

NATIONAL TRANSPORTATION SAFETY BOARD

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



March 1, 2019

MATERIALS LABORATORY FACTUAL REPORT

Report No. 18-105

A. ACCIDENT INFORMATION

Place : Guthrie Center, Iowa
Date : November 18, 2018
Vehicle : Piper PA-28-236
NTSB No. : WPR19FA022
Investigator : Elliott Simpson, AS-WPR

B. COMPONENTS EXAMINED

Exhaust muffler with risers, heat exchanger shroud, heat exchanger intake tube, and cabin heat supply tube.

C. DETAILS OF THE EXAMINATION

An overall view of the submitted components is shown in figure 1. The shroud and mufflers were crushed, and the upper side of the shroud was bent forward, partially exposing the mufflers. The right aft riser was not included with the submitted components, and the remaining risers were bent and crushed. The aft muffler had multiple cracks including a longitudinal crack at the forward upper side of the aft muffler as shown in figure 1.

The heat exchanger shroud was disassembled from the mufflers and pried open to expose the interior surface. Tan deposits were observed covering the interior surface of the shroud as shown in figure 2.

An overall view of the mufflers after the shroud was removed is shown in figure 3. The forward and middle mufflers were crushed but appeared intact. No visual evidence of cracks or perforations through the muffler wall was observed in the forward or middle muffler.

The aft muffler was also crushed, and multiple cracks and perforations through the muffler wall were observed at the left end of the muffler. A circumferential crack extended around approximately $\frac{3}{4}$ of the circumference of the muffler adjacent to the left end face as indicated in figure 3. At the upper forward side shown in figure 1, a longitudinal crack extended 2.75 inches at the location of a longitudinal seam weld. The crack was gaped open as shown, and portions of wall material were missing at the crack opening. On the lower side of the aft muffler (see figures 4 and 5), perforations and another longitudinal

crack were observed. The muffler wall was crushed and folded at the location of the crack on the lower side of the muffler.

The fracture features for cracks and perforations on the aft muffler were examined closely using an optical stereomicroscope. A magnified optical image of the longitudinal crack fracture surface at the upper forward side of the aft muffler wall is shown in figure 6. The fracture surface was oxidized with dark-colored deposits on the surface consistent with a preexisting crack.

A close view of the muffler wall fracture features associated with the circumferential crack at the left end of the aft muffler is shown in figure 7. The fracture surface had dark oxidation and deposits across much of the thickness, but a thin portion of the fracture at the exterior surface was in a slightly different fracture plane and had a light gray appearance consistent with final fracture at impact.

The cracks and perforations in the wall at the lower side of the aft muffler were generally associated with wrinkles, folds, and deformation on the muffler wall. Sliding contact marks on the lower surface were also observed associated with the longitudinal crack opening on the lower side. Oxidized fracture surfaces were observed adjacent to the interior surfaces of the perforations and cracks, and light gray fracture features were generally observed adjacent to the exterior surface.

The thickness of the muffler wall adjacent to the longitudinal crack at the upper forward side was measured using a point micrometer. At the measurement location, loosely-adhering oxides and deposits on the interior surface were scraped away using a metal pick. In the area where oxides and deposits were scraped away, the wall thickness measured 0.018 inch. For comparison, the muffler wall thickness was measured near the middle of the muffler. Before completing the measurement, a transverse cut was made near the middle of the muffler. The wall thickness adjacent to the transverse cut near the middle of the muffler was 0.109 inch.

Tan deposits were observed coating the interior surface of the cabin heat supply tube as shown in figure 8. A sample of the tan deposit was scraped from the interior using a scalpel to facilitate compositional analysis of the deposit using energy dispersive x-ray spectroscopy (EDS). The sample was placed on an aluminum stub coated with carbon tape. For comparison, a sample was collected from the interior surface of the heat exchanger intake tube and was also placed on the coated aluminum stub. Resulting EDS spectra for the two samples are shown in figure 9. The tan deposit had high peaks of lead and bromine, consistent with exhaust deposits. The sample collected from the intake tube interior surface had a high peak of silicon with no peaks of lead or bromine.

