Aviation Investigation Final Report

Location:	Clewiston, Florida	**Incident Number:**	ENG20LA031
Date & Time:	May 3, 2020, 13:15 Local	**Registration:**	N1WT
Aircraft:	Airbus Helicopters AS350	**Aircraft Damage:**	None
Defining Event:	Flight control sys malf/fail	**Injuries:**	1 None
Flight Conducted Under:	Part 91: General aviation - Personal		

Analysis

The No. 2 hydraulic system (HYD2) pulley bearing likely failed due to being installed skewed onto its pulley, resulting in abnormal bearing loads which led to its premature failure. The plastic deformation observed on the raceways and rolling elements, as well as contact damage on the bearing cage, were consistent with sliding of the rolling elements against the raceways and cage due to abnormal loading and forced rotation of a seized bearing.

The seizure of the HYD2 pulley bearing led to the deterioration of the drive belt, resulting in its failure and the subsequent loss of hydraulic pressure in HYD2. Loss of hydraulic assistance from HYD2, which included the tail rotor servo control, resulted in higher pedal forces to control the helicopter in the yaw axis. It is likely the HYD2 pulley bearing did not show obvious visual evidence of deterioration during past inspections, including the last scheduled inspection about 13 flight hours prior to the incident, and visual detection of the deteriorating bearing may not have been possible without removal of the bearing from the pulley.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this incident to be:

Seizure of the hydraulic pump pulley bearing due to its improper installation by the manufacturer, leading to a failure of the hydraulic pump belt and the resultant partial loss of hydraulic assistance to the pedals.

Findings

Aircraft	Pump, main - Failure
Aircraft	Pump, main - Incorrect service/maintenance

Factual Information

History of Flight

Approach-VFR pattern downwind	Flight control sys malf/fail (Defining event)

HISTORY OF FLIGHT

On May 3, 2020, about 1315 eastern daylight time, an Airbus Helicopters AS350 B3 helicopter, N1WT, made an emergency landing at Airglades Airport (2IS) in Clewiston, Florida. The pilot, the only occupant on board, reported an inflight hydraulics anomaly and declared an emergency. The pilot subsequently landed at 2IS. The pilot reported no injuries and the helicopter was not substantially damaged. The flight was conducted under the provisions of Title 14 *Code of Federal Regulations* Part 91, which began at Fort Lauderdale Executive Airport (FXE), landed at Palm Beach County Park Airport (LNA), and subsequently departed LNA for 2IS.

According to the pilot's written statement to the Federal Aviation Administration, he reported that upon entering the left downwind for runway 13 at 2IS, the pedals felt "rock hard" and the "HYD2" and "SERVO" caution lights illuminated on the caution and warning panel. The pilot reported light smoke in the cockpit along with an odor of "something burnt," and opened the window to clear the smoke and odor. The pilot executed a shallow approach to a run-on landing at 2IS.

DAMAGE TO THE HELICOPTER

An AS350 B3 equipped with a dual hydraulic system has two hydraulic pumps that each provide hydraulic pressure to their respective [independent] hydraulic system. The hydraulic pump for the No. 1 hydraulic system (HYD1) is located at the forward side of the main gearbox and is driven directly by the main gearbox. The hydraulic pump for the No. 2 hydraulic system (HYD2) is belt-driven by the hydraulic pump drive assembly. The hydraulic pump drive assembly, located near the aft-right side of the main gearbox, is composed of the hydraulic pump pulley, a drive coupling, and a driveshaft that ultimately powers the hydraulic pump.

A postlanding inspection of the incident helicopter identified the HYD2 belt had fractured, with significant wear on localized sections of the belt grooves. Remnant belt material was observed on the grooves of the HYD2 pump pulley and on the transmission deck, below the belt's normally installed location. Additionally, the grooves of the pulley exhibited a blackened appearance consistent with overheating. The HYD2 pump pulley and its bearing would not rotate freely when turned by hand. The HYD2 drive assembly, the HYD2 pump and its pulley assembly, and the belt were retained for further examination.

