Australian Government
Australian Transport Safety Bureau

Loss of control involving Eurocopter MBB BK117 B-2 VH-VSA

28 km SSE of Port Pirie Aerodrome, South Australia | 15 February 2013

Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation
AO-2013-030
Final – 15 July 2014

Cover photo: **Helicopter operator**

Released in accordance with section 25 of the *Transport Safety Investigation Act 2003*

Publishing information

Published by: Australian Transport Safety Bureau
Postal address: PO Box 967, Civic Square ACT 2608
Office: 62 Northbourne Avenue Canberra, Australian Capital Territory 2601
Telephone: 1800 020 616, from overseas +61 2 6257 4150 (24 hours)
Accident and incident notification: 1800 011 034 (24 hours)
Facsimile: 02 6247 3117, from overseas +61 2 6247 3117
Email: atsbinfo@atsb.gov.au
Internet: www.atsb.gov.au

Addendum

Page	Change	Date

Safety summary

What happened

VH-VSA

Source: Helicopter operator

On 15 February 2013, the crew of a Eurocopter Helicopter MBB-BK117 B-2 (BK117), registered VH-VSA, were conducting a trauma recovery flight from Port Pirie to Adelaide Hospital, South Australia. After reaching the cruise altitude of 5,000 ft above mean sea level, the crew observed fluctuations of the hydraulic system pressure gauges. Shortly after, the helicopter sustained an uncommanded and violent nose-up pitch and rolled left before descending. The pilot regained control at about 800 ft above ground level. Control checks by the pilot confirmed normal control had resumed and the pilot flew the helicopter back to Port Pirie Aerodrome. No injuries were reported by the occupants and the helicopter sustained minor damage.

What the ATSB found

The ATSB did not find any mechanical or system faults that could account for the hydraulic system pressure fluctuations. The ATSB found that the helicopter was being operated at a weight, density altitude and airspeed, and in meteorological conditions that were conducive to the onset of retreating blade stall. The uncommanded and violent nose-up pitch and left roll were consistent with the onset of that condition. The pilot’s instinctive action of pushing the cyclic control forward delayed recovery from the stall.

What's been done as a result

The operator issued an urgent *Immediate Safety Notification* advising all company BK117 pilots of the conditions conducive to retreating blade stall and the correct actions to recover from that condition.

Safety message

This incident highlights the importance of pilot awareness of the factors conducive to retreating blade stall, including high all-up weight, high density altitude, high airspeed, manoeuvres that increase flight loads and flight in turbulence. Similarly, the importance of initially reducing collective pitch to optimise recovery is emphasised as incorrect recovery actions can result in loss of control of the helicopter.

Contents

The occurrence **1**
Context **3**
Pilot information 3
Helicopter information 3
General 3
Auto flight control system 3
Hydraulic system 3
Control runaway 4
Weight and balance 4
Examination and testing 6
Retreating blade stall 6
Weather information 7
Previous occurrences 7
ATSB investigation 200003143 7
ATSB investigation 200506614 8
Safety analysis **10**
Introduction 10
Operational factors 10
Mechanical factors 10
Conclusion 11
Findings **12**
Contributing factors 12
Other findings 12
Safety issues and actions **13**
General details **14**
Occurrence details 14
Aircraft details 14
Sources and submissions **15**
Sources of information 15
References 15
Submissions 15
Australian Transport Safety Bureau **16**
Purpose of safety investigations 16
Developing safety action 16

The occurrence

On 15 February 2013, the pilot of Eurocopter MBB-BK117 B-2 (BK117) helicopter, registered VH-VSA (Figure 1), was conducting a trauma retrieval operation from Port Pirie Hospital to the Royal Adelaide Hospital, South Australia. On board were the pilot, a crewman, two medical staff and a patient. Shortly after reaching cruise altitude of 5,000 ft above mean sea level the pilot noted light to moderate turbulence with a tailwind of about 15 kt. The pilot set 60 per cent torque and maintained a cruise speed of 115 kt. The helicopter's never exceed speed (V_{NE}) for the conditions was calculated as 120 kt.

About 12 minutes into the flight, the crewman commenced the top of climb checks and reported to the pilot that the two hydraulic system pressure gauges were fluctuating with one system reading at the top of the green band (indicating the normal operating range) and the other at the bottom of the green band. The pilot and crewman discussed the actions to be taken if either hydraulic pressure decreased below the green band and reviewed the helicopter checklists. The *Hydraulic system pressure low or high* checklist directed the crew to land as soon as practicable if either hydraulic system entered the yellow arc pressure regions of the gauge, which were either side of the green band.

