Accident
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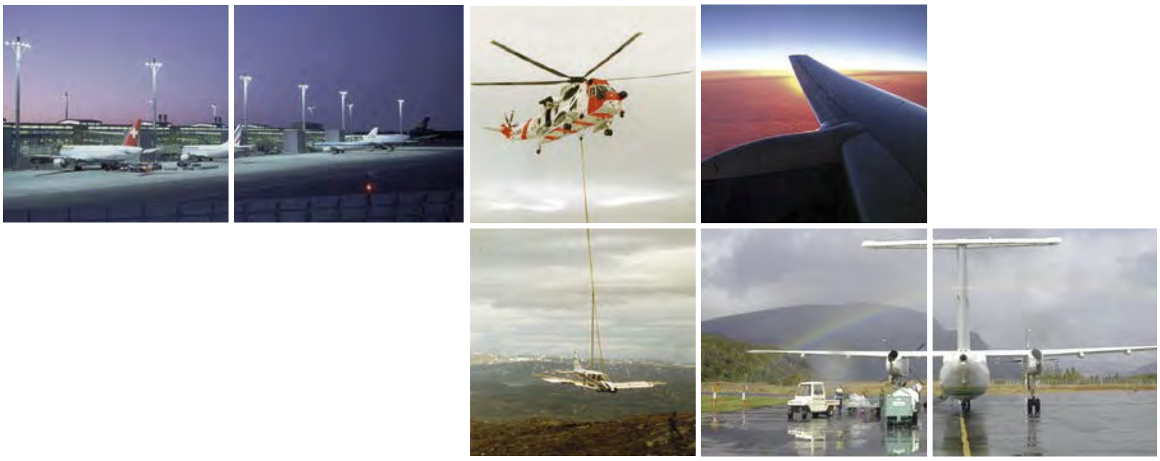

REPORT ON AIR ACCIDENT AT SKJELBREIA IN SKI, AKERSHUS ON 2 APRIL 2009 WITH DIAMOND DA40-D, LN-NEX

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 casual 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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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.

CONTENTS

AIR ACCIDENT REPORT

Aircraft:	Diamond Aircraft Industries GmbH DA40-D
Nationality and registration:	Norwegian, LN-NEX
Owner:	Oslo Flyveklubb, Norway
User:	Same as owner
Accident site:	Skjelbreia in Ski, Akershus County Position N59° 49,278’ E010° 56,972’
Accident time:	Thursday, 2 April 2009 at 1215 hours

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

NOTIFICATION

On Thursday, 2 April at 1305 hours the Accident Investigation Board Norway (AIBN) was notified by the Joint Rescue Coordination Centre for Southern Norway (JRCC-SN) that LN-NEX had encountered engine problems and made a forced landing in Østmarka at northern part of Follo. It was furthermore stated that the two persons on board were found uninjured and had been flown to the hospital by a Sea King from the rescue service.

The AIBN dispatched three inspectors and began the investigation at the accident site that same afternoon. In accordance with ICAO Annex 13, notification of the accident was sent to Bundesanstalt für Verkehr – Fachbereich Luftfahrt (UUB/LF), which is the air accident investigation authority in Austria where the aircraft was manufactured. Notification was also sent to Bundesstelle für Flugunfalluntersuchung (BFU), which is the air accident investigation authority in Germany where the engine and propeller were manufactured. BFU appointed an accredited representative, who together with advisers from the engine manufacturer Thielert Aircraft Engines GmbH (TAE), have assisted the AIBN with the investigation. The European Aviation Safety Agency (EASA) was also informed.

SUMMARY

While practicing steep turns at 2 000 feet in connection with pilot training, all thrust from the propeller was suddenly lost. The aircraft made a forced landing on the ice-covered lake Skjelbreia. At the end of the run after landing the aircraft turned over in a river pool and came to rest with its cockpit partially under water. The two persons on board managed to evacuate the aircraft after some difficulties.

The crew was found and picked up by a rescue helicopter after about 40 minutes. Both were physically unharmed, but had suffered mild hypothermia.

Technical investigations revealed that the propeller thrust was lost because the inner power transmission hub in the clutch, Clutch Hub (P/N 05-72211-K011) had disintegrated. The clutch hub,

which had only been in operation two-thirds of its service time, was marked by excessive wear. There were several fatigue cracks in the fracture surfaces.

The AIBN believes that the excessive wear led to an increasing relative movement between the clutch hub and the adjacent hubs. This caused overloading and fracturing so that the clutch hub finally disintegrated. The excessive wear was probably a result of insufficient dampening in the clutch spring mechanism.

In the AIBN's opinion, the commander handled the entire emergency situation in a very good manner, which undoubtedly led to the accident not having a more serious outcome.

1. FACTUAL INFORMATION

1.1 History of the flight

1.1.1 The accident occurred in connection with pilot training with LN-NEX. The aircraft belonged to Oslo Flyveklubb and was based at Kjeller Airport (ENKJ). On board the aircraft there was an instructor (hereafter called the commander) and a student pilot. The purpose of the flight was to practice landings.

1.1.2 LN-NEX was prepared and a pre-flight inspection was conducted. According to the commander, the aircraft had fuel for nearly three and a half hours of flying. The planned flight time for this flight was about two hours. After take-off from Kjeller, LN-NEX continued directly to Moss Airport Rygge (ENRY) where the student pilot completed eleven landing circuits.

1.1.3 The aircraft then left Rygge CTR via Kambo. The crew contacted Farris Approach and requested, and received, clearance to fly at altitudes of up to 3 000 feet en route to Kjeller. The plan for the return flight was to enter the Kjeller traffic pattern via Lutvann.

1.1.4 When the aircraft reached the boundary between Farris and Oslo TMA, Oslo Approach denied the request from LN-NEX for clearance to continue into Oslo TMA at the originally allocated altitude. Altitude was therefore reduced to 2 000 feet and the flight continued outside controlled airspace.

1.1.5 In order to give the student pilot enhanced learning benefits en route between Rygge and Kjeller, the commander and the student pilot agreed on practicing steep turns. The student pilot made 360° turns, alternating right and left. The turns were made with a bank angle of about 45°. It was while making a right steep turn that the crew suddenly heard an abnormal sound from the engine.

1.1.6 In his statement to the AIBN the commander described the sound as distinct, but more like a "crunch" sound than a bang. They also felt a jerk in the aircraft and it seemed as if the thrust disappeared. The commander took over the controls and pulled back on the throttle to reduce the engine speed which had abruptly increased substantially. Apart from the abnormal sound and loss of thrust, the sudden engine over revving was the only fault indication that was registered.

1.1.7 The course was instantly set towards Kjeller and the aircraft was trimmed to a lower speed. At one point in time the commander attempted to increase the engine power to feel whether the propeller was pulling. He felt that this was not the case and retarded the throttle again.

1.1.8 The commander and his student pilot realised that it was not possible to continue the flight even though the engine continued to run. They therefore looked for suitable places for a forced landing. The entire area within gliding distance was covered with trees and rough terrain with some marshes and lakes. They picked out three possible ice-covered lakes and after a brief discussion they agreed to land on Skjelbreia lake. They changed frequency to Oslo Approach and sent out a distress call.

1.1.9 As LN-NEX approached Skjelbreia from the south, the crew first planned to land northwards. When they approached the lake, however, they saw that high-voltage power lines crossed the southern end of the lake. The commander therefore chose to pass the lake and then turned back to land from the north. At a small depression in the terrain at the northern end of the lake they had to make a steep turn to the left to sufficiently clear the terrain. Last stage flaps (landing position) was set while the aircraft was in this turn.

1.1.10 The end of the approximately 565-metre long lake was surrounded by trees that rose about 15 metres (50 ft) above the lake surface[1]. LN-NEX cleared these tree tops and came in over the ice with a higher than normal landing speed. The commander put the aircraft into a side-slip to shorten the landing distance. He also activated the emergency beacon before the aircraft landed.

1.1.11 LN-NEX covered nearly the entire length of the lake before settling on the snow-covered ice. The tracks showed that the aircraft gradually came into deeper snow towards the end of the landing run. The heavy braking force from the snow led to the noseleg breaking. The aircraft then turned over onto its back. LN-NEX came to rest upside-down in an open water-filled pool in the mouth of a river at the southern end of Skjelbreia (see Figure 1).

[1] According to the Airplane Flight Manual, this type of aircraft has a landing distance of 744 metres, over a 15-metre high obstacle (at MTOM)

Figure 1: LN-NEX resting upside-down after the forced landing. The photo shows oil spillage on the fuselage behind the engine cowling and on the lower left wing (in front of the L/H main landing gear leg). Photo: AIBN

1.1.12 The distance from the site where the aircraft came to rest and the first point of contact on the ice was 70 m, 50 m and 27 m for the left main wheel, right main wheel and nose wheel respectively (see Figure 2).

Figure 2: The wheel tracks in the snow (dyed red) seen from where the aircraft stopped. Photo: AIBN

1.1.13 After the aircraft turned over, large parts of the cabin were immerged in water. Both the commander and the student pilot initially wound up with their heads under water. The student pilot managed to get out of his seat and over to the back part of the cabin which was not quite as deep under water. Here he tried to kick out one of the side windows without succeeding.

1.1.14 The commander sat in his seat with his head and chest under water. He had problems releasing his seatbelt. First because something came in the way of the belt lock (possibly part of a garment) and then because it was difficult pushing the release knob. After getting his head above water and breathing, he managed to twist so that he finally managed to open the belt.

