

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



ERA23LA218

MATERIALS LABORATORY

Factual Report 24-060

September 27, 2024

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A. ACCIDENT INFORMATION

Location: Greenville, North Carolina
Date: May 5, 2023
Vehicle: Piper PA-28-180 (N180LR)
Investigator: Leah Read, AS-ERA

B. COMPONENTS EXAMINED

Components from a Lycoming O-360-series engine:
Crankshaft (Part No. 74251), connecting rods and associated bearings, main journal bearings, and oil filter screen with metallic particles and flakes

C. EXAMINATION PARTICIPANTS

Specialist Brian Fuchs
National Transportation Safety Board
Washington, DC

D. DETAILS OF THE EXAMINATION

Figure 1 shows the parts as received at the materials laboratory. Most parts were intact, but the connecting rod for piston 3 showed significant damage at the connection to the crankshaft journal and the cap was broken into multiple pieces. One bolt from connecting rod 2 showed cutting marks consistent with a metal saw; it was confirmed that the cutting occurred during the engine examination. The oil filter, shown in Figure 2, contained flakes of silver-colored metal.

The crankshaft (Figure 3) showed damage to most bearing surfaces. The forward main bearing journal showed gray and white streaks around its circumference, consistent with material transfer. The middle main bearing journal (between the second and third connecting rod journals) was discolored with a yellow/brown patina, consistent with exposure to elevated temperature. The aft main bearing journal was silver in color with no discoloration or evidence of damage. Crankpin journals 1, 2, and 3 (numbered from fore to aft) were discolored and the surfaces were rough. Brown and black metal and corrosion deposits were visible around the outer wall of the three journals. X-Ray Fluorescence (XRF) was used to determine the composition of the metal deposits. Measurements taken on journals 1, 2, and 3 showed a higher concentration of copper (3-5 wt%) than a measurement taken on a clean (silver-colored) part of the main crankshaft (<0.05 wt%).¹ Journal 3 also showed surface damage consistent with gouging or hard contact with other surfaces. Journal 4 showed some brown discoloration and deposits, but to a lesser

¹ XRF measurements penetrate into the surface being measured. Thus, a measurement of a material with a thin deposit layer will show a combination of the deposit layer and base material.

extent than the other three journals. A micrometer was used to measure the diameter of journal 4 as received, which was found to be 2.1243 inch.

Bearings submitted with the parts also showed damage consistent with contact and wear. The bearings were washed in ethanol in an ultrasound bath to remove dirt and residue. The forward main journal bearing (Part No. SL-13884) showed smearing in and around one oil channel, to the degree that much of the channel had been filled in and one inlet hole had been covered completely (Figure 4). XRF measurements of the bearing surface showed a high amount of aluminum (>60 wt%). The outer surface showed high amounts of iron (>90 wt%) and low amounts of aluminum (<1 wt%).

The second pair of main journal bearings (Part No. SL-11020) did not show the level of wear seen in the forward bearings, though the inner surface was shiny and silver in color with some areas showing dark circumferential streaks (Figure 5). The outer surface showed a dark, dull band approximately 0.11 inch wide going around the outer circumference of the bearing. XRF measurements on the inner bearing surface showed a high amount of copper (>80 wt%) and lead (approx. 12 wt%).

One half of the final pair of main journal bearings was marked in yellow with a symbol resembling an "R". The inner surface did not show smearing, though a section of the shiny silver layer was worn away on the inner part of one half, revealing a copper-colored layer (Figure 6). The outer surface showed a dark, dull band approximately 0.26 inch wide running around the circumference of the two bearings. The band intersected the holes in the bearing. XRF measurements on the inner bearing surface showed a high amount of lead (>70 wt%) and copper (>10 wt%).

