

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



ANC24LA017

MATERIALS LABORATORY

Factual Report 24-062

September 17, 2024

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A. ACCIDENT INFORMATION

Location: Kekaha, Hawaii
Date: February 27, 2024
Vehicle: MD Helicopter 369E/500E, N633JH
Investigator: Chihoon Shin, AS-40

B. COMPONENTS EXAMINED

Overrunning clutch assembly, KAflex driveshaft assembly, and grease samples.

C. EXAMINATION PARTICIPANTS

Specialist Matthew R. Fox, Ph.D.
NTSB
Washington, DC

D. DETAILS OF THE EXAMINATION

An overall view of the submitted components is shown in figure 1. The flex couplings at each end of the KAflex driveshaft assembly were fractured. Additionally, the overrunning clutch inner race and the output bearing retainer were fractured at the location of the output bearing. The output bearing outer race was separated from the bearing retainer and appeared to be free of grease. The output bearing inner race and most of the balls for the bearing were missing.

The flex couplings for the driveshaft were fractured through ligaments of one flex plate at the forward flex coupling and two flex plates at the aft flex coupling. Fracture surfaces on each of the fractured plates were examined using an optical stereomicroscope. Fracture surfaces showed rough matte gray features in the core region with smoother fractures through the exterior coating material, features consistent with overstress fracture. No evidence of progressive fracture features such as fatigue was observed.

A closer view of the components at the forward end of the overrunning clutch assembly is shown in figure 2. The output coupling, sleeve spacer, output bearing, and clutch inner race showed heat tinting, oxidation, and deformation consistent with high heat exposure. A rectangular area that appeared to be carbonized adhesive was observed on the side of the output coupling.

A closer view of the forward fracture surface on the clutch inner race is shown in figure 3. The forward sleeve spacer adjacent to the output coupling was intact on the inner race, but the surfaces were oxidized, and the flange at the aft side of the spacer was heavily deformed and rubbed circumferentially on one side. The aft sleeve spacer appeared intact within the overrunning clutch assembly and was not

examined in detail. The clutch inner race fracture was located between the sleeve spacers, a location corresponding to the position of the output bearing. The fracture surfaces and adjacent areas were tinted to a bluish black color consistent with oxidation at high temperatures. The same areas showed extensive deformation consistent with ductile fracture at high temperatures.

The output bearing outer race and remaining balls and bearing cage material are shown in figure 4. The outer race was oxidized and heat tinted consistent with high heat exposure. The balls also showed heat tinting and deformation consistent with high heat exposure. The bearing cage was destroyed, and molten and resolidified remnants of cage material were fused to the bearing outer race and around the remaining balls.

One of the bags of grease shown in figure 1 contained a brown colored grease that was collected from the area around the clutch outer race splines at the aft (input) side of the overrunning clutch. The other bag of grease shown in figure 1 contained a sample of Mobil 28 grease that was a brighter red color and was collected from a tube in the operator's consumables cabinet. Using a paper shop towel, a swab of the brown grease was collected from the bag. The towel was then rinsed with acetone while collecting the product of the rinse in a beaker. The beaker was then placed in an ultrasonic cleaner for approximately 5 minutes. A collection of particles was observed at the bottom of the beaker after cleaning.

The acetone and grease solution was drained away from the particles, and the particles were collected onto a glass plate for further examination. Representative images of the particles are shown in figure 5. The largest particles were brown and had a textured appearance such as those shown in the upper left image in figure 5. Many of these brown textured particles had a black surface on one side such as the particle shown at the upper right image in figure 5. Other particles appeared as flat metallic flakes such as the smaller particles shown in the upper right and lower right images in figure 5. Some translucent particles with smooth rounded surfaces consistent with sand particles were observed such as the larger particle in the lower right image in figure 5. A few light-colored particles with a rough speckled surface and a black surface on one side were also observed as shown in the lower left image in figure 5.

The helicopter had experienced a forced landing and came to rest on its side at a beach known as Honopu Beach. Sand particles were observed on the exterior of the overrunning clutch housing. A sample of the sand particles were collected from an area around the forward seal, and the particles had an appearance similar to the rounded particles extracted from the brown grease.

