Aviation Investigation Final Report

Location:	SPENCER, Iowa	**Accident Number:**	CHI98FA323
Date & Time:	August 20, 1998, 21:14 Local	**Registration:**	N30SV
Aircraft:	Bell 222	**Aircraft Damage:**	Destroyed
Defining Event:		**Injuries:**	3 Fatal
Flight Conducted Under:	Part 91: General aviation		

Analysis

The helicopter experienced an in-flight break-up when it was traveling at about 130 knots at 960 feet above the ground. The wreckage path was on a 090 heading between 0.8 to 1.2 miles west of the Spencer, Iowa, airport. Examination of the swashplate outer ring pins revealed a bending fatigue fracture occurred in the 'white' pin. The fatigue cracking originated in the undercut fillet radius adjacent to the head of the pin. The 'white' and 'red' bores and the 'red' pin (The white pin was not located) were checked for proper dimensions. The examination indicated an insufficient interference fit between the outer swashplate bores and the outer diameter of the swashplate ring pins.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The below standard (loose) fit of the 'white' swashplate outer ring pin resulting in fatigue and subsequent separation of the pin, and ultimately the in-flight breakup of the rotorcraft. A factor was the manufacturer's dissemination of the pin which did not meet dimensional standards.

Findings

Occurrence #1: AIRFRAME/COMPONENT/SYSTEM FAILURE/MALFUNCTION
Phase of Operation: DESCENT

Findings
1. (C) MISCELLANEOUS,DOWEL/PIN - LOOSE

2. (F) AIRCRAFT/EQUIPMENT INADEQUATE - MANUFACTURER
3. (C) MISCELLANEOUS,DOWEL/PIN - FATIGUE
4. MISCELLANEOUS,DOWEL/PIN - SEPARATION

Occurrence #2: IN FLIGHT COLLISION WITH TERRAIN/WATER
Phase of Operation: DESCENT - UNCONTROLLED

Factual Information

On August 20, 1998, at 2114 central daylight time (All times central daylight time), a Bell 222, N30SV, operated by Rocky Mountain Holdings, was destroyed as a result of an in-flight breakup during cruise descent. The pilot, flight nurse, and flight paramedic were fatally injured. The 14 CFR Part 91 flight had departed from the Sioux Valley Hospital, Sioux Falls, South Dakota, and was en route to the Spencer Municipal Hospital, Spencer, Iowa, for a patient transfer. Visual meteorological conditions prevailed and a company VFR flight plan had been filed.

The Sioux Valley Hospital Communications Center's Transport Request form indicated that they had received a call from the Spencer Municipal Hospital for a helicopter transport at 2027. The transport log indicated that the pilot was notified at 2027 and that the pilot checked the weather. He confirmed that the weather was acceptable for a VFR night flight at 2031. The transport log indicated that the helicopter departed at 2039. The distance to the Spencer Municipal Hospital was 71 miles. The ETE was 33 minutes. The helicopter had 1:45 hours fuel on board.

The transport log indicated that the pilot made three position reports during the flight. At 2052, the helicopter had an ETA of 22 minutes. At 2101, the helicopter had an ETA of 13 minutes. At 2109, the helicopter ha an ETA of 5 minutes. The pilot did not indicate there was any anomaly concerning the flight when he provided the position reports.

Radar data indicated the helicopter maintained a direct course to Spencer, Iowa. The helicopter maintained an altitude between 2,500 to 3,000 feet msl at an airspeed of approximately 130 knots. The last radar contact was at 2114:18. It indicated the helicopter was 1.5 miles from the Spencer Municipal Airport on about the 290 radial at 2,300 feet msl. The elevation at the Spencer Municipal Airport is 1,339 feet msl. The last radar contact indicated the helicopter was about 961 feet above ground level.

The helicopter impacted the ground approximately 0.8 miles west of the Spencer Municipal Airport.

Personnel Information

The pilot was a commercially rated helicopter pilot with an instrument rating in helicopters. He also held a private pilot airplane single engine land rating. He held a Second Class Medical Certificate. He had a total of about 3,918 hours of flight time. 3,872 hours were in helicopters. 597 hours were in the Bell 222SP helicopter. He had completed recurrent ground and flight training in the Bell 222SP helicopter on April 26, 1998, and had successfully completed a Part 135 check ride on April 27, 1998.

The pilot had eight years experience operating from the Sioux Valley Hospital. The flight paramedic had one year eight months experience in the hospital's flight department. The flight nurse had four months experience in the hospital's flight department.

