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

AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

			Reference:	CA18/2/3/9428		
Aircraft registration	**ZS-HFO**	**Date of accident**	3 April 2015	**Time of accident**	0903Z	
Type of aircraft	Robinson R44 Raven II		**Type of operation**	Private		
Pilot-in-command licence type	Private	**Age**	40	**Licence valid**	Yes	
Pilot-in-command flying experience	Total flying hours	337.8		Hours on type	287.7	
Last point of departure	Helipad, Reaction Unit South Africa, Durban, Kwa-Zulu Natal Province					
Next point of intended landing	Verulam Recreational Grounds, Durban, Kwa-Zulu Natal Province					
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)						
Polo field in Verulam, Durban (GPS position: 29°38.764ôSouth 031°03.455ôEast, elevation 100 feet AMSL)						
Meteorological information	Surface wind: 180°/5kt, Temperature: 31°C, Visibility: + 10km.					
Number of people on board	1 + 1	**No. of people injured**	1 + 1	**No. of people killed**	0	

Synopsis

On 25 March 2015, the helicopter which was later involved in the accident was delivered to the owner, who was also the pilot. That delivery took place following the installation and break-in of the engine after overhaul. On Thursday, 2 April 2015, the pilot flew the helicopter for the first time after delivery, on a local flight. On the next day, 3 April 2015, the pilot was accompanied by a passenger on a private flight with the intention of landing at the Verulam Recreational Grounds and then giving a static display of the helicopter. However, the pilot was unable to land at the Grounds because a large vehicle was in close proximity to the intended landing area and that vehicle had to be moved before the helicopter could land. While the pilot was orbiting the field at approximately 400 feet above ground level (AGL) the helicopter engine failed. As the pilot was over a built-up area at the time, he identified an open field for landing purposes, which required him to execute a 180° turn. The field was surrounded by some tall trees and the pilot had to stretch the autorotation in an attempt to clear those trees: in doing so, the main rotor RPM decayed rapidly and as the pilot was now committed to the landing he was unable to restore the RPM. The helicopter then touched down hard in an upright position and started to roll over to the right and came to rest in a semi rolled-over attitude. The passenger, who was occupying the left front seat, suffered a back injury during the accident sequence and was admitted to hospital. During the sequence the pilot suffered from a laceration to his left elbow.

Probable cause

An unsuccessful forced landing following an engine stoppage in flight which was attributed to a loose fuel pipe that supplies fuel from the fuel control unit (FCU) to the fuel flow divider.

ASP date		Release date	

AIRCRAFT ACCIDENT REPORT

Name of Owner	: Reaction Unit South Africa
Name of Operator	: Private
Manufacturer	: Robinson Helicopter Company
Model	: R44 Raven II
Nationality	: South African
Registration Marks	: ZS-HFO
Place	: Polo field in Verulam, Durban
Date	: 3 April 2015
Time	: 0903Z

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 (1997) 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 24 November 2014, the pilot, who was also the owner of the helicopter, flew the helicopter to an aircraft maintenance organisation (AMO) to have an engine oil leak rectified: the crank shaft seal was leaking. After the seal was replaced, an engine ground run was performed; however, the engine was started without oil in it. The engine was then removed from the airframe and was forwarded to an engine overhaul facility in Gauteng, which received it on 15 December 2014. Work on the engine commenced in early January 2015 after the company reopened for business. Following the overhaul the inter-cylinder baffling was installed on the engine but the engine was not subjected to a post-maintenance bench test run-in procedure. The engine was crated and couriered to the AMO in mid-March 2015.

1.1.2 After the AMO received the engine it was installed in the airframe. On 24 March 2015 the AMO conducted a ground run to assist with the break-in of the engine as it was not subjected to a bench test procedure following the overhaul. The ground run was followed by a post-maintenance test flight. For the purpose of the ground runs and post-maintenance flights, a 200 litre drum of fuel was purchased from a petroleum service provider at Virginia aerodrome. The duration of the first ground run and test flight was logged in the flight folio as 1.6 hours. On the next day, the same procedure was followed and 0.5 hours was logged in the flight folio. Later, on the same afternoon, the helicopter was delivered to the owner. Before take-off from the AMO the remaining fuel in the drum was emptied into the helicopter: both the main as well as the auxiliary tank indicated a fuel level of approximately half a tank. The flight time from the AMO to the helicopter owner's helipad was approximately 12 minutes (0.2 of an hour).

1.1.3 On 2 April 2015, the owner flew the helicopter on a local flight. According to the flight folio entry, the duration of that flight was approximately 12 minutes (0.2 of an hour). On the next morning, 3 April 2015, the pilot took-off from his helipad with a passenger on board with the intention of landing at the Verulam Recreational Grounds, where the helicopter would have been on a static display. The pilot was, however, unable to land at the Grounds because a large vehicle was parked in close proximity to the allocated landing area. The vehicle had to be moved before the pilot could land and while this was taking place the pilot orbited the area at a height of approximately 400 feet above ground level (AGL). The Grounds are surrounded by a residential area and while orbiting them, the engine failed. The pilot indicated in a later interview that there were no warning lights, or any fluctuation in any of the engine instruments prior to the failure. The pilot immediately identified an open area (Polo field) from the air, for landing purposes, but preparation for landing required him to execute a 180° turn. As he approached the field the main rotor's revolutions per minute (RPM) started to decay and the audio warning sounded for low rotor RPM; moreover, the caution light illuminated on the instrument panel. The pilot had to stretch the autorotation in order to clear some high trees that surrounded the Polo field, and this he managed to do.

1.1.4 The helicopter impacted the ground hard in an upright position and came to rest on its right-hand skid gear in a semi rolled-over position. One of the main rotor blades was supporting the helicopter after it became stuck in the soil on the right-hand side of the fuselage. The passenger, who was seated in the left front seat, sustained an injury to his lower back and was admitted to hospital. The pilot suffered from a laceration to his left elbow.

1.1.5 The accident occurred during daylight conditions at a geographical position that was determined to be 29°38.764ô South 031°03.455ô East at an elevation of 100 feet above mean sea level (AMSL).

