

# Boeing 737-59D, G-BVKA

## AAIB Bulletin No: 3/97 Ref: EW/C96/8/2 Category: 1.1

<b>Aircraft Type and Registration:</b>	Boeing 737-59D, G-BVKA
<b>No &amp; Type of Engines:</b>	2 CFM56-3C1 turbofan engines
<b>Year of Manufacture:</b>	1990
<b>Date &amp; Time (UTC):</b>	6 August 1996 at 0727 hrs
<b>Location:</b>	Stand C30, London Heathrow Airport
<b>Type of Flight:</b>	Public Transport
<b>Persons on Board:</b>	Crew - 7 - Passengers - 37
<b>Injuries:</b>	Crew - Nil - Passengers - Nil
<b>Nature of Damage:</b>	Auxiliary Power Unit damaged beyond repair
<b>Commander's Licence:</b>	Airline Transport Pilot's Licence
<b>Commander's Age:</b>	39 years
<b>Commander's Flying Experience:</b>	5,800 hours (of which 4,450 were on type) Last 90 days - 177 hours Last 28 days - 43 hours
<b>Information Source:</b>	AAIB Field Investigation

### History of event

Following an uneventful flight from Paris, the crew started the Auxiliary Power Unit (APU) shortly after landing on Runway 09L at London Heathrow. After a short taxiing distance, the aircraft was parked on Stand C30, electrical power was transferred to the APU and the engines were shut down. During the subsequent turnround period, the APU continued to supply the generator busbars and also provided pneumatic air to the left air conditioning pack which, together with the recirculation fan, was used to provide air conditioning.

In preparation for the subsequent scheduled flight to Paris, the passengers began boarding as the crew were completing their flightdeck checks. The commander then became aware of an electrical burning smell and asked the first officer if he could smell it. Because there was some doubt, the flight service manager (FSM) was called to the flight deck for her opinion. The commander, as a precaution, then decided to switch off the recirculation fan and to pull the

associated circuit breaker. Leaving the first officer to monitor the situation on the flight deck, the commander then left the aircraft to investigate the cargo holds since he was concerned in case the smell was originating from smouldering wiring, baggage or freight. Instructing the baggage loaders to inspect the rear hold, he carried out an inspection of the electrical and electronic equipment bay and the front hold, but nothing abnormal was found. However, when he returned to the flight deck, he was immediately aware of the burning smell. Additionally, co-incident with his arrival back on the flight deck, the APU electrical supply tripped off line and the 'Maint' and 'Fault' lights illuminated on the APU forward overhead panel. Although there was no indication of an APU fire, the commander was concerned with the deteriorating situation and decided to disembark the passengers. He immediately called the FSM to the flight deck and instructed her to disembark the passengers through the forward door and for the cabin crew to then leave the aircraft. While the FSM was carrying out the commander's instructions, the flight crew selected standby power and called ATC to ask for the Rescue and Fire Fighting Service (RFFS). The aircraft was then quickly secured and the flight crew left the aircraft.

Just after the commander had returned to the flight deck after his inspection of the cargo holds, witnesses on the apron heard a loud 'bang' and saw an object ejected from the rear of the aircraft which struck the concrete apron some 6 metres to the rear of the aircraft. While the commander briefed the RFFS on the situation, the first officer left the flight deck to investigate the witnesses' observations and located a large and extremely hot metal component amongst some apron vehicles which were parked about 70 metres on the right side of the aircraft. Examination of the component by the operator's engineers identified it as the APU turbine wheel hub.

### **Subsequent investigation**

Subsequent inspection of the aircraft and the APU confirmed that the turbine wheel hub had been released and had been ejected from the APU exhaust duct. The damage to the aircraft was limited to a small hole; spiral contact marks, made by the turbine wheel hub, were evident in the APU exhaust duct.

The APU was removed from the aircraft and taken by AAIB to the manufacturer for strip examination. This revealed that there had been a gradual failure of the No 1 bearing which had led to the main rotor shaft, on which both the compressor and turbine wheel were mounted, moving forward. This displacement had allowed the compressor impeller blade leading edges to contact the abradable material of the air inlet housing and the forward face of the turbine wheel to contact the non-rotating seal plates. The associated frictional heating had caused melting of the wheel and the loss of sufficient turbine blade tip material to reduce the turbine wheel diameter to less than that of the internal diameter of the exhaust nozzle. The resulting imbalance of the main rotor assembly then induced a failure of the tie bolt just forward of the turbine wheel.

The manufacturer initially considered that the No 1 bearing failure had been due to contamination of the bearing. However, their subsequent analysis of the failure was unable to prove whether it had been induced by contamination or had been due to a fatigue failure of the bearing which had previously occurred in other units. The manufacturer has stated that the risk of similar failures will be reduced by a direct lubrication design improvement which has been developed by them and is expected to be incorporated into production units by 1998. The manufacturer's bearing analysis also revealed that the thrust loads on the bearing in-service were lower than predicted, which can result in ball 'skidding' and bearing failure as occurred in this case.

The manufacturer issued a Service Bulletin in August 1996 which introduced additional magnetic plug and oil filter element examinations for APUs with less than 1500 hours running time since manufacturer, or overhaul. The manufacturer is also designing a device which will prevent a released turbine wheel being ejected from the exhaust duct, with a view to this modification being available for fitment during 1997. In the longer term, the No 1 bearing will be redesigned to withstand the actual thrust loads that are generated by the rotor system.

### **Safety Recommendation**

As a result of the findings arising from this investigation, the following Safety Recommendation is made:

**97-3:** In order to reduce the potential incidence of turbine wheel separation and release from APS 2000 auxiliary power units, the FAA should actively progress with the manufacturer the current program to develop the retention device for the turbine wheel to retain it within the turbine containment zone. Additionally, the direct lubrication modification for the No 1 bearing and redesign of this bearing for improved life should be implemented as soon as possible.