The bearings from the rods (Part No SL-13521) had a copper-colored appearance on the inner wall of the bearing. The copper-colored material on the inner surface of the bearings from rods 1 and 2 was extruded out the sides of the bearings, causing the bearings to be misshapen (Figure 7). XRF readings of this layer showed a high concentration of copper (>60 wt%). Comparatively, the bearings from rod 4 showed little damage.

The remains of connecting rod 3 were examined for evidence of pre-existing damage (Figure 8). Most surfaces showed signs of smearing and deformation consistent with post-fracture hard contact damage. A portion of the fracture surface for one bolt showed a rough, matte gray finish consistent with overload failure. A thin, flattened fragment was identified as a piece of the bearing and was subjected to XRF examination. This piece showed an elevated amount of copper (>5 wt%) on one side. No evidence of pre-existing damage was seen.

A selection of large metal flakes from the oil filter (Figure 9) were cleaned with acetone in an ultrasound bath and examined with a field-emission scanning electron

microscope. Energy Dispersive Spectroscopy (EDS) was used to determine their composition (Figures 10-13). The flakes were arbitrarily numbered 1-4 for tracking purposes. Flakes 1,3 and 4 showed high amounts of aluminum. Flake 2 showed high amounts of iron and aluminum.

Submitted by:

Brian Fuchs
Materials Engineer

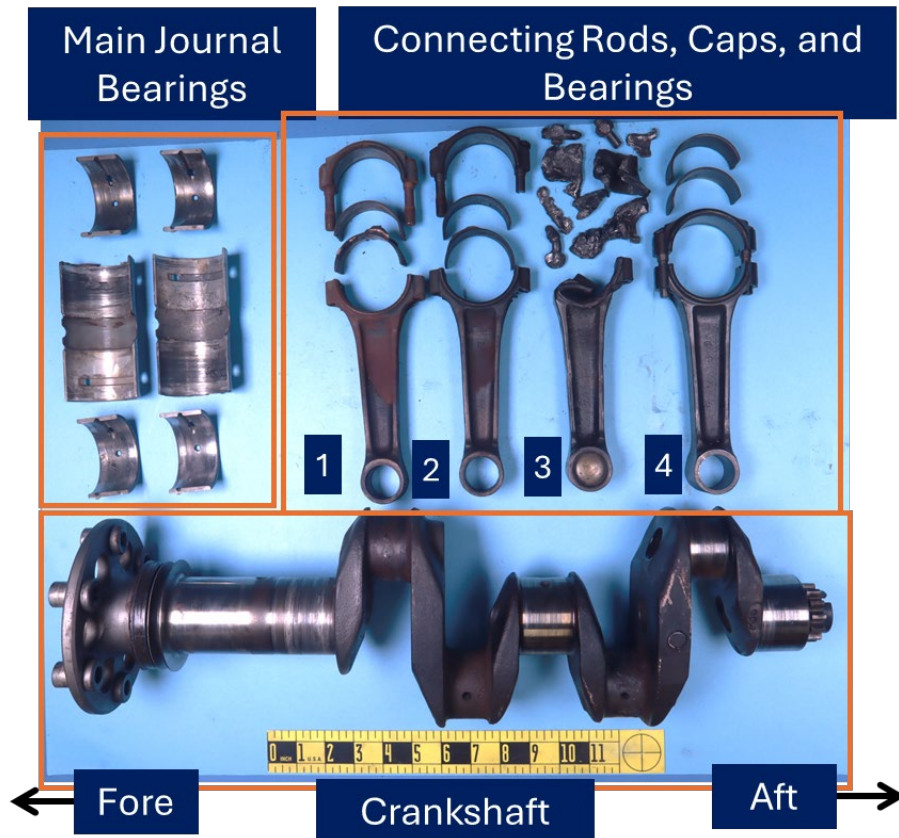


Figure 1. Crankshaft, bearings, and connecting rods as received. Connecting rod journals are numbered starting at 1 at the fore and increasing as one moves aft.

