

NATIONAL TRANSPORTATION SAFETY BOARD

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



August 30, 2021

MATERIALS LABORATORY FACTUAL REPORT

Report No. 20-035

A. ACCIDENT INFORMATION

Place : Azusa, CA
Date : September 11, 2019
Vehicle : Sikorsky S-58ET, N1168U
NTSB No. : WPR19LA255
Investigator : Fabian Salazar (AS-WPR)

B. COMPONENTS EXAMINED

Separated tail rotor blade piece and three additional tail rotor blades.

C. DETAILS OF THE EXAMINATION

SEPARATED TAIL ROTOR BLADE PIECE

A piece of tail rotor blade containing the root end was submitted for evaluation, as shown in Figure 1. The blade had separated perpendicular to the blade length along a chord plane located approximately 3 inches from the bottom of the blade.

The fracture surface of the blade is shown in Figures 2 and 3. The fracture surface was relatively flat. A thumbnail-shaped pattern consistent with fatigue was observed emanating from the pressure side of the blade at approximately mid-chord. The edge of the thumbnail-shaped pattern (red dotted line, Figure 2) indicated the fatigue had propagated through roughly 77% of the blade width. The woody features within the thumbnail-shaped pattern were consistent with fatigue in aluminum with elongated grains.

Crack arrest marks (yellow arrows, Figure 3) were visible on the fracture surface. The crack arrest marks emanated from a broad fatigue origin (white bracket, Figure 3). No external nicks or gouges were observed at the fatigue origin.

The fracture surface was sectioned from the blade bottom and the paint was removed from the blade surfaces using Cee Bee A-202 epoxy and polyurethane stripper manufactured by McGean-Rohco, Inc., Cleveland, Ohio. Craze cracking was observed in the anodized coating in several locations (black arrows, Figure 4). The anodized coating was present and intact along the edge of the fracture surface, including at the fatigue origin.

The fracture surface was examined using a Thermo Scientific Apreo 2 field emission scanning electron microscope (SEM). SEM images of the fracture surface shown in Figure 5 confirms the crack arrest marks (yellow arrows) emanating from a broad fatigue origin (white bracket) on the pressure side of the blade. The intact anodized coating (orange arrows) along the edge of the fracture surface is also visible. No damage or contamination was observed at the fatigue origin.

SEM images of the fracture surface approximately mid-thickness through the blade and at the edge of the shear lip along the suction side of the blade are shown in the bottom and top images, respectively, in Figure 6. The fracture surface features mid-thickness were consistent with mixed mode fracture. The fracture surface in the shear lip were dimpled rupture consistent with overstress.

The manufacturer drawing stated the blade should be made from 6061 aluminum per QQ-A-325 with T6 temper. The composition, hardness, and conductivity of the blade root were evaluated.

The composition of the sectioned blade was analyzed using an Olympus Vanta x-ray fluorescence (XRF) alloy analyzer and was identified as 6061 aluminum alloy.

The transverse cut surface on the blade root was ground with silicon-carbide paper to a finish of 600 grit, and the prepared surface was tested using a Rockwell indenter. The average hardness in the blade cross-section measured 53.1 HRB, which exceeded the 42 HRB minimum specified on the drawing.

The conductivity of the sectioned blade was analyzed using a Fischer Sigmascope SMP350 Conductivity Meter. The conductivity of the blade material measured 44.0%ICAS, which is within the range of 40.0-50.0%ICAS specified for a T6 temper of 6061 aluminum.

ADDITIONAL TAIL ROTOR BLADES

The other three tail rotor blades from the accident aircraft were submitted for evaluation. As shown in Figure 7, two of the blades were intact but damaged; one intact blade was bent and had a wrinkle in the bottom third of the airfoil. The third blade had been sectioned through the airfoil near the root end. Key overall dimensional measurements of each blade and the corresponding drawing specification are given in Table 1.

Table 1: Tail rotor blade dimensional measurements

Tail Rotor Blade	Span (inches)	Chord length (inches)
Intact, straight	47 7/8	7 5/16
Intact, bent	47 5/8	7 1/4
Sectioned	N/A	7 5/16
Specified per drawing	47 7/8	7 19/64" ± 1/64

The hardness in the blade flex shank for the three tail rotor blades was evaluated per Sikorsky Service Bulletin 58B15-6. The paint was removed from the top and bottom blade surfaces in the blade flex shank areas using Cee Bee A-202 epoxy and polyurethane stripper manufactured by McGean-Rohco, Inc., Cleveland, Ohio. The cleaned surfaces were then ground with silicon-carbide paper to a finish of 600 grit, and the prepared surfaces were tested using a Rockwell indenter. The hardness measurements are listed in Table 2.

