

NATIONAL TRANSPORTATION SAFETY BOARD

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



November 6, 2014

MATERIALS LABORATORY FACTUAL REPORT

Report No. 14-062

A. ACCIDENT INFORMATION

Place : Houlton, Maine
Date : January 17, 2014
Vehicle : Eurocopter AS350 B3
NTSB No. : ENG14TA096
Investigator : Paul Cox, AS-ERA

B. COMPONENTS EXAMINED

Axial and centrifugal compressor wheels, gas generator turbine wheel, engine air intake duct, and sand filter pieces from a Turbomeca Arriel 2B engine.

C. DETAILS OF THE EXAMINATION

An overall view of the submitted components is shown in figure 3. The axial compressor, centrifugal compressor, and gas generator turbine wheels were intact. A large portion of the air intake duct and most of the sand filter were missing.

The air intake duct was discolored and the edges around the missing portion of the duct were wrinkled and distorted with flowing deformation consistent with exposure to high heat. The interior of the duct contained charred debris with embedded glass fibers consistent with remains of the engine cowling, which was made of glass fiber reinforced composite and honeycomb. Pieces of aluminum alloy material were also found within the duct. Most of the pieces had a flowed appearance consistent with solidification from a molten condition. Some of the pieces were pieces of sheet with a circular cut-out pattern consistent pieces of the sand filter. Additional sand filter pieces included in the submitted components are shown in figure 1. Flowed deformation from a previously molten condition was observed at the edges of several pieces identified as pieces of the sand filter.

The chemical composition of the air intake duct and the sand filter was analyzed using a Thermo Scientific Niton XL3t-980 x-ray fluorescence (XRF) alloy analyzer. The XRF analyzer identified air intake duct material and the sand filter material as aluminum alloy 6061 and aluminum alloy 5086, respectively.

Charred debris with embedded glass fibers were observed on both the axial and centrifugal compressor wheels. A view of an area where this debris accumulated in the

axial compressor is shown in figure 2. Some glass fiber segments were also observed on the gas generator turbine wheel.

A sample of the charred debris with embedded fibers was removed from the air intake duct and analyzed using energy dispersive x-ray spectroscopy (EDS) in a scanning electron microscope (SEM). The EDS spectra of the charred resin material and the fiber remnants are shown in figure 3.

An overall view of the axial compressor wheel is shown in figure 4. Deposits of varying color including black, gray, and orange were observed on the airfoil surfaces. Charred deposits with embedded fibers were observed mostly near the base and pressure sides of the blades. All of the blades showed impact damage at their leading edges near the blade tips. Close views of impacts on two of the blades is shown in figure 5. Deposits of varying colors are shown in the upper image in figure 5. A lip of material as indicated in the lower image in figure 5 was observed at the edges of many of the impact areas.

A pie-shaped section of the axial compressor wheel was cut to facilitate examination of the impact damage at the leading edge of one of the blades. An image of the impact area on the sectioned blade as viewed in the SEM using a backscatter detector in composition mode¹ is shown in figure 6. The area showed smearing and deformation consistent with sliding contact. Streaks of areas with a relatively lighter shade of gray were observed as indicated in the image in figure 6. The EDS spectrum of the lighter gray areas are shown in the upper spectrum in figure 6, and results for darker gray areas within the impact region are shown in the lower spectrum in figure 6. Higher peaks of nickel, cobalt, iron, and chromium were observed in the lighter shaded areas relative to the darker shaded areas.

Areas of the axial compressor blade away from the impact area were also analyzed using EDS. Figure 7 shows a typical EDS spectrum of the blade leading edge surface away from the area of impact. For comparison, the EDS spectrum on the cut surface representing the bulk composition of the titanium alloy axial compressor is shown in figure 8.

The centrifugal compressor wheel was covered mainly in black deposits including deposits containing glass fibers. The leading edges of the compressor wheel blades were examined using a stereo microscope. Results of the examination revealed 6 of the 11 blades showed some impact damage.

Overall views of the gas generator turbine wheel are shown in figure 9 showing the upstream and downstream sides of the wheel. The blades were generally brown in color with areas of some blades appearing light gray. Light gray and black deposits were observed mostly at the leading edge and on the convex face of the blades. Some

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.

shallow spalled areas with green oxides were observed on the leading edges of some blades.

One of the blades showing a typical deposit pattern on the leading edge was removed from the gas producer turbine for SEM examination and EDS analysis. Typical EDS spectra covering relatively large areas of the leading edge deposits are shown in figure 10. Some areas of the deposits appeared relatively thicker when viewed using the secondary electron detector and appeared relatively darker when viewed using the backscatter detector. EDS analysis showing typical spectra for these thicker deposits that appeared darker when viewed using the backscatter detector is presented in figure 11. The convex side of the blade was analyzed using EDS at several locations along the midchord, and typical spectra for these areas are presented in figure 12.

Next, the turbine blade was sectioned spanwise, and the cut surface was rough ground to a 600 grit finish. The sectioned piece was examined using SEM and EDS. AS viewed using backscattered electrons, the cross-section near the blade surface was a different shade of gray than the rest of the blade, consistent with a surface coating. Typical EDS spectra for the bulk of the blade cross-section (the substrate) and for the surface coating as analyzed on the cut surface of the blade are shown in figure 13.

