Department of Trade

ACCIDENTS INVESTIGATION BRANCH

Piper PA E 23 (Aztec) Series 250 G - AYSF Report on the accident 7 n.m. north east of Moffat Dumfriesshire, Scotland on 27 July 1976

Including the Review before
Mr C E Jauncey
now
The Hon Lord Jauncey
Captain Duncan McIntosh OBE AFC *Pilot Assessor*
and
Mr John Barker *Engineer Assessor*

LONDON
HER MAJESTY'S STATIONERY OFFICE

List of Aircraft Accident Reports issued by AIB in 1978/79

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2/78	Agusta Bell 206BG–AVSN DH 82a (Tiger Moth) G–ANDE at Biggin Hill Aerodrome Kent May 1977	July 1978
3/78	Piper PA E 23 (Aztec) Series 250 G–AYSF at Moffat Dumfriesshire Scotland July 1976	
4/78	British Airways Boeing 747-136 G–AWNA at Bombay Airport November 1975	July 1978
5/78	Brantly Helicopter 305 G–ATLO at Astley Village, Stourport-on-Severn October 1976	August 1978
6/78	Boeing 707 Series 436 G–APFK at Prestwick Airport, Scotland March 1977	January 1979
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9/78	Boeing 707 321C G-BEBP Lusaka International Airport Zambia May 1977	June 1979
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Department of Trade

ACCIDENTS INVESTIGATION BRANCH

Piper PA E 23 (Aztec) Series 250 G - AYSF Report on the accident 7 n.m. north east of Moffat Dumfriesshire, Scotland on 27 July 1976

Department of Trade
Accidents Investigation Branch
Kingsgate House
66-74 Victoria Street
London SW1E 6SJ

12 May 1978

The Rt Honourable Edmund Dell MP
Secretary of State for Trade

Sir

I have the honour to submit the report by Mr P J Bardon an Inspector of Accidents, on the circumstances of the accident to Piper PA E 23 (Aztec) Series 250 G–AYSF which occurred 7 n.m. north east of Moffat Dumfriesshire, Scotland on 27 July 1976.

I have the honour to be
Sir
Your obedient Servant

W H Tench
Chief Inspector of Accidents

Accidents Investigation Branch
Aircraft Accident Report No. 3/78
(EW C571)

Owner:		Air Navigation and Trading Co. Ltd.
Operator:		McDonald Aviation Co. Ltd
Aircraft:	*Type:*	Piper PA E 23 (Aztec) Series 250
	Nationality:	British
	Registration:	G–AYSF
Place of accident:		7 nm. northeast of Moffat Dumfriesshire, Scotland 55° 26′ N 03° 21′ W
Date of accident:		27 July 1976 All times in the report are GMT

Synopsis

The accident was notified by the Scottish Air Traffic Control Centre (ScATCC) on 28 July 1976. The investigation was carried out by operations and engineering personnel of the Accidents Investigation Branch and human factors personnel of the RAF Institute of Pathology and Tropical Medicine.

The accident occurred when the aircraft struck high ground during a charter flight from Blackpool to Perth. The aircraft was destroyed by fire and its six occupants were killed. It is probable that the accident was caused by a loss of control whilst the pilot was attempting to maintain height after a failure of the left engine and an unsuccessful attempt to feather the propeller. The report recommends that the propeller control system be further investigated and operational techniques be reassessed in order to ensure that minimum propeller drag is always obtainable following engine failure, and that in the meantime operators are advised of the limited performance capabilities associated with this type of aircraft in the circumstances in which this accident occurred.

1. Factual Information

1.1 History of the Flight

The accident occurred during a flight from Blackpool to Perth and was the final leg of a group charter which had originated from Perth at 0710 hrs. The first two parts of the charter, Perth – Isle of Man – Blackpool, had been flown in another aircraft of the same type which had then become unserviceable at Blackpool. The aircraft was replaced by G–AYSF, which was leased from a company based at Blackpool and was flown to Leeds and back by one of that company's pilots. The pilot who had originated the charter remained at Blackpool. It was expected that the original aircraft would be ready for service by the time G–AYSF returned from Leeds but in the event, repair work was not completed. Because the charterers were anxious to avoid delay, it was arranged that G–AYSF should be used for the return flight to Perth, but flown by the pilot who had begun the charter.