Figure 1: VH-VSA

Source: Helicopter operator

Shortly after 1400 Central Daylight-saving Time[1] a 'violent', uncommanded nose-up pitching of the helicopter occurred. The pilot instinctively applied full forward cyclic control, but using both hands given the severity of the pitch-up, in an attempt to regain control but was unable to arrest the continuing nose-up pitch. At about 70° nose-up the helicopter rolled left through approximately 120° and commenced a steep descent. On seeing the ground through the windscreen, the pilot applied full rearward cyclic, which resulted in the helicopter pulling out of its now near vertical nose-down attitude and levelling off at about 1,000 ft (about 800 ft above ground level). During the occurrence, the crewman broadcast a Mayday call,[2] giving details of the helicopter's location and situation. This radio call was heard by the flight crew of an overflying aircraft and relayed by that crew to the Rescue Coordination Centre - Australia.

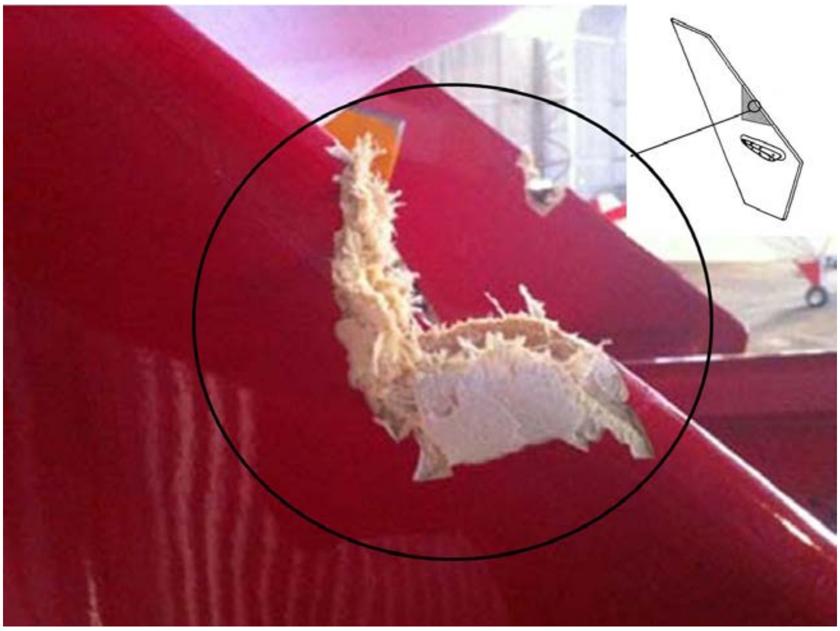
1 Central Daylight-saving Time (CDT) was Coordinated Universal Time (UTC) + 10.5 hours.
2 Mayday is an internationally recognised radio call for urgent assistance.

After levelling out, the pilot noticed that the tail rotor pedals were initially heavy to operate, and looked for a suitable place to land the helicopter. This included consideration of the volume of road traffic on the available roads, which negated their use, and the need for an area and surface that was suitable for a running landing at a possibly higher than normal speed. Given these considerations, and that the helicopter was stable and under control, the pilot decided to return to Port Pirie Aerodrome, about 15 NM (28 km) to the north-north-west. A short time later, with the helicopter stable at 600 ft with minimum cruise power, the pilot conducted a full control check and confirmed the resumption of normal control of the tail rotor pedals.

On approach to Port Pirie Aerodrome the pilot was contacted by the airport operator to ascertain where the pilot intended to land the helicopter as emergency services were standing by. The pilot advised a running landing would be conducted and identified a suitable site. During the downwind check, both hydraulic system pressure gauges were confirmed to be within the normal operating range.

After landing, the Mayday call was cancelled and all occupants disembarked with no injuries. The helicopter sustained minor damage to the horizontal stabiliser end plates (Figure 2), which were struck by the main rotor blades. The main rotor blades themselves were undamaged.

Figure 2: Horizontal stabiliser end plate damage



Source: Helicopter operator

Context

Pilot information

The pilot had been flying since 1995 and held a Commercial Pilot (Helicopter) Licence with a current Class 1 Medical Certificate. His total aeronautical experience was about 3,932 flying hours with about 3,834 hours on helicopters. Since obtaining the BK117 endorsement he had accumulated about 243 flight hours on the aircraft type.

The pilot reported he was not affected by fatigue at the time of the occurrence.

Helicopter information

General

The helicopter, Eurocopter MBB-BK 117 B-2 serial number 7186, was manufactured in Germany in 1990 and first registered in Australia in 2006. The helicopter was fitted with two Textron Lycoming LTS-101-750B1 turboshaft engines and was configured for medical trauma retrieval. It had accumulated about 8,400 hours total time in service at the time of the occurrence.

