

NATIONAL TRANSPORTATION SAFETY BOARD

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



January 9, 2017

MATERIALS LABORATORY FACTUAL REPORT

Report No. 17-004

A. ACCIDENT INFORMATION

Place : Spanish Fork, Utah
Date : August 1, 2016
Vehicle : Beech C99, N234AV
NTSB No. : WPR16LA155
Investigator : Chris Shaver, AS-WPR

B. COMPONENTS EXAMINED

Vertical stabilizer, rudder, and rudder trim tab pieces.

C. DETAILS OF THE EXAMINATION

Overall views of the submitted vertical stabilizer, rudder, and rudder trim tab pieces are shown in figure 1. The pieces were fractured in a nearly horizontal plane at the upper ends of the submitted pieces and had been cut from the remainder of the structure at the lower ends to facilitate shipment to the NTSB Materials Laboratory. The piece of the rudder trim tab remained attached to the rudder. The mating upper pieces of the vertical stabilizer, rudder, and rudder trim tab were not recovered.

The leading edges of the vertical stabilizer, rudder, and rudder trim tab were all flattened adjacent to the fractures. Vertical spars in the vertical stabilizer and rudder were bent aft. Skin on the vertical stabilizer and rudder was deformed adjacent to the fracture into curled rolls turning downward and aft, and some areas were crushed consistent with the vertical stabilizer moving forward relative to another object. Sliding contact marks were observed at the leading edges, vertical spars, and deformed faces of the skin panels adjacent to the fractures. No evidence of any biological or manufactured foreign material transfer was observed associated with any of the fracture surfaces as observed visually and under optical magnification.

An oblique view of the vertical stabilizer is shown in figure 2. The leading edge of the vertical stabilizer was covered with a black elastomer. Impact marks were observed in the elastomer adjacent to the fracture as shown in the lower image in figure 2. One mark curved from the left side and ended in a point to the right of the aircraft centerline. A separate impact mark was observed above the other mark, and an unlabeled bracket in figure 2 indicates the spacing between the lower edges of the marks, which measured approximately 0.10 inch.

An area with heavy sliding contact was selected for closer examination using a scanning electron microscope (SEM) with energy dispersive x-ray spectroscopy (EDS). The area selected for further examination was from the left skin just forward of the forward vertical spar as noted in figure 2 and shown in closer views in figure 3. The skin adjacent to the fracture surface was deformed inward, and sliding contact marks were observed on the exterior surface of the skin. Paint and primer was missing from the areas with deformation and sliding contact. Fracture features on portions of the fracture surface in this area were obliterated by sliding contact, and the edge of the skin at the fracture face was flattened and rolled over onto the adjacent surfaces. The lower image in figure 3 shows rolled material associated with the obliterated fracture face and a closer view of sliding contact marks on the exterior surface of the skin.

Deposits of particles were observed on the interior surface mostly on the rib adjacent to the fracture as indicated in figure 3. The deposits were caked on and remained largely in place after being exposed to blasts of compressed air.

The area shown in figure 3 was sectioned from the remainder of the vertical stabilizer to facilitate an SEM examination. The surfaces were imaged using backscattered electrons¹ to help identify any potential foreign material on the surface for further compositional analysis using EDS. An area of sliding contact on the skin surface that appeared black in the optical image in figure 3 is shown in figure 4 as viewed in the SEM using backscattered electrons. The area of sliding contact appeared darker in the SEM image, consistent with lower atomic weight material. Many lighter gray particles were observed within the contact area, and an example of two of the particles are shown in figure 5. The particles generally appeared curved and deformed, and many appeared to have step features at the surface consistent with high strain deformation.

An EDS spectrum from the darker area in figure 4 (in the area of sliding contact) is shown in figure 6. The largest peaks were aluminum and carbon with additional peaks of oxygen, magnesium, silicon, sulfur, chlorine, calcium, titanium, chromium, iron, and zinc. EDS spectra of the paint and the primer layers were also taken as shown in figures 7, 8, and 9. The three highest peaks in the external paint layer were carbon, oxygen, and titanium. In the primer layer under the external paint layer, the three highest peaks were carbon, oxygen, and silicon. The internal surface of the skin had a primer layer with an EDS spectrum with high peaks of oxygen, carbon, chromium and zinc.

The gray particles shown in figure 5 had high peaks of aluminum with metallic element peaks of magnesium, copper, and manganese (see spectrum in figure 10). The spectrum was consistent with aluminum alloy 2024, and similar metallic element peaks were observed in EDS spectra of the skin surface as shown in figure 11.

