FINAL REPORT

AAIU Synoptic Report No: 2008-017
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In accordance with the provisions of SI 205 of 1997, the Chief Inspector of Air Accidents, on 02 August 2007, appointed Mr. Frank Russell as the Investigator-in-Charge to carry out a Field Investigation into this Accident and prepare a Synoptic Report.

Aircraft Type and Registration:	Enstrom F-28 C, G-WSEC
No. And Type of Engines:	1 x Lycoming H10-360-E1AD
Aircraft Serial Number:	398
Year of Manufacture:	1977
Date and Time (UTC):	02 August 2007 @ 18.40 hrs
Location:	Near Newtownmountkennedy, Co. Wicklow
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Aircraft destroyed
Commander's Licence:	See Paragraph 1.2
Commander's Details:	Male, aged 65 years
Commander's Flying Experience:	2,000 hours (of which approximately 200 were on type)
Notification Source:	AAIU advised by Gardaí from Wicklow Garda Station
Information Source:	AAIU Field Investigation

SYNOPSIS

After practising some circuits and groundwork at Newcastle Airfield, the Pilot flew westwards with the intention of crossing the high ground just south of Kilpeddar Army Range and routing via Calary Upper towards Kilmacanogue, Co. Wicklow. However, before that high ground was reached, the cockpit filled quickly with smoke; there were loud noises from the engine compartment and a total loss of engine power occurred. The Pilot turned south to find any open field in which to carry out an emergency autorotation. As there were few, if any, suitable flat fields available, the Pilot carried out a landing on an up sloping field, where the helicopter bounced on landing, before finally falling over on its left-hand side.

As the Pilot and passenger swiftly exited safely by the right side door, the forward section of the helicopter was engulfed by fire. Neither Pilot nor passenger reported any injuries during their hurried evacuation. Subsequently, the Investigation found that a major in-flight fire had occurred in the engine compartment, initiated by a fretted and leaking fuel hose.

FINAL REPORT

1. FACTUAL INFORMATION

1.1 History of the Flight

The Pilot and passenger initially flew from Kilmacanogue to Wicklow Town and then turned northwards to Newcastle Airfield, on the coast. Weather conditions for the flight were good, with excellent visibility and very little wind. At Newcastle Airfield the Pilot carried out a number of circuits, some ground work and then flew westwards towards the Wicklow hills. On this part of the flight the Pilot said that the engine began to run roughly and the oil temperature was high, but still indicating in the green. Before he could reach the summit of the rising ground of some 1,000 ft, he heard loud noises from the engine compartment and suffered total loss of power, as very white dense smoke entered the cockpit area. This smoke was so bad, the Pilot recalled, that he had no sight of the airspeed indicator (ASI) or the engine and rotor RPM gauges. The red generator light had also come on. As the helicopter was flying over a mostly wooded area the Pilot turned southwards to seek out a suitable unobstructed landing area. The Pilot recalled the Enstrom was a good glider, and during the autorotation, he said that he flew the helicopter by feel only, as the smoke seriously impaired his forward view from the cockpit. The passenger also recalled that the visibility was so bad due to smoke that he could not fully see the Pilot. Witnesses on the ground also saw smoke coming from the helicopter.

The Pilot attempted a run on landing on an up sloping grass field. Here, on the approach to land, the helicopter cut through some ESB domestic power lines, just before the first touch on. It continued uphill at least another 50 metres before coming to rest on its side, directly under ESB high-tension lines. The Pilot and passenger released their 4-point harnesses and exited the helicopter within 10 seconds. Almost immediately the helicopter was engulfed in flames, which destroyed the cabin, engine and gearbox area (**Photo No. 1**). Only the rear section of the tail boom remained recognisable and intact. Both the Pilot and Passenger were shocked by their experience but otherwise unhurt. The Fire Services were quickly on the scene and contained the fire from destroying the rear of the tail boom and tail rotor section. The Gardaí secured the accident site until AAIU Inspectors arrived. Later ESB technicians switched off the power supply in the area for a number of hours as a precautionary measure.

