SL Report 2007/28

REPORT ON AVIATION ACCIDENT ON 24 OCTOBER 2004 AT BREISTEIN FERRY QUAY IN ÅSANE, HORDALAND, NORWAY INVOLVING ENSTROM 280C, G-ECHO

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.

Submitted
September 2007

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REPORT ON AVIATION ACCIDENT

Type designation:	Enstrom 280C[1]
Registration:	G-ECHO
Owner:	Cast Designer 5382 Skogsvåg
User:	Private
Crew/Commander:	1
Passengers:	Two, of whom one died
Accident site:	In the sea approx. 40 metres from Breistein ferry quay, Hordaland, Norway (60°29’43”N 005°24’02”E)
Accident time:	Sunday 24 October 2004, approx. 1242

All times given in this report are local time (UTC + 2), if not otherwise stated.

NOTIFICATION

The Duty Officer of the Norwegian Accident Investigation Board (AIBN) was notified of the accident at 1252 on 24 October 2004 by the Joint Rescue Coordination Centre for Southern Norway. The notification stated that a small helicopter of unknown type and registration had crashed into the sea at Breistein ferry quay north of Bergen. There were reportedly three persons on board, and two of these had been rescued and brought ashore. In cooperation with the police the AIBN immediately started preparations to salvage the wreckage. Two representatives of the AIBN turned out and arrived in Bergen at 2000 the same day.

In accordance with ICAO Annex 13, Aircraft Accident and Incident Investigation, the US (country of manufacture) accident investigation board, National Transportation Safety Board (NTSB), and the UK (country of registration) accident investigation board, Air Accidents Investigation Branch (AAIB) were notified by AIBN. The Air Accidents Investigation Branch assigned a contact person to assist in investigations.

SUMMARY

The Commander had just recently ferried the helicopter from England and operated it from his home on Sotra. On the day of the accident some car parts located near Breistein ferry quay in Åsane north of Bergen were to be picked up. The Commander’s son and his cohabitant came along for the flight. The helicopter was readied for the flight, and the flight to Breistein took place without incident. The helicopter landed on the parking area by the ferry quay, and the passengers went to collect the parts while the Commander stopped the rotor. The engine was kept running and after approximately 10 minutes the passengers returned. The rotor was reengaged and the checklist for

[1] The model is termed 280-UK-2 by the British CAA

start and takeoff was completed. The helicopter then lifted to a low hover and engine performance was checked before further ascent and departure towards the sea commenced. After approx. 50 m of flying, just as the helicopter passed the edge of the quay, the Commander became aware that engine RPM were decreasing. Attempts to limit the reduction in RPM were unsuccessful and the helicopter made an emergency landing in the sea approx. 40 m from the ferry quay. The helicopter sank immediately and one of the passengers drowned. No-one on board was wearing a life jacket.

Investigations have revealed that several of the engine spark plugs were significantly worn and that one of the plugs had a lead ball in the spark gap. This may have led to a significant reduction in engine power during a critical phase of the takeoff. The parking area was surrounded by elevated terrain and several lamp-posts and masts. This made the takeoff difficult and precluded alternative emergency landing locations. The safety margins during takeoff were further reduced due to the helicopter being slightly overweight. The AIBN is of the opinion that weather conditions had no bearing on the course of events. A defect discovered in the engine's turbocharger had in the opinion of the AIBN no decisive impact on the course of events.

The AIBN has not issued any safety recommendations following this investigation.

1. FACTUAL INFORMATION

1.1 History of the flight

1.1.1 The Commander, who also had the helicopter at his disposal on a daily basis, had it parked on his property on Sotra west of Flesland. During Saturday it became apparent that some small parts for a car repair were missing. The parts were located in the Commander's son's house by Breistein ferry quay in Åsane north of Bergen. They decided to fly there and pick up the parts the following day. Driving there by car would take approx. 1 ½ hours. The son and the his cohabitant should come along for the flight.

1.1.2 The helicopter's fuel tanks were almost full, and it was therefore only necessary to perform a daily inspection this Sunday. During the inspection the fuel tanks and fuel filter were drained for eventual water, but none was found. The actual mass and balance of the helicopter were not calculated before takeoff. The Commander had not previously landed at Breistein ferry quay, but he had been there many times before and was familiar with the area. Prior to takeoff, the Commander was routinely in contact with the air traffic control tower at Bergen airport Flesland (ENBR). He was assigned an altitude restriction of 1,000 ft within the control zone of Bergen airport Flesland. At the same time he was provided with a current weather report (TAF) and the current weather at the airport (METAR). The Commander was familiar with the planned flight route and did not plan the flight beyond this. He did not obtain permission from the landowner to land on the ferry quay.

1.1.3 Upon boarding at Skogvåg the Commander provided a safety briefing where the function of the seat belts and door locks were explained. The flight would mainly be over land and life jackets were not worn. After start-up an engine test was carried out. According to the Commander, the engine provided normal values and the engine RPM drop during the magneto tests were in the order of 50 – 100 revolutions. Departure took place at approx. 1205. The Commander established contact with the tower at Flesland and flew northwest in the control zone towards Åsane. The flight then continued outside controlled airspace towards Flaktveit and on to Breistein. Upon arrival at Breistein ferry quay at approx.

1225, the Commander first flew over the quay area to see if there were any obstacles. He then flew out to sea before turning round and landing on the ferry quay. The helicopter landed with the nose pointing northwest on the parking area (see fig. 2). The rotor was stopped and the two passengers left the helicopter. According to the Commander, the engine's RPM were maintained at 1,800 and slight fuel leaning[2] was implemented. After approx. 10 minutes the passengers returned with the parts and boarded the helicopter. The woman sat in the middle, while the Commander's son sat to the right next to the door.

1.1.4 According to the Commander the entire checklist for *"Engine Warmup and Ground Check"* was completed again. The mixture control was set to full rich and the magneto test was within the limits. The time was approx. 1240 when the rotor was engaged and the helicopter lifted to a low hover. The Commander has explained that the helicopter hovered at an expected manifold pressure of approx. 28 inHg. All other indications were also as expected. He then turned the helicopter in excess of 180° to the left so that it faced eastwards and then rose to a height of approx. 15 ft above the parking area before he started acceleration out towards the sea. After approx. 50 m the helicopter passed the edge of quay a good height above the 19 ft tall masts on the vehicle boarding ramp. The speed was at that point slightly above 30 mph. The Commander has further explained that he had plenty of clearance to the approx. 26 ft tall lamp-posts on both sides (see fig. 1). He then noticed that the engine RPM had decreased from 2,900 to 2,800 and were continuing to decrease. In order to counter this he lowered the collective somewhat and increased manifold pressure to the maximum without effect. He noticed that the amber overboost warning light had come on. In an attempt to increase rotor RPM the helicopter's nose was raised, but this could not prevent it from hitting the sea relatively gently and with little forward speed.

[2] The engine is usually fed a fuel mixture that is too rich when idling. The air/fuel ratio may be adjusted with the mixture control so that one avoids sooting of the spark plugs, among other things.

Figure 1: Picture taken towards the east. The helicopter was parked approximately beside the number 6 and took off in the direction of the front of the brown car.

1.1.5 The helicopter, which was then in the sea approx. 40 m from the quay edge, immediately started to sink. The cabin filled with water in a matter of seconds. It then tilted to the left causing the rotor to lash into the water. The female passenger explained that it became dark and that she lost her bearings. She did however manage to unbuckle the safety belt. Without knowing how, she managed to get out of the helicopter after a short while and up to the surface. The Commander had trouble getting his bearings in the helicopter due to large amounts of air bubbles and increasing darkness. He couldn’t find the door handle, but managed to unbuckle his seatbelt and tried to kick out the front window to escape. He also registered that there was another person in the cabin and tried to unbuckle that persons seatbelt. However, the helicopter was sinking and the situation became extremely critical. He had to get out and exited the helicopter, presumably through the front window. After swimming towards the surface for a while he became unsure as to whether he was swimming down or up. He continued to swim, however, but lost consciousness at some point. After a short while he appeared at the surface and lay floating with his face down.