1.2 Injuries to persons

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

1.3 Damage to aircraft

1.3.1 The helicopter sustained a substantial amount of damage during the impact sequence.

Figure 1. A photograph of the helicopter showing how it came to rest

1.4 Other damage

1.4.1 There was no other damage incurred.

1.5 Personnel information

1.5.1 Pilot-in-command

Nationality	South African	Gender	Male	Age	40
Licence number	0272321365	Licence type	Private pilot		
Licence valid	Yes	Type endorsed	Yes		
Ratings	None				
Medical expiry date	31 December 2015				
Restrictions	Pilot must wear corrective lenses				
Previous accidents	None				

Flying experience:

Total hours	337.8
Total past 90-days	0.7
Total on type past 90-days	0.7
Total on type	287.7

1.6 Aircraft Information

Airframe:

Type	Robinson R44 Raven II	
Serial number	11540	
Manufacturer	Robinson Helicopter Company	
Year of manufacture	2006	
Total airframe hours (at time of accident)	948.8	
Last MPI (hours & date)	946.0	25 March 2015
Hours since last MPI	2.8	
C of A (issue date)	17 February 2011	

C of A (expiry date)	16 February 2016
C of R (issue date) (present owner)	15 April 2011
Operating categories	Standard Part 91

Engine:

Type	Lycoming IO-540-AE1A5
Serial number	L-31632-48A
Hours since new	948.8
Hours since overhaul	2.8

Main rotor blades:

Type	Robinson Part No. C016-5
Serial numbers	3394 and 3396
Hours since new	948.8
Hours since overhaul	TBO not yet reached

1.7 Meteorological information

1.7.1 The weather information provided in the table below was obtained from the pilotõs questionnaire.

Wind direction	180°	Wind speed	5 knots	Visibility	+ 10 km
Temperature	31°C	Cloud cover	Scattered	Cloud base	2 000 ft
Dew point	Unknown				

1.7.2 The meteorological aerodrome report (METAR) for King Shaka International aerodrome (FALE) on 3 April 2015 at 0830Z was as follows:

FALE 030830Z 17006KT 9999 FEW016 BKN025 26/21 Q1014 NOSIG=

Wind	-	170° at 6 knots
Visibility	-	9999 metres
Clouds	-	FEW (1 to 2 octas) at 1600 feet
		Broken (5 to 7 octas) at 2500 feet
Temperature	-	26°C

Dew point	-	21°C
Barometric pressure	-	1014 hPa (hectopascal)

1.8 Aids to navigation

1.8.1 The helicopter was equipped with standard navigational equipment. At the time of the accident, the pilot was conducting a local flight in an area with which he was very familiar.

1.9 Communication

1.9.1 The pilot was flying below the terminal control area (TMA). After the accident, he phoned air traffic control (ATC) at Virginia aerodrome (FAVG) to inform them of the accident. They then notified ATC at King Shaka International aerodrome (FALE), who informed the Accident Investigator on first standby, of the accident, and issued a mandatory occurrence report (MOR) with reference number LE-68-2015.

1.10 Aerodrome information

1.10.1 The accident did not occur at an aerodrome.

1.11 Flight recorders

1.11.1 The helicopter was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR). The regulations do not require these items to be fitted to this type of helicopter.

1.12 Wreckage and impact information

1.12.1 The helicopter impacted the ground in an open grass field (Polo field); at the moment of impact it was travelling in a north-easterly direction. Observation of the ground impact markings indicated that no lateral movement took place during the impact sequence. The front cross tube assembly separated from the fuselage during impact and the helicopter started to roll over to the right, but came to rest in a semi rolled-over attitude when one of the main rotor blades impacted the grass surface on the right-hand side of the helicopter. This blade supported the fuselage and, with the assistance of the horizontal stabilizer, allowed the helicopter to remain in a semi rolled-over attitude as shown in Figure 2 below.

Figure 2. A photograph of the helicopter after it came to rest

1.12.2 Both fuel tanks remained intact during the accident sequence and they both still contained some fuel. The gascolator was removed during the on-site investigation and the fuel that was in the unit was drained into a clean glass container; the results of a subsequent test showed that the fuel was of the correct grade and free of contamination.

(a) (b)

Figure 3. A photograph of the gascalator that still contained some fuel (a), and the fuel sample that was found to be clean (b)

1.12.3 The collective pitch lever was found to be in the fully-up position; this corresponded to the main rotor blade pitch angle, which was at its maximum pitch setting. The tail boom and tail rotor assembly displayed minor damage and control continuity was not compromised. The main rotor transmission remained intact and neither of the drive belts fractured.

1.12.4 The engine did not sustain any impact damage. Because the helicopter came to rest in a semi rolled-over attitude, it was only possible to remove the spark plugs on the left-hand side of the engine when looking at the wreckage from the aft position. All the spark plugs displayed a light greyish colour consistent with normal engine operation. It was possible to rotate the engine using the cooling fan.

Figure 4. A photograph of the engine taken during the on-site investigation

1.12.5 The cockpit/cabin area remained intact. The two front seat structures displayed some compression deformation, which was associated with the vertical impact trajectory of the helicopter. See Figure 5 on the next page.

Figure 5. The left front seat support structure, with the pilot seat visible next to it

1.13 Medical and pathological information

1.13.1 The pilot held a valid aviation medical certificate issued by a CAA-approved medical examiner.

1.14 Fire

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

1.15 Survival aspects

1.15.1 Because of the low kinetic forces associated with the impact sequence, the accident was considered to be survivable.

1.15.2 The pilot and the passenger were properly restrained by making use of the three-point safety harnesses provided in the helicopter. Both the front seat structures display evidence of deformation associated with the vertical impact sequence. The cockpit/cabin area remained intact.

1.16 Tests and research

1.16.1 The helicopter was fitted with a Lycoming IO-540-AE1A5 engine, with serial No. L-31632-48A. The engine was not damaged during the accident sequence. An assessment of the engine determined that it could be run within the airframe because neither fuel tank was ruptured and both tanks still contained fuel, which was found to be free of any contaminants. Before starting the engine, a minor fuel stain was noted on the right-hand side of the crankcase, when viewed from the aft position. An investigation took place to trace the source of this fuel stain and it was found that the fuel supply pipe that routed from the fuel control unit (FCU) to the fuel flow divider was not properly secured at its fitting to the fuel flow divider. (The fuel control installation diagram attached to this report as Annexure B provides the reader with a layout of the system, and illustrates the fuel pipe in question). With the engine installed in the airframe, the fuel flow divider was located directly below the main transmission platform, and was therefore in an area that was difficult to inspect visually. The connecting fitting (the blue fitting visible in Figure 5) was tightened and the engine started without any difficulty, after which it ran for a substantial period of time.

