SOUTH AFRICAN CIVIL AVIATION AUTHORITY

Section/division Accident and Incident Investigation Division — Form Number: CA 12-12a

AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

Reference:	CA18/2/3/9236

Aircraft registration	**ZS-RTV**	**Date of accident**	29 October 2013	**Time of accident**	0700Z
Type of aircraft	Robinson R22 Beta – Helicopter		**Type of operation**	Private (Part 91)	
Pilot-in-command licence type	Private	**Age**	22	**Licence valid**	Yes
Pilot-in-command flying experience	Total flying hours	118.6	Hours on type	97	
Last point of departure	Mossel Bay Aerodrome (FAMO), Western Cape				
Next point of intended landing	Mossel Bay Aerodrome (FAMO), Western Cape				
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)					
On a farm approximately 4 km from George Aerodrome (GPS position: S34° 02'36.41" E022° 22'10.89")					
Meteorological information	Surface wind: 040°/5 kt, temperature: 22 °C, visibility: +10 km				
Number of people on board	1 + 0	**No. of people injured**	1	**No. of people killed**	0

Synopsis

The pilot conducted a private flight from Mossel Bay Aerodrome with the intention of flying to Knysna and back to Mossel Bay Aerodrome. In the cruise at 1100 feet AMSL whilst approaching Herolds Bay and flying along the coast, the engine of ZS-RTV started backfiring and the aircraft started yawing and vibrating. The engine then failed and the pilot entered into autorotation. During touchdown on an open field on a farm, the aircraft bounced and rolled over to the left due to the uneven ground.

Investigation revealed that the exhaust pushrod on No. 1 cylinder of the engine was found bent and fractured as a result of a sticky valve which caused the engine failure.

The helicopter sustained substantial damage during the accident sequence and the pilot was admitted to hospital with minor injuries.

Probable cause

Unsuccessful autorotation following an engine failure.

Contributory factor/s

Engine failure due to sticky exhaust valve resulting in a bent pushrod which caused engine failure.

SRP Date	17 January 2017	Release Date	06 February 2017

AIRCRAFT ACCIDENT REPORT

Name of Owner	**:** Shone Electrical Aviation Division
Manufacturer	**:** Robinson
Model	**:** R22 Beta
Nationality	**:** South African
Registration Marks	**:** ZS-RTV
Place	**:** Farm Seaview Brakfontein, George
Date	**:** 29 October 2013
Time	**:** 0700Z

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Purpose of the Investigation:

In terms of Regulation 12.03.1 of the Civil Aviation Regulations (2011) this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and ***not to establish legal liability****.*

Disclaimer:

This report is produced without prejudice to the rights of the CAA, which are reserved.

1. FACTUAL INFORMATION

1.1 History of flight

1.1.1 On 29 October 2013 at 0630Z the pilot took off in a Robinson R22 helicopter, ZS-RTV, from Mossel Bay Aerodrome (FAMO) on a private flight to the Knysna with the intention of landing back at Mossel Bay Aerodrome. This was a private flight and the pilot was accumulating flying hours towards a Commercial Pilot’s license. The day prior to the flight the aircraft was refuelled and the morning prior to the flight the pilot did the Weight and Balance calculation for the flight.

1.1.2 After take-off the pilot initiated a right hand turn to Hartenbos and contacted George Air Traffic Control (ATC) for routing through their airspace. George ATC instructed ZS-RTV to orbit 2 minutes outside the Controlled Zone (CTR) at the Great Brak River. After 5 minutes ZS-RTV was then cleared to fly inbound and to report at Herolds Bay.

1.1.3 The pilot stated that during cruise at 75 knots whilst at approximately 1100 feet AMSL and flying along the coast approaching Herolds Bay, the engine of ZS-RTV started backfiring. The helicopter also started yawing and vibrating. She noted that the manifold pressure increased from 20 inches mercury to 28 inches mercury where after the rotor and engine revolutions per minute (RPM) reduced sharply. The pilot declared an emergency with George ATC and decided to route inbound as the coastline had an uneven and unsafe terrain. The engine failed and she performed an autorotative landing. The pilot manoeuvred the helicopter towards a nearby open field and during touchdown the aircraft bounced and rolled over to the left, due to the uneven ground.

1.1.4 During the landing sequence the pilot sustained a laceration to her head resulting from impact with the cyclic. The pilot exited the wreckage and a cyclist that witnessed the accident assisted the pilot and alerted the relevant emergency services. The FAGG Emergency and Rescue Services dispatched to the scene and the pilot was taken to hospital with minor injuries.

1.1.5 The accident occurred during daylight conditions at a geographical position determined to be South 34° 02'36.41" E022° 22'10.89".