The particles extracted from the brown grease and the sand particles sampled from the exterior surface of the clutch housing were collected onto carbon-coated aluminum stubs for analysis in a scanning electron microscope (SEM) using energy

dispersive spectroscopy (EDS). SEM images of several particles extracted from the brown grease as viewed using the backscattered electron detector in composition mode are shown in figures 6 through 8.¹ Some of the rounded particles had a relatively uniform light gray appearance such as the particle shown in the upper image in figure 6. These particles exhibited widespread charging in response to the electron beam as shown by the overexposed areas in the image.² Other rounded particles had a more variable appearance with dendritic structures and less overall charging such as the particle shown in the lower image in figure 6. Smaller particles with a somewhat spongy surface appearance were also observed such as the particle shown in figure 7. An SEM image of a rough light-colored particle shown in the lower left image in figure 5 is shown in figure 8. These particles appeared to be an accumulation of fine angular particles that had been formed together into a larger particle.

Representative EDS spectra for particles extracted from the brown grease are shown in figures 9 through 11. Particles such as the larger rounded particle shown in the lower right image in figure 5 and the particles shown in figures 6 and 7 had typical spectra as shown in figure 9. Spectra similar to those shown in figure 9 were also obtained from the sand particles collected from the exterior surface of the clutch housing.

The relatively larger rounded particles shown in the upper and lower images in figure 6 corresponded to the upper and middle spectra shown in figure 9, respectively. The rounded particles had high peaks of silicon, magnesium and oxygen as shown in the upper two spectra in figure 6. Substantial peaks of aluminum, calcium, titanium, and iron were also observed associated with some of the particles as shown in the middle spectrum. The relatively smaller particles with a spongy surface appearance such as the particle shown in figure 7 corresponded to the lower spectrum shown in figure 9. These particles were characterized by spectra with a high peak of titanium and smaller peaks of carbon and oxygen.

A typical EDS spectrum for the brown textured particles is shown in the upper spectrum in figure 10. High peaks of carbon and oxygen with smaller peaks of sodium, aluminum, silicon, and calcium were observed. While a magnesium peak was also detected, the relative size of the magnesium peak was considerably smaller than both the aluminum and silicon peaks. By comparison, the magnesium peak in spectra obtained from the sampled sand particles generally was either higher than

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

² Charging is the accumulation of negative charge on the surface that develops during electron imaging of nonconductive samples in a SEM under high vacuum and can result in distorted and overexposed images.

both peaks or was similar in height to the aluminum peak as shown in the upper and middle spectra in figure 9.

A typical EDS spectrum for the rough speckled accretions (see lower left image in figure 5 and image in figure 8) is shown in the lower spectrum in figure 10. High peaks of carbon, oxygen, magnesium and silicon with smaller peaks of aluminum, calcium, titanium, chromium, and iron were observed.

Typical EDS spectra obtained from metal flakes extracted from the brown grease sample are shown in figure 11. The spectra for some flakes had a high peak of iron with relatively small peaks of chromium and manganese, a spectrum consistent with low alloy steel. Spectra for other metal flakes had a high peak of iron with a substantial peak of chromium and a smaller peak of nickel, a spectrum consistent with a stainless steel.

Submitted by:

Matthew R. Fox, Ph.D.
Chief Technical Advisor, Materials Laboratory



Figure 1. Overall view of the submitted components and grease samples.

