

National Transportation Safety Board

Office of Research and Engineering

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MATERIALS LABORATORY

Factual Report 24-088

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A. ACCIDENT INFORMATION

Location: Colquitt, Georgia
Date: June 5, 2024
Time: 06:30 eastern daylight time
10:30 coordinated universal time
Vehicle: Piper PA-25-235, N8715L
Investigator: Ralph Hicks, AS-ERA

B. COMPONENTS EXAMINED

Fuel shutoff valve remnants

C. EXAMINATION PARTICIPANTS

Specialist Erik Mueller, Ph.D., PE, FASM
Office of Research and Engineering – Materials Laboratory Division
NTSB, Washington, DC

D. SUMMARY

The fuel shutoff valve failed from the two fractured rivets that joined the stem flange to adjacent internal components of the valve. With the rivets fractured, the valve stem actuator arm could and did move independently of the gate, as evidenced by circumferentially-oriented smearing damage on the rivet fracture surfaces. The deeper rivet fractured from intergranular corrosive attack, which weakened the part. The other rivet fractured from overstress in bending and shear.

E. DETAILS OF THE EXAMINATION

On June 5, 2024, a Piper PA-25-235 airplane was substantially damaged during an accident near Colquitt, GA. The commercial pilot sustained minor injuries. The pilot reported that the engine speed had dropped during climb, eventually losing all power. The pilot attempted a forced landing, where the airplane impacted trees coming to rest in shallow water. The airplane was retained for further examination, and remnants from the fuel shut-off valve were sent to the NTSB Materials Laboratory for additional examination.

Figure 1 shows the components from the shut-off valve as received. The valve body housing had already been disassembled, with the six screws and washers packaged separately. Of note, the valve stem flange had separated from the gate.

The actuator arm was attached to the stem and rotated between the stops within the valve body housing cover. Figure 2 shows the two maximum positions of the arm, showing (in these figures) the 270° and 0° positions. The stop pin was in place and

prevented over-rotation in either direction. A marking placard had been attached to the opposite exterior of the valve body. This stated the fuel valve was FAA PMA assembly, manufactured by Airborne Mechanisms, E. Cleveland, OH, with P/N 1H14 and S/N 8H.

Figures 3 and 4 show the opposite faces of the valve stem assembly and the body's interior, showing the gate. The two key features were corrosion on the interior body of the valve, as indicated by the left side of the stem flange in Figure 4, and the two fractured rivets, which had joined the stem flange to the gate. Figure 5 shows two views of the stem-side interior surface, which exhibited white, gray, and rust-colored deposits.

A closer view of the fractured rivets on the stem flange, illustrated in Figure 6, showed that one exhibited more of these deposits than the other. The left rivet is the one that sat deeper into the valve body than the other. For this report, the left rivet in Figure 6 is identified as the lower rivet, and the one on the right is the upper rivet.

The portion of the stem flange at the upper side of the image in Figure 6 exhibited a reflective horizontal band parallel to the flange direction (shown above the rivets in Figure 6). This band exhibited multiple parallel streaks, oriented vertically and towards the left in the figure. This band was consistent with grinding against an adjacent surface.

Figure 7 shows a closer view of the upper rivet on the stem flange as received. This rivet had been bent outward and upward toward the stem, depicted towards the right in the figure. While the fracture surface generally exhibited a rough, fibrous surface with a dull luster, three distinct regions, annotated in Figure 7, showed a reflective, streaky texture. These areas exhibited features with post-fracture smearing damage.

The valve stem flange was cleaned sequentially in an ultrasonic bath with acetone followed by Evapo-Rust.¹ In Figures 7 and 8, which show the upper rivet pre- and post-cleaning, little material was removed, indicating a lack of corrosion compounds and deposits on this rivet fracture surface. A side view, in Figure 9, shows localized necking near the fracture surface, as well as outward-oriented edge deformation, consistent with shear.

The upper rivet fragment is illustrated in Figure 10 from the side after it was removed from the stem flange. The body of the remnant was intact and cylindrical, with some white-colored deposits on the sides. The area near the fracture surface, on the left in the figures, exhibited necking and outward smearing deformation. The rivet was examined using a field emission scanning electron microscope (SEM). The fracture surface, shown in Figure 11, displayed dimpled rupture, as typified in Figure 12. The

¹ Evapo-Rust - a commercially-available chelating rust stripper currently manufactured CRC Industries, headquartered in Horsham Township, PA.

areas with smearing, shown in Figure 13, were present over the dimpled rupture features. These features were consistent with overstress fracture, followed by post-fracture smearing of the surface.

Energy dispersive x-ray spectroscopy (EDS) of the rivet found the chemical composition consistent with a 5000-series aluminum alloy.² The valve stem flange was consistent with carbon steel coated with cadmium, as examined using EDS.

Figures 14 and 15 show the fractured lower rivet, both as received and after cleaning. This fractured subcomponent exhibited enough corrosion product to obscure the underlying fracture surface. Even after successive cleaning attempts, globules of surface corrosion were still present. Figure 15 shows several areas of reflective regions, consistent with post-fracture smearing. Fewer areas exhibited smearing features on this rivet fracture surface than on the upper rivet.

This rivet fracture surface was examined using an SEM, as demonstrated in Figure 16. While part of the surface protruded from the rivet hole, a small crescent region was present below and within the hole. A backscattered view, shown in Figure 17, revealed areas of disparate material compositions.³

These regions were probed using EDS. The medium gray areas, consistent with smeared areas, were exhibited spectra of an aluminum alloy consistent with that of the rivet material. The darker gray regions were consistent with aluminum oxide, containing minor amounts of sodium, phosphorus, magnesium, sulfur, and cadmium. The light areas were consistent with iron oxide and aluminum oxide, with the same minor amounts as the other surface oxides.

