Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A05Q0119

COLLISION WITH WATER

HÉLI-EXPRESS INC.
BELL 205 A-1 HELICOPTER C-GADA
SOLITUDE LAKE, QUEBEC
16 JULY 2005

Canada

Aviation Investigation Report

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Summary

The Bell 205 A-1 helicopter (registration C-GADA, serial number 30031), with a pilot and a loadmaster on board, was engaged in forest fire suppression operations at Solitude Lake, Quebec, about 25 nautical miles northwest of Port-Cartier, Quebec. At approximately 1220 eastern daylight time, the helicopter hover taxied from a fuel cache site located at the south end of the lake. The helicopter was slinging an empty water bucket on a 100-foot longline. While decreasing power to bring the helicopter to a hover, the pilot felt a vibration, followed by a loud bang, and what seemed to be a loss of power. The helicopter quickly lost altitude and pitched nose down and to the right before striking the water. The pilot and loadmaster managed to exit the helicopter while it was sinking and were rescued by nearby firefighters. The pilot-in-command was seriously injured. The loadmaster sustained minor injuries. The helicopter was substantially damaged.

Ce rapport est également disponible en français.

Other Factual Information

The helicopter was owned and operated by Héli-Express Inc. The pilot-in-command was certified and qualified for the flight in accordance with existing regulations and was operating in visual meteorological conditions. He had approximately 8000 hours of total flying time, with 60 hours on the Bell 205. He had completed his training and pilot proficiency check on the Bell 205 on 07 July 2005 and occupied the position of chief pilot. The helicopter was equipped with a vertical reference kit (with bubble window) that allowed the pilot to operate the helicopter from the left seat while watching the load and longline.

The loadmaster, seated in the right seat, held a commercial helicopter licence but was not type rated on the Bell 205. He was on board as an observer for longline aerial operations training. He was not at the controls at the time of the occurrence. As a low-time pilot, he was hired by the company to help with secondary duties such as loading passengers, preparing cargo nets, and fuelling.

On 15 July 2005, the Bell 205 was flown to a base camp 25 nautical miles north of Port-Cartier to conduct forest fire duties. The morning of July 16, the helicopter was flown to the fuel cache situated along the river to the south end of Solitude Lake and then returned to base camp. The 100-foot longline was connected to the helicopter. The helicopter then conducted two cargo net flights before returning to base camp. At approximately 1100 eastern daylight time,[1] a portable fuel pump and water bucket were boarded before departing for the fuel cache where the helicopter was refuelled with approximately 1000 pounds of fuel.

At approximately 1210, the water bucket was connected to the 100-foot longline. The helicopter then took off from the fuel staging area, and slowly hover taxied in a north-northwesterly direction over the water. Although the pilot had many flying hours using a longline and many hours using the water bucket on lightweight helicopters, it was the first time he was using them together while flying the Bell 205, a medium-weight helicopter. The helicopter was approximately 1000 feet from shore when the crew felt a vibration and heard a bang, which was followed by what seemed to be a loss of power.

The pilot applied collective to avoid descending, pushed the cyclic forward to gain speed and ordered the loadmaster to jettison the water bucket. The helicopter lost altitude, pitched nose down, and banked to the right before striking the water. Both occupants exited the helicopter while it was sinking. Other helicopters operating on the fire arrived promptly on site. The crew was rescued by firefighters with a small motor boat. The helicopter rolled inverted and sank in approximately 25 feet of water.

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[1] All times are eastern daylight time (Coordinated Universal Time minus four hours).

The loadmaster was evacuated by helicopter to the local hospital. The pilot-in-command was first evacuated to the base camp where he was stabilized. He was then transported by ambulance to hospital where he arrived approximately four hours after the occurrence. At the time of the occurrence, the pilot-in-command was wearing the lap-belt, but was not wearing the shoulder harness. It is common practice for pilots flying vertical reference operations to leave the shoulder harness unfastened since considerable upper body movement is required to lean into the vertical reference bubble window during longline operations.

