

NATIONAL TRANSPORTATION SAFETY BOARD

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

March 22, 2021



MATERIALS LABORATORY ADDENDUM REPORT

Report No. 21-008B

1. ACCIDENT INFORMATION

Place : Phoenix, Arizona
Date : May 13, 2020
Vehicle : Mooney M20J, N201HH
NTSB No. : WPR20LA144
Investigator : Stephen Stein, AS-WPR

2. COMPONENTS EXAMINED

Bags of swabs and debris

3. DETAILS OF THE EXAMINATION

This report is an addendum to the factual report on the NTSB Materials Laboratory examination of crankshaft and connecting rod remnants from a Mooney 20J accident that occurred in Phoenix, AZ on May 13, 2020. This report details a collection of swabs and debris sent later to the NTSB Materials Laboratory.

Figure 1 shows one of the two bags with collections of swabs. This bag was marked, "Foreign Material – Output N201HH." This bag contained five collections of swabs, shown in Figure 2. These were marked as follows:

- "Outlet port base plate surface"
- "Base plate outlet port"
- "Outlet port groove"
- "To sump gov. body bore"
- "Gov. body outlet bore"

Figure 3 shows the second of the two bags with swab collections. This bag was marked, "Other Swabs N201HH." This bag held 13 collections of swabs, shown in Figure 4. These were marked as follows:

- "Final plate swabbing"
- "Base plate on idler gear"
- "Base plate sump"

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- “Flyweight swabs”
 - “Materials from idler gear face”
 - “Idler gear body face gear surfaces”
 - “Face near PRV near damage”
 - “Base plate outlet port”
 - “Drive gear gov. body bore metallic particles”
 - “Spool valve swabs”
 - “Idler gear inside face”
 - “Drive gear upper lands flyweight side”
 - “Drive gear wiping of gears”
 - “Drive gear upper lands”

Loose debris from the collection marked “Gov. body outlet bore” in Figure 2 were cleaned using acetone in an ultrasonic bath and are shown in Figures 5 and 6. This debris exhibited multiple colors visually, with a blocky jagged appearance. These debris were consistent with non-metallic particles.

The debris in Figure 6 was examined using a scanning electron microscope (SEM) with an energy dispersive x-ray spectroscopy (EDS) instrument. A typical view of the debris is illustrated in Figure 7. The debris exhibited electron charging properties, consistent with nonconductive materials. A typical EDS spectrum of the debris is shown in Figure 8. This showed large peaks of carbon, oxygen, nitrogen, silicon, magnesium, and calcium, with minor peaks of aluminum (marked as Br in the figure) and titanium. These elements were consistent with materials found in soils or sands.

One particle (Figure 9) exhibited EDS spectra different than those of other particles, as shown in Figure 10. This spectrum exhibited multiple barium peaks and a sulfur peak, in addition to those displayed in Figure 8.

The debris in the collection marked “Drive Gear Gov. Body Bore Metallic Particles” in Figure 3 were also cleaned using acetone in an ultrasonic bath. These cleaned particles were examined using a SEM with an EDS, and a typical image of the particles is shown in Figure 11.

The light-colored particles in the figure were found to be consistent with lead (Pb) oxide compounds when examined using EDS. The particles also contained minor amounts of phosphorus and bromine. These were consistent with compounds that form after the combustion of avgas with tetraethyl lead additives. Similar lead-based particles were also found in a later re-examination of the particles from the governor body outlet bore.

The lighter gray particles were consistent with a copper-tin (or bronze) alloy. The darker gray particles were mostly iron, with detectable amounts of molybdenum, manganese, and chromium, consistent with an alloy steel. The darkest particles were consistent with an aluminum alloy. It should be noted that many of these particles exhibited areas of mixed constituents or cross-contamination, consistent with repeated impact with each other.

These compositions were consistent with those of materials typically used in the manufacture of rotating engine components, such as connecting rods, crankshafts, pistons, and bearings.