1.1.15 The commander then discovered an opening on his right side which was partially under water. Both persons on board managed to evacuate the aircraft through this opening. It proved later that it was the canopy that had partially opened so that it was through this opening they came out (see Figure 3).

Figure 3: The opening through which the commander and the student pilot evacuated. Photo: AIBN

1.1.16 After they had got out the commander and the student pilot stationed themselves on the wing of LN-NEX awaiting assistance.

1.1.17 About 40 minutes after the accident the crew was found by a Sea King rescue helicopter and transported to hospital for further examination. Apart from suffering hypothermia, they came away from the accident without physical injuries.

1.2 Injuries to persons

Table 1: Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatalities				
Serious				
Light/none	2		2	

1.3 Damage to aircraft

Detailed description of damage to the aircraft is given in Section 1.12.

1.4 Other damage

Approximately 2 – 3 litres of engine oil leaked into the pool at the mouth of the river. Sawdust was strewn to soak up the oil spillage after the aircraft was removed.

1.5 Personnel information

1.5.1 Commander

Male, age 28, completed in the autumn of 2008 a combined bachelor programme and commercial pilot training in England, where he then also completed flight instructor training. After returning to Norway he began as an instructor with Oslo Flyveklubb in December 2008. He held a valid CPL (A) without medical restrictions, and maintained the necessary qualifications to be an instructor for this type of aircraft.

Table 2: Flying hours commander

Flying hours	All types	Relevant type
Last 24 hours	7	7
Last 90 days	85	55
Total	368	58

According to the commander it was an entirely ordinary day with regard to his health condition. He had slept well and had had breakfast before heading for Kjeller to fly this session with his student pilot.

1.5.2 Student pilot

Male, age 33, had 37 flying hours as a student pilot at Oslo Flyveklubb. He started his pilot training in 2006 and has had this instructor since February 2009.

1.6 Aircraft information

1.6.1 General

1.6.1.1 Diamond DA40 is a four-seater single piston engine aircraft type which was designed and originally manufactured in Austria. The first flight took place in 1997. DA40-D is the designation for the diesel engine powered version. This model is either equipped with a Thielert Aircraft Engines GmbH TAE 125-01 “Centurion 1.7” or with a TAE 125-02-99 “Centurion 2.0” diesel engine.

1.6.1.2 The aircraft type is certified in accordance with the requirements in JAR-23 Amendment 1, while the engine type is certified in accordance with JAR-E Change 10. The propeller originally had a German type certificate based on the certification provisions in FAA FAR Part 35 Amendment 35-5.

1.6.1.3 EASA has subsequently issued type certificates based on the earlier type certifications of aircraft, engine and propeller types, (cf. EASA Type Certificate Data Sheet (TCDS) numbers A.022, E.055 and P.094 respectively).

1.6.2 Relevant data for LN-NEX

Manufacturer: Diamond Aircraft Industries GmbH
Type designation: DA40-D
Serial No.: D4.028
Year of manufacture: 2003
Airworthiness documents: Norwegian Certificate of Airworthiness, dated 18 September 2008 and Airworthiness Review Certificate (N-ARC) valid until 20 April 2009.
Total flying hours: 1 499 hours
Time since last inspection: 91 hours (200-hour inspection)
Type of engine: Thielert Aircraft Engines GmbH TAE 125-02-99
Engine Serial Number: 02-02-02002
Engine total time: 288 hours
ASSY Clutch, P/N 05-7211-K006002, S/N 20480
Clutch Hub, P/N 05-72211-K011

1.6.3 The power plant in general

1.6.3.1 Thielert Aircraft Engines GmbH TAE 125-02-99 is a liquid-cooled, turbo-charged diesel engine. It has a rated power output of 99kW (135 hp) at 3 900 rpm. This is the same power output as the TAE 125-01. The engine has two separate oil systems, one for the engine and one for the gearbox.

1.6.3.2 The transmission ratio between the propeller and engine is 1 : 1,69. Maximum permissible propeller rpm during normal operation is 2 300, which corresponds to an engine rpm of 3 887. The propeller rpm never exceed 2 500. This corresponds to an engine rpm of 4 225.

1.6.3.3 The engine is equipped with a clutch to dampen torsional pulses and crankshaft vibrations between the engine and propeller. Apart from lacking a clutch release mechanism, this clutch is comparable to clutch designs usually used in cars (see Section 1.16.2).

1.6.4 Engine installation on LN-NEX

1.6.4.1 On 2 July 2005, LN-NEX experienced a serious air incident during which the engine broke down. The aircraft then had a Thielert Aircraft Engines GmbH TAE 125-01. The incident is described in RAP SL 2011/20. LN-NEX was then stored until the damaged engine was replaced by another (used) engine of the same type and model that was installed in February 2006.

1.6.4.2 On 3 March 2007, an entirely new engine was installed. This was type TAE 125-02-99 “Centurion 2.0”. The aircraft then had a total time of 1 211 hours. This was the engine that was installed on the aircraft when it broke down at Skjelbreia on 2 April 2009.

1.6.4.3 The engine's clutch was replaced in August 2008. The aircraft then had a total time of 1 303 hours. The clutch had a time-in-service of 196 hours when the accident occurred. It was 104 hours left until the next inspection of the unit was due. According to the maintenance programme for LN-NEX, the clutch was to be removed for inspection every 300 hours (Time Between Inspection - TBI).

1.6.4.4 The unit which was installed, ASSY clutch with part number 05-7211-K006002 and serial number 20480, was supplied by TAE (see Figure 5). The manufacturer had issued an associated Authorised Release Certificate EASA Form 1. The document states that the inner power transmission hub in the clutch, Clutch Hub (part number 05-72211-K011), was not new, but had been repaired by TAE in accordance with Assembly Manual AM-02-02 Iss. 01 Rev. O1. Before it was overhauled it had a time since new of 300 hours.

1.6.4.5 The Part-145 workshop that installed the clutch during the last replacement has explained to the AIBN that the clutch was delivered from the manufacturer as a complete assembled unit which was installed directly on the engine's fly wheel. The workshop also stated that a centring tool was used to install the clutch correctly. The reason why the clutch was replaced was that the time-in-service of the existing unit had expired.

1.6.4.6 The manufacturer has confirmed that the clutch is delivered as a complete assembled unit consisting of the Clutch Hub, adjacent hubs, springs and friction disc with friction lining. Prior to delivery of each unit, the spring tension of each unit is checked to be in accordance with pre-defined values.

1.7 Meteorological information

At the request of the AIBN, the Norwegian Meteorological Institute prepared a weather report for the Ski – Kjeller area in the period 1100 – 1300 hours local time (the time just before the time of the accident). The report states that there was a high pressure front over all of Southern Scandinavia with calm wind conditions and little precipitation over most of the area. Eastern Norway was partially covered by high Cirrus clouds, but there seemed to be few clouds immediately east of the Oslofjord. METAR from Gardermoen and Rygge shows that there were no clouds under 5 000 feet and synop for Blinderen did not report clouds under 8 000 feet.

Weather observation (METAR) from Gardermoen, 1210 hours:

ENGM 021010Z 20007KT CAVOK 08/01 Q1023 NOSIG=

Weather observation (METAR) from Rygge, 1220 hours:

ENRY 021020Z 19007KT CAVOK 08/02 Q1025 NOSIG=

1.8 Aids to navigation

Not relevant

1.9 Communications

1.9.1 When LN-NEX did not receive permission from Oslo Approach to continue into Oslo TMA, the crew reported that they would leave the frequency and go over to Oslo Traffic, which is one of the open frequencies for uncontrolled traffic in the airspace under Oslo TMA. The aircraft's transponder code was set at 7 000, which is the standard code for unidentified traffic outside of controlled airspace.

1.9.2 After the emergency situation had occurred, LN-NEX resumed contact with Oslo Approach. The following distress call was sent from the aircraft:

MAYDAY, MAYDAY, MAYDAY. Lima November - November Echo X-ray over Østmarka. We have a propeller failure and might require a forced landing

1.9.3 Oslo Approach initially responded by asking if it was LN-NEX on the frequency. LN-NEX confirmed this and repeated that the aircraft was in an emergency situation. Oslo Approach acknowledged:

Echo X-ray, MAYDAY received

1.9.4 There was substantial activity on the frequency with several scheduled aircraft on their way towards Gardermoen. This led to the air traffic controller being busy responding to calls from other aircraft and issuing clearances for a period of time immediately after receiving the distress call.

1.9.5 About 15 seconds after the first distress call, LN-NEX called Oslo Approach again and asked for confirmation that MAYDAY was received and stated that they would land on a lake. The transmission was broken and weak, and parts of it fell out. Oslo Approach responded:

Lima Echo X-ray, Kan du gjenta? (Can you repeat?)

LN-NEX responded by repeating the distress call from the beginning. The quality of this last transmission from LN-NEX was even worse and was finally disrupted. The air traffic controller again confirmed that the distress call had been received, and added:

Vi alarmerer (We will alert)

1.9.6 The response from Oslo Approach was not heard by the crew of LN-NEX, which at this point in time had lost their radio communication because the aircraft was at a low altitude and outside the coverage area.

