Aerospatiale AS332L, G-PUMA

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Aircraft Type and Registration:	Aerospatiale AS332L, G-PUMA
No & Type of Engines:	2 Turbomeca Makila 1A turboshaft engines
Year of Manufacture:	1983
Date & Time (UTC):	6 March 1997 at 1440 hrs
Location:	Santa Fe Galaxy oil rig and Aberdeen Airport
Type of Flight:	Public Transport
Persons on Board:	Crew - 2 - Passengers - 16
Injuries:	Crew - None - Passengers - None
Nature of Damage:	Loss of 5 bolts and damage to 4 tail rotor blades
Commander's Licence:	Air Transport Pilot's Licence (Helicopters)
Commander's Age:	45 years
Commander's Flying Experience:	7,300 hours total (of which 5,600 were on type)
	Last 90 days - 71 hours
	Last 28 days - 61 hours
Information Source:	AAIB Field Investigation

The helicopter was being operated from Aberdeen Airport to a 'jack-up'oil rig which was being towed towards its intended position inthe North Sea. The sector was some 20 minutes in duration and,after disembarking the 16 passengers, the First Officer performeda short 'walk-around' inspection, with the rotors running. Duringthis inspection he noted that four bolts were missing from theright-hand side of the fairing which covers the inclined portionof the tail rotor drive shaft (Figure 1). The crew consideredthe alternatives and elected to fly the aircraft back to Aberdeenas there was no evidence of unusual vibration or any other aircraftproblem. The return flight was without passengers and at Aberdeenthe aircraft was shut down. It was found that five bolts werenow missing, with a further bolt found to be loose, and that therewas damage consistent with bolt contact with the leading edgesof four of the five tail rotor blades. Replay of the HUMS (Health& Usage Monitoring System) confirmed that the blade damagehad not resulted in a detectable change in vibration and the helicoptermanufacturer subsequently confirmed that all of the blades wererepairable and none had suffered any significant structural damage.

Recent maintenance

The most recent maintenance input had been during the previousnight (5 March) and the helicopter had since had a ground runand seven flight sectors before any bolts were noted as missing;there is no evidence as to the time of release of the first fourbolts. The maintenance actions had included the scheduled inspectionof the tail rotor drive shafts (mandatory Service Bulletin 05.37),repeated every 50 flight hours. This inspection requires the removalof the fairings over the tail rotor drive shaft, including theinclined fairing, No 8. This fairing is secured by a total of19 bolts on the left and right-hand sides. The bolts secure thefairing, which is of composite construction, to a pair of longbrackets mounted on the transmission deck and the threaded portionsof the bolts are retained in 'stiffnut' self-locking nuts, anchoredby rivets to these brackets. The configuration is shown in Figure1. The 'stiffnuts' are of the metal-to-metal variety, inwhich the portion of the thread furthest from the anchor lugsis deformed into a slight ellipse, designed to produce a consistentand controlled elastic deformation every time the thread of thebolt passes through this portion of the nut.

This arrangement, with multiple bolts and anchored stiffnuts,had been introduced by a recommended Service Bulletin (SB 53.61)in 1986, replacing the previous design in which the left-handside of the fairing was hinged and the right-hand side securedby over-centre type clasps (SARMA fasteners). The earlier configurationhad led to significant service difficulties in the UK and elsewhereand AS 332L G-TIGD was destroyed in an accident at AberdeenAirport on 4 July 1983, when a hinge pin became detached in flight,leading to the loss of the fairing, damage to the tail rotor bladesand consequent loss of the entire tail rotor gearbox. The accidentto G-TIGD was the subject of a detailed AAIB investigation, culminatingin the accident report, AAR 4/84.

The work on G-PUMA on the night of 5 March had been performedby an experienced technician during a routine 2100-0700 hrs nightshift, the last night of a block of six in a 'semi-permanent'night shift pattern. The technician and his supervisor both statedthat the re-fitting of the fairing, including the securing bolts,would have been performed at about midnight and had been entirelystraightforward and unhurried. The technician stated that he hadbeen well-rested, was fit and had applied the normal techniqueof installing the bolts with a small ratchet spanner as thereis no installation torque specified.

Further investigation

Detailed investigation after the incident concentrated on theanchored 'stiffnuts', which had been replaced with new hardwareafter the incident. Simple tests showed that these stiffnuts hadlost almost all of their self-locking function and that the boltsfrom G-PUMA could be run through the thread of the nut using lightfinger pressure only. More detailed investigation showed thatthis loss of the self-locking function was caused by a combinationof wear on the nut and bolt. Thus, an 'old' bolt in an 'old' nutcould be run through with finger pressure, whereas either an 'old'bolt/'new' nut or 'new' bolt/'old' nut combination would providean intermediate degree of locking.

There was no evidence that either bolts or nuts from G-PUMA hadbeen replaced since the implementation of the Service Bulletinin 1986, neither was there was any indication in the maintenancedocumentation that either should be changed. In practise, it hadclearly been possible to achieve a satisfactory torque at re-installationbut this had latterly been achieved totally by compression ofthe material between the bolt head and the nut, rather than bythe action of the 'stiffnut'. The washers installed under thebolt heads were also found to be 'dished' by permanent plasticdeformation. This further illustrated that the apparent lockingtorque was being achieved by

deformation of the material sandwichedbetween the bolt head and the nut without the self-locking actionof the 'stiffnut'.

At the time of the incident, G-PUMA had accumulated a total ofsome 16,260 flight hours, with the tail rotor drive shaft fairingsremoved at least every 50 flight hours for scheduled inspection.The technicians confirmed that loose bolts had been noted on anumber of previous occasions and that the action had simply beento re-torque them; the matter had thus not been taken furtherand had not become an issue for the company's Quality Assurancedepartment.

A number of manufacturers of this form of generic anchor stiffnutwere contacted by AAIB. They confirmed that this type of stiffnutwould generally be manufactured to the controlling specificationof the United States' Military Standard ('Mil Std') MIL-N-25027or to a similar European specification. In this case, the helicoptermanufacturer's standard was confirmed as being derived from MILN25027.The 'Intended Use' paragraph of the MIL-N-25027 standard applies,in general, a reusability limit of 15 cycles. However, civil airworthinessauthorities, including the CAA, normally accept multiple re-usesproviding a periodic check is made of the locking quality, performedby a simple 'run-down' check of the torque required to run thebolt through the stiffnut: CAA guidance is given in Leaflet 25of the CAA's 'Civil Aircraft Airworthiness Information and Procedures'(CAAIP). The manufacturer of the AS332 notes that similar criteriaare also detailed in the manufacturer's "Standard PracticesManual" (Chap 20.02.05.404).

Following the incident the operator took the initial step of wire-lockingthe bolt heads and subsequently replacing the nuts and bolts withnew items. On 13 March 1997, following the incident to GPUMA,the CAA requested operators to apply a check of the nuts throughoutthe UK AS332 fleet and accepted an operators' suggestion to replacethe anchor stiffnuts at 3,600 hour intervals. The operator ofGPUMA amended their maintenance schedule to include thisperiodic replacement but did not include an amendment to ensureperiodic checking of the self-locking function.

Recommendations

The following Safety Recommendations have been made to the CAA:

Recommendation 97-38

It is recommended that the CAA ensure that periodic checking ofstiffnut locking function is applied within the maintenance schedulefor all removable panels on the AS332L.

Recommendation 97-39

It is recommended that the CAA should formally remind operators,engineers and maintenance organisations of their responsibilityin the routine checking and maintenance of stiffnuts and otherself-locking fasteners.