



# National Transportation Safety Board Aviation Accident Final Report

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<b>Location:</b>	FRESNO, Texas	<b>Accident Number:</b>	FTW99FA192
<b>Date &amp; Time:</b>	July 17, 1999, 12:31 Local	<b>Registration:</b>	N110HH
<b>Aircraft:</b>	MBB BK-117-B2	<b>Aircraft Damage:</b>	Destroyed
<b>Defining Event:</b>		<b>Injuries:</b>	3 Fatal
<b>Flight Conducted Under:</b>	Part 91: General aviation - Positioning		

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## Analysis

The helicopter was making a VFR approach to a fueling site when witnesses observed components of the main rotor system separate from the helicopter. Subsequently, the helicopter entered an uncontrollable descent and impacted the ground. Examination of the helicopter revealed that one of the four main rotor blades separated due to the failure of the tension-torsion strap (T-T strap), which secured the blade to the main rotor head. Examination of the failed T-T strap revealed that the polyurethane protective coating had debonded from a portion of the strap allowing corrosive agents, including carbon, sulphur, and chlorine into the strap. The strap separated as a result of fatigue cracking of the wires making up the strap. The fatigue cracking emanated from corrosion pits and deposits that were introduced to the strap when the polyurethane protective coating debonded. The T-T strap had accumulated a total of 7,815.3 flight hours and 35,971 flights at the time that it failed. It had been in service since the helicopter was manufactured in 1987. Following the accident, a life limit of 120 months or 25,000 flights (whichever comes first) was established for the T-T straps.

## Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: the loss of control during approach due to the corrosion of the T-T strap which resulted in fatigue cracking and subsequent separation of the strap and main rotor blade from the helicopter.

## Findings

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Occurrence #1: ROTOR FAILURE/MALFUNCTION

Phase of Operation: APPROACH - VFR PATTERN - BASE LEG/BASE TO FINAL

Findings

1. (C) ROTOR SYSTEM,MAIN ROTOR TENSION TORSION BAR - CORRODED
2. (C) ROTOR SYSTEM,MAIN ROTOR TENSION TORSION BAR - FATIGUE
3. (C) ROTOR SYSTEM,MAIN ROTOR TENSION TORSION BAR - SEPARATION

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Occurrence #2: LOSS OF CONTROL - IN FLIGHT

Phase of Operation: APPROACH - VFR PATTERN - BASE LEG/BASE TO FINAL

Findings

4. AIRCRAFT CONTROL - NOT POSSIBLE - PILOT IN COMMAND

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Occurrence #3: IN FLIGHT COLLISION WITH TERRAIN/WATER

Phase of Operation: DESCENT - UNCONTROLLED

Findings

5. TERRAIN CONDITION - GROUND

## Factual Information

### HISTORY OF FLIGHT

On July 17, 1999, at 1231 central daylight time, a Messerschmit-Bolkow-Blohm BK-117-B2 helicopter, N110HH, operating as LIFEFLIGHT 1, was destroyed when it impacted terrain following the separation of a main rotor blade during an approach to an unmanned fueling site near Fresno, Texas. The airline transport rated pilot and two medical crewmembers were fatally injured. The helicopter was registered to and operated by Hermann Memorial Hospital Systems, of Houston, Texas. Visual meteorological conditions prevailed for the 14 Code of Federal Regulations Part 91 positioning flight, for which a company VFR flight plan was filed.

According to Hermann Hospital dispatch records, LIFEFLIGHT 1 departed Hermann Memorial Hospital at 1226 and was destined for the Columbia Clearlake Regional Hospital, near Clear Lake, Texas, with an intermediate refueling stop at the Fresno fueling site. At 1227, LIFEFLIGHT 1 was issued a clearance from Houston Hobby air traffic control tower into Hobby Class B airspace. At 1231, LIFEFLIGHT 1 reported that the landing area was in sight. No further communication was received from the helicopter.

According to a witness, who was driving westbound on FM2234, he first noticed the LIFEFLIGHT helicopter flying southbound approximately level with powerlines. He stated that the helicopter turned to the left and hovered for a second, and then he observed "sparks or possible flames shoot out from the top middle of the helicopter," near the main rotor system. He witnessed pieces of the main rotor system separate from the helicopter. Subsequently, the helicopter entered a nose low attitude and passed behind trees out of the witness' view.

Another witness, who was driving northbound on FM521, observed the LIFEFLIGHT helicopter traveling southbound, approximately 35 feet agl. He stated that the helicopter made a left turn, as if it was going to land; he then observed an "explosion," and the helicopter impacted the ground.