1.9.7 The air traffic controller continued to call up LN-NEX several times but with no response.

1.9.8 In a subsequent interview with the AIBN, the commander said that he then and there was frustrated at having to identify himself again instead of receiving immediate and clear confirmation that the distress call had been received and understood. At the same time he stated that it was understandable that the air traffic controller was uncertain about who was calling as LN-NEX had not been on the frequency before the distress call was sent.

1.9.9 When radio communication was disrupted and LN-NEX disappeared from the radar, the Joint Rescue Coordination Centre Southern Norway was alerted by Oslo Air Traffic Control Centre, which reported the last radar position and agreed on a search with a Sea King rescue helicopter. The air traffic controller then coordinated the search until the aircraft was found and the two persons on board were transported from the accident site.

1.10 Aerodrome information

Not relevant

1.11 Flight recorders

1.11.1 The aircraft did not have a Flight Data Recorder or Cockpit Voice Recorder. This is neither mandatory for aircraft in this category.

1.11.2 LN-NEX was equipped with an electronic engine control (Full Authority Digital Engine Control – FADEC) which also registered and stored a number of engine data. The entire data log from the last flight was downloaded and made available to the AIBN in connection with this investigation. A 40-second extract that gives a graphical presentation of the FADEC log in the period where power was lost is enclosed with this report (see Appendix B).

1.11.3 In this extract the time line is divided into seconds, from second 152.76 to second 192.87.

1.11.4 Initially, the power lever was in a position that corresponds to a power output of about 80% and an engine speed of 3 530 – 3 540 rpm. Corresponding propeller speed is 2 089 – 2 095 rpm.

1.11.5 The first sign of something abnormal occurred at second 162 where the engine's speed suddenly increased to 4 962 rpm in the course of three seconds. At the same time there was a steep fall in manifold pressure. In the two seconds that followed the rpm peek, engine speed decreased to 4 491 rpm before it again increased to 4 827. At the same time the power lever was pulled back to 10%. This resulted in engine speed falling to 3 400 rpm.

1.11.6 At second 172 the power lever was gradually pushed forward to a position that corresponds to 22% power output, before being retarded to the previous lowest level eight seconds later. In the course of these eight seconds engine speed increased to 4 168 rpm.

1.11.7 The readings from FADEC correspond with the commander's statement to the effect that he first retarded the power lever back to idle when the engine over revved, and that he subsequently tried to push it gradually forward again to see if he could get any thrust from the propeller, but without any noticeable effect.

1.12 Wreckage and impact information

1.12.1 <u>The accident site</u>

Skjelbreia lies on the border between the municipalities of Enebakk and Ski. The lake lies 217 metres above sea level (710 feet). The nearest building is the Ski Club's cabin which lies at a distance of 755 metres in a beeline from the crash site. There is a roadway from there. The major part of the lake stretches in a south-easterly direction and is about 565 metres long. At the southern end there is a marsh area with the mouth of a river and several pools. This is where LN-NEX came to rest after landing on the ice.

1.12.2 Description of damage to the aircraft

1.12.2.1 The first examination of the wreckage was conducted at the accident site. Oil spills were observed on the bottom right-hand part and the lower side of the engine cowling, and on the lower surface of the right wing. The oil seemed to have spread outwards while the aircraft was still airborne (see Section 1.16.1.3). The day after the accident the aircraft was lifted out by helicopter and brought to the AIBN's premises at Lillestrøm for further inspection.

1.12.2.2 The aircraft was damaged as follows:

- The nose landing gear was broken and had separated from the aircraft.

- All three propeller blades were broken and the propeller spinner was partially crushed.

- On the right-hand upper side of the engine cowling there was a slash of about 50 x 40 cm.

- The upper part of the forward canopy was crushed.

- The right wing leading edge had indentation/crushing damage from the landing lights and further on about 50 – 60 cm inwards towards the wing root.

- The front part of the wheel pants on both main landing gear legs had indentation/crushing damage.

In addition, instruments and the cockpit interior were damaged by oil and water.

1.12.2.3 The engine was removed from the aircraft by the AIBN and sent to Thielert in a sealed crate. Opening of the crate and further inspections were carried out under the supervision of representatives from the AIBN and BFU (see Section 1.16).

1.13 Medical and pathological information

1.13.1 The commander and student pilot were brought to Ahus University Hospital. They both suffered hypothermia but otherwise had no physical injuries.

1.13.2 Blood samples were taken of the crew at the request of the commander. No findings of alcohol or other illegal substances were made.

1.14 Fire

There was no fire.

1.15 Survival aspects

1.15.1 Search and rescue

1.15.1.1 Substantial resources were dispatched to find LN-NEX. The search was initially started by a civilian helicopter that happened to be in the area when the accident occurred. The search was continuously expanded so that there were eventually five helicopters participating (including one Sea King rescue helicopter, one air ambulance helicopter and one police helicopter). The search was coordinated by Oslo Air Traffic Control Centre.

1.15.1.2 No signals were received from the emergency locator beacon in i LN-NEX.

1.15.1.3 The starting point for the search was LN-NEX's last position on the air traffic controller's radar screen and their distress call which contained information to the effect that they would attempt to land on a lake. As the aircraft's colour was mostly white where it laid upside-down at the end of the ice and snow-covered lake, it was not easy to spot from a distance (see Figure 4).

Figure 4: The accident site with LN-NEX laying upside-down. The aircraft wreckage was not easily visible from a distance. Photo: AIBN

1.15.2 The landing

1.15.2.1 Judging by the damage to the aircraft and the commander's statement, the impact energy from the landing and subsequent overturn was not greater than the three-point belts worn by the two persons on board could absorb. None of them sustained physical injuries as a result of the landing and overturn.

1.15.3 The evacuation

1.15.3.1 The evacuation is described in further detail in Sections 1.1.13 through 1.1.15. The commander had problems releasing his seat-belt and both persons on board initially had difficulty finding a way out of the cabin. Because the aircraft rested with its wings on the edge of the pool and because the pool was deep enough, the canopy could be opened sufficiently so that they both managed to evacuate through this opening. This type of aircraft also has an extra emergency exit in the rear which was not used in this case.

1.15.4 Hypothermia

1.15.4.1 Both of the crew were wet after getting out of the aircraft. They attempted to wring out their clothes so that they would dry faster in the sun. With an outdoor temperature of about 8 ºC, they suffered some hypothermia during the approximately 40 minutes they were outdoors and waiting to be rescued. The nature of the snow made the area nearly impassable if they were to attempt to walk to a cabin.

1.16 Tests and research

1.16.1 Examination of the engine, gearbox and propeller control

1.16.1.1 When the gearbox was dismantled, one could see that the inner power transmission hub in the clutch, Clutch Hub (P/N 05-72211-K011) had disintegrated (see Figure 5). A further description of the findings in connection with the inspection of the clutch can be found in Section 1.16.2.

1.16.1.2 The gearbox was otherwise intact and there was no leakage of gear oil, neither externally or internally. Nor had any engine oil leaked into the clutch. The clutch and the friction disc’s friction coating were dry and showed no signs of abnormal movement between friction surfaces.

1.16.1.3 The external oil leakage on the engine cowling and wing proved to be engine oil. According to the manufacturer this had probably been vented out as a result of the abnormal high pressure that occurred in the crankcase when the engine over revved after it no longer had any connection with the propeller.

1.16.1.4 Apart from the disintegrated clutch hub, no faults were found in the engine, gearbox or propeller control that can explain how LN-NEX suddenly lost propeller thrust. The propeller blades were moreover in the cruising position.

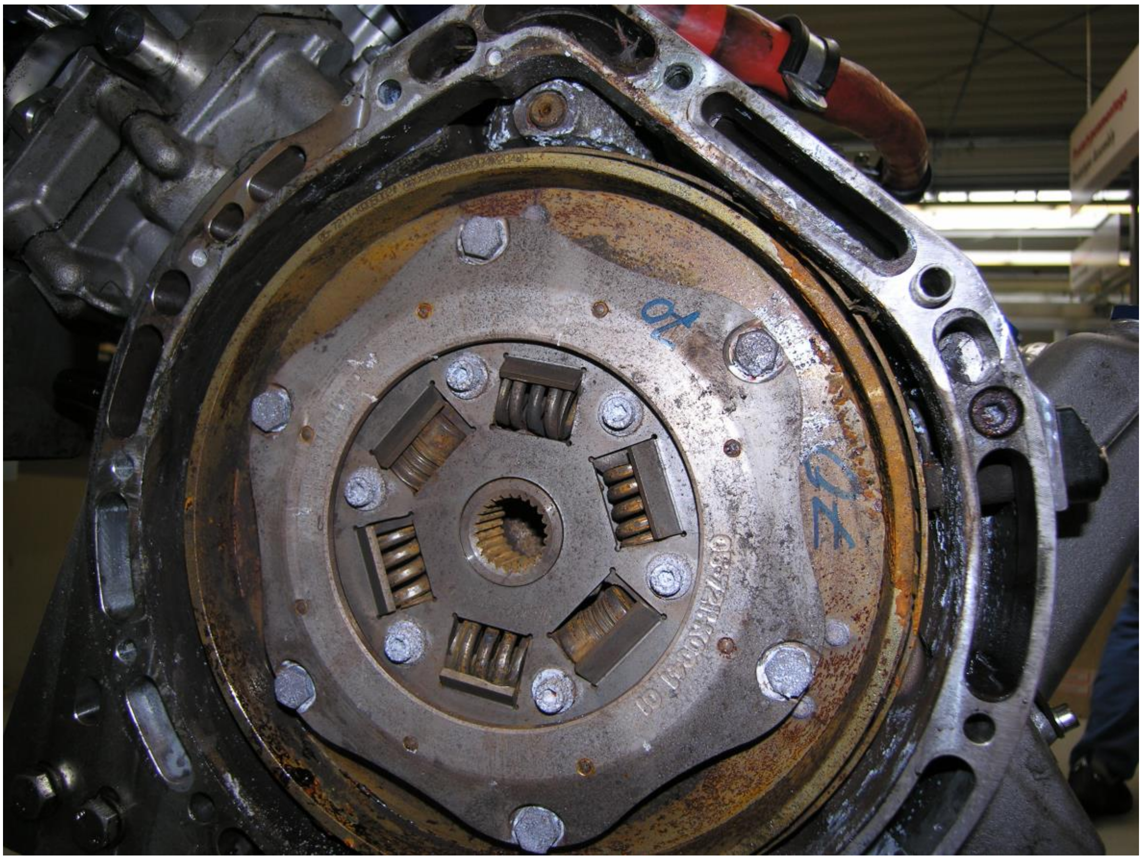


Figure 5: Photo taken after the gearbox had been removed. The clutch is located on the engine's flywheel. Photo: AIBN

