Aviation Investigation Final Report

Location:	HIGHLAND, California	**Accident Number:**	LAX97GA235
Date & Time:	July 6, 1997, 17:03 Local	**Registration:**	N27591
Aircraft:	Bell BHT-206L-1	**Aircraft Damage:**	Destroyed
Defining Event:		**Injuries:**	1 Fatal
Flight Conducted Under:	Public aircraft		

Analysis

The pilot was conducting water dropping operations as part of an ongoing forest fire fighting effort. A firefighter reported that the helicopter made two water drops before the accident. A battalion fire chief, who was directing the effort, reported that he saw the helicopter making water drops on a slope. After a water drop which involved an abrupt pull up and turn after the water was released from the bucket, he reported hearing the words 'May Day,' 'I have a flame out' and finally 'I'm going down'. Several other people who were monitoring the common frequency also reported hearing a transmission with the phrase 'flame out.' The helicopter impacted the bottom of the canyon. An inspection revealed that the lines from the engine fuel nozzle to the fuel control and the airframe fuel filter contained fuel. The lines and in-line filters contained both fuel and particulate matter in the bottom of both filter housings. Testing revealed that the manifold check valve leaked from both inlet ports. When the valves were disassembled additional foreign material was found. The material was found to be a combination of organic and inorganic materials. A 5-gallon fuel sample was taken from the refueling truck on the day of the accident. The analytical report stated that the sample submitted was that of aviation turbine fuel. No contamination was noted. According to historical records, there have been a series of engine flameout related accidents and incidents related to this engine make and model. Controlled tests have demonstrated that should entrapped air migrate through the fuel system to the engine, an engine flame out can occur.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: Loss of engine power due to fuel contamination. Also causal was the ingestion of entrapped air that occurred during an abrupt maneuver and fuel-borne contamination that caused the fuel system check valves to leak, resulted in a lower than expected fuel level in the main fuel cell. A

related factor was mountainous terrain.

Findings

Occurrence #1: ABRUPT MANEUVER
Phase of Operation: MANEUVERING - AERIAL APPLICATION

Findings
1. (C) FLUID,FUEL - CONTAMINATION,OTHER THAN WATER
2. (C) FLUID,FUEL - FLOW RESTRICTED
3. (C) FUEL SYSTEM,TRANSFER PUMP - LEAK
4. (C) FUEL SYSTEM,TANK - LOW LEVEL

Occurrence #2: LOSS OF ENGINE POWER(TOTAL) - NONMECHANICAL
Phase of Operation: MANEUVERING - AERIAL APPLICATION

Findings
5. AUTOROTATION - INITIATED - PILOT IN COMMAND
6. AIR/GROUND COMMUNICATIONS - INITIATED - PILOT IN COMMAND

Occurrence #3: FORCED LANDING
Phase of Operation: EMERGENCY DESCENT/LANDING

Occurrence #4: IN FLIGHT COLLISION WITH TERRAIN/WATER
Phase of Operation: EMERGENCY DESCENT/LANDING

Findings
7. (F) TERRAIN CONDITION - MOUNTAINOUS/HILLY

Factual Information

HISTORY OF FLIGHT

On July 6, 1997, about 1703 hours Pacific daylight time, a Bell BHT-206L-1, N27591, operating with the call sign H-520, crashed in the San Bernardino mountains north of Highland, California. The pilot was conducting water dropping operations as part of an ongoing forest fire fighting effort. The aircraft was destroyed and the commercial rated helicopter pilot, the sole occupant, received fatal injuries. The aircraft was being operated by the USDA Forest Service under contract as an exclusive public-use aircraft when the accident occurred. The flight originated about 1630 from the Patton Helibase in Highland, California. Visual meteorological conditions prevailed with localized smoke in the fire areas. No flight plan was filed.

