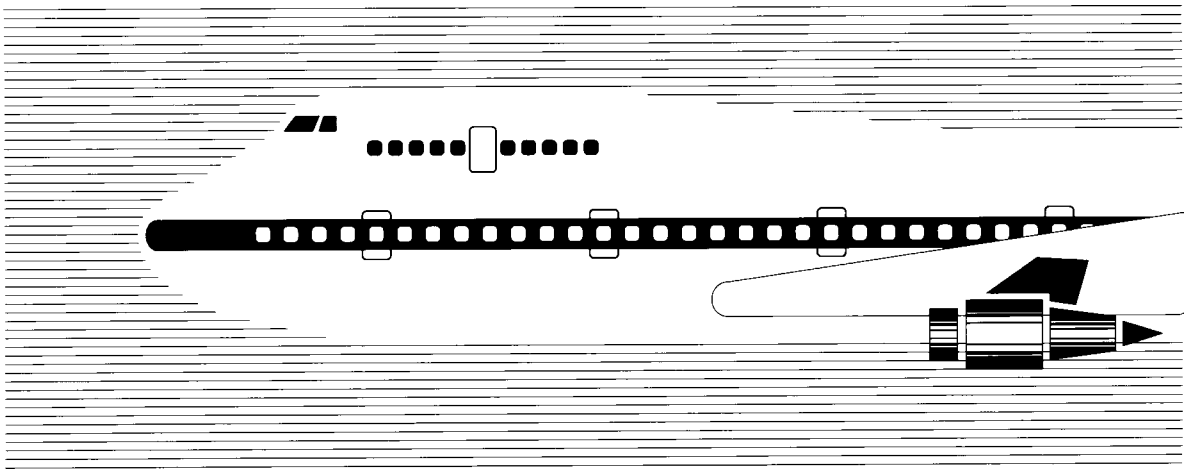
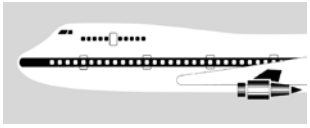
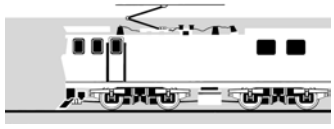


AVIATION OCCURRENCE REPORT

02-005 Hughes 369D helicopter ZK-HRV, engine failure and forced landing, near Tarawera 30 April 2002


TRANSPORT ACCIDENT INVESTIGATION COMMISSION
NEW ZEALAND

The Transport Accident Investigation Commission is an independent Crown entity established to determine the circumstances and causes of accidents and incidents with a view to avoiding similar occurrences in the future. Accordingly it is inappropriate that reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

The Commission may make recommendations to improve transport safety. The cost of implementing any recommendation must always be balanced against its benefits. Such analysis is a matter for the regulator and the industry.

Report 02-005

Hughes 369D helicopter ZK-HRV

engine failure and forced landing

near Tarawera

30 April 2002

Abstract

On Tuesday 30 April 2002, at about 1630, New Zealand Helicopters Hughes 369D helicopter ZK-HRV was being flown on a scenic passenger flight from Mount Tarawera to the company base near Rotorua when engine trouble arose. Before the pilot could land the helicopter, the engine failed and he was forced to make an auto-rotational landing on difficult terrain, where the helicopter rolled over. None of the 4 occupants was injured in the accident.

The engine failed from oil starvation, following a fracture of a fitting in the oil line to the torque gauge.

A safety issue identified was the need for pilots and operators to better understand the torque gauge oil line system on this helicopter type.

