FLIGHT SAFETY FOUNDATION
HELICOPTER SAFETY
Vol. 28 No. 2 *For Everyone Concerned With the Safety of Flight* March–April 2002

Boost Pump Failure Starves Bell 214B Engine of Fuel

Canadian investigators said that the aircraft flight manual did not adequately describe the potential consequences of a boost pump failure and that the pilot's lack of recurrent training might have affected his ability to conduct an autorotation.

FSF Editorial Staff

About 0655 local time July 4, 1999, a Bell (now Bell Helicopter Textron) 214B operated by East West Helicopters descended from about 400 feet above ground level (AGL) into a shallow, rapidly flowing river 35 nautical miles (65 kilometers) northwest of Kaslo, British Columbia, Canada. The helicopter broke apart on impact and came to rest on rocks in the middle of the river. The four occupants were killed.

The Transportation Safety Board of Canada (TSB) said, in its final report on the accident, that the causes and contributing factors were the following:

- "The helicopter engine lost power in flight (engine flameout) because of fuel starvation;
- "The usable fuel in the left[-forward] cell was exhausted. Although there was fuel in the right[-forward] cell, it was not available at a usable rate because the right boost pump was inoperative and the fuel transfer was slower than engine fuel usage; [and,]
- "When the right boost pump is inoperative, the fuel-quantity gauge indicates more fuel than is actually on board. The actual amount of usable fuel would be difficult to determine in flight."

The helicopter was based at a heli-logging staging area on a forest-service road that runs through a valley. The night before the accident, maintenance was performed on the helicopter by an aircraft maintenance engineer (AME) and an apprentice AME.

"[They] had worked on the helicopter in the staging area until midnight," the report said. "It is not known what maintenance may have been performed at that time."

About 0600, East West Helicopters' operations manager drove the pilot, copilot, AME and apprentice AME to the helicopter. The operations manager then drove about 0.25 nautical mile (0.46 kilometer) south on the forest-service road and parked his vehicle in a log-landing area.

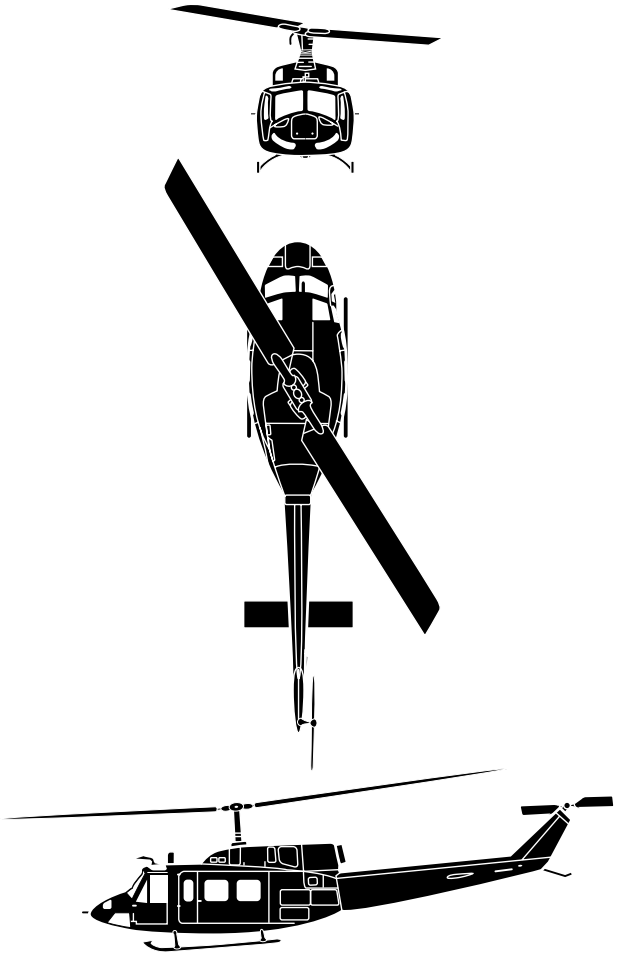
The pilot, 48, held a commercial helicopter pilot license and had about 14,000 flight hours, including about 2,750 flight hours in heli-logging operations and 300 flight hours in type. He was employed by East West Helicopters in June 1998 and flew Bell 214 and Bell 206 helicopters for the company.

