APPENDIX G: RELEVANT SAFETY RECOMMENDATIONS FOLLOWING THE G-REDL ACCIDENT IN 2009

AS332 L2 Super Puma, G-REDL	**11 nm NE of Peterhead, Scotland**	**1 April 2009**	**Accident**

Safety Recommendation 2011-032

It is recommended that, in addition to the current methods of gearbox condition monitoring on the AS332 L2 and EC225, Eurocopter should introduce further means of identifying in-service gearbox component degradation, such as debris analysis of the main gearbox oil.

Date Safety Recommendation made: 15 November 2011

LATEST RESPONSE

Response received: 27 June 2012

Based on FMECA (Failure Mode Effect and Criticity Analysis) and confirmed by the experience, two types of debris can be generated by gearbox deterioration:

- 3D-particles (volume) or 2D-particles (surface): these types of particles are usually generated by degradation of high-loaded functional surfaces like bearing races or gear tooth (spalling, scale, flaking …) or by part breakages.

- Wear particles: these types of abrasive particles are usually caused by abnormal high-contact of surfaces (fretting, micro-pitting…) and are generally in suspension in the oil.

A third type of debris can be found in gearboxes is associated with the manufacturing process (swarf…), the assembly process (piece of lockwire, fragment of cotter pin…), or maintenance actions (leading to introduction of foreign objects). All these debris are considered as some 3D or 2D particles.

Because the types of these generated particles are very different, adapted monitoring means must be used in order to monitor each type.

Two monitoring means are presently available to detect such debris:

Magnetic plugs: these collect the particles and are visually inspected in order to detect 3D or 2D debris, but they can also collect wear particles. An electrical system can be added in order to give an in-service information of particle presence (warning on pilot on instrument panel and/or HUMS system for the maintenance) as soon as the particle(s) collected is (are) able to close the bridge between the two electrical parts of a magnetic plug. All Eurocopter fleet gearboxes are equipped with magnetic plugs (manual or electrical ones) and this is the main monitoring means to detect internal gearbox component degradation (they are also associated to the oil filter cartridge inspection).

Spectrometric Oil Analysis Program (S. O. A. P): this is used to monitor evolution of the concentration of different metals or else (particle per million) in suspension in the lubricant. It requires following of a dedicated and strict procedure to take periodically a volume of oil in defined conditions (warm and mixed oil taken with specific equipment by qualified personnel with a qualified process) and sending it to qualified laboratory.

SOAP is a monitoring means that is well known to Eurocopter and its principle is described in EC Technical Publications (Standard Practice Manual WC 20.08.02.601 attached). SOAP is considered by Eurocopter as an optional and additional monitoring means. SOAP can be used to monitor the evolution, between two oil replacements, of metallic material concentration or possibly some other material (like mineral) which are in suspension in the oil. SOAP can trigger the requirement of a close monitoring of the main monitoring means (magnetic plugs and filter) if certain dedicated thresholds are exceeded.

This means was introduced in the past during the development of SA 330 (Puma) and at the beginning of AS 332 (Super-Puma) production because the technologies used (bolted assemblies, machining without grinding, etc.) sometimes produced wear particles. This is no longer the case as a result of modern technologies used on the AS332 L2 and EC225 main gear boxes (Electron beam welding instead of bolted assemblies) and manufacturing processes (super finishing, grinding) which generate parts more reliable regarding wear degradation.

Despite the fact that these old technologies could generate some wear particles relevant to SOAP, the experience of Eurocopter demonstrates that this means was not efficient and that, in practice, it had led to many unjustified removals of gear boxes with unnecessarily interference to flight operations and wasted maintenance costs. Against this background, Eurocopter so issued Service Letter 759-00-86 in 1986 25/06/1986).

It also has to be noted that SOAP is not adapted to detect 3D or 2D particles because such particles are not in suspension in the oil. So SOAP is not adapted to detect spalling.

In addition, the magnetic plugs are able to detect incipient spalling at a level where, even if the whole volume of particles generated was in suspension in the oil, the concentration would not be detectable by SOAP taking in account the important oil volume in a main gear box.