Aircraft Information

The helicopter was a twin engine Bell 222SP, serial number 47044. In the medical configuration, the helicopter had four seats which included the patient stretcher. The gross weight was 7,850 pounds. The engines were 650 shaft horsepower Allison 250-C30G engines. The helicopter was on an Approved Airworthiness Inspection Program (AAIP). The helicopter had flown 2.5 hours since the last inspection and had a total of 3,251 hours.

The engine logbooks indicated that the left engine was last inspected on July 16, 1998. The right engine was last inspected on July 17, 1998. The engines' next inspection was due in about another 50 flight hours.

The Sioux Valley Hospital had started operating the helicopter in January 1993. The aircraft had a 738.4 total hours when it was put into operation by the hospital.

The airframe logbook indicated that the helicopter had undergone a "B" inspection on August 17, 1998. The mechanic who signed off the inspection reported that during the performance of the B inspection, he discovered the friction on the swashplate was below the allowable limits. He reported that he and another mechanic performed the necessary work to bring the friction into the proper limits. In order to do the inspection, the mechanics disconnected the swashplate drive links, cyclic links, and pitch links. The mechanic reported that torque wrenches were used when the components were re-attached, although, the mechanic reported he could not specifically recall if the drive link bolts had been checked with a torque wrench. The mechanic reported that after the work was completed, the mechanics inspected each other's work for proper safeties and cotter keys. The mechanic reported that after all the maintenance was performed, the pilot on-duty (who happened to be the accident pilot), examined the preformed maintenance and conducted a ground run. The mechanic reported that the pilot indicated that the helicopter was satisfactory.

The helicopter was not flown on August 17, 1998, but it received two preflight inspections by the on-duty pilots. On August 18, 1998, the helicopter flew a 0.8 hour flight, and had received two preflight inspections by the on-duty pilots.

On August 19, 1998, the mechanic performed maintenance on the helicopter in the morning that included changing the bearings of the cyclic links. The mechanic reported that he changed both bearings of the left cyclic link and the upper bearing of the right cyclic link. The maintenance to the cyclic links did not require the drive links to be disconnected. The mechanic reported that he entered the logbook entries for the maintenance performed on the emergency locator transmitter and a helipilot computer. The inspection of the logbook

indicated that the entry for the maintenance performed on the cyclic links was not entered into the logbook, although a record of the maintenance was listed in the mechanics' maintenance computer.

On August 19, 1998, the aircraft flew a 0.9 hour flight, and it had received a Daily Preflight check by the on-duty mechanic and two pilot preflight checks by the on-duty pilots.

On August 20, 1998, the aircraft received a Daily Preflight by the on-duty mechanic in the morning. The logbook also indicated that the accident pilot, who was scheduled as the night pilot (1900 August 20 through 0700 of August 21), performed a preflight inspection of the helicopter. At 2039, the pilot departed the hospital on the accident flight.

Maintenance records indicated that an overhauled swashplate was installed on the helicopter on July 16, 1997. On August 20, 1998, the time since overhaul was 462.6 hours.

The helicopter departed with 1:45 hours of fuel on board. It had approximately 1:15 hours of fuel on board when it impacted the ground.

Meteorological Conditions

At 2053, weather conditions reported at the Spencer Municipal Airport were VMC. The winds were 260 degrees at 12 knots gusting to 26 knots. Visibility was 10 miles with an 8,500 foot overcast layer. The temperature was 74 degrees Fahrenheit. The dew point was 68 degrees Fahrenheit. The altimeter was 30.26.

At 2153, weather conditions reported at the Spencer Municipal Airport were VFR. The winds were 080 degrees at 15 knots. Visibility was 6 miles with 8,500 foot broken layer. The temperature was 70 degrees Fahrenheit. The dew point was 68 degrees Fahrenheit. The altimeter was 30.20.

Wreckage and Impact Information

The helicopter wreckage was located on a line approximately 0.8 to 1.2 miles west, northwest from the runway intersection at the Spencer Municipal Airport. The direction of travel was approximately 090 degrees.

The majority of the helicopter wreckage landed in two mature bean fields where the beans had grown to about 38 inches in height. On August 21, 1998, aerial searches were conducted to locate the main sections of wreckage. On August 22, 1998, about 45 volunteers searched the bean fields for 2.5 hours to locate additional wreckage. The areas searched were located north and west of the location of the tailboom and tailrotor.