Matthew R. Fox
Senior Materials Engineer



Figure 1. Overall view of submitted components.



Figure 2. Close view of charred debris on the centrifugal compressor.

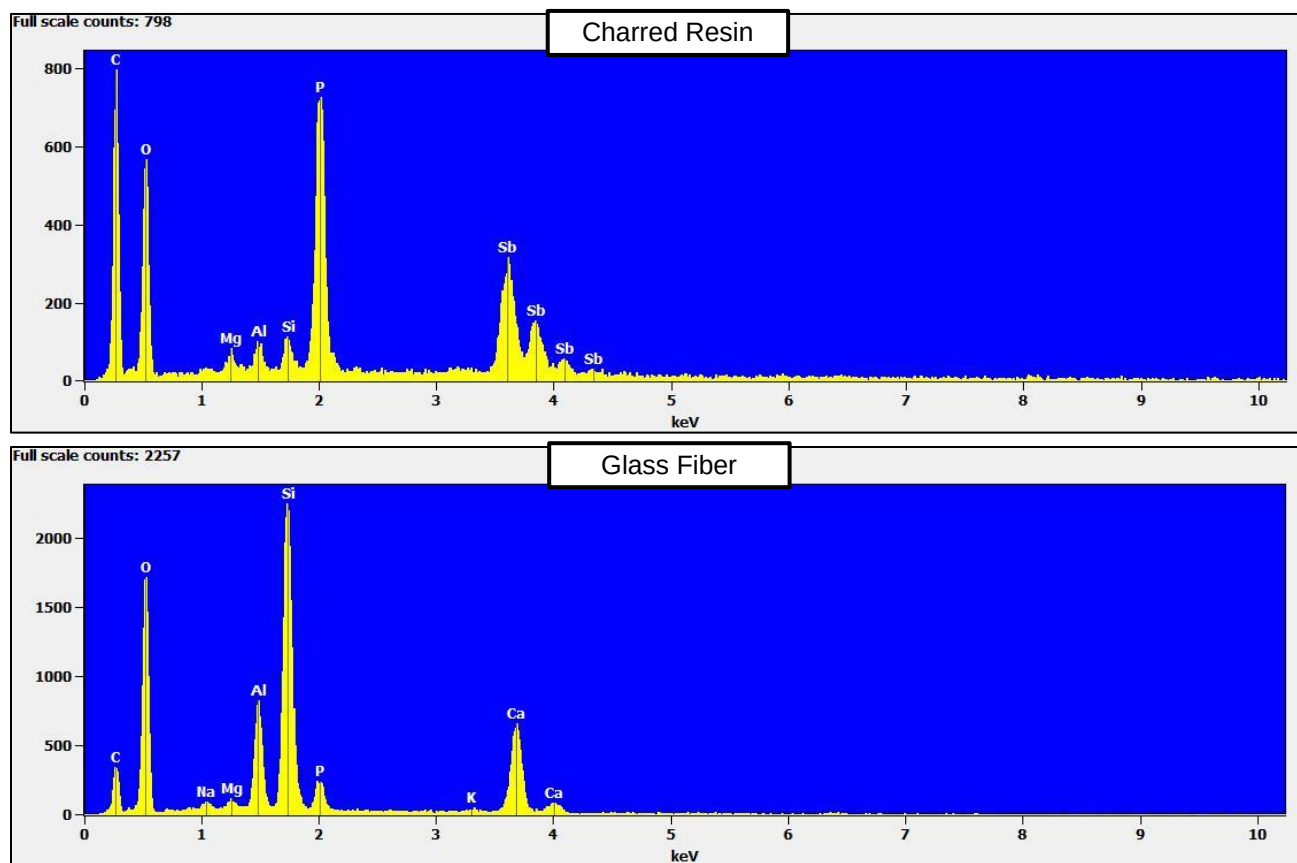


Figure 3. EDS spectra for the charred resin debris (upper spectrum) and fiber remnants (lower spectrum) collected from inside the air intake duct.



Figure 4. Overall view of the upstream side of the axial compressor.

