Aviation Investigation Final Report

Location:	QUINCY, California	**Accident Number:**	LAX99FA057
Date & Time:	December 23, 1998, 11:51 Local	**Registration:**	N4590
Aircraft:	Bell UH-1H	**Aircraft Damage:**	Destroyed
Defining Event:		**Injuries:**	1 Fatal
Flight Conducted Under:	Part 133: Rotorcraft ext. load		

Analysis

While conducting external load operations, the pilot radioed that the engine had failed. Witnesses reported visually observing the main rotor slowing and the individual blades becoming visible before the helicopter descended steeply into a reservoir from about 200 feet agl. The main rotor driveshaft, main rotor blades, and the tail rotor blades exhibited signatures consistent with low rotor rpm at impact. Engine examination revealed that the gas producer and power turbine assembly had failed as a result of the cumulative effects of thermal stress due to over-temperature operation. Further examination revealed that the exhaust gas temperature harness on the engine had a low signal output resulting in a low EGT indication in the cockpit which caused the company pilots to unknowingly operate the engine in excess of maximum EGT. According to other company pilots who flew this helicopter on typical external load operations, the engine would reach its EGT limit before the maximum torque was achieved. The operator did not routinely perform health indicator tests (HIT checks) which were developed by the U.S. Army to detect changes in engine power output. Review of the helicopter's FAA Type Certificate Data Sheet (H15NM) revealed the requirement for HIT checks to be accomplished prior to each takeoff and recorded in a log record.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: An inaccurate exhaust gas temperature gauge, that allowed the engine to be run over-temperature unknowingly by the pilot, which resulted in the subsequent failure of the turbine sections. Also causal was the pilot's failure to maintain rotor RPM during the autorotation. A factor in the accident was the operator's failure to adequately perform engine health indicator tests.

Findings

Occurrence #1: LOSS OF ENGINE POWER(TOTAL) - MECH FAILURE/MALF
Phase of Operation: HOVER - OUT OF GROUND EFFECT

Findings
1. (C) ENGINE INSTRUMENTS,EGT/TOT GAGE - OUTPUT LOW
2. (C) TURBOSHAFT ENGINE,FREE(POWER) TURBINE - OVERTEMPERATURE
3. (C) TURBOSHAFT ENGINE,FREE(POWER) TURBINE - DISINTEGRATED
4. (C) TURBOSHAFT ENGINE,GAS GENERATOR TURBINE - OVERTEMPERATURE
5. (C) TURBOSHAFT ENGINE,GAS GENERATOR TURBINE - DISINTEGRATED
6. ROTORCRAFT OPERATIONS - PERFORMED - PILOT IN COMMAND
7. (F) MAINTENANCE,RECORDKEEPING - INADEQUATE - COMPANY/OPERATOR MANAGEMENT

Occurrence #2: LOSS OF CONTROL - IN FLIGHT
Phase of Operation: EMERGENCY DESCENT/LANDING

Findings
8. (C) ROTOR RPM - NOT MAINTAINED - PILOT IN COMMAND

Occurrence #3: IN FLIGHT COLLISION WITH TERRAIN/WATER
Phase of Operation: DESCENT - UNCONTROLLED

Findings
9. TERRAIN CONDITION - WATER

Factual Information

HISTORY OF FLIGHT

On December 23, 1998, at 1151 hours Pacific standard time, a Bell UH-1H, N4590, entered an uncontrolled descent following a loss of engine power and impacted in Belden Reservoir, 7 miles west of Quincy, California. The helicopter was destroyed and the commercial licensed pilot was fatally injured. Visual meteorological conditions prevailed for the external load operation that was conducted by Westwind Helicopters, Inc., under 14 CFR Part 133.

According to the operator, the helicopter was engaged in a long line external load operation in support of Pacific Gas and Electric Company (PG&E). The pilot was lifting construction equipment, typically in 500 pound loads, from a hillside construction site to a base location at a small resort at the north end of Belden Reservoir.

