Air Accident Investigation Unit Ireland

ACCIDENT REPORT
Avid Mk. IV Flyer, EI-HAM
Leegane, Co. Wexford
3 October 2010

An Roinn Iompair
Turasóireachta agus Spóirt
Department of Transport,
Tourism and Sport

AAIU Report No: 2011-018
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In accordance with the provisions of SI 460 of 2009, the Chief Inspector of Air Accidents, on 3 October 2010, appointed Mr. Leo Murray as the Investigator-in-Charge to carry out a Field Investigation into this Accident and prepare a Report. The sole purpose of this Investigation is the prevention of aviation accidents and incidents. It is not the purpose of the Investigation to apportion blame or liability.

Aircraft Type and Registration:	Avid Mk. IV Flyer, EI-HAM	
No. and Type of Engines:	1 x Stratus EA-81	
Aircraft Serial Number:	1072-90	
Year of Manufacture:	1996	
Date and Time (UTC[1]):	3 October 2010 @ 17.00 hrs	
Location:	Leegane, Co. Wexford	
Type of Flight:	Private	
Persons on Board:	Crew – 1	Passengers – 1
Injuries:	Crew – 1	Passengers – 1
Nature of Damage:	Destroyed	
Commander's Licence:	JAA[2] Private Pilot Licence (Aeroplanes)	
Commander's Details:	Male, aged 81 years	
Commander's Flying Experience:	1,123 hours, of which 47 were on type	
Notification Source:	An Garda Síochána	
Information Source:	AAIU Field Investigation	

1 **UTC:** Co-ordinated Universal Time, equivalent to local summer time minus 1 hour.

2 **JAA**: Joint Aviation Authorities.

SYNOPSIS

The aircraft was on a local flight with two occupants on board when the engine overheated. This caused a pressure cap installed on the cooling system expansion bottle to fail. The cockpit filled with coolant vapour, obscuring visibility and rendering control of the aircraft difficult. The Pilot attempted to make a precautionary landing under power in a field. The aircraft impacted heavily, which resulted in severe damage to the airframe. Both occupants were seriously injured. There was no fire. The AAIU makes one Safety Recommendation in relation to this accident.

1. FACTUAL INFORMATION

1.1 History of the Flight

The Pilot departed ILAS[3] Airfield at Taghmon, Co Wexford with the intention of conducting a short local flight with a friend. The Pilot, who was part owner of the aircraft, occupied the right seat and the passenger occupied the left seat. The passenger was also the holder of a pilot licence. After a few minutes of flying at an altitude of approximately 1,000 ft, the Pilot noticed that the engine temperature had risen to about 180 °F, as indicated by the water temperature gauge. This was followed by what he termed an *"explosion"* when vapour rapidly filled the cockpit. The Pilot described how this *"completely clouded over all the glazed areas and instruments"*. This had a disorienting effect and came as *"a great shock because of its instantaneous happening"*. The Pilot recalled that the aircraft doors were opened in flight but all the glazed surfaces remained completely obscured.

With his vision of the instrument panel and external references obscured, the Pilot attempted to make a precautionary landing in a field while engine power was still available. The aircraft cleared trees at the boundary of a large field but impacted heavily on touchdown resulting in severe damage and distortion of the airframe. Both occupants were seriously injured during the impact sequence. While initially rendered unconscious, the Pilot subsequently managed to evacuate the aircraft unaided despite his injuries, and made his way to a nearby farmhouse where he raised the alarm. A local girl was first on the scene and remained with the passenger, who was unable to evacuate the aircraft until the arrival of the Emergency Services.

1.2 Aircraft Damage

The aircraft was extensively damaged by impact forces. The left main undercarriage detached during the initial impact. This impact was followed by propeller strike marks where the propeller blades disintegrated under power. The aircraft then impacted the ground heavily as evidenced by a large witness scar on the surface. The aircraft travelled a total of 26.5 metres from the initial point of impact before coming to rest facing back along the direction of ground travel.

1.3 Aircraft Information

1.3.1 General

The Avid Flyer Mk. IV is a two-seat, kit-built[4] aircraft which is typically powered by a ROTAX 582 (48.5 kW) two-stroke engine. Seating is provided for two occupants and is arranged side-by-side. The aircraft has two doors which open upwards, and are located on either side of the fuselage. There is a choice of wing types and undercarriage configurations available to the builder.