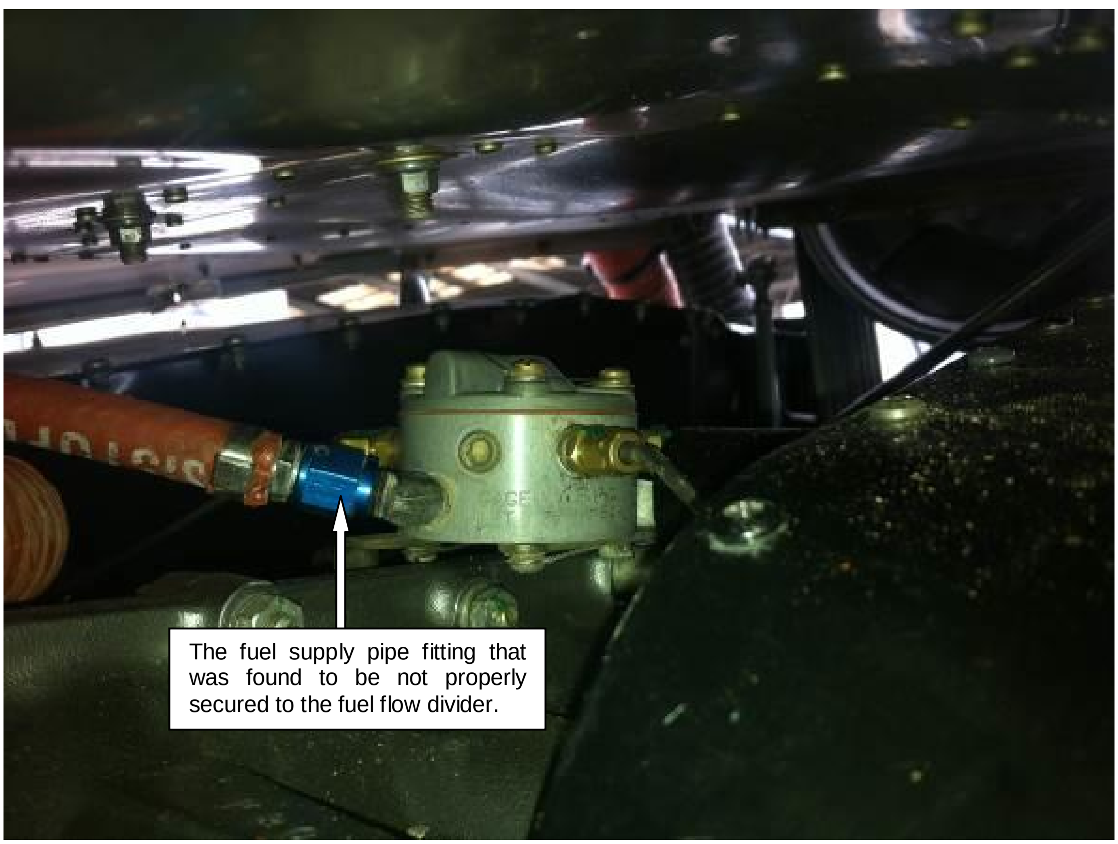


Figure 5. A view of the fuel supply line from the FCU to the fuel flow divider

The fuel flow divider consists of a valve, sleeve, diaphragm and a spring. The valve is spring-loaded to the closed position: this effectively closes the path of the fuel flow from the fuel injector servo to the nozzles and at the same time isolates each nozzle from all of the others at engine shutdown.

The servo is designed to meter fuel in proportion to the amount of air being consumed by the engine. This metered fuel from the injector servo enters the fuel flow divider and is channelled to a chamber beneath the diaphragm. At idle, the fuel pressure is only sufficient to move the flow divider slightly open, exposing the bottom of a ñVò slot in the exit to each nozzle. This position provides the level of accuracy of fuel distribution needed for smooth idle. As the engine accelerates, the metered fuel pressure at the flow divider inlet and in the nozzle lines increases. It gradually moves the flow divider valve open against the spring pressure until the area of the ñVò slot opening at each nozzle is greater than the area of the fuel restrictor in the nozzle. At this point, responsibility for equal distribution of metered fuel flow is assumed by the nozzles.

The two primary functions of the fuel flow divider are:

(1) assure equal distribution of metered fuel to the fuel nozzles (one nozzle per cylinder) at and just above idle; and

(2) provide isolation of each nozzle from all the others for clean engine shutdown.

Figure 6. A fuel flow divider with the fuel pipe from the FCU disconnected (for illustration)

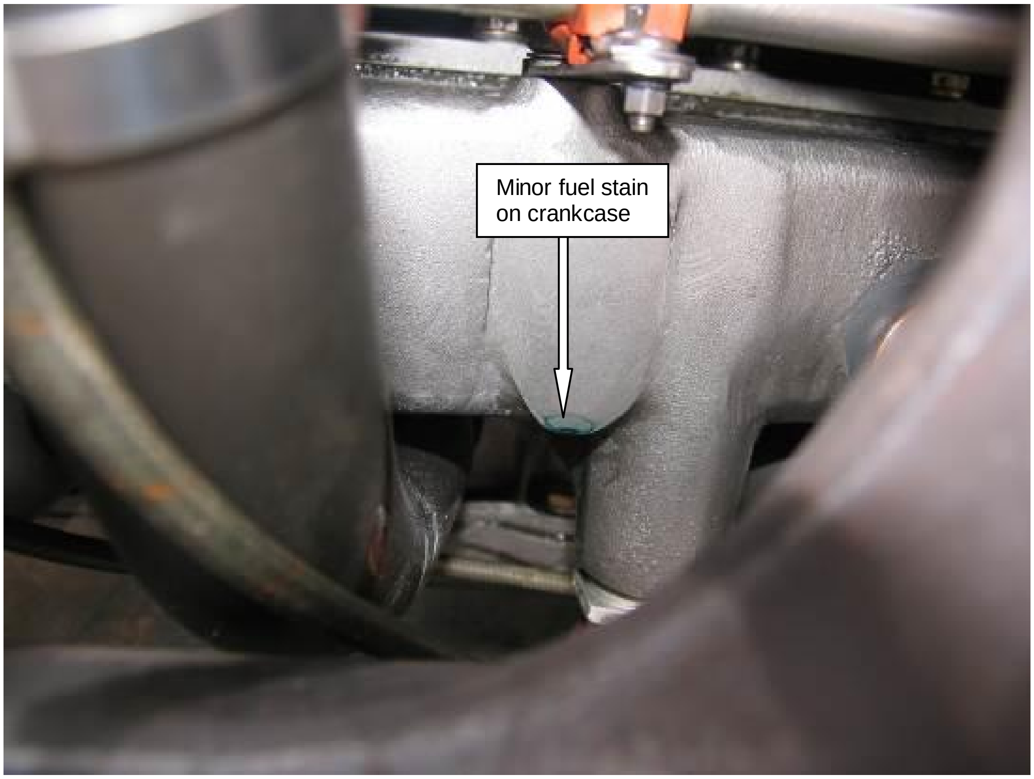


Figure 7. The fuel stain on the side of the crankcase

1.17 Organizational and management information

1.17.1 The accident occurred during a private flight. The pilot had obtained prior permission from the Civil Aviation Authority (CAA) for his intended ad-hoc landing at the Verulam Recreational Grounds. The form CA91-06 was completed and submitted to the flight operations department (FOD) on 30 March 2015. The ad-hoc landing was accordingly approved.

