No: 7/92 **Ref: EW/C92/2/5** **Category: 4**

Aircraft Type and Registration:	Aerospatiale AS332L Super Puma, G-TIGO
No & Type of Engines:	2 Turbomeca Makila 1A turboshaft engines
Year of Manufacture:	1983
Date & Time (UTC):	22 February 1992 at 0830 hrs
Location:	Aberdeen Airport
Type of Flight:	Engine run
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Heat damage to rotor brake calliper and disc; some sooting on accessory gearbox components
Commander's Licence:	Commercial Pilots Licence (Helicopters)
Commander's Age:	23 yrs
Commander's Flying Experience:	1840 hrs (of which 1650 were on type)
Information Source:	AAIB Field Investigation

A ground run was required in order to check the T4 temperature indicator for the No. 2 engine. A co-pilot was detailed to conduct this task and, because of the high wind conditions prevailing, he elected to carry out a "high wind" start. This entails applying the rotor brake so that the rotors are held stationary during the engine start; subsequent brake release then results in rapid rotor 'spin-up', and reduces the risk of blade sailing. The pilot reported that it was a normal start and that the engine run resulted in normal T4 indications. The engine was then shut down, the rotor brake applied and the co-pilot left the aircraft in order to complete preparations for a subsequent flight in that aircraft. However when he returned some 15-20 minutes later, he observed smoke and a small flame emanating from the main gearbox (MGB) platform area. He alerted ground crew who were busy loading freight aboard the aircraft, and then entered the flight deck to make a radio call to the Airport Fire Services. However the fire was successfully extinguished by ground staff.

Description of the rotor brake system

This is a hydraulically operated system with the brake unit, consisting of a calliper bolted to the MGB, installed above a carbon disc mounted on the tail rotor drive shaft. A fixed friction pad is attached to one side of the calliper, with opposing pads actuated by hydraulically operated pistons on the other. Return springs pull the pistons, and hence the pads, away from the disc when hydraulic pressure is removed. The operating system consists of two levers, the Brake Lever and Safety Lever, mounted on the overhead panel close to the windscreen, and respectively connected by control cables to a pressure reducing valve and a safety valve within a hydraulic unit. When the Safety Lever is in the "Flight" (ie fully forward) position, the safety valve is closed, which allows no hydraulic pressure to the brake unit, even if the Brake Lever should be inadvertently pulled. When the Safety Lever is in the "Ground" (ie fully back) position, the **RB SAFE** caption on the master warning panel is illuminated, meaning that the Brake Lever can now be applied. Brake pressure progressively increases, with Brake Lever activation, up to the 21 bar detent. This is the normal position for stopping the rotors during shut-down. Further Brake Lever movement to a 105 bar detent is inhibited by a baulk, which can only be removed by operation of an additional lever on the bulkhead behind the pilot. This is the "static" position used for "high wind" starts, and was selected on G-TIGO prior to starting the No. 2 engine.

A pressure switch illuminates a **ROT BR** caption when pressure in the brake line exceeds 2.5 bar. The same switch is used for the rotor brake discrete signal on the combined CVR/FDR.

Examination of the rotor brake

It was evident that the brake calliper had been subjected to intense heat. The unit was covered in a black residue and a crack had developed in the area of the casting immediately above the carbon brake disc, although this had not resulted in a hydraulic fluid leak. The bolts that connected the two halves of the calliper were found to be loose; it was considered that this was due to a heat-induced stress relieving process in the castings. Some localised melting of the casting had occurred adjacent to the steel brake pad backing plate on the front of the unit. The alloy in this region was of a thinner section compared to that at the rear, with presumably a corresponding reduction in thermal capacity which had resulted in higher local temperatures.

Disassembly of the caliper unit revealed evidence of hydraulic fluid leakage from around the pistons, with the seals having been severely heat affected. In the absence of any other burnt component on the aircraft, it was considered that the fire had resulted from ignition of the leaking fluid due to frictional heat from the calliper.

Damage to the aircraft was superficial, consisting mainly of sooting on the accessory gearbox and accessories, in addition to minor heat damage to the transmission deck beneath the MGB.

Flight Data Recorders

The flight data recorder fitted was a Penny and Giles Model 900 Combined Voice and Flight Data Recorder (CVFDR) and a satisfactory replay was obtained using the AAIB replay facilities.

The appended recordings show several No. 2 engine parameters, together with main rotor rpm (NR) and the rotor brake discrete recording. It can be seen that the rotor brake trace appeared to indicate that the rotor brake had been released approximately 30 seconds prior to starting the engine (the latter indicated by the gas generator rpm (Ng) starting to rise). However, the rotors would normally be expected to start turning at an Ng of less than 20% with no brake applied, whereas it can be seen that the NR did not start to rise until the Ng had exceeded 65%, some 12.5 seconds *after* the brake had apparently been reapplied. It was therefore initially concluded that there had been a recording fault associated with the discrete signal, over the period covering the engine start.

