INCIDENT

Aircraft Type and Registration:	Cessna 750 Citation X, G-CDCX
No & Type of Engines:	2 Rolls-Royce AE 3007C1 turbofan engines
Year of Manufacture:	2002
Date & Time (UTC):	20 September 2006 at 1740 hrs
Location:	Luton Airport, Bedfordshire
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	None
Commander's Licence:	Air Transport Pilot's Licence
Commander's Age:	N/K
Commander's Flying Experience:	8,500 hours (of which 300 were on type) Last 90 days - 20 hours Last 28 days - 10 hours
Information Source:	Aircraft Accident Report Form submitted and AAIB investigation of failed components

Synopsis

As the aircraft reached its cruising altitude, the fluid contents of Hydraulic System A were lost. The crew recalculated the distance required for a landing with this failure, and decided to continue to their planned destination, Luton Airport. As the aircraft slowed down after touchdown, nosewheel steering became ineffective and the aircraft drifted to the left of the runway. The aircraft came to a halt with its nosewheel in the grass at the edge of the paved surface. The aircraft was undamaged. Two defects were identified in the hydraulic system. One of these, a pressure hose failure, had probably been damaged on a previous flight.

History of the flight

As the aircraft reached cruising altitude, on a flight from Newcastle to Luton Airport, the master caution light illuminated, together with a 'LOW FLUID' caution for Hydraulic System A. The crew observed the hydraulic fluid level decreasing on the flightdeck display and, shortly afterwards, the A system Power Transfer Unit (PTU) failed. They completed the non-normal checklist for this problem, which included tripping the PTU circuit breaker. After declaring a 'PAN', the crew recalculated their landing distance requirements and decided to continue to Luton. The loss of Hydraulic System A disabled the left engine thrust reverser and required the landing gear to be deployed using the emergency system. It also meant that emergency braking and nosewheel steering systems would have to be used on landing.

The touchdown was uneventful and, as the aircraft decelerated through 70 kt, nosewheel steering was required to maintain the runway heading. After it had slowed further, nosewheel steering proved ineffective and the aircraft began to drift to the left edge of the runway. It came to rest with the nosewheel on the grass to the side of the runway but with both main wheel on the paved surface. The crew were uninjured and the aircraft was undamaged. The aircraft was recovered from the runway and towed to a maintenance hangar for investigation and rectification.

Hydraulic system description

The Cessna 750 is equipped with two independent hydraulic systems; each is powered by an engine driven pump (EDP). Power for System A is provided by the pump on the left engine and for System B by the pump on the right engine. Both systems provide power for the primary flight controls. System A provides the only power for the landing gear actuators, wheel brakes, nosewheel steering system, the inboard speed brakes and the outboard roll spoilers. In order to provide a secondary power supply in the event of an EDP failure, Hydraulic System A is fitted with a PTU, which is essentially a hydraulic pump driven by pressure from System B. The PTU operates automatically when a drop in system pressure is detected and is fitted with a flow limiter. This prevents an excessive drop in pressure in System B in the event of a fluid leak in System A. In addition, an emergency electric pump pressurises System A should both the left engine EDP and the PTU fail.

In the event of a complete failure of System A, landing gear deployment and emergency braking is provided by a pneumatic source, and nosewheel steering by a hydraulic accumulator. Two valves are fitted in the nosewheel steering system, which allow the system to become pressurised; a blocking (or sequence) valve and a steering shutoff valve. The blocking valve remains closed until it receives a signal from either of the main landing gear squat switches, and the steering shut off valve remains closed until the nose landing gear squat switch is activated. Should either of these two valves fail to open, the nosewheel steering system remains inoperative.

Aircraft examination

Initial examination of the aircraft revealed that two failures were present in Hydraulic System A which had led to the loss of its hydraulic fluid. A pressure hose connecting the PTU to the system had failed, and a leak was present between a pipe union and the hydraulic manifold. After the union had been disassembled, an O-ring seal within the union was found to be defective. Following replacement of the affected parts, tests were carried out on the nosewheel steering system and landing gear squat switches. These revealed that the operating solenoid within the blocker valve was operating intermittently; however, no abnormalities had been reported during routine testing of the system, or by the flight crew, prior to this incident[1]. The valve was removed and, together with the O-ring and the failed pipe, dispatched to the AAIB for detailed examination.

Examination of the O-ring revealed signs of mechanical damage to its outer edge, which were indicative of it having been 'pinched' during installation. There was also evidence of erosion of the edge of the seal face, which appeared to have been produced by a mechanical process; no evidence of any chemical erosion was identified during this examination. It was not possible to determine when the damage to the seal occurred.

Footnote

[1] The available evidence indicated that failures of this valve are uncommon and any reported failures are thoroughly investigated by the manufacturer.

The failed hydraulic hose, Part Number AE1011923H0152, was surrounded by a woven thermal sheath, which was in turn covered by a woven fibre protective outer sheath. The outer sheath had melted in five places along its length, exposing the thermal layer, which was discoloured. In one area, adjacent to the hose end fitting used to attach it to the pressure outlet of the PTU, the thermal layer had been 'blown' outwards; the hose had failed at this point. The damage observed was consistent with the hose having been exposed to abnormally high temperatures; there was no evidence of thermal distress to other components in close proximity. The aircraft's maintenance organisation stated that, prior to this event, Hydraulic System A had suffered a leak, unrelated to the defects described above, whilst the aircraft was in the descent phase of a flight. Due to a high cockpit workload, the flight crew had not tripped the circuit breaker for the PTU prior to landing, so it had remained running for some time before being shut down. They also stated that operation of the PTU with low fluid levels would have resulted in an increase in the temperature of the remaining fluid, and hence the PTU itself.

Conclusions

The failure of the emergency nosewheel steering was the result of an intermittent failure of the steering blocker valve solenoid. The loss of hydraulic fluid from System A was caused by the failure of the pressure hose connected to the PTU, and a damaged O-ring seal in a union associated with the hydraulic manifold. The failure of the O-ring, in isolation, was likely to have resulted in some loss of hydraulic fluid but it was considered unlikely that the rapid fluid loss witnessed by the flight crew would have resulted solely from this defect. The thermal damage to the PTU pressure hose indicated that it had been subject to temperatures beyond its normal range of operation. This would have affected its ability to withstand its normal operating loads. It was possible that the heat damage associated with the failure may have occurred during the incident flight, but it was considered more likely that the prolonged operation of the PTU during the previous fluid leak event resulted in thermal distress to the hose. This went undetected and probably led to its failure on this flight. No other failures of this nature have been reported and therefore no safety recommendations are considered necessary by the AAIB at this time.