ACCIDENTS INVESTIGATION BRANCH
Department of Trade and Industry

Sikorsky S-6IN G-ASNM of BEA

Report on the accident in the North Sea approximately 50 nautical miles east of Aberdeen on 15 November 1970

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Department of Trade and Industry
Accidents Investigation Branch
Shell Mex House
Strand
London WC2

23 June 1971

The Rt. Honourable John Davies MBE MP
Secretary of State for Trade and Industry

Sir,

I have the honour to submit the report by Mr G M Kelly on the circumstances of the accident to Sikorsky S–61N G–ASNM which occurred in the North Sea approximately 50 nautical miles east of Aberdeen on 15 November 1970.

I have the honour to be

Sir,

Your obedient Servant,

V A M Hunt
Chief Inspector of Accidents

Accidents Investigation Branch

Civil Accident Report No EW/C364

Aircraft:	Sikorsky S–61N G–ASNM
Engines:	Two General Electric CT 58 – 110 – 2
Registered Owner and Operator:	British European Airways Helicopters Ltd
Crew:	Commander – Captain D A Creamer – uninjured Co-Pilot – Captain K E N Gregson – uninjured
Passengers:	1 -- uninjured
Place of Accident:	In the North Sea approximately 50 nautical miles east of Aberdeen
Date and Time:	15 November 1970 at about 0020 hours All times in this report are GMT

Summary

The helicopter was on a night flight from Dyce Airport to an oil rig in the North Sea when the main gearbox oil pressure gauge indication fell to zero, and shortly afterwards unusual mechanical noises emanated from the region of the engines and main gearbox. A landing was commenced but the engines stopped one after the other during the approach. A vertical power-off touchdown was made on a rough sea after the second engine stopped about twenty feet above the water. The crew and passenger boarded a life-raft but the helicopter capsized and sank. The survivors were soon rescued by a passing ship. The report concludes that the accident was due to a sudden loss of main gearbox lubrication which resulted in mechanical failure causing both engines to stop.

1. Investigation

1.1 History of the flight

G–ASNM took off at 2347 hrs on 14 November to fly from Dyce Airport to the oil rig Staflo in the North Sea. All was satisfactory during the start up, take-off, and initial part of the cruise and at 0010 hrs the main gearbox oil pressure was seen to be 40 psi and its temperature +89°C. Both of these readings were normal.

At 0015 hrs the helicopter was flying at 1250 feet about 50 nautical miles on a magnetic bearing of 118° from Dyce when the master warning light and the main gearbox low oil pressure warning light illuminated. The main gearbox oil pressure gauge was then seen to be indicating zero but all other indications were normal.

The captain told the co-pilot to transmit distress calls and alerted the passenger. As he did so he reduced height to about 50 feet and speed to 40 knots so as to be able to make an immediate landing if necessary. As sea conditions were bad he headed for Dyce whilst he considered the possibility that the indication may have been a false one, and whilst the co-pilot transmitted further distress calls as no reply had then been received.

After about a minute an unusual mechanical noise was heard from the engine and main gearbox region and the captain turned into wind to land. No 1 engine then stopped and the co-pilot told the captain, who, however, did not hear him. No 2 engine accelerated automatically to about 95 per cent power turbine rpm, the co-pilot performed the engine failure drill, and the captain continued the landing. When the helicopter was about twenty feet above the water No 2 engine stopped and the captain made a power-off vertical touch-down with a low rate of descent. The landing lights went out on touchdown; all other lights remained on. The crew could not be precise about the time that elapsed between the initial indication of loss of oil pressure and touch-down but estimated it at three minutes.

1.2 Injuries to Persons

Injuries	*Crew*	*Passengers*	*Others*
Fatal	–	–	–
Non-fatal	–	–	–
None	2	1	–

1.3 Damage to aircraft

The aircraft was undamaged in the landing, but about five minutes after touchdown it capsized and sank.

1.4 Other damage

There was no other damage.