Eurocopter considers that magnetic plugs and/or chip detectors are the most efficient means to detect gearbox internal failure modes, and that they are sufficient to ensure the flight safety so that further means of identifying in-service gearbox component degradation, such as debris analysis of the main gearbox oil, are not necessary. Here, it is relevant to note that the particle detection capability of the sump and epicyclic plugs has been enhanced by the removal of the ring of magnets from the lower area of the epicyclic module.

AAIB Assessment – Not Adequate – closed

(SRIS Reference: GB.SIA-2011-0032)

AS332 L2 Super Puma, G-REDL	11 nm NE of Peterhead, Scotland	1 April 2009	Accident

Safety Recommendation 2011-033

It is recommended that Eurocopter review their Continued Airworthiness programme to ensure that components critical to the integrity of the AS332 L2 and EC225 helicopter transmission, which are found to be beyond serviceable limits are examined so that the full nature of any defect is understood.

Date Safety Recommendation made: 15 November 2011

LATEST RESPONSE

Response received: 27 June 2012

The examination of the critical components found beyond serviceable limits has been a part of the Eurocopter Continued Airworthiness Process for several decades. This doesn't mean that all parts found to be beyond their serviceable limits are subject to a deep laboratory examination. It means that all parts which, on inspection/detection, are found with an unknown degradation mode or with known degradation mode but beyond what is expected are subjected to a more in-depth analysis.

When, after initial inspection, such situation is reported to the Eurocopter Technical Support, an In Service Incident Report (ISIR) is issued and analyzed in the frame of the Continued Airworthiness Progress involving most of the Eurocopter Directorates (Airworthiness Department, Design Office lead functions, Technical Support, Flight Test, Quality…). The Continued Airworthiness Board performs a risk analysis for each ISIR, defines if laboratory investigations, tests and calculations are necessary and decides on protective and corrective measures when necessary.

1/ The first step of this process is the collection of such events which can be discovered by the Operators or by the Repair and Overhaul centers world-wide. The necessity to report technical occurrences toward the manufacturer is permanently reminded through different ways:

- In each aircraft Maintenance Program Generalities

- In the Information Notice 2046-I-00 "Occurrence Reporting" which is also reminded in the Safety page of the Eurocopter website (document attached).

- In the "Eurocopter technical and publications services network information manual" used by the broad Eurocopter network.

- During seminars and numerous customer meetings.

Additional ways are specifically dedicated to the world-wide Eurocopter approved D-level R&O centres (Repair Stations):

- Each contract signed between Eurocopter and a D-level centre specifies the application of EI (Eurocopter Instruction) 050 19-031 "Technical Requirements for the EUROCOPTER D-level Centers / Dynamic & Hydraulic Components and Blades".

- The Repair Letter n° 213 sent to all approved D-level centers to remind the requirement to inform Eurocopter of "any difficulty, incident or anomaly discovered, likely to affect the safety or airworthiness of an aircraft". This Repair Letter n° 213 which is also attached refers to EI 050 19-031

- Training VDI (Visual and Dimensional Inspection) given to all new D-level centers mechanics.

- These EC approved D-level R&O centres are audited every 2 years and the process is reminded each time a mechanic comes in Eurocopter for training (Protocol Audit F050 17-001-3 / §A.4.1)

A dedicated Technical Support team is in place in the Eurocopter Dynamic Components R&O centre (DERH). This team is in charge of the first step of investigation, reporting, and is part of the SMS MRO (Safety Management System Maintenance Repair and Overhaul). The SMS MRO is in place and has been approved by the EASA: Information to relevant people of issues found by mechanics (Quality issue, abnormal degradations…)

Eurocopter is also working on a Web tool which will permit to follow the Repair and Overhaul activities of all approved D-level centers. It will then be possible to question each D-level centers on the origin of the identified degradation (A/C, event circumstances…) and ask for dynamic components for investigation.

2/ The second step is the analysis as described here above including the laboratory investigation with the objective of understanding the origin of the degradation and also to confirm that the maintenance program is able to detect the ongoing degradation before reaching failure which, itself, could lead to a critical situation. Depending on the result of this analysis and the risk associated with the degradation, new measures can be implemented regarding the design, the manufacturing process or the maintenance program.

Following the issuing of this Safety Recommendation, Eurocopter's Continued Airworthiness Process has been explained again to, and considered by, the EASA and subsequently validated by it.

