Europa, G-KWIP, 12 March 2000

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Aircraft Type and Registration:	Europa, G-KWIP
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	1995
Date & Time (UTC):	12 March 2000 at 1200 hrs
Location:	Hollymeadow Farm, Bradley, Derbyshire
Type of Flight:	Private
Persons on Board:	Crew - 1 - Passengers - 1
Injuries:	Crew - 1 (Serious) - Passengers - 1 (Serious)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	64 years
Commander's Flying Experience:	500 hours (of which 250 were on type)
	Last 90 days - 5 hours
	Last 28 days - 4 hours
Information Source:	AAIB Field Investigation

History of the flight

The accident occurred shortly after take off when an uncommanded reduction in engine power necessitated a landing in the only available suitable area. Both pilot and passenger received serious injuries and had little recollection of the events leading up to the accident. Some evidence was obtained from eye witness reports.

The pilot had been collaborating with a friend who was developing a Light Aircraft Glass Cockpit display system (LAGC), a pre-production version of which had been installed in G-KWIP and flown successfully for approximately 3 hrs. The purpose of the accident flight was to fly from Hollymeadow Farm near Ashbourne to Tatenhill, Staffordshire in order to have the installation inspected and to undertake some calibration work. At approximately 1300 hrs the pilot and passenger pushed the aircraft from the hangar onto an adjacent grass area. Both men seated themselves in the cockpit, the pilot occupying the left seat and the passenger the right. The starboard door was closed, but the pilot's door remained open. The engine was heard to start and run normally but some 2 to 3 minutes later was heard to stop. A witness, standing by the hangar door, saw the pilot climb out of the aircraft and move to the area of the aircraft's nose; he could not see what the pilot did but shortly afterwards the pilot returned to the cockpit. The owner of another Europa arrived and, following a brief discussion with the pilot already seated in the cockpit, went into the hangar to prepare his own aircraft. G-KWIP was restarted and the aircraft doors were closed. One witness, who was familiar with the aircraft, considered that it sounded noisier than usual either from the recently changed propeller or the application of more power than was normally used.

The aircraft taxied towards the northern end of the strip and was out of the view of witnesses for some ten minutes. The pilot believes that their intention was to make some adjustments to the LAGC before departure. One witness, concerned by the delay in the aircraft departing, climbed a low grass bank in front of the hangar and saw G-KWIP lined up on the grass runway, which has a heading of 225°M. At the same moment the aircraft commenced the take-off run and all four witnesses positioned themselves in front of the hangar to watch the departure.

Three witnesses were standing on the concrete below the grass bank and first saw the aircraft at a height of approximately 25 to 50 feet with flaps, main landing gear and outriggers extended. At this point the engine note changed as if it had reduced power slightly and light grey or blue smoke was seen to come from the area of the engine cowling. The aircraft remained in the same nose up take-off attitude and commenced a gentle turn to the left. The smoke stopped as abruptly as it had started and the engine sounded as if it was 'picking up' again, but the left wing and nose dropped and the aircraft descended rapidly, striking the ground in a left wing low and nose down attitude. There was no fire and people from the hangar ran the short distance to the wreckage where they rendered assistance to the two occupants until the emergency services arrived.

Impact parameters

The post-accident position of the wreckage and the pattern of damage sustained by the airframe showed that the aircraft had impacted the ground whilst rotating in yaw to the left in a steep nose down attitude, with a negligible horizontal velocity component. At the instant of impact, the aircraft was pointing back towards the runway. These impact conditions were consistent with a severe wing drop/incipient spin to the left. The degree of damage sustained was such that the probability of survival would normally be regarded as very low.

Aircraft details

The pilot, a PFA approved inspector, had played a major role in building the aircraft and had planned to take a 20% financial share in its ownership. During the 210 flying hours accumulated up to the time of the accident, G-KWIP had been the subject of ongoing development and modifications resulting in an aircraft which, at the time of the accident, differed in several respects from the 'standard' Europa. The more significant of these developments are summarised below:

<u>During initial build</u>:

- Changes to engine cooling, involving the relocation of the two engine coolant radiators from their standard positions in the forward part of the cowl to new locations on either side at the rear of the cowl, just ahead of the firewall, taking inlet air from the cowl and exhausting it through two specially constructed outlet ducts on either side at the trailing edge of the cowl. These changes were made in an effort to correct an anticipated shortcoming in the cooling effectiveness of the standard radiator configuration.

