AAIB Bulletin No: 2/96 **Ref: EW/C95/7/4** **Category: 1.1**

INCIDENT

Aircraft Type and Registration:	Airbus A310-222, F-OHPE
No & Type of Engines:	2 Pratt & Whitney JT9D-7R4E1 turbofan engines
Year of Manufacture:	1983
Date & Time (UTC):	9 July 1995 at 0118 hrs
Location:	On departure from Glasgow Airport
Type of Flight:	Public Transport
Persons on Board:	Crew - 7 Passengers - 209
Injuries:	Crew - None Passengers - None
Nature of Damage:	Compressor damage to No 1 engine
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	44 years
Commander's Flying Experience:	11,000 hours (of which 300 were on type) Last 90 days - 200 hours Last 28 days - 90 hours
Information Source:	AAIB Field Investigation

The crew commenced their duty in Tenerife at 1445 hrs on Saturday 8 July 1995 and flew the aircraft on an 18 minute positioning flight from Tenerife South to Las Palmas. At 1722 hrs the aircraft departed Las Palmas for Glasgow, arriving at 2121 hrs. At 0113 hrs on Sunday 9 July the aircraft departed Runway 05 at Glasgow, with 7 crew and 209 passengers on board, for its return flight to Las Palmas. The Glasgow weather observation, timed at 0120 hrs, gave a surface wind of 060°/10 kt, visibility 10 km in moderate rain, with scattered cloud at 2,400 feet and broken cloud at 4,600 feet. The temperature was +13°C with a dewpoint of +11°C and the QNH was 1025 mb.

During the initial climb the aircraft encountered an area of moderate rain and light turbulence. Although the Electronic Aircraft Central Monitor (ECAM) system showed that the outside air temperature was not in the icing range, the commander selected engine anti-icing ON and ignition to CONTINUOUS as a precaution. As the aircraft climbed through FL120, with NAV and PROFILE engaged and No 1 autopilot in command, the crew heard a loud 'bang' and noticed the Engine

Pressure Ratio (EPR) on No 1 engine drop to 1.1. As this occurred, the aircraft yawed to the left and the No 1 autopilot disengaged. However, the No 1 engine recovered almost immediately but the crew noticed that although the EGT was within the normal operating range, at 545°C, it was higher than the No 2 engine EGT, which was 380°C. There were no other abnormal indications. The commander then re-engaged No 1 autopilot and selected the ENGINE page on ECAM. As this also showed no abnormalities, the commander decided to continue the climb.

As the aircraft climbed through FL170, the crew heard three further bangs and saw fluctuations on the engine instruments for No 1 engine. The throttles were retarded to the idle position but again all the engine parameters were within the normal range, except that the N1 (fan speed) for No 1 engine was 20% higher than that of the No 2 engine. Passengers seated on the left of the aircraft, and a stewardess in the rear of the cabin, noticed flames issue momentarily from the tail pipe of the engine.

The commander declared an emergency, transmitting "WE HAVE AN ENGINE FAILURE" on the Scottish control frequency of 126.25 MHz, and elected to return to Glasgow, which was brought to full emergency status. The commander later reported that the No 1 engine was operated at idle power until the aircraft was established on the localiser for the final approach. It was then used normally and selected with caution to full reverse on landing (the Quick Reference Handbook (QRH) checklist regarding 'ENGINE STALL' states that 'if the stall does not recur....continue normal engine operation').

The aircraft, which does not have a fuel jettison capability, landed at an all up weight of 124 tonnes, 2 tonnes above its normal maximum landing weight. After landing the aircraft taxied to its stand and the passengers were disembarked normally.

Examination of engine

The investigation and rectification action on the left engine was conducted by personnel from a Belgian maintenance organisation with whom the airline had a contract (the aircraft itself was on a short term lease from Airbus Industrie). The engine was subjected to a boroscope examination, with no damage apparently being found. It was subsequently established that there had been a compressive failure of a 'teleflex type' feedback cable close to its attachment to the 3.0 bleed actuator. The 3.0 designation describes the axial location on the engine of a bleed ring which bleeds excess air from the low pressure compressor at low power settings. Actuation is via a fuel-driven actuator, operating on a master bellcrank, which in turn drives slave linkages attached to the bleed ring at intervals around the compressor casing. The feedback cable's function is to provide bleed actuator position information to the engine vane bleed control (EVBC). However, after the cable was replaced, the engine would not accelerate above idle. Further investigation revealed that there was low fuel delivery pressure from the fuel pump. A new pump was fitted, but during the subsequent engine runs a significant throttle stagger developed above 1.12 EPR.