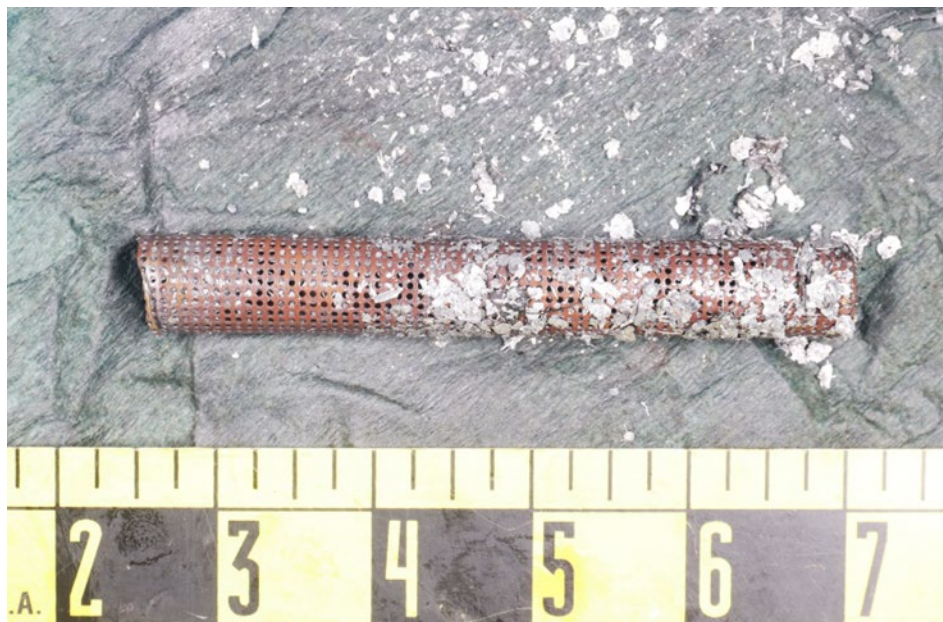


Figure 2. Oil screen as received. Silver-colored metal particles were seen inside and outside of the screen.