A closer view of the un-smeared regions of the fracture surface showed mixed dimple rupture and intergranular attack, as illustrated in Figure 18. This attack was exemplified by the darker lack of material between grains and the general blocky morphology of the surface. Examining the parts of the fracture surface near the smearing damage revealed wear streaks over the intergranular and dimpled rupture features, consistent with post-fracture contact (Figure 19).

Figure 20 shows a side view of the lower rivet in the stem flange after cleaning. The surfaces of the rivet were jagged and erratic. After sectioning the stem flange to remove the rivets, the lower rivet exhibited areas of corrosion deposits. In addition, the sides of the rivet exhibited areas of missing material (Figure 21). The amount of

² Energy dispersive x-ray spectroscopy (EDS) - a characterization method coupled with SEM where the energy of x-rays characteristic to individual atoms are measured and used to identify elements.

³ Backscattered electrons - SEM micrographs produced using backscattered electrons display contrast that is associated with the atomic numbers of the elements in the micrograph. Materials containing elements with higher atomic numbers visually appear lighter relative to other materials containing elements with lower atomic numbers.

corrosion and missing material corresponded with the corrosion and material deposits on the bore of the mating rivet hole, shown in Figure 23. These features were consistent with corrosive attack and overstress fracture of the lower rivet.

Submitted by:

Erik M. Mueller
Materials Research Engineer

F. FIGURES

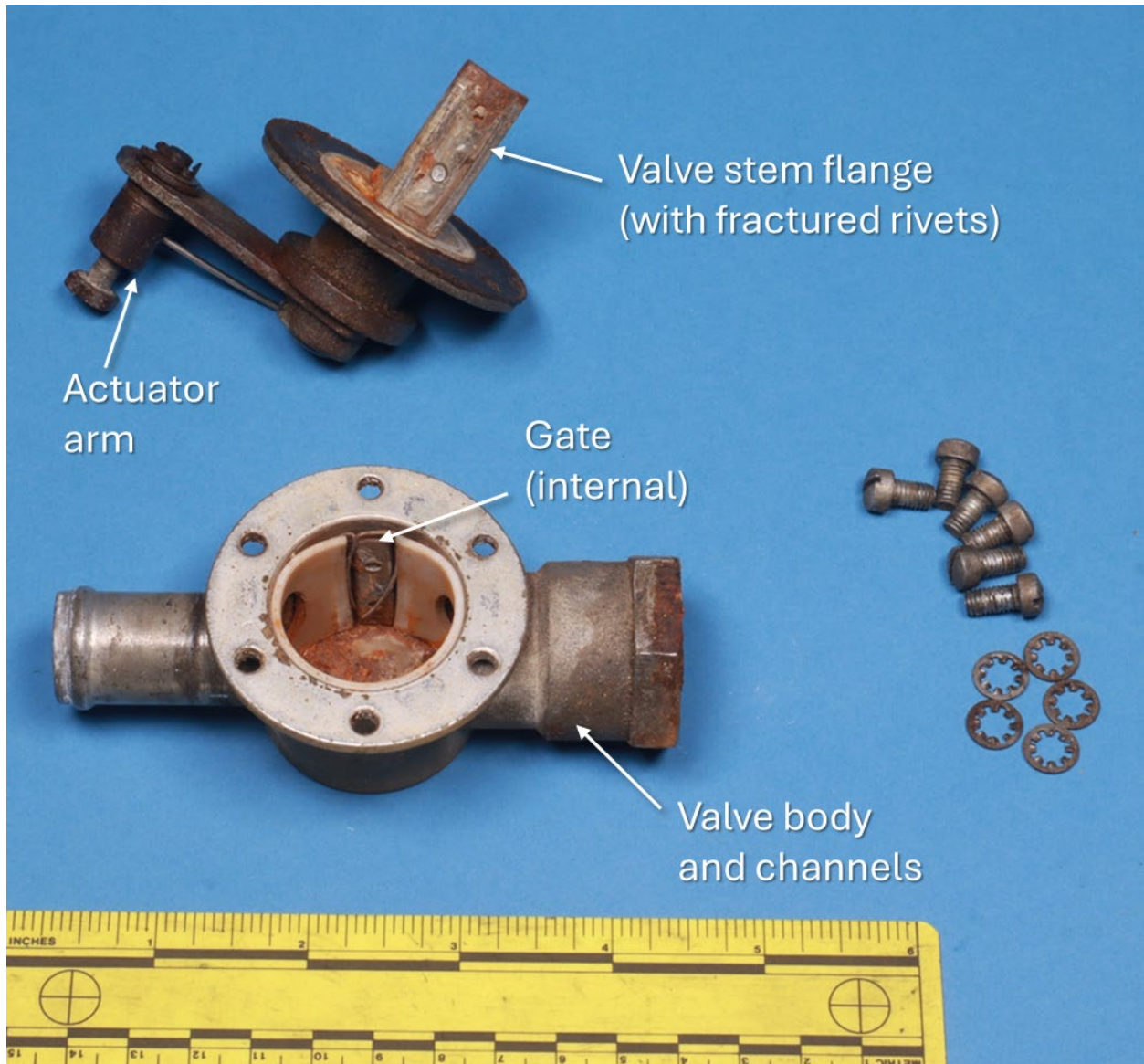


Figure 1. View of the components from the fuel shutoff valve.