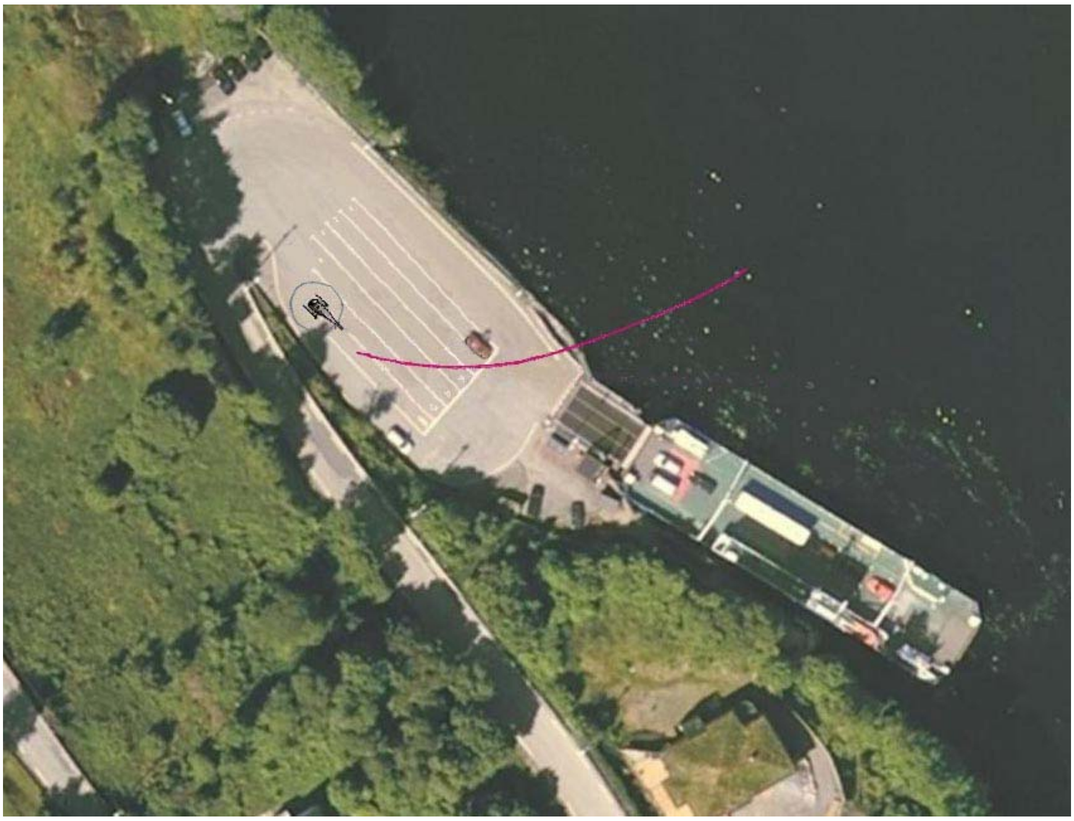


Figure 2: Manipulated image showing approx. where the helicopter started and the assumed flight path.

1.1.6 A witness stood fishing with three friends on the ferry quay. He explained later to the police that he saw the helicopter arrive and land. After approx. 10 minutes it started up again and rose 3 – 4 metres straight up before turning left and flying towards the sea. When the helicopter passed the edge of the quay it appeared to immediately lose lift and dropped towards the sea surface. Just before it hit the surface the tail went down and the back end of the skids hit the sea surface first. The helicopter stopped almost immediately and tilted left so that the main rotor hit the water with a slam. It then sank with the nose first within roughly five seconds. As the helicopter disappeared, the female passenger came into view. The woman had only swum 5 – 10 m towards land before she was picked up by a fast rigid inflatable boat (RIB) that came to assistance.

1.1.7 After the woman had been picked up by the boat, the witnesses on land discovered an object resembling a person floating in the water. The boat operator was alerted of this and moved the boat closer. The boat operator and the female passenger attempted to pull what turned out to be the Commander into the boat. He was too heavy, however, and they chose to tow him ashore while holding his head above water. When they reached the quay, more people got into the boat and helped to drag the Commander into the boat. After a short while he started to breath and it was considered best to leave him in the boat until rescue personnel arrived.

1.1.8 The operator of a 20 ft long open work boat[3] explained to the police that he was on his way from a fish farming facility north of Votloholmen in Sørfjorden to Hamreneset on Osterøy. He was approximately in the middle of the fjord going north in Osterfjorden level with Breistein ferry quay when he noticed a helicopter on the quay. He steered

[3] This is the same boat as is previously described as a rigid inflatable boat (RIB)

slightly left to get closer and saw the helicopter lift off from the parking area. The helicopter turned around its own axis and swung towards the fjord. The witness noted that the main rotor must have been close to the lamp-post lining the quay edge. When the helicopter passed the quay edge, it seemed to lose speed and height. The helicopter hit the surface gently and tipped sideways so the main rotor whipped up water. The boat operator turned the boat in the direction of the accident and accelerated to full speed. He saw a woman in the sea whom he easily managed to pull into the boat.

1.1.9 According to the police log, the fire brigade with divers arrived at 1257. Neither the helicopter nor the missing passenger were found. During the search it became clear that it rapidly became deeper beyond a 20 m deep shelf by the quay. The helicopter was located with the aid of a camera at a depth of 62 m at 1512. The deceased passenger was found lying on the seabed approx. 5 m from the cockpit.

1.2 Injuries to persons

Table 1:Injuries to persons

Injuries	Crew	Passengers	Other
Fatal		1	
Serious			
Minor/none	1	1	

1.3 Damage to aircraft

The helicopter was destroyed. For details, see section 1.12.2.

1.4 Other damage

None

1.5 Personnel information

1.5.1 The Commander, male, 56 years old, acquired his private pilot’s licence for aeroplanes at Bergen Aeroklubb in 1983. In April 2003 his Norwegian pilot’s licence was accepted (validated) by the Federal Aviation Administration (FAA- The US air transport authorities) and he was permitted to fly “*Airplane Single Engine Land Rotorcraft-Helicopter*”. Validation was provided conditional on possession of a valid Norwegian licence. The Commander’s Norwegian private pilot’s licence PPL(A) was valid until April 2005. The right to fly single-engine land aircraft (SEL) was last renewed on 20 March 2004 and was valid at the time of the accident.

1.5.2 The Commander had a second-class medical certificate valid until 11 March 2005. The medical certificate had the following limitations: “VNL Shall have available corrective spectacles for near vision and carry a spare set of spectacles.”

1.5.3 The Commander acquired his helicopter licence on the helicopter type Enstrom 280 in the USA in connection with the validation of the Norwegian private pilot’s licence. He thereafter flew a few hours on the helicopter type EXEC 162 before continuing flying Enstrom 280 in connection with the purchase of G-ECHO.

1.5.4 On 2 July 2004 the Commander sent a letter to the Norwegian Civil Aviation Authority with the aim of discussing possible procedures for converting his American private pilot's licence for helicopters to PPL(H). This conversion had not taken place at the time of the accident.

Table 2: Flight time

Flight time	All types	Current type
Last 24 hours	0:20	0:20
Last 3 days	0:20	0:20
Last 30 days	2:15	2:15
Last 90 days	approx. 10	approx. 10
Total	335:35	63:25

1.6 Aircraft information

1.6.1 General

Make:	Enstrom
Type designation:	280C[4]
Serial number:	1017
Year of manufacture:	1975
Airworthiness certificate:	Valid until 29 March 2005
Total flying time:	774 hours
Daily inspection:	Performed in the morning of 24 October 2004

Time since last maintenance (Star Annual): 29:45 hours

Engine:	Lycoming HIO-360-EIAD
Engine serial number:	L-19112-51A
Total engine operation time:	591 hours
Time since last maintenance (engine):	29:45 hours
Fuel:	AVGAS 100LL
Maximum takeoff mass:	2,350 lb (1 066 kg)
Diameter main rotor:	32 ft (9.75 m)

The main rotor rotates clockwise when viewed from above.

