No: 9/90 **Ref: EW/C1159** **Category: 2a**

Aircraft Type and Registration:	Aerospatiale AS332L, G-PUMA
No & Type of Engines:	2 Turbomeca Makila 1A turboshaft engines
Year of Manufacture:	1983
Date and Time (UTC):	6 May 1990 at 1430 hrs
Location:	Aberdeen Airport
Type of Flight:	Ground run
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Fire damage to rotor brake, transmission bay and sliding cowling
Commander's Licence:	Airline Transport Pilot's Licence (Helicopters)
Commander's Age:	47 years
Commander's Total Flying Experience:	Approximately 8000 hours (of which 1500 were on type)
Information Source:	AAIB Field Investigation

Circumstances

After having flown earlier in the day, the aircraft was subjected to a standard chemical wash whereby the engines were turned by means of the starter while the cleaning agent was introduced into the intakes. During the washing process, the rotors were prevented from turning by means of the rotor brake. The compressor wash was carried out by ground engineers, but the subsequent engine drying run had to be done by a pilot. At approximately 1430 hrs, the pilot boarded the aircraft for this purpose. As no flight was intended, he did not examine the technical log, or follow the normal pre start checklist, but carried out an abbrieviated checklist from memory. In fact there was a technical log entry to the effect that the utilities accumulator had become exhausted shortly after the aircraft was shut down. However, system pressure would still have been available from the electrical pump, had it been selected.

The pilot started the No.2 engine first and recalled that the rotors started turning at about 5000Ng (gas generator rpm). Shortly after this, the pilot was somewhat surprised to observe that the main rotor gearbox "P" (oil pressure) caption was still illuminated on the central warning panel, although the oil pressure gauge indication was satisfactory at 6 bar. Assuming a pressure switch malfunction, the pilot elected to continue, and so he started the No.1 engine and accelerated it to flight idle. However he

noted that the No.1 hydraulic system pressure had reduced to zero. He then observed the ground crewman outside signalling him to shut down. The pilot accordingly pulled back the speed select levers and additionally recalled operating the rotor brake, although the latter was ineffective. By this time, approximately 3½ minutes had elapsed since he had engaged the No. 2 engine starter motor. He was then informed that the aircraft was on fire, following which he discharged the engine fire bottles. The airport fire services arrived and the pilot left the aircraft without injury.

Examination of the aircraft

It was apparent that the fire had been centred on the rotor brake, which is located immediately aft of the main rotor gearbox (MGB). There was considerable fire damage in this area of the transmission bay, with a large hole burnt through the sliding cowling aft of the rotor head. An alloy platform over the tail rotor drive shaft had partially melted and deposited molten metal onto the transmission deck. The associated heat had produced a 4 inch diameter hole in the roof of the aft part of the cabin, close to the MGB rear support frame. Droplets of hydraulic fluid were observed in this area and approximately 2.5 litres of fluid had been lost from the left hand hydraulic reservoir.

The engine fire bottles are located in the transmission bay and it was evident that these had discharged. The engines had not been affected by the fire. Part of the pipework running between the fire bottles and the engine bays had been burned through where they passed beneath the rotor brake assembly. It was thus probable that leaking extinguishant contributed to the containment of the fire in this area.

The rotor brake unit was still in position, although the alloy calliper had 'opened-out' due to a combination of heat and hydraulic pressure within the cylinders. This had caused the pistons to displace further than normal from the cylinders, almost to the point of disengagement. This displacement would have allowed fluid to be released from the cylinders to initiate the fire. Evidence of the high temperatures that were attained was provided by a partially melted brake pad steel backing plate. The remainder of the rotor brake operating system was intact, although much of the pipework in the area had been blackened from the effects of the fire.

Description of the rotor brake system

The brake unit consists of a calliper bolted to the MGB above the tail rotor drive shaft. A fixed pad is attached to one side of the calliper, with opposing pads attached to hydraulically operated pistons on the other. Return springs pull the pistons, and hence the pads, away from the disc when hydraulic pressure is removed. A carbon disc is located between the pads and is attached to the tail rotor drive shaft. Hydraulic power is provided from the left hand pump on the MGB. When the rotors are stationary, the system is supplied from an electric pump. Pressure is maintained via the utilities accumulator, which can be recharged if necessary by means of a hand pump.

