

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



WPR23LA295

MATERIALS LABORATORY

Factual Report 24-017

April 12, 2024

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A. ACCIDENT INFORMATION

Location: Renton, Washington
Date: July 31, 2023
Vehicle: Larry W. Fish Lancair 360, N68XA
Investigator: Stephen Stein, AS-WPR

B. COMPONENTS EXAMINED

12V DC battery including fractured battery terminals with attached wire terminal connectors.

C. EXAMINATION PARTICIPANTS

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

D. DETAILS OF THE EXAMINATION

Overall views of the battery and fractured terminals are shown in figure 1. Both the positive and negative battery terminals were fractured, and wire terminal connectors remained attached to the separated pieces of the battery terminals as shown in the right image in figure 1.

The battery terminals were made of nearly pure lead, which is a relatively soft and easily deformed metal. The battery terminals were deformed, and the terminals appeared to be thinned and pressed into the connections at the clamped faces. A view of the negative battery terminal showing deformation at the clamping surfaces relative to the outer edges is shown in figure 2.

The mating fracture surfaces of the negative battery terminal are shown in figure 3. The mating fracture surfaces showed deformation consistent ductile overstress fracture under torsion loading with relative motion from the mating side as indicated by arrows in figure 3. The fracture surfaces appeared smeared, and spheres of remelted lead balls were observed deposited on adjacent surfaces. Additionally, the nut for the negative terminal connections had an area where surface appeared cratered at the edge of a wrench flat with smooth rounded features at the edges. The overall appearance of the cratered area was consistent with damage from electrical arcing as indicated in figure 3.

A close view of the positive battery terminal piece fracture surfaces with attached wire terminal connectors is shown in figure 4. Most of the fracture surface had matte gray features consistent with ductile overstress fracture. The overall

deformation pattern at the fracture location appeared consistent with overstress fracture from torsion loads.

The fracture surfaces were examined using a scanning electron microscope (SEM), and images of portions of the fracture surfaces on the negative and positive battery terminals are shown in figures 5 and 6, respectively. The fracture surfaces of the negative battery terminal were mostly smeared consistent with sliding contact between the mating fracture faces under mostly shear loading with limited tensile stresses in the fracture plane. On the positive terminal the fracture surfaces mostly showed elongated dimples, consistent with a combination of tension and shear stresses on the fracture plane.

The arc damaged area of the nut on the negative terminal was analyzed in the SEM using energy dispersive x-ray spectroscopy (EDS). The spectra obtained in the cratered area were compared to a corner of the nut wrenching flat where the cadmium coating appeared to be mostly disturbed by mechanical means. The baseline spectrum obtained in the area where the cadmium coating appeared to be mechanically disturbed is shown in the lower image in figure 7, where expected peaks associated with the steel nut and cadmium coating along with other light elements were observed. In the cratered area, peaks associated with copper were detected in addition to others shown in the baseline spectrum.

Submitted by:

