

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



ERA23FA070

MATERIALS LABORATORY

Factual Report 23-006

February 3, 2023

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A. ACCIDENT INFORMATION

Location: Charlotte, North Carolina
Date: November 22, 2022
Vehicle: Robinson R44, N7094J
Investigator: Ralph Hicks, AS-ERA and Van McKenny, AS-40

B. COMPONENTS EXAMINED

Swashplate assembly with attached pitch change link and yoke assemblies, main rotor blade pitch horn piece, and two forward upper flight control tube assemblies.

C. EXAMINATION PARTICIPANTS

Specialist Matthew R. Fox, Ph.D.
NTSB
Washington, DC

D. DETAILS OF THE EXAMINATION

An overall view of the submitted components is shown in figure 1. The forward left upper flight control tube assembly was separated from the corresponding lug on the swashplate assembly, and the attaching hardware was missing. The forward right upper flight control tube assembly had been disassembled from the swashplate before the parts were sent to the NTSB materials laboratory. The yoke and one of the pitch control end fittings was fractured, and both had rough matte gray fractures and deformation consistent with ductile overstress fracture. The pitch horn piece, which had been cut from the rest of the blade, included the mating side of the fractured pitch control end fitting.

A diagram from the Robinson R44 Illustrated Parts Catalog shows the hardware used to attach the upper flight control tube assemblies. As shown in figure 2, the control attachment at each of the three locations consist of a bolt, two flat washers, two hat-shaped spacers, a nut, and a palnut. As shown in the diagram, the hat-shaped spacers are oriented such that the "top" of the hat faces the bearing in the control end fitting, and the "brim" of the hat faces the attachment lug on one side of the fitting and a flat washer on the other. As measured on an exemplar spacer in the assembly, the outside diameter of the "brim" portion measured 0.560 inch, and the outside diameter of the center "hat" portion measured 0.387 inch.

Close views of the forward and aft sides of the swashplate are shown at the right in figure 1. The upper end fitting for the aft upper flight control tube was attached to the swashplate lug, but the attachment bolt was bent. Orange torque paint was intact on the pal nut, nut, washer, and lug surfaces.

The end fitting for the aft control was disassembled from the lug to facilitate further analysis of the nut. The nut was analyzed using an Olympus Vanta x-ray fluorescence (XRF) alloy analyzer, and the analysis showed high levels of cadmium, consistent with a cadmium-plated nut such as an MS21042 nut. According to Robinson Helicopter Company Service Letter SL-50 dated October 13, 2014, MS21042 nuts on critical fasteners (such as those attaching the upper flight control tube assemblies to the swashplate assembly) should be replaced with a D210-series corrosion-resistant nut when performing maintenance that involves disassembly of that joint.

On the forward side of the swashplate assembly shown in figure 1, orange torque paint was observed on the palnut, nut, washer, and lug surfaces for the fixed link attachment on the center lug, and a remnant of red torque paint was observed on the lug surface adjacent to the orange stripe. A remnant of red torque paint was also observed on the forward right lug as indicated in figure 1. The submitted hardware for the forward right attachment included the bolt, washer, and spacers from the fitting side of the attachment and did not include hardware from the nut side of the attachment where the torque stripe is to be applied. No evidence of torque paint of any color was visible on the nut side of the forward left lug surface.

Closer views of the forward left lug on the swashplate assembly are shown in figure 3. The bore of the hole on the nut side of the lug was relatively shiny consistent with contact wear and had a circumferential imprint consistent with wear contact with a bolt thread. Areas of rubbing damage and multiple curved imprints were observed on the spacer contact face around the hole bore on the fitting side of the swashplate lug.

To facilitate further examination of contact marks on the fitting side of the forward left lug on the swashplate assembly, the lug was cleaned using a soft-bristle brush dipped in a solution of Alconox detergent and water then rinsed with water and methanol. The cleaned lug was then cut from the remainder of the swashplate using a handheld bandsaw, and cutting debris was removed using compressed air.

The cleaned and sectioned forward left lug was imaged using a Keyence VHX-7000 optical microscope using the stitching function and various lighting modes. A stitched image of the fitting-facing side of the lug is shown in figure 4 using the optical shadow mode. Various curved imprints on the surface are indicated with unlabeled arrows in figure 4.

