

Aircraft Type and Registration: Aerospatiale AS355F1 Ecureuil II, G-SASU

No & Type of Engines: 2 Allison 250-C20F turboshaft engines

Year of Manufacture: 1983

Date & Time (UTC): 7 July 1994 at 1620 hrs

Location: Stapleford Tawney Aerodrome, Essex

Type of Flight: Air Test

Persons on Board: Crew - 1 Passengers - 2

Injuries: Crew - None Passengers - None

Nature of Damage: Substantial damage to lower fin and left skid

Commander's Licence: Airline Transport Pilot's Licence (Helicopters)

Commander's Age: 45 years

Commander's Flying Experience: 8911 hours (of which 550 were on type)
Last 90 days - 180 hours
Last 28 days - 65 hours

Information Source: AAIB Field Investigation

History of the flight

Following scheduled servicing, engine ground runs lasting approximately 10 minutes had been carried out, to check the balance of rotating components, before making an airborne power check. The commander carried out an external examination of the helicopter before boarding it together with a mechanic and the licensed engineer in charge of its servicing. At the time the weather was generally fine with a westerly wind of about 10 kt but occasional passing showers had earlier induced a slightly gusty wind from the south.

The engines started normally and nothing abnormal was noticed as the helicopter was prepared for flight. The commander then hover-taxed the helicopter about 100 metres to Runway 10 with the intention of transitioning to forward flight along the runway. However, whilst in the hover at about eight feet above the ground and just as he was about to begin the transition, the tail rotor gearbox chip warning light illuminated. The commander was in the process of explaining the associated Flight Manual guidance to the engineer when, within two or three seconds of the light illuminating, the helicopter started to yaw to the left and roll violently to the right. Initially, 'for a split second', the

commander thought the motion was caused by a gust but he rapidly realised he had full right pedal applied and diagnosed a tail rotor drive failure. Using large cyclic inputs to regain a reasonably level attitude whilst the helicopter yawed, the commander was able to land it on its skids within about one complete rotation. After touchdown, the helicopter continued to rotate and 'padded' from one skid to the other. The 'padding' stopped after the speed-select and fuel cut-off levers had been closed.

The manufacturer's Flight Manual listed the fault indicated by the tail rotor gearbox chip detector warning light as 'Metal particles in the TGB oil' and gave the corresponding pilot action as 'Continue the flight - avoid prolonged hover flights'. Under the 'Tail Rotor Malfunction' section which dealt with loss of tail rotor effectiveness in the hover, or at low speed near the ground, the Manual advised the pilot to 'Land quickly to prevent excessive rotation occurring'.

In view of the rapidity of the failure of the gearbox after the first chip detector warning indication, the following safety recommendation is therefore made:

94-37 The CAA should, in conjunction with the aircraft manufacturer, review the wording given in the manufacturer's Flight Manual for the AS355, and similar types, of the pilot action to be taken in the event of a tail rotor gearbox chip detector warning.

Examination of the aircraft

An initial examination of the aircraft was made by the operator immediately after the event. This revealed that the tail rotor would turn freely without turning the tail rotor drive shaft forward of the tail rotor gearbox (TRGB). The TRGB oil level, as viewed in the sight glass, was assessed as being in the normal range and when the magnetic chip detector plug was removed, and found to have attracted several large steel shreds, oil dripped in the usual way from the self sealing plug point. The fairings from the tail rotor gearbox and tail boom were removed and aircraft was then left overnight in the operator's hangar in almost precisely the same position that it had occupied during the maintenance immediately preceding the accident flight.

The following morning examination continued with AAIB personnel present. An inspection of the airfield area over which the aircraft had been flying when the accident occurred revealed clear evidence of the aircraft having rotated during the alighting but no detectable oil spillage. It was established that a part of the servicing which the aircraft had undergone immediately before the accident had been the replacement of a tail rotor drive shaft bearing support, which had necessitated the removal of the tail rotor and gearbox. This had been done, without draining the oil from the gearbox, and the assembly rested on a level stand. After the assembly had been re-installed, the oil level was checked and the inspector believed that it indicated that the gearbox oil level was satisfactory.

The examination showed that there was evidence of oil runs on the tail boom, immediately below the chip detector socket and running along the underside of the tail boom and dripping off the radio aerials; there was also evidence of a puddle of oil having been cleaned up from the hanger floor immediately below the TRGB. Examination of the inside of the TRGB cowling and the tail boom revealed no evidence of any quantity of oil having been thrown from either the forward oil seal of the TRGB or the tail rotor spindle scroll seal whilst the transmission had been operating. This examination also showed that the input pinion housing at the forward end of the TRGB was discoloured where it bolted onto the main gearbox casting.

The tail rotor and TRGB were separated and removed from the aircraft. On looking through the TRGB oil filler hole, with its oil strainer removed, a number of heavily damaged and blackened bearing rollers, a considerable quantity of swarf and very little oil could be seen. The TRGB was taken to the UK main agent immediately, for strip examination in the presence of the AAIB. This revealed that the aft pinion bearing had overheated, its rollers had seized on the bearing outer race which subsequently had spun in its housing. This had resulted in the light alloy bearing housing becoming semi-molten around the bearing, destroying its location and allowed the pinion to disengage from its mesh with the output crown wheel. The resultant tooth 'skipping' which had occurred between the crown wheel and pinion had generated a great deal of swarf and heated the pinion to the point where the metal of the teeth had flowed to form a toothless cone.

