Accident
Investigation Board
Norway

Issued June 2013

REPORT SL 2013/18

REPORT ON AIR ACCIDENT AT BRANNSLETTA IN NESSEBY IN FINNMARK COUNTY NORWAY ON 26 NOVEMBER 2009 WITH EUROCOPTER AS 350 B3, LN-OML OPERATED BY HELITRANS AS

Accident Investigation Board Norway • P.O. Box 213, N-2001 Lillestrøm, Norway • Phone: + 47 63 89 63 00 • Fax: + 47 63 89 63 01
www.aibn.no • post@aibn.no

This report has been translated into English and published by the AIBN to facilitate access by international readers. As accurate as the translation might be, the original Norwegian text takes precedence as the report of reference.

Photos: AIBN and Trond Isaksen/OSL

CONTENTS

AIR ACCIDENT REPORT

Aircraft:	Eurocopter AS 350 B3
Nationality and registration:	Norwegian, LN-OML
Owner:	Helitrans AS, Trondheim Airport Værnes, Norway
User:	Same as owner
Commander:	Minor injuries
Passengers:	None
Accident site:	At Brannsletta in Nesseby, Finnmark County, Norway (70° 00' N 029° 15' E)
Accident time:	Thursday, 26 November 2009 at approx. 1005 hours

All times stated in this report are local time (UTC + 1 hour) unless otherwise indicated.

ACCIDENT NOTIFICATION

On Thursday, 26 November at 1010 hours, the Accident Investigation Board's on-duty officer received notification from the East Finnmark police district that a helicopter had crashed at Brannsletta in Nesseby Municipality. The helicopter was burnt out and the only person on board had suffered minor injuries. The notification was confirmed shortly afterwards by personnel in the control tower at Kirkenes Airport Høybuktmoen (ENKR). It was stated that the helicopter was LN-OML. The Accident Investigation Board called out two accident inspectors, who arrived at the accident site the next day.

In accordance with ICAO Annex 13, Aircraft Accident and Incident Investigation, the AIBN notified the authorities in the manufacturing country France of the incident. The French accident investigation authority, Bureau d'Enquêtes a d'Analyses pour la Sécurité de l'Aviation civile (BEA), appointed an accredited representative who assisted the AIBN in the investigation.

SUMMARY

The helicopter was to bring a container and an excavator from a mountain top west of Bugøynes and down to an unloading site. During the second flight of the day, with parts of the excavator hooked up under the helicopter in a longline, the commander noticed the helicopter started shaking and got a warning that the hydraulic system had lost pressure. The commander was then in the process of putting the excavator down onto the unloading site, but the control problems arose so quickly that he did not have time to release the cargo before it hit the ground. He regained partial control of the helicopter after managing to open the cargo hook, but could not prevent it hitting the ground and overturning onto its side. An intense fire started and large parts of the helicopter were consumed by fire. The commander rapidly exited the helicopter without help and suffered only minor injuries.

The investigation was impeded by the fact that the helicopter burned up, and there were as a result few pieces of wreckage that could be investigated. The investigation is accordingly mostly based on the commander's statement, evidence on the accident site and witness statements. It has not been possible to find an exact explanation to why the control problems occurred.

1. FACTUAL INFORMATION

1.1 History of the flight

1.1.1 The helicopter was parked in the Air Force hangar at Kirkenes Airport Høybuktmoen (ENKR). On the day in question, a container and some excavator parts were to be lifted down from a mountain top west of Bugøynes. The commander arrived at the hangar in the morning and completed the daily inspection of the helicopter. The fuel tank was approx. 45% full (243 liters). The hydraulic tank had the correct oil level. There was nothing else of note, and the helicopter was pulled out of the hangar and started.

1.1.2 The commander submitted a VFR flight plan for flying in the Brannsletta area for a period of five hours, significantly longer than the mission was expected to take. This was done to avoid time pressure in the event of any waiting or additional assignments. Due to darkness, the take-off clearance was given as "Special VFR”. After starting up, the commander performed a routine test of the hydraulic system of the flight controls, without noticing anything abnormal (see Item 1.6.4.3 and Chapter 1.6.7). The helicopter took off at 0918 hours and left the Kirkenes control zone (CTR) shortly after. The flight to the unloading site in Brannsletta took approx. 14 minutes. A representative from the client was waiting there and came along up to the 289 meter-high mountain top approx. 1 km south of the unloading site. The first lift was a container weighing approx. 1,100 kg.

1.1.3 After the container had been put down at the unloading site, the helicopter flew back to the mountain top. The next lift was part of an excavator which was stated to weigh 1,260 kg. A 15.5 meter longline was used. With the nose pointing into the wind, the commander lifted the part in hover and noted that he was using 92% of the available engine power (9.2 on the First Limit Indicator – FLI). The weight indicator in the cockpit was showing 1,300 kg. He then flew northwest down towards the unloading site.

1.1.4 The helicopter flew east of the unloading site and continued in a wide, sinking left turn. The speed was slowly reduced on a final approach headed south, into the wind. The helicopter stopped with the excavator approx. 5 meters above the ground 6 – 7 meters north of where the commander intended to put it down. The power take-off from the engine was then approx. 90%. The commander has explained that he was in the process of looking down through the floor window to make the final fine adjustments towards the unloading site when he noticed that the helicopter started shaking. He heard the audio warning for missing hydraulics (gong) and saw that the red warning light for hydraulic pressure was lit on the warning panel.

1.1.5 The shaking increased to a point where the instruments could not be read. The controls became noticeably heavy and it was difficult to control the helicopter which yawed left and lowered its nose. The commander was worried that the excavator might hit two people on the ground and tried to maneuver away from them. In the external mirror, he could see the excavator part hitting the ground somewhat to the left of the planned landing site and that the helicopter started dragging the excavator part along the ground.

The commander released the load using the handle for mechanical release down on the collective stick. The helicopter was then headed nose first for the ground on a north-eastern heading. When the cargo hook under the helicopter opened, the commander managed to lift the nose and reduce the descent rate to some extent before the helicopter hit the ground. When the commander realized that he could not avoid hitting the ground, he lifted his arms to protect his face. There was never time to take actions in accordance with the emergency checklist.