Erik M Mueller
Materials Research Engineer

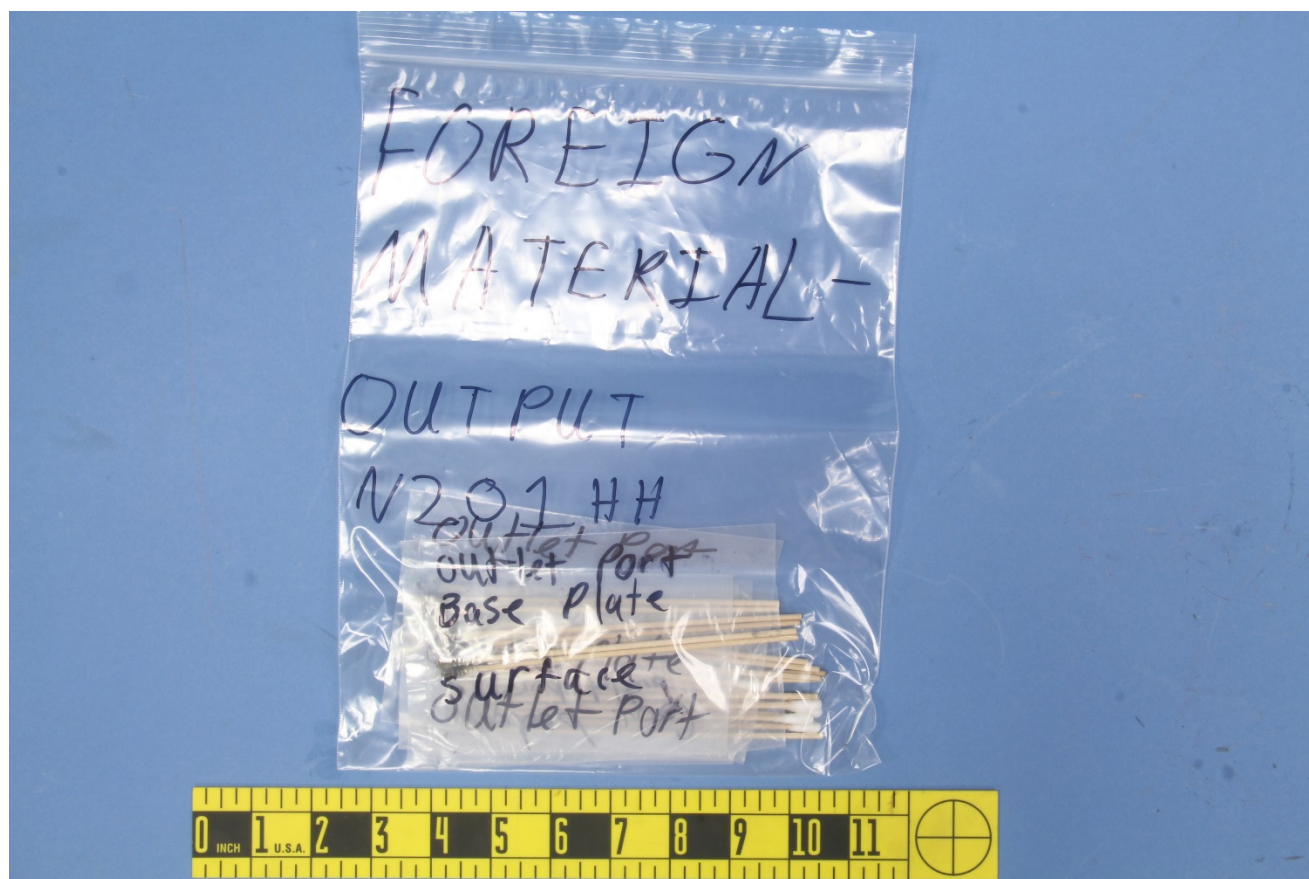


Figure 1 – The bag of swabs marked “Foreign Material – Output”, as received.

