BAe 146-300, G-UKHP

AAIB Bulletin No: 3/2003	**Ref: EW/G2001/10/18**	**Category: 1.1**
INCIDENT		
Aircraft Type and Registration:	BAe 146-300, G-UKHP	
No & Type of Engines:	4 Lycoming ALF 502R-5 turbofan engines	
Year of Manufacture:	1989	
Date & Time (UTC):	30 October 2001 at 2005 hrs	
Location:	Paris, Charles de Gaulle Airport, France	
Type of Flight:	Public Transport	
Persons on Board:	Crew - 6	Passengers - 67
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to yellow hydraulic system components	
Commander's Licence:	Airline Transport Pilots Licence	
Commander's Age:	55 years	
Commander's Flying Experience:	11,495 hours (of which 2,464 were on type)	
	Last 90 days - 217 hours	
	Last 28 days - 71 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB	

The aircraft was operating a scheduled passenger flight from London Stansted Airport to Paris Charles de Gaulle Airport. The first officer was the handling pilot and the aircraft was about 3 nm from touchdown on Runway 27L. The landing gear was already down and locked. Shortly after the selection of flaps to 33°, a loud mechanical bang was heard by the crew, followed by a very loud, low pitched graunching noise. The noise appeared to emanate from the centre left floor area. All of the engine parameters were normal. A Yellow hydraulic system caution illuminated on the Central Warning Panel (CWP) and it was noted that the Yellow hydraulic system pressure and quantity indications were fluctuating erratically. This alert was quickly followed by Flap Fault, AC Pump Failure, and AC Pump High Temperature alerts on the CWP. The commander instructed the

handling pilot to continue the approach to land, as the flaps were indicating close to the 33° landing setting, the approach was stable and clearance to land had been obtained.

During the landing roll, the Lift Spoilers powered by the Green hydraulic system deployed, but the Yellow system lift spoilers did not deploy. Wheel braking was normal, using the pre-selected Green hydraulic system and the AC Pump High Temperature and AC Pump Fail captions extinguished. The commander considered that this was a result of the automatic shutdown of the Yellow system AC Pump, which occurs on the ground only. However, the Yellow system low quantity alert was still present.

As the aircraft decelerated, the In-Flight Supervisor (IFS) made an emergency call to the flight deck but, because of the high workload, the call was not answered immediately. Shortly afterwards, the IFS appeared at the flight deck door to inform the commander that there was dense smoke in mid cabin. This was acknowledged by the commander, who then switched off the air conditioning packs and the APU. The commander took control of the aircraft and applied vigorous braking. The IFS reported heavy dense smoke in the cabin, much worse, low visibility in the cabin. The aircraft was brought to a halt on the high-speed exit taxiway Y7. The commander ordered an evacuation and the crew carried out the evacuation drills. ATC had been advised of the intention to evacuate and the emergency services were quickly in attendance.

Three of the aircraft emergency slides were activated, both forward doors and the rear left slide. Visibility was poor in the mid cabin area, being limited to three seat rows. The evacuation was completed swiftly with no injuries being attributed to the evacuation itself. However, after exiting the aircraft, some passengers were noted to be choking and vomiting in the assembly area.

Once clear of the aircraft, the commander noted that wispy black smoke was escaping from all aircraft exits and a large pool of hydraulic fluid was forming below the hydraulic system bay drain. The hydraulic bay was saturated with hydraulic fluid and was contaminated with dense black smoke.

The passengers were escorted away to the terminal building, while the flight crew assisted in the preparation of the aircraft for towing off the taxiway.

Description of the hydraulic system

The BAe 146/RJ family of aircraft are fitted with two hydraulic systems, Yellow and Green. Each system is powered by an Engine Driven Pump (EDP), on engine No 2 and engine No 3 respectively. In case of a failure of No 3 engine or EDP, Green system can be pressurised by a Power Transfer Unit (PTU) using power from Yellow hydraulic system. In case of failure of No 2 engine or EDP, Yellow hydraulic system can be powered by an AC electric pump. In normal operation, the AC pump switch is selected to AUTO for take-off and landing, as part of the appropriate checklist, such that the pump will be activated automatically in the event that the Yellow hydraulic system pressure reduces below about 1,500 psi.

