National Transportation Safety Board
Office of Aviation Safety
Washington, DC 20594

WPR23LA004

AIRWORTHINESS

Specialist's Factual Report

March 28, 2024

A ACCIDENT

Location: Fresno, California
Date: October 1, 2022
Time: 0955 Pacific daylight time
Helicopter: Bell 206B, registration N284CA

B AIRWORTHINESS SPECIALIST

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C SUMMARY

On October 1, 2022, about 0955 Pacific daylight time, a Bell 206B helicopter, N284CA, operated by Organ Mountain Aviation Company, was substantially damaged when it was involved in an accident near Fresno, California. The pilot and passenger were seriously injured. The helicopter was operated as a Title 14 *Code of Federal Regulations* (CFR) Part 91 postmaintenance check flight. The passenger reported that at the completion of the operational check items, as they were returning to the airport, he heard a loud crack or pop noise. The helicopter began to spin to the right and the pilot told the passenger that they had lost tail rotor control as he initiated an autorotation. The passenger recalled that as they got closer to the ground, the rate of spin increased. The helicopter impacted a tree, terrain, and subsequently rolled onto its left side.

Postaccident examination of the helicopter found that on the No. 4 segmented tail rotor drive shaft (**Figure 1**), the splined adapter on the forward end of the drive shaft had separated from the drive shaft tube (**Figure 2**), possibly due to a disbond between the splined adapter and the shaft tube. The No. 4 segmented drive shaft was retained for further examination. The scope of this report is focused primarily on the No. 4 segmented tail rotor drive shaft of the accident helicopter and the inspections required of the segmented tail rotor drive shafts.

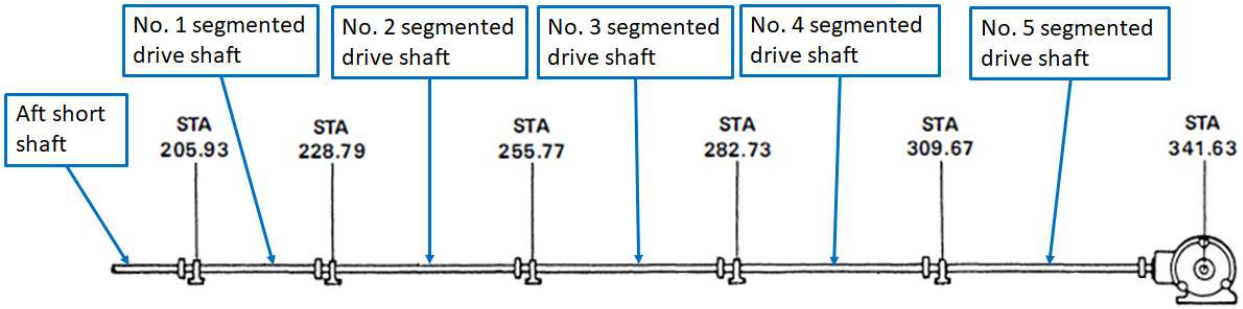

Figure 1. A diagram of the segmented drive shaft system. (Image courtesy of Bell)

