Australian Government
Australian Transport Safety Bureau

Aviation Safety Investigation Report - Final

British Aerospace Plc BAe 146-100A, VH-NJX

Occurrence Details

Occurrence Number:	200205865	Location:	Perth, Aero.
Occurrence Date:	02 December 2002	State:	WA
Occurrence Time:	0630 hours WST	Highest Injury Level:	Minor
Occurrence Category:	Incident	Investigation Type:	
Occurrence Class:		Investigation Status:	
Occurrence Type:		Release Date:	21 August 2003

Aircraft Details

Aircraft Manufacturer:	British Aerospace Plc	Aircraft Model:	BAe 146-100A
Aircraft Registration:	VH-NJX	Serial Number:	E1003
Type of Operation:	Air Transport, Domestic, High Capacity, Passenger, Scheduled		
Damage to Aircraft:	Nil		
Departure Point:	Perth, WA	Departure Time:	
Destination:	Newman, WA		

Factual Information

The British Aerospace 146-100A (BAe 146) was being prepared for a regular public transport service from Perth to Newman, WA. As the copilot boarded the aircraft to conduct pre-flight checks he detected strong fumes in the cabin and the flight deck. He noted that the auxiliary power unit (APU) was supplying bleed air to one of the aircraft's two airconditioning packs that in turn supplied conditioned air to the flight deck and cabin. In an attempt to clear the fumes, he directed the bleed air supply to the alternate pack.

Bleed air from the APU was generally used when airconditioning was required during ground operations or during the takeoff and landing phases. During flight, the airconditioning packs receive bleed air from the engines.

As the copilot continued the pre-flight checks, he noticed the cabin fumes becoming stronger and so shut down the airconditioning pack and opened the flight deck windows.

Maintenance engineers were requested to investigate the source of the fumes and subsequently discovered an oil leak in the APU generator drive adaptor pad. Rectification work, including the replacement of a carbon seal, was carried out 11 days later, on 13 December. To enable the aircraft to continue in service on the day of the incident, the APU was isolated from the airconditioning system in accordance with the terms of the aircraft's Minimum Equipment List (MEL) that permitted operation of the aircraft in non-standard configurations. The operator reported that the maintenance engineers then addressed the defect in accordance with the Civil Aviation Safety Authority (CASA) airworthiness directive AD/BAe146/86, effective 3 April 2001, and the British Aerospace Systems Inspection Service Bulletin (ISB) 21-150. That ISB called for certain actions to be performed whenever a cabin air quality problem was identified, which was suspected of being associated with oil contamination of the air supply from the airconditioning packs. No oil contamination was found. The engineers then operated both packs using bleed air from engines 1 and 4 until they were satisfied that there were no fumes and the aircraft was then released for service.

The copilot had been exposed to the fumes for approximately 30 minutes. The two cabin crew, who boarded the aircraft shortly after the copilot, were exposed to the fumes for approximately 20 minutes. All three were eventually affected by the fumes, became unwell, and were removed from flight duty. In accordance with company standard practice they underwent medical examinations. The pilot in command was exposed to the fumes for less than 5 minutes and was not affected. Impaired performance due to the inhalation of contaminated air is considered a potential threat to flight safety. For that reason, company procedures emphasise the importance of flight crew donning oxygen masks if poor air quality is suspected during flight.

The pilot in command and a replacement crew subsequently departed in the same aircraft for the flight to Newman. The cabin crew reported a slight smell of fumes toward the rear of the aircraft during the first sector. On the return sector, both cabin crew reported feeling unwell, with symptoms consistent with fumes inhalation.

Follow-up inspections of the airconditioning system, engines and APU were carried out in accordance with the CASA airworthiness directive and no contamination was evident. On 6 December, the operating crew indicated that a smell was apparent and it appeared to be consistent with the operation of the APU. As the APU was still isolated, engineers doubted that it could be contaminating the airconditioning system. All four engines and the regenerative ducts were again checked, with no contamination evident. Follow up inspections were scheduled in accordance with the ISB.