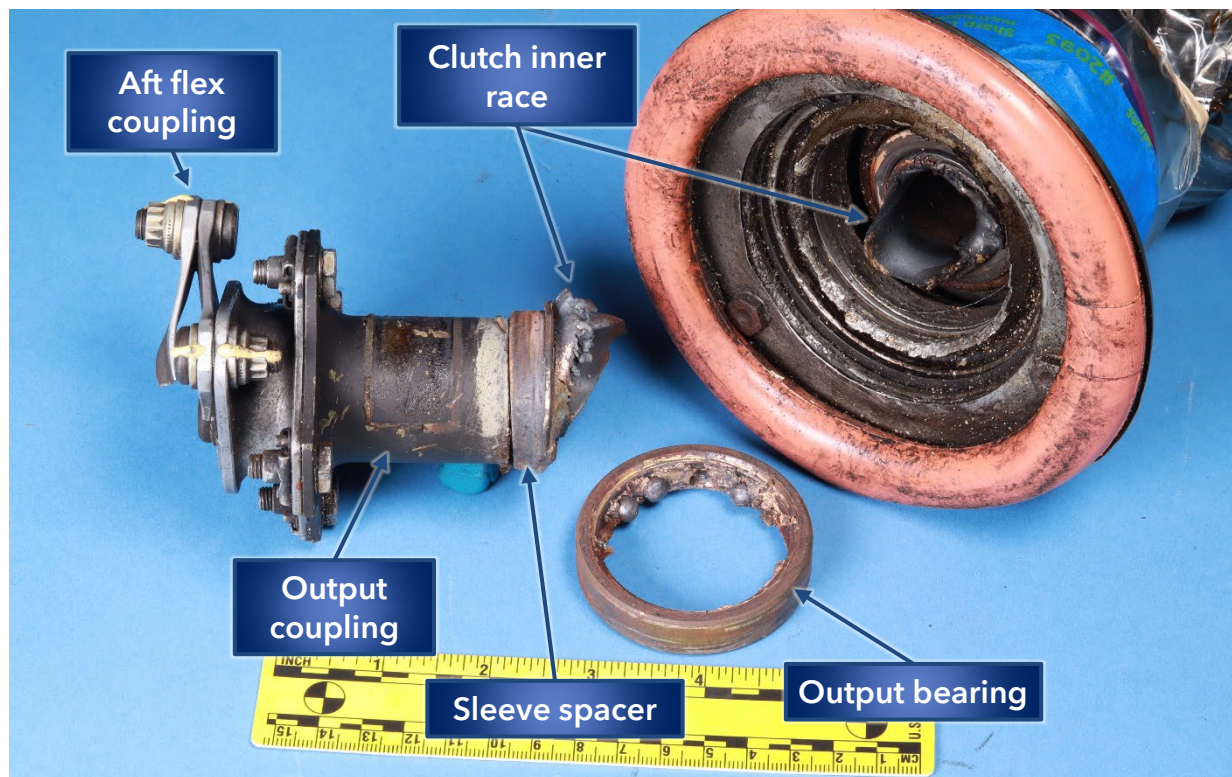


Figure 2. Closer view of components at the forward end of the overrunning clutch assembly.

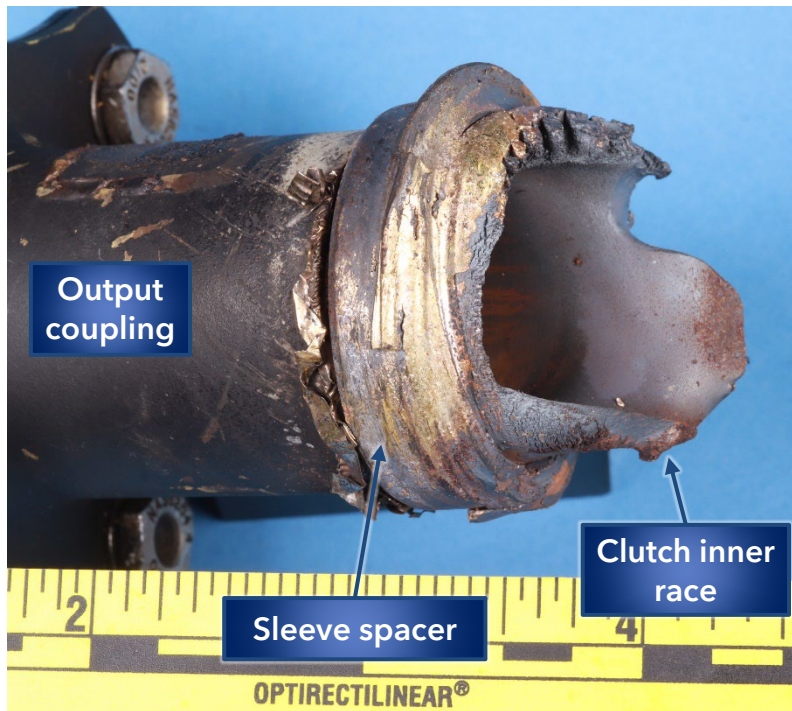


Figure 3. Forward side of the clutch inner race fracture.



Figure 4. Output bearing outer race with cage and ball remnants.