The flight plan filed at Blackpool indicated the pilot's intention to make an Instrument Flight Rules (IFR) flight at Flight Level (FL) 070 via Dean Cross VHF omni Range (VOR), Talla VOR and Edinburgh, to Perth. The enroute time was estimated as 1 hour 10 minutes at a cruising speed of 140 knots, and the endurance was given as 4 hours. Enroute and terminal weather was good and the aircraft took off at 1713 hrs with one pilot and five passengers. At 1732 hrs the pilot informed London Air Traffic Control Centre (LATCC) that he had been unable to contact Manchester, and because he suspected some unserviceability in the aircraft's VHF navigation and communication equipment, cancelled his IFR flight plan and stated that he would continue under Visual Flight Rules (VFR) at FL 35.

At 1738 hrs the pilot reported 5 miles east of Dean Cross – though at the time the VOR was out of service. He also reported his height as FL 35 and his estimated time of arrival (ETA) over Talla as 1758 hrs. Both the elapsed time from Blackpool to Dean Cross and the ETA for Talla indicate a ground speed of about 150 knots. At 1741 hrs the pilot contacted ScATCC, repeating his 1738 hrs position, flight conditions and ETA Talla. At 1747 hrs, he informed ScATCC that he was descending to 3,000 feet to remain in Visual Meteorological Conditions (VMC) and asked for the regional altimeter setting; he was given both the Tyne and the Belfast settings of 1015 and 1018 mbs respectively which he acknowledged. The route being followed involved flying over high ground, the highest point of which was 2,756 feet amsl.

At 1752 hrs he informed ScATCC of his intention to climb back to FL 35 to remain "VMC on top". The aircraft did not report over Talla and all attempts to contact it proved fruitless. After due progress through the alert and distress phases at 1900 hrs and 2000 hrs respectively, the Search and Rescue Services were alerted. At 0532 hrs on 28 July the wreckage of the aircraft was found by a Royal Air Force helicopter on a hill approximately 2,500 feet amsl in a position almost on track, and 3.5 nm short of Talla VOR. The aircraft had been destroyed by fire and the six occupants had been killed.

The accident occurred in daylight at about 1756 hrs.

1.2 **Injuries to persons**

Injuries	Crew	Passengers	Others
Fatal	1	5	–
Non-fatal	–	–	–
None/minor	–	–	

1.3 **Damage to aircraft**

The aircraft was destroyed.

1.4 **Other damage**

There was superficial damage to open moorland.

1.5 **Crew information**

Pilot:	Male
Age:	23 years
Licence:	Commercial Pilot's Licence valid to 2 May 1986
Aircraft rating:	Beechcraft 95. Piper PA 23
Instrument rating:	Valid until 31 March 1977
Last medical examination:	4 March 1976 Class 1 no restrictions
Total pilot hours:	345
Flying hours in command of PA 23:	100
Flying hours in PA 23 in last 28 days prior to accident:	45 hours 50 minutes
Last Certificate of Test on PA 23:	12 May 1976
Rest period:	15 hours 55 minutes

The pilot had completed his flying training at a CAA approved school and obtained his Commercial Pilot's Licence on 3 May 1976. He was employed by Aerosport Ltd, who seconded him to McDonald Aviation Ltd, both companies being based at Dundee Airport. After further training to meet the requirements of the latter company he made his first commercial flight on their behalf on 7 June 1976.

1.6 **Aircraft information**

1.6.1 G–AYSF was a Piper PA E 23-250 (Aztec) which is a twin-engined six seat low wing all metal monoplane powered by two Lycoming I0-540-C4B5 engines driving Hartzell two

bladed constant speed fully feathering propellers. Provision is made for seating two pilots side by side and dual controls are fitted. Two passenger seats are located side by side forward of a two place bench seat fitted at the rear of the cabin.

Date of manufacture:	September 1968			
Certificate of Airworthiness:	In the General Purpose category and valid until 12 May 1978			
Certificate of Registration:	The aircraft was registered in the name of Air Navigation and Trading Company Ltd on 17 March 1976			
Total airframe hours:	3530 hours			
Total engine hours:	Right:	4,829 hours 50 minutes		
	Left:	4,809 hours		
Total hours since last check:	13:55 (check 1)			
Engine serial nos:	Left:	L-1771-48	Right:	L-2171-48
Propeller serial nos:	Left:	BP 557	Right	BP 3158
Certificate of Maintenance:	According to the log books the aircraft was maintained in accordance with the approved maintenance schedule No. ARB/GPMS/FW/1971 as amended. Its last Certificate of Release was issued on 7 July 1976 valid for 50 flying hours prior to a Check II.			

