

NATIONAL TRANSPORTATION SAFETY BOARD

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



February 23, 2015

MATERIALS LABORATORY FACTUAL REPORT

Report No. 14-088

A. ACCIDENT INFORMATION

Place : St. Albans, Vermont
Date : April 18, 2014
Vehicle : Ultimate Aero 10-200, N827D
NTSB No. : ERA14LA202
Investigator : Todd Gunther, AS-ERA

B. COMPONENTS EXAMINED

Whirl Wind Aviation 200C-series propeller and governor.

C. DETAILS OF THE EXAMINATION

An overall view of the submitted components is shown in figure 1. The propeller was a Whirl Wind Aviation (WWA) model 200C propeller, serial number 200C-280 which was installed on a Lycoming IO-360 engine. Blade 1 was fractured in the root within the hub as shown in figure 2, and the portion outboard of the fracture was not recovered. Blade 2 was largely intact but showed damage consistent with exposure to a fire. A bag containing bearing balls and retainers that were recovered loose from inside the propeller hub and from the ground at the crash site and the governor were also received but were not examined in detail.

A drawing showing the overall construction of the root end of a Whirl Wind 200C or 400C series propeller blade is shown in figure 3. The drawing in figure 3 was adapted from WWA Mandatory Service Letter SL-200C/400C-002 dated February 4, 2003, which required the installation of pan-head screws into the root end face of the blade. According to a subsequent WWA mandatory service letter (SL-200C/400C-070214 dated July 8, 2014), the 200C series propellers affected by WWA SL-200C/400C-002 had serial numbers 200C-238 and lower. The propeller on the accident airplane was serial number 200C-280, and the propeller blades did not have the pan-head screws shown in figure 3.

As installed, the blades are retained in place during operation with a split ring insert that rests against the shoulder on the outer ferrule (the shoulder is labeled in figure 3) and against the bearing race half on the root side of the blade bearing (bearing that facilitates pitch changes). The bearing race half on the airfoil side of the bearing is retained by the propeller hub. At rest, the blade is prevented from moving inward by a

split ring that sits in a groove in the outer ferrule and fits against the exterior face of the propeller hub.

1. Blade 1

To remove the fractured end of blade 1 from the hub, remaining bearing balls and retainers were removed from the blade 1 bearing, and the split ring insert located between the shoulder of the blade ferrule and the root-side bearing race was removed. Next, the pitch change pin was pulled from the pitch change link. However, the root side of the bearing race could not be removed easily from the fractured end to allow removal of the blade through the hole in the propeller hub. To facilitate removal of the blade 1 piece, a cut was made through the hub transverse to the blade axis approximately 1.5 inches from the hub face. The blade root piece with the root-side bearing race was then removed from the hub and cleaned in a degreasing solution.

Views of the fracture surface after removal from the hub and cleaning with a degreaser are shown in figure 4. The outer ferrule was fractured around approximately 2/3 of the circumference with a fracture intersecting the outer surface in the fillet radius adjacent to the shoulder. The fracture surface had relatively flat features with curving crack arrest lines, features consistent with fatigue. The fatigue features emanated from an origin area at a bolt hole for one of the two bolts attaching the pitch change pin as indicated with a bracket in the lower image in figure 4. The primary crack propagated around approximately 1/3 of the circumference to the locations indicated with unlabeled arrows in the upper image in figure 4. Fatigue features from secondary fatigue cracks were observed propagating up to the dashed lines shown in the upper image in figure 4. At the location of the dashed lines, shear fractures were present where the outer ferrule fractured to the root face, and the remainder of the outer ferrule separated where it was bonded to the inner ferrule root flange.

A closer view of the fatigue origin area is shown in figure 5. The origin was located at the edge of the hole as indicated with a bracket in figure 5, and propagated toward the fillet surface adjacent to the shoulder. Arrows in figures 4 and 5 indicate where the crack then radiated in either direction along the surface and circumferentially around the hole. The shoulder and fillet surface adjacent to the fracture had a rough crater-like appearance consistent with a peening operation.

Approximately 4 threads were observed between the threaded end of the bolt attaching the pitch change pin to the blade root and the fracture surface at the origin. The bolts attaching the pitch change pin were removed and the pitch change pin was separated from the inner ferrule end flange to facilitate photographing the threads by transmitting light through the hole (see figure 6) and for measurement of the thread depth. Partially cut threads consistent with a location at or near the end of the tapped threads were observed in the bolt hole adjacent to the fracture surface as indicated in figure 6.