Auto flight control system

The helicopter was fitted with a dual redundant, three axis auto flight control system (autopilot 1 and autopilot 2), which was engaged at the time of the in-flight upset. During the pitch up the system disengaged and was not re-engaged for the rest of the flight. The pilot observed the caution autopilot 1 and autopilot 2 lights illuminate, confirming both systems had disengaged.

Hydraulic system

The BK117 incorporated two independent hydraulic systems that assisted the pilot's control inputs to the main rotor in the longitudinal, lateral and collective[3] axes. The two systems (systems 1 and 2) were contained within the tandem hydraulic unit (THU) and consisted of one actuator for each axis of operation per system (six in total). Under normal operations system 1 provided hydraulic boost to the three main rotor axes. VH-VSA also incorporated a hydraulically-assisted tail rotor, which was supplied by system 2.

Manual selection between the hydraulic systems was available to the pilot through a three-position hydraulic test switch on the overhead console. The system 1 and 2 THU actuators were mechanically interconnected in a parallelogram to ensure identical pilot input to both systems and prevent unexpected inputs to the flight controls (runaway) during system transfer. The *Hydraulic system pressure low or high* checklist contained a caution against operation of the test switch during flight.

In the event of system 1 control valve seizure/jamming or the hydraulic pressure dropping below a pre-set value of about 50 per cent normal operating pressure, a spool valve automatically transferred hydraulic authority to system 2. In this case, system 2 provided primary hydraulic pressure to the main rotor and hydraulic assistance to the tail rotor was removed. This increased the tail rotor control forces felt by the pilot.

System monitoring was provided by two hydraulic pressure gauges (one per system), also located on the overhead console. Two warning lights were located on the annunciator panel that indicated transfer from system 1 to system 2, and low system 2 hydraulic pressure. Once a hydraulic system changeover from system 1 to system 2 occurred, reinstatement of system 1 as the primary system was only achievable by manual reset of the hydraulic test switch.

---

3 Raising a helicopter's collective lever increases the main rotor thrust (effectively lift) produced by the main rotor blades.

Control runaway

Control runaway can be described as an uncommanded system operation. On a helicopter this can result from a flight control system/component failure, such as an autopilot/trim malfunction, or a condition where multiple hydraulic systems are not correctly synchronised after a system switchover. If not countered by the pilot, a control runaway results in an uncommanded control input.

The BK117 flight manual contained the following information regarding a control runaway:

> Normal procedure – Hydraulic System Check (Ground)
>
> CAUTION
>
> IF, AFTER CROSSOVER FROM SYSTEM 1 TO SYSTEM 2, A RUNAWAY OF CYCLIC STICK OR COLLECTIVE PITCH OCCURS (INCREASED CONTROL FORCES IN THE LONGITUDINAL-, LATERAL-, OR COLLECTIVE AXIS) RESELECT SYSTEM 1 IMMEDIATELY AND SHUT DOWN THE ENGINES.

and:

> System emergency/Malfunction conditions – 3.6.3 Cyclic Trim Actuator Failure/Runaway
>
> <u>Conditions/Indications</u>
>
> – Unsymmetrical cyclic stick forces.
>
> NOTE Cyclic stick full travel remains operative.
>
> <u>Procedure</u>
>
> CAUTION
>
> THE CYCLIC STICK SHALL BE HELD IN NEUTRAL POSITION AFTER LANDING UNTIL IT HAS BEEN LOCKED.
>
> LAND AS SOON AS PRACTICABLE
>
> System emergency/Malfunction conditions – 3.6.7 Yaw Actuator Runaway
>
> <u>Conditions/Indications</u>
>
> – Jolt, associated with sudden yaw motion
>
> – CSAS [Control and Stability Augmentation System] YAW caution light comes on
>
> <u>Procedure</u>
>
> CAUTION
>
> AVOID HARD AND ABRUPT LEFT OR RIGHT PEDAL MOVEMENTS AFTER PRESSING STABILIZATION CUTOFF PUSHBUTTON.
>
> 1. Yaw motion – Counteract
>
> 2. STABILIZATION CUTOFF push–button (on cyclic stick) – Press