Prior to flight the aircraft had been refuelled with Avgas 100 L to a total of 120 Imperial gallons, providing an endurance, at 75% of rated power, of just over 5 hours.

Maximum total weight authorised:	2,260 kg
Accident weight:	2,180 kg (estimated)
Centre of gravity limits:	97.0 inches aft of datum to 100 inches aft of datum. Datum is 80 inches ahead of the wing leading edge outboard of the tapered sections.
Accident Centre of gravity:	Calculated to be 99.4 inches aft of datum.

1.6.2 *Propeller control*

Pitch control of the propellers in this aircraft is achieved by the application of pneumatic and spring pressure to one side of a piston tending permanently towards coarse pitch. To counter this coarsening tendency and thus permit intermediate settings a supply of engine oil at boosted pressure is applied to the other side of the piston. This supply is controlled by a propeller governor unit operating in conjunction with a lever control in the cockpit. To prevent unwanted feathering when the oil pressure falls after shut down on the ground, spring loaded latches are incorporated. Above an rpm nominally of about 800 according to the propeller manufacturer, and 1,000 according to the Flight Manual, centrifugal force holds these latches in the disengaged position. Above these speeds it is possible to

feather if required but at lower rpm the latches will engage and feathering will not be possible. Provided this rpm is maintained, the propeller will feather automatically in the event of a complete loss of oil pressure.

1.7 Meteorological information

A post-accident appreciation of the weather is as follows:

Over southern Scotland there was a subsided anti-cyclonic airflow with a variable moisture content at low levels.

Wind:	2,000 ft - 320/30 knots
Cloud:	Mainly 3-6/8 strato cumulus base 3,500 ft tops 4-5,000 ft but small patches of stratus/strato cumulus base 2,000-2,500 ft possibly covering high ground, but likely to be of limited extent only.
Visibility:	30 km or more, but nil in hill fog.
Weather:	Partly cloudy. Small patches of hill fog possible on higher hills.
Freezing level:	12,000 ft.
Icing index:	Nil.

Relevant observations from Eskdalemuir Observatory, approximately 12 nms south-south east of the accident site were as follows:

1700 hrs:	Visibility – 50 km
	Wind – 250/10 knots
	Cloud – 1/8 4,000 ft, 6/8 25,000 ft
1800 hrs:	Visibility – 45 km
	Wind – 280/7 knots
	Cloud 3/8 3,500 ft, 6/8 25,000 ft

No actual or forecast weather information was supplied by Blackpool Meteorological Office directly to the pilot of G–AYSF for the route Blackpool–Perth. However an employee of Air Navigation and Trading Co Ltd at Blackpool telephoned the Meteorological office to obtain the latest available weather reports from Edinburgh and Perth, which were given as:

Edinburgh 1500 hrs:	Wind – 270/17 knots
	Visibility – 60 km
	Cloud – 1/8 3,400 ft, 7/8 25,000 ft
Perth:	Wind – 310/12 knots
	Ceiling and visibility unlimited

This information is stated to have been given to the pilot. The ground temperature at Blackpool (height 34 ft amsl) at 1712 hrs was 17°C and the QFE 1034.

1.8 Aids to navigation

1.8.1 *On the ground*

Dean Cross VOR was promulgated by NOTAM as being unserviceable until further notice at 1702 hrs on 27 July 1976 and was reinstated as serviceable at 2125 hrs on the same day. All other relevant navigation aids, namely Talla, Pole Hill, Newcastle, Glasgow, and St Abb's Head were functioning normally. Distance measuring equipment (DME) was also available from Glasgow.

1.8.2 *In the aircraft*

The aircraft was equipped with two VHF navigation communication/transceivers, DME, ADF and a radar transponder. No unserviceabilities had been recorded.

1.9 Communications

RTF communication was established on frequency 118.4 Mhz (Blackpool Aerodrome/ Approach Control) at 1701 hrs, and after take-off the aircraft was cleared to change frequency to 120.8 Mhz (Manchester Control). This was an inappropriate frequency for the route northwards towards Dean Cross and eventually the pilot contacted the London Flight Information Northern region on frequency 134.7 Mhz. At 1741 hrs he contacted ScATCC on frequency 133.2 Mhz.