Contents

Figures

Abbreviations

CAA	Civil Aviation Authority
FAA	Federal Aviation Administration
HMI	Handbook of maintenance instructions
km	kilometre
MDHI	MD Helicopters Incorporated
nm	nautical mile
RPM	revolutions per minute
TOT	turbine outlet temperature
US	United States

Data Summary

Aircraft registration:	ZK-HRV
Type and serial number:	Hughes 369D, 1192D
Number and type of engines:	one Allison 250-C20B
Year of manufacture:	1982
Date and time:	30 April 2002, about 1630*
Location:	6 nm south-west of Mount Tarawera latitude: 38° 14.8′ south longitude: 176° 22.9′ east
Type of flight:	air transport, scenic
Persons on board:	crew: 1 passengers: 3
Injuries:	nil
Nature of damage:	substantial
Pilot's licence:	commercial pilot licence (helicopter)
Pilot's age:	34
Pilot's total flying experience:	164 hours 28 hours on Hughes 369 type
Investigator-in-charge:	J J Goddard

* all times in this report are New Zealand Daylight Time (Universal Coordinated Time + 13 hours)

1 Factual Information

1.1 History of the flight

1.1.1 The pilot started work at the company's Whakarewarewa base, just south of Rotorua, at 0800 on Tuesday 30 April 2002. After completing a pre-flight inspection and cleaning the helicopter, he checked the day's bookings. No flights were booked until 1600, when he was to fly to the company's Mount Tarawera landing site to pick up a group of 3 passengers who were on a routine combination fly/drive tour. He was to fly them around Mount Tarawera, then past Waimangu and back to the base.

1.1.2 No other flights eventuated, so the 1600 booking was to be the first flight of the day. After lunch he fuelled the helicopter with Jet A1 fuel to a total of 260 lb, the quantity required for the flight. He started the engine at about 1600, and after normal checks, lifted off at about 1615 to fly to Mount Tarawera.

1.1.3 The flight to Mount Tarawera took 7 to 8 minutes, with the helicopter performing normally en route in pleasant flying conditions. The landing on the airstrip on Mount Tarawera at an elevation of 3200 feet was normal, and the pilot kept the rotors turning while the passengers were boarded by the company driver.

1.1.4 After briefing the passengers, the pilot lifted the helicopter off, with all indications of normal operation. He flew the helicopter along the mountain crater rim as normal, then in a cruise-descent across Lake Rotomahana to the Waimangu Valley, slowing to a slow level cruise as he did so. At the end of the Waimangu Valley he commenced a cruise-climb, turning to head for the company base. At that time he observed that the amber "engine chip" light was illuminated on the instrument panel.

1.1.5 The pilot started to look for a suitable place for a precautionary landing, in accordance with the requirement to "land as soon as possible", which was indicated by the amber warning. Because the terrain close by was undulating and unsuitable he decided to head for a nearby airstrip he knew of. Having so decided, he transferred his attention back to the instrument panel and observed that as well as the amber "engine chip" light, the engine oil pressure and temperature gauge indications were very low. He decided to land straight away, and looked out again for any immediate landing spot. As he did so he heard the "low RPM" warning, so he lowered the collective control to enter autorotation. This was followed by a "poof" sound from the engine, accompanied by the red "engine out" light. At this stage the helicopter was at about 700 feet above the local terrain.

1.1.6 The pilot aimed the helicopter for a small level part of a farm track in very undulating terrain, and carried out an auto-rotational flare and landing onto it. During the landing the helicopter rolled or tripped over onto its right side, following ground contact by the tail stinger at low forward speed. He checked that the passengers were unhurt, and helped them climb out, he then turned off the helicopter electrics, fuel and emergency locator transmitter.

1.1.7 A telephone call to his company produced prompt assistance, and the occupants were rescued back to base after about 45 minutes.

1.2 Personnel information

1.2.1	pilot:	male, aged 34
	licence:	commercial pilot licence (helicopter)
	helicopter type ratings:	Hughes 369, Robinson R22
	medical certificate:	class 1, valid to 4 May 2002
	last annual pilot competency check:	21 March 2002
	last biennial flight review:	21 March 2002
	flying experience:	total: 164 hours total, Hughes 369: 28 hours total, last 90 days: 45 hours
	duty time:	8 hours
	rest before duty:	15 hours

1.2.2 The pilot had completed his training for his commercial licence in March 2002, passing his flight test on 6 March on a Robinson R22 helicopter. He had then been employed by the helicopter company to fly ZK-HRV on local scenic flights. After further training by the operator on ZK-HRV, and on the operator's routes, he commenced commercial flying on 26 March.