The pilot-in-command suffered a broken back. The loadmaster wore both the lap-belt and the shoulder harness. He received only minor injuries. Neither the pilot nor the loadmaster was wearing a lifejacket as per the company operations manual, Part 1, Chapter 4, Section 4.25, Operations over Water. The pilot-in-command did not know how to swim. Neither crew member was wearing a helmet; the use of helmets was not mandatory.

The helicopter came to rest inverted approximately 1000 feet from shore in about 25 feet of water and silt, which totally obscured the water during salvage operations. The initial attempt to retrieve the helicopter by the cargo hook resulted in the lift beam being torn off and lost. The water bucket, the tail rotor, and all parts that had been separated from the airframe could not be located due to the lack of visibility under water. Once the helicopter was recovered, examination of the airframe confirmed a nose-down impact on the right side (Photo 1).

Photo 1. Damage to Bell 205 A-1, C-GADA

The main rotor blades had been severely damaged from impact with the water. Signs of delaminating of the re-enforcing straps near the blade roots, usually associated with blade coning, were not present. Coning is the result of upward blade movement if rotor rpm decays following a loss of power and application of collective. The examination revealed that the impact loads had also broken the four main transmission pylon mounts. The transmission remained attached to the airframe only by the hydraulic lines and the flight controls. During the impact, the rotor head contacted the mast. The mast was disassembled and examined; no pre-accident condition, which could have been causal to the accident, was revealed. The main power shaft between the engine and the transmission was a KAflex type. Only the connectors to the engine and transmission were recovered, with some of the flexible segments still attached. All fractures associated with the KAflex were examined and found to have resulted from overload. The hollow portion of the shaft grooved a circular imprint of the shaft ends on both the connectors. This could only have occurred if the shaft assembly had remained in position until impact.

Records indicate that the helicopter was certified and equipped in accordance with current regulations and approved procedures, and was within weight and balance limits before and after the water bucket was released. The last 100-hour inspection was completed 12 July 2005.

The helicopter was equipped with a Lycoming (Honeywell) model T53 13B turboshaft engine, serial number LE-O7556. The engine was last overhauled by Air Asia Company Ltd. on 10 January 2002 and installed on PK-UHJ, an Indonesian Bell 205A-1 helicopter. Air Asia repaired the engine on 12 August 2003 for high oil consumption and re-installed it on PK-UHJ. That helicopter was imported to Canada in 2003 and privately registered as C-GADA on 02 April 2004 to a company based in British Columbia. It was acquired by Héli-Express Inc. three weeks later and commercially registered on 22 April 2004.

The engine was removed on 16 September 2004 and forwarded to Eagle Copters for a hot section inspection (HSI) and replacement of time-expired turbine disks. The engine was re-installed on C-GADA on 09 February 2005. At the time of the accident, it had accumulated 171 hours since the HSI and 993.3 hours since overhaul. Following the occurrence, the engine was removed and forwarded to Honeywell's facilities in Phoenix, Arizona, United States, for examination. The teardown was attended on behalf of the TSB by an investigator from the National Transportation Safety Board.

There are 31 blades (part number 1-100-361-06) on the first stage compressor disk. Each blade has a locking tab (part number 1-100-505-02). These are single use only items and should be replaced at each disassembly. The examination revealed that all the locking tabs, locking the blades to the first stage compressor disk, were found unbent (see Photo 2). All of the blades had moved back and there was rotational scoring on all aft blade platforms, with corresponding damage on the outer diameter of the vane support.

The manufacturer had no history of known compressor blade walking incidences that would first manifest themselves as an aerodynamic instability leading to compressor surge/stall. This can be explained by the fact that reducing the gap between the trailing edge of the blade and the leading edge of the vane has no adverse effect on the airflow within the engine.

The disassembled engine was returned to the TSB Engineering Laboratory. The additional test results are outlined in report LP 046/2006 (Testing of Locking Tabs). The report shows that a calculated rearward acceleration in the vicinity of 2034 g would have been required to unbend the tabs. The relatively low impact sustained by the helicopter, the forward direction of the helicopter during the impact, and the observations made during the testing suggest that it is unlikely that the first stage compressor blades moved aft during the accident, unbending the tabs. It is likely that the tabs were not replaced and bent, as required, during the last maintenance conducted on the compressor (Photo 2).

