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Aircraft accident investigation bureau AAIB

Final Report No. 1920 by the Aircraft Accident Investigation Bureau

concerning the accident

to the helicopter Agusta Bell AB206B Jet Ranger III, HB-XUW

on 9 August 2003

in Rotgrueb/Chäshalten, municipality of Rümlang/ZH,

approx. 2.5 km SW of Zurich Airport

Bundeshaus Nord, CH-3003 Berne

Ursachen

Der Unfall ist darauf zurückzuführen, dass die Luftsteuerleitung zwischen *fuel control unit* und *accumulator* undicht war. Daraufhin verlor das Triebwerk des Helikopters Leistung. Der Pilot musste eine Notlandung durchführen, bei welcher der Helikopter beschädigt wurde.

General Information on this Report

This report contains conclusions by the AAIB on the circumstances and causes of the accident which is the subject of the investigation.

In accordance with Annex 13 of the Convention on International Civil Aviation of 7 December 1944 and article 24 of the Federal Air Navigation Law, the sole purpose of the investigation of an aircraft accident or serious incident is to prevent future accidents or serious incidents. The legal assessment of accident/serious incident causes and circumstances is expressly no concern of the investigation. It is therefore not the purpose of this investigation to determine blame or clarify questions of liability.

If this report is used for purposes other than accident prevention, due consideration shall be given to this circumstance.

The definitive version of this report is the original in the German language.

Unless otherwise indicated, all times in this report follow the universal time co-ordinated (UTC) format. At the time of the accident, Central European Summer Time (CEST) applied as local time (LT) in Switzerland. The relation between LT, CEST and UTC is: LT = CEST = UTC + 2 h.

For reasons of protection of privacy, the masculine form is used in this report for all natural persons, regardless of their gender.

Final Report

Owner	BB Heli AG, 8172 Niederglatt, Switzerland
Keeper	BB Heli AG, 8172 Niederglatt, Switzerland
Aircraft type	Helicopter Agusta Bell AB206B Jet Ranger III
Country of manufacturer	Italy
Country of registration	Switzerland
Registration	HB-XUW
Location	Rotgrueb/Chäshalten, municipality of Rümlang/ZH
Date and time	9 August 2003 at 13:45 UTC

General

Brief description

On the afternoon of 9 August 2003, the Agusta Bell AB206B Jet Ranger III helicopter, HB-XUW, was on a private local flight, departing from and returning to Zurich Airport. During the flight over VFR Route 2, engine problems developed. The pilot decided to make an emergency landing. When setting the helicopter down and during the subsequent slide on a meadow, the main rotor severed the tail rotor drive shaft. All three occupants were able to exit the helicopter uninjured.

Investigation

The accident took place on 9 August 2003 at 13:45 UTC. 'Zurich Tower' aerodrome control raised the alarm, upon which the aerodrome fire-fighting services were called to the site of the accident, approximately 2.5 kilometres from their base.

The AAIB investigator arrived at the site of the accident at 16:30 UTC and opened the investigation.

1 History

1.1 Pre-flight history and history of the flight

1.1.1 Pre-flight history

The type Agusta Bell AB206B helicopter registration HB-XUW was used by the BB Heli AG company as a charter and training helicopter as well as for commercial use. The pilot reserved the helicopter, based on Zurich Airport, a few days before the flight involved in the accident. He intended making a local flight with an acquaintance and a child on board. On Saturday 9 August he took over helicopter HB-XUW at the helipad east. The pilot who had been flying HB-XUW before handed over the helicopter to him with the engine running. According to the statement of the pilot involved in the accident, at the time of the hand-over there were approximately 30 USG of fuel on board.