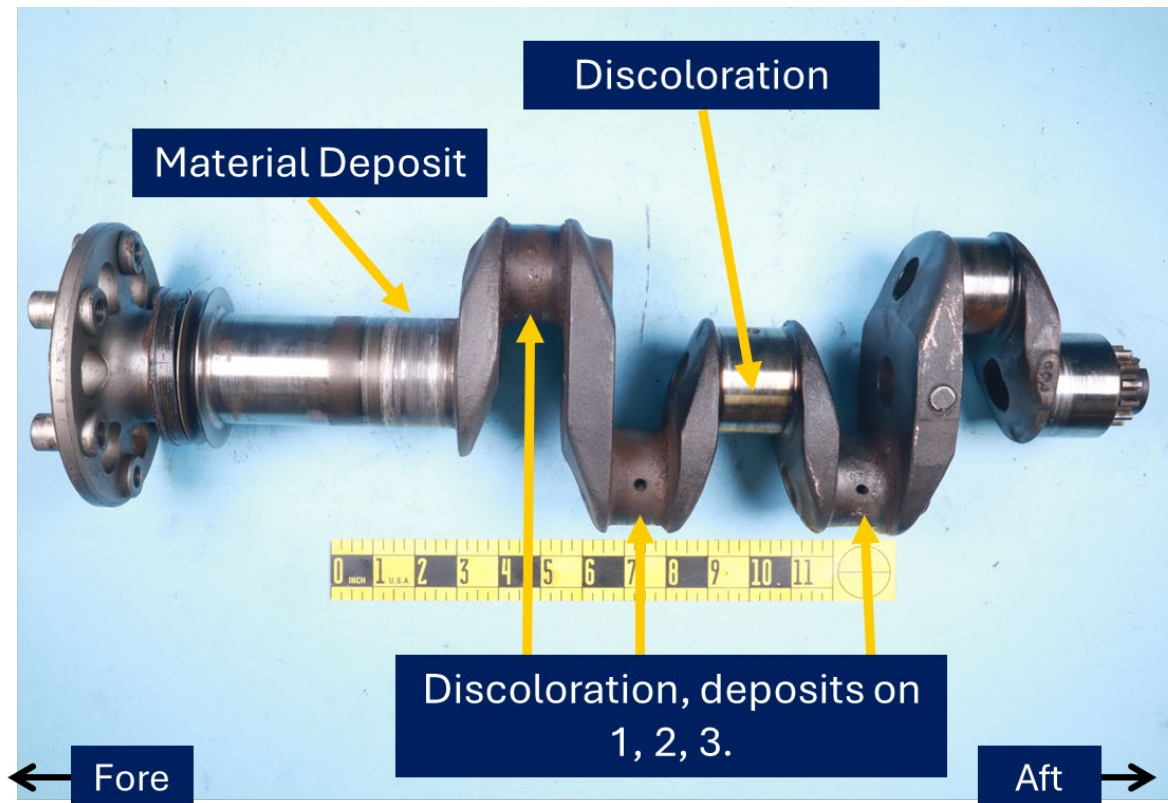


Figure 3. Parts of the crankshaft showed damage consistent with contact and exposure to high temperatures. Crankpin journals are designated 1 to 4 moving fore to aft.



Figure 4. Wear on the forward main journal bearing.

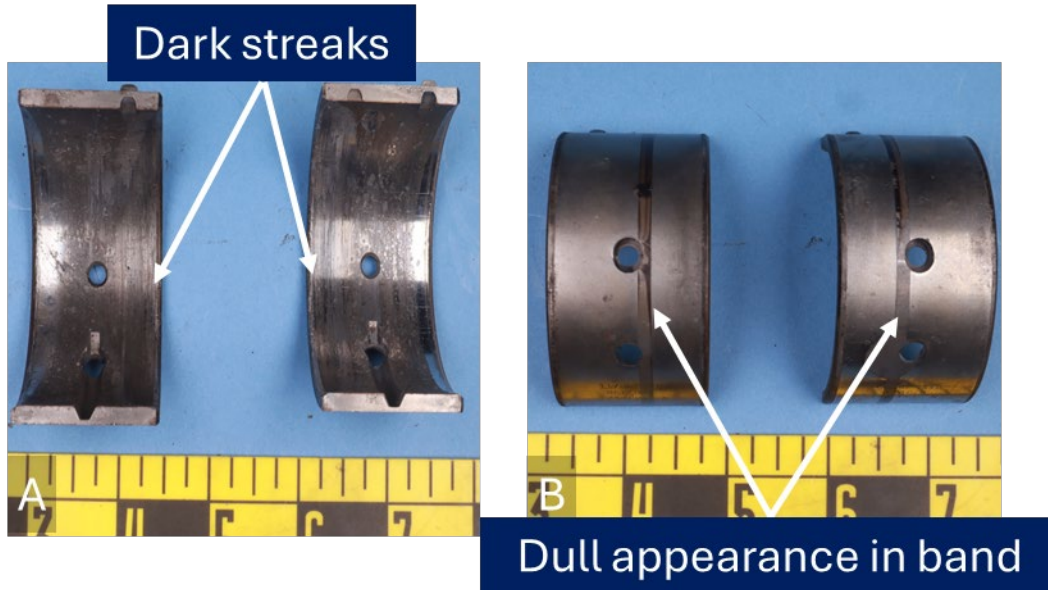


Figure 5. Second set of main journal bearings. A) Inner bearing surface. B) Outer bearing surface.