TEST AND RESEARCH

The HYD2 pulley bearing, part number (P/N) 704A33-651-269 and serial number (S/N) 15-15733, was a double-row ball bearing that was introduced onto the AS350-series helicopter via modification (MOD) 07-9568. The bearing is composed of a single-piece, double-row inner ring; two outer rings; a single-piece cage; and 14 balls (spherical rolling elements) in each row for a total of 28 balls. Bearing sealing flanges, also known as a bearing shield, covered the roller elements and its cage on both sides of the bearing for a total of two sealing flanges per bearing. Each bearing sealing flange contained four distinct locations with pre-drilled greasing holes, to be used to add grease to the bearing.

The retained HYD2 components were shipped to Airbus Helicopters' materials laboratory in Marignane, France for examination. The hydraulic pump, once removed from the pulley assembly, was able to be rotated by using its driveshaft, with no evidence of binding or restriction during rotation. The pulley bearing's visible surfaces were thermally discolored. The bearing was removed from the pulley, revealing smearing damage found within a 140° arc on the inner diameter of the pulley, along with residual grease (see *Figure 1*). The direction of the smearing damage was parallel to the bearing's rotational axis. Additionally, longitudinal scratches, also parallel to the bearing's rotational axis, was observed on the inner diameter of the bearing inner ring. The bearing was disassembled and its inner ring, outer rings, cage, and rolling elements exhibited a black-colored residue consistent with thermally degraded grease (see *Figure 2*). After cleaning the inner and outer rings and the rolling elements, examination of their surfaces revealed plastic deformation as well as cage material transfer on the raceways. The cage showed evidence of abnormal contact damage between it and the rolling elements. Hardness testing of the undamaged portions of the inner ring, outer ring, and rolling elements revealed they met drawing requirements.