About 1630 all helicopters on station were directed to begin dropping water on the Hemlock fire that had just jumped across a fire line. A battalion fire chief, onboard Air Attack 310, was directing the effort. The chief reported that he saw H-527 and H-520 making water drops on a slope in Division B at 1703. The drops involved an abrupt pull up and turn after the water was released from the bucket. As the two aircraft were departing the area, he heard the words "May Day," "I have a flame out" and finally "I'm going down". He then observed H-520 impact the bottom of the canyon. He stated that it appeared to him as if the aircraft's main rotor struck the west canyon wall before the aircraft came to rest.

After making a water drop, the pilot of H-527 was heading back to the water point when he saw H-520 heading toward the fire area. A few seconds later he reported hearing "I've got a flame out" and subsequently turned back toward the fire area. He reported seeing a cloud of dust and flew closer to investigate. As he neared the crash site, he saw H-520 on the ground at the bottom of the canyon. A ground scar was visible on the west side of the canyon about 5 to 10 feet from the top.

A firefighter with Vista Grande Hotshots, reported that H-520 made two water drops before the accident. Several other people who were monitoring the common frequency also reported hearing a transmission with the phrase "flame out."

PERSONNEL INFORMATION

The pilot satisfactorily completed initial company training on May 9, 1995.

He satisfactorily completed recurrent Bell 206 company training on May 30, 1997. That training included instruction in refueling procedures, fuel consumption computations, emergency procedures, performance characteristics, and operating limitations.

He satisfactorily completed a company FAR 135 proficiency check on May 30, 1997. That check required him to perform emergency procedures, simulated engine failures, and autorotations.

He had been issued a USDA/USDI Interagency Helicopter Pilot Qualification card on April 7, 1997. The card had an expiration date of April 30, 1998. The card indicated that he was approved for external load operations, fire suppression and retardant/water dropping.

A review of the pilot's duty log revealed that he worked 12 days and then had 2 days off duty. His standard duty day was 9 hours but on two occasions he worked 12-hour days. During the preceding month he flew a total of 13.9 hours. He flew on 12 duty days, averaging about 1.2 hours on those days. On June 24th he flew a total of 5 hours.

AIRCRAFT INFORMATION

The aircraft had originally been manufactured with an Allison 250-C28 engine. The aircraft had a supplemental type certificate for an Allison 250-C30P that was installed at the time of the accident.

A review of the aircraft maintenance records revealed entries indicating that the aircraft was being maintained in an airworthy condition.

Bell Helicopter Alert Service Bulletin No. 206L-86-41, requiring the airframe fuel filter is modified with a bleed hole for entrapped air had been applied.

The aircraft was equipped with a cargo hook that had both manual and electrical cargo releases.

The flight following log showed a total of six flights for a total flight time of 6.8 hours. Total fuel onboard, dispensed by the fuel trucks, was computed by the owner and refueler as 240.6 gallons.

The refueler reported that the H-520 began the duty day at Trimmer Helibase with 95.6 gallons of fuel. The basis for this statement is the assumption that the fuel quantity gauge was properly calibrated. There was no evidence or history found to suggest it was not operating accurately.

The pilot made his first refueling stop at Fox Field in which 30.7 gallons were added. The flight time for the first flight was recorded as 1.3 hours.

From Fox Field, the pilot completed the remainder of has flight to Patton Helibase in .7 hours. After arrival at Patton, the pilot flew a reconnaissance flight for 2.2 hours and then external load flight for .8 hours. The aircraft was next refueled with 47 gallons from a from a fuel truck

belonging to ERA, another contract company. It was later refueled with an additional 39 gallons from a fuel truck belonging to Rogers Helicopters.

The pilot flew another reconnaissance flight for 1.2 hours and then returned for refueling. The refueler reported that he added 14 gallons at that time. The pilot then departed on the sixth and final water dropping flight for .6 hours or until the accident.

The operator reported that was standard practice for the pilot to monitor his remaining fuel quantity with a watch.

According to the manufacturer, the low fuel light is designed to illuminate at between 7.4 and 11 gallons or between 50 and 75 pounds.

The aircraft was equipped with an external 'Bambi' water bucket with a 144-gallon capacity.

