Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A05P0227

ENGINE POWER LOSS LEADING TO LOSS OF CONTROL

ENSTROM 280C (HELICOPTER) C-FKEO
DUNCAN, BRITISH COLUMBIA
17 SEPTEMBER 2005

Canada

Aviation Investigation Report

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Summary

The privately registered Enstrom 280C helicopter (registration C-FKEO, serial number 1046) departed Duncan Airport, British Columbia, at about 1925 Pacific daylight time for a local visual flight rules flight, with the pilot and one passenger on board. About 10 minutes later, in daylight visual meteorological conditions, the helicopter crashed into a field 0.8 nautical mile south of the airport while on approach to the airport. Both occupants were fatally injured and the helicopter was destroyed. There was an intense, post-impact fire.

Ce rapport est également disponible en français.

Other Factual Information

The pilot added 62 litres of 100LL avgas before departing the Duncan Airport on the accident flight. About 10 minutes after departure, the helicopter was flying low over a forested area on approach to the airport from the south when popping and banging sounds occurred and the helicopter began to fly erratically. Moments later, the helicopter began to pitch up and down, and for about the last 10 seconds of the flight, an increasing trail of grey-black smoke emanated from the helicopter.

During the last 300 feet of the flight path, the tail rotor assembly broke away from the helicopter. The helicopter climbed steeply then descended rapidly to the ground. An explosion and fireball occurred at ground impact, and the helicopter came to rest on its left side. Both occupants were fatally injured at impact, and the cabin and pylon areas were destroyed by impact forces and fire. The wreckage distribution patterns and the dimensions of the debris trail are characteristic of an in-flight break-up event (see Figure 1).

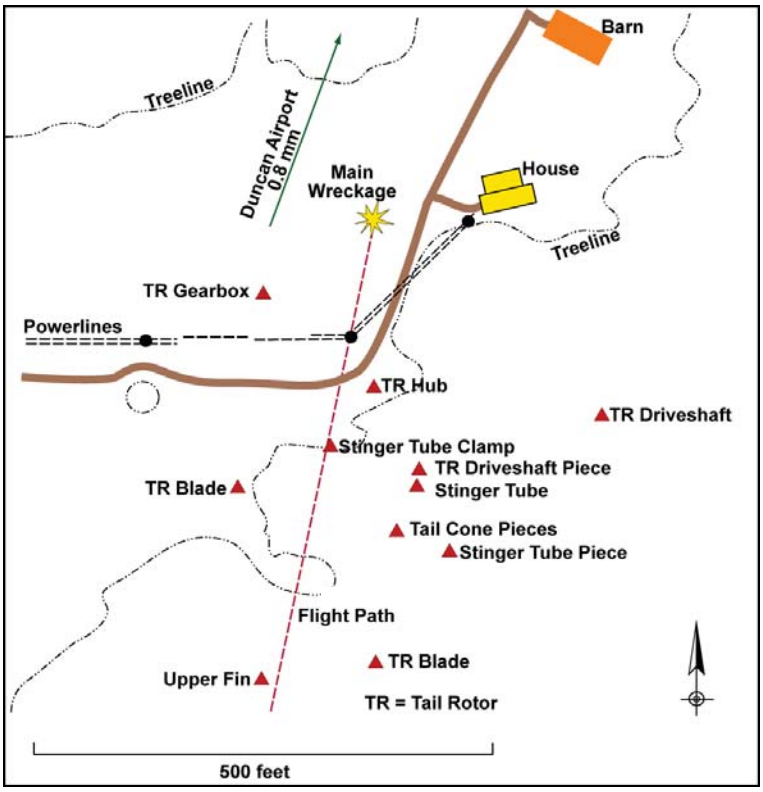

Figure 1. Diagram of wreckage site

The flight was conducted in weather conditions appropriate for a visual flight rules flight, and no adverse meteorological phenomenon was identified.

The pilot held a valid Canadian private pilot licence (aeroplane) and a private pilot licence (helicopter). He had accumulated more than 1500 hours of total flight time on fixed-wing aircraft and about 90 hours on helicopters that included 62 hours on Robinson R22 helicopters and 28 hours on the accident helicopter. A review of pertinent medical records revealed no factor that would have contributed to the accident circumstances.

No damage to the trees or powerlines along the flight path or evidence of tree- or wire-strike damage, on the helicopter wreckage, were found. The only notable ground scars were an impression directly under the helicopter and burns to the grass around the cabin area.