[4] The model is termed 280-UK-2 by the British CAA

1.6.2 Mass and balance

Table 3: Mass and balance calculation

	Masse (lb)	Arm (in)	Mass x Arm
The helicopter's basic empty mass according to weight report of 22 March 2004	1,673.5	101.84	17,0428
Commander's mass (including 3 kg clothes). Commander's estimate.	216.0	64.00	13,824
Mass passenger 1 (including 3 kg clothes). Provided by the police	205.0	64.00	13,120
Mass passenger 2 (including 2 kg clothes). Passenger's estimate	126.7	64.00	8,109
Fuel (110 litres) Commander's estimate	172.0	93.20	16,030
Luggage	5.0	93.20	446
Total	2,398.2	92.56	221,977

According to the Flight Manual for Enstrom 280C the front centre of gravity limitation is 92.0 in.

The rear centre of gravity limitation at 2,350 lbs is 94.6 in.

The helicopter mass was accordingly approx. 48 lbs (21.8 kg) above the maximum allowed, while the centre of gravity was within the limits.

1.6.3 Turbo

1.6.3.1 When flying it is desirable to maintain engine manifold pressure even though atmospheric pressure decreases with altitude. This is done either by using a mechanically driven compressor or a compressor driven by an exhaust turbine. The latter alternative (termed turbo for simplicity) exploits excess energy from the exhaust and therefore usually provides better fuel economy compared to mechanically driven compressors. Many turbo systems have a bypass to lead some of the exhaust gases around the actual turbine section of the turbo unit so that turbine RPM, and thereby manifold pressure, is reduced. The volume of exhaust gasses that are led through the pipe, and thereby around the turbo, is regulated by a valve (wastegate) or limited by a fixed restrictor. The advantage of a fixed restrictor is that the system has few moving parts and thereby high reliability. The disadvantage is that the size of the restrictor is necessarily a compromise, and that the manifold pressure may become too high during high power draw from the engine. This problem can be solved by installing a pressure valve that opens and releases air when the manifold pressure becomes too high. Alternatively, regulation may be left entirely up to the pilot in the form of a warning being provided once manifold pressure exceeds a certain limit, as was the case with G-ECHO.

1.6.4 History

1.6.4.1 When the helicopter was manufactured in 1975 its type designation was 280 and it did not have a turbocharger. In August 1978 the helicopter, which at the time had the registration letters G-BDIB, was rebuilt to a 280C. At the time the helicopter had a total operating time of 184.4 hours. The work was performed by Spooner Aviation (Engineering) Ltd, of Shoreham, Sussex in England. The rebuilding was extensive and affected a number of details, but mainly entailed the installation of a new engine with a turbocharger. The original engine was replaced by the engine that was present during the accident (S/N L-19112-51A). The work was, according to documentation, performed in accordance with “Enstrom Turbo conversion drawing 28-1000050”. The actual engine installation was performed in accordance with “Enstrom Turbo conversion drawing 28-1000050 B. No 78513”. The Spooner Aviation company no longer exists.

1.6.4.2 The manufacturer Enstrom has stated that the bypass tube in the 280C did not originally have a restrictor. The exhaust flow through the bypass tube was consequently a result of the size of the hole bored in the actual exhaust pipe at the branching. However, experience showed that this hole was burned larger by the hot exhaust and it was decided to manufacture new bypass tubes with a restrictor built in to the actual pipe. The new bypass tube with built-in restrictor was introduced in June 1977 and had the part number 28-1250017-1. The new type of tube was not introduced in connection with a Service Directive Bulletin or Service Information Letter, but only included in revised versions of the parts catalogue.

1.6.4.3 The engine’s turbo system was modified in April 1991 by Skyline Helicopters Ltd, Wycombe Air Park, Buckinghamshire, England. The modification was done as a consequence of Service Directive Bulletin (SDB) 0058 published by Enstrom. The work entailed removing the excess pressure valve on the induction inlet and replacing this with a pressure switch connected to an amber warning light in the cockpit. At the time the helicopter had a total operating time of 532:33 hours. Following this, the design of the turbo system should be as shown on the illustration below.

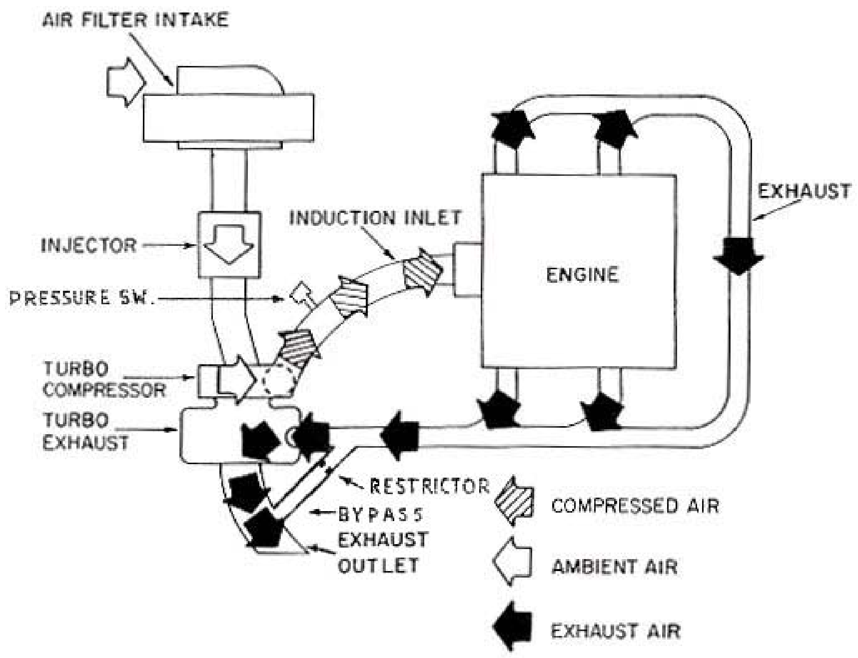


Figure 3: Illustration of the turbo system on the Enstrom 280C

1.6.5 Description of the turbo system on G-ECHO

Air is drawn in through the air filter intake and on through the injector where the manifold pressure is regulated by using the collective/throttle. The correct air/fuel mixture is also determined in the injector. The air is then drawn into the turbo's compressor section and fed into the engine. The combusted exhaust fumes are led from the engine to the turbine section of the turbo and then out via the exhaust pipe. A 184 mm long bypass tube with an external diameter of 29 mm and an internally calibrated restrictor serves to reduce the turbo RPM. The instrument displaying the manifold pressure is marked with a red line at 36.5 inHg. If manifold pressure exceeds 36.5 inHg, this is registered by a pressure switch in the induction inlet and an amber warning light is illuminated on the instrument panel. The manifold pressure must then be reduced by using the throttle. The turbo system in the Enstrom 280C is designed to provide a manifold pressure of 36.5 inHg up to an altitude of 12,000 ft.

1.6.6 Maintenance

1.6.6.1 The last maintenance inspection (Star Annual) on G-ECHO was performed by HFI Engineering, Sandy, Bedfordshire in England in connection with transfer of ownership of the helicopter. This inspection corresponds to a Norwegian annual inspection. The work that led to the renewal of the airworthiness certificate was according to the documentation performed in accordance with "Light Aircraft Maintenance Schedule (LAMS) Helicopters". This is a standardised maintenance programme for helicopters with piston engines and a maximum takeoff weight of up to 2,730 kg. This means that the inspection is not adapted to individual helicopter types or a helicopter's modification status. The work that was signed off on 29 March 2004 included standard items, a number of replacements in the rotor system, a complete repainting of the helicopter and preparation of a new weight report.

1.6.6.2 A “Star Annual” includes a “100 hour check”. According to “LAMS Helicopters” this shall include “CHK” (check) of spark plugs. “CHK” is described as: *“…the verification of compliance with the type design organisation’s recommendations”*. Correspondingly “INSP” (inspect) under the point *“73 Turbocharger, control system, pipelines, hoses”*. “INSP” is described as:

> *“An “Inspection” is a visual check performed externally or internally in suitable lighting conditions from a distance considered necessary to detect unsatisfactory conditions/discrepancies using, where necessary, inspection aids such as mirrors, torches, magnifying glass etc. surface cleaning and removal of detachable cowlings, panels, covers and fabric may be required to be able to satisfy the inspection requirements.”*

1.6.6.3 Following the completion of the Star Annual inspection the helicopter was flown for approx. four hours before the flight to Norway commenced on 13 July 2004. The Commander flew the helicopter home and thereafter for a further approx. 12 hours in Norway before the accident. No other maintenance beyond daily inspections was carried out during the time G-ECHO was in Norway. The Commander experienced no significant problems with the helicopter while he used it.

