Accident
Investigation Board
Norway

Issued November 2018

REPORT SL 2018/10

REPORT ON AIR ACCIDENT AT HØYLAND, HÅ MUNICIPALITY IN ROGALAND 30 APRIL 2016 INVOLVING AIRBUS HELICOPTERS AS 350 B3, LN-OSG

The Accident Investigation Board has compiled this report for the sole purpose of improving flight safety. The object of any investigation is to identify faults or discrepancies which may endanger flight safety, whether or not these are causal factors in the accident, and to make safety recommendations. It is not the Board's task to apportion blame or liability. Use of this report for any other purpose than for flight safety shall be avoided.

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Photos: AIBN and Trond Isaksen/OSL

REPORT ON AIR ACCIDENT AT HØYLAND, HÅ MUNICIPALITY IN ROGALAND 30 APRIL 2016 INVOLVING AIRBUS HELICOPTERS AS 350 B3, LN-OSG

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Date of submission: 13.11.2018
SL Report: 2018/10

This investigation has had a limited scope, and the AIBN has therefore chosen to use a simplified report format. This report format, in accordance with the guidelines given in ICAO Annex 13, is only used when necessitated by the scope of the investigation.

All times given in this report are local time (UTC + 2 hours) unless otherwise stated.

Type of aircraft:	
-Type and registration:	Airbus Helicopters AS 350 B3, LN-OSG
-Year of manufacture:	2011
-Engine:	Turbomeca Arriel 2B1
Operator:	Pegasus Helicopter AS
Radio call sign:	HAK35
Date and time:	Saturday, 30 April 2016 at 1220 hours
Incident location:	On an airstrip at Høyland, Hå municipality in Rogaland
ATS airspace:	Uncontrolled airspace class G
Type of occurrence:	Air accident, loss of control in hover at low altitude after the hydraulic system was inadvertently switched off.
Flight type:	Commercial, proficiency check (PC)
Weather conditions:	METAR ENZV 301020Z 10012KT 9999 FEW012 SCT025 BKN035 08/02 Q1013 TEMPO SHRA=
Light conditions:	Daylight
Flight conditions:	VMC
Flight plan:	VFR
Persons on board:	2
Injuries:	None
Damage to aircraft:	Total loss. Main gearbox and engine assembly displacement, main rotor destroyed, engine and engine compartment fire and tail boom broken.
Other damage	Minor damage to ploughed field.
Commander:	
- Age:	33
- Licence:	PPL(H)
- Pilot experience:	Total: 225 hours, 83 of which on the type in question. Last 90 days: 30 hours, all of which on the type in question. Last 24 hours: 2 hours.

Examiner:	
- Age:	55
- Licence:	CPL(H), FE (H)
- Pilot experience:	Total: 11 500 hours, approx. 5 000 of which on the type in question. Last 90 days: 70 hours, 5 of which on the type in question. Last 24 hours: 2 hours, 0 of which on the type in question.
Sources of information:	"NF-2007 Reporting of accidents and incidents in civil aviation" from the company and Avinor, Pegasus Helicopter AS' internal investigation, as well as AIBN's own investigations.

FACTUAL INFORMATION

History of the flight

The commander was carrying out an annual proficiency check (PC) for the privilege to pilot helicopters of the type AS 350. He had agreed with the examiner to carry out the flight on Saturday morning. He drove to Stavanger Airport Sola (ENZV) and prepared LN-OSG (Preflight) at approx. 0800 hours. The examiner arrived at Sola by air and was met by the commander.

Together they reviewed the exercises that would be included in the proficiency check. This included a simulated loss of hydraulic pressure in hover, which would be carried out by activating the "HYD TEST" pushbutton on the centre pedestal. The point of doing this was to land the helicopter in a controlled manner before the accumulators on the three hydraulic servo actuators that move the swashplate and thereby control the main rotor blades, were emptied. A loss of hydraulic pressure entails that the pilot must use significant force to operate the controls, which is particularly challenging in hover.

LN-OSG took off from Sola at 1200 hours and set course toward an airstrip in Hå municipality. This is directly south of the control zone at Sola. When they arrived in the area in the vicinity of the airstrip, they switched to local radio frequency 123.50 MHz while also listening to the frequency for Sola approach (APP) at 119.60 MHz.

