Airbus A310-300, N835AB, 31 May 1998 at 1515 hrs

AAIB Bulletin No: 4/99 Ref: EW/C98/5/9 Category: 1.1

Aircraft Type and Registration:	Airbus A310-300, N835AB
No & Type of Engines:	2 Pratt & Whitney PW4152 turbofan engines
Year of Manufacture:	1992
Date & Time (UTC):	31 May 1998 at 1515 hrs
Location:	Stand M24 at London Heathrow Airport
Type of Flight:	Public Transport
Persons on Board:	Crew - 12 - Passengers - 204
Injuries:	Crew - Nil - Passengers - Nil
Nature of Damage:	Damage to left engine cowl
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	52 years
Commander's Flying Experience:	17,499 hours (of which 1,459 were on type)
	Last 90 days - 195 hours
	Last 28 days - 70 hours
Information Source:	AAIB Field Investigation

History of the flight

Approximately one hour into a scheduled passenger flight from Kingston, Jamaica, to Heathrow Airport the YELLOW hydraulic system failed as a result of a loss of fluid quantity. The appropriate Electronic Centralised Aircraft Monitoring system (ECAM) drill was completed and this was supplemented by reference to the Flight Crew Operations Manual (FCOM). Upon arrival at Heathrow, where the meteorological conditions were CAVOK with a light westerly wind, a manual landing with the flaps/slats set to 30/40 degrees was completed on Runway 27 where the surface was dry. Reverse thrust was used during the landing run and gentle braking was applied in the later stages to slow the aircraft to normal taxi speed. During the lengthy taxi to the allocated stand, M 24, occasional gentle braking was required; the brakes worked correctly and all indications were normal.

The aircraft was taxied onto the stand at a very slow speed, brought to a halt in the correct position and the parking brake applied. However the commander then became aware of some movement on the left side of the aircraft which he thought may have been movement of the jetway, but on

looking to his right he saw that the aircraft was slowly moving forward. He therefore applied maximum pressure to the brake pedals, but to no avail. The ground crewman, who had plugged into the ground intercom whilst the aircraft had been momentarily stationary, repeatedly instructed the crew to stop but the aircraft continued moving until the No 1 engine struck the jetway. The crew then shut down the No 2 engine and completed the associated checks. The passengers later vacated the aircraft using steps which were positioned at the rear doors. When the aircraft had come to a brief halt initially there had been no time for the chocks to be placed in position before the aircraft had begun to move forward again.

The above account was compiled from crew statements, analysis of the Cockpit Voice Recorder (CVR) and the Digital Flight Data Recorder (DFDR). However the DFDR data did not include a parking brake discrete and thus it was not possible to identify the times at which the parking brake had been applied and subsequently released.

Examination of the aircraft

The No 1 engine nose cowling had contacted a vertical steel post that formed part of the jetty structure. A rotating beacon mounted on the post, together with its mounting bracket, became embedded in the lip of the cowling at the three o'clock position (when viewed from the front). The contact with the jetty had been sufficiently forceful to displace the jetty towards the terminal building. The tyres on the steerable wheels that supported and positioned the end of the jetty had left skidmarks over a metre in length from their initial position. The aircraft had finally halted some 11 metres forward of its correct parking position.

Subsequent inspections revealed that the No 1 engine and pylon had escaped damage in the incident. Examination of the hydraulic components in the right hand main gear bay revealed fresh hydraulic fluid around a sampling valve. The valve, which was attached to a manifold, was in the YELLOW hydraulic system and reportedly sprayed fluid when the system was pressurised (by means of an electric pump) in order to open the cargo doors after the incident. It was later found that an 'O' ring seal in the valve had failed. After this had been replaced the system was charged, purged and was then found to function normally.

Description of the hydraulic system

The aircraft has three independent hydraulic systems designated GREEN, BLUE and YELLOW. Each engine has two variable displacement hydraulic pumps; engine No 1 has one GREEN and one BLUE system pump, while engine No 2 has one GREEN and one YELLOW system pump. If the engine pumps are unavailable, hydraulic power can be generated by:

- Two electric pumps in the GREEN system (primarily for ground testing)

- One electric pump in the YELLOW system to pressurise the brake accumulators, if required, or to operate the cargo doors

- A hand-pump in the YELLOW system to operate the cargo doors when the YELLOW electric pump is not available

- An emergency ram air turbine (RAT) driven pump for the YELLOW system

In addition, two non-reversible power transfer units are installed to provide hydraulic power transfer without fluid exchange from the GREEN system to the BLUE or YELLOW system. These would be used in the event of an engine, or engine pump failure, or for ground testing. A diagram of the YELLOW system is shown at Figure 1.