The helicopter's structure was deformed by ground impact in a manner consistent with vertical descent in a 45° nose-down attitude. The three main rotor blades exhibited damage characteristic of low rotational energy at ground impact. The sections of the main rotor flight controls situated directly below the transmission were fire-damaged to the extent that flight control continuity could not be ascertained.

The aft end of the tail cone exhibited main rotor strike damage. Tail section parts found along the flight path as far back as 500 feet from the main wreckage site also exhibited main rotor strike damage. The orientation of the strike marks on the tail components indicates that the main rotor blades contacted the tail cone. Subsequent strikes to components located aft of the tail cone (such as the tail rotor blades) occurred when those components moved into the main rotor path.

The fuel tanks and cabin section of the helicopter were largely consumed in a post-impact fire. The accessory section of the engine was extensively damaged by fire, and some accessories, including the magnetos and the fuel servo, were completely destroyed. The engine-driven fuel pump was significantly damaged by fire.

The accident helicopter was manufactured in 1976 and was powered by a turbocharged Lycoming HIO-360-E1AD engine. In 1979, while registered in the United States as N562H, the accident helicopter sustained substantial damage in a hard landing accident following a loss of engine power. In April 1997, at 1060 hours time since new (TSN), the helicopter, then registered in Canada as C-FKEO, again sustained substantial damage when the landing skid caught the ground during hover exercises and the helicopter rolled onto its side. The helicopter remained out of service for seven years and flew again on 13 May 2004.

The accident pilot purchased the helicopter on 04 August 2005 when it had accumulated 1125 hours TSN. The last logbook entry, dated 13 September 2005 (four days before the accident flight), indicates that the helicopter had accumulated 1129.2 hours TSN. The accident flight was about 10 minutes, making a total air time since manufacture of 1129.4 hours.

Canadian Aviation Regulations (CARs) require that every accident to an aircraft be recorded in the aircraft logbooks. There is no record of any accident in the Canadian logbooks for C-FKEO, which began in 1992.

Excluding the engine accessories, detailed examination of the engine did not identify any pre-impact anomaly that would have prevented the engine from operating normally. Nonetheless, analyses of rotating components crushed during impact, such as the engine cooling fan and camshaft drive gear, indicate that the engine was not operating at impact. No anomalies were found in the drive train between the engine and main rotor.

Analysis of the oil filter converter plate gasket, a known cause of in-flight fires in aircraft equipped with similar engines, and the subject of the United States Federal Aviation Administration (FAA) Airworthiness Directive (AD) 2002-12-07, indicated that the gasket was composed of the correct material and was therefore unlikely to have been the source of an oil leak and subsequent engine fire.

The engine was equipped with a Crane (Lear Romec Division) engine-driven rotary fuel pump, part number RG17980K, serial number B 8714. The fuel pump examination found that the diaphragm (part number RA-7434), located between the relief valve housing and relief valve assembly cover, had been reduced by fire to an ash deposit. An area between the two relief valve attaching screws opposite the vent fitting (see Photo 1) was free of ash deposit. This ash-free area would be adjacent to the magnetos when the pump was installed on the engine. The gasket between the relief valve housing and the fuel pump housing had also been reduced

to an ash deposit. However, the ash pattern resembled the complete gasket shape. The installation torque on the four relief valve-to-pump-housing attachment screws could not be determined due to fire damage. No additional anomalies were observed regarding the fuel pump.

Numerous Service Bulletins (SBs) have been issued against fuel pump model RG17980K. Crane, the manufacturer of the fuel pump, issued SB 101SB020 dated 03 September 1999 (a replacement for SB 101SB018), which contains actions to be taken to address the problem of fuel leaking past the relief valve gasket by periodically ensuring that valve cover screws are tightened to the correct torque valve. This SB has a further action to inspect the split lines between the pump housing, relief valve housing, and relief valve cover for indication of fuel leakage or noticeable gasket extrusion adjacent to the pump inlet and outlet ports. It was indicated within the SB that this condition could result in a fire hazard, fuel flow fluctuations, or engine stoppage.