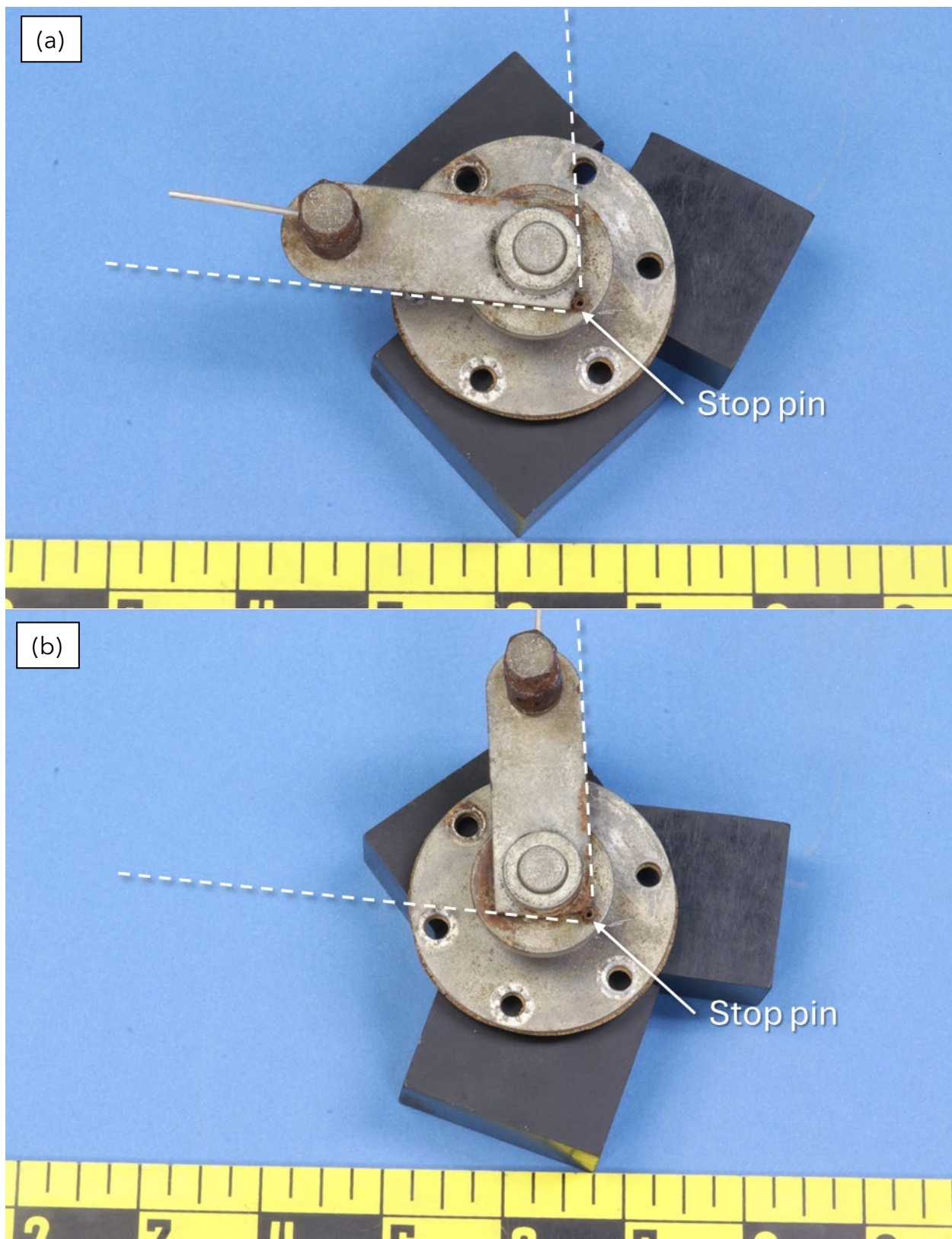


Figure 2. View of the lever and arm outside the fuel shutoff valve, showing the maximum travel in each direction (denoted by dashed white lines).



Figure 3. View of the valve body and stem positioned showing the rivet fracture surfaces.

