

NATIONAL TRANSPORTATION SAFETY BOARD

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



April 4, 2017

MATERIALS LABORATORY FACTUAL REPORT

Report No. 17-032

A. ACCIDENT INFORMATION

Place : Williamson, Georgia
Date : November 17, 2016
Vehicle : Curtiss JN4D
NTSB No. : ERA17FA050
Investigator : Ralph Hicks, AS-ERA

B. COMPONENTS EXAMINED

St. Croix wood propeller pieces.

C. DETAILS OF THE EXAMINATION

An overall view of the submitted propeller pieces are shown in figure 1. The propeller was a St. Croix fixed-pitch wood-laminate propeller with formed copper sheets with lead/tin filler attached at the tips and leading edges. The propeller had been installed on a Hispano-Suiza E2 engine. Total time on the aircraft at the time of the accident was 58.2 hours. Most of the submitted pieces were recovered on or near the main wreckage and were blackened consistent with exposure to fire, but one piece including the tip and trailing edge of one blade was recovered 670 feet from the main wreckage site. The blade piece recovered away from the main wreckage is shown labeled blade A in figure 1 for reference in this report, and the other blade is shown labeled blade B.

The leading edge strip on blade A had a transverse fracture between the leading and trailing edges of the strip at a location where the piece transitioned from the full-width tip portion to the leading edge strip. Closer views of the mating pieces shown in close proximity to each other as viewed looking at the pressure face and suction face are shown in figures 2 and 3, respectively. The underlying wood of the blade was fractured spanwise along the wood grain, and the fracture intersected two of the rivet holes attaching the leading edge/tip piece. The thickness of the leading edge strip was 0.027 inch.

The fracture surfaces were initially examined visually and with an optical stereomicroscope. Fracture features on the inboard (closer to the blade root) leading edge piece were degraded due to high temperature oxidation, so additional examination of the fracture surfaces focused on the mating outboard side of the fracture. In order to facilitate further examination of the outboard side of the fracture, the leading edge piece was cut at the location indicated by a dashed line in figure 3 and was then cleaned with an ultrasonic cleaner while submerged in acetone.

An overall view of the leading edge strip piece from the outboard side of the fracture after cleaning is shown in figure 4, and closer views of fracture surfaces at the pressure and suction sides of the piece are shown in figure 5. Fractures on each side of the leading edge strip intersected rivet holes for two rivets. Fracture features showed substantial damage consistent with fracture surface recontact. As indicated in the upper image in figure 5, green-colored deposits were observed on some areas of the fracture surface at the pressure side of the fracture. On the suction side of the strip shown in the lower image in figure 5, gray deposits covered most of the fracture surface.

The leading edge piece shown in figures 4 and 5 was examined next using a scanning electron microscope (SEM). Most of the fracture surfaces were damaged from post-fracture recontact or were obscured by oxides or deposits. However, pockets of protected fracture features were observed as shown in figures 6 through 9. As indicated in the upper image in figure 5, figures 6 and 7 show two areas to the trailing side of the rivet hole, and figures 8 and 9 show two areas to the leading side of the rivet hole on the pressure side of the strip. In these areas, transgranular fractures with curving crack arrest lines were observed, features consistent with fatigue. Fatigue features emanated from origins at the filled depression associated with the rivet, and unlabeled arrows in figures 6 through 9 show the observed direction of crack propagation toward the trailing edge in figures 6 and 7 and toward the leading edge in figures 8 and 9.

An SEM image of the fracture surface near the middle of the leading edge piece on the suction side is shown in figure 10. Fracture features were rubbed consistent with fracture surface recontact, and the general direction of fracture propagation is indicated with an unlabeled arrow. Although no fatigue striations were detected in this area, the more prominent fracture features were similar to those in fatigue regions shown in figures 6 through 9. Toward the leading edge, the fracture surface on the suction side was completely obliterated by post-fracture contact. Closer to the trailing edge, the fracture surface was largely covered by the gray deposits shown in figure 5.