Table 2: Tail rotor blade flex shank hardness measurements

Tail Rotor Blade	Average Measured Hardness, Top Surface	Average Measured Hardness, Bottom Surface
Intact, straight	93.7 HRE	94.1 HRE
Intact, bent	95.8 HRE	94.6 HRE
Sectioned	92.5 HRE	91.1 HRE

All of the hardness measurements met the service bulletin specified minimum hardness of 85 HRE in the blade flex shank.

Adrienne V. Lamm
Materials Engineer

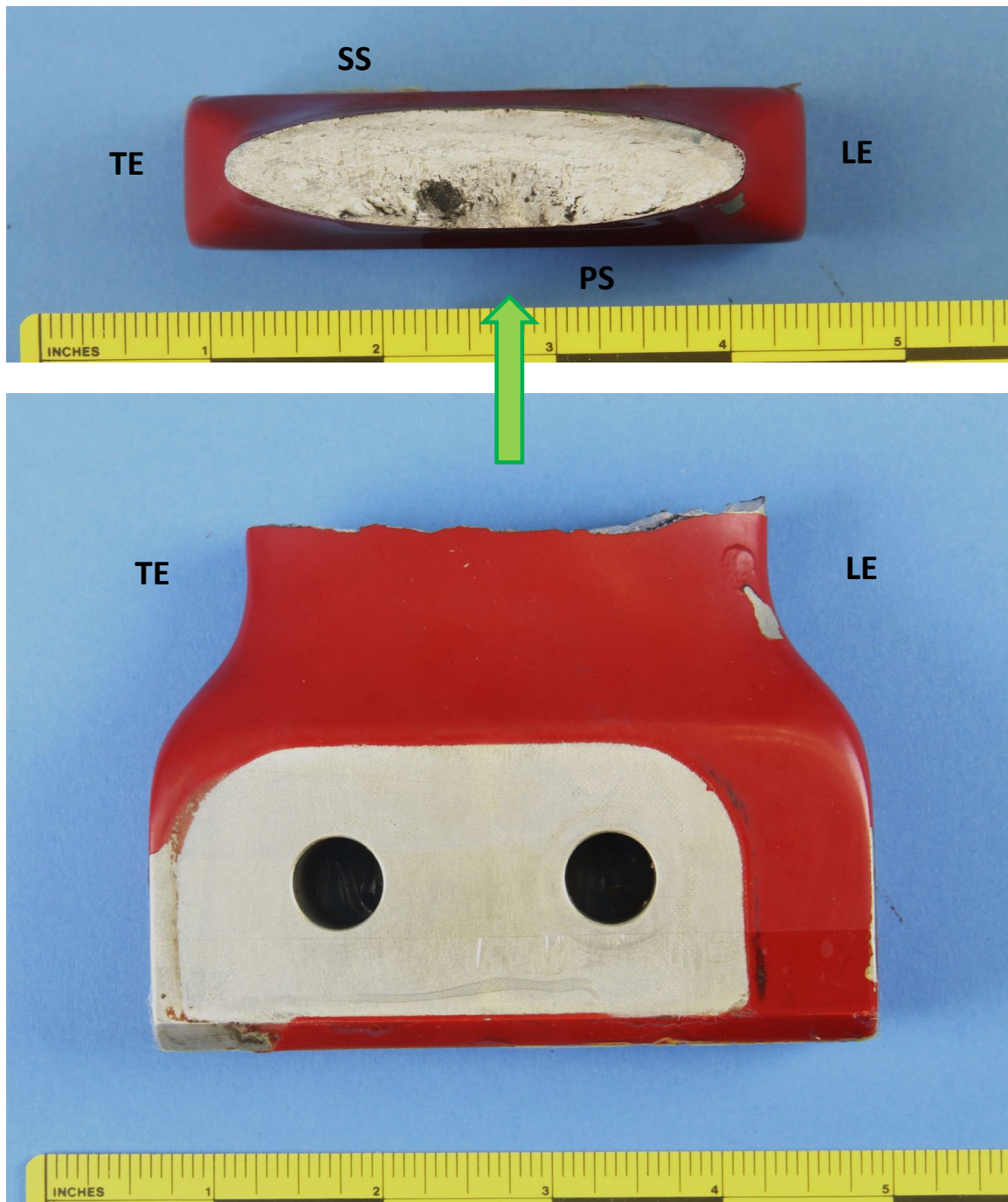


Figure 1: Overall macro photos of the submitted tail rotor blade piece. The leading edge (LE), trailing edge (TE), pressure side (PS), and suction side (SS) of the blade are labeled.