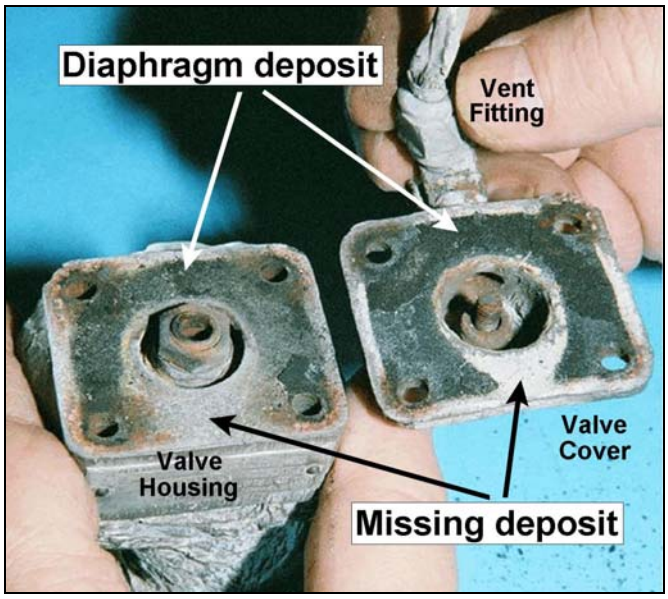

Photo 1. Valve housing and cover with gap in diaphragm

Crane SB RG17980-73-001 was issued on 29 November 1999 as an alternate means of compliance with Crane SB 101SB020. Crane SB RG17980-73-001 introduced fuel pump design enhancements that provide improved relief valve housing sealing characteristics and resistance to fuel leakage.

Crane SB 3402 issued 30 July 1993 applied to newly manufactured pumps assembled between October 1986 and December 1989 and to pumps that were overhauled since October 1986. This SB stated that the diaphragms used in the regulating valves of these pumps may not fully conform to the manufacturing process specifications. Fuel leakage past a failed diaphragm will exit the pump via the valve cover vent. If the vent is not plumbed to an overboard drain or holding tank, fuel may accumulate in an area where an ignition source exists (that is, turbocharger, exhaust components).

In an engine-driven fuel pump application, failure of the diaphragm may cause the regulator valve to malfunction and result in the loss of fuel pressure. In turbocharged applications, fuel leaking into the vent line could have the effect of fuel mixture enrichment. According to the supporting information in the SBs, fuel leaking past a defective diaphragm or past the gasket as a result of insufficient torque on the attaching screws can cause a fire hazard, fuel flow fluctuation, or engine stoppage.

Textron Lycoming issued SB 494 on 01 November 1990 and SB 497 on 15 November 1990, which required the installation of restricted fuel pump vent fittings incorporating an “R” stamped on them. This installation was to prevent excess fuel from entering the engine induction system as

a result of engine-driven fuel pump diaphragm failure, especially when the electric fuel boost pump is energized. The Enstrom helicopter is flown with the electric fuel boost pump operating continuously.

Further, Textron Lycoming issued SBs 529 and 539, which were reprints of Crane SB 101SB020 and RG17980-73-001.

The incorporation of SBs into the aircraft maintenance program is not mandatory in Canada unless the SB changes an Airworthiness Limitation or the operator has stated in the maintenance program that applicable SBs will be completed (Transport Canada Airworthiness Notice B55 refers).

In addition to the SBs, three ADs have been issued regarding this fuel pump. AD 91-08-07, effective 06 May 1991 (supported by Textron Lycoming SBs 494 and 497), requires that, when this fuel pump is installed on a turbocharged engine, such as in the Enstrom 280C helicopter, the fuel pump vent fitting must contain a restrictor. The AD prescribes that the vent fitting be stamped with the letter "R" to indicate that it incorporates the restrictor. Examination of the accident fitting showed neither the restrictor nor the "R" marking.

AD 2003-14-03, which supersedes AD 98-18-12, requires a torque check inspection of the four fuel pump relief valve attaching screws (part number AN500A10-22) for the prescribed torque of 23 to 25 inch-pounds. This inspection is to be completed every 50 hours time in service or every six calendar months, whichever comes first. These screws secure the assembly of the valve cover, diaphragm, valve housing, and gasket to the fuel pump. It has been determined that loss of torque on these screws allows the extrusion of the gasket (part number RA-15981) between the valve housing and the pump housing and the extrusion of the diaphragm between the valve housing and the valve cover (see Photo 2). According to the information in the ADs, extrusion of the gasket and/or the diaphragm is known to have caused serious fuel leakage, which in turn can lead to engine failure, engine fire, and damage to, or loss of, various aircraft. The most likely source of ignition from an external fuel pump leak is the extremely hot turbocharger and exhaust system.