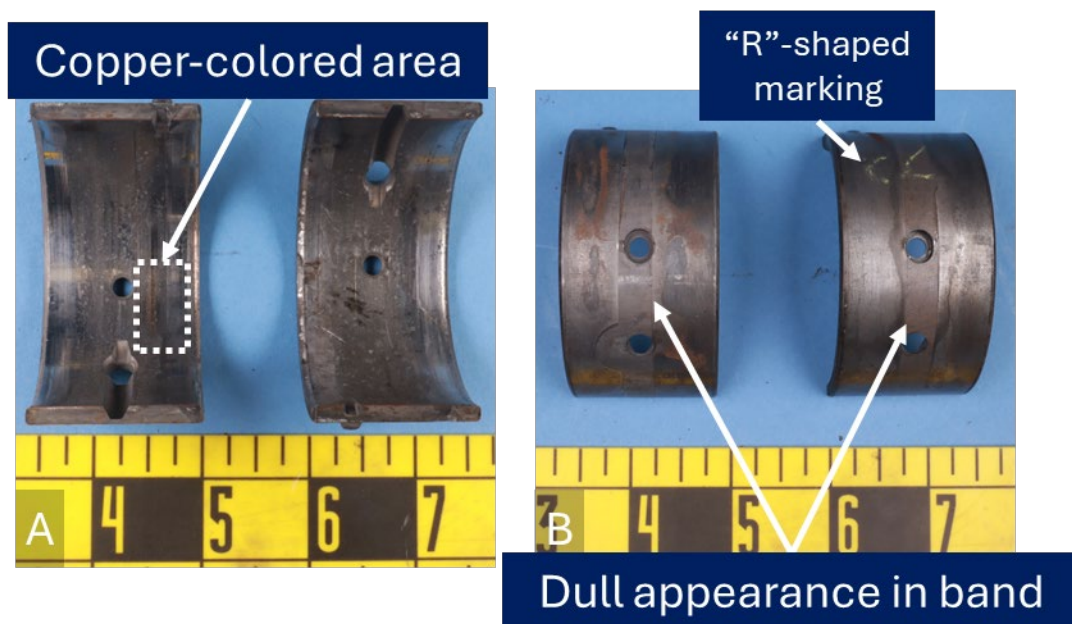


Figure 6. Final set of main journal bearings. A) Inner bearing surface. B) Outer bearing surface.

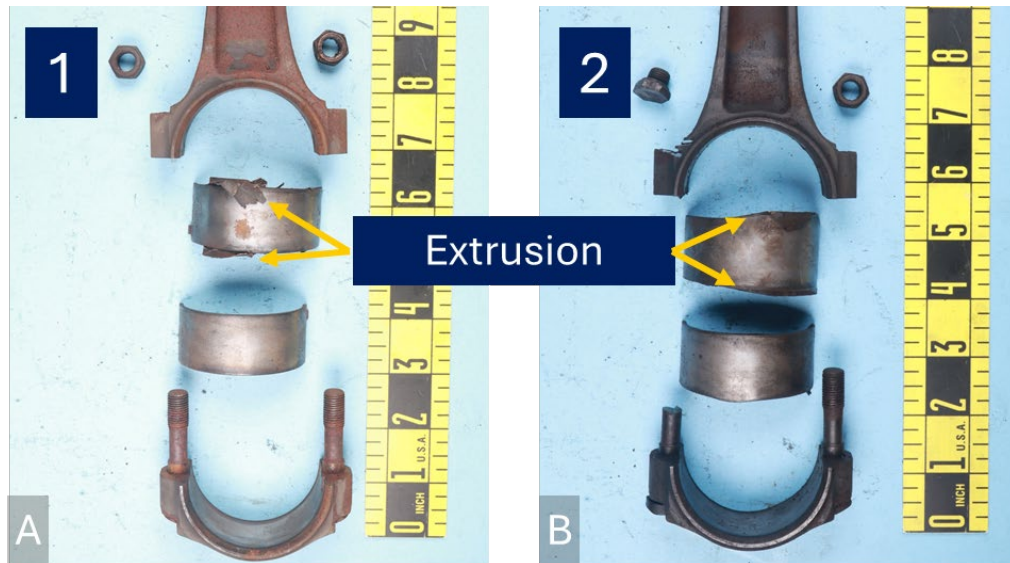


Figure 7. Bearings from A) connecting rod 1 and B) connecting rod 2. The inner layer of the bearing was extruded out the sides for both rods.

