NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594

February 29, 2016

MATERIALS LABORATORY FACTUAL REPORT Report No. 16-002

A. ACCIDENT INFORMATION

Place : Orlando, Florida
Date : March 22, 2015
Vehicle : Robinson R44 II, N30242
NTSB No. : ERA15FA164
Investigator : Eric Alleyne, ASI-ERA

B. COMPONENTS EXAMINED

1) Swashplate assembly with sectioned aft push-pull tube, sectioned front right push-pull tube, and lower scissor attached;
2) Upper portion of front left push-pull tube;
3) Two pieces of a main rotor blade.

C. DETAILS OF THE EXAMINATION

1. Swashplate and push-pull tube examination

A swashplate assembly and a portion of a push-pull tube were sent to the NTSB Materials Laboratory for examination. As indicated in figure 1, the swashplate assembly consisted of an upper swashplate and a lower swashplate. The lower swashplate had four push-pull tube attachment lugs: aft, front left, front right, and front scissor (middle). Push-pull tubes were connected to the aft attachment lug, front right attachment lug, and front scissor attachment lug. The front left push-pull tube was not attached to its corresponding lug, as shown in figures 2 and 3a, and the associated attachment bolt assembly was missing.

Notable events compiled from the maintenance and journey logs were as follows:

Date	Airframe time, hr	Event
12/28/2014	1186.1	100 hr inspection, pitch link replaced.
3/8/2015	1253.7	Track and balance performed.
3/22/2015	1267.5	Time at start of accident flight.

Push-pull tube rod ends are connected to the swashplate attachment lugs by a bolt assembly as illustrated in figure 3b. According to the R44 maintenance manual, the assembly consists of a bolt, safety washer, two spacers on either side of the rod end

ball bearing, washer, self-locking nut, palnut, and a torque stripe.[1] Remnants of torque striping were observed on the aft attachment lug bolt assembly but not on the forward right or front scissor lug bolt assemblies. The forward left attachment lug was examined for any remnant of a torque stripe but none was found.

The breakaway torque values of the palnuts and self-locking nuts were measured with a calibrated torque wrench. The bolts were all NAS 6605-17 bolts with a 5/16" diameter shank. The nuts were plated with cadmium, determined using a handheld X-ray fluorescence spectrometer, consistent with MS 21042L-series self-locking nuts. According to the R44 maintenance manual, self-locking nuts should be torqued to 240 in-lbs and palnuts should be torqued to between 20 in-lbs and 40 in-lbs. The measured breakaway torque values are shown in table 1. The breakaway torque values for the self-locking nuts ranged from 100 in-lbs to 170 in-lbs and the breakaway torque values for the palnuts ranged from 26 in-lbs to 37 in-lbs.

The lower swashplate attachment lug bolt holes were examined for indications of damage or deformation. For convenience, the side of the lug that butted up against the rod end was referred to as the "rod end-side" of the lug and the other side was referred to as the "opposite side." As shown in figure 5a, the rod end-side of the front left push-pull tube attachment lug exhibited approximately 0.008 inch of outward deformation along the outer lower portion of the bolt hole. There were no other notable features on the front left lug nor were there any signs of deformation on any of the other lugs (see figures 5b through 8).

2. Main rotor blade examination

Two pieces of a main rotor blade were also sent to the NTSB Materials Laboratory for examination as shown in figures 8a and 8b. The pieces consisted of an approximately 95-inch long section of blade from the outboard tip to a fracture through the spar at the inboard end and a smaller piece of the blade consisting of the trailing edge, upper and lower skins, and honeycomb core. The small piece was separated from the rest of the blade by a chordwise fracture approximately 80 inch from the blade tip and a longitudinal fracture that proceeded inboard just aft of the spar.

The deformation and fracture features on the blade were visually examined. The blade exhibited an aft bend that extended from the blade tip to the approximate position of the chordwise fracture, buckling of the upper and lower skins, and a comparatively severe forward bend at the inboard end, as indicated in figure 8b. The fracture at the inboard end of the spar (not shown) was located at a circular hole in the spar and exhibited 45° inclined fracture surfaces, consistent with an overstress fracture. The features were consistent with compressive buckling of the rotor blade.

The fracture features on the smaller piece of the blade are shown in greater detail in figures 9a and 9b. Along the outboard portion of the longitudinal fracture, the

[1] R44 Maintenance Manual and Instructions for Continued Airworthiness, Robinson Helicopter Company, Torrence, California, June 2014.

upper and lower blade skins were fractured aft of the spar. As the fracture progressed inboard, the path of separation transitioned to a disbondment between the skin and the spar, as indicated in figure 9a, consistent with a transition to a tearing mode. The transition from the chordwise fracture to the longitudinal fracture is shown in greater detail in figure 9b. The chordwise and longitudinal fractures formed a continuous curve, consistent with the primary fracture path. A branching crack, indicated in figure 9b, started at a 90° angle to the primary path and progressed outboard along the trailing edge of the spar approximately 2.5 inch. The observed features were consistent with the skin separation initiating at the trailing edge of the blade.

The fracture at the trailing edge was examined in greater detail as shown in figures 10a and 10b. The fracture at the trailing edge was comparatively straight and the paint was cracked adjacent to the fracture, as shown in figure 10a. The fracture surfaces, the inboard half being shown in figure 10b, were inclined at 45° to the skin and were consistent with an overstress fracture. Notable features at the fracture included a blend along the trailing edge, as indicated in figure 10a, and the end of a metal strip in the inboard portion of the trailing edge, as indicated in figure 10b. The plane of the fracture coincided with the end of the strip, as the metal strip was not observed on the outboard half of the fracture.

Donald Kramer, Ph.D.
Sr. Materials Engineer

Table 1: Breakaway torque values for self-locking nuts and palnuts on the lower swashplate lugs.

Lower swashplate location	Self-locking nut breakaway torque, in-lbs	Palnut breakaway torque, in-lbs
Aft attachment lug	170	37
Front right attachment lug	100	28
Front scissor attachment lug	150	26