The commander first carried out two simulated engine cuts at low altitude and then undertook a steep approach to the airstrip. Hover was established at an altitude of approx. 1-2 metres above ground. As planned and briefed in advance, the examiner then activated the "HYD TEST" pushbutton. The commander then moved the "HYD OFF" switch on the collective to off, most likely inadvertently. He then immediately switched this back on, most likely in an attempt to correct the error.

The helicopter started rotating to the left, and the examiner assisted by compensation with right pedal input. The helicopter was unstable in the horizontal plane and moved to the left over a field. The examiner said: "My controls", and attempted to gain control over the helicopter. In this phase, he observed that the "HYD OFF" switch was in the normal position, and presumed that the helicopter was experiencing an actual hydraulic failure. The uncontrollable movements were so significant that the main rotor blades impacted the ground and the helicopter's tail boom. The helicopter came to rest on the landing gear and the engine was shut down before the helicopter was evacuated. A fire broke out in the engine compartment.

Damages on the airframe

Three of the main gear box's four suspension bars were torn off when the rotor blades hit the ground. The main rotor blades broke and the aft part of the tail boom was torn off. The main gear box and engine were displaced to the right (see Figure 1).

Figure 1: Scope of damage. Photo: The Police

Damages to engine and dynamic components

The drive shaft between the engine and main gearbox was twisted off and ruptured due to the shock load that occurred when the rotor blades hit the ground. The engine's module 5, the reduction gearbox, ruptured as a result of the accident sequence. The free turbine, which now had no mechanical connection to the drivetrain, quickly accelerated to an RPM where the turbine blades are designed to separate from the blade root, which is where the turbine blade is attached to the turbine disc (see Figure 4). This happens at approx. 150% of the free turbine's RPM (NTL). Figure 2 shows a generic sequence of events when the drive shaft between the engine and main gearbox decouples.

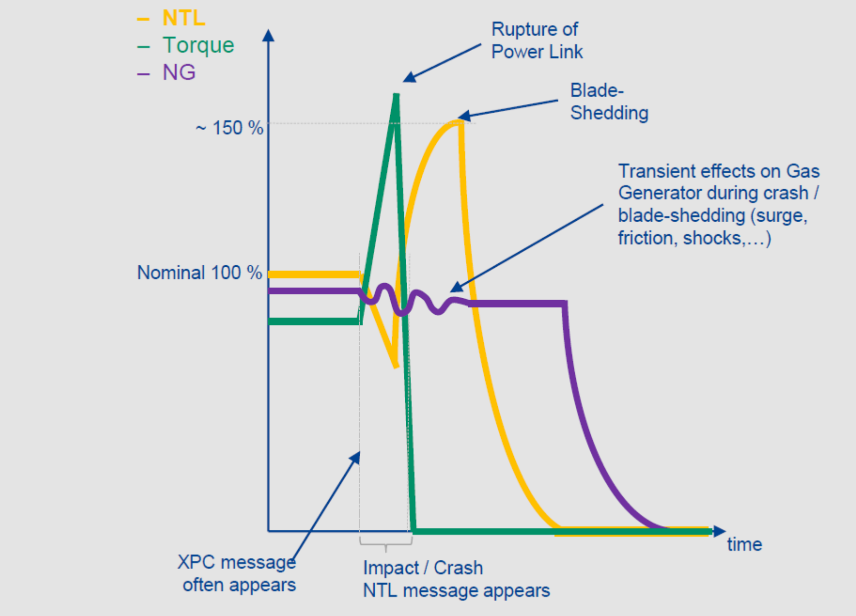

Figure 2: Generic sequence of events when the free turbine disconnects. Source: Safran Helicopter Engines

The consequence of the engine's reduction gearbox rupture was that both sensors that provide the free turbine rotation speed signal (NTL on Figure 2) to the engine's electronic control (DECU) were damaged. Engine parametres are stored in the engine's DECU. These data were extracted and show the engine parameters after the main rotor hit the ground and the tail boom. The data show that the DECU functioned as intended. This means that, in the event of loss of information about the free turbine's RPM (NTL), it stops regulating by freezing the fuel flow at a level corresponding to the power demand at the time the NTL signals were lost. The fuel flow control was transferred to the Engine Back-up Control Ancillary Unit (EBCAU), which aimed to maintain between 100,5% and 103,5% free turbine speed (NTL). The actual fuel flow to the engine on and after the regulation was transferred to the EBCAU is unknown.

