Report 00-009

McDonnell Douglas Helicopter Company 369E

ZK-HFT

loss of engine power

near Te Anau

17 October 2000

Abstract

On Tuesday 17 October 2000, at about 1250, a MDHC 369E helicopter ZK-HFT, was returning to Queenstown with 2 people on board when the pilot made a forced landing owing to a loss of engine power.

ZK-HFT had been chartered for an inspection of a slip on the road between The Divide and Homer Tunnel. After completing the inspection and while flying down a valley east of Te Anau, the helicopter had a sudden uncommanded power loss. The pilot entered ZK-HFT into auto-rotation and attempted to restore power - without success. The pilot completed an auto-rotational landing, during which the main rotor blades severed the tail boom. The helicopter remained upright after the landing. The pilot and passenger were not injured.

The reason for the loss of engine power was not determined.

Contents

List of Abbreviations

C	Celsius
ELT	emergency locator transmitter
FCU	fuel control unit
MDHC	McDonnell Douglas Helicopter Company
nm	nautical miles
PSI	pounds per square inch
PTG	power turbine governor
RPM	revolutions per minute
TOT	turbine outlet temperature
UTC	Co-ordinated Universal Time

Data Summary

Aircraft type, serial number and registration:	MDHC[1] 369E, 0452E, ZK-HFT
Engine type and serial number:	Allison 250-C20B, CAE 836524
Year of manufacture:	1991
Date and time:	17 October 2000, 1250 hours[2]
Location:	15 nm east of Te Anau latitude: 45° 14′ south longitude: 168° 00′ east
Type of flight:	air transport, charter
Operator:	Southern Lakes Helicopters Limited
Persons on board:	crew: 1 passengers: 1
Injuries:	nil
Nature of damage:	aircraft moderately damaged
Pilot's licences:	Commercial Pilot Licence (Helicopter) Private Pilot Licence (Aeroplane)
Pilot's age:	49
Pilot's flying experience:	12 720 hours (about 8000 hours on type)
Investigator-in-charge:	I R M^{c}Clelland

[1] McDonnell Douglas Helicopter Company
[2] All times in this report are New Zealand Daylight Time (UTC + 13)

1. Factual Information

1.1 History of the flight

1.1.1 On the morning of Tuesday 17 October 2000 the pilot of ZK-HFT, an MDHC 369E helicopter operated by Southern Lakes Helicopters Limited (the operator), was contracted to assist in the inspection of the road near Homer Tunnel, after overnight avalanches in the area. At about 0830 ZK-HFT departed Queenstown for The Divide, 10 nautical miles (nm) east of Milford Sound. On board the helicopter were the pilot and a civil engineer, who was to do the road inspection. The civil engineer was familiar with helicopters, having worked around them for over 10 years.

1.1.2 Owing to poor weather the pilot was unable to fly directly to The Divide. Instead he flew initially towards Te Anau via Mararoa River, and then north up the Upukerora and Eglinton Rivers, eventually following the road to The Divide. After offloading the civil engineer at The Divide, ZK-HFT continued to the operator's main base near Te Anau, landing at about 1000.

1.1.3 At the base, the pilot shut down ZK-HFT and refuelled the helicopter to full from the operator's bulk fuel installation. At about 1145 the pilot started ZK-HFT and returned to The Divide. The weather was still poor, the pilot reporting some sleet and rain about with cloud covering the tops of the hills. The pilot said the engine anti-ice was selected on and remained on for the remainder of the flight. The ambient temperature was estimated to be about freezing at The Divide, with the local wind reported as a light westerly or south-westerly at about 5 to 7 knots.

1.1.4 At The Divide the pilot uplifted the civil engineer and 2 workers, and proceeded to Homer Tunnel before returning to drop off the 2 workers at The Divide. The pilot started the return flight to Queenstown, planning to follow the road to about abeam Te Anau Downs and then fly around the base of the higher mountains, South Mavora Lake to Queenstown.

