**No: 9/91** **Ref: EW/C1193** **Category: 1a**

| | | |
|---|---|---|
| **Aircraft Type and Registration:** | Boeing 757-23A, PH-AHK | |
| **No & Type of Engines:** | 2 Rolls-Royce RB 211-535E4 turbofan engines | |
| **Year of Manufacture:** | 1989 | |
| **Date & Time (UTC):** | 15 January 1991 at 1230 hrs | |
| **Location:** | London Gatwick Airport | |
| **Type of Flight:** | Public Transport | |
| **Persons on Board:** | Crew - 9 | Passengers - 195 |
| **Injuries:** | Crew - None | Passengers - None |
| **Nature of Damage:** | No. 6 landing gear wheel, bearing and axle damaged beyond repair | |
| **Commander's Licence:** | Netherlands Airline Transport Pilot's Licence | |
| **Commander's Age:** | 38 years | |
| **Commander's Flying Experience:** | 8,800 hours (of which 450 were on type) | |
| **Information Source:** | AAIB Field Investigation | |

The aircraft took-off from London Gatwick on runway 08 Right at 1230 hrs. Just after lift-off, at a height estimated to have been not more than 50 feet agl and just before the landing gear was retracted, a wheel was seen to fall to the ground by an eye witness.

Neither the operating crew nor the ATC tower controller were aware of this event until the eye-witness telephoned ATC about one minute after it had occurred. The tower controller then informed the commander that the aircraft appeared to have lost a wheel. The commander requested a visual inspection of his landing gear and was given radar directions for an extended right-hand circuit to bring his aircraft past the ATC tower at a height of 200 feet. Meanwhile, airport vehicles inspected the runway for debris and located the wheel, which had bounced along the north side of the runway and passed just north of the ILS localiser aerial, before coming to rest near the airport boundary fence. The commander was advised that the wheel had been identified as one from the main landing gear, and visual inspection of the aircraft during its fly-past by ATC indicated that the inner rear wheel (No.6) of the left main bogie was missing.

The aircraft flew a further extended circuit to allow time for other aircraft to land. It was then landed at 1301 hrs. After inspection of the landing gear by the airport fire service, which reported no damage other than the missing wheel, the aircraft was taxied back to the passenger terminal.

The commander later reported that an anti-skid warning light had illuminated for a short time approximately 5 minutes after he had received the initial ATC report of the missing wheel. However, the light then went out and, on landing, the anti-skid system appeared to operate normally. This light had also illuminated for a short time on the previous day and this had been reported to the ground engineers, but they had found no fault.

Examination of the wheel and the associated bearings revealed that the outer bearing, part number LM718947/LM718910 (DAS2062-273), had failed in such a manner as to allow the wheel to slide outboard on its axle and to pivot upwards. This pivoting action had caused the outer diameter of the inner bearing housing to contact the inner diameter of the torque tube/thrust assembly of the brake, which had then resulted in the corner of the thrust plate machining into the housing. This machining had resulted in the bearing housing becoming 'parted', leaving the inner bearing housing of the wheel on the axle and allowing the remainder of the wheel, together with the cup and some rollers of the outer bearing, to come off the axle and depart the aircraft. The cones of both the inner and outer bearings remained on the axle. The cup of the inner bearing was not recovered.

The wheel and the bearing remains were taken to the wheel manufacturers for further examination. Inspection of the outer bearing showed that it had "burned-up". This condition can result from inadequate bearing lubrication, which can occur due to insufficient quantity of lubricant to maintain a lubricant film, or due to the lubricant used not being capable of maintaining a proper film thickness for the bearing speeds and loads involved. Due to the severity of damage to the outer bearing it was not possible to obtain any further information from the examination except that the failure had occurred over a short period of time. The examination of the remains of the inner bearing showed good evidence that it had been operating with excessive end play (photograph No.s 1 & 2). The evidence also indicated that this condition had been existent for a long time, possibly since the wheel was fitted to the aircraft 356 landings prior to the accident. There was also evidence that there had been a lubrication problem within the bearing in that there had either not been enough grease or that a poor quality of grease had been used.

The parts of the failed bearing were sent to the manufacturer, Timken USA, for detailed material analysis. After exhaustive testing it was established, beyond reasonable doubt, that the bearing was the correct item and that it had been manufactured by Timken.

There are a number of possible causes of excessive endplay. The wheel retaining nut may not have been torqued correctly; the bearing bedding-in torque may not have been applied correctly; the bearings may not have been rotated or oscillated whilst the torque was being applied or excessive wear or failure may have occurred within the bearings.

