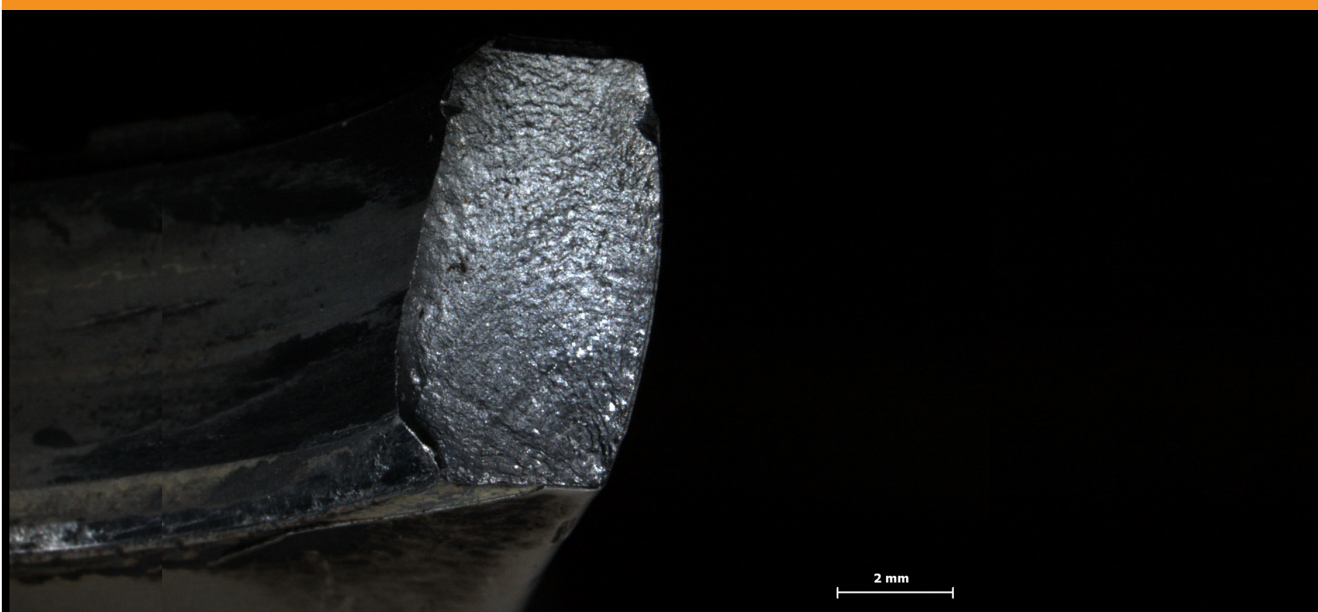




**Australian Government**

**Australian Transport Safety Bureau**



**ATSB TRANSPORT SAFETY REPORT**  
Occurrence Investigation Report AO-2008-068  
Final

**Tail rotor pitch link failure  
near Hoxton Park Aerodrome, NSW  
19 September 2008  
VH-BUK  
Eurocopter AS350 BA**





**Australian Government**  

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# CONTENTS

---

**THE AUSTRALIAN TRANSPORT SAFETY BUREAU ..... v**

**FACTUAL INFORMATION ..... 1**

    Sequence of events..... 1

    Aircraft information ..... 1

    Pitch link history ..... 1

    Pitch link examination ..... 3

        Rod end fractures..... 3

        Pitch link spherical bearing ..... 5

        Unbroken Pitch link..... 6

        Elastomeric bearing ..... 7

        Aircraft manufacturer ..... 8

**ANALYSIS ..... 9**

**FINDINGS..... 11**

    Contributing safety factors..... 11

**SAFETY ACTIONS ..... 13**

    Bearing wear not detected by required inspections ..... 13

*Action taken by Eurocopter* ..... 13

*Action taken by Civil Aviation Safety Authority*..... 13

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Figure 1 courtesy Eurocopter AS350 BA Aircraft Maintenance Manual.

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### **Abstract**

On 19 September 2008, during a flight from Fitzroy Falls to Rosehill, NSW, the pilot of a Eurocopter AS350 BA helicopter, registered VH-BUK, experienced the onset of severe vibration within the tail rotor controls and made an emergency landing at Casula High School. Subsequent examination of the aircraft revealed that one of the tail rotor pitch change links had fractured, resulting in lateral movement of the tail rotor and damage to the tail boom and tail cone.