Photo No. 1: Accident Site and burnt remains of G-WSEC

1.2 Commander's Licence

The Pilot, who is also the registered owner of the aircraft, was asked as a matter of routine by the Investigation to produce his flying licence and last medical certificate some days after the accident. In reply, he said that such flight documents he possessed were in a bag that he always kept on board the aircraft. These may have been destroyed in the aircraft fire, he said. The Investigation could not find the remains of any bag, which might have verified this statement; such was the level of fire destruction to the cockpit area. The Pilot was then given ample time, which eventually ran into months, to produce copies of his licence and medical certificate from the appropriate licensing authorities. In this case it was understood by the Investigation to be the USA Federal Aviation Administration (FAA).

As no such documents were forthcoming, the Investigation contacted the IAA, the UK Civil Aviation Authority (CAA) and the USA FAA, where a search revealed that there was no record of the Pilot having a current licence in any of those jurisdictions. To date, the Pilot has not produced a valid licence from these or any other jurisdiction. This is in contravention of the normal Aviation Regulatory Requirements in any jurisdiction.

1.3 Technical Investigation

The helicopter was moved to the AAIU facility at Gormanston for a detailed technical examination. It was noted that considerable melting of aluminium components in the engine compartment had occurred. This included lower sections of the crankcase and the left side cylinders. In addition both fuel tanks, which are located above the engine compartment, had melted away completely. After the accident, the helicopter was lying on its left-hand (LH) side. Consequently when the LH cylinder barrels melted completely, they flowed downwards to the left side of the helicopter. The right cylinders also showed signs of severe heat distress but had not melted and flowed downwards. The LH side of the engine bay contained lumps of aluminium alloy where the melted aluminium had pooled and later solidified as it cooled. In this area, icicles of solidified aluminium had formed. The orientation of these icicles indicated that the melting and re-solidification had taken place while the helicopter was lying on its LH side, i.e. after the helicopter had landed and fallen over onto its LH side. This indicated that the melting, and the associated intense fire, in this area had taken place after the helicopter had landed. However just forward of the engine, close to the location of the turbo-charger, a piece of aluminium was found that had solidified when the helicopter was in a vertical position.

On further examination of the helicopter, a length of fuel hosing was discovered. This hose was found loose in the engine bay. Examination of this hose showed that a hole had been worn through the side of the hose. Further investigation of the hose showed:

- It was a Lycoming Part Number LW-12878-4S260, which has one end wrapped in foil by the helicopter manufacturer, which turns the part into Enstrom part Number 28-12463-1. **Photo Nos. 2** and **3** show this hose as found on an undamaged Enstrom helicopter. **Figure 1** shows the schematic location of the hose.
- It carried a tag that gave a manufacturing date of 1989.
- The hose connected the fuel control unit (fuel servo) that is located under the engine with the fuel distributor/divider that is located on top of the engine.

- The purpose of the hose is to carry fuel from the fuel control unit (fuel servo) to fuel distributor/divider, with a nominal working pressure of 24 PSI.
- Both ends of the hose were normally screwed into aluminium fittings. These had melted, which accounted for the hose being found loose in the engine compartment.
- The hole was worn approximately 7 inches from the fuel control unit (fuel servo) end of the hose.

Consultation with the helicopter's manufacturer indicated that at a point approximately 7 inches from the fuel control unit (fuel servo) end of the hose, the hose is routed between the oil outlet line and the magneto. At a point 7 inches further along the hose, it is normally secured by a clamp to prevent contact with the adjacent oil line or the magneto. The damaged section of this hose is shown in **Photo No. 4**.

1.4 Engine Information

The helicopter's stainless steel engine data plate was recovered at the accident scene. It had separated from the engine as the section of the engine, on which it was mounted, had melted. This indicated that the engine was a Lycoming HIO-360-E1AD, s/n L-18105-51A. The logbook supplied by the owner was for this engine serial number. The logbook shows that Lycoming last overhauled this engine in their Williamsport facility, on 26 October 1998, on Work Order A-5809.

1.5 Helicopter Log Books

The airframe logbooks recorded no flying time entries since July 2002. The last STAR annual inspection is dated 28 June 2005. In the engine logbook, the last flying time entries are July 2002. The last engine annual inspection is dated 15 March 2003.