1.1.5 On the return flight the pilot reduced speed on several occasions to fly through areas of reduced visibility, but had cleared the worst of the weather by about Knobbs Flat. The wind was light with no noticeable turbulence reported. ZK-HFT was in the cruise, flying about 500 feet above the ground entering the Upukerora Valley, when the pilot and civil engineer felt a sudden bump and the aircraft begin to descend. They heard a change in engine sound but no unusual noises. The pilot initially tried to counter the descent by raising the collective lever but quickly realised that this had no effect. The pilot also observed the N1 engine gauge[3] reading decreasing. The civil engineer initially braced but then relaxed when the pilot raised the collective lever.

1.1.6 The civil engineer questioned the pilot about the bump and the pilot replied that they had an "engine failure". The pilot immediately lowered the collective lever, entered auto-rotation and headed towards a clear area. With the throttle still fully open, the pilot engaged the relight button in an attempt to restore engine power. The pilot also initiated several short flaring manoeuvres while in auto-rotation to try and regain some main rotor speed, which was at the low end of the normal green operating range.

[3] A gauge that measures the speed of the engine gas generator section. Read as a percentage.

1.1.7 The pilot continued the relight attempt and observed the turbine outlet temperature (TOT) gauge reading increasing past 800°C[4], but none of the remaining power-related gauges indicated any power restoration. The relight attempt was discontinued and the pilot focused on the landing. Approaching the clear area down wind, the pilot flared the helicopter hard to reduce the rate of descent and forward groundspeed. The tail rotor struck the ground during the flare, causing the tail of the helicopter to rise and the main rotor blades to sever the tail boom about halfway along its length. After the pilot levelled the skids from the flare the helicopter struck the ground firmly but remained upright. Throughout the auto-rotation and flare there was no audio or instrument warning to indicate an engine malfunction.

1.1.8 After landing, the pilot and civil engineer both noted that the engine audio and instrument warning indicators were functioning. The pilot retarded the throttle to idle but heard the engine still running and so, concerned about fire, he shut the engine down using the fuel shut-off lever. The emergency locator transmitter (ELT) activated during the landing. After checking for any injuries and not wanting to initiate a full-scale search, the pilot turned the ELT off.

1.1.9 The pilot and civil engineer exited the helicopter and inspected it for fire and damage. There was no fire and most of the damage was confined to the tail rotor, severed tail boom area and main rotor blades. An inspection of the engine air intake on top of the fuselage revealed no accumulation of snow or ice on or around the engine air filter. The pilot used a cellular telephone to summon assistance. Another of the operator's helicopters arrived about 30 minutes later and evacuated the 2 occupants.

1.2 Personnel information

1.2.1 The pilot, aged 49, held a Commercial Pilot Licence (Helicopter) and a Private Pilot Licence (Aeroplane). His Class 1 medical certificate was valid to 8 November 2000. The pilot was rated on the MDHC 369E and had accrued over 12 720 flying hours, including over 8000 hours on the 369-type helicopter.

1.2.2 The pilot had a 48-hour rest period before the flight and had been on duty for about 5 hours at the time of the accident.

1.3 Aircraft information

1.3.1 ZK-HFT was an MDHC 369E, serial number 0452E, single-engine helicopter manufactured in the United States in 1991. In 1997 MDHC, previously Hughes Helicopters, was purchased by Boeing Corporation and the company was renamed Boeing Helicopters - Mesa.

1.3.2 The 369E was designed as a high-speed lightweight utility helicopter. The 369 series of helicopter was common in New Zealand, with about 60 of the helicopter type flying - most powered by a single Allison 250-C18 or C20B engine.

1.3.3 ZK-HFT was imported into New Zealand in 1991 and was flown mainly privately until the operator leased the helicopter in early 2000. The helicopter had been issued with a non-terminating Certificate of Airworthiness in the standard category.

1.3.4 Engineering support for ZK-HFT was provided by a local aircraft maintenance organisation. The helicopter had amassed some 1518 hours since manufacture and 14 hours since its last inspection, which was recorded as having been completed on 2 October 2000. The inspection, a 300-hour check, was recorded as having been completed in accordance with the maintenance organisation's schedule and the operator's maintenance manual requirements.