The loss of the YELLOW system has no effect on normal braking, which is supplied from the GREEN hydraulic system. In the event of the loss of the latter however, alternate braking is available from the YELLOW system. The brake accumulators are normally charged by the YELLOW system, and are protected by non-return valves so that they maintain pressure when the engine driven and electric pumps are not operating. The accumulators can be charged from the flight deck (when the YELLOW system is otherwise unpressurised) by pressing a pedestal mounted switch for a few seconds. The accumulator pressure is indicated on a gauge on the instrument panel. This gauge is combined with left and right brake pressure indicators, which operate only when alternate braking has been selected (ie YELLOW system), or when the parking brake is applied.

The parking brake is operated by the YELLOW system, with the accumulators maintaining brake pressure after the aircraft is shut down. The description of the system in the FCOM notes that: *'Operating the Parking Brake control handle deactivates the other braking modes and the antiskid system and supplies the brakes with yellow high pressure or accumulator pressure limited at 2100 psi. The return lines are shut off to allow an autonomy of at least 12 hours.'* An additional note in the 'Controls' section of the manual states that: *'Application of the parking brake deactivates normal and alternate modes.'*

Tests on the braking system

Following an initial inspection, the aircraft was towed to a maintenance area where the 'O' ring in the sampling valve was replaced and further investigation was conducted. Although chocks were used, it was found that the parking brake operated normally, with pressure being available in the accumulators when the switch on the pedestal was operated. Moreover, it was observed that the accumulator (and brake) pressures had remained steady after the aircraft had been left overnight. It was additionally noted that when the parking brake was selected OFF, and the accumulators were charged to their maximum regulated pressure, the gauge indicated a noticeable pressure drop over a period of around 10 to 15 minutes. However the rate of decay subsequently appeared to reduce. These observations were at variance with a later test conducted by maintenance engineers which monitored accumulator pressure, with the parking brake OFF, over a period of two hours. In this case, the engineers reported negligible pressure loss.

Despite the contradictory nature of these two tests, it was concluded that the pressure loss noted on the first occasion was in accordance with an expanded description of the parking brake system contained in the Maintenance Manual. This noted that the parking brake operated valve (located between the brake automatic selector and the distribution dual valve) shuts off the supply to the alternate brake system to prevent leakage through the dual valve. This implied that the 12 hour

period of accumulator pressure is maintained by closing off the leakage path noted above. Thus some leakage would be expected to occur with the parking brake set to OFF.

Each brake assembly contained nine pistons operated by the normal (GREEN) system, and six operated by the alternate (YELLOW) system. Starting with all the brakes OFF, the accumulator was charged by operating the pedestal mounted switch, followed by the application of the parking brake. The YELLOW system pistons were observed to operate. The GREEN hydraulic system was then pressurised by means of the electric pump, and the parking brake was set to OFF. The foot brakes were then operated and the movement of the GREEN system brake pistons was noted. The parking brake was then set to ON again (which operated the appropriate brake pistons) and the foot brakes operated. This produced no movement of the GREEN pistons. The accumulators were then discharged (by selecting alternate braking and repeatedly applying the foot brakes), which enabled the 'pre-charge' accumulator pressures to be noted, which were approximately 1,000 psi in each case. The subsequent application of the parking brake did not of course produce any brake piston movement; neither did operating the foot brakes as long as the parking brake remained ON.

The foregoing simply proved that the braking system functioned in the way described in the FCOM, with no defects being found. The final check was to conduct a taxi trial with the aircraft during which no problems were identified.

Discussion

The loss of the YELLOW hydraulic system early in the flight presented no problems other than an extended landing distance due to the loss of some of the spoilers. However there would have been a period of around 6 hours when the YELLOW system was unpressurised, apart from the accumulators. In the event that the leak had occurred 'downstream' of the non-return valves that protected the accumulators, then these also would have depressurised as a result. However, although the leak in this case due to the failed 'O' ring seal was 'upstream' of the non-return valves, it was possible that the accumulators lost a significant amount of pressure through the alternate brake system over the 6 hour period due to the parking brake having been OFF in flight. The Checklist contained no warning of this possibility, or advice on taking the precaution of charging the accumulators before parking the aircraft at a stand.

It seems probable that there was insufficient pressure remaining in the accumulators to hold the aircraft against the idle thrust from the engines after the parking brake had been applied. It is also probable that the parking brake was not released after the aircraft started to move forward again, which would have restored normal brake application via the foot brakes.

Safety action

The aircraft manufacturer, Airbus Industrie, responded to a draft of this Bulletin by stating that the FCOM Standard Operating Procedures already require checking of the accumulator pressure when applying the parking brake. However, the manufacturer additionally stated the following:

> 'We are developing a modification to avoid recurrence of such an incident. This modification consists of changing the priority between the parking brake and the brake pedals. In case of no accumulator pressure when the parking brake is set, the normal braking through the brake pedals will remain available and the crew will be able to stop the aircraft.'