All RTF transmissions from the aircraft were routine and there were no indications of distress or emergency but according to the transcript of the RTF recording, transmission and reception of messages were indistinct on frequency 133.2 Mhz, and one other aircraft reported that reception was poor. However there is no indication that G–AYSF was affected. The nearest relay transmission centre to the accident site was within 23 nm and at a height sufficient to provide adequate coverage.

1.10 Aerodrome and ground facilities

Not relevant.

1.11 Flight Recorder

Not required and not fitted.

1.12 Wreckage

1.12.1 *The aircraft – on site examination*

The wreckage was contained within a relatively small area close to the point of initial impact. There had been an intense ground fire as a result of fuel spillage, which had largely reduced the wreckage to ashes. The bulk of the wing structure and the whole of the front fuselage was completely destroyed, but some sections of the nose panel and engine cowlings had been thrown clear and survived to permit more detailed examination.

It was apparent that the aircraft had struck the ground with a high rate of descent and low forward speed. The aircraft was complete at impact and the wreckage characteristics were consistent with a spin to the left. Evidence of power at impact was found on the right propeller blades but no such evidence could be found on the left propeller blades. The remains of the engine and propeller cockpit controls were identified and their associated cables located. It was found that the control levers were set to positions consistent with the following conditions:

(a) Left engine/propeller
Throttle: closed
Pitch control: feathering position
Mixture control: full lean/cut-off

(b) Right engine/propeller
Throttle: fully forward
Pitch control: maximum rpm
Mixture control: full rich

Both main tank selectors were in the "inboard main" position with the crossfeed "off".

1.12.2 *Engines and propellers – subsequent examination.*

1.12.2.1 *The left engine*

The left engine was carefully examined for any evidence which may have led to engine failure or precautionary shut down.

External examination revealed an abnormal amount of oil on the outside of the crank-case in the general area behind the propeller flange, the source of which was traced to the joint between the propeller governor unit and the main body of the engine. It was found that the governor unit was loose to the extent that when it was displaced by hand, oil was seeping through a gap of 0.010 inches around the top and rear edges of the flange: this was due to the four attached nuts of the unit having become loose to varying amounts. The propeller governor unit was secured to the crank case by four studs which pass through the mounting flange. Each stud was fitted with a plain nut and plain washer with a serrated washer interposed between the two and providing the only form of locking. The general arrangement of the mounting is shown at Appendix A, which illustrates the small recess in the mounting flange into which the nut/washer combination fitted. It can also be seen from the drawing that the main body of the propeller governor unit over-hangs the studs and thus restricts access to the nuts. On G–AYSF, three of the nuts and washers had been fitted as described, but the fourth incorporated an attachment bracket in lieu of the plain washer, but as no packing had been fitted into the recessed part of the mounting flange, the bracket had been forced into the recess by the pressure of the nut and had been distorted. However this nut was one of the tighter of the four and appeared not to be directly related to the overall looseness of the unit.

The nuts and associated studs were examined for evidence of distortion or damage to establish whether the looseness could be attributed to either impact forces or to differential expansion during the post impact fire. No form of distress could be found. The studs were screwed tightly into the crank case and the crank case thread was also undamaged.

The upper panel from the left hand engine cowling was found to be heavily contaminated with oil over the whole of the inside surface, including those areas which would have been shielded from any oil splash caused by damage to the engine sump during impact. It appeared that the governor unit was therefore loose before the crash resulting in a loss of oil.

Simulation of the governor installation in the 'as found' condition indicated that the rate of oil loss would have been in the order of 2.7 imperial pints per minute with the oil at normal running temperature and pressure.

The nuts, washers and serrated lock washers were carefully examined. There was evidence on each of the nuts and lock washers of the nuts having been tightened sufficiently to cause the washer serrations to bite into the nut material. No positive conclusion could be reached as to the exact tightness of the nuts at the time the unit was last installed, which, according to the aircraft log books was on 27 October 1975 whilst in the care of the previous owner, and some 252 flying hours prior to the accident. However, because there was no record of further work having been carried out on the unit since that time it must be concluded that the nuts were tightened at least to the point where some degree of locking was achieved.

The engine was examined internally as far as possible, and although there was evidence of light scoring on some cylinders, there was no indication of seizure, bearing failure or other mechanical distress. A total loss of oil was therefore not indicated.