1.5 Crew information

Captain David Alan Creamer, aged 35, held a valid helicopter airline transport pilot's licence endorsed for command of the Sikorsky S–61N. His last competency check on the S–61N was on 1 October 1970, his last route check was on 12 May 1970, and his last emergency equipment test was on 16 April 1970. His total flying experience was approximately 3,800 hours, of which 3,150 were on helicopters including 900 on the S–61N. Captain Creamer's flight time during the last 28 days and his duty and rest periods in the last 7 days were in accordance with authorised limits.

Captain K E N Gregson, aged 38, held a valid helicopter airline transport pilot's licence endorsed for command of the Sikorsky S–61N. His last competency check on the S–61N was on 18 March 1970 and his last route check on 10 October 1970. His last emergency equipment test was on 23 October 1969, this being taken with the 13 month period laid down in the Air Navigation Order. Captain Gregson's total flying experience was 4,560 hours, of which 3,750 were on helicopters including 1,050 on the S–61N. His flight time in the last 28 days and his duty and rest periods in the last 7 days were well within authorised limits.

1.6 Aircraft information

Sikorsky S–61N G–ASNM, Serial No 61221, was manufactured in 1964. Its transport category (passenger) certificate of airworthiness was last renewed in January 1970 and it had been maintained in accordance with an approved schedule. The last check 1 and certificate of maintenance were signed on 2 November 1970; at this time the aircraft had flown a total of 4,197 hours. Between then and the time of the accident the aircraft flew a further 36 hours.

A replacement main rotor gearbox which had undergone its second overhaul was fitted on 27 June 1969. Gearboxes of this type have a life of 1,200 hours between overhauls. At the time of the accident the gearbox had run 3,321 hours since it was manufactured, 1,125 of which had been since the second overhaul. The only significant work carried out on the gearbox since its installation was confined to a check tightening of its oil supply connections after it had run 754 hours, and the replacement of a seeping oil supply pipe connector after 873 hours. Up to the time of the accident there had been no further instances of oil leaks. The oil pressure indicator and its transmitter were replaced the day before the accident, and the accident flight was the first one thereafter.

1.7 Meteorological information

Whilst the weather had no bearing on the cause of the accident it did affect the behaviour of the aircraft on the water. From the flight meteorological forecast and reports by the crew of the helicopter and rescue ship the following assessment of the weather has been compiled:

Situation	–	A northerly polar airstream covered the British Isles.
Weather	–	Occasional showers but none at the time of the accident.
Cloud base	–	1,500 feet.
Visibility	–	30 km, 6 km in showers.
Wind	–	Northerly at 25 knots from sea level to 2,000 feet.
Air temp	–	plus 2°C at level.
Sea conditions	–	Sea State 4 (9 foot waves) to 5 (14 foot waves) Swell 5, sea and swell running in the same direction.

1.8 Aids to navigation

Not relevant.

1.9 Communications

BEA helicopter flights from Dyce to oil rigs maintain contact with Scottish Air Traffic Control Centre (ATCC) on 133.2 MHz until the rig is contacted on 122.95 MHz or on HF. If contact is lost with both these stations messages are passed via London Birdlip on 6567 KHz. Position reports are passed every ten minutes. G–ASNM's report at 0010 hrs was received and acknowledged by Scottish ATCC. Starting at 0015 hrs the helicopter sent out distress messages on 133.2 MHz, 121.5 MHz, 6567 KHz and 122.95 MHz in that order, but received no reply on any frequency.

At 0015 hrs Scottish ATCC received a distress message from G–ASNM on 133.2 MHz reporting reduced oil pressure and giving its position as "52 miles from Aberdeen on a track of 118°". Before the controller could establish two-way communication the transmission faded, presumably as the aircraft descended. Acting on this message Scottish ATCC informed the Edinburgh Rescue Co-ordination Centre at 0016 hrs and search and rescue action was commenced, continuing until all on board the aircraft had been rescued. The only other message received was by a United States Air Force C–141 over Benbecula. At 0021 hrs the C–141 informed Scottish ATCC that it had received a distress message from G–ASNM on 243.0 MHz giving a position 51 miles from Aberdeen on a track of 118°M. Since NM did not carry UHF radio the C–141 could not establish contact, the transmission being presumably due to second harmonic radiation.

1.10 Aerodrome and ground facilities

Not relevant.

1.11 Flight recorder

No flight recorder was required or fitted.