Fatigue striations were counted in the images shown in figures 6 through 9. The areas in figure 6 and 7 were located 0.052 inch and 0.091 inch from the trailing side of the rivet hole, respectively. The striation density at these locations was estimated to be 22,770 striations per inch at the figure 6 location and 20,250 striations per inch at the figure 7 location. The areas in figures 8 and 9 were located 0.11 inch and 0.79 inch from the leading side of the rivet hole, respectively. The estimated striation densities at the locations to the leading side of the rivet were 79,320 striations per inch at the figure 8 location and 20,895 striations per inch at the figure 9 location.

Areas of the fracture surface and deposits on the surface were analyzed using energy dispersive x-ray spectroscopy (EDS). An area of the fracture appearing relatively free of deposits revealed a spectrum shown in figure 12 with large peaks of copper and smaller peaks of oxygen and carbon. The filler material was observed on the exterior surface adjacent to the rivet holes, and a typical spectrum of the filler is shown in figure 13, where large peaks of lead and tin were observed with smaller peaks of carbon, oxygen,

and phosphorus. An area of green deposits on the fracture surface at the pressure side of the leading edge piece was analyzed, and a typical EDS spectrum is shown in figure 14. In the area of green deposits, large peaks of copper, carbon, and oxygen were observed with smaller peaks of aluminum, silicon, phosphorus, sulfur, chlorine, potassium, calcium, and iron. Gray deposits on the suction side fracture surface produced an EDS spectrum such as the spectrum shown in figure 15, where large peaks of aluminum, carbon, and oxygen were observed with smaller peaks of phosphorus, lead, chlorine, tin, and copper.

The builder of the accident airplane maintained an online blog.¹ A search of the blog revealed multiple entries related to the propeller and engine. In an entry dated May 6, 2013, the builder noted that the propeller that was fabricated for use on the accident airplane was designed for the Hispano-Suiza E engine, and when fitted to the hub for the Hispano-Suiza E2 engine, the thickness of the propeller was approximately ½ inch too thin for the length of the hub. A new hub was subsequently acquired and installed on the accident airplane to fit the thinner propeller. According to type certificate data on the Federal Aviation Administration website,² the Wright Hispano E engine was rated 180 horsepower at 1,800 revolutions per minute. In the builder's May 6 blog entry, the builder noted the Hispano-Suiza E2 engine had a higher horsepower than the model E.

An entry in the builder's blog dated October 14, 2013, documented the first engine run, and the first flight was listed in an entry dated November 29, 2013. In an entry on April 23, 2014, the builder noted the airplane had been running rough with hesitation and backfires for a few seconds when accelerating. This issue was corrected by adjusting the engine idle speed from 350 revolutions per minute up to 480 revolutions per minute. In a November 9, 2014, entry, the builder noted a recent issue with an oil leak that led to an overhaul of the engine, and an entry on July 6, 2015, indicated the airplane was back in the air after a year.

The airplane was housed in a museum, and according to the builder's blog, the propeller was polished on at least one occasion as noted in the April 23, 2014, entry. The type of polish used was not specified. However, various brands of metal polish can contain oxides of either aluminum or silicon.

Matthew R. Fox
Senior Materials Engineer

¹ <http://curtissjennyrestoration.blogspot.com>

² http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgMakeModel.nsf/Frameset?OpenPage



Figure 1. Overall view of the submitted propeller pieces.



Figure 2. Mating sides of the copper leading edge fracture in blade A showing the aft (pressure) face of the blade.



Figure 3. Mating sides of the copper tip and leading edge fracture in blade A showing the forward (suction) face of the blade. A dashed line indicates the approximate location where the leading edge was cut to facilitate further examination of the fracture surface.

