**No: 8/88** **Ref: EW/C1053** **Category: 1a**

| | |
|---|---|
| **Aircraft Type and Registration:** | Shorts SD3-30, G-BHWT<br>Vickers Viscount 806, G-APIM |
| **No & Type of Engines:** | G-BHWT: 2 Pratt & Whitney PT6A-45R turboprop engines<br>G-APIM: 4 Rolls-Royce Dart 510F turboprop engines |
| **Year of Manufacture:** | G-BHWT: 1980 G-APIM: 1958 |
| **Date and Time (UTC):** | 11 January 1988 at 1244 hrs |
| **Location:** | Southend Airport |
| **Type of Flight:** | Positioning/Training |
| **Persons on Board:** | Crew - 2 Passengers -None |
| **Injuries:** | Crew -None Passengers - N/A |
| **Nature of Damage:** | G-BHWT: Right hand engine, engine mounting and propeller. Wing twisted at wing/fuselage mountings. Nose area of fuselage buckled.<br>G-APIM: Nose and cockpit area severely damaged. |
| **Commander's Licence:** | Airline Transport Pilot's Licence with Type Rating Examiner's Rating |
| **Commander's Age:** | 41 years |
| **Commander's Total Flying Experience:** | 12,000 hours (of which 1500 were on type) |
| **Information Source:** | AAIB Field Investigation |

The Shorts SD3-30 aircraft was manufactured in 1980 and sold to an airline in the United States of America where it was operated until July 1985. Between July 1985 and February 1987 (18 months) the aircraft flew only 2.6 hours. In February 1987 the aircraft was re-issued with an American Certificate of Airworthiness (C of A) and sold to a United Kingdom (UK) company. Between the end of March and the beginning of July 1987 the aircraft was not flown whilst awaiting the issue of a UK C of A.

On the night of Thursday 7/8 January 1988 the aircraft's hydraulic system was reported as faulty in that the hydraulic failure warning lights illuminated intermittently during flight. This was a recurrance of a long standing defect. When the hydraulic system was serviced it was noted that both the emergency brake and landing gear accumulators had low nitrogen pressures. The system was drained and refilled with hydraulic oil, an engine run was carried out and all indications were found to be satisfactory. On 8 January an engineering company at Southend, which was an associated company of the organisation from whom the aircraft was leased, was contacted by the operator and it was agreed that the problems with the hydraulic system differed from those that had been reported before, and the

aircraft would be flown to Southend for repair. The operator was to provide an Order Number for the work however, in the event no Order Number was ever submitted. The aircraft was flown for two more flights on the night of 8/9 January and then flown to Southend to have the hydraulic system investigated in greater depth. This was the fourth occasion during the period of the lease that the aircraft had been returned to Southend for rectification of hydraulic problems.

Upon arriving at Southend on the morning of Saturday 9 January there were no hydraulic faults with the aircraft recorded in the aircraft's technical log or reported to the engineering company. An engineer from that company examined the aircraft's hydraulic system that morning, found that the emergency brake accumulator nitrogen pressure was very low and that the emergency landing gear accumulator nitrogen pressure was also well down. He also noted that there was a leak at an accumulator shut off valve, and that the brake control valve also appeared to have an internal leak. An engine ground run was carried out and the main hydraulic system appeared to be performing satisfactorily. This information was communicated to the aircraft's operating company at Biggin Hill, together with a request for spare parts. As no agreement could be reached on who was going to pay for the spares, it was decided to leave the decision on what action should be taken until Monday 11 January. The engineer was instructed to leave everything until then.

The engineer at Southend reported that during the morning of 11 January he had a telephone conversation with the operating company during which he informed them of the problems with the aircraft's hydraulic system, specifically that it had no emergency brakes, although the main system appeared to be serviceable, and that in his opinion the aircraft was not serviceable to fly. The operating company spokesman said that he was a pilot and in his opinion the aircraft was fit for a ferry flight to Biggin Hill. However, the operating company denies that the engineer at Southend advised them that the aircraft was not serviceable to fly, and state that their spokesman made the decision to proceed with the ferry flight after due consideration of all the information given to him by the engineer at Southend. At the operating company's request the engineer also spoke on the telephone to the commander who was proposing to conduct the ferry flight and informed him of the hydraulic problems,specifically that it had no emergency brakes. Part of the commander's reply was reported to be: "I am not too bothered Biggin Hill has a long runway which is into wind today and we can always use reverse." However, the Commander has subsequently stated that this phrase has been taken out of context from what was actually said, and that he considered all the implications of flight with an unserviceable emergency brake system. None of these hydraulic problems were entered in any of the aircraft's technical records.