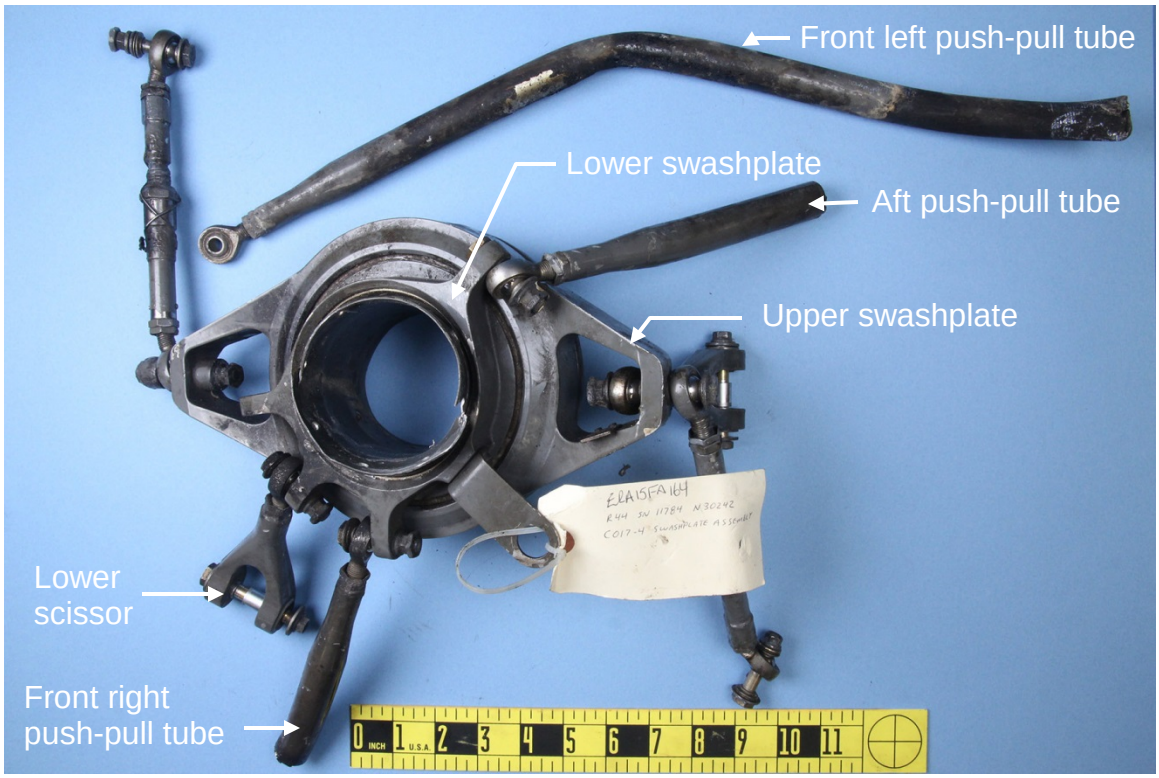


Figure 1: Image of the swashplate assembly and connecting rods as received. In the image, the assembly is oriented such that the lower swashplate is on top of the upper swashplate.

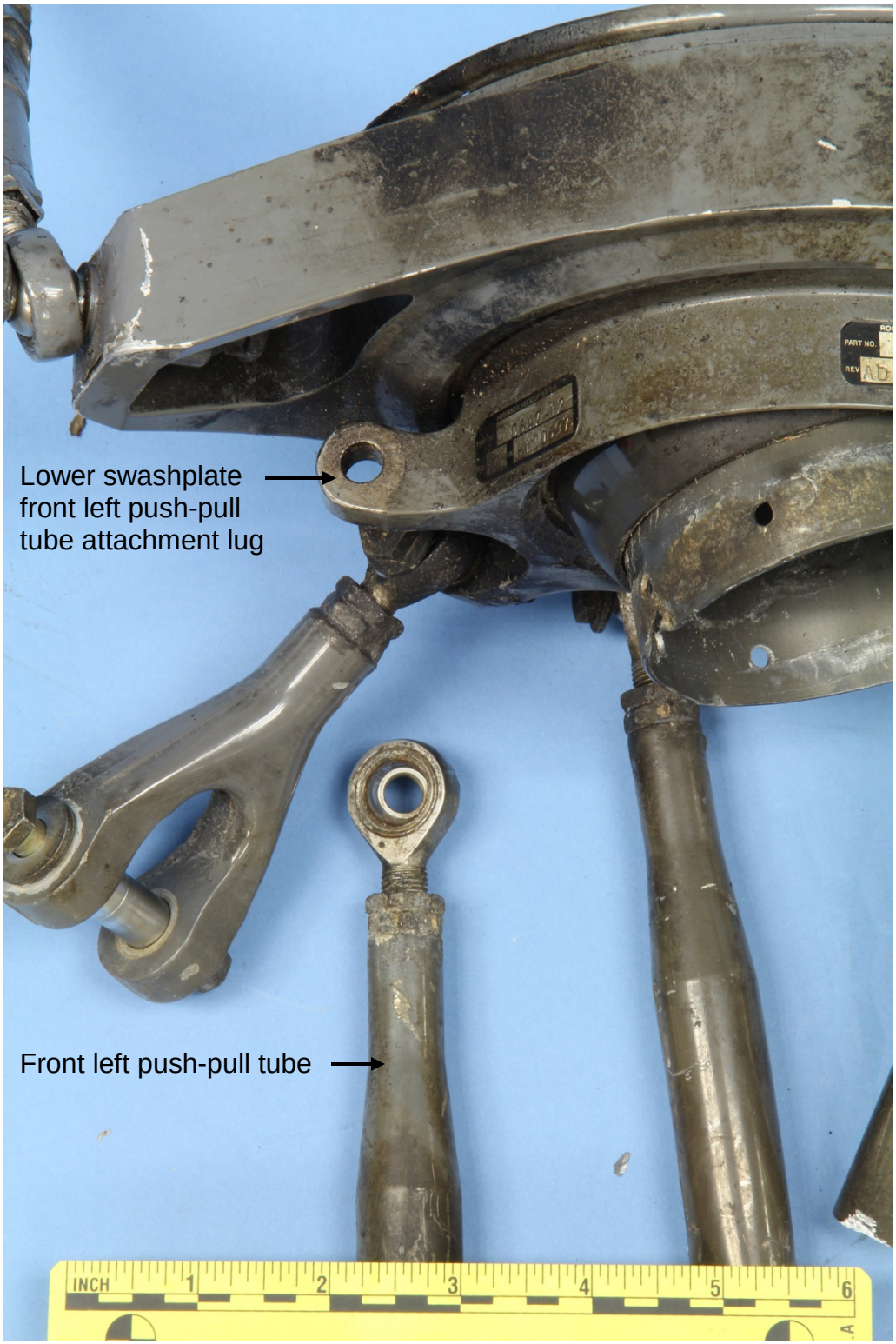
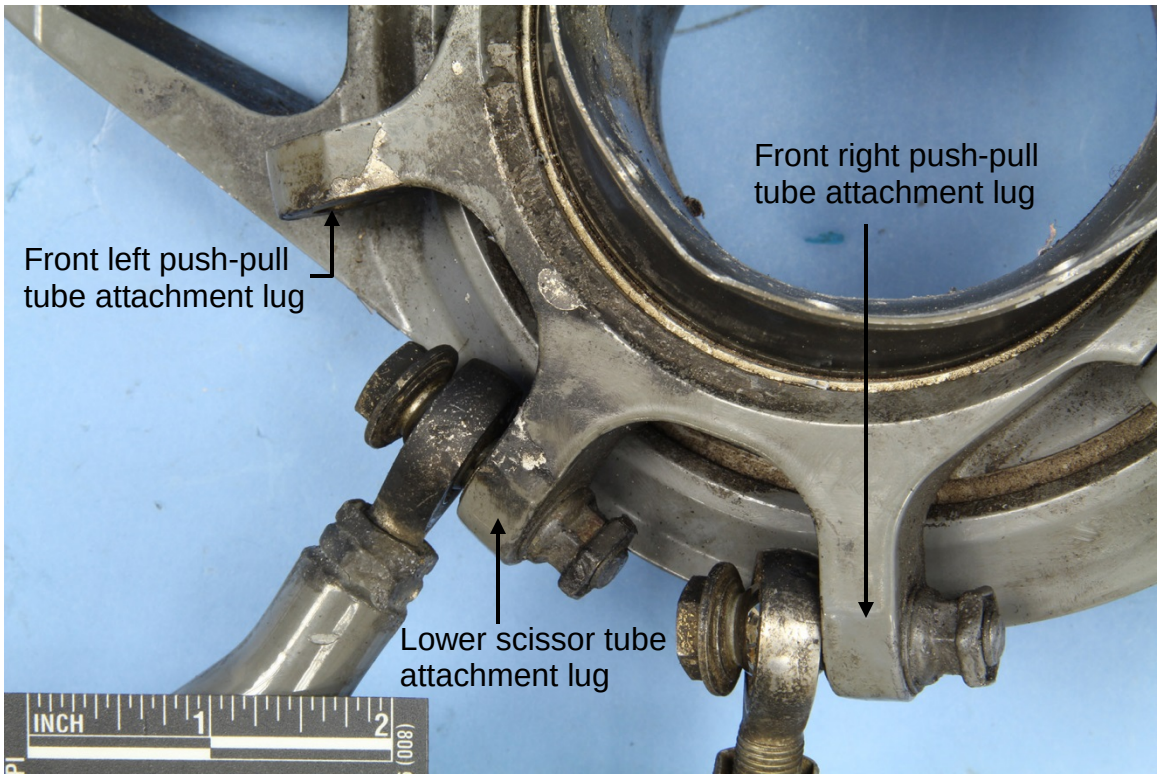