Figure 1: Google view of the coastal route from Mossel Bay to Knysna

Figure 2: Google view of the accident site

1.2 Injuries to persons

Injuries	Pilot	Crew	Pass.	Other
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	1	-	-	-
None	-	-	-	-

1.3 Damage to aircraft

1.3.1 The aircraft sustained substantial damage.

Figure 3: A view of the aircraft wreckage and accident site

1.4 Other damage

1.4.1 No other damages were caused.

1.5 Personnel information

1.5.1 Pilot-in-command

Nationality	South African	Gender	Female	Age	22
Licence number	0272441098	Licence type	Private Pilot		
Licence valid	Yes	Type endorsed	Yes		
Ratings	None				
Medical expiry date	31 May 2015				
Restrictions	None				
Previous accident	None				

Flying experience:

Total hours	118,6
Total past 90-days	39,4
Total on type past 90-days	23,9
Total on type	97,0

1.6 Aircraft Information

1.6.1 Aircraft Description

The Robinson R22 is a two-bladed, single-engine light utility helicopter manufactured by Robinson Helicopter. Due to relatively low acquisition and operating costs, the R22 has been popular as a primary rotorcraft trainer.

The basic structure is welded chromoly steel tubing. The forward fuselage is made of fiberglass and aluminium with a Plexiglas canopy. The tailcone, vertical and horizontal stabilizers are aluminium.

Instead of a floor-mounted cyclic stick between the pilot's knees, the R22 uses a unique teetering "T-Bar" control connected to a stick that emerges from the console between the seats.

Powerplant

The R22 Beta II uses a horizontal mounted four-cylinder air-cooled Lycoming O-320-J2A piston engine that is normally aspirated and equipped with a carburettor.

1.6.2 Airframe:

Type	Robinson R22 Beta	
Serial number	3586	
Manufacturer	Robinson	
Year of manufacture	11 March 2004	
Total airframe hours (at time of accident)	3204.5	
Last annual inspection (hours & date)	3137.2	03 October 2013
Hours since annual inspection	2.0	
C of A (issue date)	14 March 2008	
C of R (issue date) (present owner)	20 May 20044	
Operating categories	Standard	

Engine:

Type	Lycoming 0-360-J2A
Serial number	L-39505-36A
Hours since new	1357.6
Hours since overhaul	86.1

1.6.3 Maintenance History

No maintenance anomalies and/or defects were recorded in the aircraft's technical logbooks prior to the flight.

1.6.4 Previous Incidents

The aircraft was involved in three prior incidents.

a) 06 July 2004
The helicopter entered into a vortex ring state during a downwind turn which resulted in ground impact and extensive damage to the aircraft.

b) 16 July 2007
During lift-off an animal ran into the skid which resulted in a hard landing and dynamic roll over. The helicopter was substantially damaged.

c) 20 March 2008
During cruise the helicopter engine experienced a loss of power and the pilot performed autorotation which resulted in a hard landing. The helicopter sustained extensive damage. The throttle linkage was found to have failed which caused the decrease in engine power.

1.6.5 Fuel

The helicopter was refuelled with 87 litres of Avgas 100LL fuel the day prior to the flight and had 112 litres of Avgas 100LL in tank for the flight. Avgas 100LL are the authorised fuel type recommended by the manufacturer. During the on-site investigation it was determined that the helicopter has approximately 98 litres (26 gallons) of Avgas 100LL fuel remaining in the fuel tank.

1.6.6 Weight and Balance

	WEIGHT	LONG. ARM	LONG. MOM.	LAT. ARM	LAT. MOM.
Empty Weight	**872.80**	102.94	**89845.73**	0.4	**44.10**
Pilot	-5	**77.5**	-403.00	**+21.0**	-109.20
Baggage (Pilot Seat)	-5	**77.5**	-403.00	**+21.0**	-109.20
Passenger	139	**78.0**	10842.00	**10.7**	1487.30
Baggage (Passenger Seat)	0	**78.0**	0.00	**-9.3**	0.00
Total Weight & Balance w/Zero Usable Fuel	**No Fuel Weight**	**No Fuel Long. C.G.**	**Long. Empty Moment**	**No Fuel Lat. C.G.**	**Lat. Empty Moment**
	1011.80	**99.50**	100687.73	**1.50**	1531.40
Main Tank	115.20	**108.6**	12510.72	**-11.0**	-1267.20
Aux. Tank	63.00	**103.8**	6539.40	**+11.2**	705.60
Total Weight & Balance w/Take Off Fuel	**Take Off Weight**	**Long. Full C.G.**	**Long. Full Moment**	**Lat. Full C.G.**	**Lat. Full Moment**
	1190.00	**100.62**	119737.85	**0.81**	969.80

The total weight of the helicopter was within limits for the flight and was determined to be 180 lbs below its maximum take-off weight limit. The centre of gravity of the aircraft was also within limits as seen in Figure 4.