1.17.2 The aircraft maintenance organisation (AMO) that conducted the last maintenance inspection on the helicopter prior to the accident was in possession of a valid AMO Approval certificate. The engine was received from an approved engine overhaul facility after overhaul and was installed in the airframe by the AMO.

1.17.3 The AMO that performed the engine overhaul was in possession of a valid AMO Approval certificate. Following the engine overhaul, the AMO issued a Certificate of Release to Service. Figures 8 and 9, below, show the engine while it was still in the engine overhaul facility before it was couriered to the AMO in Durban.

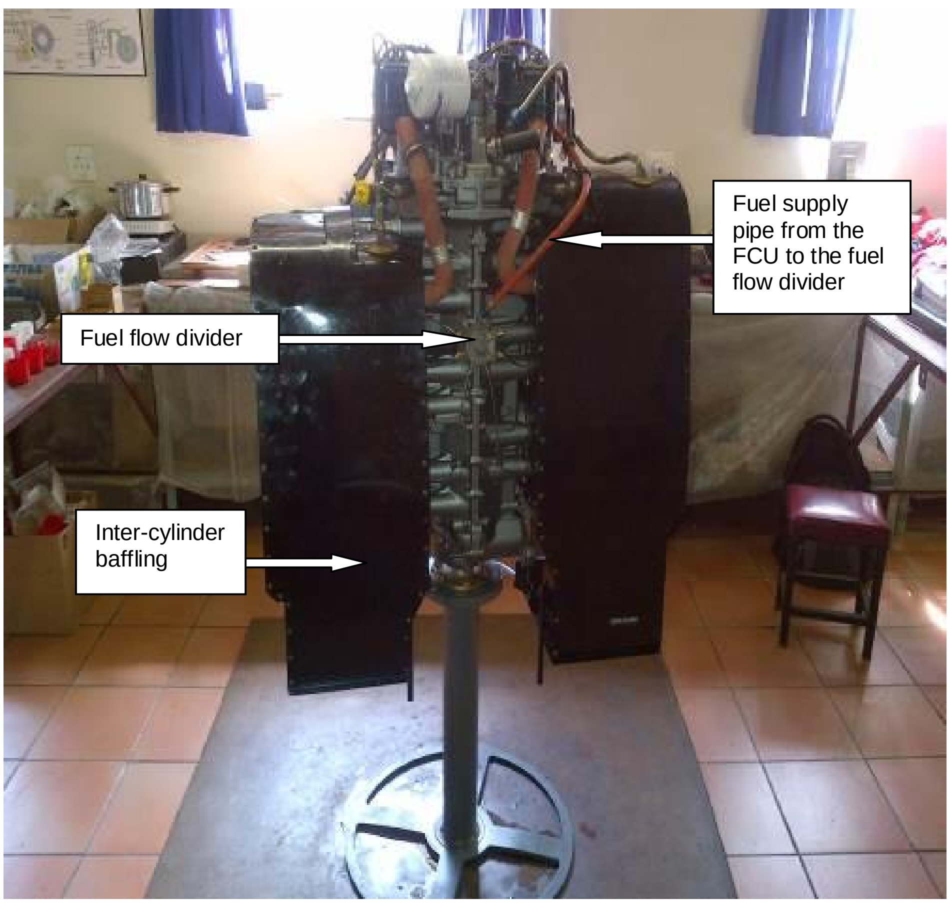


Figure 8. The engine after it was overhauled

Figure 9. The bottom side of the engine without the exhaust stack installed

1.18 Additional information

1.18.1 Emergency procedures: Pilot's Operating Handbook, Section 3

Power failure between 8 feet and 500 feet AGL:

1. *Lower collective immediately to maintain rotor RPM.*
2. *Adjust collective to keep RPM between 97 and 108% or apply full down collective if light weight prevents attaining above 97%.*
3. *Maintain airspeed until ground is approached, then begin cyclic flare to reduce rate of descent and forward speed.*
4. *At about 8 feet AGL, apply forward cyclic to level ship and raise collective just before touchdown to cushion landing. Touch down in level attitude and nose straight ahead.*

1.18.2 Air restart procedure

CAUTION

"Do not attempt restart if engine malfunction is suspected or before safe autorotation is established. Air restarts not recommended below 2 000 feet AGL.

1. Mixture – Off.
2. Throttle – Closed.
3. Starter – Engage.
4. Mixture – Move slowly rich while cranking".

1.18.3 Fuel system description

A description of the fuel system is attached to this report as Annexure A.

1.18.4 Lycoming engine break-in

Lycoming Service Instruction No. 1427C, issued on 29 December 2010, identifies the steps required for engine break-in after overhaul. This service instruction is attached to this report as Annexure C.

1.19 Useful or effective investigation techniques

1.19.1 No new methods were applied.

2. ANALYSIS

2.1 Man (Pilot)

The pilot held a valid private pilot licence. On the day before the accident flight he had conducted a local flight in the area; this was his first flight since he flew the helicopter to the AMO on 24 November 2014. Prior permission had been obtained from the regulating authority for the unscheduled landing that was planned at the Verulam Recreational Grounds; however, he was unable to land at the designated landing area because a vehicle was found to be in close proximity to the landing area. While that vehicle was being relocated, the pilot continued to orbit the area at a height of approximately 400 feet AGL when the engine stopped. The pilot did not opt for an engine restart because his height of 400 feet was much less than the 2000 feet AGL mentioned in Section 3 of the POH for an engine restart. Instead, the pilot identified an open area for a forced landing. That open area was a Polo field surrounded by high trees which presented an obstacle from the direction from which the pilot approached the field. The pilot had to ‘stretch’ the autorotation in order to clear the trees and in doing so, he allowed the main rotor’s RPM to decay below the normal operating range. As indicated in the pilot’s statement, the audio warning for low main rotor RPM sounded as they approached the field. It was evident during the on-site investigation that the pilot applied maximum collective pitch in an attempt to cushion the landing but because the main rotor’s RPM was already low (below 97%) a hard landing followed; there was very little energy left in the main rotor blades to produce any downwash to cushion the landing. Following impact, the helicopter started to roll to the right and came to rest in a semi rolled-over attitude.