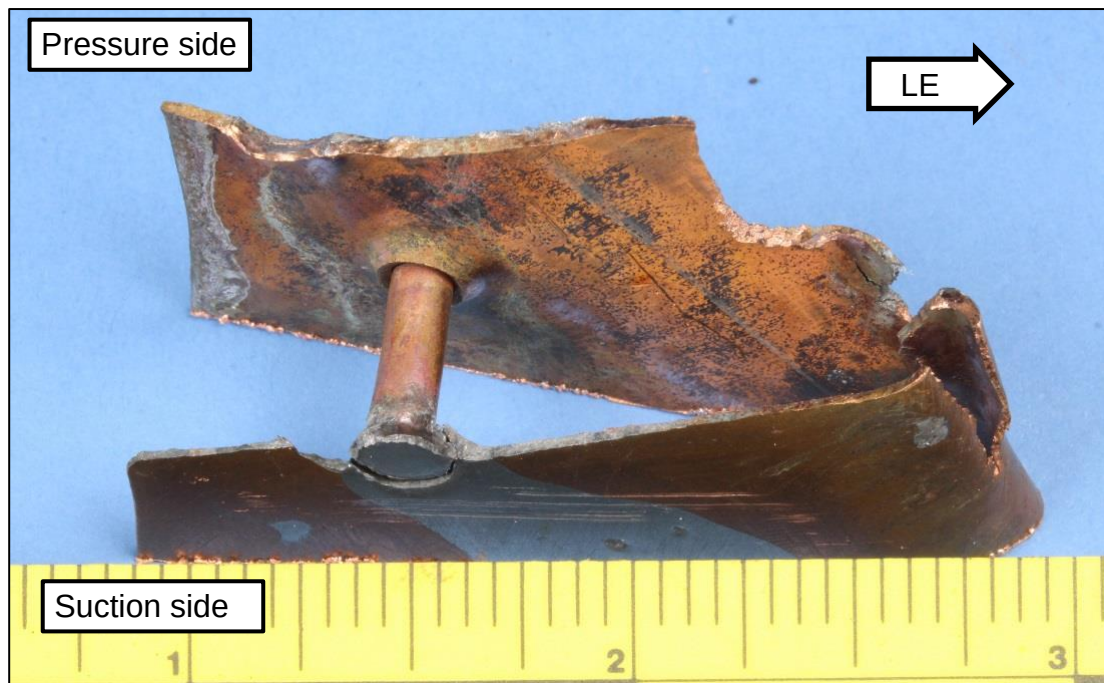


Figure 4. Close view of the fractured leading edge piece after sectioning and ultrasonic cleaning in an acetone bath.