1.16.2 Examination of the clutch

1.16.2.1 Clutch Hub (part number 05-72211-K011) is mounted between two adjacent hubs and transmits power from the crankshaft to the engine gearbox (see Figure 6).

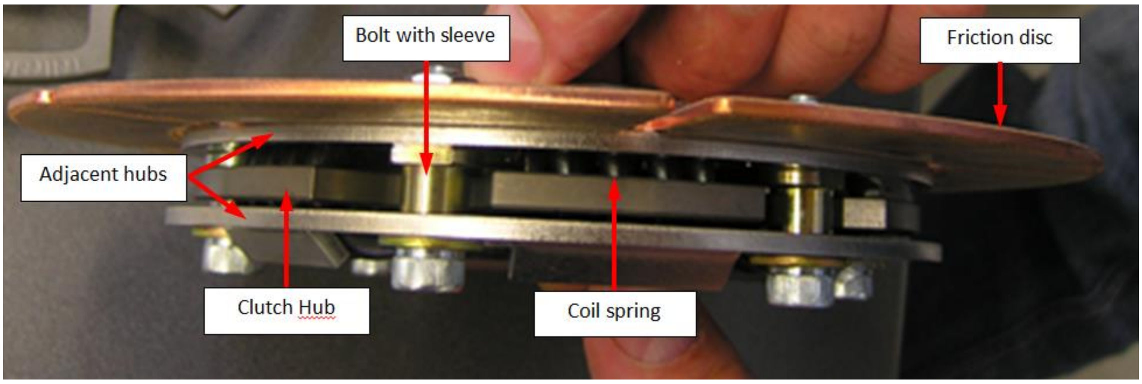


Figure 6: ASSY Clutch as delivered from the manufacturer. Photo: AIBN

1.16.2.2 Six springs of three different types are to ensure that the propeller runs softer (see Figure 7). The clutch functions such that vibrations, pulses and jolts are first intercepted by these springs so that a minor relative movement occurs between the Clutch Hub and the two adjacent hubs. The movement is restricted by the two disc springs which can only be compressed to a modest degree. Impacts that are so strong that the spring system "bottoms" are absorbed in that the friction coating on the friction disc yield.

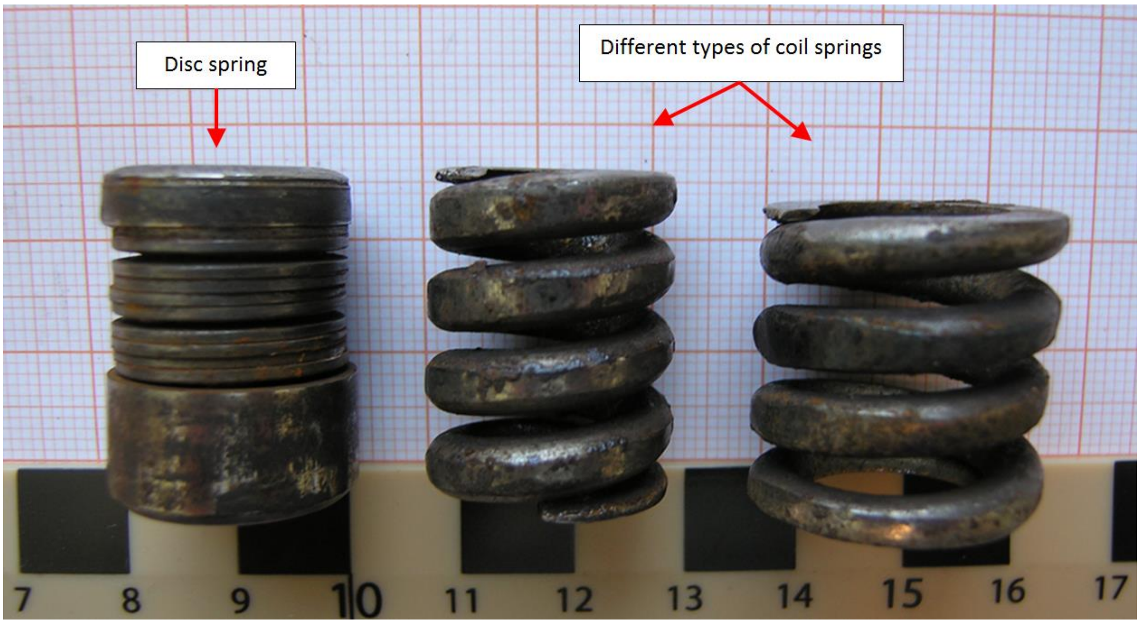


Figure 7: The three different types of springs mounted on the clutch hubs to damp torsional vibrations, pulses and jolts. The two coil springs types have different diameters and lengths. The unit consists of a total of six springs, two of each type. Photo: AIBN

1.16.2.3 Before delivery of new clutch units, the factory tests and adjusts spring tension (see Section 1.6.4.6).

1.16.2.4 When the AIBN measured the dimensions of the springs, it proved that both of the two coil springs that had the greatest diameter did not have the correct length. The length of the two springs was measured at 23.8 mm and 24.8 mm respectively. According to information from TAE the correct length is 27.5 mm. The other coil springs were also somewhat shortened (in the order of 1 mm).

1.16.2.5 The Clutch Hub was broken in six places so that the rim was separated from the inner part. In addition, three of the twelve radial spokes between the cut-outs were broken (see Figure 8).

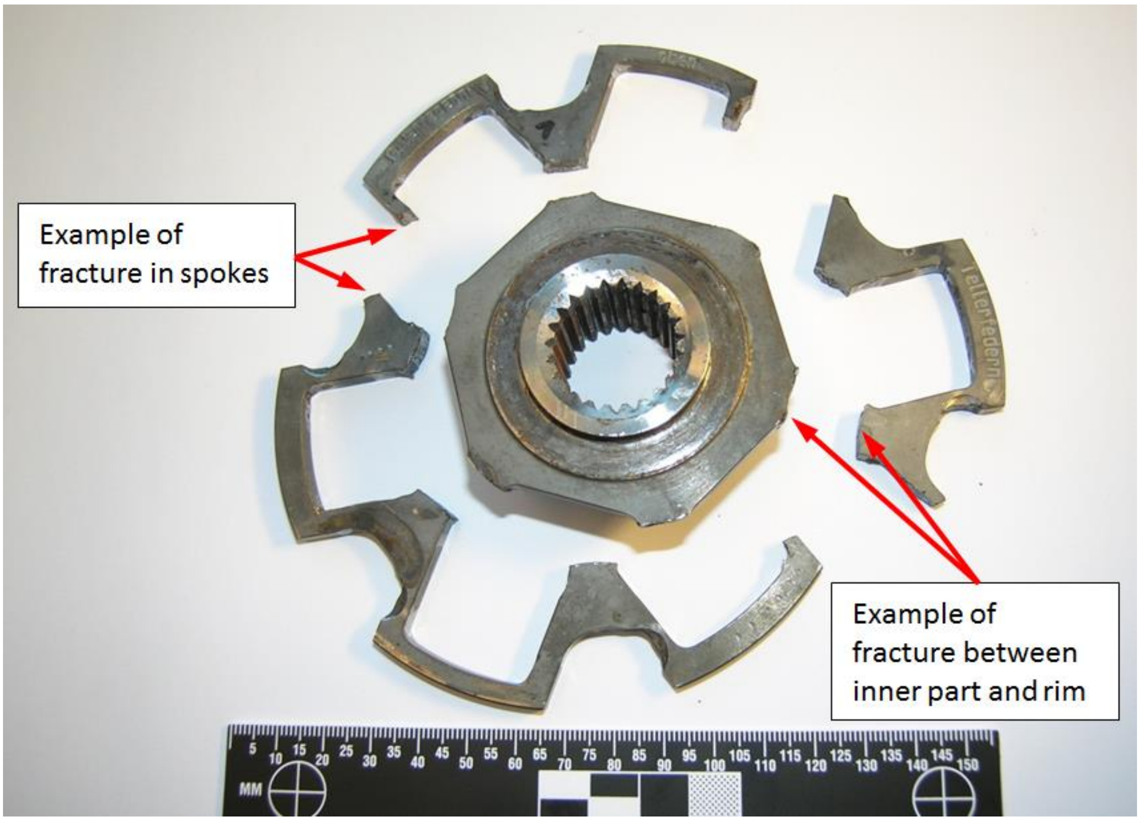


Figure 8: There were a total of nine fractures in the Clutch Hub which had been split into four pieces. Photo: AIBN

1.16.2.6 The fracture surfaces were examined more closely in an electron microscope. Signs of fatigue were found in several of the fractures, both those between the inner part and the rim, and those in the spokes.