LN-OSG – DECU Memories Readout Review

❑ **Context Recordings : Main Findings**

Flight	Crash & Rupture of Power Link			Red "GOV" → DECU freezes HMU's Stepper Motor → Fuel Flow control handed over to EBCAU (neutral position = no)					Engine Stopped	
t (sec)	0	+ 0.7	+ 0.8	+ 2.5	+ 3.1	+ 4.2	+ 4.7	+ 6.3	< 17 sec	
NG (%)	93.9	93.8	91.8	94.2	93.7	100.4	100.3	101.7	4.8	4.7
NTL (%)	56.3	66.2	33.5	34.3	70.4	34.3	70.4	70.4	34.3	70.4
dNTL / dt (%/s)	-181.1	-110.2	20.3	0	0	0	0	0	0	0
T4 (°C)	727	727	700	857	844	1019	956	1012	1019	1020
Torque (daNm)	Max 150			0	0	0	0	0	0	0
Fuel Flow (XR °)	42.9	43.5	43.1	43.1	43.1	43	43.1	43.1	43.1	43.1
Neutral position	yes	yes	yes	no	no	no	no	no	no	no
Message	XPC	XPC NTL	XPC NTL	XPC NTL Torque	XPC NTL Torque	XPC NTL Torque T4	XPC NTL Torque T4	XPC NTL Torque T4	XPC NTL Torque T4 P3_drift / Extinction	XPC NTL Torque T4 P3_drift / Extinction
		1				2			3	

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SAFRAN

Figure 3: Data from DECU. Source: Safran Helicopter Engines

The consequential damage sustained by the engine due to the free turbine blades separation caused hot combustion gases to enter the engine compartment from the still running gas generator, which continued to run after the DECU froze the fuel flow and with the EBCAU trying to maintain 100% NTL.

Fire development

The turbine blades on the free turbine are designed to break off at the blade roots at approx. 150% RPM from the turbine disc and thereby separate from the free turbine wheel (see Figure 4).

