AAIB Bulletin No: 2/95 **Ref: EW/G94/08/12** **Category: 1.1**

INCIDENT

Aircraft Type and Registration:	Boeing 747-212B, G-TKYO
No & Type of Engines:	4 Pratt & Whitney JT9D-7Q turbofan engines
Year of Manufacture:	1980
Date & Time (UTC):	19 August 1994 at 0140 hrs
Location:	Newark Airport, New Jersey, USA
Type of Flight:	Scheduled passenger
Persons on Board:	Crew - 21 Passengers - 331
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to bleed air ducts and electrical systems at No 3 pylon
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	15,453 hours (of which 10,213 were on type) Last 90 days - 179 hours Last 28 days - 79 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and AAIB enquiries

G-TKYO was operating a scheduled passenger service from Newark to Heathrow. Shortly after takeoff from Newark, at about 300 feet agl, two muffled (but distinct) 'bangs' were heard followed by a right wing overheat warning, No 4 generator failure warning, hydraulic systems 3 and 4 overheat warnings and fire detection loop fault warnings on the No 4 engine fire detection systems. The wing overheat drill was carried out and the associated overheat warning extinguished. The hydraulic overheat warnings and the No 4 generator were successfully reset. The aircraft returned to Newark without further incident until, after landing and on selection of reverse thrust, no reverse thrust indication was obtained for the No 4 engine which subsequently ran down as the aircraft vacated the runway.

The National Transportation Safety Board examined the aircraft at Newark. On examination of the right wing leading edge it was found that a bleed air duct, part number 69B40118-6, which was fitted at the R9 position had fractured at the annular weld adjacent to the flange, at the outboard end. This duct is fitted just inboard of the No 3 pylon. Secondary damage had occurred to adjacent ducts and

electrical looms; also a number of circuit breakers were found tripped due to electrical short-circuits in damaged wiring within the leading edge. The No 3 pylon 'blowout' panels had functioned as intended and no structural damage had occurred. The fuel condition actuator for the No 4 engine was found in the closed position. It is probable that this actuator was signalled to close by a spurious input from the damaged electrical looms, so causing the engine to run down. The No 4 thrust reverser was found in the deployed position, suggesting that the indication of 'non-deployment' on the flight deck was also spurious. The fractured R9 duct carried the markings 250/BAS/7-90 and 74736A2074R4 RELIEVED adjacent to the part number. Records showed that at the time of the incident G-TKYO had a total of 57,151 hours and 11,384 cycles. The operator stated that the requirements of Boeing Service Bulletin 36A2074, revision 5, were embodied at 44,534 hours/9,993 cycles. This Service Bulletin calls for dye penetrant inspection, proof pressure test and stress relieving of the relevant ducts. The stress relieving of the duct was carried out by a Boeing approved vendor in the USA and was categorised as 'terminating action' under the requirements of the Service Bulletin; otherwise repeat inspections are required.

Metallurgical examination of the duct fracture was conducted by the Structural Materials Centre of the DRA at Farnborough. No evidence of fatigue, or of cracking existing at the time the duct was stress relieved, was found. It was concluded that the fracture of the duct had occurred due to growth of cracks around the weld by a process consistent with a sustained load mechanism (SLC). The report stated '...the fact that SLC has occurred suggests that either the (stress relieving) treatment was not effective in removing residual stresses or that crack growth occurred under the influence of a combination of other stresses which acted on the duct in service.' The report also concluded that the stress relieving process is not sufficient to prevent SLC in these ducts.

Boeing have supplied details of six other cases of titanium bleed air duct failures which have occurred after the terminating action of Service Bulletin 36A2074 had been carried out. In two cases the parts were not available to Boeing for analysis, and in one case the analysis was inconclusive. In three cases there was evidence that undetected cracking had existed before the stress relieving process had been carried out.

The AAIB is advised that titanium and its alloys can be adversely affected by the migration of hydrogen to areas of stress, where hydrides can form and have an embrittling effect. In such circumstances the removal of stresses will prevent further hydride formation and delay cracking, however if significant in-service or installation stresses do exist the process can continue to the point of failure, especially if pre-cracking has gone undetected. It would appear that in order to reduce the risk of failure it is necessary to reduce the in-service stresses as well as those internal to the material. This might be achieved by the use of lower strength duct material with a greater wall thickness, or by the introduction of mechanical devices such as bellows to limit the stresses which can be applied. An alternative approach would be to life-limit the ducts.

A number of bleed air duct system failures on Boeing 747 aircraft have been investigated by the AAIB (Bulletin 8/91, Addendum 6/92, Bulletins 10/92 and 3/93). The associated causes have been varied and the AAIB continues to be concerned at the frequency of bleed air duct system failures, in addition to their potential effects on flight safety.

Safety Recommendation

In view of the above findings, the AAIB makes the following Safety Recommendation:

94-39: The Boeing Commercial Airplane Company, the FAA and the CAA should jointly consider whether the stress relieving and inspection requirements of Boeing Service Bulletin 36A2074 are adequate to permit the affected bleed air ducts to continue in service on Boeing 747 aircraft.