Eurocopter considers that the Continuing Airworthiness process currently in place provides sufficient assurance and warranty that components critical to the integrity of all helicopter transmission which are found to be beyond serviceable limits are examined so that the full nature of any defect is understood.

AAIB Assessment – Adequate – closed

(SRIS Reference: GB.SIA-2011-0033)

AS332 L2 Super Puma, G-REDL	**11 nm NE of Peterhead, Scotland**	**1 April 2009**	**Accident**

Safety Recommendation 2011-034

It is recommended that the European Aviation Safety Agency (EASA) review helicopter Type Certificate Holder's procedures for evaluating defective parts to ensure that they satisfy the continued airworthiness requirements of EASA Part 21.A.3.

Date Safety Recommendation made: 15 November 2011

LATEST RESPONSE

Response received: 23 October 2012

The Agency carried out in April 2010 an audit of Eurocopter on the design Organisation Approval (DOA) side as part of the defined annual Standardisation Audit Plan. The scope of this audit included the review of the actions taken by the Type Certificate Holder on occurrences.

EASA's audit confirmed that the manufacturer was able to demonstrate that its procedures for compliance with the requirements of Part 21.A.3 are comprehensive and appropriately used.

AAIB Assessment – Adequate – closed

(SRIS Reference: GB.SIA-2011-0034)

AS332 L2 Super Puma, G-REDL	11 nm NE of Peterhead, Scotland	1 April 2009	Accident

Safety Recommendation 2011-035

It is recommended that the Federal Aviation Administration review helicopter Type Certificate Holder's procedures for evaluating defective parts to ensure that they satisfy the continued airworthiness requirements of Federal Aviation Regulation Part 21.3.0.

Date Safety Recommendation made: 15 November 2011

LATEST RESPONSE

Response received: 29 May 2012

A review of the process verifies that Type Certificate (TC) Holders' procedures for evaluating defective parts satisfy the continued airworthiness requirements of 14 CFR 21.3. Procedures for evaluating defective parts are further contained in the Instructions for Continued Airworthiness Instructions required by 14 CFR 21.50 and must be submitted to and accepted by the FAA. In addition, TC holders that have an Organization Designation Authorization are required to have an FAA approved manual that documents their procedures for reporting any failure, malfunction, or defect in any product or article covered by 14 CFR 21.3.

[The FAA] believe the FAA's current process ensures that all TC holders have procedures in place for evaluating defective parts to ensure the requirements of 14 CFR 2 1.3 are satisfied.

AAIB Assessment – Adequate – closed

(SRIS Reference: GB.SIA-2011-035)

AS332 L2 Super Puma, G-REDL	11 nm NE of Peterhead, Scotland	1 April 2009	Accident

Safety Recommendation 2011-036

It is recommended that the European Aviation Safety Agency (EASA) re-evaluate the continued airworthiness of the main rotor gearbox fitted to the AS332 L2 and EC225 helicopters to ensure that it satisfies the requirements of Certification Specification (CS) 29.571 and EASA Notice of Proposed Amendment 2010-06.

Date Safety Recommendation made: 15 November 2011

LATEST RESPONSE

Response received: 11 January 2013

EASA have requested Eurocopter to complete their current fatigue justification file of the Main Rotor Gearbox (MGB). Since the root cause of the accident is highly suspected to originate from spalling degradation, EASA have requested that Eurocopter provide a complementary assessment aiming to take into consideration MGB fatigue tolerance evaluation for "environmental effects, intrinsic/discrete flaws, or accidental damage" [see Certification Specifications (CS) 29.571 and Notice of Proposed Amendment (NPA) 2010-06]. The methodology for such fatigue re-evaluation is based on the following:

- to review Super-Puma AS332 and EC225 MGB overhaul and incident records in order to determine the list of credible flaws (threat) likely to occur on MGB power gears;
- to analyse the impact of those defects, as determined by the review of in-service records, in terms of fatigue behaviour and crack propagation;
- to provide an updated justification of the status of the available MGB monitoring means (e.g. chips detectors efficiency, overhaul checks);
- to perform complementary computations to assess the behaviour of MGB components with catastrophic failure modes (PSE).

Furthermore, Eurocopter have launched an 18 months duration test program for MGB actual spalling testing. It aims to gather more information about any potential MGB component degradation modes, in particular spalling degradation phenomenon and its growth speed. EASA is following the testing and depending on the results, the current MGB monitoring strategies might be reconsidered.