1.12.2.2. *Service Manual*

Instructions for the removal and replacement of the governor unit are contained in the aircraft service manual only. In the section dealing with the removal and replacement of the propeller governor unit, no mention was made of the type of nuts and washers to be used, nor was there any instruction to torque tighten the nuts to any specific value, only that the nuts should be "torqued even". In section 2 of the same manual there are instructions which call attention to the importance of correct tightening of all nuts on the aircraft, and a table is given listing the correct torque values for the various standard nut types used. The governor replacement instructions did not cross refer to these tables nor to the engine parts catalogue which lists the types of nut and washers to be used on the governor installation. Also there was no mention made of the attachment which utilises one of the governor attachments studs and had been fitted on G–AYSF without any packing in the flange recess.

In an effort to assess the installation standard of governor units in service, which to some extent must reflect the adequacy of the service manual instructions, five governor installations were selected at random and examined, including two on an Aztec aircraft. It was found that the two Aztec installations and one other were not fitted with serrated washers or any other form of locking. In addition, the attachment brackets on the Aztec were found to have been fitted in exactly the same manner as on G–AYSF, that is with no packing in the small recess in the mounting flange.

1.12.2.3 *The left propeller*

The left propeller was examined for evidence of engine power and blade pitch setting at the time of impact. It was found that one blade had been completely undamaged by impact. The impact damage to the other was confined to slight scoring and bending together with light edgeways damage caused by contact with a small rock at the impact point. The blade damage, and also the damage pattern found on the spinner and air cylinder, was entirely consistent with the propeller having struck the ground whilst stopped at an approximately two o'clock to eight o'clock position with the blades unfeathered.

The examination of the blade pitch change mechanism clearly indicated that at the time of impact, the propeller latches were engaged, with the result that the propeller had not feathered. (See Appendix B). Impact witness marks made by the piston on the air cylinder wall were consistent with an 'engaged' state of the latches. The point of latch engagement for this type of propeller varies between individual propellers, but should lie in the range of 19-22°. The fine pitch stop is normally set to approximately 14½° and the feather position is normally between 79 and 81°.

No evidence was found of any malfunction of the propeller mechanism. Also, the governor was found to function correctly on test, even with the unit loosened to simulate the oil leak.

1.12.2.4 *The right engine*

Examination of the right engine was limited in extent because of extensive fire damage, but it was considered that, apart from minor defects, the engine had been capable of delivering adequate power.

1.12.2.5 *The right propeller*

Considerable leading edge and tip damage including chordwise scraping marks on the blades indicated that the propeller had been under power at impact. Though it was not possible to estimate blade pitch, the nature of the damage indicates that the propeller was in the fine pitch range at the moment of impact.

1.12.3 *Fuel system*

The fuel tanks and system as a whole were destroyed by fire, but the intensity of the fire indicated that there was a considerable amount of fuel present at the time of the accident. The fire distribution indicates that there was fuel present in both left and right sides.

1.12.4 *Flying controls*

All primary control cables were found to be complete and intact. The rudder pedal assembly had survived and the pilot's right pedal was bent forwards.

1.12.5 *Instrumentation*

All aircraft instruments were extensively damaged by fire, and it was possible only to establish that one altimeter had a sub-scale setting of 1009 millibars. The remains of two wrist watches were recovered, and although the time of their failure could not be read accurately, it was possible to establish that the 'hour' hand indication of one of them was reading close to 7 o'clock.

1.13 Medical and pathological information

After full post-mortem and toxicological examination, death in all cases was attributed to multiple injuries consistent with severe vertical deceleration. No medical factor which might account for the accident was found.

1.14 Fire

The wreckage was almostly completely consumed by post-impact ground fire.

1.15 Survival

The accident was non-survivable.

1.16 Tests and research

Propeller feathering

Under the heading 'Emergency Procedures' the Flight Manual gives the following procedure for shutting an engine down in flight:-

"While the aircraft is slowing down to the single engine cruising speed of about 140 mph at low altitudes and at moderate power settings the propeller on the dead engine should be feathered by pulling the throttle to the idling position and the prop pitch control back fully; then the mixture should be set at idle cut off, and the ignition off".