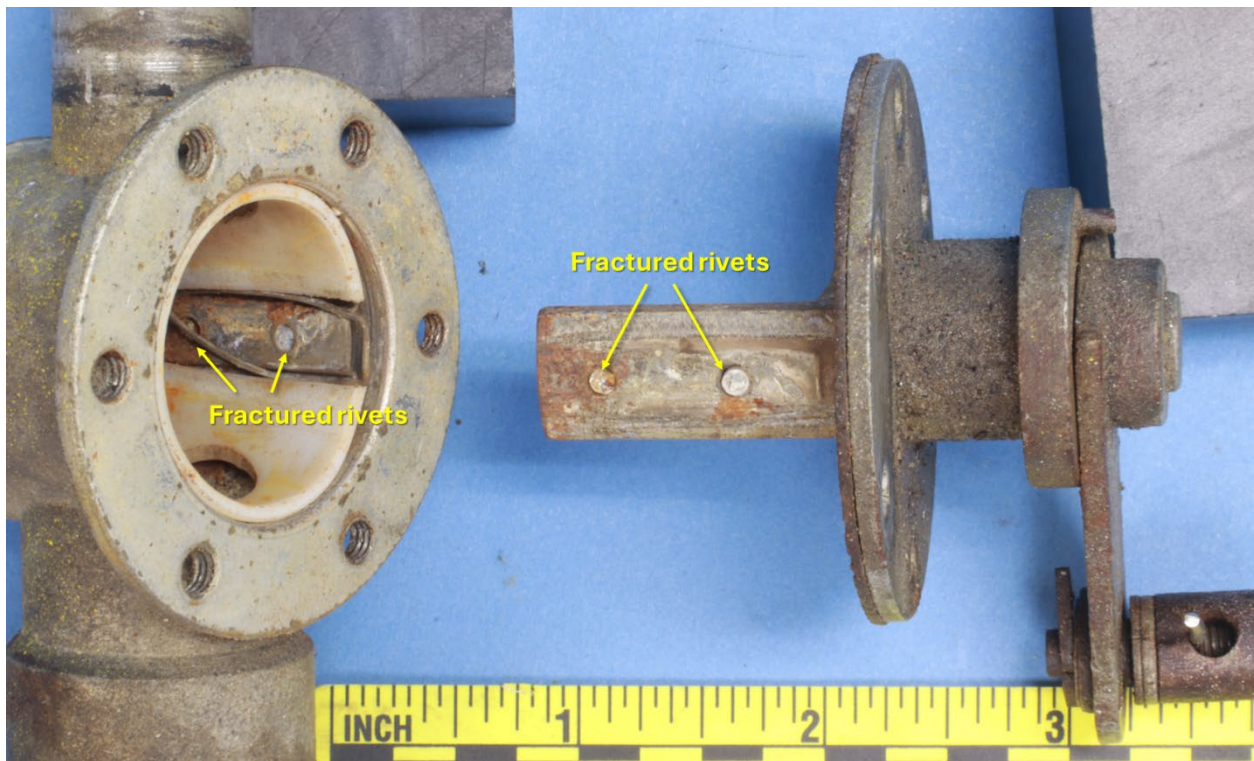


Figure 4. Closer view of the stem flange and interior of the valve body, with the fractured rivets annotated.

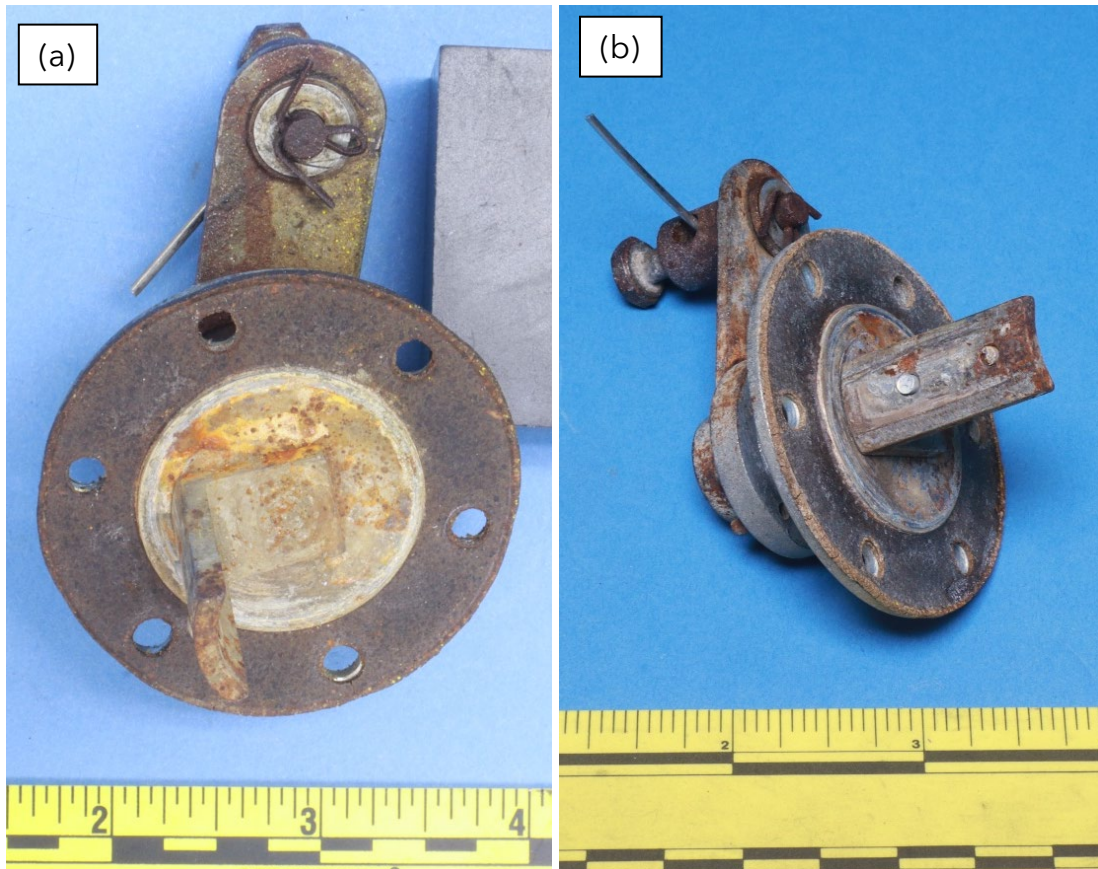


Figure 5. Views of the valve stem flange inside the valve body showing (a) the stem joint and (b) the fractured rivet side of the flange.



Figure 6. Closer view of the fractured rivets from the valve stem flange, showing a horizontal streak of sliding wear.

