ACCIDENT

Aircraft Type and Registration:	Europa XS, G-BYFG
No & Type of Engines:	1 Jabiru Aircraft Pty 3300A piston engine
Year of Manufacture:	2003
Date & Time (UTC):	29 May 2009 at 1419 hrs
Location:	South of Carsington Water, north-east of Ashbourne, Derby
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Substantial
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	59 years
Commander's Flying Experience:	2,150 hours (of which 110 were on type) Last 90 days - 8 hours Last 28 days - 2 hours
Information Source:	AAIB Field Investigation

Synopsis

The engine suffered a sudden and significant loss of power in flight. The pilot, who was unable to restore power, carried out a forced landing in a field, during which the aircraft collided with a hedge and was substantially damaged. He received minor injuries and was able to vacate the aircraft unaided. The investigation could not positively determine the cause of the power loss, but an unapproved modification to the fuel system may have been a contributory factor.

History of the flight

The purpose of the flight was to ferry the aircraft from Fishburn Airfield, near Durham, to its base at Tatenhill, near Burton-on-Trent. The aircraft had been at Fishburn for repair work following a landing accident in February 2008 (AAIB report EW/G2008/02/05 refers). After completion of the work, various taxi trials and a test flight were successfully undertaken. The inspection and test flight for the renewal of its Permit to Fly were completed in March 2009.

The pilot, an instructor with over 100 hours on type, had been asked to conduct the flight by the owners as they were not in current flying practice on the aircraft. One of the co-owners had flown the pilot to Fishburn in another aircraft and assisted with the preparations for the return flight.

Prior to the flight, the pilot taxied the aircraft to the fuel bowser for refuelling, during which he remained in his seat. The fuel sight tube is located on the centre tunnel near the front of the pilot's footwell and was difficult to see from his seated position, so he engaged the help of the co-owner, who stood beside the cockpit with his head positioned so that he could see the top of the sight tube. Fuel was added by an assistant and the co-owner instructed him to stop when the level approached the top of the sight tube, to avoid fuel overflowing out of the filler neck. Fuel was then carefully added until the fuel level was at the top of the sight tube, which the pilot and co-owner took to signify that the tank was full. A total of 26 litres of Avgas were uplifted.

The pre-flight and pre-takeoff checks were completed satisfactorily. Prior to the power checks the pilot selected the fuel selector to the other tank outlet to check the fuel supply from that part of the fuel tank. During the power checks, operation of the carburettor heat control only produced a small reduction in engine rpm, but a temperature rise was observed on the carburettor temperature gauge, confirming that the system was operational.

Once established in the cruise the pilot elected to fly at a reduced power setting in order to arrive at Tatenhill at a similar time to a slower aircraft that was following. The pilot obtained the weather from the East Midlands Airport ATIS; this gave a temperature of 24°C and dewpoint of 12°C. The flight had progressed normally for about 90 minutes when there was a sudden and significant loss of engine power. The pilot carried out his standard actions: applying carburettor heat, selecting the electric fuel boost pump ON and selecting the other fuel source. None of these actions had any effect on the engine performance, so he adjusted the throttle position to give the maximum power that was available.

The pilot then declared a MAYDAY to East Midlands Radar and stated his intention to land at nearby Ashbourne airfield. Within a few minutes the engine had lost all power and he was left with no option but to select a field and conduct a forced landing. As the aircraft descended, it became apparent that the chosen field was unsuitable because it was crossed by power cables and he decided to land in another field. However, no suitable fields were within the remaining gliding range. During the landing the aircraft floated above the down-sloping field, towards a tall hedge at the far end. He decided to try to fly through the hedge rather than risk a potential stall by attempting to climb over it. This rapidly slowed the aircraft and it came to rest, upright, in the field on the other side of the hedge.

The pilot received minor injuries and was able to exit the aircraft unaided. The aircraft had sustained substantial damage, including the detachment of the engine. After vacating the aircraft, he selected the electrical master switch and the fuel selector to OFF, before contacting East Midlands Radar using his mobile telephone. The emergency services were quickly on the scene and the pilot was taken to hospital.