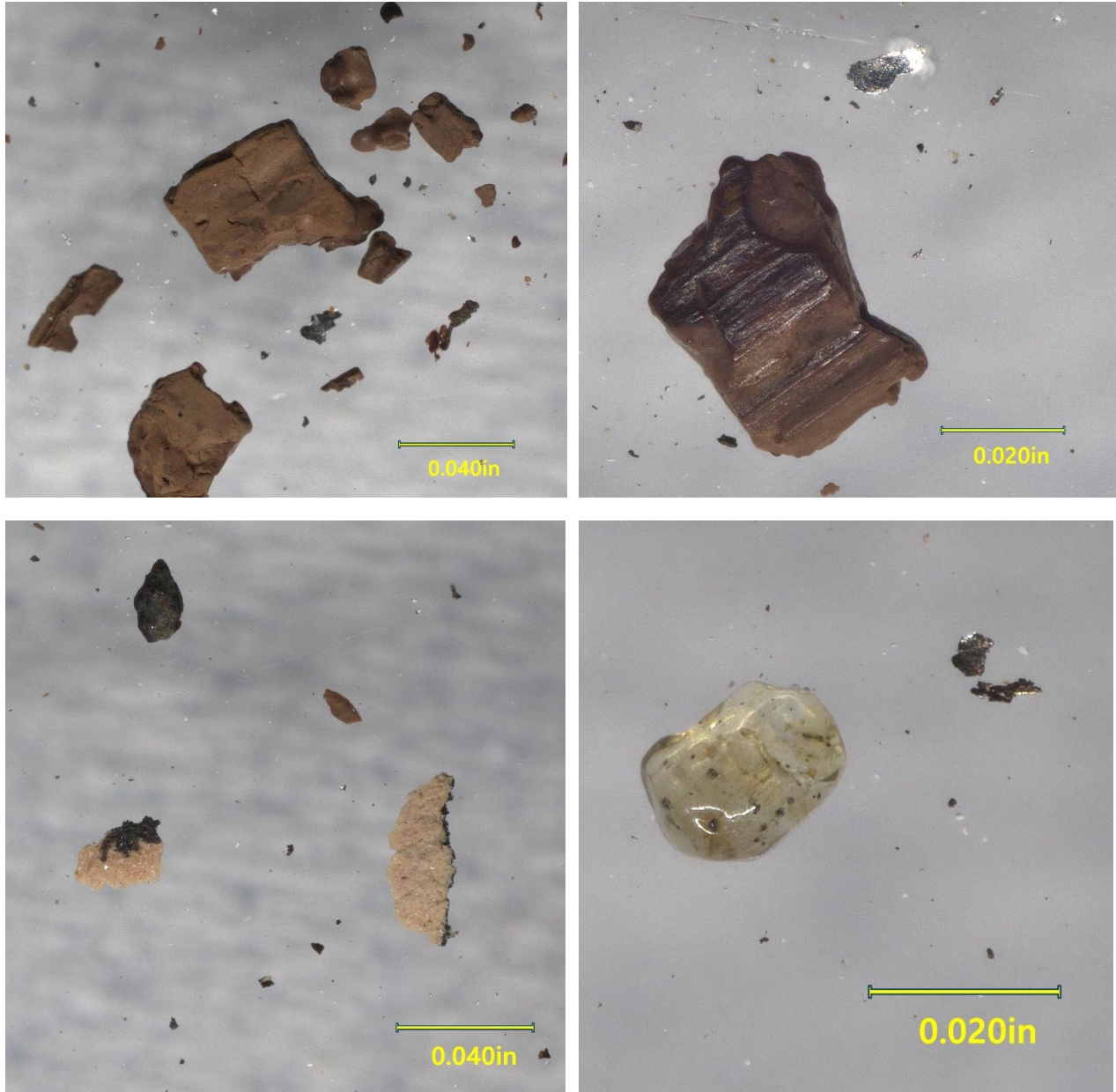


Figure 5. Particles extracted from the brown grease sample including brown clay-like textured particles with a black surface (upper images), shiny flattened metallic flakes (right images), translucent particles with smooth rounded surfaces consistent with sand (lower right image) and rough light-colored accretions with a black surface (lower left image).

