**INCIDENT**

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| **Aircraft Type and Registration:** | Eurocopter EC155 B1, G-ISSV |
| **No & Type of Engines:** | 2 Turbomeca ARRIEL 2C2 turboshaft engines |
| **Year of Manufacture:** | 2006 |
| **Date & Time (UTC):** | 10 March 2007 at 1801 hrs |
| **Location:** | Norwich Airport, Norfolk |
| **Type of Flight:** | Public Transport |
| **Persons on Board:** | Crew - 2 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Fire damage to hoist electrical connector and oil cooler support fairing |
| **Commander's Licence:** | Airline Transport Pilot's Licence |
| **Commander's Age:** | 46 years |
| **Commander's Flying Experience:** | 5,107 hours (of which 47 were on type, including 30 hours simulator training)<br>Last 90 days - 97 hours<br>Last 28 days - 28 hours |
| **Information Source:** | AAIB Field Investigation |

**Synopsis**

The aircraft was being refuelled on the ramp with the rotors running when a localised fire broke out in the area of the external connector for the electric hoist, on the upper right side of the fuselage. The fire went out as soon as electrical power was removed on shutting down the engines.

The investigation established that the fire was caused by the 28 volt DC electric hoist power supply shorting to the body of the hoist's fixed electrical connector and earthing through the carbon fibre composite fairing on which the connector is mounted. The short was probably caused by moisture ingress into the connector due to a damaged seal. A contributory factor was that the connector is always live whenever the electrical system is powered.

Three safety recommendations are made to the aircraft manufacturer.

**History of the flight**

The aircraft landed back at Norwich Airport after an uneventful VFR flight of 1 hour and 41 minutes to five North Sea platforms.

After disembarking the passengers on the operator's ramp at Norwich, a rotors-running refuel was commenced. One engineer supervised the refuelling at the hose connector at the rear of the fuselage and another stood at the front left door. The co-pilot then disembarked to obtain a weather update and check the load for the next

sector. The wind at the time was from 240º at 10 kt. A company Sikorsky S-76 was parked approximately 25 metres directly behind G-ISSV.

Soon after the co-pilot returned to the aircraft, both crew members smelt an odour of 'antiseptic', which grew stronger with time. They initially thought it was emanating from the nearby aircraft paint hangar and asked the engineer at the front left of the aircraft to investigate. The engineer observed wisps of smoke coming from the right side of the helicopter and after crossing over to its right side, saw six-inch flames emanating from the hoist connector, which were being blown towards the engine intake. He signalled to the commander to shut the aircraft down and stopped the refuelling. The crew of the S-76 also saw the flames, which they described as resembling those of a "gas ring burner". The commander of the S-76 immediately radioed the crew of G-ISSV on the ATC ground frequency to inform them that they had an engine intake fire. The flames disappeared as soon as the engines were shut down.

The AFRS were summoned by ATC and were quickly in attendance, but the fire had already gone out by the time they arrived at the aircraft.

Throughout the incident there were no indications in the cockpit of a fire. The time from the crew sensing the unusual smell until the engines were shut down was approximately 63 seconds.

**Aircraft information**

*General*

The EC155 B1 is a twin-engine helicopter that can accommodate up to 12 passengers and two crew. The basic structure of the aircraft is of aluminium alloy, but composite materials are widely used in its construction.

G-ISSV was manufactured in 2006 and commenced operations from Norwich Airport in December 2006. The aircraft was primarily used to transport oil industry personnel to and from offshore platforms.

At the time of the incident it had flown 110 hours since new. There were no deferred defects recorded in the technical log.

*Mission selector switch*

The mission selector switch is a three-position switch, located on the overhead panel, which enables the crew to activate either the electric hoist or the cargo sling. The crew's pre-start checklist required them to check that the switch was in the OFF position.

*Electric hoist*

The aircraft was delivered with option 'OP 45C07', which provides the wiring and hard points to accommodate a removable electric hoist but the operator had never installed one, as it was not required for the company's operations. The hoist is fixed to the upper right side of the helicopter and its electrical connector plugs into a fixed connector mounted on the oil cooler support fairing (Figure 1). According to the manufacturer, around 45 EC155 helicopters have been delivered with the hoist option to date.

