

# Aircraft Accident Report

3X023-0/01  
September 2002

## Factual Information

Kind of occurrence:	accident
Date:	27. March 2001
Location:	near Birkenfeld
Aircraft:	helicopter
Manufacturer/type:	Eurocopter SA 315B "Lama"
Injuries to persons:	helicopter pilot suffered minor injuries
Material damage:	helicopter destroyed
Other damage:	field damage

### History of the flight

With the a.m. helicopter external load flights for the purpose of forest fertilising were conducted. During the lifting of the load for the fourth aerial work flight after a refuelling break - at that moment the lime container had already been lifted by about 2 m - the pilot noticed a push in the pedals of the tail rotor control. Immediately afterwards the tail rotor control became ineffective and the helicopter started to turn counter-clockwise about the yawing axis. After several rotations the helicopter touched the tops of several trees, crashed on the ground and came to lie on the starboard side.

### Investigation

The accident was investigated on the site by a field inspector of the BFU. The following findings have been made:

Two of the three tail rotor blades had been broken, the third blade had only been bend. The leading edges of the blades did not show any imprints which would have

indicated rotation during the impact. The tail rotor drive shaft had been bent off shortly behind the cabin but did not show any traces of high torsion strain. The tail rotor gear box was still filled with oil. It could be turned smoothly and was capable of transmitting torque. The tail rotor control was not interrupted and was functioning except for an impact induced rupture of the control cable on the aft cable drum.

Most of the oil had leaked out of the main gear box at the accident site. The oil showed a peculiar rusty brown discoloration. The oil filter as well as the magnetic chip detector was free of chips. In the course of the investigation by the BFU a chemical analysis of the oil was not found to be necessary.

With rotating the main gear box manually it was found that the torque was no longer transmitted from the main rotor shaft to the tail rotor drive shaft. The output flange on the main rotor gear box could be turned smoothly. As an internal damage to the main gear box had to be assumed the gear box was removed from the helicopter and transported to Braunschweig to the BFU for further investigation.

During the disassembly of the gear box all parts inside the housing were found to be covered by a reddish brown greasy patch. The bevel gear on the main rotor shaft serving as a transmission element for the tail rotor drive could be rotated relative to the shaft. The connection in this area is realised via a multiple-spline shaft with a transition fit and a high axial preloading by means of a shaft nut. The latter could be screwed off manually after removal of the locking wire.

The teeth on the main rotor shaft had been worn off to such a degree that the positive engagement with the

bevel gear had been lost. The loss of material of the teeth was even over the whole circumference. The connection area was filled with sludge of a rusty colour. There were no visible chips or particles of the lost tooth portions. However, plastics particles had been found in the remaining tooth roots. During a subsequent analysis, the particles were found to be a bearing adhesive, similar to the product known under the brand name 'Loctite'.

The manufacturer of the helicopter stated upon inquiry that according to the maintenance documents the use of a product such as *Loctite* was not specified and that the product even was adverse to this function.

With regard on long term experience by similar applications, the certified maintenance company, which had performed the last major overhauls of the gear box finds adhesives useful. The company stated further that, *Loctite* had been used only if there was light play in the spline shaft connection within the tolerances specified by the manufacturer, and that, it had been applied to the mating faces beneath the spline shaft to achieve a better positioning of the pinion.

The manufacturer knows of a similar component failure, which happened appr. 20 years ago. As a result of the investigation conducted at that time a special inspection to be performed at regular intervals of 400 (+20) hours in service is included in the maintenance schedule of the SA 315B. During this inspection the angular play on the output flange of the gear box is measured. According to the existing inspection records, the main gear box had been installed after 304 hrs (TSO) into the accident helicopter. The inspection of the angular play had been performed 208 hrs after that installation and 186 hrs before the accident.

## Analysis

As the technical investigations show the failure of a spline shaft connection in the main gear box had caused the tail rotor drive to fail. Such a technical failure on a helicopter results in a loss of control which in hover flight cannot be coped with by the pilot.

The findings made on the spline shaft connection indicate wear as a result of friction, in particular friction corrosion. A detailed tribological analysis of the damage had not been conducted. Friction causes at least a minimum relative motion between the contact surfaces and the damage evolution extends over a longer period of time. Thus a form fitting without a sufficient permanent mechanical force transmission may fail.

The design of the spline shaft and the pinion provides a transition fit and conditionally no play. The tolerances due to the manufacturer's documents can lead to a light clearance between pinion and spline shaft. In this case only the rather high preloading of the shaft nut was left to prevent a relative motion in axial and in circumferential direction. The following factors may

have caused the wear in the connection:

1. The dimensions of the spline shaft and the pinion resulted in a clearance within the connection. The transition fit by design is allowing that. Relative movements could have been prevented either by a designed pressure fit or by assembling a matching pair.
2. The preloading due to the manufacturer's directive is not sufficient to prevent relative movement if clearance within the spline shaft connection exists.
3. The preloading is sufficient, however the shaft nut had not been fastened by the required torque or contamination of the mating faces, e.g. by *Loctite*, had lead to axial play in the course of the operation.

It could not be clarified in the scope of the investigation in which way the play causing the friction wear was produced.

Wear of metal components in gear boxes is indicated by chafing and corrosion products such as rust in the oil circuit. This kind of wear leads to a discoloration of the oil and forms a brown deposit on the magnetic chip detector.

An assessment of the effectiveness of the special inspection, i.e. measuring the radial play on the drive flange, which had been prescribed by the manufacturer already a long time ago, was not a subject of the investigation.

## Conclusions

Following the failure of the tail rotor drive the accident was inevitable. The cause of the wear leading to the component failure could not be determined with sufficient certainty.

## Safety Recommendations

The BFU is convinced that the continuous inspection of the gear box oil for rusty reddish contamination is the only safe method to recognise wear. Following the investigation the manufacturer published the Service Alert Bulletin no. 05.99 providing a programme for continuous supervision of the gear box by measurement of angular play and oil checks. Besides the BFU recommends the daily oil check as the most effective practice.

Investigator-in-charge	Hasenfuß / Leibe
field investigation	Herzberg