COMMUNICATIONS

A voice, believed to be the pilot's, was heard over the common use frequency. Listeners to the transmission generally agreed that the voice they heard stated "flame out." Of those who replied, all agreed that they did not hear any reply after they responded to the call. The frequency in use at the time of the accident was an internal channel. Consequently, no recording of the communications traffic is available for review.

WRECKAGE AND IMPACT INFORMATION

The crash site was located .3 mile west of the fire in Little Sand Canyon at 34 degrees 09 minutes 29 seconds north latitude and 117 degrees 13 minutes 26 seconds west longitude. The elevation of the site was about 1,660 feet msl. The terrain at the bottom of the canyon sloped away from the wall toward a creek at approximately -10 degrees. The aircraft came to rest in an upright position on a heading of 252 degrees. The water bucket was still attached to the sling line.

Fragments of Plexiglas were found near ground scars at the top of the canyon wall about 50 feet above the final position of the aircraft.

Both landing gear skid tubes were separated from the airframe. The forward cross tube was still attached to the fuselage while the aft cross tube was separated from the fuselage with portions of the belly structure remaining attached to the cross tube saddles. The rear cross tube was deformed downward with its lower surface 11.75 inches from a level surface.

The main fuselage exhibited multiple examples of overstress fractures. The belly section was fractured at FS stations 43, 96, and 142. The structure surrounding the aft fuel cell was fractured and the fuel cell was ruptured. The roof was fractured downward beneath the transmission. The structure beneath the right front seat was crushed downward 5.5 inches.

There was evidence of compression buckling at the base of the center console. The right and left doorposts were fractured, as was the windscreen center post. There was evidence of structural penetration at FS 220. The underside of the nose between the chin bubbles was crushed upward. The manual cargo release functioned when tested.

The tailboom was separated at BS (Boom Station) 44. The aft portion of the tailboom was bent upward at BS 170 and the gearbox mounting block was fractured at BS 174.105. The aft end of the tail boom was located about 15 feet east of the main wreckage. The center section of the tailboom was located immediately to the south of the aircraft.

One main rotor blade rotor hub and blade assembly was removed from the mast. There was no evidence of torsional distortion of the splines. The main rotor feathering and flapping bearings were in place and operable. The swashplate and sleeve assembly were in place and operable. A single main rotor pitch change link was fractured. Both rotor blades were damaged. One blade had fractured and was separated 40.5 inches outboard of the retention bolt hole.

The hydraulic system exhibited impact damage. The two forward legs of the reservoir were fractured. Both hydraulic filter differential buttons were recessed. The extension arms on all three hydraulic servo actuators were bent upward. The two cyclic boost extension tubes between the servos and the 90-degree bellcranks were fractured at their aft ends. The flight control system exhibited evidence of impact damage, however, a visual examination established that control continuity had been maintained.

The transmission remained mounted to the nodal beam support system. The nodal beam flexible assemblies were separated from their aft attachment fittings. The main driveshaft forward and aft couplings showed the presence of grease. Their splines were in place in both the inner and outer coupling members with no evidence of torsional deformation. The mast was hand rotated and produced movement of the transmission input quill.

The tailrotor hub and blade assembly remained connected; however, both blades showed evidence of structural collapse. The first blade was bent outward while the second blade was bent inward. The pitch change mechanism was moved in and out without evidence of binding. The 90-degree gearbox was hand rotated and turned smoothly. The tailrotor driveshaft exhibited several fractures with some evidence of rotational scaring. The hangar bearings and disk couplings did not display any evidence of unusual wear.

The line from the engine fuel nozzle to the fuel control was removed and found to contain fuel. The airframe fuel filter was removed and was found to contain 25 milliliters of fuel. The fuel had an odor and appearance consistent with aviation turbine fuel. A trace of particulate matter was found in the bowl of the filter, however, the filter element itself appeared clean and unblocked. The main fuel tank (aft) was ruptured and empty. Both forward fuel cells were undamaged. The fuel probe was removed from the left fuel cell and approximately 1.5 inches of fuel was observed. However, fuel was observed leaking from the aft end of the engine as it

drained rearward from the fuel lines. Both ejector pumps were removed and a .38-inch o-ring was found resting on the venturi cone of the right ejector pump. Both fuel boost pump circuit breakers were found in the set position.