1.6.6.4 According to Lycoming Service Instruction No. 1042X of 9 July 2002, the following Champion spark plugs are approved for use in HIO-360-E engines:

- RHB 32E
- RHB 37E

The spark gap shall be between 16 – 22 thousandths of an inch.

1.6.7 Flight Manual

1.6.7.1 In “Flight Manual Enstrom 280C”[5] the following is stated under the heading “Maximum power takeoff from confined areas”:

> *”**NOTE:** If RPM is lost due to overpitching, it may be regained by maintaining 36.5 inches of manifold pressure, lowering collective slightly and applying some aft cyclic.*
>
> *In both preceding conditions it is imperative that the helicopter has accelerated a little beyond translational speed in order to accomplish these maneuvers. Therefore, good judgement must be used to determine the rate at which the helicopter is accelerated from hover to translational speed and to determine if sufficient distance is available to clear obstacles under the existing density altitude conditions.”*

1.6.7.2 In “Flight Manual Enstrom 280C” in the chapter entitled “Emergency & Malfunction Procedures” the following is stated under the heading “Ditching without power”:

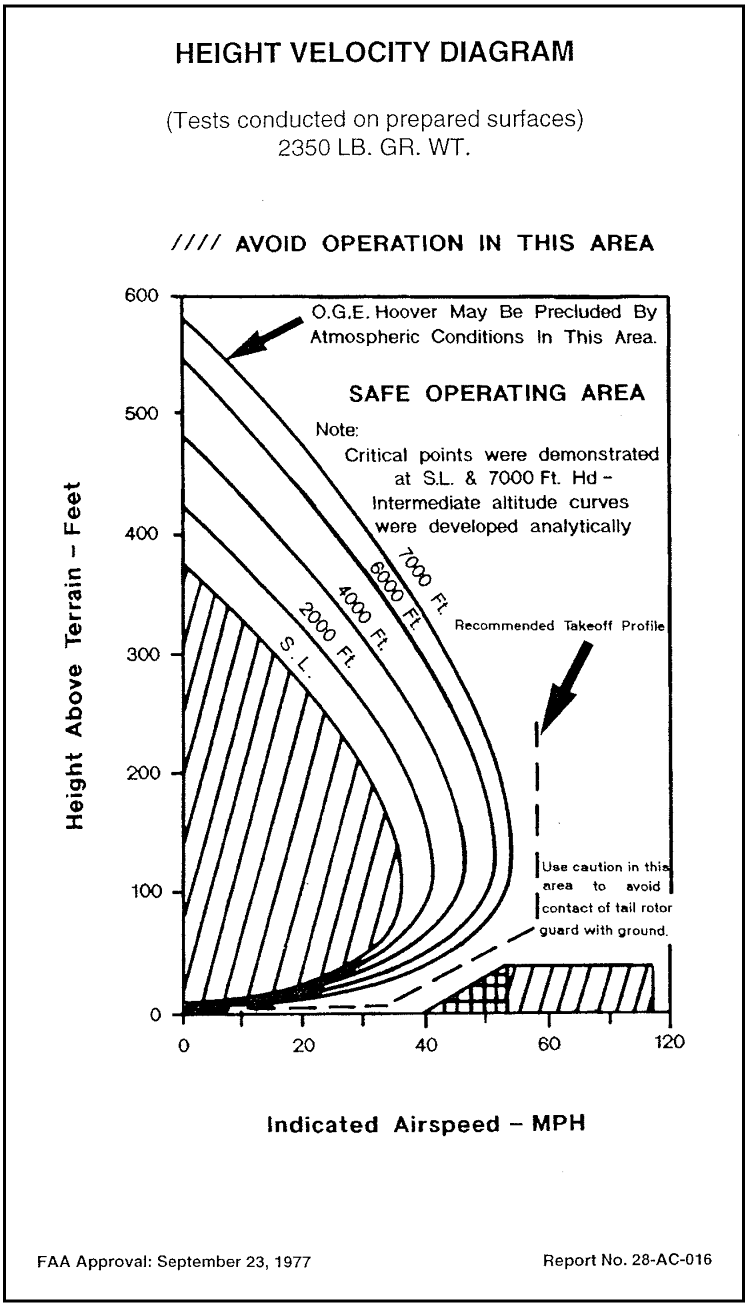
> *“1. Turn off master and alternator switches*
>
> *2. Unlatch both doors.*
>
> *3. Complete normal autorotation to land in water at zero airspeed.*

[5] Report No. 28-AC-016. FAA Approval: September 23, 1977. Revised: May 22, 1989

4. *As collective pitch reaches full up and aircraft settles in water, apply full lateral cyclic in direction aircraft tends to roll.*

5. *After rotor strikes water and stops, exit all occupants and clear aircraft."*

1.6.7.3 The "Height Velocity Diagram" from "Flight Manual Enstrom 280C" is reproduced below.



1.7 Meteorological information

1.7.1 The Norwegian Meteorological Institute has informed that during the morning of 24 October there was a low pressure southwest of Ireland and one in the Norwegian Sea. The fronts related to these lows were south and northwest of southern Norway respectively. There were thus no fronts in the area. Local weather observations show that there was little wind and local showers in north Hordaland on the morning in question. At 1100 there was a north-westerly wind of approx. 10 kts along the coast. At 1400 the wind had turned to the north and decreased to 5 kts. Wind on the ground is determined by topography. The Norwegian Meteorological Institute was of the opinion that there was little vertical wind that could cause downdraughts.

1.7.2 The Commander has in his report estimated that there was a local variable wind of 0-5 kts at the accident site. In a conversation with the AIBN however, he explained that that he did not notice any wind while standing on the ferry quay, and that he assumed that there was no wind during takeoff. Further, it was slightly overcast with cloudbase above 3,000 ft and visibility was good. The temperature was announced to be 12 ºC, and air pressure (QNH) 1000 hPa. According to the Commander the sea was almost glassy when the accident occurred.

1.7.3 METAR

ENBR 241050Z VBR03KT 9999 FEW014 SCT018 SCT045 09/06 Q1000 NOSIG=

1.7.4 IGA PROG 240900-241800UTC OCT04 STAVANGER AOR COASTAL AND FJORD AREAS

WIND SFC……………:	VRB/05-10KT
WIND 2000FT……….:	VRB/05-10KT, LOC N-LY/10KT COT N-PARTS FIRST HR
WIND/TEMP FL050…:	VBR/05-10KT, LATE BECMG 180-210/KT S-PART. TEMP: MS03-PS00, LATE BECMG PS01-PS02 S-PART
WIND/TEMP FL100…:	260-290/10KT, STRONGEST S-PART. LATE BCMG 210-240/10-25KT, STRONGEST S-PART. TEMP: MS08-MS05, MS10-MS09 N-PART FORENOON
WX……………………:	SCT SHRA FIRST HR, ELSE NIL
VIS……………………:	+10KM
CLD…………………..:	FEW 1000-1500FT, SCT/BKN 2000-5000FT RISK LOC BKN 0800-1500 FIRST HR
0 ISOTHERM…………..:	3500FT-FL050, BCMG FL050-060 S-PART
ICE……………………:	FBL/NIL
TURB…………………:	FBL/NIL

=

1.8 Aids to navigation

The Commander navigated in a familiar area in accordance with visual flight rules. Navigational aids are not otherwise relevant for the investigation.

1.9 Communications

The Commander established two-way radio communications with the air traffic control tower at Flesland (TWR) while flying within the control zone (CTR) on the way to Breistein. He did not re-establish contact with the tower before departure from Breistein. Accordingly the air traffic control service was not aware that the flight back to Skogsvåg had commenced.

1.10 Aerodrome information

Not relevant

1.11 Flight recorders

Not mandatory and not installed.

1.12 Accident site and helicopter wreckage

1.12.1 Accident site

1.12.1.1 The accident happened in the sea approx. 40 m east of Breistein ferry quay. The actual ferry quay consists of a paved area approx. 80 x 30 m in size and a vehicle boarding ramp (see fig. 1). The area is surrounded by high terrain to the south and west. Along the quay edge, which borders the area to the northeast, there was a line of approx. 8 m tall lamp-posts in addition to two 5.8 m tall columns on the boarding ramp. The Commander flew over the edge of the quay between two of the lamp-posts and close to the northernmost column. At high tide the distance from the sea to the quay edge is 2.5 m.