### PERSONNEL INFORMATION

The pilot was hired by Hermann Hospital on July 23, 1990. On July 27, 1990, he completed initial BK-117 ground and flight training, which was administered by American Eurocopter, Grand Prairie, Texas. On August 2, 1998, the pilot satisfactorily completed his most recent annual recurrent ground and flight training for the BK-117. On August 13, 1998, the FAA issued the pilot an airline transport certificate for helicopters. He also held a commercial certificate with airplane single and multi-engine land ratings and type ratings in the Bell 206 helicopter, Hughes 369 helicopter, and the Boeing Vertol 234. According to Pilot Flight Duty Time Forms that were provided by Hermann Hospital, the pilot had accumulated a total of 1,459.5 flight hours with Hermann Hospital, since his date of hire. There were no restrictions or limitations listed on the pilot's FAA second class medical certificate issued on June 7, 1999. The Pilot/Operator Aircraft Accident Report (NTSB Form 6120.1/2), which was completed by Hermann Hospital, indicated that the pilot had accumulated a total of 9,233 flight hours, of which 8,763 hours were in rotorcraft.

The two medical crewmembers, a flight nurse and a paramedic, were based at the Hermann Memorial Hospital.

## AIRCRAFT INFORMATION

The 1987, red and black, twin-engine helicopter was equipped with two Honeywell LTS101-750B-1 turboshaft engines, a four bladed main rotor system, and a two bladed tail rotor. The airframe had accumulated a total of 7,815.3 flight hours and 35,971 flights at the time of the accident. The helicopter underwent its most recent inspection, in accordance with its approved inspection program, on July 7, 1999. The left engine had accumulated a total of 6,216.2 hours at the time of the accident and underwent its last 1,200-hour inspection on July 8, 1998. The right engine had accumulated a total of 2,737.4 hours at the time of the accident and underwent its most recent 1,200-hour inspection on October 6, 1998.

The main rotor head and tension torsion straps (T-T straps) had accumulated a total of 7,815.3 hours at the time of the accident. The T-T straps had not been replaced since they were installed on the helicopter in 1987. The main rotor head and T-T straps were last inspected on May 1, 1997, in accordance with the manufacturer's recommended 2,400-hour inspection interval, at a total time of 6,027.1 hours. At the time of the accident, the T-T straps were not time-life-limited.

The T-T straps installed on LIFEFLIGHT 1 were manufactured by Bendix Corporation. A T-T strap contains between 11,900 and 12,000 windings of grade 304 stainless steel wire continuously wrapped around two steel bushings that are separated by a distance of approximately 9.6 inches. Each bushing contains an axial tube portion and a radial flange at the end of the tube portion. The area between the straight portions of the bundles of wires, between the bushings, is hollow. A cast polyurethane bushing retention block is installed adjacent to each bushing in the area between the straight portions of the bundle of wires. The wound wires, bushings, and bushing retention blocks are encapsulated in polyurethane, to prevent exposure of the wires to the environment.

## METEOROLOGICAL INFORMATION

At 1153, the weather observation facility located at the William P. Hobby Airport, Houston, Texas, (located 10 miles northeast of the accident site), reported scattered clouds at 3,000 feet, broken layers at 7,000 and 25,000 feet, wind 160 degrees at 7 knots, visibility 10 statute miles, temperature 88 degrees Fahrenheit, dew point 72 degrees Fahrenheit, and altimeter 30.12 inches of Mercury. The remarks section stated that there were rain showers in the vicinity of the airport.

Reproduced satellite images were obtained through McIDAS and displayed on an NTSB workstation. At 1215 and 1245, the images revealed only one area of cloud coverage, which was located at the flight path's mid-point.

According to cloud to ground lightening strike data, provided by Global Atmospheric, Inc., during the period between 1226 to 1231 there were no cloud to ground lightening strikes within

10 nautical miles of the accident location. Furthermore, no thunderstorms were in the accident site vicinity at the time of the accident.

## WRECKAGE AND IMPACT INFORMATION

A global positioning satellite (GPS) receiver located the accident site at North 29 degrees 34.33 minutes latitude, and West 095 degrees 26.24 minutes longitude. The fuselage of the helicopter came to rest on a measured magnetic heading of 190 degrees, 635 feet southwest of the fueling facility. Ground scars at the accident site revealed that the helicopter initially impacted the ground on the left side of the fuselage in a near inverted position, and then came to rest upright 26 feet southeast of the initial ground impact point. The transmission and main rotor assembly remained secured to each other, but separated from the engines and airframe and came to rest 19.6 feet south of the fuselage. The four main rotor blades were found separated from the main rotor hub (rotor star). One main rotor blade (red) was located 686 feet west of the fuselage, a second blade (blue) was located 275 feet north of the fuselage, a third blade (yellow) was located 329 feet north of the fuselage, and the fourth blade (green) was located 237 feet east of the fuselage.