1.3 Aircraft information

1.3.1 ZK-HRV was a Hughes 369D single-engine helicopter, serial number 1192D, constructed in 1982. It had flown a total of 11 620 hours since new, and 24.7 hours since the last routine maintenance. The Allison 250-C20B gas turbine engine had run 10 873 hours since new. The standard category Airworthiness Certificate was non-terminating. The Certificate of Maintenance Review was valid to 19 March 2003.

1.3.2 A review of the aircraft logbook indicated no recent maintenance activity likely to have involved access to the instrument panel, or removal of any instruments.

1.4 Wreckage and impact information

1.4.1 The accident site was on undulating and uneven pasture land, on a farm vehicle track, and at an elevation of about 1900 feet. The helicopter was lying on its right side, on a westerly heading, across the farm track. A group of ground marks some 8 metres away indicated that the initial touchdown had been along the track to the north, and on both main skids and the tail stinger. The position of the marks was consistent with a landing at low forward and vertical speed, but with the helicopter yawed to the left, and with the tail touching first (see figure 1).

1.4.2 The helicopter had rolled onto its right side, yawing left some 90° as it came to rest. The main cabin structure was intact, with some broken acrylic windows. Both skids had separated, and lay alongside. The tail boom was in place, but had received a significant main rotor strike, probably after the tail contact with the ground on landing. The main rotor blades showed damage typical of ground contact while rotating without power.

Figure 1
ZK-HRV accident site

1.4.3 The occupants had exited from the helicopter through the left (upper) doors, without particular difficulty.

1.4.4 The helicopter instruments and controls provided no significant evidence, apart from the presence of some oil, which was in an unusual area around the base of the instrument panel and the cabin floor.

1.4.5 The helicopter was removed to a maintenance hangar to facilitate examination of the engine and associated systems. The engine oil tank contained only a minimal quantity of oil; the oil cooler and associated plumbing contained about 500 millilitres of oil. The nominal capacity of the tank was 3 US quarts (2.8 litres). The fuel tank was approximately one third full of Jet A1 fuel.

1.4.6 Examination of the rear of the instrument panel showed that a nylon TEE fitting on the rear of the engine torque gauge had fractured, and that engine oil had escaped from it down the rear of the instruments and beneath the cabin floor. The TEE fitting, which incorporated a bleed valve, connected the torque gauge to the flexible plastic oil line which transmitted oil pressure from the engine reduction gearbox (see figure 2).

1.4.7 The flexible plastic oil line, and a similar line to the oil pressure gauge, ran from the engine reduction gearbox along the top member of the cabin roof to the back of the instrument panel. Both appeared to be in serviceable condition. Each line was attached to the engine through a snubber, designed to restrict the flow rate of oil should a failure of the line occur.

1.4.8 The two engine chip detectors were grossly contaminated with carbon and metallic particles, which would have produced the engine chip light reported by the pilot. The oil scavenge filter contained similar material. The engine was removed and dismantled for inspection. The coupling shaft between the compressor and the gas producer turbine stage had failed at its rear spline, with evidence of gross overheating and distortion. The rear bearings in the turbine section, numbers 6, 7 and 8, had failed in a manner consistent with oil starvation.

