

Zenair CH 601UL Zodiac, G-RUVI

AAIB Bulletin No: 12/2003	Ref: EW/G2003/06/25	Category: 3
Aircraft Type and Registration:	Zenair CH 601UL Zodiac, G-RUVI	
No & Type of Engines:	1 Rotax 912 UL piston engine	
Year of Manufacture:	2002	
Date & Time (UTC):	28 June 2003 at 1230 hrs	
Location:	Droppingwells Farm, near Bewdley, Worcestershire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Right main landing gear, right wing and centre section	
Commander's Licence:	National Private Pilot's Licence	
Commander's Age:	67 years	
Commander's Flying Experience:	5,238 hours (of which 20 were on type)	
	Last 90 days - 43 hours	
	Last 28 days - 24 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent telephone enquiries	

Synopsis

This was the first flight of a recently constructed aircraft and it was using premium unleaded motor fuel. The engine had been run on the ground for about 12 minutes and the aircraft had then been parked in the open for over an hour. Subsequently, the aircraft was started up, taxied and took off, but the pilot had omitted to select on the electric fuel pump. During the initial climb the engine lost power and a forced landing was carried out. The aircraft was inspected following the accident and no apparent faults were found with the engine or the fuel system. It was concluded that a vapour lock had occurred in the fuel lines to the engine mechanical fuel pump, and that this could have probably been avoided had the electric pump been operational. The aircraft's fuel system was not fitted with a vapour return line, which was required on all Rotax 912 equipped aircraft using unleaded motor fuel and issued with a UK PFA permit to fly; this was to comply with CAA Airworthiness Notice 98B.

History of Flight

The aircraft had recently been constructed and was being prepared for its first flight. Prior to this initial flight, there had been several ground tests carried out and these included approximately two hours of engine runs, with no apparent problems. The aircraft had been fuelled with premium unleaded motor fuel (Mogas) obtained from a local garage. The pilot carried out various pre-flight checks with the engine running for about 12 minutes, about 2 minutes of which was at full throttle.

There were no reported problems. The engine was then shut down so that inspections could be carried out and the aircraft was parked for about 1 hour and 15 minutes in the open, on the airfield. Subsequently, the engine was restarted and the aircraft was taxied to the runway where the pre-flight checks were carried out. During these checks, the fuel pressure was noted to be satisfactory at 0.27 bar but for all of the pre-flight engine runs the electric fuel pump was not switched on. This meant that only the mechanical engine driven fuel pump was available to provide the required fuel pressure to the carburettors and this was the case throughout the accident flight.

Having completed all his pre-flight checks, the pilot applied power for takeoff on Runway 27. The aircraft took off but as it left the ground the engine began to lose power. At a height of about 100 feet the engine was still not producing the expected power and, despite the occasional surge, it was not enough to maintain the aircraft in flight. As the pilot determined that there was insufficient room to land back on the grass strip, he elected to carry out a forced landing. At this point, there was only one field available for such a landing, which was just off the end of the airstrip. However, this consisted of standing corn with an up-slope in the intended landing direction. The landing was made straight ahead and the pilot aimed for a light touchdown but, as the left wing contacted the corn, it caused the aircraft to slew to the left. The right main landing gear dug into the ground and collapsed, with subsequent damage occurring to the right wing and the underside of the aircraft. There was also minor damage to the tip of one propeller blade. The pilot exited the aircraft uninjured.

The weather at the time of the accident was obtained from an aftercast by the Meteorological Office. There was no significant weather and the surface temperature was 19°C with a dew point of 10°C, giving a humidity of 56%. The wind was variable at less than 5 kt.

Fuel System

G-RUVI was fitted with a 60 litre fuel tank located in the fuselage, just above the footwell. Fuel flowed, via a fuel tap on the cockpit centre console, to a gascolator located on the bottom right of the engine firewall. From here it was supplied in parallel to both an electric fuel pump, mounted on the firewall, and a mechanical engine driven fuel pump. Two fuel filters were installed, one fitted in the inlet line to the engine drive pump, the other in the outlet line from the electric pump. A non-return valve (NRV) in the electric pump prevented reverse flow of fuel when the engine driven pump was operating. The fuel lines to the mechanical pump, which was mounted on the front of the engine, ran over the top of the engine.