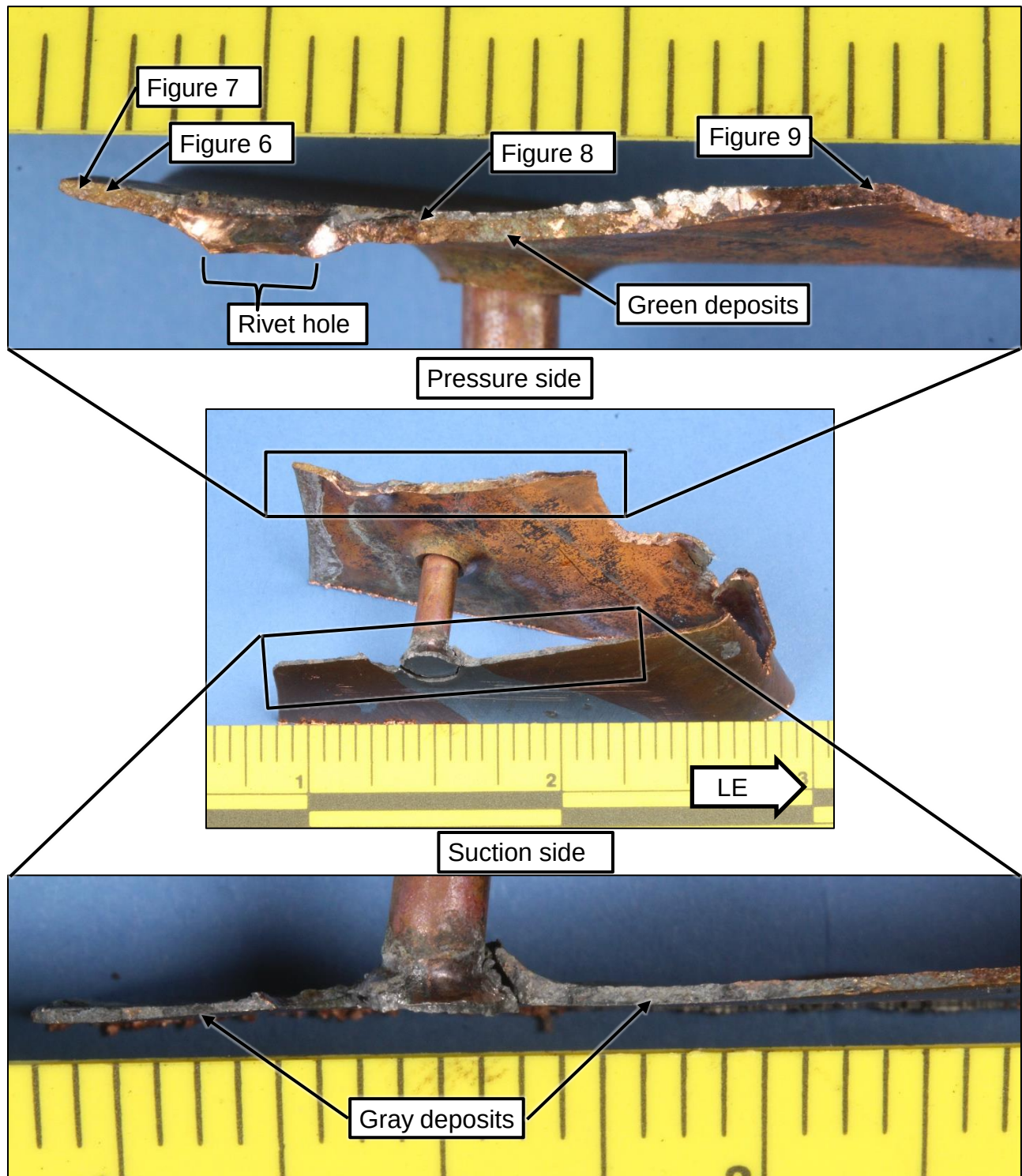


Figure 5. Close views of fracture surfaces on the leading edge piece. Approximate locations of SEM images in subsequent figures are indicated in the upper image.

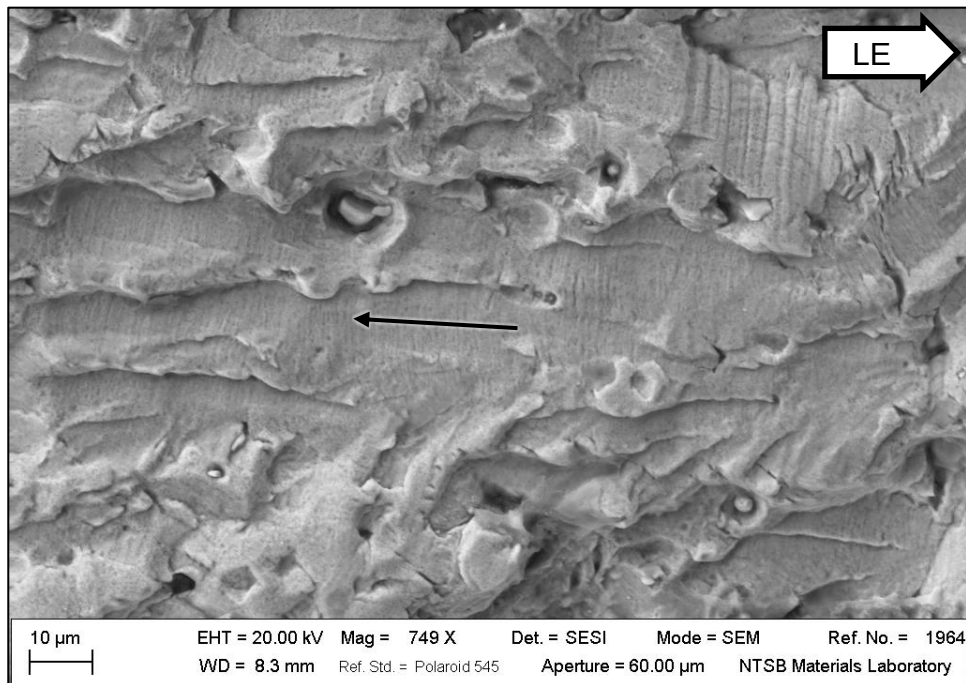


Figure 6. Fatigue features on the pressure side of the leading edge strip 0.052 inch from the trailing edge of the rivet hole (see figure 5). An arrow indicates the general direction of crack propagation.