**Figure 1**

Location of EC155 Hoist Fixed Connector (circled)

The hoist's fixed connector, identified as '24 DELTA', is manufactured from a part number CA3106F32-6PBF80 MIL-C-5015 specification circular bayonet connector. The female half of the connector is mounted on the sloping surface of the oil cooler support fairing on the engine deck and protrudes through the fairing. The fairing is constructed of carbon fibre composite material and is secured to the aircraft aluminium alloy structure by metal screws around its periphery.

When the hoist is not installed, a blanking or 'shunt plug' must be installed on the fixed connector. The shunt plug comprises the male half of the MIL-C-5015 connector, which has been modified in accordance with the helicopter manufacturer's specifications. The modifications include soldering a wire between two of the pins, to provide continuity for the monitoring circuit for the wire-cutting squib, and filling the backshell of the plug with potting compound.

The hoist connector provides the 28 volt DC power supply, and earth return, for the hoist's electric motor, the command signals for the hoist and a signal to fire the hoist emergency wire-cutting squib. The power for the hoist motor is supplied from electrical master box '2 ALPHA', located in the nose of the helicopter. The electrical circuit is protected by a single 130 ampere fuse and the supply to the hoist connector is live whenever the aircraft generators are on line, even if the mission selector switch is in the OFF position. The power supply is wired to contact 'W' of the connector and the earth return for the hoist motor is via contact 'X'. There is no means provided for the crew to switch off the 28 volt DC power supply for the hoist motor.

The connector incorporates an elastomeric seal, located at the interface of the mating surfaces between the two halves of the connector, which renders it weatherproof. The connector was originally designed with an O-ring type seal, which locates in a machined groove in the body of the fixed connector. G-ISSV's hoist connector, and other new connectors examined, were found fitted with square cross-section seals, but all nevertheless retained the groove for an O-ring seal. It is not clear when the change of seal type occurred, or why this change was effected.

**Aircraft examination**

The aircraft was examined in the operator's maintenance hangar at Norwich Airport. The hoist connector was fire damaged and the right side of the oil cooler support fairing was badly charred in the vicinity of the connector (Figure 2). Localised charring was also visible at three fastener locations around the edges of the fairing, where it attached to the aluminium framework of the fuselage. The fire damage was more evident on the external side of the connector and the fairing.

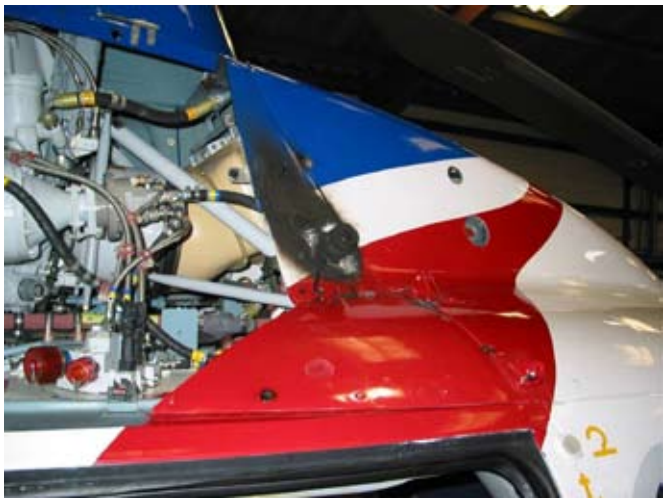

**Figure 2**

Fire damage to hoist fixed connector and oil cooler support fairing

*Hoist connector examination*

The fire-damaged connector was examined at the helicopter manufacturer's facility in France. On

disassembly, evidence was found of arcing between the power contact ('W') and the body of the connector (Figure 3). The burning damage to the inner surface of the body was in the plane of the interface between the fixed connector and the shunt plug. The elastomeric insulator material in the vicinity of the power contact was heavily charred and partly burnt away. The heat damage was greatest in the vicinity of the power contact and the area of shorting on the connector body. The other contacts were free from significant heat damage.

Closer examination of the other contacts revealed the presence of verdigris deposits (the green deposits found on copper) on several of the pins and pin sockets. No evidence was found of any foreign object having been trapped between the fixed connector and the shunt plug.

The environmental seal between the two parts of the connector was destroyed in the region closest to the power and earth pins. The remaining 60% of the seal was heat affected, but intact. Examination showed that it was deeply indented around the circumference due to being crushed against the sharp edge of the O-ring groove (Figure 4). Several deep circumferential cuts were also visible on one part of the seal circumference.