1.12.1.2 Immediately after the accident a loose stay was found on one of the lamp-posts along the quay edge. Closer examination showed that the stay had not been severed as a result of contact with the helicopter. No other traces of the helicopter were found on the ferry quay.

1.12.1.3 The helicopter was located at a depth of 62 m, lying on a small shelf on a very steep incline. It is therefore possible that the helicopter had plunged further out into the fjord after hitting the seabed the first time.

1.12.1.4 The water temperature in the area was estimated by the Institute of Marine Research to be approx. 12 °C

1.12.2 The helicopter wreckage

1.12.2.1 The helicopter wreckage was found intact lying on its left side. Damage was apparently limited, and both the main rotor and tail rotor were both attached to the helicopter. The wreckage was salvaged by using a strap attached to the main rotor mast. The salvage operation was carried out using a barge with a crane and a Remotely Operated Vehicle (ROV). The helicopter wreckage was recovered on 25 October at 0230 and immediately hosed down with freshwater. Following a preliminary examination the wreckage was transported to the AIBN’s premises in Lillestrøm for closer inspection.

Figure 4: The helicopter photographed at night after it had been salvaged. The front windscreen and the windows in both doors are shattered. Further, the damage on the front and the bending of the main rotor blades are visible.

1.12.2.2 In Lillestrøm it was determined that the damage to the helicopter was mainly as follows:

- Both front windscreens shattered and the middle column broken at the top
- Moderate impact damage to the nose
- The window in front of the rudder pedals on the left side broken
- Right door open
- The windows in both doors broken
- Right skid bent upwards somewhat at the front
- All main rotor blades bent downwards in an even arc
- Some smaller dents along the tail boom
- Vertical tailfin knocked loose
- Left horizontal fin bent upwards
- Damage to tail boom after contact with tail rotor blade (with rotation of tail rotor)
- Moderate bending of both tail rotor blades

- Saltwater damage, particularly to instruments/radio equipment and aluminium alloy components

1.12.2.3 Flight Controls were examined with regard to possible control issues. No malfunctions or damage to the controls, transfer mechanisms or rotors were found that could be related to the status prior to the accident. Neither was any damage to the rotors discovered that could be attributed to collisions with birds, contact with stays or similar. A fracture in the mixer at the bottom of the main rotor mast showed clear signs of overloading.

1.12.2.4 The transmission belts between the engine and the main gearbox were not worn and were correctly tightened. Further, more than a litre of oil was found in the main gearbox and there were no metal particles on the main gearbox magnetic plug.

1.12.2.5 The engine was thoroughly examined during the period between 27 October and 3 November with the purpose of finding possible reasons for engine power failure.

- It was determined that the fuel tanks contained a mixture of saltwater and AVGAS 100LL.

- No contamination or other restrictions were found in the filters in the fuel tanks, fuel lines, fuel selection valve, water separator/fuel filter and the filter in the throttle unit.

- The air filter had little contamination and provided good airflow. No indication of restrictions or leaks in the intake pipes were found.

- Engine controls worked as expected and were seemingly correctly adjusted.

- Mixture Control was found in the “full rich” position.

- The turbocharger was not damaged and rotated freely. No signs of restrictions or leaks in the exhaust pipes were found. However, it was discovered that the exhaust bypass tube lacked a restrictor (see section 1.6.5). There was no indication that such a restrictor had been installed in the tube.

- The oil sump contained a mixture of saltwater and oil. The exact amount of oil was not verified, but the amount found was considered to be adequate for normal operation of the engine.

- No metal particles were found in the oil sump or oil filter.

- The spark plugs were removed and examined. The upper spark plugs were in a relatively good condition, but the spark plug in cylinder no. 1 was short-circuited by a lead ball. These plugs were of the type Champion RHB 32E. The lower spark plugs of the type Champion RHB 36P were worn and had large spark gaps (see table 4).

- Valve covers were removed and the valve mechanism was inspected without anything out of the ordinary being discovered. The cylinders and valves were then inspected internally with the aid of a borescope. Some soot was discovered that had probably been dislodged when saltwater penetrated the hot cylinders. No other damage or wear that could have led to loss of engine power was found.

- The cylinders were subjected to a leak check. Applied air pressure was 80 psi (see table 5).

- In order to test the engine further if possible, the saltwater damage in the electric fuel pump was repaired and the spark plugs were installed. The fuel system was cleared of water and the fuel tank was filled with AVGAS 100LL. An attempt was made to start the engine using a new battery. The starter worked as expected and the engine was supplied with fuel, but it did not start. Closer inspection revealed that the magneto had considerable saltwater damage. The damaged magneto[6] was then replaced with an airworthy magneto and the spark plugs were replaced with new ones. The engine still failed to start. Closer inspection revealed that there was only a weak spark in two spark plugs. This was probably due to corrosion and the possibility of flashover in the magneto cover[7] and corresponding issues in the high-voltage cables to the spark plugs.

- After the starting attempts a new cylinder leak check was performed (see table 5).

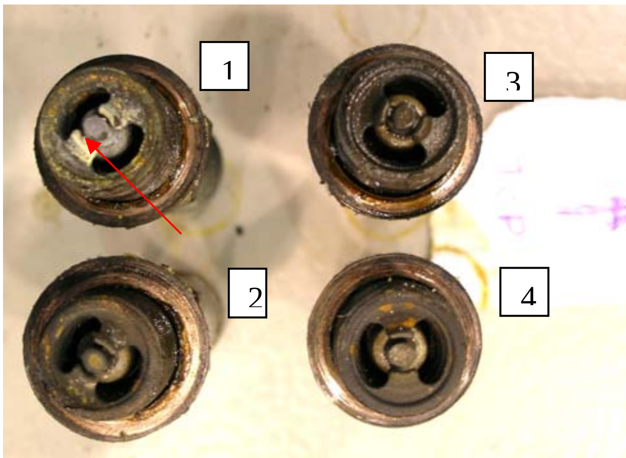


Figure 5: Upper spark plug set. The plugs are marked with the cylinder numbers. The red arrow indicates the lead ball in the plug from cylinder no. 1

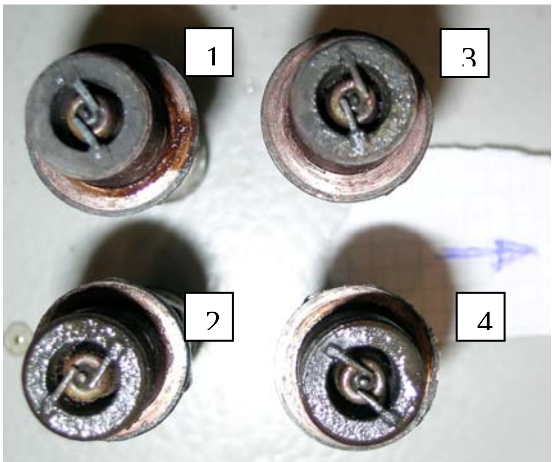


Figure 6: Lower spark plug set. The plugs are marked with the cylinder numbers

[6] The engine is equipped with a dual magneto
[7] The high voltage cables are integrated with the magneto cover. For this reason the magneto cover was not exchanged.

Table 4: Spark plug conditions

Cylinder no.	Position	Spark gap Thousandth of an inch	Description
1	Upper	20	Moderately worn. Lead ball in spark gap. Light yellow-brown
	Lower	24	Worn centre electrode. Soot-coloured
2	Upper	20	Moderately worn. Chocolate brown
	Lower	20	Little wear. Some oil. Soot-coloured
3	Upper	20	Moderately worn. Some oil. Chocolate brown
	Lower	32	Worn centre electrode. Soot-coloured
4	Upper	20	Moderately worn. Chocolate brown
	Lower	24	Worn side electrodes. Some oil. Soot coloured

Table 5: Results from the cylinder leak tests before and after the start attempts, measured in psi. A pressure of 80 psi was applied to the cylinders.

Cylinder No. 1	Before start attempt	10
	After start attempt	30
Cylinder No. 2	Before start attempt	35
	After start attempt	40
Cylinder No. 3	Before start attempt	10
	After start attempt	45
Cylinder No. 4	Before start attempt	72
	After start attempt	72

1.13 Medical and pathological information

1.13.1 A routine blood sample of the Commander was taken after the incident. The sample showed no traces of alcohol or medication.