A 'T' fitting was installed in the fuel lines to the carburettors such that a pressure line could be taken to a cockpit mounted pressure gauge. In order to dampen pressure fluctuations at the gauge, a restrictor was fitted in the T piece at its connection to the gauge line. This was an approved modification and not part of the original engine/fuel system fitted at manufacture.

G-RUVI did not have a carburettor intake air heat system fitted or a vapour return line installed to route fuel/vapour back to the fuel tank.

Fuel System Testing

Following the accident, and with the aircraft still in its final resting position, the engine was restarted and reportedly ran normally. The fuel system was later tested in accordance with published procedures. Fuel flow rates of the engine driven fuel pump and the electric pump were measured in isolation and shown to be well above those required for a Rotax 912. In addition, the NRV in the outlet line from the electric pump was also checked and found to be operating normally.

Fuel system requirements

The aircraft manufacturer, in addition to the standard construction kit for the aeroplane, provides an optional anti-vapour lock system. This incorporates a fuel return line, with a restricted flow, such that fuel vapour is allowed to return to the fuel tank and a cooling flow of fuel is maintained through the fuel lines at all times. The fuel system on G-RUVI had been constructed based on the standard kit build instructions from Zenair and thus it did not include the vapour return line system. In addition,

the Rotax 912 installation manual makes a brief mention of a return to fuel tank line as though it was a standard requirement for the engine.

Airworthiness Notice (AWN) 98B provides details about the use of unleaded motor fuel in aircraft and provides exemptions to ANO article 112 which allow aircraft and engine combinations that are approved by the CAA to operate with unleaded Mogas to BS EN228 or BS7070 standard. The PFA have an agreement with the CAA that allows them to issue additional approvals for different aircraft/engine combinations, and to grant compliance with CAA AWN 98B. A letter from the PFA to all owners of aircraft with Rotax 912 engines was issued in September 2001 and this detailed the procedure to be followed to obtain the approval required. A particular point was made in the letter, and attached checklist (PFA/ULM2) to be followed during the approval process, that a vapour return line must be fitted to the fuel system as recommended by Rotax.

Analysis

As there was no apparent problem with the fuel system or the engine following the accident, one possibility considered for the loss of engine power was carburettor icing. This was given particular consideration as the aircraft was not equipped with a carburettor intake air heat system and carburettor icing is more likely to occur, and be more severe, when using Mogas when compared with AVGAS. However, given the weather conditions at the time, and using the probability chart provided in CAA Safety Sense Leaflet 14, there would only have been a risk of severe icing at decent power and moderate icing at cruise power.

Another possibility considered was that a vapour lock in the fuel supply line to the carburettors had formed. This occurs when the fuel 'boils' in the fuel lines and creates vapour. For the fuel to boil it needs to either be heated or have its pressure reduced such that the critical combination of vapour pressure and fuel temperature is achieved. Unleaded motor fuel has a higher vapour pressure than AVGAS. This makes the fuel more volatile and, therefore, more prone to the production of vapour. It is likely that, as the aircraft had been run for a prolonged period on the ground and then left for over an hour, the fuel lines to the mechanical engine pump on top of the engine had become heat soaked and thus allowed vapour to form in the lines. When the aircraft was subsequently started and taxied for the flight, using just the engine driven pump, the vapour prevented adequate fuel flow through the pump and this resulted in the loss of power during the takeoff.

Had the electric pump been in operation, it is probable, as this pump operates in parallel with the engine driven pump and provides a secondary fuel path to the carburettors, that a vapour lock in the engine pump lines would not have been noticed, as adequate fuel flow would still have been available to the engine. It is also less likely that the electric pump would have suffered vapour lock as it is mounted on the firewall to the rear of the engine, close to the gascolator. Therefore, the fuel lines from the pump would not have been exposed to the same heat as those associated with the engine driven pump. Also, as the electric pump is mounted low on the firewall, pressure in the lines to the carburettors is increased whenever it is operating.

Safety Recommendation

For the Zenair CH601, fitted with a Rotax 912 engine and using unleaded fuel, to be issued with a PFA permit to fly, it must have a vapour return line fitted, otherwise the aircraft is operating in contravention of CAA AWN 98B. As it would appear that some aircraft are in operation without such a vapour return line fitted, the following recommendation is made.

Safety Recommendation 2003-124

The PFA should inform all owners of the Zenair CH601 aircraft, fitted with Rotax 912 engines and issued with permits to fly, of the need to install a vapour return fuel line to the fuel system in order to comply with CAA AWN 98B.