ACCIDENT

Aircraft Type and Registration:	Piper PA-31-350, N66886
No & Type of Engines:	2 Lycoming 540-J2B2 piston engines
Year of Manufacture:	1974 (Serial no: 31-7405188)
Date & Time (UTC):	9 April 2014 at 1447 hrs
Location:	Field near Stonehaven, Aberdeenshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	60 years
Commander's Flying Experience:	3,188 hours (of which 19 were on type) Last 90 days - 16 hours Last 28 days - 1 hour
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was on a ferry flight from Seattle in the USA to Thailand via Canada, Greenland, Iceland, Scotland and across Europe. However the flight crew abandoned the aircraft in Greenland late in December 2013 after experiencing low oil pressure indications on both engines. This may have been due to the use of an incorrect grade of oil for cold weather operations. The aircraft remained in Greenland until 28 February 2014, when a replacement ferry pilot was engaged. Although the engine oil was not changed prior to departing Greenland, the flight continued uneventfully to Wick, in Scotland. Following some maintenance activity on the right engine, the aircraft departed for Le Touquet in France. However, approximately 25 minutes after takeoff, the engines successively lost power and the pilot carried out a forced landing in a ploughed field. Examination of the engines revealed that one piston in each engine had suffered severe heat damage, consistent with combustion gases being forced past the piston and into the crankcase.

History of the flight

This accident occurred to a private aircraft and did not result in any injuries, so the AAIB initially dealt with it in the form of a correspondence investigation. However, in attempting to discover the facts surrounding the double engine failure, it was realised that this could not be achieved without conducting an examination of the engines. It then became apparent that the flights preceding the accident flight were relevant to the investigation. These flights were conducted outside the United Kingdom and involved foreign nationals, so no formal statements from the flight crew or maintenance personnel were available.

Some of the following information on the recent history of the aircraft is therefore based on anecdotal evidence.

The aircraft, a Piper PA-31-350 Chieftain, registration N66886, was purchased in Seattle, USA, in August 2013 and was in the process of being delivered to a customer in Thailand. The intended routing for the aircraft was that it would fly east across the continental USA and then across the North Atlantic from Canada to Greenland, Greenland to Iceland, Iceland to Scotland, Scotland to France and onward to Thailand.

The information indicated that the aircraft was flown from Seattle as far as Sondrstrom in Greenland by two pilots normally employed by an Asian airline. The ferry flight was abandoned at Sondrstrom late in December 2013, with the aircraft being parked and the pilots leaving it there due to reports of low oil pressure on both engines. It was considered that the low engine oil pressure may have been caused by the aircraft being operated in extremely low temperatures in December with the incorrect grade of engine oil for cold-weather operations. Arrangements were subsequently made, in conjunction with an aircraft handling company based at Wick in Scotland, to send an appropriate quantity of multigrade oil suitable for low-temperature operation, together with two replacement oil filters, to Sondrstrom for installation on the aircraft in order to permit further flight. The aircraft was, however, left at Sondrstrom until the 28 February 2014 when a replacement ferry pilot was engaged to continue the ferry flight to Thailand by the originally intended route. It is apparent from the engine log books that no engine oil change or any other maintenance activity was conducted at Sondrstrom; the pilot commented that this was due to a combination of a lack of maintenance facilities and normal indications, including oil pressure, when he started the engines. In fact the most recent log book entry prior to the aircraft's arrival in the UK was dated 12 August 2013, when the engines were each subjected to an Annual Inspection and serviced with Aeroshell W100 oil.

Having departed Sondrstrom, the flight continued uneventfully, with no engine oil pressure problems, through Narsarsuaq in Greenland then via Iceland to Wick Airport in the north of Scotland, arriving there on the 3 March 2014 where the right-hand engine was noted to be running roughly. After investigation by a local qualified aircraft engineer, it was discovered that the No 4 cylinder had low compression and consequently a replacement cylinder set, complete with associated seals, gaskets and other required parts, was fitted to the aircraft. The work was completed and certified in the engine logbook on the 27 March 2014.

The ferry pilot subsequently arrived at Wick to resume the aircraft ferry flight on the 9 April 2014 and, following an inspection of the aircraft, he departed at 14:50 hours local with the intention of completing the first leg of his flight to Le Touquet Airport in France. However, approximately 25 minutes after departure, and at Flight Level 090 routing from Aberdeen direct to the VOR located at St Abbs Head, the pilot noted falling manifold pressure and fuel flow on the right-hand engine. He selected the mixture to rich, switched on the standby fuel pump and changed the fuel supply from the outboard to the inboard tank. He then engaged the starter and conducted the re-start procedure, without success. The pilot increased the power on the left engine and informed Aberdeen of his problem, requesting a diversion there. Having altered course towards Aberdeen, the pilot then found

he was unable to maintain height due to a loss of power on the left engine. Although he had received clearance to land, it quickly became apparent that he would be unable to reach Aberdeen; he therefore opted to put the aircraft down in a ploughed field. Shortly before touching down, both engines failed completely and the pilot reduced his airspeed before landing heavily and coming to a halt after a short ground-slide. There was no fire and the pilot was uninjured.