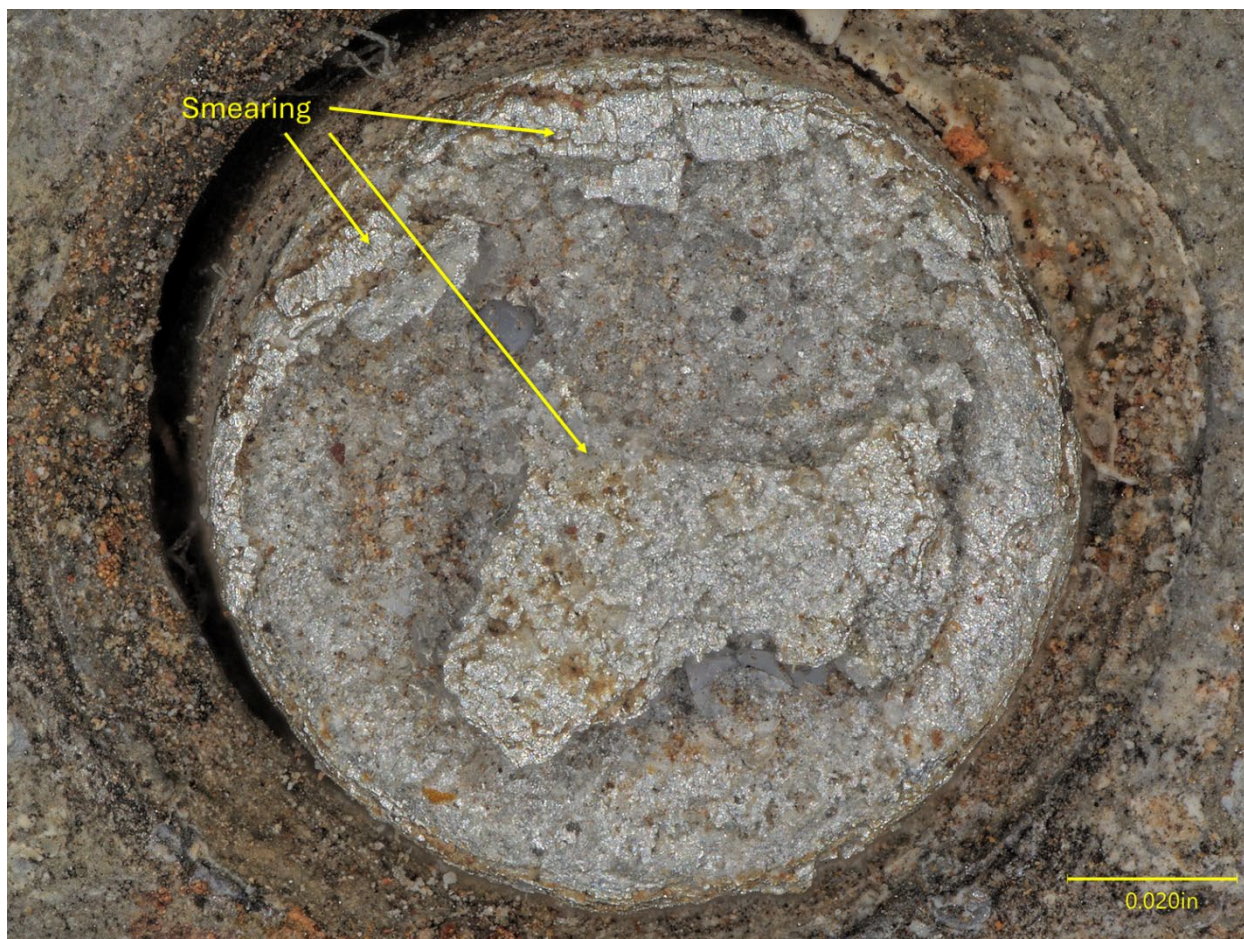


Figure 7. View of the upper fractured rivet, as received, with areas of smearing damage.



Figure 8. View of the upper rivet, after cleaning.

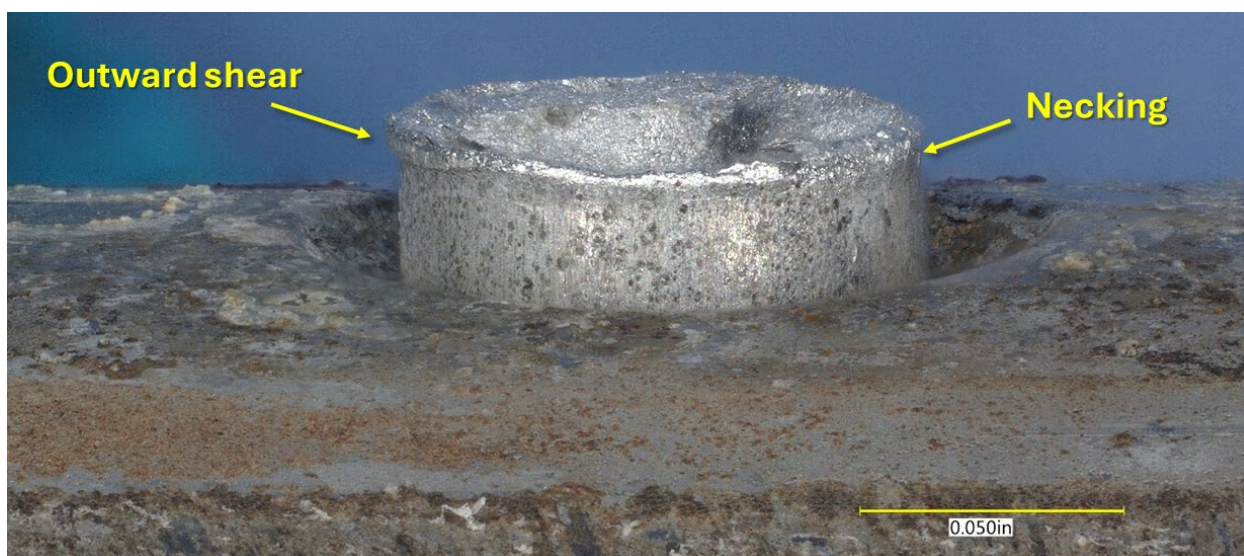


Figure 9. Side view of the upper rivet, after cleaning, with areas of plastic deformation annotated.