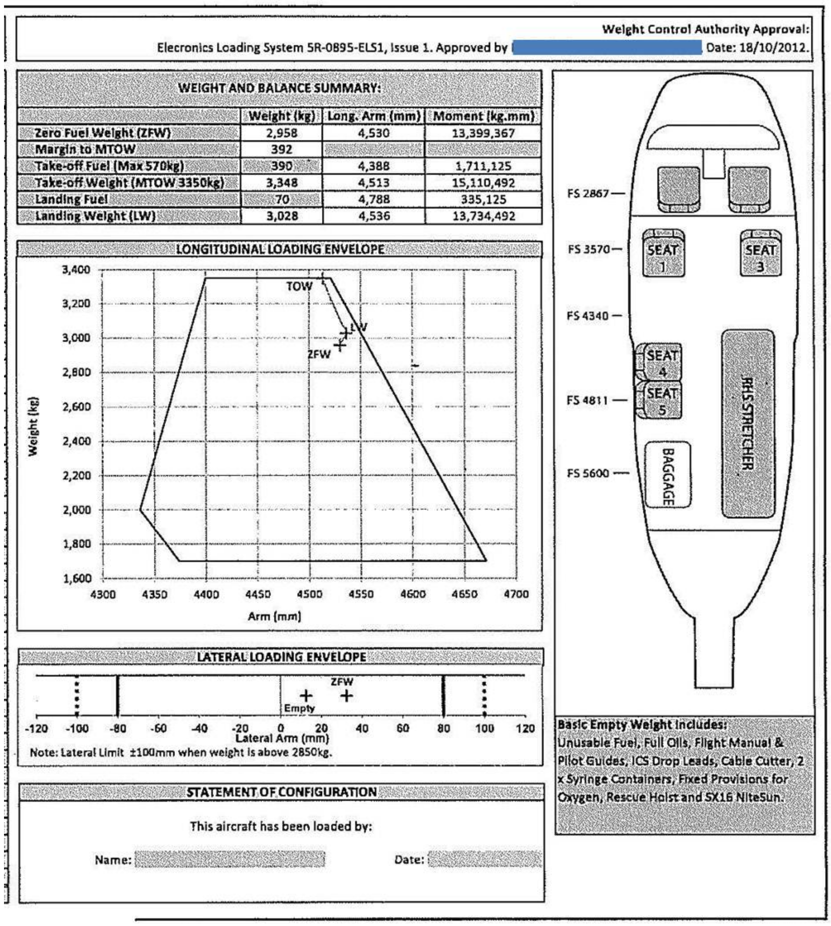
While the possibility of a cyclic runaway occurring in flight existed, there was no evidence of any system or mechanical emergency/malfunction conditions during the occurrence flight.

Weight and balance

The helicopter was configured for single pilot, primary trauma retrieval operations, which included two crew seats in the cockpit, seating for four in the rear cabin, a single stretcher and the installation of medical equipment. This configuration increased the helicopter's empty weight by about 700 kg, restricting the amount of fuel able to be carried to 390 kg. That was less than the amount of fuel required for the flight under the instrument flight rules (IFR)[4] as a result of the operator-specified variable and fixed fuel reserves and a 30-minute holding fuel requirement at Adelaide. As a result, the pilot elected to remain visual for the IFR portion of the flight and conduct the final route segment in accordance with the visual flight rules.[5] This removed the 30-minute holding fuel requirement at Adelaide and reduced the operator's fixed fuel reserve for the flight to 20 minutes.

A review of the pilot's weight and balance data for the flight showed the helicopter had a take-off weight (TOW) of about 3,350 kg, which was the maximum allowable for the helicopter (Figure 3). The load distribution created a right lateral and rearward longitudinal centre of gravity that was within the approved loading envelope at take-off. As the loss of control occurred about 12 minutes after take-off, the TOW and centre of gravity at the time of the occurrence would have been similar to that at take-off.

Figure 3: Weight and balance sheet



Weight Control Authority Approval:
Elecronics Loading System 5R-0895-ELS1, Issue 1. Approved by [redacted] Date: 18/10/2012.

WEIGHT AND BALANCE SUMMARY:

	Weight (kg)	Long. Arm (mm)	Moment (kg.mm)
Zero Fuel Weight (ZFW)	2,958	4,530	13,399,367
Margin to MTOW	392		
Take-off Fuel (Max 570kg)	390	4,388	1,711,125
Take-off Weight (MTOW 3350kg)	3,348	4,513	15,110,492
Landing Fuel	70	4,788	335,125
Landing Weight (LW)	3,028	4,536	13,734,492

Basic Empty Weight includes:
Unusable Fuel, Full Oils, Flight Manual & Pilot Guides, ICS Drop Leads, Cable Cutter, 2 x Syringe Containers, Fixed Provisions for Oxygen, Rescue Hoist and SX16 NiteSun.