1.16.2.7 In addition to the fractures there was substantial wear where the disc springs had been sitting. There was also wear that showed that the Clutch Hub had struck the bolt sleeves (see Figure 10) which also function as spacers between the two adjacent clutch hubs (see Figure 11). Each disc spring had worn away about 3 mm of the material in the rear spoke (see Figure 9).

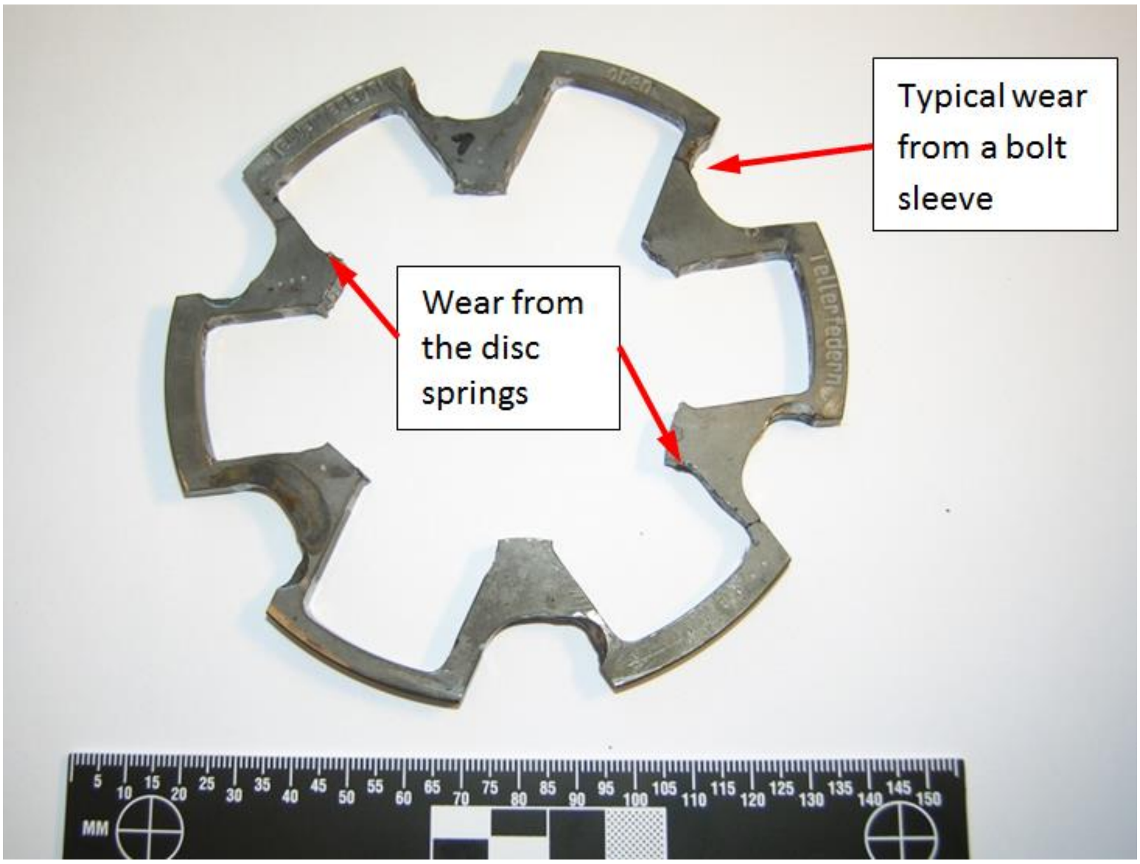


Figure 9: Wear on the Clutch Hub (inner part left out for clarity). Photo: SHT

1.16.2.8 Similarly, all the sleeves mentioned in Section 1.16.1.5 were completely worn down where the Clutch Hub had struck against the bolts (see Figure 10). On the reciprocal impact points on the Clutch Hub there were marks from the bolts' threads.

Figure 10: The bolts that hold the Clutch Hub and the adjacent hubs together. Impacts from the Clutch Hub have worn a hole through all the sleeves. Photo: AIBN

1.16.2.9 The two adjacent clutch hubs both had wear depressions from the springs (see Figure 11).

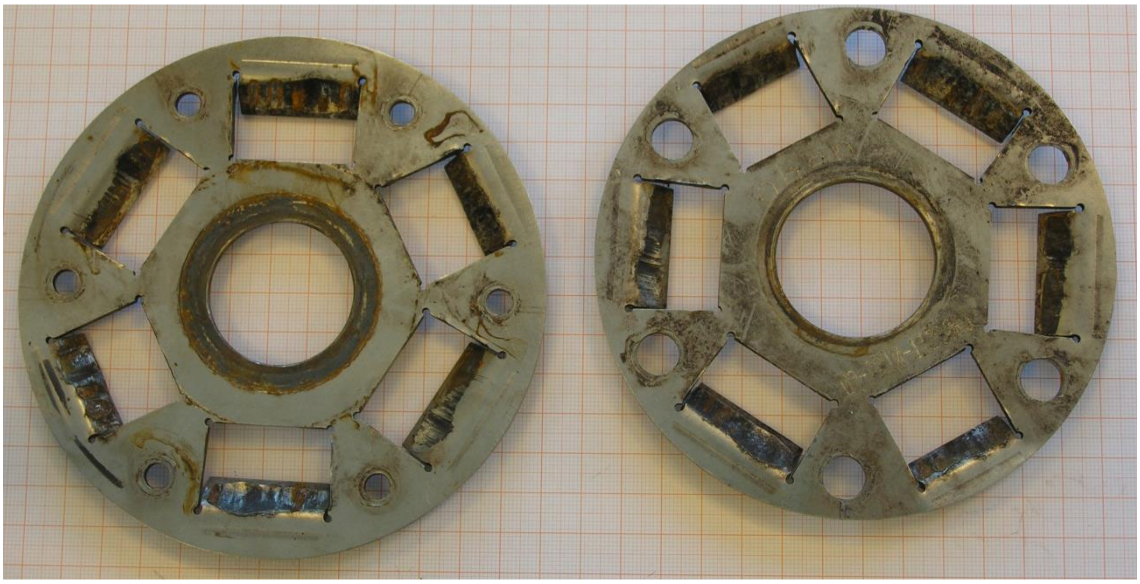


Figure 11: Adjacent clutch hubs with wear depressions from the springs. Note the different dimensions (both in width and length) of the cut-outs in the hubs. These are adaptations to the different types of springs. Photo: AIBN

1.16.2.10 Wear marks on the springs, in addition to the fracture surfaces on the inner part of the Clutch Hub, indicate that the springs and fracture surfaces have scraped against each other. This shows that the inner part of the Clutch Hub and adjacent hubs have rotated with different speeds after the Clutch Hub disintegrated. This means that the rim and the springs spun along with the adjacent hubs without any power being transmitted to the propeller (see Figure 12).

Figure 12: Wear marks on one of the coil springs after scraping against the fracture surfaces in the inner part of the Clutch Hub. Photo: AIBN

1.16.2.11 Wear marks were found on both sides of the flanges on the Clutch Hub (see Figure 13). There were signs of overheating (discolouration) from rubbing against the Clutch Hub in the opening in one of the adjacent hubs.