The yellow main rotor blade, the inner sleeve assembly, the blade mounting fork, and the control lever (pitch horn) remained secured to each other. The T-T strap, serial number 5050, which secures the yellow main rotor blade to the rotor star by way of a quadruple nut and retaining pin in the rotor star and a retaining nut in the blade mounting fork, was separated in two sections. The quadruple nut was found secured within the rotor star and the outer retaining nut was found secured to the blade mounting fork. One section of the separated T-T strap remained secured to the outer retaining nut and another section of the T-T strap remained secured to the quadruple nut. The T-T strap's polyurethane sheath was compromised and its wires were exposed. The T-T strap was sent to the NTSB Materials Laboratory in Washington, D.C. for further examination.

The remaining three main rotor blades were separated at the connection fitting (blade mounting fork). Their T-T straps were intact and secured between the blade mounting fork and the rotor star. Each of the blade's fracture surfaces were flush with the outer portion of the connection fitting. The composite fibers of the red and green blades exhibited compression and tensile type overload signatures, and the fibers of the blue blade (opposite the yellow blade) exhibited overload signatures in the upward direction.

Continuity was established from the main transmission assembly to the rotor star. All gears rotated and no binding was noted. The entire retaining system within the rotor star, from the hoisting ring to the lower cover plate and securing nut was in place and secure. Each of the pitch control links was found secured, except for the one from the yellow blade (p/n 105-13142) that separated at the threaded section of the upper rod end. The pitch control link was sent to the NTSB Materials Laboratory for further examination. The outer needle bearing assembly for the yellow blade was fractured. The outer needle bearing assembly and its fractured section were sent to the NTSB Materials Laboratory for further examination. Flight control continuity for the tail rotor system was established from just aft of the cabin area to the tail rotor blades. Determination of flight control continuity from the tail rotor pedals to just aft of the cabin was precluded by impact damage. Determination of flight control continuity from the cyclic and

collective controls up to the swashplate was precluded by impact damage.

## AUTOPSY AND MEDICAL INFORMATION

On July 19, 1999, an autopsy was performed on the pilot and both medical crewmembers at the Office of the Medical Examiner of Harris County, Houston, Texas. Toxicological testing on the pilot, performed by the FAA's Civil Aeromedical Institute, Oklahoma City, Oklahoma, for carbon monoxide, cyanide, alcohol, and drugs were negative.

## TESTS AND RESEARCH

An examination of the separated T-T strap, the separated pitch control link, and the outer needle bearing assembly (along with its fractured piece) was conducted at the NTSB Materials Laboratory in Washington, D.C.

Visual examination of T-T strap (serial number 5050) revealed that it separated along the straight portion of the bundle of wire, between the bushings. Individual wires separated at various points along the straight portion of the wire bundle and around the outer bushing (nearest to the blade mounting fork). A crack in the polyurethane coating was noted between the straight segments of the T-T strap and the outboard bushing. The crack measured 0.1 inch and did not penetrate the polyurethane skin. The T-T strap exhibited debonding between the polyurethane coating and the flange portion of the bushing in the area transitioning from the straight portion to the curved portion at the outboard bushing. The debonding was confirmed when the tip of a fine point screw driver was slipped between the polyurethane and the flange portion of the bushing.

The fractured wire ends from the outboard side were excised from the T-T strap and representative wires in each of the fracture areas were examined using a scanning electron microscope (SEM). On average, 70% of the wires that were examined contained fatigue cracking. The fatigue cracks emanated from corrosion pits at the diameter surface (10%), deposits at the diameter surface (50%), and the remaining from a clean round surface (10%). These examined wires were concentrated in the core of the wire bundle. On average, 30% of the wires contained mechanical damage as a result of the wires rubbing against each other. Additionally, wire ends that contained cup-cone features typical of overstress separations were found in areas located midway between the two bushings and were concentrated near the outside edges of the straight portions, rather than the core.

X-ray energy dispersive spectroscopy (EDS) analysis was performed on deposits that were observed on the wires' surfaces, in the corrosion pits, on the polyurethane, and in the grease that was removed from the debonding area between the polyurethane and flange portion of the bushing. The spectrums revealed elemental peaks of carbon, sulfur and chlorine (corrosive agents).

