CIVIL AVIATION AUTHORITY OF NEW ZEALAND

AIRCRAFT ACCIDENT REPORT

OCCURRENCE NUMBER 00/2821

SIKORSKY S-55B

ZK-HSC

NEAR WANGANUI

29 AUGUST 2000

Glossary of abbreviations used in this report:

Avgas	aviation gasoline
C	Celsius
CAA	Civil Aviation Authority
E	east
ELT	emergency locator transmitter
hPa	hectopascals
km	kilometre(s)
m	metre(s)
ml	millilitre(s)
NZST	New Zealand Standard Time
US	United States (of America)
UTC	Coordinated Universal Time
Vne	maximum permitted airspeed

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Aircraft type, serial number and registration:	Sikorsky S-55B, 130168, ZK-HSC
Number and type of engines:	1 Wright R-1300-3D
Year of manufacture:	1954
Date and time:	29 August 2000, 0930 hours* (approx)
Location:	15.5 km north-east of Wanganui Airport Latitude: S 39° 52.8' Longitude: E 175° 10.2'
Type of flight:	Agricultural - spraying
Persons on board:	Crew: 1
Injuries:	Crew: 1 fatal
Nature of damage:	Helicopter destroyed
Pilot-in-command's licence	Commercial Pilot Licence (Helicopter)
Pilot-in-command's age	33 years
Pilot-in-command's total flying experience:	515 hours, including 450 helicopter 250 on type
Information sources:	Civil Aviation Authority field investigation
Investigator in Charge:	Mr A J Buckingham

* Times are NZST (UTC + 12 hours)

Synopsis

The Civil Aviation Authority was notified of the accident at 1030 hours on Tuesday 29 August 2000. The Transport Accident Investigation Commission was in turn notified shortly thereafter, but declined to investigate. A CAA site investigation was commenced later the same day.

The helicopter was spraying liquid fertiliser on a property near Wanganui. When it did not return from its fifth sortie, the loader and farmer made their way to the operating area, where they observed a plume of smoke near a line of poplar trees. On closer inspection they found the burnt-out wreckage of the helicopter. The pilot had not survived.

1. Factual information

1.1 History of the flight

1.1.1 On 29 August 2000, helicopter ZK-HSC was engaged in spraying liquid fertiliser on a property in the Makirikiri Valley, to the north-east of Wanganui. The helicopter had arrived at the property about 0830 hours, after ferrying from Inglewood. After a reconnaissance flight with the property owner, the pilot commenced spraying operations about 0900 hours.

1.1.2 The helicopter did not return from the fifth sortie in the expected time, and the loader and farmer decided to investigate. They travelled by four-wheel motorcycle to the back of the farm, and on crossing the main ridge between the Makirikiri valley and the next valley system to the south, saw a column of smoke rising from behind a line of poplar trees in a large gully.

1.1.3 They found the helicopter on its side in a small creek close to the poplars; the wreckage had been largely destroyed by fire. The pilot had not survived. The farmer returned to the ridge top and alerted emergency services using the loader's portable telephone.

1.1.4 The accident occurred in daylight, at approximately 0930 hours NZST, 15.5 km north-east of Wanganui Airport, at an elevation of 460 feet. Grid reference 260-S22-956452, latitude S 39° 52.8', longitude E 175° 10.2'.

1.2 Injuries to persons

Injuries	*Crew*	*Passengers*	*Other*
Fatal	1	0	0
Serious	0	0	0
Minor/None	0	0	

1.3 Damage to aircraft

1.3.1 The helicopter was destroyed.

1.4 Other damage

1.4.1 Four poplar trees and a dead tree of unknown type were substantially damaged by the impact of the helicopter.

1.5 Personnel information

1.5.1 The pilot held a valid Commercial Pilot Licence (Helicopter), first issued on 30 June 1997, and a current Class 1 medical certificate. He held a Grade 2 agricultural rating, a chemical rating, and type ratings for Hughes 269, Robinson R22 and Sikorsky S-55 helicopters.