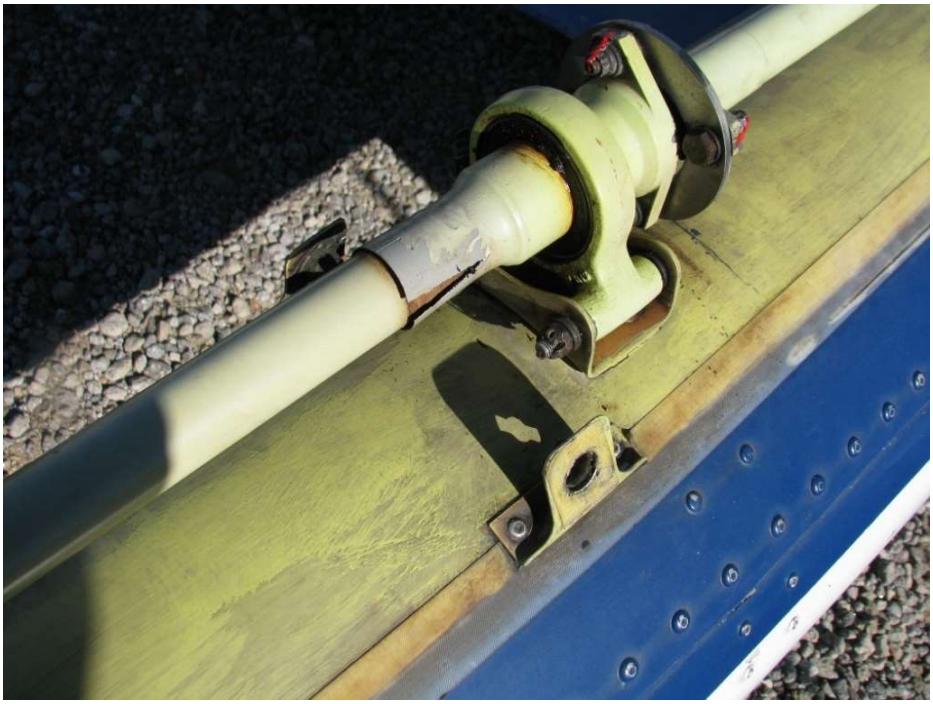

Figure 2. The separated splined adapter at the forward end of the No. 4 segmented tail rotor drive shaft. (Image courtesy of Bell)

D DETAILS OF THE INVESTIGATION

1.0 Helicopter Information

1.1 Helicopter Description

The Bell 206B helicopter has a two-bladed semi-rigid (teetering) main rotor system that provides helicopter lift and thrust. A two-bladed teetering tail rotor system provides lateral thrust to counteract main rotor torque and for directional control of the helicopter. The accident helicopter had Van Horn Aviation (VHA) tail rotor blades installed under the provisions of Federal Aviation Administration (FAA) Supplemental Type Certificate (STC) No. SR02249LA. Only the helicopter's main rotor flight controls are hydraulically assisted. The airframe is equipped with a skid-type

landing gear. A single Rolls-Royce Model 250-C20 turboshaft engine, mounted behind the main transmission, provides power to the rotor system. The Bell 206B is type certificated under FAA type certificate data sheet (TCDS) No. H2SW.[1] According to TCDS No. H2SW, the Bell 206B was approved on August 19, 1971 under the certification basis of Civil Air Regulations (CAR) Part 6.[2]

1.2 Accident Helicopter History

The accident helicopter, serial number (S/N) 1578, was manufactured in 1975. At the time of the accident, engine S/N CAE-832817 was installed. According to aircraft records, the accident helicopter had an aircraft total time (ATT) of 26,191.4 hours and an engine total time of 20,767.5 hours at the start of the date of the accident.

2.0 Wreckage Observations

2.1 System Description

The Bell 206B tail rotor is powered by the tail rotor drive system via a series of segmented drive shafts and a tail rotor gearbox.[3] The steel forward short shaft is located underneath the engine and is connected to the aft end of the freewheeling unit and the forward end of the oil cooler blower shaft. The oil cooler blower, also driven by the tail rotor drive system, is located behind the engine. The aluminum aft short shaft is located behind the oil cooler blower and is connected to the aft end of the oil cooler blower shaft. Five aluminum segmented [tail rotor] drive shafts are installed in series on the tail boom, between the aft short shaft and the tail rotor gearbox. The five segmented drive shafts are supported by five hanger bearing assemblies that are attached to the top of the tail boom structure and are covered with cowlings. Steel laminated flexible disc couplings are installed between all drive shaft flange attachment points along the tail rotor drive system. The flexible couplings accommodate minor angular and axial misalignments between the drive shaft attachment points.