The EVBC was then replaced, but the engine still would not run properly. It was then decided to change the engine. The aircraft finally left Glasgow on the afternoon of Sunday 16 July.

The engine was subsequently stripped at an engine overhaul facility in Brussels, and a summary of the findings was later presented to the AAIB. It was established that 3.0 bleed ring had become detached from the actuating linkage due to a failure of a clevis bolt in the bellcrank that attached to the actuator rod. The position of the failure is indicated on the accompanying diagram and photographs. The bolt tail and clevis pad were found in the compressor casing, and it was apparent that the fracture face consisted of approximately 90% fatigue, the remainder being overload. Following the migration of the top portion of the bolt out of its location, the bellcrank would have become disconnected from the clevis. The detached portion of the bolt presumably fell into the bleed annulus and was ingested into the high pressure compressor. Severe damage was caused to the blades and vanes. It was subsequently discovered that the powerplant engineers had not boroscoped this part of the engine at Glasgow. Following the discovery of the broken feedback cable (a failure that they had seen on previous occasions) they had merely wished to check the turbine for evidence of overheat damage. The maintenance organisation's report did not give a reason for the fatigue failure. However, some wear was evident on the shank of the remaining portion of the bolt. The report also noted evidence of wear elsewhere in the actuating linkage.

The fuel pump was subjected to a bench test, where the hydraulic function was found to be low in delivery pressure. This was due to worn gear teeth. However, it was not clear how such a relatively minor defect could have accounted for the inability of the engine to accelerate above idle following the cable change. A bench test of the EVBC revealed no anomalies.

No explanation was given for the failure of the feedback cable, which in fact was not returned to Brussels. The cable had failed close to the 3.0 actuator, with the failure taking the form of an 'S' bend, indicative of a compressive failure. It was concluded that the most probable cause for the surges experienced in this incident was the bolt ingestion event. When the surges occurred during the climb, the bleed valve would have been in the fully closed position, with any failure of the feedback cable having no immediate impact on engine operation. The surge would have caused the valve to open, but it would have closed again upon surge recovery. The feedback cable is loaded compressively when the valve moves in the closing direction. When the bolt failed, the movement of the actuator output rod would no longer have been limited by the valve ring, leading to the potential for the output rod and feedback cable to overtravel. This has led to the suggestion that the cable failure may have been the result of the feedback arm on the EVBC reaching its stop prior to the actuator rod achieving its extended limit of travel. Whatever the exact cause, it remains likely that the feedback cable failure occurred as a consequence of the bolt failure and surges. However, the engine manufacturer confirmed the comments made by the engineers at Glasgow in that these cables are susceptible to wear, binding and occasional breakage. In connection with this Pratt & Whitney have issued Maintenance Advisory Note No MAN-JT9D-7R4-1-91, recommending cable inspection at 3,000 hour intervals.

Information from the engine manufacturer indicated that there has been a history of engine surges stemming from wear problems associated with the 3.0 bleed actuation linkage. A number of Service Bulletins (SBs) have been issued in order to address these problems, including SB JT9D-7R4-72-336, which introduced a vibration damping system to the bleed valve assembly.

Two other relevant Bulletins are SB -72-444 (revised bleed system hardware) and -72-508 (provision of new bolts with larger heads and new steel bushings in the master actuator location). Neither of these SBs were embodied on the subject engine. SB-72-444 was issued in April 1991 as a Category 4 requirement, meaning that it should be incorporated at the next shop visit. The engine manufacturer was aware of approximately three instances of bolt ingestion, all involving post SB-72-444 engines, and which were different to those involved in the subject incident. SB-72-508 corrected the problem of these bolt failures.

