Europa, G-KWIP

BULLETIN ADDENDUM	
AAIB File:	EW/C2000/03/04
Aircraft Type and Registration:	Europa, G-KWIP
Date & Time (UTC):	12 March 2000 at 1200 hrs
Location:	Hollymeadow Farm, Bradley, Derbyshire
Information Source:	AAIB Field Investigation

AAIB Bulletin No 4/2001

In the original AAIB report into this accident, published in Bulletin 4/2001, it was noted that one of the main coolant hose segments connecting the bottom spigot of the radiator to the swirl pot had become disconnected. The potential for disturbance of this section of the hose during impact with the ground or during the subsequent recovery of the wreckage was assessed as low, and on the balance of the available evidence it was considered most probable that the disconnection occurred during flight. It was concluded that the consequential ingestion of coolant vapour and spray into the engine cowl in the vicinity of the carburettor intakes caused both the power reduction during climbout, observed by witnesses on the ground, and the accompanying light grey or blue *smoke* seen emanating from the cowling. It was further concluded that this power loss was a factor contributing to the loss of control that occurred shortly thereafter.

Following publication of this report and Safety Recommendation 2001-37, extensive testing and research carried out by the owner of the aircraft and others has brought to light information not available at the time of the original investigation. Close liaison with AAIB has been maintained throughout, and this addendum addresses those aspects of the original AAIB report which require amendment or clarification in light of this work.

In the original report, it was noted that the bore size of the disconnected coolant hose, in the mid region of hose remote from the clamped region, was significantly larger than the external diameter of the metal connecting piece to which it had originally been joined. From this, it was inferred that an oversized hose had been installed.

It has now been established that hoses supplied as standard by the aircraft manufacturer met the requirements of SAE J20R4 Class E (suitable for use to 125°C) which calls for a minimum wall thickness of 4.3 mm. The wall thickness in the oversized region of the disconnected hose from G-KWIP was typically 3.7 mm or less; somewhat greater in the region beneath the hose clamp, but still less than the nominal 4.3 mm minimum thickness of an new hose.

The reinforcement matrix of hoses to SAE J20R4 Class E comprise an anisotropically orientated (to give better burst strength compared to random) short-length fibre chop, not a woven or long-strand type of reinforcement. Instrumented tests carried out by the owner on a series of hoses purchased as new spare have shown that this type of hose will typically start to inflate and stretch at pressures of approximately 5.0 bar (Absolute), 4.0 bar (Gauge), and a temperature of the order of 160°C, and will rupture at pressures of the order of 5.5-6.5 bar (Absolute) 4.5-5.5 (Gauge) and temperatures of 165°-175°C. In one case, it was possible to stop the test after the hose had started to bulge, and before rupture occurred: the physical characteristics of this hose matched very closely those of the oversized region of the hose from G-KWIP. This pressure/temperature relationship correlates well with the predicted vapour pressure/temperature relationship for a 50% antifreeze/water mixture, which the original report noted was the approximate concentration determined from chemical analysis of coolant residues recovered from G-KWIP.

In light of this knowledge, it would appear that the bore of the hose was correctly sized at the time of installation, and subsequently became enlarged as a result of excessive temperature and pressure developing within the cooling system. It remains the AAIB view this most probably occurred during takeoff on the accident flight, and that the pressure generated within the cooling system at this time forced the hose off the connecting piece before the hose reached the point of rupture, but after it had stretched. Based on the test data provided, this is most likely to have occurred at a pressure slightly in excess of 5.0 bar (Absolute), 4.0 bar (Gauge), and a temperature slightly in excess of 160°C.

Instrumented tests up to the point of rupture were also carried out on examples of the coolant system overflow bottle. These suggested that at temperatures below 90°C, the bottle would withstand pressures up to approximately 5.0 bar (Gauge) without failing due to rupture; failure occurred at approximately 5.1 bar (Gauge) at this temperature. Prior to failure, the bottle bulged outward in a manner very similar to that observed on the bottle recovered from G-KWIP. It then split down one of the corner lines and pulled apart, producing a thin membrane of drawn polymer which fully bridged the opening which would otherwise have developed between the two rupture edges; finally, this membrane too burst. When examined under the microscope, the resulting rupture boundaries were extremely smooth and rounded, indicative of substantial plastic flow of material as the membrane of polymer material stretched out from these edges. In contrast, the split in the base of the bottle recovered from G-KWIP exhibited relatively brittle characteristics, with signs of shear in the fracture consistent with ripple-like buckling (oil-canning) of the base, due to impact deformation.

In summary, a comparison of the bottle from G-KWIP with the failed test article confirmed that the bulging of the former was caused by excessive pressure in the coolant system. The split in the bottom seam did not exhibit any similarities with the extreme plastic flow associated with the failure of the test article. On the available evidence, therefore, it would appear that the seam failure occurred during the impact. The mode of failure is consistent with a localised buckling of the lower part of the bottle due to it being driven upward and rearward, against its bulkhead fixings, by the left cowl during impact with the ground.

In the original AAIB report it was noted that the technical records for the aircraft showed that the antifreeze concentration in the coolant had been reduced in stages from an initial value of 100%, to 75%, and finally to 60%. The report also noted that chemical analysis of coolant residues from the wrecked aircraft showed that the actual coolant concentration was approximately 50%; it should be noted that this concentration was in accordance with the engine manufacturer's recommendations at the time of the accident.

The PFA has made a change to the recommended instrumentation of aircraft using recommended 50% antifreeze mix (ref Popular Flying May/June 2001 Page 22 - 25) that will give the pilot warning of boiling.

The engine manufacturer issued mandatory Service Bulletins SB-912-039 and SB-914-025 in December 2002, which increased the size of the vent hole in the cap of the coolant overflow bottle from 0.6 mm (as specified at the time of the accident to G-KWIP) to 2.5 mm. This modification should prevent a build of excess pressure in the bottle in the event of the coolant boiling, limiting the pressure in the hose to 0.9 bar (Gauge).