NATIONAL TRANSPORTATION SAFETY BOARD

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

September 30, 2021

MATERIALS LABORATORY FACTUAL REPORT — Report No. 21-073

A. ACCIDENT INFORMATION

Place	:	Thonotosassa, Florida
Date	:	February 9, 2021
Vehicle	:	Vans RV7, N611E
NTSB No.	:	ERA21LA127
Investigator	:	Brian Rayner, AS-ERA

B. COMPONENTS EXAMINED

Fuel fittings and hose.

C. DETAILS OF THE EXAMINATION

An overall view of the submitted hose and fitting assembly is shown in figure 1. The 90-degree outlet fitting had been attached to the fuel pump outlet, and the fuel pressure adapter fitting is shown attached to the outlet fitting. A 45-degree fitting and hose are shown attached to the fuel pressure outlet on the side of the adapter fitting. The adapter fitting and outlet fitting were found separated after the accident and were subsequently reassembled and tested before submission to the NTSB Materials Laboratory. During testing, the adapter fitting was reportedly torqued to 150 pound-inches.

The hose and fitting were removed from the side of the adapter fitting, and the outlet and adapter fittings were separated to facilitate further examination of the joint. The silver-colored 90-degree outlet fitting was made of zinc-coated steel, and the black-colored fuel pressure adapter fitting was made of an aluminum alloy. The outlet end of the outlet fitting and the male and female ends of the adapter fitting were reportedly -6AN fittings. The outlet ends on each of the two fittings are shown for comparison in figure 2, showing similar thread profiles and sealing surface angles.

The adapter fitting was reassembled on the outlet fitting and tightened to a snug condition. The joint was then CT scanned using a General Electric Nanomex 180 X-ray inspection system, and a cross-sectional x-ray image of the joint is shown in figure 3. The images showed the nut on the adapter fitting had a recess that housed a higher-density (higher relative to the aluminum alloy) curved rod (or retaining ring) that nearly circled the nut. The retaining ring rested against a shoulder on the body of the adapter which acted to retain the nut with the adapter body when the joint was disassembled and to transfer clamping force between the nut and the adapter body in the assembled condition shown.

Next, the outlet fitting was placed in a clamp, and the torque required to rotate the nut from finger-tight through approximately 60 degrees of nut rotation (1 nut flat) was measured. The body of the adapter tended to rotate with the nut, so the body was held in place with another wrench during the test. The measured peak torque after 60 degrees of nut rotation was 445 pound inches.

After testing, the nut was sectioned longitudinally on opposite sides using a water-cooled abrasive saw. The first cut extended through the nut cross-section into the body of the adapter, and the second cut extended through most of the nut cross-section. Following the cuts, the nut was pried open to fracture the remaining ligament on the partially cut side. The resulting sectioned and disassembled components of the adapter fitting are shown in figure 4. The retaining rod that had been housed in the nut recess was apparently made of steel and had been cut during the first saw cut as shown in figure 4.

Following separation, the nut threads were examined and appeared to be free of deformation or damage. The contact face in the recess in the nut for the retaining rod had a rubbed appearance, and the black surface finish was disturbed. The contact face on the adapter body shoulder showed heavy rub damage around the circumference as shown in figure 5, and the edge of the shoulder was deformed radially outward to form a lip. Corresponding rub damage and material transfer was observed on the retaining rod, particularly near the end closer to the cut location.

Next, a wrench flat on the body of the adapter fitting was successively ground using 240-grit to 4000 grit silicon-carbide paper in preparation for elemental composition, electrical conductivity, and hardness testing. The opposite flat was also ground to ensure a flat surface for hardness testing. An Olympus Vanta x-ray fluorescence (XRF) alloy analyzer was used to analyze the elemental composition. After multiple tests in the same areas, the analyzer twice found a weak match with aluminum alloy 6061. However in the several remaining tests, the analyzer did not find an alloy match. Results from all tests showed high levels of silicon and low levels of magnesium relative to the expected compositional ranges for the respective elements in aluminum alloy 6061.

