Piper PA-28-180, G-AVNP

AAIB Bulletin No: 1/2004	Ref: EW/C2001/4/3	Category: 1.3
Aircraft Type and Registration:	Piper PA-28-180, G-AVNP	
No & Type of Engines:	1 Lycoming O-360-A4A piston engine	
Year of Manufacture:	1967	
Date & Time (UTC):	28 April 2001 at 1730 hrs	
Location:	Nayland Airfield, Suffolk	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - 1 (Serious)	Passengers - 1 (Minor)
Nature of Damage:	Right wing detached, forward fuselage and empennage severely damaged	
Commander's Licence:	Private Pilot's Licence with IMC and Instructor Rating (lapsed)	
Commander's Age:	67 years	
Commander's Flying Experience:	1,287 hours (of which 800 hours were on type)	
	Last 90 days - 5 hours	
	Last 28 days - 2 hours	
Information Source:	Examination by maintenance organisation and subsequent examination the AAIB	

Synopsis

The aircraft, flown by two qualified and experienced pilots, suffered a power loss necessitating a forced landing. At that time the aircraft was in a position to land on Nayland airfield in Essex. At a late stage in the approach however, the handling pilot was unable to prevent the aircraft's right wing from impacting with a large tree; the right wing was torn from the fuselage and the aircraft came to rest inverted on its right side. Both pilots, one of whom was seriously injured, were able to vacate the cabin with external assistance. The fuel selector was selected to the right tank, that was ruptured in the impact, and although it was not possible prove that this tank contained fuel at impact calculations showed that it should have contained approximately 8 US Gallons (USG). Subsequent examination and testing of the engine and its components revealed no anomalies and it was concluded that, due to the ambient weather conditions at the time, induction system icing was the most likely cause of the power loss. A recommendation has been made to the CAA for measures to be taken to significantly

reduce the numbers of accidents resulting from forced landings, brought about by induction system icing.

History of the flight

The aircraft had flown from Southend Airport to Wickenby Airfield, Lincolnshire on the morning of the accident. Both occupants were qualified Private Pilots (here referred to as Pilot A and B). Pilot A had previously held an instructor rating and had considerable instructing experience. Pilot B had flown a total of 214 hours of which 31 hours were on type and was studying for a JAR Airline Transport Pilot's Licence.

The aircraft had been refuelled to full tanks (50 USG total) before departure from Southend. Pilot B acted as commander for the flight to Wickenby, with Pilot A assisting with the navigation and radio communications. The flight, which was uneventful, took approximately 1.7 hours.

The pilots swapped roles for the return flight to Southend, with Pilot A as Commander in the left seat. The pre-flight checks revealed no anomalies; the fuel gauges indicated that both tanks were approximately 3/4 full and this was confirmed by a visual check of the tanks contents. The typical fuel usage rate for this aircraft model is 9.6 USG/hour.

The aircraft made a normal takeoff from Wickenby at 1555 hrs and routed towards RAF Mildenhall maintaining radio contact with London Information. Throughout the flight regular cruise checks were carried out including the monitoring of engine rpm before and after the application of carburettor hot air to check for the presence of induction system ice.

In the Mildenhall area the commander deviated to the left of the planned route to remain clear of two large areas of rain cloud. At 1717 hrs, as the aircraft passed to the east of the Stansted Control Area the crew made contact with, and were identified by, Essex Radar. Shortly after this, while cruising at 1,500 feet agl and 5 to 10 minutes after their last cruise check, the engine suffered a sudden loss of power. Pumping the throttle lever and the selection of carburettor hot air did not restore normal power and preparations were made for a forced landing. Fields in the local area were not ideal for a forced landing but ahead of them they sighted Nayland Airfield. The airfield, 5 nm north-west of Colchester, has a 600 metres long grass runway orientated 14/32, delineated by white markers. Pilot A carried out the forced landing checks while Pilot B transmitted a MAYDAY radio call and unlatched the cabin door.