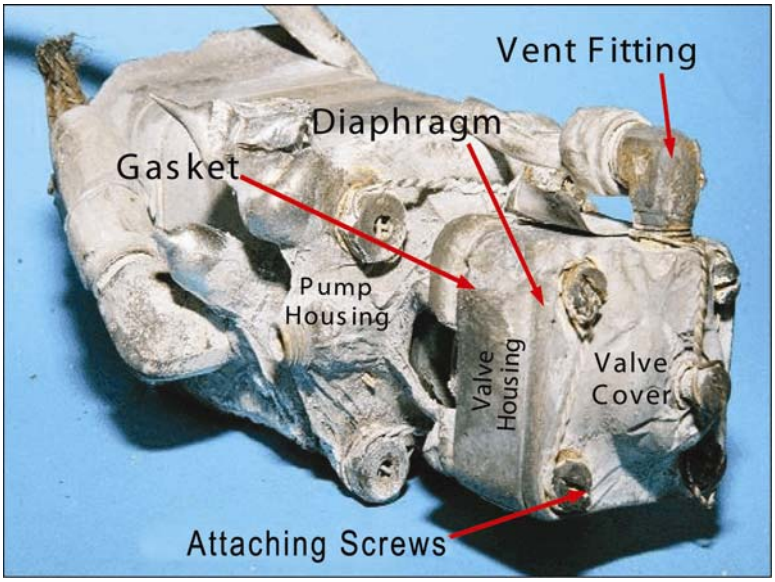

Photo 2. Engine-driven fuel pump

AD 2003-14-03 further allows a terminating action (replacement of the pump with one having a new design valve housing) to be performed once in lieu of the repetitive maintenance action. The pump in C-FKEO did not incorporate the redesigned valve housing, nor was there any

record of the pump being so modified. Accordingly, none of the conditions for terminating action were met, and the repetitive maintenance action of either AD continued to be applicable to the installed pump.

ADs are deemed mandatory by CARs and must be completed on aviation products to which they apply and be recorded in the appropriate logbooks.

Transport Canada (TC) provides the aviation industry with an electronic list of applicable ADs. A search of the TC list of ADs applicable to C-FKEO (Enstrom 280C helicopter and Lycoming HIO-360-E1AD engine) did not find AD 91-08-07 listed. The applicability section of the FAA–issued AD identifies the accident engine as subject to the AD. The TC list is not the sole source of information for aircraft owners and maintainers concerning applicable ADs; other sources include engine and airframe manufacturers.

The maintenance actions recorded in the helicopter logbooks indicated that all maintenance on this helicopter since November 1993, including the rebuild in March 2004, was performed by the same approved aircraft maintenance organization (AMO).

The investigation into this accident examined many aspects of the helicopter's service history and found numerous maintenance-related anomalies. The following items are most pertinent:

- known defects not recorded in the logbooks
- known accident history not recorded in the logbooks
- performed maintenance not recorded in the logbooks
- post-maintenance release to service with outstanding defects
- required independent inspections not performed
- maintenance performed incorrectly
- maintenance conducted by unlicensed person(s)
- ADs not completed as required

About 4.5 flight hours before the accident, the pilot e-mailed an extensive list of aircraft defects to the maintenance facility with a request that the defects be rectified. It is not known if any of the listed defects, such as difficulty starting the helicopter, were related to the cause of the accident. None of the e-mailed defects was recorded in the aircraft logbooks; CARs require that defects and rectification of those defects be recorded in the aircraft logbooks.

Review of the Canadian logbooks for C-FKEO indicated that, with the exception of AD 2003-14-03, no SB or AD pertaining to the engine-driven fuel pump had been entered as completed in accordance with Section 605.96 of the CARs. AD 2003-14-03 was performed once at 1059.8 airframe hours sometime between 03 March and 13 May 2004, that is, at least 16 calendar months and 70 hours time in service before the accident. Based on this logbook entry, the repetitive action of the AD was at least 20 hours time in service and 10 calendar months overdue.

The supporting logbook entries detailing the maintenance performed between 03 March and 13 May 2004 record that the AN500A10-22 screws were tightened to "60" lbs" (60 inch-pounds), asserting that AD 2003-14-03 was completed with this action. This recorded torque is nearly three times the torque of the 23 to 25 inch-pounds prescribed by the AD. Engineering

calculations show that AN500A10-22 screws stretch and fracture when the applied torque exceeds approximately 40 inch-pounds. The screws from the accident pump were specifically examined during the disassembly of the fuel pump; none showed signs of stretch or fracture. The screws, therefore, had not been tightened to the value recorded in the logbooks.