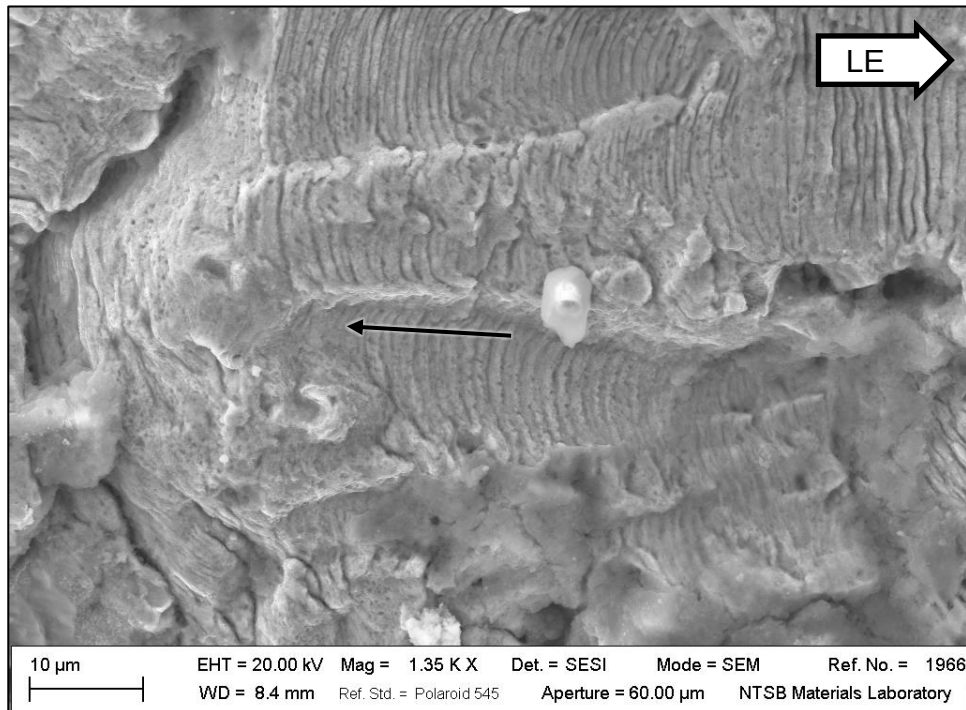


Figure 7. Fatigue features on the pressure side of the leading edge strip 0.091 inch from the trailing edge of the rivet hole (see figure 5). An arrow indicates the general direction of crack propagation.

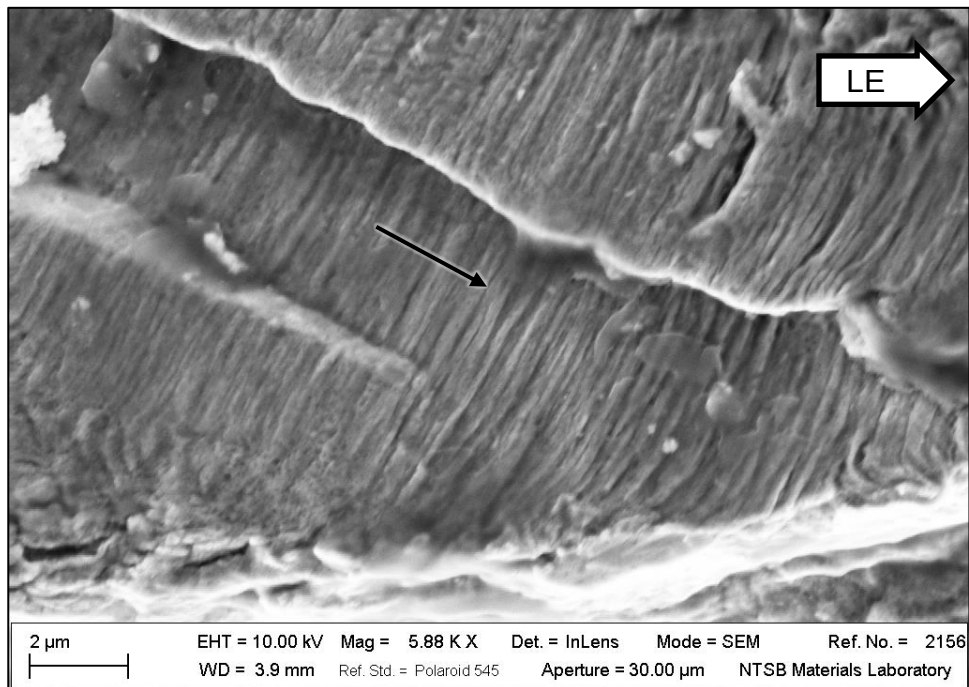


Figure 8. Fatigue features on the pressure side of the leading edge strip 0.11 inch from the leading side of the rivet hole (see figure 5). An arrow indicates the general direction of crack propagation.

