Boeing 737-3M8, G-EZYB

AAIB Bulletin No: 9/2002	**Ref: EW/G2002/03/17**	**Category: 1.1**
Aircraft Type and Registration:	Boeing 737-3M8, G-EZYB	
No & Type of Engines:	2 CFM56-3C2 turbojet engines	
Year of Manufacture:	1988	
Date & Time (UTC):	13 March 2002 at 2145 hrs	
Location:	In flight, south of Edinburgh Airport	
Type of Flight:	Public Transport	
Persons on Board:	Crew - 4	Passengers - 89
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Overheating of flexible hose	
Commander's Licence:	Airline Transport Pilots Licence	
Commander's Age:	36 years	
Commander's Flying Experience:	5,000 hours (of which 2,500 were on type)	
	Last 90 days - 91 hours	
	Last 28 days - 34 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB	

History of flight

As the aircraft was descending through FL200 for an approach to Edinburgh Airport, both flight crew detected a trace of smoke and a "burning" smell on the flight deck. The commander called the senior cabin attendant to the flight deck to confirm that there were no problems in the cabin. As she entered the flight deck, the burning smell became more apparent and the cabin attendant noticed flames coming from the wall just behind the commander's seat. She immediately took a BCF extinguisher and applied it to the area of the fire; the flames appeared to go out. During this time, both pilots donned their oxygen masks and the commander declared a 'Mayday' with 'Scottish Control' and requested vectors to Edinburgh.

With the first officer handling the aircraft, the commander then informed the senior cabin attendant of his intention to land within about five minutes. He also instructed her to brief the rest of the crew and then the passengers about the imminent precautionary landing; the crew had agreed not to initiate an evacuation after landing unless the situation deteriorated. After the normal descent and approach checks were completed, the senior cabin attendant reported that the cabin was secure for landing. With about 15 miles to go for Runway 06, the commander took over the handling duties and subsequently made a normal landing. He brought the aircraft to a stop on the runway where it was met by the Airport Fire Service (AFS). When cleared by Edinburgh ATC, the commander established communication with the fire officer on frequency 121.6 MHz. Then, once the engines were shut down and the aircraft was on APU power, the airstairs were lowered and the fire crew came on board to confirm that there was no indication of any fire. The passengers and crew disembarked normally with the aircraft still on the runway. Once the AFS had declared the aircraft safe, G-EZYB was towed to a remote stand.

Engineering investigation

Inspections of the area of the reported fire revealed extensive overheating damage to a flexible hose connected to port S2 of the upper left combined pitot/static probe, Figure 1 *(jpg 38kb)*. This is the static pressure connection for the No 1 Auxiliary static lines which supply the cabin pressure controller and cabin pressure/differential pressure gauge. The conductive flexible element of the hose contains one coil of steel wire, connected to metallic fittings at each end. Most of the non-conductive material had been burnt away, as shown in Figure 2 *(jpg 16kb)*.

The 737-300 has four combined pitot/static probes, two on each side of the forward fuselage. The upper left pitot/static probe is located above the flight deck floor line, just aft of the left-hand pilot's seat, with the lower probes below the floor line. Pitot pressure is sensed by the opening at the front of the probe, with static pressure being sensed by ports on the contoured mid section of the probe.

To prevent ice accumulation on the probe an internal heater element is installed. This is powered from the 115v AC transfer bus No 1, via a control switch on the overhead panel (window and probe heat module) to the input terminal of the probe. The low side of the 115v AC system is connected to the aircraft structure and, to provide a complete circuit, one of the terminals of the probe heater is connected to an AC ground on the aircraft structure. A current transformer is used to sense current flow through the heater circuit which, via a switching circuit, provides a master caution indication in the flight deck if the heater is not powered. Protection of the heater circuit is provided by a 5A circuit breaker (CB) and, during the incident, the pitot/static heat for the probe was selected to ON, and the CB remained latched, throughout the incident

Replacement of the upper left pitot/static probe was carried out 227 flying hours, 211 flight cycles prior to the incident, on the night of 8/9 February 2002, due to a leak in the captain's static system and the No 1 auxiliary static line. At that time, two flexible hoses for the No 1 auxiliary system were also replaced although this is not regarded as a factor in the incident. There were no reported problems with the pressurisation system prior to the incident and this confirmed that the hose had not degraded significantly prior to the incident flight.

The aircraft manufacturer carried out a detailed inspection of the static hose, the pitot/static probe and the associated 5A CB. This was tested to the manufacturers specification and was found to be within the prescribed limits. A test of a new static flexible hose revealed that a current of 1A at 115v AC was the minimum current required to start the overheating of the non-metallic parts and this indicated that overheating of the hose was possible at a much lower current than the rated 5A of the CB. Testing of the pitot/static probe heater element found it to be open circuit between the input terminals, with one input line shorted to the probe body. The probe index pins, which ensure correct alignment of the probe with the airflow, and counter-sink attachment holes showed signs of corrosion and electro-deposition. The probe also showed signs of excess corrosion which had penetrated the protective nickel plating on its body. The corrosion was as a result of the by-products of exterior cleaning of the aircraft, coupled with thermal cycling of the probe, and there was also evidence of internal contaminates, probably due to the corrosion, which had allowed the internal shorting of the heater element to the probe body.

With the heater element shorted to the probe body, the supply current sought the path of least resistance to ground.

Normal electrical bonding of the probe to the airframe is through the probe mounting bolts and it was by this route that the return current initially found its way to ground when the probe heater failed and shorted to the probe case. However, over time, corrosion increased the resistance of this primary bonding path and the path of least resistance then progressively became the metallic parts of the S2 static flexible hose, as this was connected to the probe at one end and metallic tubing at the other. The return current taking this path then caused the non-metallic parts of the hose to overheat and eventually catch fire. The failure of the 5A CB to trip concurred with the results of the testing carried out by the manufacturer, which indicated that the current required to cause overheating was well below the rating of the 5A CB designed to protect the system. As current was being supplied to the probe throughout this incident, the pitot/static power fail indication system did not illuminate the 'upper left pitot/static heat' light or the master caution light.

In view of the potentially serious consequences of a fire such as this, in an area not normally or readily accessible in flight, the following recommendation is made:

Safety recommendation 2002-12

The FAA, in conjunction with the manufacturer, should conduct a review of the adequacy of the bonding between all electrically heated devices external to the aircraft and the aircraft structure, for all aircraft types fitted with such devices, including pitot/static probes, static ports, temperature probes and angle of attack sensors, to ensure that, in the event of any malfunction of such devices, that return current will be conducted to a suitable ground in a safe manner.

Following this incident the operator carried out a fleet wide inspection of all the combined pitot/static probes, but no other incipient failures were reported. Additionally, the aircraft manufacturer has undertaken a review of the bonding arrangements of the combined pitot/static probes to prevent further occurrences.

Conclusion

The cause of the fire was overheating of non-metallic parts of the S2 static flexible hose connected to the upper left pitot/static probe. The overheating was as a result of internal shorting of the probe heater to the probe body in combination with degraded bonding between the probe and structure. Corrosion, as well as electro-deposition due to multiple current paths (caused by the probe heater failure to the probe case) contributed to this bonding degradation, making flexible hose metallic components the path to ground.