1.13.2 An autopsy was performed on the passenger. The cause of death was determined to be drowning.

1.14 Fire

No fire occurred during the accident.

1.15 Survival aspects

1.15.1 There were several witnesses to the accident and the police was immediately notified. Several of the witnesses, among them a person in a boat, participated in the initial rescue work.

1.15.2 The helicopter was not equipped with flotation gear for emergency landing on water.

1.15.3 The helicopter was equipped with four-point seatbelts on the two outer seats and a two-point seatbelt on the middle seat. All seatbelts were found undamaged with the belt buckles open. The buckle on the seatbelts could be opened and closed with ease.

1.15.4 No one on board was wearing a life jacket. Two life jackets were however available in the cargo hold in the rear of the helicopter. These were not accessible from the cockpit during flying.

1.15.5 The helicopter’s two doors could be opened from the inside with a small handle close to the floor. The door locks were also designed to open when subjected to relatively moderate pressure from the inside. All windows consisted of thin Plexiglas which can relatively easily be broken by e.g. kicking.

1.15.6 The helicopter was equipped with an Emergency Locator Transmitter – ELT. This does not work underwater and was destroyed by the time spent in saltwater.

1.16 Tests and research

None

1.17 Organisation and management information

1.17.1 At the time of the accident the helicopter was registered in the British aircraft register. This entails that the helicopter in Norway was to be operated in accordance with a combination of Norwegian and British[8] laws and regulations.

1.17.2 The Commander has informed the AIBN that he acquired the helicopter via the company Cast Designer in the spring of 2004 under the clear condition that it would be transferred to the Norwegian aircraft register. The Commander sent an application to the Norwegian Civil Aviation Authority on 30 April 2004 concerning temporary registration of the helicopter for ferry flying home to Norway. At the time the registration letters LN-OCS

[8] Regulations administered by the UK aviation authorities (Civil Aviation Authority – CAA)

were already reserved. The helicopter was flown to Norway in early July 2004. The helicopter was then still registered in the UK aircraft register with the registration G-ECHO. According to the Commander, the plan for Norwegian registration was postponed to after October 2004. The decision was made following a conversation with an inspector in the Norwegian Civil Aviation Authority. The reason was that re-registration would be simpler after the aforementioned date due to the introduction of new JAA regulations.

1.18 Additional information

1.18.1 The Commander explained to the AIBN that the helicopter should have had no problems with the takeoff in question in terms of performance. He experienced good engine performance and had no problems with the takeoff from his home shortly before the accident. The reduction in RPM was unexpected and it seemed as though the engine power was significantly reduced. However, he did not notice any vibrations or strange sounds during the short time the problems lasted.

1.18.2 The AIBN has been in touch with pilots with extensive experience with the helicopter type. They were of the opinion that the helicopter with normal rotor RPM and a speed of 30 – 40 mph had good power reserves. The relatively large rotating mass in the main rotor made it correspondingly demanding to increase the rotor RPM if the RPM already had decreased too much. The only practical method of increasing RPM was lowering the collective, perhaps combined with raising the helicopter’s nose.

1.18.3 The helicopter was ordinarily refuelled at Flesland. However, according to the Commander he had on the Tuesday prior to the accident filled the helicopter with fuel from two sealed barrels of fuel that he had collected from the fuel supplier at Flesland. He had used a funnel with leather filter during refuelling.

1.19 Useful or effective investigation techniques

No methods that qualify for special reporting have been used during this investigation.

2. ANALYSIS

2.1 Introduction

The investigation has mainly been based on the Commander’s statement and AIBN’s examinations of the helicopter wreckage. Witnesses and clues at the accident location have been of limited usefulness in explaining the course of events. Based upon the available information, the AIBN has not been able to determine the exact cause of the accident. A number of conditions that affected the course of events and conditions of general relevance to safety are analysed below. Several of the conditions are of a general nature and may be viewed in relation to other helicopter accidents that have recently been investigated by the AIBN, e.g. the accident to LN-ODK (report 2007/13).

2.2 Preconditions and planning

2.2.1 Immediately following the accident, claims were made by the media that the Commander did not have the authorisation to operate G-ECHO in Norway. A complete assessment of legal issues concerning this will require a comprehensive investigation of legislation in England, the USA and Norway including time-limited transition arrangements. The

AIBN is of the opinion that these issues have not affected the course of events and has therefore chosen not to investigate these issues further.

2.2.2 It was a Sunday and a fitting occasion to combine a useful trip with a family trip. The Commander was familiar with the area where he had previously flown both aeroplanes and helicopters. He knew the parking area at Breistein ferry quay well even though he had never landed there before. Weather conditions were good, and there was no reason to expect problems flying VFR with a helicopter on the day in question. In situations such as these it could be natural to reduce planning to a minimum. On the one hand the Commander had the opportunity to take a Sunday trip with his family in the local area. Alternatively a number of tiresome preparations would have had to be carried out. For example it would have been challenging to identify the responsible landowner who could provide permission to land on the quay. Mass calculations would have shown that one passenger would have to be left behind, or that some of the fuel would have had to be drained off the tanks. Only two life jackets were available, and it was easy to conclude that it was unnecessary to wear them as the flight would be mainly over land. One would also have to consider whether the size of the parking area and the surrounding obstacles would allow a takeoff in accordance with the Flight Manual, and whether it was possible to avoid landing and takeoff over the sea. In such a situation it could be easy to conclude that the trip could be carried out with minimal risk even without detailed planning. With hindsight it is easy to see that the safety margins were inadequate and that the flight was not planned with sufficient regard to an assessment of safety margins in relation to the helicopter's performance and the landing conditions at Breistein ferry quay.

2.2.3 Available information indicates that the helicopter was approx. 48 lb (21.8 kg) overweight during takeoff from Breistein ferry quay. In formal terms the helicopter was not constructed for such a load and the manufacturer's specified performance consequently does not apply. In this particular case the overweight is regarded as small (2%), and in the opinion of the AIBN only relevant with regard to reducing safety margins in the case of any problems. The helicopter must have been approx. 79 lb overweight when it took off from the Commander's home. When the helicopter took off from the ferry quay, the temperature was approx. 10 °C and air pressure was 1000 hPa. This provides a density altitude of - 6 ft. The density altitude was thus a factor that should have had a beneficial effect on the helicopter's performance.

2.3 Course of events

2.3.1 According to the Commander, the helicopter's performance was good and as expected both during the takeoff from his home and when it lifted to a low hover on the ferry quay. The following departure was demanding, particularly because the helicopter had to hover 15 – 20 ft above ground before forward flying could commence. The helicopter was thus out of ground effect[9]. Operations at speeds below 35 mph (translational speed[10]) outside of ground effect are not recommended and are warned against in the helicopter's Flight Manual (see section 1.6.7.3). In this area high power from the engine is required and any loss of engine performance entails a high risk of accident. The acceleration forward and possible lift to ensure clearance of the obstacles along the quay edge would require

[9] Ground effect is usually considered to apply until the helicopter has reached a height corresponding to half the rotor's diameter. For the Enstrom 280C this is 16 ft (488 m).

[10] With a flying speed of 10 – 15 mph the efficiency of a rotor starts to increase because it is supplied with new "undisturbed" air (translational lift). This effect means that rotors usually have a minimum power requirement at a flying speed of approx. 40 – 50 mph.

further power from the engine. It is not surprising that the Commander's main focus during this phase was outside of the cockpit and that he therefore did not monitor manifold pressure and engine RPM. During this period it is not unlikely that engine RPM and thereby rotor RPM may have decreased somewhat without being noticed.

2.3.2 According to the Commander it was virtually calm at the takeoff site. Combined with little wind at higher altitudes, the probability of downdraughts of wind and thereby local gusts was very small. However, the Commander had no wind indicator at the landing site that could indicate wind direction or eventual gusts. Although based on meteorological information and the Commander's statement the AIBN finds this unlikely, it cannot be ruled out entirely that the helicopter was subjected to an unexpected gust from behind when it left the quay edge. Any gust from behind would reduce flying speed and thereby reduce the performance of the helicopter.