1.5.3 Up until 25 August 2000, the pilot had flown 515 hours in total, comprising 64 hours on aeroplanes and the balance on helicopters. His total time on the Sikorsky S-55 was approximately 250 hours, all accumulated in the six months prior to the accident. Apart from type rating training, virtually all of this time was on agricultural operations. All flying on type up to 24 June 2000 was under the direct supervision of the company chief pilot.

1.6 Aircraft information

1.6.1 Sikorsky S-55, manufacturer's serial number 55-238, was manufactured in 1954 as a HRS-3 military variant for the US Marine Corps, and allocated military serial number 130168. In 1975, it was converted to civil S-55B configuration by a (FAA- and Sikorsky-approved) repair station in Sanford, Florida. Total airframe hours at the time of conversion were 4877.6.

1.6.2 The helicopter was imported into New Zealand in August 1993, and was registered as ZK-HSC in April 1995. HSC was issued a non-terminating Airworthiness Certificate on 12 August 1997, in the Standard category, valid for private and aerial work operations.

1.6.3 Up to but not including 29 August 2000, HSC had accrued 6502.5 airframe hours. Time flown on 29 August is unknown but likely to be about 2 hours. The most recent maintenance was a 100-hourly check performed at 6414.7 hours, on 30 June 2000. An annual review of airworthiness was carried out at the same time as the 100-hourly check, and additional work included the fitting and testing of an electronic fuel flow indicating system.

1.6.4 The engine, Wright R-1300-3D, serial number KF[1]480425 had run 780.5 hours since overhaul, and 356.5 since top overhaul. The most recent check was a 50-hourly performed on 8 August 2000, at 746.5 hours since overhaul.

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[1] Indicates licence-built by Kaiser-Frazer Corporation

1.6.5 The helicopter was equipped with a digital engine analyser and an electronic fuel flow indicating system, however destruction by fire precluded the retrieval of any data from these systems.

1.6.6 The engine was operated on 100/130 octane avgas. Refuelling on site was done from a fuel tank on the support vehicle assigned to the task. The fuelling equipment incorporated a filter that extracted any water contamination that may be present in the supply tank.

1.6.7 Precise calculations of all-up weight and centre of gravity at the time of the accident were not possible, as the contents of the spray and fuel tanks had been lost on impact. Spray loads of between 500 and 600 litres were carried on each sortie, and the fuel had been topped up to a level of 260 litres after the third sortie. The loader advised that refuelling was done when the fuel level reached 140 litres, and that the top-up was good for three or four sorties.

1.6.8 The spray booms were suspended from hard points on the aft underbelly of the fuselage and braced on either side to hard points on the fuselage sides. The spray pump was mounted on what would normally be the passenger step below the main cabin door on the right-hand side of the fuselage, and the spray tank was mounted inside the main cabin. The span of the booms was slightly less than the main rotor diameter.

1.7 Meteorological information

1.7.1 The 0900 METAR (routine meteorological report) for Wanganui Airport indicated a light southerly drift, 30 km visibility, cloud cover "few[2]" at 2500 feet, "broken[3]" at 3000 feet, temperature +12º C, and QNH 1012 hPa.

1.7.2 The farmer whose property was being treated reported that about 0700 hours, the weather "looked like drizzle", but progressively cleared up, with the sun breaking through the cloud cover from time to time.

1.7.3 The loader described the weather at the time of the helicopter's final departure as "a slight breeze from the west with little cloud over and sunshine".

1.8 Aids to navigation

1.8.1 Not applicable.

1.9 Communications

1.9.1 Not applicable.

1.10 Aerodrome information

1.10.1 Not applicable.

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[2] 1-2 oktas (eighths of sky cover)

[3] 5-7 oktas

1.11 Flight recorders

1.11.1 Not applicable.

1.12 Wreckage and impact information

1.12.1 The wreckage lay on its left side, on a general north-westerly heading, in a small creek in which it had landed heavily. Before final impact, the helicopter had struck the tops of a line of mature poplar trees, oriented approximately magnetic north-south. Four adjacent trees had been "topped", losing about 25 feet on average. The trees were generally about 95 feet in height.