Scattered particles of varying composition were observed throughout the areas of sliding contact on the obliterated fracture surfaces and on the exterior surface of the skin.

¹ SEM images produced using a backscatter detector in composition mode have contrast that is associated with atomic weight of the elements in the image. Areas with elements having higher atomic weights appear as a relatively lighter shade of gray compared to areas having elements with lower atomic weights.

Most of the particles had a spectrum consistent with aluminum alloy 2024, but others had spectra consistent with a low alloy steel, stainless steel, brass, and a nickel-base alloy with iron and chromium. Particles with a shape and EDS composition consistent with glass fiber fragments were also observed on the surfaces.

A sample of the particles remaining caked onto the rib adjacent to the fracture after being blast with compressed air (see indicated area in figure 3) was extracted from the surface by pressing an aluminum stub covered with carbon tape onto the surface and lifting several times. The extracted particles were then analyzed using EDS, and two of the resulting spectra are shown in figure 12. The EDS spectra for the particles showed many of the peaks observed for particles on the skin surfaces in the areas of sliding contact. Particles with a shape and EDS composition consistent with glass fiber fragments were also observed scattered within the extracted sample.

Matthew R. Fox
Senior Materials Engineer

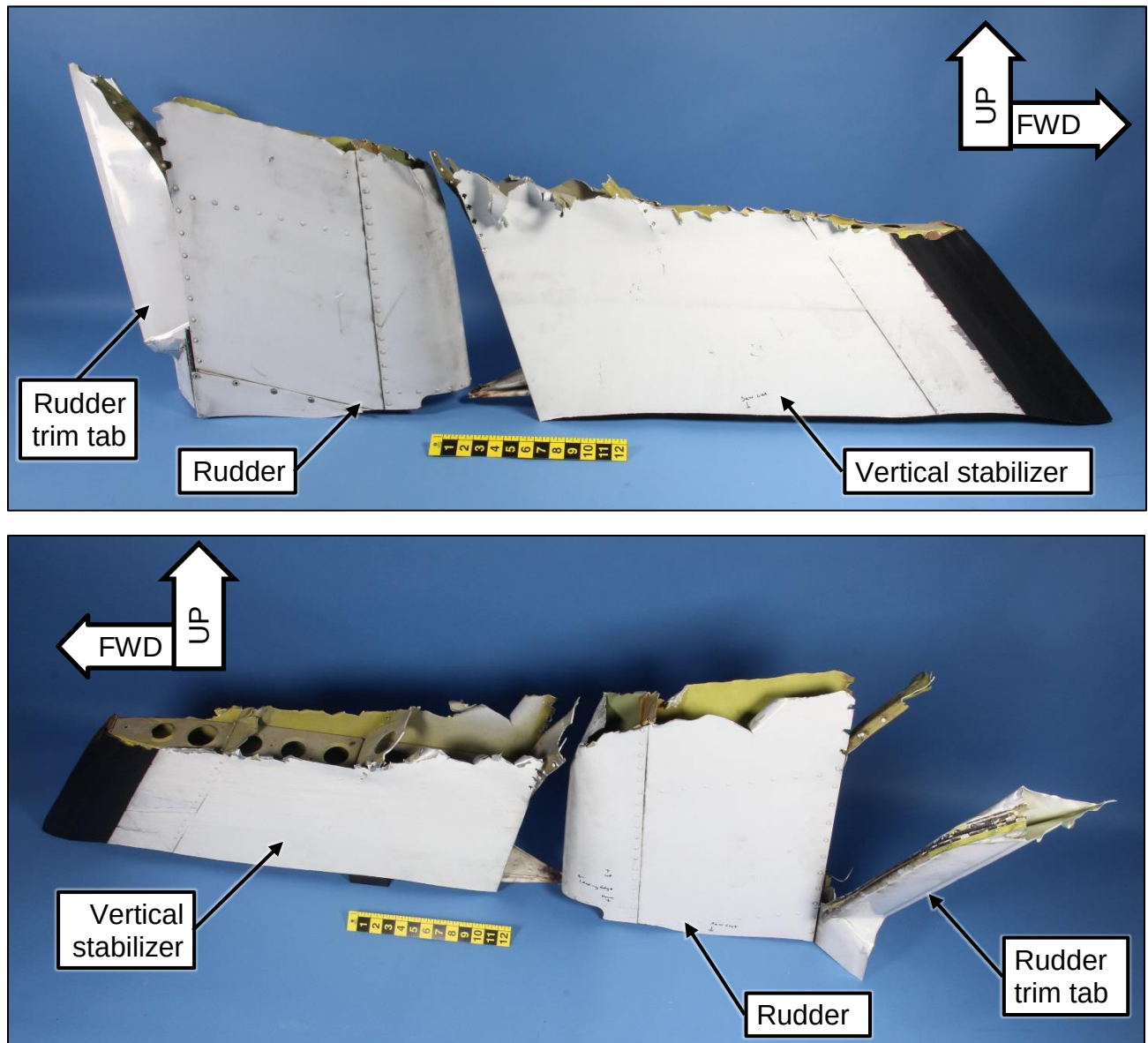


Figure 1. Overall views of the vertical stabilizer, rudder, and rudder trim tab as received.