After initial build:

- The Warpdrive fixed (ground adjustable) pitch propeller was replaced with an Arplast PV50 variable pitch propeller.
- The coolant used initially was 100% glycol but his was subsequently changed to a 75% concentration of glycol in water, which gave improved heat transfer and cooler operating temperatures.
- Replacement of the two coolant radiators with a single, larger, radiator served by a specially constructed duct on the lower cowl, just behind the propeller. The oil cooler was also relocated to the rear of the cowl on the left side, drawing air from the cowl and discharging it through a specially constructed outlet duct. These revisions, which according to the pilot were similar to changes implemented by the manufacturer, enhanced visibility over the nose but did not improve cooling efficiency.
- Relocation of the single (replacement) radiator to the rear of the cowl on the right side, taking air from inside the cowl and discharging it through a specially constructed duct on the right side of the cowl just forward of the firewall.
- Further dilution of the coolant concentration to approximately 60% glycol.
- The stall strips on the wings, which the kit manufacturer recommended should be installed on all Europa aircraft to temper the stalling characteristics, were removed because it was felt that they compromised take off performance to a degree which outweighed their potential benefits elsewhere in the flight envelope. Flight tests for renewal of the Permit to Fly, which were carried out after their removal, reported no significant adverse stalling characteristics.
- The aircraft was used as a development test-bed for a proposed Light Aircraft LAGC (Glass Cockpit) display system. This system comprised a series of transducers (pressures, temperatures etc) and an interface unit, linked to a laptop PC running dedicated software to provide a variety of user-selectable display formats on a high brightness touch sensitive display screen. The LAGC system in its development form was designed so that it could be plugged into the aircraft's existing systems with a minimum of disturbance. The display screen was installed on the left instrument panel, and the laptop computer was inserted into slot-type stowage beneath the right hand panel. The right hand panel housed a full set of standard *mechanical* flight and engine instruments. This was the configuration of the LAGC at the time of the accident; the total number of parameters measured was 19, and the system monitored key parameters and displayed warnings if limit values were exceeded. A planned future development provided for data logging, allowing the storage of data during flight for subsequent download and analysis; however, this facility had not been implemented at the time of the accident.
- The pitot static system was subject to an ongoing series of changes. These included the installation of separate, but adjacent, pitot and static probes beneath the left wing to replace the original pitot probe on the tip of the fin and dual static ports on each side of the rear fuselage; this too, according to the pilot, was broadly comparable to revisions implemented on production Europas of the period. At the time of the accident, the pitot pressure was taken from the pitot probe under the left wing, with static taken from the standard ports on the rear fuselage. The LAGC pitot and static pressure transducers were supplied via tappings from the primary pitot and static lines, using semi-rigid nylon type tubing pushed over 'fir tree' type fittings at the transducers, and laboratory-type quick release connectors with 'O' ring seals at the 'T' connections to the primary system.

Detailed wreckage examination

Airframe

The aircraft suffered extensive structural disruption in the cockpit area, including break-up and dislocation of both sidewalls, the cockpit floor, and the central tunnel which houses the monowheel. Both of the harnesses and their attachments survived the accident intact but their effectiveness was limited by extensive disruption of the forward fuselage and cockpit structure during the impact.

The circumstances of the accident did not suggest any problem with the structure or flying controls, and these areas were not subject to extensive investigation. However, it was apparent that the aircraft had been structurally complete at impact and no evidence was found of any pre-impact defect or malfunction of the flying controls. The elevator trim was near the nose up end of its range, but the system was electrically operated by push buttons on top of the control column, and it was entirely possible that the pilot's body had lain against the aft trim button after the accident. The pitot static system had been disrupted in the impact and could not be tested.

Fuel system

The fuel system had been disrupted in the impact. A very small amount of clean fuel, with no separated water visible, was recovered from the drain lines but there was insufficient to allow for testing.