1.12.2 The helicopter had descended at an angle of approximately 55º after colliding with the poplars, striking another two trees a distance of 12 and 22 m respectively from the poplars, before impacting in the creek. The direction of travel between the poplar strike and final impact was 070º M.

1.12.3 The main rotor blades bore evidence of very low rpm at the time of final impact, and the nature of the damage to the underside of one blade in particular indicated that the helicopter had descended through the various trees with low rotor rpm. The debris around the initial poplar strike was contained in an area equivalent to about one main rotor diameter, also suggesting low rotor energy at that point.

1.12.4 During the impact sequence, the aftermost 1.85 m of the tail boom, together with the horizontal stabilisers, pylon and tail rotor broke free, escaping the effects of the fire that consumed most of the wreckage (see 1.14). A ground imprint of the tail rotor indicated that the blades had stopped rotating by the time they struck the ground.

1.12.5 Drive train integrity could not be established, owing to the destruction by fire of the clutch assembly, main driveshaft and the lower main transmission case. However, tail rotor drive integrity was verified, the entire (steel) tail rotor driveshaft being present, from the driven bevel gear at the front end, to the coupling at the intermediate gearbox at the aft end of the tail boom. The shaft was bent through an angle of about 150º in the vicinity of the tail boom fracture described in 1.12.4. The forward section of the shaft (between the main transmission and the coupling at the fuselage/tail boom join) was fractured 3.15 m aft of the transmission end. Visual examination of the fracture established that it had occurred as a result of torsional overload.

1.12.6 Both the intermediate and tail rotor gearboxes were fitted with magnetic chip detector plugs, which were examined on site. Nothing abnormal was found. The section of the tail rotor drive system contained within the pylon assembly was continuous, and unaffected by the damage to the rest of the helicopter.

1.12.7 Pre-accident flight control integrity could not be established because of fire damage. However, examination of those components that survived (mainly associated with the rotor head) exhibited only impact-related damage. The full lengths of both tail rotor pitch-change cables were present, one having parted under the influence of intense heat. No pre-impact failure was evident.

1.12.8 The tail rotor pitch change mechanism at the tail rotor gearbox was found to be jammed in the “full left pedal” position. However, no significance could be attached to this, as both cables had been subjected to considerable tension when the tail boom fractured. Both cables had been pulled a short distance into the sheet metal skin of the surviving section of the tail boom, at the fracture site.

1.12.9 No engine control integrity could be established, owing to a combination of fire and impact damage. The mixture control at the carburettor was found in the “full rich” position, but there was nothing else of significance apparent.

1.13 Medical and pathological information

1.13.1 Post-mortem examination of the pilot established that he had died in the post-crash fire. No evidence was found to indicate any pre-existing medical condition or incapacitation that would have affected his ability to fly the helicopter.

1.13.2 Toxicological tests disclosed no alcohol, or recreational or medicinal drugs, and a blood carbon monoxide level of 5% saturation.

1.14 Fire

1.14.1 Fire consumed most of the helicopter, with the exception of the main rotor blades, rotor head, the upper case of the main transmission, the accessory and main crankcase sections of the engine, the lower portions of the engine compartment doors, part of the main cabin door and the section of tail boom described in 1.12.4. The engine had been partially embedded in the muddy creek bottom, which had afforded it some protection.

1.14.2 One or more of the fuel cells had ruptured on impact, providing a starting point for the fire. The considerable amount of magnesium alloy throughout the airframe, once ignited, resulted in a particularly intense and destructive fire. Burning fuel was carried some distance down the creek in which the helicopter impacted, with vegetation on the creek banks burnt or scorched for at least 30 m downstream.

1.14.3 There was no evidence to suggest an in-flight fire, although this possibility could be completely eliminated only in the engine area forward of the cylinder baffles.