1.1.2 History of the flight

The pilot received clearance to leave CTR Zurich via departure route 4 (Dübendorf). He then flew over the Pfannenstielkette, Lake Zurich and the Albiskette towards the Bremgarten area. On this flight path the passenger wanted to view his place of work on the Üetliberg tunnel construction site. Subsequent to this request, the pilot received clearance from Zurich TWR aerodrome control to fly into CTR Zurich via arrival route 2 via Gasometer and Katzensee. He passed Gasometer at about 3500 ft and began to descend direction Katzensee, where he arrived at approximately 2500 – 3000 ft. The pilot received the instruction to approach the helipad east. The pilot describes the subsequent history of the flight as follows:

Now the helicopter began to shake all at once, and at about the same time the yellow low rotor RPM warning lamp lit up. I can't say any longer whether an audio warning sounded. As a reaction, I immediately initiated a fast descent, in order to build up speed again, and lowered the collective, upon which the warning went out. I checked whether the twist grip was fully open; it was. After the low rotor rpm lamp went out, I thought that maybe everything would be back to normal now, but when I pulled on the collective blade adjustment lever again the low rotor rpm warning lit up again immediately and in addition I felt strong vibrations. I decided on an autorotation in the direction of the fields which were in front of me on the right. I can no longer recall any speeds during the autorotation. In view of the height which was still available, I didn't carry out a classic rotation with a flare, but almost a normal approach; I did carry out a flare over the last few metres. Touchdown was certainly harder than for a normal landing, but actually it wasn't so bad."

The passenger sitting in front perceived the situation as follows: *"All at once, the nose of the helicopter dropped suddenly. I can't say with any certainty but I can't remember any warning, either audio or visual."*

Once the helicopter had come to a standstill on its skids, the pilot noted that the engine was still running. He used the twist grip to bring the rpm back to idle and then tried to accelerate the engine again; he got the impression that the engine was incapable of running up properly and was threatening to shut down. He then allowed the engine to idle for a short time to cool down before shutting it down.

The pilot also stated: *" ... Over the entire sequence, I saw the red (engine out) lamp once or twice."*

According to the tracks on the ground and the marks on the tail rotor guard, the helicopter came into contact with the ground in a "nose-up" attitude and expended its residual forward motion by slipping and sliding for a few metres on the dry terrain. Strong deceleration forces occurred in the course of this procedure.

On leaving the helicopter, the pilot saw that the main rotor was still turning, but that the tail rotor was not moving.

All the occupants were able to exit the helicopter, standing on its skids, normally and uninjured.

1.2 Injuries to persons

	Crew	Passengers	Third parties
Fatally injured	---	---	---
Seriously injured	---	---	---
Slightly injured or uninjured	1	2	

1.3 Damage to the aircraft

Both main rotor blades severed the tail rotor drive shaft which ran along the top of the tailboom; the tailboom was buckled during the hard landing.

1.4 Damage to third parties

Slight damage to the terrain.

1.5 Information on persons

1.5.1 Pilot

Person	Swiss citizen, born 1964
Licence	PPL (H), first issued in Switzerland on 13.06.1997
Ratings	RTI (VFR)
Helicopter type	B 206 / 206L, EC120B
Medical fitness certificate	Class 2
Last medical examination	05.10.2001, findings: fit, without limitations
Flying experience	150:59 hours total on helicopters
on the accident type	Approx. 70 hours
during the last 90 days	11:53 hours, all on the accident type

The pilot began his pilot's training on fixed-wing aircraft. He acquired his PPL(A) in July 1994. The SEP(L) rating to fly single-engined aircraft was valid at the time of the accident.

1.6 Information on the aircraft

1.6.1 General

Type	Agusta Bell AB206B Jet Ranger III
Manufacturer	Giovanni Agusta SPA, Italy
Registration	HB-XUW
Characteristics	Helicopter with semi-rigid two-blade main rotor and turbine drive
Year of construction/ serial number	1990/8722
Engine	Allison 250-C20J turbine engine
Certification	VFR day and night, departure with helicopters in ground fog and high fog
Certification in commercial use	VFR by day
Operating hours	3634:26 hours
Airworthiness certificate	Standard category, issued by the Federal Office for Civil Aviation on 16.03.1995

1.6.2 Engine

Serial number	CAE-270 367
Operating time from new	3634:26 hours
Operating time since overhaul	135:17 hours
Operating time since installation	135:17 hours

1.6.3 Mass and centre of gravity

The mass and centre of gravity were within the permitted range.

1.6.4 Maintenance

The Allison 250 PN250-C20J/SN CAE-270367 engine fitted to the helicopter was repaired and overhauled by the Standard Aero Canada company.

Subsequently, between 26.02 and 01.04.2003 it was fitted to HB-XUW by the Ben Air Helicopter-Service AG company. At this time the helicopter's total flying time was 3499:09 hours.

