AAIB Bulletin No: 1/2005 **Ref: EW/C2004/07/01** **Category: 1.3**

Aircraft Type and Registration:	Piper PA-28-161 Cherokee Warrior II, G-BJYG	
No & Type of Engines:	1 Lycoming O-320-D3G piston engine	
Year of Manufacture:	1981	
Date & Time (UTC):	4 July 2004 at 1139 hrs	
Location:	Offshore, in Liverpool Bay, 2 nm north of Wallasey, Merseyside	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - 1 (Fatal)	Passengers - 1 (Fatal)
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	56 years	
Commander's Flying Experience:	440 hours (of which 65 hours were on type) Last 90 days - 1 hour Last 28 days - 1 hour	
Information Source:	AAIB Field Investigation	

Synopsis

The aircraft departed from Liverpool Airport for a local flight. About 30 minutes into the flight the pilot broadcast a 'PAN' call, shortly followed by a 'MAYDAY' call, informing Air Traffic Control (ATC) that he had an engine problem. The aircraft ditched about 2 nm offshore and rapidly became submerged. Neither of the two persons on board survived.

History of flight

On the day before the accident the pilot contacted the flying club at Liverpool Airport, from where the aircraft was operated, and booked a flying slot for midday on Sunday 4 July. On the Sunday morning he visited the airport to check that the weather was suitable for his flight. It is not known whether he went out to where the aircraft was parked at this time. He left the airport and returned about one hour later, accompanied by his wife.

On his return he carried out a pre-flight inspection of the aircraft. After a while he came back to the clubhouse bringing with him a fuel strainer which contained a fuel sample drawn off from the aircraft's fuel system. (No one present could recollect where exactly he said the sample had come from.) In the sample could be seen a considerable amount of water and some black debris. He remarked that this was the third or fourth sample he had taken from the aircraft containing mainly water, and he asked that the strainer be retained at the club to be shown to the owners of the aircraft whom he knew were planning to fly later in the day. He then borrowed another fuel strainer and returned to the aircraft to complete his pre-flight inspection. He was followed out by a club instructor who noticed that he drained off several more samples from under one wing of the aircraft before a pure fuel sample was obtained.

The pilot booked out for a local flight by telephone and then departed. The aircraft took off at 1106 hrs from Runway 27 and then turned left, climbing towards Chester, a visual reporting point to the south. As he departed from the vicinity of the airport he was instructed to change to the Liverpool Approach frequency and he later reported on that frequency that he was leaving the zone at Chester.

Just over half an hour later, at 1138 hrs, the pilot made a 'PAN' call on Liverpool Approach frequency in which he passed information that he was "OFF WALLASEY" losing altitude and losing power. In reply the pilot was given heading information for a direct return to the airport. Half a minute after his 'PAN' call the pilot broadcast a 'MAYDAY' call saying that he was ditching the aircraft.

There were two training aircraft from Liverpool Airport in the immediate area where the aircraft ditched. They flew overhead the site and although they could see the spot where the aircraft entered the water there was no sign of it, or of any wreckage. Two nearby lifeboats launched and were on scene very quickly but were not able to find any evidence of the aircraft in their search of the area. As the tide fell the aircraft was located and at 1845 hrs the two bodies were recovered by divers.

Pilot information

The pilot learned to fly at Liverpool Airport and qualified for his Private Pilot's Licence (PPL) in 1992. Since then he had flown regularly, both on club aircraft, including G-BJYG, and on a group aircraft of which he owned a part share, although recently the shared aircraft had not been available for him to fly because it was undergoing maintenance.

The pilot was described as a keen club flier and was often accompanied by his wife when flying. However, in the three months preceding the accident he had only recorded one flight, of one hour's duration in a Cessna 172.

Aircraft information

The aircraft was based at Liverpool Airport and had been so for a number of years. It was privately owned and flown but was also operated by a flying club on a lease-back arrangement.

The aircraft had two fuel tanks and the usual practice, as taught at the flying club, was to run on one tank for 30 minutes and then to switch to the other tank. The aircraft had previously flown on the day before the accident on a flight lasting one hour and fuel had been used from both tanks.