STATEMENT OF CONFIGURATION

This aircraft has been loaded by:

Name: Date:

Source: Helicopter operator, modified by the ATSB

---

4 Instrument flight rules permit an aircraft to operate in instrument meteorological conditions (IMC), which have much lower weather minimums than visual flight rules. Procedures and training are significantly more complex as a pilot must demonstrate competency in IMC conditions, while controlling the aircraft solely by reference to instruments. IFR-capable aircraft have greater equipment and maintenance requirements.

5 Visual flight rules (VFR) are a set of regulations which allow a pilot to only operate an aircraft in weather conditions generally clear enough to allow the pilot to see where the aircraft is going.

Examination and testing

Initial operator assessment

The helicopter was transported by road to Adelaide Airport for examination and testing by the operator, which identified that:

- the damage to the stabiliser end plates from the main rotor blade strikes was within the foam insert area of both stabiliser end plate leading edges and was repairable
- although there was paint transfer from the stabiliser end plates on the main rotor blades, the blades were defect free and in a serviceable condition
- there were no defects in the hydraulic or pitot static systems
- an auto flight control system self-test function had recorded a pitch servo modular failure, a yaw servo failure and a pitch trim switch failure. These fault codes were considered by the operator to be the product of the recovery actions taken by the pilot and not defects or faults that had contributed to the incident.

Third-party maintenance organisation

Following the operator's initial assessment, and on the advice of the helicopter manufacturer, the helicopter was sent to a third-party maintenance organisation for control rigging checks of the main and tail rotor system. These checks were carried out in accordance with the aircraft maintenance manual (MM) and were found to be within operational limits.

Original equipment manufacturer

The THU and tail rotor actuator (TRA) were sent to the original equipment manufacturer for detailed examination, testing and assessment under the supervision of the German Federal Bureau of Aircraft Accident Investigation (Bundesstelle für Flugunfalluntersuchung). As part of this testing, the THU was subjected to a series of rapid inputs in an attempt to force a significant hydraulic pressure drop within the system and automatic switchover from system 1 to system 2. The maximum pressure drop achieved was insufficient to result in an automatic switchover of systems.

Examination of the TRA did not identify any defects that would have affected its function or pilot pedal operation.

As a result of the findings by the original equipment manufacturer, the THU and TRA were not considered contributory to the occurrence.

Retreating blade stall

Retreating blade stall is described in the United States *Federal Aviation Administration Helicopter Flying Handbook, FAA-H-8083-21A* as follows:

> In forward flight, the relative airflow through the main rotor disk is different on the advancing and retreating side. The relative airflow over the advancing side is higher due to the forward speed of the helicopter, while the relative airflow on the retreating side is lower. This dissymmetry of lift increases as forward speed increases.
>
> To generate the same amount of lift across the rotor disk, the advancing blade flaps up while the retreating blade flaps down. This causes the AOA [angle of attack] to decrease on the advancing blade, which reduces lift, and increase on the retreating blade, which increases lift. At some point as the forward speed increases, the low blade speed on the retreating blade, and its high AOA cause a stall and loss of lift.
>
> Retreating blade stall is a major factor in limiting a helicopter's never-exceed speed (V_{NE}) and its development can be felt by a low frequency vibration, pitching up of the nose, and a roll in the

direction of the retreating blade. High weight, low rotor rpm, high density altitude[6], turbulence and/or steep, abrupt turns are all conducive to retreating blade stall at high forward airspeeds. As altitude is increased, higher blade angles are required to maintain lift at a given airspeed.

Thus, retreating blade stall is encountered at a lower forward airspeed at altitude. Most manufacturers publish charts and graphs showing a V_{NE} decrease with altitude.

When recovering from a retreating blade stall condition, moving the cyclic aft only worsens the stall as aft cyclic produces a flare effect, thus increasing the AOA. Pushing forward on the cyclic also deepens the stall as the AOA on the retreating blade is increased. Correct recovery from retreating blade stall requires the collective to be lowered first, which reduces blade angles and thus AOA. Aft cyclic can then be used to slow the helicopter.

Common Errors

1. Failure to recognize the combination of contributing factors leading to retreating blade stall.

2. Failure to compute V_{NE} limits for altitudes to be flown.

Weather information

The crew reported that the atmospheric pressure at the time of the occurrence was 1015 hPa with an air temperature of about 33 °C on the ground at Port Pirie and about 22 °C at the cruise altitude. The cloud base was about 6,000 ft and described as ‘few cumulus’ with visibility greater than 10 km. There was a north-westerly wind of about 15 kt with areas of moderate turbulence.

The density altitude at the cruise level was subsequently calculated to be about 7,000 ft.