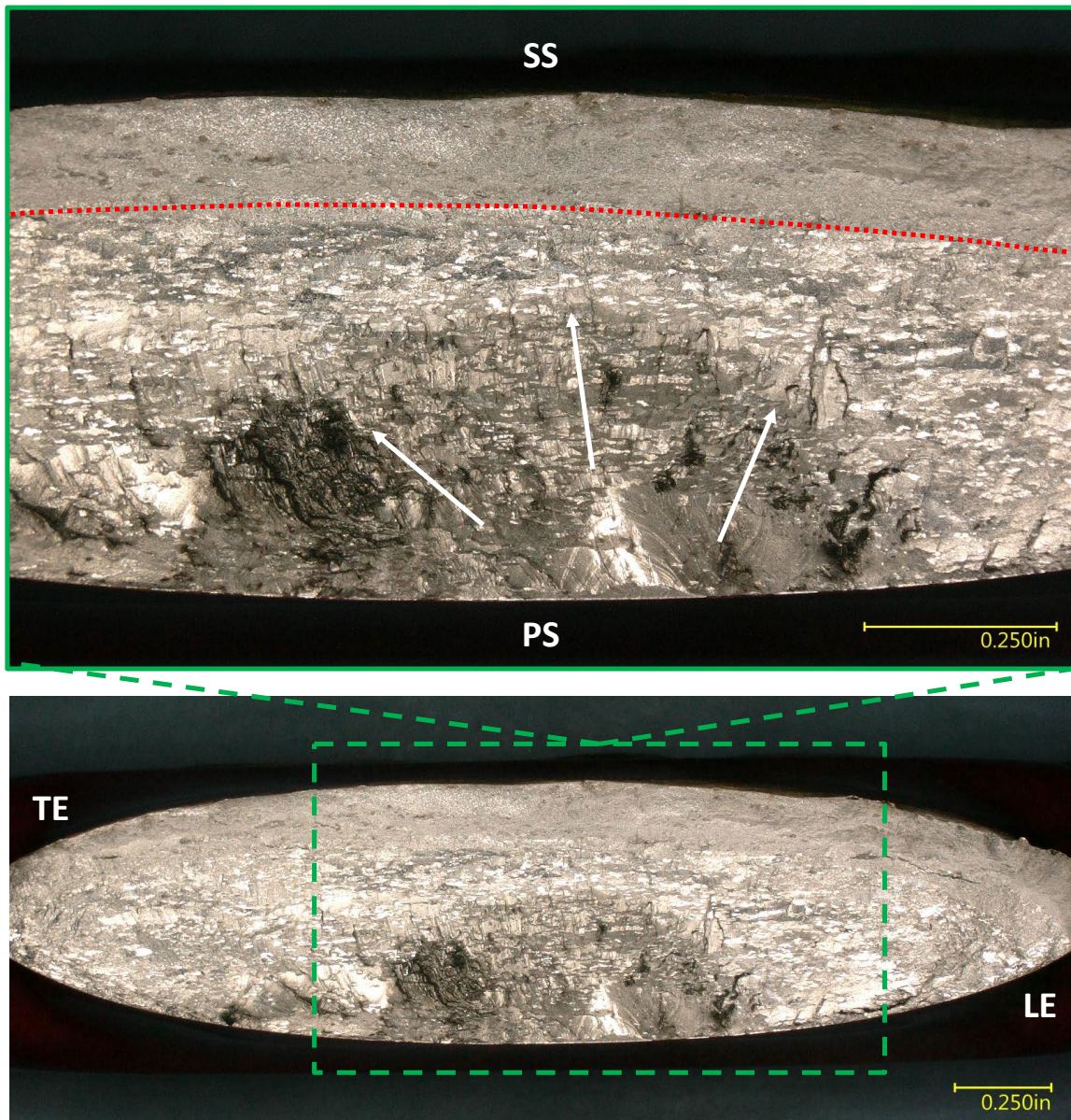


Figure 2: Digital microscope images of the fracture surface on the separated blade as viewed perpendicularly. The red dotted line indicates the edge of the thumbnail-shaped pattern of fatigue. The white arrows indicate the direction of fatigue propagation.