The aircraft was recovered to Tatenhill the following day. It was later taken to the AAIB facilities for detailed examination.

Aircraft description

The Europa is a side-by-side two-seat homebuilt aircraft. Over 1,000 kits have been delivered to date and several hundred have been completed and are now flying. The aircraft is often fitted with a Rotax engine, but installation of the Jabiru engine is approved by the Light Aircraft Association (LAA).

Fuel system

General

The fuel system on the Europa incorporates a single saddle-shaped tank located behind the seats. G-BYFG was placarded as having a total useable capacity of 65 litres (56 main and 9 reserve). The main fuel supply is drawn from the upper part and one side of the tank. The other side of the 'saddle' is used as a small reserve fuel supply. A schematic of the fuel system is provided in Figure 1. According to the engine manufacturer the fuel consumption of this engine type at 75% power is 26 litres per hour, with the caveat that: *'actual consumption will vary depending on installation, propeller and power settings'.*

There were no records available of fuel uplifts on the aircraft, nor were any required to be kept.

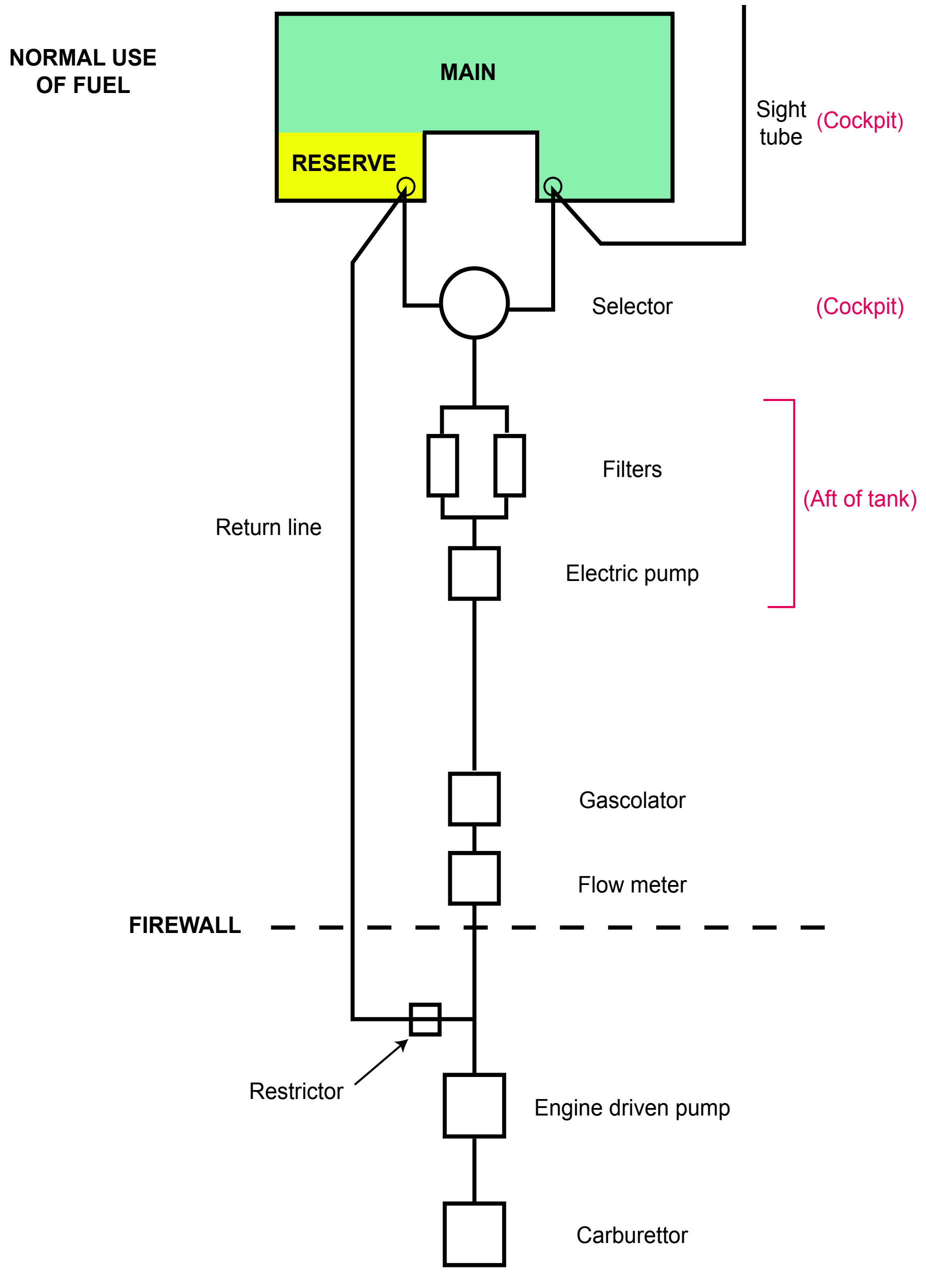

Figure 1

G-BYFG fuel system schematic

Fuel system modification

Under the direction of an LAA inspector, the fuel lines were replaced in June 2007 and a worksheet, signed by another LAA inspector, certified the satisfactory completion of this task. The entry also states that an additional return line *'required for MOGAS usage'* had been installed at the same time. This modification was not approved by the LAA. Examination of the aircraft showed that the bleed return line was connected between the main fuel line, immediately upstream of the engine-driven fuel pump, and the reserve side of the fuel tank. A restrictor was soldered into the 'T-piece' connecting the bleed return line to the main fuel line. Placards were fitted to the aircraft indicating that unleaded Mogas could be used. The co-owner stated that the aircraft was being prepared for the use of Mogas but further testing needed to be completed before modification approval could be applied for.

Fuel quantity indication

Fuel quantity indication was provided by means of a clear plastic sight tube mounted on the centre tunnel, close to the pilot's right lower leg (Figure 2). The sight tube must be calibrated during aircraft construction. The kit manufacturer's build manual suggests adding a card with dark and light stripes behind the tube to make the fuel level in the sight more visible; however, this was not used on this aircraft. Due to its location forward of the tank, the indicated fuel level is sensitive to changes in pitch attitude.