An approach was made to Runway 32, but late on the final approach Pilot A became aware of a large tree very close ahead, which she was unable to avoid. The right wing struck the tree and detached from the fuselage. The remainder of the aircraft struck the ground in an erect, nose down attitude and rolled onto the right side, preventing the occupants from opening the cabin door. The only other exit available was the baggage door, located behind the rear seats, also on the right side of the fuselage.

Pilot A had suffered significant hip and leg injuries in the impact. Pilot B sustained multiple cuts, grazes and bruises. Pilot B managed to push out the left window panel and release the seat belts for herself and Pilot A but was unable to assist Pilot A out of the aircraft or to get out past her. Pilot B noted that there was no smell of fuel. Fortunately a passer-by, responding to the Pilots' shouts for help, pulled Pilot A through the left window aperture, assisted by Pilot B, and then helped Pilot B out. The emergency services arrived shortly afterwards and righted the aircraft. There was no fire.

Wreckage

The aircraft was recovered from the accident site and returned to Southend Airport by the organisation responsible for its maintenance. It was reported that the left fuel tank was found to contain approximately 40 litres (10.6 USG) of fuel and that there was no significant smell of fuel near the main wreckage, suggesting that the left tank had not been leaking after the accident. The right tank had been ruptured by impact with the tree and lay some 30 metres from the main wreckage. It is not

known whether evidence of fuel from that tank was apparent on the tree or on the ground around the base of the tree. The fuel selector lever was found selected to the right tank.

Subsequently inspection of the aircraft by the AAIB showed that the electric fuel pump was functional and some fuel was found in the carburettor float chamber. No airframe anomalies were found. The engine was strip examined, the magnetos were rig tested and the carburettor was strip examined and then test run on a similar engine.

The engine and accessory examination and testing revealed no anomalies, with the exception of severe distress to the operating mechanism for Nos 3 and 4 inlet valves. Both of these valves are driven open against their springs by a single integral cam lobe formed on the case-hardened steel camshaft. The cam lobe acts on each valve through a chilled cast iron follower body, a pushrod and rocker assembly. The lobe was found severely worn and both follower bodies had extensive surface pitting of the face contacted by the cam. However, the overhaul agency noted that distress to the extent found was quite common on engines received for overhaul, particularly those that had operated for close to the normal overhaul period. The agency estimated that approximately 70% of such engines exhibited generally similar damage, but in no case had it been reported that significant power loss had been associated with the condition. The problem appeared to have started 10 to 15 years previously and to have affected both original equipment and reground camshafts.

Aircraft history

At the time of the accident the aircraft had accumulated 10,231 operating hours since manufacture. The engine had accumulated 1,881 hours since overhaul. The aircraft had suffered a propeller strike in March 1999, 427 operating hours before the accident, and an engine shock-load inspection had been carried out. Three of the cylinder/piston assemblies and the camshaft and all 8 cam follower bodies had been replaced at this time.

Aircraft documentation indicated that the aircraft had generally been operated frequently and had been serviced and checked in accordance with the Maintenance Schedule (CAA/LAMS/A/1999/Issue 1). Indications from the last engine run check, 11 operating hours prior to the accident, were normal. No reports of previous incidents of power loss were found.

Weather

An aftercast by the Meteorological Office showed that at the time of the accident there was an unstable flow from the west-south-west over the southern half of the British Isles. A trough line was just clearing the area where the accident occurred and showers were possible. The estimated wind at 1,000 feet amsl in the accident area was 250°/25 kt. The surface visibility was estimated at generally 30 km or more, but locally 7 km in showers. Cloud at low level was listed as generally few cumulus with a base of 2,500 to 3,000 feet amsl, but with scattered or broken cumulus with a base of 2,500 feet amsl associated with showers. The ambient temperature at the surface was estimated at 10°C with a dew point of 6°C, giving a relative humidity of 76%. Estimates for these parameters at the aircraft's cruising altitude were not available. Reports and TAFs for airfields in the vicinity corresponded closely to the above. The aftercast estimated that a line of showers would have crossed the area at around the time of the accident and that there would have been some associated local increase in the relative humidity.