At 3554:37 hours, the 1500-hour inspection was carried out on HB-XUW between 02.06 and 19.06.2003 on the premises of Ben Air Helicopter-Service AG. During this work, various dynamic components were disassembled, overhauled or inspected and then re-fitted. These components were removed and re-fitted at Ben Air Helicopter-Service AG. Parts such as the main rotor mast, main rotor gearbox, free-wheel clutch and main drive shaft were inspected and overhauled by SwissHelicopter Maintenance. On conclusion of this work, a ground test run and a test flight were carried out.

At 3570:20 hours, according to the component card, the PT-governor was replaced on 26.06.2003 on the premises of Ben Air Helicopter-Service AG.

At 3605:31 hours, a 100-hour inspection on the airframe and engine of HB-XUW was carried out between 15 and 18 July 2003 on the premises of Ben Air Helicopter-Service AG.

1.7 Meteorological information

1.7.1 General

The information in sections 1.7.2 and 1.7.3 was provided by MeteoSwiss.

1.7.2 General weather situation

Switzerland was affected by a uniform area of high-pressure. At altitude, slightly moister air was being drawn in, enabling cumulo-nimbus cloud to form in the afternoon.

1.7.3 Weather at the time and location of the accident

The following information on the weather at the time and location of the accident is based on a spatial and chronological interpolation of the observations of different weather stations.

Cloud	1-2/8 CB at 7500 ft/AMSL,	
	1-2/8 SC at 8500 ft/AMSL, above: 6/8 cirrus	
Weather	-	
Visibility	22 km	
Wind	at 1416 ft/AMSL variable at 3 knots	
	at 2100 ft/AMSL north-north-west at 2 knots	
	at 2800 ft/AMSL north-north-west at 2 knots	
Temperature/dewpoint	35 °C / 9 °C	
Atmospheric pressure	QNH LSZH 1020 hPa	
Hazards	None	
Density altitude	2212 ft AMSL	
Position of the sun	Azimuth: 232°	Elevation: 48°

1.8 Ground navigation equipment

Not applicable.

1.9 Communication

In the course of the autorotation, the pilot informed Zurich TWR aerodrome control about the impending emergency landing outside the airport area. Both during the autorotation descent and after the landing, the pilot was asked by Zurich TWR aerodrome control whether he needed assistance, but he said that he did not: "*Do you need assistance?" "Negative"*.

The helicopter was fitted with an ELT, which was not triggered by the landing.

1.10 Airport installations

Not applicable.

1.11 Flight recorders

Not present; not prescribed.

1.12 Information on the site of the accident and the damaged helicopter

1.12.1 The site of the accident

The field chosen by the pilot for the autorotation was on a level above the general terrain. The area was level and overgrown with stubbly, dry grass. This field could be approached from virtually all directions. A telephone line and a power line restricted the possible approach directions only slightly.

Coordinates: 682 175 / 254 855

1.12.2 The damaged helicopter

The only external damage to the helicopter which was highly visible was the severed tail rotor drive shaft panelling on the top of the tailboom. The tail rotor drive shaft, running underneath this panelling, was severed. Both ends of the main rotor blades were slightly damaged; signs of buckling were visible at the transition from the fuselage to the tailboom. The tail rotor guard showed clear traces of abrasion. The plate around the pin fitted underneath the main rotor gearbox showed distinct signs of impact.

1.12.2.1 Findings at the site of the accident at the time of recovery

1.12.2.1.1 Tank contents

On the occasion of the first inventory at the site of the accident, the tank contents display came to rest several times at approximately 4 USG. After a few further power-on procedures (battery ON-OFF-ON), the tank display showed approximately 20 USG. The investigator drained off 23 litres of fuel at the site of the accident. After the helicopter was recovered, the remaining quantity was determined on the maintenance company's premises; a further 55 litres could be drained off. In total, therefore, there were approximately 78 litres in the tank. The indication of approximately 20 USG was correct.

1.13 Medical findings

There is no indication that the pilot was under the influence of alcohol or pharmaceuticals.

1.14 Fire

Fire did not break out.

1.15 Possibilities of survival

1.15.1 Survivability of the accident

In the course of the emergency landing/autorotation, the pilot was able to reduce both the vertical and horizontal speed of the helicopter to such an extent that no forces harmful to the health of the occupants resulted.