1.15 Survival aspects

1.15.1 Superficial soot particles in the pilot’s airways and the low blood carbon monoxide level indicate that the pilot died very soon after the fire erupted. Because of the degree of fire destruction of the aircraft, it was not possible to investigate or comment on the impact forces involved.

1.15.2 HSC was equipped with a Pointer 3000 ELT, but no signal was received by satellite or other aircraft after the accident. The ELT was not found in the wreckage and was presumed to have been destroyed by fire.

1.16 Tests and research

1.16.1 The engine was recovered from the accident site by helicopter and transported to the nearest road access, from where it was taken to an overhaul facility in Palmerston North. After an external clean to remove impacted mud and fire debris, the engine was stripped under CAA supervision.

1.16.2 The magnesium alloy front[4] crankcase section had burned away, and there was superficial fire damage to the front side of the cylinders. Some pushrod tubes and ignition leads were fire-damaged, but there was no fire damage to the rear of the engine (the accessory section). One pushrod was found bent, but the damage had been caused by impact.

1.16.3 No mechanical fault was found in the cylinders, valve mechanisms, pistons and rods, crankshaft, supercharger, and accessory drives. The lubrication system appeared normal, with oil present in the rocker box scavenge and main sumps, and the oil filter matrix contained only normal filtrates, mainly carbon particles. The magnetic plug in the main sump was clean.

1.16.4 The Stromberg injection carburettor was removed and examined externally. About 250 ml of fuel and 100 ml of slightly muddy water was drained from the section of the carburettor body in which the fuel strainer is located. A quantity of mud was present in the throttle body, below the throttle valves. No mud appeared to have reached as far as the supercharger impeller. The carburettor was sent to an overhaul facility in Australia for functional testing.

1.16.5 On initial test, the carburettor exhibited a fuel leak from the regulated impact pressure chamber, and on examination, the leak was found to be from a ruptured balance diaphragm. This diaphragm is exposed to unmetered fuel pressure on one side and regulated impact air pressure on the other. The rupture indications were consistent with failure on impact rather than a pre-existing failure.

1.16.6 Once the balance diaphragm was replaced, the carburettor functioned normally throughout the test regime, with the exception of the idle setting point. This was not able to be tested due to impact damage.

1.16.7 Fuel was present in the delivery line between the engine-driven fuel pump and the carburettor. The fuel pump was rig-tested and performed to specification.

1.16.8 Both magneto bodies had been contaminated with mud and water. Neither could be bench tested, although it was possible to examine individual components. One coil and one capacitor (from the same magneto) were "dead", but both were water-contaminated. The sealant at the electrode end of the capacitor had perished to a degree that would permit the ingress of water under pressure. Both magneto drives on the engine accessory case were normal.

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[4] The "front" end of the engine actually faces the rear of the helicopter in this installation.

1.16.9 The fertiliser application on the property was completed on 12 September 2000 using an AS350 helicopter. The investigator-in-charge took the opportunity to fly as a passenger on a simulated spray run at about the same time of day as the accident, with particular interest in the possible effects of sun glare and the definition of the poplar line against a "razorback" ridge immediately to the east of and parallel to the tree line. The direction of the spray run was deduced from fertiliser patterns on the ground on the day of the accident.

1.16.10 It was concluded that the position of the sun was unlikely to have been a problem to the pilot of HSC, and that the tree collision was unlikely to have been due to the pilot's failing to sight them against the background of the ridge. With the height of the ridge about twice that of the poplars, pull-up would have had to be commenced well in advance of the poplars in order to clear the ridge.

1.16.11 It was noted that the descent angle from commencement of the spray run to the pull-up point was relatively steep, and that spray runs were flown at 80 knots. (Vne for the S-55 is 95 knots indicated airspeed.)

1.17 Organisational and management information

1.17.1 Nil.

1.18 Additional information

1.18.1 Nil.

1.19 Useful or effective investigation techniques

1.19.1 Ascertaining the attitude of the helicopter when it collided with the poplar trees posed some difficulty. A three-view drawing of the helicopter was copied onto a transparency, and laid over a photograph of the damaged trees. The drawing had been scaled according to pre-measured distances in the photograph.