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

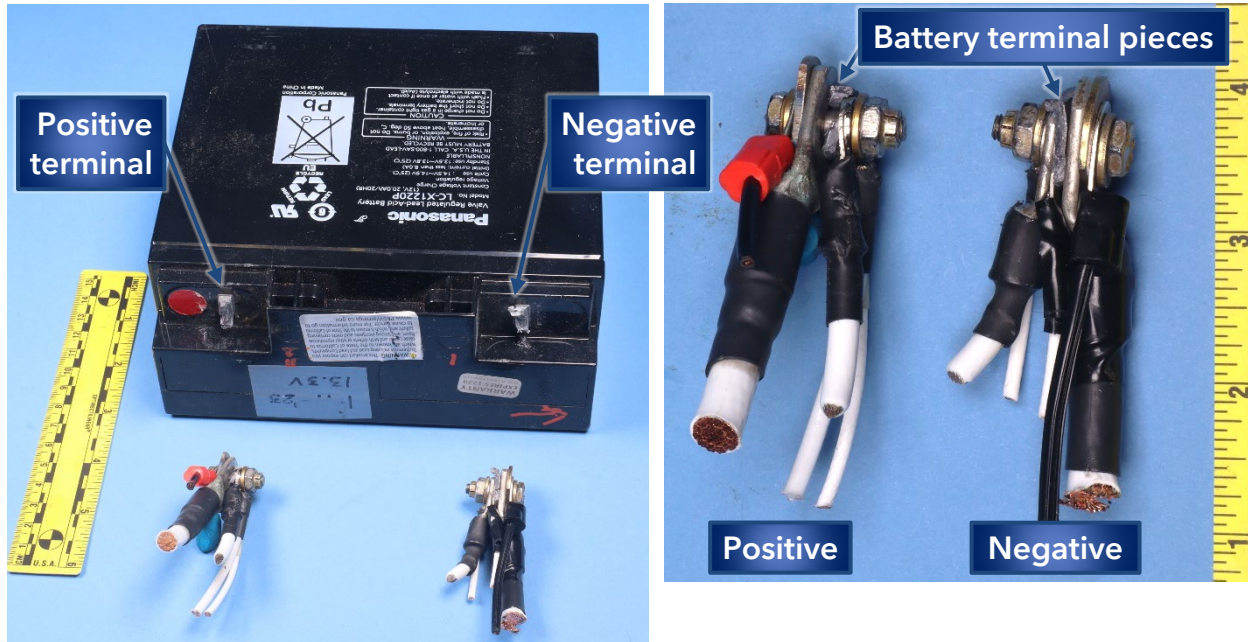


Figure 1. Overall view of the submitted battery and fractured battery terminal pieces with attached wire terminal connectors (left image) with a closer view of the terminal pieces and attached connectors (right image).

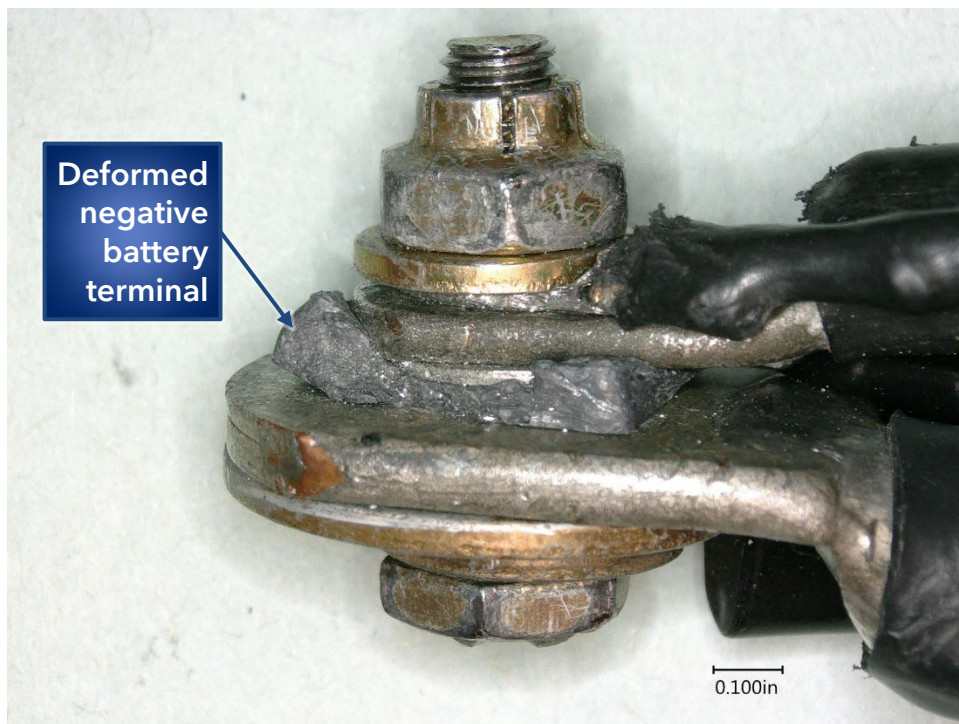


Figure 2. Close view of the negative terminal connection showing the outer surface of the battery terminal (the side opposite the fracture).

