

BAe 146-200, G-MIMA

AAIB Bulletin No: 6/2004	Ref: EW/C2003/09/02	Category: 1.1
INCIDENT		
Aircraft Type and Registration:	BAe 146-200, G-MIMA	
No & Type of Engines:	4 Lycoming ALF502R-5 turbofan engines	
Year of Manufacture:	1987	
Date & Time (UTC):	8 September 2003 at 1435 hrs	
Location:	Gatwick Airport, West Sussex	
Type of Flight:	Public Transport (Passenger)	
Persons on Board:	Crew - 5	Passengers - 52
Injuries:	Crew - None	Passengers - 2 (Minor)
Nature of Damage:	Internal damage to the APU	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	53 years	
Commander's Flying Experience:	9,730 hours (of which 5,289 were on type)	
	Last 90 days -162 hours	
	Last 28 days - 43 hours	
Information Source:	AAIB Field Investigation	

Synopsis

After shutdown, following an uneventful flight, smoke/fumes appeared in the cabin and on the flight deck as the passengers were disembarking. Without a specific checklist or training to cover this situation, the crew followed the evacuation checklist, with the exception of firing the APU fire bottle as they initially thought the origin of the smoke was in the avionics bay. They also completely de-powered the aircraft. The source of the fumes was traced to the recently replaced APU, where the main rotor bearing appeared to have suffered a cage failure. This in turn led to damage to a carbon oil seal, which consequently allowed hot engine oil to enter the bleed air airstream and subsequently enter the cabin as smoke/fumes. The APU manufacturer has undertaken the investigation of the cause of the bearing failure.

History of flight

After an uneventful flight and landing at Gatwick Airport, the aircraft was shut down on stand with ground power connected and the passengers began a normal disembarkation. The flight crew then became aware of an odour in the flight deck but were unable to identify its source. A couple of minutes later, the first officer observed smoke emanating from beneath the commander's seat and so

he called for fire assistance on the radio whilst the commander ordered an emergency evacuation using the aircraft's public address system. The cabin crew noticed the odour and haze inside the cabin at approximately the same time and reacted to the evacuation order by arming and deploying the slide on the rear door, through which approximately eight passengers evacuated. Another 10 passengers continued their disembarkation through the front left door and down the airstairs albeit with increased haste. Two minor injuries to passengers resulted from the evacuation. Prior to vacating the flight deck, the commander actioned what he believed to be the appropriate actions from the evacuation checklist drills to ensure that the aircraft was completely depowered. He checked the aircraft to ensure that no persons remained on board, vacated it himself and then briefed the Airfield Fire Service crew on the situation. He noted that the smoke had filled the cabin and was of a fairly dense and uniform appearance.

Outside the aircraft, the cabin crew were directed to a crewroom and subsequently positioned back to the Isle of Man on another flight. The commander and first officer remained with the aircraft which was subsequently towed to a remote stand. A company engineer checked the aircraft and decided that the problem lay with the APU. Later that day the pilots flew the aircraft to Stansted, where the APU was changed, and then flew it back to the Isle of Man the following day. This meant that the cabin crew and flight deck crew did not meet up immediately after the event, or at all, as required by the company Operations Manual.

Checklists

The crew commented that there was not an appropriate checklist to deal with smoke/fire at this particular stage of the operation. They used the evacuation checklist as a basis for shutting down the aircraft but decided against discharging any of the fire extinguishers into the engines or APU as they considered the origin of the smoke was probably in the avionics bay. The evacuation checklist does not cater for switching off ground electrical power but the crew decided to completely depower the aircraft in view of their concern regarding the avionics bay.

Communication

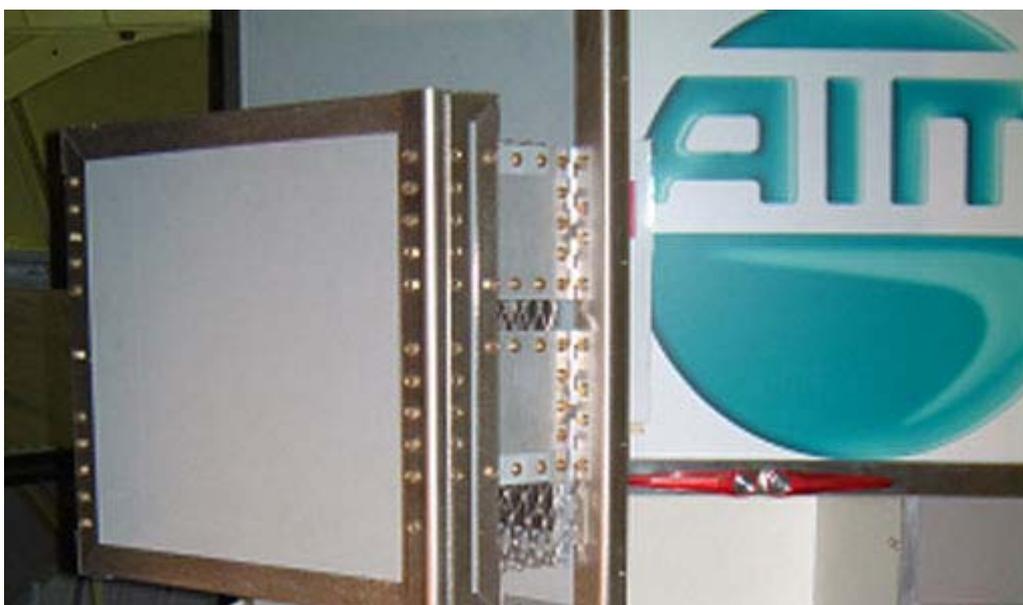
The requirement to lock the flight deck door only applies until engine shutdown and the company does not have a Standard Operating Procedure (SOP) as to when it is opened after shutdown occurs. The bulkiness of the particular door fitted to G-MIMA and the consequent limited aisle space means that, in practise, it is awkward to open the door once the passengers have started to disembark. It is usual to leave it closed until disembarkation is complete, as happened in this incident. However, with the door closed and passengers disembarking, the cabin crew are unable to stand in a position where they can easily see along the aisle to the rear of the aircraft. This problem is not limited to the BAe 146 aircraft with this type of door fitted. A new flight deck door, Figure 1, has been designed with a hinged decompression panel which is automatically closed as the door is opened, rather than the current decompression 'cage' of the existing door, Figure 2, and this considerably reduces the door's bulk and will ease current aisle congestion. The first of these doors on the BAe 146 should be introduced in April 2004.