Flight tests were conducted on 3 similar aircraft to establish the airspeed at which the propeller windmilling rpm was too low to enable the propeller to be feathered. In each case the mixture control of the left engine was selected to 'idle cut-off', the throttle closed, and the propeller control lever selected to the fully fine position. The airspeed was reduced in steps of 5 mph from about 120 mph to 80 mph, the rpm being allowed to stabilise at each airspeed step after which the feathering capability was determined. The results of the tests showed that the lowest speed at which feathering was possible varied with aircraft and was between 85 mph and 95 mph; the worst case being associated with a recently overhauled engine, which could be expected to have a higher than normal running friction. This was contrary to the belief that windmilling rpm in excess of 800-1000 would be available at the Minimum Control Speed (Vmca) of 80 mph. It is clear from these tests, that after an engine shut-down in flight, it is possible for a pilot to find himself below the airspeed which will produce sufficient windmilling rpm to keep the latches withdrawn and enable the propeller to be feathered. It was also established that due to friction inherent in the latch assembly a windmilling rpm higher than the engagement value was required to withdraw them.

A further performance measurement was made demonstrating the effect of a failure of a propeller to feather. With the left engine at idle power, and maximum power and maximum propeller rpm selected on the right engine, at a weight of 2,180 kg (the estimated accident weight) the aircraft was descending at 200 ft/min. This is in contrast with a scheduled rate of climb of 150 ft/min when the propeller of the failed engine is feathered. The effect of a windmilling propeller compared with a feathered propeller on a failed engine is therefore a decrement of 350 ft/min in Flight Manual schedule data.

Further flight test data with regard to stalling speeds was accumulated by the CAA on seven aircraft. In each case, the aircraft was trimmed to 1.5 times the scheduled stalling speed, power off, and airspeed reduced at a rate as close as possible to 1 mph IAS/second.

In the clean configuration it was found that the stalling speed was about 10 mph faster than that given in the Flight Manual for the same weight.

2. Analysis

The precise reason for the pilot's decision to shut the left engine down cannot be known. It can only be assumed that the oil leak from the mounting flange of the propeller governor unit was a factor in his decision but how he became aware of the presence of this leak could not be determined.

The absence of any RTF communication from the aircraft after 1752 hrs, together with other evidence, puts the time of the accident at about 1756 hrs. The sequence of events that culminated in the aircraft spinning into the ground must therefore have occurred within the space of about four minutes. Though it has not been possible to determine precisely what happened during that period, some inferences can be drawn from the available evidence. The first of these is that at the time the aircraft was most probably flying in or near the tops of cloud and this may have constituted an additional complicating factor when the emergency occurred, since the pilot would have been aware of the proximity of the high ground, but been unable to see it. This may well have had a bearing on his subsequent actions.

The evidence that the aircraft was in a spin to the left at impact is conclusive. Moreover, there would seem to be a clear correlation between that evidence and the power off condition of the left engine and the unfeathered state of its propeller. From the position

of the cockpit controls, it is clear that the pilot had taken action to feather the propeller but it is believed that this action was unsuccessful. Though it can be demonstrated that in certain circumstances that the blades of a feathered propeller can be moved to the unfeathered position by impact forces, it is not considered that these circumstances pertained in this instance. It is concluded therefore that the spin was entered whilst the pilot was attempting to maintain control of the aircraft with the left propeller in a windmilling condition.

The reason for the loss of control in this configuration can only be a matter for conjecture, but presumably it must have been associated with a substantial decay in airspeed to below Vmca. As shown by the flight tests, a loss of airspeed would most probably have occurred with one propeller windmilling had any attempt been made to maintain height in that configuration and bearing in mind the aircraft's close proximity to the high ground, it is likely that the pilot would have made such an attempt. Moreover, the rate of speed decay would have been markedly increased by any turning manoeuvres that may have been made.

The reason that the propeller did not feather after the pilot had moved the control lever to the feather position appears to have been because the latches had already engaged by the time he took this action, presumably because the windmilling rpm had fallen to below the latch engagement value. As the flight tests showed, the windmilling rpm was sensitive to small changes in engine friction, which in turn affected the airspeed at which latch engagement occurred. Any increase in engine friction therefore would require a higher airspeed to prevent the latches from engaging.

If, as seems probable, the oil leak from the governor started, or became significant, some time after take off and progressively became worse, then it is possible that the reduction in oil contents could have resulted in a corresponding engine temperature rise with the associated tendency towards increased cylinder friction. It is clear however that the oil contents were not so far reduced that oil pressure was lost entirely because that would have resulted in the propeller feathering itself regardless of the setting of the propeller lever in the cockpit.

It is concluded therefore that at the time when the pilot attempted to feather the propeller, the airspeed was in the range that would normally provide a windmilling rpm sufficient to keep the latches disengaged. However, on this occasion, because the engine running friction was probably higher than normal, the pilot's action of closing the throttle resulted in a decay in rpm to below the latch engagement value and thus prevented the blades from feathering when he selected the propeller control lever to the feather position.