1.1.6 The helicopter hit the ground, overturned to the left and the main rotor hit the ground. After 1 – 2 seconds, everything was quiet and the helicopter was lying on its left side. Multiple warning lights were lit in the cockpit. The commander unbuckled and was on his way out when he noticed that his head was held back by the helmet cable. He realized that the helicopter had caught on fire and felt the radiating heat. To get out quickly, he took off his helmet and jumped out and forward. He could not say how he exited the cockpit, but suggested that it was through a hole in the front window on the left side of the cockpit. There was no time to turn off switches or shut the fuel valve. When he came out, the fire was burning fiercely on the left side near the main gearbox, and the wind was pushing the flames towards the cockpit (see also Figure 4).

1.1.7 The two persons at the unloading site both witnessed the accident. One was an Arctic Helicopter employee and had worked as a loadmaster on occasion. He described the approach as very calm and controlled. The load was not moving from side to side and everything looked normal until the helicopter started jumping and moving abnormally. The load hit the ground and he realized that this would end wrong. The loadmaster believes he saw flames on the left side near the main gearbox before the helicopter hit the ground. The other person who saw the accident, however, believed that the flames were only there after the helicopter hit the ground. In all other aspects, the witnesses' description of what they saw correlated. When the loadmaster saw the flames, he immediately ran to a truck to get a fire extinguisher. He was very surprised when he saw the commander get out of the burning wreckage by himself shortly afterwards. The commander has explained that he did not notice much of the crash itself. The instrument panel was smashed in some and he suffered a minor abrasion on his foot. He was otherwise unharmed.

1.1.8 After a short time, the fire had engulfed the helicopter and extinguishing it was no longer feasible. The commander's mobile phone burned up, but the loadmaster's telephone was used to alert the control tower at Høybuktmoen and the company's flight director. The control tower registered receipt of the notification at 1007 hours.

1.2 Injuries to persons

Table 1: Injuries to persons

Injuries	Crew	Passengers	Others
Fatalities			
Serious			
Light/none	1		

1.3 Damage to aircraft

The aircraft was a total loss (see Chapter 1.12.2)

1.4 Other damage

Some minor damage to the excavator. A small area with low vegetation sustained fire damage.

1.5 Personnel information

1.5.1 The commander, male age 28, started his pilot training at the European Helicopter Center at Sandefjord Airport Torp (ENTO) in the autumn of 2003. He completed the JAR-FCL commercial pilot training in 2004 and in this connection he received a type rating for AS 350. After a brief period where he did not work as a helicopter pilot, the commander started flying Robinson R44s for Midtnorsk Helikopterservice in 2005. He then flew Bell 206s before he started flying AS 350s for the company Helikopterdrift. The commander was first employed by Helitrans on 15 September 2009 in connection with Helitrans' takeover of Helikopterdrift.

1.5.2 The commander held a JAR-FCL Commercial Pilot Licence CPL (H) valid until 31 July 2013 and a Class 1 medical certificate valid until 12 February 2010, with the limitation *"VDL Shall wear corrective lenses and carry a spare set of spectacles"*. The last renewal of the type rating for AS350/350B3 (OPC/PC) was granted on 24 September 2009.

1.5.3 The commander has explained that he had practiced flying with the hydraulic power system off about 20 times, most recently in connection with OPC/PC on 24 September 2009. The normal procedure was that the instructor turned off the hydraulic pressure by pushing the HYD TEST button (see Item 1.6.4.3) on the pedestal console. When speed had been reduced as recommended to 40 – 60 kt, the remaining pressure in the accumulators was emptied using the HYD switch on the collective stick. He had also practiced landing without hydraulic pressure by setting the helicopter down with a low forward speed.

1.5.4 The commander had slept well that night. He got up at 0700 hours and ate breakfast. He felt rested and fit when he started the working day.

Table 2: Flying hours commander

Flying hours	All types	Relevant type
Last 24 hours	2:20	2:20
Last 3 days	2:20	2:20
Last 30 days	30:20	6:30
Last 90 days	174	17
Total	845	30

1.6 Aircraft information

1.6.1 <u>Helicopter data</u>

Manufacturer: Eurocopter

Type designation: AS 350 B3

Serial No: 4494

Year of manufacture: 2007

Nationality and registration:	Norwegian, LN-OML
Airworthiness certificate:	Valid until 3 July 2010
Accumulated flying hours:	555 hours
Engine:	1 Turbomeca Arriel 2B
Engine output:	847 hp (maximum take-off power)
	728 hp (maximum continuous power)
Maximum weight (without external cargo):	2,250 kg
Maximum weight on cargo hook:	1,400 kg
Maximum total weight with external cargo:	2,800 kg
Weight, empty:	1,247 kg
Fuel:	Jet A1

1.6.2 General

The helicopter was bought new by Helitrans and started operating for the company 17 July 2008.

1.6.3 Relevant weight and location of the center of gravity

When the accident occurred, LN-OML had the following weight and arm, based on information provided by the commander:

	Arm (m)	Weight (kg)	Momentum
The helicopter's empty weight	3.50	1,247	4,364.5
Commander	1.55	72	111.6
Baggage in the cabin	2.25	3	6.8
Baggage right cargo hold	3.20	5	16.0
Baggage left cargo hold	3.20	10	32.0
Fuel (185 liters)	3.48	130	451.8
	3.40	**1,467**	4,982.7

The limitations for the center of gravity's location (arm) with the relevant weight (without external slung load) is 3.17 – 3.50. The helicopter had a slung load weighing 1,300 kg with arm 3.38 m. This resulted in a total weight of 2,767 kg and the location of the center of gravity was 3.39. With the relevant weight, the limitations are 3.29 – 3.43. The helicopter was therefore operated within the limits as regards both weight and the location of the center of gravity.

