BAC 1-11 475 Series, VP-CDA

AAIB Bulletin No: 2/2001

Ref: EW/C2000/2/4 - Category: 1.1

Aircraft Type and Registration:	BAC 1-11 475 Series, VP-CDA
No & Type of Engines:	2 Rolls Royce Spey 512-14DW turbojet engines
Year of Manufacture:	1978
Date & Time (UTC):	28 February 2000 at 1400 hrs
Location:	London Luton Airport
Type of Flight:	Positioning
Persons on Board:	Crew - 2 - Passengers - 3
Injuries:	Crew - None - Passengers - None
Nature of Damage:	Damage to nose landing gear tyres and doors
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	64 years
Commander's Experience:	13,800 hours (of which 8,300 were on type)
	Last 90 days - 33 hours
	Last 28 days - 32 hours
Information Source:	AAIB Field Investigation

History of the flight

On 25 February 2000 the aircraft flew two sectors; Cairo to Brindisi and Brindisi to Luton. The crew reported that during the departure from Brindisi, the No 1 Hydraulic System, Engine Driven Pump (EDP) FAIL light illuminated briefly; this amber caution light indicates that either the reservoir pressure is below 8 psi or the EDP output pressure is below 1,500 psi. As the illumination was brief, after which the light remained out and there was no obvious malfunction, the crew took no action.

At some point in the descent for Luton (the crew thought between FL250 and FL200), the EDP FAIL light came on again; initially it was intermittent but soon became continuous. The EDP was switched to OFF or possibly ISOL(ate), the crew could not recall which. During the approach, the Auxiliary Pump was selected ON and the landing gear lowered using the normal system. At some point the crew had noticed that the No 1 Hydraulic System Quantity Indicator was registering at the bottom of the Green sector. The remainder of the arrival at Luton was uneventful and the aircraft

was taxied to the stand. After shutdown, the commander noticed a major leakage of hydraulic fluid in the left main landing gear bay.

Rectification work was undertaken and, on 28 February, the aircraft was prepared for a preplanned positioning flight to an engineering facility at Bournemouth. The aircraft was on South Stand 19 with 2 pilots and 3 engineers on board. The pushback was normal and both engines were started during the procedure. The Park Brake was applied and the tug was disconnected with the aircraft on taxiway A5 facing East. When the tug was clear, the No 2 EDP was selected to ON with normal indications. The No 1 EDP was then selected ON and, coincident with the normal "clunk" sound from below the floor, the nose started to sink slowly with a "stepping" motion and settled gently on the collapsed nose landing gear (NLG) and doors. The aircraft was shut down immediately and the occupants vacated without injury.

Hydraulic and landing gear systems description

The BAC 1-11 has two independent hydraulic systems normally powered by the left (No 1) and right (No 2) EDP's. If the EDP's fail, or are deselected by the crew, then electric AC-pumps can be switched-on to provide hydraulic power. In addition, a DC-powered auxiliary pump can be used to pressurise No 2 system. Both systems power the primary and secondary flying controls, but only No 1 system is used for landing gear extension/retraction and the co-pilot's windscreen wiper. It is normal procedure for crews to energise the No 1 AC pump for take off as this would facilitate landing gear retraction in the event of failure of No 1 engine or EDP.

A schematic of the landing gear system is given at Appendix 1. Of particular note is the nose uplock/downlock jack which is spring-loaded to the locked position and is pressurised hydraulically to unlock each time the landing gear is selected UP or DOWN. This hydraulic pressure is controlled by the Steering and Lock Changeover Valve, which comprises a spool moving in response to hydraulic pressures and cam action.

BAC Service Newsletter (SNL) 32/43 dated 18 May 1978 gave details of three incidents of inadvertent NLG retraction. All occurred during hydraulic power selection and one of the three involved an inappropriate position of the Steering and Lock Changeover Valve spool, due to an abnormal balance of pressures across it caused by maintenance activity on the standby steering accumulator. A modification, 32-PM4679, was devised to obviate the problem identified as the cause of this incident and VP-CDA had this modification embodied at build. The modification was, it should be noted, specifically aimed at maintaining the correct pressure in the system when the standby steering accumulator was depressurised. As described below, the rectification work on the hydraulic system of VP-CDA was in an area far removed from the steering accumulator, but the incident described in the SNL illustrates how a temporary mis-positioning of the Steering and Lock Changeover Valve spool can lead to a transient application of system pressure sufficient to release the downlock.

Engineering activity

The source of the hydraulic leak was traced to a flexible hose on the outlet (pressure) port of the No 1 auxiliary AC pump. Two engineers from the aircraft's maintenance provider travelled from Bournemouth with the required spare hose, which they fitted. According to their recollection, they had to add "about two-thirds of a five US-gallon drum" (2.77 imperial gallons) of hydraulic fluid to the reservoir to replenish it to full on the sight-glass (the reservoir capacity is 2.75 imperial gallons). The reservoir was then pressurised with air to its normal value of 38 psi.