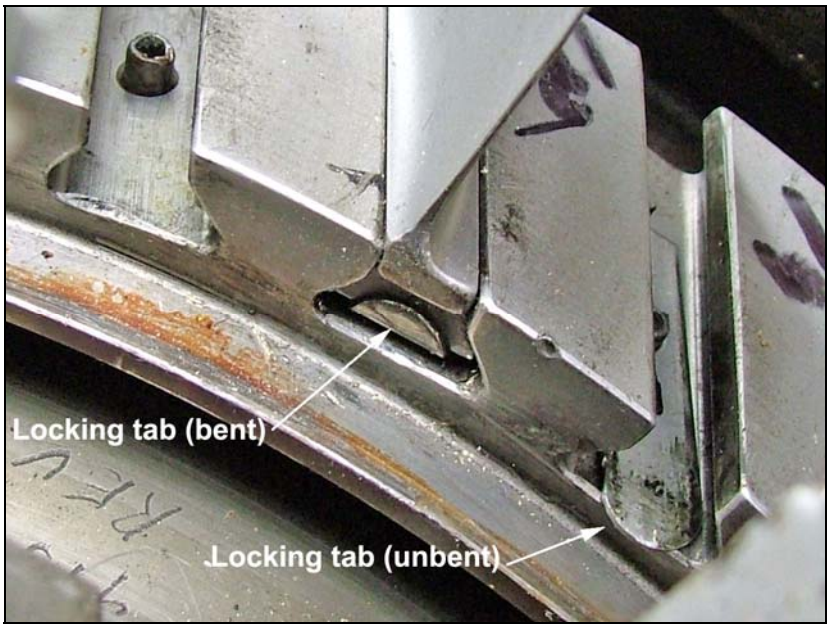

Photo 2. Locking tabs

The engine teardown at the Honeywell facility also revealed that the following parts had been procured under a U.S. Army code, and their installation is not authorized in a certified engine:

- Power shaft bearing retainer assembly: part number 1-060-090-03, serial number 33640.39
- Left-hand nozzle assembly: part number 1-130-730-02, serial number 3257041
- Second-stage gas producer turbine nozzle: part number 1-120-000-14, serial number 3313

These parts would have been exposed during the overhaul at the Air Asia facility, a Honeywell authorized repair facility. An overhaul requires that all parts be checked and recorded. The nozzle assembly and second-stage turbine nozzle would have been exposed at the last HSI done at the Eagle Copters facility.

Installation was based on the availability of identification tags confirming the airworthiness of the parts. Control of aviation parts on components that were first designed and put in service for the military can be confusing, and even more so in the case of this model of engine (T53-L-13B) for which the U.S. Army owns the drawings. Although this version of the engine (T53-13B) is certified by the Federal Aviation Administration (FAA), a large quantity of parts in the Illustrated Parts Catalog (IPC) share the same part number as the military ones. Therefore, the identification on a data plate or the scribe on a part, along with its tag confirming its traceability, is not sufficient to attest that the part is authorized for commercial use. Its validity

must be checked against a Commercial and Government Entity (CAGE) code, which identifies the manufacturer and the purchaser. These codes are available on the Business Identification Number Cross-reference System (BINCS) Web site.

The CAGE code 81996 found scribed on the three unauthorized parts described earlier in the report refers to material being manufactured for the U.S. Army Aviation and Missile. For this occurrence engine, the proper CAGE code for these parts should have been 91547. The tags do not include the CAGE code nor is it required. This can result in the issuance of a certificate of airworthiness without the benefit of complete and adequate documentation.