3 **ILAS**: Irish Light Aviation Society.

4 **Kit-built:** Factory produced components assembled and finished by an amateur builder.

EI-HAM was fitted with a standard wing and was first flown on 27 January 1997 powered by a ROTAX 582 engine. After completing just over 5 hours of flight time, the original builder decided to install a Stratus EA-81 four-stroke engine.

The aircraft was out of service for a considerable period while this installation took place. The aircraft was purchased by the current owners in 2008, and was registered to them on 28 April 2008. The aircraft first flew with the new engine installation on 30 March 2009.

1.3.2 Engine Installation

The Stratus EA-81 is a conversion based on a water-cooled 1.8 litre Subaru EA-81 engine. The converted engine incorporates a belt reduction drive and a lightweight induction manifold, twin altitude-compensating carburettors and Lycoming motor mounts. The engine is zero-timed to factory specification. Prior to delivery the engine is completely assembled and test run. Each engine includes a reduction drive, electric starter, air filters, ignition coil, fuel pump and propeller extension.

The engine cooling system in EI-HAM consisted of an air-cooled radiator mounted underneath the fuselage to the rear of the cockpit, an engine-driven water pump installed at the rear of the engine block, a thermostat and an expansion bottle which was mounted on brackets on the fuselage frame behind the right seat. The expansion bottle was mounted in this location due to lack of available space forward of the engine firewall. An air valve mounted at the highest point of the cooling system permitted bleeding of air from the system. The radiator was connected by aluminium tubing, external to the fuselage, to a coolant outlet hose routing from the engine block through the thermostat. The return connection from the radiator was through similar externally mounted aluminium tubing and a hose back to the water pump.

Correct operation of the system allows the engine to warm up following start, with the thermostat initially remaining closed and the coolant circulating through the engine block. As the engine reaches an appropriate operating temperature, the thermostat valve opens and the coolant then passes to the radiator. Following the cooling process in the radiator, the coolant returns to the engine block.

In EI-HAM, a pressure vent cap, rated at 0.9 bar[5], was mounted at the front of the engine and was installed to permit pressurised engine coolant to pass directly to the expansion bottle, should the coolant pressure exceed 0.9 bar. The expansion bottle itself was also fitted with a pressure vent cap which was rated at 50 kPa[6], equivalent to 0.5 bar. The temperature of the cooling system was monitored by a water temperature gauge on the instrument panel which operated by means of a thermal switch located in the casing of the water pump. The gauge indicated water temperature on a scale between 100 °F and 250 °F.

The Pilot informed the Investigation that, since installation of the Stratus EA-81 engine, the aircraft had flown over 50 hrs without incident. He recalled that during this time the engine tended to run at an operating temperature of approximately 100 °F to 120 °F which was significantly cooler than a normal operating temperature of 180 °F. With a radiator of fixed area and with no mechanical adjustment of the cooling available, the owners of the aircraft had been experimenting with the application of duct tape to the radiator surface to achieve the required cooling during the flights prior to the accident. A Flight Test Report completed by the Pilot on 20 June 2010 recorded that the coolant temperature during the pre-flight ground run was 160 °F.

5 Bar: A unit of pressure equal to hundred thousand Newton's per square metre.

6 kPa: KiloPascal, a unit of pressure. 100 kPa is equivalent to 1 bar.

1.4 Pilot Information

The Pilot was properly licensed. He held a Private Pilot Licence (Aeroplanes) first issued in the State on 29 August 1972, and valid until 1 September 2013. A Single Pilot Class Rating was valid until 30 November 2010. A Class 2 Medical Certificate pertaining to the licence was valid until 30 November 2010.

The Pilot had accumulated a total of 1,123 hours of flight experience of which 47 hours were on the Avid Mk. IV. The Pilot also had considerable experience on a Luton LA.5 Major which he also owned and continued to fly following acquisition of the Avid.

1.5 Maintenance Information

An Annual Inspection was carried out on the aircraft on 23 June 2010 at 72 hours airframe time. As an amateur built aircraft, EI-HAM was operated under a Flight Permit issued by the Irish Aviation Authority (IAA). The Flight Permit was issued on 8 September 2010 and was valid for one year. The aircraft was properly maintained in accordance with the 'Maintenance Schedule for ILAS Administered Permit to Fly Aircraft'.