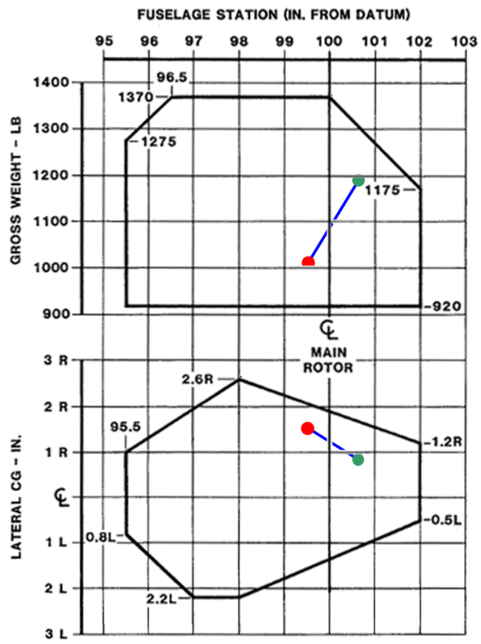


Figure 4: Centre of gravity graph as calculated

1.7 Meteorological information

1.7.1 Weather information was obtained from South African Weather Service that was taken from George Aerodrome (FAGG) which is approximately 4km from the accident site.

Wind direction	170°	Wind speed	04 kts	Visibility	10 000 m
Temperature	21 °C	Cloud cover	Nil	Cloud base	N/A
Dew point	16 °C	QNH	1012 hPa		

The satellite image on the weather report also showed clear skies over Herolds By at the time of the occurrence.

1.8 Aids to navigation

1.8.1 The helicopter was equipped with approved navigational aids. No defects to the navigational equipment were reported or recorded prior to the accident flight.

1.9 Communication

1.9.1 The helicopter was equipped with approved communication equipment. No defects to the communication equipment were reported or recorded prior to the accident flight.

1.9.2 The pilot of ZS-RTV was in communication with George ATC on the 118.9 MHz VHF frequency when the accident occurred.

1.10 Aerodrome information

1.10.1 The accident occurred in a grass covered open field on Farm Seaview Brakfontein in George, Western Cape. The accident site is approximately 4 km from George Aerodrome (FAGG).

1.11 Flight recorders

1.11.1 The helicopter was not fitted with a Cockpit Voice Recorder (CVR) or a flight data recorder (FDR), nor was this required by regulations.

1.12 Wreckage and impact information

1.12.1 In the cruise at 1100 feet AMSL with the airspeed of approximately 75 knots the engine of the helicopter started backfiring and the helicopter started yawing and vibrating. The engine manifold pressure increased from 20 inches mercury to 28 inches mercury where after the rotor and engine RPM reduced sharply. The pilot then routed inbound from the coastline where after the engine failed. The pilot executed an autorotative landing on uneven terrain where after the helicopter bounced and rolled over to the left.

1.12.2 During the impact with the ground the helicopter sustained damage to the main rotor, tail rotor, tail boom, skids, fuselage and windscreens. The tail rotor and tail drive was located approximately 13 meters main wreckage.

Figure 5 & 6: View of the aircraft wreckage

1.13 Medical and pathological information

1.13.1 The pilot sustained a laceration to her head from the impact with the cyclic.

1.14 Fire

1.14.1 There was no evidence of pre- or post-impact fire.

1.15 Survival aspects

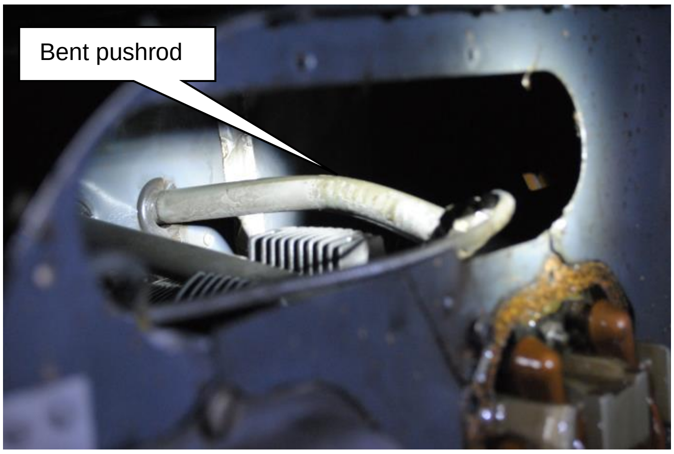
1.15.1 Although the windscreens broke during the impact sequence, the cabin area sustained no damage.

1.15.1 The pilot sustained a laceration to her head from an impact with the cyclic. She was however properly restrained at the time of the accident by the equipped safety harness which subsequently prevented further injuries.