The fuel selector valve was found at an intermediate position, approximately 20% of the way between the left tank and right (reserve) tank. However, the valve lever was potentially subject to disturbance by persons attending to the injured occupants immediately after the accident, and in any event, even if the valve had been in this position prior to the accident, the misalignment was not sufficient to restrict fuel flow to any significant extent. The gascolator filter housing was closed and tightly sealed with the locking pin in place, and the drain valve was shut. The housing contained a small amount of fuel, which was of slightly cloudy appearance, but it contained no visible particulates and the element was clean. The electrical fuel pump was free of obstruction and pumped vigorously when connected across a 12V supply. The mechanical fuel pump on the engine was activated manually and found to pump effectively. The fuel flow transmitter was unobstructed, and the impeller rotated freely in response to a flow of air through the unit. The vent return line to the tank, which was connected to a 'T' connector at the flow meter, contained a small restrictor in accordance with the aircraft kit manufacturer's recommendations; the restrictor was clear of obstruction.

The air filter from the left carburettor was detached, and both carburettors had pulled off their respective inlet manifold connections at the rubber connecting rings; their clamps were still in place, however. The left filter-retaining clamp was recovered from the lower cowl. It was evident that both air filters were in place on their respective carburettors, and the carburettors were also in place at the time of impact with the ground. The left carburettor mixture (choke) lever was slightly off its fully open position as found, but the mixture levers of both carburettors would have been susceptible to disturbance during the impact. The left carburettor fuel feed pipe had fractured at a brass connector joining the flexible hose to the fuel pressure transducer. Detailed examination of the fracture face under the microscope showed that the failure was due to overload consistent with the impact, and there was no evidence of fatigue. The jubilee type hose clamp securing the fuel feed hose to the right carburettor fuel inlet was loose and had migrated off the end of the hose. It was evident that the clamp had not been tightened when the hose was last connected to the carburettor; however, the hose itself was still securely in place on the spigot, and there was no evidence of any leakage of fuel. Both carburettors were stripped and examined in detail: both diaphragms were intact and in good condition, with no tears or punctures; the jets were clear; and vacuum testing confirmed that both float chamber needle valves closed positively onto their seats and maintained a good seal.

In summary, no evidence was found of any defect or malfunction of the fuel system which could have caused the power loss, or the visible symptoms of light grey or blue smoke described by the witnesses.

<u>Cooling system</u>

The Rotax 912 series of engines employ a combination of air and liquid cooling: air is used to cool the cylinders (which incorporate cooling fins in the conventional manner); the heads are liquid cooled. The coolant at the time of the accident was a water/glycol mix at a nominal 60% concentration which, from experimentation on G-KWIP, had been found to provide the most effective cooling in normal operation.

The basic elements of the cooling system on G-KWIP at the time of the accident comprised the standard Rotax installation in which the separate water jackets, formed integrally with each cylinder head, were connected via lengths of radiator hose to a standard Rotax swirl pot (a small header tank) positioned centrally above the rear section of the crankcase. The swirl pot functioned as a combined mixing chamber and a system filling point, the latter being achieved by means of a conventional automotive type filler/pressure relief cap. In the event of the system pressure rising sufficiently to lift the relief valve in the cap, the resulting discharge passed via a length of small diameter tubing to an over-flow bottle mounted on the left side of the firewall. The over-flow bottle, which was also a standard Rotax item, incorporated a vent to atmosphere in the form of a small hole in the screw cap. The coolant system was filled to a level whereby, during normal operation, the expansion bottle would be approximately half filled with coolant. The lower part of the swirl pot chamber was connected to the bottom spigot of the coolant radiator by a large-bore radiator hose, which on G-KWIP comprised three separate rubber hose sections connected by metal joiner tubes. As found, the upper end of the middle section of the rubber coolant hose connecting the swirl pot to the bottom of the radiator block had separated from the joiner tube which normally connected it to the top section of hose, and the hose clamp was missing, see Figure 1. The coupling would have been substantially protected from direct disturbance during the impact, and the inherent flexibility of the installation made it unlikely that movement of hoses elsewhere in the system could have pulled the coupling sufficiently to cause the disconnection.

A series of witness marks were found which had been produced by long-term contact between the bottom section of hose and the tubular steel engine mount frame, which allowed each of the hose sections to be re-located accurately in its *in-service* position. With the assembly thus positioned, it was found that the lengths of the individual hose sections allowed for only a small amount of engagement between the (disconnected) middle hose section and its associated joiner tube, see Figure 2a. This limited amount of engagement was confirmed by a visible discontinuity in the surface colour of the joiner tube (at the position shown by red arrow in Figure 2a) and a distinct witness line around the circumference of the tube at this same location (see Figure 2b), consistent with the position of the end of the hose prior to the disconnection.