The engine teardown report prepared by Honeywell indicates that there was no pre-existing condition found in the engine that would have interfered with its normal operation. The type of damage to the engine was indicative of engine rotation and operation at the time of impact with the water. Supporting this assessment was the fact that molten aluminum was found splattered in the combustion chamber and on all turbine blades. This condition would require sustained combustion, which in turn requires engine rotation. Rotation at the time of impact was evidenced by several areas of rubbing and scoring, as follows:

- rotational scoring through about 60 degrees on the particle separator lower assembly half;
- leading edge blade tip corners were separated on nearly all of the blades of the first and second stage axial compressor with the remaining material bent opposite the direction of rotation;
- trailing edge of blades on the five axial compressor stages bent opposite to rotation;
- rotational scoring on about 200 degrees on the centrifugal compressor shrouds; and
- foreign object damage[2] on the five stages of the axial compressor (the first two stages showed heavier damage).

The fuel control unit (FCU), model TA-7, was tested at the Goodrich facilities, with a TSB technical investigator in attendance. The FCU and power turbine governor were found to be functional. All of the tested values were either within and/or slightly beyond the acceptance test procedure specification limits. Neither the functionally tested values nor the disassembly of the FCU disclosed any pre-existing conditions that would have interfered with normal engine operation.

Teardown of the main transmission and free wheeling unit did not reveal any pre-condition that would have led to a loss of rotor control. Engine compressor stall or surging has been known to leave impinge marks on the gears of the 42-degree gearbox or tail-rotor gearbox. The tail-rotor gearbox was not recovered. Examination of the 42-degree gearbox did not reveal any signs of impingement.

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[2] This type of damage is attributable to foreign objects being aspirated into the engine.

The helicopter is equipped with warning lights that advise the pilot of the loss of important parameters, systems, or components. All instrument panel, annunciator panel, and vertical reference bubble window caution warning light bulbs, of which there are 46, were recovered from the wreckage and sent to the TSB Engineering Laboratory to determine their ON-OFF state at impact. TSB Engineering Laboratory report LP 090/2005 concludes that none of the lamp filaments exhibited any of the characteristics normally associated with an incandescent filament when shocked. It is therefore likely that all the lamps were OFF at the time of impact. An engine warning light would typically turn ON between 5 and 11 seconds after a failure. A low rotor warning light would take about 3 seconds. Neither the pilot-in-command nor the loadmaster remembers seeing any warning lights or hearing any warning horns during the occurrence.

Fuel samples taken from the helicopter fuel tank, engine fuel filter, and ground pump were sent to the TSB Engineering Laboratory for analysis. TSB Engineering Laboratory report LP 085/2005 concludes that the engine was fuelled by a mixture of Jet A and 14.86 per cent by weight or more of 100LL aviation gasoline (AVGAS). An analysis of the fuel recovered from the FCU, conducted by Honeywell, showed 11 per cent by weight of AVGAS. Although the engine manufacturer does not include AVGAS as an approved fuel for the T53 engine, the engine is able to function without immediate harmful consequences. The FCU is designed for scheduling fuel of various specific gravities. AVGAS is an acceptable emergency fuel for the military version of this model of engine.

The Société de protection des forêts contre le feu (SOPFEU) is responsible for the prevention, detection and suppression of forest fires in Quebec. During forest fire suppression operations, the SOPFEU will order fuel from the closest fuel wholesaler. Barrels are used, cleaned, refilled, and resealed at the wholesaler's distribution yard and then delivered to the customer. Because the wholesaler is delivering a product to an off-airport location, it need only abide by provincial regulations. An order of 40 barrels of Jet A1 fuel was placed by the SOPFEU on 15 July 2005 with the wholesaler in Sept-Îles, Quebec, about 100 km from the base camp. However, 36 barrels of Jet A1 fuel and 4 barrels of AVGAS were delivered. The 40 barrels delivered were white in colour. The identifying stickers are white with black lettering. The markings on the identifying stickers affixed to the barrels showed the appropriate information specified in provincial regulations, in that they included type of fuel, date, batch number, and dangerous goods information. The only visible difference on the barrels were the words 100LL AVGAS and JET A1 (Photos 3 and 4).

