**No: 10/91** **Ref: EW/G91/03/11** **Category: 1c**

| | |
|---|---|
| **Aircraft Type and Registration:** | Cessna 172, G-AWXV |
| **No & Type of Engines:** | 1 Rolls-Royce Continental O-300-D piston engine |
| **Year of Manufacture:** | 1968 |
| **Date & Time (UTC):** | 21 March 1991 at 1335 hrs |
| **Location:** | Crossens, near Southport, Lancashire |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Right main landing gear folded back and attachments damaged, insurance write-off |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 30 years |
| **Commander's Flying Experience:** | 90 hours (of which 27 were on type) |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot and inquiries by AAIB |

The aircraft was on a return flight from Sleap, Shropshire, to Blackpool Airport, approximately a 45 minute flight. The fuel tanks had been filled (23 US Gallons per side) at departure from Blackpool. A 1320 hrs weather report at Warton Airfield, a few miles south of Blackpool, included wind from 320° at 15 kt; visibility 35 km; cloud 2 oktas at 2000 feet, ambient temperature +9°C. After passing the Liverpool Zone at 1500 feet amsl the aircraft was climbed to 2500 feet and the pilot asked Warton Airfield ATC for a Radar Advisory Service and penetration of the Warton Military Air Traffic Zone. At this point the pilot was flying with the right fuel tank selected. The C172 Operating Handbook specifies that individual tanks may be selected in cruising flight in the absence of manoeuvres involving prolonged slips or skids. It is estimated that each tank would have been around three-quarters full at this point.

After approximately 1 minute level at 2500 feet, Warton ATC advised a descent to 1000 feet amsl to avoid conflicting traffic. The pilot applied full carburettor hot air, throttled the engine back to around 1500 rpm and commenced a descent, applying a gentle right skid to achieve around 1000 feet/minute at 100 KIAS. The engine was momentarily warmed on two occasions during the descent, using the pilot's normal procedure of advancing the throttle fully over a period of around 3 seconds, with hot air remaining selected, and maintaining full power for around 4 seconds before returning the throttle to idle. After passing through 1500 feet amsl the throttle was opened in anticipation of levelling off but the engine failed to respond, remaining at 1500 rpm. At this stage the aircraft was just heading out over the Ribble Estuary, which at the time was filled with water.

The pilot adopted glide speed, made a Mayday call to Warton ATC, turned south towards the land and, selecting both fuel tanks and checking magneto, mixture and carburettor hot air selections, attempted to restart the engine. It remained at around 1500 rpm and, about 1-2 minutes after entering the glide, he shut-down the engine. He left the battery selected on to enable flaps to be deployed, chose a field and initiated a curving approach aimed at achieving an approximately into-wind touchdown as soon as possible after crossing a drainage ditch forming the field boundary. Flap deployment was not required. Wind turbulence increased at low level and very shortly before touchdown the right wing dropped, possibly due to a gust, and the right main wheel contacted the upwind bank of the drainage ditch a few inches below the top, causing the right main landing gear leg to fold back against the fuselage. The aircraft slewed to the right and came to rest on the left main and nose wheels and the right wing tip. The pilot, who was wearing a lap and diagonal strap, evacuated the aircraft without injury, signalled to an aircraft circling overhead that had been diverted from local flying by Warton ATC, and made for a phone.

The emergency services attended the scene. The response time was not critical as the police had been informed by Warton ATC shortly after the accident that there was no fire and that the pilot was apparently uninjured, but the evidence indicated that the response may have been hindered by the lack of an early well defined position. Warton ATC had monitored the aircraft on SSR during the descent until close to touchdown but lacked readily available maps of the area south of the Ribble Estuary from which the radar range and bearing information could be translated into a National Grid position for passing to the emergency services. This was rectified immediately after the accident, with Ordnance Survey maps of the whole 40 nm radius area covered by the approach radar being placed on permanent display in the tower. In addition, a simple program has been incorporated into Personal Computers available in the tower to speedily translate a radar range and bearing input into National Grid coordinates.

A Licensed Engineer from the maintenance organisation responsible for the aircraft examined it at the crash site on the day following the accident. Substantial quantities of fuel were found in both tanks and the engine started readily and ran normally throughout its speed range. Further comprehensive checks of the fuel system and engine, including checks of the carburettor hot air system, carried out on behalf of AAIB after recovery of the aircraft to Blackpool, revealed no evidence of failure or defect.

A Blackpool Airport observation near the time of the accident indicated a sea level ambient temperature of 8.6°C (estimated as equivalent to 5-7°C in G-AWXV's operating altitude range) and a relative humidity of 69%. The chart of carburettor induction system icing probability in CAA Aeronautical Information Circular (AIC) 59/1990 (Pink 8) indicates that in these conditions there is a serious risk of icing at any power for a typical light aircraft piston engine without carburettor hot air selected. CAA Safety Sense Leaflet 14 (Piston Engine Icing, published 1991) provides similar information and also suggests (para i) that for descent and approach 'At intervals of about 500 feet increase power to cruise setting to warm the engine and to provide sufficient heat to melt any ice'. With hindsight, the pilot knows of no other measures that he could have taken to avoid induction system icing, which he considers to have been the cause of the power loss. He did not believe that the evidence indicated that fuel starvation could have been the cause. Both the pilot and Warton ATC have supplied very full information on this accident to enable their experience to benefit others.