1.6.4 System description

1.6.4.1 The type of helicopter in question is equipped with one single hydraulic system which supplies power to the hydraulic actuators on the flight controls (servos). The system hydraulic pump is powered by the main gearbox via a drive belt. The pump draws oil from a tank and delivers 6 liters/min to the system via a filter. A valve regulates the pressure to 40 bar.

1.6.4.2 Normally, the main rotor is controlled using three servos and the tail rotor by one servo. The servos relieve the pilot by making the control forces very small. If the system pressure falls below 30 bar, the red HYD warning light on the instrument panel will light up and a warning signal will sound. If the system pressure falls below the pressure required by the servos at any time, an accumulator connected to each servo will provide the necessary oil pressure for a brief period. When the accumulators have been emptied of oil, the pilot must operate the flight controls manually without help from the servos. This requires substantial force, especially at high speeds or in hover.

1.6.4.3 As emerges from Figure 1 below, quoted from the Eurocopter training manual Section 8.10, the hydraulic system is also equipped with two switches, A and B. Switch A is HYD TEST, a push-button used to test e.g. the accumulators and the warning system. This switch is located down on the pedestal console. Switch B is on the collective stick and is referred to as the *hydraulic cut-off switch.* These switches shall be used to test the hydraulic system before each flight, as well as to simulate the loss of hydraulic pressure during flight.

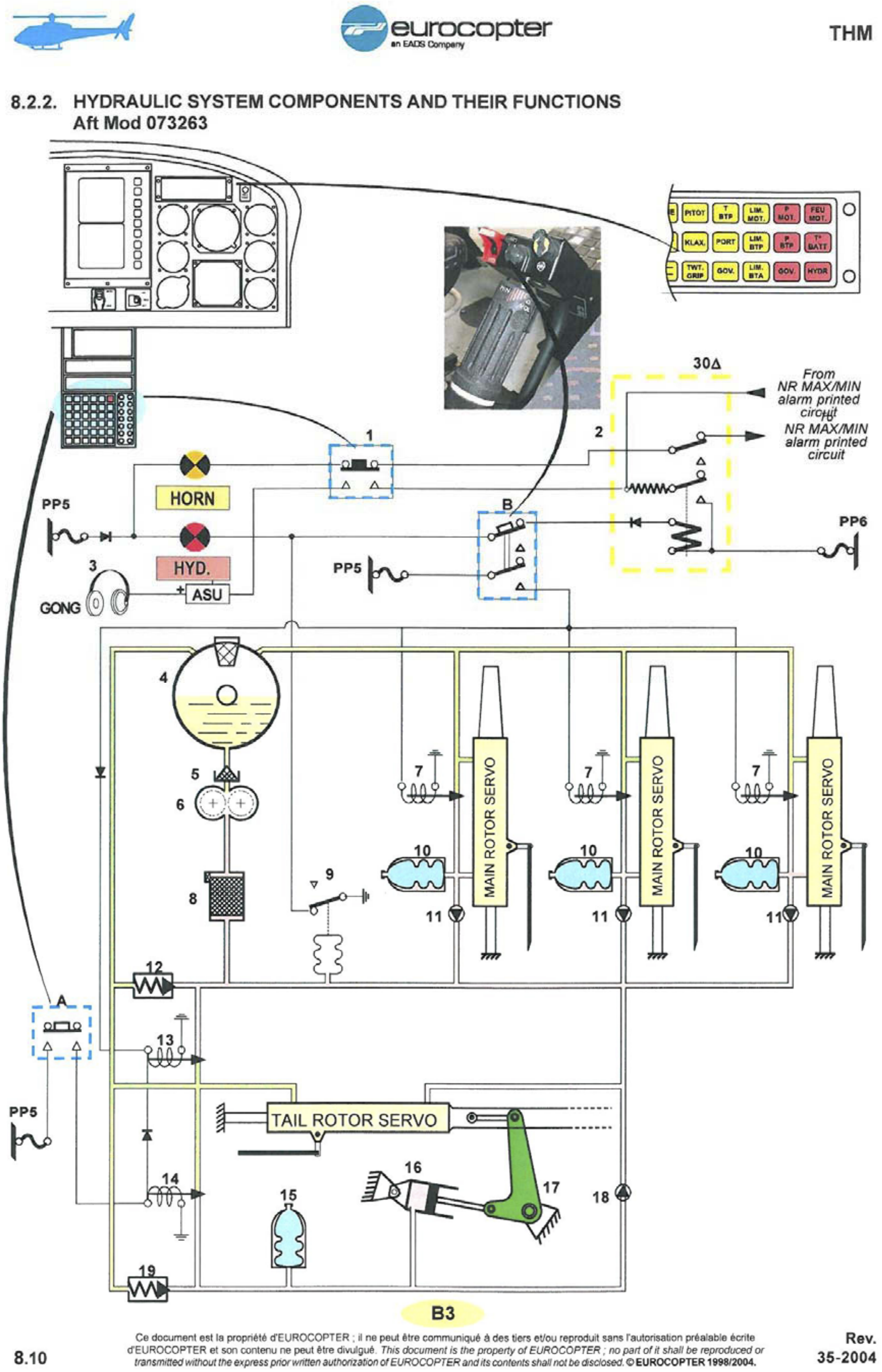

Figure 1: Schematic presentation of the hydraulic system.

1.6.4.4 The cargo hook is not part of the helicopter's standard equipment. It is installed under the belly and can be released electrically using a push-button on the cyclic stick or mechanically using a handle on the collective stick. When the helicopter is using a longline, an electrically operated cargo hook is also placed at the far end of the line. The push-button on the cyclic stick is then rewired to operate the cargo hook at the far end of the longline. LN-OML was equipped with a cargo hook of the type “Cargo swing” under the belly. The helicopter's flight manual contains a separate supplement for the cargo hook. The supplement's description of emergency procedures only covers engine failure and cargo indicator error, referring to the flight manual's general emergency procedures for other emergencies (see Chapter 1.6.7).