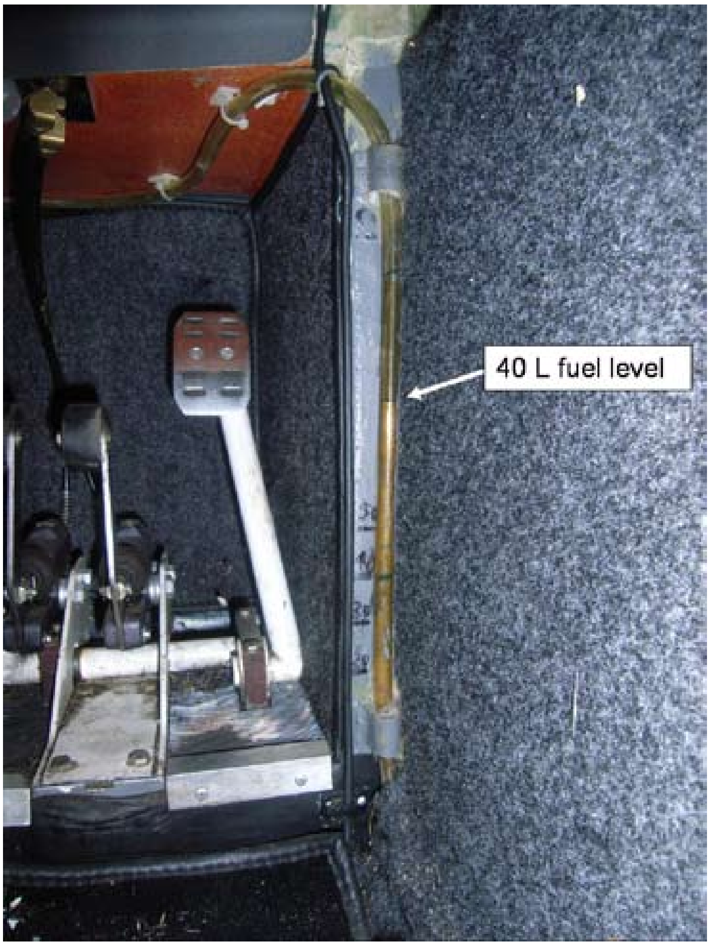

Figure 2

Fuel sight tube

The fuel sight tube on G-BYFG was discoloured and it was therefore difficult to read the fuel level in the tube. Graduation markings (20, 30, 40 and 50) were visible on the structure behind the sight tube (Figure 2), but it was not clear what these markings represented. Close examination of the sight tube revealed a line marked on the sight tube next to the '40' graduation. The significance of this line was not established. During the wreckage examination by the AAIB, water was poured into the fuel tank with the aircraft in its normal ground attitude, until the level in the sight tube reached the '40' graduation. This corresponded to an actual quantity in the tank of only 20 litres. When 40 litres were added to the tank, the level in the sight tube was well above all the graduations. With the level at the top of the sight tube, the total quantity in the tank was in excess of 60 litres.

Discussions with the co-owner revealed that the fuel sight tube had been calibrated following replacement of the fuel lines. These calibrations had been marked on an additional strip of metal that had been affixed beside the sight tube, on top of the abovementioned graduations. The metal calibration strip was subsequently found tucked in the bottom corner of the centre tunnel stowage pocket. It is not known when the strip became detached nor how it came to be in the stowage. The accuracy of these calibration marks could not be verified as the position in which the strip had been attached was not known.

Fuel system examination

When the aircraft wreckage was examined by the AAIB, no fuel was found anywhere in the fuel system or its components. However, given the length of time that had elapsed since the accident, this was not taken to be indicative of the quantity of fuel remaining in the aircraft at the time of the accident.

Examination of the carburettor did not reveal the presence of any debris in the float bowl and the carburettor functioned normally during subsequent engine testing. The fuel filters contained small particles of debris, but this was not considered to be unusual or significant. Only one of the two fuel filters was fitted with the required safety spring, however the filter element remained properly located. Inspection of the disrupted fuel pipes forward of the firewall showed that they had been forcibly pulled from their fittings when the engine detached.

The fuel system, up to the point where the engine had detached, was found to be free from leaks and capable of supplying fuel to the engine. There was no evidence of fuel staining on the airframe, which might have been indicative of a leak. A flow rate test using the aircraft's electric fuel boost pump showed that there was sufficient flow to satisfy the engine's demand at all engine power settings.

A further test was performed using an electric fuel pump to simulate the engine-driven pump. This pump was run with the fuel selector in the RESERVE position until that side of the tank was depleted, whereupon the flow decreased and eventually stopped. The fuel selector was then selected to MAIN and the electric fuel boost pump was then selected ON. Although the flow recommenced, it was at a much lower rate than before, even with both pumps running. It was apparent that air was being drawn into the fuel system through the fuel bleed return line from the now empty reserve side of the tank. Blocking the bleed return line restored the flow to its previous level.

Engine testing

The engine was examined and no pre-existing defects were identified. It was taken to a maintenance organisation specialising in this type of engine and after some minor remedial action to correct accident damage, it was mounted in a test stand. The engine started on the first attempt and ran smoothly at various power settings, despite one ignition system being inoperative due to accident damage. Following this test, the fuel bleed return line was introduced into the fuel system to replicate the aircraft's fuel system. It was found that the engine would run normally with the bleed return line closed off, but as soon as it was opened to atmosphere, air was drawn into the engine-driven fuel pump in preference to fuel, resulting in a significant loss of engine power.

LAA advice on aircraft modifications

The LAA produces Technical Leaflets to advise owners of procedures to be followed to ensure the continued airworthiness of their aircraft; these are available on the LAA website. There are several references to the modification process including Technical Leaflets TL 2.01 and TL 3.01.