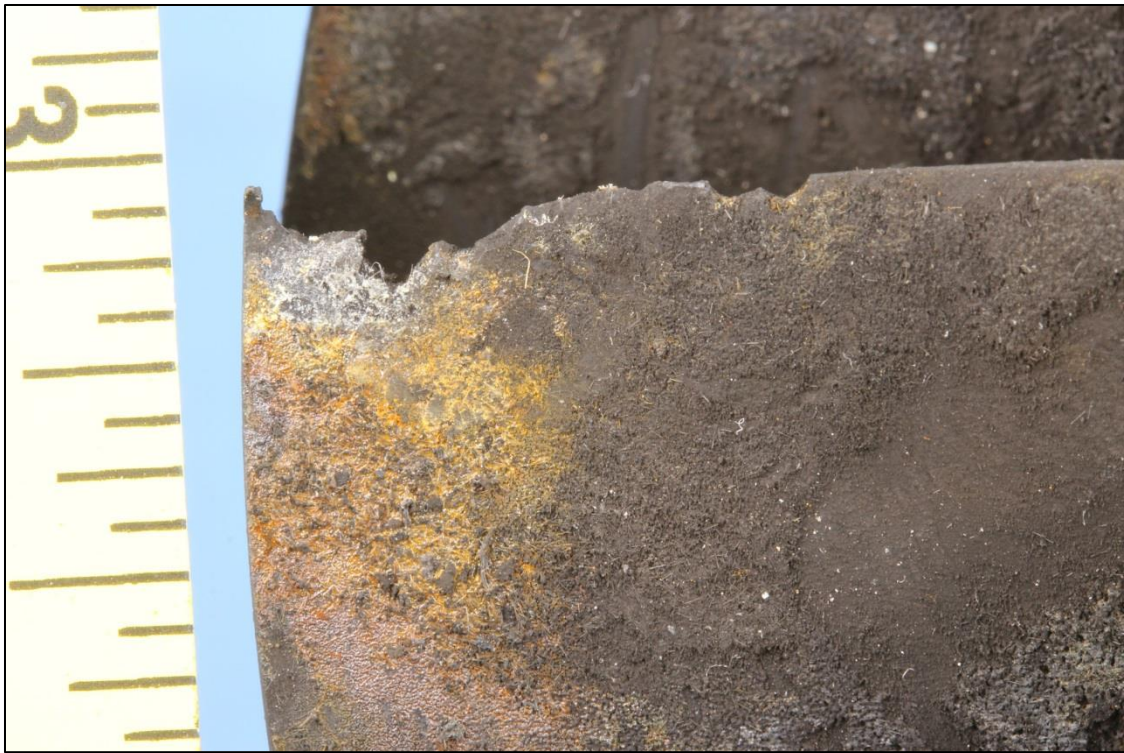


Figure 5. Close views of impact damage near the tips of axial compressor blades.

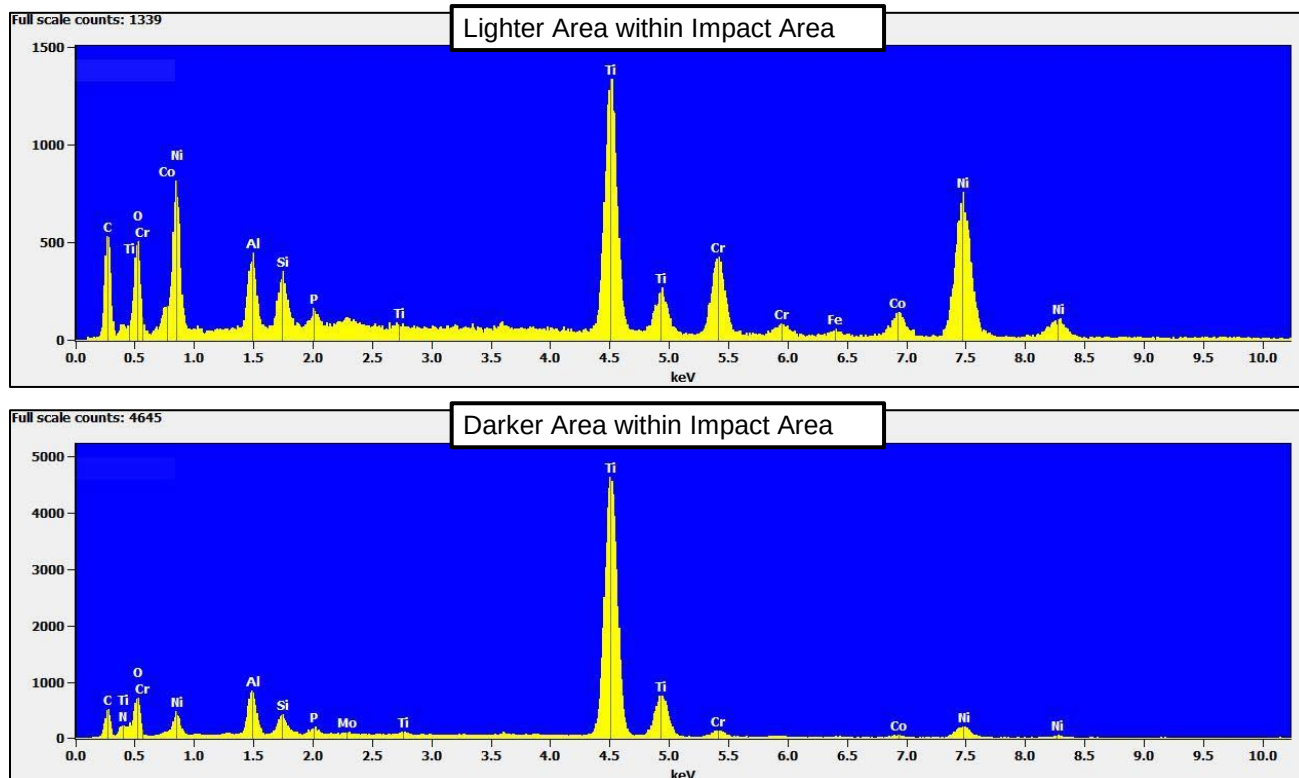
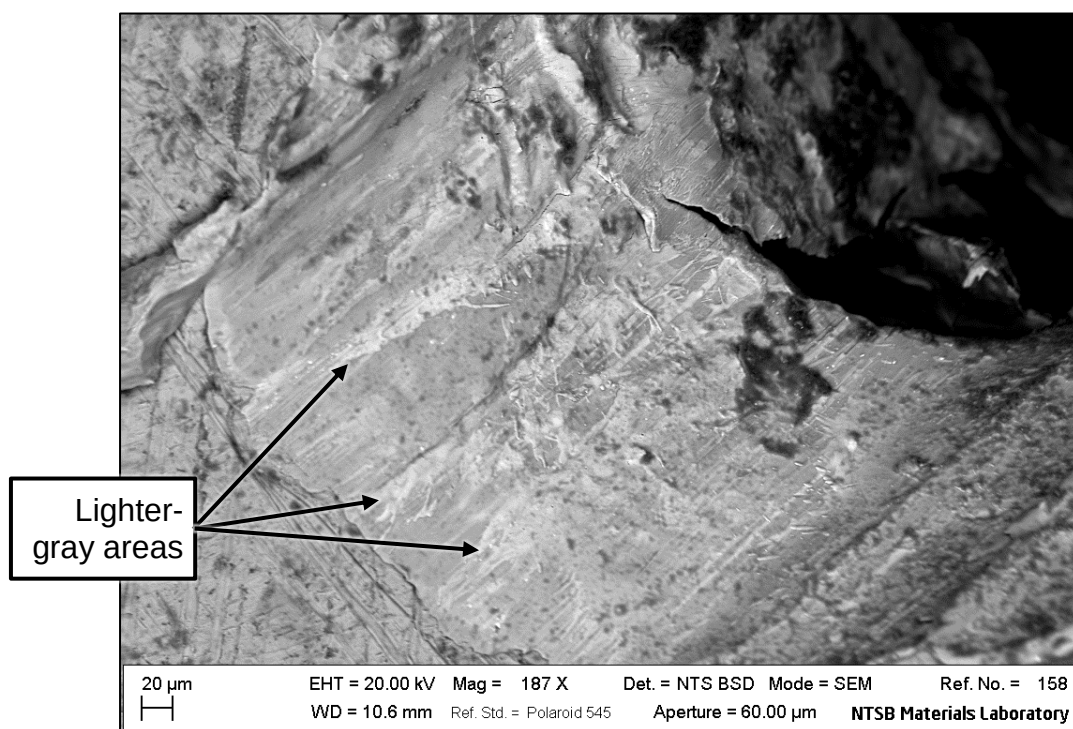