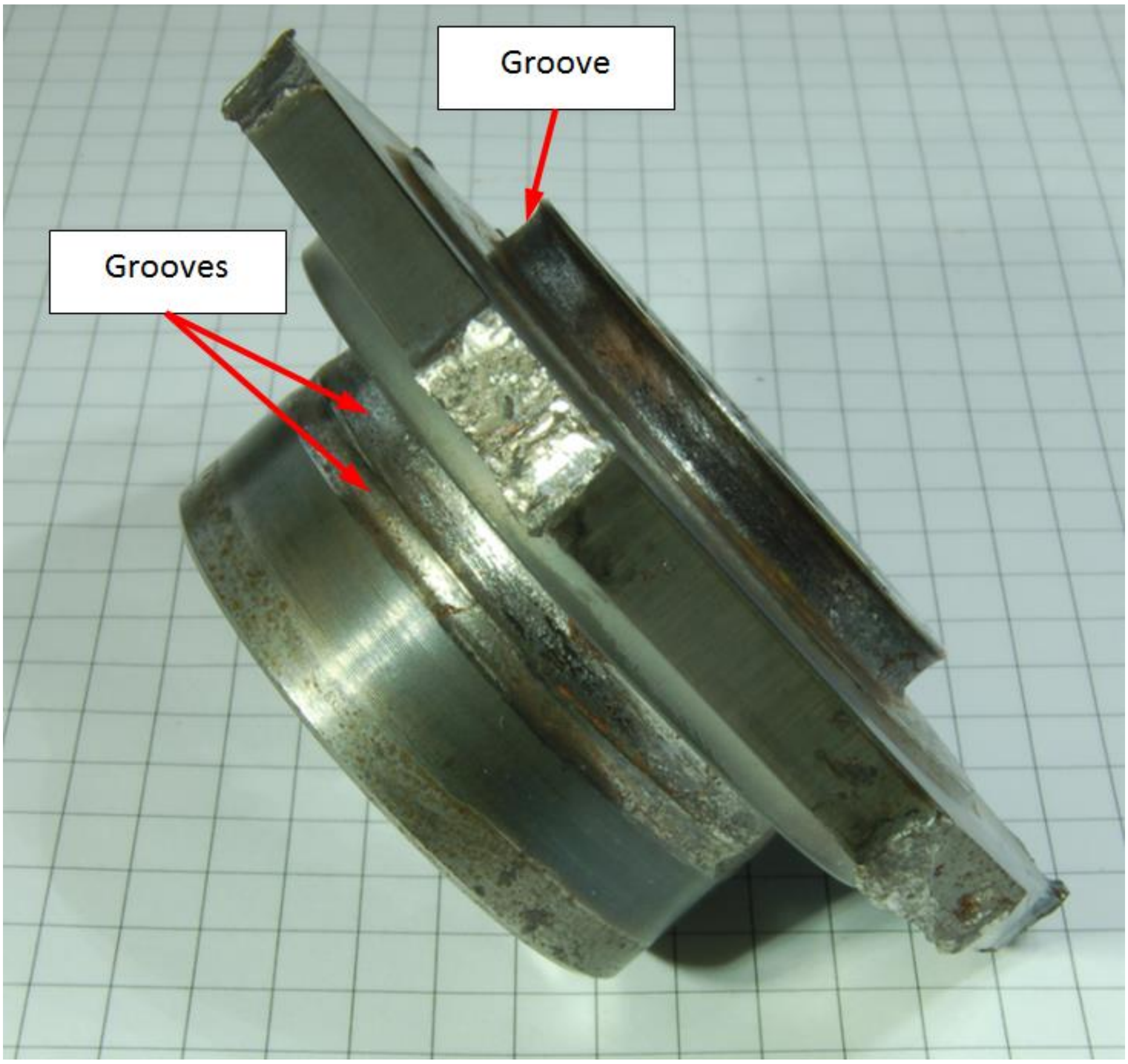


Figure 13: Wear marks (grooves) on both flanges on the Clutch Hub. The photo also shows wear on the inner part fracture surfaces after scraping against the coil springs. Photo: SHT

1.16.2.12 Wear marks from the friction disc shown in Figure 5 were found on the brackets of the clutch pressure plate (see Figure 14).

Figure 14: Bracket with wear marks (groove) from the friction disc. Photo: AIBN

1.16.2.13 All the spacers were in place on the pressure plate's eight pressure adjustment points (see Figure 15).

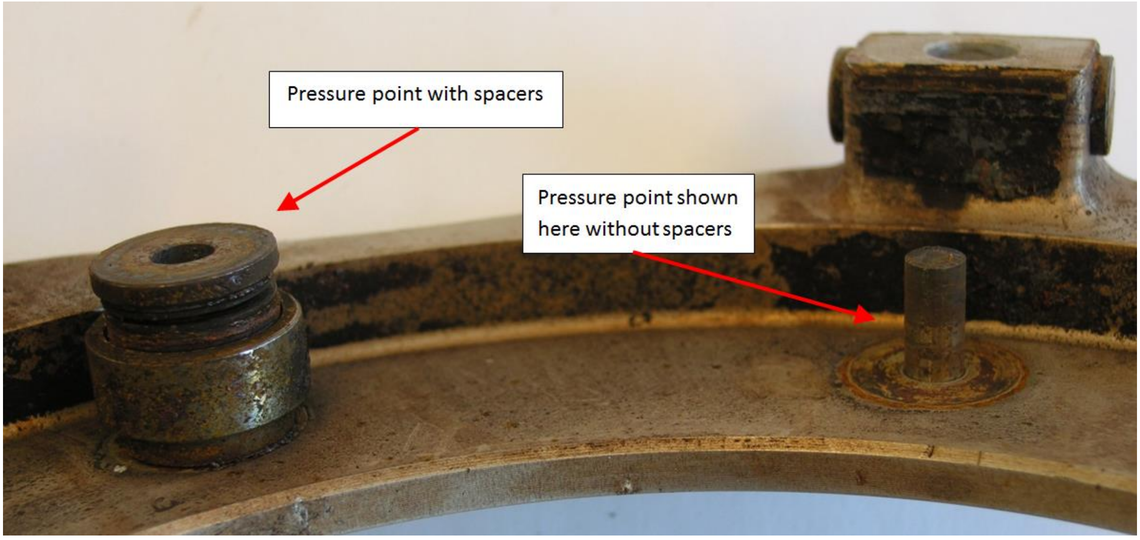


Figure 15: Pressure adjustment point with spacers. Photo: AIBN

1.16.3 <u>Examination of the engine's electrical system – Engine Loom</u>

1.16.3.1 The engine's electrical wiring system was removed from the engine by the AIBN and sent in a sealed package to Thielert. In agreement with the AIBN, the package was opened and the Engine Loom examined closely under the supervision of a representative from BFU. No faults were found in the Engine Loom. BFU has prepared a Concise Engineering Report following this examination, which is enclosed with this report (see Appendix C).

1.17 Organisation and management information

1.17.1 Oslo Flyveklubb was an approved flying school for JAR PPL (A) flight training. See also RAP SL 2011/20 Sections 1.17.2, 1.17.3 and 1.18.1. These sections deal with operation and maintenance of LN-NEX.

1.18 Additional information

1.18.1 In connection with this investigation, the AIBN contacted the French air accident investigation authority, Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation civile (BEA), which is currently conducting a thematic investigation of incidents/accidents involving Thielert engines, including seven cases of clutch failure.

1.18.2 After having been presented with a description of the accident with LN-NEX and seen photographs of the damage to the clutch, BEA was of the opinion that two of their seven cases seemed to have significant similarities with the clutch failure in LN-NEX:

- *Reg. sign:* F-GUVC / *Type of aircraft:* Diamond DA40 / *Incident date:* 23 June 2009
- *Reg. sign:* F-HCPM / *Type of aircraft:* Robin DR400 Ecoflyer / *Incident date:* 18 May 2010.

1.18.3 Also in these two cases, measurements showed that the coil springs with the greatest diameter were shorter than the value given to the AIBN from TAE. In the one clutch the length of the two relevant springs was measured at 24.6 mm and 25.7 mm respectively. In the other clutch one of the relevant springs was measured at 25.5 mm. The other spring could not be measured because it had been cut up in connection with metallurgical tests.

1.19 Useful or effective investigation techniques

No methods qualifying for special mention were used.

2. ANALYSIS

2.1 Introduction

The accident happened as a result of LN-NEX suddenly losing all propeller thrust after the clutch failed while the aircraft was at an altitude of about 2 000 feet over Østmarka. In this analysis the AIBN will discuss in more detail the clutch failure, how the commander and the student pilot handled the emergency situation that occurred, radio communication between LN-NEX and Air Traffic Control after the emergency situation occurred, and illuminate certain aspects of the emergency evacuation.

2.2 Clutch failure

2.2.1 It seems clear that the Clutch Hub disintegrated within its normal time-in-service interval as a result of an abnormally high level of wear. As far as the AIBN can see, the engine has not been exposed to any form of abnormal use in the period after the clutch was installed. If so, this should have been revealed by the FADEC data, which did not show any extreme values prior to the clutch failure.

2.2.2 The damage to the Clutch Hub and bolt sleeves show that the hub had struck against the bolts a repeated number of times (see Figure 10). The abnormal level of wear on the spokes in the Clutch Hub (see Figure 9) caused an increasing relative movement in relation to the adjacent hubs. This increased play gradually became about 3 mm before the disc springs were subject to any load at all. This in turn led to the impacts being increasingly stronger until the Clutch Hub finally disintegrated. The wear pattern and the character of the fatigue fractures indicate that the abnormal wear has occurred over time, probably several flights.

2.2.3 In the AIBN's view, there are two factors that could explain this abnormal wear. One is that the clutch was not correctly centred so that rotation became eccentric and thus led to abnormal loads. The other is that the total spring damping effect was not sufficient to prevent the Clutch Hub from striking against the bolts, allowing abnormal wear to occur.

2.2.4 It has been discussed whether an incorrect installation led to the abnormally high level of loads, which in turn resulted in the Clutch Hub failure. The wear marks on both flanges on the Clutch Hub (Figure 13), and the wear marks from the friction disc against the brackets of the clutch's pressure plate (Figure 14), show that at one point in time there must have been significant eccentric rotation.

2.2.5 As far as the AIBN understands, an incorrect installation can occur in two ways:

- By the lack of spacers in some of the pressure adjustment points against the friction disc (see Section 1.16.2.13).

The AIBN has checked the pressure adjustment points and found that all the spacers were in place.

- By the gearbox not being properly aligned on the engine crankcase when it was installed. This can for example occur if some of the bushings (bushing P/N 05-7212-K005901) are missing.

If the gearbox had been installed off-center, this should have been detected when the gearbox was removed after the accident. When the gearbox was removed nothing was registered to indicate that it had been installed off-center on the engine's crankcase[2].