Though it is clearly stated in the Flight Manual that feathering will not be possible below 1,000 rpm, it is quite likely that the pilot did not expect the rpm to fall below that value as quickly as it presumably did after he had closed the throttle. The loss of rpm could have been prevented if the throttle had not been closed at all, or at least had been selected to some intermediate setting. This is not to say that the pilot ought to have known this, since it is not a standard procedure nor is it a technique specifically recommended for this type of aircraft. It is for consideration therefore that the technique for shutting down an engine of this type ought to be revised in the light of this accident and that the necessity to close the throttle fully as the first action in the shut down drill ought to be re-evaluated. Certainly the necessity to maintain 1,000 rpm in order to feather ought to be given greater prominence in the Flight Manual than is the case.

Though it was positively established that the holding down nuts of the propeller governor unit were loose, no reason for this could be found. However, the degree of locking achieved is entirely dependent upon the extent to which the lock washer bites into the nut and backing materials. This is proportional to the amount that the nut is turned beyond the point of initial contact with the serrated washer, which in practice is

governed by the applied torque. Because of the lack of spring in the lock washer material there is no follow up locking in the event of the initial tightness being lost, and the nut is completely free to vibrate loose. It appears from this accident that this can occur quite quickly, and since the oil is fed from the unit at a pressure of 275-300 psi, the consequence of any loosening is a rapid loss of oil. It is questionable therefore whether the form of locking specified by the manufacturers is adequate. Whilst accepting that the service manual does specify the torque values for the types of nuts in general use on the aircraft, it would seem reasonable to expect, in view of the critical nature of both the installation as a whole and the locking technique itself, that the section dealing with the governor replacement should draw greater attention to the importance of applying the recommended torque.

It was also noted that access to the securing nuts is restricted to the extent that special offset spanners are required to tighten the nuts satisfactorily. It is considered that this could have had an effect upon the accurate tightening and subsequent checkings of the nuts.

The loss of an engine at a time when the aircraft was at a relatively low height over inhospitable terrain created a situation that was not necessarily catastrophic in itself. However the failure of the propeller to feather, which the pilot could not have expected, simply made an accident inevitable in the circumstances.

3. Conclusions

(a) Findings

(i) The aircraft documents indicate that it had been maintained in accordance with an approved maintenance schedule.

(ii) The pilot was properly licensed and adequately experienced for the flight.

(iii) Some time after take off the left engine developed a severe oil leak through the mounting flange of the propeller governor unit, and the pilot, having carried out the engine failure procedure, was unable to feather the propeller.

(iv) The left propeller could not be feathered because at the time the feathering action was taken the rpm had fallen to below the latch engagement value. It is probable that the latch engagement occurred at an airspeed higher than normal because the windmilling rpm was affected by increased engine running friction due to a partial loss of oil.

(v) The recommended shutdown drill did not appear to recognise the possibility that the action of closing the throttle could result in a rapid loss of rpm sufficient to engage the latches before the feathering action could be taken.

(vi) At the weight pertaining at the time of the accident, it would not have been possible to maintain height with one of the propellers in a windmilling condition.

(vii) Control of the aircraft was lost whilst the pilot was probably attempting to maintain height with a reducing airspeed and the aircraft hit the ground in a left hand spin.

(viii) The nut/washer combination used to secure the propeller governor unit to its mounting flange did not make provision for preventing the nut from loosening further once its initial tightness was lost.

(b) *Cause*

The accident was probably caused by a loss of control when the left propeller could not be feathered following an attempt by the pilot to shut the engine down after the development of a severe oil leak. The aircraft entered a spin from which there was insufficient height to recover.

4. Safety Recommendations

It is recommended that

4.1 The propeller control system of this type of aircraft and related operational techniques be improved insofar as this is possible to ensure that a feathering capability is retained at all times, and is not related to aircraft speed. As an immediate measure, operators should be advised that difficulty in feathering may be experienced at times at normal aircraft operating speeds due to a low windmilling rpm and that the scheduled single engine performance cannot be achieved with the aircraft in this configuration.

4.2 Consideration be given to a revision of the method of securing the nuts on the propeller governor unit to ensure that the degree of locking provided by the locking arrangements is independent of the tightness of the nuts.

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Inspector of Accidents

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