Maintenance log books for the accident airplane were reviewed. According to the maintenance logs, a new log book was created on August 27, 1991 because the previous log books were lost. At the time the log book was created, the airframe had accrued a reported 1,922.58 hours time in service (TIS). A subsequent log book entry indicated two of the three mufflers were replaced on August 12, 2002 at 2,203.64 hours TIS, but the

positions of the two replaced mufflers were not specified. Later entries noted the middle muffler was replaced on March 1, 2012 at 2,752 airframe hours TIS, and the forward muffler was replaced on January 23, 2008 at 2,689 airframe hours TIS. A 100-hour inspection was completed before the accident flight at an airframe time of 2,955 airframe hours TIS, which reportedly included a visual inspection of the mufflers with the heat exchanger shroud removed. None of the maintenance log entries in the 1033 hours TIS since 1991 specifically mentioned replacement of the aft muffler, but the replacement of two mufflers in 2002 in unspecified locations (which could have included the aft position) occurred 752 hours TIS before the accident. At least one of the mufflers installed in 2002 was replaced at less than 549 hours TIS.

Matthew R. Fox, Ph.D.
Senior Materials Engineer

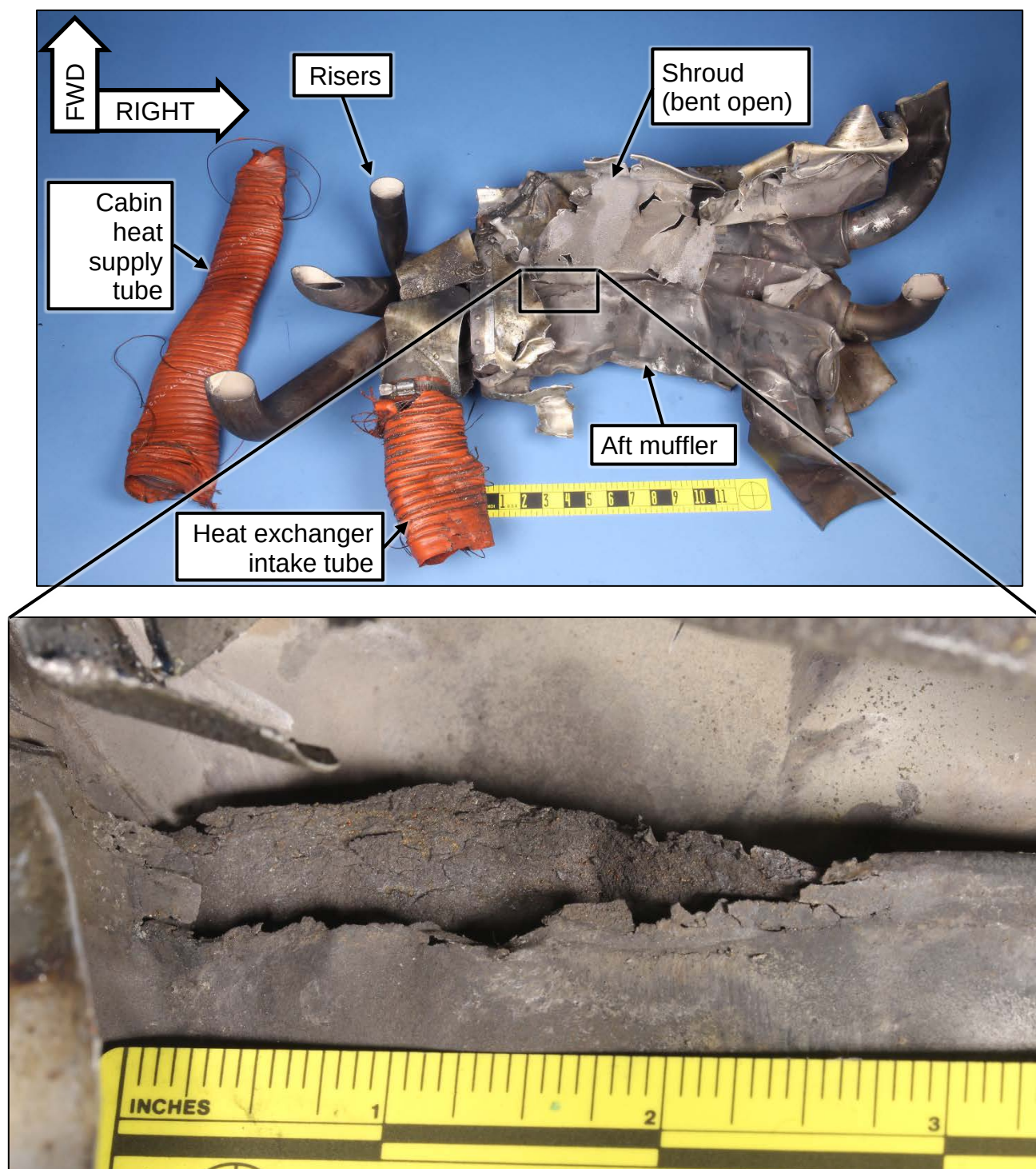


Figure 1. Overall view of the submitted components (upper image) with a closer view of an open crack at the upper forward side of the aft muffler (lower image).

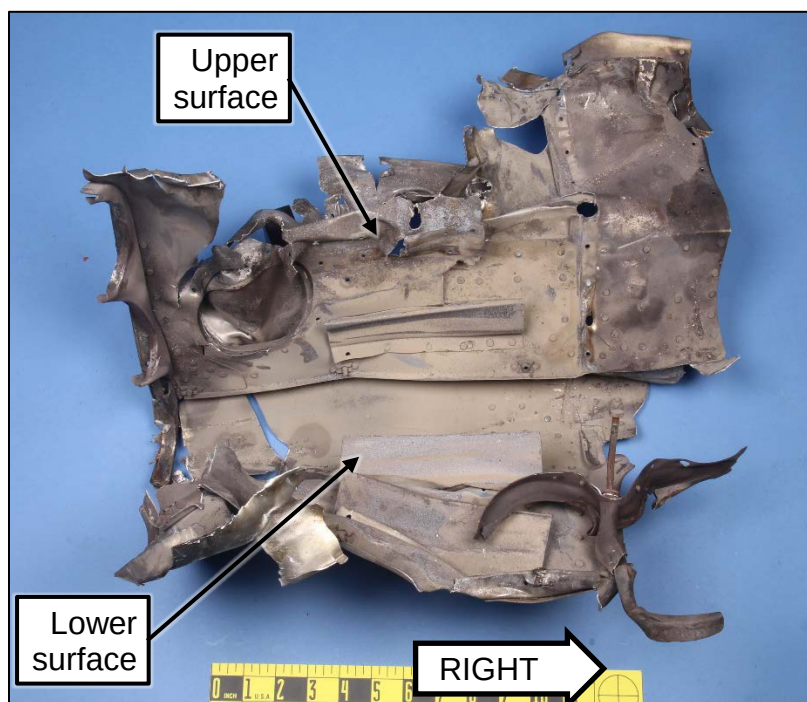


Figure 2. Interior surface of the heat exchanger shroud after disassembly. Tan deposits were observed on the interior surfaces.