The engine was inspected on site. The outer combustion case and the compressor air discharge tubes exhibited denting. Several oil lines were crushed, torn, and leaking oil. The igniter exciter box was broken from its mount. The terminal block on the starter generator was fractured. All engine mounts were bent and fractured. The engine was not equipped with auto ignition.

The fuel control linkage was separated. The fuel control throttle was bent. The main fuel line to into the fuel control was bent and crushed. The fuel control pointer was indicating between 0 and 30 on the quadrant scale. The power turbine governor linkage was separated at the linear actuator.

The compressor turned freely when rotated by hand. N1 continuity was noted as the starter generator also rotated with the compressor. Compressor impeller rub was noted on the shroud at the 5 to 7 o'clock position. The compressor exhibited some oil streaking on the impeller with dirt adhering to the oily spots.

The power turbine governor pointer was indicating "MAX." The power turbine turned freely when rotated by hand. N2 continuity was noted when the output driveshaft turned as the power turbine was rotated.

The main driveshaft was separated from the splines on the engine output drive. The engine inlet bell housing was separated from the firewall. The cycle counter read 7878.

MEDICAL AND PATHOLOGICAL INFORMATION

An autopsy was conducted on July 7, 1997, by the San Bernardino County Coroner's Office, with specimens retained for toxicological examination. The toxicological test results were negative for alcohol and all screened drug substances.

Safety Board investigators found medication in the wreckage in a non-prescription container. The capsules were later identified as Norvasc, Lotensin, and Lotrel. According to the Safety Board flight surgeon, these drugs are used in the treatment of high blood pressure.

The pilot's last flight physical recorded a sitting blood pressure reading of 150/82. There was no reference made regarding high blood pressure or any prescribed medication.

FIRE

The brush fire near the accident site was already in progress when the accident occurred. The fire continued to burn and moved closer but did not reach the wreckage. The fire was finally

halted by fire fighters before it reached the aircraft.

TESTS AND RESEARCH

After a visual inspection, the engine was removed from the aircraft and shipped to the engine manufacturer's facility for further testing. The engine, an Allison 250-C30P, S/N CAE 890523, was prepared for test cell operation. A pneumatic line pressure check was performed with no leaks noted. The engine was started and run with the original crushed fuel line and bent throttle shaft. After start it was noted that the engine was limited to 570 shp.

To verify that the crushed fuel line was the reason that the engine was not producing rated power, the engine was shut down and a new fuel line was installed. The next three starts were aborted because of hot starts. The start/de-rich was moved through its full travel and then set at one click. The next and all subsequent starts were within the normal temperature range. A full power calibration was completed with all power points meeting standards except for "Max Continuous" and "takeoff" power in which the engine had been limited to 570 shp.

After the power calibration was completed the engine was shut down and the fuel control was replaced with a new unit. The engine was restarted and the engine was run up to "Max Continuous" and "takeoff" power, producing 635 shp. Another power calibration check was completed with all power points calibrated. Additionally, several waveoff maneuvers were completed without any discrepancies being noted. The engine is rated at 650 shp.

During the run, the engine exhibited no internal or external failures. The engine air inlet was clear and unobstructed. The engine produced power in the first "run as received condition" in excess of that required for flight.

The original fuel control was placed on a flow bench. The governor reset and slope checks were found to be lower than normal. The manufacturer stated that these values were consistent with a bent shaft. The acceleration fuel flow schedule was low on points 1, 3 and 4, but was high on points 10, 11, 17, 21, and 22.

Safety Board investigators together with the owner, operator, aircraft, and engine manufacturers estimated the fuel consumption based on the performance charts in the aircraft POH. During the first and second flights, the consumption was estimated at 77.1 gallons based on the airframe manufacturer's fuel flow estimates. During the third through sixth flights, the rate based on the same estimates for a consumption of 142 gallons. Fuel consumption for the six flights was estimated at 209.1 gallons.