A blue plexi-glass piece and two sections of the tailrotor driveshaft cover were located at the westernmost end of the debris field. Numerous small parts of aircraft wreckage were located

in the debris field between the western end of the debris field and the fuselage located at the eastern end of the wreckage path.

The fuselage impacted the bean field approximately 0.5 miles from the initial point of in-flight breakup. The direction of travel of the fuselage after ground impact was about 090 degrees. The longitudinal axis of the aircraft was found heading about 320 degrees.

The left landing gear sponson was located about three feet in front of the initial impact point of the fuselage. The right landing gear sponson separated from the fuselage and was located about 150 feet east of the left sponson. The fuel bladder from the right sponson was found near the right sponson. The fuel bladder had burst and there was evidence of jet fuel having sprayed on the bean plants in the debris area of the fuselage wreckage.

The majority of the fuselage, which included the area from the nose section to the tailboom attachment area, was destroyed by fire. The transmission and engines received fire damage and were found inverted under the right side of the fuselage wreckage.

All engine components were located at the main wreckage site. Both engines had broken off from the airframe mounts, but each engine was found within its respective engine compartment. Both engines and gearboxes were consumed by fire.

The tailrotor driveshaft assembly at the main impact site included the first two sections of the tailrotor driveshaft. The number one tailrotor drive shaft had separated from the transmission during impact. The section between the engine firewalls was consumed by fire. The number two section of tailrotor drive shaft was intact but was bent and crushed.

The right horizontal stabilizer and a section of the tailboom which remained attached to the stabilizer was located about 0.35 miles from the main wreckage on a heading of 290 degrees.

A fiber washer that was part of the "white" drive link/swashplate outer ring pin assembly from the main rotor was found about 0.15 mile west of the tailboom and tailrotor, and about 0.35 miles west of the main wreckage.

The tailboom and attached tailrotor were located about 0.2 miles from the main wreckage on a heading of 270 degrees.

The main rotor and attached blades were located about 0.18 miles from the main wreckage on a heading of 300 degrees.

Examination of the main rotor assembly indicated that the "white" swashplate outer ring pin that attached the white drive link to the rotating swashplate was fractured within the bolt hole of the swashplate. The corresponding pin, nut, washers, and cotter key had separated and were not located. The "red" swashplate outer pin and drive link assembly remained attached to the swashplate.

Medical and Pathological Information

An autopsy was performed on the pilot at the LCM Pathologists, P.C., Sioux Falls, South Dakota.

A Forensic Toxicology Fatal Accident Report was prepared by the FAA Civil Aeromedical Institute. The report concerning the pilot indicated the following results:

Carbon Monoxide: Not performed due to lack of suitable specimen.

No Cyanide detected in blood.

35 (mg/dL, mg/hg) Ethanol detected in muscle.

37 (mg/dL, mg/hg) Ethanol detected in kidney.

19 (mg,dL, mg/hg) Acetaldehyde detected in kidney.

No drugs detected in blood.

The detection of ethanol and acetaldehyde was the result of putrefaction.

Tests and Research

The engine inspection indicated that both engines were rotating at the time of impact. The No. 2 engine had evidence of fused aluminum deposits on the 1st stage nozzle guide vanes.

The swashplate assembly, main rotor hub, and the main transmission and mast assembly were examined at the Bell Helicopter Textron Metallurgical Laboratory in Fort Worth, Texas, under the supervision of the National Transportation Safety Board.

The main rotor mast, main rotor trunnion, rotating controls drive plate and main rotor controls drive hub were inspected to determine that they were properly indexed relative to the master splines and to each other. The components were found to meet the engineering drawing requirements for indexing relative to the master splines and to each other.

The main rotor hub assembly was tested to determine the spring rates of the elastomeric bearings. No abnormal spring rates were observed in the test.

The fractures observed in the main rotors controls installation components and transmission case were determined to be the result of overstress fractures.

The examination of the swashplate outer ring pins revealed a bending fatigue fracture

occurred in the "white" (S/N TI 15) pin. The fatigue cracking originated in the undercut fillet radius adjacent to the head of the pin. The pin was found to meet the engineering drawing requirements for hardness and the remaining portion of the fillet radius was within the engineering drawing limits.

An examination on the S/N TI 15 pin's fracture surface with an optical and a scanning electron revealed no discrepancies in the fatigue origin area. The fracture surface had dark corrosion products in it. A fatigue striation count was made from replicas of the fracture surface that indicated the pin had 196,000 load cycles that caused fatigue growth. It was not known how many load cycles did not cause fatigue growth.