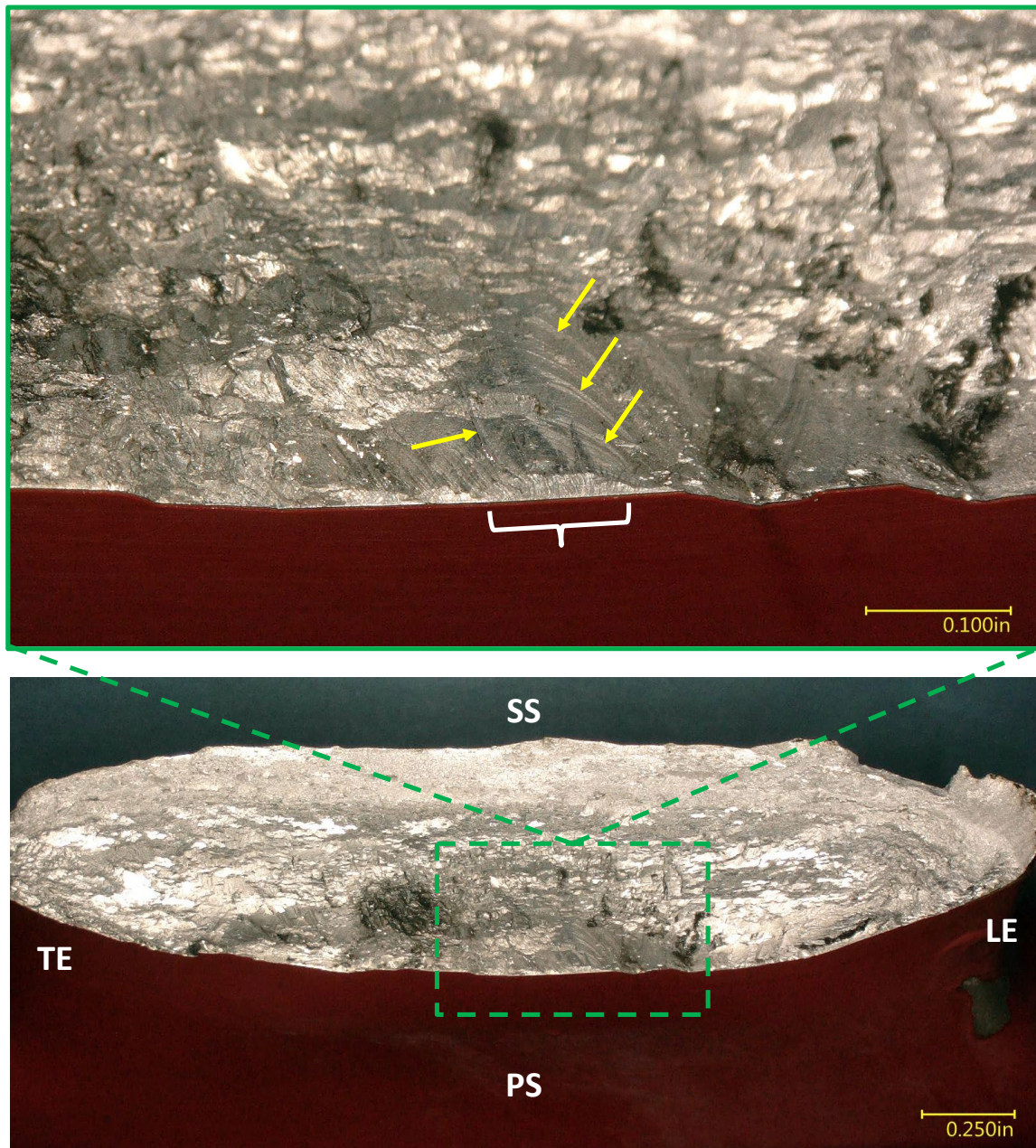


Figure 3: Digital microscope images of the fracture surface on the separated blade as viewed when tilted to show the pressure side (PS). The yellow arrows point to crack arrest marks. The white bracket indicates the fatigue origin area.