Figure 6. SEM image of an area of impact on an axial compressor blade as viewed using backscattered electrons (upper image) and EDS spectra of areas within the SEM image showing compositional differences between the lighter gray areas indicated in the image (upper spectrum) versus the darker gray areas (lower spectrum) within the impact area.

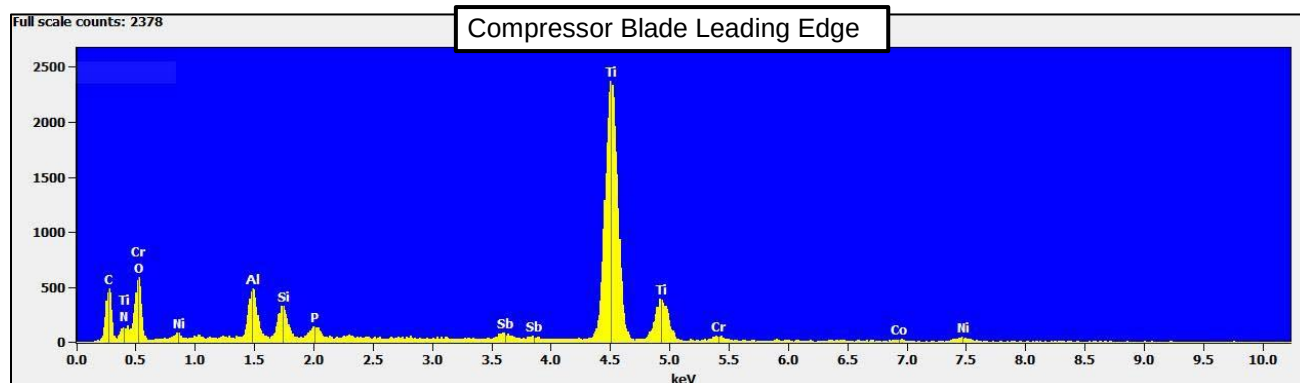


Figure 7. Typical EDS spectrum of the axial compressor blade leading edge surface at midspan (away from the area of impact).