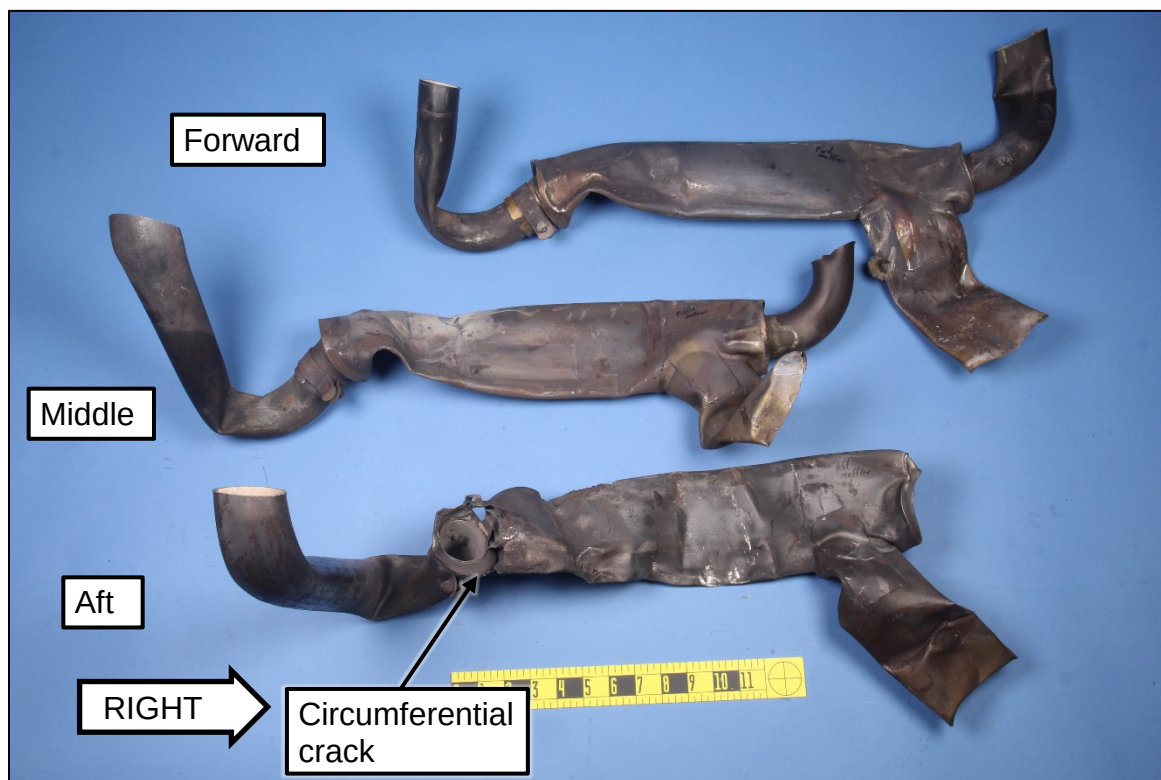


Figure 3. Overall view of the upper surfaces of the forward, middle, and aft mufflers from the heat exchanger system.



Figure 4. Overall view of the lower surface of the aft muffler.