Conductivity was measured on the adapter body using a Fischer Sigmascope SMP350 conductivity meter fitted with a FS24 probe. The electrical conductivity measured 43% IACS, which is consistent with the expected value for aluminum alloy 6061 in the T6 and T651 temper conditions.[1]

[1] ASM Handbook Vol. 2, *Properties and Selection: Non-Ferrous Alloys and Special-Purpose Materials*, ASM International, Materials Park, Ohio (1990) 103.

Hardness was measured on the adapter body using a Rockwell indenter. Results of the hardness tests showed an average hardness of 62.0 HRBW, which is consistent with the expected hardness of aluminum alloy 6061 in the T6 and T651 temper conditions.[1] Aluminum alloy 6061-T6 has a lower hardness, tensile yield strength, and tensile ultimate strength than aluminum alloys 2014-T6, 2024-T6, or 7075-T73 used in AN standard fittings manufactured with materials specified in Military Specification MIL-F-5509D.[2]

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

[2] Military Specification MIL-F-5509D, *Fittings, Flared Tube, Fluid Connection*, US Dept. of Defense (1978).

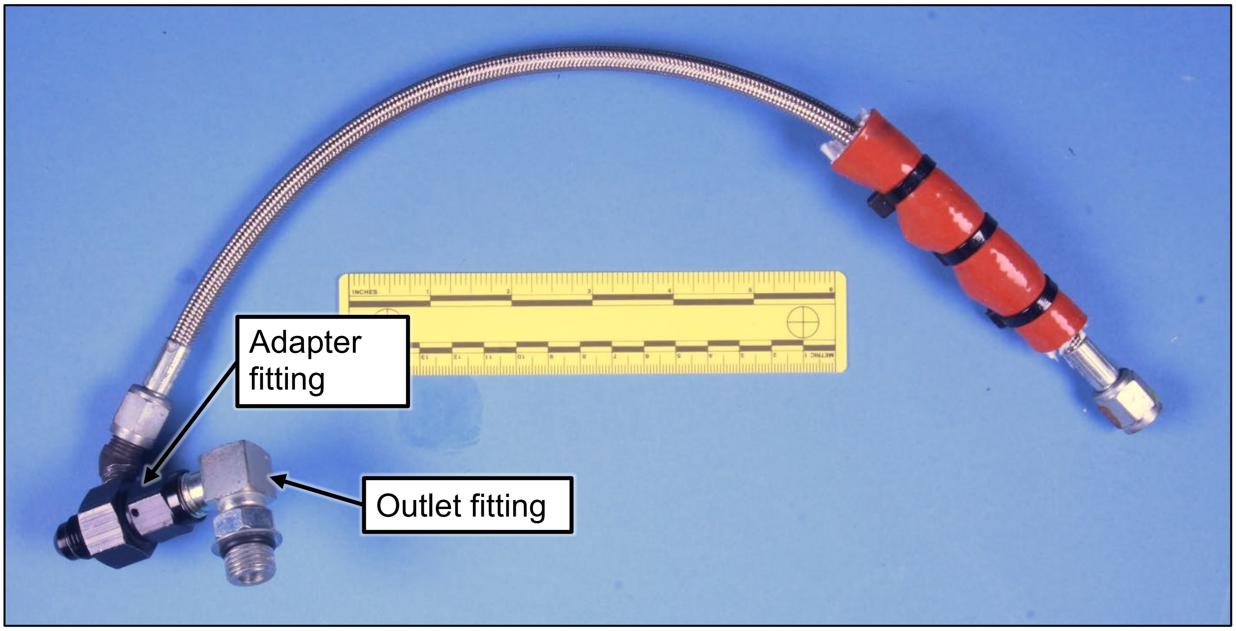

Figure 1. Overall view of the submitted fuel line fittings and hose.