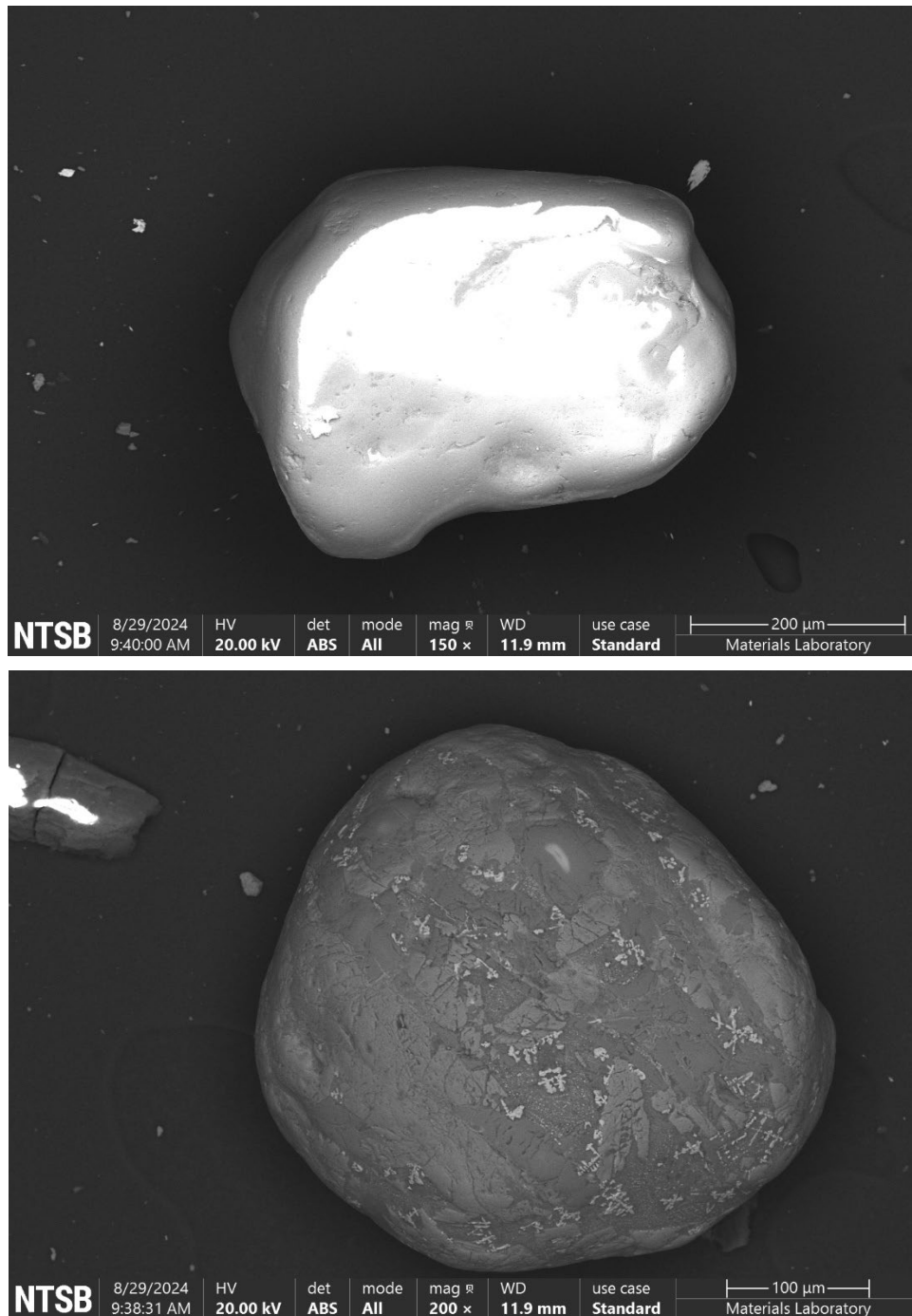


Figure 6. SEM images of rounded particles extracted from the brown grease sample as viewed using the backscattered electron detector in composition mode.

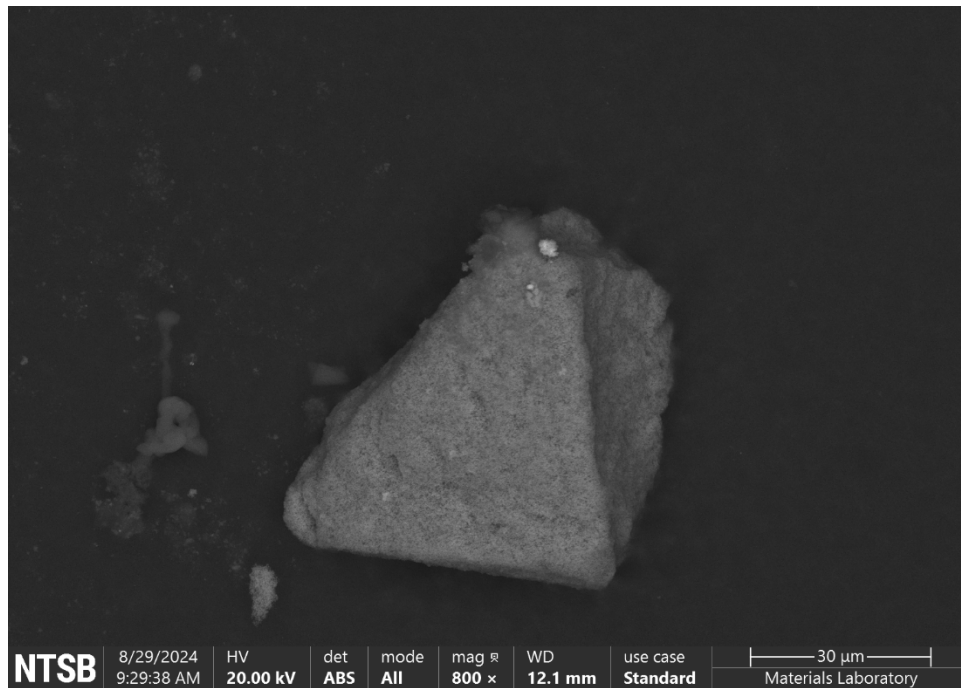


Figure 7. SEM image of a titanium-rich particle extracted from the brown grease sample as viewed using the backscattered electron detector in composition mode.