[4] The maximum operating limit is 810°C and normal reading during cruise would be about 700°C.

1.3.5 ZK-HFT was powered by an Allison 250-C20B engine, serial number CAE 836524, which was installed in the helicopter at time of manufacture. The engine had accumulated about 1518 hours at the time of the accident. During an earlier check some possible damage had been identified in the compressor and combustion sections of the engine. At the 300-hour check these sections were removed and loaned replacement sections installed. The loaned sections were owned by the maintenance organisation and hired by the operator until the damaged sections could be inspected and repaired if required. A freewheeling unit was also exchanged at this time. The original freewheeling unit was reinstalled after inspection on 4 October 2000 at about 1507 engine hours.

1.3.6 As part of the 300-hour inspection the engine bleed air valve needed to be replaced as it had accrued the maximum 1500 hours permitted. Inspection of ZK-HFT confirmed that the original bleed air valve was still installed on the engine. All other airworthiness directives were recorded as having been completed.

1.3.7 The pilot and several aircraft engineers reported that the engine had consistently run about 20°C above normal since manufacture, which was considered acceptable by the owner. A TOT calibration completed on 29 September indicated that the TOT gauge was reading about correctly. No trend analysis checks were reported. A torque meter calibration completed on 2 October indicated that the torque gauge was under-reading by about 2 pounds per square inch throughout the operating range.

1.3.8 A review of the documentation for the loaned compressor and combustion sections indicated both items were correctly maintained.

1.3.9 The MDHC 369 series of helicopter was equipped with aural and instrument warnings to alert the pilot to an engine malfunction. The warnings were activated when the engine RPM decreased below 55% N1, or the main rotor RPM decreased below 468 RPM - equivalent to about 98 ±1% N2[5]. In cruise flight N1 would normally read about 90% and N2 normally about 102%.

1.3.10 The 369 helicopter had an engine ignition system that was designed to automatically activate when the engine RPM decreased below 55% N1, thereby assisting in the restoration of engine power. Should the ignition system activate, the pilot would be alerted by the illumination of a warning light on the helicopter's instrument panel.

1.4 Meteorological information

1.4.1 A series of cold fronts had passed over the country in the days preceding the accident, dropping snow along the Southern Alps. On Tuesday 17 October a ridge of high pressure had begun to extend over the South Island. The surface and upper level winds were generally from the south-westerly direction, of light to moderate intensity.

1.4.2 The pilot and civil engineer reported the weather to be low broken cloud with some snow and sleet or rain in places. Some snow was encountered during the flight from The Divide to Homer Tunnel and back, but The Divide continued to remain basically clear. When flying through the snow showers, the snow was observed to be blown away quickly and not build up on the helicopter. The wind was light with very little turbulence encountered during the flight. The temperature was about freezing at The Divide and about 4°C at the accident site.

[5] A measure of the speed of the power turbine section of the engine. Read as a percentage.

1.5 Tests and research

1.5.1 The helicopter was lifted out by another helicopter and transported to an approved maintenance facility for examination. The main rotor blades were removed for ease of transport. The initial inspection of the helicopter indicated nothing unusual other than the damage resulting from the auto-rotational landing and the main rotors striking the tail boom. Inspection of the cabin area showed the fuel shut-off lever had been selected off and the cabin heat and engine anti-ice had been selected on. All fuel and pneumatic control lines and fittings were inspected for cracking, leaks or loose attachments - none was found. The oil levels were normal.

1.5.2 Fuel samples were taken from the operator's bulk fuel installation, the helicopter's fuel tank and subsequently from the engine's fuel control unit (FCU). About 150 litres of fuel remained in the fuel tank. The fuel was sent to a laboratory for testing. The fuel met the required specifications detailed by the manufacturer. A small amount of unidentified black particulate was recovered from the FCU sample which was not considered sufficient to affect the performance of the control unit or engine.