The pitch link had fractured from fatigue cracking that was the result of stresses induced in the link by excessive play in the heavily-worn spherical bearing. It was probable that bearing wear outside of maintenance manual limits existed, but was not detected, during the most recent after last flight (ALF) inspection.

As a result of this occurrence, the helicopter manufacturer released Safety Information Notice (No. 2000-S-65) and the Civil Aviation Safety Authority released an Airworthiness Bulletin (AWB 27-009) to remind operators, pilots and maintenance personnel of the requirements for ALF inspections for pitch link condition and bearing play.

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# THE AUSTRALIAN TRANSPORT SAFETY BUREAU

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The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory Agency. The Bureau is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

## **Purpose of safety investigations**

The object of a safety investigation is to enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not the object of an investigation to apportion blame or determine liability. However, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

## **Developing safety action**

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

The ATSB has decided that when safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed (for example the relevant regulator in consultation with industry) to assess the costs and benefits of any particular means of addressing a safety issue.

**About ATSB investigation reports:** How investigation reports are organised and definitions of terms used in ATSB reports, such as safety factor, contributing safety factor and safety issue, are provided on the ATSB web site [www.atsb.gov.au](http://www.atsb.gov.au)



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# FACTUAL INFORMATION

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## Sequence of events

On 19 September 2008 at 1600 EST<sup>1</sup>, a Eurocopter AS350 BA helicopter, registered VH-BUK, departed Rosehill heliport for Fitzroy Falls with a pilot and six passengers on board. The passengers disembarked at Fitzroy Falls and the helicopter was shut down. The helicopter was restarted after approximately 10 minutes and the pilot returned towards Rosehill heliport with no passengers.

The pilot reported that approximately 20 minutes into the return flight, minor vibration was felt in the anti-torque pedals, but no other warning signs were evident. Approximately 5 minutes after the onset of the vibration it became violent. The pilot entered autorotation<sup>2</sup>, declared a MAYDAY<sup>3</sup> and conducted a run-on landing on the Casula High School oval. The pilot was not injured.

Subsequent examination of the aircraft revealed that one of the tail rotor pitch change links had fractured, resulting in lateral movement of the tail rotor and damage to the tail boom and tail cone.

## Aircraft information

The AS350 BA helicopter, serial number 2197, was manufactured in 1989 and first registered in Australia in 2003. It was powered by a single, Turbomeca Arriel 1B turboshaft engine and had accumulated 3,619.8 hours total time in service.

## Pitch link history

The pitch links were aluminium in construction and consisted of a swaged-in, self-lubricating spherical bearing at one end and an elastomer-damped, sleeve-type bearing at the opposite end (Figure 1). The pitch links were not service life limited components and they were not recorded on the original aircraft build documentation. Manufacturing records for the links could not be located. However, the manufacturer indicated that the links were probably made prior to 1993.

The part number on the links had been changed from 350A33.2145.00 to 350A33.2145.01 during service to reflect a modification to the spherical bearing material. Maintenance records showed that this modification was made in 1994, at 1,492.6 aircraft hours. The elastomeric damping bush was also replaced at this time. The aircraft had accumulated 3,619.8 hours at the time of failure. The bearings were therefore considered to have accumulated approximately 2,130 hours since new.

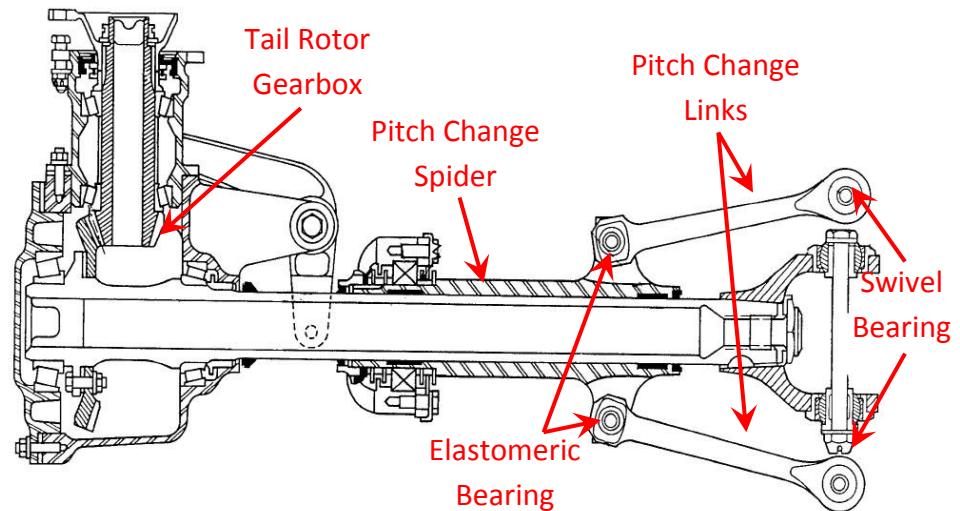
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<sup>1</sup> The 24-hour clock is used in this report to describe the local time of day, Eastern Standard Time (EST), as particular events occurred. At the time of the event Eastern Standard Time was Coordinated Universal Time (UTC) + 10 hours.