2.2.6 The wear marks mentioned in Section 2.2.4 can just as well have occurred after the Clutch Hub had disintegrated, when blows from the asymmetrical hub against the springs must have led to considerable eccentric rotation which lasted up until the engine stopped when the aircraft turned over at the end of landing run.

2.2.7 The AIBN is thus of the opinion that there is no evidence to support that the Clutch Hub disintegrated as a result of incorrect installation of clutch or gearbox.

2.2.8 The AIBN finds it more probable that the clutch failure is a result of insufficient dampening in the clutch spring mechanism. That again could be the result of weakened springs, and can explain the abnormal wear and the play which finally led to the Clutch Hub disintegrating. This type of clutch failure is otherwise not unknown to the automotive industry.

2.2.9 The accident with LN-NEX and the incidents with the two French aircraft mentioned in Section 1.18 occurred within a period of a little over one year. As far as the AIBN is aware of, there have been no similar incidents of clutch failure since then. The AIBN is, however, neither aware of any specific modifications or alterations introduced to prevent the re-occurrence of such a failure.

2.2.10 The AIBN believes this and similar incidents should give the EASA, both in the capacity as type-certifying authority and issuer of DOA/POA, cause to obtain verification that the manufacturer has taken the necessary steps to ensure the airworthiness of all parts and components, hereunder that they meet aviation quality standards.

2.2.11 The AIBN also questions whether a clutch design such as this is really suited for use in an aircraft, and where the consequences of engine failure can become very serious.

2.3 Handling of the emergency situation

2.3.1 On a single-engine aircraft complete or partial loss of thrust will always be serious. Especially if there are no suitable emergency landing sites within gliding distance. In this case the aircraft was flying at a relatively low altitude over terrain covered with trees and small ponds and lakes. Few of these were large enough to be suited as an emergency landing site.

2.3.2 Because all thrust was lost more or less immediately it was not possible to continue flying to any of the nearby airports or to an area with more suitable emergency landing sites.

2.3.3 Considering that the aircraft was about 1 300 feet over the terrain, it took about 2 – 3 minutes from when thrust was lost and until LN-NEX came to rest after the accident. This entailed that the crew had a limited period of time in which to establish gliding speed, attempt to regain thrust, look for suitable landing sites, communicate with Air Traffic Control and carry out the forced landing.

[2] The AIBN is familiar with EASA Emergency Airworthiness Directive AD No.: 2011-0087-E which orders replacement to a new friction disc that is less sensitive to incorrect installation of the gear box on the engine crankcase. As far as the AIBN can see, this was not a relevant issue in this case.

2.3.4 The situation became even more complicated because the landing direction had to be changed at the last moment to avoid high-voltage power lines and because they had to land over high trees at the beginning of a lake shorter than the landing distance required by this type of aircraft.

2.3.5 In the AIBN's opinion the commander handled the entire emergency situation in an excellent manner, which undoubtedly led to the accident not having a more serious outcome. The cooperation between the commander and the student pilot after the emergency situation occurred was also a positive contribution.

2.4 Communications during the emergency situation

2.4.1 When the emergency situation occurred LN-NEX was in uncontrolled airspace, without radio communication with Air Traffic Control and without a flight plan. The transponder code for VFR traffic outside controlled airspace does not give a positive identification and is not normally monitored by Air Traffic Control. A long period of time could thus have lapsed before the aircraft had been identified as missing after the forced landing.

2.4.2 It was therefore important that the commander managed to re-establish contact with Oslo Approach and report the emergency. The distress call and subsequent communication with Oslo Approach provided sufficient information to enable rapid initiation of a search and rescue operation on the basis of the aircraft's last radar position and the information about LN-NEX attempting to land on a lake. The AIBN believes that this strongly contributed to the aircraft being found as quickly as it was.

2.4.3 The AIBN can understand that the commander in a stressful situation was uncertain as whether Air Traffic Control had received and would follow up the distress call. There could be a perception among private pilots that "everyone become silent" when someone sends a MAYDAY on a frequency. However, one cannot expect that this would occur on very busy frequencies such as Oslo Approach. This would be neither practically possible, nor advisable from a safety point of view. The principle concern is to receive confirmation that the distress call has been received. It is a confirmation that Air Traffic Control will implement its alarm and alerting routines.

2.4.4 It is therefore very important that the crew of an aircraft in an emergency situation under similar conditions to ascertain that the distress call has actually been received. The AIBN would therefore point out that any pilot who is uncertain as to whether a distress call has actually been received or who cannot wait on receiving assistance from Air Traffic Control, can stop all radio traffic on the frequency by using the following phrase:

"STOPP SENDING – MAYDAY" or "STOP TRANSMITTING – MAYDAY"

2.4.5 For an aircraft in an emergency situation, use of the transponder code for emergencies is also recommended, particularly if obtaining contact with Air Traffic Control or other aircraft is unsuccessful. In this case Air Traffic Control found LN-NEX on the radar after the distress call so that the setting of the transponder code was of no significance.

2.4.6 Having heard the recording of the communications in connection with this accident, it is also the AIBN's assessment that the air traffic controller handled the situation correctly and in a professional manner – both while the emergency situation was ongoing and during the subsequent rescue action.

2.5 Emergency evacuation

2.5.1 This accident shows that in some situations it can be difficult to open belt locks of the type where one must press a release device (automotive seatbelt type), rather than the more traditional locks which are released by pulling the belt buckle. If a belt lock of the first-mentioned type is subject to a load, for example the weight of a person is pulling on the belt if the aircraft is resting inverted, considerable strength is required to press in the release knob. It can therefore be wise to a have a tool readily accessible to cut the belt.

2.5.2 Similarly, the AIBN finds it can be prudent to plan in advance how to get out quickly following an overturn with types of aircraft where exiting is done by lifting up the canopy. This particularly applies to types of aircraft that do not have an extra emergency exit, as opposed to the DA 40. If the canopy is blocked on an otherwise intact aircraft, the plexiglass may prove hard to break. In the event of fire or water intrusion, there will often be a short time at disposal to evacuate.

2.5.3 Otherwise, it is the AIBN's view that it was a good idea to activate the emergency beacon while the aircraft was still airborne. As the forced landing was relatively soft it is not certain that the beacon would have been activated by the built-in G switch. Unfortunately, the signals did not reach out. The AIBN assumes this was because the aircraft ended upside-down so that the transmitter's aerial came into the shadow of the aircraft structure. This is not uncommon in accidents like this.

3. CONCLUSIONS

The accident with LN-NEX occurred because the aircraft lost all propeller thrust as a result of the inner power transmission hub, Clutch Hub (P/N 05-72211-K011), disintegrating. The Clutch Hub, which had only been in operation for two-thirds of its time-in-service, was marked by substantial wear. The AIBN is of the opinion that this substantial wear led to an increasing relative movement between the clutch hub and the adjacent hubs. This caused overloading and fracturing so that the clutch hub finally disintegrated. The wear probably occurred as a result of insufficient dampening in the clutch spring mechanism.

Investigation results

a) The commander had a valid CPL (A) and necessary instructor qualifications for this type of aircraft.

b) The aircraft had a valid Certificate of Airworthiness and a valid Airworthiness Review Certificate (N-ARC).

c) While making steep turns at 2 000 feet in connection with pilot training, all thrust from the propeller was suddenly lost.

d) The aircraft made a forced landing on the ice-covered lake Skjelbreia.

e) At the end of the landing run, the aircraft turned over and came to rest inverted in a pool at the mouth of a river at the end of the lake, so that the cockpit was partially submerged.

f) After the aircraft had turned over, both persons on board were strapped to their seats with their heads and upper part of their bodies under water.

g) The two persons on board managed to evacuate the aircraft after some difficulties.

h) Aircraft with a mostly white surface can be difficult to detect in snow-covered terrain

i) Air Traffic Control alerted the Joint Rescue Coordination Centre at an early point in time and an extensive search and rescue action was quickly initiated.

j) After about 40 minutes the crew was found by a rescue helicopter. Both of them were physically uninjured but suffered mild hypothermia.

k) The distress call transmitted was an important factor for locating the aircraft relatively rapidly.

l) The inner power transmission hub in the clutch, Clutch Hub (P/N 05-72211-K011) had disintegrated. There were several fatigue cracks in the fracture surfaces.

m) The Clutch Hub, which had only been in operation two-thirds of its time-in-service, was marked by substantial wear.

n) The length of the coil springs with the greatest diameter in the ASSY clutch with Part No. 05-7211-K006002 and S/N 20480 were measured 23.8 mm and 24.7 mm respectively. The correct length of these springs is 27.5 mm according to TAE.

o) The ASSY clutch was delivered as a complete assembled and adjusted unit from the factory.

p) There is no indication that the clutch or gearbox had been incorrectly installed during the clutch replacement that a Norwegian workshop had carried out.

q) The weather had no bearing on the sequence of events.