The retaining nut and bolt assemblies were removed and the T-T strap was soaked in methylene chloride to remove the polyurethane and expose the wires. The diameters of the cleaned wires measured 0.006 inch. Visual examination revealed that wire strands separated in the area that extended from the transition area to approximately 15 degrees toward the

hollow portion of the assembly. The wire ends were examined with a binocular microscope and contained knife edges, consistent with fretting. The fretting damage was most severe at the location where the wires made contact with the flange portion of the bushing in the 15 degree region, and extended from the flange face to an area approximately 0.3 inch axially toward the center of the bushing. Examination of the wire ends with an SEM revealed that separated wires near the bushing contained fatigue cracks that originated from deposits on the surface and fretting. Additionally, the paint layer on the exterior flat radial portion of the flanges was worn off and the base metal surfaces exhibited fretting damage.

Seven additional Bendix T-T straps (three from the accident helicopter) were also examined. Each of these T-T straps exhibited debonding between the polyurethane coating and the flange portion of the bushings, similar to the debonding observed on the failed T-T strap.

The pitch control link for the yellow blade was fractured at the end which attaches to the blade pitch horn. The fracture surface exhibited a 45 degree shear plane and the control tube exhibited bending deformation. No fatigue or pre-existing cracks were noted. Additionally, there was no heat damage to the bearing.

The outer needle bearing assembly was examined and contained no cracks and the cage rotated freely when manipulated by hand. A small fragment, measuring 1.7 inches circumferentially, had separated. SEM examination of the fragment revealed that the fracture surface contained features typical of overstress.

The engines were examined at the Honeywell Product Safety and Integrity Investigation Laboratory in Phoenix, Arizona. The examination of the left engine, serial number LE-45654, revealed that the leading edge of one blade was bent opposite to the direction of rotation on the axial compressor rotor, and rub marks were observed on the impeller shroud assembly. Rotational scoring was observed on the shroud line edge of the centripetal impeller, the gas producer turbine shroud, and on the aft edges of each blade tip of the power turbine rotor. Metal spray deposits were observed in the gas producer turbine's nozzle and rotor assemblies and in the power turbine's rotor and nozzle assemblies. Examination of the right engine, serial number LE-45643, revealed that the leading edges of blades were bent opposite to the direction of rotation on the axial compressor rotor, and rub marks were observed on the impeller shroud assembly. Rotational scoring was observed on the aft inner diameter of the compressor rotor assembly shaft, on the gas producer turbine shroud, on each of the blade tips of the power turbine rotor, and on the power turbine shroud. Metal spray deposits were observed in the gas producer turbine's rotor and nozzle assembly and in the power turbine's rotor and nozzle assembly. According to a report by Honeywell, "the teardown and examination of both engines disclosed that the type and degree of damage was indicative of engine rotation and operation at the time of impact with the ground."

#### ADDITIONAL DATA

The helicopter was released to the owner's representative on June 6, 2000.

Following the accident, the NTSB Investigator-In-Charge met with officials from the FAA Rotorcraft Directorate, American Eurocopter, and Eurocopter Germany. The Luftfahrt-

Bundesamt (LBA), the airworthiness authority for the Federal Republic of Germany, participated via teleconference.

As a result of the meeting, on August 6, 1999, Emergency Airworthiness Directive (AD) 99-17-07 was issued (later superseded by AD 2000-01-11) affecting all MBB BK-117 helicopter variants. The AD introduced limits to the calendar age and number of flights of the T-T straps after which the straps have to be replaced. The AD required that, before further flight, a component log card or equivalent record be created, which established the calendar age and number of flights on the T-T strap. The AD mandated that any T-T strap that had accumulated 25,000 or more flights, or was 15 or more years of age, be removed from the helicopter. Furthermore, the AD required inspecting and removing, as necessary, unairworthy T-T straps.

As a result of the investigation, on December 15, 2000, AD 2000-26-06 (which superseded AD 2000-01-11) was issued. The AD established a life limit on main rotor T-T straps installed on all MBB BK-117 helicopter variants. The AD required that each T-T strap be replaced every 120 months or 25,000 flights, whichever comes first.