There were three fuel drains: one at the lower rear inboard edge of each tank, accessible from the inboard lower wing surface, and one from the engine fuel bowl, accessed at the lower left cowling. The Pilot's Operating Handbook (POH) required a pilot to operate the fuel drains as part of a pre-flight inspection. The purpose of this action is to check for water or contaminants in the fuel and to prevent their accumulation. The suggested action was to drain off sufficient fuel to remove all contaminants. It was reported that the fuel drains were checked before the flight on the day preceding the accident and that there was no evidence of water or other contaminants.

The POH did not contain a specific procedure for ditching. There was however a general procedure for a power off landing. This indicated that the best gliding speed was 73 kt and recommended that touchdown was made at the lowest possible airspeed and that the door was unlatched. The clean stall speed was 50 kt, and with full flap selected was 44 kt. The aircraft had mechanically operated flaps.

The aircraft was fitted with a Global Positioning System but it was considered unlikely that the pilot had used it and no data was recovered from it. There was a transponder fitted to the aircraft but the selector was found switched to the 'standby' position.

Previous engine failure

On the 15 May 2004, G-BJYG had an engine failure in flight, which resulted in a forced landing in a field. The aircraft was undamaged but, immediately after the incident, an attempt was made to restart the engine during which a small fire developed in the engine cowl. The maintenance organisation for the aircraft then attended to the aircraft and replaced several parts affected by the fire, including the carburettor heat box bearings and bushings and wiring to the alternator and engine starter. Whilst the aircraft was still in the field fuel was drained from the wing tanks in order to reduce its weight. None of this drained fuel exhibited any signs of water or contamination and it was later used in other aircraft with no reported problems.

The maintenance organisation ran the engine several times before the owner flew it out of the field. It was flown first to Sleap Airfield where it was refuelled and then to Barton for further maintenance

and an annual inspection. No fault was found with the engine and the engine failure could not be fully explained. However, the weather at the time of the forced landing placed the aircraft in conditions that lie within the 'Moderate icing at cruise power and Serious icing at descent power' category of the carburettor icing chart reproduced later in this report.

Meteorological information

The weather conditions at Liverpool Airport recorded at 1120 hrs on 4 July 2004 were as follows: Surface wind from 290º at 15 kt, visibility 10 kilometres, scattered cloud at 2,000 feet, temperature 16ºC, dewpoint 10ºC and pressure 1012 mb. Meteorological data recorded in the 24 hours preceding the accident was examined and showed that there was no evidence of any rain having fallen in the period.

A graph to illustrate the probability of carburettor icing is reproduced below at Figure 1.

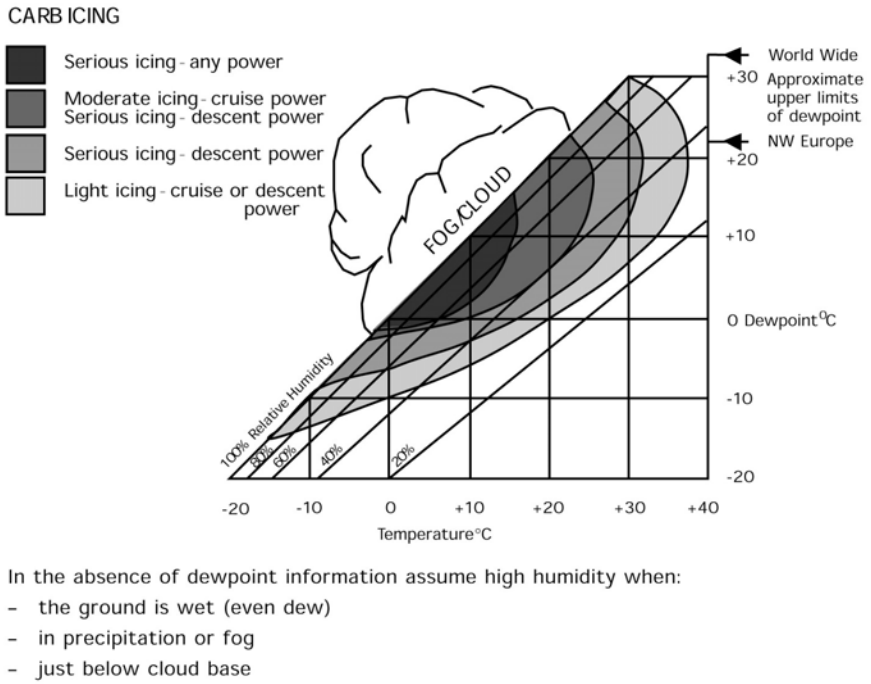

Figure 1

The conditions at the location where the aircraft ditched were described by the coastguard and an attending lifeboat as follows: Tide state, high water (8 metres depth); wind north-westerly force 4; sea state moderate and swell 1 metre. The direction of swell was reported as being confused because of the effect of sandbanks in the area.

