.
Damit wird der Hydrostößel vorgespannt.

1.5 Bei vollständig gedrücktem Ventil sind die Vorgaben gemäß TM 25 zu überprüfen. Es muss mindestens 1mm Spiel zwischen Kipphebel und Rotocap vorhanden sein (she. Bild).
Wenn sich dieses Mindestspiel nicht einstellt, ist zur Behebung des Problems Kontakt mit der Firma Sauer Flugmotorenbau herzustellen, wo weitere Instruktionen erfragt werden können.
Weitere Ventile werden auf gleiche Weise eingestellt.

Hinweis: Wir weisen darauf hin, dass nach Reparaturarbeiten mit Eingriff in den Ventiltrieb, sich Hydrostößel erst "setzen" müssen. Dies bedeutet, dass der Motor nach Abschluss der Reparatur ca. 10 bis 15 Minuten betrieben werden muss. Danach ist die Grundeinstellung zu wiederholen.

2. **Motore ohne Hydrostößel:**

   Stellen Sie sicher, dass die Zündung ausgeschaltet ist.

   Führen Sie die Maßnahmen gem. 1.1., 1.2. und 1.3. durch.

2.1. Bei Motoren mit mechanischen Stößeln ist ein Ventilspiel von 0,2 - 0,25 mm erforderlich.
Dieses Ventilspiel ist zu überprüfen und gegebenenfalls nachzustellen.
Dazu ist der Motor von Hand durchzudrehen und die Kipphebelgeometrie zu prüfen. Bei halb gedrücktem Ventil, sollte die Ventileinstellschraube senkrecht zum Ventilschaft stehen. Bei vollständig gedrücktem Ventil muss mindestens 1 mm Spiel zwischen Rotocap und Kipphebel vorhanden sein. (Siehe TM25).
Zu keiner Zeit darf ein Kipphebel den Rotocap berühren.

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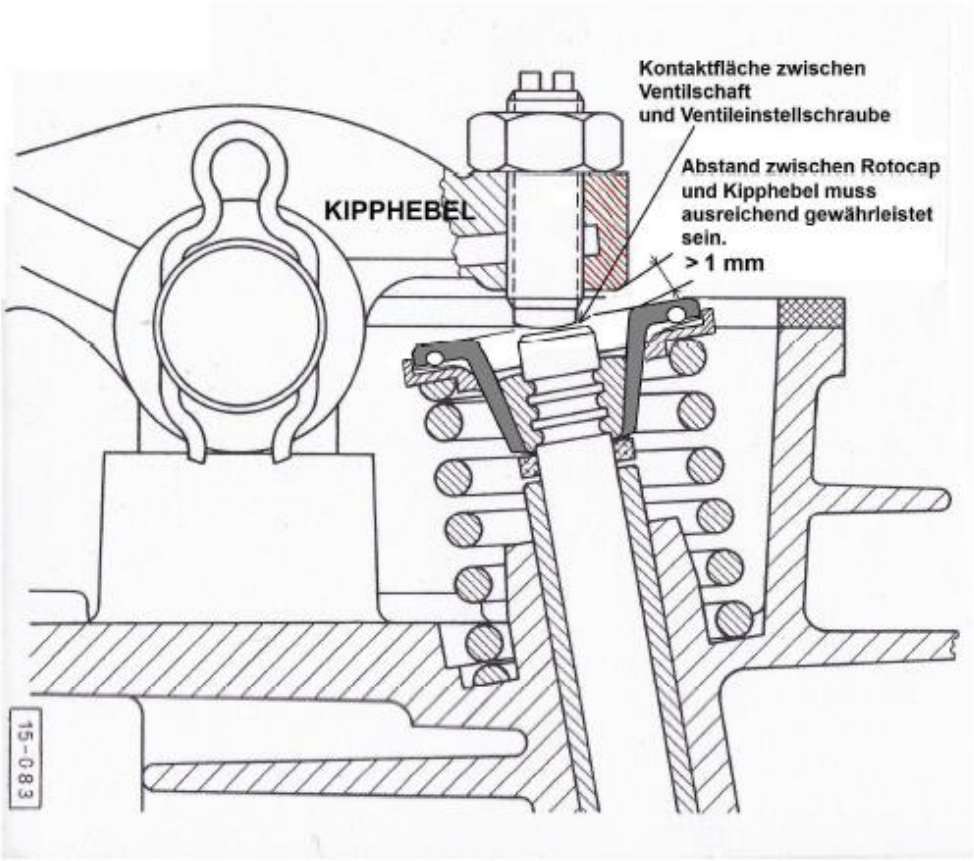

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5.4 Technical Bulletin Nr 26 (Non official translation in English)

TECHNICAL BULLETIN N° 26

Date 14 December 2016

Subject

Adjustment of the valve and testing of the geometry of the rocker for motors with or without hydraulic compensation for the valve lash (hydraulic tappet).

Equipment in question

Motor S1800 ( ), LBA equipment No 4590
Motor S1800 UL

Motor S2100 ( ), LBA equipment No 4608
Motor S2100 UL
Motor S2200 UL
Motor S2400 UL

Motor S2500 ( ), LBA equipment No 4580
Motor S2500 UL

Issue

Due to inadequate valve adjustments in motors with hydraulic compensation (hydraulic tappet) of the valve lash, motor breakdowns have occurred in the past.

In the case of valve gear with hydraulic compensation of the valve lash (hydraulic tappet), a repetitive adjustment is superfluous in a normal situation. Only after disassembly works of the valve gear (disassembly of the cylinder head, the valve-rocker shaft, the tappets and hydraulic tappets), an "**initial adjustment**" of the valves, as described below, would be necessary.