Figure 2: Side view of lower swashplate and front left push-pull tube, with missing front left push-pull tube rod end to attachment lug bolt assembly.

a)



b)

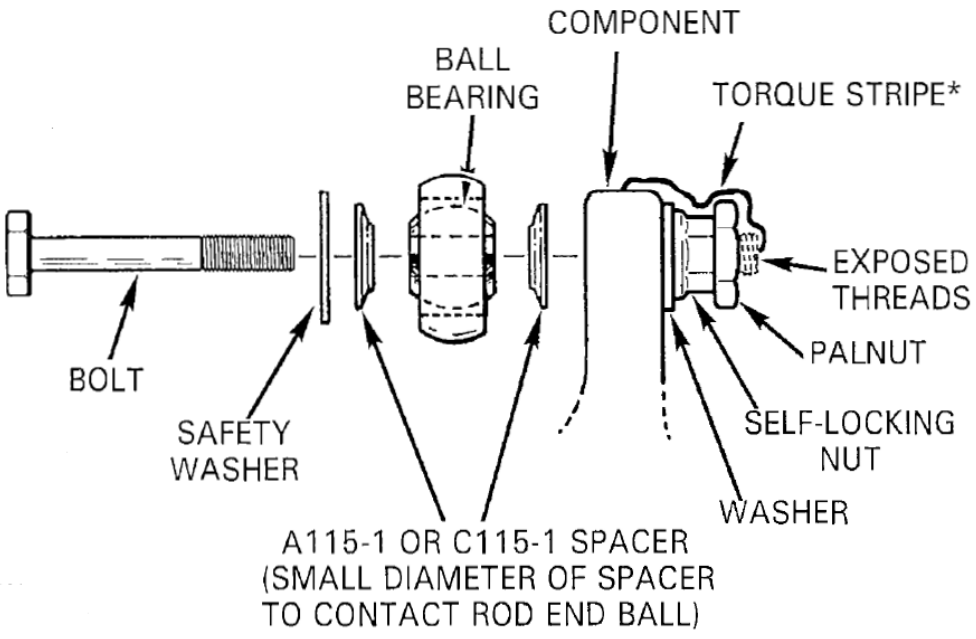
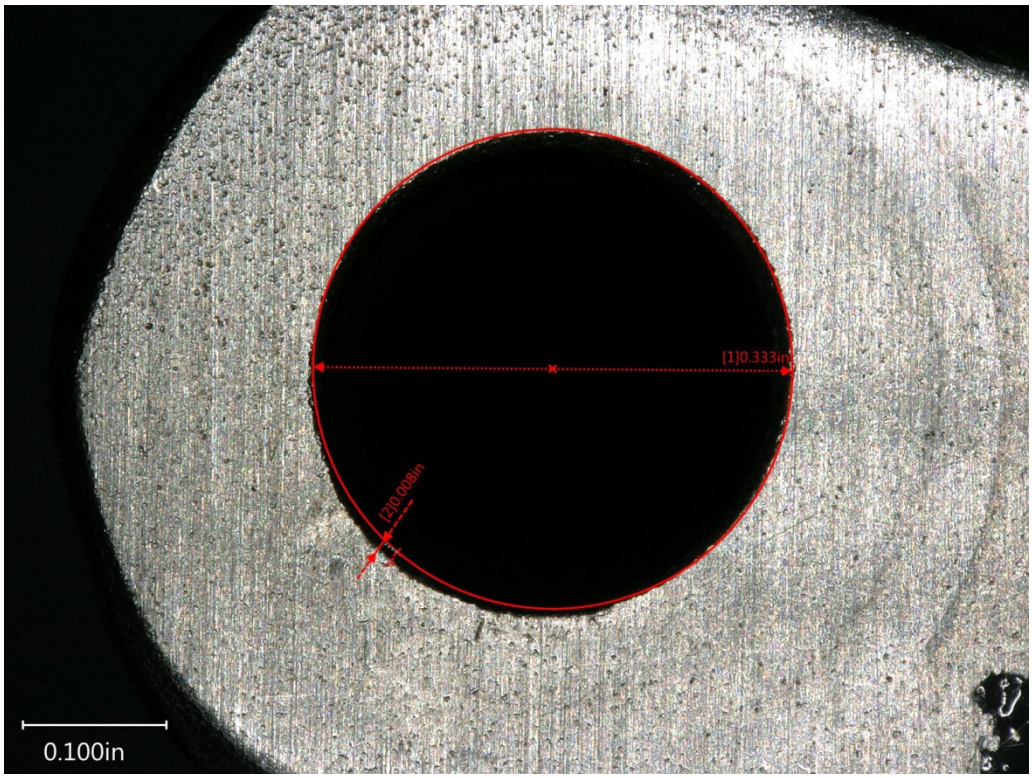


Figure 3: a) Image of the forward portion of the lower swashplate with missing front left push-pull tube rod end to attachment lug bolt assembly and b) schematic illustrating the rod end to attachment lug bolt assembly.

a)



b)