1.12 Wreckage

No wreckage examination was possible as the aircraft capsized, sank and was not recovered. However, after touchdown the crew saw a lot of oil on the port outside of the fuselage which had apparently come from the area of the main gearbox.

1.13 Fire

There was no fire.

1.14 Survival aspects

After touchdown the captain kept the aircraft's nose to the sea for a short time using rotor system kinetic energy. During this time the helicopter pitched and rolled a lot but showed no sign of overturning. Meanwhile the co-pilot took the sea anchor from its stowage under his seat – with some difficulty due to the aircraft's motion – and clipped the ripcord line to the appropriate strut in the cockpit. He next attempted to clip the sea anchor main line to the aircraft's tow rope, which runs from the keel to a point below the forward edge of the co-pilot's window. The tow rope terminates in an eye and then a shackle, the clip on the sea anchor main line being able to engage the shackle only and not the eye. To perform this action the co-pilot had to lean out of the window and stretch foward – a difficult task in the dark with the aircraft's motion and breaking waves. In the event he was unable to clip the lines together because he was not aware that the anchor line clip would only engage the shackle and in the bad conditions under which he had to work did not discover this. He, therefore, tied the two lines together and operated the sea anchor, which he saw open in the water.

When the rotor stopped, the aircraft's 26 man liferaft was launched from the emergency door on the port side of the rear fuselage, a difficult procedure in the rough sea conditions. It was blown downwind and the co-pilot and passenger together had difficulty pulling with cold wet hands on its thin nylon lanyard to haul it back to the door. The aircraft remained nose to sea while the co-pilot and passenger boarded the liferaft and loaded the aircraft's emergency equipment pack and a floating emergency radio responder beacon. At this moment the aircraft yawed to starboard, about 20° to the sea according to the co-pilot's estimation, and was hit by a large wave that caused it to roll slowly in the same direction. Some part of the aircraft's structure aft of the emergency door tore the liferaft's upper compartment, whereupon the co-pilot cut the lanyard and cast off to prevent further damage. The aircraft capsized and as it did so the captain jumped into the water and swam to the raft. It is estimated that about five minutes elapsed between touchdown and the time the aircraft rolled over.

Because of the damage to the liferaft the upper compartment was completely deflated and the crew were unable to close the protective canopy. When the crew came to operate the emergency responder radio beacon they found that its water soluble switch had been actuated by water in the liferaft and extended the aerial which had broken off ¼ inch from its base, presumably having been stepped on during the process of boarding the liferaft. Each crew member, however, had a personal beacon on his life jacket and one of these was switched on.

At about 0100 hrs a light was sighted and a signal rocket from the emergency pack was fired (this pack contained a total of 2 rockets and 6 distress flares). Partly because of the liferaft's movement and partly because the crew had never used a rocket of this type before it was fired on an unduly low trajectory. Nonetheless it was seen by the crew of a Swedish ship, the M/V

Gripen, which was four miles away. The liferaft crew used the remaining signals sparingly but had consumed four of their flares before they were sure the ship would not lose sight of them. The crew reported that the polythene pack around each signal was so tough it had to be opened with a knife. The survivors were taken on board the *Gripen* at 0130 hrs.

In their reports the crew included the following suggestions:

> Vital items of equipment meant to be carried in a liferaft – in this case the emergency signals and radio beacon – should wherever practicable be packed in the liferaft.
>
> Liferafts should have an internal light, preferably automatically operated.
>
> Life jackets, especially those of crew members, should have protective gloves attached to them.
>
> A cleat and external handles should be fixed at the emergency exit of the S61 to make control of the liferaft easier during evacuation.

1.15 Tests and research

No tests or research were carried out.

1.16 Technical investigation

The technical investigation centred on the main gearbox and its oil supply system. The power turbine on each engine drives directly aft into the main gearbox input assembly at approximately 19,000 rev/min. The gearbox combines and reduces the two engine inputs to give the desired main rotor speed of 203 rev/min. Free wheel units are built into each input from the engines so that single engine operation is possible without driving the power turbine of the opposite engine, and to allow the rotor to disengage from the power turbines during autorotation.