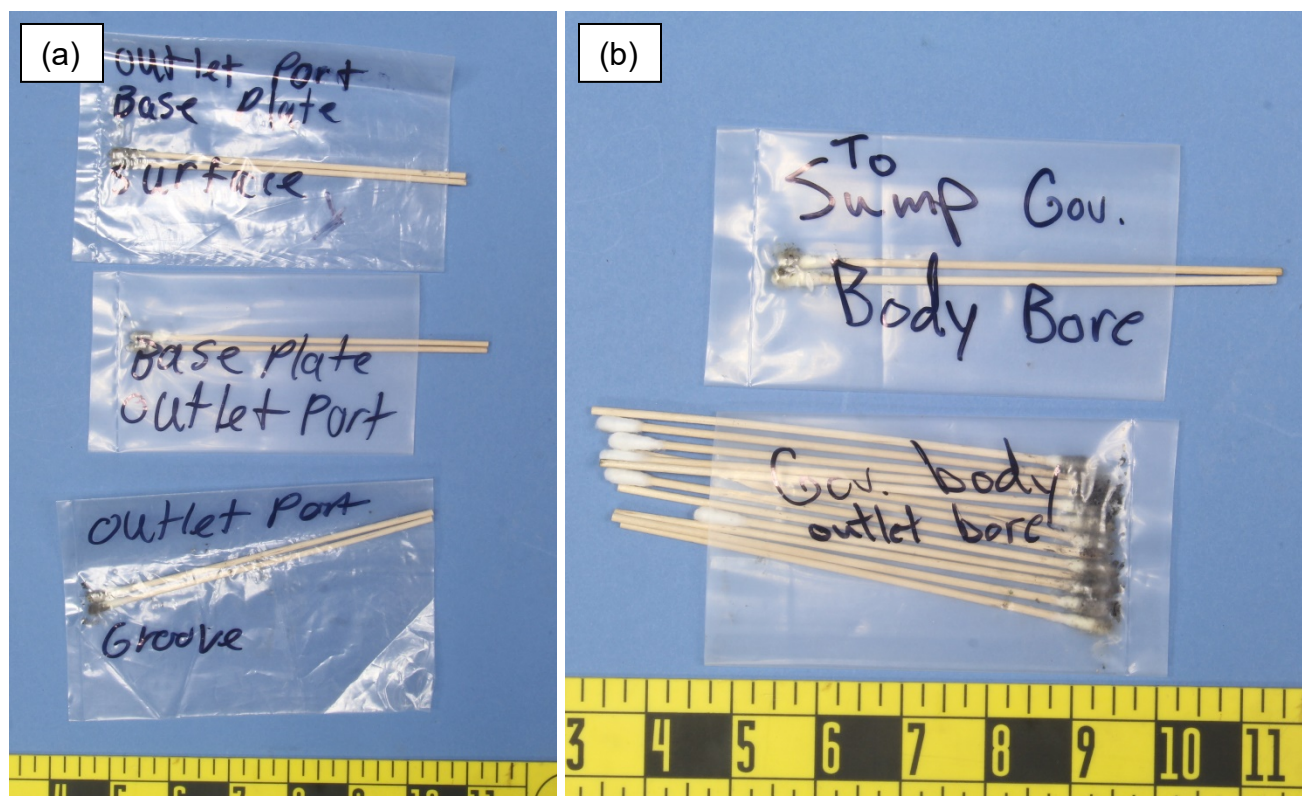


Figure 2 – The collections of swabs from various areas in the bag show in Figure 1.

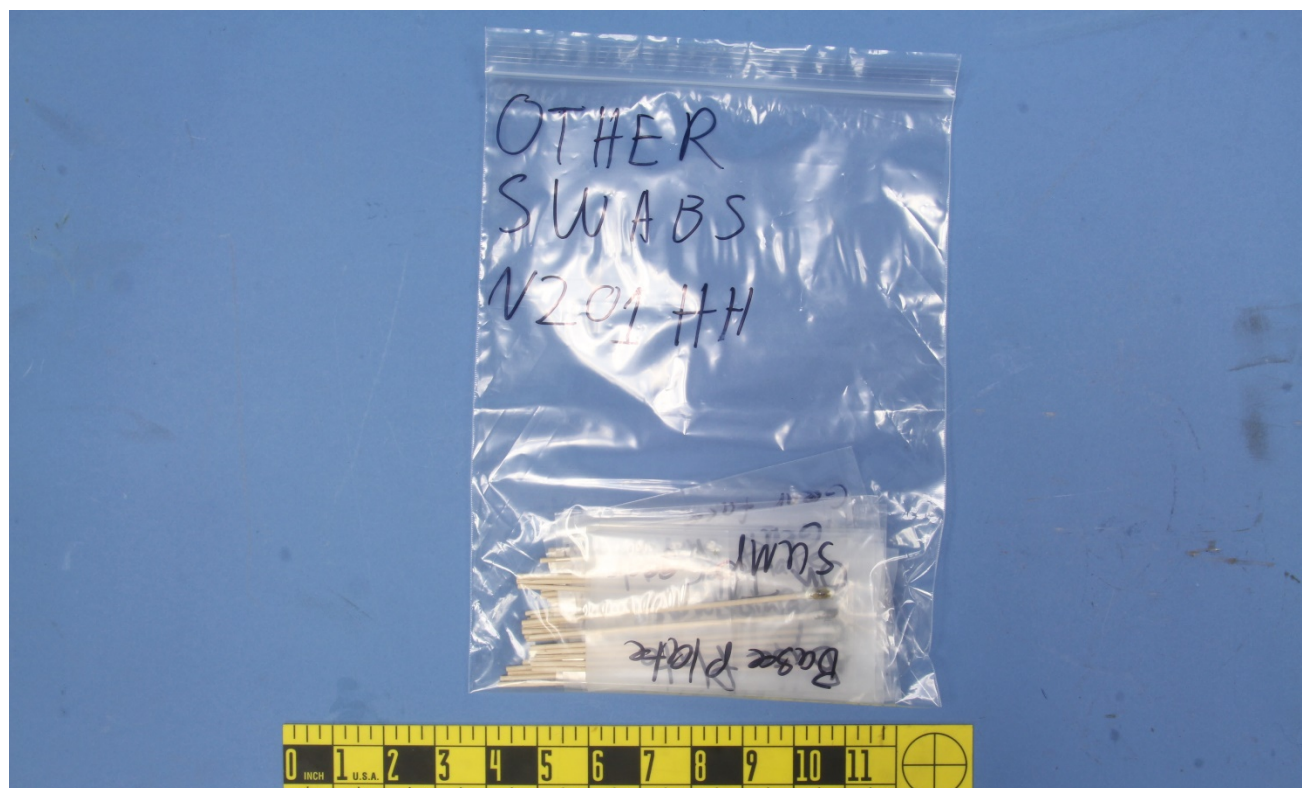


Figure 3 – The bag of swabs marked "Other Swabs", as received.