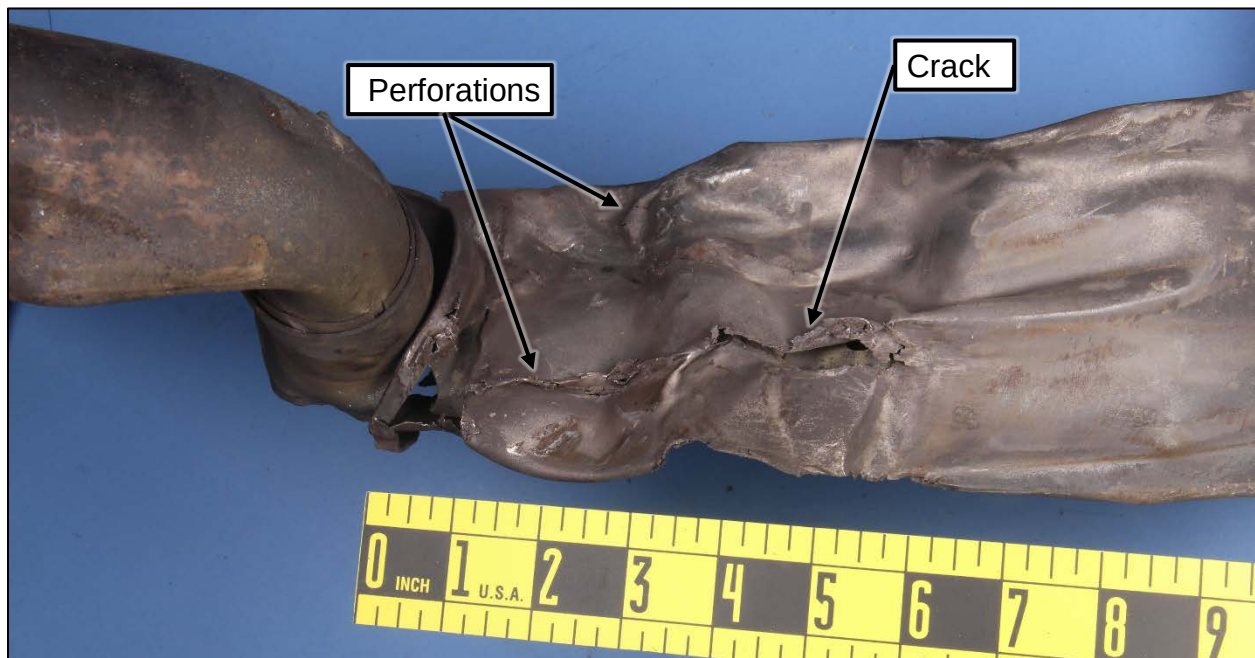


Figure 5. Close view of cracks and perforations on the lower left side of the aft muffler.

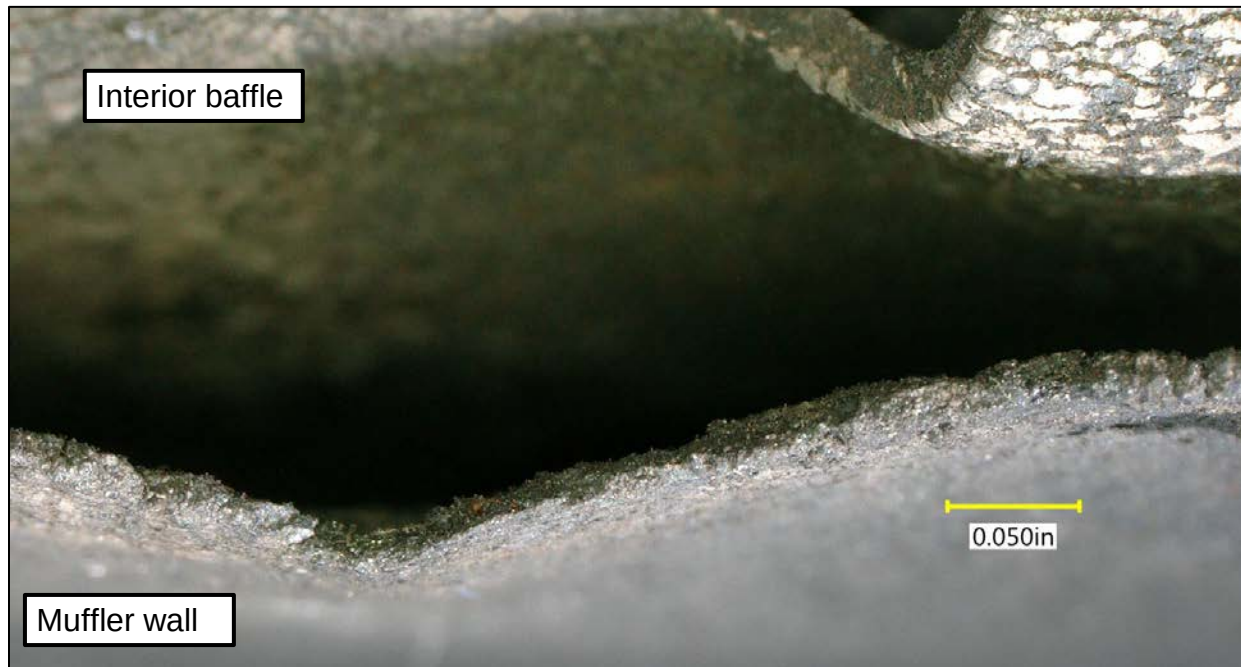


Figure 6. Close view of the oxidized fracture surface associated with the longitudinal crack at the upper forward side of the aft muffler (see figure 1).