The surface ambient temperature and relative humidity conditions were within the 'float carburettor - severe icing at cruise power' envelope on the standard induction system icing chart.

Discussion

The damage to the engine valve operating mechanism found during the examination had clearly occurred before ground impact. Such damage however was not abnormal and previous experience indicated that it was unlikely to have caused a significant power loss and would not have led to

sudden major loss of power. No abnormality had been apparent to the pilot on the previous takeoff, only 1.6 hours prior to the power loss. It was therefore concluded that the valve operating mechanism damage had not been responsible for the power loss. The engine strip examination and component testing revealed no other signs of engine anomaly.

The destruction of the right fuel tank prevented the aircraft's fuel state at the time of the accident from being established with absolute certainty. After reportedly having departed Southend with full tanks (50 USG total), the aircraft had flown for approximately 3.25 hours at the time of the power loss. With the typical usage rate of 9.6 USG/hour, the fuel remaining was therefore estimated at 18.8 USG. When the aircraft was recovered the left tank contained approximately 10.6 USG. Given that no significant quantity had leaked from this tank, it therefore appears that the remaining right tank contents should have been approximately 8 USG. It was not known whether evidence of this fuel was apparent where the ruptured right fuel tank came to rest but it is considered unlikely that fuel exhaustion had caused the power loss.

The ambient temperature and relative humidity conditions were within the 'float carburettor - severe icing at cruise power' envelope on the standard induction system icing chart. It is noted however that the chart differentiates only between carburettor equipped and fuel-injected engines. It appears likely that many variables will influence the formation of carburettor ice and that these will differ between different engine and/or aircraft types and/or due to individual variation in the condition of aircraft of the same type. The chart therefore provides only a very generalised indication of the possibility of induction system icing occurring at certain ambient temperature and relative humidity combinations. However, no other reason for the engines power loss was found and it is concluded that induction system icing was the most likely cause.

Induction system icing

Pilots of single engine aircraft should always be prepared for an engine failure or loss of power and the subsequent forced landing. This can be brought about by numerous factors including mechanical and electrical failure, lack of fuel, and induction system icing. The successful outcome of any 'forced' landing of course will be determined by the adequate execution of the enforced descent, the approach and the terrain chosen, or available, for landing. Mechanical failures can be reduced by adequate design, manufacture, rectification and maintenance. Electrical failures can be reduced by system duplication and fuel starvation (excluding mechanical fuel system failures) can be minimised by adequate flight planning and flight profile execution. Induction system icing is a known hazard and its effects can be minimised by the introduction of hot air into the carburettor intake, recognition and avoidance by the pilot, of the conditions conducive to induction icing.

It is widely recognised that ice build-up in the induction system, of the more widely used types of carburettor equipped light aircraft piston engines, is a common event in the UK, and can insidiously reach proportions where continued engine operation is threatened. Papers dealing with such icing as a cause of aircraft accidents date back over many years and the CAA has regularly drawn pilots' attention to this threat in the periodic General Aviation Safety Information Leaflet (GASIL) publications. The number of previous accidents, occurring during forced landings carried out as a result of induction system icing, could not be established with certainty because melting of the ice after the accident almost invariably leaves a lack of direct evidence. However, a previous AAIB study for the 16 year period, January 1985 to December 2000, showed that the maximum total number of accidents and incidents that could possibly be attributable in some way to induction system icing was as follows :-

Reported Occurrences	185
Reported Accidents	110
Aircraft severely damaged or destroyed	67

Persons Injured (including fatalities)	62
Fatalities	16

It is probable that the generally accepted procedures, aimed at preventing serious induction system icing, were followed in many of the cases. Such procedures are given in a CAA Safety Sense Leaflet (14A, issued in 2000) and an Aeronautical Information Circular (Pink 145/97). The procedures are non-specific in some areas, such as the time for which 75% power should be applied during a low-power descent in order to warm the engine. This is possibly because of an apparent lack of available information on the performance of hot air systems and because of the variation between aircraft. The time of power application however is likely to be highly relevant in some circumstances.