An internal wet sump lubrication system uses pressure, spray and splash to lubricate the various gears, drives and bearings of the main gearbox. A gear type pump mounted on the accessory section draws oil from the sump and distributes it via an oil cooler and external pipes to various inlet connections on the magnesium alloy gearbox casing. The oil distribution pipes are of rigid stainless steel and the numerous associated pipe connectors and gearbox inlet adaptors are made of aluminium alloy. In such a system, however carefully the rigid pipes are connected, there is always a possibility that some residual stress can remain on pipes and connectors after assembly.

As there was no wreckage to examine the investigation was concentrated on considering the various ways in which the S–61N's gearbox oil supply system could fail. These investigations suggested only one hypothesis that would satisfactorily explain a sudden failure such as was experienced by G–ASNM. This was that the combined effects of residual stress and vibration on the oil supply pipes had led to a failure of one of the inlet adaptors and/or the threads in the gearbox into which they screw, or to a failure of one of the pipe connectors. Such a failure could result in a sudden and complete loss of the pressure oil supply to the main gearbox.

It was also established that the likely initial consequence of such a loss of lubrication would be a mechanical failure of the high speed input of each engine to the main gearbox. A consequence of this would be a rapid increase in power turbine speed of the associated engine that would cause the over-speed shut-off system to stop the engine.

2. Analysis and Conclusions

2.1 Analysis

Loss of main gearbox oil pressure

As the aircraft was not recovered the only direct evidence available concerning the failure is that given by the occupants. In summary this is as follows: at 0010 hrs the main gearbox pressure and temperature gauges showed normal readings, as they had done throughout the flight, but at 0015 hrs the low oil pressure warning light lit and the oil pressure gauge indicated zero. Before long unusual mechanical noises emanated from the engine and main gearbox area and very shortly afterwards the No 1 and then the No 2 engine stopped. Finally, after landing a lot of oil was seen on the outside of the fuselage, apparently emanating from the main gearbox area. Such a sequence of events indicates that a sudden and large leakage caused a loss of pressure oil supply to the main gearbox and that the lack of lubrication led to mechanical failure which in turn caused the engines to shut down automatically.

Because the wreckage could not be examined, it was not possible to establish with certainty the cause of the failure of the gearbox oil supply. However, from a study of the design of the gearbox oil supply and previous experience of oil leaks it appears that the cause may well have been a failure of one of the oil supply inlet adaptors and/or the threads in the main gearbox into which they screw, or to a failure of an oil pipe connector. The relevant circumstances of the accident were put before the Air Registration Board, the manufacturer and the operator and subsequent consultation between these bodies led to a decision to replace all adaptors and connectors with ones made of steel, to fit steel inserts to all the gearbox inlet points, and to carry out other less immediate precautionary modifications and investigations of the oil supply system.

Engine shut-down

Immediately following the indication of gearbox oil pressure failure the captain brought the aircraft down to a height and speed from which an immediate landing could be made. Because of the rough sea and because no reply had been received to the distress messages he did not land immediately, as advised in the operations manual, but headed towards Aberdeen whilst he considered the possibility of false oil pressure failure indication and whilst further distress messages were transmitted. This was an understandable decision in the circumstances but even though a landing was commenced as soon as unusual noises emanated from the main gearbox region both engines stopped before touchdown and a power-off landing had to be made. The short time that elapsed between the indication of oil pressure failure and the complete loss of power to the rotor system – approximately three minutes – indicates the importance of landing as quickly as possible if gearbox oil

pressure is lost. The circumstances of this accident permitted a rapid and safe descent from cruising altitude. What would have happened if the helicopter had been flying higher, in cloud, and over land when failure occurred is a matter for speculation.

The crew's evidence together with the knowledge of the likely initial mechanical consequence of a loss of main gearbox lubrication suggest that each engine shut down automatically following a failure in its associated high speed input assembly to the main gearbox. It is worth noting that for military versions of the S–61N the manufacturer had developed an emergency system to lubricate the input assembly bearings from a separate source following failure of the main gearbox oil pressure supply, so as to extend the time between indication of lubrication failure and the loss of power to the rotor system. It is understood that after the accident the manufacturer undertook to investigate the possibility of adapting this system for commercial use.