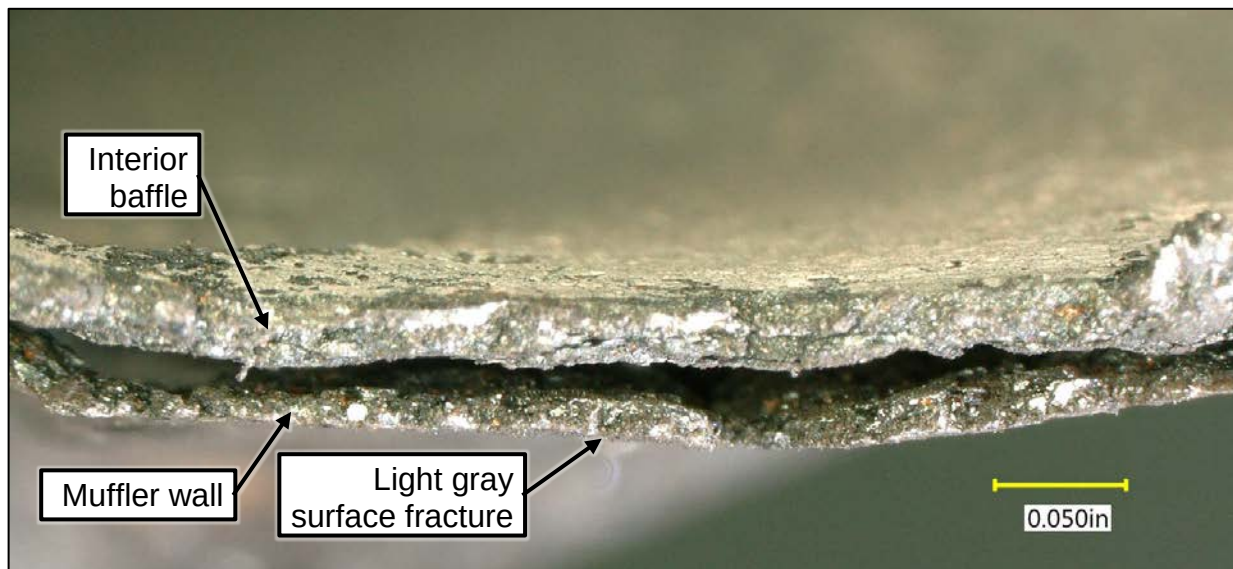


Figure 7. Fracture features associated with the transverse fracture at the left side of the aft muffler.