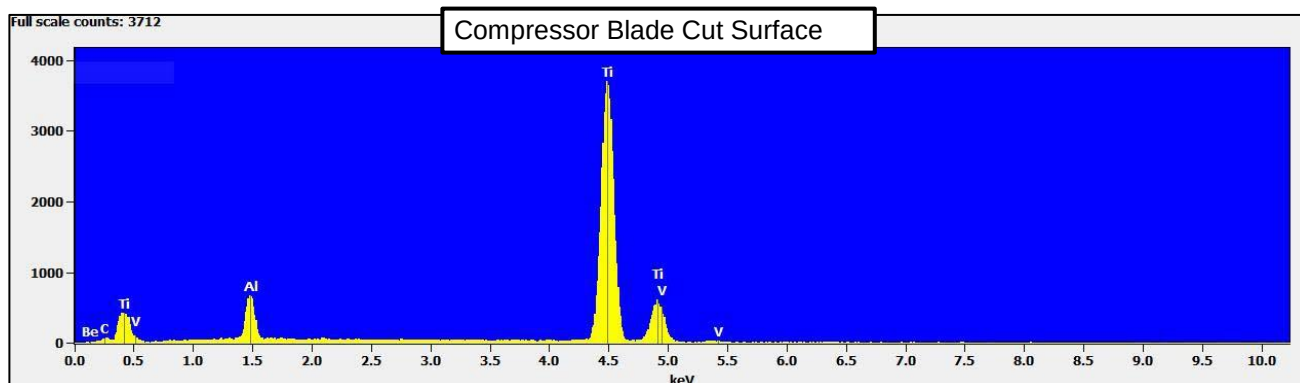


Figure 8. EDS spectrum of the axial compressor blade as collected from the surface of a cut through the blade made to facilitate the SEM examination and EDS analysis of the axial compressor.

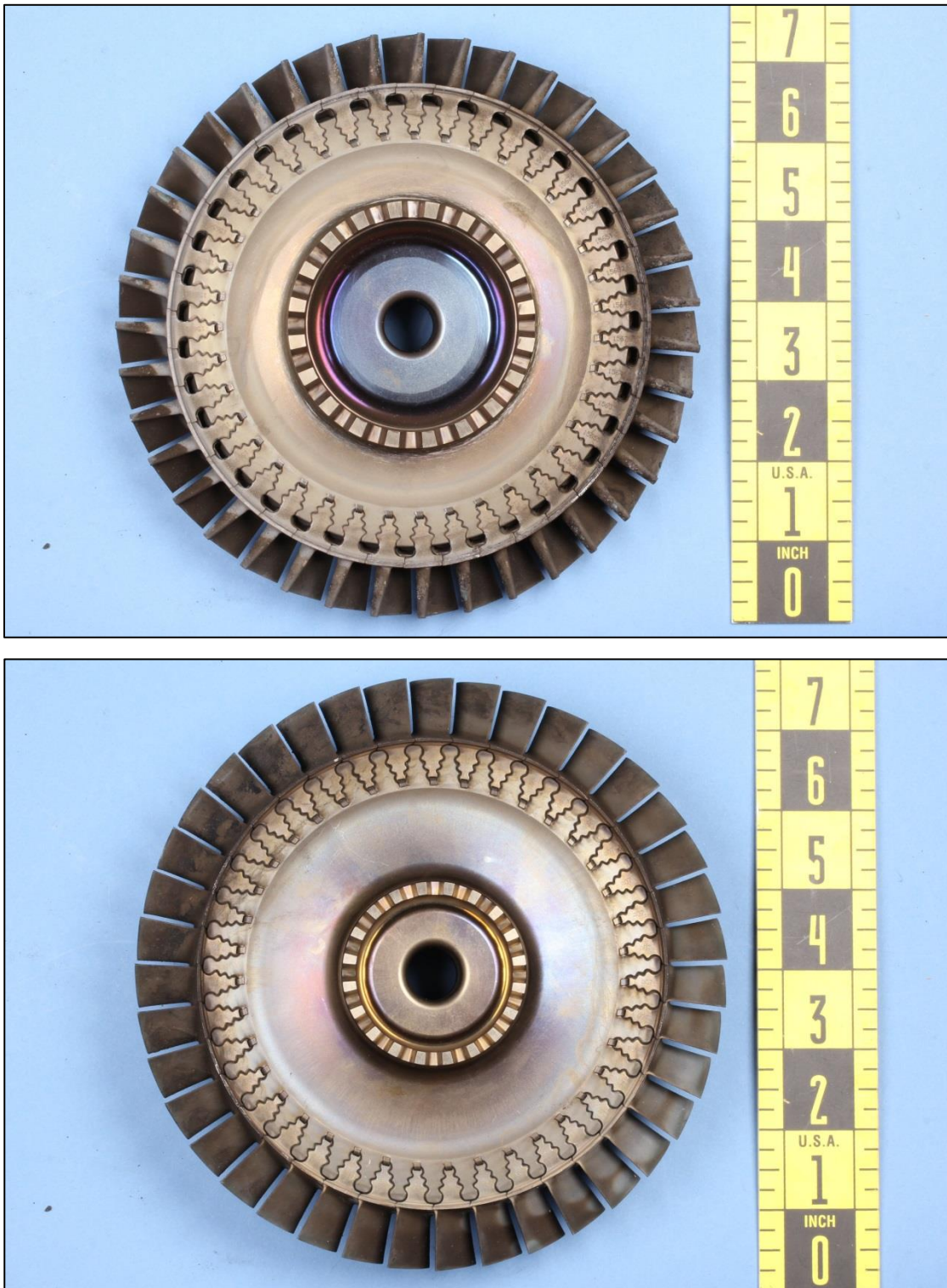


Figure 9. Overall views of the upstream (upper image) and downstream (lower image) sides of the gas generator turbine wheel.