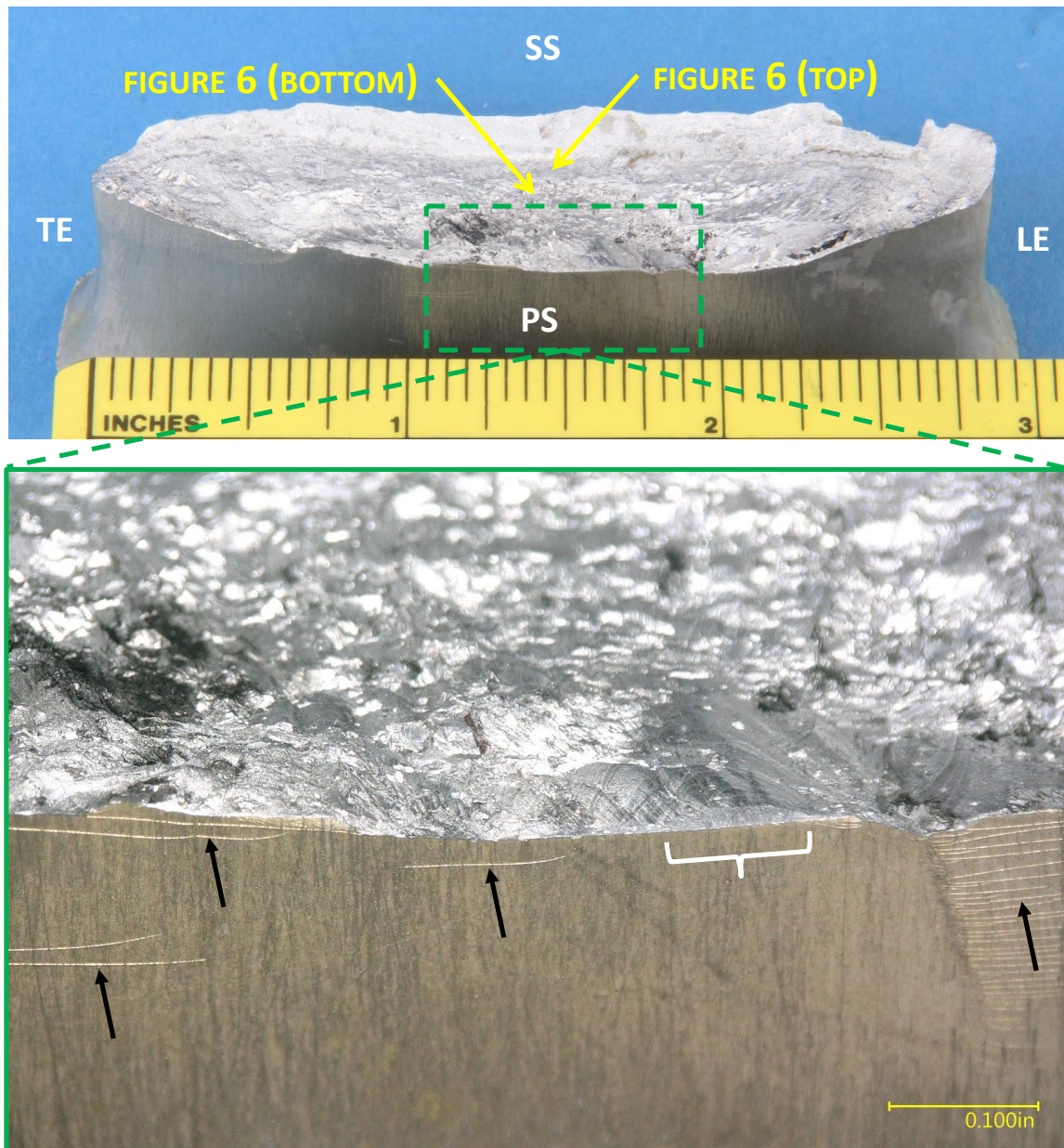


Figure 4: Digital microscope images of the fracture surface on the separated blade as viewed when tilted to show the pressure side (PS) after the paint was removed from the blade surface. The white bracket indicates the fatigue origin area. Craze cracking (black arrows) was observed in the anodized coating in several locations.