1.5.3 The main transmission and power train, and engine were rotated by hand without restriction or unusual noise. When connected to an electrical power source, the helicopter's warning and ignition systems functioned correctly. The magnetic chip detector plugs for the transmission were inspected and although some metal elements were found on one of the plugs, these were identified as probably being from the bearings in the transmission and not associated with the power loss. Some straw was located in the air intake for the engine but the intake was otherwise free of any major obstruction.

1.5.4 The engine was removed and inspected. The compressor and turbine elements rotated freely. The fuel burner-can displayed no unusual characteristics. The FCU, power turbine governor (PTG), engine-driven fuel pump and fuel nozzle were removed for further testing by an independent specialist in Australia. All fuel and air lines were then checked for blockages and none was found. The engine magnetic chip plugs were clear of any debris. The engine was then sent to an approved overhaul facility for disassembly and inspection.

1.5.5 The Australian Transport Safety Bureau, acting on behalf of the Commission, oversaw the performance testing and inspection of the engine fuel equipment. The specialist reported the following:

> Bench testing of the Fuel Equipment did not reveal any discrepancies [that] could be related to the in-flight engine power loss incident. All the units were found to operate in such a manner that they would not have caused a sudden power loss/engine deceleration under normal steady conditions. Although the FCU and PTG, in particular, failed to satisfy all serviceable test limits, these could not be considered, based on bench test alone, to be contributory to the incident. The failed serviceability aspects are considered to be most likely attributable to normal wear and tear.
>
> Disassembly and inspection of the units did not reveal any discrepancies which could be considered to have contributed to an in-flight power loss as reported. The condition of the internal components confirmed normal wear and tear only.

1.5.6 The engine was subsequently disassembled and inspection of the separated modules revealed no defects or abnormalities which might have contributed to the sudden power loss. The bleed air valve was tested and functioned as designed.

1.6 Additional information

1.6.1 On 25 September 2000 a model 369HS helicopter, similar to ZK-HFT and belonging to another operator, was conducting a training exercise in the Mackenzie Basin area. Included in the exercise was the instruction of snow-landing techniques. After demonstrating several landings the pilot and trainee were returning to base when, after about 2 minutes' flying, the engine failed. A successful auto-rotation and landing were carried out with no damage or injury. The second operator reported that after an inspection of the helicopter, including finding no foreign matter in the engine intake area, and talking to the aircraft engineer, the helicopter was started and run without problem. An engineering inspection was then completed before the aircraft was cleared to fly again.

1.6.2 The second operator believed that powdered snow may have built up around the engine air intake during the landing exercises. He contended that as the helicopter descended the snow melted and was ingested into the engine in sufficient quantities to cause a flameout and power loss. The continued presence of snow for a short time then prevented a relight of the engine before landing.

1.6.3 The Commission was only made aware of the incident several weeks after it occurred and, so was unable to eliminate other possible causes of the engine failure, including fuel exhaustion.

1.6.4 On 16 March 2001, following the repair of the airframe and reassembly of the engine using the original components, ZK-HFT was test flown and returned to service. The maintenance facility reported no problems that could have been associated with the loss of engine power on 17 October 2000.

2. Analysis

2.1 No conclusive reason could be found to account for the power loss. The helicopter had operated satisfactorily in the days and morning before the accident. There was ample fuel on board and the samples taken indicated there was no contamination that would have caused the engine to lose power.

2.2 The helicopter had been clear of falling snow and sleet for about 10 minutes and was in stable flight at the time of the power loss. The pilot acted promptly to enter auto-rotation after recognising that the sudden descent was not caused by local turbulence. The pilot's attempts at restoring power were appropriate given the unknown cause of the power loss. Despite the helicopter's low height at the time of the power loss, the pilot minimised the damage to the helicopter and prevented any injury to the occupants by conducting an effective down-wind landing to the only available landing area.