Archived charts and meteorological data obtained from a radiosonde ascent for the 15 May 2004, the date of the previous engine failure, were examined. The weather on that day showed a light north-westerly airflow over the Shrewsbury/Liverpool area, a broken or overcast cloud layer at 4,500 feet, visibility of 10 to 20 kilometres and pressure of 1030 mb. The temperature at 2,000 feet was estimated at 12ºC with the relative humidity at 67%.

Recorded information

Air Traffic Control (ATC) voice communications with the aircraft were recorded and available to the investigation. The background noise during the pilot's transmissions was analysed and in the early transmissions it was possible to detect a specific noise which was reduced to a value of 50% of its original frequency in the 'MAYDAY' transmission. However the source of this sound could not be determined; it was of too high a frequency to be engine or propeller noise.

Recorded radar data from St Anne's Radar head (N5345:58.00 W00259:33.00), 20 nm north of the accident site) was also available. However, because the aircraft transponder was not switched to 'ON' only primary returns would have been recorded. A track of primary returns believed to be approximately the route of the aircraft were found but could not be positively identified as G-BJYG. These returns showed an aircraft tracking from an area to the south of Chester, in a north-westerly direction, then north along the estuary of the River Dee before turning right onto an easterly heading.

Accident site

The emergency services located G-BJYG about 2 nm north of Wallasey, it had submerged in the sea and had come to rest on the seabed on a heading of about 170°. At low tide, only the tip of the vertical stabiliser of the aircraft was visible and at high tide, the aircraft was about 8 metres below the surface of the sea. Recovery of the pilot and passenger, who were in the aircraft, took place later the same day, at low tide. Their lap strap and diagonal harnesses were still being worn and were secure and the only entry door, on the right of the aircraft, was found open.

Detailed aircraft examination

Following a successful recovery of the aircraft from the sea, it was taken to the AAIB facilities at Farnborough for further examination. The damage to the aircraft was extensive and indicated an impact with the sea at a pitch attitude of 20° nose down, with about 5-10° of left bank and some right yaw. The impact forces had caused the nose gear to collapse and caused extensive damage to the leading edges of both wings including separation of the right wing, and the tail had twisted to the left opening up the right rear fuselage. Due to the nose down attitude, the engine had been pushed

rearwards, as had the instrument panel, causing deformation to the supporting structure around the cabin and its roof. The propeller was undamaged and indicated that the engine was not under power at the time of impact.

Inside the cockpit, the engine throttle was found at idle and the engine mixture was set to lean. Later examination of the damage to the carburettor confirmed that the throttle was at idle at impact. The carburettor heat selection could not be determined due to the damage to the instrument panel and the possibility that the cable operated control may have moved due to the damage to the operating mechanism on the underside of the engine. The starter key was still in the magneto switch and was positioned at R (right), but the key was bent with distortion to the surrounding panel; it is therefore possible that this moved from either L (left) or BOTH during the accident. The electric fuel pump switch was selected ON. Additionally the flaps were up and the pitch trim was at the neutral position.

The stall warning circuit breaker (CB) was found tripped. The stage at which this happened could not be determined; it could have occurred at any time before the accident or as a result of the impact forces.

Both fuel tanks had ruptured at impact but the left fuel filler cap remained in place; the right fuel filler cap, however, was missing and was not found. Inspection of both of the fuel tanks did not reveal any prior damage, nor were there any signs of corrosion. The seal around the left filler cap was in good condition and the cap fitted snugly to the filler. The fuel lines from the fuel tanks to the engine had also been ruptured in the accident, but there were no signs of any pre-existing damage or restriction. The fuel selector in the cockpit was found selected to the left tank and a flow test of the selector in both left and right positions did not reveal any restrictions. The fuel strainer had been compromised and was found full of sand and sea water, however the filter screen was clean. The electric fuel pump had also been damaged during the accident, but a strip examination did not reveal any problems and fuel was found in the down stream section of the pump. The engine driven fuel pump was intact and a subsequent bench check revealed a good suction force, and likewise fuel was discovered in the pump. The inlet fuel filter to the carburettor was inspected and found to be clean with a small amount of fuel in the fuel inlet pipe.