2.3.3 When it was discovered that engine RPM was decreasing, the Commander reacted by lowering the collective and increasing manifold pressure. This should initially result in increased engine RPM, but the rotor on the Enstrom 280 has a relatively large rotating mass and a lot of power is required to increase RPM. The low speed of just above 30 mph combined with low altitude provided little margin for error. When the nose was raised in a final attempt to increase rotor RPM, it is likely that the speed fell below the limit for translational lift, which in turn led to an increased need for engine power to maintain the height (see section 1.6.7.3). The Commander therefore arrived at a situation where landing in the sea became the only option. The AIBN is of the opinion that the Commander carried out the emergency landing well. The short time at his disposal and the Commander's attempts to control the helicopter prevented him from carrying out the steps in the emergency checklist (see section 1.6.7.2).

2.3.4 The AIBN is of the opinion that the helicopter did not enter "vortex ring state" before colliding with the sea. The risk of this is greatest at an angle of descent of approx. 70°. In this case the helicopter descended approx. 10 m over a distance of approx. 40 m. This translates to an angle of descent of 14° which corresponds to a moderate descent rate.

2.3.5 The AIBN cannot entirely rule out that the low engine RPM was a result of the high weight of the helicopter combined with an unfavourable departure route. By operating the overweight helicopter on a ferry quay surrounded by high terrain and obstacles, the Commander exposed himself and the passengers to an unnecessarily high risk. Further, the Commander took off towards the sea. This left no safe emergency landing alternatives for a helicopter without flotation gear. An alternative procedure could have been to hover to e.g. 40 ft above the quay. The helicopter could then have accelerated horizontally out to sea and the power requirements would have been less. Such a procedure would however not have been within the recommended procedure in the helicopter's "Flight Manual" and could have led to a hard landing on the ferry quay if the engine failed while hovering. In general one can conclude that the ferry quay did not allow for a safe takeoff and departure with a single-engine helicopter. The landing site in question would for example not meet the requirements in BSL JAR-OPS 3 for performance class 3[11], which applies to commercial operations. The AIBN is of the opinion that private pilots would also benefit by taking into consideration the limitations that apply to class 3 when selecting landing sites. It would increase safety margins in the case of engine failure.

[11] According to JAR-OPS 3.545 (c) it is required that the helicopter shall be able to perform a safe emergency landing in case of engine failure.

2.3.6 It seems likely that engine performance was significantly reduced at an early stage of the departure sequence from the ferry quay. The Commander’s own statement clearly indicates this. If the helicopter had normal engine RPM when it passed an estimated 25 ft above the quay edge with a speed of approx. 30 mph, it may seem peculiar that it ran out of energy and had to land in the sea after only a further approx. 40 m. An explanation for this may be that the engine during this critical phase didn’t supply the expected power. This possibility is further explored in the chapter below.

2.4 Engine faults

2.4.1 General

2.4.1.1 Saltwater damage has precluded a complete functional test of the engine. The results of the investigations that have been carried out may be summarised as follows:

- No mechanical faults or damage to the engine or turbocharger were found.
- The significant leaks that were discovered during the cylinder leak check are most probably related to impurities in the valves as a result of the rapid cooling that occurred when seawater entered the hot engine.
- Tests show that the engine has unrestricted access to fuel and air.
- The engine controls work as expected.
- No obvious faults were found on the ignition magneto and accompanying spark plug leads. It has not, however, been possible to test this functionality satisfactorily.

2.4.2 Spark plugs

2.4.2.1 The upper spark plug in cylinder no. 1 was found to have a lead ball in the spark gap (see fig. 4). It is very likely that this was present before the helicopter crashed into the sea. A build-up of lead in spark plugs happens over time and is not unusual. High lead content in the AVGAS 100LL fuel easily leads to the condensation of lead vapour which is deposited in the coolest areas of the cylinder head. This usually happens in the coolest part of the spark plug and rarely occurs on the electrodes. Even though it is unusual, it is possible that lead deposits from other areas of the cylinder head or piston head may have come loose and then stuck in the spark gap. Regardless of the origin of the lead ball, a short-circuited spark plug can lead to some loss of power. Such a short-circuit should ordinarily be discovered during a correctly performed magneto test, which should be performed before each departure.

2.4.2.2 By comparing the colour of the four upper spark plugs one can see that the spark plug from cylinder no. 1 is considerably lighter than the three others. The colour of the plug is normal for a “good” engine, but also indicates that this plug has been hotter than the others and that soot and oil has been burnt off to a greater degree. This may be due to normal variations in oil consumption and combustion temperature. Another explanation may be that the lead ball, due to insufficient cooling, has started to glow. This could have led to premature ignition and a significant loss of power. Such a problem may have built up over time, but the consequences may only have become critical during the last departure with a high power output and thereby high spark plug temperatures.

2.4.2.3 Spark plugs are subject to high levels of stress, and inspection, cleaning and testing is ordinarily carried out every 100 flying hours. During maintenance of spark plugs it is important to remove excess lead and to check wear and electrode gaps. At the time of the accident the helicopter had flown for 29:45 hours since the "Star Annual" inspection. The AIBN doubts that the distance between the electrodes on the spark plugs was within the specified values of 16 – 22 thousandths of an inch when the "Star Annual" inspection was completed. Wear corresponding to 11 thousandths of an inch could not occur during so few hours of flight. The conclusion is therefore that the spark gap cannot have been checked during the inspection. If the spark gap was within the limits when the inspection was completed, they must have been exchanged with worn-out spark plugs at a later date. The AIBN has no information indicating such an inappropriate exchange, and considers this to be highly unlikely.

2.4.2.4 A large spark gap arises over time and will eventually place high demands on the rest of the ignition system. It may lead to starting problems and RPM drops in excess of permitted values during the magneto check. A large spark gap may further lead to a weak or missing spark when pressure is high in the cylinders (high manifold pressure). It cannot therefore be ruled out that the high manifold pressure that was required during takeoff from Breistein ferry quay with a heavy helicopter induced ignition failure. This could have happened although the ignition system seemingly worked satisfactorily during the magneto test and previous less demanding departures.

2.4.2.5 The AIBN has noted that the spark plugs of the type RHB 36P, which were found in the lower position on the engine in G-ECHO, are not specified in the aforementioned Service Letter published by the engine manufacturer Lycoming. In the opinion of the AIBN this has no practical implications because the heat value (36) lies between the two recommended values (32 and 37, see section 1.6.6.4), and that platinum (P) and solid steel (E) electrodes are normally interchangeable on other comparable engines.

2.4.3 <u>Missing restrictor in bypass tube</u>

2.4.3.1 The examination of the engine revealed that the turbocharger's bypass tube lacked a restrictor (see fig. 3). According to the manufacturer, a restrictor should have been fitted to the turbocharger in question. No traces indicate that there has ever been such a restrictor in the tube. The AIBN is of the opinion that the tube lacking the restrictor has at some point been erroneously installed. This is quite possible because the tube without the restrictor was standard equipment on the turbocharger before the modification of June 1977. The AIBN has not allocated resources to determine when the wrong pipe was installed. The fault may be difficult to detect during routine inspections and requires the exhaust system to be dismantled. If no one questions the engine's performance at high altitudes, the fault may remain undiscovered for a long time. The AIBN is therefore of the opinion that the helicopter manufacturer Enstrom should inform all users of 280C of the possible fault and describe a procedure for the inspection of the bypass tube in question.

2.4.3.2 Without the calibrated restrictor, a large proportion of the exhaust gasses will be led outside the turbocharger. The turbocharger will therefore rotate at a lower speed than it would have with the restrictor installed. This will not be very noticeable at low altitudes, but will limit the engine's performance at high altitudes. According to the Commander, the amber warning light lit up when he tried to increase the manifold pressure to the maximum after engine RPM had started to decrease. This indicates that manifold pressure had exceeded the maximum permitted level of 36.5 inHg. The missing restrictor was therefore not the cause of the drop in engine RPM. The fact that despite this error the engine was able to provide full power is also supported by the Commander's confirmation that everything seemed normal during previous takeoffs. However, the AIBN is of the opinion that the missing restrictor limited the engine's power reserves in an emergency situation. With the restrictor in place, the Commander could have put more strain on the engine than it was designed for. This could theoretically have made a difference in a difficult situation, but could have caused damage to the engine. However, the AIBN is of the opinion that this extra power would probably not have been sufficient to avert the accident. First of all, the helicopter has a large mass in the main rotor and therefore requires a lot of engine power in order to increase RPM quickly. Secondly, an unusually high manifold pressure may have aggravated the situation if the loss of power was originally caused by a large spark gap on the spark plugs.