For each segmented drive shaft, a flanged adapter attached to the aft end of the [drive shaft] tube and a splined adapter is attached to the forward end of the tube. Each splined adapter contains external splines to which a coupling adapter, containing internal splines and a flanged end, is installed. On segmented drive shaft part numbers (P/Ns) 206-040-369-101, 206-040-931-009, and 206-040-931-101, the

[1] TCDS No. H2SW was initially issued to the basic 206 variant on April 28, 1964, and subsequently to the 206A variant on October 20, 1966.
[2] The Civil Aeronautics Board (CAB) CAR Part 6, titled *Rotorcraft Airworthiness*, preceded Title 14 CFR Part 27, titled *Airworthiness Standards: Normal Category Rotorcraft*.
[3] Bell 206A and 206B S/Ns 4 through 1251 were originally manufactured with a single, long tail rotor drive shaft in place of the 5 segmented drive shafts. The 5 segmented drive shafts were introduced on Bell 206B S/N 1252 and subsequent.

flanged and splined adapters are both bonded to the tube.[4] On segmented drive shaft P/Ns 206-040-385-105 and 206-040-385-109, the flanged and splined adapters are both riveted to the tube.[5] According to Bell, a tail rotor drive system installation can use a mix of bonded and riveted segmented drive shafts, but may not mix 1.00-inch diameter and 1.25-inch diameter segmented drive shafts within a particular installation. The bonded and the riveted segmented drive shafts are not life limited.[6]

For helicopters equipped with VHA tail rotor blades installed under the provisions of STC No. SR02249LA, the applicable instructions for continued airworthiness (ICA), document No. VMM-206-301, requires early serial numbered helicopters to meet certain requirements in order to be eligible to install the VHA tail rotor blades. Specifically, for Bell 206A and 206B helicopters with S/N 498 through 2211, the tail rotor gearbox has to be modified to the P/N 206-040-400-013 configuration per Bell Technical Bulletin (TB) No. 206-99-168. Additionally, the installation and rigging of the tail rotor hub and blade assembly must comply with the provisions of Bell Service Instruction No. 206-112.

2.2 No. 4 Tail Rotor Drive Shaft

Examination of the recovered wreckage found the splined adapter at the forward end of the No. 4 segmented drive shaft had separated from the drive shaft tube. The No. 4 segmented drive shaft was subsequently shipped to the NTSB Materials Lab in Washington, District of Columbia for further examination.

Lab examination of the No. 4 segmented drive shaft found no evidence of anomalous damage within the splined connection. The serial number marking "VN12657" was observed on the outer surface of the splined adapter. The adhesive material between the shaft tube and the splined adapter showed evidence of heating and resolidification. Additional findings from the materials lab examination can be found in Materials Laboratory Factual Report No. 23-081 in the docket for this investigation.

[4] Segmented drive shaft P/N 206-040-369-101 has a shaft tube diameter of 1.25 inches. Segmented drive shaft P/N 206-040-931-009 and -101 have a shaft tube diameter of 1.00 inches.
[5] Bell Technical Bulletin No. 206-06-186, initially released on April 11, 2006, introduced a riveted aft short shaft and segmented drive shafts to replace the bonded aft short shaft and segmented drive shafts. At the time of this report, the latest version of this Technical Bulletin was Revision B, dated September 7, 2007.
[6] According to Bell, it was unlikely that a fatigue evaluation was conducted during certification of the bonded drive shafts based on the CAR 6 design requirements for rotor drive system components.

3.0 Segmented Drive Shaft Inspection Requirements

3.1 Scheduled Inspections

The Bell 206B maintenance manual required recurrent inspection of the segmented drive shafts at a 100-hour interval, during Event No. 3 of a 100-hour progressive inspection, or during Event No. 4 of a 300-hour progressive inspection.[7] The inspection criteria for the segmented drive shafts was the following:

Examine long tail rotor driveshaft or segmented driveshafts and aft splined adapter for condition and security. Check aft splined adapter for adequate lubrication and freedom of movement.