The pilot had not received recurrent flight training in a Bell 214B after completing flight training for his type endorsement more than two years before the accident.

"Several pilot-proficiency-check (PPC) reports contained comments that the pilot's handling of emergency procedures needed improvement; however, there is nothing in the pilot's

file to indicate that extra training was received," the report said. "A PPC report for a flight in January 1993 noted that the pilot needed to be briefed on autorotation procedures, both straight-in and 180-degree turns. There was no record found of the pilot having flown a PPC on the Bell 206 or Bell 214."

The report provided no information about the copilot; the copilot and the apprentice AME occupied seats in the passenger cabin. The AME occupied the right seat in the cockpit. The pilot occupied the left seat in the cockpit.



Bell Helicopter Textron 214B

The Bell Helicopter Textron 214B is a medium-sized commercial helicopter based on the Model 214 Huey and Model 214A Isfahan military utility helicopters. Called the BigLifter, the Model 214B first flew in 1974.

The helicopter can accommodate a pilot and 14 passengers or 7,000 pounds (3,175 kilograms) of cargo carried internally or externally, and can be configured for agricultural operations and for fire-fighting operations.

The 214B has one Lycoming T55-08D turboshaft engine rated at 2,930 shaft horsepower (2,185 kilowatts) and a two-blade main rotor and tail rotor. Maximum takeoff weight is 13,800 pounds (6,260 kilograms). Cruise speed with an internal load of 4,000 pounds (1,814 kilograms) is 140 knots.♦

Source: *Jane's All the World's Aircraft*

The Bell 214B is certified for single-pilot operation. The report said that the pilot is required to occupy the right seat in the cockpit during passenger flights. During heli-logging operations, however, the pilot usually occupies the left seat and concentrates on maneuvering the helicopter; the copilot occupies the right seat and monitors the engines and auxiliary systems.

"For external-load flying [e.g., heli-logging], a supplement to the aircraft's type certificate can be issued by Transport Canada (TC) for a specific aircraft," the report said. "This supplement allows a single pilot to fly that aircraft from the left seat, provided that certain modifications — including installation of dual controls, a left-door bubble window and critical instruments added to the left-door window sill — have been made to the aircraft.

"The accident aircraft had been modified to be flown from the left seat, but a supplemental type certificate had not been issued for this aircraft."

The pilot started the helicopter's engine about 0630 and operated the engine on the ground for 10 minutes to 15 minutes.

"The helicopter then took off and ascended briefly into the cloud base at about 500 feet [AGL] before descending below the cloud," the report said.

The pilot told the operations manager by radio that he was conducting a power check and that heli-logging operations could not be conducted that day because of fog obstructing the logging site. The logging site was at an elevation of about 3,660 feet — 1,000 feet higher than the staging area. There was no further radio communication between the pilot and the operations manager.

"The helicopter then flew down the valley at about 400 [feet AGL], staying closer to the northwest side of the valley, and passed nearly overhead the operations manager," the report said. "The helicopter continued down the valley, then made a 180-degree turn and flew up the southeast side of the valley [past the log-landing site]."

The operations manager then heard the helicopter returning. As the helicopter neared the log-landing site, the sound ceased. The operations manager observed white vapor trailing the helicopter as it continued flying south at about 400 feet AGL. He heard and observed slowing rotation of the main-rotor blades.

"The helicopter then made a descending 180-degree turn toward Glacier Creek, with the main rotor continuing to slow," the report said. "Immediately before the helicopter disappeared from sight behind trees, the main rotor appeared to have stopped turning."

The helicopter broke into four main pieces on impact; all the pieces were found within a few feet of each other. The fuel cells ruptured on impact, but there was no fire. The AME, copilot and apprentice AME were killed on impact. The pilot, who wore a flight helmet, survived the impact but died from injuries 45 minutes later.

"The main-[rotor blades] and tail-rotor blades exhibited very little rotational impact damage," the report said. "The fuselage exhibited indications of high-speed, near-vertical impact damage with a low-speed forward component. … The injuries to the occupants and the damage to the aircraft are consistent with high vertical-impact forces that characterize an unsurvivable accident."

The copilot was found about 10 feet (three meters) from the cabin. The apprentice AME was found beneath the wreckage. The pilot and AME were found seated in the cockpit. Both cockpit seats had four-point occupant-restraint systems, but the pilot and the AME had used only the lap belts; the shoulder straps were found stowed behind the seats.

