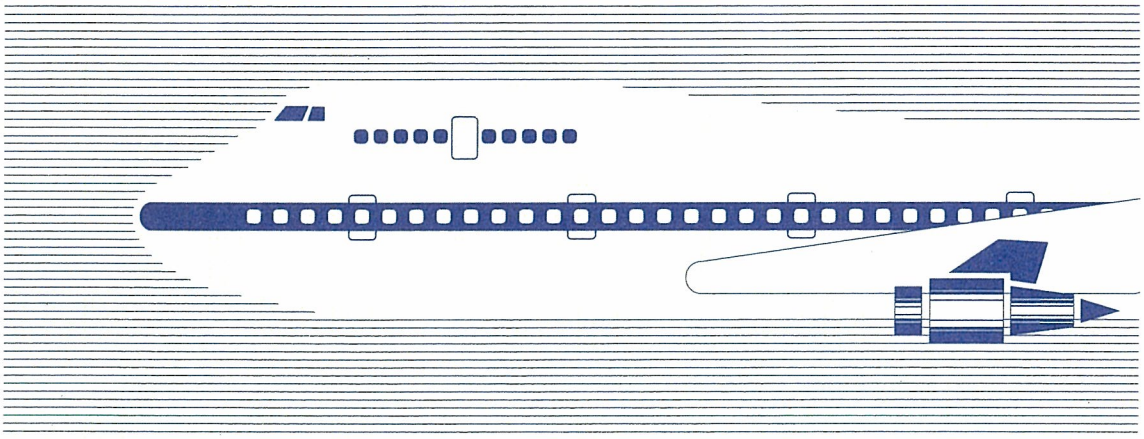


AVIATION OCCURRENCE REPORT

NO. 93-005

AEROSPATIALE AS 350D

ZK-HGV

VICTORIA FLAT, FOX GLACIER

17 MARCH 1993

TRANSPORT ACCIDENT INVESTIGATION COMMISSION

WELLINGTON • NEW ZEALAND

The Transport Accident Investigation Commission is an independent Crown agency established under its own Act of Parliament. The Commission conducts transport accident and incident investigations with the principal purpose of determining their causes and contributing factors with a view to avoiding similar occurrences in the future. The Commission seeks to identify safety deficiencies in the course of its investigations and make recommendations designed to eliminate or reduce such safety deficiencies.

TRANSPORT ACCIDENT INVESTIGATION COMMISSION
TE KOMIHANA TIROTIRO AITUA WAKA

NO. 93-005

AEROSPATIALE AS 350D

ZK-HGV

VICTORIA FLAT, FOX GLACIER

17 MARCH 1993

A B S T R A C T

This report relates to the accident involving an engine failure, and subsequent forced landing, in an Aerospatiale AS 350D helicopter during a scenic flight over the Fox Glacier on 17 March 1993. The safety issues discussed in the report are related to the promulgation and implementation of manufacturer's Service Letters and the inspection of unmodified fuel pump assemblies.

TRANSPORT ACCIDENT INVESTIGATION COMMISSION

AIRCRAFT ACCIDENT REPORT NO. 93-005

Aircraft Type, Serial Number and Registration:	Aerospatiale AS 350D, 1537, ZK-HGV
Number and Type of Engines:	1 Textron Lycoming LTS 101-600A-2
Year of Manufacture:	1982
Date and Time:	17 March 1993, 1010 hours *
Location:	Victoria Flat, Fox Glacier
Type of Flight:	Air Transport – Scenic
Persons on Board:	Crew: 1 Passengers: 6
Injuries:	Crew: 1 Minor Passengers: 3 Serious, 3 Minor
Nature of Damage:	Substantial
Pilot in Command's Licence:	Commercial Pilot Licence (Helicopter)
Pilot in Command's Age:	25
Pilot in Command's Total Flying Experience:	1886 hours (234 on type)
Information Sources:	Transport Accident Investigation Commission field investigation
Investigator in Charge:	Mr D G Graham