The swashplate outer ring assembly, part number 222-010-404-113, S/N TI 6, was inspected. The holes where the fractured "white" pin and the "red" pin had been located were measured at four locations. The fractured "white" pin hole was 0.0015 to 0.0051 inch above the engineering drawing requirement of 0.6230 to 0,6235 inch. The "red" pin hole was 0.0007 to 0.0031 inch above the engineering drawing requirement. Both holes had visual evidence of wear. Wear also occurred where the pin corners contacted the inner ring. The heaviest wear occurred as a result of a counterclockwise (as viewed looking inboard) force on the pin in the hole. The TI 6 swashplate had been in service for 462 flight hours.

The engineering drawings required that the swashplate outer ring pins diameters be within 0.6240 to 0.6250 inch. The white pin from the TI 6 swashplate was S/N TI 15. It was not possible to measure the diameter of pin TI 15 since it had not been located at the accident site. The red pin from the TI 6 swashplate was S/N TI 37. Various measurements taken of the TI 37 pin indicated diameters of 0.6243. 0.6236, 0.6238, 0.6234, and 0.6229 inch.

Examination of the swashplate outer ring assembly revealed that the flats of the swashplate pin heads were causing wear on the inside surface of the swashplate ring. The wear pattern indicated the swashplate pin was turning in a counterclockwise direction. No wear or movement of the pin is permitted by the maintenance manual.

The swashplate, the white drive link and trunion bearing, the fractured trunion bolt, and the exemplar red drive link and trunion assembly were examined for verification purposes at the National Transportation Safety Board's Metallurgical Laboratory.

Additional Information

The definition of interference fit according to the Dictionary of Aeronautical Terms, Aviation Supplies and Academics, ed. Dale Crane, is, "A type of fit used when assembling certain mechanical devices. To create an interference fit, a hole is made smaller than the part that fits into it. The material containing the hole is heated to expand the hole, and the object to fit in the hole is chilled to shrink it. The parts are easily assembled when one is hot and the other is cold, but when they reach the same temperature, the fit is so tight they will not loosen in service."

The swashplate outer ring assembly that had been replaced during overhaul on July 16, 1997, was obtained from the maintenance facility that overhauled the swashplate. The facility's maintenance records indicated that the swashplate had been sent in for overhaul because of loose swashplate outer ring pins. A technician from the maintenance facility reported that the pins were loose enough that they could be tapped out of the pin holes with a soft face hammer. The serial number of the replaced swashplate outer ring was S/N VN 06-0088. The VN 06 number indicated the TI 6 and VN 06 swashplates had been manufactured by different vendors.

The VN 06 swashplate had 2,462 flight hours when it was replaced. The engineering drawings required the diameter of the pin holes to be 0.6230 to 0.6235 inch. The diameter of the pin bore holes were measured at 0.0002 to 0.0123 inch above what the engineering drawings required.

The VN 06 swashplate outer ring pins' diameters were measured. Both pins had 2,462 flight hours. The engineering drawings required a diameter of 0.6240 to 0.6250 inch. The pins had diameters that measured 0.0003 to 0.0011 inch below the minimum required diameters.

18 additional TI swashplate outer ring pins were obtained for dimensional checks. The inspection revealed that two of the TI pins had diameters that measured 0.6238. Sixteen of the pin diameters ranged from 0.6240 to 0.6243 inch, all on the low side of the 0.6240 to 0.6250 inch range.

26 additional swashplate outer ring pins that had serial numbers which started with the vendor identification of EA were obtained for dimensional checks. The inspection revealed that the EA pins' diameters ranged from 0.6243 to 0.6252 inch. Of the 52 measurements taken, all except five measurements were on the high side of the allowed range.

A swashplate, p/n 222-010-403-7, S/N CL-0046 was obtained for inspection. The swashplate outer ring pin, S/N 02-00198, was heat pressed out of the swashplate outer ring. The swashplate was heated to 250 degrees Fahrenheit and the pin was pressed out. It took 3,642 pounds of pressure to break the pin free from the swashplate. The pin diameter was not recorded.

A TI swashplate, S/N TI 5, was obtained for inspection. The swashplate outer ring pins, S/N TI 35 and S/N TI 45 were pressed out of the swashplate outer ring. The swashplate was heated to 250 degrees Fahrenheit and the pins pressed out. It took 1,969 pounds and 1,328 pounds of pressure, respectively, to break the pins free from the swashplate. The TI 35 pin diameter measurement was 0.6243 inch. The TI 45 pin diameter measurement was 0.6238 inch.