Approximately one minute after the engine parameters stabilised, an apparent instability can be seen. This was not fully explained; however, it was surmised that it may have been due to a series of "grab/fade" cycles on the brake pads. The oscillations on the Ng and Nf (free turbine rpm) traces were in anti-phase; ie the Ng reduced as the Nf increased, which is to be expected. Some 35 seconds after ground idle was selected, the rotor brake discrete showed an "OFF" indication. This appeared to be a valid indication, since there was an accompanying increase in NR, together with a torque reduction. Finally, the end of the trace showed a reapplication of the brake which resulted in a rapid reduction in NR (and Nf).

Additional investigations

The operator conducted an extensive investigation into this incident, including "high wind" starts on another aircraft, which generated comparative FDR records. On one test, the Brake Lever was moved from the 105 bar position into the 21 bar detent, and the subsequent NR acceleration compared to that obtained when the lever was moved from the 105 bar detent to the fully OFF position. It was found that the traces were virtually identical, ie the rotor Brake Lever, at the 21 bar position, had little effect on the rate of increase of NR.

The operator also attended the manufacturer's bench test of the brake hydraulic unit. This tested the unit for all combinations of the Safety and Brake Lever positions, and it was found to operate normally. However the integral pressure switch, which signals the FDR and the ROT BR caption, was found to be faulty. When the pressure was increased from 21 bar to 105 bar, the light went out at 80 bar and came on again at 70 bar, instead of remaining on. This anomaly explained the brake OFF signal on the FDR trace during the engine start sequence, and probably indicates the approximate point at which the pilot moved the Brake Lever from the 105 to the 21 bar position. Another, less significant, fault on the same switch was that with pressure decreasing, the light extinguished at 1.3 bar instead of the 1.5 bar required in the test schedule.

The switch was removed and installed on the hydraulic unit in another aircraft, and a series of ground tests conducted with a pressure gauge inserted in the rotor brake system. These confirmed the existence of the fault, although it was intermittent in nature, with a false indication occurring on about 50% of occasions. It was not possible to confirm the pressure at which the switch changed state however, due to the difficulty in controlling the system pressure with the Brake Lever. Vibration was found to be an additional influence on the switch behaviour. The tests also revealed a tendency for the system pressure to bleed away when the Brake Lever was moved slowly from the 21 to the 105 bar position, such that the maximum pressure was only about 71 bar. This problem is being addressed by the manufacturer of the hydraulic unit.

Conclusions

The investigation confirmed that most of the ground run had been conducted with the rotor brake applied. It is possible that this resulted from the Brake Lever being moved from the 105 bar detent to the 21 bar position, instead of being moved to the fully OFF position. At the same time, the Safety Lever must have been left in the "Ground" position. Subsequent ground tests showed that the rotors would spin up with the brake thus applied. The apparent 12.5 seconds lag between the indicated brake OFF (ie false) indication and the start of Nf and NR indications was explained by the intermittent nature of the pressure switch fault, since vibration was found to influence the point at which the switch changed state. Towards the end of the run, after ground idle had been selected, either the Brake Lever had been positioned to "OFF", or the Safety Lever had been moved to the "Flight" position.