<sup>2</sup> Descent with power off, air flowing in the reverse direction upwards through lifting rotor(s), causing it to continue to rotate at approximately cruise RPM.

<sup>3</sup> International call for urgent assistance.

**Figure 1: Tail rotor drive assembly**



The links were subject to inspection in accordance with the aircraft maintenance manual (AMM) at 500-hour / 2-year intervals as well as during the after last flight (ALF) inspection nearest to 30 aircraft hours.

The 500-hour service required a check of the pitch link self-lubricating spherical bearing in accordance with section 65.20.00.601, paragraph 4.2 of the maintenance manual. This involved the removal of both links and a detailed visual inspection and measurement of axial and radial play in the spherical bearing.

The links were to be discarded if axial or radial play was measured outside of prescribed limits, the Teflon fabric was extruded from the bearing, there was persistent discolouration of the ball, or if there was any scoring of the ball.

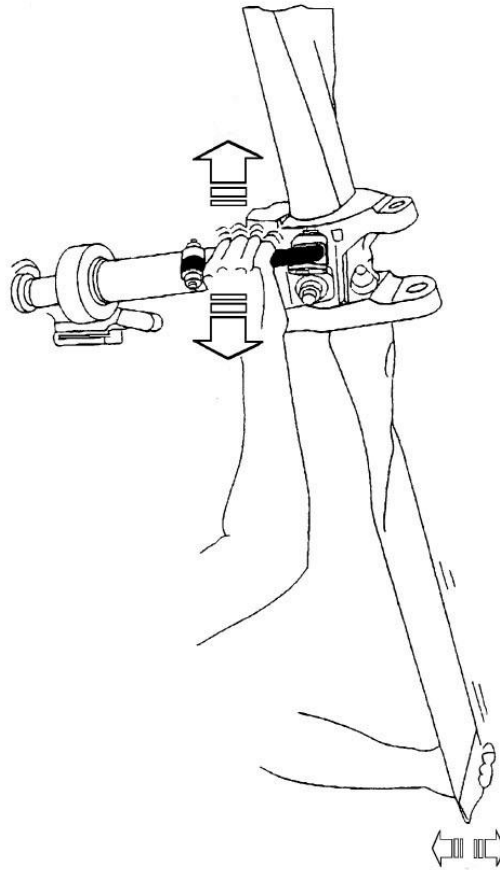
Inspection requirements for the elastomeric dampers involved a visual check to ensure the rubber was free of significant cracks and bonding separation. The maximum allowable crack depth was 5mm.

The ALF checks, per section 05.21.00.603 of the maintenance manual, consisted of a visual inspection similar to the 500-hour service check, as well as a tactile check to confirm there was no play in the spherical bearing. The tactile check was best illustrated by Figure 2 and involved imparting an oscillating axial load on the bearing, while applying a low-amplitude, see-saw motion to the blades.

The previous 500-hourly inspection was conducted in July 2007 when the aircraft had accumulated 3,293.6 hours total time in service and the links were inspected at that time with no defects recorded.

The ALF inspection was to be carried out by qualified maintenance personnel or by a suitably trained pilot. Records showed the most recent 30-hour inspection was completed by the pilot at 3,606.4 aircraft hours on 15 September 2008, approximately 13 hours prior to the failure of the pitch link. Around this time, the tail rotor was closely inspected by the pilot of VH-BUK as well as the pilot of a second AS350 that was present at the same location. The tactile check of the links was directly compared between the two aircraft. A small amount of play was identified in the links belonging to the second aircraft; however, no play in the links on VH-BUK was detected.