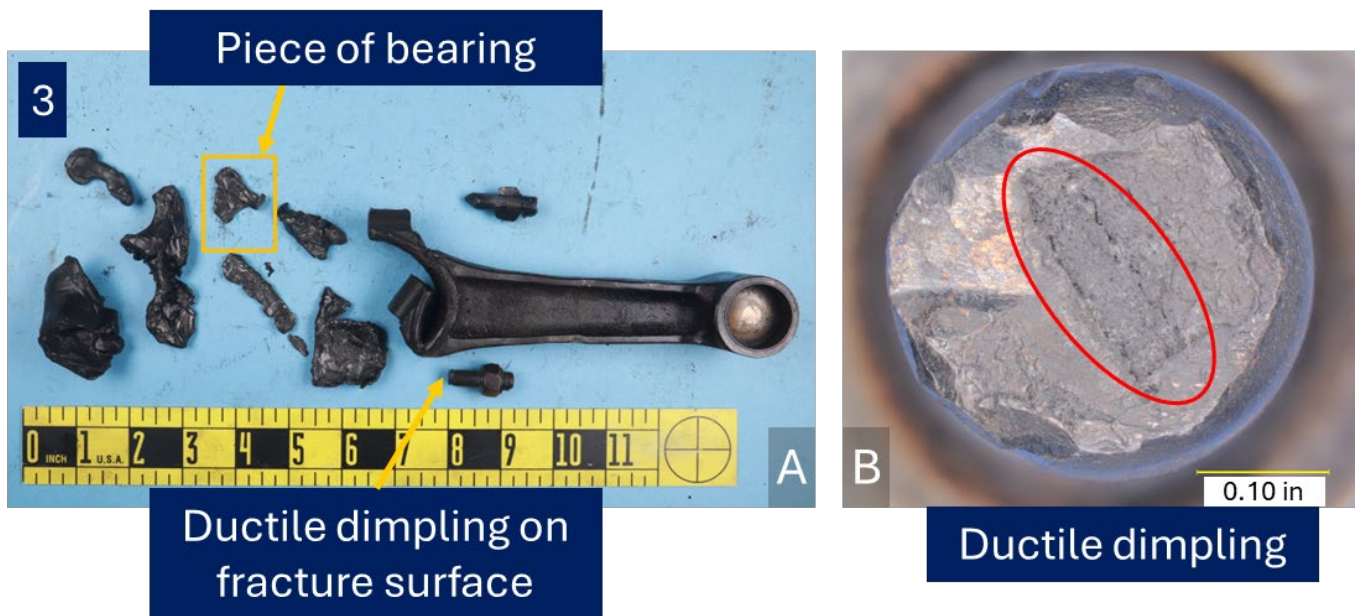


Figure 8. A) Connecting rod 3. The highlighted piece of bearing was subjected to XRF analysis. B) The fracture surface on the bolt highlighted in A.



Figure 9. Particles from the oil filter subjected to EDS analysis. EDS Spectra for each particle can be seen in the following figures.