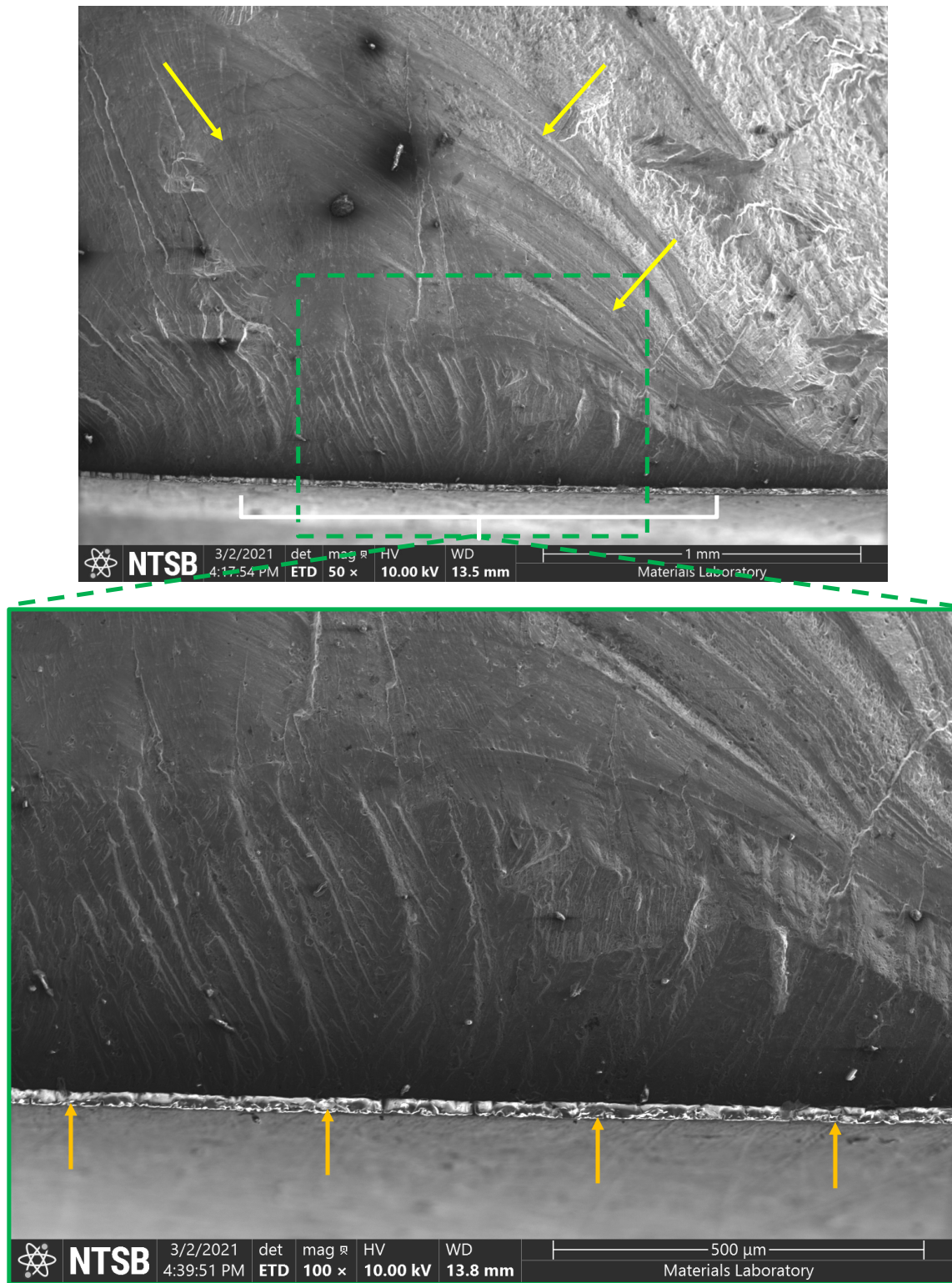


Figure 5: Secondary electron (SE) SEM images of the fatigue origin (white bracket) on the fracture surface. The yellow arrows in the top image point to crack arrest marks. The orange arrows in the bottom image point to intact anodized coating along the edge of the fracture surface.