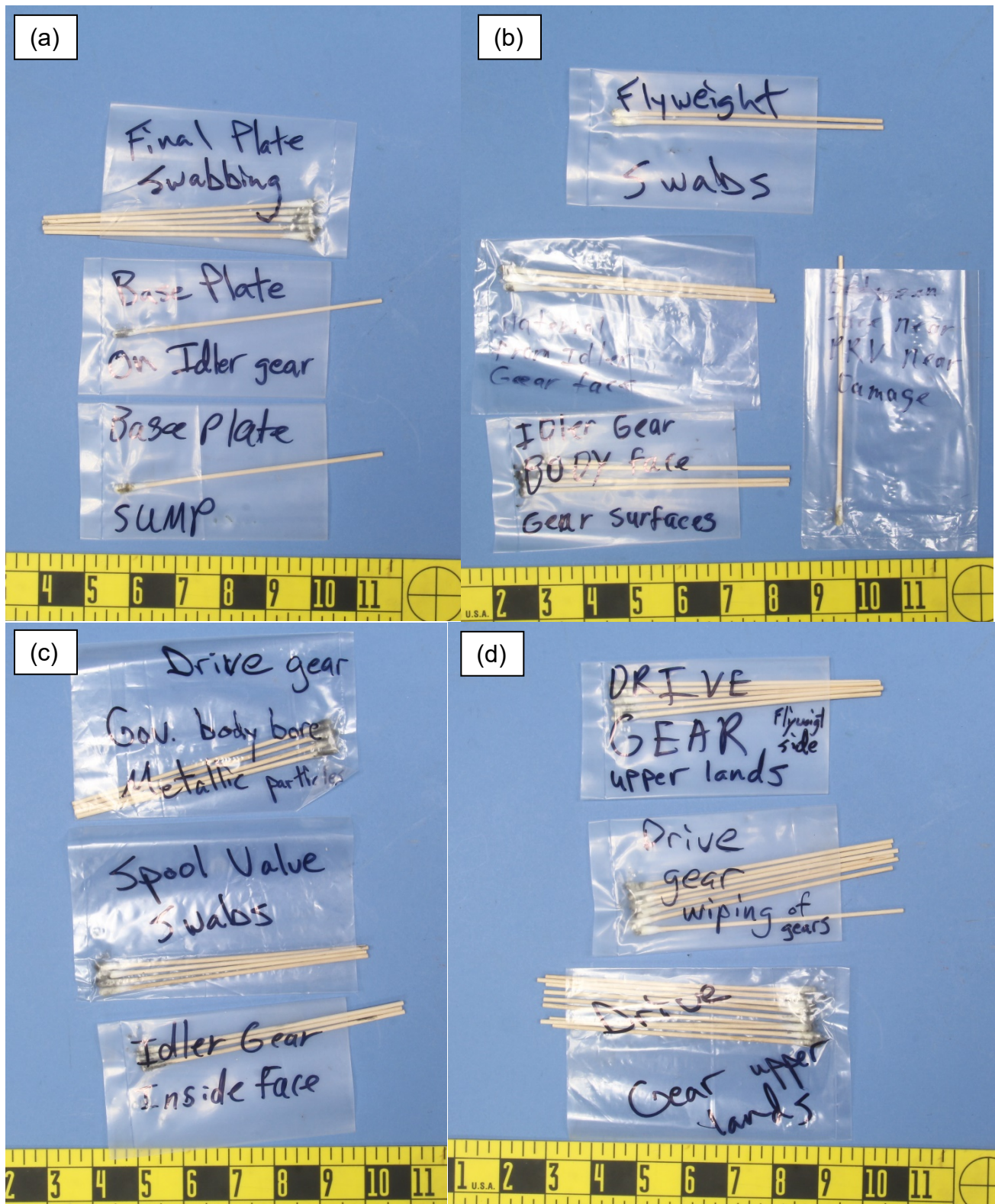


Figure 4 – The individual swab collections from various locations in the bag in Figure 3.



Figure 5 – The solid debris from the bag marked governor body outlet bore, after cleaning with acetone.