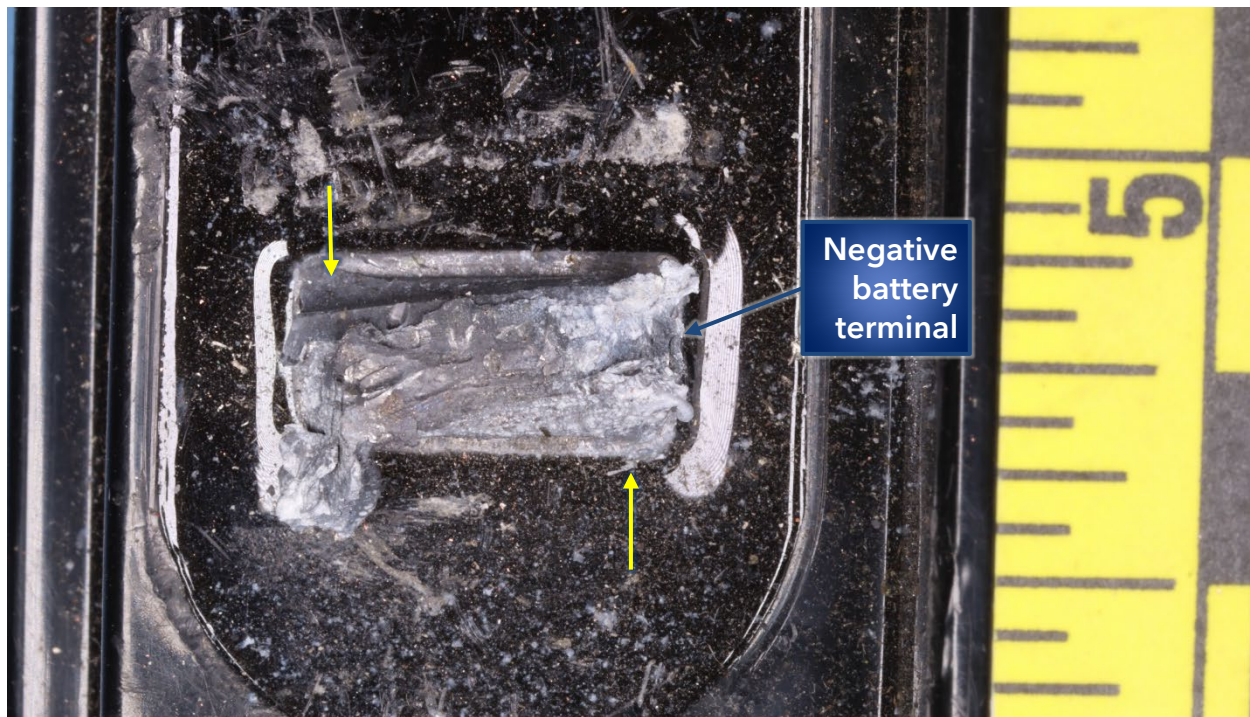
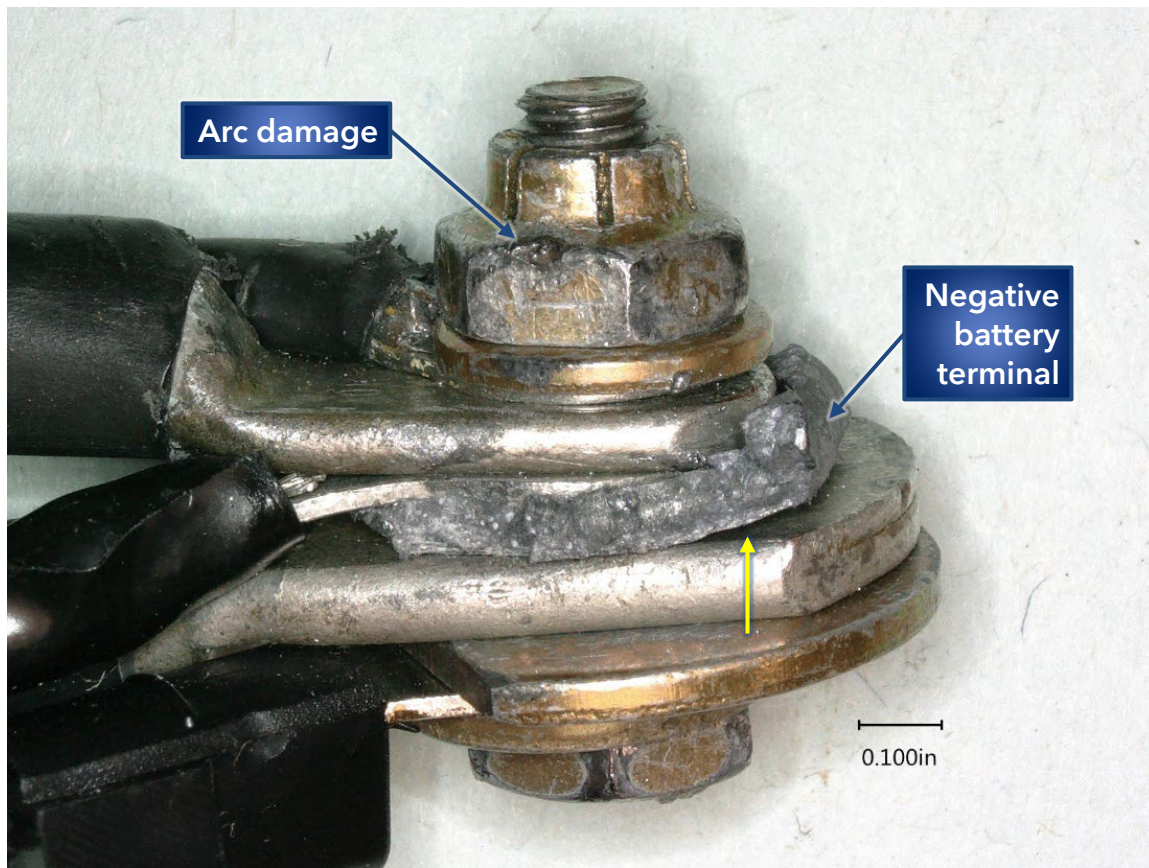