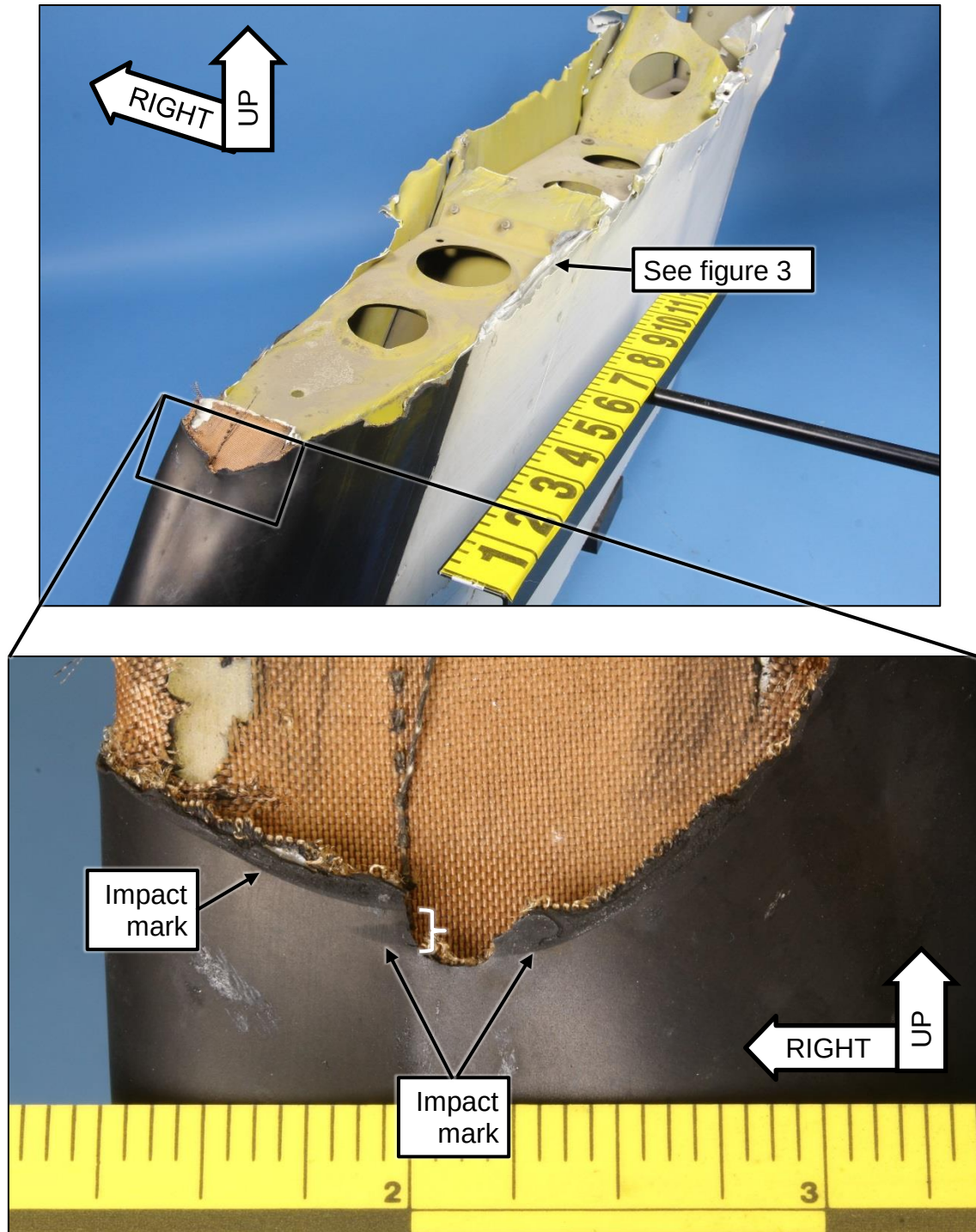


Figure 2. Oblique view of the vertical stabilizer fracture with a closer view of impact marks on the elastomer at the leading edge.