**Figure 2: Tactile check for bearing play**



## **Pitch link examination**

### **Rod end fractures**

Figure 3 shows the failed pitch change link, with two clear fractures at approximately the 4 and 10 o'clock positions through the rod end.

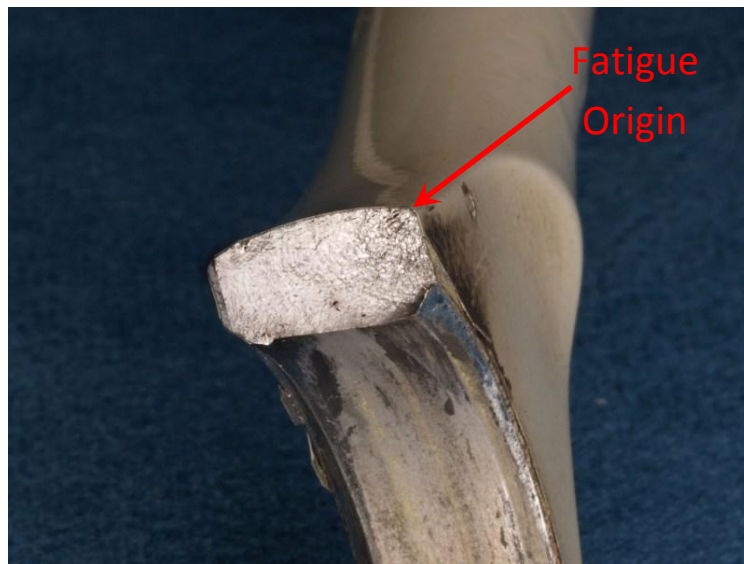
The fracture surface at the 4 o'clock position (Figure 4a) exhibited clear beach marks, consistent with fatigue failure. The fatigue failure extended over a majority of the fracture surface and the origin was at the corner indicated. Examination of the fracture surface using a scanning electron microscope (SEM) revealed fatigue striations indicative of high cycle fatigue (Figure 5). There was no indication of inclusions or defects observed at the fatigue origin.

The fracture surface at the 10 o'clock position (Figure 4b) exhibited two distinct fracture regions, consistent with a combination of a small amount of fatigue originating on the inside surface of the rod end, coupled with a large region of overstress.

**Figure 3: Fractured pitch change link**



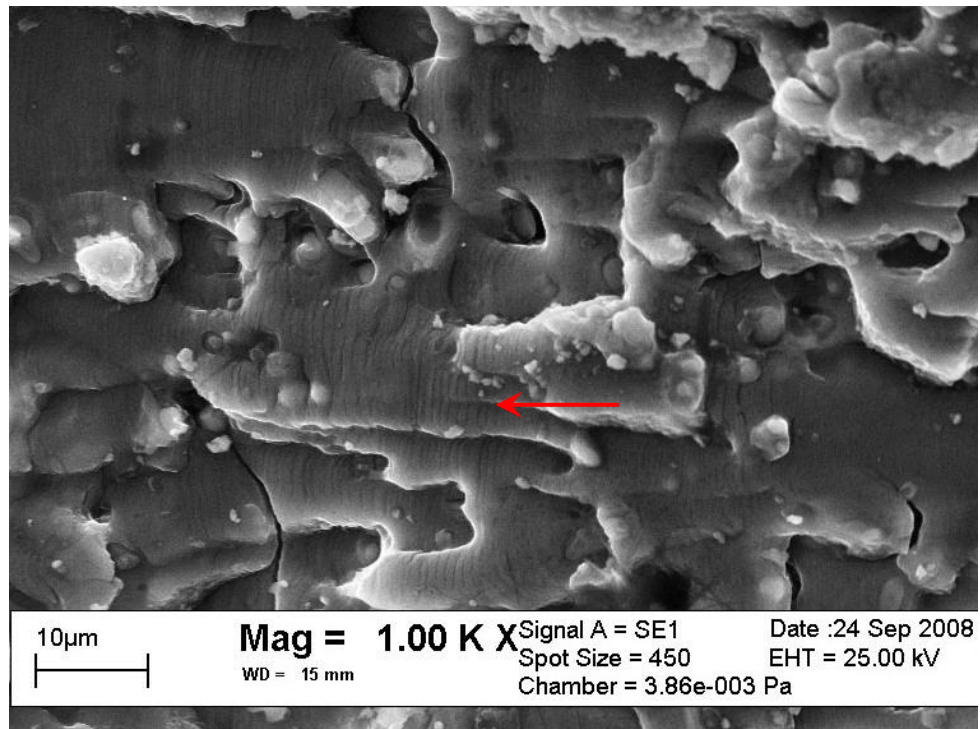
**Figure 4a: Fracture surface at 4 o'clock position, exhibiting beach marks**