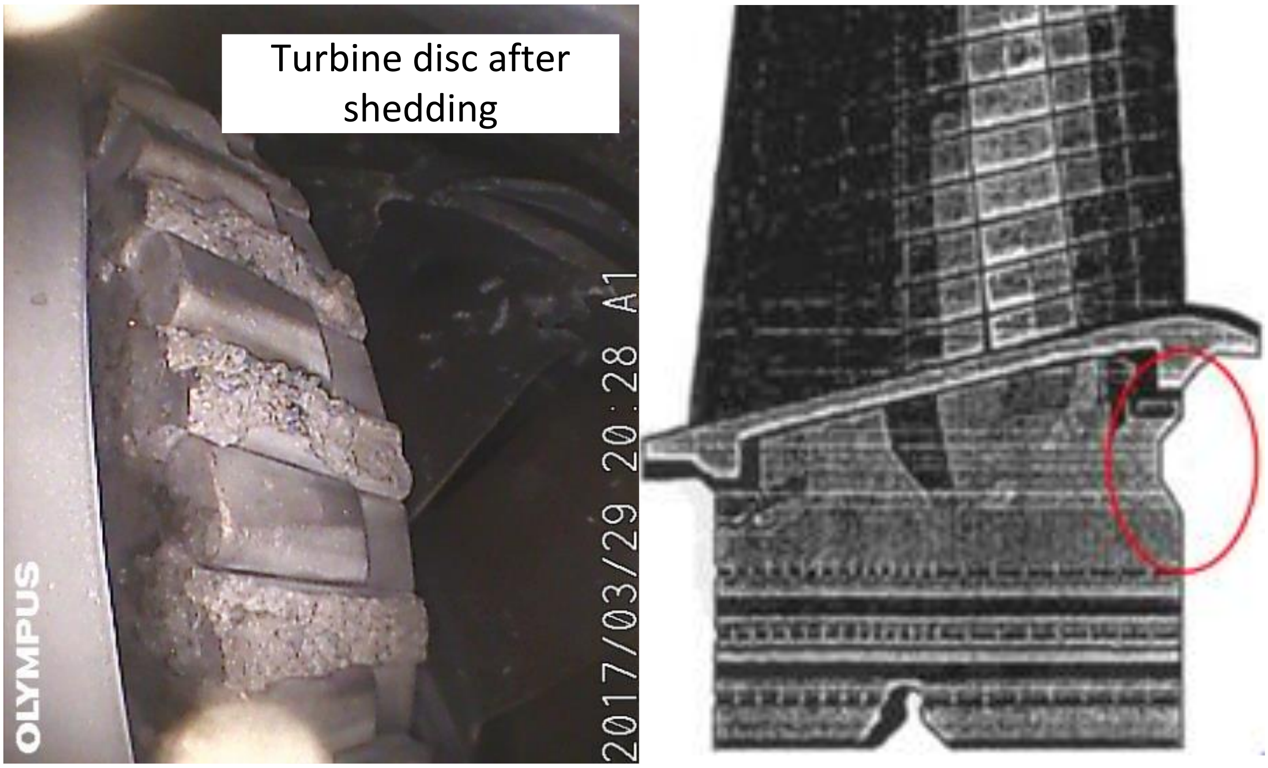

Figure 4: Turbine disc after shedding and turbine blade with designed break point. Photo: Safran Helicopter Engines

The objective of this design is to ensure that the free turbine does not reach an RPM of approx. 170%, which would have resulted in rupture of the turbine disc and causing significantly greater damage due to ejected shrapnel from the turbine wheel. The turbine blade fragments were caught by the engine's "containment shield". Even though the "containment shield" caught the turbine blade fragments, the kinetic energy in the turbine blades caused the turbine casing to deform. This allowed combustion gases at high temperature to escape the engine and enter the engine compartment (see Figure 5).

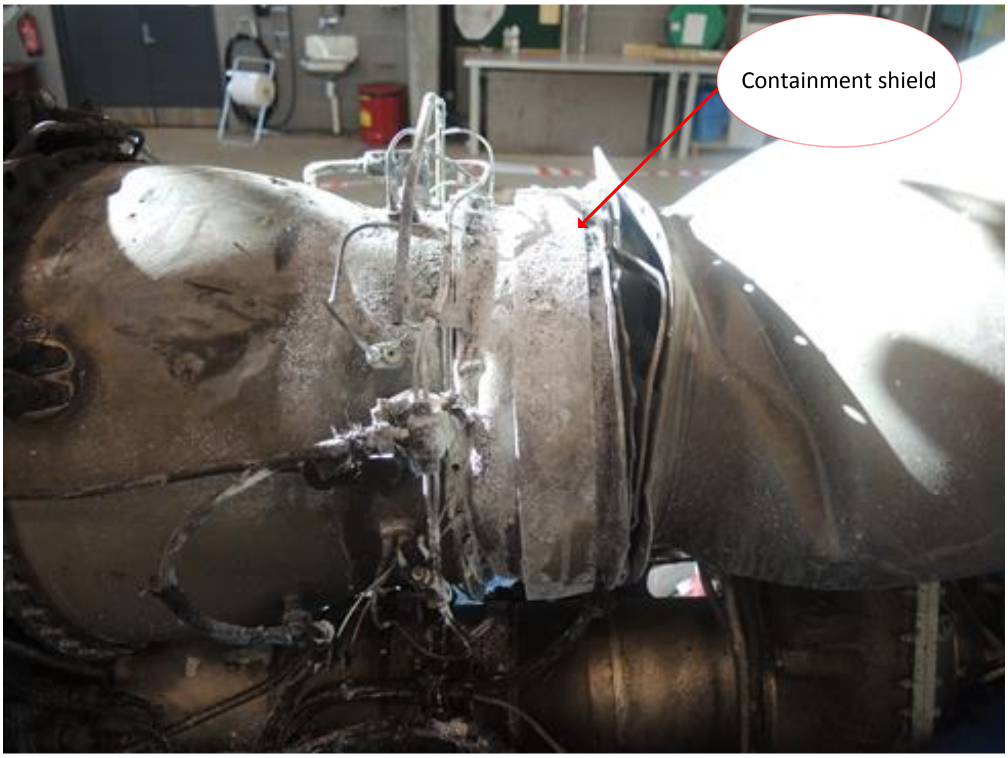

Figure 5: The "containment shield" and deformed turbine casing. Photo: AIBN

The fire that broke out in the engine compartment involved the engine's air intake, which was equipped with an air filter (see Figure 6). The filter material was by design impregnated with oil, and was intended to prevent small particles from accompanying the air stream into the engine. The air intake filter was completely burnt (see Figure 7). The engine itself and its accessories had only minor thermal damage.

