AAIB Bulletin No: 9/93 **Ref: EW/C93/4/3** **Category: 1a**

INCIDENT

Aircraft Type and Registration:	Boeing 767-322ER, N654UA	
No & Type of Engines:	2 Pratt & Whitney PW-4060 turbofan engines	
Year of Manufacture:	1992	
Date & Time (UTC):	12 April 1993 at 1249 hrs	
Location:	Runway 09R, London Heathrow Airport	
Type of Flight:	Public Transport	
Persons on Board:	Crew - 9	Passengers - 76
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Internal damage to No 2 engine	
Commander's Licence:	Airline Transport Pilot's Licence (USA)	
Commander's Age:	Not known	
Commander's Flying Experience:	Approx. 26,000 hours (of which 3,500 were on type)	
Information Source:	AAIB Field Investigation	

The aircraft was about to depart on a scheduled service to Seattle, USA. The actual take-off weight was calculated to be 325,272 lb, and a reduced thrust take off was planned using an engine pressure ratio (EPR) of 1.42. The weather conditions at the time were fine and clear, with a surface wind of 110°/5 kt, temperature +13°C, QNH 1001 mb. The threshold elevation of Runway 09R is 75 feet amsl.

The take-off run was commenced at 1249 hrs. The crew reported that as the aircraft approached an indicated airspeed of 80 kt there was a loud bang and the aircraft swerved sharply to the right. Directional control was maintained, the take off was abandoned, and the aircraft was brought to a halt on Block 79 of the runway. The ATC controller in the tower informed the crew by RTF that smoke could be seen coming from the right engine. An Aircraft Ground Incident was declared by the controller, and the emergency services were quickly in attendance on the runway.

The crew had initially considered that a tyre burst may have occurred, but once the aircraft had been stopped it became apparent that the right engine had run down completely. The appropriate engine shut down drills were then carried out. There was no fire warning indication on the flight deck.

Once the Airport Fire Service were in attendance, communication with the aircraft was established on 121.6 MHz. However as no fire was observed, the commander taxied the aircraft clear of the runway using left engine power. After the aircraft had vacated the runway onto Block 59, an increased amount of "smoke" was observed coming from the pylon area at the rear of the No 2 engine (the aircraft was positioned crosswind at that time). The commander therefore discharged the aircraft fire extinguishers into the right engine, and the Airport Fire Service also discharged BCF extinguishant into the engine.

Company engineering personnel arrived at the scene, opened several access panels around the engine and pylon, and requested that the engine be cooled. The Fire Service discharged approximately 10,000 litres of water around the engine area. The aircraft was then towed back to the parking stand.

Flight Recorders

The flight data recorder (FDR), a Sundstrand UFDR, was removed and a replay carried out using the AAIB replay facilities. The cockpit voice recorder was also replayed, but since electrical power had been left on the aircraft the recording of the event had been 'overwritten'.

Figure 1 shows some of the parameters during the aborted take off. Engine power was increased gradually on both engines, at around 10 seconds from an arbitrary datum. The maximum EPR recorded was 1.44 on No 1 engine and 1.43 on No 2 engine. The EPR then started to decrease from 1.43 on No 2 engine at 28.5 seconds, as shown in Figure 1. The EPR on No 1 engine remained at 1.44 until almost 30 seconds, before reducing in response to the thrust lever angle. Engine EPR was sampled every second; the thrust lever angle was only sampled once every 2 seconds, so that every second one of the two engine thrust lever angles was recorded. It is probable therefore that the engines were throttled back together between 29.5 seconds and 30.5 seconds as shown in Figure 1. The airspeed at the engine power reduction was 70 kt. Airspeed increased to a maximum of 75 kt two seconds later.

Exhaust gas temperature (EGT) continued to rise on No 2 engine after the engine had been throttled back, and it reached a maximum of 492 °C at 35 seconds. The maximum recorded EGT on No 1 engine was 468 °C at 31.5 seconds, just after the engines were throttled back. EGT is only sampled every 4 seconds so the actual temperature may have been higher than the value recorded.

Wheelbraking commenced just after 34 seconds as indicated by the brake pressure. Reverse thrust was not used during the deceleration.

External examination of No 2 engine

The engine bore no external signs of damage, apart from minor sooting of the jetpipe. However, it was apparent that there was major internal damage as the engine could not be turned, and a small quantitiy of debris was recovered from the runway. This consisted of what appeared to be a major portion of a high pressure compressor variable inlet guide vane (IGV), the end fitting of another IGV, two fragments of compressor blade and two bushings of a plastic material. In addition, there was a quantity of a fine particulate material in the jetpipe.

Engine details

The engine was a Pratt and Whitney 4060, serial no 724665. It had been installed new on the aircraft, which was delivered to the Operator on 10 November 1992. The engine hours and cycles were respectively 2,017 and 339.

Subsequent examination of engine

The engine was shipped to the manufacturer's overhaul and repair centre in the USA, where it was subjected to a strip examination in the presence of an FAA representative.

Within the extensively damaged high pressure compressor (HPC) it was found that two adjacent stage 5 blades had fractured less than one inch above their root platforms. Metallurgical examination of these revealed that the leading blade had suffered a fatigue failure which had progressed from the vicinity of the concave aerofoil side of the leading edge. The leading edge was heavily damaged and the fatigue origin site had been destroyed. It was determined that the fracture on the adjacent blade had been caused by rapid tensile-shear overload, probably from impact with the released portion of the preceding blade.

Corrective action

The engine manufacturer was aware of a number of similar '5th stage blade aerofoil events' and these are discussed in the All Operator Wire "PW400/72-35/TS: PWA:2-12-23-1".

The cause of such blade failures is due to high vibratory stresses which can occur when the variable vane system is more than 4° open from the normal vane schedule, during certain operating speeds. Tests have indicated that variations exist between engines in the scheduled versus actual positions of the variable vanes during transient engine operation. This hysteresis is believed to be the result of adverse tolerances within the stator vane system.

The All Operator Wire refers to the corrective action, which is a Service Bulletin that modifies the software within the electronic engine control (EEC). The effect of this is to change the stator vane schedule such that the vanes are closed by 5° within the N2 speed range of 9,100 to 9,550 RPM.

The revised software has been certified and is available for incorporation as per Sevice Bulletin PW4ENG 73-131. The FAA had been witholding 180 minute extended twin operations (ETOPS) approval for this engine type pending a solution to these failures. Although the Service Bulletin has not been given mandatory status by issue of a related Airworthiness Directive, its embodiment is a requirement for 180 minute ETOPS. The Boeing fleet retrofit is currently 33% complete, with 80% being forecast for the end of the year. (NB. The aircraft featured in this incident was on a flight which was subject to the 120 minute ETOPS requirements, which did not require the embodiment of this Service Bulletin.)

The Pratt and Whitney 4000 Series engine has not, thus far, been validated by the UK CAA. However, they have been supplied with all the information concerning this failure so that it can be considered as part of any future validation.