It was noted that the bore of the disconnected hose segment was a nominal 30 mm diameter, whereas the mating (external) diameter of the joiner tube was 25 mm, see Figure 3. At the end of the hose which had been connected to the joiner, the hose clamp had induced a permanent set in the wall of the hose which had effectively resulted in the hose 'necking down' to match the 25 mm tube; this showed that the clamp had been tightened down hard when it was originally installed. However, the 5 mm mismatch on diameters would have required a circumferential compression in the hose wall of approximately 15 mm merely to bring the hose into contact with the joiner around the full circumference. This alone would have required forces sufficient to produce the observed crushing and necking of the hose, even without the additional forces which would then have been required to clamp the hose securely onto the joiner.

The joiner tube itself was a plain metal tube with no belled (raised) lip to help retain the hose. A shallow circumferential groove had been cut adjacent to the ends of the joiner (visible in Figures 1 to 3), apparently in an effort to improve retention, but for this to have provided an effective restraint it would have been necessary for the rubber to extrude down into the grooves; requiring very high clamping forces. The internal surfaces of the hose at the disconnection were smooth around the full area of contact and there was no evidence of extrusion into the retaining groove, suggesting that the effective clamping pressure had been insufficient to gain any advantage from the groove.

The adjacent (top) section of hose, which was still connected to the joiner tube, was correctly sized at 25 mm bore, and circumferential witness marks were found in the bore of the hose where the rubber had extruded down into the groove in the joiner. It was evident that this hose had been clamped firmly onto the joiner at some stage; however, it was found that the clamp screw turned easily with the fingers, and even without unscrewing the clamp it was possible, without any great effort, to manually slide the hose off the joiner tube.

The joint between the lower and middle hose sections utilised what appeared to be a proprietary metal joiner tube with conventional belled ridges at each end, providing a more positive retention of the hoses. These connections had remained secure.

The coolant expansion bottle was heavily deformed consistent with it having been subject to excessive internal pressure at elevated temperatures, causing it to 'inflate' and adopt a partially spherical shape (see Figure 4). In addition, the bottom seam weld was ruptured. The damage to the bottle was not compatible with the impact, but rather to an overpressure within the coolant system.

Engine strip examination

Hand cranking confirmed that the propeller drive train was serviceable and that all valves opened and closed normally. The compression on all four cylinders appeared normal. A bulk strip examination of the engine revealed no evidence of damage or abnormal wear of the pistons, rings, or cylinder walls, and the cylinder head joints displayed no evidence of leakage. The ignition system was checked by cranking the engine, and a visible spark was obtained at each of the plug positions.

It was noted that the oil residues on the Nos 2 and 4 (left hand) cylinder walls appeared slightly watery, and the carbon deposits on the associated piston crowns and cylinder heads, whilst essentially normal in themselves, had an unusual sheen suggesting the presence of some form of surface contamination. The spark plugs all showed typical colouration, but the No 2 upper plug exhibited a distinct surface sheen similar to that noted on the Nos 2 and 4 piston and head deposits. It was considered that the visible sheen might be a glycol residue resulting from the ingestion of coolant from the disconnected radiator hose. Accordingly, swab-samples were taken from the cylinder walls, together with scrape-samples from the cylinder heads, and sent for chemical analysis. A small amount of coolant recovered from the radiator matrix was also analysed, both to provide a comparative sample for glycol and to determine the concentration of glycol in the coolant water. The results showed that each of the carbon and cylinder swab samples contained significant quantities of glycol, consistent with that present in the coolant sample. The glycol concentration in the liquid sample was established as 50% by weight (approximately 48% by volume).

Discussion

There was clear evidence that the coolant system had been subjected to a significant overpressure. This certainly resulted in the partial rupture of the lower seam of the expansion bottle and almost certainly caused the main coolant hose assembly to pull apart at a connection between one of the hoses and a metal joiner tube. Whilst it was not possible totally to eliminate the possibility that the hose disconnection might have been caused by post accident disturbance of the wreckage prior to examination by AAIB, the weight of available evidence points very strongly to the disconnection having occurred in flight: caused by the same over-pressure event which damaged the overflow bottle. Specifically:-

- The significantly over-sized hose in relation to the joiner tube diameter would have reduced the potential clamping effectiveness, increasing the risk of the hose sliding off the joiner under the pressure of fluid within.
- The joiner tube had no 'belled' lip of the kind usually incorporated into spigots and joiners used in engine cooling systems, and provided elsewhere on the cooling system of G-KWIP; increasing the risk of the tube sliding off the joiner under pressure. The ease with which the adjoining (correctly sized) hose could be slid off the same joiner manually, without recourse to slackening of the clamp first, was evidence that the shallow circumferential grooves which had been cut into the joiner, presumably to improve retention, were not effective.
- Witness marks on the hose and joiner tube were evidence of minimal installed overlap between the hose and the joiner.