3.2 Conditional Inspections

In the *Conditional Inspections* section of the Bell 206B maintenance manual, a sudden stoppage or acceleration of the main rotor system, required a conditional inspection. Within these inspection criteria, all bonded tail rotor drive shafts were considered to be unserviceable and scrapped if any of the following were found in the sudden stoppage inspection:

- *Any impact damage to a main rotor blade leading edge or lower skin, or any main rotor blade skin buckling or tears.*
- *Main rotor mast is sheared, power on or off, or with torsional yielding, or Total Indicated Runout (TIR) check exceeds limits.*
- *Any deformation of any coupling disc that results in gaps between laminates greater than 0.015 inch (0.381 mm).*
- *Structural failure or distortion of any coupling disc bolts.*
- *Structural failure or distortion exceeding the specified limits of the tail rotor driveshaft steel or aluminum adapters.*

Additionally, a sudden stoppage or sudden acceleration of the tail rotor system required a condition inspection. For the segmented drive shafts, the following inspection criteria applied to the bonded drive shafts:

> *All bonded tail rotor driveshafts shall be considered unserviceable and scrapped, if during a sudden stoppage inspection any of the following conditions, which are attributed to sudden stoppage, are noted:*

[7] The Bell 206 100-hour progressive inspection is split into four Events at a 25-hour interval between each Event. The Bell 206 300-hour progressive inspection is split into six Events at a 50-hour interval between each Event.

a. Any impact damage to a tail rotor blade leading edge or skin, or any tail rotor blade skin buckling or tears.
b. Any deformation of any coupling discs that results in gaps between laminates greater than 0.015 inches (0.38 mm).
c. Structural failure or distortion of any coupling disc bolts.
d. Structural failure or distortion exceeding specified limits of tail rotor driveshaft steel or aluminum adapters.

The hard landing conditional inspection required that the tail rotor driveshaft assembly be removed and overhauled if damage to the fuselage structure or tail boom is such that a major repair alignment in a fixture is required, or if the landing gear crosstubes permanent set exceeded limits.

Lastly, the conditional inspection for engine compressor stall or surge, without a noticeable yaw during the surge/stall, required inspection of the bond lines on all bonded segmented drive shaft adapters for any evidence of cracks and voids as well as inspection criteria similar to the tail rotor sudden stoppage or acceleration condition inspection discussed above. If any defects were found, the condition inspection required that all bonded segmented driveshafts be scrapped.

3.3 Recurrent Proof Load Testing

Bell Alert Service Bulletin (ASB) Nos. 206-20-139 and 206L-20-184 required an initial and recurring visual inspection and proof load testing of installed segmented drive shafts with bonded adapters that were either 1.00-inch or 1.25-inch in diameter.[8, 9] The ASB contained two parts. Part I required, within the next 75 flight hours or 3 months after release of the bulletin, and every 300 flight hours or 12 months thereafter, a visual inspection of the bond line of the bonded adapters, application of an index mark on each bonded adapter, and a proof load test using a bonded shaft tool. **Attachments 1 and 2** of this report contains Bell ASB Nos. 206-20-139 and 206L-20-184, respectively.

On June 15, 2022, Transport Canada released Airworthiness Directive (AD) No. CF-2022-33, which required accomplishment of Bell ASB No. 206-20-139. Subsequently, on March 16, 2023, the FAA released AD No. 2023-06-05, which required compliance with aspects of Transport Canada AD No. CF-2022-33. **Attachments 3 and 4** of this report contains the ADs issued by Transport Canada and the FAA, respectively.

[8] Bell ASB No. 206-20-139 applied to the 206A, 206B, and TH-67 helicopters. Bell ASB No. 206L-20-184 applied to the 206L, 206L-1, 206L-3, and 206L-4 helicopters.
[9] The affected P/Ns were 206-040-330-003/-101; 206-040-365-001/-101/-105/-117/-121/-123/-125; 206-040-369-001/-101; and 206-040-931-009/-011/-101/-103.

3.4 Accident Drive Shaft Inspection History

Based on the accident helicopter's maintenance records, the last 100-hour inspection was accomplished on September 30, 2022, at an ATT of 26,191.4 hours (the accident flight was the postmaintenance check flight). On August 11, 2022, at an ATT of 26,113.7 hours, multiple inspections were accomplished, including 100-hour airframe and engine inspections, 300-hour airframe and engine inspections, and Part I of ASB No. 206-20-139. Between the time of the release of ASB No. 206-20-139 until the date of the accident, the operator accomplished Part I of the ASB a total of four times (**Table 1**). According to helicopter records, about 77.7 hours elapsed between the last accomplishment of Part I of ASB No. 206-20-139 until the time of the accident.