Photo 3. View of fuel barrels and identifying stickers

This fire operation required four helicopters, all of which used Jet A1 fuel. Since no other aircraft requiring AVGAS had been contracted, the helicopter operator was not concerned that there could be barrels of AVGAS mixed with the delivery.

Photo 4. Fuel barrel identifying stickers

AVGAS is considered a Class 1 petroleum product and under existing provincial regulations, a Class 1 product over 45 litres does not require any kind of colour coding of the container. However, a container under 45 litres, containing a Class 1 product, must be predominately red in colour. Therefore, by provincial law, the 205-litre barrels of AVGAS do not have to differ in colour from a Class 2 (Jet fuel) or a Class 3 product. No colour differentiation of the identifying stickers is necessary. The different products in the containers were not visible to the user, and do have a different colour and smell. AVGAS is blue and Jet fuel is yellow. Workers loading the product at the wholesaler and those delivering the product to the SOPFEU had mistakenly mixed some AVGAS barrels with the Jet A1 barrels. During the fuelling process, the helicopter pilots using the product mistakenly identified the AVGAS barrels as Jet A1 barrels.

Transport Canada regulations define an aerodrome as, "Any area of land, water (including the frozen surface thereof) or other supporting surface used or designed, prepared, equipped or set apart for use whether in whole or in part of the arrival and departure, movement or servicing of helicopter and includes any buildings, installations and equipment in connection therewith." The base camp and fuel cache from which the accident helicopter and three other helicopters were operating would be considered an aerodrome by definition. Distributors of a petroleum product at an aerodrome are subject to provincial regulations. Although federal standards exist to properly identify a petroleum product by colour of container, pump, or identifying sticker, these standards cannot be enforced.

The Transport Canada Vertical Reference Flying Pilot's Guide explains that people have little or no depth perception beyond 15 feet. A pilot flying longline operations must ensure an adequate scan of the surrounding area and not fixate on any one thing for too long so that the helicopter's speed, altitude, depth, and rate of closure can be adequately estimated. Objects in the periphery, ambient light, and shadows are some of the essential information necessary for the brain to properly assess the helicopter's position and movement.

Longline operations require that the pilot position the helicopter in proximity to fixed objects, in this case preferably on the left side of the helicopter where the pilot is seated. The pilot must stop the helicopter's forward speed and maintain the helicopter's position relative to these objects constant while descending to fill the water bucket. It is equally important to climb enough to ensure that the water bucket is well clear of the water surface before transitioning to forward flight. At 1000 feet from shore, the pilot would not have been able to adequately judge the helicopter's forward speed and altitude above the water. Had the water bucket inadvertently dragged on the water surface and entered the water, it would have acted as an anchor, abruptly restricting the aircraft's forward motion.

Analysis

Although the fuel product identifying stickers met provincial regulations, the similarity between the stickers may lead to misidentification of the fuel product. Operating with a small amount of AVGAS had no consequence on engine performance.

Extensive examination of the engine and FCU did not reveal any anomaly or defect that could have contributed to or caused a loss of power to the engine. The locking tabs on the first stage of the compressor had been left unbent at the last engine overhaul. Except for having a high potential for engine mechanical or structural damage, the backward movement of the compressor blades had no effect on the engine operation during this event. Other than not being certified for use in civilian-registered helicopters, the presence of unauthorized parts also had no effect on engine performance. The finding of unbent locking tabs and unauthorized parts indicates a lack of quality control on the part of both maintenance facilities involved. Because military and commercial parts may have the same part number, it is essential to cross-reference the CAGE code of the parts so as to trace their origin and confirm their authorized use in commercial aircraft. The lack of a CAGE code on the accompanying tag resulted in the issuance of a certificate of airworthiness without the benefit of complete and adequate documentation.

The presence of melted metal throughout the combustion chamber and turbine blades is indicative of power being produced at the time of impact. Main rotor blades did not present the damage usually associated with blade coning that occurs if rotor decays following a loss of power.