A thermal sensor is fitted to the AC pump stator windings, in order to generate an AC Pump High Temperature alert on the CWP when the temperature reaches 204°C (tolerance ?9°C). On the ground, this will also result in the automatic shutdown of the AC hydraulic pump. In the air, the AC Pump High Temperature alert caption is displayed on the overhead panel, and the pump should be shutdown manually in these circumstances.

Engineering examination of the aircraft

Subsequent engineering examination of G-UKHP took place after the aircraft had been towed off the taxiway. Inside the hydraulics bay, it was readily observed that a flexible pipe, part number SA7670006-116, which is connected to the PTU, had ruptured as a result of chafing against an adjacent rigid pipe, part number HC321B0029-000. The Yellow hydraulic system reservoir was effectively empty and the AC hydraulic pump was felt to be excessively hot.

The flexible pipe and the AC hydraulic pump were replaced. The hydraulics bay was cleaned of escaped fluid. The Yellow hydraulic system reservoir was replenished with fluid and, after required serviceability checks, the aircraft was returned to service with no further recurrence of the smoke.

Although the AC hydraulic pump and the hydraulics bay had been drenched with hydraulic fluid, there was no sign that there had been any burning of the fluid.

AC hydraulic pump examination

The AC hydraulic pump was subjected to a strip examination by an overhaul agency in the United States. It was found that several internal bearings were worn, rough and scored, which could well have accounted for the reported noises heard during the final approach phase. In addition, it was noted that the pump thermostat failed to open. Thus, the thermal protection that should have been afforded at about 204°C was not available.

The normal operating temperature of the AC hydraulic pump motor is about 62°C. If the pump was running after the loss of the system fluid, the case temperature would have rapidly increased. Given the failed state of the thermostat, there is no indication of what temperature was actually attained by the pump during this event, except that no internal damage was done to the motor windings or the stator. However, since the AC Pump High Temperature caption illuminated on the overhead panel, then the temperature, as sensed by a thermostat on the motor windings, must have exceeded 195°C to 213°C.

Analysis

The airframe manufacturers engineering assessment of this event considered that the dense black smoke was generated by the impingement of hydraulic fluid spray onto the overheated AC hydraulic pump. The pump will automatically run if the system pressure drops, even if the reason for the drop is total loss of fluid. It is therefore not surprising that the pump became abnormally hot.

The unpleasant effects of phosphate-ester type hydraulic fluid misting from a high pressure leak are well known but, at ambient temperatures, this does not usually result in any form of black smoke.

Information from the airframe manufacturer indicates that the flash point of this type of hydraulic fluid, without a flame being present, is between 471°C and 507°C. If a flame is present, the flash point is 182°C and the fluid will continue to burn if ignition occurs at 210°C. However, although this type of hydraulic fluid can burn in the presence of a flame at the AC hydraulic pump overheat warning temperature, such a resultant fire would have left evidence of scorching of the surrounding area. Neither the hydraulics bay, its components, nor the internal structure of the AC hydraulic pump itself, showed any signs that a fire had occurred.

The airframe manufacturer indicated that it was unlikely that any hydraulic fluid had been able to enter the air conditioning system under these circumstances. Also, when positive aircraft cabin pressure differential exists, the air flow is routed from the cabin, through the hydraulic bay, before being vented overboard via the outflow valves.

Smoke and fumes in the cabin

The PTU components and the AC hydraulic pump are located within the pressure shell of the aircraft, in a vented bay immediately forward of the main landing gear bay, beneath the cabin floor.

As a result of previous occurrences of the ingress of hydraulic mist into the passenger cabin during engine ground running on the BAe 146/RJ aircraft series, the manufacturer has issued a modification (reference HCM30497A), designed to improve the sealing of the hydraulics bay. The modification was promulgated by means of Service Bulletin SB.53-158-30497A, but this had not been installed in G-UKHP at the time of this event.