In case of valve gear with mechanical tappets (without hydraulic tappets), a valve lash is needed, which should be adjusted to 0.2 - 0.25mm.

If due to ignorance of the existence of hydraulic valves, the valves are adjusted with a lash as described above, it may be that there is too little space between the rotocap (pressure cup on the rotary spring) and the valve-rocker, as in this case the depth of penetration of the set screw in the valve gear is insufficient.
When the valve is pushed in, the valve-rocker risks touching the rotocap. Due to this, the valve keys can wear out and, in extreme cases, come out of place. The valve is no longer held in place and is sucked into the cylinder, which has fatal consequences for the motor.

Check the operating manual of your motor to see if it is equipped with hydraulic tappets. In case of doubt, ask the manufacturer.

Urgency of the measures:

For motors with hydraulic tappets:
Measures 1.1 to 1.4 over the next 20 flight hours.
Measure 1.5 for all other checks at 100 hours.

For motors without hydraulic tappets:
Measure 2.1 in the next checks at 50 hrs as well as for all other 100 hr checks.

Measures to be taken and valve adjustment

1. **Motors with hydraulic tappets:**

   Make sure that the ignition is cut.

1.1. The initial adjustment of the valve gear is done as follows:

1.2. Take off the valve-rocker covers. Do not damage the protection covers on the control rods of the valve-rockers by removing the clips on the valve-rocker cover.

1.3. Look for the top dead-centre on the cylinder to be adjusted by turning the propeller. Adjustment of the valve gear is always done when the cylinder concerned is at the top dead-centre.

1.4. Remove the set-nut on the valve that you want to adjust and unscrew the set screw until you are sure that it is no longer touching the valve stem and that there is movement between the set screw and the valve stem. Then re-tighten the set screw just enough that it touches the valve stem. From this point, turn the set screw again one or two more times to the right. Thus, the hydraulic tappet is pre-stressed.

1.5 When the valve is completely pushed in, the conditions in TM25 are to be checked. There should be at least 1 mm of lash between the valve-rocker and the rotocan (pressure cup on the rotary spring) (see plan).
If the adjustment of this minimum lash does not work, you may contact Firma Sauer Flugmotorenbau who will give you instructions on how to resolve this problem.
The other valves are adjusted in the same way.

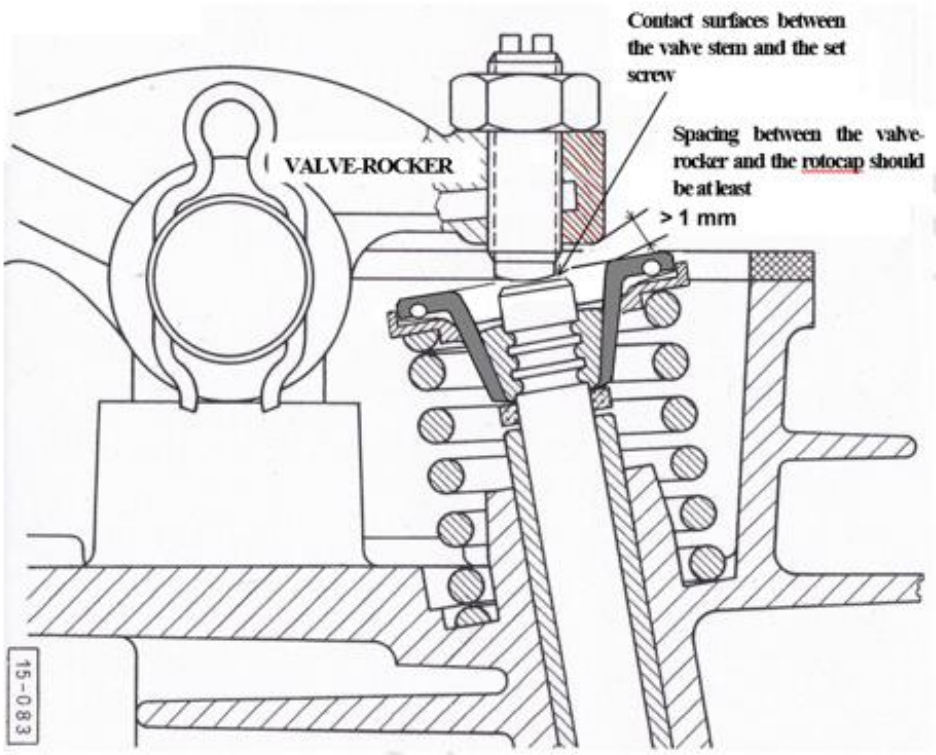
Comment: we would point out that after repair works requiring an intervention on the valve gear, the hydraulic tappets should first be "broken in". This means that the motor, after the end of the repair, should be started up for around 10 to 15 minutes. After this, the initial adjustment should be repeated.

2. **Motors without hydraulic tappets:**

   Make sure that the ignition is cut.

   Proceed as described in 1.1, 1.2 and 1.3.

2.1. In case of motors with mechanical tappets, a valve lash of 0.2 to 0.25mm is necessary. This valve lash should be checked and, where appropriate, adjusted again.
For this purpose, manually turn the motor to check the geometry of the valve-rocker. When valve is mid-stroke, the set screw should be perpendicular to the valve stem. When valve is pushed in, there should be at least **1 mm** of lash between the rotocap and the valve-rocker. (See TM25).
At no point should a valve-rocker touch the rotation device.



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