* All times in this report are NZDT (UTC + 13 hours)

1. NARRATIVE

1.1 The first flight of the day for AS 350D, ZK-HGV, had comprised a "Twin Glacier" scenic flight. The pilot's pre-flight inspection prior to departure had disclosed nothing unusual and all indications during the subsequent engine start were within the normal parameters. Engine performance was completely satisfactory throughout the flight which had included a snow landing at an elevation of about 6500 feet amsl above Fox Glacier followed by a descent to Franz Josef where the helicopter was refuelled before returning to the Glacier Helicopters' base at Fox Glacier township, shortly before 1000 hours.

1.2 Members of an overseas Ramblers Club who were on a tour of North and South Islands had arranged for a similar flight later in the morning. Due to the numbers involved two AS 350 helicopters and a Bell Jetranger were to be used to enable the parties to fly as a group. The precise route and duration of the flight were left open as the weather was overcast and there was a possibility that the varying cloudbase which had lowered to an estimated 5500 feet in some areas, might preclude the intended high-level landing and traverse to the Franz Josef Glacier. Conditions were nevertheless suitable for scenic viewing of Fox Glacier and it was therefore planned that the three helicopters would depart in company, and make the snow landing together, if conditions permitted.

1.3 Departure was scheduled for about 1000 hours. Accordingly the engine of ZK-HGV was not shut down at the conclusion of the first flight, but was left running at ground idle by the earlier pilot. The pilot rostered for the Rambling Club members flight carried out routine preliminary checks on ZK-HGV, and confirmed the fuel contents as 40% of the total capacity. He then assisted the passengers to board the helicopter and briefed them regarding the proposed flight. A slight delay ensued to coordinate departure with the other helicopters.

1.4 Lift-off and climb were normal and the pilot of ZK-HGV, which was the leading helicopter, followed the promulgated route skirting the southern side of the Fox River valley, then climbed in an easterly direction above the lower part of the Glacier towards a prominent feature on the northern side known as "Victoria Falls". At a climb airspeed of 90 knots the pilot took particular note that all indications were normal. TOT was 720°C at 90% torque. The all-up weight of the aircraft was approximately 100 kg below the maximum authorised weight of 1950 kg.

1.5 The helicopter was flying 1100 to 1200 feet above ground level in the "Victoria Falls" area when it yawed to the right suddenly and the main rotor rpm warning horn sounded. The pilot corrected the yaw, and lowered collective without delay to commence an autorotational descent. He cancelled the warning horn and was adjusting main rotor rpm when engine power briefly returned but ceased completely within a few seconds.

1.6 The pilot of the following helicopter had observed ZK-HGV yaw to the right and realised that an engine problem had occurred. He maintained radio contact with the pilot of ZK-HGV who had advised him of the sudden power loss, and kept the helicopter in view to monitor its progress during the emergency and to assist as required. Initially the pilot of ZK-HGV considered descending to the river flat at the foot of the Glacier but it was evident that this area could not be reached safely. At this time the helicopter was above Victoria Flat, a flatter region of the Glacier which although severely undulating and crevassed presented the best available landing site. The pilot flew ZK-HGV in a right descending turn of about 270°, selecting the smoothest contours for a landing across the Glacier towards the north.

1.7 The pilot was well aware of the broken, uneven nature of the icy surface, and endeavoured to ensure that ZK-HGV touched down with the skids level. Firm contact was made in a level attitude, with some residual forward speed. The helicopter remained upright but, as it slid over the frozen surface, it struck a ridge of ice, fracturing the skids and disrupting the lower structure of the cabin. About 10 m further on it entered a shallow crevasse and came to rest rolled onto its left side.

1.8 The right cabin door was dislodged during the latter stages of the ground slide and the passenger seated in the rear, nearest the door, fell from the helicopter. The passenger received bruises and abrasions but was otherwise unharmed. No conclusive reason was obtained to explain why this passenger, who recalled tightening her lap-belt before the landing, was thrown clear at this time. The seatbelt anchorages were intact. The tongue and buckle

assembly, which was open when inspected, operated normally. The pilot, who was restrained by a lap-belt, sustained a compressive spinal injury and other minor injuries but was able to vacate the cabin without undue difficulty. (The low-back type pilot's seat fitted to ZK-HGV did not suit the installation of a shoulder harness).