Technical Leaflet TL 2.01 explains the responsibilities of the aircraft owner. In Section 3 the requirement to ensure the aircraft conforms to a LAA-approved design standard is discussed and includes reference to:

> *'making sure that any modifications are approved by LAA Engineering (not just the local inspector).'*

Technical Leaflet TL 3.01 deals with the approval of prototype modifications and sets out the process to be followed. It includes a section on the process for approving a modification application, which includes the following note:

> *'Once an aircraft has been modified it may not be flown until it has been approved.'*

Mandatory Permit Directive

Mandatory Permit Directive MPD: 1998-019 R1, relates to flexible fuel tubing. The MPD states:

> *'Prior to the issue or the renewal of a Permit to Fly, inspect all tubing used in fuel systems, including fuel delivery tubes, vent tubes and fuel sight gauge tubes for discolouration, shrinkage, degradation or embrittlement.'*

Completion of this mandatory inspection should be recorded in the aircraft logbook, however no such record could be found for G-BYFG.

Analysis

Whilst no positive evidence for the power loss could be identified, a number of possible scenarios were explored.

Carburettor Icing

The temperature and dewpoint obtained from the East Midlands Airport ATIS by the pilot were plotted on the carburettor icing chart from CAA Safety Sense Leaflet 14, '*Piston Engine Icing*', along with an estimated temperature for the altitude at which the flight was conducted. This indicated that moderate carburettor icing could be expected at cruise power, becoming severe at descent power. Given that the aircraft was being flown at a low cruise power setting it is reasonable to assume that moderate to severe carburettor icing could have been experienced. However the pilot reported that his regular checks did not indicate any carburettor ice formation and his application of carburettor heat after the engine had faltered had no effect. Nevertheless, given the ambient conditions and low cruise power setting, carburettor icing cannot be discounted as a possible cause of the power loss.

Debris in the fuel system

Because of the position of the fuel bleed return line, unfiltered fuel could be fed directly to the carburettors irrespective of the position of the fuel selector. This could lead to debris causing a blockage within the carburettor. However as the orifice in the restrictor in the fuel bleed return line was relatively small, any significant debris passing along this line was more likely to be trapped by the restrictor before it could reach the carburettor. Although some debris was found in the fuel filters, none was found in the carburettor and it performed normally during the engine testing. Flow testing of the fuel system showed that it was capable of delivering sufficient fuel flow at all power settings. It is therefore unlikely that the power loss was the result of debris in the fuel system.

Fuel quantity

The fuel tank was filled to the top of the sight tube prior to departure, corresponding to a quantity in excess of 60 litres, which should have been adequate for the planned flight. Following the accident the pilot selected the fuel selector to OFF which should have prevented fuel leaking from the main supply pipe after the engine had detached, although fuel could still have leaked from the reserve side of the tank through the fuel bleed return line. Due to the tank design, this would have only emptied the top part and reserve side of the tank and any fuel remaining in the main side should have remained in the tank. However, none was present when it was examined by the AAIB. Given the amount of time that had elapsed between the accident and the examination of the wreckage, no conclusion could be reached regarding the amount of fuel remaining at the time of the accident.

Vapour locking

There was no history of vapour locking problems on this particular aircraft. Vapour locking generally occurs when slow-moving or stationary fuel is subjected to heat soak, causing it to vaporise in the fuel lines, interrupting the flow of fuel to the engine. The conditions at the time that the power loss occurred would not have been expected to have been particularly favourable for vapour locking, but vapour locking could not be entirely discounted as a possible cause.

The intention of fitting the bleed return line was to reduce the possibility of vapour locking. However, by connecting it upstream of the engine-driven fuel pump instead of downstream, it introduced the possibility of air or debris being drawn into the fuel system, with the potential for interrupting the fuel flow to the engine.

Conclusions

Despite extensive examination and testing, the cause of the power loss could not be positively determined. An unapproved modification to the fuel system may have been a contributory factor, but other possibilities could not be discounted.

There is always the possibility of an engine failure occurring, which, in a single-engined aircraft, necessitates a forced landing. There is therefore a need for pilots to be prepared for and well-practised in making forced landings.

The aircraft's fuel system had been modified without the approval of the LAA. The nature of the modification introduced the potential for fuel starvation to occur in certain circumstances. The importance of following the correct procedures when developing and installing modifications to Permit-to-Fly aircraft is emphasised in Technical Leaflets and other guidance material produced by the LAA.