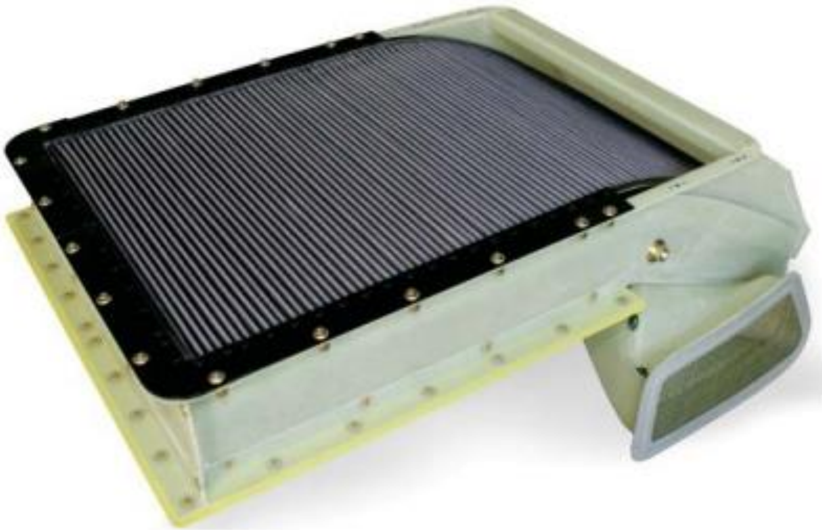

Figure 6: Air intake filter Source: FDC/aerofilter

Figure 7: Engine cowling with incinerated air intake filter. Photo: AIBN

Data from the helicopter's digital fuel control (DECU) show that the engine's gas generator maintained an RPM (NG) of approx. 100% for approx. 6 seconds after the helicopter hit the ground. Thereby it continued to produce hot exhaust gases that escaped into the engine compartment. Interpretation of data from the DECU indicates that the gas generator lost fuel supply after approx. 10 seconds and came to rest after approx. 17 seconds.

The crew noticed the smell of smoke, and brought the cockpit fire extinguisher with them when they evacuated the helicopter. They attempted to put out the fire with the fire extinguisher, which was in vain. Witnesses nearby the accident site assisted with extra fire extinguishers, and gained control over the fire. A fire truck arrived at the accident site approx. 10 minutes later and covered the helicopter in foam.

The hydraulic system

The helicopter's hydraulic system is of the single-circuit type. Three servo actuators move the swashplate and control the main rotor. These servo actuators are equipped with accumulators where the pressure builds up to the hydraulic system's operating pressure after start-up. The tail rotor control is also servo assisted. This servo actuator is equipped with a hydraulic load compensator. This load compensator will permanently assist pedal input if hydraulic pressure is lost. This pressure reserve is intended to allow enough time to secure the flight and to reach the hydraulic failure safety speed (40–60 kts) with hydraulic assistance. At this speed, the helicopter can be manoeuvred without using significant force to move cyclic and collective even if hydraulic pressure is lost.

The hydraulic system has two control switches that can be operated by the pilot.

- Activation of the "HYD TEST" pushbutton (see Figure 8 and detail "A" in Figure 9) entails that the hydraulic oil from the pump is returned to the tank, while the accumulators on the main rotor's servo actuators maintain the accumulated pressure. Hydraulic pressure is lost in both the load compensator, which is part of the tail rotor control system, and the servo actuator for tail rotor control. Removing the pressure from the load compensator means that the pedals can be centred before start-up. While flying, the pedals are "harder" when this switch is activated. The objective of this switch is primarily to check that the flight controls are servo-assisted using accumulator pressure after start-up. This is part of the normal check list for starting up the helicopter. Secondarily, the switch is used during training to simulate loss of pressure from the hydraulic pump.

- There is a control switch (see Figure 8 and detail "B" in Figure 9) on the collective lever for the pilot sitting in the primary position (right side) which, when activated, depressurises the hydraulic system, and opens the return to tank from the servo actuators' accumulators. The pressure in the load compensator in the tail rotor control system is maintained. This means that only manual forces on cyclic and collective control the main rotor. The objective of this switch is to check that the hydraulic system is operational after start-up, and also to be able to switch off the system if there is a hydraulic failure. A hydraulic failure in one of the actuators for controlling the main rotor may result in asymmetric forces on cyclic with subsequent control difficulties.