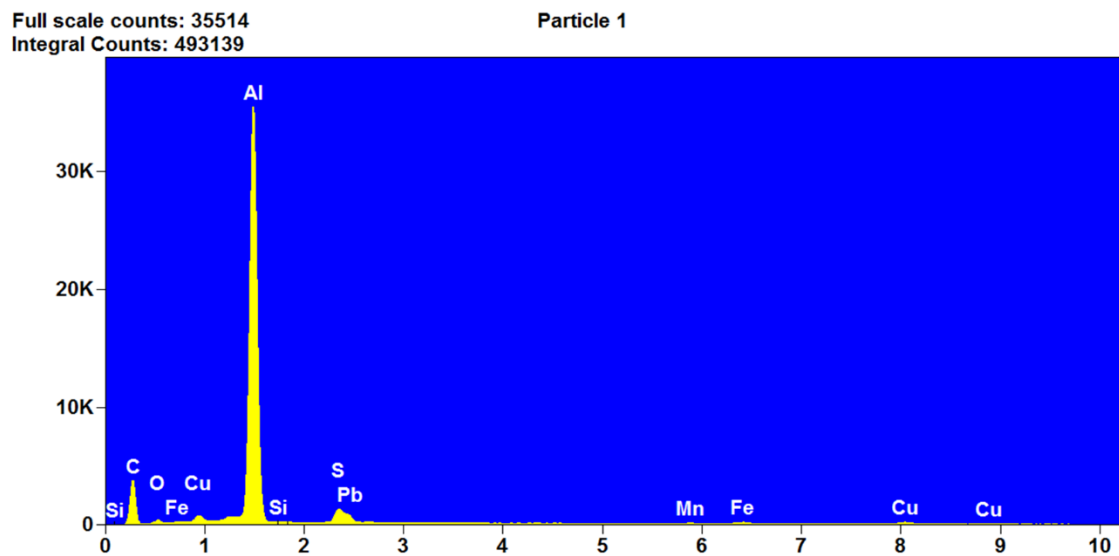


Figure 10. EDS Spectrum for particle 1.

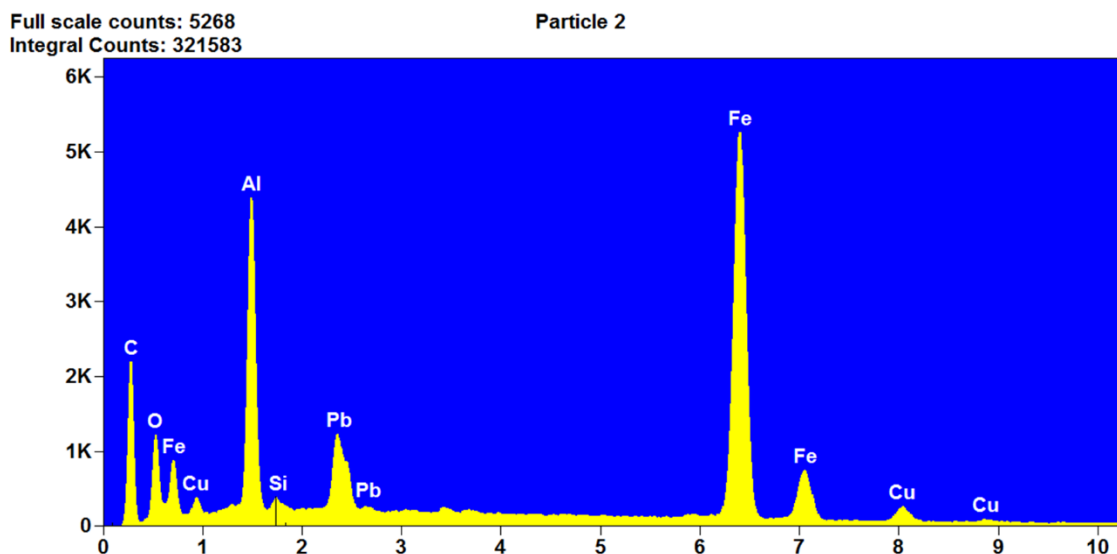


Figure 11. EDS Spectrum for particle 2 showing strong peaks for aluminum and iron.