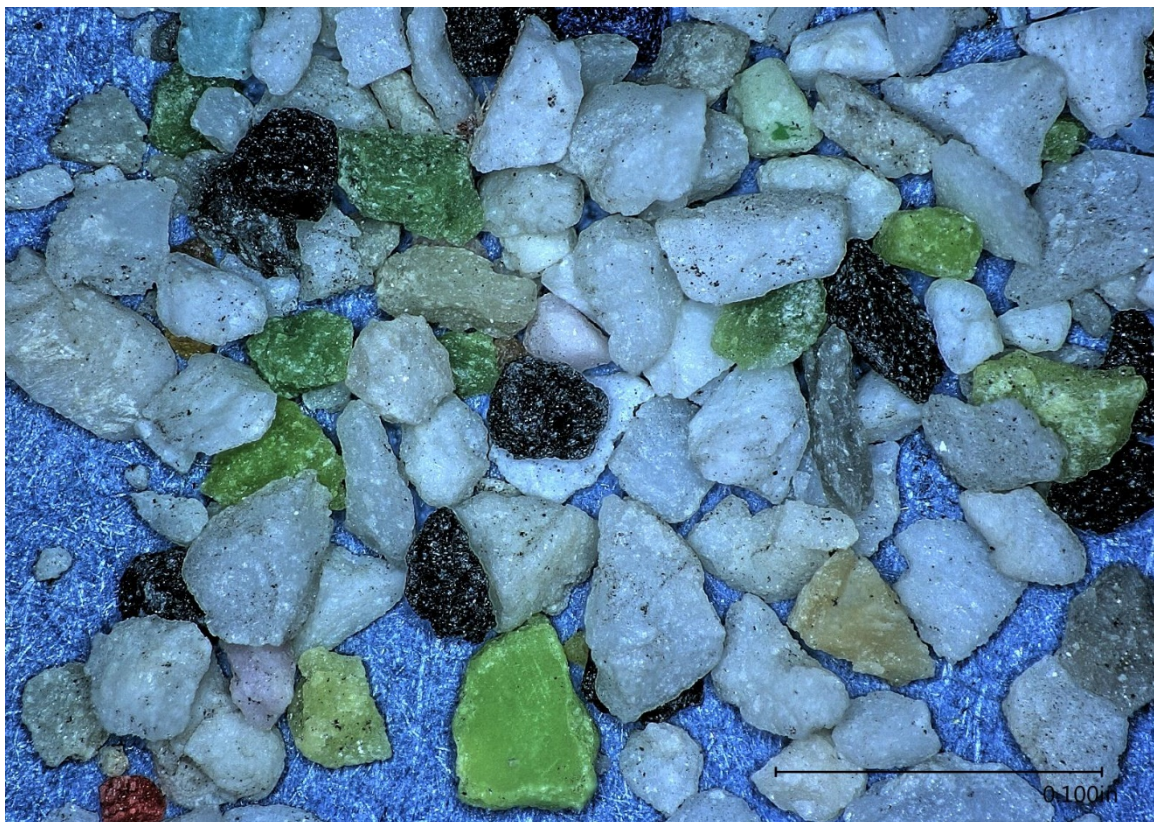


Figure 6 – Closer view of the debris particles in Figure 5.