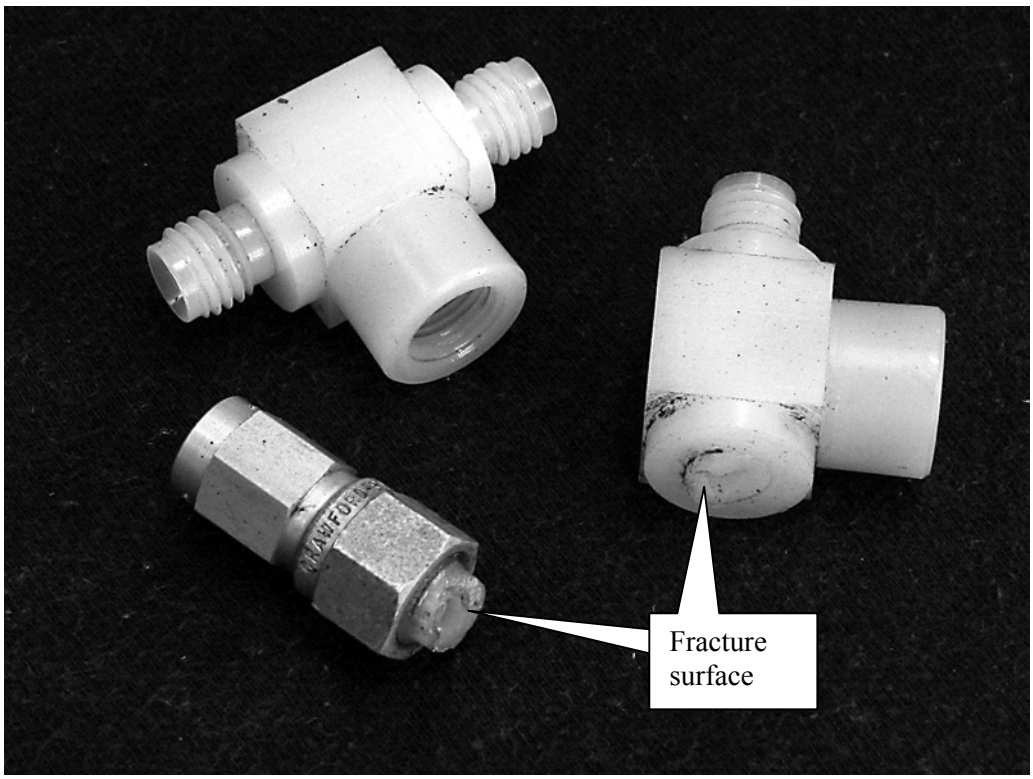


Figure 2
Nylon TEE fittings from the torque and oil pressure gauges of ZK-HRV

1.5 Tests and research

1.5.1 The snubber from the torque meter oil line, and a similar new item, were tested on a fuel flow calibration test rig, to compare relative flow rates. The test rig used "Aviation calibration fluid, type 2", which was a little less viscous than turbine engine oil at operating temperature. At a pressure of 80 pounds per square inch, a typical operating pressure, the snubber from ZK-HRV allowed a flow rate of 100 pounds per hour, which was equivalent to about 60 litres per hour of fluid. The new snubber allowed 135 pounds per hour at the same pressure.

1.5.2 The broken nylon TEE fitting from ZK-HRV was examined by a specialist materials consultant. He reported that the fracture appeared to have occurred rapidly, and in a downward direction. He commented that the fitting had been manufactured with sharp corners at changes of section, rather than with radiused corners, and that failures could occur more easily where stresses concentrate at such sharp junctions. The fracture had originated at a sharp corner at the base of a thread. He was unable to test the material for age-induced degradation, but was of the opinion that such degradation was likely.

1.6 Additional information

1.6.1 The local weather at the time of the accident was reported as: no cloud, visibility 60 km, wind light and variable, temperature 17 ° Celsius.

1.6.2 The pilot, in the 6 weeks he had been flying ZK-HRV, had observed that the more critical instrument to monitor when making power changes was the turbine outlet temperature (TOT) gauge rather than the torque gauge, because it reached its limit first. As a consequence, on the accident flight he was not aware of whether the engine torque gauge was indicating normally, or whether (or when) it had ceased to indicate at all.

1.6.3 MD Helicopters Incorporated (MDHI), the present manufacturer of the helicopter type, advised that the fleet-wide history of oil starvation events was very limited, and that none had been attributed to failure of the torque or oil pressure instrument fittings. One oil starvation/engine failure had occurred in 2000, when an oil line pulled from the engine at a loose "B" nut.

1.6.4 MDHI also advised that the requirement for snubbers in the torque and oil lines was introduced by Service Bulletin in 1989 to ensure compliance with Federal Aviation Administration (FAA) rules. The rules required instrument lines carrying flammable fluids to be restricted to prevent the escape of excess fluid in case of line failure. The snubber specified for the torque line had been calculated to allow a flow rate which could empty the oil tank in 6.5 minutes. A period of at least 5 minutes was specified in FAA rules, to permit a controlled landing.