Whether from the hose disconnection or the split expansion bottle, the released coolant would have been discharged under pressure into a region of the engine compartment in close proximity to the carburettor intakes; particularly the left carburettor, with the consequent probability of coolant being ingested into the engine. This would almost certainly have led to a power reduction to some degree, accompanied by a copious discharge of grey vapour from the exhausts. The fountain of coolant discharging into the cowl would also be expected to emerge in the form of a white/grey cloud streaming back from the two radiator outlet ducts, positioned on either side to the rear of the cowl, and from any other gaps which might have existed in the cowl, eg the gap around the exhaust mufflers; coolant coming into contact with the hot exhausts further increasing the amount of visible *smoke*. Both the exhaust discolouration and the discharge from the cowl area would have been short lived, terminating as soon as the supply of coolant was exhausted. The relatively short duration of the visible smoke seen by the witnesses is consistent with the coolant system becoming depleted after a very short time, implying a high rate of coolant leakage such as would be expected from a disrupted hose, rather than the much lower discharge rate to be expected from the smaller rupture in the seam of the expansion bottle.

A sustained boiling event, accompanied by the discharge of coolant into the overflow bottle sufficient to overwhelm the small vent hole in its cap, appears to offer the most likely explanation for the over-pressure event. Once this hole was overwhelmed, the pressure within the primary coolant circuit would have risen rapidly, inflating the bottle and causing the seam to rupture, and placing stress on all of the hose connections in the cooling system. The lack of any 'belled' profile on the joiner tube linking the top and middle sections of the radiator hose would have made this connection more prone to disconnection under higher than normal pressure than hose connections elsewhere in the system. Of the two connections at the top joiner tube, the middle hose section would have been the more vulnerable, due to the mismatch on diameter and the attendant reduction in effective clamping pressure: to that extent, therefore, it is not surprising that this joint failed first; once it had failed, the pressure would have been relieved and no further hose disconnections would have occurred; further damage to the overflow bottle would also have been curtailed.

The cause of the boiling event remains unknown. It is possible that the radiator had become obstructed at, or immediately before, the start of the take off, eg as a result of picking up a plastic bag or some other foreign object, but there is no evidence for this. In the absence of hard evidence, it is considered more likely that the boiling was caused by the combination of the slightly unusual operating conditions and the glycol concentration used in the coolant.

It is understood that the concentration of glycol used in the initial flight trials of G-KWIP was 100%, but this was found to give poor cooling performance due to the relatively poor heat transfer properties of glycol compared with water, leading to unacceptably high cylinder head temperatures. A reduction in the concentration of glycol to 75% was found to reduce the temperatures to more acceptable levels, and as a result of further development and testing the coolant was diluted further to a nominal 60%. Analysis of the post accident residue from the radiator of G-KWIP suggested that the actual concentration was closer to 50%. It is understood that G-KWIP was not unusual in this respect, and that most Europas currently flying operate with coolant concentrations of between 50% and 70%.

The concentration of glycol in the coolant is considered highly significant, because whilst any dilution will tend to improve the efficiency of heat transfer leading to lower cylinder head temperatures, it also reduces the temperature at which the coolant will boil. A coolant comprising 100% glycol would be expected to have a boiling point of the order of 210°C at 1 bar (slightly above the normal system operating pressure of 0.9 bar); this reduces to approximately 140°C at 80% concentration, and 130°C at 50% glycol. At atmospheric pressure, these figures reduce to 190°C, 122°C, and 110°C respectively. It follows that whilst a reduced glycol concentration might give significant benefit in the form of improved cooling efficiency, and hence lower operating temperatures overall, this will be at the cost of a potentially large reduction in the margin of safety between the normal coolant operating temperature and the *boiling* temperature. A reduced margin would not be explicitly apparent to the pilot, but it would be possible for a relatively small change in operating conditions to push the temperature above the boiling threshold, even though the engine temperature itself might remain comfortably below the max allowable, which on the Rotax 912 is 150°C. This appears to offer the most plausible explanation for the sudden boiling, and the attendant hose disruption and loss of power, on G-KWIP.