1.6 Other Documents

Detailed examination of the helicopter's cockpit area failed to find any traces or remnants of any logbooks or licences or the POH (Pilot's Operating Handbook).

1.7 Other Information

The helicopter had operated in Ireland for a number of years prior to this accident. The Pilot/Owner took legal possession of G-WSEC on 04 April 2007, just four months before this accident. He had been in contact with a UK licenced engineer in May 2007 to have him come over to Ireland to carry out the required Annual Inspection sometime in August 2007, however the accident intervened.

2. ANALYSIS

2.1 Operational Analysis

Autorotation is a condition in which the rotor of a helicopter is driven solely by the action of the air ascending through its blades rather than by engine power. In helicopters, descending with the power off, air flows in the reverse direction upward through the main rotor, causing it to continue rotating at cruising RPM. To maintain this rotor RPM, the helicopter is allowed to descend by lowering the collective lever so that the relative airflow strikes the blade in a manner in which the airflow itself provides the driving force. Under these conditions, the rate of descent becomes the power equivalent, and the helicopter is said to be in a state of autorotation.

Autorotation landings are practiced to train pilots to enable them to land the helicopter in case of an actual engine failure. Various expressions used by pilots while carrying out autorotations are autorotative landing, touchdown autorotation, or autorotation to touchdown. All these mean that the pilot will land without applying power to the rotor.

A critical factor in any autorotation is that the pilot must maintain the minimum airspeed, as outlined in the Emergency Section of Helicopter Operations Manuals, all the way down to the flare height, which is normally about a rotor diameter above the landing point. This means that the angle of descent in an autorotation is very steep and the pilot must make a rapid decision to select an unobstructed flat landing zone, if at all possible. Such a decision can be most critical, as there is no second chance in these circumstances.

In the subject event, the Pilot was flying westwards towards rising and mostly wooded mountain slopes. As smoke entered the cockpit he felt that his helicopter was beginning to loose power, as his forward visibility reduced. He quickly realised that he must turn away from this wooded area underneath his flight path, while he still had time. This he did and, as the engine suffered total power loss, he put the helicopter into autorotation in the direction of a large green field. However, unknown to the Pilot, and most likely unseen by him as well, there were two sets of ESB wires criss-crossing this green field. A wire strike on the helicopter as it approached probably further distracted the Pilot, as he endeavoured to land on the difficult up sloping field. This first landing was heavy, as evidenced by the deep witness skid marks in the ground and bits of perspex and other debris strewn along the ground. These continued some 50 metres to the helicopter's final resting position at the top of the rising ground, which was directly underneath ESB high-tension wires. In spite of the rapidly spreading fire the Pilot and passenger managed to exit the helicopter safely.

Engine-on autorotations are regularly practiced by pilots against the day when they might have to carry out an 'engine-off' autorotation in real-time. In such circumstances, there is a saying among helicopter pilots that being able to walk away from an emergency autorotation is, by definition, a successful autorotation. In this accident, with its doubly demanding circumstances of seriously impaired visibility and engine failure, the Pilot can indeed be considered to have carried out a successful autorotation.

2.2 Technical Analysis

The vertical aluminium alloy icicle (noted above in 1.3) indicates that a substantial fire was already burning, and had achieved the melting point of aluminium (approximately 600º C), while the helicopter was still in the normal vertical (flying) position. This indicates that a fuel-fed fire occurred prior to the landing and that this fire was located forward of the engine, in the engine bay.

The fuel hose damage is consistent with wear or fretting damage over an extended period of time. The contact with either the magneto or the oil pipe was probably caused by the absence of the securing clamp, the mispositioning of the clamp, or distortion of the clamp in subsequent maintenance. The result was that contact between the hose and the oil pipe or magneto was not prevented. Due to the extensive melting in this area, it is impossible to make a definite determination regarding these alternative possibilities. The mechanism of such fretting failure in this type of hose is that an external item (such as the oil pipe or magneto in this case) wears through the outer protective layers of the hose and then starts to wear through the metal braid.