A schematic of the operating system is shown in the attached Figure and it can be seen that it consists of two levers, mounted on the overhead panel close to the top of the windscreen, operating on a

pressure reducing valve and a safety valve respectively. When the Safety Lever is in the "Flight" (ie fully forward) position, the safety valve is closed which allows no pressure to the brake unit even if the Brake Lever should inadvertantly be pulled. When the Safety Lever is in the "Ground" (ie fully back) position, the **RB.SAFE** caption is illuminated, meaning that the Brake Lever can now be applied. Brake pressure progressively increases with lever movement up to the 21 bar detent. Further movement to the 100 bar detent is inhibited by a baulk which can only be removed by operation of an additional lever on the bulkhead behind the pilot. The latter position is used to maintain the rotors stationary whilst both engines are started in high wind conditions; brake release then results in rapid rotor spin-up, reducing the possibility of blade sailing.

A pressure switch illuminates a **ROT.BR** caption when the pressure in the brake line exceeds 2.5 bar.

Examination and test of the rotor brake system

A new brake unit and disc were slaved into the system together with a pressure gauge immediately upstream of the brake unit. Electrical power was applied to the aircraft and the utilities accumulator was recharged using the handpump in the cockpit. When the Safety Lever was pulled back to the "Ground" position, the **RB.SAFE** caption illuminated as expected. Movement of the rotor Brake Lever towards the 21 bar position caused the **ROT.BR** caption to illuminate at around 2.5 bar. (It was subsequently found to extinguish at about 1.5 bar). No leaks were observed in the system. Some pressure remained when the Brake Lever was returned to within three quarters of an inch from the fully forward position. However, the lever had to be physically held in this position; when it was released, the spring attached to the lever appeared to be effective in returning it to the OFF (forward) end of the slot. It was found that pressures in excess of around 5 bar had to be applied to clamp the disc, ie to overcome the force exerted by the piston return springs.

Whilst this examination was in progress, it was found on another AS332 (G-PUMD) that if the Safety Lever was moved away from the "Ground" position by about half an inch before releasing the brake, then the **ROT.BR** caption remained lit regardless of the subsequent position of the Brake Lever. It was found possible to duplicate this condition on MA. The light remained on for several hours even if the accumulator was allowed to discharge, thus demonstrating that pressure was trapped between the valve and the brake unit. Problems with the pressure gauge prevented an accurate assessment of this pressure, although it was estimated to be around 5 bar.

In considering the possibility that trapped pressure in the brake line had caused this incident, it was noted that representatives from the helicopter manufacturers were of the opinion that the observed damage must have resulted from considerably higher pressures than 5 bar, and the compressor wash had been preceded by a fuselage and rotor wash which involved turning the tail rotors (and thus the main rotors) by hand. This clearly would have been impossible had the brake been on. None of the ground crew would have had reason to move the Safety Lever away from the "Ground" position where it was left after the earlier flight.

A subsequent incident occurred on another AS 332 whereby the **ROT.BR** caption illuminated when the Brake Lever was pulled back, even though the Safety Lever was fully in the "Flight" position. This was later found to be due to to a missing component within the safety valve and thought to have been the result of unauthorised maintenance at some indeterminate time following build. The valve from MA had no such fault and apart from two minor excursions from the schedule, functioned satisfactorily on test. The two deviations were a slightly premature pressure build up with brake lever movement, and a high internal leak rate to return. The latter may have contributed to the exhaustion of the utilities accumulator.