Figure 10. Opposite 180° views of the upper rivet fragment, after removal from the valve stem flange.

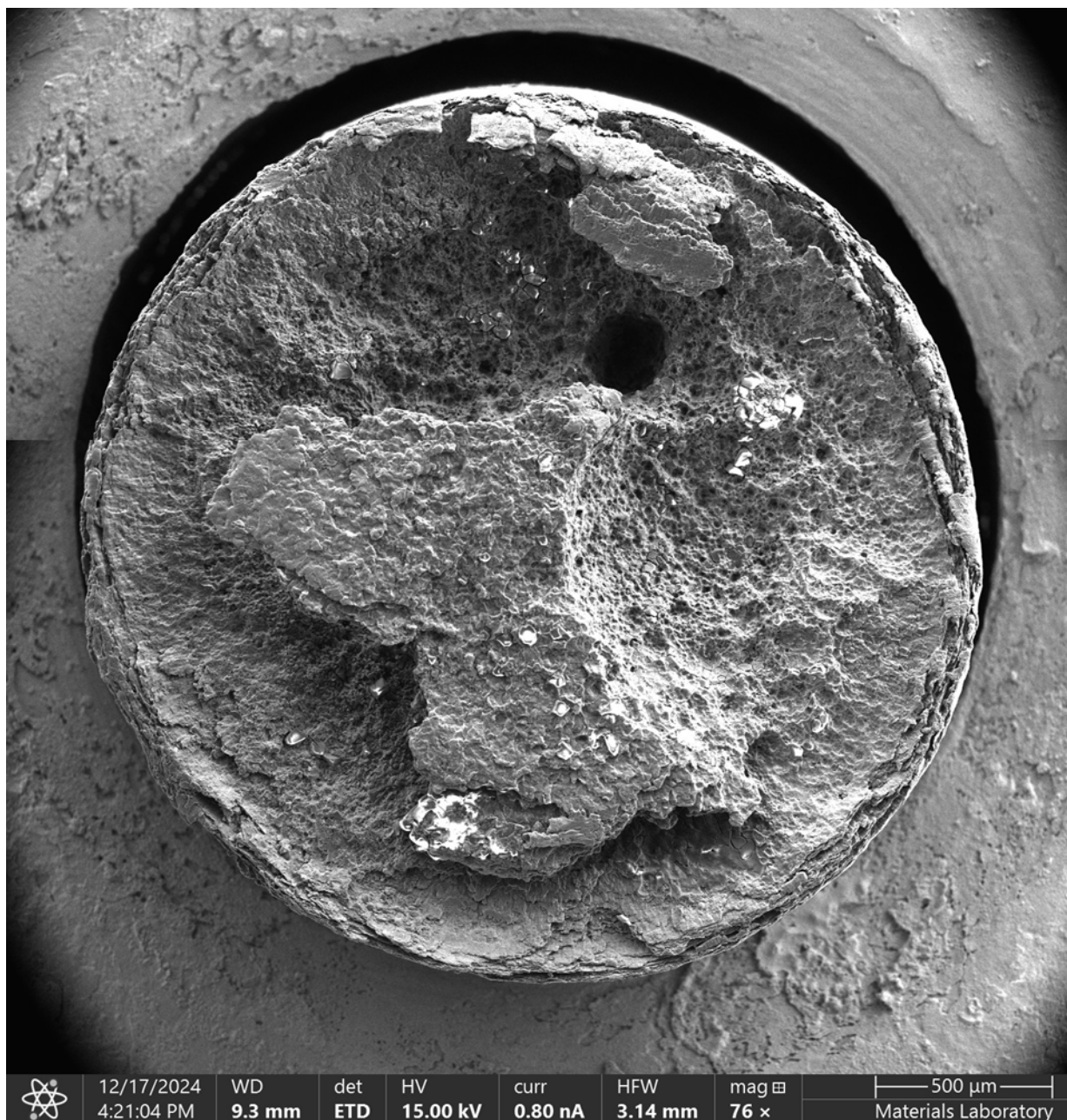


Figure 11. Secondary electron (SE) montage image of the upper rivet fracture surface.