1.9 The helicopter's battery was also dislodged during the ground impact sequence, precluding further use of the radio. The second helicopter had remained in flight nearby and the pilot of ZK-HGV visually signalled a "thumbs-up" to indicate that everyone had survived the landing and subsequent roll-over. The pilot of the second helicopter who had observed ZK-HGV sustain damage during the ground slide, and recognised that at least some serious injury may have resulted, immediately flew from the area and proceeded to the Fox Valley where he was able to establish direct radio communication and alert medical and rescue personnel concerning the occurrence.

1.10 A rescue helicopter was organised promptly from Fox Glacier, taking an experienced mountaineer/ ambulance officer to the site. The pilot of the second helicopter disembarked his passengers and returned to the scene with the District Nurse. Meanwhile the pilot of ZK-HGV and those passengers who were able to assist had retrieved survival equipment including sleeping bags from the accessible right side locker of ZK-HGV and had made the two most severely injured passengers as comfortable as possible while awaiting rescue (the survival equipment had been stowed in both the right and left side lockers, to ensure availability of essential items should access to one side of the helicopter be prevented, as in this occurrence). Each of the passengers was wearing suitably warm clothing and robust boots at the time of the accident. All of the occupants of ZK-HGV were flown out to Fox Glacier for further medical examination. The four most seriously injured passengers and the pilot, together with the husband of one of the injured who had been a passenger in the second helicopter, were then transferred by helicopter to Greymouth.

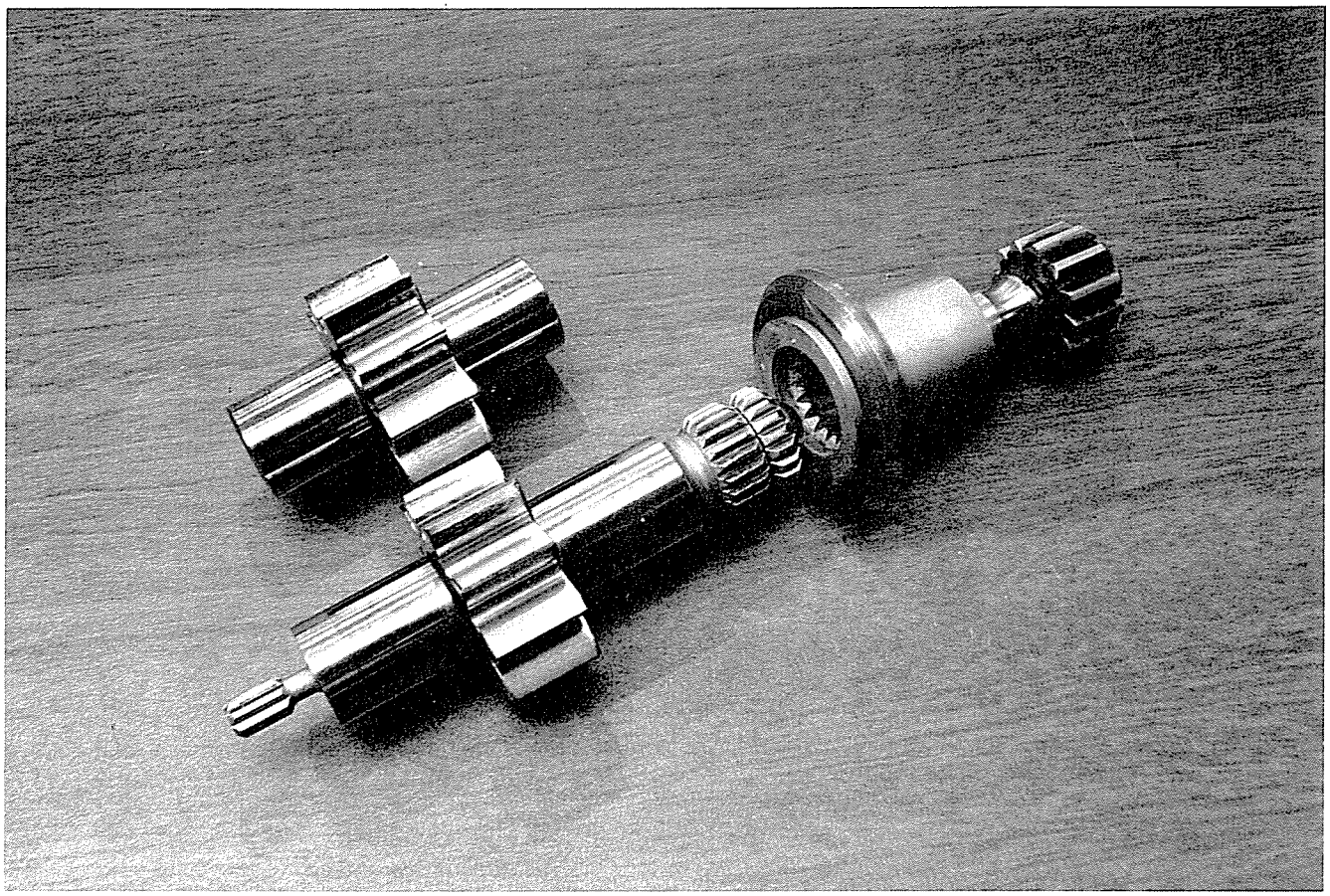
1.11 The elevation of the accident site was 2500 feet amsl. The general down slope was about 5°. The surrounding area comprised numerous ridges and undulations, interspersed with crevasses, slots, and melt holes. As was to be expected the skid assembly understructure, and cabin of ZK-HGV had been substantially damaged during the landing and the main rotor blades and rotor head assembly were destroyed. The tail boom had fractured both at its forward end, and adjacent to the horizontal stabiliser. The engine compartment was relatively undamaged. On-site examination of the engine and its accessories disclosed no external defects or abnormality.