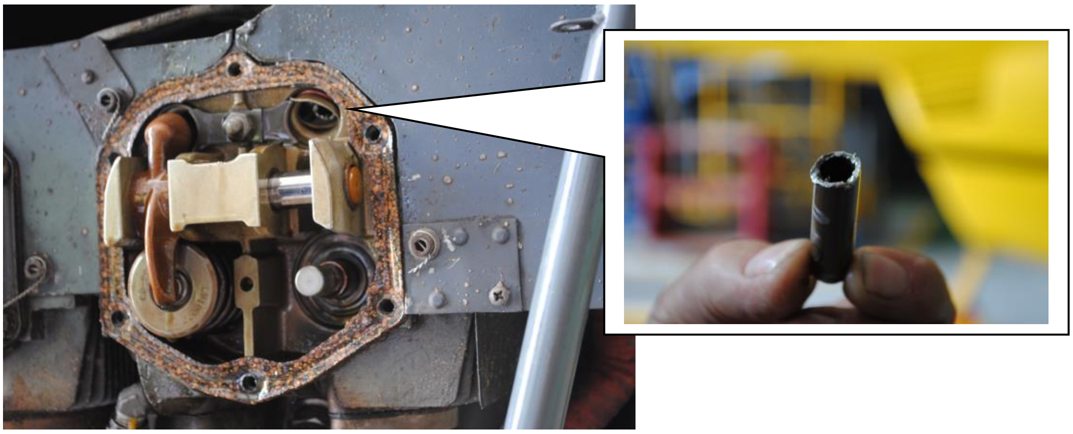
1.16 Tests and research

1.16.1 <u>Engine Investigation</u>
The wreckage was recovered to an approved AMO at Mossel Bay Aerodrome for further investigation. The following findings were made:

- The exhaust pushrod on No. 1 cylinder of the engine was found bent.
- After opening the No.1 cylinder rocker box cover, the pushrod was found fractured. The exhaust valve was fractured with the stem remaining in the cylinder head.
- Although the exhaust valve was fractured, the springs, spring seat, keepers, rocker arm, and rotor cap remained assembled in their normal positions and sustained no damage.
- Carbon build-up was found on No. 1 sparkplug.



<u>Figure 7:</u> View of the exhaust pushrod on No. 1 cylinder of the engine that was found bent



<u>Figure 8 and Inset:</u> A view of the broken part of the No. 1 cylinder exhaust pushrod

Occurrences at the Operator:

It was found that the Operator had a similar bent pushrod occurrence on a Robinson R44 with a Lycoming IO-540-AE1A5 engine three weeks prior. The incident occurred whilst the helicopter was in the hover and it landed safely. Following further investigation it was found that the Operator changed from using Aeroshell Aviation W100 Plus oil to Exxon Elite 20W-50 oil on all their Robinson helicopters starting approximately 3 weeks prior to the occurrences.

Note: Both oil types that were used were approved by the Manufacturer.

The following is the sequence of occurrences on the two different helicopters of the Operator after changing from using Aeroshell Aviation W100 Plus oil to Exxon Elite 20W-50 oil:

	Robinson R22 (ZS-RTV) Lycoming 0-360-J2A (Engine)		**Robinson R44** Lycoming IO-540-AE1A5 (Engine)	
Last SB 388C done (Hours & Date)	3037.3	19 Aug 2013	603.8	14 Dec 2012
Change to new Exxon oil (Hours & Date)	3186.5	23 Oct 2013	801.7	04 Oct 2013
Incident (Hours & Date)	3204.4	29 Oct 2013	822.2	09 Oct 2013
ncident (Hours after oil change & Occurrence)	17.9	*During cruise*	20.5	*After take-off in the hover*

Figure 9

1.17 Organisational and management information

1.17.1 The aircraft was approved to be utilised by the Aviation Training Organisation (ATO) no: CAA/0202 which was in possession of a valid ATO certificate.

1.17.2 The last maintenance that was carried out on the aircraft prior to the accident was conducted by AMO (Aircraft Maintenance Organisation) No. 1122. The AMO was in possession of a valid AMO Approval certificate to perform the required maintenance.

1.18 Additional information

1.18.1 None.

1.19 Useful or effective investigation techniques

1.19.1 None considered necessary.

2. ANALYSIS

2.1 In the cruise at 1100 feet AMSL with airspeed of approximately 75 knots the engine of ZS-RTV started backfiring and the aircraft started yawing and vibrating. The manifold pressure increased from 20 inches mercury to 28 inches mercury whilst the rotor and engine RPM reduced sharply. The engine failed and the pilot initiated an autorotative landing. During touchdown the aircraft bounced and rolled over to the left due to the uneven ground.

2.2 During the investigation the exhaust pushrod on No. 1 cylinder of the engine was found bent. The exhaust valve was fractured with the stem remaining in the cylinder head. History suggests that since 1980 the engine type experienced similar failures that were caused by valve sticking.

Valve sticking is almost exclusively limited to exhaust valves and exhaust valve issues seem to be more prevalent on helicopter engines due to their high constant loading with no variance in operating conditions. This creates a good environment for deposits to crowd the valve that will lead to valve sticking.

2.3 Other factors that could lead to deposit build-up in engines resulting in sticky valves are engines that are inoperative for long periods, operating in dusty conditions, extended ground operations and inadequate engine cooling. The Manufacturer implemented mandatory inspections to identify and decrease/eliminate deposit build-up. It was found that the Operator of ZS-RTV complied with the mandatory inspections and adhered to sticky valve prevention practices.

2.4 It was however found that the Operator changed to a different approved engine oil on their Robinson helicopters including ZS-RTV prior to the accident. Although the Operator had two similar bent pushrod occurrences on two of their helicopters following the oil product change, there are currently no substantiating data to support the possibility that a specific type or brand of oil is more susceptible to the formation of deposits within the exhaust valve guides of the engine type.