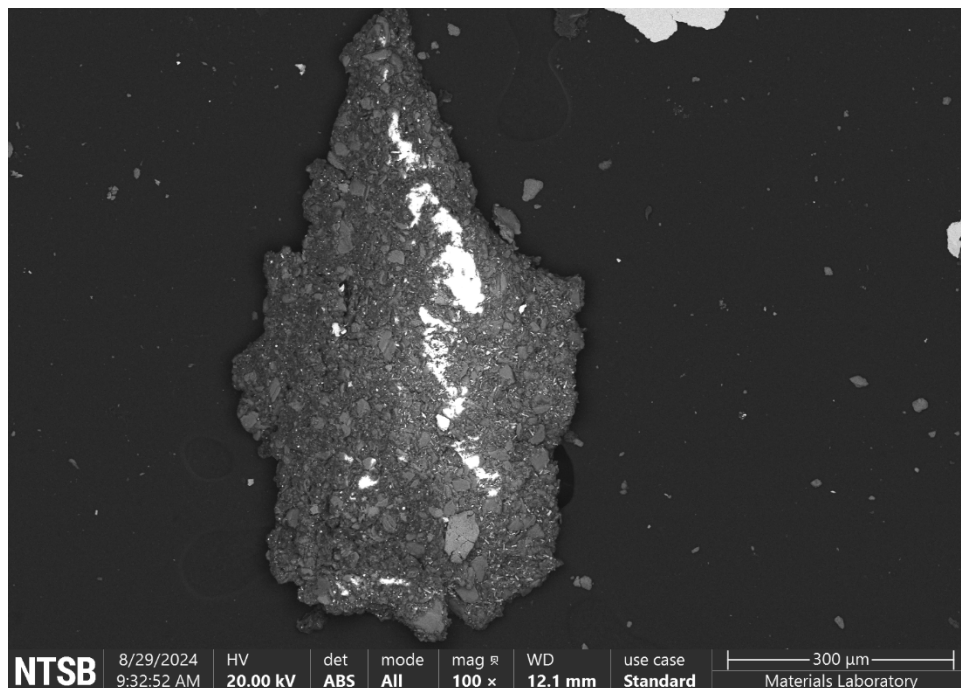


Figure 8. SEM image of a rough accretion extracted from the brown grease sample as viewed using the backscattered electron detector in composition mode.