2.4.3.3 The fact that the manifold pressure could reach 36.5 inHg after the engine RPM began to decrease is an important indication of the engine's condition. The turbine in the turbocharger depends on the energy from the hot exhaust to power the compressor. The missing restrictor in the bypass tube further reduced the supply of exhaust to the turbine. The high manifold pressure therefore indicates that the engine at that point still supplied enough hot exhaust to fully power the turbocharger.

2.5 Survival aspects

2.5.1 Many aspects were in favour of good opportunities to survive the emergency landing in the sea. The emergency landing was controlled and happened close to shore, and the sea temperature was relatively high. There were several witnesses to the accident and help arrived immediately. That fact that a boat and competent and efficient assistance arrived immediately was decisive for the survival of the Commander.

2.5.2 Due to a high centre of gravity, the helicopter type will relatively quickly tip to one side or in the worst case turn upside down before sinking. It is therefore imperative that those on board manage to exit the helicopter before it sinks and swim towards the shore. An important factor is that all on board are familiar with the seatbelt mechanisms, opening of doors and emergency exits and that they are aware of relevant emergency procedures. One example is that evacuation may not commence before the main rotor has stopped. The AIBN is not in a position to say whether the Commander provided adequate information regarding emergency procedures. In this case the helicopter sank immediately, before the three on board managed to unbuckle themselves and exit the helicopter. The thin Plexiglas window at the front down by the rudder pedals to the left was broken. This could have been caused by water pressure if the landing took place with a few knots of forward speed. If so, it is a good explanation for why the cockpit immediately filled with water.

2.5.3 This helicopter type is very cramped with three persons on board and it is generally important for passengers to know how seatbelts and door locks operate. When the helicopter tips sideways, evacuation becomes more difficult. It would be natural to try to evacuate through the door facing upwards, but in this case no one managed to get out before the cockpit was completely filled with water and air bubbles. Experience from previous accidents shows that without practice it can be easy to lose one's bearings and that it may be difficult to find e.g. door locks under water. This is confirmed by the two survivors who could not tell whether they exited through the doors or the broken windows.

2.5.4 The survival chances for a person being dragged down with a helicopter to the seabed depends on several factors. Depending on how much air the person has in the lungs and the person's physical condition, a depth is reached where the water pressure causes the person to sink. Below this depth the person must swim upwards in order counteract the tendency to sink. From a depth of 60 m, for example, only specially trained persons will in all probability have a chance of reaching the surface. There is therefore reason to believe that the Commander was close to drowning during this accident. The deceased passenger was found next to the helicopter. This may indicate that he got out of the helicopter, but that he didn't manage to make it to the surface.

2.5.5 The AIBN is of the opinion that it could have been possible to survive the accident if life jackets had been worn. Assuming that everyone evacuated the wreckage and managed to inflate their life jackets before losing consciousness, all would have made it to the surface. With witnesses and boats present, a life could have been saved. This and other previous accidents show that there is not enough time to put life jackets on when a critical situation arises. The only reasonable alternative in the case of flying over water is therefore that everyone on board wears a life jacket and that the helicopter is equipped with emergency flotation equipment. This became a requirement in 2005 when the national regulation BSL D 3-2 was introduced.

3. CONCLUSIONS

3.1 Findings

a) The Commander had a valid US approval to operate a helicopter of the type in question.

b) The helicopter had valid UK registration and airworthiness certificate.

c) The AIBN has not considered legal aspects regarding the right of the Commander to operate G-ECHO in Norway. However, no findings indicate that these issues have affected the course of events.

d) The last inspection of the helicopter was performed in England barely 30 flying hours before the accident.

e) The planning of the flight was partially inadequate. The helicopter's mass and balance was not properly calculated, and necessary preparation in connection with the landing site was not carried out.

f) No problems were experienced during the flight from Sotra to Breistein ferry quay.

g) The landing site at Breistein ferry quay was surrounded by elevated terrain, lamp-posts and the sea. The site provided meagre safety margins in the event of the helicopter malfunctioning during departure.

h) Information available to the AIBN indicates that the engine was operating normally on the ferry quay prior to takeoff.

i) The helicopter lifted to a hover approx. 15 ft above the parking area before acceleration towards the quay edge and the sea was initiated. Acceleration and climb in order to clear the obstacles lining the quay edge required full engine performance.

j) The Commander was not aware that the engine RPM (and thereby the rotor RPM) had decreased until the helicopter had passed the quay edge.

k) When the Commander in an attempt to remedy the situation lowered the collective and attempted to increase engine power, the warning light for high manifold pressure came on. This indicates that the engine was still providing considerable power.

l) When engine RPM continued to decrease, the Commander had no other option than to perform a controlled emergency landing in the sea.

m) The helicopter started to sink immediately upon collision with the sea, probably because a thin Plexiglas window at the bottom left side was pushed in by the water pressure during the landing.

n) None of the three people on board escaped the helicopter before the cockpit was filled with water. Darkness and air bubbles made evacuation more difficult, and the two survivors cannot say with certainty how they escaped.

o) The Commander and one of the passengers were dragged down with the helicopter. The passenger most likely did not have enough energy to swim to the surface after exiting the wreckage.

p) The Commander lost consciousness while swimming towards the surface and was saved by eyewitnesses to the accident.

q) The helicopter and the deceased passenger were located on the seabed at a depth of 62 m two and half hours after the accident.

r) The helicopter was salvaged after approx. 14 hours. However, the stay in saltwater caused so much damage to the wreckage that it is not possible to determine the exact condition of the helicopter prior to the accident.

s) The general condition of the spark plugs and the short time the helicopter had flown since the last inspection, according to maintenance documentation, may indicate that inspection of the spark plugs was not satisfactorily performed during the last inspection.

t) The missing restrictor in the bypass tube in the turbo system had only a theoretical effect on the course of events. It is not to be expected that this fault could have been discovered during ordinary maintenance inspections.

u) The AIBN cannot completely rule out the fact that wind may have contributed to worsening the situation during departure.

v) The calculated overweight of approx. 2 % was only relevant in the sense that safety margins in the event of any problems would be reduced.

3.2 Significant findings

a) The investigation has revealed a lead ball in the spark gap of the upper spark plug in cylinder no. 1. This may lead to a significant loss of power, particularly during high engine strains. This may have been the cause of the loss of power and thereby the reduction in engine RPM.

b) The investigation has revealed that the lower spark plugs in the engine were worn and that they had large spark gaps. Large spark gaps may lead to a significant loss of power, particularly during high engine loadings. This may have been a cause of the loss of power and thereby the reduction in engine RPM.

c) It may appear that the flight was planned with little regard to assessing safety margins in relation to the helicopter's performance and the landing conditions at Breistein ferry quay.

d) No one on board was wearing a life jacket. This may have been crucial to the ability to survive.

4. SAFETY RECOMMENDATIONS

The AIBN does not issue any safety recommendations in connection with this investigation.

Accident Investigation Board Norway

Lillestrøm, 19 September 2007

APPENDICES

Abbreviations

ABBREVIATIONS

AIBN	Accident Investigation Board Norway
BSL	Bestemmelser for sivil luftfart [Regulations for civilian aviation]
CAA	Civil Aviation Authority – the aviation authorities in the UK
CTR	Control zone
TWR	Aerodrome control tower
in	inch (2.54 cm)
inHg	inches of mercury
JAA	Joint Aviation Authorities – organisation for cooperation between European aviation authorities
JAR-OPS	Joint Aviation Requirements – Operations – operative pan-European regulations
lb	pound (0.454 kg)
METAR	METeorological Aerodrome Report – routine aviation weather report
QNH	altimeter setting related to pressure at sea level
PPL(A)	Private Pilot Licence Aircraft
PPL(H)	Private Pilot Licence Helicopter
SEL	Single Engine Land
TAF	Terminal Aerodrome Forecast
UTC	Universal Time Coordinated