Boeing 767-336, G-BNWF

AAIB Bulletin No: 2/99 Ref: EW/C98/5/1 Category: 1.1

Aircraft Type and Registration:	Boeing 767-336, G-BNWF
No & Type of Engines:	2 Rolls Royce RB211-524H turbofan engines
Year of Manufacture:	1989
Date & Time (UTC):	1 May 1998 at 0938 hrs
Location:	London Heathrow Airport
Type of Flight:	Public Transport
Persons on Board:	Crew - 10 - Passengers - 198
Injuries:	Crew - Nil - Passengers - Nil
Nature of Damage:	Loss of No 8 brake, damage to right main landing gear and loss of hydraulic fluid
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	11,200 hours (of which 1,355 were on type)
	Last 90 days - 110 hours
	Last 28 days - 65 hours
Information Source:	AAIB Field Investigation

History of flight

The aircraft was on a scheduled passenger flight to London Heathrow where the runway in use for landing was 09L, the runway surface was dry. The landing weight was 112·2 tonnes with an associated Vref of 130 kt. The surface wind was 360_/10 kt and the commander (handling pilot) completed a normal manual landing using flap 30 with the autobrake set to level 3. The touchdown, at 136 kt, was described by the crew as normal and full reverse thrust was utilised initially. At 94 kt the autobrake was deselected by a forward movement of the speedbrake lever, manual brakes were

applied and reverse thrust was cancelled. The commander noted that during the initial application the right brakes appeared to grab slightly but thereafter the braking was normal. Whilst taxiing to the stand the brakes were used on several occasions and the performance of the brakes and all indications were normal except that the right rear brake temperature, as indicated on the EICAS, rose from level 3 when clear of the runway to level 5 when parked on the allocated stand; this indication was confirmed by the FDR. Most of the passengers had disembarked when the crew were informed that the right brakes were smoking, they then noted that the EICAS was indicating RF for the right hydraulic system; this is displayed when the hydraulic reservoir requires refilling. By this stage all passengers had disembarked, the crew then completed their shutdown checks and vacated the aircraft in the normal manner.

Examination showed that the brake reaction rod at the No 8 wheel (outboard rear wheel at the right main landing gear) had failed at its rod end attachment to the brake assembly (Figure 1). The brake assembly had then rotated with the wheel, rupturing the hydraulic and electrical connections and causing the loss of hydraulic fluid. As No 8 is an 'aft' rod, the rod remained attached at the centre bolt of the landing gear leg (where the fore and aft rods meet) and had simply trailed, wearing on the runway surface.

Flight Recorders

Although the aircraft was fitted with a Flight Data Recorder a more comprehensive selection of parameters was available from the Quick Access Recorder (QAR) so it was from this equipment, after replay by the operator, that the following data was drawn. The circuit breaker for the Cockpit Voice Recorder had not been pulled and so the CVR had recorded over the period pertinent to the event.

The QAR confirmed the crew's recollection of events and showed that, after two to three seconds of manual braking, at a speed of approximately 76 kt, brake pressures on both landing gears momentarily decreased. No unusual peturbations in the heading or accelerometer parameters were observed but the recorded values of No 8 brake temperature decayed to zero and the quantity of hydraulic fluid in the right hand system began to reduce very slowly.

During the taxi to the stand the brakes were used on several occasions, each of which resulted in a reduction of right hydraulic system fluid quantity. In addition, the temperatures recorded from the other seven brakes increased with higher values from the right main gear brakes until, as the aircraft was turning right onto the stand at 0942 hrs, an overtemperature warning was triggered by the No 7 brake.

Description

Figure 2 shows the undamaged brake assembly and torque reaction rod at No 7 wheel, adjacent to the failure at No 8 wheel. The torque loads from each brake assembly are reacted by the associated brake reaction rod, which is attached to the torque arm of the piston housing by the brake attachment pin. This pin is retained within the brake piston housing by a concentric retaining bolt. At the other end of the brake rod the centre bolt acts as a pivot pin, securing the forked ends of the fore and aft brake rods at the lower end of the landing gear leg.

Detailed examination

The separated end cap of the brake reaction rod was recovered from Runway 09L and the fracture surfaces were examined in detail. The examination showed that the failure was an 'overload' failure in tension, with satisfactory strength in the steel material and no evidence of any pre-existing defect to reduce the strength of the rod. There was also some evidence that, before final separation, the rod had been rapidly subjected to a few (<10) applications of a cyclic load approaching the final failure load.

Further examination of the No 8 brake at an overhaul facility confirmed that there was not a problem with the brake hardware, with normal brake wear for the number of landings. However, when the brake housing was checked for dimensions, it was found that the bushing for the attachment pin was 'ovalised' in the direction of the loads applied by the brake rod, confirming that there had been high loads along this axis.

Previous occurrences

This incident was broadly similar in outcome to, but differed in detail from, a number (> 20) of previous cases of brake reaction rod separations on Boeing 767 aircraft with carbon/carbon brakes world-wide. These incidents occurred in the period since August 1992 and AAIB was involved in an extensive investigation in September 1993 following two particular incidents at London Heathrow. At that time the CAA was sufficiently concerned about the risk posed by a failure simultaneously affecting two separate brakes on one landing gear leg that a performance limitation was imposed on Boeing 767 aircraft. Double brake failures had been caused both by failure of the centre bolt and by simultaneous failures at the brake units.

There had been extensive experimental and analytical work by the airframe and brake manufacturers to understand and remedy the problem. In general, the problem appeared to have arrived with the introduction of carbon/carbon brakes to the Boeing 767 fleet and was caused by the high loads generated in a highly energetic vibration mode between a fore-aft pair of brakes and their associated brake reaction rods.

The concern from the operators and regulators had resulted in a series of maintenance and hardware changes and it had appeared that these changes had eliminated the problem, at least as far as British-registered aircraft were concerned. A number of failures had, however, still occurred to other operators world-wide.

Up to the incident to G-BNWF there had been no record of any previous failure where the brake rod's end cap had failed. Thus, the failure of the brake reaction rod in this incident, to G-BNWF, appears to be a new failure mode, still related to the dynamic characteristics of the carbon/carbon brake on the Boeing 767.

In this particular case, with a simple failure of a 'trailing' rod, the effects of the failure were relatively innocuous, resulting simply in the loss of the single No 8 brake. Of concern, however, is that the same mechanism could result in a failure of a 'leading' rod or, as happened in some previous "1992/93" cases, simultaneous failures of a pair of rods.

Further action

In the summer of 1998 the airframe and brake manufacturers achieved certification of an updated brake for the Boeing 767 family, using a new carbon brake material, similar to those in the Boeing 777 family. Development flight testing has indicated that these brakes are less prone to producing damaging dynamic effects, such as have caused brake rod failures in the Boeing 767 family. The operator is to equip its fleet of Boeing 767 aircraft with the modified brake assemblies.