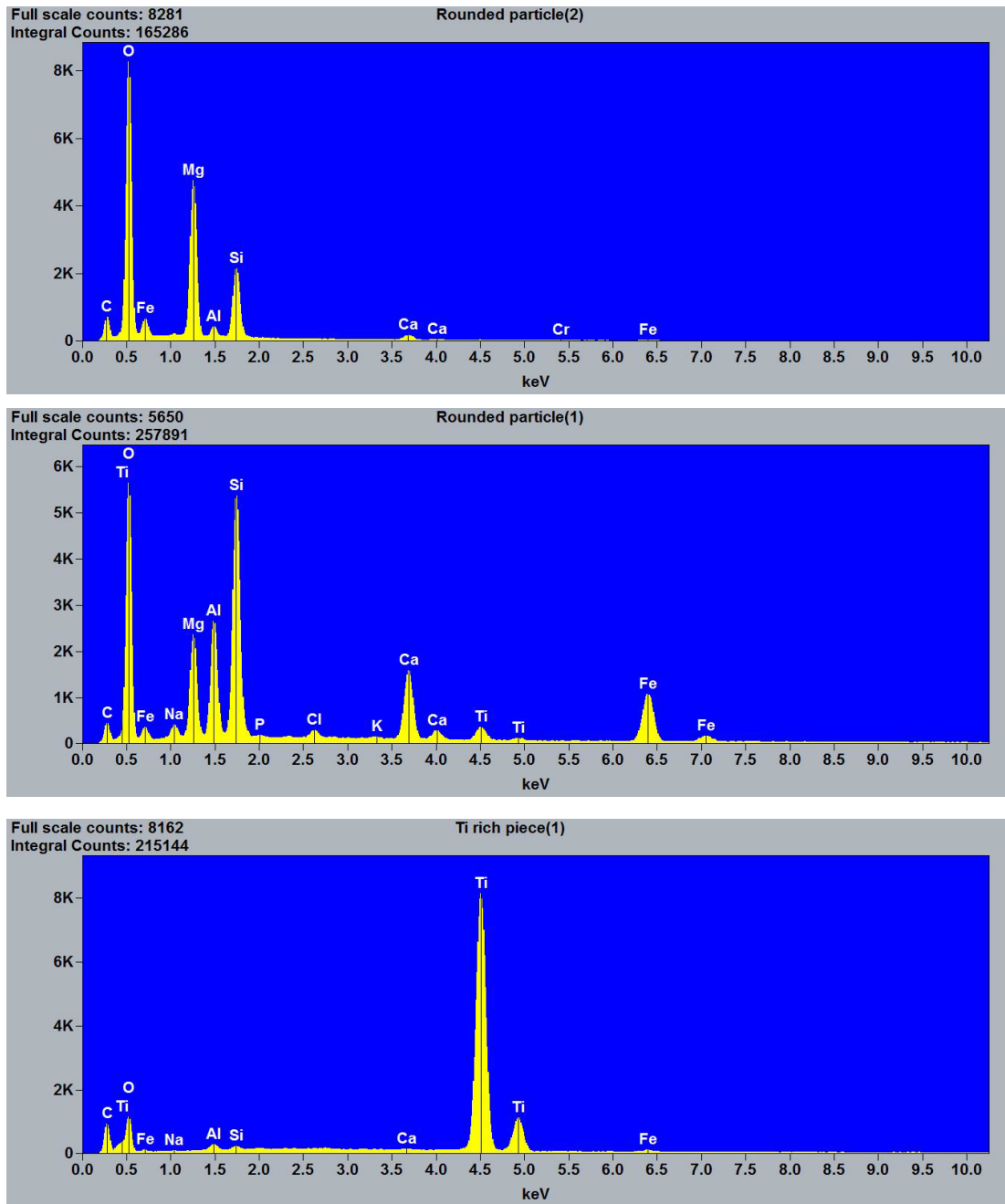


Figure 9. EDS spectra obtained from rounded particles extracted from the brown grease sample. The upper and middle spectra show typical analysis results associated with rounded particles showing high peaks that included silicon, magnesium, and oxygen, and the lower spectrum was typical of smaller particles with a high titanium peak.

