SERIOUS INCIDENT

Aircraft Type and Registration:	Agusta Bell 206B Jet Ranger II, G-SUEZ
No & Type of Engines:	1 Allison 250-C20 turboshaft engine
Year of Manufacture:	1970
Date & Time (UTC):	20 February 2012 at 1500 hrs
Location:	Approx 3.4 miles NW of Perth, Scotland
Type of Flight:	Aerial Work
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Engine compressor and case damaged
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	36 years
Commander's Flying Experience:	1,891 hours (of which 1,020 were on type) Last 90 days - 168 hours Last 28 days - 38 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent AAIB enquiries

Synopsis

After suffering an engine failure at 600 ft agl the helicopter completed a successful autorotation into a field. The engine failure was a result of a fracture in fatigue of a stage-two compressor blade.

History of the flight

The helicopter was carrying out a pipeline inspection approximately 2 nm north-west of Perth. At 600 ft agl a loud bang was heard by the crew and the helicopter yawed to the left. The main rotor rpm decreased and the engine was seen to "wind down". The pilot completed a successful autorotation into a field after which he reported the incident to ATC. There were no injuries.

Investigation

Initial inspection revealed that the engine had suffered from a failure of the axial compressor and the compressor case had been breached. No damage was found to any other components or structure of the helicopter. The engine was removed and inspected at the operator's maintenance organisation where numerous fragments of compressor blades and stator vanes were recovered. The engine was then dispatched to an approved overhaul facility where it was examined under the supervision of the AAIB and a representative of the engine manufacturer.

Several ruptures were observed to the compressor case in the plane of the stage-two and three compressor discs. Removal of the compressor cases showed that

all the blades on stages two through to six of the axial compressor had separated from their associated discs. The stage-one compressor blades remained attached to the disc but had suffered from significant trailing edge damage. The stage-two and three compressor stator vanes had been heavily damaged and distorted. Most of the stator vanes from subsequent stages had separated from the compressor case. The centrifugal impeller showed signs of impact damage but was intact. Impact damage was observed on the compressor diffuser tubes and the turbine. The extent of the damage to the compressor assembly prevented the identification of the cause of the failure using optical examination so it was dispatched to the engine manufacturer for a detailed investigation.

Metallurgical tests of the compressor components confirmed that no material abnormalities were present and there was no evidence of Foreign Object Damage (FOD). The fracture surface of a large number of the compressor vanes had been smeared during the incident which prevented their initial failure mode from being identified. Scanning Electron Microscope (SEM) examination of the remaining fracture surfaces showed some features indicating that they had failed due to tensile overload.

The compressor blade fracture surfaces had also suffered from significant secondary damage, but most contained localised areas where the initial fracture surface was visible. SEM examination of these areas confirmed that these compressor blades had failed due to overload. However, a section of a fracture face on one stage-two compressor blade had evidence of crack progression in fatigue. Further examination suggested that the crack had propagated in High Cycle Fatigue (HCF) from the suction side of the blade. Secondary damage to the majority of the fracture surface prevented the initiation point of the crack from being identified. Further SEM examination revealed pits in the leading edge blade root area of several stage-two and three compressor blades, the largest of which was 0.0053" deep and 0.0055" wide.

Maintenance requirements

The manufacturer's Maintenance and Operation manual (72-00-00 page 617) for the M250 engine contains a 300-flying hour inspection which includes a task that states:

> *'Inspect the compressor case when operating in an erosive and/or corrosive environment.'*

The United Kingdom is considered to be a corrosive environment. This task makes reference to Paragraph 1.D (9), 72-00-00, which states:

> *'(9) Erosion and Corrosion Inspection*
>
> *If the aircraft is frequently subjected to sand or dust ingestion or operated in a corrosive environment (salt laden or other chemically laden atmosphere such as pesticides, herbicides, sulphur, industrial pollutants, etc), inspect compressor blades, vanes, and case plastic coating for erosion or corrosion damage. Engines operated in a corrosive environment should be subjected to daily water compressor rinses.'*

There is no requirement to use additional optical magnification when completing the visual inspection. The compressor blade and vane inspection limits are specified in section 72-30-00 paragraph 5 of the Maintenance and Operation Manual.

Maintenance activity

A review of the maintenance records for the helicopter confirmed that the compressor had been installed in the engine on 19 August 2011 and had operated 341 flying hours prior to the failure. The compressor had previously been installed on an engine fitted to a helicopter that had been operating outside the UK. Before its installation into G-SUEZ, the engine's compressor had undergone a 300-hour inspection. A 300-hour inspection had been subsequently completed on the compressor in January 2012.

The maintenance organisation's 300-hour inspection for the Allison 250 engine contained the task shown in Table 1.

Whilst the required maintenance task for the inspection of the compressor was detailed in the helicopter's maintenance programme and provided a generic reference to the engine Maintenance and Operation Manual, it did not provide a reference to the specific section of the manual which detailed the full inspection requirements. In discussions with representatives of the maintenance organisation it became apparent that the use of a generic reference and the description of the inspection task in the maintenance programme was ambiguous.

The maintenance organisation confirmed that G-SUEZ was subject to routine compressor washes as part of the normal daily maintenance requirements when operating from its maintenance facility. At the time of the incident, G-SUEZ had been operating away from its main maintenance base for two days and had not received a compressor wash during this period. It was not possible to determine how frequently the compressor had been washed prior to its installation in G-SUEZ.

Analysis

The damage observed to the compressor was consistent with a failure within the stage-two compressor rotor which resulted in significant downstream damage to the engine. The examination of the remains of one stage-two blade root indicated that the probable cause of the event was the fracture of a stage-two blade due to crack progression in fatigue. Whilst the origin of this crack could not be identified, there was no evidence of Foreign Object Damage to the stage-one compressor blades, or to the inlet guide vanes. It was not possible to eliminate the possibility of the presence of pitting which had been observed on other blades. If pitting was present this could have been a potential initiator of the fatigue crack.

The manufacturer's inspection programme for the engine type includes visual inspections of the compressor rotor

DATA REFERENCE	INSPECTION TASK DESCRIPTION	Mech	Insp
Allison 250 M & O	Inspect the compressor case halves. NOTE: only required if flown 300 hours since last compressor split – see six monthly inspection		

Table 1

for damage and pitting during the 300-hour compressor case inspection task. Whilst wording of the compressor inspection task in the maintenance organisation's 300-hour inspection programme reflected the wording of the manufacturer's manual, it did not provide the reference to the specific tasks associated with the inspection requirements contained in that manual. This lack of references were such that the requirements were ambiguous, and therefore could result in an incomplete visual inspection of the compressor rotor.

Safety action

As a result of this investigation, the maintenance organisation has revised its maintenance programme to include a specific task for the inspection of the compressor rotor during the 300 hour inspection. In addition, the inspection task now includes specific references to the sections of the manufacturer's manual which lay out the inspection criteria and limitations.