**Figure 4**

Damage to hoist connector environmental seal

**Figure 3**

Evidence of arcing between power contacts and body of connector

The quality of the potting on the shunt plug was found to be satisfactory and no potential leak paths for moisture through the potting were found.

*Fixed connector orientation*

It was noted that the fixed connector on G-ISSV was installed with the power and earth contacts lowermost. The connector on another of the operator's recently-delivered EC155 helicopters was similarly oriented. However, inspection of another new EC155 at the aircraft manufacturer's facility showed that the fixed connector on this aircraft was installed with the power and earth contacts facing aft (Figure 5).

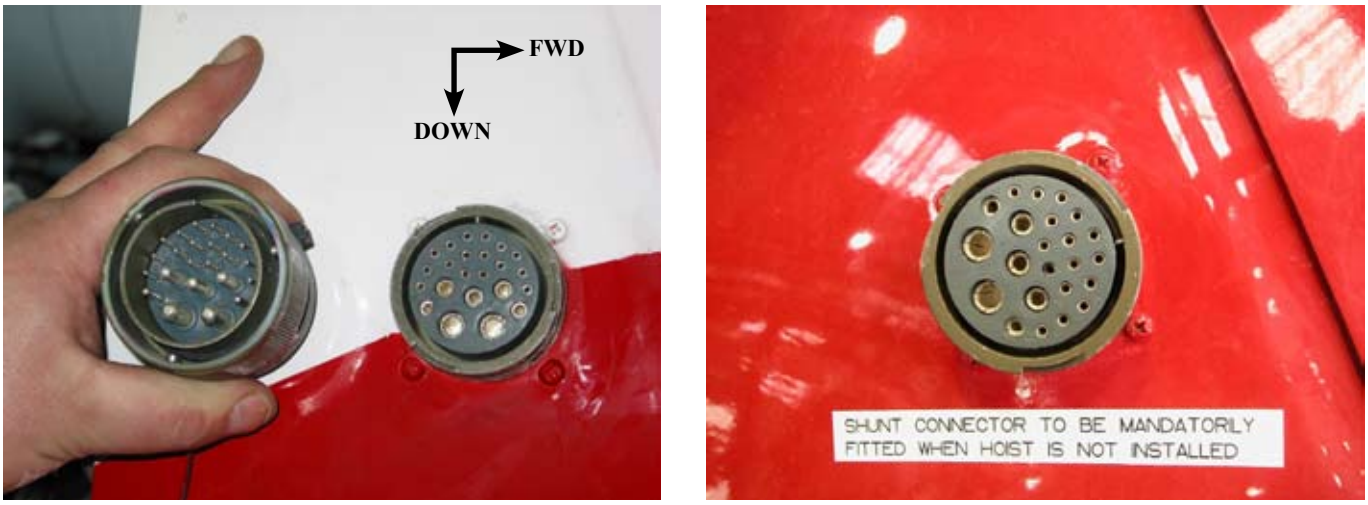


**Figure 5**

Differing orientations of hoist fixed connector

The orientation of the fixed connector is not specified in the instructions for installing the connector at aircraft build.

**Additional information**

*Previous hoist connector fire*

The AAIB became aware of a previous hoist connector fire in 2005 on an EC155 in China. Photographs of the fixed connector and shunt plug from this aircraft showed that the damage was very similar to that found on G-ISSV, with evidence of arcing between the power pin and the body of the shunt plug. The fixed connector on this aircraft had also been installed with the power and earth contacts facing downwards. No definitive cause for the fire was established.

**Analysis**

*Hoist connector damage*

The strip examination of the fixed connector and shunt plug showed that arcing had occurred between the positive contact 'W' for the hoist motor and the body of the connector. The fire damage to the panel and the charring around the three fastener holes is indicative that electrical current passed through the carbon fibre fairing and earthed to the aircraft structure. The electrical resistance of the shorting path was sufficiently high that the resulting current did not exceed the 130 ampere rating of the fuse.

The similarity of the damage observed on the hoist connector in the previous incident in 2005 suggests that both fires were caused by similar mechanisms.

*Cause of arcing*

In order for the positive supply to the hoist connector to short to the connector body, a conductive medium must be present. It was initially thought that a foreign object might have become trapped between the fixed connector and the shunt plug, prior to installation of the shunt plug. However, if this had been the case, it is unlikely that the aircraft would have been able to complete over 100 flight hours prior to the incident occurring and, furthermore, no evidence of a foreign object was found.