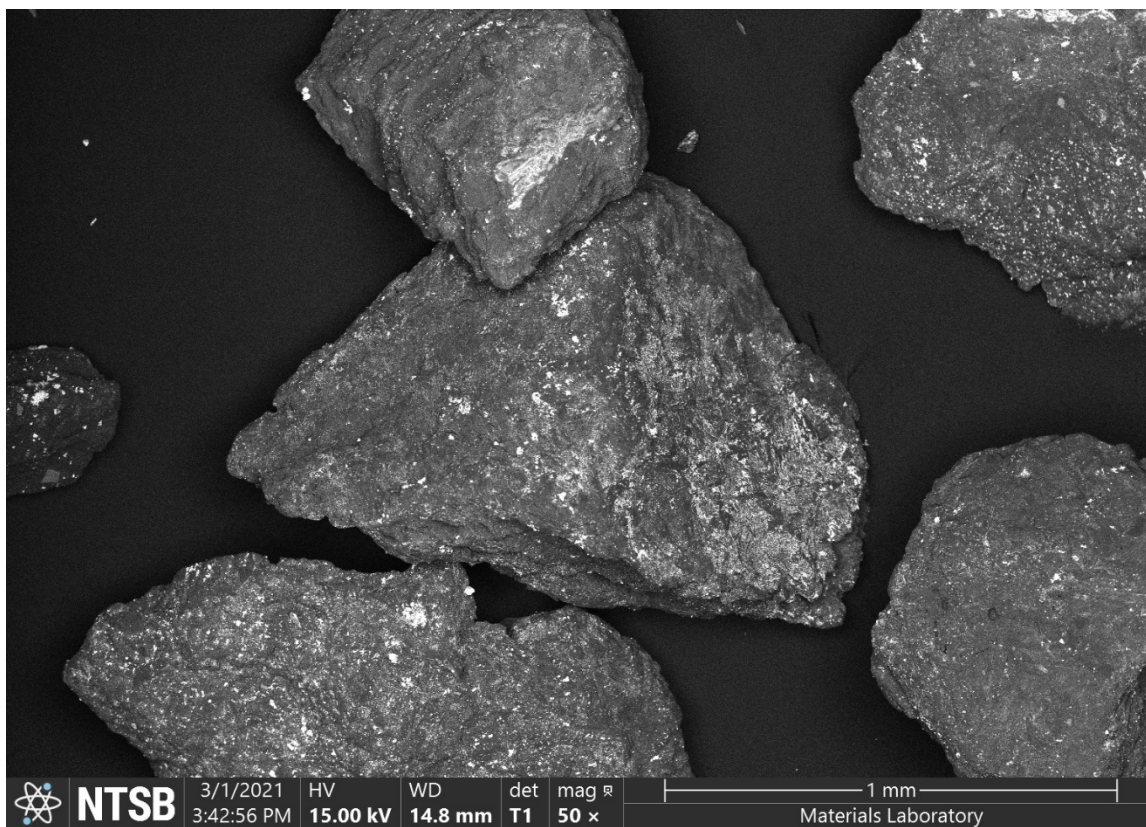


Figure 7 – Backscattered electron (BE) micrograph of some of the debris shown in Figure 5.

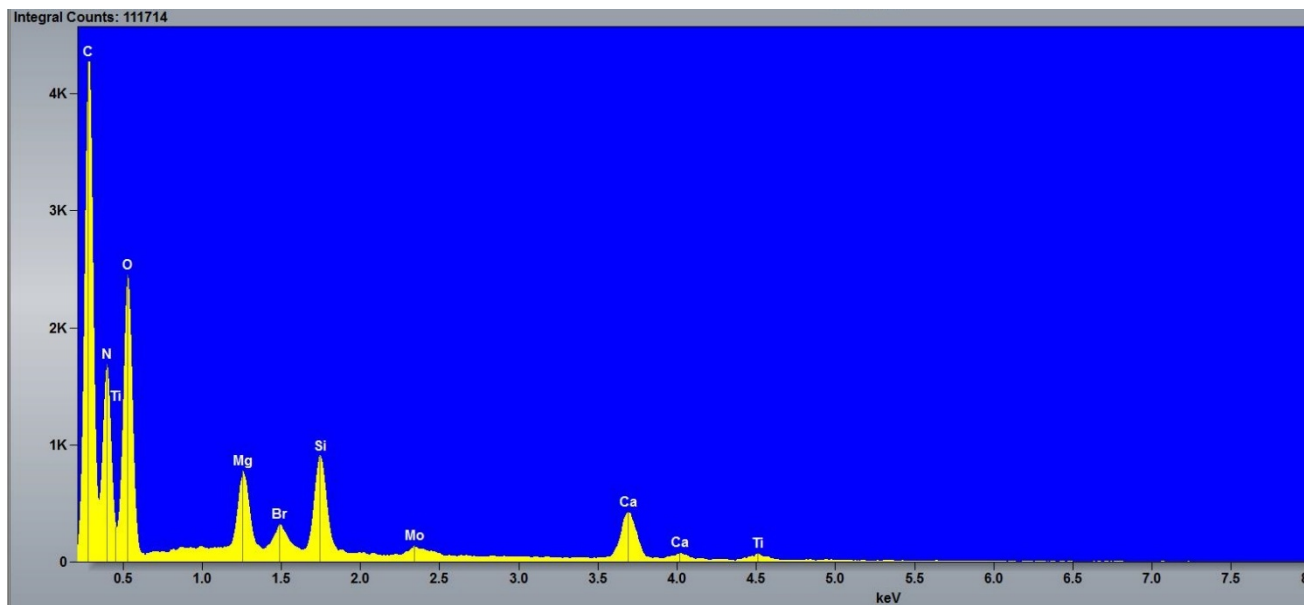


Figure 8 - Typical EDS spectrum of the debris in Figure 7.

