

**No: 10/88**

**Ref: EW/C1048**

**Ref: 1a**

**Aircraft Type and Registration:** Boeing 747-136 G-AWNB

**No & Type of Engines:** 4 Pratt and Whitney JT9D-7 Turbofan Engines

**Year of Manufacture:** 1970

**Date and Time (UTC):** 1 November 1987 at 1318 hrs

**Location:** London/Heathrow Airport

**Type of Flight:** Public Transport

**Persons on Board:** Crew -16 Passengers -322

**Injuries:** Crew -None Passengers -None

**Nature of Damage:** Left landing gear support beam end fitting failed, damage to wing top skin panels and secondary structure

**Commander's Licence:** Air Transport Pilot's Licence

**Commander's Age:** 43 years

**Commander's Total Flying Experience:** 9260 hours

**Information Source:** Crew Report and AAIB and Aircraft Manufacturer's Inspection of Components

When the throttles were advanced to 1.2 EPR with the brakes 'ON' in preparation for take-off the crew heard a "bang". A cockpit check revealed no unusual indications and take-off, climb and flap retraction proceeded normally. At about 5000 ft the steward reported that a skin panel had ruptured in the left wing forward of the inboard spoiler and behind the aft spar. Following consultations with engineering staff the crew jettisoned fuel and landed back at London (Heathrow) at a weight 5300 kg below max landing weight. No problems were experienced in handling and a normal landing was made.

Examination showed that there had been a failure at the outboard end of the left wing landing gear support beam where it attaches to the aft face of the rear wingspar. The wing gear is mounted between the rear spar and the support beam (see Fig.1). The support beam is designed to be fail-safe in the event of any disconnection at the outboard end. If unsupported at the outboard end the beam, acting as a cantilever, is capable of supporting 90% of the design ultimate undercarriage loads but, at any given load, will deflect to a far greater degree than it would intact. Such deflection will result in abnormal movement of the undercarriage leg and also of the inboard flap, the inboard rail of which is attached to the support beam. There would have been some increased movement of the flap under flight loads but no adverse effect on the aircraft's performance or control was remarked upon by the crew. Upward

bending of the beam had caused it to hit and rupture the light structure and honeycomb sandwich panelling which form the top wing skin aft of the wing box. With this type of failure there is also the possibility of damage to adjacent control cables and hydraulic lines.

The outboard end fitting (Fig. 2) is an articulated joint comprising a spherical bearing on the beam which attaches to a separate vertical hinge on the rear wing spar. The spherical bearing is mounted in doubled plates which are clamped to either side of the support beam end. The central retaining pin for the spherical bearing is a hollow fuse pin and lubrication is by grease injected through a nipple into the pin core. Grease then flows outward through passages in the pin and in the copper-beryllium inner race to lubricate the surfaces between the pin (chrome plating on steel) and the inner race and between the inner race and the outer race (stainless steel). The outer race is located in copper beryllium bushes in the support beam end plates. These bush surfaces are not lubricated but are assembled into the beam end plates with wet primer to provide a seal against moisture ingress.

A preliminary metallurgical inspection was carried out by the Materials Department, RAE Farnborough and a full examination by the aircraft manufacturer. The end plates had both suffered nearly identical fractures initiating from the internal bore surfaces; two fractures in each case running inboard along lines focusing on the centre of the bore and angled at about 45° above and below the beam spanwise direction. Small areas of pre-existing cracking could be seen emanating from the bore internal surface (which mates with the copper-beryllium bush). This surface was severely pitted by corrosion which was unevenly distributed over the bore surface but was present at the origins of the cracks. The pre-existing cracking was found to be predominately due to stress-corrosion and the four separate areas of cracking (top and bottom fractures, fore and aft end plates) had penetrated by between 0.1 and 0.3 ins (combined penetration of corrosion and cracking). Later analysis of the end plate material (9Ni-4Co-0.3C) showed it to be within specification.

Samples of "old" grease were taken from the outside of the assembly (grease which had obviously been ejected from between the bearing surfaces during re-greasing) and samples were also obtained of deposits on the surface of the fuse pin and on the internal bore of the support beam end fittings.

Although fresh grease was found inside the fuse pin the material on the bearing surfaces between the pin and the inner race and between the inner race and outer race showed signs of stagnation and deterioration. The chrome plating on the surface of the pin had been almost completely destroyed. An area of intact plating remained, close to the grease transfer passages, and it was apparent that during re-greasing it had been possible for fresh grease to be forced through to the spherical bearing surfaces, ejecting old grease from the periphery, but that old grease was not being purged from all the areas requiring lubrication. It should be noted that this bearing assembly experiences minimal movement and there is no requirement in normal servicing for the components to be rotated or exercised in any way to keep the grease mobile. Furthermore, there is no requirement for this assembly to be dismantled and visually inspected other than during major structural surveys. On G-AWNB the assembly had last been dismantled in 1973 during implementation of a service bulletin and would have been last lubricated in June 1987. At the time of the failure the aircraft had completed 63,721 flying hours and 15,887 landings.