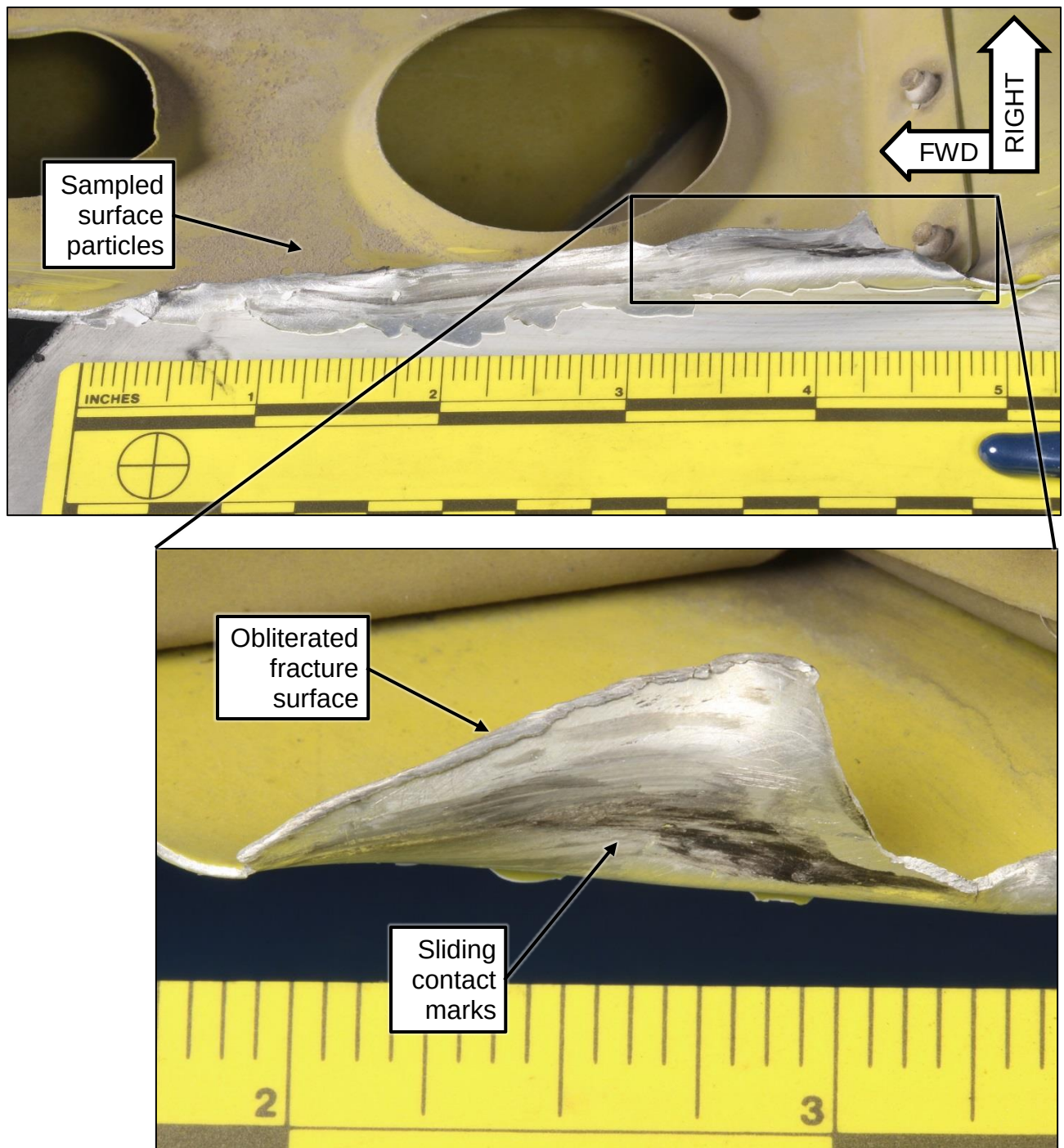


Figure 3. Close views of the deformed skin, sliding contact marks, and obliterated fracture surface on the left skin panel (see figure 2 for location).