1.19.2 Although there were obvious limitations with this method, it was found that the most likely attitude (or "best fit") in which the helicopter struck the trees was upright with little or no yaw.

1.19.3 The discrepancy between the initial presumed heading of about 070º and the final north-westerly heading may be explained that a rotor turning anticlockwise (viewed from above) striking trees while in autorotation will cause the airframe to rotate in the same direction, that is, anticlockwise. A strike with power on will result in a tendency for clockwise rotation of the airframe.

2. Analysis

2.1 The scope of this investigation was severely limited by the fact that the helicopter had been largely destroyed by fire.

2.2 The condition of the rotor blades and the distribution of the tree debris indicated that the helicopter had struck the trees with little or no power applied to the rotor system.

2.3 Possible reasons for the lack of power indications include:

- A partial or total engine failure;
- A failure of the drive train between the engine and the main rotor transmission;
- A deliberate closing of the throttle by the pilot, after encountering some other form of difficulty or malfunction.

2.4 Examination of the engine did not reveal any mechanical cause of failure, and similarly, examination of the available engine accessories revealed no overt causal indications.

2.5 The water in the carburettor could not be completely ruled out as a cause of engine failure. However, the carburettor was immersed in the mud and water of the creek in which the helicopter landed, and the rupture of a diaphragm between adjacent fuel and air cavities provided a possible pathway for the ingress of water. The pilot's and loader's pre-flight checks would have detected water in the respective fuel tanks, and in any case the refuelling filter was designed to eliminate water from the fuel before delivery into the aircraft.

2.6 That there was a significant quantity of fuel on board the helicopter was evident from the extent of the burning of the creek bank vegetation downstream of the accident site.

2.7 The main drive train was completely destroyed by fire, thus no conclusion could be drawn on its pre-accident integrity. A driveshaft failure would result in an immediate engine overspeed, but the engine displayed no indications of having been oversped. The tail rotor drive system appeared to have been functioning normally before the accident.

2.8 Possible reasons for the pilot himself closing the throttle include:

- The onset of some form of physical incapacitation;
- Encountering control difficulties, such as retreating blade stall or hydraulic control boost failure.

2.9 The post-mortem examination of the pilot did not reveal any pre-accident incapacitation, although this examination was also constrained by fire damage. Toxicology results were negative, or in the case of the carbon monoxide reading, not significant.

2.10 A full examination of the control systems, including the hydraulics, was not possible, as most of the components were destroyed by fire. Those that had survived did not exhibit any pre-accident damage.

2.11 Retreating blade stall is an aerodynamic phenomenon affecting the main rotor, and can be encountered when the helicopter is being flown close to its maximum airspeed, particularly at a heavy weight. It can also manifest itself when the helicopter is being manoeuvred harshly, more so when either or both the preceding two conditions exist.

2.12 The onset of retreating blade stall is indicated by a progressively increasing level of rotor-related vibration or "roughness" throughout the airframe, and if measures are not taken to reduce airspeed or the severity of the manoeuvre, the helicopter will pitch up and roll to the left (in the case of a rotor turning anticlockwise as viewed from above).

2.13 The possibility of retreating blade stall could not be ruled out, especially in light of the presumed direction of the final spray run. A steep descent at 80 knots, probably with the helicopter still reasonably heavy, and a pull-up to clear the ridge ahead could have combined to produce the effect.

2.14 However, despite the various possibilities discussed in this section, there was insufficient evidence available to assign a definite cause for this accident.

3. Conclusions

3.1 The pilot was appropriately licensed, rated and experienced for the task being undertaken.

3.2 There was no evidence to suggest pilot incapacitation.

3.3 The helicopter had a valid Airworthiness Certificate and had been maintained in accordance with normal aviation practice.

3.4 The helicopter collided with trees with little or no power to the rotor system.

3.5 The reason for the absence of power could not be determined.

3.6 No cause could be established for this accident.

(Signed)

Richard White
Manager Safety Investigation
9 March 2001