1.6.5 Maintenance

The aircraft had recently been through the following relevant inspections/maintenance procedures:

- 26 April 2009: 200-hour inspection. Accumulated flying hours: 386.45 hours (168 flying hours before the accident). Number of cycles: 1,737
- 4 September 2009: Combined 100/500/600-hour inspection. In connection with this inspection, the tail rotor servo was taken out and installed in another helicopter. Servo P/N SC5084-1, S/N 318 was installed. Accumulated flying hours: 481.40 hours (74 flying hours before the accident). Number of cycles: 2,042.
- 1 October 2009: Check of hoses in accordance with TO 350-00-001. Accumulated flying hours: 506.15. Number of cycles: 2,150.
- 23 November 2009: Change of hydraulic oil (to a type better suited to the cold) in accordance with SB 05.00.45. Accumulated flying hours: 545.40 hours. Number of cycles: 2,249.

During the inspections performed on 26 April and 4 September 2009, the task *“Hydraulic pump – drive shaft. Visual check and greasing spline.”* was performed.

1.6.6 The following relevant components were installed in the helicopter when it crashed:

- Hydraulic pump P/N A5026780, S/N 80179008
- Filter regulation unit P/N BFS-155-1, S/N 1847
- Servo main rotor front P/N SC5084-1, S/N 1377
- Servo main rotor right/left P/N SC5083-1, S/N 3382
- Servo main rotor right/left P/N SC5083-1, S/N 3386
- Servo tail rotor P/N SC5072, S/N 318

1.6.7 Aircraft flight manual – Flight Manual AS 350 B3

1.6.7.1 The following is quoted from Section 3 of the flight manual, "Emergency procedures".

5 HYDRAULIC SYSTEM FAILURES

5.1 Yaw Servo-control Slide-valve Seizure

- In hover : If no movement about the yaw axis, land normally ; if rotation about the yaw axis, cut off hydraulic pressure by actuating the switch situated on the collective pitch control lever.
- In cruising flight : Reduce speed, entering into a side-slip if necessary, then cut off hydraulic pressure by actuating the switch situated on the collective pitch control lever.

5.2 Main Servo-control Slide-valve Seizure

- Actuate the switch, situated on the collective pitch control lever, to cut off hydraulic pressure.
  Load feedback will be felt immediately ; load feedback may be heavy if the helicopter is flying at high speed :
  . collective pitch : 20 daN (44 lbs) approx. pitch increase load R
  . cyclic : 7 to 12 daN (15 to 26 lbs) approx. left-hand cyclic load R
  . cyclic : 2 to 4 daN (4 to 9 lbs) approx. forward cyclic load R
  . yaw pedals : practically no load in cruising flight.
- Reduce speed to 60 kt (111 km/h) and proceed as in the case of illumination of the "HYD" light.

EASA Approved: 350 B3 3.2

A 03-25 Page 5

Figure 2: Copy from the helicopter's emergency checklist Chapter 3.2, page 5.

FLIGHT MANUAL

2 WARNING-CAUTION-ADVISORY PANEL

The Warning-Caution-Advisory Panel located on the instrument panel includes lights of different colors :

- Red to indicate a failure requiring immediate action.
- Amber to indicate a failure which does not require immediate action.

2.1 Red Lights

LIGHT	FAILURE	PILOT ACTION
HYD	Loss of hydraulic pressure or Pressure <30 bars	Keep aircraft to a more or less level attitude Avoid abrupt maneuvers CAUTION : DO NOT DEPRESS "HYD TEST" PUSHBUTTON AS THIS WILL DEPRESSURIZE THE YAW LOAD COMPENSATOR, RESULTING IN HEAVY PEDALS CONTROL LOADS. DO NOT ATTEMPT TO CARRY OUT HOVER FLIGHT OR ANY LOW SPEED MANEUVER. THE INTENSITY AND DIRECTION OF THE CONTROL FEEDBACK FORCES WILL CHANGE RAPIDLY. THIS WILL RESULT IN EXCESSIVE PILOT WORKLOAD, POOR AIRCRAFT CONTROL, AND POSSIBLE LOSS OF CONTROL. BE CAREFUL NOT TO INADVERTENTLY MOVE THE TWIST GRIP OUT OF THE FLIGHT STOP (TWT GRIP AND GOV AMBER LIGHTS EXTINGUISHED). NOTE : Pressure in accumulators allows enough time to secure the flight and to establish the safety speed. - In hover IGE : . Land normally . Collective - - - - - - LOCK. . Shutdown procedure - - APPLY. - In flight : Smoothly. . Cyclic/Collective- - - SET IAS within 40 to 60 kt (hydraulic failure safety speed). . Collective HYD switch- OFF. Pilot has to exert forces : - on collective to increase or decrease power, around no force feedback point. - on forward and left cyclic. LAND AS SOON AS POSSIBLE

EASA Approved: 350 B3 **3.3**

A B 03-25 Page 2

LIGHT	FAILURE	PILOT ACTION
		NOTE : Speed may be increased as necessary but controls loads will increase with speed. - Approach and landing : . Over a clear and flat area, make a flat final approach, nose into wind. . Perform a no-hover/slow run-on landing around 10 knots. . Do not hover or taxi without hydraulic pressure assistance. - After landing : . Collective - - - - - - - LOCK. . Shutdown procedure- - - - APPLY.

Figure 3: Copy of the helicopter's emergency checklist Chapter 3.3, page 2 and parts of page 3.

1.6.7.2 The helicopter's complementary flight manual Chapter 7.8 states the following regarding loss of oil pressure:

> *The average time required to attain the required recommended safety speed range (40 to 60 kt) from VNE or the hover is less than 30 seconds. If the accumulators are properly serviced they will power the flight controls throughout the maneuvers required to reach the recommended safety speed range. If control force feedback is felt prior to attaining the safety speed range then the pilot should immediately select the hydraulic cut-off switch to OFF.*

1.6.7.3 The flight manual has a supplement referring to the external cargo hooks of the "Cargo swing" type. This contains no special emergency procedures as regards loss of hydraulic oil pressure.