When the circular continuity of the braid is destroyed (i.e. it has completely worn through at one section of the circumference) the fretted ends of the braid turn inwards and pierce the inner wall of the hose, producing tiny pinholes. In this case, the Avgas fuel in the hose, under a pressure of 24 PSI, then exited through these small holes in a very fine spray. Because the fine spray had a very large surface area, and was sprayed into a hot engine bay, it vaporised readily and quickly.

Thus the exiting fuel was converted into fuel vapour, which easily ignited. In the area of the leak, a number of vapour ignition sources were available, particularly the engine exhaust manifold and the exhaust-driven turbo-charger.

Another effect of the leak would have been to reduce the fuel supply to the engine. This would have resulted in the initial loss of power, as reported by the Pilot.

When the fuel vapour initially ignited in the engine bay, the fire was probably small, due to the limited escape of fuel from the pinholes in the fuel hose. This initial small fire probably accounted for the increase in oil temperature observed by the Pilot. As the temperature in the engine bay rose, further damage to the engine would have resulted. Such damage would probably have included melting and burning of the fuel hose, thereby increasing the fuel supply to the fire. The situation would then have escalated rapidly, causing a major loss of power and producing thick smoke that entered the cockpit area, probably through the cabin ventilation and heating system.

Because of the high level of vibration found in helicopters, it is essential that all hoses and wires be properly secured to avoid fretting against adjacent items and structures. Thus, when a clamp is missing or misaligned, the high vibration levels can result in serious fretting damage.

As the helicopter has no recorded maintenance since 2005 and no recorded engine maintenance since 2003, the helicopter's UK CAA Certificate of Airworthiness was not valid at the time of the accident.

Lycoming, who performed the last engine overhaul in 1998, has informed the Investigation that it is their policy to replace all flexible hoses, such as the hose that failed in this accident, during an engine overhaul. The Investigation has not been able to determine why a hose manufactured in 1989, nine years prior to the overhaul, was fitted to the helicopter at the time of the accident. However the Investigation would point out that the records for this helicopter were poorly maintained since 2002, and not maintained at all since 2005, which is two years prior to the accident.

The experience of the AAIU is that substantial documents such as logbooks invariable survive a fire in a recognisable condition, albeit severely damaged. The absence of such remnants after the accident is rarely consistent with such documents being present before the event.

It is a matter of concern that this helicopter had continued to operate for several years in Ireland, despite it not having a valid Certificate of Airworthiness, and without recorded maintenance for several years.

During this Investigation, an Airworthiness Directive, 2008-14-07, was issued by the US FAA. This related to cracking of the stainless steel fuel lines in injected Lycoming engines such as that fitted to G-WSEC. The Investigation examined the lines in question and found no evidence of cracking.

3. CONCLUSIONS

(a) Findings

1. The Pilot carried out a successful autorotation in the trying circumstances of dense smoke in the cockpit and subsequent engine failure.

2. The Pilot, while advising the Investigation that he had accumulated approximately 2,000 hours over his flying career, did not produce any evidence of associated flight time logbooks or a valid flying licence and medical certificate.

3. The Certificate of Airworthiness for G-WSEC, which was last renewed by the UK CAA on 29 June 2005, was no longer valid as a consequence of the failure to maintain the aircraft in accordance with the relevant approved maintenance schedule. This is contrary to Article 10 of the UK Air Navigation Order.

4. The fuel hose from the fuel servo to the fuel distributor came into contact with the adjacent structure, due to a missing or misaligned securing clamp.

5. Fretting of this fuel hose eventually resulted in a fuel spray that ignited and created a major fire in the helicopter's engine bay.

6. Smoke from this fire entered the cockpit, possibly through a compromised cockpit heating system, causing the pilot to loose external visibility.

7. The loss of fuel, due to the fuel leak, would have cause the engine to lose power.

8. The initial small fire quickly increased in size and caused major damage to the engine and ultimately caused the engine to fail.

(b) Cause

A missing or misplaced clamp that secured the fuel hose probably caused the initiating failure. As a result, this hose fretted against the adjacent structure and ultimately developed a fuel leak. The ignition of the leaking fuel lead to the loss of the helicopter.

