No: 5/88 **Ref: 1b**

Aircraft Type and Registration:	Piper PA-31-350, G-OGRV	
No & Type of Engines:	2 Lycoming TIO-540-J2BD piston engines	
Year of Manufacture:	1979	
Date and Time (UTC):	23 January 1988 at 0220 hrs	
Location:	Manchester International Airport	
Type of Flight:	Cargo (Mail)	
Persons on Board:	Crew -1	Passengers -None
Injuries:	Crew -None	Passengers -N/A
Nature of Damage:	Damage to left wing, left propeller blades and nose area	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	29 years	
Commander's Total Flying Experience:	2901 hours (of which 412 were on type)	
Information Source:	AAIB Field Investigation	

The aircraft was undertaking a regular night mail flight from East Midlands airport to Belfast when, shortly after take-off at 2340 hrs, its landing gear (which was hydraulically operated) failed to successfully retract. Although the three green "gear locked-down" lights were extinguished after "gear-up" selection, the red "gear in-transit" light stayed on, and remained on, despite several re-selections of the lever. After trying without success to lower the gear using the emergency hand pump, the pilot decided to divert to Manchester where the operating company was based.

At 2350 hrs the pilot contacted Manchester ATC, explained his situation and expressed the intention to land at the airport. ATC suggested that he fly past the tower for a visual inspection, but the pilot decided to hold-off at FL60 whilst he considered the problem. At 0003 hrs, ATC suggested that a descent into warmer air might help. The pilot replied that he had managed to obtain a green light for the right gear. At 0008 hrs, ATC declared a "Full Emergency" in anticipation of a possible accident on the airfield.

At 0020 hrs, the pilot reported an endurance of 2 hours, and then made an approach so that the gear could be visually inspected from the ground. ATC confirmed that the right gear appeared down, but that the left gear appeared up, and that the nose gear was difficult to see. Discussion with personnel

from the aircraft's operator led to the suggestion that ice might be a factor. The aircraft was therefore flown, for a period of 1 hour and 20 minutes, in an area of warmer air and manoeuvred in a variety of ways, in an attempt to obtain a safe gear-down indication.

At 0148 hrs, another flypast was made for the benefit of company personnel on the scene and the gear position was re-affirmed. At about this time the company, via ATC, requested the aircraft's fuel state. The pilot replied that he had 6 gallons remaining in the left tanks and 10 gallons in the right. He informed ATC that he wished to remain close to the airfield, since he had only some 10 minutes of usable fuel remaining in his left tanks.

At 0159 hrs, ATC suggested to G-OGRV that if he wished to initiate his approach, they would "hold-off" an inbound aircraft. This was acknowledged. The pilot of G-OGRV was then asked if he wished to proceed downwind in preparation for a long final approach. The pilot replied that he would initiate his downwind-leg, but stated that he wished to remain close to the airfield.

At 0203 hrs, the pilot of G-OGRV was asked when he would wish to land. He replied "about five minutes". ATC then instructed him to carry out another orbit, and roll out onto a northerly heading.

At 0205 hrs G-OGRV was cleared to descend to 4000 feet. Two minutes later the pilot of G-OGRV reported that he had shut down the left engine. ATC responded "Roger, turning you in very shortly". G-OGRV then asked to turn back to the airfield as soon as possible. At 0208 hrs, he was informed that he had 8 nm to run to touchdown and was cleared to descend to 1500 feet. At 0210 hrs, at a range of 4½ nm, the pilot of G-OGRV called that the lights were in sight, and shortly afterwards was cleared to land.

The pilot feathered the right engine as he crossed the runway threshold, turned off the master switch and made a skillful touchdown on the right main gear.

The aircraft touched down approximately one third of the way down runway 24, which was 3048 metres in length. During the landing run the airframe made contact with the runway during the last 70 metres. The aircraft finally came to rest on an approximately southerly heading, some 1500 metres from the 24 threshold. As the aircraft came to rest it was approached by the Manchester Airport Fire Brigade, assisted by the Local Authority Brigade, but in the event neither was. required. Damage was confined to the underside of the left outer wing, the tips of two propeller blades on the left engine, nose landing gear doors, pitot probes and entry step.

The aircraft was recovered to the operator's maintenance facility at the airport. After placing the aircraft on jacks, it was de-fuelled. Approximately 2 gallons were removed from the left main tank and 3 gallons from the right. The flight manual stated that the "unusable fuel" was some 2 gallons per tank.

With the battery master switch on, both fuel gauges indicated less than 'empty'.