The wheel retaining nut had remained on the axle and its locking system had remained intact to the extent that it could be seen that the nut had not 'backed-off'. A check of the remaining wheels on the left main landing gear bogie showed that the torque settings of the wheel retaining nuts were within the specified range. Enquiries made with the maintenance organisation that fitted the wheel established that, at the time the wheel was fitted, their maintenance manuals showed the amended torque settings for the wheel retaining nut and that the wheel was fitted in accordance with the maintenance manual procedures. Examination of the maintenance documentation showed that when the No. 6 wheel was fitted to the aircraft, the No. 5 wheel was also replaced. One week before the accident the No. 5 wheel was removed for tyre damage, and examination of the wheel bearings showed them to be serviceable with no visible evidence of having run with excessive endplay which would have occurred if the wheel retaining nut had not been correctly torqued. The associated bearings were put back into service.

From the examination of the remains of the No. 6 wheel bearings there was good evidence to indicate that the excessive endplay had not been as a result of pre-existing failure or material defect within the bearings.

During the examinations of the bearings and their housings substantial quantities of a black coloured grease were found in areas that indicated that a lack in quantity of grease should not have occurred. Samples of this grease were removed and, when analysed, were found to be Aeroshell Grease 5. When the bearing was serviced in September 1990, the maintenance organisation had a bearing pressure greasing system in operation which used Aeroshell Grease 5. The Dunlop Wheel Maintenance Manual specifies a grease that meets the MIL-G-81322 specification, with which Aeroshell Grease 22 complies for the lubrication of these wheel bearings. The Boeing 757 Maintenance Manual specifies that Aeroshell Grease 5 or Aeroshell Grease 22 can be used. This was done with the approval of Dunlop. The grease manufacturer has stated that Aeroshell Grease 5 is compatible in all proportions with Aeroshell Grease 22. The bearing manufacturer however recommends that in this type of application greases that have extreme-pressure (EP) additives should be used. Neither Aeroshell Greases 5 or 22 contain these EP additives.

When samples of the grease from the failed bearings were analysed by the Analytical and General Chemistry Section of the RAE Farnborough, approximately 23% of the solid materials present were found to be carbon. Optical microscopy of this carbon-based material showed a few angular grains to

be present which were identified as sand. X-ray diffraction and scanning electron microscopy established the presence of the 'Cliftonite' form of carbon. Cliftonite is apparently a form of Diamond which is produced by subjecting carbon to extremely high pressures and temperatures. Abrasive particles and a hard form of carbon have thus been found, although at which point the former were introduced and the origin of the latter are not clear, particularly since there was no evidence of any associated graphite or fibres from the carbon brake-pack.

The aircraft manufacturer, Boeing, have knowledge of similar occurrences of Boeing 757 main landing gear wheel bearing failures which have resulted in the loss of a wheel during take-off. The following is an extract from a Boeing telex on this subject:

"In 1988/1989 one 757 operator whose airplanes are equipped with Dunlop carbon brakes reported the loss of five main landing gear wheel assemblies during take-off. The loss of one of the wheels was attributed to loosening of the axle nut due to inadvertent omission of the axle nut lock bolts during a previous wheel change. The cause of the other four wheel losses has been attributed to disintegration of the wheel outer bearings. Following a subsequent investigation, we concluded that the loss of wheel bearing preload was most likely a major cause of the reported bearing disintegration that resulted in departure of the wheels from the airplane. As a result of this investigation and to ensure that adequate wheel bearing preload exists, a service letter was released recommending that the wheel bearing axle nut torque be increased. The Maintenance Manual procedure was revised accordingly in the 20 June 1989 revision.

Subsequently, another operator reported the loss of the No.3 wheel during take-off. During the previous landing, the flight crew reported that the EICAS brake temperature indication for the number 3 wheel brake was 3 units higher than other wheels, and the EICAS "antiskid" message was annunciated. After landing, the No.3 front wheel hub cap was observed to be missing. During the next take-off, the No.3 wheel departed the airplane. The wheel had accumulated 253 landings since installation on this airplane. The wheel retaining nut torque for all other wheels on the airplane were checked and found to be within the 110-160 foot-pound value specified in the service letter and Maintenance Manual procedures.

The damaged parts were returned to Boeing for examination. Based on the results of our examination, the wheel loss has been attributed to disintegration of the P/N LM718910 outer bearing. Disintegration of this bearing allowed the wheel to pass over the wheel retaining nut and depart the airplane. Due to the severity of the damage to the outer wheel bearing, we were unable to confirm the cause of the bearing disintegration and resultant wheel loss."

During the course of this investigation a number of wheel overhaul facilities were visited and it was noted that it was not uncommon to find bearings removed from an in-service wheel to be in a severely damaged state and very close to the point of failure. In every case the wheel had been removed from an aircraft for a tyre change.