1.6 Engine Suppliers

The Investigation made contact with the engine suppliers in the United States. They stated that, while they told customers to put an overflow bottle in the system, they did not supply the bottle as part of the kit. They also stated that the cap on the overflow bottle should be vented, although it should not be a pressure cap.

1.7 AAIU Field Investigation

The AAIU Inspector on Call was informed of the accident by An Garda Síochána at 17.30 hrs on the day of the accident. Two Inspectors of Air Accidents travelled to the scene and inspected the aircraft that evening.

The aircraft battery was disconnected at the site for safety reasons. Inspection of the site identified that the aircraft had impacted heavily while under power. The propeller drive belt had sheared under tension, the three propeller blades were recovered and showed evidence of fracture upon ground impact. The engine block was intact with only minor external damage. The instrument panel was destroyed in the impact and, except for the altimeter, provided no useful information to the Investigation. The water temperature gauge and thermal switch were tested and found to function correctly. A site survey was completed on the day following the accident and the wreckage was then removed to the AAIU facility at Gormanston, County Meath for further technical examination.

Following recovery to Gormanston, the cooling system was examined. The pressure vent cap at the front of the engine was removed. A small section of the internal seal ring had fractured and separated, which may have occurred during impact. This meant that the pressure vent cap could not be tested for correct operation, however the spring mechanism was intact and operated correctly. The electrical generator and water-pump were driven by a belt from an engine-driven pulley. A small section of the pulley was damaged by rearward movement of the engine block during impact. The belt was intact. The water pump was removed and was found to rotate freely.

A section of undamaged tubing containing the thermostat was removed and tested. It was found to open fully at its rated temperature of 180 °F. However when cold, the thermostat valve did not fully close and a significant amount of coolant passed through the partly open valve.

The cooling system pipework had fractured on the port side of the aircraft at the entry point to the radiator. The fracture was due to impact forces. A small amount of coolant remained in the radiator. The expansion bottle had detached from its support bracket and contained no coolant. The expansion bottle pressure vent cap, complete with the cap seat, was located under the right seat. The radiator and associated pipework had distorted due to impact. Approximately 80% of the upper radiator surface was covered by strips of grey duct tape (**Photo No. 1**).

Photo No. 1: Radiator showing the taped upper surface

Except for the pipe fracture adjacent to the radiator, there was little damage to the cooling system pipework. On examination, it was found that the rubber seal around the expansion bottle pressure vent cap had failed under pressure from the cooling system. The expansion bottle installed on its mounting bracket and the failed vent cap are illustrated in **Photo No. 2** and **Photo No. 3** respectively.

Photo No. 2: Expansion bottle

Photo No. 3: Vent cap with failed seal

1.8 Survivability

Impact and deceleration forces were high, resulting in serious injuries to both occupants. Both seats were fitted with four-point harnesses; both the harnesses and the attachment points remained intact throughout the impact sequence and provided some restraint to the occupants. However, during the deceleration both wings had moved forwards with substantial crushing to the cockpit compartment welded-steel tubular structure. This crushing brought the occupants into contact with parts of the cockpit structure inflicting injury, and making subsequent egress difficult.

The starboard wing came into contact with an electric fence which was powered at the time and remained so until arrival of the AAIU Inspectors. Fuel from both main wing tanks spilled from their respective vent caps and posed a potential fire hazard to the occupants and rescuers.

2. ANALYSIS

Before the accident flight, approximately 80% of the upper radiator surface had been covered with duct tape, in an attempt to reduce air-flow through the radiator, reducing its cooling efficiency and raising the engine operating temperature.

During the flight, while operating at approximately 1,000 feet, the Pilot noticed the engine temperature increasing to 180 °F. It is probable that, shortly thereafter, the engine suffered an over-temperature condition causing the coolant to boil with a consequent increase in pressure. This in turn caused the engine mounted pressure cap to open allowing the pressurised coolant to pass into the expansion bottle mounted at the rear of the Pilot's seat. As this bottle was also fitted with a pressure cap, the coolant remained pressurised. The seal of the expansion bottle cap then failed, allowing coolant vapour under pressure to escape rapidly into the cockpit area. The vapour immediately condensed on the cold glazed surfaces and instrument faces, thus obscuring the Pilot's vision and necessitating an immediate forced landing.

