AS355F2, G-EPOL

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INCIDENT

Aircraft Type and Registration:	AS355F2, G-EPOL
No & Type of Engines:	2 Allison 250-C20F turboshaft engines
Year of Manufacture:	1983
Date & Time (UTC):	3 June 2000 at 1225 hrs
Location:	Boreham Airfield, Essex
Type of Flight:	Public Transport-Police Operations
Persons on Board:	Crew - 1 - Passengers - 2
Injuries:	Crew - None - Passengers - None
Nature of Damage:	Minor electrical damage
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	39 years
Commander's Flying Experience:	3,805 hours (of which 281 were on type)
	Last 90 days - 55 hours
	Last 28 days - 25 hours
Information Source:	AAIB Field Investigation

History of the flight

Shortly after the helicopter had levelled at 2,000 feet agl following a normal departure with two passengers on board, the pilot noticed the No 1 (left) engine fire warning caption illuminate briefly. He immediately turned back towards the departure airfield and during this turn the fire caption illuminated once again and remained ON. The pilot therefore shut down the No 1 engine and monitored the fire warning light in accordance with the Flight Crew Checklist actions; however the fire warning remained illuminated and so he activated the No 1 engine fire extinguisher. This action did not extinguish the fire warning and he therefore selected the second (ie the No 2 engine) fire extinguisher to discharge into the No 1 engine compartment. However, the No 1 engine fire warning remained illuminated and a strong smell of burning became apparent in the cabin. (The

rear seat passenger later stated that the burning smell may have been present after the first engine fire extinguisher was activated, but the front seat passenger and the pilot were not sure of this).

The pilot contacted ATC and the helicopter's base advising them of his intention to carry out a forced landing. The rear seat passenger then noticed smoke under the instrument panel coaming and upon further examination it was found that the smoke was emanating from an electrical panel adjacent to the pilot's left knee in the area below his collective lever. The smoke became noticeably denser over a very short period of time and the pilot then conducted a successful 'run-on' forced landing on an open grassed area of the airfield. The occupants vacated the helicopter after the pilot had shut down the No 2 engine, applied the rotor brake and switched off all electrical supplies. Once outside the helicopter, the pilot and his passengers did not see any evidence of fire in the engine area of the helicopter.

Engine fire extinguishing system description

A schematic diagram of this system is attached at Appendix A. The helicopter was equipped with two fire bottles which were activated by electrically fired explosive 'squibs'. Each fire bottle had two discharge heads, each equipped with a squib, so that each fire bottle could be discharged into either engine compartment, depending upon which squib was fired. Mounted in the associated switch panel in the roof of the cockpit were four push button 'latch- ON' switches, one for each squib. On the left hand panel were the two switches for the No 1 engine compartment fire extinguishant and on the right hand panel were the two switches for the No 2 engine compartment fire extinguishant. Selection of any of these four switches supplied aircraft direct current (DC), through current limiting resistors, to the associated squib. There were two circuit boards on which these current limiting resistors were mounted; one circuit board for the No 1 engine latch-ON switches was located in a panel in the lower right hand side of the central console, below the right collective lever; and the No 2 engine circuit board was in a panel in the cockpit roof. Each firing circuit was protected by a 6.3 ampere circuit breaker. Once activated, the explosive squibs were designed to fire in less than one millisecond and the associated filaments then usually melt and become 'open circuit'; however occasionally such squib filaments do not melt on activation and remain 'closed- circuit'.

Engineering examination

Engineers from an approved maintenance organisation examined the helicopter after this incident and found that the circuit board (card reference number 19 alpha 2, part number 355A67.7532 02) and four current limiting resistors for the No 1 engine latch-On switches had severely overheated to the extent that severe burning and charring of the board material had occurred. None of the protection circuit breakers for the engine compartment fire extinguisher system had tripped. Examination of the No 1 engine compartment revealed no evidence of any fire, but the engineers did find a broken electrical connection to a terminal block within the fire detection system, which would have caused the No 1 engine fire warning. This failure was attributed to vibration of the unsupported electrical wire near its connection to the terminal block, which they considered a not uncommon failure from their experience on this helicopter type. The 'spent' explosive squibs from the two fire bottles were scrapped by the maintenance organisation and were therefore not subsequently available for examination.

Sequence of events

The above findings indicated that a false No 1 engine fire warning had been initiated by the failure of the broken electrical connection to the terminal block within its fire detection system. After the pilot had activated the No 1 engine fire extinguisher system in response, the evidence indicated that one of the two fire bottle explosive squib filaments had not melted on firing and therefore maintained its closed circuit state. This intact filament had allowed the DC current to continue to flow through the current limiting resistors as the current shorted to 'ground' through the filament. As a result of passing the shorted current, the associated resistors had suffered severe overheating and had burnt the circuit board material on which they were mounted, generating the observed smoke from the lower right hand side of the central console where the No 1 engine circuit board was located, below the right collective lever.