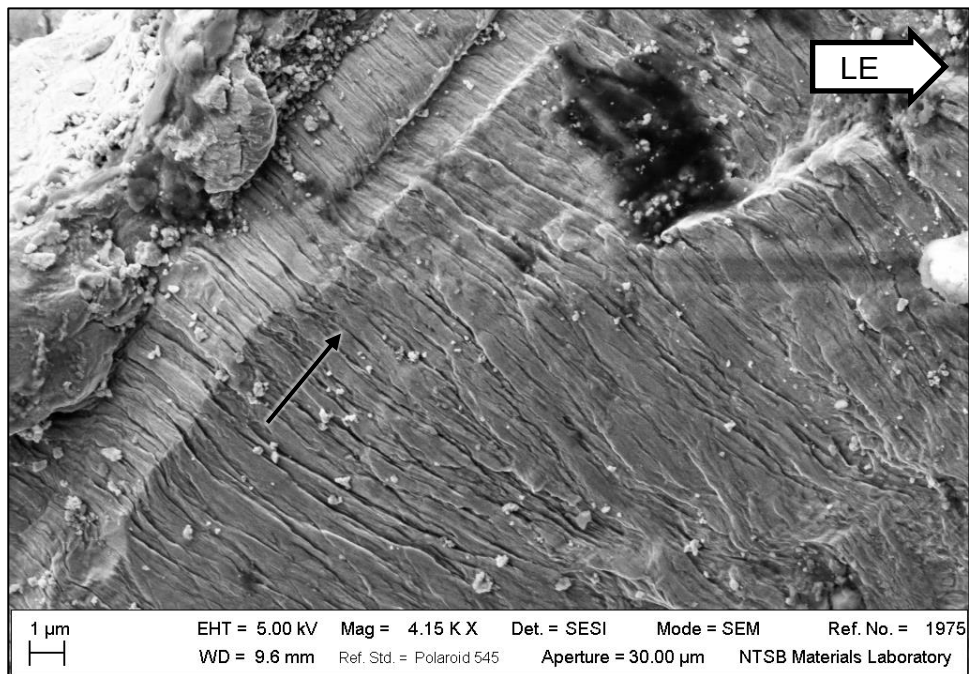


Figure 9. Fatigue features on the pressure side of the leading edge strip 0.79 inch from the leading side of the rivet hole (see figure 5). An arrow indicates the general direction of crack propagation.