Figure 1: New door design



Figure 1
New door design

Figure 2: Standard of door fitted to G-MIMA



APU

The APU on this aircraft is a Honeywell Garrett type 36-100M. It was started as per the company SOP's during the descent into Gatwick at approximately 5,000 feet. On final approach the air conditioning system is supplied solely by the APU and, after landing, the electrical system is also supplied solely from the APU. When the APU is supplying air conditioning and electrical power, it predominantly supplies air to the cabin rather than the flight deck.

Engineering investigation

A few days before this incident, the aircraft had an APU change because of a required hot section inspection. This was coincident with a C7 check, which was completed the day before the incident. APU serial number P-309 was fitted; this APU had been returned to the UK agent some time earlier for high oil consumption and was repaired in June 2003. Replacement of the main rotor bearing, amongst other parts, had been carried out. The APU was fitted to G-MIMA on 3 September 2003 and, being shipped 'dry', was replenished with oil in accordance with the Maintenance Manual. The aircraft had flown four sectors, with less than an hour of APU time, when the incident occurred. After the APU was removed and examined it was established that, although there was no apparent oil leak, a few traces of oil were present in the intake plenum. However, the APU main rotor was partially seized. As there were no apparent problems with the aircraft installation, a further replacement APU was fitted and 'ground run' and the aircraft released to service. It subsequently operated without further incident.

The APU was shipped to the manufacturer's facility in Germany for a teardown examination under the supervision of the AAIB. It was found to contain more than two litres of oil (at least 2.1 US quarts); nominal capacity is 2.5 US quarts. The oil was contaminated to some extent by what appeared to be metallic debris and/or carbon but there was no evidence of any breakdown of general lubrication in the unit. However, metallic debris was found on the magnetic chip detector and speed sensor plugs. Further teardown showed that there were compressor impeller/shroud and turbine rub marks, and that the ball bearing locating the compressor and turbine shaft had a broken cage. Most of this cage had broken into fragments which were found throughout the reduction gearing, with consequential damage to the gears. The balls themselves had developed minor flats, but the bearing failure was still at a relatively early stage when the APU had been shut down. The cage failure led to a loss of location of the balls and this had allowed the shaft to move against a carbon oil seal. This in turn allowed hot APU oil to enter the airstream and thus produce the fumes/smoke in the cabin air supply.

Analysis

The reason for the bearing failure has not yet been determined, but it was established that it had been fitted correctly, had been adequately lubricated, and that the cage failure was the first element of the failure sequence. The bearing and some associated parts were returned to the manufacturer's US base for an in-depth examination, but no further report had been received by the date of this report.

Smoke and/or fumes in the cabin resulting from APU oil seal deterioration has occurred periodically with this and similar APUs. In itself, it is not particularly hazardous but, as illustrated by this incident, it can lead to quite reasonable actions by crews, such as diversions and evacuations, which in turn may present their own hazards.

The aircraft's crew was presented with a situation that did not conform to a practised emergency scenario. Using the limited information available, the commander made a timely decision to evacuate the aircraft and then had to consider how best to prepare the aircraft for that evacuation. An open flight deck door would have increased the information upon which he could base his decisions, by giving an immediate indication of the severity and location of the smoke. Although this information could have been acquired using the interphone, this method would have taken more time and added scope for misinterpretation of the information. An open door would also have allowed a cabin crewmember to stand in the aisle and observe the whole of the cabin, whilst also providing a quick

way for the commander to establish how much of the disembarkation had taken place and decide whether an evacuation was necessary. The introduction of the new design of flight deck door will offer greater flexibility to crews in deciding whether to keep the door open or closed after engine shutdown.

Although there was no specific checklist to follow, the evacuation checklist provided the most obvious starting point. The crew followed this list, with the addition of switching off all electrical power but omitting the discharging of the fire extinguishers. They believed the source of the smoke was in the avionics bay, and this influenced their decision not to discharge the APU fire extinguisher. An awareness of the smoke in the cabin may have led them to consider other possibilities as to the source. Having made the decision to evacuate, the procedures appear to have been executed most effectively by all members of the crew.

After the event, circumstances led to the cabin crew and flight deck crew taking different routes back to their home base without fully debriefing and discussing the situation. The company operations manual does require the commander to ensure a debrief with all members of the crew takes place and it would appear that there was limited opportunity after this incident for this to occur. Members of the cabin crew felt particularly isolated not knowing the cause of the event or how their actions had contributed to the safe outcome.

The Operating company has since issued a Flight Operations Newsletter highlighting the requirement to hold a post incident de-brief.