1.15.2 Raising of the alarm and rescue

The ZRH Tower aerodrome controller raised the alarm, upon which the airport fire-fighting services were called out to the site of the accident and arrived there a few minutes after the helicopter had come to a standstill.

1.16 Tests and research results

1.16.1 Engine investigations

After the helicopter had been recovered, the following tasks were performed (extract from the work report):

"Task to be performed	***Task performed***
Determine remaining fuel in tank	*Rear pump empty at 45 litres* *Both pumps empty after 55 litres*
Check fuel filter for residues	*Airframe side filter normal, engine fuel filter exhibits black particles*
Check fuel boost pump for function	*Rear pump: 12 PSI* *(with stationary engine 28V APU voltage)* *Front pump: 10 PSI*
Check all fuel control tubes for leaks	*1 tube on fuel control loose (tube from accumulator)*
Check engine for metal particles	*No metal particles on magnetic plug*
Check engine for external damage	*No damage present"*

On the basis of finding '1 tube on fuel control loose' (tube from accumulator), the engine was bench-tested by a specialist company.

On 18 September 2003, in the presence of the investigator, a static test was carried out on the test bench, during which the operation of the engine and the delivered power was measured.

Extract from the test report:

"Summary

On engine receipt at (maintenance company), an inspection was carried out of the external condition and the engine log book was surveyed. The following anomalies were noted:

- *The Compressor, Turbine and Accessory Gearbox modules found fitted were not recorded in the engine log book Assembly Record cards (Part V) although the correct module log cards were in the engine log book. No reference was made in the Engine log book when these modules were installed, no reference was made on the module log cards stating which engine they were installed on, and when they were installed.*
- *Pneumatic air tube (Pt No 6877277) "B" nut (see Annex 1) between accumulator and Fuel Control Unit was found to be loose at the FCU connection. Air leak found at this point during receipt pneumatic test. Torque slippage paint previously applied to "B" nut found to be incorrect for torque loading required.*
- *Pneumatic air tube (Pt No 230546628) between Compressor scroll and PC air filter was found to be installed incorrectly (PC air filter strengthened end "B" nut installed at scroll) This tube is marked "PC filter this end" at the "B" nut.*

The engine test consisted of three phases:

Phase 1:

The engine was tested with the pneumatic air tube between the accumulator and the Fuel Control Unit correctly fitted and torque loaded. This was to prevent any possible high lightoff temperatures during start.

The engine started correctly and was taken up to maximum condition (100% N1 +N2) and stabilized for 2 minutes. No anomalies were detected with an observed and uncorrected 429 shaft horse power being produced.

The engine was retarded to normal cruise setting with no anomalies detected.

Phase 2:

Whilst the engine was running in the Normal Cruise setting, the "B" nut of Tube Pt No 6877277 (Accumulator to Fuel Control) was loosen sufficiently to align the torque slippage paint (original received leaking position). The engine instantly lost approx. 100 degree Celsius and 64 SHP. With the "B" nut still loose, the engine was taken up to maximum conditions and achieved 420 SHP (-9 SHP from 1st plot). The engine was retarded to normal cruise settings.

Phase 3:

With the engine running at normal cruise setting with the "B" nut still loose, tube Pt No 6877277 (Accumulator to Fuel Control) was moved by hand to simulate normal vibration and ram air effect that would be encountered with the engine installed in an aircraft. On moving the tube, the engine instantly lost power to an extent that a flame out occurred and the engine shut down."

2 Analysis

2.1 Technical aspects

2.1.1 Engine

When the engine was dismantled, it was found that the “B” nut on the control tube between the accumulator and the fuel control unit was not correctly tightened at the latter. The torque paint (slippage mark), which is applied after tightening to the correct torque, had shifted approximately 30° in the ‘loose’ direction. When installed correctly, this connection is airtight. A leak may occur at this connection under a corresponding mechanical load, such as occurs in turbulence or in alternating airflow conditions within the engine compartment. This leads to a reduced pneumatic signal to the fuel control unit and hence to a reduction in power.

