Boeing 777-236, G-VIIU

AAIB Bulletin No: 9/2002	**Ref: EW/G2002/04/20**	**Category: 1.1**
INCIDENT		
Aircraft Type and Registration:	Boeing 777-236, G-VIIU	
No & Type of Engines:	2 General Electric Co GE 90-85B turbofan engines	
Year of Manufacture:	1999	
Date & Time (UTC):	28 April 2002 at 1720 hrs	
Location:	Heathrow Airport	
Type of Flight:	Public Transport	
Persons on Board:	Crew - 15	Passengers - 159
Injuries:	Crew - None	Passengers - None
Nature of Damage:	APU damaged	
Commander's Licence:	Airline Transport Pilots Licence	
Commander's Age:	45 years	
Commander's Flying Experience:	7,930 hours (of which 1,520 were on type)	
	Last 90 days - 135 hours	
	Last 28 days - 70 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

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History of the incident

The aircraft was being pushed back from its stand with the APU providing primary aircraft power. The No 2 engine Autostart sequence was initiated but almost immediately, about 4 seconds later, the APU generator dropped off-line, the aircraft reverted to 'Stand-by' electrical power and the No 2 engine autostart disengaged. About 6 seconds after that, thick blue/white smoke started to enter the cockpit, rapidly, through the co-pilot's overhead louvre. Similar smoke also entered the forward part of the passenger cabin, extending as far back as the No 3 door, and, outside the aircraft, a plume of smoke was observed emanating from the rear fuselage.

Although no 'Fire' warning had been activated, the crew discharged the APU fire bottle; the airport fire service also attended the aircraft and followed as it was towed back onto the stand. Subsequently, the passengers and crew were disembarked normally, but quickly, via the embarkation airbridge at door 2L. Approximately 10 to 15 minutes after the APU generator had dropped off-line, the aircraft's 'Stand-by' electrical power also failed.

Engineering examination

The aircraft was withdrawn from service and towed to a hangar where the APU was removed. Initial examination showed that the APU rotating assembly had seized and some damage to the tips of the 3rd stage turbine blades could be seen. The APU, which was an Allied Signal/Honeywell Model 331-500B, was returned to the manufacturer's European overhaul facility for strip examination and assessment.

The strip examination revealed that the APU had suffered a contained mechanical failure. The primary failure had been the separation of a 1st stage turbine blade. The subsequent mechanical damage and imbalance resulting from this failure had led, amongst other consequences, to the fracture of the main oil feed pipe to the rear turbine bearing. The oil released by this failure had subsequently burned and generated the smoke which entered the aircraft hull and exhausted to atmosphere. It is not known if the smoke which entered the hull was the result of re-ingestion of smoke from the exhaust or of secondary damage to the APU air-oil seal system.

The failure of the 1st stage turbine blade root (P/N 3842151-2) was assessed as being the result of hot gas corrosion which initiated a material failure outboard of the blade's fir-tree root and below the root platform which forms the gas path inner wall. This was a recognised failure mode for this APU model. Investigation of previous failures has shown that, although turbine debris has, in some cases, severed the oil lines that traverse the exhaust flow path, releasing oil and resulting in fire in the exhaust duct, in all cases the fire has been confined within the exhaust duct, which is designed as a fire containment structure, and no damage to the airframe has resulted.

The manufacturer of the APU issued a Service Bulletin (Allied Signal SB 331-49-7504, issued in November 1999) recommending the rework or replacement of early-standard turbine blades (P/N 3842151-2), with updated blades (P/N 3842151-3), to be effected at the next time 1st stage turbine blade replacement was necessary. (The APU under investigation had early standard blades) The updated blades have a protective coating applied below the platform, to reduce the rate of corrosion attack. Mixing of -2 and -3 blades on the same rotor is not authorised by the Service Bulletin, but neither is it specifically prohibited. The mixing of early-standard and updated blades on a turbine assembly would negate the benefits intended from implementation of the Bulletin.

The manufacturer has also issued a Field Service Note (Allied Signal FSN 49-00-00-27, issued in August 1998), recommending that airlines operating the APU in a corrosive environment conduct periodic hot section borescope inspections per the Boeing Airplane Maintenance Manual to identify turbine corrosion before it progresses to the point of turbine blade failure.

Full implementation of SB 331-49-7504 and adherence to the recommendations of FSN 49-00-00-27 has been shown to give considerably improved reliability and an overall operational cost saving after less than five months. The improved reliability may be considered to be of greater significance for APUs which are fitted in aircraft used for ETOPs.