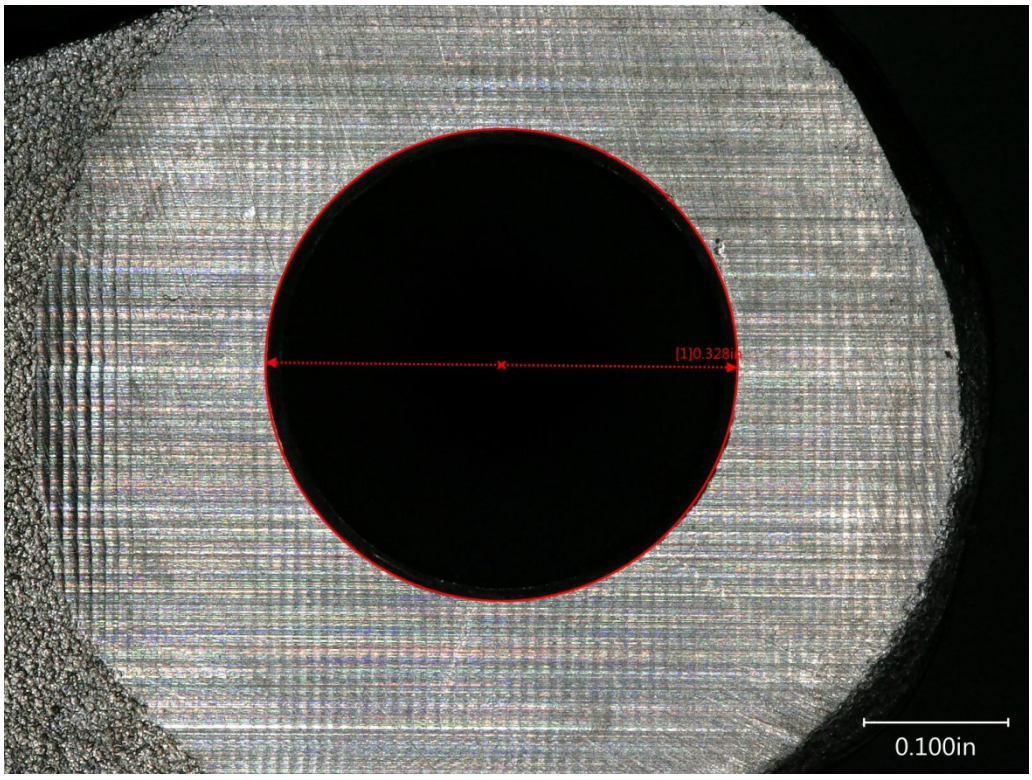
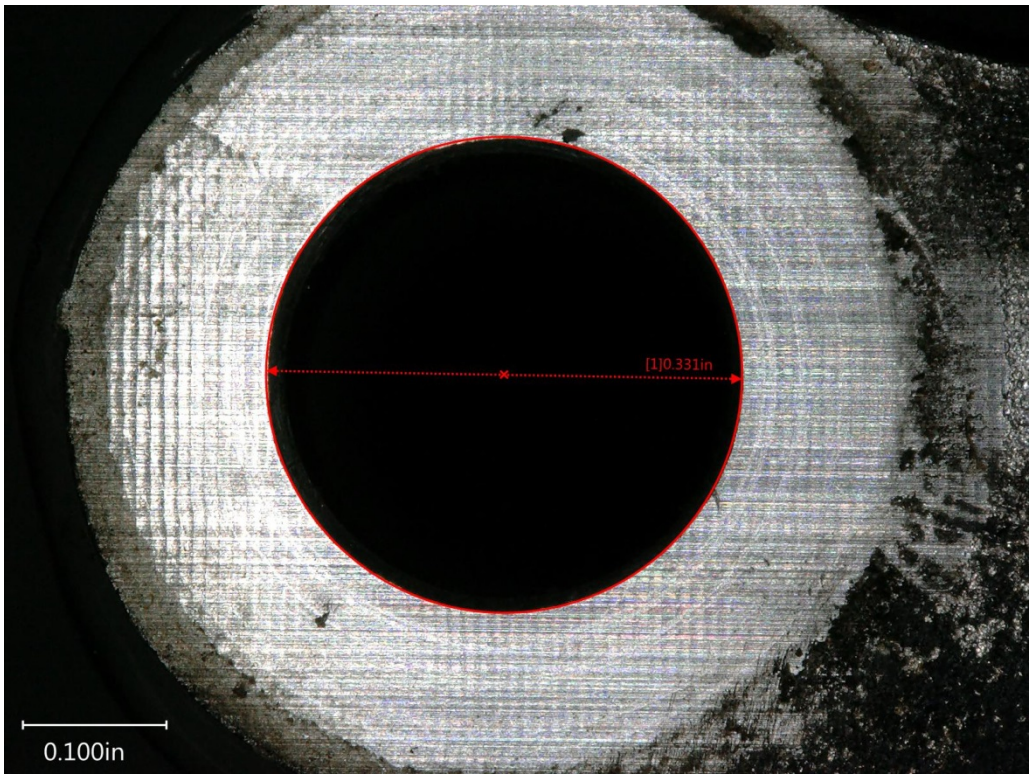


Figure 4: Lower swashplate front left push-pull tube attachment lug; a) rod end-side of lug; b) opposite side of lug.

a)



b)