The hole depth from the inner ferrule end flange face to the fracture surface was measured for each of the attachment bolt holes using a vernier caliper. At the fatigue

origin, the hole was 0.806 inch deep, and the other hole was 0.796 inch deep. According to a representative from the propeller manufacturer, production procedure notes for the blade specified a hole depth up to 0.750 inch. A vernier caliper was also used to measure the distance between the shoulder and the root end face of the blade. The shoulder was located 0.782 inch from the root face of the inner ferrule root flange in the area where the pitch change pin had been attached.

The inner ferrule from blade 1 consisted of a root flange that was welded at three locations to a center tube. The inner ferrule was fractured at the 3 weld locations as indicated in figure 4. Fracture features at the weld locations had rough features and deformation adjacent to the fracture consistent with overstress fracture.

2. Blade 2

The airfoil on blade 2 was cut chordwise near the blade root to facilitate handling and examination of the blade root. The blade root was then disassembled from the hub, and grease was wiped away with disposable wipes. A view of the blade 2 root after disassembly and wiping away the grease is shown in figure 7.

Next, the bolts for attaching the pitch change pin were removed, and the pitch change pin was separated from the inner ferrule root flange. The depth of the pitch change pin attachment holes were measured from the root face of the inner ferrule root flange using a vernier caliper. One bolt hole had a depth of 0.67 inches, and the other hole had a depth of 0.70 inch. The shoulder was located 0.782 inch from the root face of the inner ferrule root flange in the area where the pitch change pin had been attached.

The root end of blade 2 was then cut axially using a bandsaw approximately through the center of the blade and the center of one of the pitch change pin attachment holes. The resulting cross-section is shown in figure 8, and a closer view of the pitch change pin attachment bolt hole is shown in figure 9. The depth the the threaded portion of the bolt hole was measured on the cross-section, and the threaded portion of the hole extended up to 0.65 inch from the root face of the inner ferrule root flange.

A closer view of the threads at the end of the pitch change pin attachment hole is shown in figure 10. Two partially-cut threads were present at the end of the threads as indicated in figure 10.

3. Manufacturing Process Changes

As of May, 2014, the pitch change pin attachment holes in newly-manufactured blades have a specified depth of 0.670 inch $\pm$ 0.010 inch as measured from the surface of the inner ferrule root flange, and manufacturing and quality controls were instituted to prevent variations in the hole depths from specified levels. Additionally, the holes in blades manufactured since May, 2014, are shaped with a flat bottom through a reaming operation, and the threads are formed with a roll-thread tap.

4. Mandatory Service Letter SL-200C/400C-013015

On January 30, 2015, Whirl Wind Aviation issued Mandatory Service Letter SL-200/400C-070214, which included a requirement to measure the depth of the bolt holes for attaching the pitch change pin on model 200C (serial numbers 200C-385 and lower) and model 400C (serial numbers 400C-226 and lower) propellers. The stated reason for the service letter was that pitch change pin attachment bolt holes could vary in depth, which in some cases could compromise the integrity of the blade outer ferrule and lead to fatigue failure of the ferrule and loss of blade retention. Upon inspection, blades found with bolt holes greater than 0.760 inch in depth as measured from the root face of the internal ferrule root flange are to be removed from service.