During the late morning of 11 January 1988 the commander and a first officer arrived at Southend in order to ferry the aircraft to Biggin Hill. The commander was aware of the aircraft's emergency hydraulic system unserviceability, which had not been entered in the technical log. He signed the technical log thereby accepting the aircraft for flight. An unserviceable emergency braking system is not an acceptable deficiency in the operator's minimum equipment list, however, this was not a public transport flight.

The flight crew entered the aircraft and the commander decided that the first officer should occupy the left hand seat in order that he should obtain flight training experience towards the award of command status. The SD 3-30, whilst equipped with full dual controls and flight instrumentation, has nose-wheel steering only at the left hand seat position. Steering control from the right hand seat can only be achieved by use of asymmetric brake or thrust.

Evidence from the Cockpit Voice Recorder shows that engine start was normal but that both pilots commented on an unusual noise which they assumed to be coming from the engine driven hydraulic pumps. All hydraulic indications were normal at that time with the system pressure reading 3000 psi. After receiving taxy clearance the first officer released the parking brake, and, as the aircraft moved forwards onto the main taxy-way, he checked the nose wheel steering and reported it to be serviceable. Both pilots checked the wheel brakes which were also declared to be serviceable. As the aircraft completed the turn onto the taxy-way the commander selected 4° of flap. Very shortly after this the first officer reported failure of the nose wheel steering, both pilots found that the wheel brakes had failed and the aircraft entered an undemanded left turn off the taxy-way and collided with the stationary Viscount aircraft. The SD3-30 collided with the Viscount, head on with the right hand side of the SD3-30 cockpit hard up against the right hand side of the Viscount's cockpit. The right hand propeller of the SD3-30 cut its way into the nose and cockpit area of the Viscount and one propeller blade cut into the pilot's seat. The SD3-30's wing centre section had been twisted through approximately 10° in the horizontal axis.

Initial visual examination showed no signs of a hydraulic leak except that the hydraulic return overpressure vent line had been venting hydraulic fluid overboard in flight. This was indicated by a glutinous layer on the lower right hand side of the aircraft eminating from the vent line just forward of the right hand stub wing and spreading back to cover the lower part of the right hand rear door and rear luggage bay door. Examination of the tarmac area where the SD3-30 was parked prior to the accident showed no traces of hydraulic fluid. There were large quantities of hydraulic fluid in the area around the hydraulic reservoir caused by the fracture of a hydraulic pipe connection during the accident sequence. The hydraulic filters were examined and a small amount of a black slimy/rubbery substance and minute metal particles were found in the return filter. A laboratory examination of the black substance showed that it was an organic growth. Unfortunately the type of growth could not be identified.

After the fractured hydraulic pipe had been repaired the system was replenished and bled. A hydraulic ground rig was connected to the aircraft, and the aircraft's hydraulic services were actuated and found to function satisfactorily. All the system pressures were then replenished to the figures stated in the aircraft's maintenance manual and the aircraft was left standing overnight. The following morning the system pressures were again checked and the emergency brake accumulator nitrogen pressure was found to have dropped from 1300 psi to 800 psi, (38%) and the emergency landing gear accumulator nitrogen pressure from 1300 psi to 900 psi, (31%). The reservoir was bled and a large quantity of gas was found to be present. The system was recharged to the specified figures and, using the ground rig, the hydraulic services were functioned. After each session of functioning the systems pressures were re-checked. On each of these checks, 5 in all, the emergency brake and landing gear accumulator

nitrogen pressures were found to have decreased significantly and gas was found in the reservoir. The emergency brake and landing gear accumulators, the two engine driven hydraulic pumps (EDP's), the return overpressure valve, the reservoir nitrogen overpressure valve and the brake control valve were removed from the aircraft for testing and strip examination.

The two emergency accumulators were taken to the manufacturer, pressure tested and strip examined. It was noted that the emergency brake accumulator had the original manufacturer's wire locking present on the end caps, whereas the emergency landing gear accumulator did not.