1.12 The wreckage of ZK-HGV was lifted off the Glacier by helicopter and transported to the operator's maintenance base. Detailed inspection of the engine by the engine manufacturers representative determined that a failure had occurred within the engine driven main fuel pump. Failure of the pump drive had caused the main fuel supply to cease with consequent complete loss of engine power. The reported sequence of events suggested that following initial failure, the pump drive had re-engaged briefly, resulting in a temporary return of engine power, before total failure occurred.

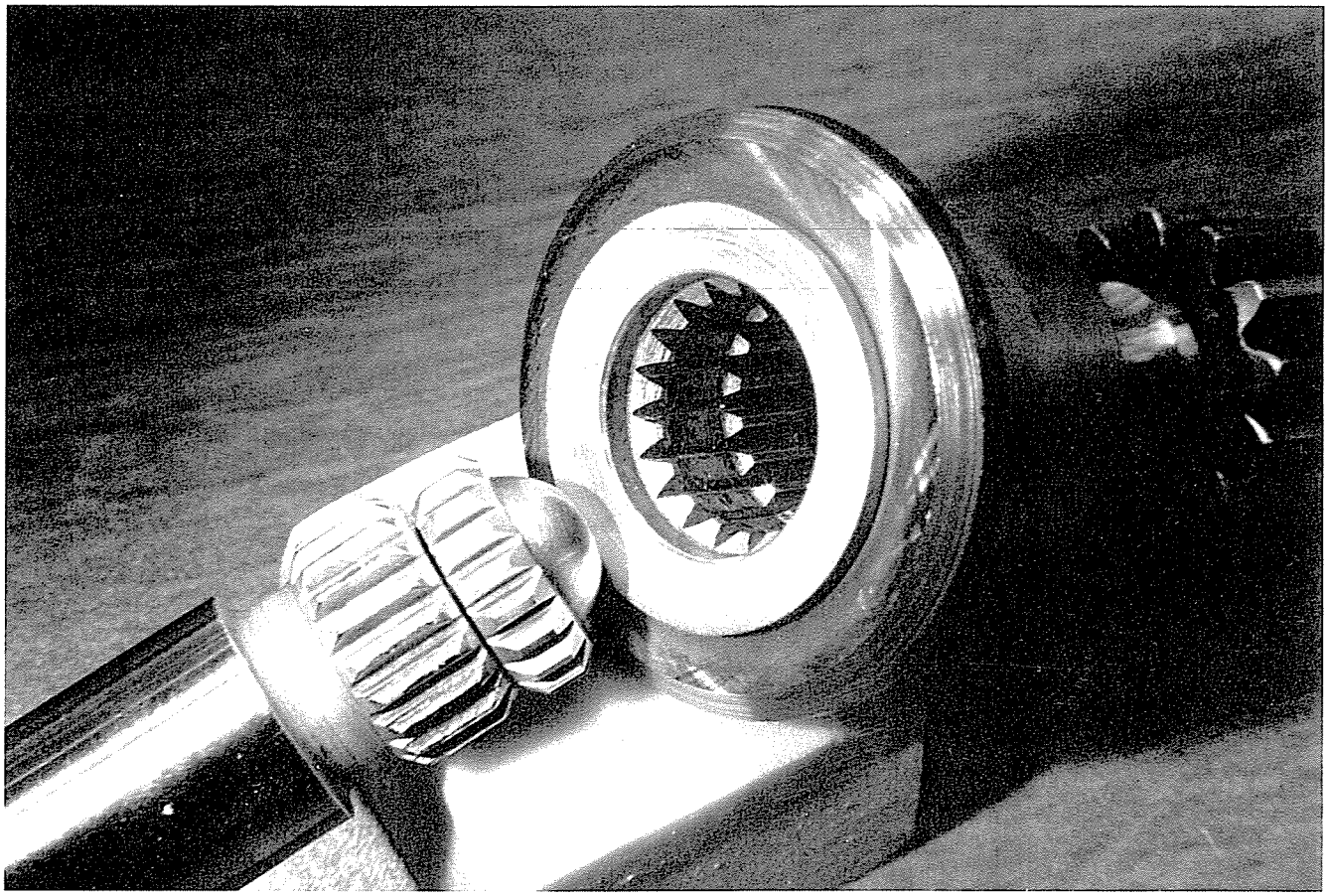
1.13 ZK-HGV was manufactured in France in 1982 as an AS 350B Squirrel helicopter, and was subsequently operated in Japan. In mid 1992 it was imported to New Zealand and in November 1992 had been converted to AS 350D configuration by the installation of a Textron Lycoming LTS 101-600A-2 engine, Serial Number LE43494. The conversion was carried out at an approved New Zealand aircraft engineering facility. The airframe had accumulated a total of 1769 hours at the time of the conversion.

1.14 The LTS 101 series gas-turbine engine was equipped with a main fuel pump, Model MFP 265, manufactured by Chandler Evans USA. Due to engine starting problems, the fuel pump fitted to the engine at the time of installation in ZK-HGV was removed in December 1992. It had been replaced by fuel pump Part Number 4-301-128-03A, Serial Number OAFP 537, installed on 15 December 1992. It was this pump which had failed. There was no evidence at the time of the most recent maintenance (a 100 hour inspection carried out on 1 March 1993) to suggest an impending failure. Engine operation and performance was entirely satisfactory.