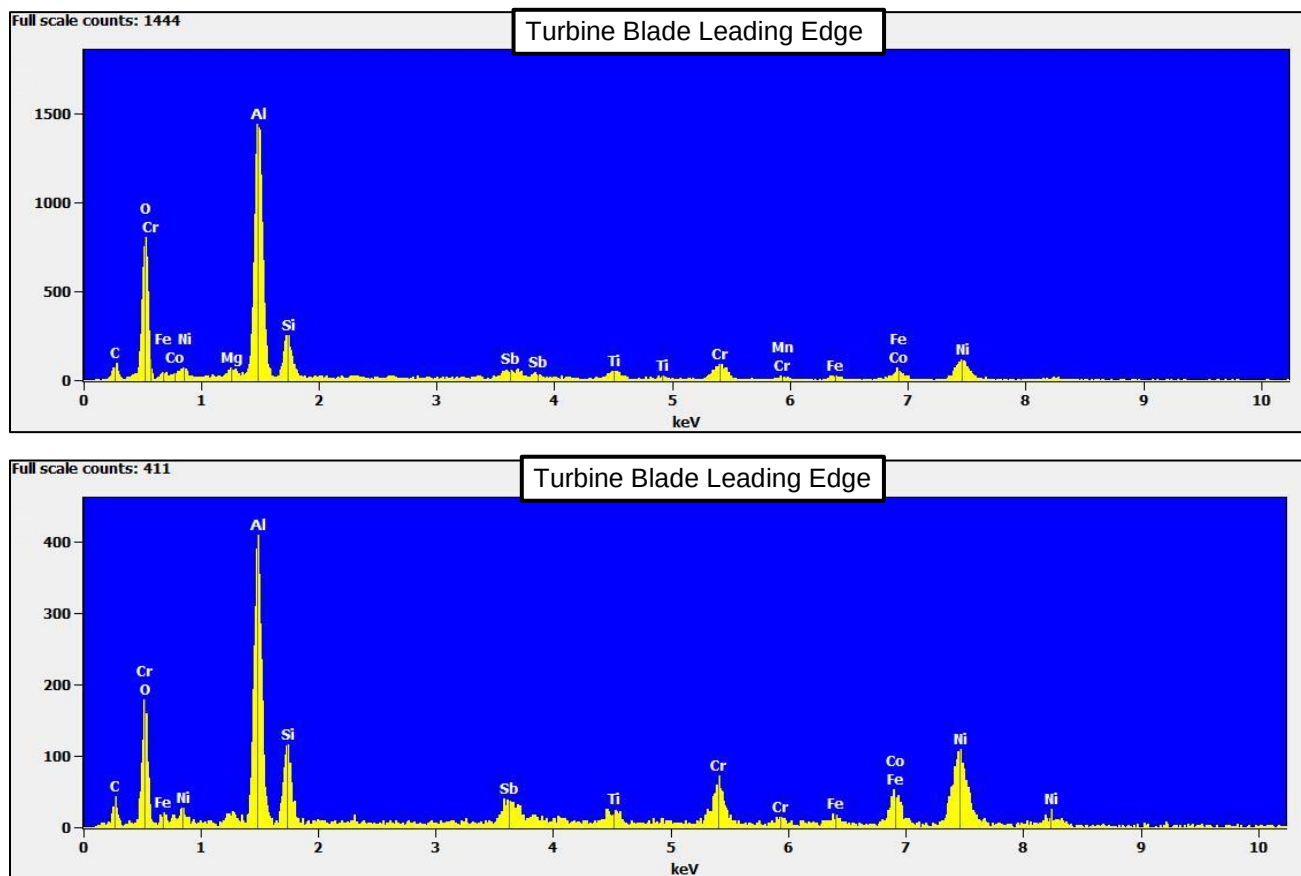


Figure 10. Typical EDS spectra of areas of the surface of the removed gas generator turbine blade at the leading edge near midspan.