There was little evidence, on the inside of the casing, of the 'shellacking' which normally results from oil being overheated. The oil level sight glass was quite darkly discoloured just below the normal maximum level of the oil and this feature, together with the shape of the reflective plate within the sight glass assembly, was observed to give a strong illusion of a satisfactory oil level despite there being no oil in the glass at all. Subsequent tests to determine the visibility of various oil levels, using the same oil as was used by the operators, confirmed the indistinct and potentially misleading nature of the indication on this particular sight glass (see illustrations).

A study of the markings on, and condition of, the TRGB oil level sight glasses of a number of similar aircraft was made. Some inconsistency of the level markings was noted but it was observed that no other sight glasses in the sample had staining similar to that of the accident aircraft. The oil was drained in controlled stages from the TRGB of one aircraft and it was discovered that the drainable content of the gearbox was 200 cc and that, between the 'Max' and 'Min' level marks, the rate of change of oil level in the sight glass was approximately 10 cc/mm. It was noted, however, that once it had dropped to a level about 4 mm above the bottom of the sight glass aperture, the indicated oil level remained constant and showing a positive level, even with the entire oil contents drained. The aircraft's manuals stated that the oil content of the TRGB was 0.33 litre, which was at variance with the observed results.

CAA Airworthiness Notice 12, Appendix 43, draws attention to the possibility that stained oil level sight glasses may give a misleading impression of the actual oil level and calls for their inspection, and cleaning, if necessary. The operator's maintenance staff were aware of the contents of this notice. There was, however, no procedure in the Maintenance Manual for the removal, cleaning and refitting of the sight glass. In the Overhaul Manual, which is held by the UK Main Agents, reference is made to a standard procedure for cleaning the sight glass during overhaul, if it is considered to be necessary. The Overhaul Manual was also the only place in which the oil level marking on the sight glass, which requires special tooling, was specified.

The following safety recommendation is therefore made:

94-38 The French DGAC, together with the manufacturer, should review the information and procedures related to the lubrication of the tail rotor gearbox and their location within the various technical manuals for the AS350 and AS355 types.

As a result of this investigation, the CAA has issued a Letter to Operators using AS350 and AS355 helicopters reminding them of the existence and import of Airworthiness Notice 12, Appendix 43.

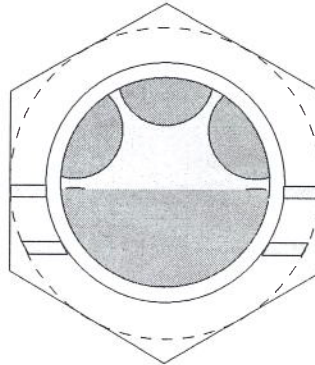
Plate 1

View of sight glass taken in bright sunlight demonstrating the sharp cutoff of the staining.

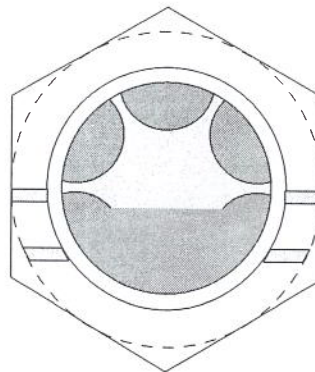
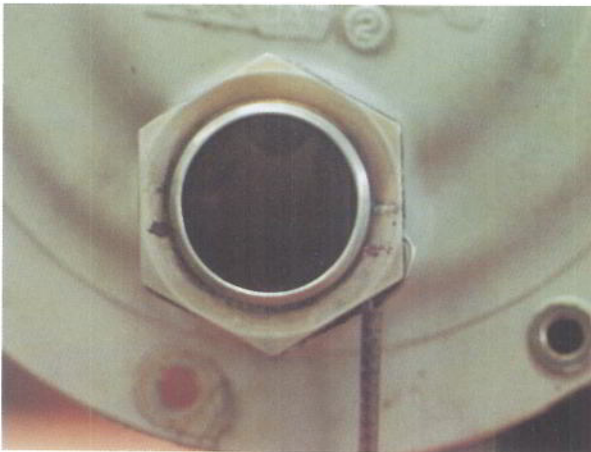


The three photographs shown below were taken during a controlled test in a brightly lit hangar and demonstrate the difficulty of discerning the oil level within the stained area.

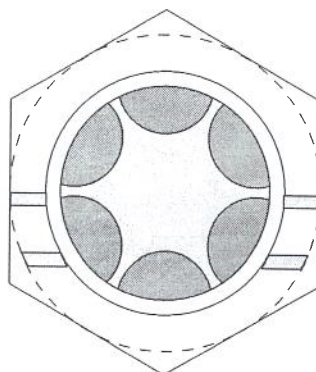
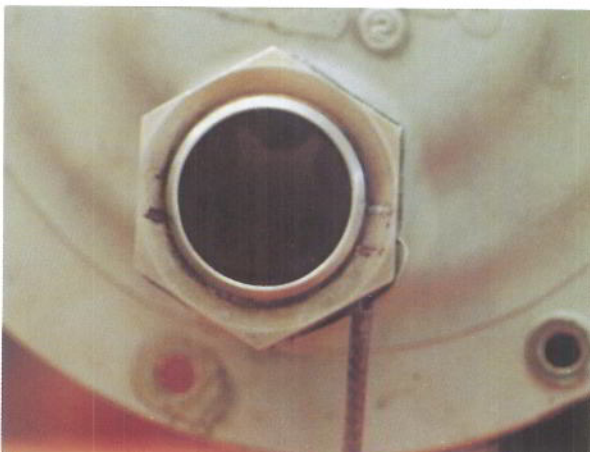
The diagrams beside each photograph show the level present at each time.



A - Sight glass filled to maximum level mark



B - Sight glass filled to 1mm below maximum level



C - Sight glass empty