1.15 The available evidence indicated that the fuel pump had accumulated a total of 2105 hours. 173 hours had been run since installation on the engine of ZK-HGV. Permissible time between overhauls was 2400 hours. Information on the Acceptance Tag which had been attached to the pump prior to its installation showed that in July 1986 it was repaired at an FAA approved facility in the United



1. General arrangement of Fuel Pump Components and Drive Assembly



2. Fuel Pump Drive Shaft internal spline wear, wear on loaded side of driver gear teeth and circumferential scoring.

States. It had run 1197.5 hours since new at the time of the repair. No details were available to indicate the reason for the repair or to describe the work carried out. The history of the pump during the 735 hours which it had run since the repair, prior to installation on the engine of ZK-HGV, was not known. It had been removed as a part-lifed serviceable component from an engine imported from the United States and had passed satisfactorily a bench-check for leakage before installation on ZK-HGV.

1.16 Examination of the fuel pump disclosed that the drive failure had occurred due to wear of the drive shaft internal spline (see figure 1 and photographs 1 and 2). No significant metallic contamination was present, suggesting that wear had occurred over a long period. The fuel pump and the fuel control unit were returned to Textron Lycoming USA for specialist investigation of the failure.

1.17 The results of the investigation were summarised as follows (reproduced in part only):

> "Visual examination of the fuel control found it to be in overall good condition. The fuel control drive shaft rotated freely and exhibited normal axial and radial play. The presence of blue grease in the shaft housing was confirmed by visual inspection.
>
> The fuel pump was received in a disassembled condition. Visual examination of the individual components revealed that the drive shaft internal spline had been completely worn away in the area that meshes with the driver gear. Examination of the driver gear external spline revealed circumferential scoring on the outer diameter and wear on the loaded side of the spline teeth. There was no evidence of lubricating grease on either the drive shaft internal spline or the driver gear external spline.
>
> Previous experience with the 4-301-128-03 configuration fuel pumps has indicated that this component is susceptible to spline wear during service life because of spline grease leakage out of the spline cavity.

CONCLUSION:

- The engine power loss was caused by the de-coupling of the fuel pump drive shaft from the driver gear.
- The de-coupling occurred due to heavy spline wear on the fuel pump drive shaft.
- The heavy spline wear occurred because the grease had leaked out of the spline shaft cavity.

CORRECTIVE ACTION:

- Textron Lycoming Commercial Service Letter (CSL) number 102, released 23 June 1992 informs operators of modifications and improvements that can be made to existing fuel pumps to improve their reliability. Specifically, vendor Service Bulletin 73-9, which introduces improved internal spline lubrication to reduce spline wear and extend pump service life. Compliance with CSL 102 will eliminate the heavy spline wear which caused this engine incident."

1.18 The drive shaft of the fuel pump assembly installed on ZK-HGV failed some 295 hours before it was due for overhaul. No mandatory requirement existed for the assembly to be inspected at some intermediate period in service to determine whether abnormal wear was occurring on the drive shaft internal spline. However the fuel pump on ZK-HGV had been repaired at an approved facility in the United States at approximately half service life. No records were available to indicate whether the drive shaft spline was specifically inspected for wear at this time but it had been returned to service as a serviceable item. It was evident, however, that modification to up-grade the pump in accordance with Service Bulletin 73-9 (issued 30 June 1985) had not been carried out at this time. Disassembly, inspection, and reassembly of the fuel pump components was not permitted other than by the manufacturer, or an approved overhaul organisation, and internal inspection should therefore only have occurred at prescribed overhaul, or in the event of investigation following earlier failure or unserviceability.

1.19 It was evident that various modifications and improvements had been introduced by the manufacturer over a number of years to up-grade the design of the fuel pump assembly and reduce or eliminate problems encountered in service, including heavy spline wear. The modification "dash number" of the failed fuel pump was "-3". Fuel pumps incorporating the latest improvements, as at the time of the accident, had a "dash number" of 10.

1.20 The installation of a fuel pump of the latest standard, or modification of an existing fuel pump to a higher "dash number" status, while publicised and recommended by the manufacturer in the form of periodic Commercial Service Letters or other service documents, remained an optional decision for consideration by owners and operators of LTS 101 gas turbine engines.

1.21 On 9 September 1993 Textron Lycoming advised the Commission as follows:

"The draft of CECO Service Bulletin Revision 1 has been submitted to Textron-Lycoming for review and is presently undergoing review for approval ...