The engineers than started the Auxiliary Power Unit and ran the AC pump to bleed the No 1 EDP. After both engines were started and the EDP's selected, they then exercised the flying controls and nosewheel steering systems to bleed any air out of the system. Because no aircraft jacks were available, they were not able to exercise the Landing Gear retraction/extension system (apart from the MLG doors) and appear to have omitted the co-pilot's windscreen wiper from this action. The aircraft was then shutdown and the next time the No 1 hydraulic system was powered was on the accident flight.

Post-incident activity

As examined by the AAIB, the aircraft had been lifted using an airbag with the free-fall lever deployed, following which the nose gear had reportedly dropped straight back into downlock. The AC pump had been run to close the main gear doors. After some delay, the aircraft was towed into a hangar and jacked. The damage was, as expected, minimal, confined to the two forward NLG bay doors and the nosewheel tyres, which had been scraped by the edges of the doors as the aircraft sank to the ground. With the doors disconnected and using the No 1 AC pump, no movement of the NLG uplock/downlock could be reproduced as power was repeatedly re-applied. It was decided to check the level of the contents of hydraulic system No 1 where it was found that about 2.5 US quarts were required to bring the level to FULL according to the reservoir sight glass.

At this time, it was realised that the No 1 hydraulic system, cockpit contents gauge was unserviceable. Later, testing of the gauging system revealed that a fault in the sender rendered it incapable of registering quantities below the green sector of the gauge, even when the reservoir was empty.

With the contents full according to the sight gauge, repeated cycling of the landing gear and all the services associated with the No 1 system (again omitting the Co-pilot's windscreen wiper) was carried-out. The object of this was not only to test for proper operation of the landing gear but also to see whether any more air could be driven out of the system as evidenced by a further fall in the reservoir level. In the event, no significant fall was noted and the aircraft was released to the maintenance organisation on the understanding that, after a landing gear-down ferry-flight to Bournemouth with the NLG locked down with a strut, key components would be removed for bench-testing. After an uneventful flight, this was done and the results are recorded below.

Component testing

The following components were removed for testing:

- Steering and Lock Changeover Valve
- Up/Down lock Jack
- Two Restrictor assemblies
- Non-return Valve

The testing did not reveal any significant defects in the components, although it was noted that the Steering and Lock Changeover Valve, whilst functionable, exceeded the permitted leak rates and flow rate pressure drops during most tests. These exceedences are not considered to have contributed to the collapse of the NLG.

Analysis

The original opinion of the on-board engineer that there had been minimal loss of fluid from No 1 hydraulic system during the flight from Brindisi was undoubtedly coloured by the (subsequently found to be erroneous) satisfactory reading on the cockpit quantity gauge. In fact, the quantity of fluid found necessary to replenish the reservoir after the flexible hose change strongly suggests that it was virtually empty, which is consistent with the loss of EDP pressure encountered at the top of descent. This is considered significant because of the much greater probability of inducting air into an empty system than would be likely if the reservoir still contained a significant quantity of fluid.

Since no other causal factors were identified, it is generally believed that the cause of the NLG collapse was the presence of air in the system, which had not been fully bled after the hose change. As discussed above, even momentary abnormal pressure differentials across a component such as the Steering and Lock Changeover Valve can cause system pressure to be ported to the uplock/downlock jack, following which the weight of the aircraft will lead to collapse of the NLG. Air can be a source of such an imbalance, although the evidence is only circumstantial to indicate that there *was* air in this particular component.

Maintenance manual information

It is common practice on most aircraft types for minor leaks of hydraulic fluid, following rectification action, to be addressed by topping-up the reservoir and exercising the flying controls and other services to bleed air from the system. It does not appear to be common to jack the aircraft and perform landing gear retractions. The BAC 1-11 Maintenance Manual (MM) Chapter 29-00 was consulted for guidance. The procedure for the hose replacement was covered in 29-00 Servicing, page 319 paragraph R entitled 'Component or Pipe Failure'. Following replacement of the defective component, this paragraph refers to a further section, MM 29-10 in which operation B1 specifies:-

> *a) Check the fluid level in the reservoir and, if necessary, replenish as detailed in 12-40-0. If the system has been completely drained, fill and prime the system as detailed in 29-00.*

MM 29-00 contained the instructions for priming the No 1 system using the AC pump. It required the aircraft to be jacked and all No 1 system hydraulic system services to be exercised until the reservoir contents level stabilises. The manufacturer, in further correspondence, was of the opinion that the replenishment of an empty reservoir was analogous to a reservoir replacement or a 'completely drained' system as described above, either of which required exercise of the landing gear according to the MM. Notwithstanding the information in the MM, it would appear that engineers and technicians may not be fully aware of the possible consequences of air remaining in the NLG system after topping-up following a major loss of hydraulic fluid. Accordingly, the AAIB make the following safety recommendation:-

Safety recommendation

Recommendation 2000-56

Airbus UK should consider re-issuing Service Newsletter 32/43 to include details of this incident and to emphasise the importance of exercising the landing gear and co-pilot's windscreen wiper following complete loss of hydraulic fluid from the No 1 system reservoir.

(Note:- Airbus UK have advised that the above recommendation has been accepted and will be actioned).