Previous occurrences

ATSB investigation 200003143

On 17 July 2000, the pilot of a BK117 helicopter, registered VH-BKZ, reported that while in a gentle climb at about 4,600 ft during a post maintenance test flight, the helicopter suddenly pitched nose-up. The indicated airspeed decreased to zero and the helicopter then pitched nose-down to a slightly inverted attitude. After descending about 2,000 ft, the pilot regained control and landed safely.

Inspection of the helicopter’s systems by the company maintenance personnel could not find any reason for the sudden loss of control.

A Bureau of Meteorology area forecast, issued on the day of the occurrence, indicated severe turbulence below 10,000 ft. The forecast also included increasing westerly wind speeds ranging from 30 kt at 2,000 ft to 45 kt at 10,000 ft. The actual weather report, for the area in which the helicopter was operating, indicated westerly wind speeds increasing from 35 kt at 2,000 ft to 50 kt at 7,000 ft. These conditions were conducive to mountain wave and rotor activity, each of which is associated with the presence of turbulence.

A rotor is a large air mass rotating about a substantially horizontal axis. It is generated in the lee of a mountain or sharp ridge in strong wind conditions. At the time of the occurrence, the helicopter was operating on the lee side of a mountain range. The ATSB concluded that it was probable that the helicopter encountered a rotor.

6 An atmospheric density expressed in terms of height which corresponds to that density in the Standard Atmosphere.

ATSB investigation 200506614

At about 1315 Eastern Daylight-saving Time[7] on 7 December 2005, a BK117 helicopter, registered VH-IME, was being operated on a medical flight at 7,000 ft, in moderate to severe turbulence and in visual meteorological conditions, when the helicopter sustained an uncommanded nose-up pitch of 40° to 45°. The pilot attempted to counter the nose-up pitch by applying full forward cyclic control, but without effect. The pilot then lowered the collective control, producing a nose-down pitching moment, before recovering to normal level flight. The Mast Moment[8] advisory light illuminated and the pilot continued the flight to the destination at reduced airspeed.

An investigation by the co-designers and manufacturer of the helicopter identified an incorrect collective pitch setting that reduced the longitudinal cyclic control authority available to the pilot. That reduced authority restricted the pilot's ability to recover the nose-up pitch.

A number of safety actions resulted from this investigation, including:

- advice to the operator from the helicopter's manufacturer to re-set the helicopter's collective pitch setting in accordance with the BK 117 C-1 model helicopter maintenance manual
- amendment of the BK117 maintenance manual to include the relevant collective pitch setting procedure from the BK 117 C-1 manual
- the issue by the ATSB of Safety Recommendation R20050014, which recommended that the Civil Aviation Safety Authority (CASA) should alert Australian operators of the collective pitch setting discrepancy in BK117 helicopters
- an interim alert to Australian operators of the BK117 helicopter by CASA to amend their operation of the BK117 pending advice from the helicopter's manufacturer.

In addition, CASA wrote to all Australian owners and operators of BK117 helicopters recommending that, pending advice from the manufacturer, operators should reduce exposure to conditions of high density altitude and atmospheric turbulence, especially if the aircraft was at high gross weight. If such conditions were encountered, CASA recommended that pilots reduce airspeed and torque settings while hand flying the aircraft with the SAS (stability augmentation system) mode engaged.

As the operator of VH-VSA was not operating the BK117 helicopter type at the time of the occurrence involving VH-IME, they did not receive the type-specific information from CASA. In addition, inspection of VH-VSA following the occurrence in 2013 identified that the collective pitch setting was in accordance with the manufacturer's requirements and, therefore, did not influence this occurrence.

Separately, on 6 October 2008, in response to reported incidents of uncommanded sudden pitch-up events in BK117 helicopters, the helicopter manufacturer issued Alert Service Information notice ASI-MBB-BK117-106 which stated:

> **To all pilots and maintenance personnel of MBB-BK117!**
>
> Due to several incidents that occurred during flights, a sudden "pitch up" of the helicopter occurred without active control inputs by the pilot.
>
> If the helicopter is flown beyond or, in case of strong gusts, close to the admissible maximum speed (V_{NE}) this can lead to retreating blade stall and thus cause a sudden pitch up. This behaviour is more likely to occur with an incorrectly adjusted pitch stop and a centre of gravity which is to [sic] far aft.

---

7 Eastern Daylight-saving Time (EDT) was Coordinated Universal Time (UTC) + 11 hours

8 The mast moment indication system is used to measure and indicate any bending moments, which occur on the rotor mast.

> For this reason, ECD [EUROCOPTER DEUTSCHLAND GmbH] points out that
>
> – the pitch stop must be adjusted i.a.w. the MM [maintenance manual] and be checked,
>
> – the correct V_{NE} table must be affixed to the helicopter and be obeyed,
>
> – i.a.w. the flight manual, the V_{NE} table only applies to calm weather and that the speed must be correspondingly reduced when the weather is gusty.
>
> In the event of an uncommanded pitch up the collective lever must immediately be lowered to lower the angle of attack and increase the airspeed on the retreating blade. Thereby returning control to the aircraft.