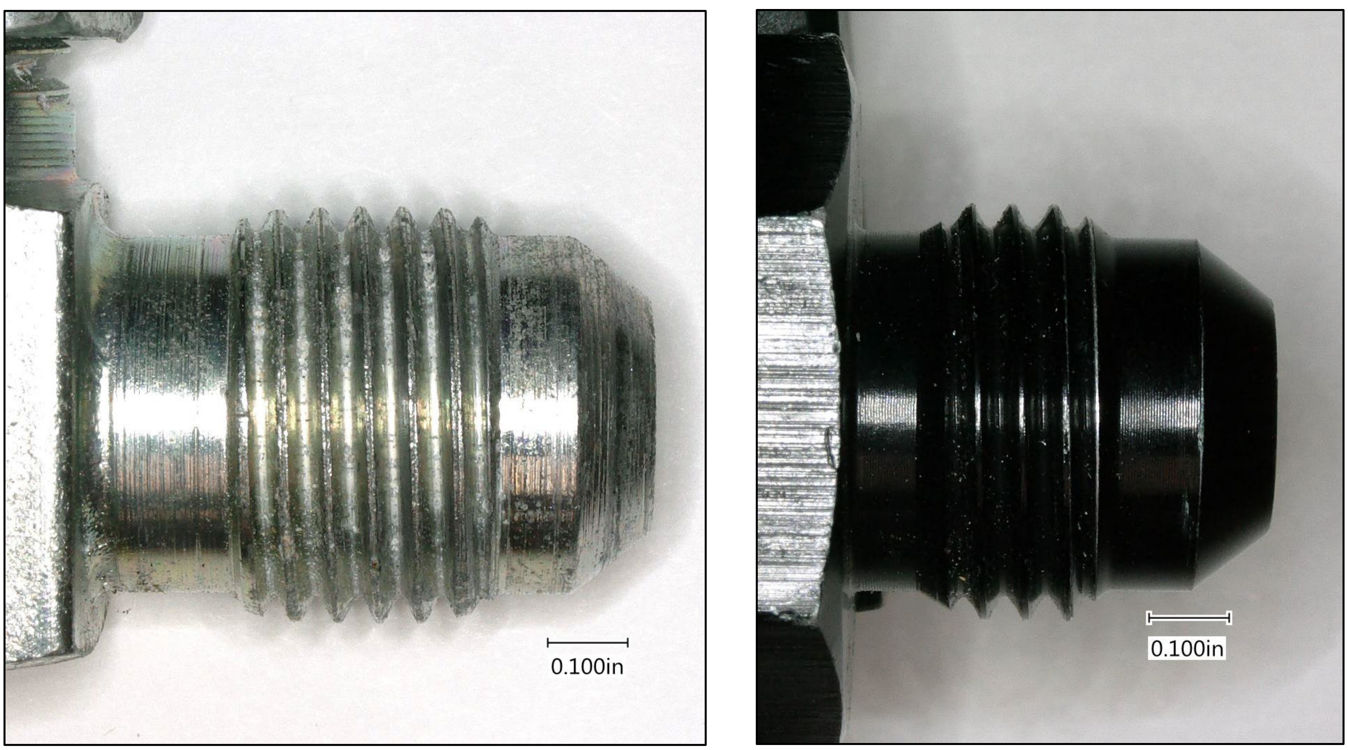

Figure 2. Threaded male end of the 90-degree outlet fitting (left) and the fuel pressure adapter fitting (right).