It is known that the aircraft spent some time at the holding point whilst adjustments were made to the LAGC computer system, before beginning the take off. It is understood that the LAGC contained an effective 'red-line' feature on the visual display of engine temperature, as well as an audio warning of a temperature limit exceedance. It is unlikely, therefore, that overheating, of itself, would have gone unnoticed and it is reasonable to assume that the temperatures did not exceed allowable values during this time. However, the airflow through the cowl of any engine with pitot-type cooling inlets will be reduced significantly when the aircraft is stationary, particularly if positioned adversely in relation to the wind, and it is probable therefore that the engine temperature would have risen during this period of ground running: possibly to a value close to the boiling point which, at a glycol concentration of 50 to 60%, is likely to have been somewhere in the range 120° to 130°C; not enough to cause any particular concern, or to trigger any warnings. However, when the throttle was advanced for take off the additional power being developed by the engine would have placed increased demands on the cooling system, and the temperature would certainly have risen further during the initial part of the climb: probably not to excessive levels, judged purely in terms of temperature, but possibly enough to push the coolant above its boiling point and cause the sudden overpressure and attendant disruption of the hose coupling.

Having suffered a power reduction, the pilot would have found himself poorly placed to climb away, and wooded areas forward of the aircraft would almost certainly have caused damage of some kind had he attempted a landing ahead. It is also probable that liquid or steam from the ruptured coolant system obscured the pilot's view ahead, increasing the workload and limiting further the options available. It appears that the pilot attempted to execute a turn to the left, and that whilst doing so the aircraft stalled and suffered a severe wing drop to the left at too low a height to allow any realistic prospect of recovery.

It is clear both from the witness accounts and from the conditions at impact that a wing drop to the left precipitated the sudden loss of control. The aircraft kit manufacturer recommends that stall strips should be fitted and these were originally fitted to G-KWIP. They were subsequently removed because it was found that, with the strips fitted, an extra 4 to 5 kt IAS was required for the aircraft to become airborne. This increased the time during which the aircraft was vulnerable to the possibility of the propeller striking the ground as a result of pitch oscillations; a characteristic associated with the relatively short distance between the main and tail wheels. It is believed that a significant number of Europas currently flying do not have stall strips installed for similar reasons. The two most recent flight tests (for the renewal of the Permit to Fly) reported 'straight stalls, with no wing drop' (1998 test, which specifically noted that no stall strips were fitted), and 'no proper stall clean; slight left wing drop flaps down' (1999 test).

Conclusions

Following a loss of engine power during climbout, the airspeed decayed during the left turn towards a suitable landing area. Before effective recovery action could be taken the aircraft stalled and entered an incipient spin to the left, striking the ground heavily.

The partial loss of power was caused by a copious discharge of coolant into the engine cowl and its resultant ingestion. The weight of evidence suggests this coolant emanated mainly from a hose disconnection, and to a lesser extent from a ruptured seam in the expansion bottle: both resulted from an overpressure of the coolant system, associated with boiling of the coolant when power was applied for take off, following an extended period of ground running with the aircraft stationary.

A significant reduction in the coolant boiling temperature, which accompanies any dilution of glycol coolant, is likely to have been a significant contributory factor. As a consequence of the non linear relationship between glycol concentration and boiling temperature, dilution of the coolant can result in the coolant boiling at a temperature significantly below the specified maximum operating temperatures for the engine.

Safety recommendation

It is recommended that:

Recommendation 2001-37

The Popular Flying Association (PFA) should review the implications of coolant concentration, particularly the margins which are likely to exist in practice between *boiling* and *engine safe operating* temperatures, and take appropriate steps both to raise awareness of these issues generally within the homebuilt aircraft community and to promulgate specific guidance to owners of affected aircraft operating on Permits to Fly.

NOTE:

It is understood that the PFA, in collaboration with the engine manufacturer's UK agent, has already begun a detailed review of the issues of concern highlighted by this investigation, including testing where appropriate, with a view to implementing these recommendations.