Boeing 747-235, N516MC, 20 December 1995

AAIB Bulletin No: 5/96 Ref: EW/C95/12/3Category: 1.1

Aircraft Type and Registration: Boeing 747-235, N516MC

No & Type of Engines:4 General Electric CF6-50-E2 turbofan engines

Year of Manufacture:1980

Date & Time (UTC):20 December 1995 at 1806 hrs

Location: London Gatwick Airport

Type of Flight: Public Transport

Persons on Board: Crew - 3 Passengers - None

Injuries: Crew - 3 Passengers - N/A

Nature of Damage: No.4 engine bleed duct, engine cowlings and wheels and brakes

Commander's Licence: Airline Transport Pilot's Licence

Commander's Age:33 years

Commander's Flying Experience:9,410 hours (of which 734 hours were on type)

Last 90 days - 206 hours

Last 28 days - 41 hours

Information Source: AAIB Field Investigation

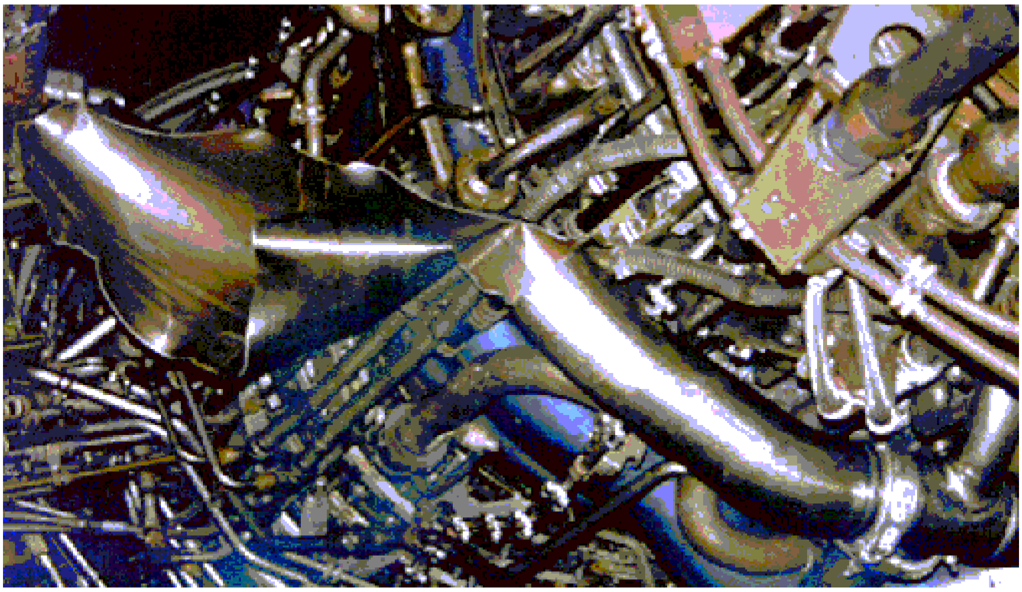
History of the flight

The aircraft was scheduled to carry out a freight flight fromGatwick to Abu Dhabi and, following the routine pre-flight checks,the aircraft was pushed back at 1744 hrs and taxied to Runway08R for take off. No abnormalities or unserviceabilities of theaircraft had been found and the brakes were released for takeoff at 1805 hrs.

As the aircraft was accelerating through 130 kt, both pilots becameaware of an unusual "engine air sound". The MasterFire Warning indicator light in front of each pilot then illuminatedand the commander rejected the take off at 140 kt, 15 kt belowV_1, and informed ATC that there was a fire(unspecified) on board. There had been no associated indicationson either the Master Warning Panel or the Engine Fire indicators. The auto brake system slowed the aircraft to a walking pace andthe aircraft was turned off onto the high speed exit at holdingpoint 'B'. The ATC 'Air Controller', who had initiated an 'AircraftGround Incident', seeing smoke emanating from the area of theaircraft's main landing gear, instructed the crew to hold at theirpresent position. The captain had intended to taxy clear of therunway 'surface' but, on receiving this instruction, immediatelystopped and shut down the engines. The fire extinguishers onall four engines were then operated. The Airport Fire Service(AFS) was in immediate attendance, with six appliances, and informedthe crew that the brakes were smoking but not yet alight (subsequentlythere was fire in three wheel assemblies), and advised evacuation. The crew therefore left the aircraft via the normal front leftdoor and were assisted to the ground by the AFS.