1.6.5 MDHI advised that nylon was the preferred material for the TEE fitting, rather than metal. The Handbook of maintenance instructions (HMI) required a yearly inspection of the lines through to the instruments. MDHI had some reports of leaking lines but none of broken TEE fittings.

1.6.6 The New Zealand Civil Aviation Authority (CAA) had no record of any similar Hughes 369 oil starvation event.

1.6.7 Discussion with experienced Hughes 369 pilots and instructors indicated that the wetline system operating the torque gauge was not well understood, or that a torque indication failure might be the first warning of an engine oil loss.

2 Analysis

2.1 The helicopter was being operated on a routine tourist flight in a normal manner, in fine weather, and by an appropriately qualified but inexperienced pilot when an engine problem was detected. Since the first symptom the pilot observed was the amber "engine chip" light, his initial reaction, of looking for a suitable place for a precautionary landing, was appropriate. Some delay in finding a landing site was probably inevitable, because of the nature of the terrain below, and his decision to head for a nearby airstrip was sensible. Very shortly afterwards, however, he observed that the engine oil pressure and temperature indications were very low, and he decided, also appropriately, that he had to land the helicopter immediately.

2.2 A few seconds later, however, as the pilot was looking for a landing spot, the helicopter engine failed, as indicated to him by the "low RPM" warning and the red "engine out" light. He was then faced with an immediate auto-rotational landing on the best place he could see within the helicopter's short gliding range. His attempt to land on a small level part of a farm track in the very undulating terrain was a good choice, and almost successful. The helicopter rolling over on landing resulted from it being not sufficiently levelled with the local uneven ground, so that the tail stinger contacted the ground, pitching the helicopter nose-down and causing the main rotor to strike the tail boom. The main rotor strike on the tail boom probably yawed the helicopter left as it rolled over. In the circumstances of this difficult landing area, the inexperienced pilot did well to achieve an emergency landing with no injuries to the occupants.

2.3 The engine failure was evidently caused by oil starvation, with gross damage to the turbine section bearings. This oil starvation was found to have resulted from a fracture of a nylon TEE fitting behind the instrument panel, causing the engine oil to be pumped away beneath the cabin floor. The TEE fitting was between the engine torque gauge and the plastic oil line from the engine reduction gearbox. The oil line transmitted engine oil pressure, modulated by the torque being produced, to the gauge. It was attached through a snubber, whose purpose was to restrict the oil loss rate in the event of such a line failure, to provide a period of at least 5 minutes in which to land the helicopter.

2.4 The cause of the fracture of the TEE fitting was not determined. The specialist's report indicated that the manufactured sharp corners of the fitting made it more susceptible to fracture, and that some age-related material degradation was likely. The fitting had probably been on the helicopter since new, for some 20 years. The fitting did not carry any significant external loads, however, and should have been only lightly stressed. The maximum internal force resulting from the oil pressure was calculated to be approximately 4.4 newton (1 pound). The back of the instrument panel was closed off, protecting components from accidental damage in service. The most likely circumstances to cause any loads on the fitting were when maintenance work was carried out on the instruments. While no recent maintenance activity involving the instruments had been recorded, there was a possibility of some irregular work being carried out behind the instrument panel, by other than qualified maintenance personnel, which may have inadvertently damaged the TEE fitting. No confirmation of this possibility was found, however.

2.5 The fleet-wide history of the Hughes 369 type showed no previous fractured TEE fittings, and no oil starvation events resulting from torque or oil pressure instrument fittings. This did indicate that the nylon fitting had a satisfactory reliability record in service.

2.6 The results of the flow test on the snubber from the torque line indicated that it performed normally in comparison with a new snubber. The actual flow rate achieved did not relate to its performance with engine oil, because of the characteristics of the calibration fluid used. The designed flow rate should have enabled a period of 6.5 minutes to exhaust the oil tank.