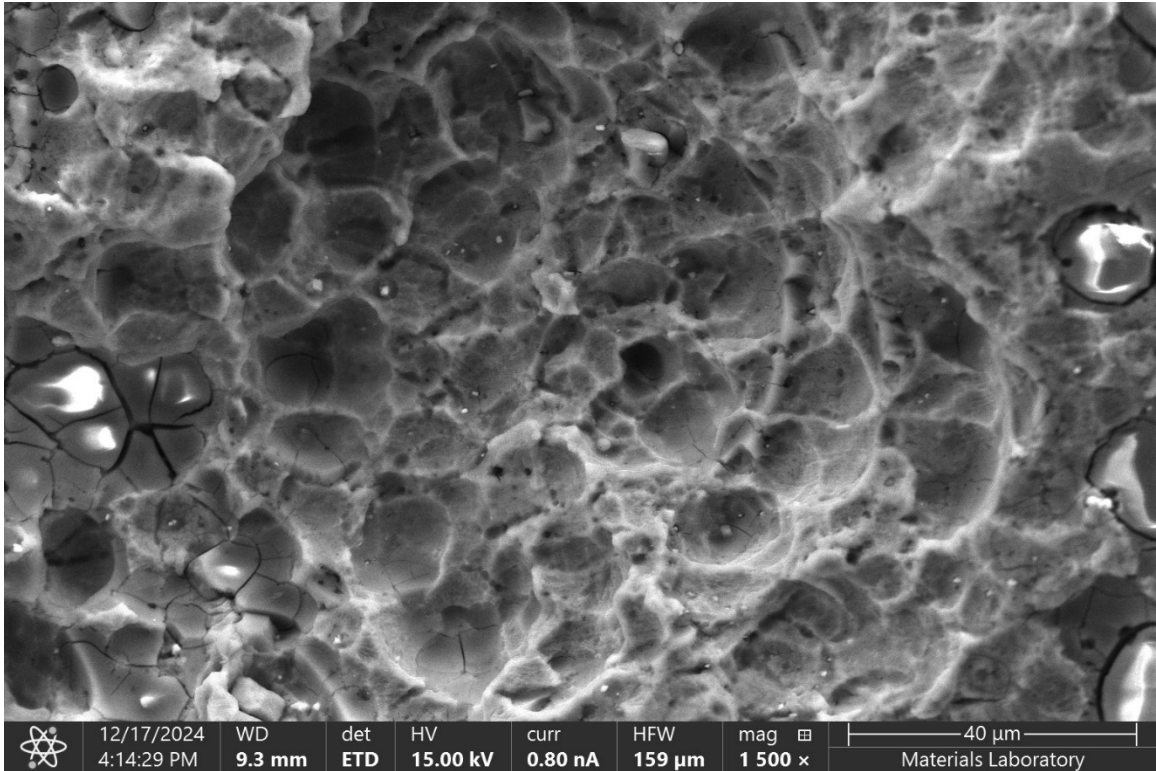


Figure 12. SE micrograph of dimpled rupture on the upper rivet fracture surface.

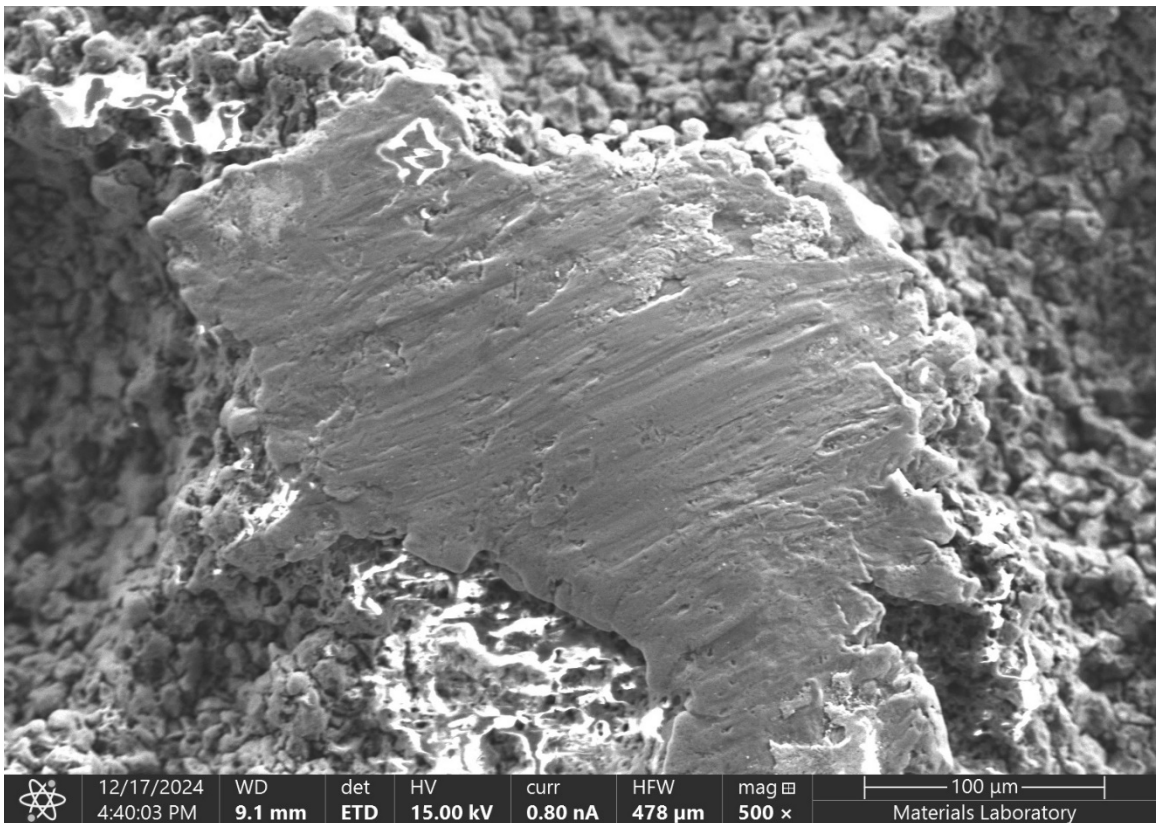


Figure 13. SE micrograph of smearing on the upper rivet fracture surface.



Figure 14. The lower rivet fracture surface, as received.