2.2 Machine (Helicopter)

Approximately three months before the accident, during November 2014, the helicopter engine sustained damage during a maintenance procedure. During that procedure the crank shaft seal was replaced because it was leaking oil but the engine was started with no oil in it. The engine was then overhauled at an approved engine overhaul facility. The engine was returned to the AMO in Durban in mid-March 2015 and they installed the engine in the helicopter without subjecting it to an engine bench test procedure following the overhaul. The break-in of the engine accounted for 2.1 hours of operation and included a post-maintenance acceptance flight; afterwards, the helicopter was delivered to the owner.

The post field investigation revealed that the fuel pipe supplying fuel from the FCU to the fuel flow divider had leaked fuel from the fitting where it attached to the fuel flow divider. There was evidence indicating that the fitting was not properly fastened during maintenance and during the operation of the engine and the break-in procedure. Thus, the fitting started to unscrew itself during engine operation, and this process was aggravated by the vibrations associated with engine operation. As the fuel flow divider is located on top of the engine, any fuel leak from that fitting would have been very difficult to detect. Indeed, it would be difficult to inspect the area in which the unit is located after the engine is installed in the airframe because the unit will then be positioned directly below the main transmission deck. The location of the unit could therefore only be inspected with difficulty and any such inspection does not form part of the pilotȇs pre-flight inspection.

As the fuel started leaking from the fitting it came into contact with the hot engine crank case and probably vaporised immediately; therefore, it did not leave any evidence, such as a fuel stain, in a place that could readily be seen by maintenance personnel. However, a minor fuel stain was noted on the right-hand side of the engine after it was recovered in the post field investigation. This stain would only have been visible if the maintenance personnel or the pilot had conducted a detailed inspection of the engine in that specific area. Apart from that one fuel stain, no other evidence associated with a fuel leak could be found. Although the fitting did not unscrew completely from the unit it is believed that the fuel pressure at the entrance to the fuel flow divider was not high enough to activate the diaphragm within the unit that allows fuel to pass to each of the fuel nozzles, and from there, to enter each of the cylinders. The engine stoppage was therefore attributed to fuel starvation and this finding is supported by the fact that the engine test run presented normal engine operation after the fuel pipe fitting connecting to the fuel flow divider was secured.

The engine was initially damaged during maintenance, when the crank shaft seal was replaced because of an oil leak. This incident placed undue pressure on the AMO to have the engine overhauled and the helicopter returned to service; after all, by this time the owner had been without it for several months. In order to minimise any further delays following the engine overhaul, a decision was made not to subject the engine to a bench test procedure, such a decision is not common practice. After the engine was installed in the airframe, efforts were made to comply with the engine break-in procedure as well as the post-maintenance acceptance flight to deliver the helicopter to its owner. The fuel flow divider and associated fuel pipe were installed by the engine overhaul facility. Afterwards, the AMO installed the engine in the airframe, having accepted that engine from the engine overhaul facility without conducting any additional checks on it to ensure all fittings were secured prior to installation. During the break-in period, normal engine operation was experienced and no anomalies were noted that could be associated with a possible fuel leak that could have resulted in engine stoppage.

2.3 Environment

Fine weather conditions prevailed at the time of the accident flight; weather conditions were not considered to have had any bearing on the accident.

3. CONCLUSION

3.1 Findings

3.1.1 The pilot held a valid private pilot licence and had the helicopter type endorsed on his licence.

3.1.2 The pilot held a valid aviation medical certificate issued by a CAA-approved medical examiner.

3.1.3 On the flight, the pilot was accompanied by a passenger who was occupying the left front seat. That passenger was seriously injured (back injury) in the accident and was admitted to hospital.

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

3.1.5 The engine sustained internal damage during maintenance; afterwards, it was overhauled by an approved engine maintenance facility before it was installed in the airframe.

3.1.6 The engine was not subjected to a bench test procedure after overhaul. Engine break-in was conducted after the engine was installed in the airframe.

3.1.7 The engine operated for a period of 2.8 hours following installation in the airframe; it then stopped while in operation in flight.

3.1.8 It was found that the fuel pipe supplying fuel from the FCU to the fuel flow divider was not properly secured at the fuel flow divider end.

3.1.9 Because the fitting was not secured, the fuel pressure delivered to the fuel flow divider was not high enough to activate the diaphragm within the divider and to allow fuel to pass through to the fuel nozzles/cylinders.

3.2 Probable cause

3.2.1 Unsuccessful forced landing following an engine stoppage in flight which was attributed to a loose fuel pipe that supplies fuel from the FCU to the fuel flow divider.

3.3 Contributory factors

3.3.1 Improper maintenance practice.

3.3.2 Flying over a built-up area at 400 feet AGL, which allowed only limited options for conducting a safe autorotational landing following the engine stoppage.

4. SAFETY RECOMMENDATIONS

4.1 It is recommended to the Director of Civil Aviation that the engine manufacturer be consulted to ensure that the fuel line connecting to the fuel flow divider from the FCU cannot become unsecured once attached and tightened to the unit. It is specifically recommended that the fuel pipe be secured by means of a wire locking once tightened. In the current configuration the application of torque seal to the unit gives maintenance personnel an indication that the pipe fitting is most probably secured: however this practice does not ensure 100% compliance and to remedy this, it is recommended that a wire locking should be incorporated.

5. APPENDICES

5.1 Annexure A (Description of the fuel system)
5.2 Annexure B (Layout of the fuel supply line from the FCU to the fuel flow divider)
5.3 Annexure C (Lycoming Service Instruction No. 1427C)

ANNEXURE A

CHAPTER 12

FUEL SYSTEM

12.000 Description

> **NOTE**
>
> Per R44 Service Bulletin SB-78B, fuel tanks without bladders should no longer be in service.