Because the brakes had seized when the aircraft stopped, the aircraftcould not be moved until 0400 hrs the following morning,which prevented further use of Runway 08R until that time.

Engineering information



The 14th stage HP air duct on the No 4 engine, part number 9068M-40-G01,had failed causing two blow-out panels to operate, and damageto one half of the reverser shroud. The No 4 reverser deployed,but would not stow. Braking, followed by the aircraft being heldstationary had caused brake overheating which led to tyre failuresand brake seizure on the right main gear, and, in order to movethe aircraft, wheels and brake packs had to be changed.

The 14th stage air is at a temperature of approximately 350_Cand would have reduced in temperature as it mixes with other enginebay air. The resultant temperature would probably not be hotenough to activate an engine bay firewarning, however, enginebay temperatures are displayed on gauges mounted on the flightengineer's panel. Engine bay temperatures are not monitored ontake off as the flight engineer's duties require him to guardthe throttles and monitor the engine instruments on the forwardpanel, he is therefore unable to see the engine bay temperaturegauges during take off.

A metallurgical examination of the duct carried out at DRA Farnboroughreported that:

'The duct had burst approximately mid way along its length becominggrossly distorted around its circumference and fracturing oneof the attachment lugs. Examination of the duct fracture surfacesrevealed the presence of a fatigue crack growing from multipleorigins at the weld toe at the base of an attachment lug. Thefatigue crack, which was approximately 40 mm in length, had penetratedthrough the saddle/duct section and extended along the duct forapproximately 5mm on either side of the saddle. This led intoa longitudinal tear approximately 450 mm in length before changingdirection in a manner consistent with a high pressure rupture,causing one end of the duct to become detached.

Examination of the other saddle-lug welds remote from the fracturerevealed one other example of cracking along a saddle weld. Thiscrack, when broken open and examined, was also caused by fatiguegrowth from multiple origins at the weld toes and had penetratedthrough the saddle material but had not progressed into the ductwall.

Examination of the fracture surfaces at high magnification byscanning electron microscopy revealed a large number of very finefatigue striations. However, due to rubbing damage at the crackorigins it was not possible to determine for how long the crackhad been present. The large number of striations observed wouldtend to suggest that the cracks had been present before the lastinspection, 104 cycles previously, although it is possible thatthey could also have been caused since by a resonant conditionpresent in the assembly.

Hardness tests carried out on a polished section of saddle materialgave an average result of 228 Hv(30kg) equivalent to a tensilestrength of approximately 740 MPa which is within the strengthrange for Inconel 625 material in a solution annealed condition(690-830 MPa).

There was no evidence of mechanical or corrosion damage thatcould have influenced the failure nor did the material conditionappear to be at fault.'

A similar occurrence to a CF6-50 engine fitted to a DC-10-30 inJune 1989 was reported in AAIB Bulletin 9/89. At that time, accordingto the engine manufacturer, there had been 84 reported failuresof the duct across the fleet, which resulted in 17 in-flight shutdownsand 9 rejected take offs. The current position (5 Jan. 96) isthat 181 events have been reported since 1985, including 18 in-flightshutdowns and 17 rejected take offs.

An improved design has been introduced by Service Bulletin 75-065which provided a duct with a revised mounting system to be fittedon an attrition basis. This duct was designed to match its thermalexpansion with that of the engine structure, and incorporatedintegral rings to replace the fillet welded lugs. The manufacturerstated that the new duct had addressed the majority of the earlyfailure modes, but had revealed new failure modes. The proposedsolution to these new difficulties introduced spring links toreduce thermal stresses and used rod-end bearings to provide animproved tolerance to misalignment. A six month service evaluationof the new configuration was due to start in February 1996 witha projected release of the field modification during the secondquarter of 1996.

In December 1994 the manufacturer replaced a fluorescent penetrantinspection (FPI) of the duct attachment lugs with a visual inspectionat the same frequency - every 750 hours or 250 cycles. The AAIBwere informed that the failed duct had been inspected 104 cyclespreviously, and was coming up to a further inspection on flighthours. Some operators have decided to continue with the FPI asthey do not have sufficient confidence in the probability of successof the visual inspection. This lack of confidence would appearto be justified by the failure of the visual inspection techniqueto detect the two cracks on the duct from N516MC 104 cycles beforethe duct failed.

During the investigation a comment was made that a cracked lugwas relatively easy to see if the visual inspection was carriedout conscientiously, and that the perceived success of the FPIhad been brought about by the enhanced inspection discipline itintroduced rather that the superiority of the FPI technique overthe visual inspection.