Aircraft recovery

The aircraft was recovered to the premises of a breakdown and accident recovery company near Aberdeen, where it was stored in the open. The engines were subsequently removed to an aircraft engineering company at Perth, where they were disassembled under the supervision of an AAIB Inspector.

Examination of the engines

Left engine

Photographs taken at the accident site indicated that the left engine nacelle and horizontal stabiliser were both heavily smeared with oil. In addition the oil filler flap on the cowling was open and the dipstick was missing. The photographs also indicated that the propeller had not been feathered.

Before commencing disassembly it was observed that the engine could be turned, albeit stiffly, and that the turbo spool could be easily rotated under finger pressure. Very little oil remained in the sump - approximately a quarter of a litre.However, it was reported that the engine had been placed upside down on the ground at some stage which, in the absence of the dipstick could have allowed oil to escape. The dipsticks in both engines were of the 'push-in' as opposed to 'screw-in', type.

On removing the cylinders it was found that the No 6 piston (rear left) had sustained severe damage, in the form of burning and melting, around a portion of its circumference and this extended to the piston skirt and rings; see Figure 1. There were two compression rings and one oil scraper ring and it was apparent that the gaps in the rings were aligned, whereas normal practice is to install the rings such that the gaps are positioned well apart from each other around the piston circumference.

Figure 1

Left engine No 6 piston, showing damage to crown, skirt and rings

It was apparent that the ends of the rings had been eroded to the extent that the gaps had widened to between 0.5 and 1.0 in.

The damage was indicative of 'blow by', where the combustion gases find a

way past the piston and into the crankcase. After removing the piston it was found that the connecting rod, together with that of No 5 cylinder opposite, had been severely heat-affected. Removal of the No 5 cylinder revealed that the big end bearing shell material had become extruded onto the flanks of the connecting rod, where it had solidified into flakes; see Figure 2. Similar debris was also found in the oil filler shaft.

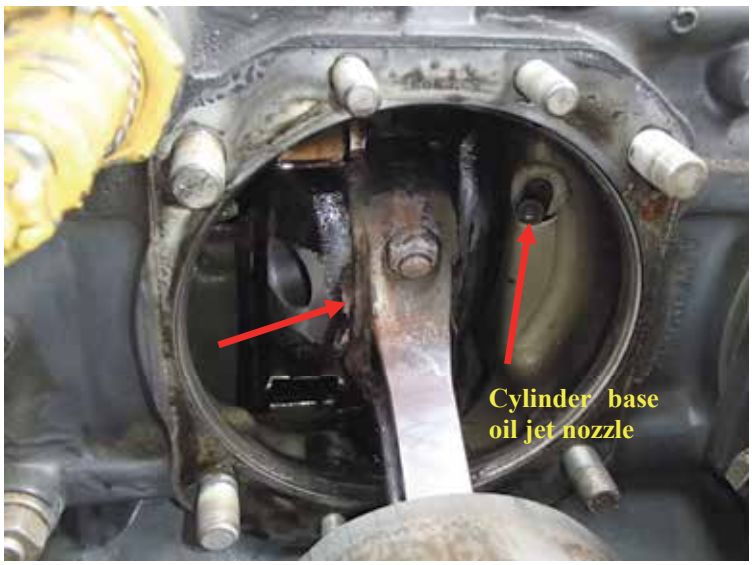

Figure 2

No 5 piston connecting rod showing flakes of extruded bearing shell material and oil jet nozzle

The connecting rod was stiff to rotate, indicating a partially seized big end bearing. The No 6 connecting rod rotated easily, but some radial play was noted, suggesting that much of the bearing shell material had disappeared from its associated bearing.

Elsewhere in the engine, the No 1 cylinder proved difficult to remove. This was found to be the result of the cylinder base jet oil nozzle (an intact example is seen in Figure 2) having become loose and, at some point, become jammed against the cylinder skirt, possibly by the big end bearing cap, which was damaged, causing distortion. The flattened remains of the nozzle were found within the crankcase.

No significant features were observed in the remaining cylinders. In particular, the combustion deposits were light and normal in appearance. Finally, it was observed that cylinder Nos 1 and 6 were not manufactured by the engine manufacturer, Lycoming, but were 'PMA' (Parts Manufacturer Approval) components, approved by the Federal Aviation Administration (FAA).

Right engine

Prior to disassembly, it was noted that the propeller, like that on the left engine, was not in the feathered position. The engine was difficult to turn, suggesting partial seizure or crankshaft distortion as a result of the ground impact, although the turbo spool could be rotated under finger pressure. The oil level did not reach the bottom of the dipstick, with 3.5 litres eventually being drained from the sump.

On removing the cylinders it was found that the No 3 piston had sustained almost identical damage to the No 6 cylinder from the left engine (see Figure 3).

The piston crown was perhaps less severely damaged in comparison with the left engine's No 6 piston, although the skirt appeared in worse condition, and the observed damage was again indicative of 'blow by' of the combustion gases. It was noted that, although the gaps in two of the rings had become aligned, this was away from the area of burn damage. It was also noted that the rings had broken into a number of segments, a likely consequence of the piston damage.