The gear fracture mechanisms investigated after the G-REDL accident have shown that the relevant degradation phase is relatively quick in comparison with other MGB degradation modes like spalling and fatigue. Therefore progressing Eurocopter's MGB testing up to components fracture is not foreseen, but should the test provide fruitful information about fatigue and fracture mechanisms, those will be used for the complementary fatigue assessment mentioned before.

In addition to the above activities, EASA consider that the safety of fleet relies primarily on the capability of the MGB magnetic plugs to ensure early detection of spalling.

In order to increase the likelihood of detecting any particles, EASA has issued Airworthiness Directive (AD) 2012-0129-E, dated 13 July 2012. This new AD retains the requirement for the accomplishment of MOD 0752522 (i.e. modification of the chip collector inside the MGB) of previous AD 2009-0099-E, which is superseded, and requires, for all models of the Super-Puma helicopter family, more stringent repetitive visual checks of all electrical and non-electrical chip detectors installed on MGB, and Intermediate Gear Box and Tail Gear Box as well.

AAIB Assessment – Adequate – closed

(SRIS Reference: GB.SIA-2011-036)

AS332 L2 Super Puma, G-REDL	**11 nm NE of Peterhead, Scotland**	**1 April 2009**	**Accident**

Safety Recommendation 2011-041

It is recommended that the European Aviation Safety Agency research methods for improving the detection of component degradation in helicopter epicyclic planet gear bearings.

Date Safety Recommendation made: 15 November 2011

LATEST RESPONSE

Response received: 13 April 2013

The EASA research project 'Vibration Health Monitoring and Alternative Technologies' (Tender number EASA.2012.0P.13) has been launched to address the Safety Recommendation. Reported results will published on the EASA website.

AAIB Assessment – Adequate – closed

(SRIS Reference: GB.SIA-2011-041)

AS332 L2 Super Puma, G-REDL	**11 nm NE of Peterhead, Scotland**	**1 April 2009**	**Accident**

Safety Recommendation 2011-045

It is recommended that the European Aviation Safety Agency require the 'crash sensor' in helicopters, fitted to stop a Cockpit Voice Recorder in the event of an accident, to comply with EUROCAE ED62A.

Date Safety Recommendation made: 15 November 2011

LATEST RESPONSE

Response received: 12 February 2015

This safety recommendation is considered within the framework of EASA rulemaking task RMT.0249 entitled "Recorders installation and maintenance thereof - certification aspects", whose Terms of reference were published on 18 September 2014 on the EASA website.

RMT.0249 is dealing with new or revised aircraft certifications specifications (ie applicable to new designs). The general objective of this rulemaking task is to improve the availability and quality of data recorded by flight recorders in order to better support safety investigation authorities in the investigation of accidents and incidents. One of the specific objectives is to "prevent premature termination of recording due to the triggering of a negative acceleration sensor".

Regarding potential requirements applicable to existing designs, this will be considered in the framework of EASA rulemaking task RMT.0308 entitled "Amendment of requirements for data recorders II".

AAIB Assessment – Partially Adequate – Open

(SRIS Reference: GB.SIA-2011-0045)

AS332 L2 Super Puma, G-REDL	**11 nm NE of Peterhead, Scotland**	**1 April 2009**	**Accident**

Safety Recommendation 2011-046

It is recommended that the Federal Aviation Administration require the 'crash sensor' in helicopters, fitted to stop a Cockpit Voice Recorder in the event of an accident, to comply with RTCA DO204A.

Date Safety Recommendation made: 15 November 2011

LATEST RESPONSE

Response received: 29 May 2012

There is no regulatory basis in 14 CFR parts 27 and 29 to require a "crash sensor" be installed in Cockpit Voice Recorders (CVR), which are installed in rotorcraft. The reference to RTCA D0204A is for Emergency Locator Transmitters (EL T) and not CVRs. To mandate that CVRs be equipped with a similar "crash sensor" as those required per RTCA D0204A for ELTs would require rulemaking. Based on [the FAA] risk analysis, [the FAA] do not believe that such mandatory action is justified.

AAIB Assessment – Not Adequate – open

(SRIS Reference: GB.SIA-2011-0046)