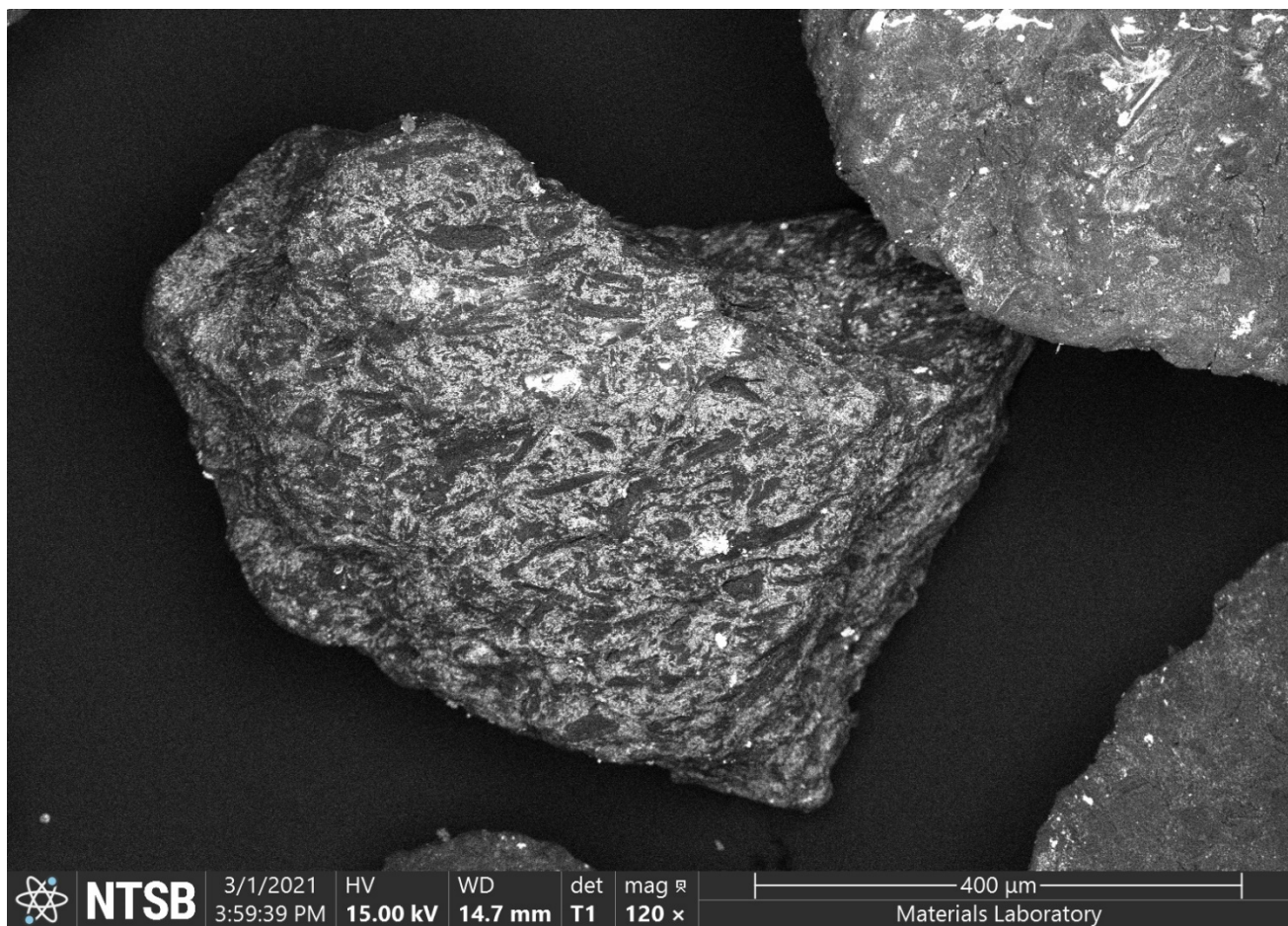


Figure 9 – BE micrograph of a debris particle exhibiting an EDS spectrum different than the other particles.