1.7 Meteorological information

1.7.1 METAR (aerodrome routine meteorological report) from Høybuktmoen:

ENKR 260850Z 16013KT 9999 BKN012 M04/M05 Q0997 RMK WIND 775FT 15019KT=

1.7.2 The commander has explained that the cloud base was at 1500 – 1600 ft. Wind speed was at an estimated 15 – 20 kt from the south – southeast up on the mountain top. Down at the unloading site, wind speed was at an estimated 15 kt from the same direction. The wind was stable with little turbulence. There were light snow showers in the area, but these disappeared after a while and visibility was good when the accident occurred.

1.8 Aids to navigation

Not relevant.

1.9 Communications

Radio communication between the commander and air traffic services at Høybuktmoen were normal until the helicopter received clearance to fly towards Brannsletta at 0816 hours. After this, there was no communication between the commander and any air traffic services units.

1.10 Aerodrome information

Not relevant.

1.11 Flight recorders

Not mandatory and not installed.

1.12 Wreckage and impact information

1.12.1 <u>The crash site</u>

The helicopter crashed at Brannsletta, a large open field approx. 80 m above sea level on the south side of Varangerfjorden. Highway 355 crosses Brannsletta just after the exit from Highway E6 towards Bugøynes. The field is partly covered by mountain birch. The burned-out wreckage ended up approx. 55 m west of where the cargo was supposed to be put down. The excavator with the longline attached ended up approx. 13 m south of the helicopter wreckage.

Figure 4: The helicopter wreckage seen towards the southwest. The plan was to put the excavator part down in front of the container (red arrow). The excavator ended up next to some trees by the persons in the picture (yellow arrow). Photo: AIBN

1.12.2 The helicopter wreckage

1.12.2.1 The helicopter ended up in one piece. The wreckage burned up, with the exception of the tail, parts of the main rotor and the engine. In addition to the abovementioned parts, the wreckage consisted mainly of ash, melted aluminum and steel parts. Some parts containing a high proportion of steel or aluminum could be identified. It was therefore possible to find the hydraulic pump and the associated steel parts. The steel parts had no obvious breakages or damage. The grooves in the hydraulic pump's driving wheel were partly filled with a charred substance. It was also possible to identify parts of the servos.

Figure 5: From left to right: hydraulic pump with driving wheel, two accumulators, servo without accumulator and complete servo with accumulator. Photo: AIBN

1.12.2.2 The tail with tail fin, stabilizer, tail rotor gearbox and the tail rotor were undamaged. The landing gear was seemingly undamaged with the exception of heat damage from the fire. The main gearbox was partially consumed by the fire and from the lower part of the gearbox only steel parts were left. There was less damage higher up. The rotor head and the inner parts of the rotor blades had sustained heat damage and were partly destroyed by overload due to the impact with the ground. It was accordingly difficult to verify the status of the parts before the crash.

1.12.2.3 The engine was found to be intact, protected by the firewalls and partially hidden under a burned-up engine cover. In addition to soot and minor fire damage, the power turbine had lost all its blades. These had pushed forward through the turbine housing with great force just ahead of the turbine's protection ring. Seen from behind, the blades had gone in a direction corresponding to 45° down to the left. In the area around the power turbine, the turbine housing and the exhaust pipe had sustained significant deformation. The engine was partially covered by soot, in particular in front of the power turbine (see Figure 6).

1.12.2.4 The flexible connection between the engine and the main gearbox was deformed in a way which indicates that the axle had rotated transmitting power while the engine and the main gearbox were out of position in relation to each other.

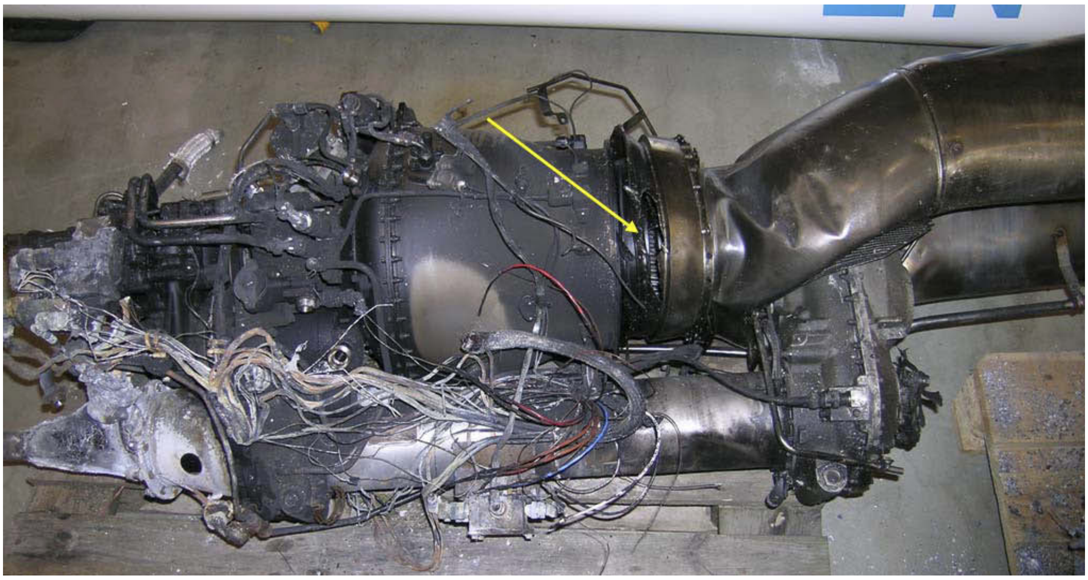

Figure 6: Engine with soot marks. Yellow arrow pointing to the tear where the turbine blades exited. The protection ring is directly to the right of the tear. Photo: AIBN

1.13 Medical and pathological information

A routine blood sample was taken from the commander. The sample showed no traces of alcohol or drugs.

1.14 Fire

A fire started immediately.

1.15 Survival aspects

1.15.1 The commander was secured in five-point seat belts and was wearing a helmet.

1.15.2 The helicopter was equipped with an automatic emergency locator transmitter (ELT) of the Kannad 406AF type. No emergency signals were registered from this.