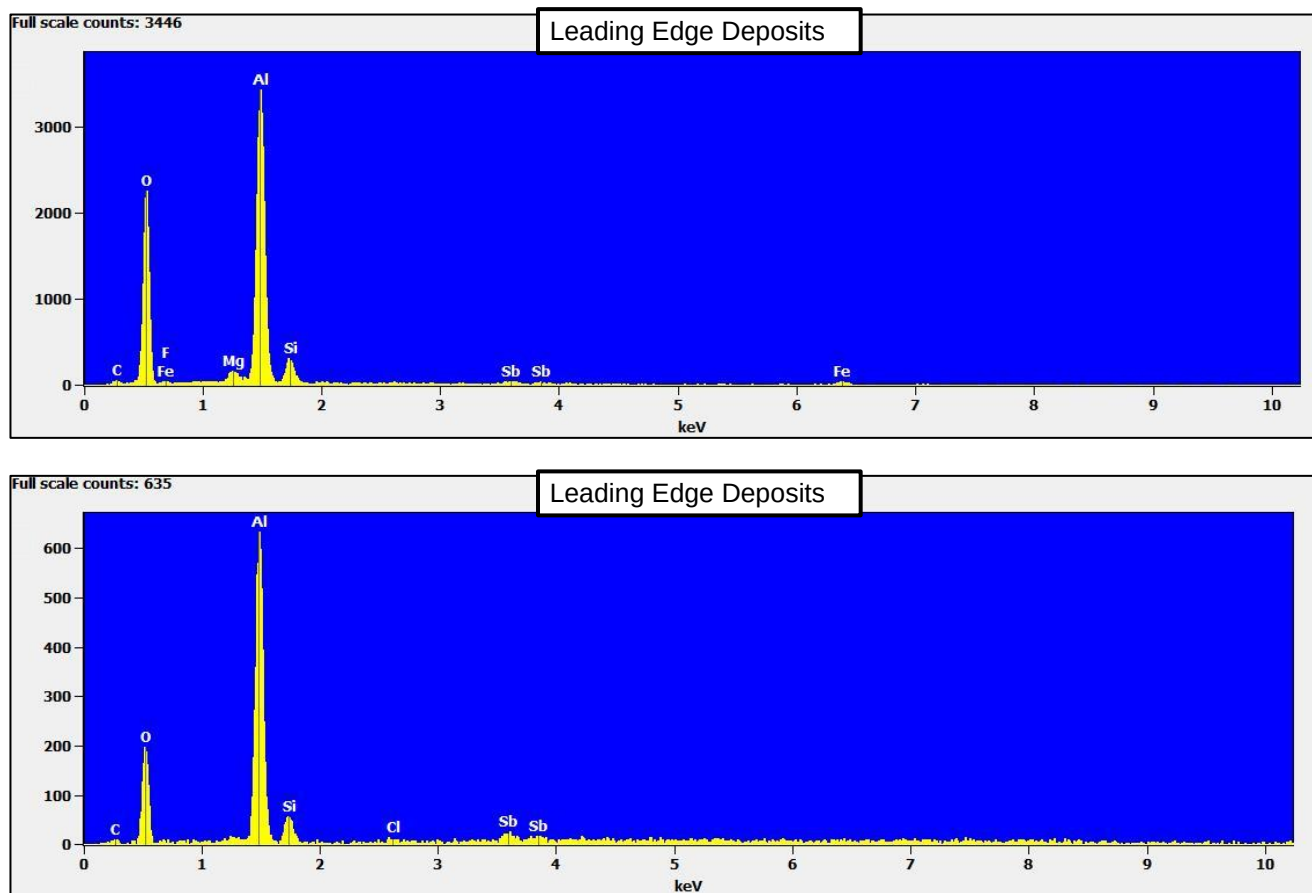


Figure 11. Spot EDS spectra of the leading edge deposits on the removed gas generator turbine blade showing results for deposit areas that appeared to be thicker on the surface when imaged using secondary electrons and appeared darker than the surroundings when imaged using backscattered electrons.