2.7 The snubbers in the torque and oil pressure gauge oil lines were required to enable a minimum period of 5 minutes of continued engine operation after a line failure, to permit a controlled landing. This was probably an acceptable period, provided that the pilot was able to recognise in good time the first symptom of the failure, which was likely to be an abnormal or zero indication on the torque gauge (or oil pressure gauge). If the problem were to remain undetected until the engine chip light illumination, as with ZK-HRV, most of the oil will have already been lost and the engine will have suffered consequent damage, with total failure imminent.

2.8 The pilot of ZK-HRV had learned, during his limited experience of the aircraft, to not monitor the torque gauge, preferring the TOT gauge indications. While the TOT may have been the more critical during his short time on ZK-HRV, this was unlikely to remain so in different weather conditions, or with other Hughes 369 helicopters. The outcome of this was that he had no awareness of the torque gauge indication at any stage of the flight, and the potential first warning of impending engine trouble was lost to him.

2.9 Discussions with experienced Hughes 369 pilots and instructors indicated that the significance of the oil line system operating the torque gauge on this helicopter type was not well understood. Many other helicopter and aeroplane types with Allison 250 engines used electrical transducers to operate the torque gauges, so the potential problem was not common. A safety recommendation was made to the Director of Civil Aviation, that he publish advisory information to increase operator knowledge of the system, and what the appropriate pilot response might be to an abnormal torque gauge indication in flight.

3 Findings

3.1 The pilot was inexperienced, but appropriately qualified for the flight.

3.2 The flight was being conducted in a normal and routine way.

3.3 During the flight the helicopter engine lost its oil through a fractured fitting in an oil line behind the instrument panel, leading to a complete engine failure.

3.4 The cause of the fracture was not determined, but it could have resulted from irregular work carried out behind the instrument panel.

3.5 The pilot's responses to those progressive symptoms which he observed were appropriate.

3.6 The auto-rotational forced landing was made on difficult terrain, and resulted in the helicopter rolling over.

3.7 The pilot was unaware of the helicopter torque gauge indication, which was probably abnormal and was probably the first warning of impending engine trouble.

3.8 A timely warning from the torque gauge indication could have enabled the pilot to make a precautionary landing under power before the engine failed.

3.9 The oil line system operating the torque gauge on the Hughes 369 helicopter type is probably sufficiently reliable to not warrant modification to components or maintenance procedures.

3.10 Operators and pilots of the Hughes 369 helicopter type need better knowledge of the torque gauge oil line system to enable understanding of abnormal indications.

4 Safety Actions

4.1 MDHI, the present manufacturer of the helicopter type, was engaged in correspondence about the issues arising from this accident. On 12 September 2002, MDHI advised:

> Subject to FAA approval, the MDHI Flight Manuals for the single engine models using wet lines are being modified to call attention to the issue of engine oil pressure. The update will indicate that, for in-flight loss of oil pressure, the operator is to land as soon as possible and shut down the engine. The operator action applies to a loss of pressure on either the oil pressure gauge or the torque meter (addressed as separate items in the manual). There will also be a note added to those sections stating that the loss of oil pressure could be the result of a failed line (this is to let the operator know that they shouldn't ignore the indication, assuming it is air in the line, etc.).

4.2 In summary, through updates to the pilot manual, MDHI intends to call greater attention to the proper operator response if a loss of engine oil pressure is encountered in flight. Design changes however, are not anticipated.

5 Safety Recommendation

5.1 On 7 October 2002 the Commission recommended to the Director of Civil Aviation that he:

5.1.1 Publish advisory information about the torque gauge oil line system on the Hughes 369 helicopter type, so that operators and pilots may better understand the significance of the system, and what the appropriate pilot response should be to an abnormal torque gauge indication in flight. (050/02)

5.2 On 25 October 2002 the Civil Aviation Authority advised:

> in response to the preliminary safety recommendation: The Director is likely to accept the recommendation as worded. He will publish an article in Vector magazine, which will include advisory material about torque gauge oil line systems

Approved for publication 27 November 2002

Hon. W P Jeffries
Chief Commissioner

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Transport Accident Investigation Commission
P O Box 10-323, Wellington, New Zealand
Phone +64 4 473 3112 Fax +64 4 499 1510
E-mail: reports@taic.org.nz Website: www.taic.org.nz

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