The report said that during external-load operations, the pilot flying often must lean to the side to observe the external line and the load attached to the external line.

"Because such a body position is difficult to achieve by a pilot wearing a shoulder harness, it is a widespread practice for the pilot maneuvering the helicopter to use [only] the lap belt portion [of the occupant-restraint system]," the report said. "The shoulder straps are commonly stowed behind the seat back to prevent them from interfering with the pilot's movements."

The report said that, because of the severity of the impact forces and the high vertical component of the impact forces that occurred in the accident, it is unlikely that the pilot and AME would have survived if they had been wearing their shoulder harnesses. Nevertheless, accident investigations and research conducted by TSB have shown that use of shoulder harnesses reduces injury or prevents injury during aircraft accidents involving moderate impact forces.

Records indicated that the helicopter, which was manufactured in 1978, had accumulated 8,575 airframe hours and 8,348 engine hours, including 3,073 hours after an overhaul of the engine. The engine manufacturer recommends that the engine be overhauled every 4,000 hours.

"The maintenance records show that the accident helicopter [engine] had been 'surging' for more than a year, since the aircraft was imported from Japan," the report said. "The records, however, do not give details of any symptoms exhibited by the aircraft."

Post-accident examination of the engine, drive-train components and rotor blades revealed negligible rotational damage. Examination of the engine instruments revealed that engine rpm was 3 percent of maximum rpm and that rotor rpm was 16 percent of maximum rpm on impact.

"A more detailed inspection of the wreckage revealed that all component breakage and damage in the flight controls, drive train and main-rotor gearbox were overload in nature and were attributable to the impact forces of the accident," the report said. "Based on this information, it was determined that the helicopter had lost power before impact."

Examination of light bulbs from the annunciator panel revealed that several warning lights — including those indicating a right-boost-pump failure, low fuel and low rotor rpm — were illuminated when the helicopter struck terrain.

"An illuminated boost-pump light indicates that fuel flow from the related fuel-boost pump has dropped to the point where the flow-activated switch operates, indicating an inoperable fuel-boost pump or a lack of fuel," the report said.

The Bell 214B has five interconnected fuel cells (see Figure 1, page 4). An electrically driven fuel-boost pump in each of the two forward cells supplies fuel to the engine.

"A fuel-cell interconnect line runs between the left[-forward fuel cell] and the right-forward fuel cell, normally ensuring that the fuel level in the two forward cells remains equal," the report said. "The fuel-quantity gauge is operated by probes located in the center cell and [in] the right-forward fuel cell. If the center fuel cell does not contain any fuel, the fuel-quantity gauge is operated solely by the probes in the right-forward cell. The fuel-quantity gauge does not directly register fuel in the left-forward cell."

The report said that the fuel-quantity indication in the Bell 214B is accurate when the right-forward cell and the left-forward cell contain an equal amount of fuel.

A float switch in the left-forward fuel cell activates the low-fuel warning light.

The Bell 214B flight manual said that unusable fuel during normal flight operations (e.g., with both fuel-boost pumps operating) is 23 pounds (10 kilograms). The flight manual said that unusable fuel with one boost pump inoperative is 103 pounds (47 kilograms).