Figure 3. Mating sides of the fractured negative battery terminal showing the connection side (upper image) and the battery side (lower image). Arrows point to the direction of deformation from relative motion of the mating side of the fracture.



Figure 4. Fracture surfaces on the connection side of the positive battery terminal.

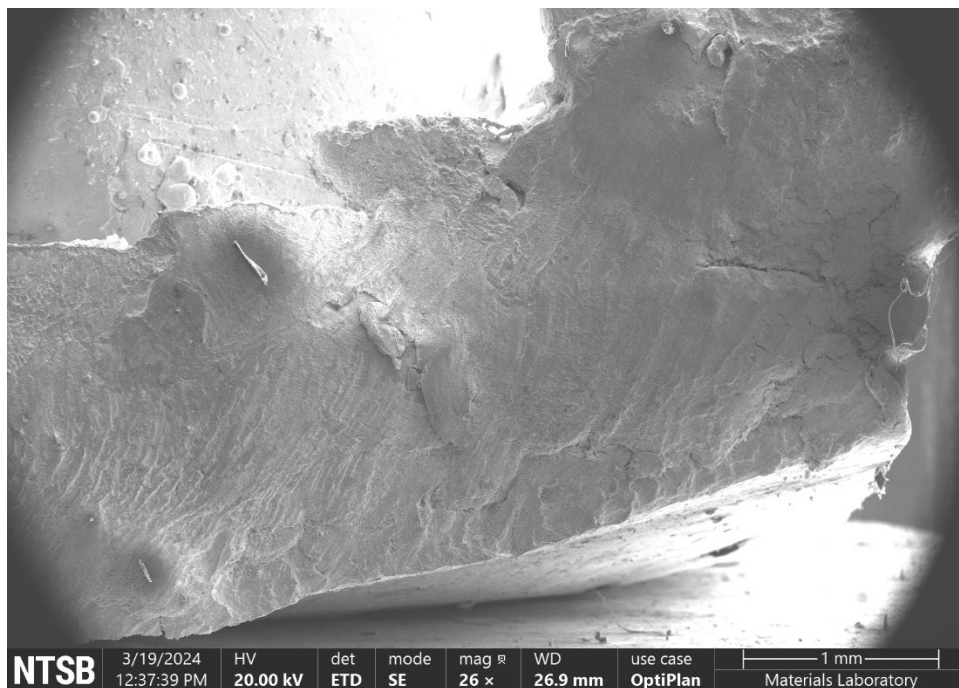


Figure 5. SEM image of fracture features on a portion of the negative terminal.