Table 1. The historical accomplishment of ASB No. 206-20-139 on N284CA.

Date	***ATT***	***Event***
October 1, 2022	26,191.4	Accident date
August 11, 2022	26,113.7	Accomplished Part I of ASB No. 206-20-139
January 20, 2022	25,830.7	Accomplished Part I of ASB No. 206-20-139
April 14, 2021	25,547.3	Accomplished Part I of ASB No. 206-20-139
September 29, 2020	25,255.6	Accomplished Part I of ASB No. 206-20-139
July 21, 2020	25,078.9	Release of ASB No. 206-20-139

The segmented drive shafts are not life limited and therefore are not required to be tracked after manufacture. Thus, the accident No. 4 segmented drive shaft's time in service could not be determined. Additionally, Bell could not find a record of the "VN12657" serial number observed on the splined adapter. Therefore, the manufacture date for the accident No. 4 segmented drive shaft could not be estimated.

3.5 Accident Drive Shaft Proof Load Testing

The operator's director of maintenance stated that they used a bonded shaft tool sourced from Helicopter Work Aids in Pineville, Louisiana, to accomplish Part I of ASB No. 206-20-139. Additionally, a second tool, containing internal splines, was installed on the oil cooler drive shaft to hold the tail rotor drive line while the bonded shaft tool was used to apply the proof load. **Figure 3** shows the bonded shaft tool and the splined tool utilized by the operator to accomplish the proof load test. Examination of the bonded shaft tool used by the operator found the dimension between the square drive to the centers of the bolt holes was about 3.019 inches (**Figure 4**). According to Bell ASB No. 206-20-139 and 206L-20-184, the bonded shaft tool may be ordered or locally manufactured. The ASB provided the dimensions of the bonded shaft tool[10] for local manufacture, which was to have a 3.00-inch distance between the square drive to the centers of the bolt holes.

[10] See Figure 1 within ASB No. 206-20-139, provided as **Attachment 1** of this report.

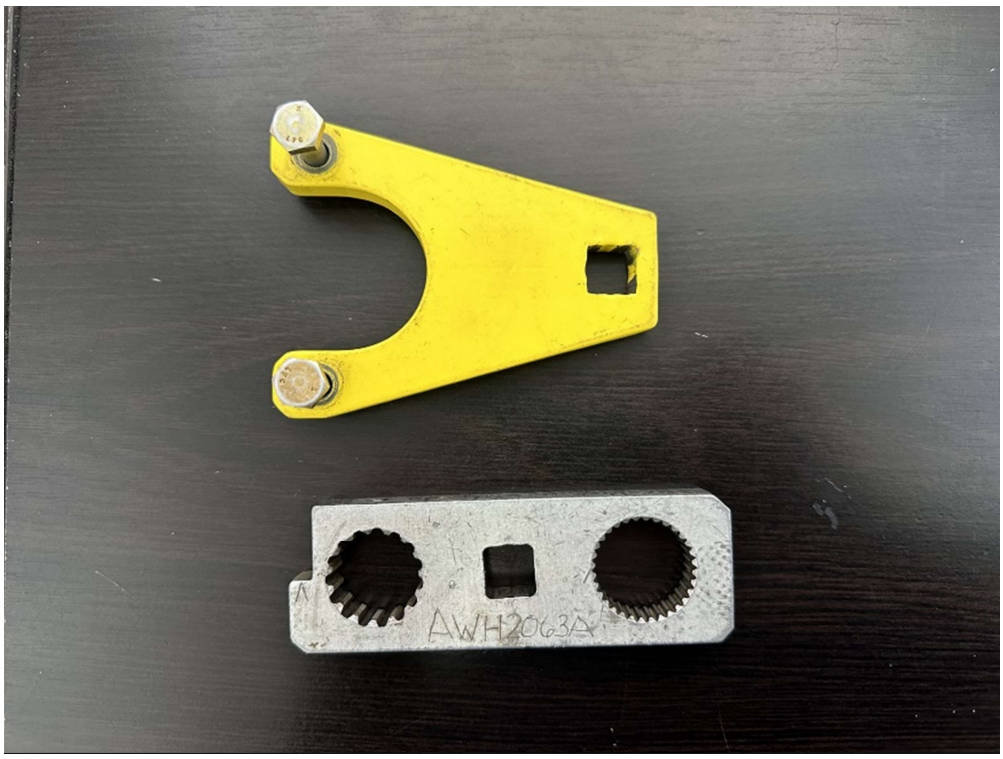

Figure 3. The tools used by the operator to accomplish the proof load test. (Image courtesy of Organ Mountain Aviation Company)