Matthew R. Fox
Senior Materials Engineer

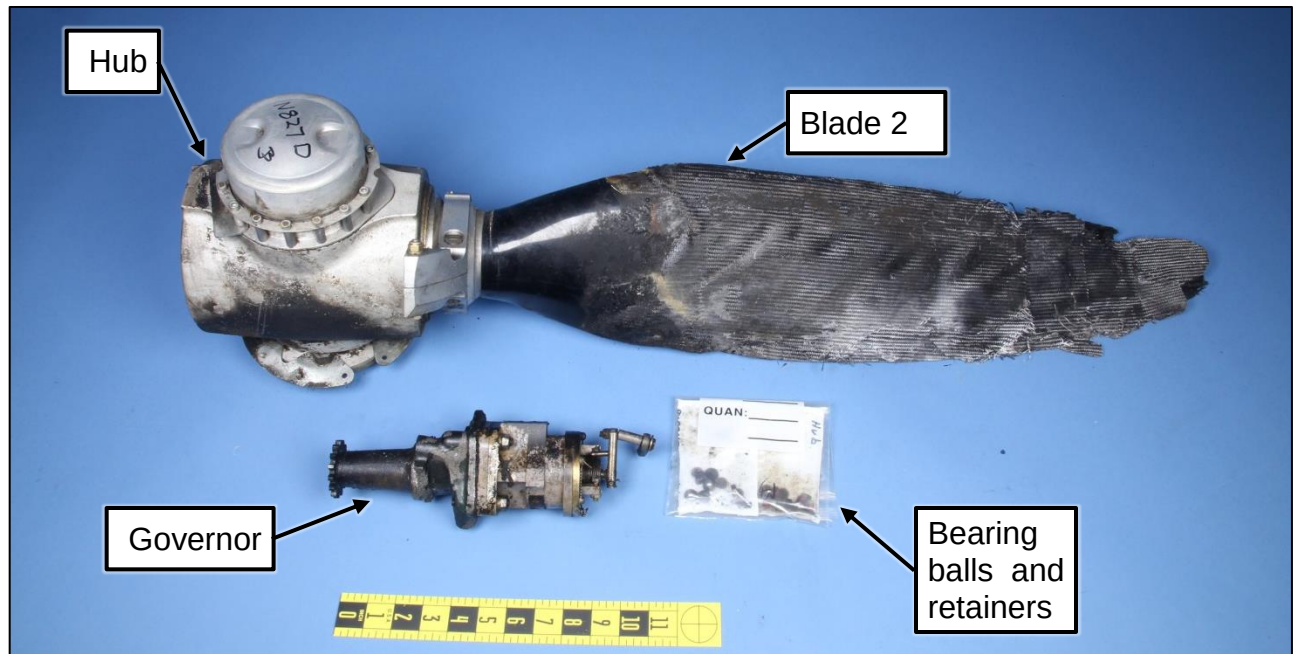


Figure 1. Overall view of the submitted components.

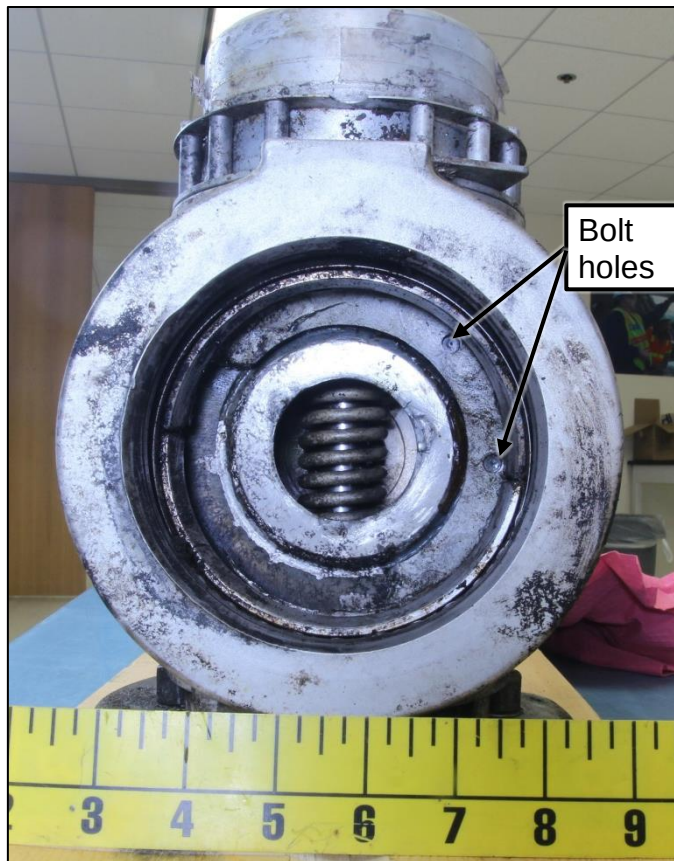


Figure 2. Blade 1 fracture surface as received. The location of threaded holes for bolts attaching the pitch change pin are indicated.