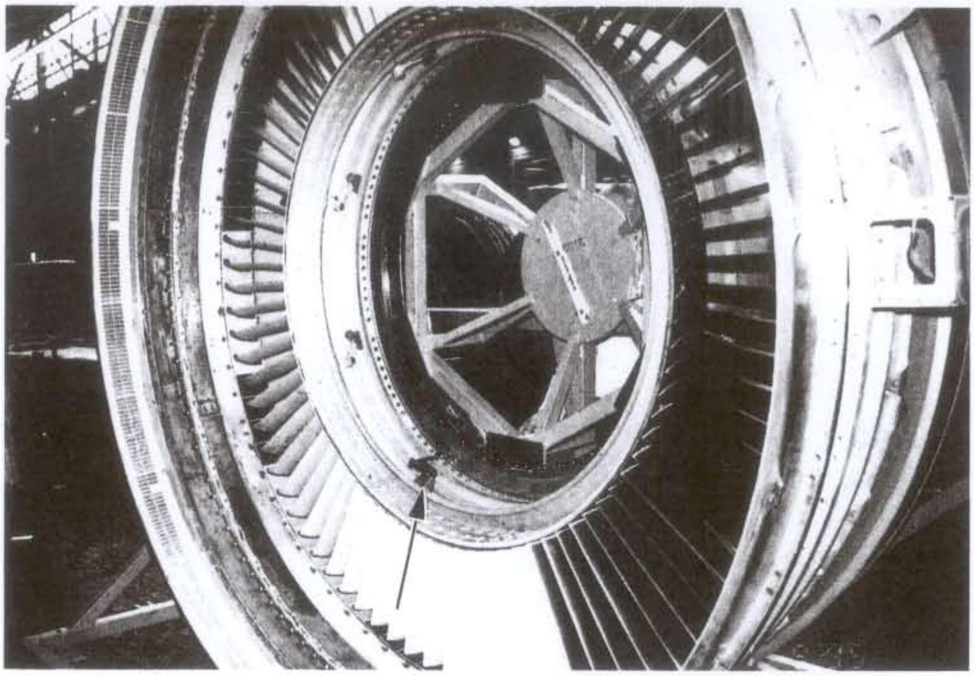
An Airworthiness Directive (AD) No 90-15-11, P & W Amendment 39-6474, Docket No 89-ANE-33-AD also applies to this area of the engine. This AD requires a number of actions, including compliance with SB -72-336, if not previously embodied. A feature of this SB is that it eliminates a previous requirement to inspect the bleed linkage components for wear at 3,000 hour intervals. However the engine records showed that only 2,493 hours had elapsed since embodiment, in February 1992, of SB 72-336 on the subject engine. (Note: some confusion clearly existed within the engine records, as they apparently showed SB-72-336 being complied with during a workshop visit in 1988). The engine manufacturer had issued an All Operators Wire in 1990, requesting bleed linkage wear data from the industry. The returns indicated very little wear occurring before 3,000 hours, with the lowest time for out of limits wear being 3,496 hours. However this assessment was based only on hardware that the engine manufacturers had examined themselves. These results are at variance with the experience reported by the Brussels-based engine overhaul organisation, which indicated that early wear continues to occur on post SB -72-336 engines. This has led them to conduct inspections at 1,800 hour intervals on those engines for which they provide total support. However, the engine manufacturer insists that bleed system durability is substantially improved by complying with the requirements of SBs -72-444 and -72-508, and point out that SB-72-444 should have been implemented at the last workshop visit.

The United Kingdom CAA have validated the engine, although it equips no aircraft currently on the UK Register. Certain mandatory requirements (beyond those imposed by the FAA) regarding Service Bulletin compliance are made for EROPS operations (extended range operations). This incident, although not technically resulting in an in flight engine shut-down, nevertheless highlighted the problems associated with the bleed system on this engine type. A complex range of packages and Service Bulletins have been devised to address the problem, although not all improvements have been mandated by means of the relevant Airworthiness Directive.