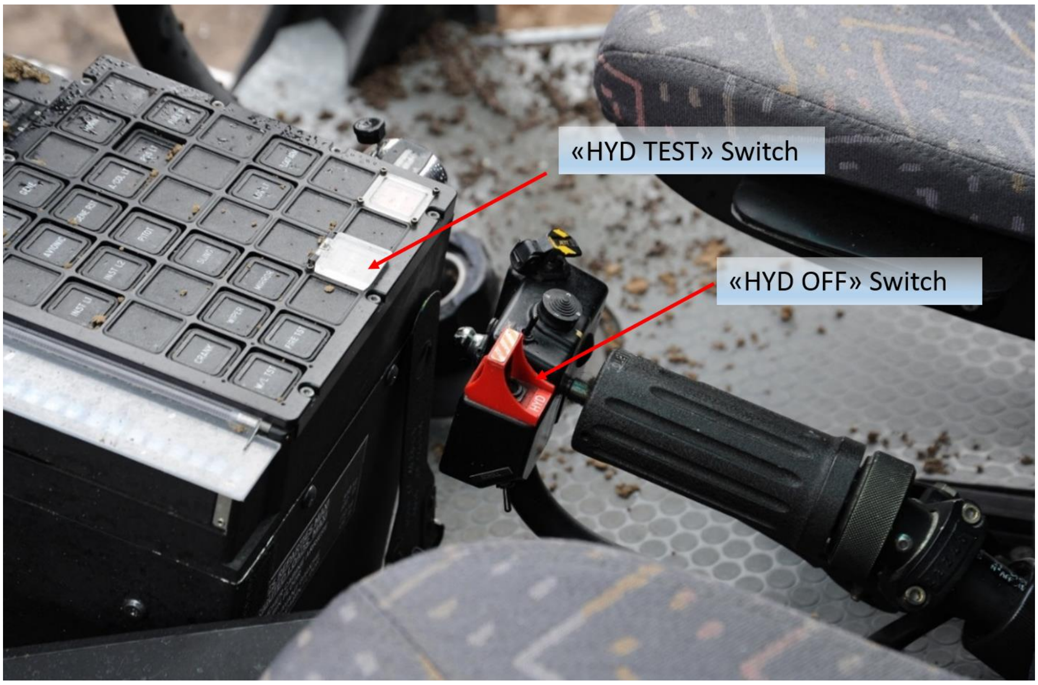

Figure 8: HYD TEST switch on pedestal, and HYD OFF switch with cover on the collective. Photo: AIBN