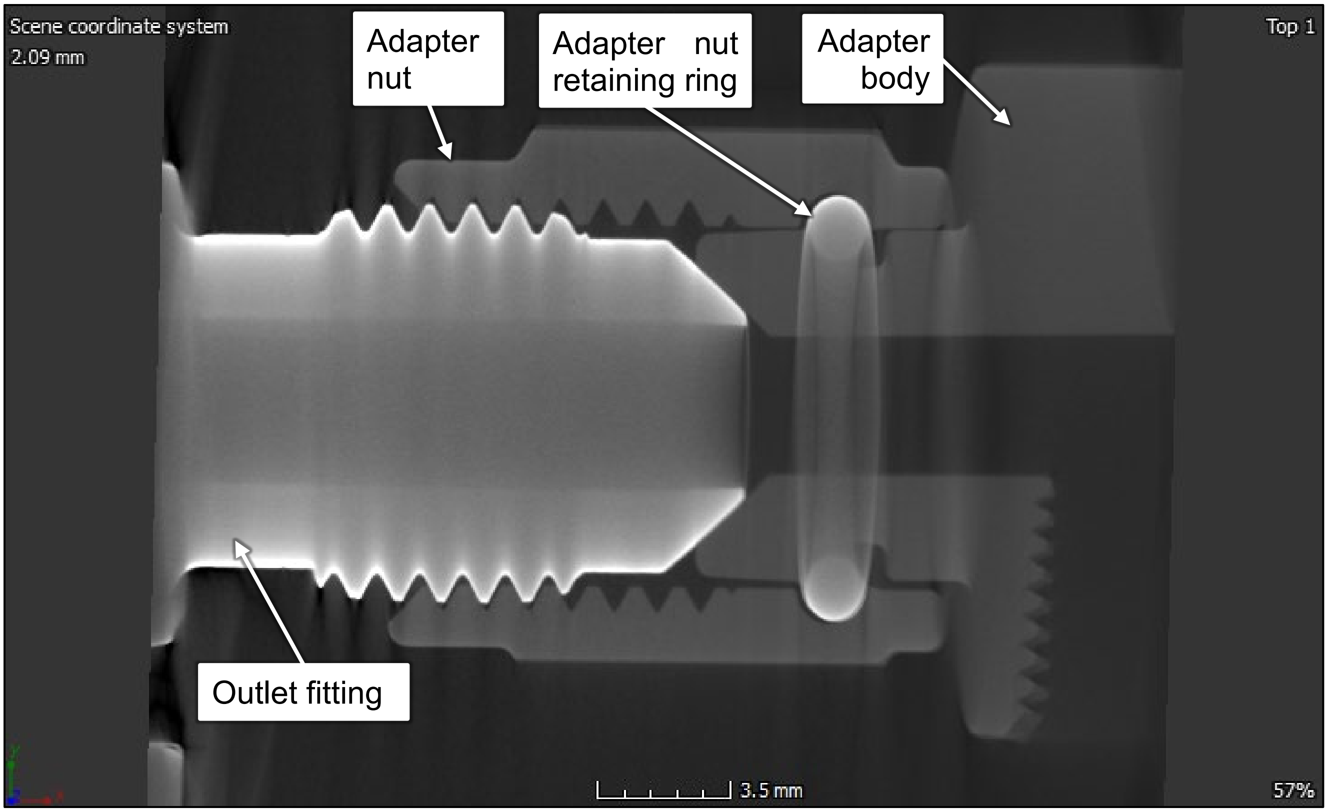

Figure 3. Cross-sectional image of the connection between the outlet fitting and the fuel pressure adapter fitting from an x-ray CT scan of the assembled fittings.