The emergency brake accumulator leaked nitrogen into the hydraulic system when low pressure nitrogen was applied to the gas side. Strip examination showed that severe corrosion had occurred within the accumulator's working area. The evidence strongly indicated that the corrosion had taken place over a long period when the unit had not been in use. ( ie the unit had either been in storage or the aircraft had not been operated). The accumulator piston had been positioned at one end of the unit for a period of time long enough to allow the piston seal to become attached to the accumulator wall. When the piston was moved the seal left pieces of its material attached to the accumulator wall. The corrosion of the aluminium alloy of the piston produced a hard grit type deposit on the surface of the piston and the accumulator bore. A black slimy/rubbery substance similar to that found in the return filter was found on the inside of the gas end cap. The damage seen inside this unit explained the nitrogen leak into the hydraulic system and indicated that the condition had been present for some considerable time.

The emergency landing gear accumulator did not leak nitrogen when low or high pressure was applied to the gas side. Strip examination showed it to be in good condition internally with no evidence of corrosion. The seal on the gas end cap was found to have rolled through 90° over approximately one third of its circumference. The seal had rolled in such a way that it could only have happened during assembly. Although no nitrogen leak was found when the unit was tested it is considered that the leak seen on the aircraft was caused by this seal allowing nitrogen to leak to atmosphere.

The two EDP's were taken to the manufacturer and test run before strip examination and no significant fault was found.

The return overpressure valve when tested was found to have a slow leak. The valve cracked open and reseated within the specified figures but had a slow leak down to 80 psi. Strip examination revealed a contamination of the valve seat. The reservoir nitrogen overpressure valve when tested was found to function within its specification.

The brake control valve was taken to its manufacturer and tested. It was found to have a small hydraulic leak which would possibly have given an extremely slow loss of brake pressure when the brakes were applied. Strip examination showed the valve to be in good condition and no specific cause of the leak could be found. It is considered that the leak was due to general operational wear within the unit and would have had no effect on the operation of the aircraft's brakes when taxying.

Examination of the aircraft's maintenance documentation showed that prior to going into storage in July 1985 there were no regularly occurring hydraulic system defects that could be associated with nitrogen leaking into the system. While the aircraft was in storage, between July 1985 and December 1987, only three maintenance ground runs were carried out; these were in July, August and September 1985. After July 1987, when the aircraft started flying on the UK Register, problems began to occur that could be associated with nitrogen in the hydraulic system. Between July and October 1987 there were six reported hydraulic system faults, the last one being that a hydraulic failure warning light had illuminated in flight. Gas was subsequently found in the hydraulic reservoir. The system was serviced and bled after every sector for the following two days. Thereafter, no gas was found and the problem was considered to have been solved. Between November and the date of the accident the frequency of the reported problems with the hydraulic system increased, the total being ten. However, subsequent information received from the operating company would suggest that more problems with the hydraulic system than those recorded in the Tech Log had taken place. The main theme of these problems were the illumination of the hydraulic failure warning lights during flight and on one occasion the system pressure falling to zero resulting in the loss of brakes and nose wheel steering. Examination of the aircraft manufacturer's release document showed that the emergency brake accumulator was the original unit fitted during manufacture but that the emergency landing gear accumulator was not original. Prior to the issue of the American Export C of A both of the emergency accumulators had been inspected by an American repair agency and released as fit for service. The release labels for the units were annotated with 'I/R/A/N NOT O/H' which means 'Inspect and repair as necessary not overhaul'. All of the hydraulic components were maintained to an "on condition" basis.

As a result of these component defects nitrogen leaked into the hydraulic system from the Emergency Brake Accumulator. The nitrogen at 1300 psi in this accumulator, worked its way up to the hydraulic reservoir which, when the hydraulic system was functioning was initially at a nominal 50 psi. The reduction in pressure of the nitrogen caused a large increase in its volume. Thus the hydraulic fluid in the return system increased in pressure until the return overpressure valve operated at 135 psi. Because the return overpressure valve was situated lower than the reservoir, hydraulic fluid was vented overboard leaving nitrogen in the reservoir. This resulted in the hydraulic reservoir containing a large volume of nitrogen and therefore, when a large demand on the hydraulic system was made, nitrogenated hydraulic fluid entered the inlets of the EDP's causing cavitation of the pumps. Associated with the cavitation would be a loud screeching sound from the EDP's.