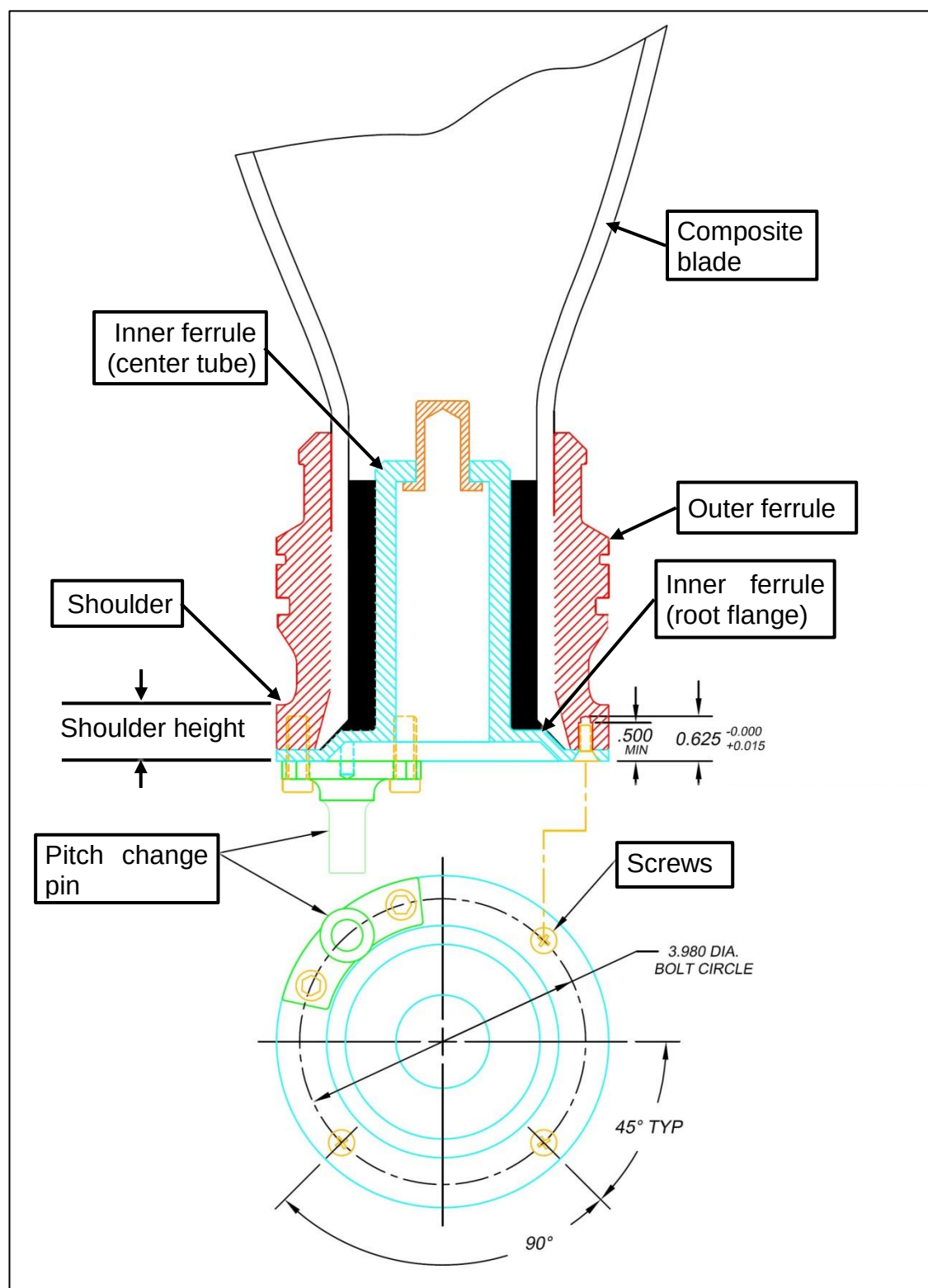


Figure 3. Section-view and end-view drawing of the hub end of the blade from the Whirl Wind 200C and 400C series propellers. (Adapted from Whirl Wind Aviation Mandatory Service Letter SL-200C/400C-002 dated February 4, 2003.)