There were three ground witnesses, who were PG&E employees, handling the loading of equipment into the external load sling at the mountain top construction site. The witnesses reported that after 4 or 5 loads had been picked up routinely, the helicopter made an abnormal sound as it approached for the next load. The sound was described by the first witness as "an alarm going off" and "like a beeping." The second said, "It wasn't a beeping but more like a tone," and the third said it was "like a buzzer or like an alarm like a whistle almost." The three said that the pilot then radioed something about it being cold, intake icing and the engine needing more heat. He interrupted the pickup operation and flew around in the area for 2 or 3 minutes before resuming the pickup operation. They then did 5 to 10 more pickups that were routine. After the next pickup, with an external load estimated at only 50 to 75 pounds, one of the witnesses reported that "the helicopter didn't sound quite right . . . I would describe it as a metallic sound like a grinding kind of sound." One of the witnesses noted that as the helicopter flew away with the load the pilot headed toward his landing (refueling) site rather than toward the drop-off zone. The pilot then radioed that he had experienced an engine failure. The witnesses reported that as the helicopter passed from their view behind a ridge, the rotor blades were more visible because they were slowing and the helicopter was in a steep descent.

A ground refueler employed by the operator for about 7 years also witnessed the accident. At the time of the accident he was standing on the dam at the south end of Belden Reservoir about 1/3 mile south of the accident site. They were using the dam as a landing site for refueling. He was looking at the ice on the water and subconsciously listening to the helicopter flying in the distance. He "heard the sound change and knew something was wrong." He looked up and the helicopter "came down like a rocket." When asked by the Safety Board investigator if the sound change was in the "whop - whop" of the rotor or the high frequency whine of the engine, he could only say, "all the sound changed."

According to the operator, the pilot flew external load operations from the left seat. The engine/main rotor tachometer, torque, EGT, and gas producer rpm gages are located on the right side of the center instrument panel. A 100-foot-long kevlar line was used.

AIRCRAFT INFORMATION

The aircraft was delivered to the United States Army as an UH-1H in 1965. Following military retirement, it was issued a type certificate in the restricted category in August 1996 following civilian conversation by Western International Aviation, Inc.

The operator of the helicopter said that the aircraft is maintained on a 100-hour program and had come out of maintenance on the morning of the accident. The helicopter was in for scheduled replacement of time expired swashplate, scissor sleeve assembly, and rotating control bolts. While the replacement of the time expired items was in progress, mechanics noted that on the right rear engine mount one attachment bolt was broken, the other was loose, and the shims under the mount were laying loose on the engine deck. The mechanics were concerned that some of the shims might have been lost and were reluctant to reassemble the mount without checking the installation alignment of the engine. Although the aircraft was not a Garlik type certificated UH-1H, the mechanics proceeded to realign the engine installation by reshimming in accordance with a Garlik Service Bulletin which, according to the operator, mirrors Bell Helicopter's procedure.

The operator reported that several of their pilots had taken checkrides in the helicopter for their U.S. Forest Service authorization card, and that the aircraft had demonstrated satisfactory autorotative landings during those checkrides. The operator also stated that health indicator test (HIT) records were kept in a book in the helicopter. The book was not located among the recovered wreckage.

Another pilot reported having flown the accident helicopter under contract to the U.S. Forest Service about 600 hours through the summer of 1998. His last flight in it was on December 20, 1998, 3 days before the accident, when he ferried it to the operator's base at Lincoln, California. He said that through the 600 hours he never had any problem with the helicopter. The aircraft was reliable, and the only unscheduled maintenance he recalled was a blown transmission seal. He also said that "HIT checks" were performed in the field both by him and the accident pilot, who was his supervisor. They were performed about once every 20 flight hours. He thinks they were required by the Forest Service and were recorded on a form provided by the Forest Service. The recordings were taken by the mechanic and were kept at the home base; they were not kept in the aircraft. He was certain that there was no recording of engine parameters on the daily flight log kept in the aircraft. He also recalled that the engine ran up against the temperature limit before it reached the torque limit. It was engine exhaust gas temperature that limited power available, not the torque limit.

Review of the helicopter's Federal Aviation Administration (FAA) Type Certificate Data Sheet

(H15NM) revealed the requirement for HIT checks to be accomplished prior to each takeoff and recorded in a log record.