This section includes procedures for maintaining R44 (Lycoming O-540 engine, carbureted) and R44 II (Lycoming IO-540 engine, fuel injected) fuel systems. Refer to carburetor, fuel control, or fuel system accessory manufacturer's instructions for continued airworthiness. Refer to Figures 12-1 and 12-2 for R44 and R44 II fuel system overviews.

The fuel system includes main and auxiliary tanks, a shutoff valve control located between the front seats, and a strainer (gascolator). The fuel tanks have flexible bladders in aluminum enclosures. Fuel tank air vents are located inside the mast fairing.

The R44 fuel system is a gravity-flow (no fuel pumps) system; the R44 II fuel system is a pressurized fuel system that includes an engine-driven pump, an auxiliary (electric) fuel pump, and a fuel return line which allows pump supply in excess of engine demand to return to the fuel tanks.

The R44 II auxiliary pump primes the engine for starting and runs in flight to provide fuel pump redundancy. The engine will function normally with either the engine-driven or auxiliary (electric) pump operating. The ignition switch prime (momentary) position operates the auxiliary fuel pump for priming prior to engine start. After start, the pump runs continuously as long as the engine has oil pressure and the clutch switch is in the engage position.

The R44 II has a pressure switch on the gascolator which illuminates the fuel filter caution light if the strainer becomes contaminated. Continued operation with an illuminated filter caution light may result in fuel starvation. A pressure switch downstream of the auxiliary fuel pump illuminates the aux fuel pump caution light if auxiliary pump output pressure is low. When the clutch switch is disengaged, the auxiliary pump is off and the aux fuel pump caution light should be illuminated. Proper mechanical fuel pump function is indicated by normal engine operation after engine start prior to clutch switch engagement and before shutdown while clutch switch is disengaged.

The R44 and R44 II have plunger-style drain valves at the gascolator and at each fuel tank sump. The gascolator is located on the lower right side of the firewall and is drained by pushing up on the plastic tube which extends below the belly. Valves for both tanks are located inside the right cowl door below the auxiliary tank. Fuel samples are taken by extending the plastic tubes clear of the aircraft and pushing on the plungers. Fuel should be sampled from all three locations prior to the first flight of the day and after refueling to verify no contamination and correct grade.

The fuel gages are electrically operated by float-type transmitters in the tanks. When the gages read E the tanks are empty except for a small quantity of unusable fuel. The low fuel caution light is actuated by a separate electric sender located on the bottom of the main tank.

The auxiliary tank is interconnected with the main tank and is located somewhat higher so it will become empty first while fuel still remains in the main tank. The fuel shutoff valve controls flow from both tanks to the engine.

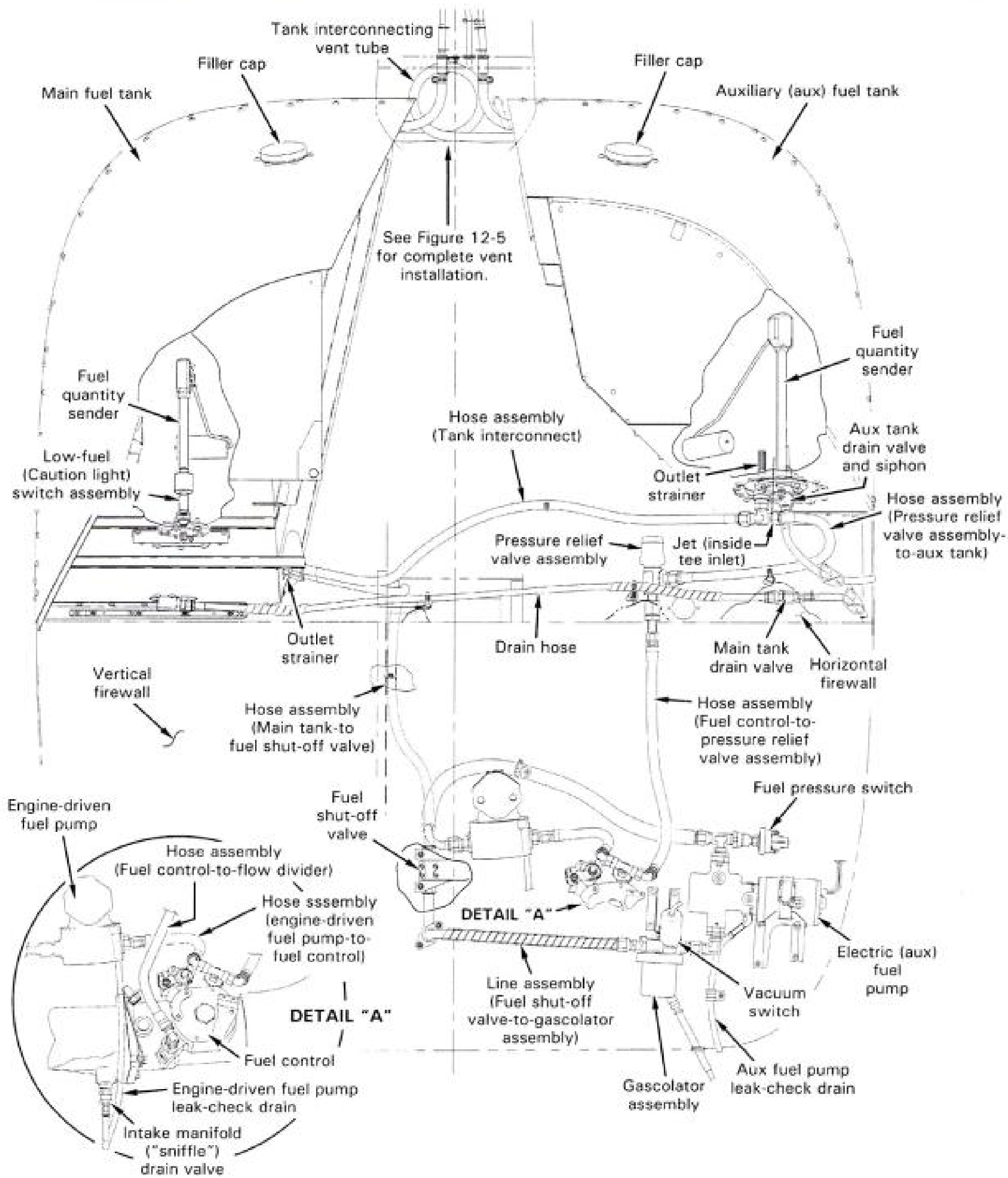
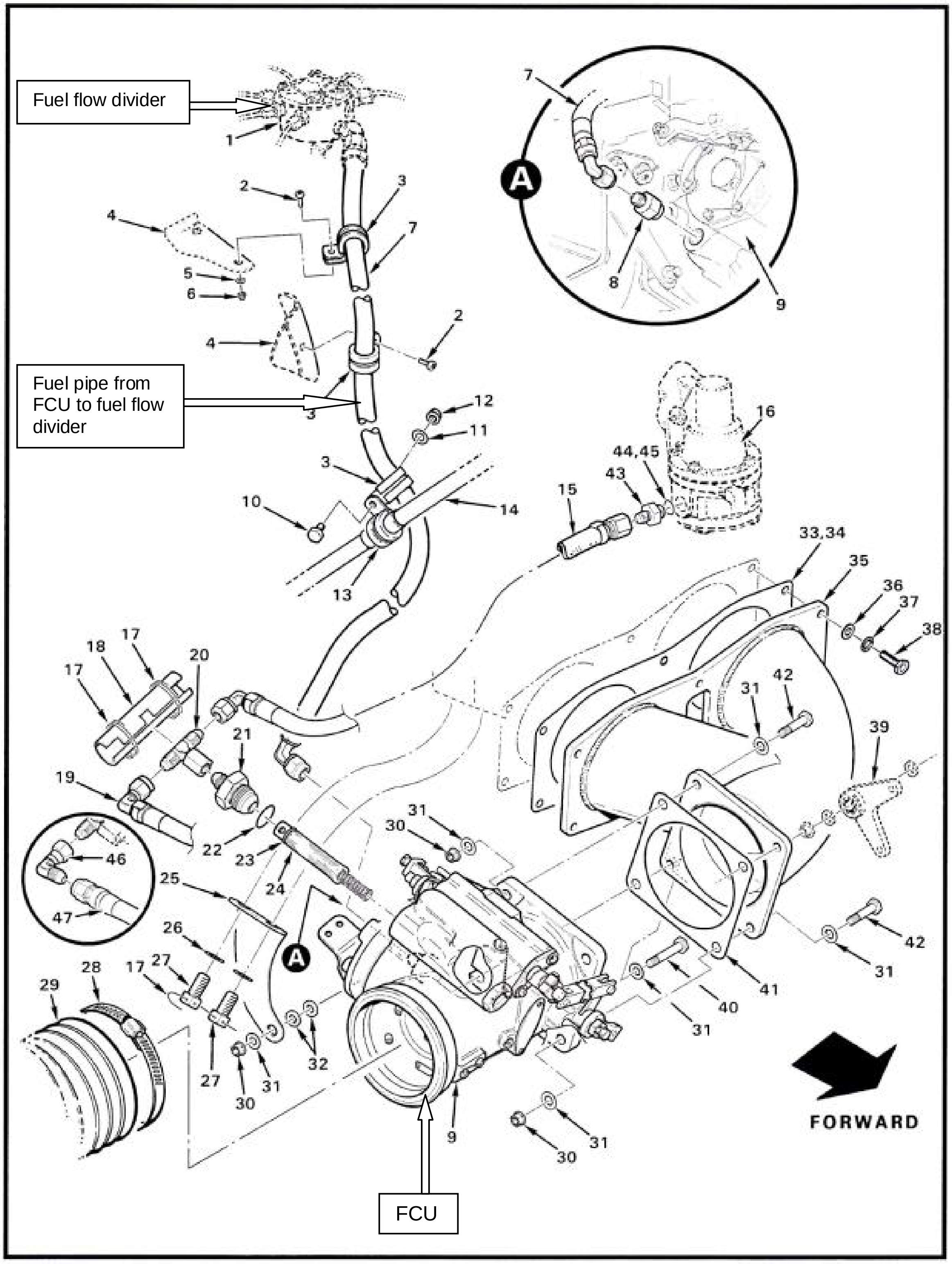