(c) Contributory Cause

Maintenance of the helicopter had failed to detect that significant fretting of the fuel hose was taking place over an extended period of time. In light of the poor maintenance history of this helicopter, the possibility of detecting such a developing fault was compromised.

4. SAFETY RECOMMENDATIONS

This Investigation does not sustain any Safety Recommendations.

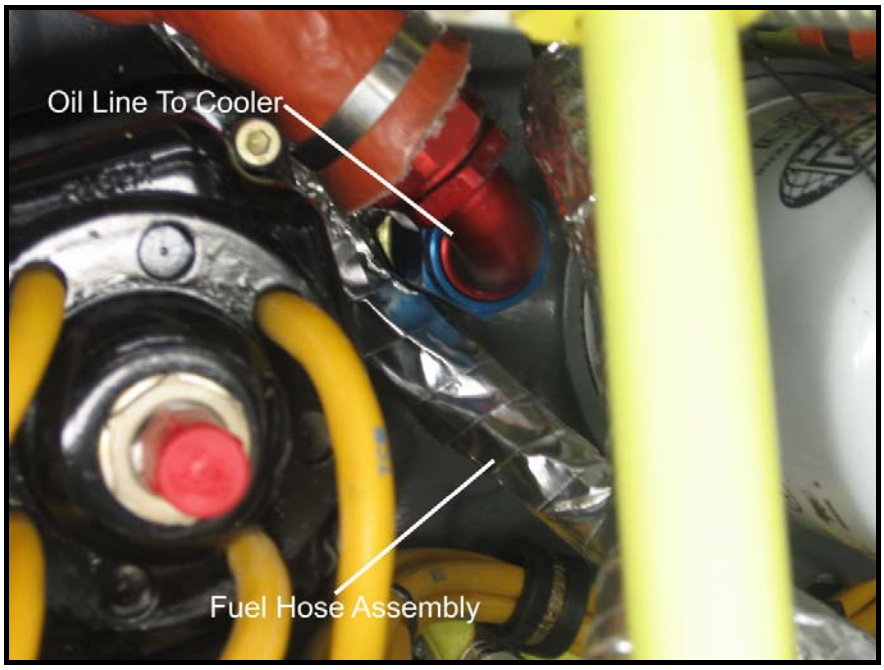

Photo No. 2: A view of the Fuel Hose showing the relative location of the Oil Pipe. (Photo taken from an in-production Enstrom F28F)

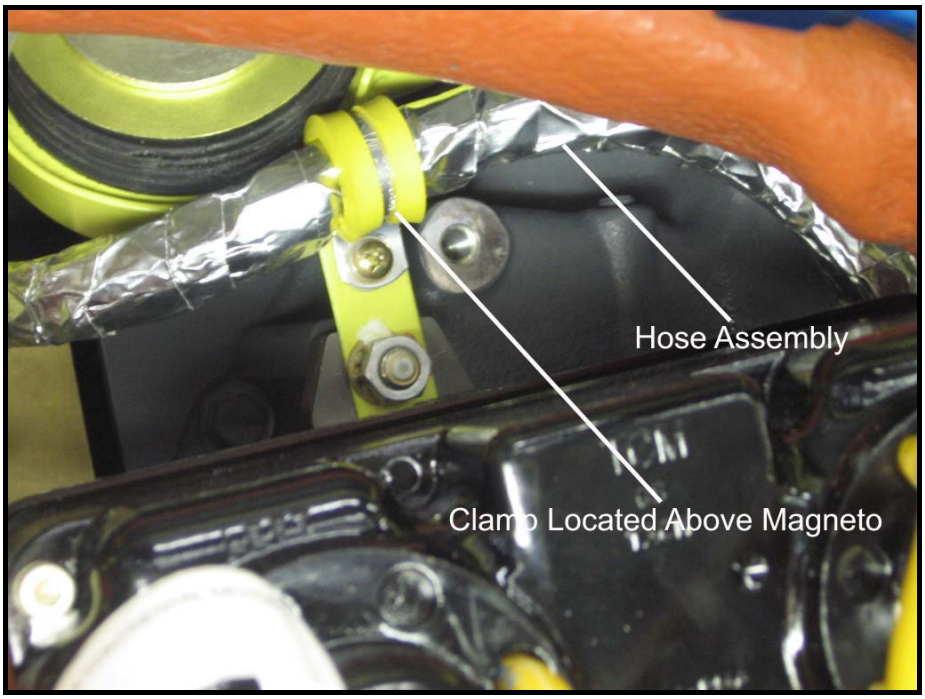

Photo No. 3: A view of the Fuel Hose showing the relative position of the Magneto and the securing clamp. (Photo taken from an in-production Enstrom F28F)