Aviation area weather forecasts issued by the Meteorological Office in accordance with the requirements of the CAA include ambient temperature estimates but provide no direct indication of likely humidity. Most weather reports include dew point, but this is reportedly not a requirement.

It is widely recognised that ice build-up in the induction system of the more widely used types of carburetted light aircraft piston engines is a common event in the UK, and can insidiously reach proportions where continued engine operation is threatened. The number of previous cases of accidents resulting from induction system icing could not be established with total certainty because melting of the ice after the accident almost invariably leaves a lack of direct evidence in such cases. AIC 59/1990 indicates that in the previous five years there had been an average of 10 occurrences, including 7 accidents, per year in the UK in which induction system icing may have been a factor. Analysis of information on previous AAIB investigations and data supplied by the CAA indicated that in a recent six year period (January 1985 - February 1991) there were 55 Reportable Accidents reported in the UK that appeared to have resulted from induction system icing. It could be expected that there had been many other unreported cases of significant power loss from which a recovery had been made. The known cases were characterised by severe power loss for which no explanation other than induction system icing could subsequently be found. They included 50 forced landings, plus other cases where aircraft damage resulted from terrain contact following engine power loss. Among the 55 damaged aircraft were 18 severely damaged and a further 12 that were destroyed. 26 persons were injured, including 3 seriously and 8 fatally.

In some of the cases there was evidence that the intake hot air system had not been used in the recommended manner, but this was not a general feature and in many cases there were positive indications that it had been used correctly. The flying experience of the commanders involved covered a wide spectrum, from a student pilot with 29 hours total on her second solo flight to an airline pilot with around 16,000 hours total. The power loss predominantly occurred following a descent, particularly after a Practice Forced Landing descent, but some cases were found covering virtually every phase of flight. Evidence on the type of fuel involved was not available, but AIC 59/1990 reports that testing has shown that carburettor induction system icing is more likely to occur with Mogas than with Avgas. This is supported by the findings of Federal Aviation Administration (FAA) Report DOT/FAA/CT-82/110 of 18 November 1983, 'Engine Performance Comparison Associated with Carburettor Icing During Aviation Grade Fuel and Automotive Grade Fuel Operation'.

British Civil Airworthiness Requirements (BCAR K5-5) require demonstration 'that air intake systems will permit the supply and maintenance of an adequate supply of air to each engine under all conditions of operation for which the aircraft is to be certificated in a manner that will permit the continued safe functioning of the engines, components and accessories.' In this context BCARs require a means of protection against induction system ice accumulation for piston engine installations. For aircraft with unsupercharged engines using conventional venturi type carburettors this is required to provide a 50°C rise in the intake air temperature when operating in moisture-free air at -1°C at 75% of Maximum Continuous Power. Compliance is generally achieved by using an exhaust gas heat exchanger to warm air taken from an alternate intake manually selectable by the pilot. Operating procedures normally require full hot air to be selected before substantially reducing power for descent. Satisfactory system function is checked by confirming an engine rpm drop when hot air is selected.

No information on the effectiveness of this type of system at low power settings and in dynamic situations has been found, but it is normal practice to warm the engine every 500 or 1000 feet during a low power descent. CAA information is that the procedure would comprise a power increase, with hot air remaining selected, to around cruise rpm, which would then be maintained for 20-30 seconds before throttling back, the intention being to generate sufficient heat to prevent induction system icing and to eliminate any ice that had already built up. It is not known if this procedure is published, and enquiries of a small sample of private pilots and instructors indicate that it is not universally followed, all of the sample noting that for warming they generally maintain increased power for a maximum of a few seconds only. Views on the purpose of warming were varied, frequently relating to prevention of supercooling of oil or cylinders. It was also noted that the rpm drop to be expected during a Ground Run-Up Check as an indication that the hot air system is functioning adequately is generally not quantified in Operating Handbooks, although Safety Sense Leaflet 14 (para d) suggests 'typically 75-100 rpm and 3-5" of manifold pressure'.

The known cases illustrate a continuing incidence of damage and injury, sometimes serious or fatal, resulting from induction system icing from which protection is apparently not necessarily provided even by adherence to accepted operational procedures. The investigation has raised doubts over the adequacy of the engine warming procedure followed by pilots, and over the adequacy of the published information on both this procedure and the procedure for checking the functioning of the hot air system.

It has been reported that a relatively cheap and passive monitoring system that would provide a direct audible/visual warning to the pilot of both the presence of induction system icing conditions and the formation of ice is in process of development, employing adaptations of conventional technology.

It has been recommended that the CAA:

1. Publish and disseminate specific advice to pilots on the procedures to be adopted to minimise the risk of induction system icing in piston engined aircraft.

2. Consider the need for Operating Handbooks and Flight Manuals to include procedures for performance checks of carburettor hot air systems that quantify the minimum acceptable reduction in engine rpm and manifold pressure.

3. Consider requiring inclusion of relative humidity or dew point in aviation forecasts and weather reports.

4. Require the fitment of a warning system to alert pilots of induction system icing on future types of aircraft certificated in the UK, and consider a similar requirement for types currently certificated.