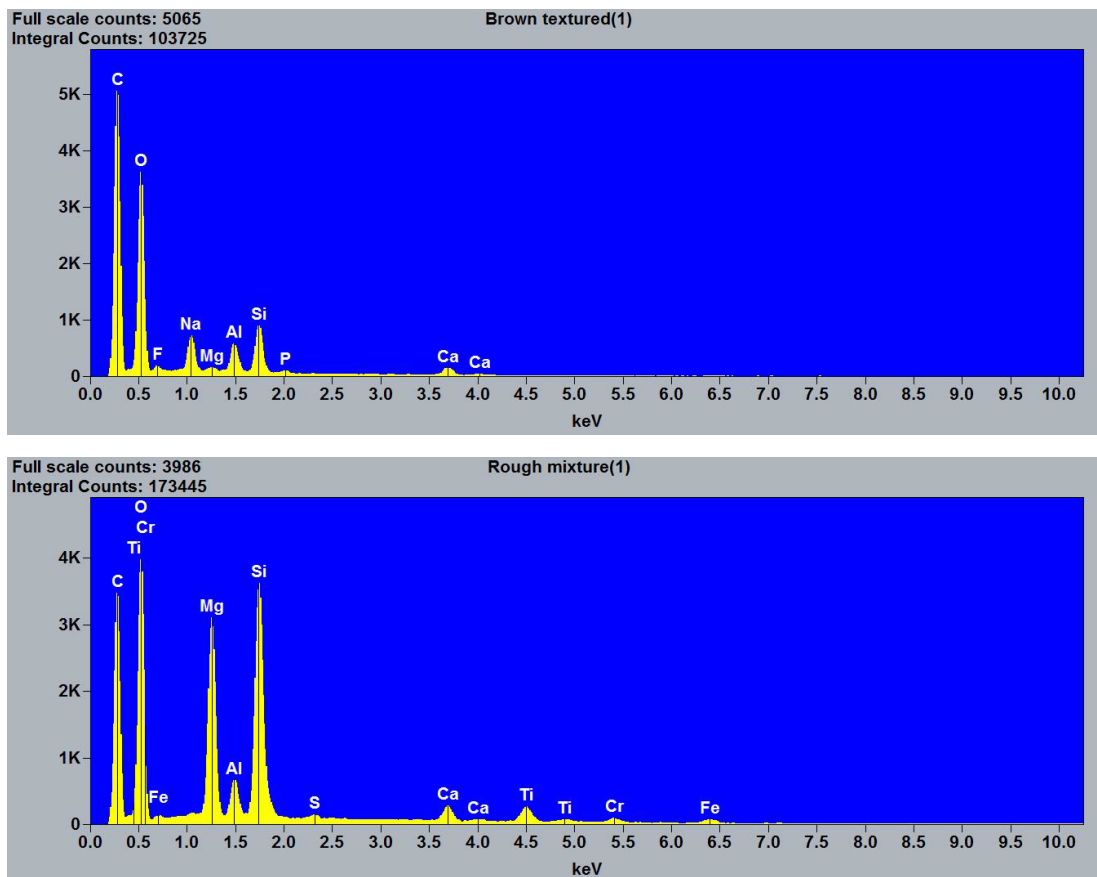


Figure 10. Typical EDS spectra associated with the brown textured particles (upper spectrum) and the rough light-colored accretions (lower spectrum) extracted from the brown grease sample.

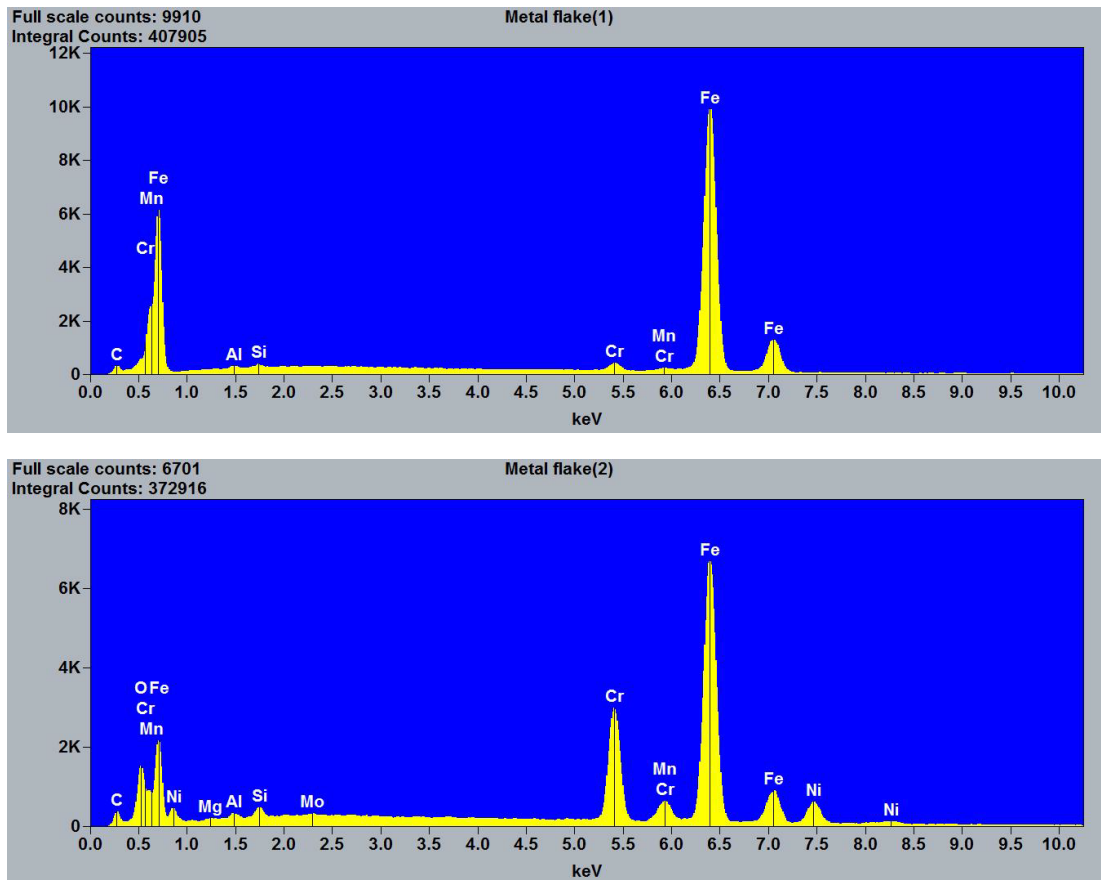


Figure 11. EDS spectra obtained from metal flakes extracted from the brown grease sample. The spectra were consistent with a low alloy steel (upper spectrum) and a stainless steel (lower spectrum).