Photo No. 4: Damaged Fuel Hose of G-WSEC showing the hole, worn through the metal braid as a result of the contact and fretting action. (The rubber material of the hose has been burned away.)

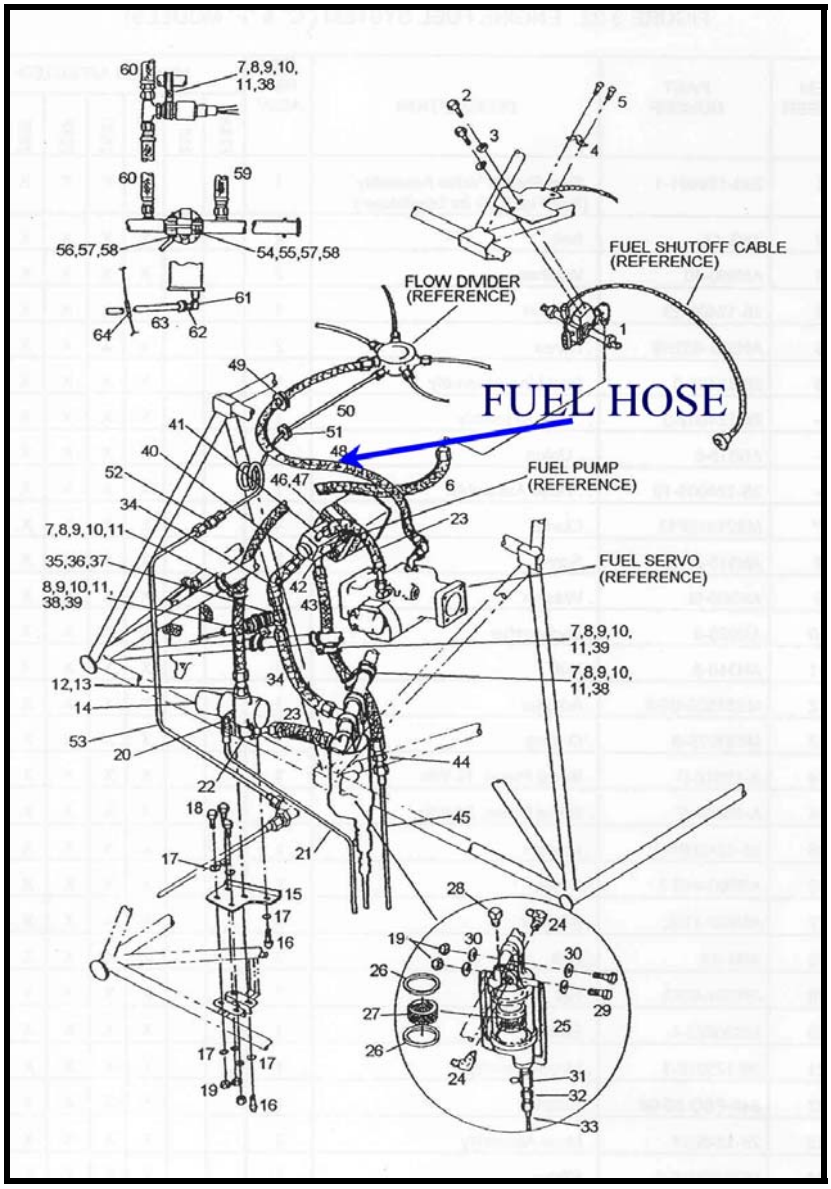

Figure 1: This shows the schematic location of the fuel hose.

- END -