Means of preventing icing, such as the application of a coating to carburettor internal surfaces and/or the use of a fuel additive, have been proposed, but have not been implemented. Furthermore, a number of relatively cheap passive monitoring systems that provide a direct audio/visual warning to the pilot of the accretion of induction system ice are also available.

Previous recommendations

Safety recommendations aimed at reducing the number of accidents caused by induction system icing were made to the CAA on 5 November 1991 (AAIB Bulletin 10/1991, G-AWXV). They included a recommendation to require the fitment of a warning system to alert pilots of induction system icing on future types of aircraft certificated in the UK, and the consideration of a similar requirement for types currently certificated. The CAA responded in May 1992 by stating that:

> *'Before accepting or rejecting this Recommendation, the Authority is consulting engine manufacturers and their airworthiness authorities for information and advice on the availability of and service experience with warning systems that may be used to warn of induction system icing. The resulting information will be reviewed, and if beneficial a dialogue will be initiated with the Authority's JAA partners with a view to establishing a certification requirement.'*

A further Safety Recommendation (2000-55) was made by the AAIB to the CAA in 2000 to re-assess ice warning systems and again consider requiring their fitment (AAIB Bulletin 12/2000, G-BIHE). The CAA responded in April 2001 stating that:

> *'The CAA accepts this Recommendation. Available induction system icing warning devices have been assessed. It was concluded that reliability is such that these devices cannot be considered a primary indication of induction system icing. Consequently, a mandatory requirement for such devices to be fitted is inappropriate. Measures to prevent recurrence will continue to focus on promoting training and good airmanship. The manner in which the aircraft was being operated may have been contributory to the accident. Single engined aircraft are inherently vulnerable following loss of engine power or engine shutdown. Accordingly, the risk of a forced landing as a result of engine failure must be anticipated during any phase of flight.'*

The accident to G-AVNP probably resulted from induction system icing that had apparently not been prevented by recommended procedures carried out by a qualified and experienced crew. Few susceptible aircraft have any form of active warning of induction system icing, other than rough running or stoppage of the engine. Moreover, the number of accidents, occurring during forced landings brought about by suspected induction system icing, remain high after many years of promoting training and good airmanship. In view of this, together with the current developments in electronic equipment capability and reliability, the following recommendation is made:

Recommendation No 2003-125

It is recommended that the CAA take measures, both technological and procedural, including the review and promulgation of published material and the re-assessment of warning systems and their capabilities and reliability, to significantly reduce the number of potential accidents, to UK registered piston-engined aircraft, resulting from engine failures brought about by induction system icing.

Current status (as at October 2003)

Over the years there has been much communication between the AAIB and CAA on the problem of carburettor icing, however limited progress had been made in reducing the number of occurrences.

With this in mind, a new approach was considered necessary. In a meeting on 31 May 2002, the CAA and AAIB committed to work together to address the problem and began a joint study, the objectives of which were to share experience and knowledge and identify the key issues relating to the problem of carburettor icing. The ultimate aim is to take all reasonable and practical actions possible to avoid forced landings and subsequent accidents brought about by carburettor icing.

This study encompasses the areas of pilot training, the guidance and learning material available to pilots and the currently published procedures for the use of carburettor heat control. All of these areas will be reviewed in detail and actions will be taken to ensure that the training procedures and material available are consistent, easily understood and reflect best practices. The CAA has also recently approved funding for and begun research into methods of detecting or preventing the formation of carburettor icing (including for example, the use of fuel additives) and the effectiveness of currently available carburettor ice detectors.