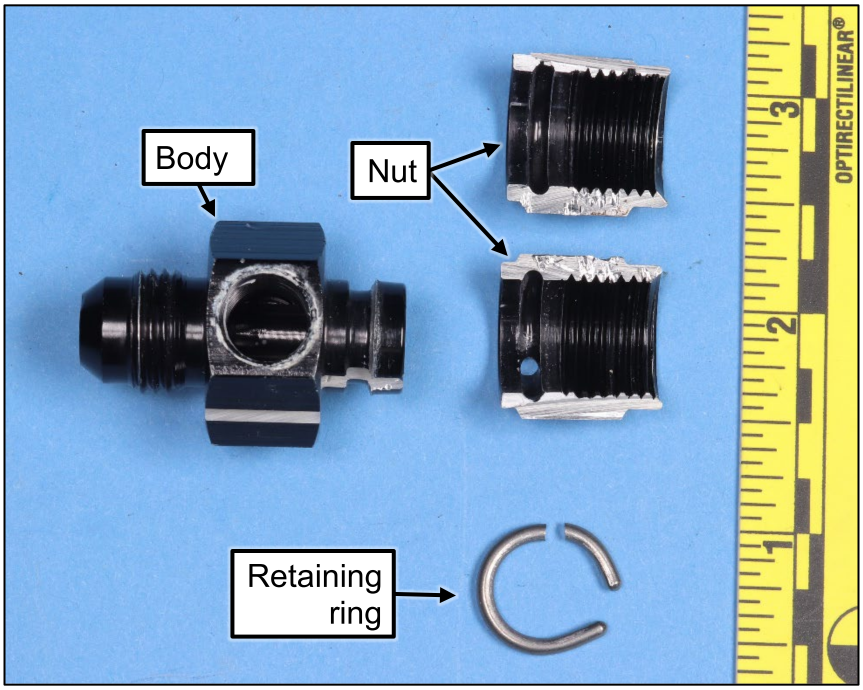

Figure 4. Overall view of the fuel pressure adapter fitting after removing the 45 degree fitting attached to the side of the adapter fitting, torque testing, and sectioning to remove the nut from the adapter body.

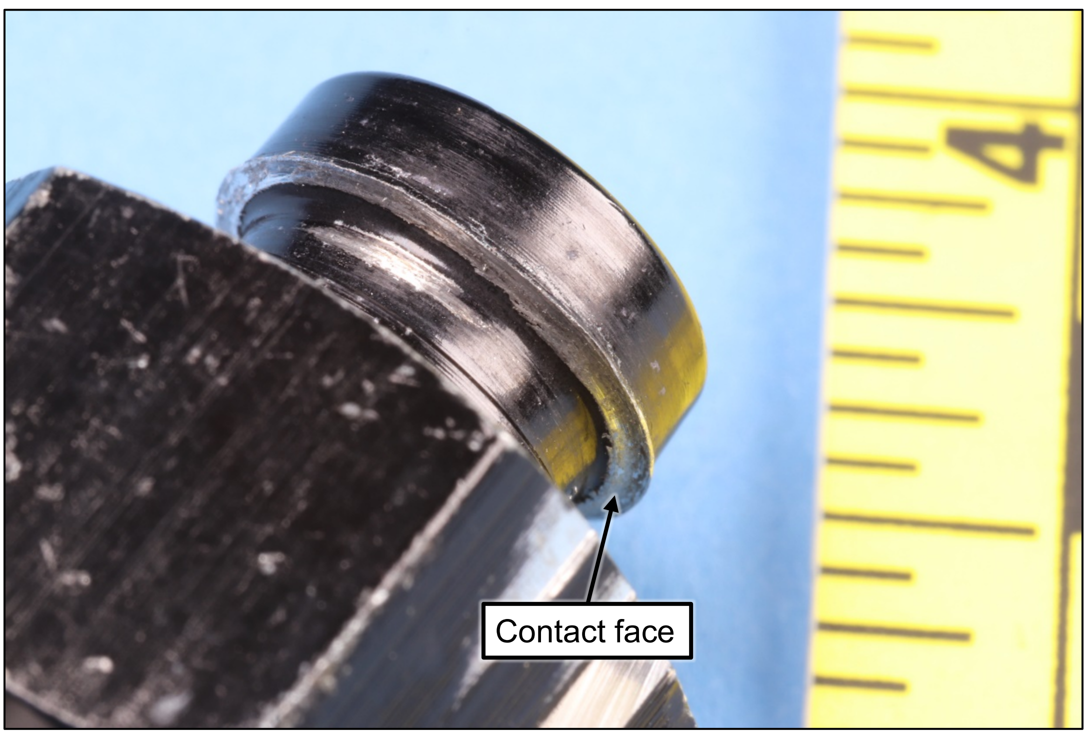

Figure 5. Retaining ring contact face on the shoulder of the adapter body after the nut was sectioned and removed.