1.15.3 The closest fire station was in Nesseby municipality, approximately 40 kilometers from the crash site. The fire department there was notified of the helicopter accident at 1016 hours. They responded with a fire engine, a tanker and five firefighters, and arrived at the crash site at 1110 hours. The helicopter was then burned out. Nine minutes later, a tanker from Sør-Varanger fire department also arrived.

1.16 Tests and research

Parts of the tail were wet with oil. In order to ascertain the type of oil, samples were sent to the helicopter manufacturer Eurocopter for analysis. The analyses showed that the oil was turbine oil of the type O-156[1], and no traces of hydraulic oil were found.

1.17 Organizational and management information

The current company has its origins in Heli-Trans, established in 1990. Later, the company changed name to Helitrans and on 1 July 2007 acquired the company

[1] NATO specification for synthetic oil for turbine engines

Helikopterdrift. At the time of the accident, Helitrans operated 19 helicopters of the types Robinson R44, Eurocopter AS 350 BA, Eurocopter AS 350 B3, Eurocopter AS 365 N2 and Bell 214. The company had approx. 80 employees. Helitrans stationed a helicopter at Høybuktmoen in September 2009 and sold services in the area via the company Arctic Helikopter. In addition to selling services, the abovementioned loadmaster from Arctic Helikopter also functioned as a facilitator and loadmaster for operations performed by Helitrans.

1.18 Additional information

1.18.1 Other relevant accidents

1.18.1.1 The Canadian accident investigation body, the Transport Safety Board, has investigated an accident involving an AS 350 B2 helicopter (C-GNMJ) which suffered a fault in the flight controls in Kamarange in Guyana on 6 February 2005. Report No. A05F0025 describes in detail the hydraulic system, the investigations carried out, test flights of the helicopter type and gives a brief summary of 26 accidents and incidents where the helicopter type's hydraulic system was a causal factor. The following relevant information from the report may be mentioned:

- Several blameworthy technical conditions relating to the hydraulic system on C-GNMJ were found, but it was not possible to determine the cause of the accident.
- Five accidents and one incident were due to faults in the hydraulic pump or its transmission belt.
- Five accidents were due to unintentional operation of either the HYD TEST switch or the *hydraulic cut-off switch*.
- Five accidents occurred as a result of the candidate losing control of the helicopter while practicing flying without hydraulic pressure.
- The following is quoted from the conclusion from test flights without hydraulic pressure, performed by the Canadian aviation authority Transport Canada (TC) prior to the accident with C-GNMJ: *"The findings in November 2003 flight tests were that the flight control forces were high at speeds higher than the safety speed, acceptable in the safety speed range, and very high and unstable in both direction and intensity in hover. TC observed that, while these very high flight control loads for hydraulics-off flight were marginally acceptable for legacy helicopters, they now would not be acceptable on a new helicopter design."*

1.18.1.2 On 26 July 2010, Eurocopter issued Alert Service Bulletin No. 29.00.13. The bulletin relates to an incident where a fire started in an AS 350. The hydraulic pressure was lost and the pilot performed an emergency landing.

1.18.1.3 Reference is also made to the Norwegian Accident Investigation Board's report SL 2011/14 which deals with external cargo and release of external cargo.

1.18.2 Use of longlines

Use of longlines is as good as standardized for transport of external cargo with helicopters in Norway. The operators believe that the method has many advantages. The distance to obstacles on the ground is greater than when using short lines. Furthermore, the working conditions are better and safer for personnel on the ground. The fact that the longline method has been standardized also yields advantages as regards predictability, continuity and training. It could be argued that the helicopter is in the dead man's curve for periods when using a longline, but this will also be the case when using shorter lines. The advantage of using a longline is that the commander has more time to move away from personnel and obstacles should anything unforeseen occur.

1.19 Useful or effective investigation techniques

No methods qualifying for special mention have been used in this investigation.

2. ANALYSIS

2.1 Introduction

2.1.1 The investigation was impeded by the fact that the helicopter burned up, and there were as a result only few pieces of the wreckage that could be investigated. The helicopter was not equipped with a flight recorder, and the investigation has accordingly to a large extent been based on the statements of the commander and witnesses.

2.1.2 Based on the commander's statement, a technical fault seems to have occurred in the hydraulic system. It was not possible to establish what went wrong in any further detail. The fault arose at a critical flying phase, as the helicopter was in near-hover, with weight near the maximum. The course of events, possible technical faults and which alternatives the commander had during the emergency which arose, are analyzed below. Furthermore, the fire and survival aspects are analyzed.

2.2 History of the flight

2.2.1 The Accident Investigation Board assumes that the helicopter was flown in a calm and controlled manner towards the unloading site and that the 15 kt wind did not cause any noticeable turbulence. A heavy compact cargo on a 15.5 m long cargo line is generally stable and relatively easy to maneuver. In the Board's opinion, conditions were therefore conducive to a controlled and safe delivery of the excavator.

2.2.2 The commander's statement that the flight controls became stiff and that it became hard to control the helicopter, correlate well with the witnesses' statements, describing how the helicopter suddenly started moving abnormally. Other than that, the witnesses noticed nothing abnormal about the helicopter. At this time, the helicopter was in near-hover and the total weight was 33 kg below the permitted maximum. The load on the main rotor was therefore great. The Accident Investigation Board assumes that the control problems which occurred were due to sinking hydraulic pressure resulting in the servos ceasing to function. Controlling the helicopter without the aid of servos in such a situation is demanding, maybe even impossible.

2.2.3 The Accident Investigation Board cannot provide a definitive explanation of why the helicopter started shaking severely. One possible cause could be that the accumulators ran out of pressure at different times. Vibrations that are normally generated when a helicopter comes out of translational lift may have been exaggerated by the control problems. The Accident Investigation Board cannot preclude that at some time, a mechanical fault developed in the main rotor and caused the shaking.