A stitched image of the same lug face using the glare removal mode is shown in figure 5. A circle fitted to one of the two longest curved imprints, the imprint on the upper outboard quadrant of the contact face, had a radius of 0.196 inch and had a center that was offset upward and inboard of the attachment hole axis. A dashed line in figure 5 shows the circumference of the circle, which intersected another of the longest curved imprints that was located on the lower inboard quadrant of the lug

face. The circle outlined with a dashed line in figure 5 had a diameter of 0.392 inch, which is slightly larger than the outside diameter measured on the "top" portion of the exemplar hat-shaped spacer, which measured 0.387 inch.

Submitted by:

Matthew R. Fox, Ph.D.
Chief Technical Advisor - Materials

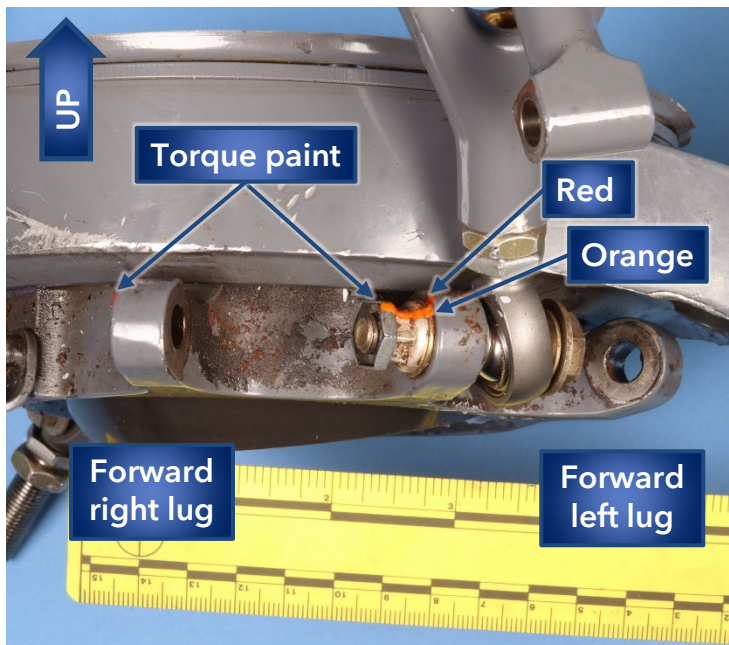
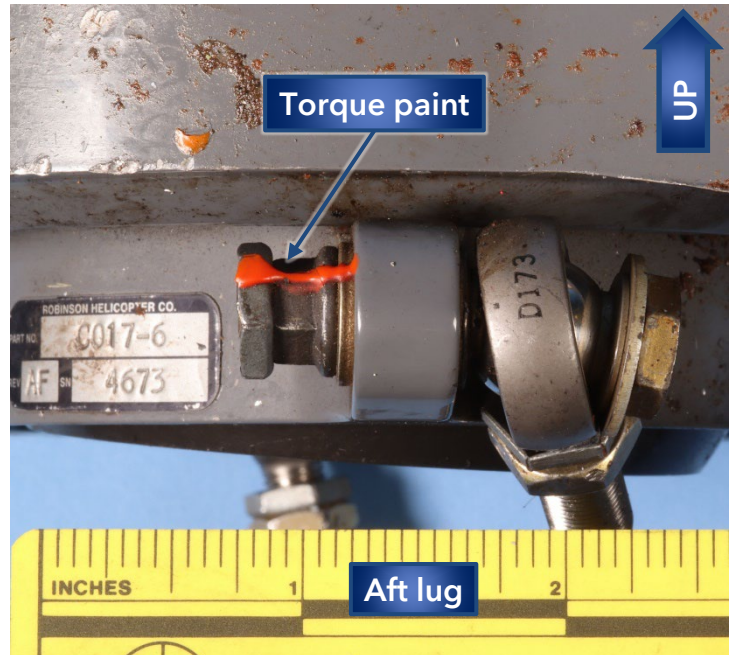


Figure 1. Overall view of the submitted components (left) with closer views of the flight control attachment lugs on the aft (upper right image) and forward (lower right image) sides of the swashplate assembly.