It was possible to recreate this situation on the engine test bench. In the absence of vibrations, the engine produced the output values according to specification or better. However, as soon as artificially generated vibrations occurred the leak became apparent, upon which the engine’s power was reduced by the fuel control unit. On the test bench, the engine shut down during such a simulated situation.

2.1.2 Maintenance

It is known that leaking tubes in the fuel control system can interfere with this complex control circuit. Rolls Royce, the engine manufacturer who produces the Allison 250 engines, writes as follows in the ‘list of warnings’ on this topic:

“Proper tightening of engine tubing connections is critical to flight safety. Correct torque values must be used at all times. Excessive torque on pneumatic sensing system connections results in cracking of the flare or adjacent tube area in contact with the ferrule. This produces an air leak which can cause flameout, power loss, or overspeed.

Torque paint (slippage marks) shall be applied to all rigid tube B-nuts in accordance with rigid tube installation procedures. Torque paint shall be removed and reapplied anytime the B-nut is retightened.

Tubing B-nuts used in installations exposed to a high degree of vibration and pressure surges are subject to torque relaxation when improperly tightened.”

In particular, the construction used on the Allison 250 engines, with the above-mentioned “B” nuts must not be fitted skewed, nor must the tube with the screwed connection be subjected to mechanical strain. In addition, the correct torque values must be applied for the installation of these “B” nuts. During each check, and whenever a tube is disturbed at one end, both ends of the tube as well as strain-free installation must be checked. New torque paint markings (slippage marks) is always required in such cases.

Last 100-hour check before the accident

The PT-governor on HB-XUW was replaced on 26 June 2003. When this task is performed, the connecting tube between the accumulator and the fuel control unit must have been disturbed. It would subsequently have had to be refitted correctly and new torque paint (slippage marks) applied.

The last 100-hour check before the accident was completed on 18 July 2003, i.e. about 3 weeks before the accident. HB-XUW flew 28:55 hours between this check and the accident. It must remain an open question whether the "B" nut which was loose at the time of the accident had slowly worked loose during operation since the PT-governor was replaced or whether the torque paint markings (slippage marks) was checked at the time of the 100-hour check on 18 July 2003.

2.2 Human and operational aspects

During the descent after passing the Katzensee reporting point, the first irregularity the pilot noticed was a shaking, and at about the same time he noticed the 'ROTOR LOW RPM' warning. These symptoms may have been caused by power fluctuations due to the leak in the tube between the fuel control unit (FCU) and the accumulator.

The pilot's reaction of dropping the helicopter's nose in the event of an engine failure must have originated as a trained reflex from his experience with fixed-wing aircraft. This reaction is fundamentally incorrect in the case of an engine failure on a single-engined helicopter. However, by considerably lowering the collective lever, he did prevent the speed falling below the permissible limit.

After the pilot took the correct decision to initiate an autorotation, the latter was not implemented consistently. His statement that he did not want to carry out a classic autorotation but that he did want to initiate a flare at the last moment creates confusion and confirms his uncertainty.

On the basis of the pilot's description, it can be assumed that this autorotation was executed without further consequences only due to the forgiving autorotation characteristics of the Jet Ranger helicopter type and the favourable terrain.

3 Conclusions

3.1 Findings

- The pilot held a private pilot's helicopter licence with endorsed helicopter B 206/206L, issued by the FOCA.
- The pilot held a private pilot's licence for fixed-wing aircraft with a rating for single-engined land-based aircraft.
- There are no indications of any health problems of the pilot during the flight involved in the accident.
- The aircraft was licensed for transport.
- The weight and centre of gravity at the time of the accident were within the prescribed limits.
- One of the B-nuts of the pneumatic tube between the fuel control unit and the accumulator was not correctly tightened and therefore the pneumatic tube was not airtight.
- This leak led to a reduction in power controlled by the fuel control unit.
- The engine behaviour exhibited during a static test essentially corresponds to that described by the pilot.
- The engine power fluctuations led the pilot to the decision to carry out an autorotation.
- The autorotation procedure led to a reduction in vertical and horizontal speed which prevented injuries to the occupants but still allowed damage to the helicopter.
- The prevailing weather conditions had no influence on the occurrence of the accident.

