BAC One Eleven 501EX, G-AWYS

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Aircraft Type and Registration:	BAC One Eleven 501EX, G-AWYS
No & Type of Engines:	2 Rolls-Royce Spey 512-14DW turbofan engines
Year of Manufacture:	1969
Date & Time (UTC):	4 January 1998 at 0907 hours
Location:	In cruise between Belfast and Birmingham
Type of Flight:	Public Transport
Persons on Board:	Crew - 5 - Passengers - 87
Injuries:	Crew - None - Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	60 years
Commander's Flying Experience:	15,100 hours (of which 7,000 were on type)
	Last 90 days - 38 hours
	Last 28 days - 7 hours
Information Source:	AAIB Field Investigation

History of the flight

During a flight from Belfast to Birmingham, the flight crew hearda series of 'popping' sounds and observed smoke coming from the'hat-rack' stowage area behind the commander's seat. The seniorcabin attendant (SCA) pulled the oven circuit breaker and wentonto the flight deck to investigate. She saw an orange flame atthe rear of the lower shelf on which were stowed the pilots' smokehoods, and fired a short burst of BCF extinguishant into the area.This extinguished the flame, but it subsequently re-ignited andtwo additional bursts of BCF were needed to finally put the fireout. The SCA, who had inhaled both smoke and BCF fumes, then removedthe two smoke hood boxes, encountering some difficulty in unfasteningthe associated securing straps. She then returned aft in orderto clear and secure the cabin, during which the passengers remainedcalm.

After closing the flight deck door, the flight crew donned theiroxygen masks and transmitted a 'Mayday' call declaring their intentionto divert into Liverpool. The appropriate smoke/fire drills werecompleted and the aircraft made an uneventful landing after receivingATC assistance, which the commander later described as "excellent".

After the aircraft had been shut down, firemen retrieved a smalloxygen mask pouch, made from a padded plastic material, from behindan electrical relay panel located at the rear of the lower stowageshelf. It was apparent that the pouch had fallen into this areathrough a one inch gap at the rear of the top shelf. Two burntpatches were visible on the pouch which, by their shape, appearedto have resulted from contact with two cables that were connectedto pins on one of the adjacent relays. The insulation on the twocables was locally charred, and there was some 'sooting' evidenton the neighbouring cables. The two damaged cables were tied backand the associated relay, which controlled the cabin sidewalllighting, was removed. The aircraft was then recovered to theoperator's maintenance base at Birmingham for a more detailedinvestigation.

Examination of the aircraft

The stowage compartment concerned was located on the left sideof the short corridor onto the flight deck, bounded at the rearby the vestibule bulkhead and at the front by the bulkhead behindthe commander's seat. The front bulkhead contained a number ofcircuit breakers, including those that protected the cabin sidewalllighting which had not tripped during the incident. The relaymounting panel, which contained three relays, was attached tothe lower shelf of the stowage compartment. It was protected fromarticles placed in this area by a full-width panel fitted betweenthe floor and the top shelf. However, a one inch gap existed betweenthe rear of the top shelf and the fuselage trim panel which hadallowed the oxygen mask pouch to fall onto the cables that wereconnected to the rear of the relay receptacle. The pouch had beenpart of a therapeutic oxygen kit that was no longer used by thisoperator, and had probably been left on the aircraft for a numberof months, although it was not possible to ascertain how longit had been lodged behind the relay panel.

The relays had not been installed during aircraft manufacture,but formed part of a modification to the cabin lighting system,designed in 1984, embodied by a former operator of this aircraft.The cabin sidewall lighting relay switched 115V/AC from the Nos1 and 2 AC busbars to the left and right cabin sidewall lightsrespectively. A 7.5 amp circuit breaker was installed in eachof the supply cables on the busbar side of the relay.

Upon removal of the relay, it was apparent that the two pins thatsupplied current to the left and right lights had been in a 'hot'condition. This was indicated by localised charring of the siliconerubber seal interposed between the relay and its receptacle, andcan be seen on the accompanying photograph(photographs of the pouch and the rear of the relay receptacleare also presented). It was found that two seals had been assembledonto the relay instead of one, leading to the possibility of higherresistance connections due to the slightly shorter length of pinengagement in the receptacle sockets. The UK agent for the manufacturerof the relay advised that the identification numbers on the relaysuggested that it was some nine years old, and thus likely tobe near the end of its useful life. The internal contacts on anyrelay tend to wear and become 'pitted' with use, leading to higherresistances and hence power consumption. Some assessment of theinternal condition of a relay can be obtained by measuring thevoltage drop between the 'IN' and 'OUT' pins with a representativecurrent applied. The manufacturer indicated that typical valuesfor the voltage drop were 125 millivolts (mV) for a new unit,150 mV whilst in service, and 175 mV for a relay at the end ofits useful life. The airline's avionics department measured thesubject relay, with

the rated current of 10 amps applied, andrecorded 290 mV for both the left and right cabin light contacts.

All relays tend to become hot during operation, due mainly tothe heat generated by the energising coil, but also due to resistancesin the internal contacts. The heat is dissipated by means of conductionalong the connecting cables and by radiation. However, the additionalpower consumed by the unit due to the developing high resistancesis likely to have been around 1 to 1.5 watts (per cable) abovethe normal in-service value, which is unlikely to have resultedin a significant temperature rise in the two cables lying in contactwith the oxygen mask pouch. It seems more probable that the pouchacted as a thermal insulation blanket such that the normal amountof heat energy in each of the cables could not be dissipated atits usual rate, leading to elevated temperatures and eventualcombustion of the pouch material and cable insulation. If thiswas the case, it is likely that the pouch fell into its as-foundposition relatively recently. There would have been no significantchange in the current passing through the cables, thus explainingwhy the associated circuit breakers did not trip. Both circuitbreakers were subsequently tested and found to be satisfactory.The 'popping' noise heard by the crew was not fully explained,but in the absence of evidence of significant arcing from thedamaged cables it was considered that this was probably due tothe pouch material combusting.

The hat-rack stowage area on another of the airline's BAC One-Elevenaircraft, which had also been modified by the same earlier operator,was examined during the investigation. The top shelf had beenremoved, although the shelf mounts had been retained. The relayinstallation appeared to be the same electrically, but the panelon which it was installed was protected by a metal box, as opposedto the full width panel used on this aircraft. The operator intendsto modify affected aircraft by installing a screen which willextend over the full height of the stowage area in order to eliminatethe possibility of loose articles falling behind the relay mountingpanel.