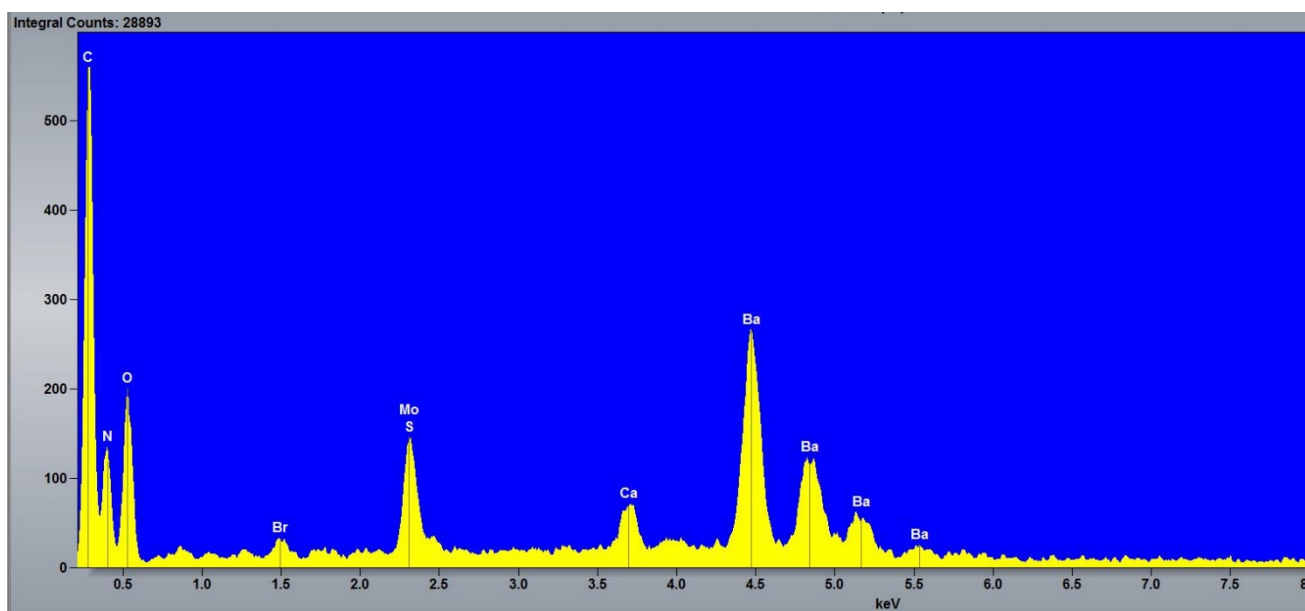


Figure 10 – Typical EDS spectrum of the particle in Figure 9.

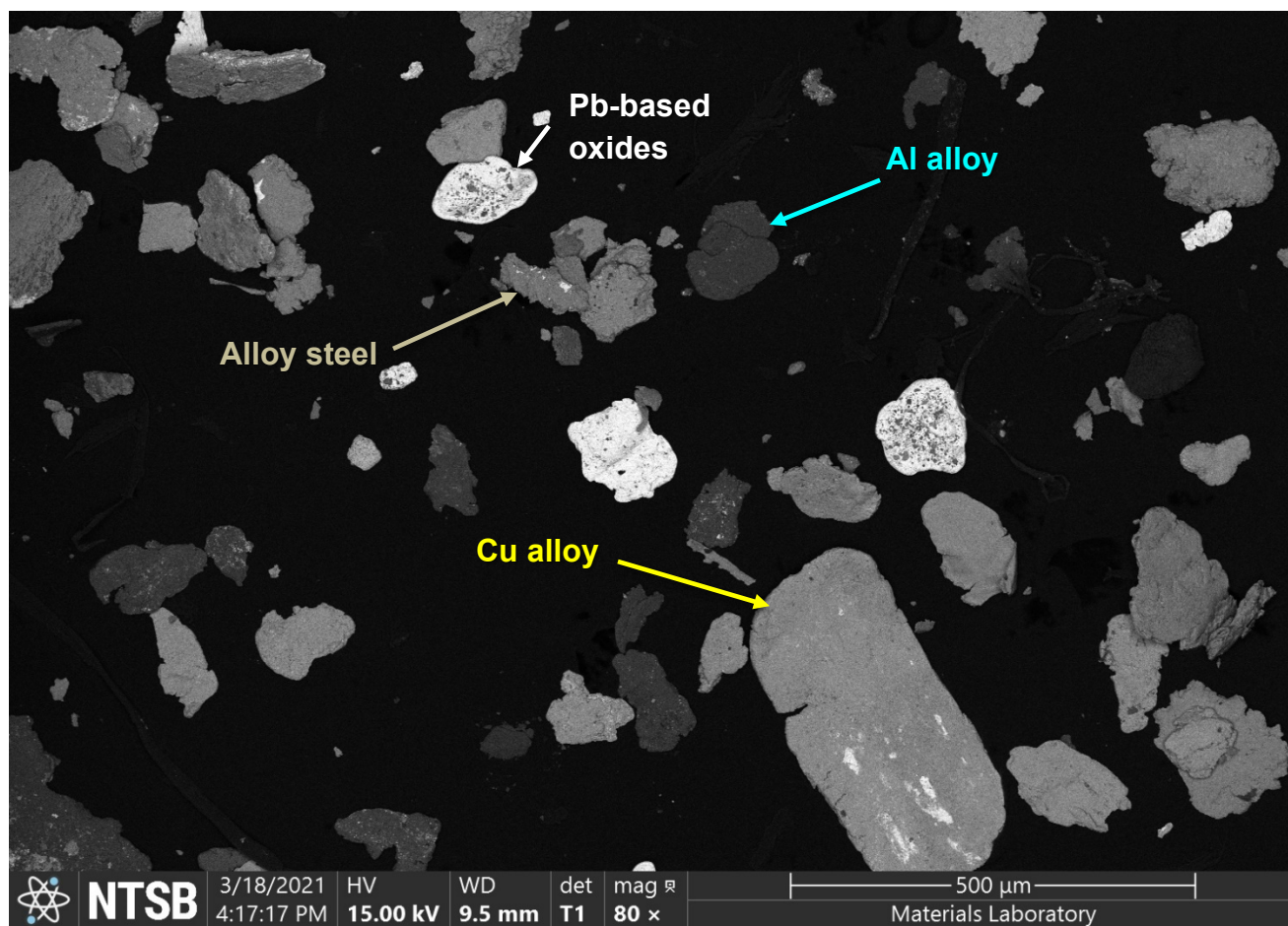


Figure 11 – BE micrograph of some of the metallic particles from the drive gear governor body bore.