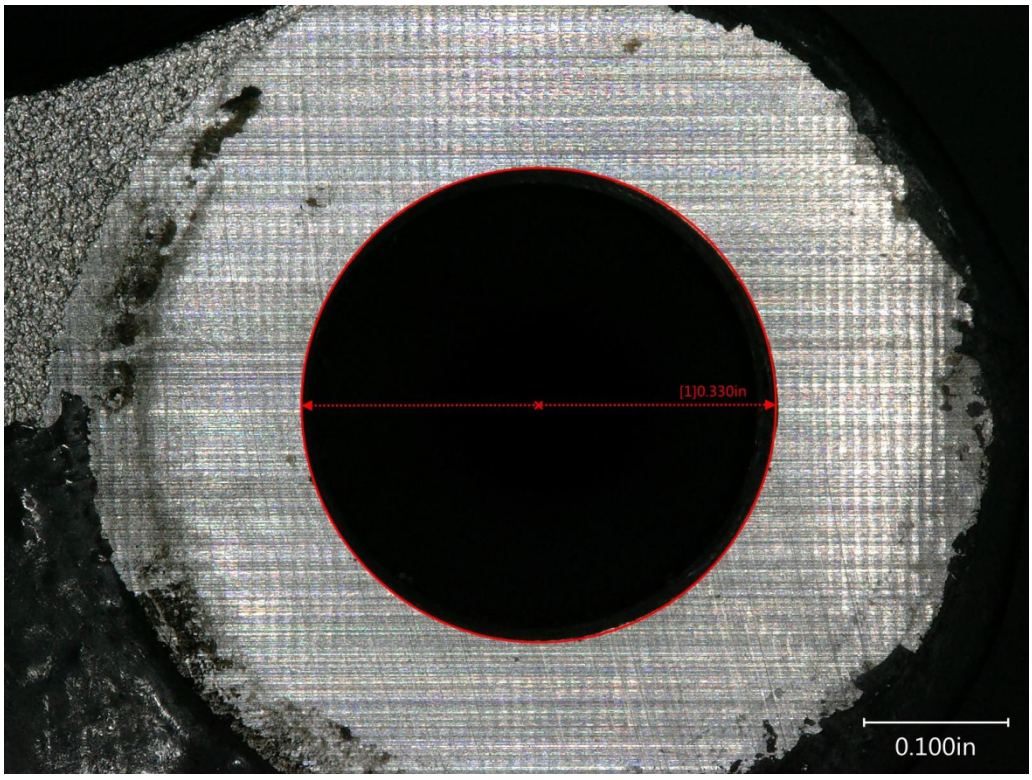
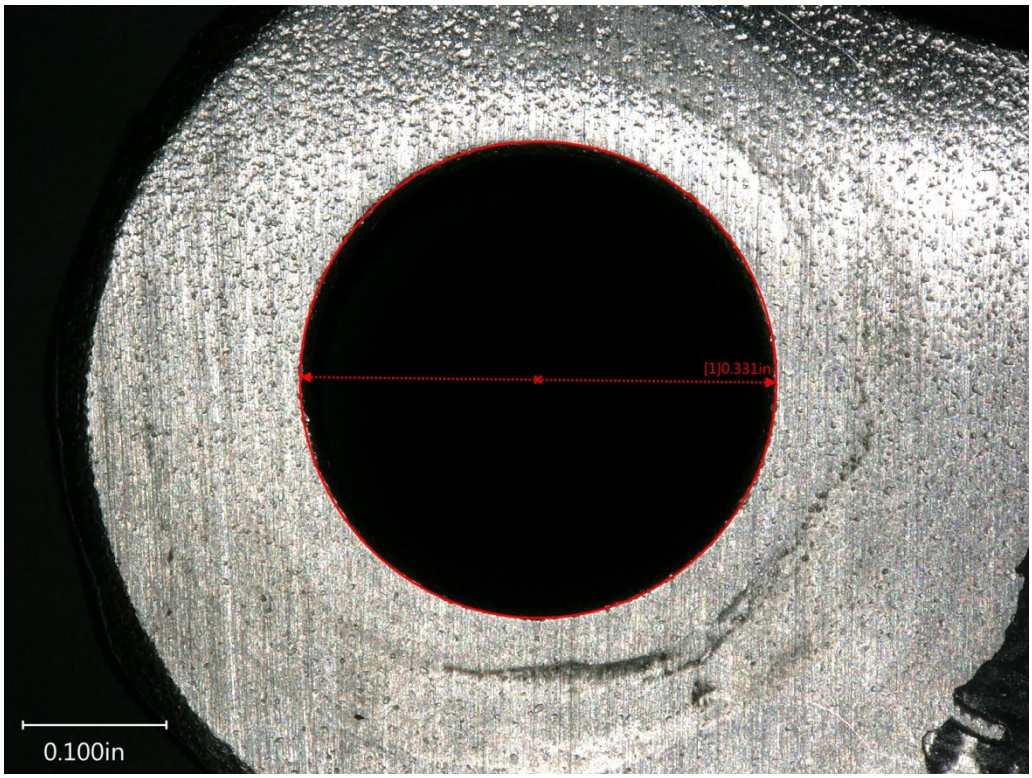


Figure 5: Lower swashplate scissor attachment lug, front-middle; a) rod end-side of lug; b) opposite side of lug.

a)



b)

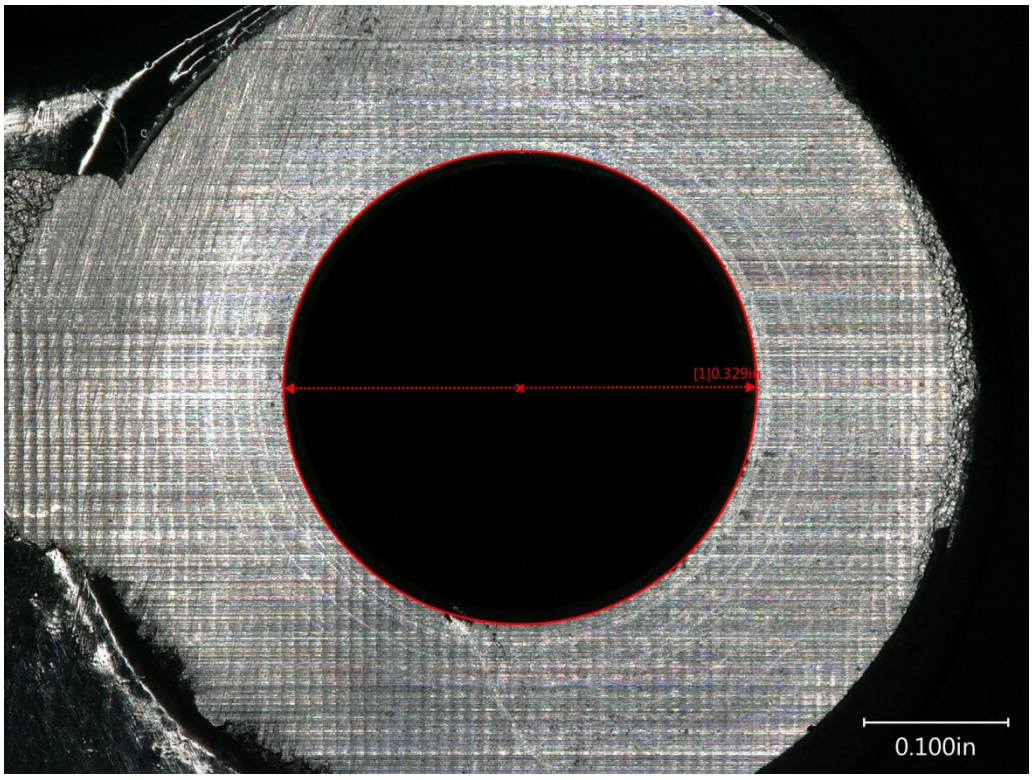
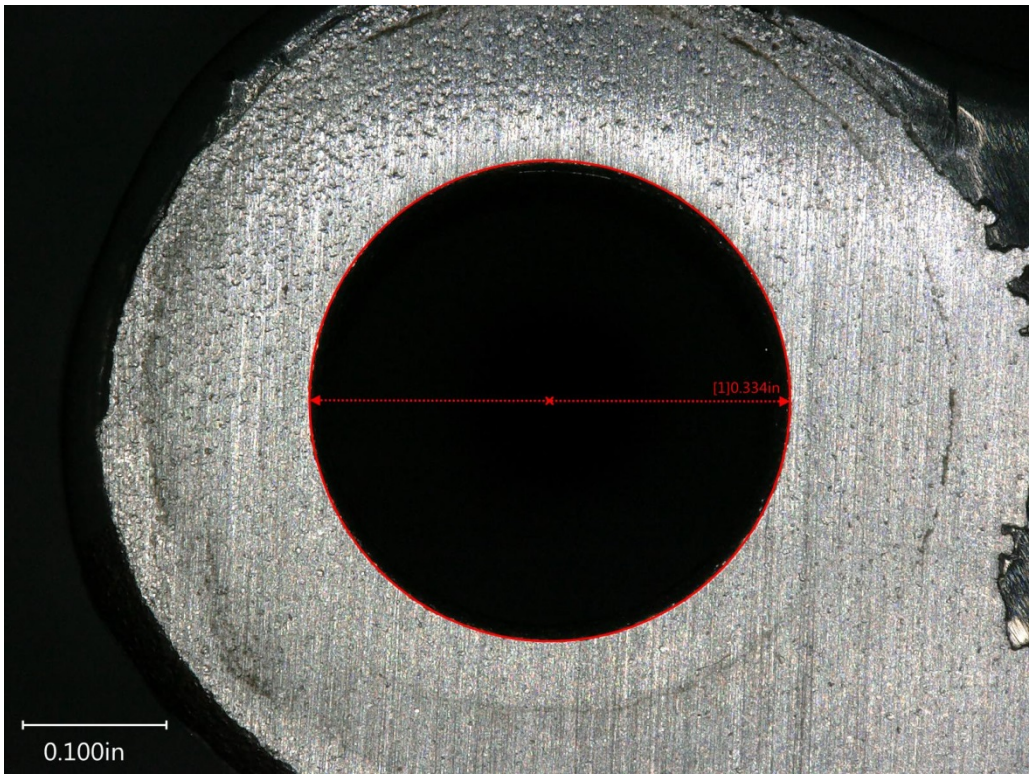