On September 14, 1998, Bell Helicopter Textron issued a Safety of Flight Message. The message stated that, "Swashplate rotating ring P/N 222-101-403-113 is used on all 222/222B/222U and 230 helicopters. Bell Helicopters has determined that rotating rings serial

number TI-1 through TI-26 are suspect and require inspection. Helicopters with suspect rotating rings installed must be inspected in accordance with this message prior to further flight."

The Safety of Flight Message outlined three inspection criteria. They were: (1) Measure the pin. Any pin that measured 0.6245 inches or less was cause for rejection. (2) Using a 0.001 inch feeler gauge, probe around the outside diameter of the pin attempting to insert gauge between the pin and swashplate rotating ring. Any detectable gap was cause for rejection. (3) Grasp drive pin and swashplate rotating pin and apply pressure to the pin in a fore-aft and up-down movement. Any looseness detected between drive pin and swashplate rotating pin was cause for rejection.

On February 2, 1999, Bell Helicopter Textron issued an Alert Service Bulletin No. 222-99-84. The message stated the following:

"Investigation of a recent accident on a Model 222 has revealed that one of the swashplate rotating ring drive pin P/N 222-010-455-003 had failed. The cause of the fatigue failure was determined to be insufficient interference fit between the rotating ring and the drive pin.

This bulletin provides procedures to accomplish a one-time torque test of swashplate rotating drive pins P/N 222-010-455-003 to determine if the interference fit between pins and swashplate rotating ring is adequate. In addition, a recurring torque test of the drive pins P/N 222-010-455-003 will be required in accordance with temporary revision to BHT-222/222B-MM-1."

Parties to the investigation included the Federal Aviation Administration, Rocky Mountain Helicopters, Bell Helicopter Textron, Allison Engine Company, and Helidyne, Inc.

The aircraft wreckage was released to the United States Aviation Underwriters.

Pilot Information

Certificate:	Commercial	**Age:**	50,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	
Instrument Rating(s):	Helicopter	**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 4, 1998
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	
Flight Time:	3918 hours (Total, all aircraft), 597 hours (Total, this make and model), 25 hours (Last 90 days, all aircraft), 6 hours (Last 30 days, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Bell	**Registration:**	N30SV
Model/Series:	222 222	**Aircraft Category:**	Helicopter
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Transport	**Serial Number:**	47044
Landing Gear Type:	Retractable - Tricycle	**Seats:**	4
Date/Type of Last Inspection:	August 17, 1998 AAIP	**Certified Max Gross Wt.:**	7850 lbs
Time Since Last Inspection:	3 Hrs	**Engines:**	2 Turbo shaft
Airframe Total Time:	3251 Hrs	**Engine Manufacturer:**	Allison
ELT:	Installed	**Engine Model/Series:**	250-C30G
Registered Owner:	ROCKY MOUNTAIN HOLDINGS	**Rated Power:**	650 Horsepower
Operator:		**Operating Certificate(s) Held:**	On-demand air taxi (135)
Operator Does Business As:		**Operator Designator Code:**	R7MA

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Night/dark
Observation Facility, Elevation:	SPW ,1339 ft msl	**Distance from Accident Site:**	1 Nautical Miles
Observation Time:	20:53 Local	**Direction from Accident Site:**	90°
Lowest Cloud Condition:	Scattered / 5500 ft AGL	**Visibility**	6 miles
Lowest Ceiling:	Broken / 8500 ft AGL	**Visibility (RVR):**	
Wind Speed/Gusts:	15 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	80°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30 inches Hg	**Temperature/Dew Point:**	22°C / 20°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	SIOUX FALLS , SD (1SD9)	**Type of Flight Plan Filed:**	Company VFR
Destination:	(1IA3)	**Type of Clearance:**	None
Departure Time:	20:39 Local	**Type of Airspace:**	Class E

Airport Information

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

Wreckage and Impact Information

Crew Injuries:	3 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:		**Aircraft Fire:**	On-ground
Ground Injuries:	N/A	**Aircraft Explosion:**	On-ground
Total Injuries:	3 Fatal	**Latitude, Longitude:**	43.140274,-95.149414(est)

Administrative Information

Investigator In Charge (IIC):	Silliman, James
Additional Participating Persons:	LARRY L ARENHOLZ; DES MOINES , IA RICK FRAZER; PROVO , UT DAVID C DOSKER; FORT WORTH , TX SCOTT S SCHEURICH; INDIANAPOLIS , IN
Original Publish Date:	June 21, 2000
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=44069