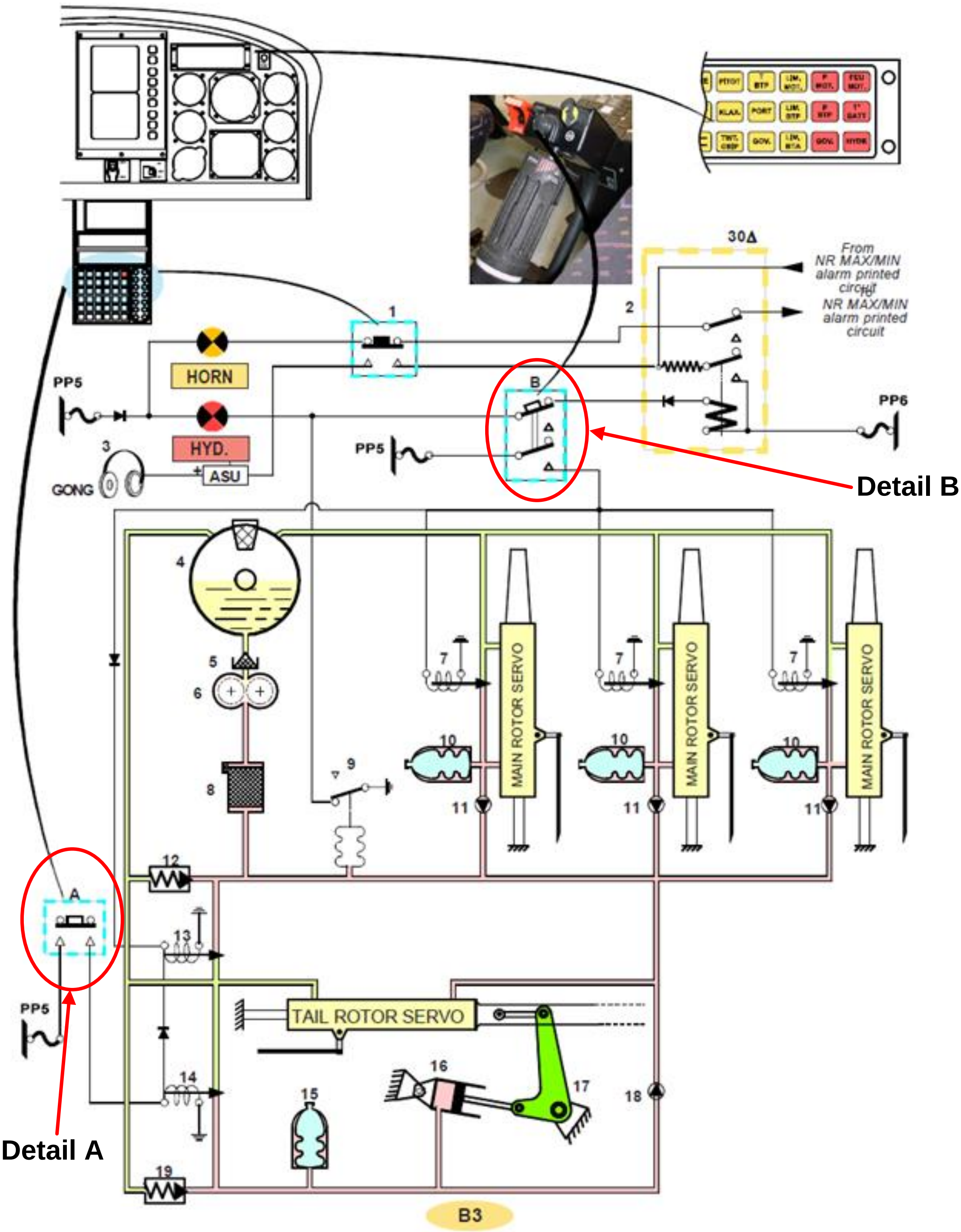

Figure 9: Hydraulic system AS 350 B3. Source: Airbus Helicopters

When the examiner activated the "HYD TEST" pushbutton, and the commander then immediately activated the "HYD OFF" switch, a sequence of events occurred in the helicopter's hydraulic system:

1. Activation of the "HYD TEST" pushbutton depressurised the hydraulic system, while the accumulators on the servo actuators for main rotor control maintained their pressure.

2. The pressure for the servo actuator for tail rotor control was lost.

3. The load compensator in the tail rotor control system lost pressure.

4. The pedals for tail rotor control became "hard".

5. Activation of the "HYD OFF" switch on the collective resulted in immediate pressure loss in the accumulators on the servo actuators for main rotor control.

6. Because the helicopter was in hover, intensity and direction of cyclic and collective control feedback changed rapidly.

The fact that this occurred in hover meant that the margins for correcting the situation were too small. With the "HYD TEST" pushbutton activated, returning the "HYD OFF" switch on the commander's collective to the normal position had no effect. With the "HYD TEST" pushbutton activated, oil from the hydraulic pump was returned to the tank regardless of the position of the "HYD OFF" switch.

Limitations laid out in Airbus Helicopters' operational documentation

Flight Manual

Airbus Helicopters Flight Manual Supplement 7 "Hydraulic Failure Training Procedure" says that the hydraulic failure simulation has to be performed (initial condition) from a "steady cruise flight condition" as indicated in the "STEP 1: FAILURE SIMULATION" of the Supplement 7 of the Flight Manual. There is no hydraulic off simulation procedure for a hover situation.

Other documentation

In order to bring practical support to the good understanding of the hydraulic off training procedure Airbus Helicopters has developed a specific video filmed in the cockpit of an AS 350 B3e equipped with a single hydraulic system. This video identifies the different steps of the procedure and highlights on the mistakes/errors to avoid. The video is applicable for all AS 350/550 equipped with a single hydraulic system.

EASA Safety information Bulletin 2018-13 issued 4 September 2018 and Airbus Helicopters Safety information Notice No. 3246-S-29 issued 9 July 2018 explains the reason for this video. The Airbus Safety Information Notice also contains a link to the video and introduces an amendment of the Flight Manual (Section 4, supplement 7).

Proficiency Check (PC)

A PC is intended to verify a pilot's ability and knowledge to operate a helicopter type. This is an annual check which is implemented under the auspices of an examiner appointed by the Norwegian Civil Aviation Authority (NCAA). A passed PC yields an annual extension of licence rights for the helicopter type. The NCAA entitles the individual examiner to carry out PCs, and an overview of approved examiners can be found on the NCAA's website.