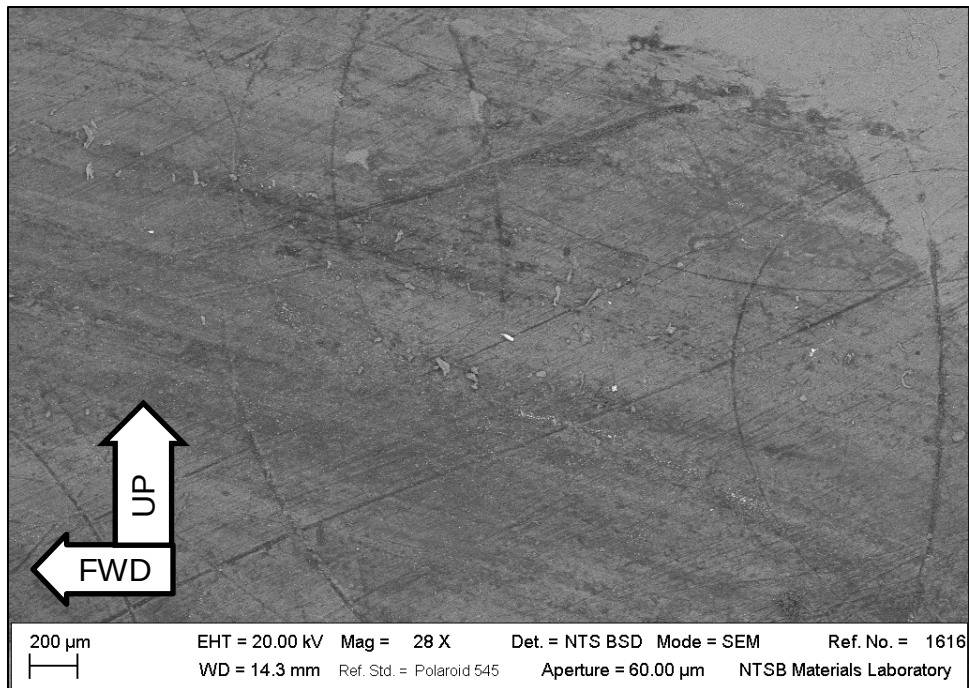


Figure 4. Area of sliding contact as viewed with an SEM using backscattered electrons.

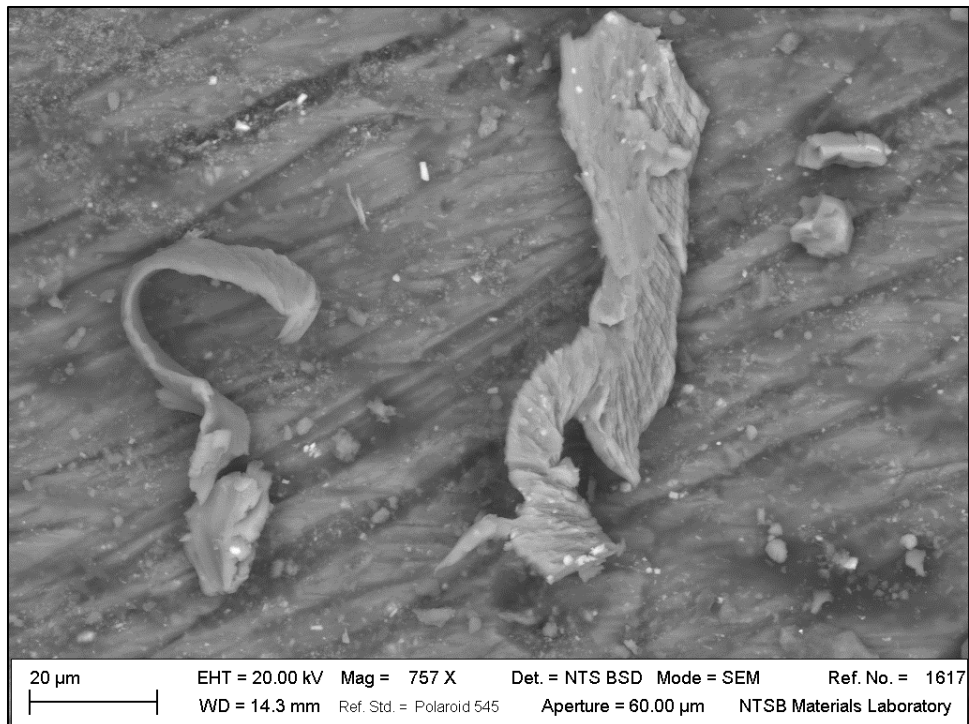


Figure 5. SEM image of medium gray particles on the surface in the area of sliding contact as viewed using backscattered electrons.