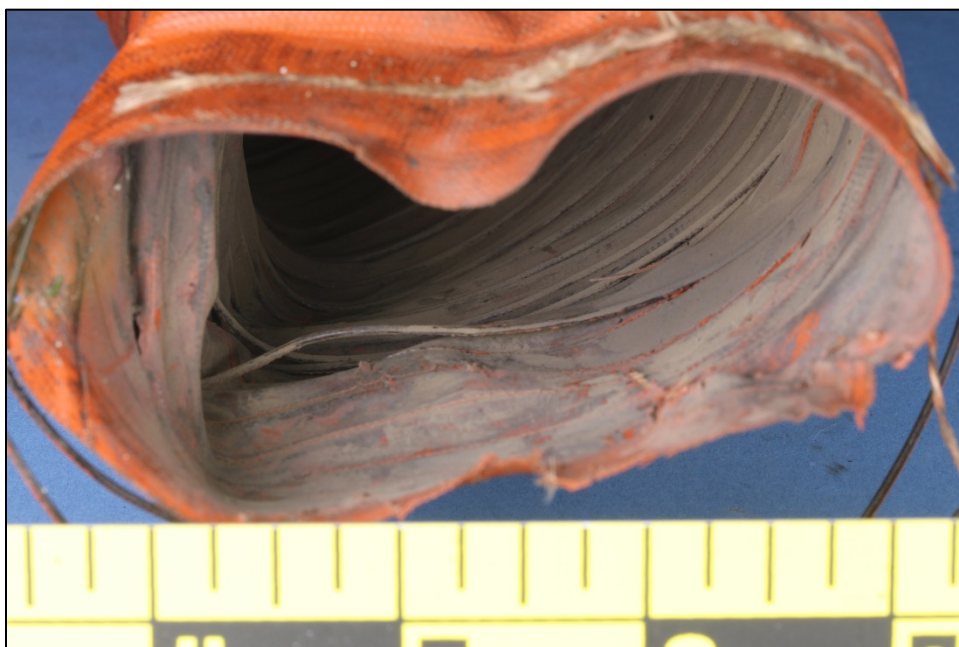


Figure 8. Tan deposits on interior of the cabin heat supply tube.

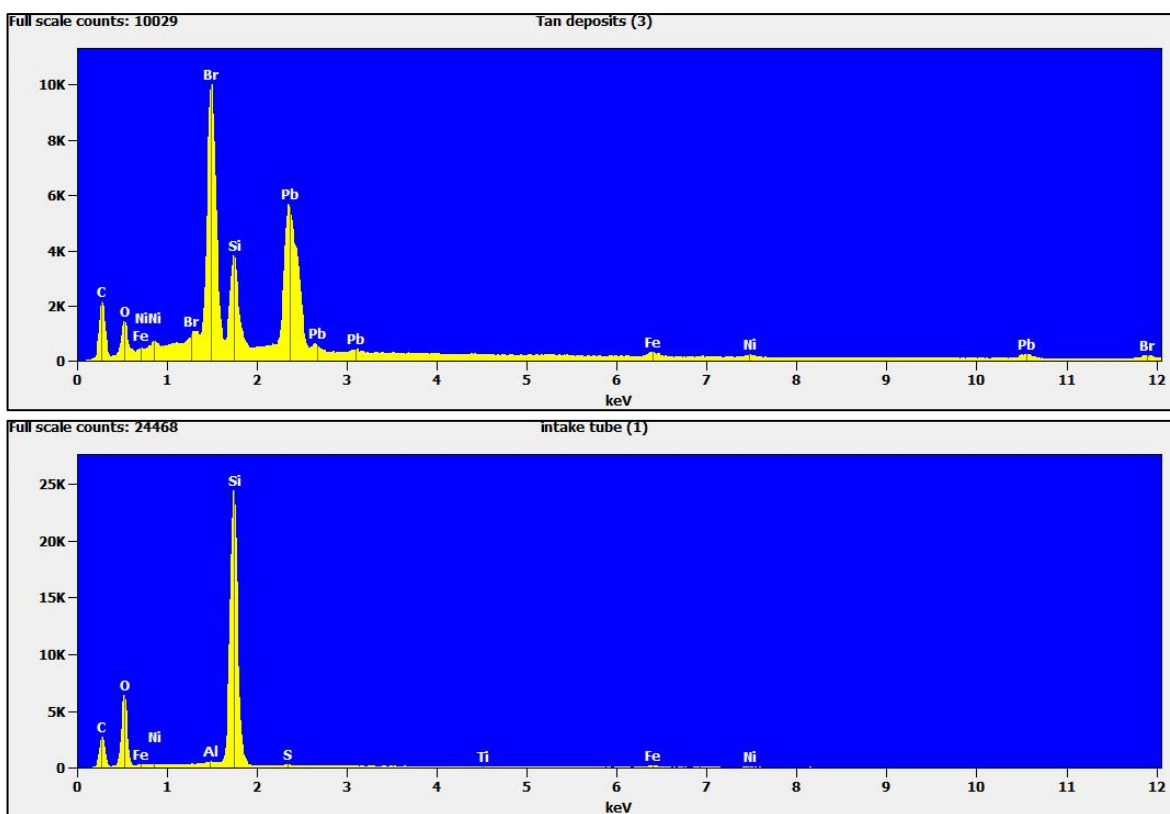


Figure 9. EDS spectra of the tan deposits from the cabin heat supply tube (upper spectrum) and of the heat exchanger intake tube interior surface (lower spectrum).