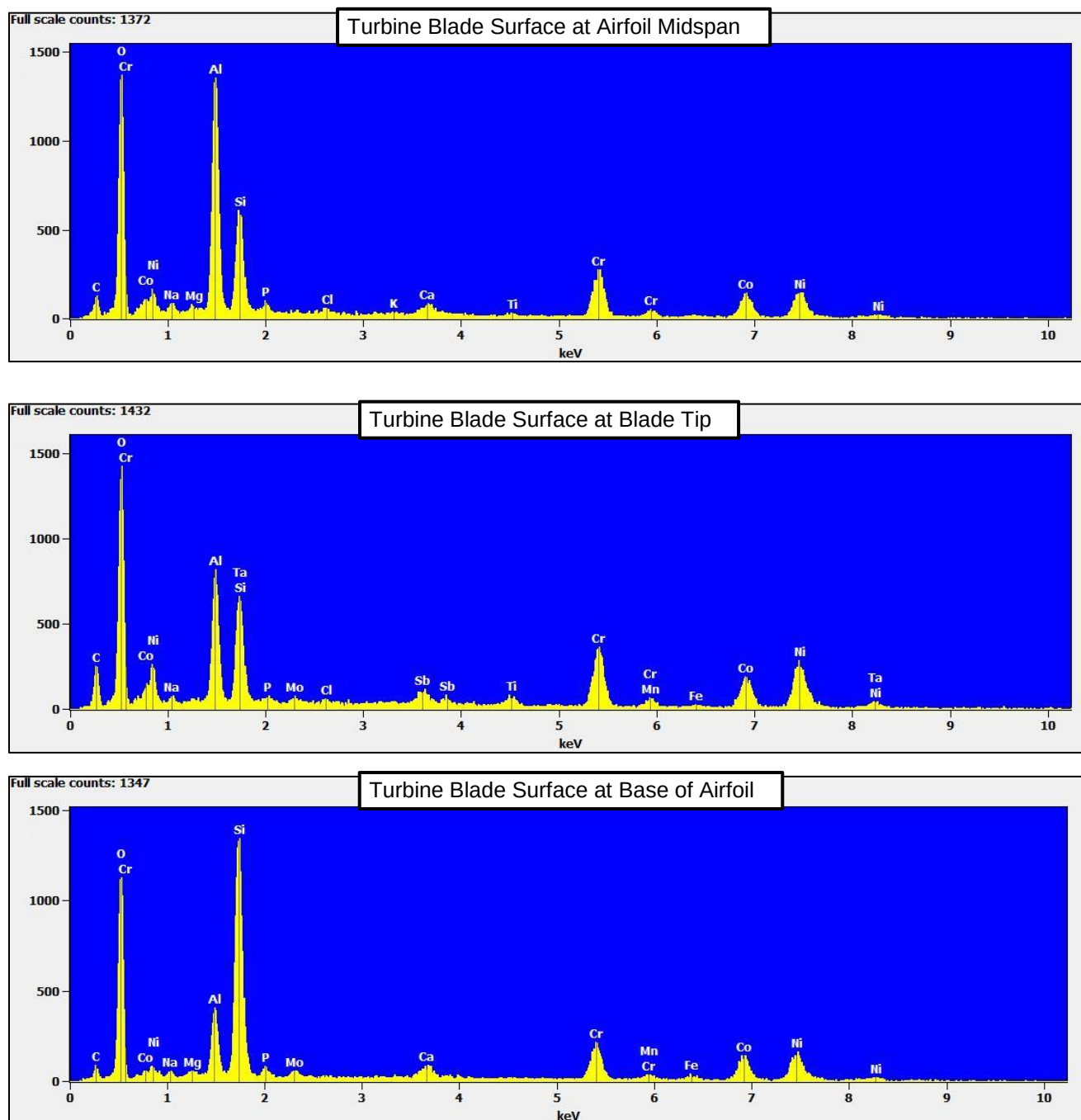


Figure 12. EDS spectra for areas of the removed gas generator turbine blade surface at the trailing edge near midspan (upper spectrum) and at the tip (middle spectrum) and the base (lower spectrum) of the airfoil near midchord.

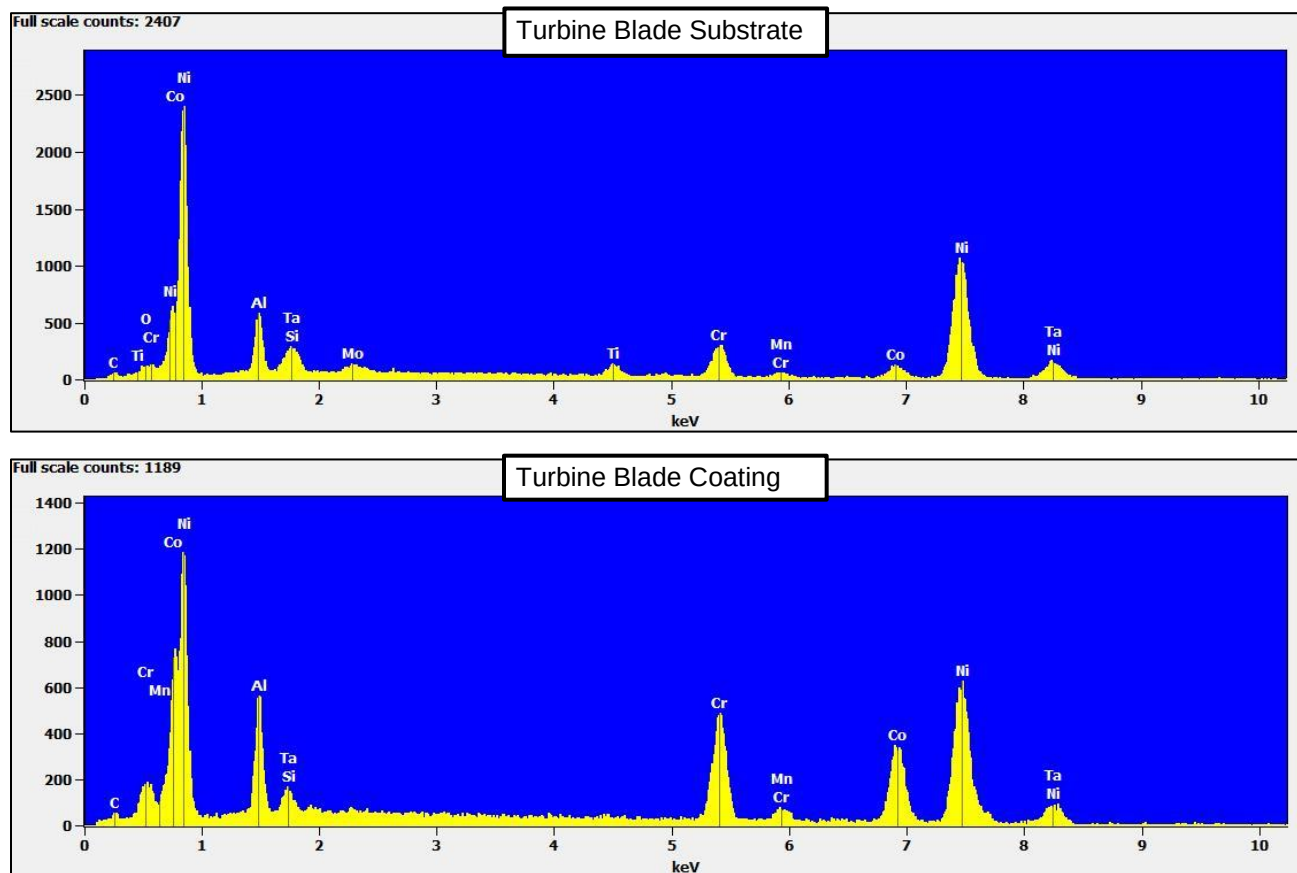


Figure 13. EDS spectra from the surface of a cut through the removed gas generator turbine blade showing a typical spectrum for the substrate (upper spectrum) and a spot in the middle of the surface coating (lower spectrum).