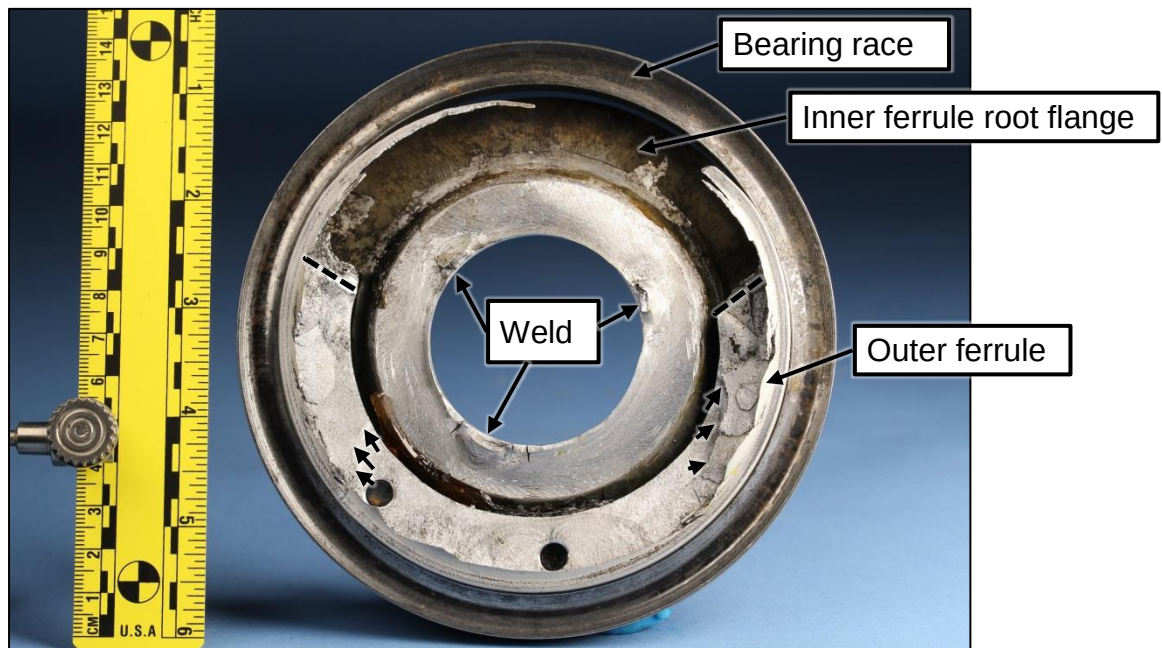


Figure 4. Blade 1 fracture surface (upper image) with a closer view of the fatigue origin area (lower image) after removal from the hub and cleaning with a degreasing solution. In the upper image, unlabeled arrows indicate the extent of crack propagation from the primary origin area as indicated with a bracket in the lower image. Dashed lines indicate the extent of cracking from secondary fatigue cracks. Unlabeled arrows in the lower image indicate the crack propagation direction in the vicinity of the bolt hole.

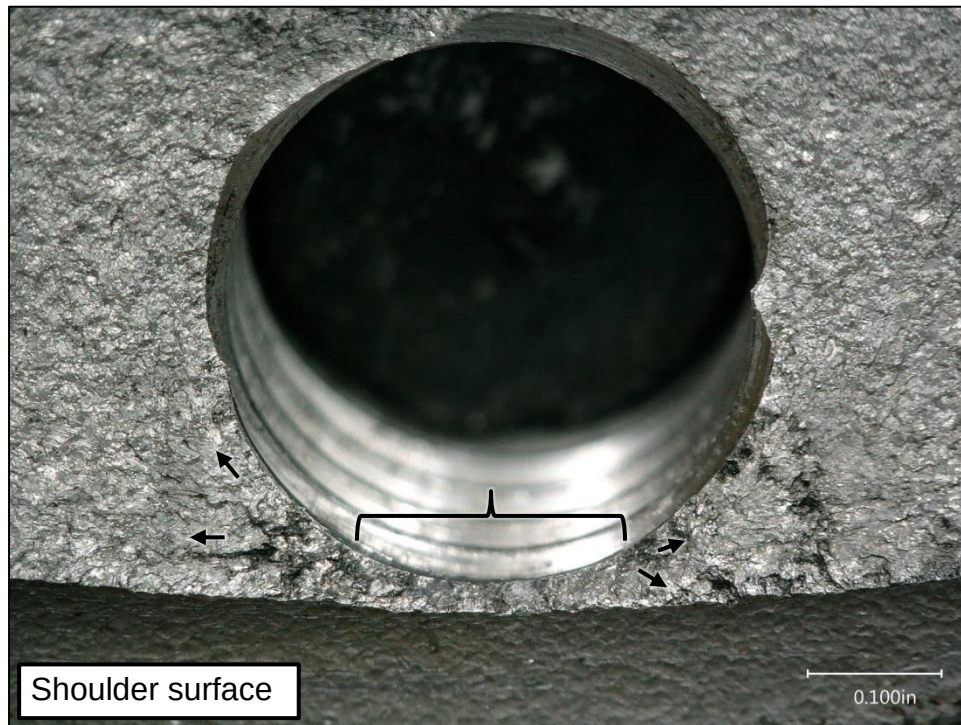
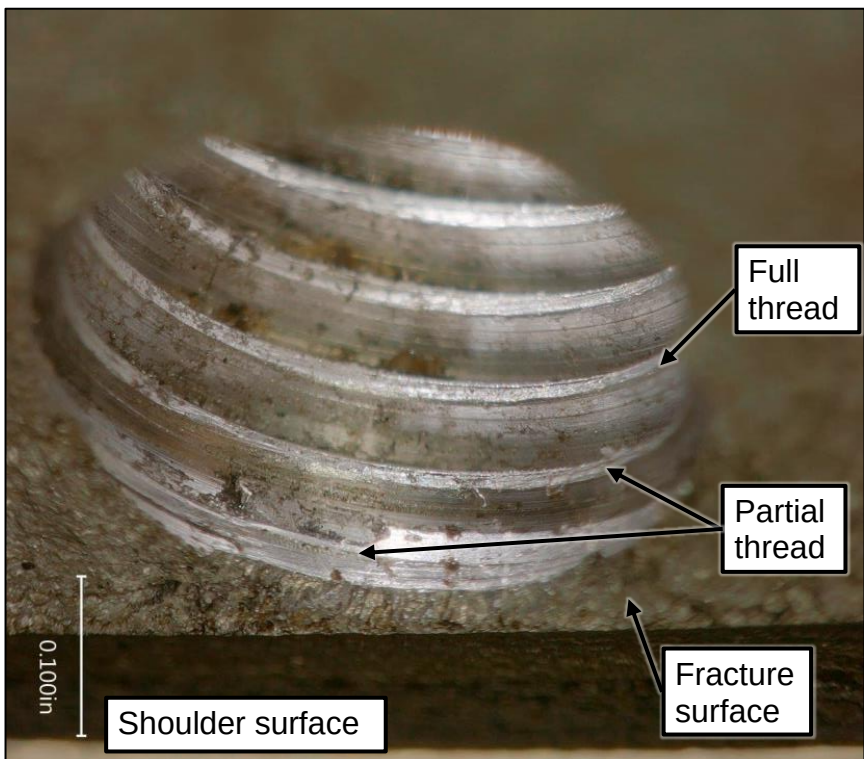