## Pilot Information

<b>Certificate:</b>	Airline transport; Commercial	<b>Age:</b>	58, Male
<b>Airplane Rating(s):</b>	Single-engine land; Multi-engine land	<b>Seat Occupied:</b>	Right
<b>Other Aircraft Rating(s):</b>	Helicopter	<b>Restraint Used:</b>	
<b>Instrument Rating(s):</b>	Airplane; Helicopter	<b>Second Pilot Present:</b>	No
<b>Instructor Rating(s):</b>	None	<b>Toxicology Performed:</b>	Yes
<b>Medical Certification:</b>	Class 2 Valid Medical--no waivers/lim.	<b>Last FAA Medical Exam:</b>	June 7, 1999
<b>Occupational Pilot:</b>	Yes	<b>Last Flight Review or Equivalent:</b>	
<b>Flight Time:</b>	9233 hours (Total, all aircraft), 9233 hours (Pilot In Command, all aircraft), 33 hours (Last 90 days, all aircraft), 22 hours (Last 30 days, all aircraft), 3 hours (Last 24 hours, all aircraft)		

## Aircraft and Owner/Operator Information

<b>Aircraft Make:</b>	MBB	<b>Registration:</b>	N110HH
<b>Model/Series:</b>	BK-117-B2 BK-117-B2	<b>Aircraft Category:</b>	Helicopter
<b>Year of Manufacture:</b>		<b>Amateur Built:</b>	
<b>Airworthiness Certificate:</b>	Transport	<b>Serial Number:</b>	7122
<b>Landing Gear Type:</b>	Skid	<b>Seats:</b>	8
<b>Date/Type of Last Inspection:</b>	July 7, 1999 AAIP	<b>Certified Max Gross Wt.:</b>	7055 lbs
<b>Time Since Last Inspection:</b>	25 Hrs	<b>Engines:</b>	2 Turbo shaft
<b>Airframe Total Time:</b>	7815 Hrs	<b>Engine Manufacturer:</b>	Honeywell
<b>ELT:</b>	Installed, not activated	<b>Engine Model/Series:</b>	LTS101-750B-1
<b>Registered Owner:</b>		<b>Rated Power:</b>	592 Horsepower
<b>Operator:</b>		<b>Operating Certificate(s) Held:</b>	On-demand air taxi (135)
<b>Operator Does Business As:</b>		<b>Operator Designator Code:</b>	GVNA

## Meteorological Information and Flight Plan

<b>Conditions at Accident Site:</b>	Visual (VMC)	<b>Condition of Light:</b>	Day
<b>Observation Facility, Elevation:</b>	HOU ,47 ft msl	<b>Distance from Accident Site:</b>	10 Nautical Miles
<b>Observation Time:</b>	11:53 Local	<b>Direction from Accident Site:</b>	45°
<b>Lowest Cloud Condition:</b>	Scattered / 3000 ft AGL	<b>Visibility</b>	10 miles
<b>Lowest Ceiling:</b>	Broken / 7000 ft AGL	<b>Visibility (RVR):</b>	
<b>Wind Speed/Gusts:</b>	7 knots /	<b>Turbulence Type Forecast/Actual:</b>	/
<b>Wind Direction:</b>	160°	<b>Turbulence Severity Forecast/Actual:</b>	/
<b>Altimeter Setting:</b>	30 inches Hg	<b>Temperature/Dew Point:</b>	31° C / 24° C
<b>Precipitation and Obscuration:</b>	Light - Showers - Rain		
<b>Departure Point:</b>	HOUSTON , TX (20TA)	<b>Type of Flight Plan Filed:</b>	Company VFR
<b>Destination:</b>	FRESNO , TX (TE11)	<b>Type of Clearance:</b>	VFR
<b>Departure Time:</b>	12:26 Local	<b>Type of Airspace:</b>	Class G

## Airport Information

Airport:	LIFEFLIGHT REFUEL TE11	Runway Surface Type:	Asphalt
Airport Elevation:	68 ft msl	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:	None
Ground Injuries:	N/A	Aircraft Explosion:	None
Total Injuries:	3 Fatal	Latitude, Longitude:	29.530714, -95.449653(est)

## Administrative Information

Investigator In Charge (IIC):	Wigington, Douglas
Additional Participating Persons:	RAYMOND E MURPHY; HOUSTON , TX THOMAS J LATSON; HOUSTON , TX
Original Publish Date:	May 9, 2001
Note:	
Investigation Docket:	<a href="https://data.nts.gov/Docket?ProjectID=46849">https://data.nts.gov/Docket?ProjectID=46849</a>

The National Transportation Safety Board (NTSB), established in 1967, is an independent federal agency mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The NTSB makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

The Independent Safety Board Act, as codified at 49 U.S.C. Section 1154(b), precludes the admission into evidence or use of any part of an NTSB report related to an incident or accident in a civil action for damages resulting from a matter mentioned in the report. A factual report that may be admissible under 49 U.S.C. § 1154(b) is available [here](#).