4. SAFETY RECOMMENDATIONS

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

Accident Investigation Board Norway

Lillestrøm, 12 November 2013

APPENDICES

Appendix A: Abbreviations

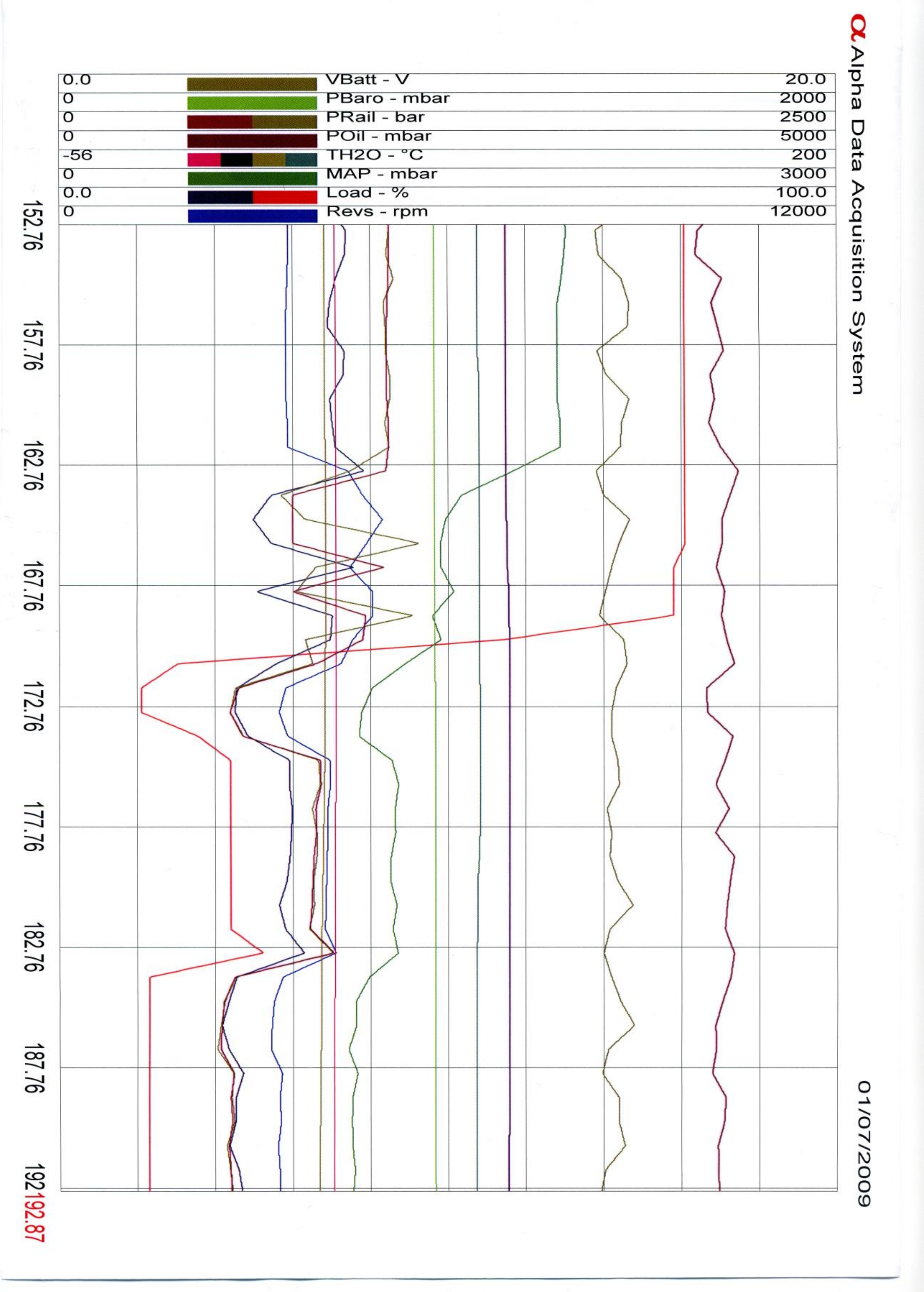
Appendix B: FADEC log

Appendix C: BFU Concise Engineering Report

Relevant abbreviations

ASSY	assembly
BFU	Bundesstelle für Flugunfalluntersuchung – The German accident investigation authority
CAVOK	Ceiling And Visibility OK – weather code for good visibility
CPL (A)	Commercial Pilot's License (Aircraft)
CTR	Control zone
EASA	European Aviation Safety Agency
FAA	Federal Aviation Administration – the US aviation authority
FADEC	Full Authority Digital Engine Control
FAR	Federal Aviation Regulation – US aviation regulations
Ft	feet (measure of length)
G switch	switch that is activated by acceleration over a pre-defined value
hp	horsepower
JAR-E	Joint Aviation Regulations – Engines – joint European certification specifications for aircraft engines
JAR PPL (A)	Joint Aviation Regulations Private Pilot's License (Aircraft)
kW	kilowatt
Kh/kh	knots – nautical miles per hour (1 knot = 1.852 km/h)
METAR	METeorogical Aerodrome Report – airport weather observations
MTOM	Maximum Take-Off Mass
N-ARC	Norway- Airworthiness Review Certificate
NOSIG	NO SIGnifikant change – no significant change is expected (used in connection with METAR)
Part No.	Part Number
Q	Q – QNH – Altimeter setting related to pressure above the sea surface
rpm	revolutions per minute
S/N	Serial Number
TAE	Thielert Aircraft Engines GmbH
TMA	Terminal Area – (type of controlled airspace)
Z	Zulu – UTC – universal standard time

FADEC-logg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192.87
01/07/2009

Concise Engineering Report

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Case details (if available)

BFU Record	DX013-0/09	Location	Kjeller (Norway)
Aircraft Type	DA40	Aircraft Registration	LN-NEX
Date Event	02.04.2009	Date Received	26.11.2009

Unit Under Investigation

Device Class	Loom	Manufacturer	Thielert
Device Type			
P/N	05-7150-E000901	S/N	00413-2007

Additional Information

IIC (AIBN): Mr. Jon Sneltvedt
ACCREP (BFU): Mr. Thomas Karge

Investigation Goals

Inspection of the loom

Condition when received

The loom was delivered to Thielert in a sealed box. The seal was undamaged and opened in the presence of a BFU employee.

Picture 1 Undamaged seal

Investigation Steps

The following persons were present during the investigation:

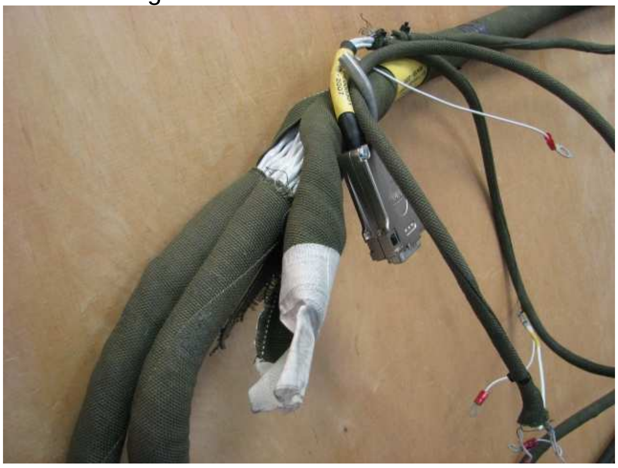
- Mr. Jan-Henning Lau (Thielert)
- Mr. Oliver Zetsche (Thielert)
- Mr. Jörg Krenkel (Thielert)
- Mr. Philipp Lampert (BFU)

First, a visual inspection of the loom was conducted. Some of the connectors were showing signs of oxidation (see picture 2 and 3), likely because parts of the loom were exposed to water due to the accident. In addition, some connectors and the loom were slightly damaged which was likely caused by the accident (pictures 4 and 5). None of the connectors was showing any signs of unusual wear.

Picture 2 Signs of oxidation

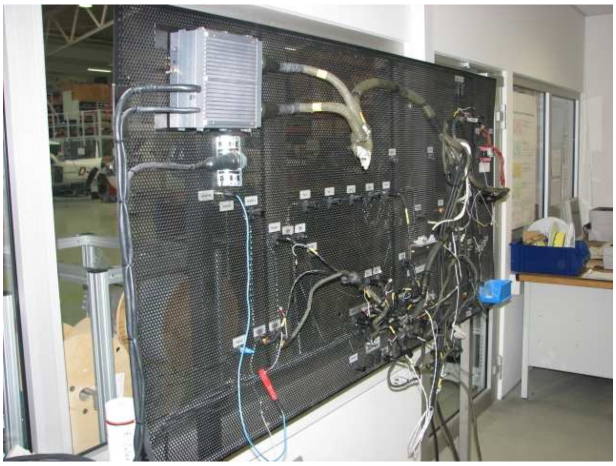
Picture 3 Signs of oxidation

Picture 4 Damage to the connector shell



Picture 5 Damage of the loom

The next step was to connect the loom to a test rig (see picture 6). In order to put the loom on the rig, some of the cable ties had to be removed. The loom tested OK (see picture 7), no short circuit or discontinuity were found. To rule out any intermittent faults, the loom was moved (shaked) in all areas. The loom still tested OK.



Picture 6 Test rig

Picture 7 Tester

As a final step, an isolation test was conducted. This was done by applying 1000V DC to the shield of the cable and measuring the current on the return path, thus getting the isolation resistance. The isolation resistance was the same as for a new, good cable. The same was done while shaking the loom. Again, no problem was found.

Picture 8 Isolation test set-up

Picture 9 Isolation tester

Findings

No pre-existing fault of the loom was found during the visual inspection and electrical testing.

Work finished

Date	26.11.2009	Work conducted by	P. Lampert
		Signature	
		Head of department	G. Blau
		Signature	

WO 115, Printed 27.11.2009