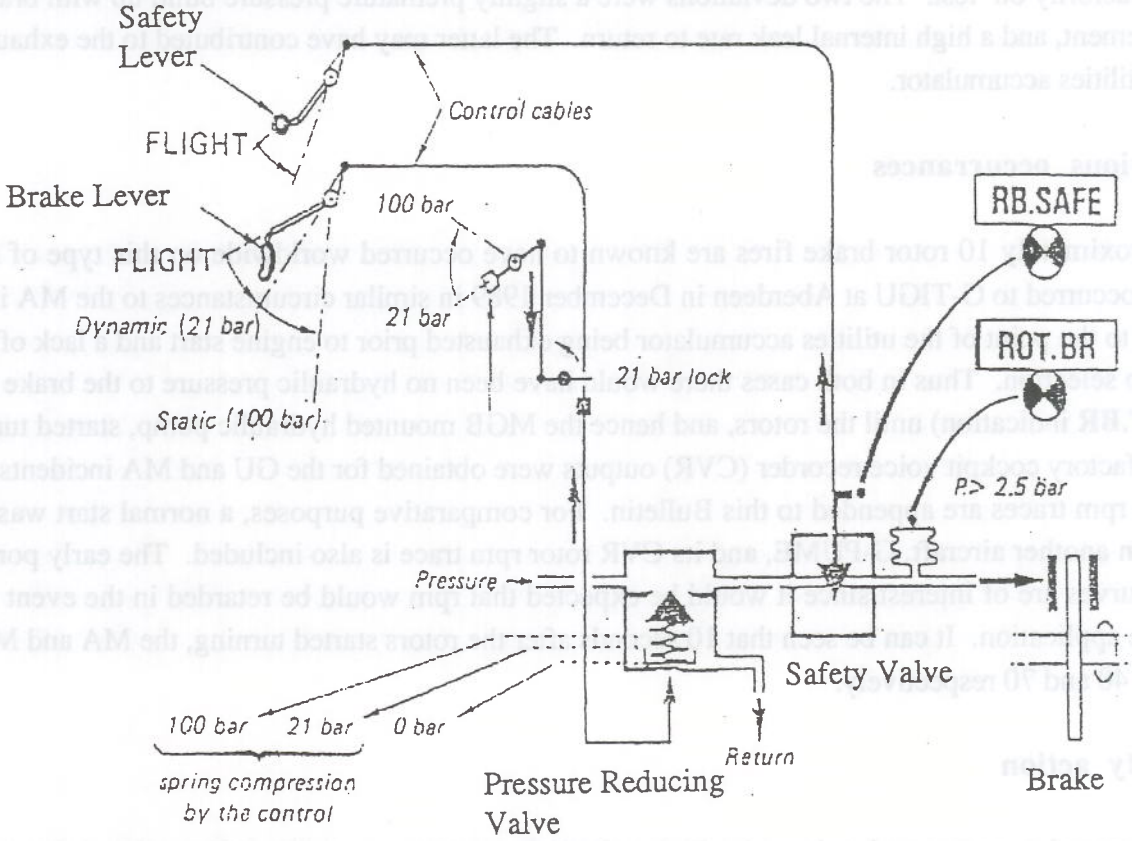
Previous occurrances

Approximately 10 rotor brake fires are known to have occurred worldwide on this type of aircraft. One occurred to G-TIGU at Aberdeen in December 1989 in similar circumstances to the MA incident, even to the point of the utilities accumulator being exhausted prior to engine start and a lack of electric pump selection. Thus in both cases there would have been no hydraulic pressure to the brake (and no **ROT.BR** indication) until the rotors, and hence the MGB mounted hydraulic pump, started turning. Satisfactory cockpit voice recorder (CVR) outputs were obtained for the GU and MA incidents and the rotor rpm traces are appended to this Bulletin. For comparative purposes, a normal start was carried out on another aircraft, G-PUME, and its CVR rotor rpm trace is also included. The early portions of the curves are of interest since it would be expected that rpm would be retarded in the event of rotor brake application. It can be seen that 10 seconds after the rotors started turning, the MA and ME rpms were 40 and 70 respectively.

Safety action

The operating company has issued a Flying Staff Instruction reminding pilots of the importance of correct operation of the rotor brake controls. The checklist has been amended to reflect this. A similar amendment has been made to the Flight Manual by the manufacturer.

As a result of the number of incidents around the world, the helicopter manufacturer has introduced a Service Bulletin (SB 7602) which gives operators the option of electrically inhibiting the engine start cycle when the brake lever is in the 21 bar detent. Following the incident to MA, the operator is progressively incorporating this modification into the AS332 fleet. The CAA are currently considering conferring mandatory status on this Service Bulletin as part of a continuing review of potential fire hazards in the transmission bays of large helicopters.



AS332 Brake System Schematic