The Bulletin has been revised so as to:

A. Detail each specific fuel pump part number series that may take benefit of the modification and;

B. Ensure that the modification remains in effect should the pump undergo repairs at other than the manufacturer's repair facility and;

C. Signify compliance by marking "SB 73-9" on the component data plate of pumps not originally included in SB 73-9.

Upon approval, the revision will be distributed to all (manufacturer's) authorised repair facilities under the manufacturer's cover.

Textron will distribute the context of the revision separately, and in a new LT 101 Service Bulletin, the intent of which is similar to Textron-Lycoming LT 101 Customer Service Letter 102.

1. It will recommend mandatory compliance with CECO 73-9.
2. It will also recommend that all pumps be replaced with pumps of the current design and production standard.

Compliance terms are yet to be determined."

2. FINDINGS

2.1 The pilot was licensed appropriately for the flight and was in current practice on the aircraft type.

2.2 The flight was conducted in accordance with the appropriate route and altitude requirements.

2.3 The pilot was familiar with scenic flying in the area and was aware of suitable action to take in the event of an emergency while above Fox Glacier.

2.4 The aircraft had a valid Certificate of Airworthiness and Maintenance Release.

2.5 The aircraft's weight and centre of gravity were within the specified limits.

2.6 The aircraft's engine had operated satisfactorily prior to the failure which preceded the accident.

2.7 During the flight a sudden, complete loss of engine power occurred.

2.8 The pilot and passengers sustained injuries and the helicopter was substantially damaged in the auto rotational landing on the crevassed surface of the Glacier.

2.9 The engine power loss resulted from failure of the fuel pump drive shaft/driver gear coupling.

2.10 The failure occurred due to heavy spline wear on the fuel pump drive shaft.

2.11 No warning symptoms had occurred, which might have alerted pilots or maintenance personnel to an incipient failure of the fuel pump drive shaft.

2.12 The fuel pump assembly had been installed on the engine of ZK-HGV as a serviceable item.

2.13 The fuel pump had not reached the total hours permitted between overhauls when the failure occurred.

2.14 The manufacturer had introduced a series of modifications and improvements to increase the reliability of the fuel pump assembly.

2.15 No requirement existed for the installed fuel pump to be of the latest modification status.

2.16 No maintenance inspection, or special procedure, existed to enable an owner or operator to detect or anticipate abnormal spline wear on the fuel pump drive shaft assembly between prescribed overhaul periods or while the pump was in service.

2.17 Disassembly of the drive shaft/driver gear coupling was not permitted other than by the manufacturer or by an approved overhaul organisation.

2.18 The principal factor in the accident was a complete loss of engine power resulting from failure of the fuel pump drive due to spline wear. The modification status of the pump assembly which was to an early standard contributed to lack of internal lubrication and accelerated spline wear within the permitted overhaul life of the pump.