In view of the findings associated with this wheel bearing failure, the following Safety Recommendations have been made to the Civil Aviation Authority:

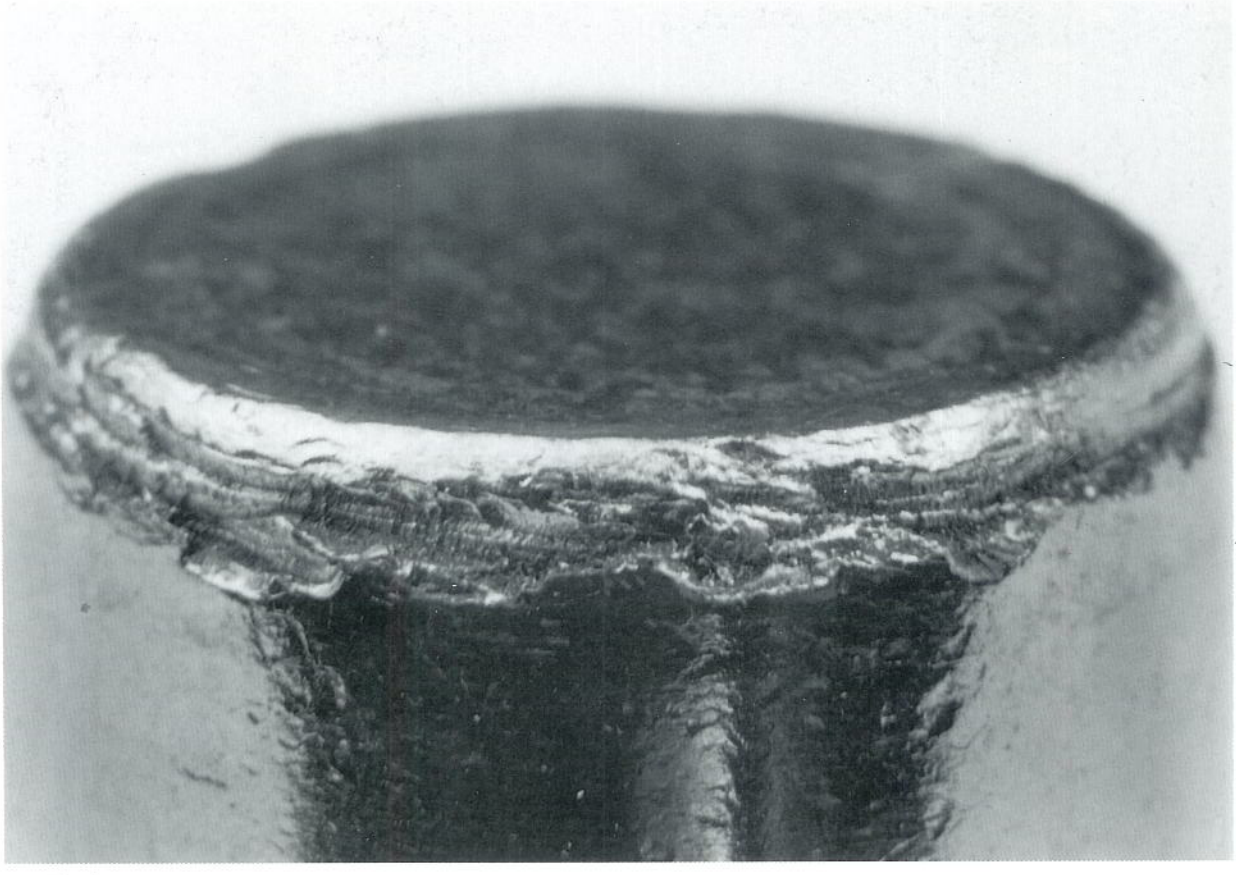
1. The CAA take action to ensure that the life assessment, maintenance and inspection procedures applicable to public transport aircraft wheel bearings in service are satisfactory, particularly as tyre lives are extended.

2. The CAA introduce a requirement to check landing gear wheel retaining nut torque during the installed life of Boeing 757 wheels in order to detect cases of excessive bearing wear before wheel detachment occurs.

3. The CAA require that the aircraft and wheel manufacturers specify the use of wheel bearing greases containing extreme pressure additives, as recommended by the bearing manufacturers.

4. The CAA evaluate the need for research into the affects upon wheel bearing life of contamination of bearing greases by carbon dust from carbon wheel brakes.

Photograph No.1 Geometric stress concentrations (GSC), a form of fatigue, over 20 degrees of the inner bearing cone, caused by heavy contact with the rollers.



Photograph No.2 Heavy GSC spalling at the small roller ends caused by heavy contact with the cone.