Figure 6: Lower swashplate front right push-pull tube attachment lug; a) rod end-side of lug; b) opposite side of lug.

a)



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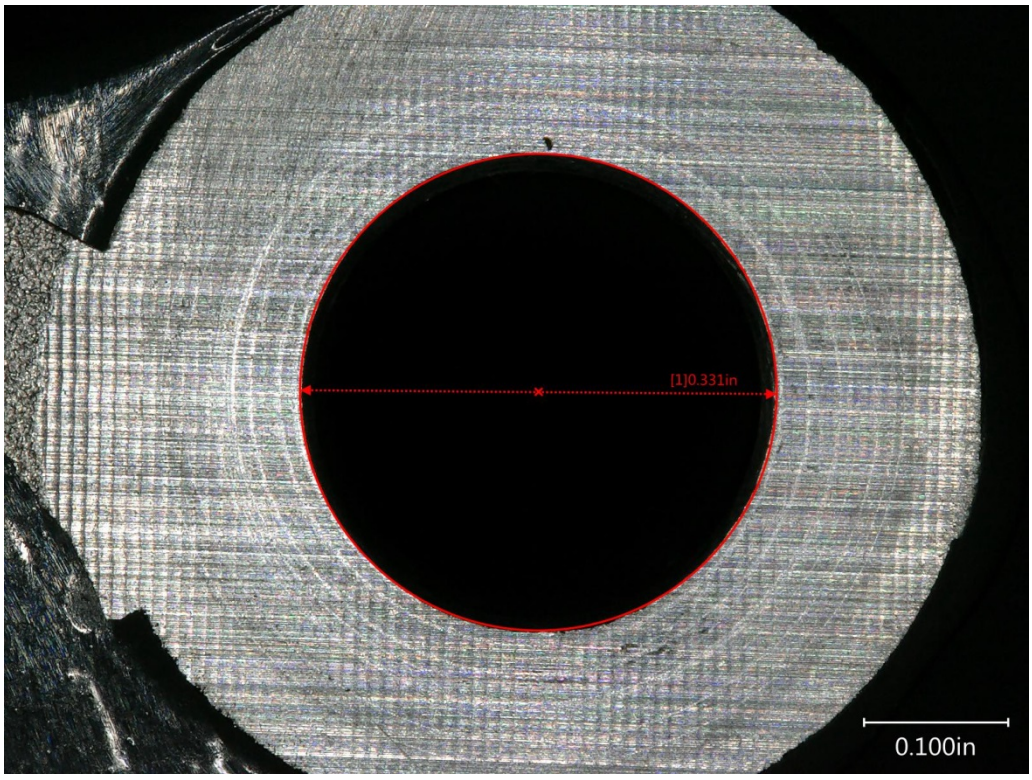
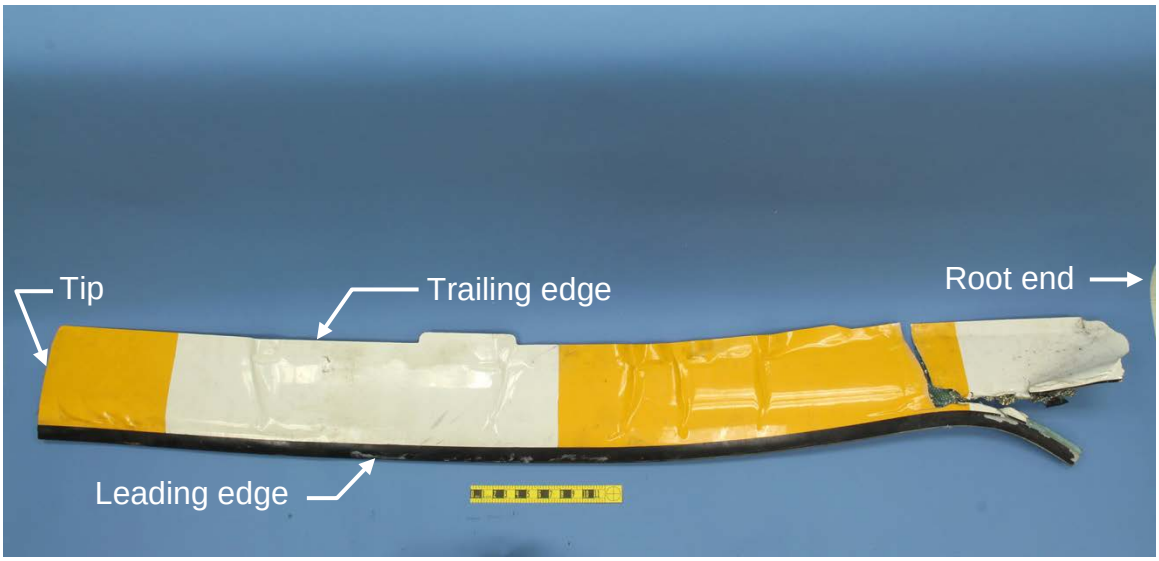


Figure 7: Lower swashplate aft push-pull tube attachment lug; a) rod end-side of lug; b) opposite side of lug.

a)



b)