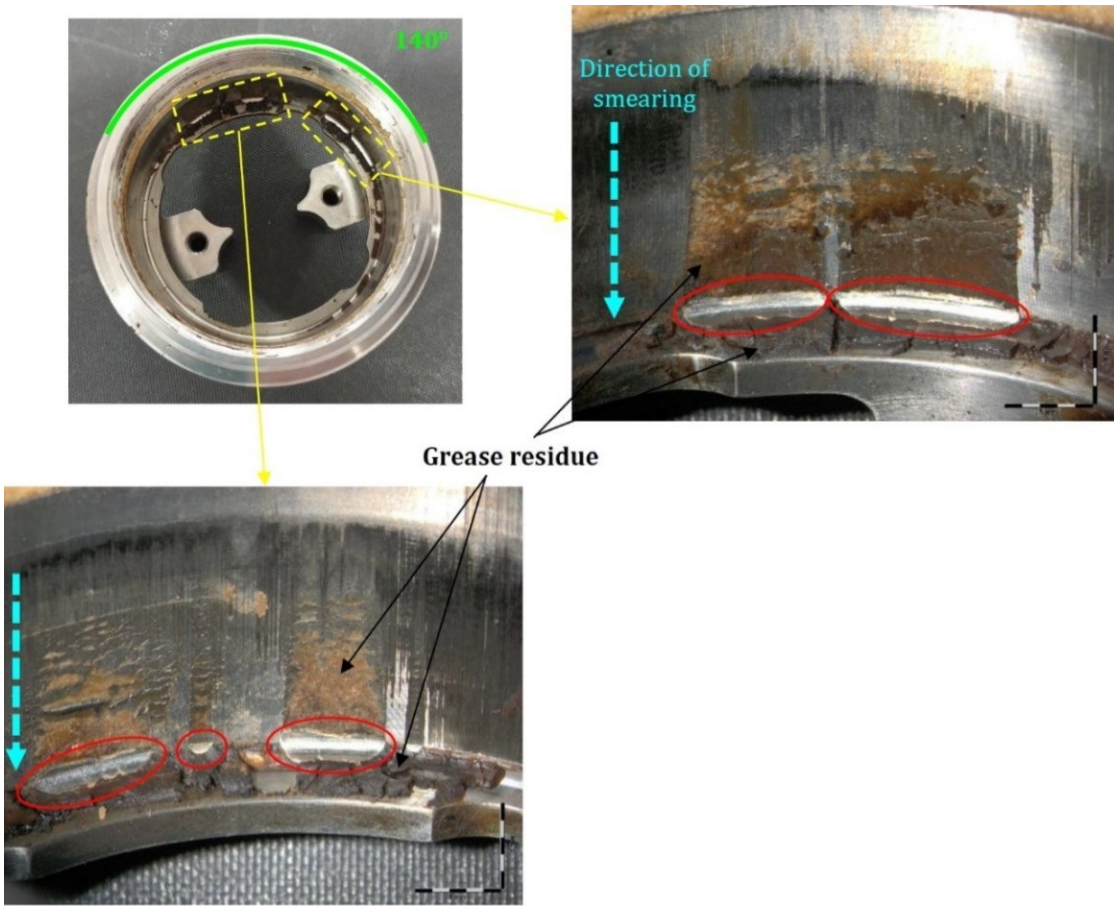

Figure 1. Longitudinal smearing damage observed on the inner diameter of the pulley. (Image courtesy of Airbus Helicopters)

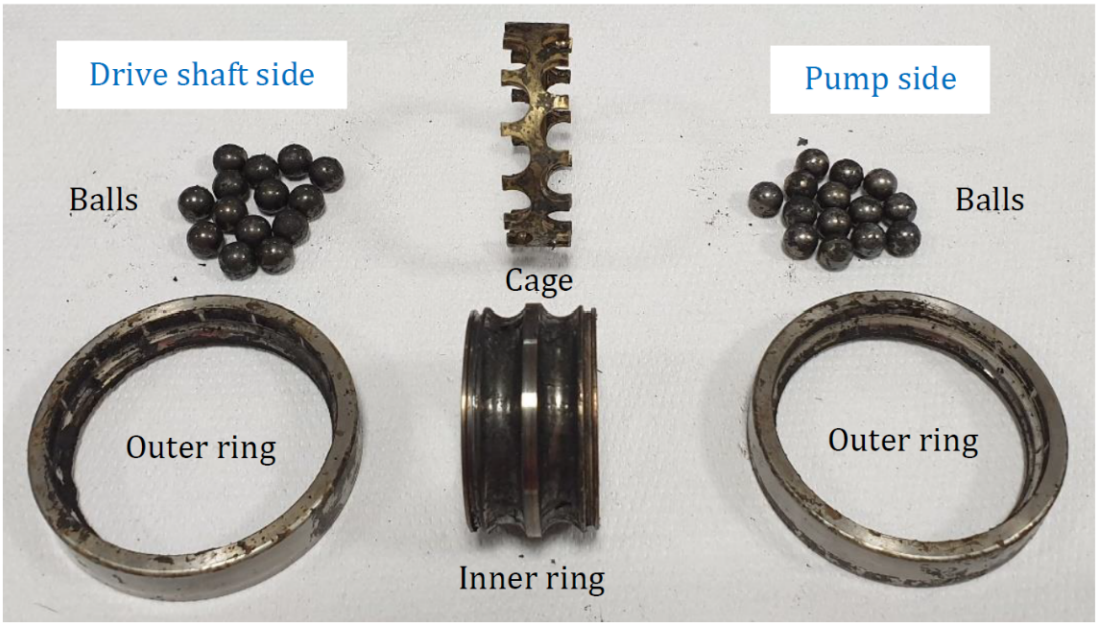

Figure 2. A view of the incident pulley bearing subcomponents. (Image courtesy of Airbus Helicopters)

Several sealing flange regreasing holes from the incident bearing were dented, giving the appearance of past insertion of a greasing syringe. Based on a comparison of exemplar bearings' sealing flanges, both prior to and after insertion of a greasing syringe, the post-insertion holes did not show distinctive differences. Thus, it could not be determined if the incident bearing sealing flanges had a dented appearance due to prior regreasing, due to damage from the incident, or because it was its preexisting condition.