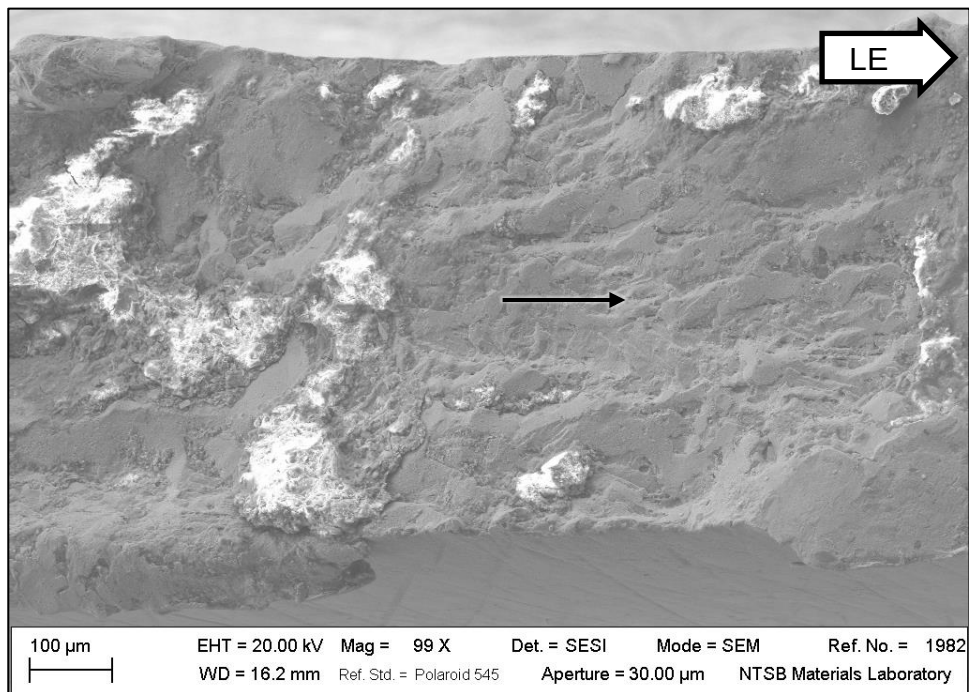


Figure 10. Rubbed fracture features on the suction side of the leading edge strip 0.5 inch from the leading side of the rivet hole. An arrow indicates the general crack propagation direction.

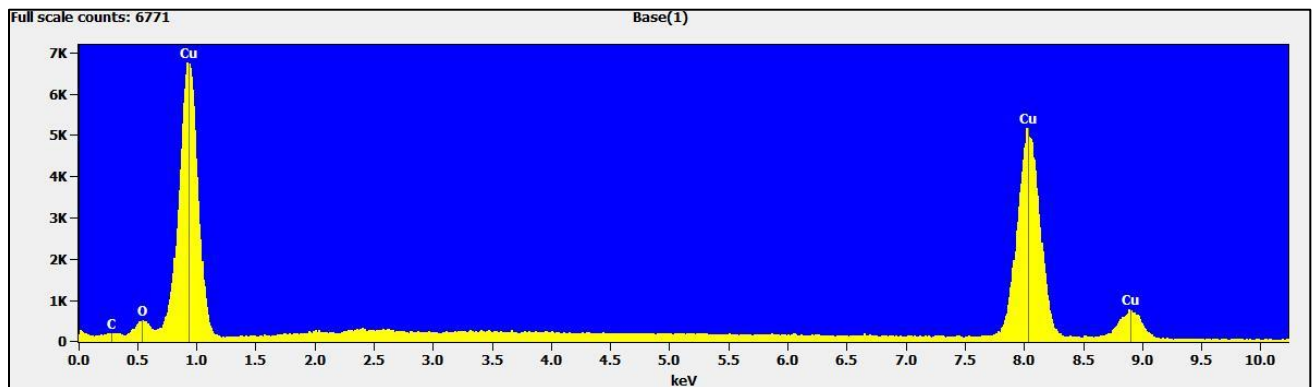


Figure 11. Typical EDS spectrum of the leading edge strip metal showing copper peaks with smaller peaks of oxygen and carbon.

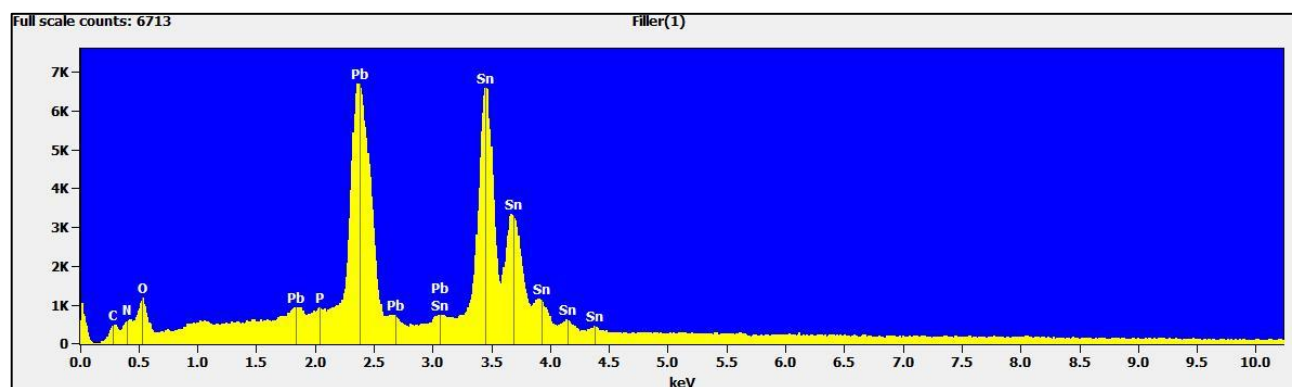


Figure 12. Typical EDS spectrum of filler metal on the leading edge strip showing peaks of lead and tin with smaller peaks of carbon, oxygen, and phosphorus.