None of the available dynamic components (the KAflex drive shaft, the main transmission, the free wheeling unit, or the 42-degree gearbox) indicated a pre-existing condition that would have interfered with their normal operation. The crew did not recall seeing any caution lights or hearing the low rotor horn, and none of the engine or low rotor RPM caution lights was lit at impact. All of these observations led to the conclusion that the helicopter systems were operating within the normal parameters at the time of impact.

At a distance of 1000 feet from shore, the pilot would not have been able to adequately judge the helicopter's forward speed and altitude above the water. It is likely that the water bucket inadvertently entered the water while the helicopter was transitioning from a hover taxi to a hover. This may have caused the vibrations and tugging felt by the pilot and the loadmaster. The application of collective and forward cyclic would have caused the helicopter to pendulum swing toward the surface of the water. The water bucket was jettisoned after collective and cyclic inputs. However, there was insufficient time, altitude or visual references to prevent the helicopter from striking the water.

The pilot-in-command was not wearing the available shoulder harness during longline operations, which likely contributed to the severity of his injuries.

The following TSB Engineering Laboratory reports were completed:

LP 085/2005 – Fuel Analysis Bell 205A-1, C-GADA
LP 090/2005 – Analysis of Warning Lamps
LP 046/2006 – Testing of Locking Tabs

These reports are available from the Transportation Safety Board of Canada upon request.

Findings as to Causes and Contributing Factors

1. The helicopter was positioned too far from shore to provide adequate visual references for longline operations, and it is likely that the water bucket inadvertently entered the water while the helicopter was transitioning from a hover taxi to a hover.

2. The anchor effect of the water bucket may have caused the helicopter to swing downwards, and there was insufficient time, altitude, or visual references to prevent the helicopter from striking the water.

3. The pilot was not wearing the available shoulder harness during longline operations, which likely contributed to the severity of his injuries.

Findings as to Risk

1. Although there was no effect on engine performance, the presence of unauthorized parts and the unbent first stage compressor blade locking tabs denotes a lack of quality control on the part of both maintenance facilities involved.

2. Although the fuel product identifying stickers met provincial regulations, the similarity between the stickers may lead to misidentification of the fuel product.

3. The crew members were not wearing a lifejacket as stipulated in the company operations manual. Although both survived their injuries, the pilot did not know how to swim and may have drowned had he not been rescued by nearby firefighters.

Other Findings

1. Many military and commercial parts share the same part numbers and therefore the accompanying tag is not sufficient to confirm that the part is authorized for commercial use. Its validity must be cross-referenced with the Commercial and Government Entity (CAGE) code. It is not mandatory to indicate the CAGE code on the accompanying tag.

2. The lack of a CAGE code on the accompanying tag resulted in the issuance of a certificate of airworthiness without the benefit of complete and adequate documentation.

Safety Action Taken

On 05 June 2006, the TSB issued Safety Information Letter A060026-1, Inadequate Identification of Fuel Barrels, to the Director General of Civil Aviation. The Safety Information Letter highlighted the criticality of proper identification of fuel barrels. The use of fuel barrels for remote helicopter operations is widespread throughout Canada.

On 11 April 2007, the TSB issued Aviation Safety Information Letter A070004, Inadequate Identification of Parts, to the Director General of Civil Aviation. The Safety Information Letter highlighted the fact that the identification on a data plate or the scribe on a part, along with its tag confirming its traceability, are not sufficient to attest that the part is authorized for commercial use. Its validity must be checked against a Commercial and Government Entity (CAGE) code, which identifies the manufacturer and the purchaser. These codes are available on the Business Identification Number Cross-reference System (BINCS) Web site.

Transport Canada published an article entitled “Inadequate Identification of Fuel Barrels” in the *Aviation Safety Letter*, TP 185, Issue 4/2006. The *Aviation Safety Letter* is distributed worldwide to over 90 000 readers.

Air Asia Company Ltd. has taken safety action to ensure that the quality control within its maintenance facility is maintained by identifying and segregating military parts from commercial ones.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 29 March 2007.

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