A review of international safety database records did not identify any additional BK117 helicopter incidents or accidents that involved uncommanded nose-up pitching. The review did however show that this type of event was not restricted to the BK117 helicopter type.

Records from the United States National Transportation Safety Board contained details of occurrences involving a Rotorway 162 light (kit) helicopter, registered N412TS and a Bell 47G2 helicopter, registered N9021R that sustained uncommanded nose-up pitch attitudes. The United Kingdom Air Accidents Investigation Branch also recorded an accident involving a Sikorsky S-58ET, registered G-BCDE, which sustained an uncommanded nose-up pitch attitude.

Safety analysis

Introduction

While cruising at 5,000 ft above mean sea level the helicopter sustained a sudden, violent uncommanded nose-up pitch, followed by a 120° roll to the left and descent of about 4,000 ft in a steep nose-down attitude before the pilot was able to regain control. This analysis will examine the operational and mechanical factors that may have influenced the occurrence.

Operational factors

The helicopter was close to the maximum take-off weight and its centre of gravity close to the rear limit of the allowable envelope at the time of the occurrence. The helicopter's cabin configuration and the number of people on board increased the zero fuel weight so that the maximum fuel load for the flight was limited to 390 kg. In consideration of the available fuel, the pilot selected an initial cruise altitude of 5,000 ft and remained below the cloud base in visual flight conditions. The selected cruise speed of 115 kt was close to the calculated never exceed speed (V_{NE}) for the conditions of 120 kt. In combination, the high all-up weight and speed required greater collective pitch, or main rotor blade angle. This placed the blades closer to their stalling angle of attack.

The cruise altitude of 5,000 ft resulted in operation at a moderately high density altitude and in areas of moderate turbulence. These conditions, coupled with the effect of the already-discussed high all-up weight are known to be conducive to the onset of retreating blade stall at high speed. The uncommanded nose-up pitch and subsequent roll in the direction of the retreating blade indicated that retreating blade stall took place.

The pilot's instinctive attempt to lower the nose with cyclic, rather than the correct action of lowering the collective to reduce the blade angles and therefore angle of attack, would have worsened the stall and delayed recovery. The subsequent ability to recover from the left roll and descent by applying rear cyclic, which also increases the angle of attack, indicated that the helicopter was no longer experiencing retreating blade stall. In the event, the recovery was facilitated by the available height and visual cues.

Mechanical factors

The Australian Transport Safety Bureau considered whether the abnormal fluctuation of the system 1 and 2 hydraulic pressure gauges reported by the pilot and crewman was indicative of a hydraulic system switchover. Extensive examination and testing of the flight control system and associated hydraulic components found no evidence of a control valve seizure or component jamming. In addition, neither crew observed either hydraulic system pressure drop below the normal range, nor did the switchover caution light illuminate. Moreover, the resumption of normal tail rotor pedal forces was not consistent with a switch from system 1 to system 2, which would have permanently increased the pedal forces until a manual reset of system 1 (on the ground).

The ATSB also considered whether the reported fluctuations resulted from control inputs that were sufficient to significantly reduce hydraulic pressure and induce an automatic switchover from system 1 to system 2. However, when tested there was no automatic switchover, despite the application of intentional excessive control inputs.

Switchover could also be affected by the activation of the hydraulic test switch on the overhead console. However, neither crew member reported activating this switch, and the manufacturer's caution against its activation in-flight and its location meant that inadvertent activation was unlikely. As a result, the likelihood of a system switchover due to temporary hydraulic exhaustion, or from activation of the hydraulic test switch, was considered remote.

The reason for the reported fluctuation of the hydraulic system pressure gauges, albeit within the normal operating range, and the temporary increased pedal forces reported by the crew was not able to be determined. Furthermore, the lack of evidence to support a hydraulic system switchover, and the absence of any system or mechanical abnormalities, exclude control runaway as a factor.

Conclusion

This incident highlights the importance of pilot awareness of the factors conducive to retreating blade stall, including high all-up weight, high density altitude, high airspeed, manoeuvres that increase flight loads and flight in turbulence. Similarly, the importance of initially reducing collective pitch to optimise recovery is emphasised as incorrect recovery actions can result in loss of control of the helicopter.