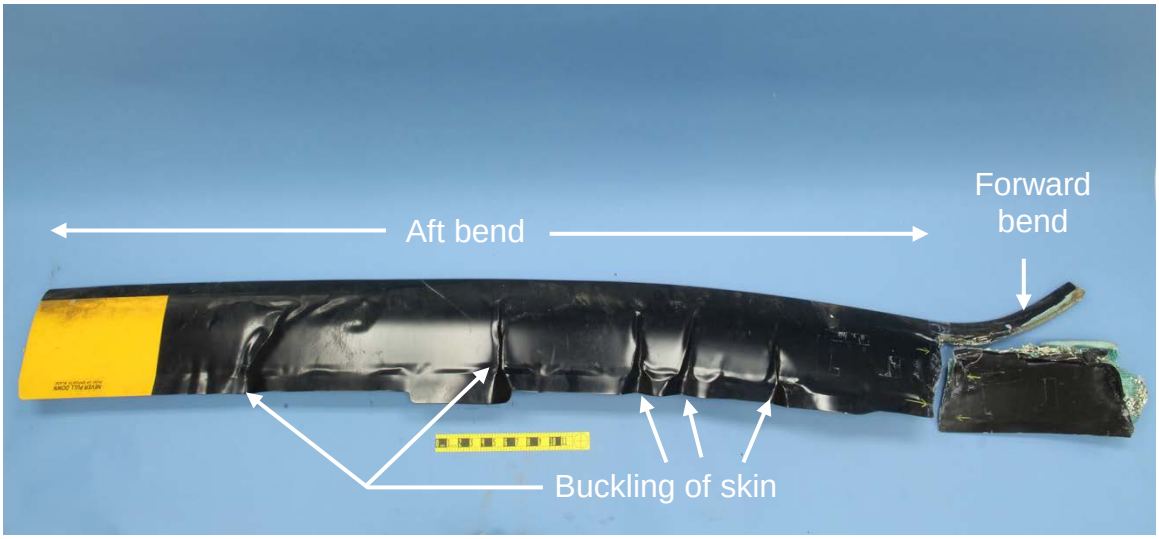
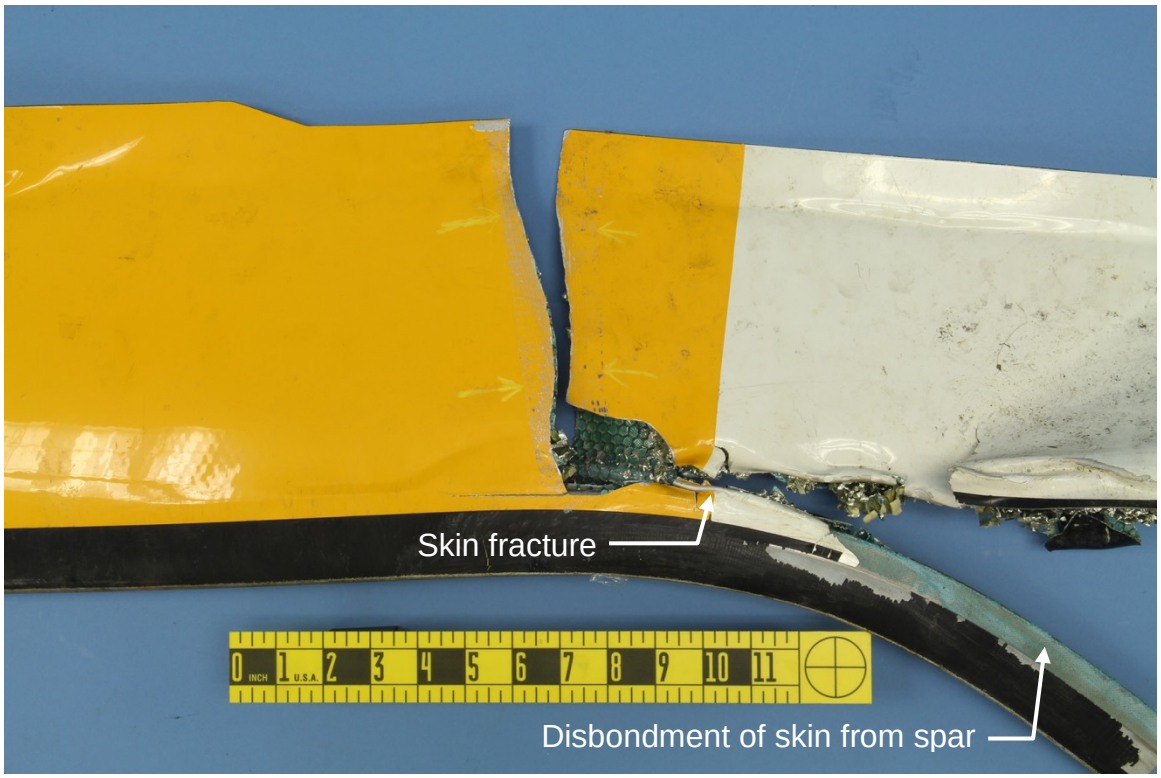


Figure 8: Images of the main rotor blade pieces: a) top side and b) bottom side.

a)