According to Airbus Helicopters, prior to installation of the bearing onto the pulley, the pulley must be heated to about 110° Celsius to ensure proper fit and alignment of the bearing. Airbus investigators performed a test using the bearing installation tools and an exemplar pulley and bearing to install the bearing without preheating the pulley. When the test installation was performed, the bearing installation was skewed. Removal of the bearing found smearing damage on the pulley, similar to the incident components. At the time of the incident, there was no postinstallation inspection requirement to ensure the bearing was properly seated on the pulley shoulder. Based on the findings developed during this investigation, Airbus Helicopters instituted, as an interim measure until a permanent corrective action is developed, a postinstallation check in their facility to verify proper seating of the bearing using a shim to detect any clearance between the bearing ring and pulley shoulder. At the time of this report, Airbus Helicopters is exploring options for an in-situ check for pulley bearings currently installed in the AS350-series fleet.

ADDITIONAL INFORMATION

N1WT Maintenance History

According to maintenance records, on March 27, 2019, the incident helicopter was located at Airbus Helicopters' facility in Columbus, Mississippi undergoing final assembly and production completion. All inspections discussed in this section were performed by Airbus Helicopters unless otherwise specified. According to the AS350 B3 master servicing manual, the 12-month/150-flight hour inspection required a visual inspection of the hydraulic pump pulley bearing and a check of the drive belt tension.

On June 20, 2019, at an aircraft total time (ATT) of 3.3 hours, the main gearbox assembly, including attached components such as the hydraulic pump assembly, was removed and replaced due to suspected contamination. A replacement main gearbox assembly, which included the incident HYD2 pump and pulley bearing, was installed. All components in the replacement main gearbox assembly were new. On October 24, 2019 at an ATT of 3.3 hours, multiple inspections were performed, including the 12-month/150-flight hour visual inspection of the hydraulic pump belt and pulley bearing. No discrepancies were noted for the hydraulic pump belt and pulley bearing. On November 4,2019, a functional check flight was performed, after which several items were noted in a discrepancy/task sheet, including an entry to wipe hydraulic pump grease from the transmission deck, the right-side cowling, and the main gearbox coupling, which was completed the next day. The helicopter had an ATT of 5.3 hours at the conclusion of the functional check flight.

The incident helicopter was subsequently flown to Airbus Helicopters' facility in Grand Prairie, Texas in mid-November of 2019. On January 30, 2020, at an ATT of 17.8 hours, the 12-month/150-flight hour inspections were performed in Grand Prairie, including the visual inspection of the hydraulic pump belt and pulley bearing. No discrepancies were noted for the hydraulic pump belt and pulley bearing. Maintenance entries by Rotortech Services in West Palm Beach, Florida, began on February 21, 2020 at an ATT of 32.3 hours. On April 28, 2020, at an ATT of 95.0 hours, multiple inspections were performed by Rotortech Services, including the 12-month/150-flight hour inspections of the hydraulic pump belt and pulley bearing. No discrepancies were noted for the hydraulic pump belt and pulley bearing. The last maintenance entry prior to the incident, performed by Rotortech Services on May 1, 2020 at an ATT of 103.2 hours, was a main rotor mast retorque. The helicopter had accumulated an ATT of about 108 hours at the time of the incident.