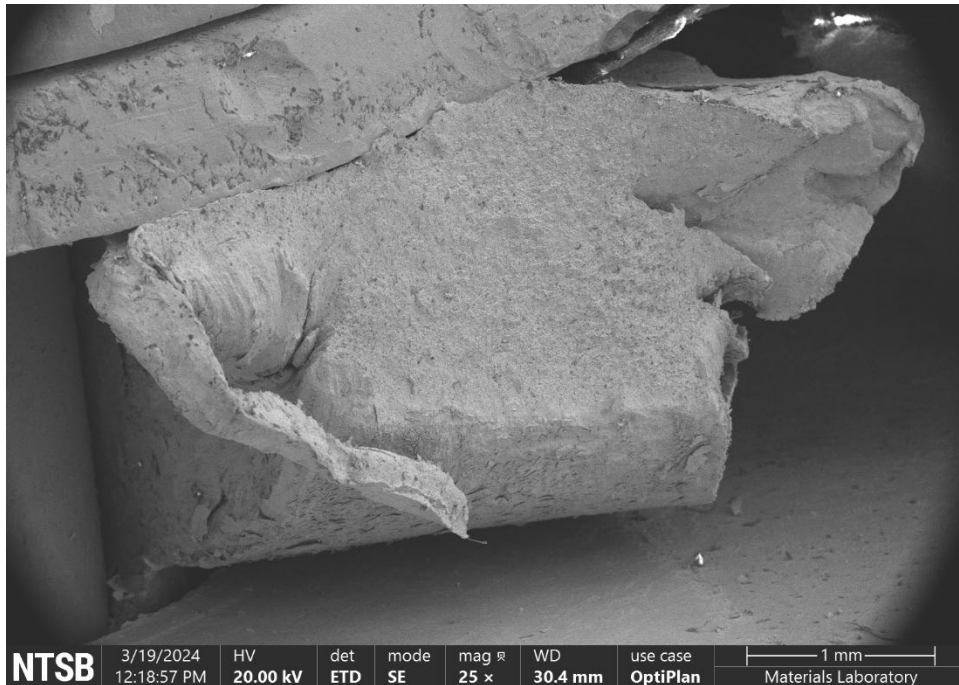


Figure 6. SEM image of fracture features on a portion of the positive terminal.

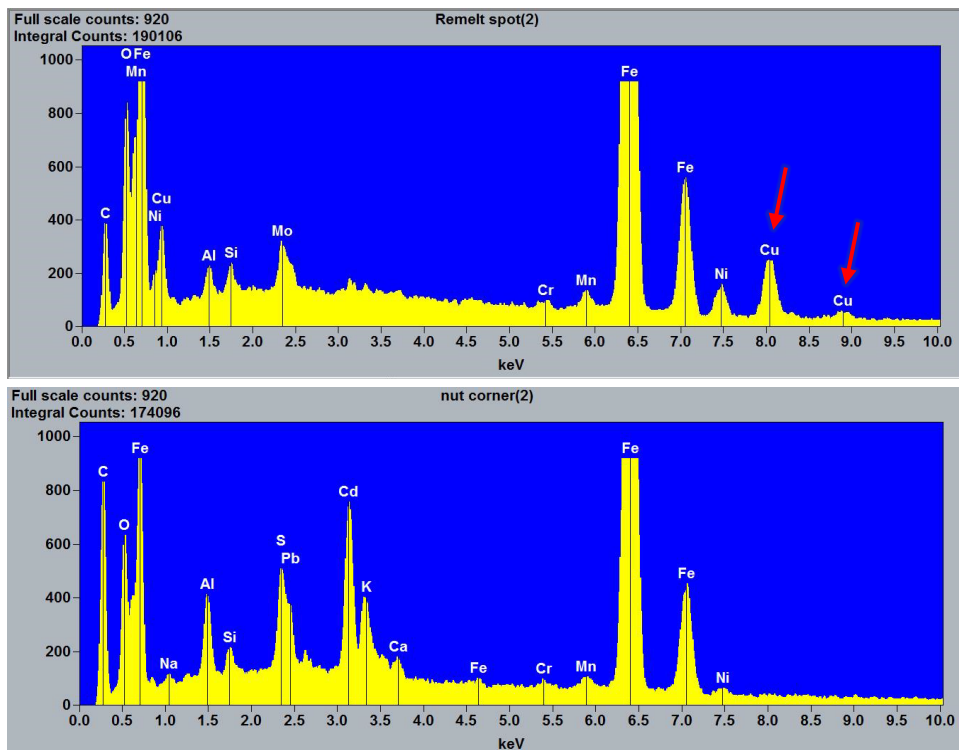


Figure 7. EDS spectra obtained within the arc damage area on the nut (upper spectrum) and on an area of the nut where most of the cadmium coating appeared to be mechanically removed (lower spectrum). Red arrows in the upper spectrum point to copper peaks that are not observed in the lower spectrum.