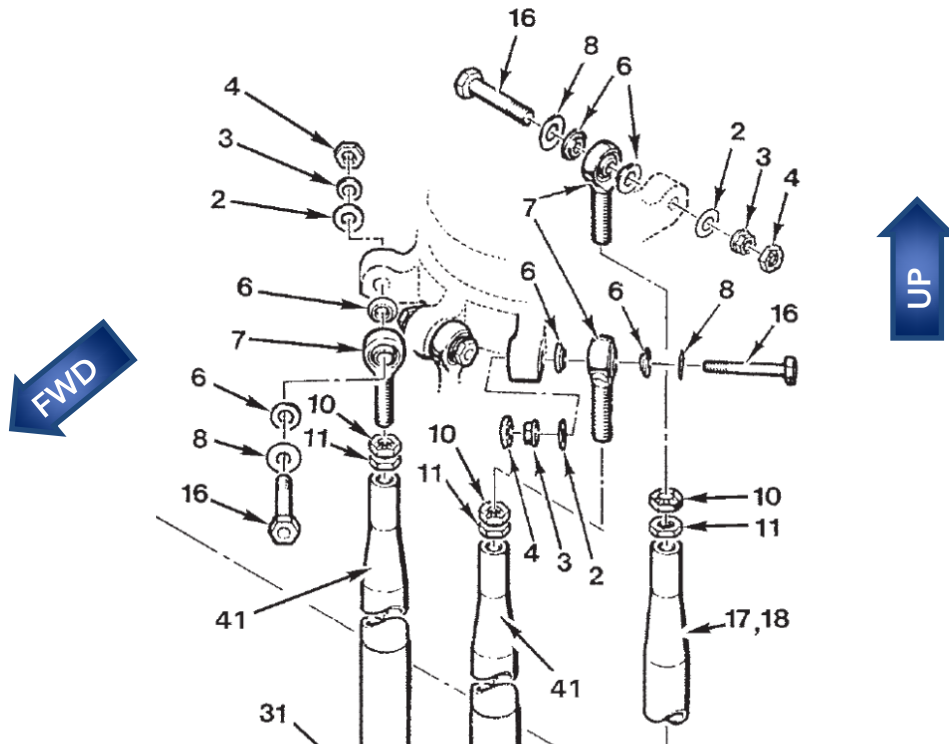


Figure 2. Diagram from the Robinson R44 Illustrated Parts Catalog showing the upper flight control tube assembly attachment to the swashplate assembly including the bolts (16), washers (2, 8), spacers (6), nut (3), and palnut (4).

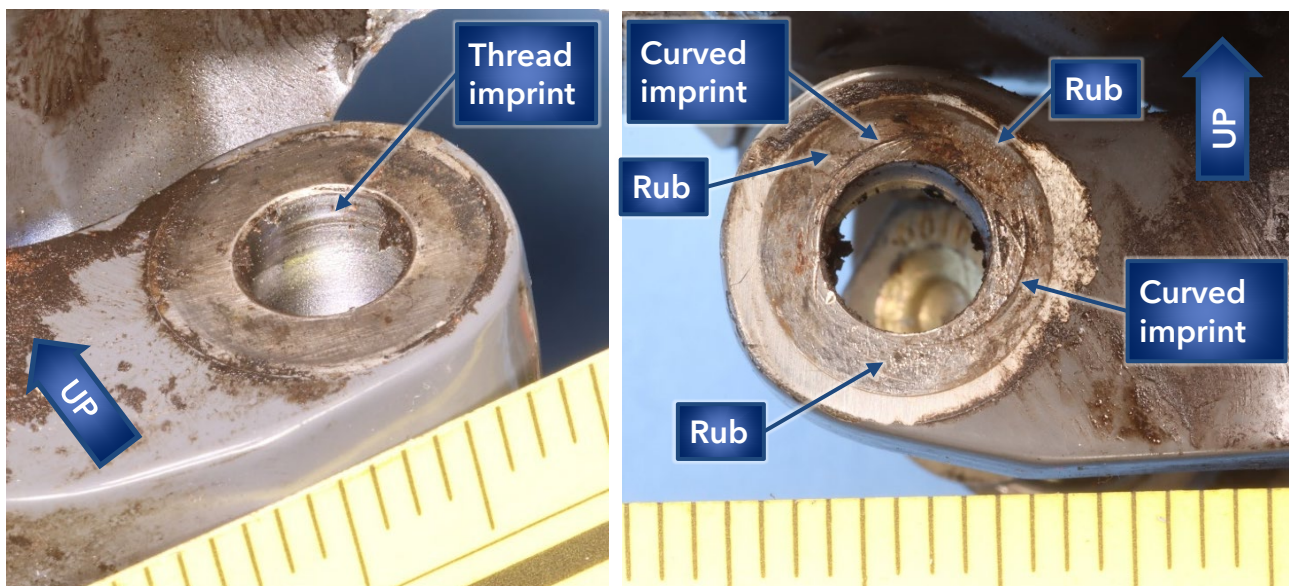


Figure 3. Close views of the swashplate lug for the forward left control attachment showing thread contact wear on the lug bore the right (nut-facing) side (left image) and rubbing damage and the two longest curved imprints around the hole bore on the left (fitting-facing) side (right image).