AS350 B3 Dual Hydraulic System

The AS350 B3 dual hydraulic system was designed to provide hydraulic assistance redundancy to the main rotor servo controls when there is a fault or failure of one of the hydraulic systems. The tail rotor servo control and the yaw load compensator and its accumulator are powered only by HYD2, i.e. there is no tail rotor servo control redundancy in HYD1. The yaw load compensator and its accumulator comprise a closed-loop system that was designed to provide continuous hydraulic assistance to the pedals, specifically the right pedal (also known as the "power pedal" in clockwise rotating main rotors), in the event of a loss of pressure in HYD2. In this scenario, the forces on the pedals are higher than when the tail rotor servo control provides normal hydraulic assistance, but the hydraulic assistance from the yaw load compensator and its accumulator is designed to keep the right pedal forces at a manageable level. According to the emergency procedures contained in supplement 23 ("dual hydraulic system") of the AS350 B3 rotorcraft flight manual, the illumination of the "HYD2" and "SERVO" caution lights are indicative of a loss of pressure in HYD2. In this scenario, the emergency procedures state to land as soon as practicable and to perform a normal approach and landing.

Pilot Information

Certificate:	Student	**Age:**	27,Male
Airplane Rating(s):	None	**Seat Occupied:**	Right
Other Aircraft Rating(s):	None	**Restraint Used:**	4-point
Instrument Rating(s):	None	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	
Medical Certification:	Class 1 Without waivers/limitations	**Last FAA Medical Exam:**	December 16, 2019
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	
Flight Time:	125 hours (Total, all aircraft), 115 hours (Total, this make and model), 8 hours (Pilot In Command, all aircraft), 100 hours (Last 90 days, all aircraft), 30 hours (Last 30 days, all aircraft), 4 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Airbus Helicopters	**Registration:**	N1WT
Model/Series:	AS350 B3	**Aircraft Category:**	Helicopter
Year of Manufacture:	2018	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	8594
Landing Gear Type:	N/A; High skid	**Seats:**	
Date/Type of Last Inspection:		**Certified Max Gross Wt.:**	
Time Since Last Inspection:		**Engines:**	1 Turbo shaft
Airframe Total Time:		**Engine Manufacturer:**	Safran
ELT:		**Engine Model/Series:**	Arriel 2D
Registered Owner:	MACNEIL AVIATION LLC	**Rated Power:**	
Operator:	MACNEIL AVIATION LLC	**Operating Certificate(s) Held:**	None

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:		**Distance from Accident Site:**	
Observation Time:		**Direction from Accident Site:**	
Lowest Cloud Condition:	Clear	**Visibility**	
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	8 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	110°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:		**Temperature/Dew Point:**	29.4°C / 26.7°C
Precipitation and Obscuration:			
Departure Point:	West Palm Beach, FL (LNA)	**Type of Flight Plan Filed:**	None
Destination:	Clewiston, FL	**Type of Clearance:**	None
Departure Time:		**Type of Airspace:**	Class G

Airport Information

Airport:	AIRGLADES 2IS	**Runway Surface Type:**	Asphalt
Airport Elevation:	20 ft msl	**Runway Surface Condition:**	Dry
Runway Used:	13/31	**IFR Approach:**	None
Runway Length/Width:	5902 ft / 75 ft	**VFR Approach/Landing:**	Full stop;Precautionary landing;Traffic pattern

Wreckage and Impact Information

Crew Injuries:	1 None	**Aircraft Damage:**	None
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 None	**Latitude, Longitude:**	26.735,-81.051109

Administrative Information

Investigator In Charge (IIC):	Shin, Chihoon
Additional Participating Persons:	Derrick Mayberry; FAA; Miramar, FL Seth Buttner; Airbus; Grand Prairie, TX Michel Martin; Airbus; Marignane Vincent Ecalle; BEA; Le Bourget
Original Publish Date:	December 20, 2021
Last Revision Date:	
Investigation Class:	Class 3
Note:	The NTSB did not travel to the scene of this incident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=101233