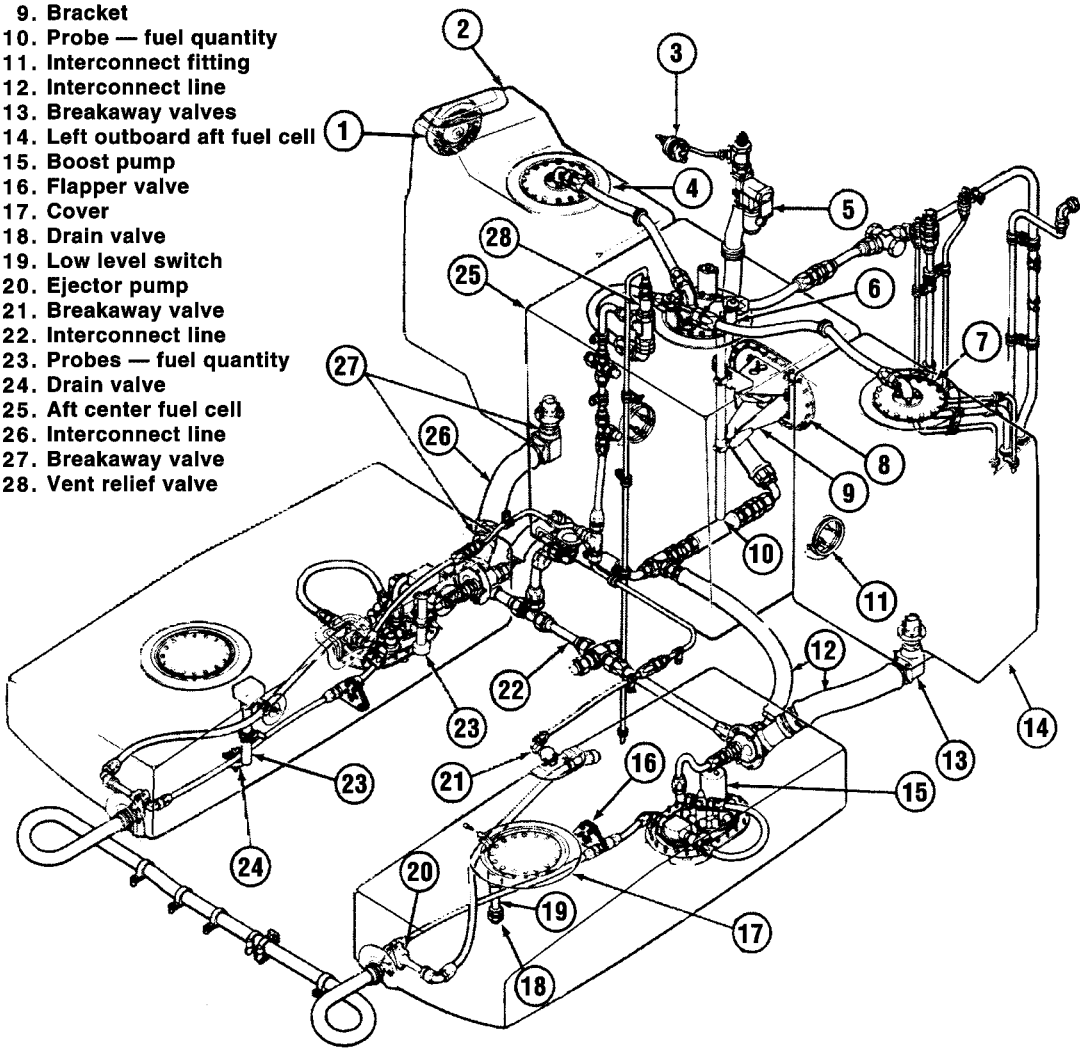
"The forward-fuel-cell interconnect [line] is unable to flow fuel between the cells as rapidly as the engine can consume fuel from the cell with the operable boost pump," the report said.

Investigators estimated that when the helicopter struck terrain, the left-forward fuel cell was nearly empty, and the right-forward fuel cell contained about 250 pounds (113 kilograms) of fuel.

"The fuel-quantity gauge is designed to retain its last indicated pointer position when power is cut off," the report said. "The

Bell 214B Fuel System

1. Filler cap and adapter
2. Right outboard aft fuel cell
3. Fuel pressure transmitter
4. Cover
5. Fuel shutoff valve
6. Cover
7. Cover
8. Access door — center cell
9. Bracket
10. Probe — fuel quantity
11. Interconnect fitting
12. Interconnect line
13. Breakaway valves
14. Left outboard aft fuel cell
15. Boost pump
16. Flapper valve
17. Cover
18. Drain valve
19. Low level switch
20. Ejector pump
21. Breakaway valve
22. Interconnect line
23. Probes — fuel quantity
24. Drain valve
25. Aft center fuel cell
26. Interconnect line
27. Breakaway valve
28. Vent relief valve



Source: Transportation Safety Board of Canada

Figure 1

[accident helicopter's] fuel-quantity gauge indicated 500 pounds [227 kilograms] of fuel when it was recovered from the wreckage."

Inspection of the accident helicopter's fuel-boost pumps, which were damaged extensively on impact, showed that the brushes, impellers, bearings and other internal components were within wear limits.

"On the right boost-pump motor, one of the brushes was stuck and would not contact the commutator," the report said. "When the brush was pushed in to contact the commutator and electrical power was reapplied, the motor operated."