3. CONCLUSION

3.1 Findings

3.1.1 The pilot was licensed for the flight in accordance with existing regulations.

3.1.2 The pilot was the holder of a valid aviation medical certificate that was issued by an approved medical examiner.

3.1.3 The helicopter was in possession of a valid Certificate of Airworthiness.

3.1.4 There was sufficient fuel on board the helicopter at the time of the accident.

3.1.5 The weight and balance of the helicopter was below its maximum allowable limits.

3.1.6 During cruise the helicopter experienced an engine failure where after the pilot performed autorotation. During the autorotative landing the helicopter rolled over due to uneven terrain

3.1.7 The pilot sustained minor injuries.

3.1.8 The exhaust pushrod on No. 1 cylinder of the engine was found bent and fractured as a result of a sticky valve.

3.1.9 A mandatory Service Bulletin, SB No. 388C was issued by the Manufacturer to address sticky valve problems. ZS-RTV complied with the Mandatory SB and the Operator adhered to sticky valve practices.

3.1.10 ZS-RTV including other Robinson helicopters operated by the Operator changed to using different approved engine oil prior to the accident. Although another helicopter has a similar occurrences relating to a sticky valve and bent pushrod there is no substantiating data to support the possibility that a specific type or brand of oil is more susceptible to the formation of deposits within the exhaust valve guides on the engine type.

3.1.11 Fine weather conditions prevailed, which were not considered to have had any bearing on the accident.

3.2 Probable cause

3.2.1 Unsuccessful autorotation following an engine failure.

3.3 Contributory factor/s

3.3.1 Sticky exhaust valve resulting in a bent pushrod which caused engine failure.

4. SAFETY RECOMMENDATIONS

4.1 None

5. APPENDICES

5.1 Valve Operating Mechanism (See Figure 9 and 10) Attachments
Description

- A conventional camshaft is located above and parallel to the crankshaft.
- The camshaft actuates tappets ***(Figure 9-12 & 13)*** which operate the valves ***(Figure 9-1 & 2)*** through pushrods ***(Figure 9-1)*** and valve rockers ***(Figure 9-2)***.
- The valve rockers ***(Figure 9-2)*** are supported on full floating steel shafts.
- The valve springs ***(Figure9-3 & 4)*** bear against hardened steel seats ***(Figure 9-5;6;7;8)*** and are retained on the valve stems by means of split keys ***(Figure9-9 & 10)***.
- A rotator cap is employed on sodium cooled exhaust valves.
- The purpose of the valve guides is to support the side forces operating on the valve stem. The guide also centres the valve on the valve seat and conducts a part of the heat from the valve head via the valve stem to the cylinder head. Valve stems and guides are normal wear items. Mutual wear increases the stem to guide clearances and exhaust valves, particularly sodium filled valves, rely on proper clearance to the guide to maintain good heat transfer properties.

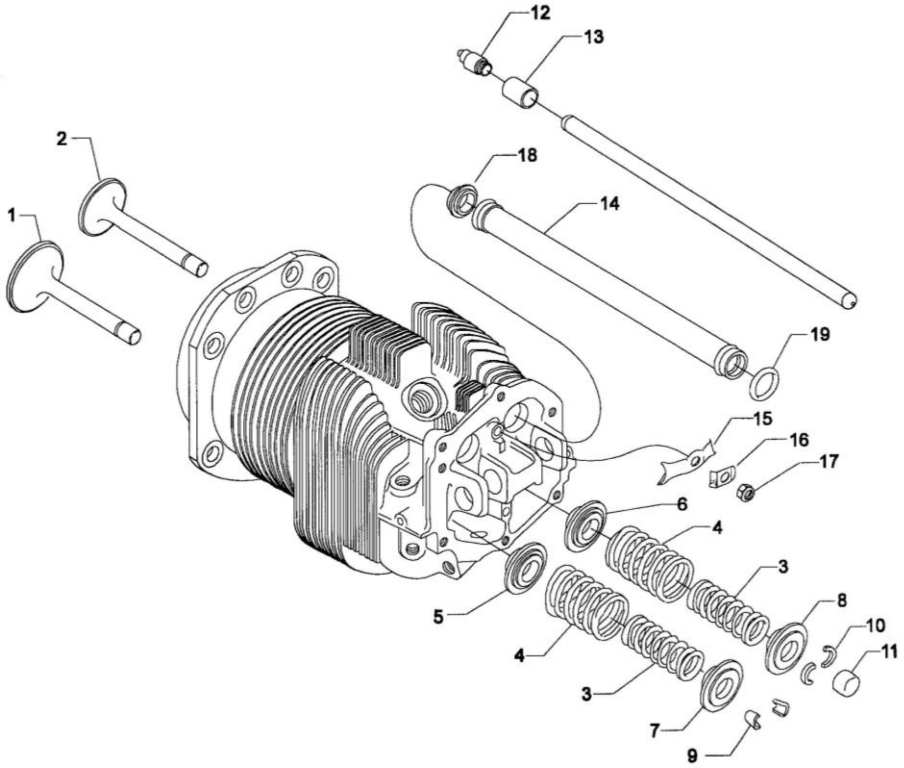


Figure 9: A schematic of the cylinder assembly

1-Intake Valve; **2**- Exhaust Valve; **3**- Valve Spring Inner; **4**- Valve Spring Outer; **5,6,7,8**-Valve Seat; **9,10**- Valve Key; **11**- Valve Stem Cap; **12**- Hydraulic Tappet Plunger; **13**- Hydraulic Tappet Socket; **14**- Push Rod Shroud Tube Assembly