The landing and aircraft behaviour on the water

The captain carried out a skilful forced landing in the dark under extrmely difficult conditions of sea and wind. After touchdown he maintained the aircraft's nose to the sea by using the controls while they remained effective, although the operations manual advises directing the nose 30 degrees to the waves following an emergency autorotative landing. The co-pilot's evidence however, is that the aircraft was only 20° to the waves when it commenced to roll over. Even allowing for an underestimation of this angle it seems likely that it would have been extremely unwise to have attempted to place the aircraft 30° to the sea, even if it had been possible to do so with accuracy. It would appear that the advice in the operations manual should be reviewed. It may also be worth noting that lowering the undercarriage to increase water stability is recommended for military versions of the helicopter.

As the sea-anchor main line was tied, and not clipped, to the aircraft tow line it is not possible to say whether the aircraft yawed and overturned in spite of the sea anchor's action or because it had become detached.

Sea-anchor operation

The difficulty experienced by the co-pilot in attaching the sea-anchor to the aircraft's tow-line resulted in a decision by the operator to lengthen the tow-line so that it can be drawn inside the cockpit for connection. This will make the task much easier. However, it is considered that if BEA helicopter pilots had been given regular practice in operating the sea-anchor the co-pilot would have been able to clip the lines together on this occasion. Before the accident BEA helicopter crews practised this operation during their initial conversion to the S–61N but in their subsequent annual emergency equipment checks sea-anchor operation was covered by an oral test alone. This level of training now seems to have been inadequate to cover extremely difficult conditions such as were experienced in this accident.

Damage to the liferaft

The collapse of the liferaft's upper compartment after it was torn by aircraft structure left the occupants unable to close the canopy, greatly reducing their protection and thus their chances of survival. It was fortunate that they were rescued quickly. It was again fortunate that the lower compartment was not also holed, as could easily have been the case, for the liferaft would then have sunk. This is a known hazard, common to all types of aircraft liferaft, and is particularly severe where there is torn aircraft structure. Steps that might be considered to reduce the risks are:

Eliminating sharp edges of aircraft structure which could cause damage to liferafts.

Ensuring that adequate emphasis is placed on the danger during crew training.

Carrying two small rather than one large liferaft in aircraft such as the S–61N.

Giving liferafts better protection against damage, perhaps by building in extra compartments.

Training

The difficulties the crew experienced with the operation of the sea-anchor, in handling the liferaft pack to and through the emergency door, and in firing the rocket signal emphasises the importance of regular, imaginative practical training being given in even apparently straight forward emergency tasks to enable crews to perform adequately under adverse conditions. It might be prudent to review the emergency training programmes on all types of public transport aircraft to see if any should be strengthened by increasing the practical training element.

2.2 Conclusions

(a) *Findings*

(i) The aircraft's documents were in order, and it was properly loaded.

(ii) The aircraft had been maintained in accordance with an approved maintenance schedule.

(iii) The crew were properly licensed and competent to undertake the flight.

(iv) There was a sudden loss of pressure lubricating oil to the main reduction gearbox.

(v) The sudden loss of oil pressure appears to have been the result of a failure of one of the oil supply inlet adaptors and/or the threads in the main gearbox into which they screw, or to the failure of an oil pipe connector.

(vi) Lack of wreckage for examination precludes the confirmation of the hypothesis expressed in (v) above.

(vii) While the crew were carrying out an emergency landing consequential mechanical failure resulted in both engines being automatically shut down one after the other.

(viii) The captain made a skilful landing in a rough sea.

(ix) After the landing the crew carried out all the emergency and evacuation actions successfully in difficult conditions with the exception that the sea-anchor cable was nor correctly secured.

(x) The aircraft rolled over when the head had fallen some 20^{o} from the sea.

(xi) The liferaft was severely damaged by part of the aircraft structure.

(xii) Search and rescue action was commenced promptly.

(xiii) Although the crew and passenger were quickly rescued by a passing ship their small supply of pyrotechnic distress signals was almost exhausted.

(b) *Cause*

The accident was due to a sudden loss of main gearbox lubrication which resulted in mechanical failure causing both engines to stop.

G M Kelly
Inspector of Accidents

Accidents Investigation Branch
Department of Trade and Industry
June 1971

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