Examiners working in organizations that do not operate the aircraft/helicopter type on which a PC shall be performed, must make sure to access updated operational documentation. The organization where the PC shall be performed must provide the examiner with the necessary documents.

THE ASSESSMENTS OF THE ACCIDENT INVESTIGATION BOARD

In this accident, the helicopter was operated outside the limitations given in the documentation from the helicopter manufacturer. The failure simulation was initiated from a hover flight condition instead of a steady cruise flight condition as described in the Supplement 7 in the flight manual. In addition the "HYD OFF" switch on the collective was inadvertently set to "OFF" immediately after "HYD TEST" pushbutton was depressed (activated) when the helicopter was in hover. This resulted in total loss of hydraulic assistance with subsequent loss of control.

In this case, an external examiner was used to perform the PC. This examiner was employed in an organisation that did not operate this type of helicopter. However, he was well familiar with the type from former employments in organisations operating AS 350 B3 helicopters. Being pilot in a company that does not operate the helicopter type, means that accessibility to operational documentation issued by the manufacturer not necessarily easily available. Examiners have to ensure that they have updated information available when preparing for a skill test. The organisation where the skill test is to be performed should also check if the examiner is updated on the helicopter type’s operational procedures.

This accident occurred with relatively small impact forces. The cabin section was intact, and the helicopter remained upright on its landing gear when everything came to rest. A fire nevertheless broke out due to the consequential damage that occurred. In this instance, the crew on board were physically unharmed, and evacuated the helicopter on their own. Had the crew been injured in such a manner that they were not able to exit the helicopter, the outcome of the accident could have had more serious consequences.

After this accident, a Safety Information Notice that highlights the challenges related to hydraulic failure training has been issued by Airbus Helicopters. Therefore, AIBN does not see the necessity of issuing a safety recommendation covering this topic.

AIBN issues two safety recommendations related to the situation where hot combustion gas leaked out from the still running engine after the helicopter came to a standstill, with a consequential fire.

Airbus Helicopters/Safran Helicopter Engines are requested to study and propose technical solutions with the purpose of reducing the risk of fire in situations where engine is still running after the free turbine has separated and the NTL signal is lost.

In case the manufacturers proposes any modifications with the purpose of reducing this risk, EASA is requested to follow up and make such modifications mandatory.

SAFETY RECOMMENDATIONS

The following safety recommendations were made by the Accident Investigation Board:[1]

Safety recommendation SL No 2018/13T

On 30 April 2016, the AS 350 B3, LN-OSG was subject to an uncontrolled landing which caused the main rotor blades to hit the ground and into the helicopter's tailboom. The engine continued to run after the free turbine had thrown its turbine blades. The turbine blades were thrown after the engine's reduction gearbox ruptured and the free turbine was decoupled and accelerated beyond the speed it was designed to withstand. The consequence of this was that hot exhaust gases escaped from the engine into the engine compartment and there was a fire.

The Accident Investigation Board Norway recommends Airbus Helicopters, in cooperation with Safran Helicopter Engines to study technical solutions for AS 350 helicopters equipped with Arriel 2 engines, as well as other Airbus helicopter types with similar Arriel engine installations. The purpose of this study should be to find ways of reducing the risk of fire following accidents where the free turbine blades have shedded.

Safety recommendation SL No 2018/14T

On 30 April 2016, the AS 350 B3, LN-OSG was subject to an uncontrolled landing which caused the main rotor blades to hit the ground and into the helicopter's tailboom. The engine continued to run after the free turbine had thrown its turbine blades. The turbine blades were thrown after the engine's reduction gearbox ruptured and the free turbine was decoupled and accelerated beyond the speed it was designed to withstand. The consequence of this was that hot exhaust gases escaped from the engine into the engine compartment and there was a fire.

The Accident Investigation Board Norway recommends that EASA study the opportunity to mandate the solutions developed by Airbus Helicopters in cooperation with Safran Helicopter Engines.

Accident Investigation Board Norway

Lillestrøm, 13 November 2018

[1] The Ministry of Transport and Communications forwards safety recommendations to the Norwegian Civil Aviation Authority and/or other involved ministries for evaluation and monitoring, see Norwegian Regulations regarding public investigations of accidents and incidents in civil aviation, § 8.