2.2.4 The commander was unable to estimate how long it took from when the shaking became noticeable until he heard the warning sound. This is understandable in light of the acute situation which arose. It is accordingly impossible to establish how long it took from the time the warnings were given and until the controls started to go stiff. The flight manual describes the time aspect in the following manner: *"Pressure in accumulators allows enough time to secure the flight and to establish the safety speed."* (see Figure 3). How long the accumulators can maintain the necessary pressure depends on how much work the servos must perform. This, in turn, depends on the load on the rotor system and how much the helicopter is maneuvered. In the situation discussed here, there is reason to assume that only a few seconds passed from the time the warning was given until the control problems became noticeable. The time aspect is crucial, because it indicates whether it is possible to land before the control loads become heavy. In this actual case, there are reasons to question whether the accumulators provided adequate assistance to safely handle the emergency situation.

2.2.5 The Accident Investigation Board believes the control problems arose at a critical flying phase. The helicopter was in near-hover, approx. 20 meters above the ground, and the commander was in the process of directing all his attention towards the ground in order to put the excavator down. The excavator made the situation worse as it caused a high load for the rotor, as it could cause the helicopter to be dragged down to the ground, and because there were people on the ground at risk of being injured by the cargo.

2.2.6 The flight manual states *"land normally"* if the HYD light becomes lit when the helicopter is in hover near the ground (in ground effect). Alternatively, the procedures are described for when the helicopter is *"in flight"*. In this case, the helicopter was in a vulnerable situation between these two alternatives. The accident serves as an illustration that very demanding situations can arise in connection with longline operations and that the emergency procedures, as in this case, are not sufficiently covered in the flight manual.

2.2.7 The commander has not given a clear explanation of why he did not release the cargo immediately, using the electric switch on the cyclic stick. The ideal course of action would have been to drop the excavator immediately, but the Accident Investigation Board can understand that the commander initially believed it was possible to lower it the last few meters without dropping it. Furthermore, there were people on the ground to protect. The commander's reaction must also be seen in light of the fact that his experience with this type of helicopter was limited and the situation arose suddenly, allowing very little time before the situation came out of control. One important lesson from the accident must be that alternative methods should be considered in the event of unforeseen situations to the extent possible. This should be described in the company's Standard Operating Procedures (SOP). In addition, all loading and unloading sites must be considered in relation to emergency release of external cargo, secure location for personnel and possible emergency landing sites. A pilot should always be prepared to drop external cargo and perform an emergency landing when the helicopter is in hover.

2.2.8 The flight manual refers to the use of the HYD switch on the collective stick to dump the pressure in the accumulators so that all three main rotor servos cease powering the flight controls at the same time. This avoids unnecessary stick force in the transition phase between hydraulically operated and manually operated flight controls. In the situation in question, the Accident Investigation Board believes that it can be questioned whether the helicopter could have been controlled in hover even if the hydraulic system had been turned off with the HYD switch in due time.

2.2.9 The Accident Investigation Board is of the opinion that the helicopter's emergency checklist is overly optimistic as regards the description of symptoms and methods in that it does not sufficiently highlight the risk of loss of control even if the checklist is adhered to. The information in the Canadian report shows that this type of helicopter cannot always be controlled when problems arise in the hydraulic system. Even without external cargo, the control problems can be difficult to handle.

2.2.10 After the control problems had started, the helicopter turned to the left. This can be explained by the fact that the pedals became heavy to operate, making it harder to counter the torque from the main rotor (against the direction of the main rotor). After the excavator hit the ground, it acted as a fixed point on the ground which the helicopter circled around. Had the commander not managed to open the cargo hook, the helicopter would most likely have hit the ground with great force. As the commander managed to open the cargo hook in time, he managed to complete a partially controlled emergency landing. The almost undamaged landing gear (see Item 1.12.2.2) indicates that the landing was not hard. Most likely, the helicopter overturned to the left due to the sideways movement, so that the main rotor hit the ground and major damage was inflicted on the rotor and the helicopter.

2.3 Fire and survival aspects

2.3.1 One of witnesses on the ground has indicated that the fire started while the helicopter was still airborne. Although there has been a case where the hydraulic system has caught fire while airborne, the Accident Investigation Board has no other information to support this (see Item 1.18.1.2). The Accident Investigation Board believes it is more likely that the fire started when the helicopter hit the ground. The fire developed very rapidly, indicating that the polyamide fuel cell had been destroyed, resulting in large amounts of fuel, approx. 185 liters, leaking. The power turbine blades, which forced their way out ahead of the surrounding protection ring, are one possible ignition source. This resulted in very high spot temperatures, and may have ignited fuel from the destroyed fuel tank which came into contact with the engine or turbine blades. That fuel from the fuel tank came into contact with hot parts in the engine is likely, as the helicopter ended up lying on its side, elevating parts of the fuel tank above the engine.

2.3.2 The commander suffered only minor injuries and managed to get out of the cockpit without help. However, the fire developed rapidly and the margins for getting out of the wreckage in time were small. The fact that the windshield was most likely broken made it easier to get out. Escaping through the right door, now facing skywards, would have taken more time. Had the commander been more seriously injured or had he lost consciousness, the situation could have become very critical.

2.3.3 The commander was secured with seat belts and was wearing a helmet. This most likely contributed to limiting the injuries and enabled the commander to evacuate rapidly without help.

2.3.4 That no signals were registered from the emergency locator transmitter may be due to it being damaged as the helicopter overturned. It may also be due to the impact forces not being sufficient to trigger the transmitter automatically, or that the transmitter burned before the signals were registered.

2.3.5 The fire started immediately and the flames quickly consumed large parts of the helicopter. The fire and rescue service, arriving at the site about one hour after the accident, could not limit the damage. All that was left to do when they arrived was to put out smoldering fires. However, if there had been a risk of a forest fire, the response time could have been a critical factor.

2.4 Loss of hydraulic pressure

2.4.1 The Accident Investigation Board accepts the commander's explanation that the hydraulic pressure became too low. This may be due to several factors, such as a fault in the hydraulic pump or its drive system, system leaks or the hydraulic system being turned off unintentionally. The latter seems less likely, in part because the switch is protected with a "guard". Moreover, the commander was not about to operate other switches at the time when the control problems occurred, so the chances of him hitting the wrong switch by mistake is unlikely.