A further cabin air quality event occurred on 12 December, when the flight deck crew detected fumes shortly after departure. The flight crew proceeded to identify the source of the fumes using a contamination source location schedule. That schedule involved selecting different combinations of engine air and airconditioning packs. The fumes were traced to the number-3 engine, which was isolated, and the flight continued as planned. Subsequent inspection revealed oil wetness in the number-3 engine high-pressure compressor; the result of a worn number-1 bearing seal. Trend monitoring had not indicated abnormal oil consumption for that engine. The engine was replaced and airworthiness directive AD/BAe146/86 was complied with. No further contamination was evident and fumes were not reported during subsequent flights.

Evidence from previous incidents of air system contamination on this aircraft type had indicated that fume events were often intermittent in nature and were associated with engine or APU oil contamination of the airconditioning system. The air supplied to the airconditioning packs was protected from contamination by oil seals in the engines and APU. A defect in one of those seals could result in oil entering the cabin airconditioning system, with the first sign of the defect being an awareness of fumes by passengers or crew members.

The investigation of cabin fumes incidents on BAe 146 aircraft has typically been characterised by a difficulty in precisely locating the original source of the oil leak that led to the creation of the fumes. That has been especially so if there was more than one engine/APU leak combination. The failure of oil seals has been a common factor in the majority of those incidents.

Analysis

It is likely that the copilot's initial attempt to clear the fumes on 2 December was unsuccessful because the problem involved more than just an airconditioning pack. An oil mist forming in the APU bay as a result of the faulty generator drive seal could have resulted in the contamination of the air supply to both airconditioning packs. The maintenance engineers believed that they had identified the source of the fumes and had taken appropriate action. It is considered likely that their assessment was correct and that the report of fumes during the following flight was due to residual contamination of the airconditioning packs.

When checking for fumes during the ground test of the airconditioning packs, the engineers used bleed air from engines 1 and 4 and consequently missed an opportunity to identify engines 2 or 3 as the possible source of the contamination. The difficulty in positively identifying the origin of the contamination was highlighted by the smell reported by the operating crew on 6 December. It could not be discounted that the cabin fumes were a result of the intermittent leak of oil in the number-3 engine, that was identified ten days after the original incident, instead of, or as well as, the APU.

Safety Action

Civil Aviation Safety Authority (CASA)

- On 23 January 2003, CASA airworthiness directive AD/BAe 146/102 became effective, requiring all operators of BAe 146 aircraft to action the requirements of BAE Systems (Operations) Limited, Inspection Service Bulletin (ISB) 21-156. That ISB relates to inspections of air-conditioning ducts. It has been found that the sound attenuating material used in the air-conditioning ducts can absorb oil and become a source of persistent air contamination.
- On 10 July 2003, CASA airworthiness directive AD/BAe 146/105 became effective, requiring all operators of BAe 146 aircraft to carry out a modification in accordance with BAE Systems Service Bulletin SB. 49-036-36019E. That modification provides an improved seal at the aircraft - APU interface, reducing the likelihood of contamination of cabin air due to ingestion of oil from the APU bay.

Operator

The operator of the aircraft involved in this incident previously incorporated various modifications to the cabin air system, APU and engines and introduced improved maintenance practices in an effort to minimise the occurrence of cabin fumes events.

More recently, the operator has undertaken to go beyond the requirements listed in CASA AD/BAe 146/102, by fully replacing the sound attenuating ducts of their entire BAe 146 fleet. On 30 April 2003 the operator advised that during the period since August 2002, when the first duct replacement was completed, there has been a reduction in safety reports received. It has not stopped air quality events occurring but has removed the occurrence of lingering odours.

The operator has also:

- commenced trials of a new bearing seal that has realised positive results during recent bench testing by the engine manufacturer
- refined a flowchart for use by engineering personnel that ensures that every regulatory aspect is completed during the maintenance investigation and certification process
- developed a stand-alone Cabin Air Quality Safety Report, as an adjunct to the Safety Occurrence/Incident Report currently in use. This allows the operator to focus on the specifics of air quality and what symptoms crews are experiencing
- employed a coordinator to be the company's single point of contact for liaison with external agencies such as CASA and the ATSB, regarding all air quality matters.