The multi-purpose grease "Aeroshell 7" had been applied as the lubrication in this assembly. It was reported that, some years previously, a grease based on molybdenum disulphide had been used. Chemical analysis of the different deposits by the RAE gave results which were similar between one another and were generally consistent with Aeroshell 7. They did, however, show some differences from Aeroshell 7 which could not be entirely resolved and showed Molybdenum to be present in the ejected material, which presumably contained the oldest grease, and in the material from the bore surface exhibiting the corrosion pitting and cracking.

The surface deposit which was recovered from the bore containing the fractures did, therefore, appear to be a mixture of the greases which had been previously used together with their products of deterioration and metallic corrosion debris. This surface is not intentionally lubricated but it would appear that, as the assembly's exterior became congested with ejected, used grease this was induced in between the bushing and the bore by the "working" of the bush in the bore under load.

It is not clear what the precise process was that led to the corrosion and pitting of the bore surfaces. Originally, the surface was plated with a cadmium/titanium finish. This would have been damaged by **mechanical wear during service but chemical** attack by the break-down products of the greases was also a possibility as signified by the presence of chloride, formate and acetate ions. However, the basic component materials used here, and very commonly used elsewhere, place copper and iron in close proximity and allow the possible creation of an electrolytic corrosion process, in the presence of moisture, in which the iron would sacrifice. In addition, it is unlikely that the deteriorated greases would be able to perform the function of excluding moisture from the surfaces which they covered. Once the degraded lubricants had penetrated between the bush and bore it is likely, therefore, that moisture also entered and assisted both chemical and electrochemical processes of corrosion.

The assembly from the right hand wing landing-gear on G-AWNB showed only a small degree of deterioration but from examination of the components and of grease samples it was clear that a similar pattern of corrosion had been initiated.

Following the incident, on the 11th November, the Civil Aviation Authority issued an Emergency Airworthiness Directive (A.D. 012-11-87) requiring an inspection of all Boeing 747-100 and -200 aircraft with over 7 years service using an ultrasonic inspection technique developed by the operator (British Airways J57U113) to detect defects or cracks. This was followed by a further requirement for dismantling and visual inspection of the affected area during the next appropriate scheduled maintenance.

Boeing developed an ultrasonic technique for crack detection of the beam end fitting (NDT Manual, D6-7170, Part 4 Chapter 57-40-03 revision 15 Feb 88) and developed a rework procedure and limits which appeared in Service Letter 747-SL-57-50-A (11 December and subsequent). A Service Bulletin (747-57-2244) issued on 31 March urged operators to carry out the described ultrasonic crack detection procedure upon the accumulation of 30,000 flight hours or 8 years service (whichever earlier) or within 18 months after receipt of the bulletin, whichever later. The bulletin also described the reworking procedure to be carried out if cracking were detected and which also could be implemented to terminate a requirement for 18 monthly repeat inspections. From airframe 696 onward bushings and bolts in the beam end assembly will be assembled with wet sealant and fillet sealed where appropriate to improve corrosion protection.

Fig. 1

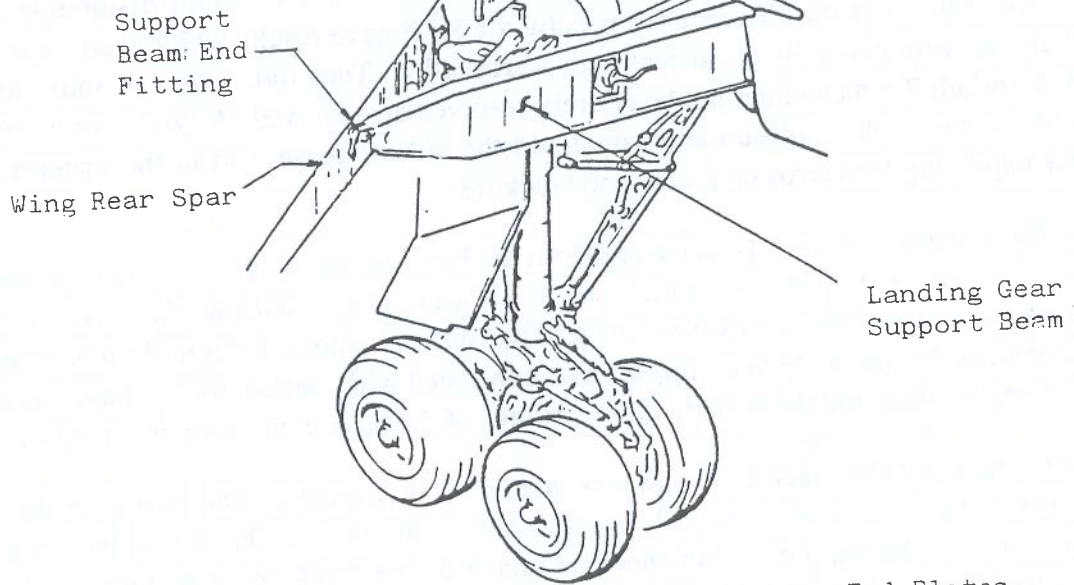


Fig. 2