Safety action

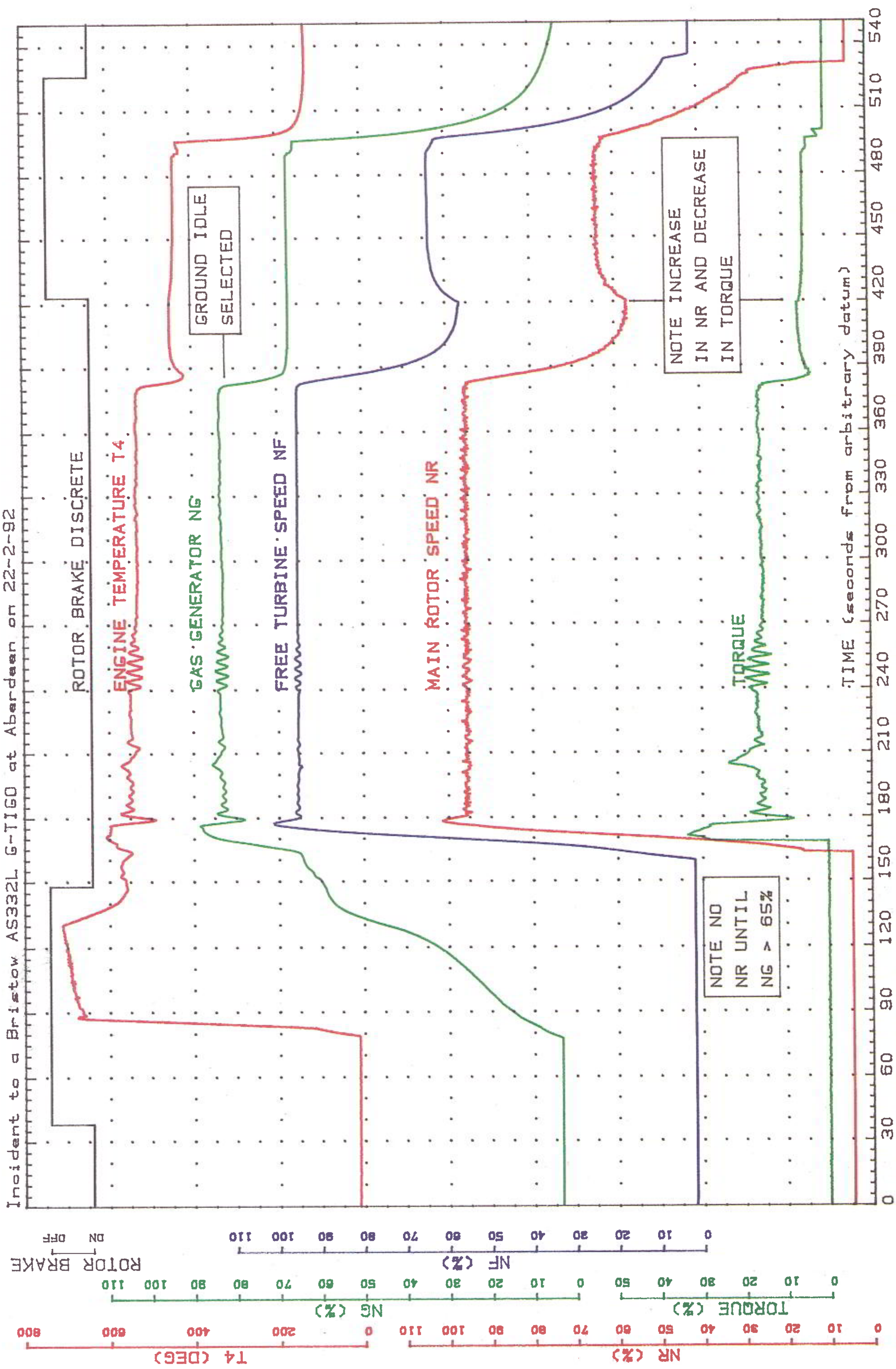
Three Service Bulletins (SB's) are pertinent to this type of incident. SB 97153-63-03, was issued by the hydraulic unit manufacturer and replaces the unreliable pressure switch of the type fitted to

G-TIGO with one from another manufacturer. The operator has made arrangements to embody this SB on all their AS332L hydraulic units. The other, issued by the helicopter manufacturer, was AS332L SB 63-45. This introduced a re-profiled quadrant gate for the Brake Lever, such that when the lever is moved away from the 105 bar detent, it is guided into the OFF position, prevent it from lodging in the 21 bar detent. The operator had already decided to embody this SB across their AS332L fleet, and had ordered the kits from the manufacturer in January 1992, ie before the incident to G-TIGO. However, the rate of installation was dependent upon the rate of delivery of the kits. The third Service Bulletin, SB76-02, embodies a modification which electrically inhibits the engines start cycle when the Brake Lever is in the 21 bar detent. This modification would not have prevented this particular incident to G-TIGO, although it may have prevented previous occurrances.

This incident was at least the third AS332L rotor brake fire to have occurred in the UK in just over two years; the other two are referred to in AAIB Bulletin 10/90. Approximately 15 similar incidents are now known to have occurred world-wide on this type of aircraft. In view of the continuing incidence of this type of event, the following Safety Recommendations have been made to the CAA:

92-35 The CAA consider requiring the mandatory embodiment of Service Bulletin Nos. SB76-02 and 63-45 on AS332L helicopters to reduce the incidence of inadvertent brake application, and associated fires, during ground running.

92-36 The CAA consider the introduction of a requirement to provide for the installation of fire detection and suppression systems within the transmission bays of large Public Transport helicopters.
(NOTE: This is similar to Recommendations made in AAIB Reports 7/84 and 3/90)



Incident to a Bristow AS332L G-TIGO at Aberdeen on 22-2-92
ROTOR BRAKE DISCRETE
ENGINE TEMPERATURE T4
GAS GENERATOR NG
FREE TURBINE SPEED NF
MAIN ROTOR SPEED NR
TORQUE
GROUND IDLE SELECTED
NOTE INCREASE IN NR AND DECREASE IN TORQUE
NOTE NO NR UNTIL NG > 65%
TIME (seconds from arbitrary datum)
0 30 60 90 120 150 180 210 240 270 300 330 360 390 420 450 480 510 540
ROTOR BRAKE
ON OFF
NF (%)
NG (%)
TORQUE (%)
T4 (DEG)
NR (%)