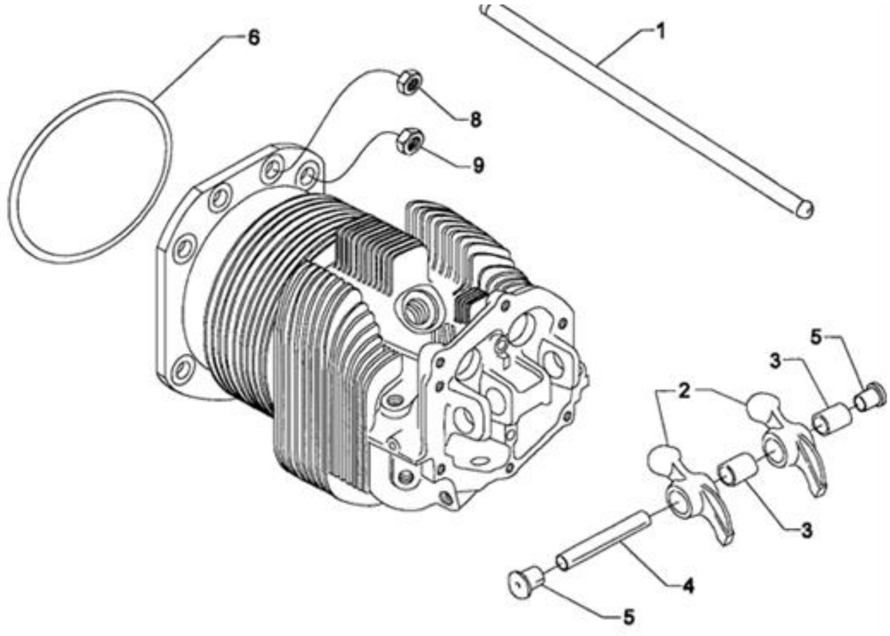


Figure 10: A schematic of the cylinder and valve rocker assembly

1- Push Rod; **2**- Valve Rocker Assembly; **3**- Valve Rocker Bushing; **4**- Valve Rocker Shaft; **5**- Rocker Shaft Thrust Button

History of Sticky Valves

On 18 June 1987 the National Transportation Safety Board (NTSB) of the United States of America issued recommendations regarding sticky exhaust valves avoidance on Avco Lycoming 0-320 series engines stating the following:

From 1980 to 1986, there were 71 accidents or incidents involving a loss of engine power due to broken or sticking exhaust valves in Avco Lycoming 0-320 series engines. Sticking exhaust valves are often accompanied by bent push rods. During this same period, the Federal Aviation Administration's National Safety Data Branch also received 219 Service Difficulty Reports regarding such valve problems. The valve problems have occurred primarily in engines installed in several models of Cessna, Piper, and Gulfstream American airplanes, and in Robinson helicopters.

Exhaust valve sticking has been the subject of several Avco Lycoming Service Publications including Service Letter No L197, "Recommendations to Avoid Valve Sticking" (July 2, 1982); Service Instruction No. 1425, "Suggested Maintenance Procedures to Reduce the Possibility of Valve Sticking" (October 21, 1983); and Service Letter L205A, "Warranty/Proration in Event of Stuck Exhaust Valves" (November 23, 1984). Valve sticking, according to Service Letter L197, can be caused by contaminants in the oil and by combustion residues. These cause lead, varnish, and carbon deposits to form on the exhaust valve stem and guide, interfering with the stem's movements and resulting in intermittent engine hesitation or miss. If the deposits are not removed, a valve could become stuck, causing engine damage.

Service Instruction No. 1425 elaborates on the problem as follows: Since the rate of oil contaminant accumulation is increased by high ambient temperatures, slow flight with reduced cooling, and high lead content of fuel, owners and operators experiencing these conditions are encouraged to consider the following suggestions for operation and maintenance if they have experienced valve sticking.

Service Bulletins issued

Following the above recommendation the following service bulletins were issued:

- Service Bulletin (SB) No. 388A was introduced.
- Service Bulletin No 388B
  Was issued in May 1992 by Lycoming which called for the inspection of the valve stem and valve guide clearance on a number of their engines. According to the SB, failure to comply with the SB could result in engine failure due to excessive carbon build-up between the valve guide and valve stem. The SB noted that the outcome of this build-up was sticking exhaust valves or broken exhaust valves, which resulted from excessive wear (bell-mounting) of the exhaust valve guide.
- Service Bulletin No 388C
  In November 2004, the SB No.388B was revised to 388C, which, in essence, combined SB No. 388B and a supplement to the SB, and added dimensions for fabrication of a tool to measure valve wobble. The SB recommended that the valve guide clearance be inspected every 300 hours for helicopters, or sooner if valve sticking was suspected.