METEOROLOGICAL INFORMATION

A refueler who was present at the time of the accident said that the weather was clear and sunny, cold, and there was little wind. A PG&E foreman estimated the temperature to have been in the mid-30 degree Fahrenheit range.

WRECKAGE AND IMPACT INFORMATION

The aircraft impacted in the Belden Reservoir near the northwestern shore, approximately 500 feet north of the dam forming the reservoir. The site is at longitude 121 degrees 09.62 minutes west and latitude 40 degrees 04.70 north (GPS). The elevation is approximately 3,000 feet msl. The reservoir, a hydro-electric generating facility on the north fork of the Feather River, is located in a mountain canyon oriented northeast to southwest, and is about 500 feet wide (southeast to northwest) and 1/2 mile long with the dam at the southwest end. On the southeast and northwest side of the reservoir, mountain terrain rises steeply to approximately 2,500 feet above the reservoir level. The shores of the reservoir and the adjacent mountain slopes are densely populated with trees typically 75 feet tall. At the northeast end of the lake is a small resort with a clearing where the helicopter was lowering its external loads; however, the helicopter was landing on the dam itself when necessary to refuel. According to witnesses, at the time of the accident there was approximately 3 inches of snow on the ground, temperatures were in the mid-30 degree Fahrenheit range, and the surface of the lake was covered with a thin layer of ice, mostly in areas near the shore. There was no fire.

The aircraft was removed from the reservoir by direction of the Plumas County Sheriff and taken to a local impound facility prior to arrival of the Safety Board investigator. According to early responders, there was a hole in the surface ice approximately 30 feet in diameter against the shoreline, and the aircraft was lying on its right side with the nose pointing southeast toward the powerhouse. The tailboom was separated from the fuselage and was adjacent to it. The helicopter components and the external load were recovered from that location.

On the bank of the reservoir where the aircraft was removed, the Safety Board investigator found a severed aluminum power transmission cable about 1-inch in diameter. The severed ends of the cable strands were dull in appearance and areas of the cable, which were under dirt, and rocks on the bank were discolored and corroded. The end of the cable was anchored into the bank about 10 feet above the water level. The foreman for PG&E told the Safety Board investigator that this was an old wire and that there had been no wires strung across that portion of the reservoir at the time of the accident.

The aircraft was examined at the facilities of Plain Parts in Sacramento, California, on December 29, 1998. All of the aircraft was present except for several doors and light sheet metal panels, paper documents, and the engine to transmission driveshaft.

The fuselage was in four sections: the cockpit and forward fuselage; the center fuselage with the engine and main rotor transmission; a section of the tailcone with the 42-degree gearbox; and the vertical fin and 90-degree gearbox. According to early responders, the forward fuselage was attached to the center fuselage at the accident site but was broken apart during the recovery. The entire fuselage exhibited uniform crushing damage along the lower surface with greater damage to the right side of the bottom. The large skin panels on the lower forward fuselage exhibited smooth, upward deflection between fuselage frames. The separated aft tailcone section exhibited a slicing cut from left to right. The width of the cut was approximately equal to the thickness of the main rotor blade. A section of the tailcone further forward was torn from the forward fuselage but remained attached by a skin panel. This section of the tailcone exhibited a straight dent approximately 3 feet long, which matched the radius of the main rotor blade leading edge. The tail rotor driveshaft separations were accompanied by bending.

The light bulbs in the cockpit annunciator panel and the master caution light assembly were removed and examined under a magnifying glass. There were three light bulbs in the master caution light assembly. In two of the bulbs the filaments were separated and the coils were uniformly and tightly wound. In the third bulb the filament was intact and the filament was also tightly and uniformly wound. The annunciator panel consists of 20 segments, each with 2 light bulbs. The filaments of all the bulbs were uniformly and tightly wound. Three of the 20 light bulbs had separated filaments; however, no one segment of the annunciator panel had both bulb filaments separated. Details of the bulb filament examination are provided on page 8 of Supplement D, attached.