Investigators found no records of how long the pumps had been in service in the accident helicopter or how long the pumps had been in service since overhaul or repair.

"Globe Motors, the manufacturer of the boost pumps, contends that both … boost pumps had been repaired since new and that these repairs were not carried out by Globe Motors," the report said. "Globe Motors does not provide any facility with parts, drawings, manuals or revisions that are required for overhaul or repairs to be carried out on these pumps."

The boost pumps, which have part no. 164A213, are condition-monitored items — that is, the manufacturer's maintenance requirements are based on service data. Globe Motors said that the design service life of the pumps is 1,000 hours.

"Information gathered from several sources — including Bell 214B operators, maintenance facilities and a component-repair-and-overhaul facility — indicates that the average time between replacement or repair of Bell 214B boost pumps is 100 [hours] to 300 hours," the report said. "The component-repair-and-overhaul facility reported that if grease is added to the pump motor bearings during repair, the boost pumps are able to operate for about twice as long (600 hours) before requiring servicing."

The report said that the Bell 214B flight manual "does not adequately describe the consequences of a boost-pump failure or emphasize its seriousness."

Boost-pump failure is discussed in the "Malfunction Procedures" section of the flight manual. The manual recommends that the pilot "land as soon as practical" when a boost-pump failure occurs.

"Because the flight manual does not refer to the possibility of incorrect fuel-quantity indication following a boost pump failure, the accident pilot may not have regarded the boost-pump failure as critical," the report said.

The report said that when the engine lost power, the pilot might not have had enough altitude to conduct an autorotation, or he might not have reacted correctly to the power loss.

"The low cloud base limited the height above the ground that the helicopter was able to fly," the report said. "Thus, the helicopter may not have been high enough [for the pilot] to carry out a successful autorotation.

"Because no mechanical malfunction was found that would have contributed to an unsuccessful autorotation and because procedures following a power loss in the Bell 214B require timely and correct pilot response, it is possible that the accident pilot's lack of recent training on Bell 214B emergency procedures contributed to the unsuccessful autorotation."

TC had not conducted an audit of East West Helicopters in the three years preceding the accident. TC conducted an audit of the company 10 days after the accident. The report said, "TC found the flight-crew-training program was lacking in several areas, including the following:

- "The training program (as reflected in the company operations manual, reissued in early 1999) had not been implemented fully;
- "Flight-crew-training records were incomplete and in need of restructuring ;
- "Essential information with regard to pilot license(s), medical-validation certificate(s), type endorsement(s), competency-check status, [flight] training received, etc., was not available;
- "Pilots had not undergone the required competency checks, and one pilot was neither trained nor endorsed on type; [and,]
- "Although the company had a system to record and track pilot-flight-duty times, flight times and rest periods, the system was not being used."

TC also found that the company had inadequate operational control because of the operations manager's workload. The operations manager also served as the company's maintenance manager and was responsible for the day-to-day operation of the trucking company that owned East West Helicopters.

"TC staff have indicated that the company corrected all of the items noted in the audit and that the company has been put on a one-year audit cycle," the report said.

Based on the findings of the accident investigation, TSB made the following recommendation to Bell Helicopter Textron and to the Canadian Minister of Transport:

> The Bell 214B and Bell 205 flight manuals [should] be modified to provide information regarding the inaccuracy of fuel-quantity indications, thereby allowing pilots to make informed decisions in the event of a loss of fuel-boost-pump pressure. [The fuel system in the Bell 205 is similar to the fuel system in the Bell 214B.]

[TSB said that, as of March 19, 2002, no response to the recommendation was received — and no response was required by law — from Bell Helicopter Textron. TC agreed with the recommendation and on Nov. 9, 2001, requested that the U.S. Federal Aviation Administration review the fuel-system designs and require revisions of the flight manuals and the emergency procedures for the Bell 214 and Bell 205 helicopters.]♦

[FSF editorial note: This article, except where specifically noted, is based on Transportation Safety Board of Canada Aviation Investigation Report no. A99P0075, *Power Loss–Fuel Starvation, East West Helicopters Ltd. Bell 214B Helicopter C-GEWT, Kaslo, British Columbia, 35 NM NW, 4 July 1999*. The 26-page report contains illustrations and appendixes.]

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