An additional 7.8 gallons was subtracted for ground running, another gallon for water pickup and drops, and another gallon as unusable as identified in the POH. Usable fuel onboard at the time of the accident was estimated 21.7 gallons or 147.6 pounds. This figure is based on the assumption that the engine condition permitted the estimated consumption rates to be obtained. At an average 30 gph consumption rate, the aircraft would have had about 43

minutes or 21.5 gallons of fuel remaining at the time of the accident.

A 5-gallon fuel sample was taken from the refueling truck on the day of the accident. The IIC submitted the sample to Core Laboratories for analysis on March 18, 1998. The analytical report stated that the sample submitted was that of aviation turbine fuel. No contamination was noted.

On August 4, 1997, an additional examination of the fuel system was conducted at the Aircraft Recovery Services facility in Compton, California. The cover to the fuel line compartment between the front and rear tanks removed and the lines and in-line filters were visually inspected for signs of leakage or damage. When none was noted, the in-line filters were removed. Fuel was found in both the filters and the lines. When both filters were further disassembled, particulate matter was observed in the bottoms of both filter housings. The filter screens, however, were not obstructed.

Although the rear fuel cell bladder was ruptured, the dual fuel boost pump assembly appeared undamaged. The pump assembly was removed by cutting the bladder around the mounting plate and was secured by the IIC for further testing.

On August 19, 1997, the IIC delivered the fuel system components to the airframe manufacturer for testing. The components consisted of an airframe fuel filter, an ejector pump assembly, a dual boost pump assembly and a fuel manifold.

The dual boost pump assembly was attached to a flow bench. It was then connected to 28VDC to check operability. Individually, the left boost pump produced 1.69 gpm flow at 9 psi. When the flow was blocked, the pressure increased to 16 psi. The right pump produced 1.69 gpm at 9+ psi. When the fuel flow was blocked the fuel pressure increased to 15 psi. When both pumps were activated, the pressure was measured at 8.7 psi with a 9 psi differential between the two pumps.

The fuel manifold was not tested at that time.

On October 1, 1997, the IIC delivered the manifold check valve, P/N 67-433, to the component manufacturer for testing. The assembly date of the component was AIQ78 (1978). The valve contained Buna-N o-rings that, according to the manufacturer, had exceeded their shelf life.

The valve was tested to standards of TM 593 paragraphs 2.1, 2.2, and 2.3. The valve failed paragraph 2.3, the internal leakage test. The test was conducted by submerging the valve in water with a 15-psi air supply connected to the outlet port. When pressure was applied a steady stream of bubbles was observed coming from both inlet ports. The valve was open in the check position.

The two check valves were removed and disassembled. The first valve consists of check valve assemblies in a machine casting manifold. When the check valve poppet, spring and o-ring

were examined, foreign material was found. The material was on and near the poppet seating area, the cross flow holes and inside the threaded area where the valve connects to the housing. Exemplars of the material were removed and displayed on a millipore grid patch for microscopic examination. The size of the contaminants varied from .002 by .008 inches to .004 to .10 inches. The origin of the material was not determined.

The second valve was removed, disassembled, and inspected. The results were similar to the first valve.

On October 22, 1997, two additional check valves, P/N 869A-6TT, were also inspected at the manufacturer's facility. The valves were assembled in 2Q82 (1982) and had Mectron Industries filters, P/N 25252, installed at the inlet connection. Both valves were pressure tested for possible internal leakage. Leakage was detected from both valves when pressure was applied.

The valves were then disassembled. Foreign material was found in the valve between the seat and the o-ring.

The foreign material from the October 1, 1997, was submitted to Seal Laboratories for analysis. The material was found to be a combination of organic and inorganic materials.

According to the aircraft manufacturer, the function of the check valves is to prevent the reverse flow of fuel into the forward fuel tank. This system is active when the fuel valve switch is turned on and fuel is being transferred from the forward tank to the rear tank. The transfer is necessary because fuel is supplied to the engine only from the rear tank. Fuel is "blown" from the fuel cell to the engine with the boost pumps in operation. With the boost pumps inoperative, fuel is "sucked" to the engine by the engine-driven fuel pump. The manufacturer reported that there is no prescribed fuel boost pump check during preflight, engine runup or before takeoff checks.