The single hydraulic system on this aircraft, which is dedicated to undercarriage operation, runs at a nominal pressure of 1850 psi supplied by a small hydraulic pump on each engine. Selection and sequencing of the individual landing gears and doors is carried out in the power pack, which is situated in the nose of the aircraft and controlled directly by a lever on the pilot's instrument panel. Once a selection has been made, pressure is applied to the system to unlock and move each leg to the opposite end of its travel, where it locks into the new position. With no further movement of the system

components, pressure rises in the system, moving the selector lever to the neutral position and isolating the pressure source. Should a leak occur in the system between the pumps and power pack, an emergency hand pump is available to provide pressure to unlock and lower the landing gear, using a protected volume of fluid in the reservoir. However, should a leak occur elsewhere in the system, then the hand pump becomes ineffective. No provision is made to enable the uplocks to be released, or to power the nose landing gear against the slipstream in order to lock-down.

Initial examination of the aircraft revealed it to have landed with the left main landing gear locked up, the right main landing gear locked down and the nose landing gear unlocked. It was apparent that a major discharge of hydraulic fluid had occurred within the right landing gear bay, and that the power pack reservoir was empty. When replenished, fluid was seen to gush from the right landing gear bay, the source of this being traced to a rupture in the "gear down" flexible hose to the actuator. The position of this rupture was adjacent to a raised edge on a "doubler plate" on the wing rear spar. Close examination revealed that no clearance existed between the hose and this edge in either the "gear-up" or "down" positions. After hose replacement and fluid replenishment, the system operated satisfactorily.

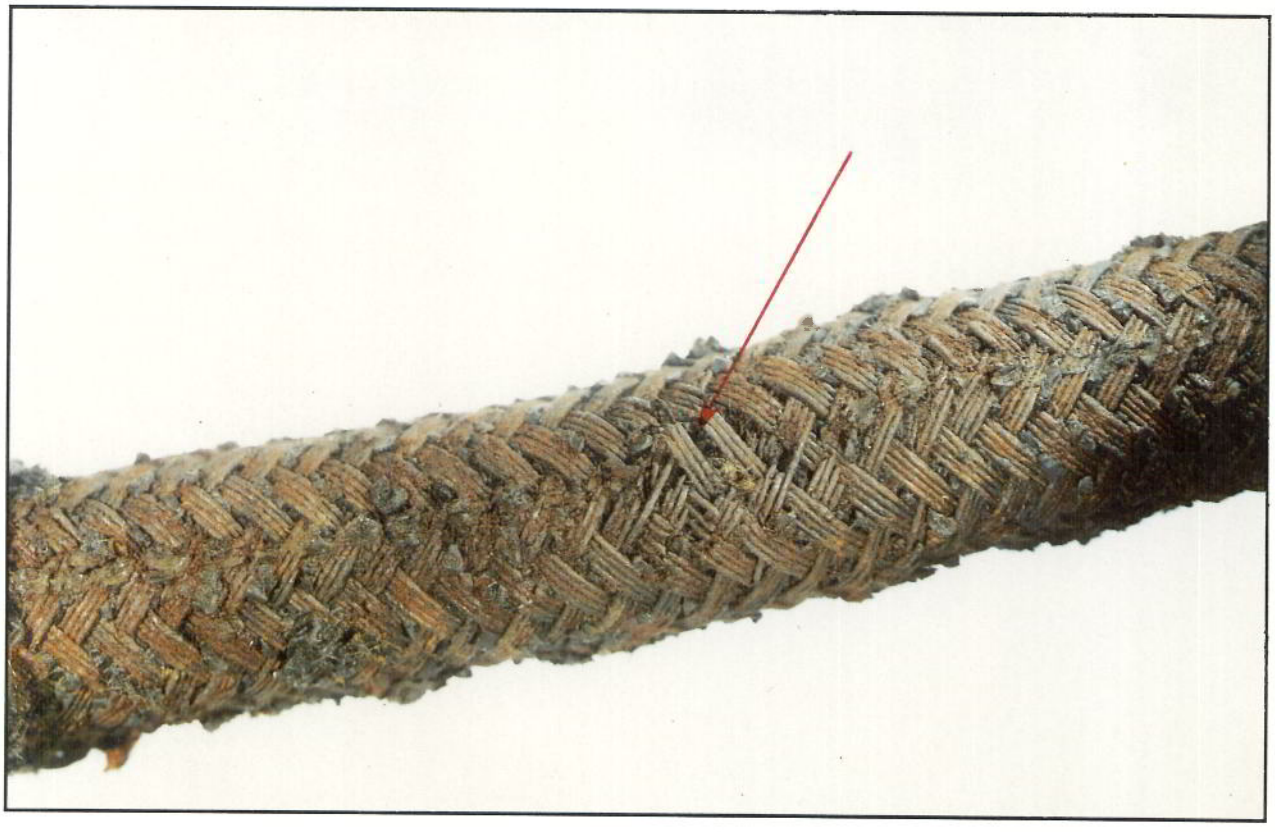
A detailed examination showed that the rupture was associated with an area of severe and relatively long-term corrosion of the high tensile steel braiding within the structure of the hose. As a result of the rupture, it could not be positively established that the outer protective layer of rubberised fabric braiding had been "chafed" sufficiently by the doubler plate to allow ingress of water. However, examination of another PA-31 operated by the same organisation revealed that one of the two gear-down hoses was also in contact with the same raised edge of the doubler plate. Localised damage and fraying of the outer braid was present. Corrosion was also present on the steel braiding of this hose, although to a lesser degree than that on the hose which failed.