Figure 3

Damaged No 3 piston on right-hand engine

Removal of the remaining cylinders revealed no additional defects. In particular, the No 4 cylinder, which had been replaced at Wick, appeared in good condition, although the associated connecting rod was stiff on its bearing. The No 3 cylinder was observed to be a PMA component, the remainder being manufactured by Lycoming.

As with the left engine, the combustion deposits in the unaffected cylinders were normal in appearance.

Oil analysis

Samples of oil taken from both engines were subjected to detailed analysis by a specialist company.

The sample from the left engine contained a significant quantity, some 2 to 4%, of water. The bulk of this is likely to have been rainwater introduced as a result of the engine having been stored outdoors, with the dipstick missing. The water content in the sample from the right hand engine was much lower, but was still considered high for used engine oil. Whilst high water content can affect the viscosity of oil, both samples were found to be broadly consistent with Aeroshell W100.

Both samples contained considerable quantities of sludge and particulates, including metal debris. The sample from the right engine had a burnt odour and it was concluded, as a result of acidity analysis, that the oil from both samples was significantly oxidised, which was indicative of being well used and exposed to elevated temperatures.

The particulate material was found to include elevated levels of silicon, which may be due to general dirt, grease and sealants. Metal particles were consistent with originating from bearings and pistons.

Additional analysis revealed that both samples contained trace metals at elevated levels; these were typical wear metals and included iron, copper, aluminium, magnesium and chromium. Lead was also present, which can come from white metal bearings but in this case was considered likely to have originated from the fuel, AVGAS. None of the analyses found any evidence of kerosene type fuels (Jet A-1).

There was no opportunity to conduct an analysis of the fuel carried in the aircraft as no samples were available in either engine, and the fuel removed from the aircraft after the accident had been transported in containers contaminated with other liquids.

Engine manufacturer's comments

The engine manufacturer confirmed that the W100 grade of oil was incorrect for cold-weather operation and commented that using this oil during cold-weather starting, without pre-heating the engine, could result in damage consistent with lack of lubrication.

The condition of the No 6 piston on the left engine and the No 3 piston on the right engine appeared consistent with detonation (pre-ignition) damage. Lycoming's experience has shown that such damage can arise from a number of factors, including lean mixture setting, incorrect ignition timing, induction leaks, excessive oil consumption and incorrect or contaminated fuel. In their opinion, the extreme heat, leading to the extrusion of bearing material in the No 5 connecting rod bearing in the left engine, may have been caused by operating the engine with less than the minimum safe quantity of oil in the sump.

The manufacturer made no comment on the use of PMA components on their engines.

Discussion

The aircraft began experiencing engine problems, leading to the forced landing, approximately 25 minutes after departing Wick, in Scotland. However, it is possible that these problems may have originated prior to the aircraft arriving in the UK. The low oil pressures in both engines, reported by the crew on the flight leg to Greenland, may have been due to the wrong grade of oil, W100, being used in what would have been very low temperatures experienced in December in Canada and Greenland. Despite supplies of multigrade oil being sent to Greenland, the engine oil was not changed. This was due to the fact that the pilot noted normal engine indications combined with the lack of maintenance facilities. Thus the aircraft continued its journey with the same oil in the engines with which it left Seattle; this was confirmed by the subsequent analysis of the oil. No further oil pressure problems were observed, although it is likely the aircraft would have been operating in warmer temperatures at the end of February in comparison with those in December.

The engine manufacturer suggested that engine damage could have occurred as a result of operating the engines at low temperatures with the wrong grade of oil. Whilst this may have been the case, it is surprising that any damage did not progress to the point where it became readily apparent during the subsequent flights, via Iceland, to Wick. In fact the pilot did report rough running of the right-hand engine, but the investigation revealed a problem

only with the No 4 cylinder compression, which led to replacement of this cylinder. Since the compressions in all the cylinders were presumably assessed during the diagnosis, it must be concluded that any damage in the No 3 cylinder of the right engine was not, at that stage, significant.

Ultimately, it was not possible to establish why pistons in both engines had suffered virtually identical types of damage, although it is likely to have been a 'common mode' failure, which could include wrong fuel, incorrect mixture settings (running too lean) and existing damage arising from the use of incorrect oil in cold temperatures. The oil analysis excluded the possibility of the aircraft having been mis-fuelled with Jet A-1 at Wick. No conclusion can be drawn regarding the possibility of one of the pilots having leaned the mixtures to an excessive degree, although this would require that either high cylinder head temperature indications were ignored, or that the temperature gauges (or sensors) on both engines were defective.

The engines would have begun to fail when the combustion gases started to 'blow by' the pistons, causing progressive damage to the piston crowns, skirts and rings. This would have also caused pressurisation of the crankcases, which in turn would have tended to blow oil out of the crankcase breathers. In the case of the left engine, the pressurisation was such that the dipstick was blown out of its tube, resulting in more oil being lost overboard. This may have accounted for the more severe damage to the left engine, having lost more oil than the right. The detached No 1 cylinder base jet oil nozzle in the left engine may have contributed to a slight reduction in the oil pressure, but is otherwise considered to have played no part in the engine failure.