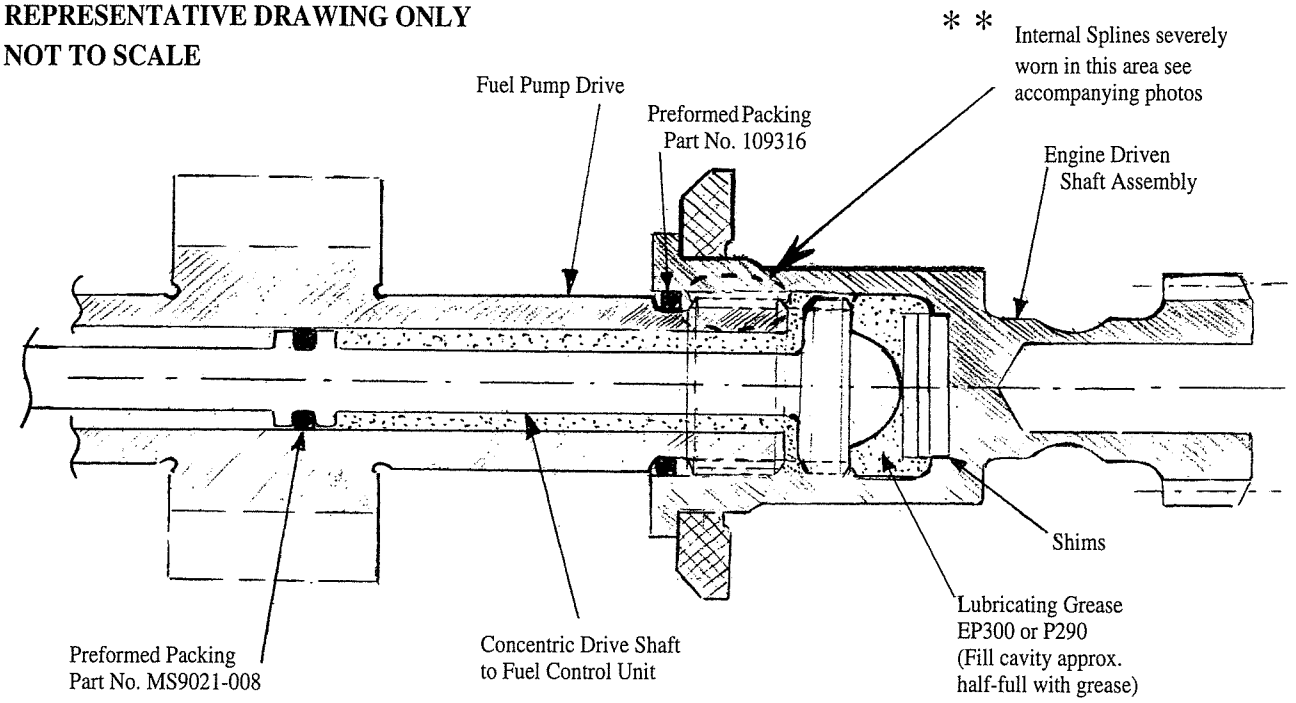


Fig 1. Cross-sectional view of affected fuel pump components, also showing fuel pump improvements per vendor service bulletin 73-9. These improvements include the addition of preformed packing P/N 109316 and the application of additional lubricating grease in the shaft cavity to eliminate spline wear.

3. SAFETY RECOMMENDATIONS

3.1 It was recommended to the Director of Civil Aviation that he:

Alert owners/operators of LTS 101 series gas turbine engines to the circumstances of the accident to AS 350D ZK-HGV and the potentially serious consequences of complete power loss resulting from failure of the fuel pump drive (060/93), and

Draw the attention of owners/operators to Textron Lycoming Commercial Service Letter 102 [dated 23 June 1992] to inform or remind them of the series of modifications and improvements that may be made to existing fuel pumps with particular reference to Chandler Evans Service Bulletin (SB) 73-9 "Improved internal spline lubrication resulting in reduced spline wear and extended pump service life" (061/93), and

Give consideration to mandatory action (such as the publication of an Airworthiness Directive) to require the installation of fuel pumps modified or manufactured to the latest improved status on LTS 101 gas turbine engines, or to require specific modifications to be incorporated, including SB 73-9, on existing fuel pumps currently at a lower modification status (062/93), and

Dependent on action taken, in 062/93 above, give consideration to requiring an inspection of fuel pump drive shaft internal/external splines in affected Chandler Evans fuel pump assemblies installed on LTS 101 gas turbine engines to ensure that spline wear will not compromise the integrity of the fuel pump drive before the assembly is withdrawn from service for overhaul, (063/93).

23 September 1993

M F Dunphy
Chief Commissioner

GLOSSARY OF ABBREVIATIONS USED IN THESE REPORTS

amsl	Above mean sea level
C	Celsius
CECO	Chandler Evans Company
FAA	Federal Aviation Administration of the United States
kg	Kilogram
rpm	Revolutions per minute
SB	Service Bulletin
TOT	Turbine outlet temperature

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