Figure 5. Closer view of the origin area as indicated with a bracket. Arrows indicate crack propagation directions emanating from the origin area.

Figure 6. Bolt hole threads adjacent to the fracture surface after the bolt was removed from the hole. Partial threads consistent with the end of the tapping operation are indicated.



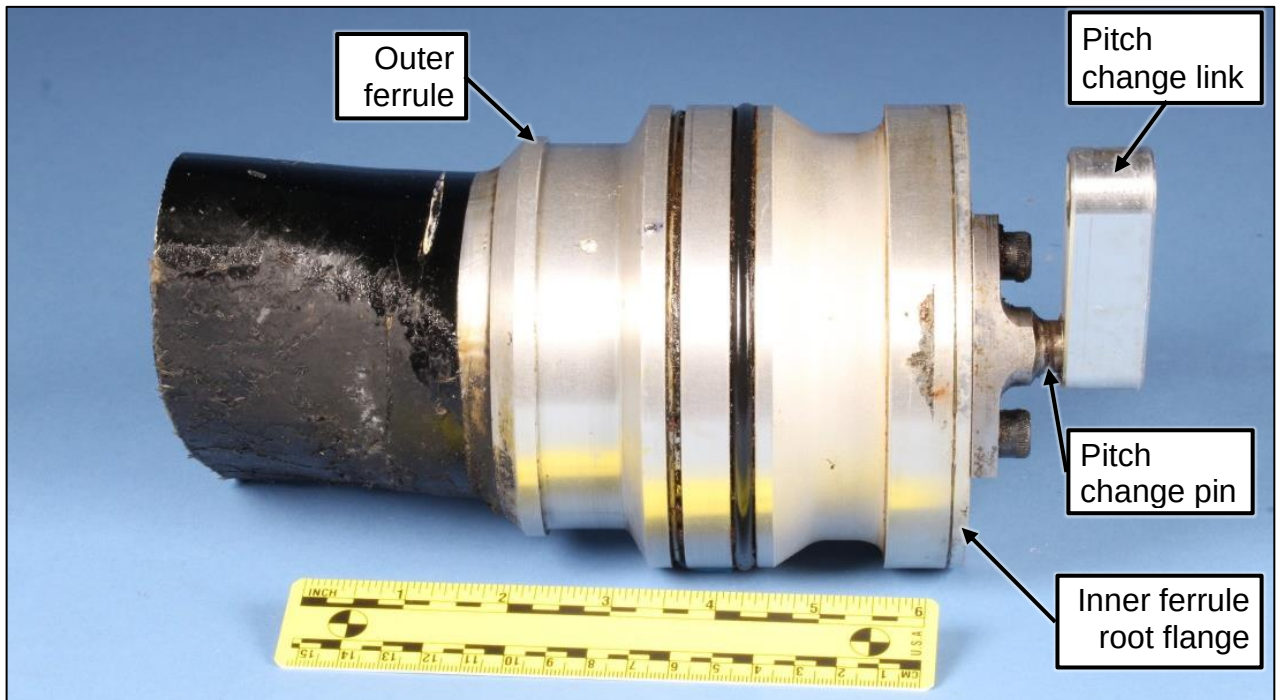


Figure 7. Root end of blade 2 after cutting off most of the blade, removal of the blade root from the hub, and wiping away grease with disposable wipes.