TC is required to periodically inspect AMOs to ensure that the maintenance those organizations perform is done in accordance with Canadian regulations. To the extent that TC resources allow, inspection frequency is to be conducted in accordance with the *Frequency of Inspection Policy Document* (FOIPD) but can be varied from the FOIPD based on risk indicators. The company maintaining the accident helicopter was ranked as an AMO Group 3 company. According to the FOIPD, 33 per cent of AMO Group 3 companies should be inspected every year. By implication, each AMO Group 3 company should be inspected every three years. No inspection of the company maintaining the accident aircraft was performed between 22 December 1999 and 16 November 2005. As well, no inspection was performed immediately following a 15 March 2001 helicopter accident (TSB report A01P0047) that was attributed to improper maintenance by the same company.

Analysis

Technical information confirms that the engine-driven fuel pump diaphragm is a known vulnerability. As the helicopter maintenance records indicated that the torque check on the relief valve retaining screws had not been repeated as required by the AD and because a portion of the diaphragm residue was found missing, a fuel leak most likely developed at the split line between the relief valve housing and the relief valve cover. This concurrently allowed the fuel to leak externally from the pump into the engine cowl where sources of ignition were abundant and, due to the lack of the required restricted fuel pump vent fitting, to leak internally into the intake manifold causing an over-rich fuel mixture. Either the over-rich mixture or the loss of fuel pressure or a combination of both would result in a rough running engine and loss of engine power. As the magnetos were among the most heavily damaged of the engine accessories, and as the leak was adjacent to the magnetos, the fire may also have affected the ignition system in flight and further contributed to the power loss.

With a loss of engine power, the pilot would have had difficulty maintaining rotor rpm, and continued level flight would have been impossible. The only option available to maintain rotor rpm would have been to enter autorotative flight, descend, and land immediately. However, with no suitable landing area below the flight path, the pilot may have been unwilling to conduct an immediate descent and the main rotor rpm may have consequently decayed. If the main rotor rpm had decayed significantly below its normal operating limit, rotor instability would have allowed the main rotor blades to strike and sever the tail cone. The tail rotor assembly departed the helicopter in flight. With the tail rotor severed from the helicopter, it would have immediately become nose-heavy. This shift in the centre of gravity (CG) would have made the helicopter difficult to control. Given the combination of the engine malfunction, rotor rpm decay, rotor strikes on the tail, tail rotor loss, forward CG, and the height above ground, it is unlikely that the pilot could have recovered control and landed the helicopter.

The helicopter was not serviced or maintained in accordance with existing Canadian regulations. Current and past ADs and SBs identified maintenance action required to prevent fuel pump leaks that have been linked to engine fire, loss of power and engine stoppage. Neither the ADs nor the SBs were recorded as completed on the occurrence helicopter, and it is likely that the work was not completed.

Because, despite increased risk indication, TC did not inspect the company performing maintenance on the accident helicopter within the three-year period specified in their FOIPD and did not inspect that company immediately following a previous maintenance-related accident, an opportunity was missed to learn that maintenance was not performed in accordance with Canadian regulations.

Findings as to Causes and Contributing Factors

1. The helicopter was not serviced or maintained in accordance with existing regulations and, as a result, maintenance actions to correct serious engine-driven fuel pump defects were not completed.

2. The engine-driven fuel pump diaphragm failure and extrusion resulted in a loss of engine power and an in-flight fire.

3. When the engine lost power, the main rotor rpm was allowed to decay significantly below its normal operating limit, allowing the main rotor blades to strike the tail cone and severe the tail rotor assembly, causing significant centre of gravity imbalance.

4. The deteriorating condition of low rotor rpm and pitch oscillations, combined with the low height above ground, prevented the pilot from recovering the helicopter, and it descended out of control and struck the terrain.

Findings as to Risk

1. Transport Canada's electronic list of Airworthiness Directives (ADs) applicable to Enstrom 280C helicopters and Lycoming HIO-360-E1AD engines did not include AD 91-08-07.

2. Transport Canada did not inspect the company performing maintenance on the accident helicopter within the *Frequency of Inspection Policy Document* (FOIPD)–specified three years, resulting in a missed opportunity to learn that maintenance had not been performed in accordance with Canadian regulations.

Other Finding

1. The accident helicopter's maintenance records were inadequately kept and did not constitute a reasonably accurate reflection of the condition of the helicopter or of the level of maintenance performed or required.

Safety Action Taken

Transport Canada has included Airworthiness Directive (AD) 91-08-07 in its electronic list for Enstrom 280C helicopters and Lycoming HIO-360-E1AD, HIO-360-E1BD, and HIO-360-F1AD engines.

An audit of A&L Aircraft Maintenance was completed in November 2005, and amendments to the maintenance procedures manual and maintenance procedures were done at that time.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 22 February 2007.