**Figure 4b: Fracture surface at 10 o'clock position**



**Figure 5: SEM image of fracture surface in Figure 4A showing fatigue striations (arrowed)**



### **Pitch link spherical bearing**

The bearing race from the fractured pitch link had severe wear as shown in Figure 6a. The Teflon liner was still present across the top of the rod end, but was completely worn from the base, which was the most heavily-loaded area of the bearing. Wear had progressed through the race, with the ball carving out several distinct grooves.

The wear edge of the Teflon liner was consistent with the grooves on one side of the race, but finished in a straight edge, distinct from the grooves on the opposite side (Figure 6b). The liner gave the appearance of being disbonded from the substrate in the area immediately adjacent (arrowed).

The ball also showed signs of heavy wear, concentrated on one side only and consistent with the wear on the race (Figure 7).

The bearing from the second pitch link had markings on the ball consistent with early wear. This bearing also exhibited a small amount of axial and radial play. Measurement of the play with a dial gauge found the play to be within the prescribed inspection limits.

**Figure 6a: Fractured rod end exhibiting severe wear**



**Figure 6b: Fractured rod end showing Teflon liner**



**Figure 7: Ball wear, fractured pitch link**



### **Unbroken Pitch link**

The unbroken pitch link was examined per the AMM requirements. A small amount of play was detected in the spherical bearing. The play was measured with a dial

gauge and found to be close to, but within the prescribed limits. There was no evidence of extrusion of the Teflon liner. The ball was not scored, but did exhibit persistent discolouration that was indicative of early stages of wear (Figure 8).

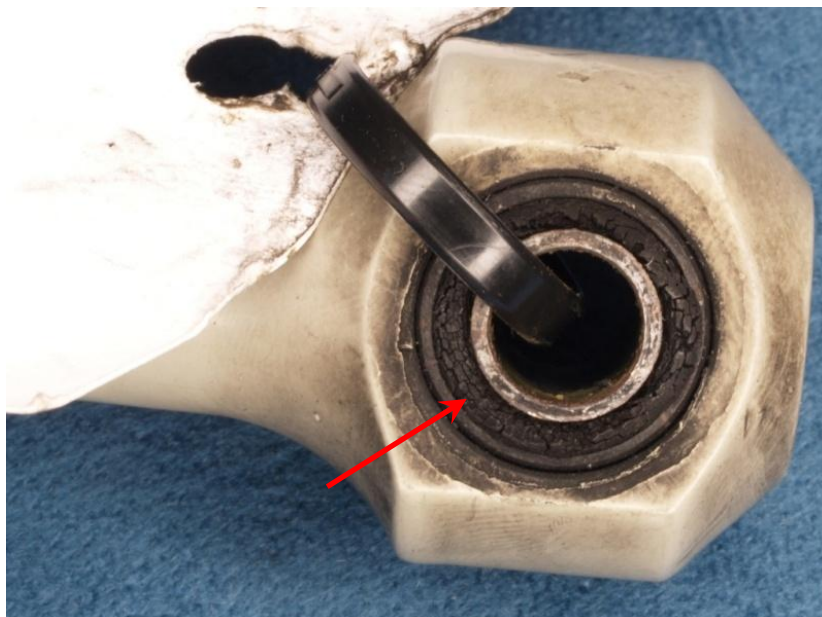
**Figure 8: Persistent discolouration of the ball**



### **Elastomeric bearing**

The elastomer in both pitch links exhibited signs of deterioration in the form of extensive surface cracking (Figure 9). None of the cracks were found to exceed the 5mm AMM inspection requirement; however, examination did reveal some bonding separation between the elastomer and the inner sleeve. Based on this, the condition of the elastomer fell outside of AMM requirements.

**Figure 9: Cracked elastomeric bearing**



## **Aircraft manufacturer**

As a result of a previous tail rotor pitch change link failure, the aircraft manufacturer released a service letter ('Lettre Service' No. 1367-64-98) in 1999 detailing an increased level of inspection for the spherical bearings. The additional criterion required a manual check by observation and feel for bearing play during ALF inspections or after the flight nearest to a 30 flying hour interval. If play was detected, then the wear in the bearings was required to be measured using a dial indicator and the links replaced if the wear limit was exceeded.