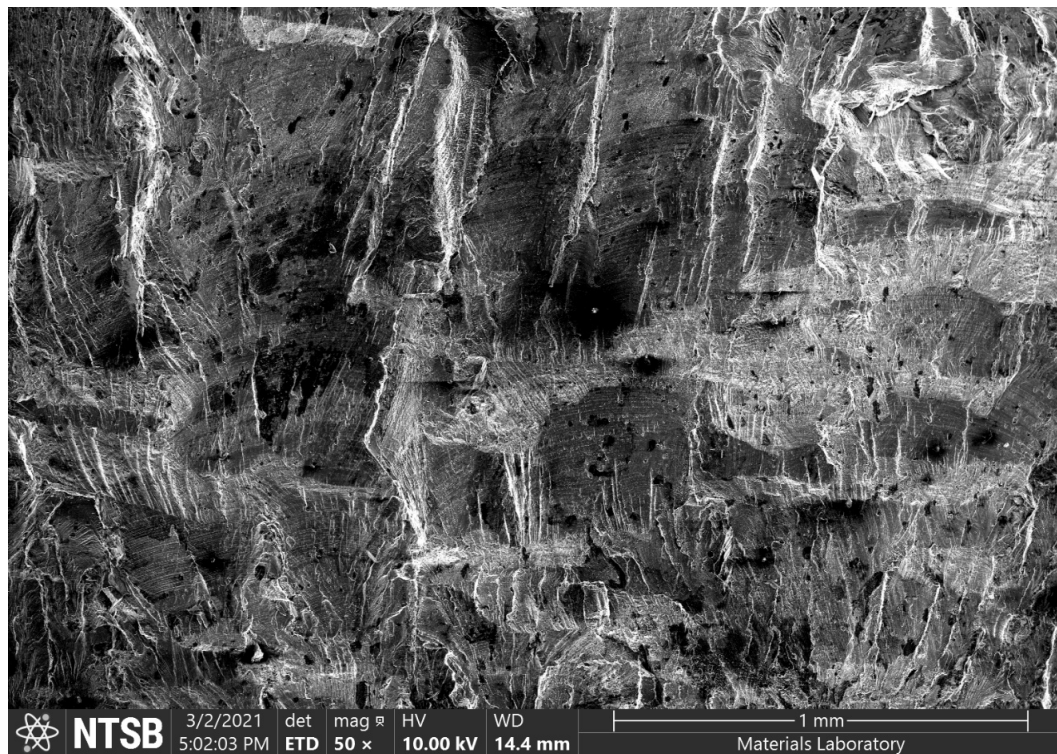
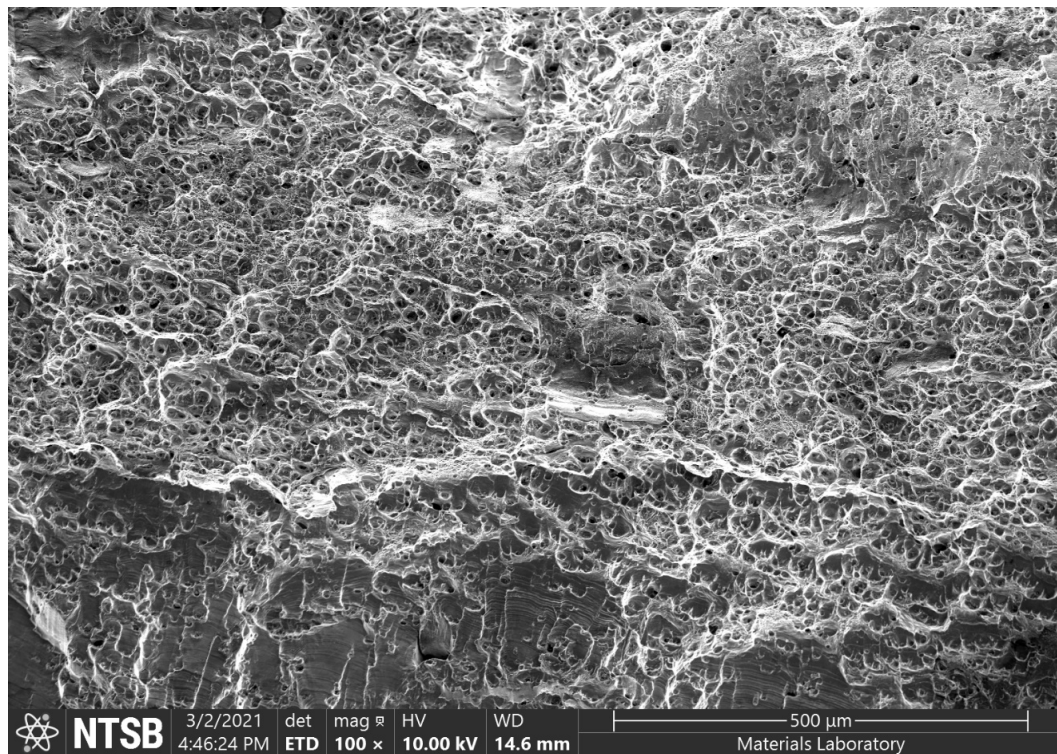


Figure 6: SE SEM images fracture surface (bottom) approximately mid-thickness through the blade and (top) at the edge of the shear lip along the suction side of the blade.