FIGURE 12-2 R44 II FUEL SYSTEM (LYCOMING IO-540 ENGINE; FUEL INJECTED)

Page 12.4 JUN 2014

ANNEXURE B

ROBINSON ILLUSTRATED PARTS CATALOG R44 SERIES



Page 28.24 FIGURE 28-25 FUEL CONTROL (SERVO) INSTALLATION JAN 2014

ANNEXURE C

LYCOMING

652 Oliver Street
Williamsport, PA. 17701 U.S.A.
Tel. 570-323-6181
Fax. 570-327-7101
www.lycoming.com

SERVICE INSTRUCTION

DATE: December 29, 2010

Service Instruction No. 1427C
(Supersedes Service Instruction No. 1427B)
Engineering Aspects are
FAA (DER) Approved

SUBJECT: Lycoming Reciprocating Engine Break-In and Oil Consumption

MODELS AFFECTED: All fixed wing and rotary wing aircraft (horizontal installations only) with Lycoming reciprocating aircraft engines installed

TIME OF COMPLIANCE: After field overhaul

NOTE

Incomplete review of all the information in this document can cause errors. Read the entire Service Instruction to make sure you have a complete understanding of the requirements.

Background

This Service Instruction identifies the necessary steps for engine break-in, including engine preparation for ground operational tests, flight tests, after-flight tests, and oil consumption limits for Lycoming engines installed in fixed wing and rotary aircraft.

NOTE

Engine overhaul includes, but is not limited to, replacing applicable components such as: fuel pump, fuel metering unit, and magnetos, if applicable, with components that are overhauled, rebuilt, or new.

Ideally, this procedure is to be done in a test cell where operating conditions can be closely monitored. If the engine is operated in a test cell, the engine must have intercylinder baffles, a cooling shroud, and a test club installed for engine Revolution Per Minute (RPM) requirements. If a test cell is not available, use a test stand with a test club and a cooling shroud for the engine test.

If a test cell or a test stand is not available, do an engine test after the engine has been installed in the aircraft with the intercylinder baffles installed. If the engine is operated in the aircraft, use a test club or aircraft propeller for correct air flow cooling. The engine-to-cowling baffles must be new or in good condition for correct cooling air flow differential across the engine. The cylinder head temperature gage, oil temperature gage, oil pressure gage, manifold pressure gage and tachometer must be calibrated for accuracy.

The purpose of a test cell or ground run test if done with the engine installed in the aircraft is to make sure that the engine is in compliance with all specifications, RPM, manifold pressure, fuel flow and oil pressure. The oil cooler system must hold oil temperatures within limits shown in the applicable Lycoming Operator's Manual.