The visual and tactile check was incorporated into the aircraft maintenance manual (05.21.00.603) for daily operating checks. The detailed measurement criteria in 65.20.00.601 was to be carried out in the event of bearing play being observed during the tactile check and/or at each 500-hour/2-year inspection.

The manufacturer had previously conducted endurance testing on the tail rotor pitch links and concluded that, once the test bearing had reached maximum allowable play as specified in the maintenance manual, there was a further 140 hours of operation before the bearing exhibited a level of damage similar to that observed in the link removed from VH-BUK. The endurance test lasted 1,892 hours, whereas the subject links failed at approximately 2,130 hours. It was also indicated that 30% of the fabric liner circumference had completely worn from the most heavily loaded area of the bearing (leaving metal to metal contact between the ball and race) approximately 90 hours prior to the end of the test. This was equivalent to three, 30-hour ALF inspections.

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## ANALYSIS

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The most likely reason for the failure of the pitch change link was as a result of progressive wear of the spherical bearing outside of the prescribed wear limits. Excessive play in the worn bearing resulted in a loading condition that originated a high cycle fatigue crack at one of the outside corners of the rod end and progressed through a majority of the section before failure. A second fatigue crack then originated on the interior surface of the rod end and progressed a short distance before the remaining material failed through overstress.

In consideration of the endurance test results provided by the aircraft manufacturer, and the extent of wear in the unbroken pitch link bearing, it was probable that bearing degradation was relatively advanced in the broken link at the time of the most recent after last flight (ALF) inspection. The reason that play was not identified in the subject pitch link during this inspection was not determined.



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## FINDINGS

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From the evidence available, the following findings are made with respect to the fractured tail rotor pitch links, from the Eurocopter AS350 BA helicopter, registered VH-BUK and should not be read as apportioning blame or liability to any particular organisation or individual.

### **Contributing safety factors**

- The onset of severe tail rotor control system vibration reported by the pilot was a result of the fracture and separation of one pitch change link within the helicopter's tail rotor assembly.
- The tail rotor pitch change link fractured as a result of the growth of a fatigue crack initiated by a loading condition attributable to a worn spherical bearing.
- It was probable that bearing wear outside of maintenance manual limits existed, but was not detected, during the most recent after last flight (ALF) inspections.  
*[Safety Issue]*



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## **SAFETY ACTIONS**

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The safety issues identified during this investigation are listed in the Findings and Safety Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

### **Bearing wear not detected by required inspections**

#### ***Safety issue***

It was probable that bearing wear outside of maintenance manual limits existed, but was not detected, during the most recent after last flight (ALF) inspections.

#### ***Action taken by Eurocopter***

As a result of this incident, the aircraft manufacturer released Safety Information Notice 2000-S-65 on 9 October 2008, to remind AS 350/355-550/555 customers of the tail rotor pitch link inspection and maintenance requirements.

Eurocopter has also considered the probability that the bearing was worn in excess of maintenance manual limits but was not detected at the last inspection, and has been working with the European Aviation Safety Agency (EASA) on complementing and adding some precision to the present wording and figure related to the pitch link inspection.

#### ***Action taken by Civil Aviation Safety Authority***

As a result of this incident, the Civil Aviation Safety Authority released Airworthiness Bulletins 27-009 Issue 2 (AS 350) and AWB 27-010 Issue 1 (AS 355 and AS 550) on 10 October 2008. The purpose of those bulletins was to remind operators, pilots and maintainers of inspection requirements relating to the tail rotor pitch change links and the importance of frequently checking for pitch link wear.



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## **APPENDIX A: SOURCES AND SUBMISSIONS**

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### **Sources of information**

Aircraft manufacturer

Maintenance personnel

Maintenance documentation

Owner/Pilot of VH-BUK

### **Submissions**

Under Part 4, Division 2 (Investigation Reports), Section 26 of the Transport Safety Investigation Act 2003, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the Civil Aviation Safety Authority, the helicopter operator and helicopter manufacturer, and the Accredited Representative from the French Bureau d'Enquêtes et d'Analyses.

Submissions were received from Eurocopter and the Bureau d'Enquêtes et d'Analyses. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Tail rotor pitch link failure near Hoxton Park Aerodrome, NSW  
19 September 2008, VH-BUK Eurocopter AS350 BA.