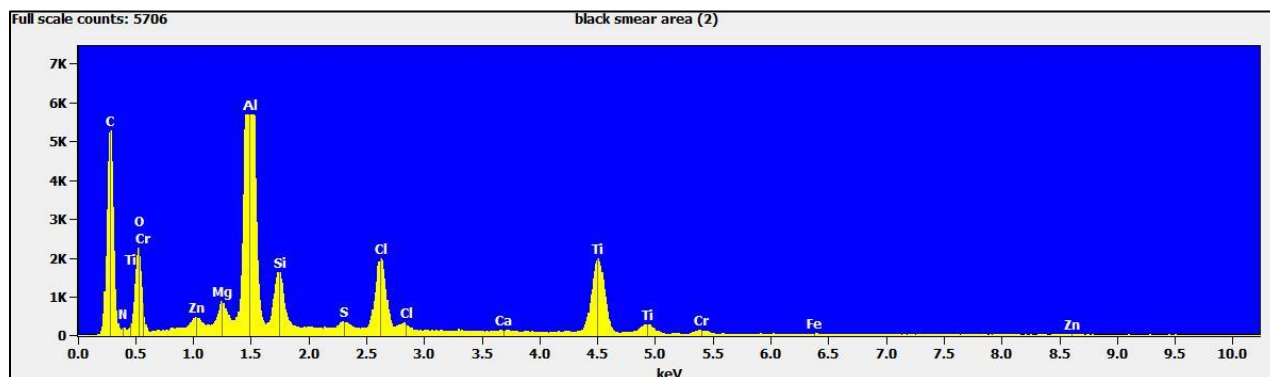


Figure 6. EDS of the surface in the darker area shown in figure 4 (area of sliding contact).

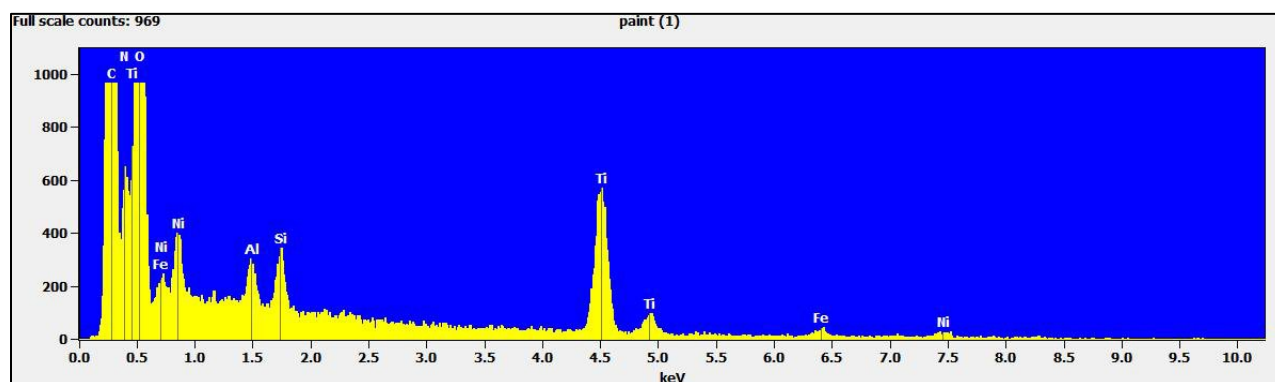


Figure 7. EDS spectrum of the exterior paint coating.

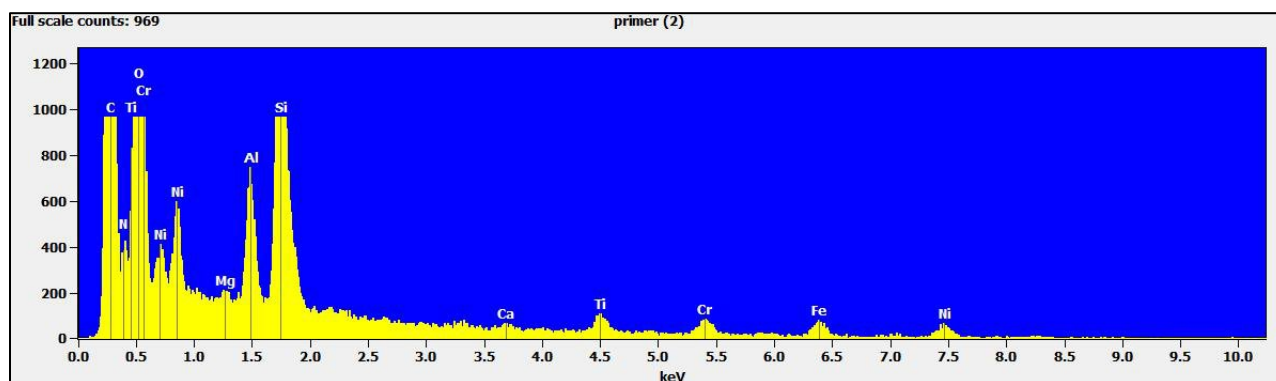


Figure 8. EDS spectrum of the primer coating under the exterior paint coating.