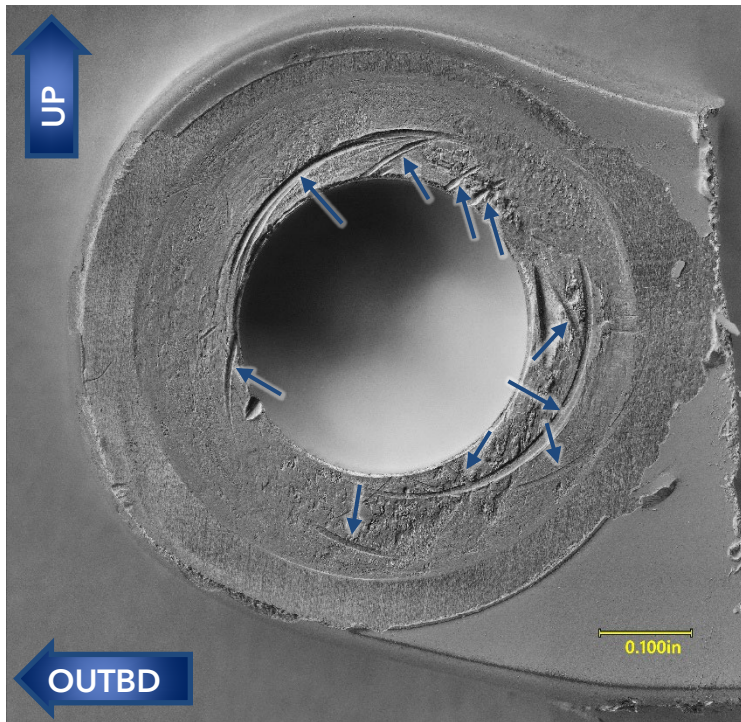


Figure 4. Stitched optical image of the cleaned forward left lug after sectioning as viewed using a Keyence VHX 7000 in shadow mode showing multiple impacts on the control fitting (left) side of the clamping face.

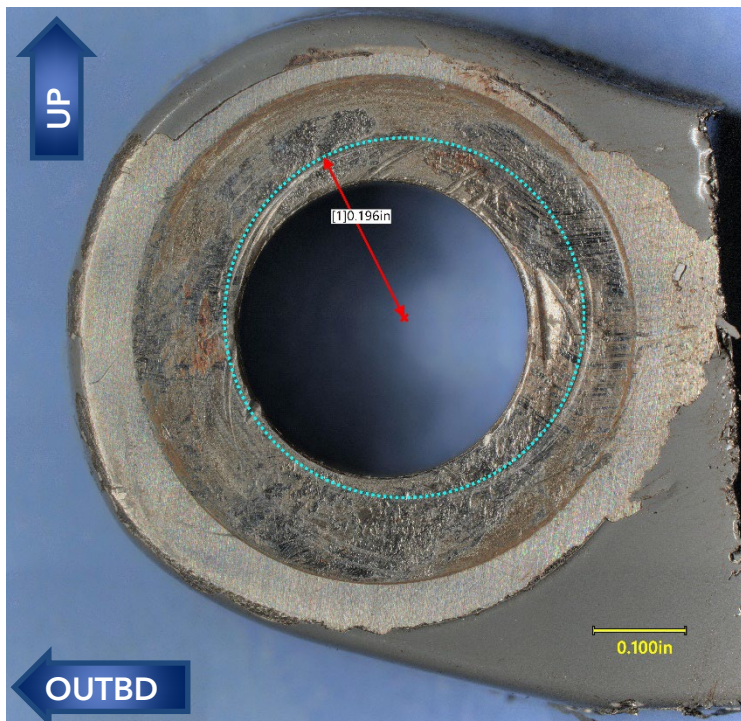


Figure 5. Stitched optical image of the cleaned forward left lug after sectioning as viewed using a Keyence VHX 7000 with glare removal measuring the radius of a circle defined by the edges of the two longest curved imprints.