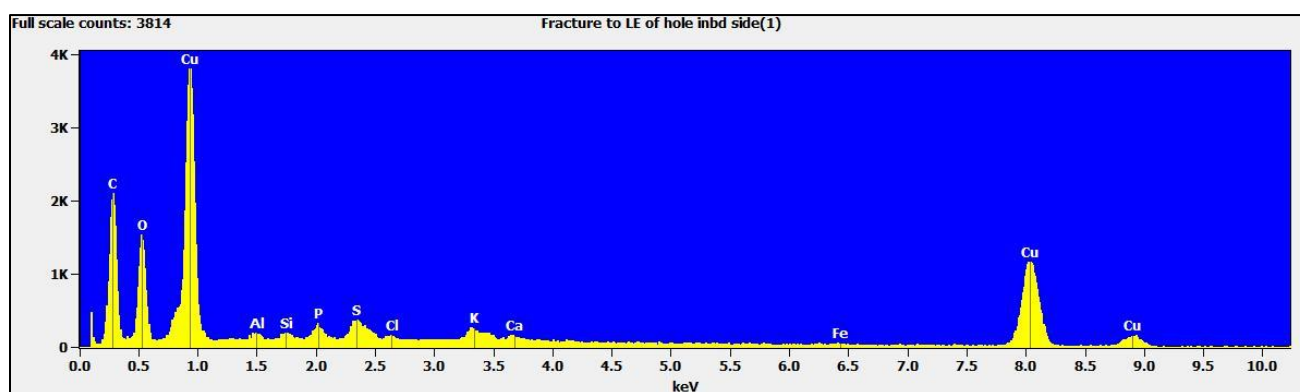


Figure 14. Typical EDS spectrum of green deposits on the surface on the pressure side of the fracture (see figure 5). Large peaks of copper, carbon, and oxygen were present along with smaller peaks of aluminum, silicon, phosphorus, sulfur, chlorine, potassium, calcium, and iron.

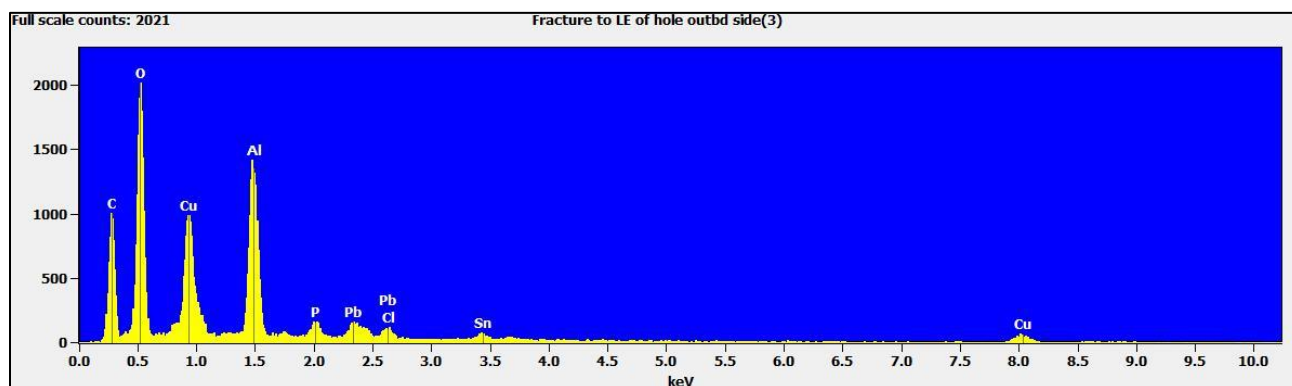


Figure 13. Typical EDS spectrum of gray deposits on the suction side of the fracture (see figure 5). Large peaks of aluminum, oxygen, and carbon were present along with smaller peaks of phosphorus, lead, chlorine, tin, and copper.