A caution panel segment light illumination on the master caution is the only cockpit indication of a boost pump malfunction.

The manufacturer further stated that if both manifold check valves leak, and both boost pumps are operating, the system will continue to operate normally. If both of the check valves leak and one boost pump is inoperative, motive flow to the ejector pumps may decrease enough to prevent fuel transfer from the front fuel cells to the rear cell. The amount of motive flow reduction is dependent on the severity of the check valve leakage. If leakage is "severe," the condition should be identifiable by the illumination of boost pump segment light.

According to historical records, there have been a series of engine flameout related accidents and incidents related to this engine make and model. Controlled tests have demonstrated that should entrapped air migrate through the fuel system to the engine, an engine flame out can occur.

The operator stated that it was a common practice for pilots to monitor their remaining fuel using a clock or watch. Experience has shown that fuel gages and low fuel warning lights sometimes do not provide as an exact indication of remaining fuel. Abrupt maneuvering has also been known to result in temporary false low fuel light indications.

ADDITIONAL INFORMATION

The wreckage was released to a representative of the registered owner on June 16, 1998.

Pilot Information

Certificate:	Commercial	**Age:**	50,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	
Instrument Rating(s):	Airplane	**Second Pilot Present:**	No
Instructor Rating(s):	Airplane single-engine; Helicopter	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 Valid Medical--no waivers/lim.	**Last FAA Medical Exam:**	April 24, 1997
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	
Flight Time:	11000 hours (Total, all aircraft), 2900 hours (Total, this make and model), 61 hours (Last 90 days, all aircraft), 13 hours (Last 30 days, all aircraft), 6 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Bell	**Registration:**	N27591
Model/Series:	BHT-206L-1 BHT-206L-1	**Aircraft Category:**	Helicopter
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	45273
Landing Gear Type:	High skid	**Seats:**	7
Date/Type of Last Inspection:	May 26, 1997 100 hour	**Certified Max Gross Wt.:**	4250 lbs
Time Since Last Inspection:	39 Hrs	**Engines:**	1 Turbo shaft
Airframe Total Time:	7705 Hrs	**Engine Manufacturer:**	Allison
ELT:	Installed	**Engine Model/Series:**	250-C30P
Registered Owner:	ROGERS HELICOPTERS, INC.	**Rated Power:**	650 Horsepower
Operator:	USDA FOREST SERVICE	**Operating Certificate(s) Held:**	None
Operator Does Business As:	REGIONAL OFFICE, R5	**Operator Designator Code:**	

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	ONT ,943 ft msl	**Distance from Accident Site:**	23 Nautical Miles
Observation Time:	16:50 Local	**Direction from Accident Site:**	238°
Lowest Cloud Condition:	Clear	**Visibility**	15 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	16 knots / None	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	240°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29 inches Hg	**Temperature/Dew Point:**	32°C / 15°C
Precipitation and Obscuration:	N/A - None - Smoke		
Departure Point:		**Type of Flight Plan Filed:**	None
Destination:		**Type of Clearance:**	None
Departure Time:	16:30 Local	**Type of Airspace:**	Class G

Airport Information

Airport:		**Runway Surface Type:**	
Airport Elevation:		**Runway Surface Condition:**	
Runway Used:	0	**IFR Approach:**	
Runway Length/Width:		**VFR Approach/Landing:**	Forced landing

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Fatal	**Latitude, Longitude:**	34.130203,-117.150726(est)

Administrative Information

Investigator In Charge (IIC):	Crispin, Robert
Additional Participating Persons:	DAVID L BOWKER; RIVERSIDE , CA EARL S PALMER; REDMOND , OR JOHN J SWIFT; INIANAPOLIS , IN JACK SUTTLE; FORT WORTH , TX
Original Publish Date:	September 28, 1999
Last Revision Date:	
Investigation Class:	Class
Note:	
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=29641