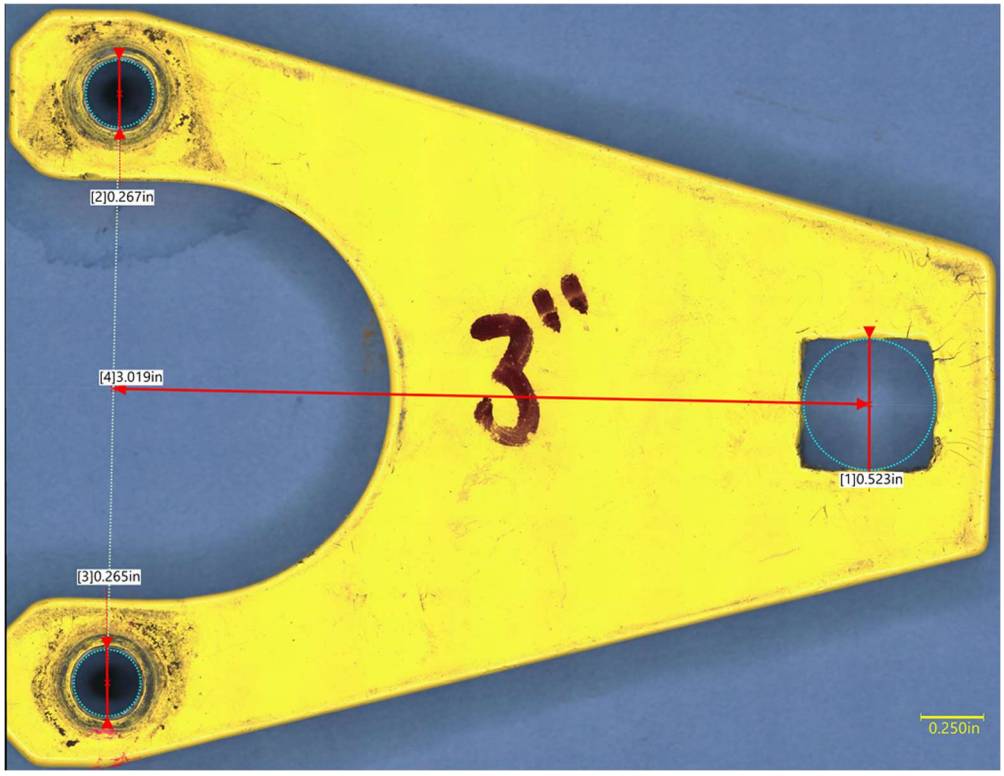

Figure 4. Measurement of the bonded shaft tool.

4.0 Past Occurrences of Segmented Drive Shaft Disbonds

According to Bell, for the 206A and 206B, between 1986 to 2023 there have been 16 known occurrences, including the N284CA accident, involving a segmented drive shaft with bonded adapters that had experienced a disbond in service. Of the 16 occurrences, 11 did not have a known cause for the disbond, primarily due to damage to the bond surfaces after the disbond occurred which precluded identification of a failure mode. For the remaining 5 disbond occurrences, 3 were attributed to the reuse of a segmented drive shaft after a known tail rotor sudden stoppage, 1 was attributed to damage to the adhesive due to media blasting of the drive shaft, and 1 was attributed to inadequate adhesive on the bond surfaces at manufacture.

E LIST OF ATTACHMENTS

1. Bell Alert Service Bulletin No. 206-20-139 Revision A
2. Bell Alert Service Bulletin No. 206L-20-184 Revision C
3. Transport Canada Airworthiness Directive No. CF-2022-33
4. Federal Aviation Administration Airworthiness Directive No. 2023-06-05

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