The flight control linkages were separated at numerous locations between the cockpit and the rotor head; however, the separations were accompanied by bending and exhibited a shiny gray/aluminum appearance. The engine power linkage was separated where the cockpit separated from the center fuselage and in proximity of the engine. The anti-torque control cables were separated in the tailcone area, were unfrayed and had bright, shiny ends at the separations.

The main and tail rotor blades remained attached to their respective hub assemblies. One main rotor blade was undamaged. The other main rotor blade exhibited scars and tears in the skin over approximately the outboard 2 feet. This blade also exhibited a smooth upward bend of approximately 15 degrees over the inboard half-span, and the rotor mast was dented in proximity of this blade's droop stop fitting. One blade of the tail rotor was undamaged and the other exhibited a sharp bend approximately 6 inches from the root. The bend was inboard approximately 20 degrees and aft (opposite the direction of rotation) 10 degrees. There was a dent in the left side of the vertical stabilizer approximately the radius and location of the tail rotor blade tip.

The engine mount frames were deformed in the downward direction and the engine was resting on the tail rotor drive shaft tunnel. The tunnel was crushed and the shaft was trapped

and disconnected from the transmission output.

The engine power output turbine assembly could not be rotated by hand, and there were metal spray deposits on the second stage power turbine rotor blades and turbine nozzle vanes. There were two small pieces of metallic debris in the tailpipe. The variable inlet guide vanes and first stage compressor blades were intact with no leading edge damage. The fuel control power lever was in the maximum power position; however, the engine throttle link arm was separated. The engine fuel and oil filters were free of debris and the fuel lines between the fuel filter and the fuel control unit contained liquid which smelled similar to turbine engine type fuel.

The engine to transmission driveshaft was recovered by divers on January 10, 1999. The driveshaft was located on the bottom of the reservoir in the area where the fuselage wreckage came to rest. The broken K-Flex fittings were present on the engine output shaft and transmission input shaft, and there were cut marks on the aft transmission beam and the engine inlet shroud which approximated the size of the fingers of the K-Flex fitting.

The main transmission aft support beam was broken in the center and deformed approximately 6 inches in the downward direction. The main transmission was canted approximately 5 degrees to the right and aft. The main transmission, the 42-degree gearbox, and the 90-degree gearbox all rotated freely and smoothly by hand, and the chip detector plugs were clear. The overrunning clutch at the main transmission input from the engine driveshaft engaged in the clockwise direction when rotated by hand, and released when rotated counterclockwise.

The engine was further examined at Allied Signal Engines in Phoenix, Arizona, on January 27 and 28, 1999. The exterior of the engine was undamaged except that one of the six exhaust gas temperature probes was bent. The power turbine assembly could not be rotated by hand. Approximately 1 quart of water was drained from the engine along with the engine oil. The magnetic plug in the nose gear case was free of metal.

When the starter/generator was removed from the engine and an adapter placed in the accessory case shaft, the gas generator assembly and the accessory case turned freely and the fuel control unit emitted a stream of residual fuel. When the rear bearing cover was removed there was a pool of unscavenged oil at the Nos. 3 and 4 bearing pack.

When the combustion chamber was removed from the rear of the engine, the turbine blades on the number 1 and number 2 (gas generator) turbine wheels and the number 3 (power turbine) turbine wheel exhibited erosion; approximately the outer 30 percent of each blade was absent and there were jagged edges on the blades. Pieces of metal debris, typically 1/8-inch in size and which resembled turbine blade material, were present in the turbine section case. There was erosion on the turbine stator vanes and there was metal transferred onto the stator aft of the number 3 turbine causing interference between the number 3 turbine and the stator assembly. After the interfering power turbine wheels and stators were removed from the

power turbine shaft, the shaft turned freely through the output gear box. The bearing assemblies on the power output shaft and in the nose gear reduction case were shiny and rolled smoothly by hand. The compressor section of the engine was undamaged except for an area of tip rubbing at the centrifugal compressor.