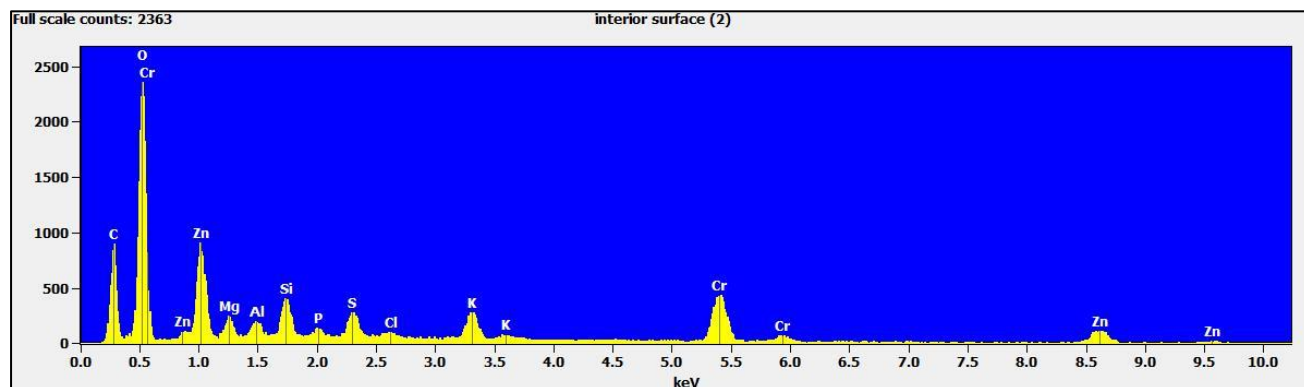


Figure 9. EDS spectrum of the primer on the interior surface of the skin.

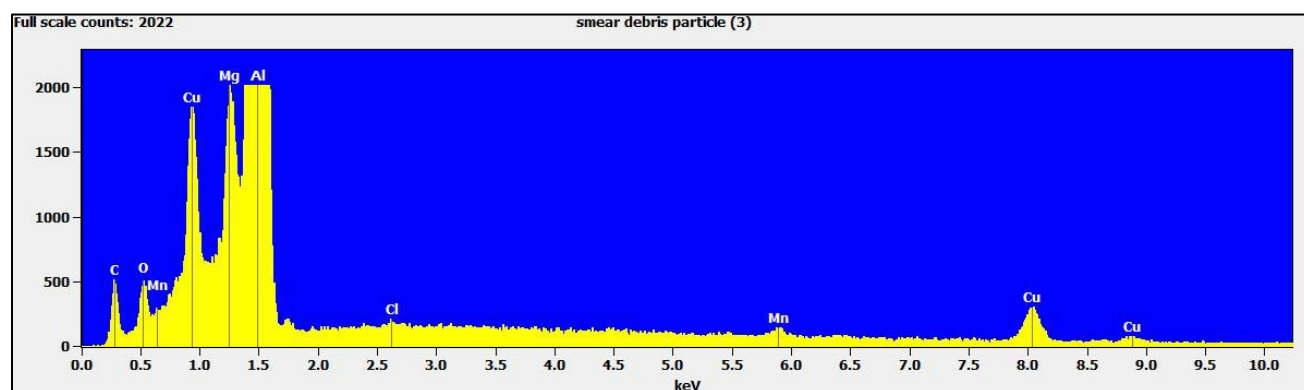


Figure 10. EDS spectrum of one of the medium gray particles such as those shown in figure 5.