Information received from the Manufacturer

The NTSB was informed about both above incidents with regards to the view that the changing to a different oil type could have contributed to the sticky valve and subsequent engine failure. The following information was then provided by the Engine Manufacturer:

Lycoming Engines has no substantiating data to support that a specific type or brand of oil is more susceptible to the formation of deposits within the exhaust valve guides on Lycoming engines.

Considering that the properly timed sequences of valve opening and closing is essential to efficient and reliable engine operation. Anytime those valves stick for any reason, it is a serious problem. The space between the continuously moving valve stem and its stationary valve guide is extremely critical.

Note that the amount of clearance can be affected by high temperatures, engine cleanliness and extended periods of engine inactivity. Changes in valve-to-guide clearance can occur during the course of engine operation.

IT IS POSSIBLE TO PROMOTE VALVE STICKING, AND THERE ARE ACTIONS THAT CAN BE TAKEN TO REDUCE OR ELIMINATE THE POSSIBILITY OF THIS CONDITION. These actions will affect engine cooling, fuel management and internal engine cleanliness.

a) Engine cleanliness

Engine cleanliness is a primary consideration that is affected by many maintenance and operational procedures. Proper air filter maintenance is one such item. The induction air filter is the first line of defence in keeping dirt and abrasives from entering the engine. To prevent dirt from entering the engine, the filter must form a good seal with the filter holder, and the induction system should be free of air leaks. The air filter should be cleaned or changed on a regular basis.

Note: IN EXTREMEELY DUST CONDITIONS, AIR FILTER CHANGE COULD BE NECESSARY AS FREQUENTLY AS EVERY FEWHOURS OF OPERATION.

b) Engine operation

An engine should be flown regularly to stay in tiptop condition. The oil in sump collects residue from combustion such as moisture, acid and lead sludge. Flying the aircraft tends to heat the oil enough to vaporize the moisture and help eliminate some of these contaminates, but an engine that is not flown will collect moisture, acids and gums which may contribute to corrosion and valve-train problems.

Note: LYCOMING ENGINES SERVICE BULLETIN NO. 480 MAKES RECOMMENDATIONS FOR 50 HOUR OIL CHANGES FOR ENGINE EQUIPPED WITH FULL FLOW FILTER OR EVERY 4 MONTHS UNDER NORMAL CONDITIONS AND WHEN OPERATING IN A DUSTY ENVIROMENT MAY REQUIRE MORE FREQUENT OIL CHANGES.

c) Ground operation

Avoiding long periods of ground operation is a vital step since moisture can enter the breather, but will not vaporize when the oil is not heated to normal operating temperatures. Ground running also involves a slight rich mixture which contributes *to the formation of lead sludge in the oil.*

Note: DURING THE FLIGHT, THE DEPOSIT OF LEAD SLUDGE IN THE OIL CAN BE MINIMIZED BY PROPER LEANING. ALTHOUGH SOME EXCESS FUEL IS REQUIRED FOR ENGINE COOLING DURING HIGH-POWER OPERATION, PROPER LEANING AT CRUISE-POWER SETTING WILL PROMOTE COMPLETE BURNING OF THE FUEL AND, THEREFORE A MINIMUM LEAD SLUDGE DEPOSITED IN THE OIL. THE AIRFRAME MANUFACTURER'S RECOMMENDATIONS AND LIMITATIONS FOR LEANING SHOULD BE OBSERVED.

d) Engine cooling baffles
Engine cooling baffles are designed to direct cooling air over the cylinders and must be maintained in good condition. If these baffles deteriorate or are installed so that cooling air is not adequately contained and directed, hot spots which promote a lead or carbon build-up may occur.

e) Aircraft operation
The pilot, as well as maintenance personnel, play an important role in ensuring that the engine operating temperatures do not promote valve sticking.

Note: GROUND RUNNING FAR IN EXCESS OF THE TIME NECESSARY FOR ENGINE WARM-UP SHOULD BE AVOIDED.

Also to be considered is continuous operation at low aircraft speeds that may not generate the most efficient flow of cooling air over the engine. This lack of effective cooling air may cause some areas of the engine to be excessively hot, and therefore have an effect on contaminates that are in the oil. The formation of deposits is promoted, with the exhaust valve guide area most likely to be affected. The results of these deposits may be stuck or sticky valve.

f) Cooling cycle of the engine
The other end of the spectrum controllable by the pilot is EXCESSIVELY RAPID COOLDOWN OF AN ENGINE THAT HAS BEEN RUNNING AT NORMAL OPERATING TEMPERATURES ESPECIALLY IN THE HELICOPTER OPERATIONS.

Lycoming engines are made of various metals that expand and contract at different rates when exposed to heat or cold.

Note: PRIOR TO ENGINE SHUT-DOWN, THE ENGINE SPEED SHOULD BE MAINTAINED AT IDLE RPM FOR ROTOR-WING INSTALLATIONS UNTIL THE OPERATING TEMPERATURE HAS STABILIZED.