The purpose for this engine break-in procedure is for correct piston ring seating and stable oil consumption on a top overhauled engine or a newly overhauled engine that is installed in the aircraft.

NOTE

The following formula is used to calculate the maximum allowable oil consumption limits for all Lycoming aircraft engines.

$$0.006 \times BHP \times 4 \div 7.4 = Qt./Hr.$$

2. ROTORY WING (HORIZONTAL INSTALLATIONS ONLY)

Break-in of helicopter engines is done by following a sequence of steps ranging from engine service of the engine on the ground to progressively increasing its power output during operation. Although this Service Instruction contains detailed information about engine break-in, it is impossible to cover all aspects of break-in for individual helicopter models. For that reason, refer to the POH for a particular helicopter model. Also, refer to the applicable Lycoming Operator's Manual for the engine.

For break-in of piston engines in helicopters:

1. Because helicopters always operate at a fixed or rated engine speed, any decrease of engine RPM necessary during break-in must be done with the helicopter on the ground and with the rotor engaged. During flight, make all power reductions by manifold pressure alone.
2. Some helicopters do not have a red line on the manifold pressure gage and use all rated power. Some gages have a red line for indication of airframer limitations but not engine performance parameters. In the case of Lycoming model HIO-360-D1A, it has graduated manifold pressure values as shown in the Lycoming Operator's Manual.
3. Because of the difference in helicopter models, refer to the helicopter POH for methods of operation for a specific helicopter regarding rotor engagement, manifold pressure ratings, the method of rotor engagement, and centrifugal clutch or manually-operated belt drive.

A. GROUND OPERATIONAL TEST

1. Refer to the latest revision of Service Instruction No. 1014 and make sure the engine has the correct grade and quantity of oil.
2. Put the helicopter in a position facing the wind to take advantage of prevailing wind to keep the engine cool.
3. Make sure the throttle and mixture control, if applicable, are at the FULL-OFF position.

NOTE

In the following step, if sufficient oil pressure indication is not seen within 30 seconds, stop the engine, identify and correct the cause.

4. Refer to the helicopter POH for the correct start-up procedures. Start the engine and operate the engine for 5 minutes at idle RPM (1200-1450 RPM).
5. Adjust the idle mixture (if applicable) and oil pressure as necessary.
6. Do a magneto check, if applicable, per the POH.
7. Stop the engine.
8. Examine the engine for oil and fuel leaks.
9. Start the engine and operate for 5 minutes at idle speed (1200-1450 RPM).

10. Engage the rotor. if necessary, and increase the engine RPM to 50% to 60% of rated engine speed for 5 minutes with rotor blades at flat pitch (collective full down).

NOTE

For correct break-in, do not let the cylinder head temperature go above 420°F (216°C).

11. If the oil pressure is at the correct operating pressure and the oil temperature is between 180°F and 200°F (82°C and 93°C), with the cylinder head temperatures between 350°F and 400°F (177°C and 204°C), increase the engine RPM to 80% of rated engine speed for 5 minutes, followed by 100% airframe manufacturer's rated engine speed for another 5 minutes.
12. After operating the engine for the last 5-minute segment, let the engine cool as recommended in the POH and then stop the engine.
13. Drain the oil from the engine and change the oil. Refer to the latest revision of Service Instruction No. 1014.
14. Remove and clean the suction screen in the oil sump.
15. Clean the oil pressure screen and/or replace the oil filter.
16. Make any necessary oil pressure adjustments.
17. Install the suction screen and oil pressure screen (or new oil filter); torque per the Table of Limits.
18. Add the correct grade and quantity of oil. (Refer to latest revision of Service Instruction No. 1014.)
19. Start the engine and let it operate at 1450 RPM idle.
20. Engage the rotor, if necessary, and increase the engine RPM to 2000 RPM.
21. Warm the engine to do a ground operational check as described in the helicopter's POH.

B. FLIGHT TEST

1. Start the engine and operate it at 1450 RPM.
2. Engage the rotor, if necessary, and increase the engine speed to 75% RPM.
3. With the engine warm, do a ground operational test in accordance with the helicopter manufacturer's POH, including the magneto check.

NOTE

Use two crew members to control and monitor the engine instruments, including the aircraft and engine operating temperatures and pressures. If any parameters are out of tolerance with the helicopter POH or engine and aircraft operating manual limitations, stop the break-in procedure. Identify and correct the problem. Do any necessary maintenance. Then continue with the break-in procedure.

4. Put the helicopter into a hover mode for 10 minutes while monitoring the manifold pressure, fuel pressure, oil temperature, oil pressure and cylinder head temperature, etc.
5. If engine instruments are satisfactory, go to cruise altitude.
6. Operate at cruise power at 70% to 75% of rated power for 30 minutes to keep a constant safe altitude.

7. At the end of the 30-minute flight at 70% to 75% power, record the manifold pressure and engine temperature.
8. Increase engine RPM and manifold pressure to maximum specified limits in the helicopter manufacturer's POH. Hold this power setting for 45 minutes at a constant safe altitude.
9. At the end of 45 minutes, again record the manifold pressure and engine temperature.
10. After the flight test and before engine shutdown, operate the aircraft either in a hover mode for 10 minutes or for the time recommended in the helicopter POH.
11. Record the manifold pressure and engine temperatures.
12. After landing, refer to the POH for cool-down and shutdown procedures.
13. Examine the engine for oil and fuel leaks. Identify and correct the cause of any leaks.
14. Calculate the fuel and oil consumption.
15. If the calculated consumption values are above the specified limits, identify and correct the cause(s). Do the flight test again before releasing the aircraft for service.
16. Remove the oil suction screen and pressure screen (or oil filter). Examine for contamination. Remove contamination. If contamination is found, identify and correct the cause of the contamination.
17. Clean the screen and, if necessary, replace the oil filter.
18. Install the suction screen and oil pressure screen (or new oil filter); torque per the Table of Limits.
19. Add the correct grade and quantity of oil. (Refer to the latest revision of Service Instruction No. 1014.)
20. After the helicopter has been released for service, operate the engine on mineral oil until oil consumption is stable. (Refer to the latest revision of Service Instruction No. 1014.) During this time, keep the engine power above 65% and monitor. Make sure that all aircraft and engine operating temperatures and pressures are kept within limits.

ISSUED			REVISED			PAGE NO.	REVISION	S.I. 1427
MO	DAY	YEAR	MO	DAY	YEAR	7 of 7	C	
10	21	83	12	29	10			