SERIOUS INCIDENT

Aircraft Type and Registration:	Boeing 777-236, G-VIIJ	
No & Type of Engines:	2 General Electric Co GE90-85B turbofan engines	
Year of Manufacture:	1997 (Serial no: 27492)	
Date & Time (UTC):	13 November 2017 at 1230 hrs	
Location:	In the decent into London Heathrow Airport	
Type of Flight:	Commercial Air Transport (Passenger)	
Persons on Board:	Crew - 14	Passengers - 149
Injuries:	Crew - None	Passengers - None
Nature of Damage:	N/A	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	49 years	
Commander's Flying Experience:	20,000 hours (of which 9,350 were on type) Last 90 days - 220 hours Last 28 days - 76 hours	
Information Source:	Aircraft Accident Report Form submitted by the operator and further AAIB investigation	

Synopsis

During descent into London Heathrow Airport a strong smell of fumes was apparent in the cockpit and the cabin. The crew actioned the appropriate checklist and the aircraft landed at Heathrow without further event. The aircraft was returned to service after engineering work.

On the next flight the aircraft returned to stand due to fumes in the cabin having taxied for takeoff. After further engineering work the aircraft was again returned to service.

The aircraft then flew once more without incident but on the return flight there were several indications of overheating in the left engine. The subsequent engineering work identified a hole in the left engine's combustor case, which resulted in the engine being changed. A replacement engine was installed and there were no further fume events.

History of the flight

The aircraft was on a scheduled flight from Houston Intercontinental Airport, USA, to Heathrow Airport. The co-pilot was the pilot flying, the commander was pilot monitoring. During the initial cruise descent inbound to Heathrow, about an hour before landing, there was a strong smell of fumes in the flight deck. This was quickly followed by reports from the cabin crew of fumes in the front and rear of the passenger cabin. The relief first

officer[1] entered the cabin to check the intensity of the fumes there. The *Smoke, Fire or Fumes* checklist was actioned and the co-pilot donned his oxygen mask first, followed, after an increase in intensity, by the commander, and the relief first officer upon his return to the flight deck.

While the checklist was being actioned reports of fumes continued in the cabin with no change in intensity in the flight deck. The pilots decided to continue to Heathrow and transmitted an urgency message to ATC. A NITS[2] brief was then made to the cabin service manager. A short time later, haze was reported at Door 2 Left, so the *Smoke Removal* checklist was actioned with little appreciable reduction in the intensity of the fumes.

The aircraft subsequently completed an uneventful autoland at Heathrow and, after an inspection of the aircraft by the RFFS, the aircraft taxied to stand and the passengers disembarked normally.

Subsequent events

On 15 November 2017, at the beginning of the aircraft's next intended flight, an oily smell became apparent as the left engine was started, and the aircraft returned to stand. Subsequent engineering work included the replacement of the APU and various components in the aircraft's air conditioning system. However, during ground run checks fumes were again identified and the left engine identified as the source. The engine was checked in accordance with the Fault Isolation Procedure for 'oil fumes / smoke in the cabin' but, based upon the description of the event, the procedure for 'fuel fumes / smoke in the cabin' was not considered to be applicable. Inspections of the left engine's compressors showed no evidence of oil. The left engine bleed air supply was isolated at the Pressure Regulating and Shut-Off Valve and the aircraft completed an uneventful flight to Seattle with the valve locked closed in accordance with the Master Minimum Equipment List on 18 November.

The following day, as the aircraft climbed through 8,000 ft after departing Seattle for Heathrow, the crew were alerted to a left engine overheat. Actions were taken in accordance with the Quick Reference Handbook and the pilots consulted the operator's maintenance control at Heathrow using a satellite phone. Engine EGT and other parameters were normal, and it was concluded that the warning was spurious, so the flight continued to its destination. Examination of the aircraft after landing identified 'sooting', heat damage and a hole in the engine combustion chamber case, just aft of one of the fuel nozzles.

The engine was removed pending further investigation by its manufacturer. Since the engine change the aircraft has operated without any further fume events.

Footnote

[1] There were three pilots on this flight; the commander and first officer who were sat in the pilots' seats, and a 'relief first officer', who sat on the 'jump seat' behind the centre consol.

[2] NITS stands for Nature [of the emergency], Intentions, Time [available before landing] and Special instructions.

Fuel nozzle installation

The GE90 engine has 30 fuel nozzles that provide fuel to the combustor. The nozzles are attached to the engine casing using bolts and each nozzle has two 'swirler' assemblies. These ensure proper mixing of the fuel and air in the combustor. The swirler assembly includes a ferrule and retainer. The retainer captures the ferrule, which floats inside the swirler assembly. The swirler assembly is welded to the combustor dome assembly.

Engine investigation

The engine manufacturer established that a swirler retainer had detached because the weld had broken. The loose retainer eventually chafed through the fuel nozzle and the resultant fuel spray ignited, burning through the combustion chamber case. This caused an overheat indication that was successfully managed by the crew during the flight from Seattle.

The cause of the retainer detaching could not be established but extensive analysis and testing discounted the possibility of loose bolts or a weld deficiency; weld repairs were permissible but no such repair had been embodied on the failed component.

Fault Isolation Manual

The Boeing 777 Fault Isolation Manual defines the procedures to diagnose faults in service.

At the time the incident occurred, the appropriate Fault Isolation Procedure consisted of two steps, depending if the fumes were associated with oil or fuel. If the fumes were associated with fuel, the engine fuel nozzles would be inspected for carbon contamination, which "*would identify unusual combustor damage before more significant consequential damage occurs*". If the fumes were associated with oil, there was no requirement to inspect the fuel nozzles. In the case of G-VIIJ, the fumes were attributed to oil, so the fuel nozzles were not inspected.

Safety actions

The engine manufacturer stated that this was the first reported event in the history of the GE90's approximately 24 million operating hours. The cause of the failure was not determined but the engine and airframe manufacturers have instigated the following safety actions:

As a precautionary measure, all swirler repair schemes will be deleted from the engine overhaul manuals.

The Fault Isolation Procedure for smoke or fumes in the cabin has been amended. If the engine is identified to be the source of fumes or smoke, the revised procedure includes a requirement to inspect the fuel nozzles irrespective of whether the fumes are believed to be associated with oil or fuel.