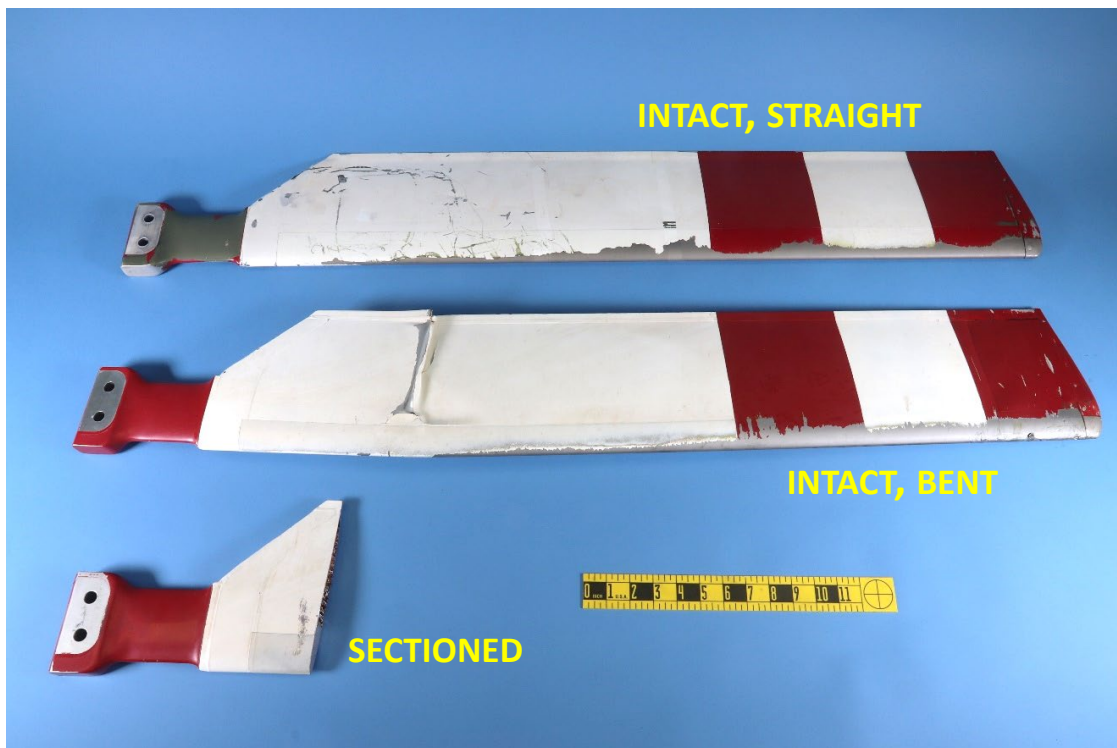
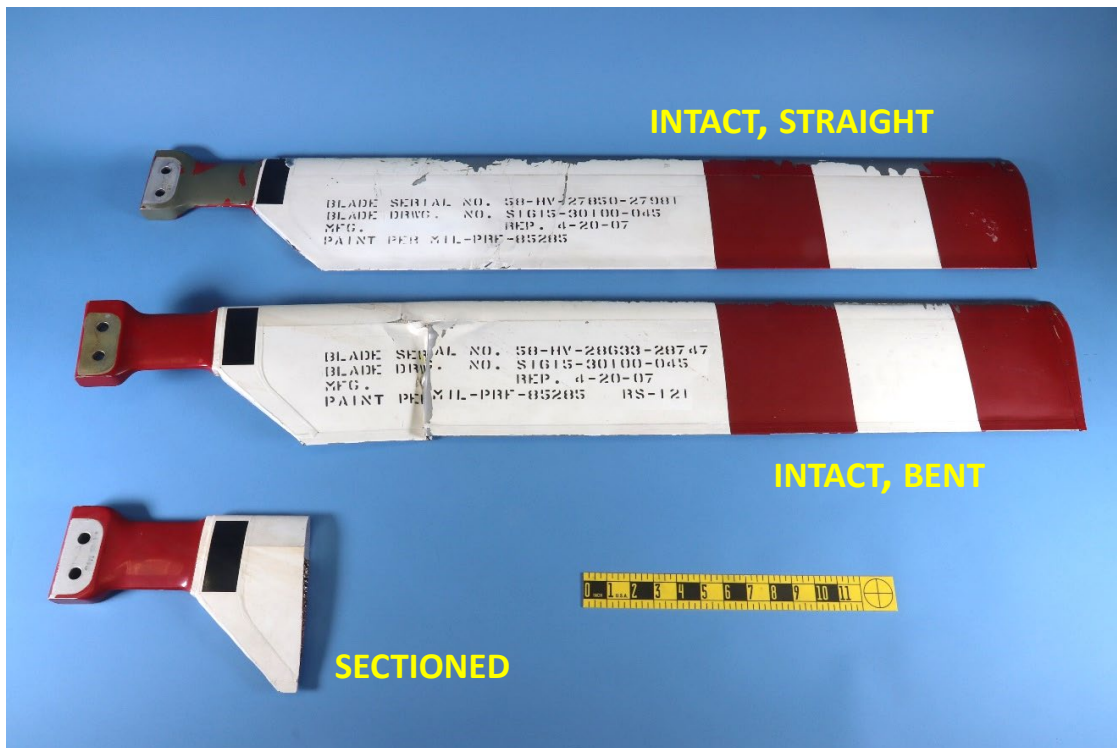


Figure 7: Overall macro photos of the other three tail rotor blades from the accident aircraft submitted for evaluation.