Functional testing was performed of the following engine accessories: start fuel nozzles, fuel manifold assemblies, exhaust thermocouple harness, fuel control unit, flow divider and dump valve, overspeed (PT) governor, interstage bleed actuator assembly and inlet guide vane actuator. The exhaust thermocouple harness failed the functional test due to low output. According to the Allied Signal representative, a low exhaust thermocouple harness output would result in the engine operating at a higher exhaust gas temperature than that indicated on the cockpit instrument.

MEDICAL AND PATHOLOGICAL INFORMATION

An autopsy was performed on the pilot by the Washoe County (Nevada) Medical Examiner-Coroner, 10 Kirman Ave, Reno, Nevada 89520 (case number 140498). Toxicology testing was performed by the FAA's Civil Aeromedical Laboratory in Oklahoma City, Oklahoma.

TESTS AND RESEARCH

A metallurgist at Allied Signal Aerospace, a party to the investigation, examined two damaged blades from each stage of the gas producer turbine and two damaged blades from the power turbine. The metallurgist opined that the gas producer turbine blades separated from a stress rupture fracture mode produced by a short time exposure (minutes to a few hours) to temperatures in excess of and near 2,000 degrees Fahrenheit. The power turbine blades also exhibited stress rupture fracture mode produced by temperatures near 2,000 degrees Fahrenheit at the tip shroud and near 1,800 degrees Fahrenheit in the midspan region. The engine exhaust gas temperature maximum operating limit for continuous operations (red line) is 1,153 degrees Fahrenheit. The engine start limit is 1,382 degrees.

ADDITIONAL INFORMATION

The aircraft wreckage was released on October 21, 1999 to Mr. Ernest De Spain, insurance adjuster for Kern & Wooley, LLC, 10900 Wilshire Blvd, Suite 1100, Los Angeles, California 90024. An additional party is Mr. Kenneth Essary, Air Technology Engines, Inc., Naples, Florida.

Pilot Information

Certificate:	Commercial	**Age:**	52,Male
Airplane Rating(s):	None	**Seat Occupied:**	Left
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	
Instrument Rating(s):	None	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 Valid Medical--w/ waivers/lim	**Last FAA Medical Exam:**	March 23, 1998
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	
Flight Time:	15000 hours (Total, all aircraft), 8000 hours (Total, this make and model), 100 hours (Last 90 days, all aircraft), 3 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Bell	**Registration:**	N4590
Model/Series:	UH-1H UH-1H	**Aircraft Category:**	Helicopter
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Restricted (Special)	**Serial Number:**	65-09986
Landing Gear Type:	Skid	**Seats:**	2
Date/Type of Last Inspection:	October 20, 1998 100 hour	**Certified Max Gross Wt.:**	9500 lbs
Time Since Last Inspection:	36 Hrs	**Engines:**	1 Turbo shaft
Airframe Total Time:	6774 Hrs	**Engine Manufacturer:**	Lycoming
ELT:	Installed	**Engine Model/Series:**	T53-L-13B
Registered Owner:	WESTWIND HELICOPTERS, INC.	**Rated Power:**	1400 Horsepower
Operator:		**Operating Certificate(s) Held:**	
Operator Does Business As:		**Operator Designator Code:**	

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	CIC ,238 ft msl	**Distance from Accident Site:**	32 Nautical Miles
Observation Time:	11:46 Local	**Direction from Accident Site:**	223°
Lowest Cloud Condition:	Clear	**Visibility**	3 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	5 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	160°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30 inches Hg	**Temperature/Dew Point:**	
Precipitation and Obscuration:	N/A - None - Haze		
Departure Point:		**Type of Flight Plan Filed:**	None
Destination:		**Type of Clearance:**	None
Departure Time:	00:00 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:**	39.960762,-121.000068(est)

Administrative Information

Investigator In Charge (IIC):	Parker, Richard
Additional Participating Persons:	LEE OSCAR; RENO , NV JOSEPH A SYSLO, JR.; FORT WORTH , TX MICHAEL A CUMMINS; PHOENIX , AZ RICHARD L FLEISCHER; RANCHO CORDOVA , CA
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Last Revision Date:	
Investigation Class:	Class
Note:	
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=45520