2.4.2 Only limited remains of the hydraulic pump were left, but what was possible to study showed no signs of failure. Charred material in the grooves of the driving wheel indicates that the drive belt was in place before the fire started. Leaks in hoses or components in the hydraulic system may explain why the pressure dropped, but it has not been possible to find traces of such leaks.

2.4.3 If the fire started before the helicopter crashed, this may indicate that a serious fault had occurred in the hydraulic pump, and that overheating in combination with a leak started a fire. Damage to hydraulic hoses as a result of a fault in the oil cooler fan is also a possibility.

2.4.4 The Accident Investigation Board cannot link potential technical faults to deficiencies in the helicopter's maintenance. The helicopter was relatively new and the Accident Investigation Board considers that it is unlikely that the work performed on the hydraulic system have introduced any faults. The oil in the hydraulic system was changed only 10 flying hours before the accident happened. The Accident Investigation Board has no evidence that the oil change introduced any faults or external oil leaks. This is based on the oil level being observed as normal before departure and that there were no traces of hydraulic fluid leaks on the tail boom.

2.5 Training

2.5.1 With his 30 flying hours on AS 350, the commander had relatively little experience with the type. However, the Accident Investigation Board believes that a more experienced pilot would not necessarily have handled the situation better. The commander had practiced landing without hydraulic pressure only two months before the accident happened. He was accordingly well familiar with the phenomenon as described in and practiced in accordance with the flight manual. However, the critical situation occurred at a low speed, in near-hover. There are no procedures regarding practicing for the phenomenon in hover, and it is accordingly hard to gain realistic insight into how the helicopter will behave if the hydraulic pressure disappears while the helicopter is in hover.

2.5.2 The Accident Investigation Board believes that the control issues in connection with the loss of hydraulic pressure must be emphasized in the initial type training, and that it should also be repeated in theory in connection with flying without hydraulic pressure during proficiency checks. Practicing loss of hydraulic pressure during hover can only take place in a simulator. As far as the Accident Investigation Board is aware, only one AS 350 simulator currently exists, located in the US. In connection with the accident at Dalamot in Ullensvang, Hordaland County, Norway on 4 July 2011 with LN-OXC, the Accident Investigation Board discussed the use of simulators in connection with practicing servo transparency (see report SL 2012/13). The Accident Investigation Board is of the opinion that similar arguments apply to use of a simulator in practicing loss of hydraulic pressure.

3. CONCLUSION

3.1 Introduction

Based on the commander's explanation, the Accident Investigation Board considers it most likely that a technical fault arose in the hydraulic system. If so, the fault occurred during a critical flying phase while the helicopter was in near-hover with a heavy external cargo. Control of the helicopter was lost and the commander did not have time to release the cargo before it hit the ground. When he released the cargo, he regained partial control of the helicopter, just before it hit the ground. The helicopter turned over onto its side and an intense fire started. The commander quickly exited the wreckage without help. Large parts of the helicopter burned up and it has not been possible to find an exact explanation to why the control problems occurred.

3.2 Investigation results

a) The helicopter was registered according to regulations and had valid airworthiness documentation.

b) The weight of the aircraft was 33 kg below the maximum weight and the location of the center of gravity was within limitations.

c) The commander had valid certificates and rating for the helicopter type.

d) The commander had practiced flying the helicopter without hydraulic pressure, but it has not been possible or prudent to train satisfactorily for the situation that arose in the case in question.

e) The commander felt rested and fit to perform the mission in question.

f) The meteorological circumstances had no influence on the course of events.

g) The Accident Investigation Board accepts the commander's explanation that the warning for loss of hydraulic pressure came on, that the helicopter started shaking and that the flight controls became heavy.

h) The commander's statement correlates well with the statements from the two witnesses on the ground at the unloading site.

i) The control problems occurred at a critical flying phase at low speed approx. 60 ft. above ground and with a high rotor load.

j) Major fire damage to the helicopter limited the technical investigations.

k) The Accident Investigation Board has not uncovered technical faults or irregularities in those parts of the aircraft that could be examined, although maintaining the assumption that the helicopter lost hydraulic pressure.

l) When the cargo hit the ground, the helicopter was dragged into a curving descent towards the ground. The commander regained partial control of the helicopter when the load was released, but he could not prevent it from hitting the ground and tipping over onto its side.

m) A fire immediately started in the helicopter, and most of the helicopter burned quickly.

n) The margins were narrow as regards the commander making it out of the wreckage in time.

o) The Accident Investigation Board finds it unlikely that the commander switched off the hydraulic system by mistake.

p) It has not been possible to find an explanation to why the helicopter lost hydraulic pressure.

q) The flight manual's emergency checklist does not give any procedures for dealing with problems that occur with external cargo.

r) An important step in regaining control of the helicopter is to release the external cargo.

4. SAFETY RECOMMENDATIONS

The Accident Investigation Board Norway makes no safety recommendations in connection with this investigation.

The Accident Investigation Board Norway

Lillestrøm, 17. June 2013

APPENDICES

APPENDIX A

RELEVANT ABBREVIATIONS

BKN	BroKeN - weather code for broken clouds
CPL(H)	Commercial Pilot License Helicopter
daN	decanewton (1.0197 kg)
E	east
FT/ft.	Feet - 0.304 m
JAR-FCL	Joint Aviation Requirements – Flight Crew Licensing
KT/kt	Nautical Mile(s) (1852 m) per hour
lb	Pound
M	Minus – weather code for temperatures below 0 °C
N	north
OPC	Operator Proficiency Check
PC	Proficiency Check
P/N	Part Number
RMK	ReMarK – supplementary information in weather codes
AIBN	The Accident Investigation Board Norway
S/N	Serial Number
UTC	Universal Time Coordinated
VFR	Visual Flight Rules
VNE	Never exceed speed
Z	Zulu time (UTC) – universal standard time