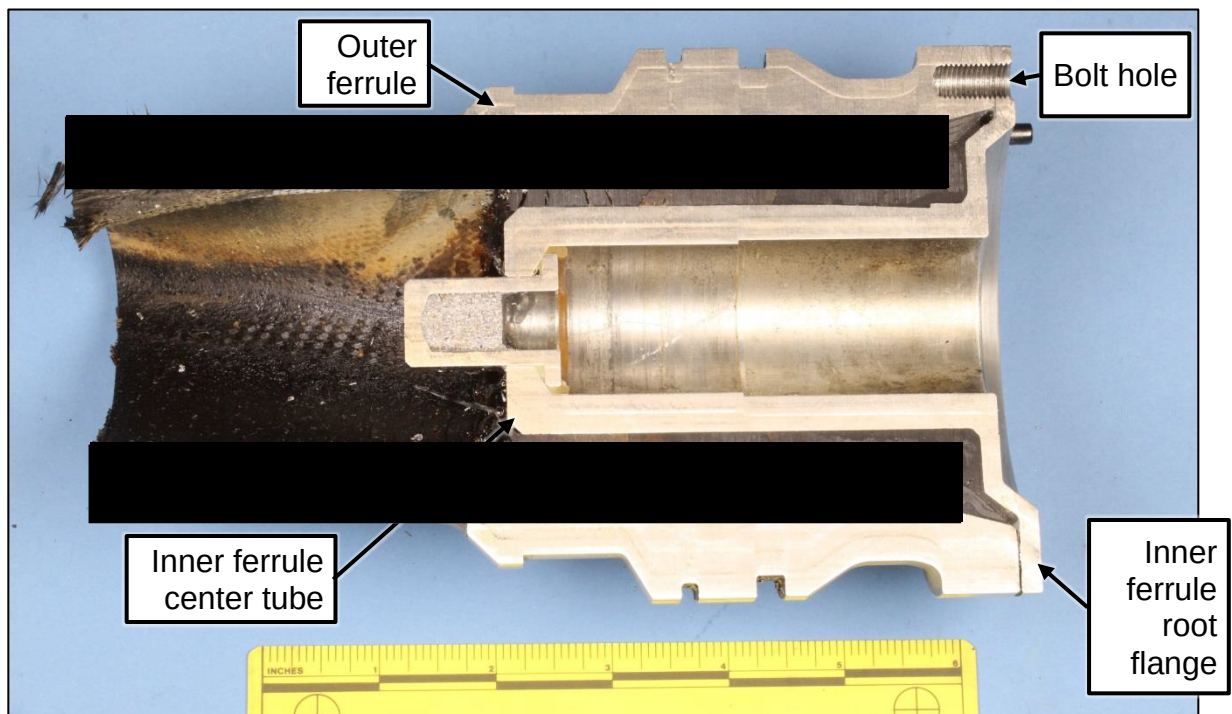


Figure 8. Cross-sectional view of the blade 2 root after an axial cut approximately through the center of the blade root and through the center of one of the holes for the pitch change pin attachment bolts. Portions of the image are redacted.