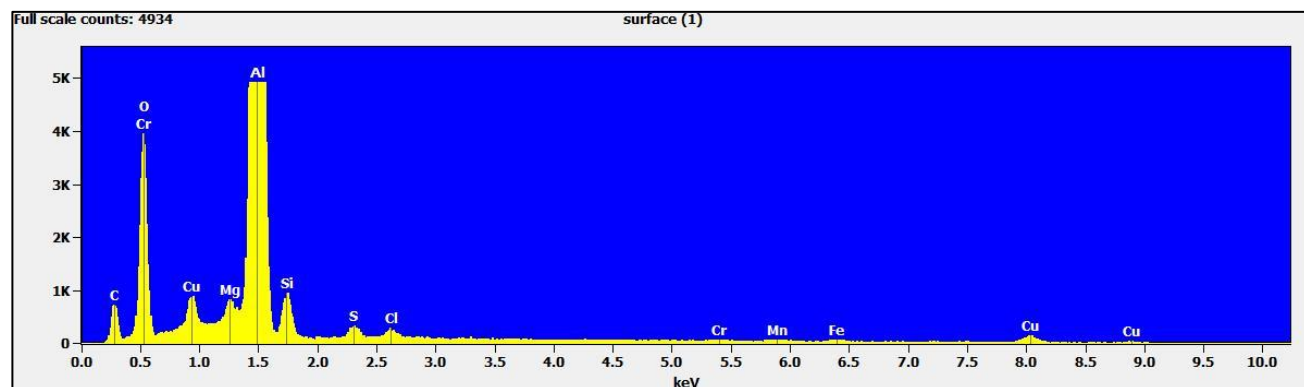


Figure 11. EDS spectrum of the surface of the vertical stabilizer skin.

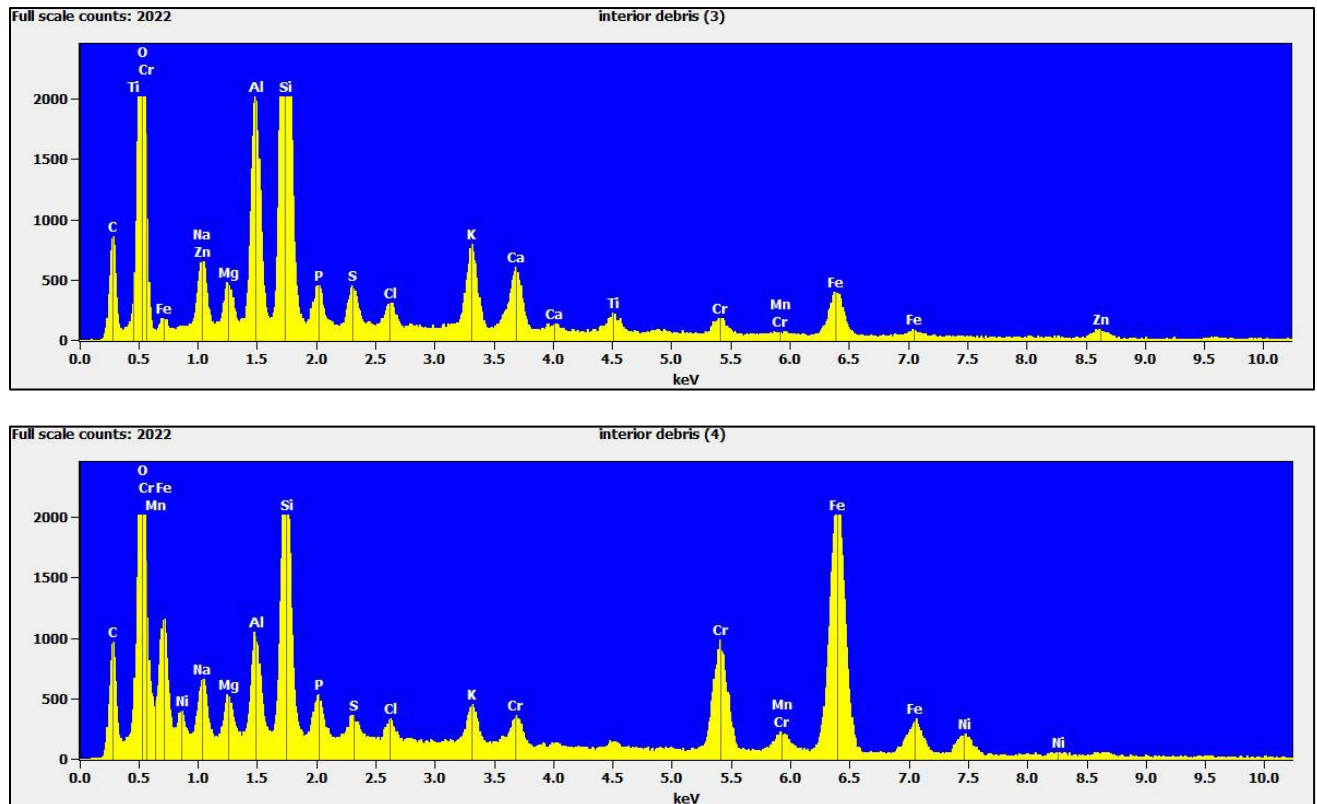


Figure 12. EDS spectra of debris sampled from the surface of the vertical stabilizer rib.