The widespread presence of the verdigris deposits on the hoist connector contacts suggests that moisture was present within the connector. Whilst it should

have been resistant to the ingress of moisture, given that it was equipped with an environmental seal and the quality of the potting of the shunt plug was acceptable, the cuts in the seal could have provided a path for moisture from rain or aircraft washing, to enter the connector over a period of time. Once inside, it could have accumulated in the small gap at the interface of the fixed connector and shunt plug, until sufficient moisture was present to cause a short circuit.

The use of a square-section seal, whilst retaining the groove for an O-ring on the seal land, provides the potential for the seal to be damaged by being compressed against the sharp edge of the O-ring groove when the connector halves are assembled. To address this issue, the following Safety Recommendation is made:

**Safety Recommendation 2007-072**

It is recommended that Eurocopter modify the method of sealing the hoist connector '24 DELTA' on EC155 aircraft, to ensure that it is effective in preventing moisture ingress into the connector.

In this and the previous hoist fire incident, the fixed connector was installed with the power and earth contacts facing downwards. This orientation of the contacts could increase the likelihood of an electrical short if moisture is present within the connector. To reduce the likelihood of shorting, the following Safety Recommendation is made:

**Safety Recommendation 2007-073**

It is recommended that Eurocopter determine the most appropriate orientation for mounting the EC155 hoist fixed connector to minimise its susceptibility to shorting from moisture ingress.

*Hoist motor power supply*

The electrical supply to the hoist's fixed connector is, by design, live whenever the aircraft generators are on line. There is therefore no way for the flight crew to isolate the supply to the connector, other than taking the generators off line, or shutting down the engines, neither of which is acceptable in flight. If a hoist connector fire were to occur in flight, and the fire were to spread, the safety of the aircraft and its crew would be at risk. To provide this means of disconnection, rather than relying on a high-current electrical fuse, the following Safety Recommendation is made:

**Safety Recommendation 2007-074**

It is recommended that Eurocopter provide a suitable means to flight crew to allow them to switch off the 28 volt DC power supply to the hoist connector '24 DELTA' on EC155 helicopters.

**Conclusions**

The evidence suggests that the fire in the hoist connector was caused by the 28 volt DC hoist motor power supply shorting to the body of the connector and earthing through the carbon fibre composite fairing. The most likely cause of the short was moisture ingress into the connector, resulting from a damaged environmental seal. A contributory factor was that the power supply to the connector is always live whenever the aircraft generators are on line.

**Safety actions taken**

Following this incident, the operator obtained approval from the helicopter manufacturer to isolate the electrical supply to the hoist fixed connector by disconnecting the power cable at electrical master box '2 ALPHA'.

On 1 June 2007, Eurocopter issued Emergency

Alert Service Bulletin (ASB) 25A085, applicable to EC155 B and B1 helicopter versions with serial numbers below 6763. This was made mandatory by EASA Emergency Airworthiness Directive (AD) No 2007-0159-E, which became effective on 6 June 2007.

The ASB requires that operators inspect the hoist fixed connector '24 DELTA' within seven days of receipt of the ASB and, if required, reposition the connector so that the power and earth contacts 'W' and 'X' are facing aft. It also requires that the power supply cable to the hoist fixed connector be disconnected at the electrical master box '2 ALPHA', until such time as a grounding strap has been installed to the body of the connector, in accordance with the instructions provided in the ASB. This is to provide a low resistance path to earth to ensure that the fuse will blow in the event of the power pin shorting to the connector body.

As a further step towards eliminating this risk, Eurocopter proposes to replace the current connector used on the EC155 with the well-proven 'screw-type' connector used on the Dauphin series of helicopters. This would fulfill the intent of Safety Recommendations 2007-072 and 2007-073.

In response to the Safety Recommendation 2007-074, Eurocopter has stated that, although, it agrees with the principle of this recommendation, it would be difficult to comply with it because of the problems inherent in installing such a line contactor. As noted above, Eurocopter proposes, instead, to install a grounding strap between the external connector and 'ground', to ensure that the fuse in the power supply line would blow in the case of a short circuit in the connector. This step would clearly reduce the possibility of a short circuit in the connector causing damage but would not necessarily protect against a short circuit in the power supply line.