1.16.6 The Operator provided the following information regarding the above requirements:

a) Regarding engine cleanliness and air filter maintenance (Refer 1.16.5a)
- ***The air filters are changed at every MPI as required by the Manufacturer's Maintenance Manual.***
- ***The helicopters do not operate in dusty conditions.***

b) Regarding engine operation and oil filter maintenance (Refer 1.16.5b)
- ***The oil filters are changed at every MPI as well as every 50 hour oil change as required by the Manufacturer's Maintenance Manual.***

c) Regarding the ground operation of their helicopters (Refer 1.16.5c)
- ***Their operations do not require long periods of ground operation.***

d) Regarding the operation of their helicopters (Refer 1.16.5e)

- ***All their pilots are required to adhere to the engine warm-up periods as recommended by the Manufacturer before take-off.***
- ***No overspeeds have been reported on their helicopters and no evidence was found to suggest that such an occurrence had happened.***

e) Regarding the cooling cycle of their helicopter engines (Refer 1.16.5f)

- ***All their pilots are required to adhere to the cool down period after landing. The engine are brought to idle for a minimum of 30 seconds and the cylinder head temperature should be below 350°C as prescribed by the Manufacturer. Their students are reminded of this during training.***

1.16.7 More information regarding stuck valves

Reference: Information from Airmark Overhaul Inc an FAA and EASA Approved Lycoming Aircraft Engine Repair and Overhaul Facility.
http://www.airmarkoverhaul.com/aircraft-repair.aspx

Sticking valves are a relatively common problem on aircraft piston engines. Lycoming Service Bulletin 388 addresses the need to regularly check clearance and provides a procedure to clean carbon accumulations to prevent problems. Most engines will give an important warning that valve stem clearance has been lost to carbon deposits, allowing for maintenance that can avoid the problem. The following will explain the most of the causes and what to watch for.

Exhaust Valve Issues
Valve sticking is almost exclusively limited to the exhaust valves. Most issues with intake valves are usually associated with improper fit or machining during repairs or loose seats usually becoming apparent soon after the cylinder is put into service. Exhaust valve issues seem to be more prevalent on helicopter engines due to their high constant loading with no variance in operating conditions. This allows prime conditions for deposits to crowd the valve that will lead to sticking.

Prevention
Many contributors factors can lead to the deposits that cause stuck exhaust valves. One very important thing operators can do is change their oil often at the regular intervals specified in the operators manual thus removing suspended solids before they can accumulate in the guides. Engines that use screen filters will benefit from changing to a full flow filter to remove more particulates from the oil. Keeping cylinder temperatures in normal operating range with proper attention to air flow and baffle sealing will help by lowering guide and valve temperatures. Proper air filtration can also help as well by keeping ingested solids to a minimum.

Causes
Longer than recommended oil change intervals, high lead content of fuel in engines certified for lower octane fuels and insufficient air filtration can lead to high amounts of suspended solids that can eventually lead to stuck valves from accumulated deposits. Deposits can accumulate within the valve guide during operation as heat evaporates engine oil allowing the suspended solids to remain behind. If these deposits accumulate at a rate that is slower than they can be worn away then they usually do not become an issue. When engine oil is heavy with deposits and high operational temperatures are encountered these deposits can accumulate at a faster rate, slowly robbing the valve of clearance. High cylinder temperatures, especially with unapproved or inferior engine oils can cause oil coke to be the source of deposits as well.

Warning Signs
While at operating temperature, clearances are higher than at room temperature, allowing extra space for deposits to accumulate. Once the engine cools and the clearances shrink

the deposits can start to cause a problem. At start up an early warning of trouble will be a hard miss and roughness that clears as the engine warms up, usually in a matter of seconds rather than minutes. This leads many operators to believe the engine is just cold natured, has a fouled plug or getting up in time but the reality is that the engine is giving notice that a major problem is looming. Given that a stuck valve can cause a forced landing and serious engine damage these symptoms should not be ignored. Valve clearances should be checked as soon as possible.

Valves tend to ride one side of the guide rather than having the carbon act like an encompassing bushing. This results in galling by metal to metal contact as deposits force the valve against the opposite side of the guide. This galling is what eventually causes the hard sticking that can occur in flight long after start up.

Valve Corrosion
Another common cause of valve sticking is the corrosion that can occur in high humidity areas as the engine sits unused for long periods of time. Corrosion can occur between the valve stem and guide binding the valve in place. Turning the propeller through can expose the problem but cylinder service will be the only way to properly fix it. Nitralloy guides are particularly predisposed to this problem since they are magnetic and will readily rust in a high moisture environment. Engines that still use these guides should not be allowed to sit for long periods without use, especially without some type of climate control such as a closed hangar.

Repair
Stuck valves will not go away by themselves. Continued operation of the engine will only increase the risk of damage. Damage could rear its ugly head in the form of bent pushrods, damaged camshaft lobes, damaged camshaft followers or damaged rocker arm supports.

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