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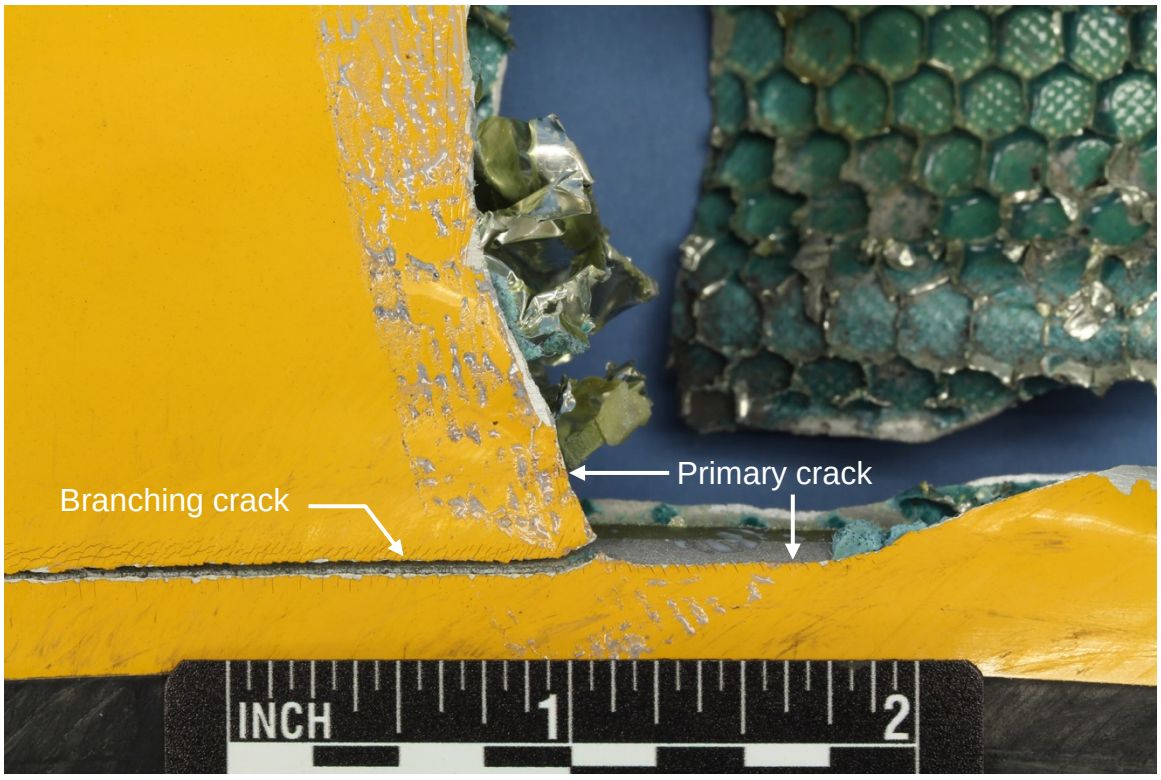
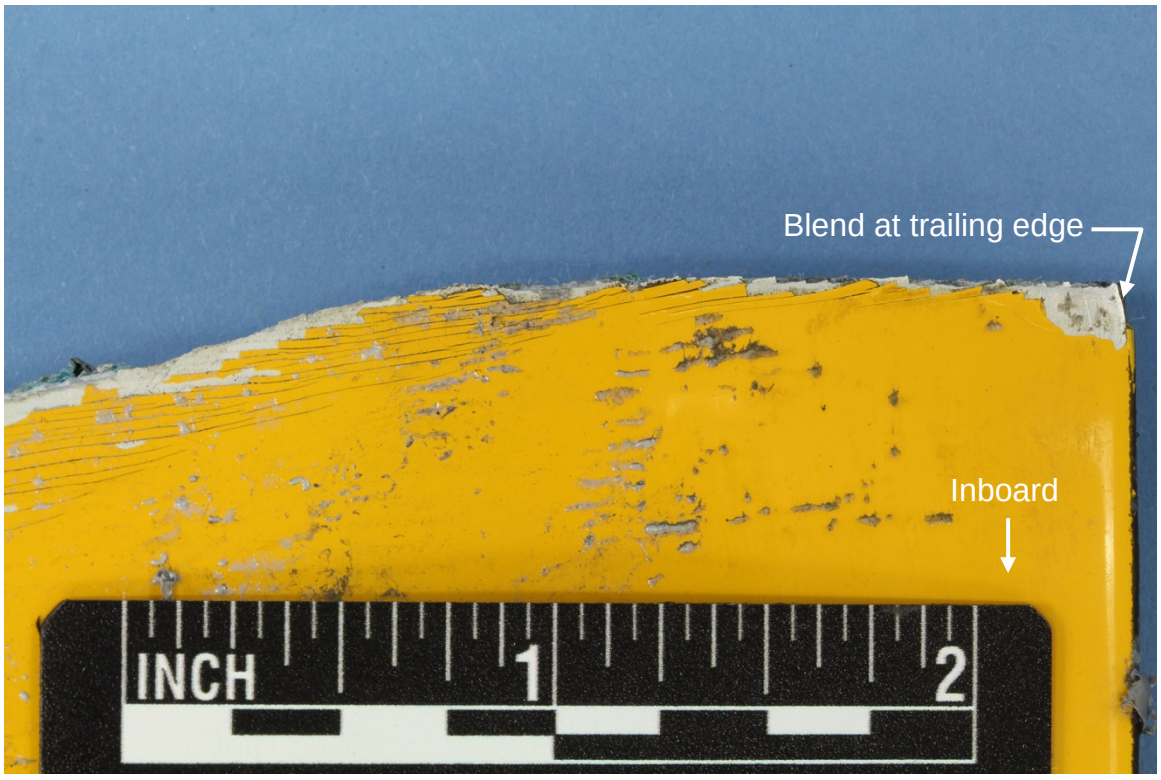


Figure 9: a) Image of the main rotor blade top side at the chordwise fracture through the trailing edge, skin, and core; b) higher magnification image near the leading edge adjacent to the spar.

a)



b)

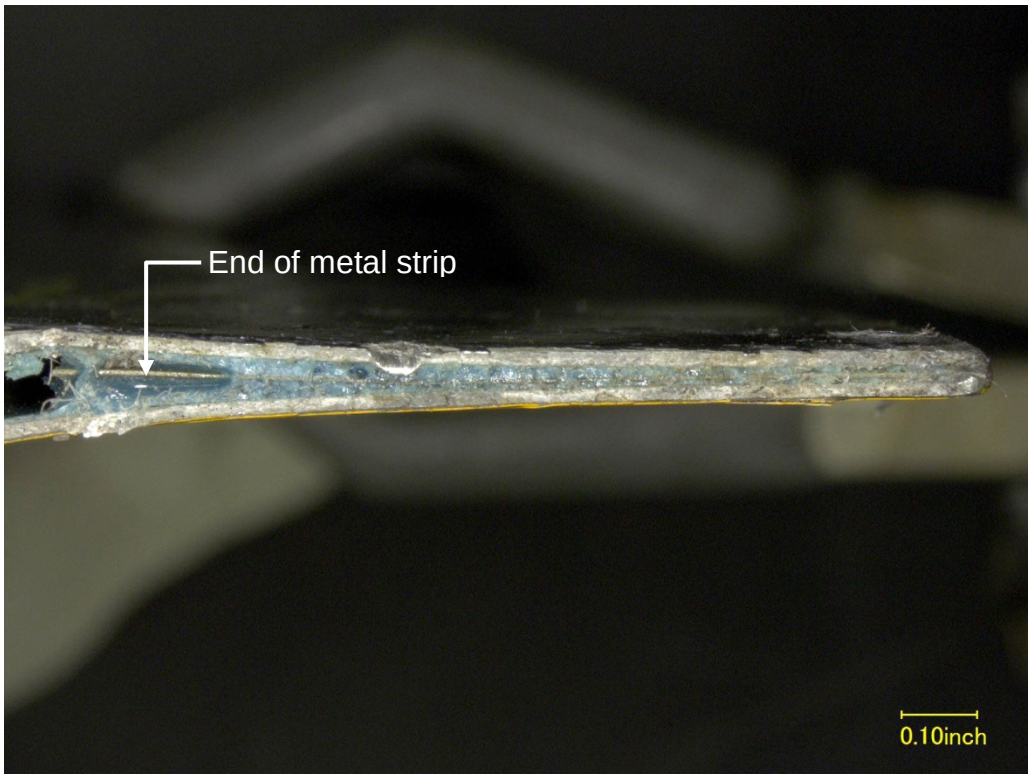


Figure 10: Images of the inboard half of the fracture at the trailing edge: a) image of the upper skin exhibiting cracks in the paint; b) image of the inboard half of the fracture.