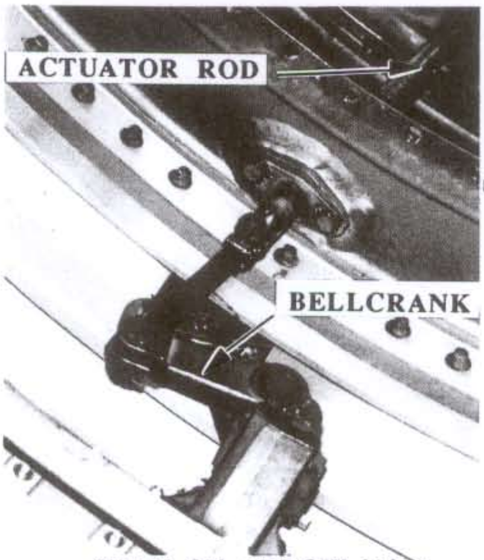
Safety Recommendation

The following Safety Recommendation has therefore been made to the FAA and engine manufacturer:

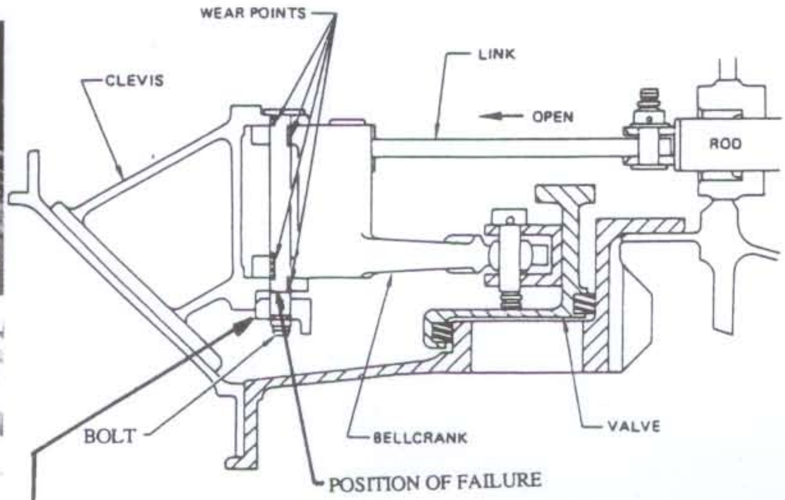
95-40: The FAA should liaise with Pratt and Whitney in order to review the requirements of AD 90-15-11, paying particular regard to the safety merits of mandating the relevant sections of the appropriate Service Bulletins (eg SBs JT9D-7R4-72-444 and -72-508) with the aim of reducing the in-service incidence of engine surges/damage arising from wear problems and failures associated with the 3.0 bleed system on the JT9D engine.



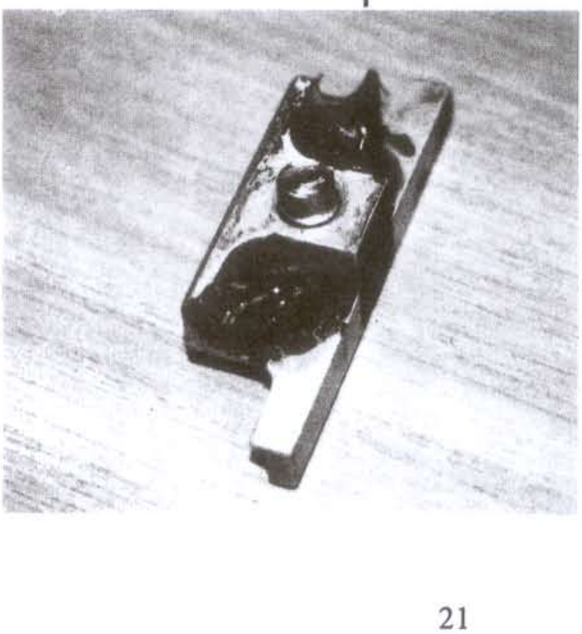
VIEW OF DIASSEMBLED FAN CASE AND 3.0 BLEED RING ON SIMILAR ENGINE



VIEW ON ARROW 'A'



BLEED VALVE ASSEMBLY LINKAGE



RETAINED PORTION OF BOLT AND CLEVIS PAD