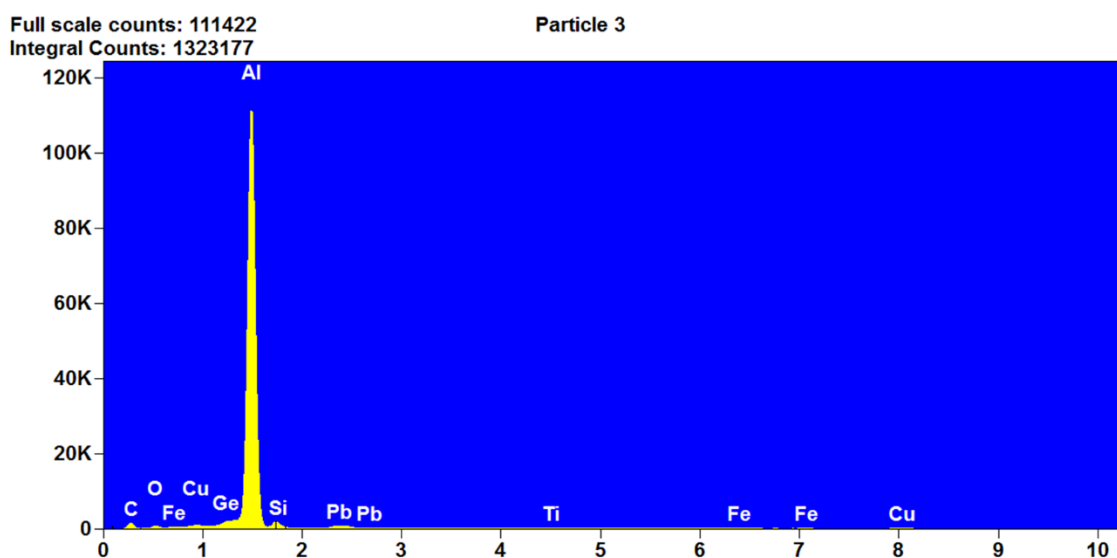


Figure 12. EDS Spectrum for particle 3.

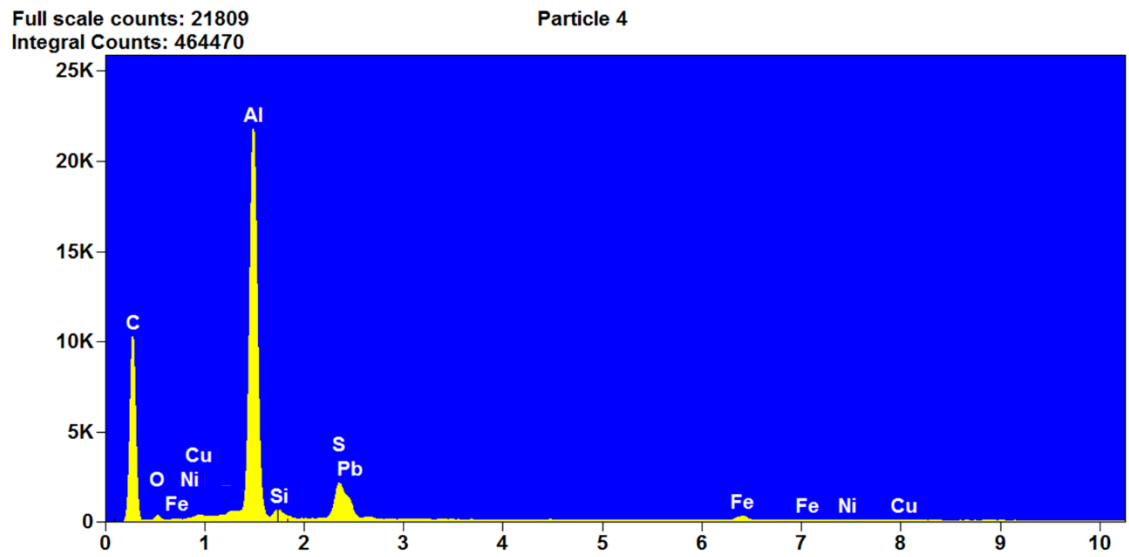


Figure 13. EDS Spectrum for particle 4.