It was apparent that the amount of clearance between the hose and spar could be affected by the orientation of the 30° "elbow" connector on the landing gear actuator, to which the hose is attached. Upon inspection of several other aircraft, this clearance was found to vary between zero and 0.5 inches.

G-OGRV was imported from the USA into the UK in 1986, when the aircraft was seven years old, and had a total airframe time of 2275 hours. After undergoing modification and maintenance at a different maintenance organisation to that of the current operator, it was granted a UK Certificate of Airworthiness in the Transport Category (Passenger) in June of that year. Since that time it had flown approximately 1000 hours. It had been maintained in accordance with the CAA approved Maintenance Schedule, within which the only direct reference to landing gear hydraulic hoses is that they be inspected at least every 100 hours. No specific record was found in the aircraft's American or British documentation of any landing gear hose replacement or testing, although they should have been subjected to visual inspections during regular maintenance whilst in the USA. A requirement existed in the Maintenance Schedule of the organisation which prepared the aircraft for UK certification that landing gear hoses be pressure-tested at four yearly intervals and inspected for condition, mounting, security and leaks every check 2, 3 and 4. All hoses examined on G-OGRV had the appearance of relatively high time units.

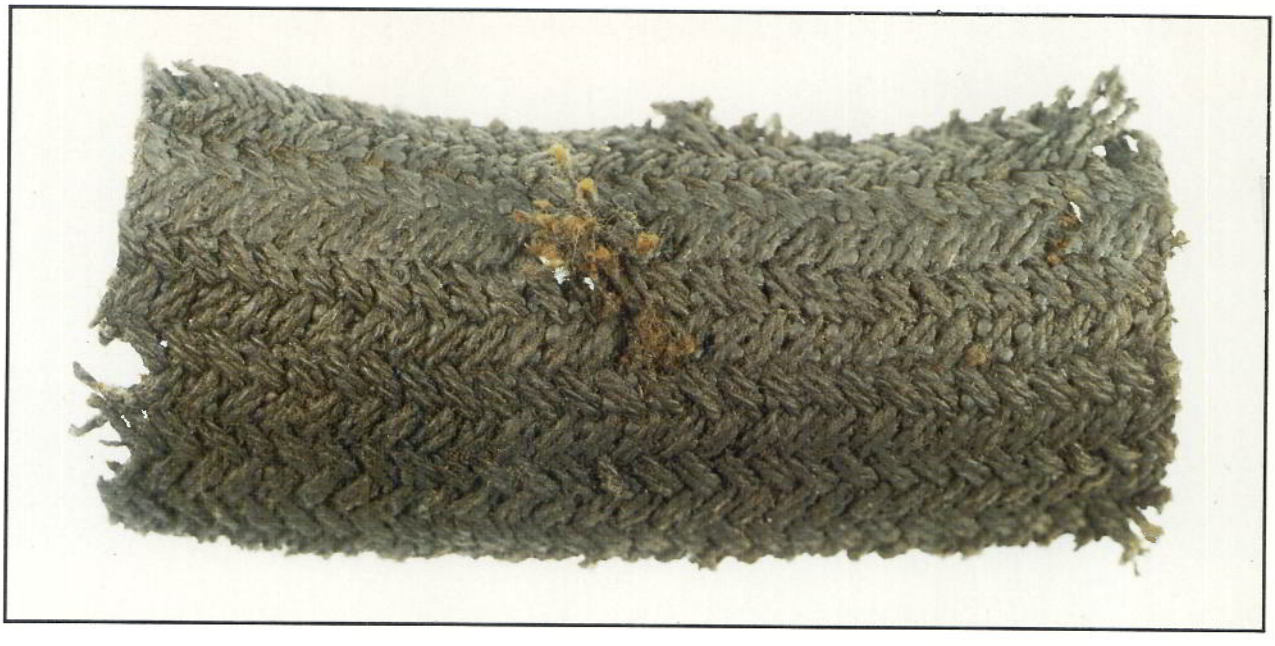
The Civil Aviation Inspection Procedures (AL/3-13, paragraph 7), relating to hose and hose assemblies states that the service life applicable to a particular assembly shall be specified in the approved Maintenance Schedule.

A recommendation has been made to the CAA that they ensure that the requirements of CAIP AL/3-13, with regard to applicable service lives and pressure testing of hoses, are applied to CAA Approved Maintenance Schedules, so that they are clearly specified.



Corroded section of hose steel braiding - outer fabric/rubber layer removed

Arrow indicates burst area



Hose outer layer covering area of rupture