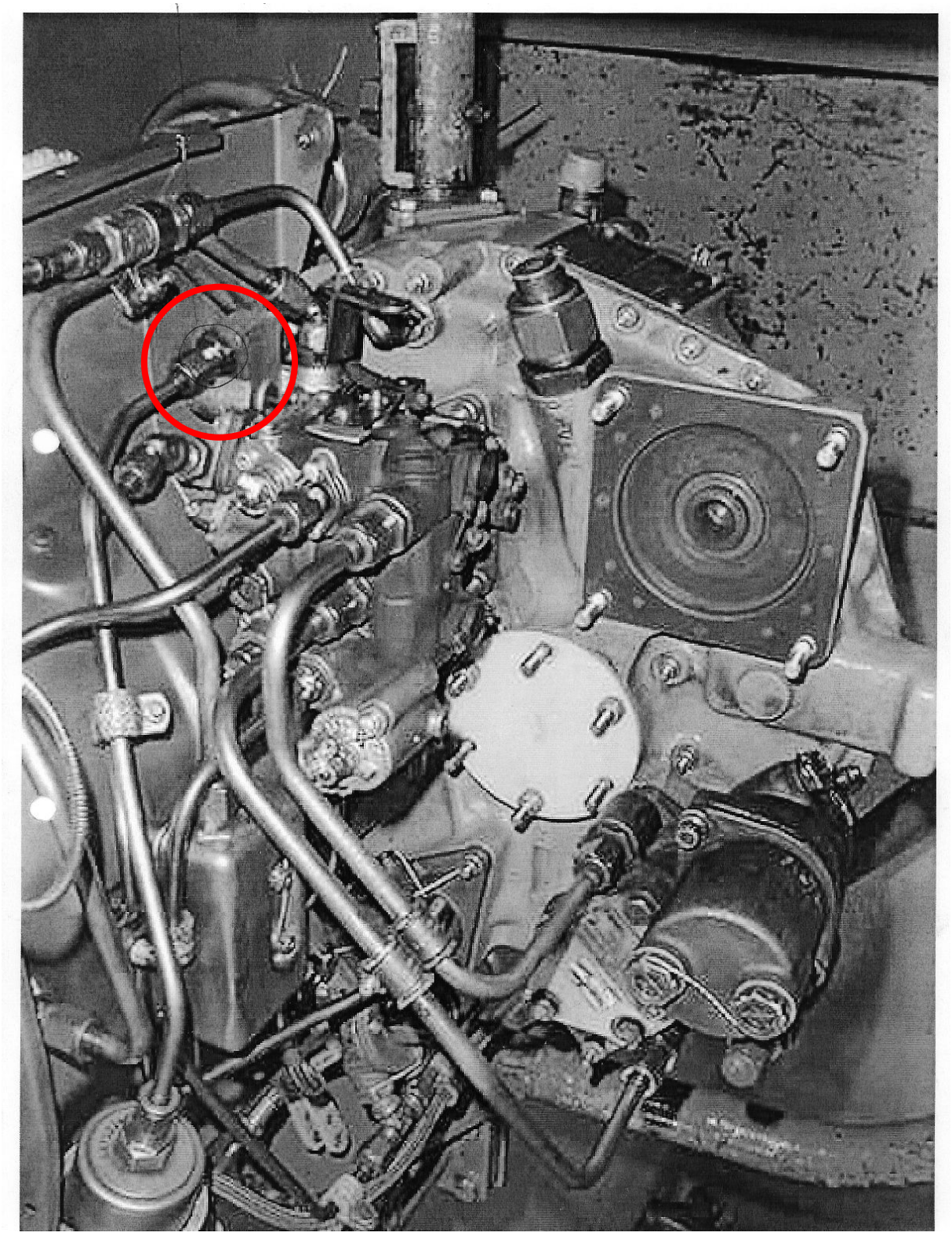
3.2 Causes

The accident is attributable to the fact that the pneumatic tube between the fuel control unit and the accumulator was leaking. The helicopter's engine subsequently lost power. The pilot had to make an emergency landing, during which the helicopter was damaged.

Berne, 25 October 2006 Aircraft Accident Investigation Bureau

Annexes

Annex 1 "B" nut on the pneumatic tube between the accumulator and the fuel control unit, FCU side



Annex 2 Torque paint (slippage marks) on the “B” nut after tightening to the correct torque value