Findings

From the evidence available, the following findings are made with respect to the loss of control involving Eurocopter MBB-BK117 B-2 helicopter, registered VH-VSA, which occurred 28 km south-south-east of Port Pirie Aerodrome, South Australia on 15 February 2013 and should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- The helicopter was operated in a configuration and meteorological conditions that led to retreating blade stall and an uncommanded nose-up pitch and left roll.
- The instinctive action of pushing the cyclic control forward delayed recovery from the stall.

Other findings

- The recovery was facilitated by the availability of sufficient height and visual cues.
- Examination of the helicopter and testing of the hydraulic flight control system found no defects or anomalies that would have contributed to the loss of control.

Safety issues and actions

The ATSB did not identify any organisational or systemic issues that might adversely affect the future safety of aviation operations. However, the following proactive safety action was reported in response to this occurrence.

Proactive safety action taken by the helicopter operator

Action number: AO-2013-030-NSA-009

On 18 February 2013 the helicopter operator issued an urgent *Immediate Safety Notification* to all company pilots. That notification provided information and guidance on the conditions leading to, symptoms of and actions for recovery from an uncommanded nose-up pitch, and departure from controlled flight that might result from retreating blade stall.

The notification required that with immediate effect:

> Operations of the BK117 B2 helicopter at weights in excess of 3200 kg **or** in conditions of forecast turbulence Pilots are to:
>
> - Calculate V_{ne} [never exceed speed] at cruise altitude and determine V_{no} (Velocity Normal Operating) which is V_{ne} minus 15 kts.
> - The helicopter is not to be flown in excess of V_{no}.
> - At high ambient temperatures plan to fly at the lowest IFR [instrument flight rules]/VFR [visual flight rules] altitude above Lowest Safe Altitude (LSALT).
> - When severe turbulence is forecast, missions are to be declined if flight through the forecast area is predicted. Flights in adjacent areas may be accepted but not at night or in IMC [instrument meteorological conditions].
> - If moderate turbulence is encountered in IMC speed should be reduced to 80 kts and the flight director assisted by hands on flying.
> - Ensure that the CofG [centre of gravity] throughout the flight remains midrange, typically, forward of a line extending from 3350kg/4475mm, 3200kg/4500mm, 3000kg/4525mm and at no time approaching the aft limit.

The operator also included a *Critical Note* in the notification that:

> Pilots are reminded that although the circumstances reported in this notice involved the operation of a BK117-B2 helicopter, the onset of RBS [retreating blade stall] is possible in any helicopter when operated at high all up weight, high IAS [indicated air speed]/TAS [true air speed], high density altitude and in turbulence or if flown with abrupt or harsh control input.

General details

Occurrence details

Date and time:	15 February 2013 – 1400 CDT	
Occurrence category:	Serious incident	
Primary occurrence type:	Loss of control	
Location:	28 km SSE of Port Pirie Aerodrome, South Australia	
	Latitude: 33° 28.85' S	Longitude: e.g. 138° 04.32' E

Aircraft details

Manufacturer and model:	Eurocopter MBB-BK 117 B-2	
Registration:	VH-VSA	
Serial number:	7186	
Type of operation:	Medical Transport Operations	
Persons on board:	Crew – 2 aircrew, 2 medical	Passengers – 1
Injuries:	Crew – Nil	Passengers – Nil
Damage:	Minor	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- pilot and crewman
- aircraft operator
- aircraft manufacturer
- United States National Transportation Safety Board
- United Kingdom Air Accidents Investigation Branch.

References

Federal Aviation Administration (2012). *FAA-H-8083-21A Helicopter Flying Handbook*. Oklahoma City: Author

Wagtendonk, W.J. (1996). *Principles of Helicopter Flight*. Newcastle: Aviation Supplies and Academics, Inc.

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the Australian Transport Safety Bureau (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 pilot, the aircraft operator, the aircraft manufacturer, the Civil Aviation Safety Authority and the German Federal Bureau of Aircraft Accident Investigation (Bundesstelle für Flugunfalluntersuchung).

Submissions were received from the pilot, the aircraft operator and the aircraft manufacturer. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

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 identify and reduce safety-related risk. ATSB investigations determine and communicate the factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, 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 initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred 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 to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

Australian Transport Safety Bureau

Enquiries 1800 020 616
Notifications 1800 011 034
REPCON 1800 011 034
Web www.atsb.gov.au
Twitter @ATSBinfo
Email atsbinfo@atsb.gov.au

Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation

Loss of control involving Eurocopter MBB BK117 B-2, VH-VSA
28 km SSE of Port Pirie Aerodrome, South Australia
15 February 2013

AO-2013-030
Final – 15 July 2014