The seats were still secure and had not suffered any deformation and they had not moved forward. The pilot and passenger harnesses were securely attached to their fittings and did not exhibit any pre-existing damage. However, the instrument panel had moved aft significantly, reducing the distance between it and the occupants. There was evidence that indicated that both the pilot and passenger had come in contact with the instrument panel during the accident.

Engine examination

A specialist engine overhaul agency carried out a strip examination of the engine, under AAIB supervision. This revealed that there had not been a catastrophic engine failure, nor was there any pre-existing damage before the accident. The spark plugs showed that the engine had been running with a normal fuel/air mixture and at the expected temperatures. The oil pump operated correctly with oil found in the oil ways, and the oil filter only contained post accident debris. The only anomaly lay with the right magneto, which had incorrect timing and, during later testing, failed to produce a spark, because of a failed capacitor. Both of these magneto failures were considered to have been as a result of the impact forces and subsequent sea water contamination.

Refuelling

On the morning of the accident the refueller had arrived on shift at 0700 hours, following which he completed his checks of the AVGAS bowser that was later used to refuel G-BJYG. The checks included the testing of the fuel in the bowser for clarity, density, contamination and water content. The latter check was carried out using litmus paper that can detect water at quantities above 30 ppm. All of these checks were satisfactory.

Prior to fuelling G-BJYG, four other aircraft received fuel from the same bowser, G-BJYG was then refuelled until both its fuel tanks were full, giving a total uplift of 33 litres for that aircraft. Immediately after filling the tanks of G-BJYG, another six aircraft took fuel before the remainder, consisting of 350 litres, was used to top up another AVGAS bowser which was then utilised for fuelling helicopters. All the other aircraft and helicopters that used the same fuel supplied to G-BJYG have flown with no reported problems or indications of any water contamination.

Fuel properties

The fuel used for refuelling was AVGAS which is light blue in colour. Water is more dense than fuel so when small quantities are present clear colourless droplets are formed underneath the fuel. If agitated the water will become suspended in the fuel for a short time but will settle out within a few minutes.

Fuel and water sampling

The fuel sample taken from G-BJYG, by the pilot prior to the accident flight and handed in to the flying school, was retrieved by the AAIB following the accident and taken for specialist laboratory analysis. The sample contained about 7.5 ml of water and 1 ml of fuel, with some debris in the water and a layer of a black substance at the interface between the fuel and water. The fuel was analysed and appeared to be consistent with AVGAS 100LL. Although the sample contained debris and a

substance at the interface, there was no evidence of any microbiological contamination. The water was also tested, but due to the small quantity, it was not possible to determine all of the constituents. It was found, though, that the sodium level in the water was low, thus ruling out sea water as a source.

Fuel samples were taken from the fuel tanks of the aircraft that had been refuelled immediately after G-BJYG. These samples were clear, bright blue and did not contain any water or other contamination and when tested at a specialist fuel laboratory, the fuel conformed to the specification for AVGAS 100LL.

Lastly, a fuel sample taken later in the day from the fuel bowser used to fuel G-BJYG was also tested and this did not contain any water or other contamination and conformed to the specification for AVGAS 100LL.

Maintenance

The last maintenance carried out on the aircraft was an annual inspection in May/June 2004, immediately following the previous engine failure and forced landing. No significant additional work was carried out to the fuel system, and the only additional work to the engine was to clean off corrosion and to replace the carburettor heat cable, damaged during the brief fire following the previous engine failure detailed above. All the tests carried out on the engine and fuel system were satisfactory with no defects. The aircraft left the maintenance facility on 16 June 2004 and had flown 8.5 hours before the accident flight with no reported problems.

Pathological information

Post Mortem examinations were carried out on both occupants. Serious injuries were sustained by each of them as a result of the aircraft's impact with the water, although the final cause of death was by drowning.