The primary cause of the engine over-temperature condition was probably due to the taping over of a large portion of the radiator core, thus causing a significant reduction in the radiator's ability to cool the engine. Operation of the engine at climb power with a relatively high gross weight (with two occupants on board) was likely to have increased the demand on the engine cooling system during the climb. The onset of overheating may also have been affected by the lower rate of available cooling air over the radiator during the climb.

It is likely that the relatively low coolant temperatures seen by the Pilot during previous flights was due to a constant flow of coolant through the leaking thermostat and back to the radiator, which meant that the coolant temperature never rose to the expected values.

The decision of the Pilot to attempt an immediate forced landing with his vision greatly obscured was correct as engine power was still available. An engine which continues to run in an over-temperature condition is very likely to seize.

The nature of the rising ground at the immediate point of touchdown was such that high deceleration forces were experienced by the occupants, resulting in severe damage to the airframe and serious injury to the Pilot and his passenger.

Although the safety harnesses on both seats remained intact, the nature of the longitudinal crushing of the pilot compartment meant that direct impact injuries during the rapid deceleration were suffered by both occupants. The accident was survivable, but only marginally so.

Owner/operators are permitted to carry out certain maintenance functions on their aircraft according to the approved maintenance schedule under the supervision of their ILAS Inspector. Any other maintenance must be agreed with, and carried out under the supervision of their Inspector. When required work has been satisfactorily completed, the Inspector will issue a Certificate of Release to Service. Accidents such as this are a reminder of the necessity for owner/operators to exercise caution when carrying out any modifications, including those of a temporary nature, and then only under the supervision of an ILAS Inspector. In consideration of this, the AAIU makes one Safety Recommendation.

3. CONCLUSIONS

(a) Findings

1. The aircraft was operating under a valid Flight Permit.

2. The Pilot was properly licensed.

3. Due to over-cooling of the engine on previous flights, a large section of the radiator surface was taped over by the Pilot prior to the accident flight, in an attempt to reduce over-cooling.

4. The over-cooling of the engine on previous flights was probably caused by a leaking thermostat valve.

5. On the accident flight the engine suffered an over temperature condition resulting in the failure of the expansion bottle pressure vent cap seal, permitting coolant vapour to directly fill the cockpit. This vapour condensed on the cold window surfaces and faces of the instrumentation in the cockpit obscuring them.

6. The Pilot attempted an immediate forced landing due to obscured visibility of the aircraft instruments and external references.

7. The forced landing was attempted in a large field, however rising terrain in the immediate area of touchdown caused large impact forces resulting in serious injury to the occupants and severe damage to the airframe.

8. The Pilot was not able to judge the forced landing accuracy due to obscured vision.

(b) Probable Cause

Taping over of a large portion of the radiator surface lead to inadequate cooling of the engine, resulting in failure of the expansion bottle pressure cap seal.

(c) Contributory Factors

1. Positioning of the expansion bottle in the aft cockpit area.

2. Operation of the engine at climb power with a relatively high gross weight (two occupants on board) may have increased the demand on the engine cooling system during this period.

3. The onset of overheating may also have been affected by the lower rate of available cooling air over the radiator during the climb.

4. SAFETY RECOMMENDATIONS

It is recommended that:
The Irish Light Aviation Society advise its members of the risks associated with carrying out unauthorised modifications to aircraft operating under a Flight Permit. **(IRLD2011010)**

Response:
The Irish Light Aviation Society confirmed, in a communication dated 9 September 2011, that they would implement the Safety Recommendation.

- END -

In accordance with Annex 13 to the International Civil Aviation Organisation Convention, Regulation (EU) No 996/2010, and Statutory Instrument No. 460 of 2009, AIR NAVIGATION (NOTIFICATION AND INVESTIGATION OF ACCIDENTS, SERIOUS INCIDENTS AND INCIDENTS) REGULATION, 2009, the sole purpose of these investigations is to prevent aviation accidents and serious incidents. It is not the purpose of any such accident investigation and the associated investigation report to apportion blame or liability.

A safety recommendation shall in no case create a presumption of blame or liability for an occurrence.

Produced by the Air Accident Investigation Unit

AAIU Reports are available on the internet www.aaiu.ie

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