2.3 Considering the experience levels and observations of the pilot and civil engineer, it was unlikely that the engine was inadvertently shut down. The lack of any aural or visual warning of an engine malfunction indicated that the engine continued to run, albeit at a reduced RPM. The observed increase in the TOT but not in the N1 or N2 indicated that the engine was not performing as required.

2.4 The examination and testing of ZK-HFT, its engine and associated accessories including the FCU, PTG, fuel pump and fuel nozzle, did not disclose anything that may have contributed to the power loss. The bleed air valve was determined to be serviceable, despite the requirement for it to be replaced at 1500 hours. Nevertheless, some interruption to the fuel or air supply, though unlikely, could not be ruled out.

2.5 The 369 series of helicopter has operated for many years and has gained a reputation as being a reliable aircraft suitable for the New Zealand environment. The manufacturer advised that there had been very few cases of unexplained power loss involving the 369 model of helicopter powered by Allison 250 C18 or C20B engines.

2.6 Several power loss incidents had been attributed to possible failures in the fuel system. These had been grouped into 3 general areas: firstly, damage to fittings during servicing; secondly, a leaking or damaged primary filter by-pass switch allowing air ingestion; and finally, contamination of the fuel nozzle screen, resulting in the collapse of the screen and limiting fuel flow to about ground idle equivalent. Although ZK-HFT completed a 300-hour check about 14 hours before the accident, there was no evidence maintenance practices contributed to the power loss.

2.7 Other power loss incidents have been attributed to loose or fractured air lines, in particular on elbow fittings near the compressor. While vacuum testing of the lines was not performed before the removal of the engine, no loose fittings were found and inspection of all the lines revealed no fractures present on the engine or its accessories.

2.8 Before the power loss, ZK-HFT had flown through inclement weather, including rain and possible snow or sleet. ZK-HFT had then descended as it returned towards Queenstown, where the temperature would have increased by about 4°C. With the increase in temperature, any build-up of snow on the air intake for the engine could have melted sufficiently to dislodge and be ingested into the engine. The intake of snow would have needed to be sufficiently large to disrupt the airflow, but not enough to prevent combustion continuing.

2.9 The manufacturer reported 11 incidents worldwide since 1970 where there was suspicion of snow involvement. Unfortunately, for about half of these incidents there was no significant fuel or engine examination to exclude other possible causes. The manufacturer agreed that an ingestion of snow could cause an engine failure. However, the amount of snow needed to be large and if the engine did "flameout" the relight system should have restored power when N2 went below 98%. There had been no documented incidents of flameout owing to flight in falling snow, but it had been listed as a possible cause in 2 or 3 accidents.

2.10 The manufacturer contended that the in-flight airflow generally prevented any build-up of snow on the intake area during flight. Snow could, however, build up if the helicopter remained on the ground for a long time in falling snow. The incident concerning the second 369 helicopter in Mackenzie Basin about 3 weeks earlier may have been due to snow building up on the helicopter after each landing. As the helicopter descended during the return to base, the snow may have melted sufficiently to be dislodged and ingested into the engine. The amount of snow was probably large enough to prevent an immediate relight of the engine.

2.11 ZK-HFT landed twice at The Divide before departing the area. Each time the helicopter was on the ground for several minutes - probably insufficient time to permit a large build-up of snow.

3. Findings

Findings are listed in order of development and not in the order of priority.

3.1 The pilot was appropriately licensed and fit to conduct the flight.

3.2 The helicopter was appropriate for the type of operation being conducted.

3.3 The helicopter had a valid Certificate of Airworthiness, and its records indicated that it was serviceable at the time of the accident.

3.4 The helicopter had operated satisfactorily during earlier flights.

3.5 The pilot's actions following the loss of engine power were timely, appropriate and resulted in no injury and limited damage to the helicopter.

3.6 There was adequate fuel on board.

3.7 Post-accident inspection and tests carried out on the helicopter, its engine and components disclosed no conclusive reason to account for the sudden power loss.

Approved for publication 16 May 2001

Hon. W P Jeffries
Chief Commissioner