Previous occurrences

Three previous occurrences of overheating of such circuit boards were found on the CAA's occurrence database and two of these appeared very similar to this incident. Following the first two occurrences, the CAA had brought this problem to the attention of the French aviation authority, the Direction Generale De L'Aviation Civile (DGAC), which responded in September 1997 with a Flight Manual addition which required the pilot to release the push button 'latch-ON' engine bay fire extinguisher switch(es) after activation. This Flight Manual amendment had been incorporated into the AS355N Flight Manual at that time and the DGAC reportedly had intended to incorporate it into the AS355F Flight Manual in 1998. However, this Flight Manual amendment had not been incorporated into the AS355F Flight Manual at the time of this incident.

Whilst this Flight Manual addition evidently represented a means of providing a rapid safety response to this problem when it was first recognised, in view of the operational implications of this type of overheating occurrence in flight with the attendant smoke release into the cockpit, it was considered that this operational approach alone did not provide a satisfactory permanent solution to this problem.

In addition, the CAA database contained a number of occurrences of spurious engine bay fire warnings which had resulted from electrical wiring failures on such helicopters. The majority of these had resulted in an engine being shutdown in flight, the engine bay fire extinguisher being activated and a precautionary landing being carried out.

Safety recommendations

In view of the above findings arising from this investigation, the following Safety Recommendations are made:

Recommendation 2000-62

It is recommended that Eurocopter, in conjunction with the DGAC, should amend the AS355F Flight Manual in a similar manner to the AS355N Flight Manual addition made in September 1997, to require pilots to reset fire extinguisher push button switches to 'OFF' after engine compartment fire bottle activation in order to prevent potentially severe overheating of the associated current limiting resistors and circuit boards, due to electrical shorting through fire bottle squib filaments if any such filaments do not melt upon squib activation.

Recommendation 2000-63

It is recommended that Eurocopter, in conjunction with the DGAC, conduct a design assessment of the engine compartment fire extinguishing system on AS355 helicopters with a view to modifying the system so that the associated current limiting resistors do not suffer potentially severe overheating due to electrical shorting through a fire bottle squib filament if it fails to melt upon squib activation; progress on this recommendation should be monitored by the UK CAA.

Recommendation 2000-64

It is recommended that Eurocopter review the incidence of spurious engine bay fire warnings caused by vibration induced failure of electrical wiring connections on AS355 helicopters and modify, as required, the associated wiring connections within the engine bay fire detection system to reduce the incidence of such failures, as far as practicable.

Eurocopter response to recommendations

Eurocopter responded to these recommendations by updating the AS355 E/F/F1/F2 Flight Manuals to reflect the applicable content of the AS355N Flight Manual, as recommended in Safety Recommendation 2000-62, and these amendments were approved by the DGAC on 20 December 2000.

With regard to Safety Recommendation 2000-63, the manufacturer responded that:

' Eurocopter do not envisage any modification on engine extinguishing system..'

The reason for this reaction appeared to be that the manufacturer adopted the view that, since this incident was initiated by a spurious engine fire warning, the appropriate action required was to seek to reduce the incidence of such false fire warnings. Eurocopter's response stated:

' Two kinds of problems are now described on AS 355F: smell of burning on board and false engine bay fire detection - but without any "real" fire on board. This implies that the main dreaded event is spurious engine bay fire warnings.

The spurious engine bay fire warning occurrences we have analysed show that 2 main origins are identified:

1. Broken electrical connection on fire detection system localised very close to the detectors,

2. Problem of failures on detectors themselves.

Eurocopter proposed to DGAC to implement precautionary measures: Today, there is no maintenance on the AS 355 F engine bay fire detection installation. Generally speaking, Eurocopter have proposed to implement maintenance as it is already existing on (the) Arrius engine (Turbomeca responsibility):

1. On electrical connection:

***** Revision of install/removal work card to introduce the use of seal putty (silicon) to strengthen the lugs

***** Checks of wires and electrical continuity at visit T or A.

2. On the detectors:

***** Checks at visit T or A

***** Detector cleaning procedure to be applied at visit 3T or A.

The corresponding work cards and PRE will be given to DGAC at the end of January 2001.

All these maintenance operations will significantly decrease the quantity of spurious warnings and consequently the number and use of the engine fire extinguishing system.'

The AAIB acknowledges the manufacturer's rapid action in response to two of the Safety Recommendations made as a result of this investigation. However, whilst the improved maintenance requirements for the engine bay fire detection system may satisfy to a reasonable extent the aim of Safety Recommendation 2000-64 to reduce the incidence of engine bay fire warning system failures as far as practicable, the manufacturer's apparent decision not to address the question of the design of the engine bay fire extinguisher system current limiting resistors and pyrotechnic squibs (Safety Recommendation 2000-63) was regretted. If this aspect is not addressed, whilst the incidence of spurious engine bay fire warnings may reduce due to the other measures, when such a warning does occur the chance will remain of overheating of the current limiting resistors, with the generation of smoke in the cockpit. The appearance of smoke in the cockpit of such police helicopters, which can operate at night over densely populated areas, could lead to serious accidents.