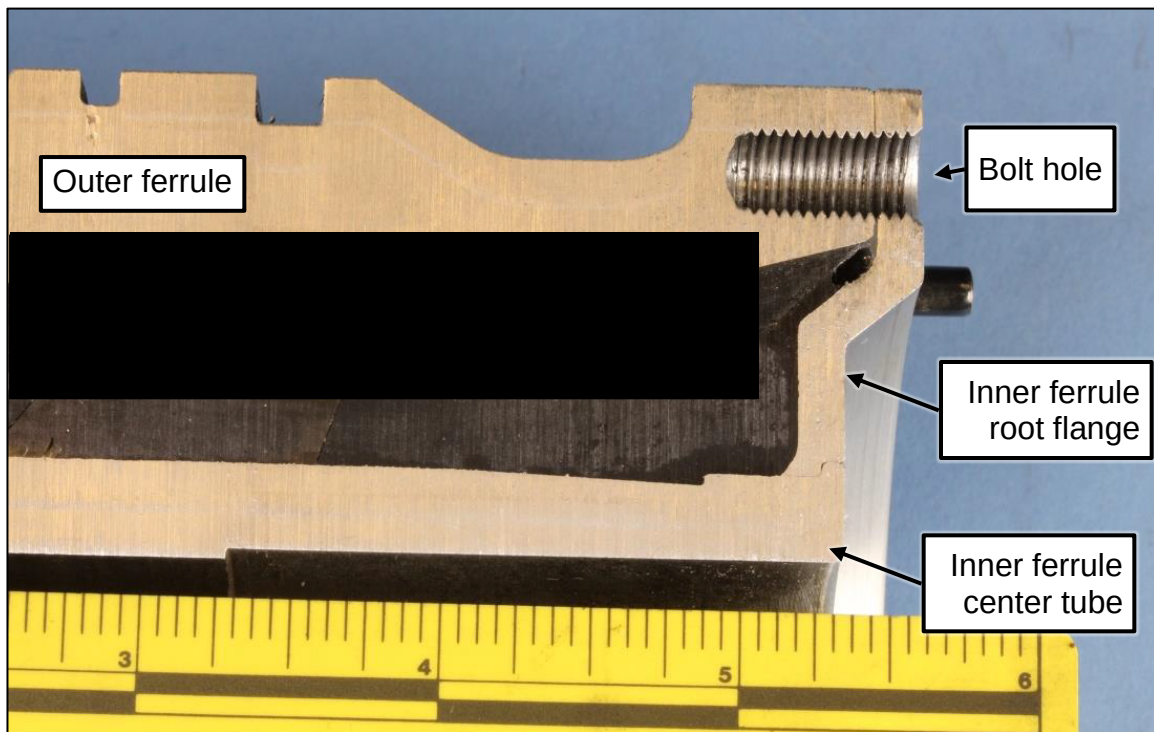


Figure 9. Closer view of the blade 2 cross-section showing the pitch change pin attachment bolt hole in the inner and outer ferrules. A portion of the image is redacted.

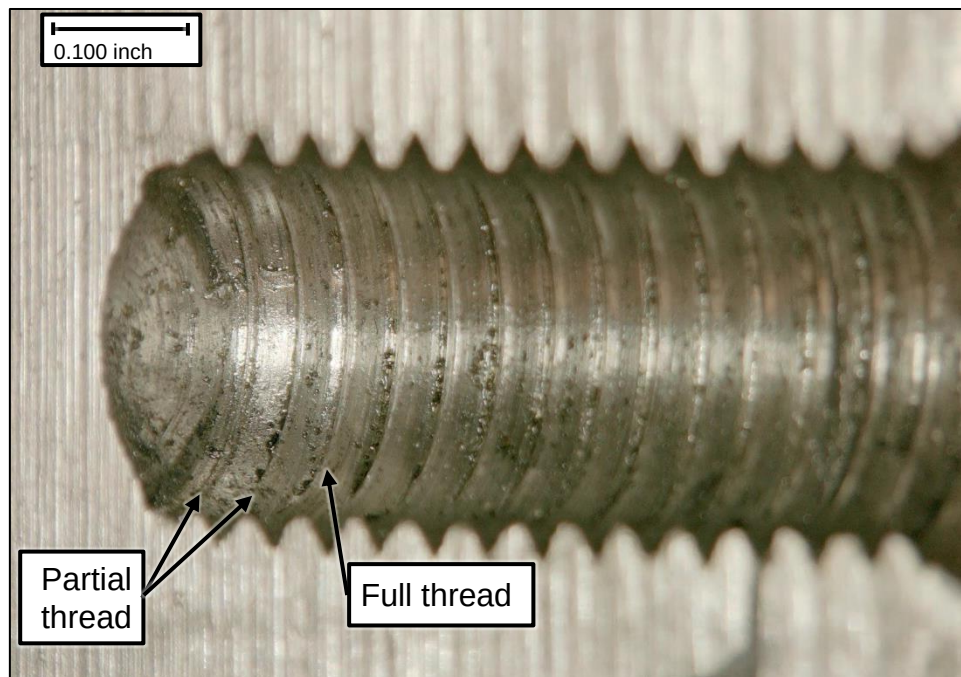


Figure 10. Threaded end of the the pitch change pin attachment bolt hole in the outer ferrule showing partially cut threads at the tip end of the hole.