Witness information

Two training aircraft from Liverpool, with instructors on board, were in the immediate area of the accident and saw the splash as the aircraft hit the water. Both aircraft flew overhead the position but nothing could be seen, with the exception of a possible fuel slick. Both instructors commented that the weather and sea conditions seemed benign and found it difficult to believe that the aircraft had disappeared so quickly without trace.

Ditching procedures

There is comprehensive information published on ditching procedures in the General Aviation Safety Sense Leaflet (GASSL) number 21A, published by the Civil Aviation Authority (CAA) and available at the website address: www.caa.co.uk/docs/33/SRG_GAD_SSL21.PDF. This document includes guidance on recommended techniques for ditching an aircraft based on the sea state and wind conditions. For the wind conditions prevailing at the time of this accident it recommends ditching with a headwind component but along the general line of any swell.

From examination of previous ditching accidents there is evidence that a large proportion of people survive the initial impact and that most lives are lost as a result of exposure to cold water and drowning.

Analysis

The origin of the water in the fuel sample left at the clubhouse remains a mystery. The bowser procedures were rigorous and given that other aircraft were refuelled at the same time from the same source it leads to the conclusion that this was not the origin. The aircraft previously flew on the day before the accident when reportedly the fuel drains were operated before the flight and both tanks were used during the flight. Therefore the water would need to have entered one or both of the fuel tanks in the 24 hours preceding the accident. Meteorological records were examined for any evidence of rainfall but there was none.

It could not be determined whether water in the fuel was responsible for the engine failure. If all the water was drained out of both tanks before the flight then it should not have caused a problem. It is worth noting that the engine failure occurred about 30 minutes into the flight, which would be about the time that the pilot would be expected to change fuel tanks.

The pilot detected the presence of water in the fuel prior to flight and believed he had taken sufficient action to remove it. However the amount of water that he found is most unusual and would probably have warranted further investigation before flight.

The post accident examination of the engine did not reveal evidence of any mechanical problem that could have led to a failure. The aircraft had suffered a previous engine failure which was also unexplained. There is thus no clear reason for either engine failure but on both occasions meteorological conditions were such that there was a risk of moderate to severe carburettor icing. Such conditions are very common in the UK and although pilots are generally well aware of the risk carburettor icing cannot be discounted in this instance.

The engine failed at a time when the aircraft, although fairly close to land was out of gliding range; making a ditching inevitable. Preparation time was short but if the pilot had been able to reduce to minimum over water speed without stalling, before touchdown, it is possible that both occupants would have been able to escape from the aircraft. With the rescue services already alerted following the 'MAYDAY' call a quick rescue could have been effected.

In fact the impact forces were so great that incapacitating injuries were sustained. This was probably as a result of either an excess over water speed at touchdown or of the aircraft's stalling onto the water. The final heading of the aircraft could not be determined but the evidence of the relatively severe impact suggests that the touchdown was made out of wind. The difference in over water speed between an out of wind (tailwind) touchdown, and an into wind touchdown in this case could have been as much as 30 kt, a significant amount. The over water speed could have been reduced further by the use of flap. An aerodynamic stall would also have led to a severe impact, but if the stall warning CB had tripped out before the impact there would not have been any aural warning of an impending stall.

Assessment of the best landing direction over water is a difficult task for a pilot where he has to consider both swell and wind direction. In this case there were a number of factors that may have contributed to his decision making. The heading given in his last communication with ATC was south-easterly and with the coast in view ahead he may still have hoped to make land. Given the limited time available and the task of flying the aircraft in an emergency he may not have had the spare capacity to assess the best landing direction based on the wind strength and sea state. Also, were he to leave it too long before turning into wind there would then be insufficient height remaining in which to do so. It appears that the door was unlatched prior to impact but the absence of flap shows that only some of the vital actions were completed, perhaps a further indication of a lack of time.

The wearing of lifejackets and the carriage of a dinghy would not have prevented the deaths of the occupants in this accident. The nature of the injuries was such that it is unlikely that any attempt to escape from the aircraft was made. A ditching in reasonable conditions should be survivable and the evidence from previous ditchings is that most people do survive the impact. Many lives are lost however as a result of the time subsequently spent in the water without appropriate equipment.