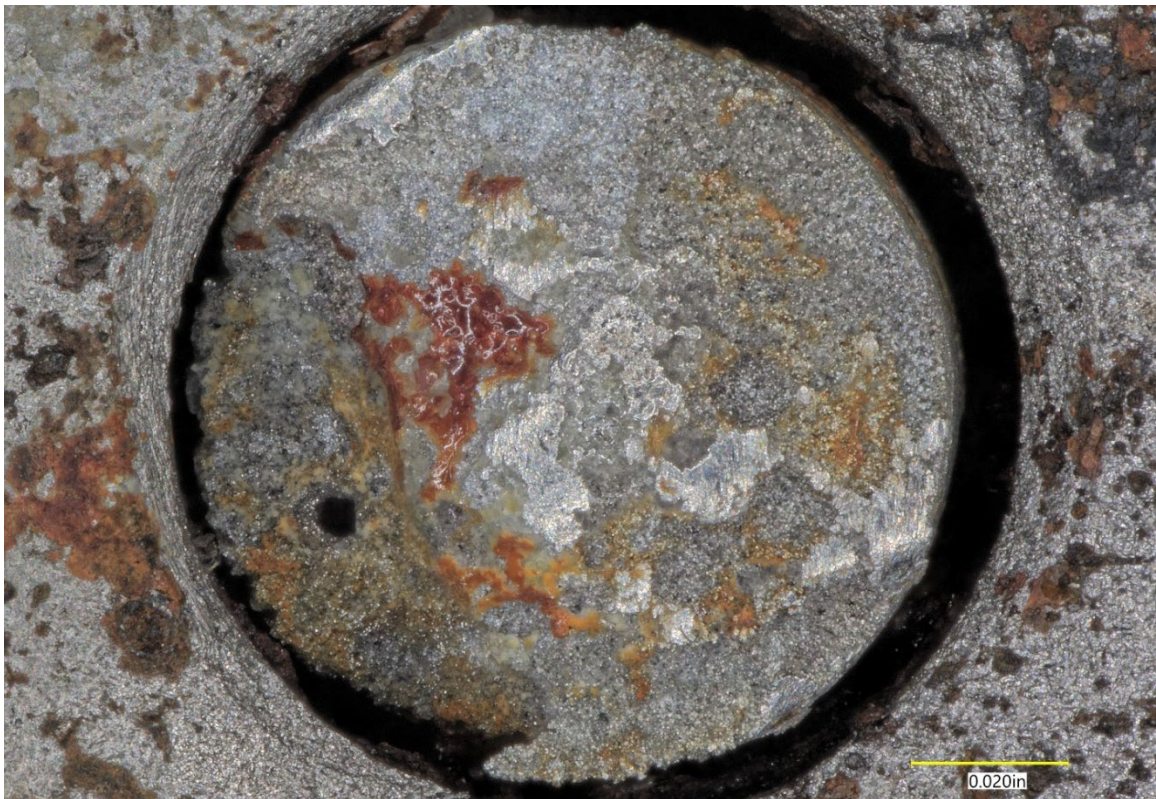


Figure 15. The lower rivet fracture surface, after multiple cleaning iterations.



Figure 16. SE montage image of the lower rivet fracture surface.

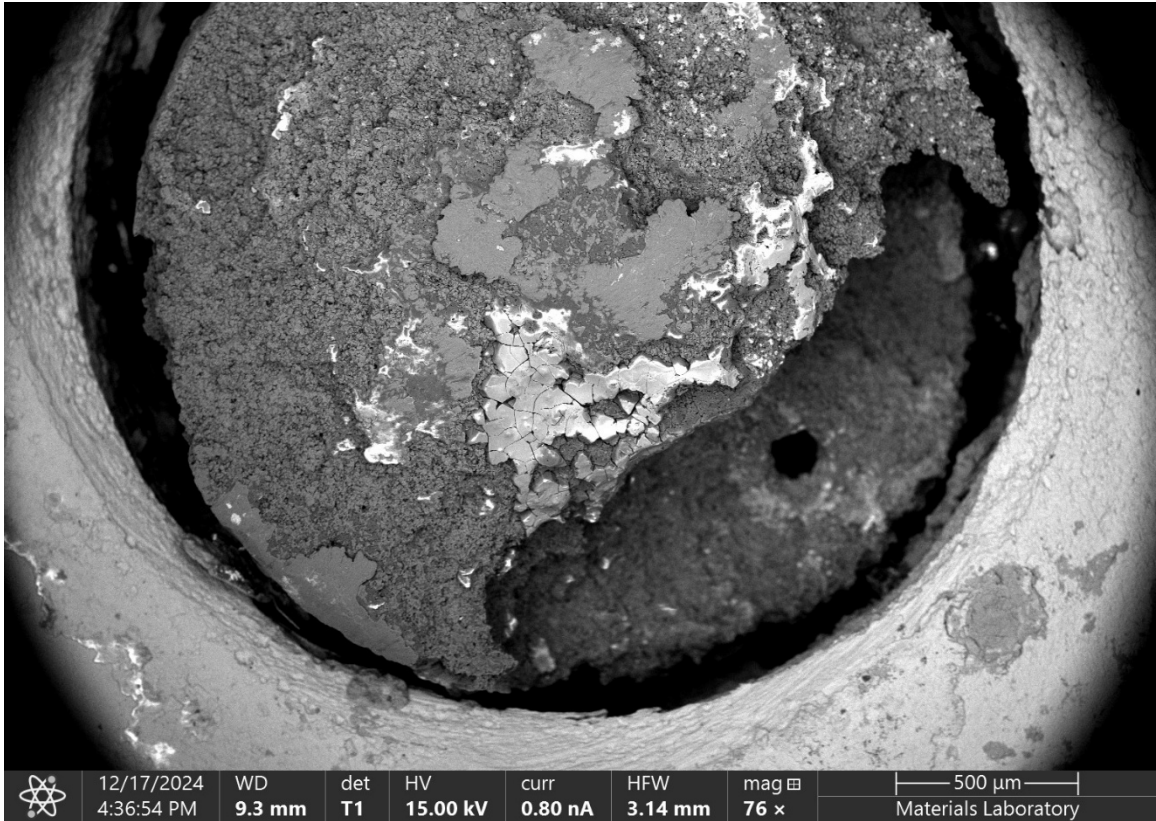


Figure 17. Backscattered electron (BE) micrograph of a part of the lower rivet fracture surface.

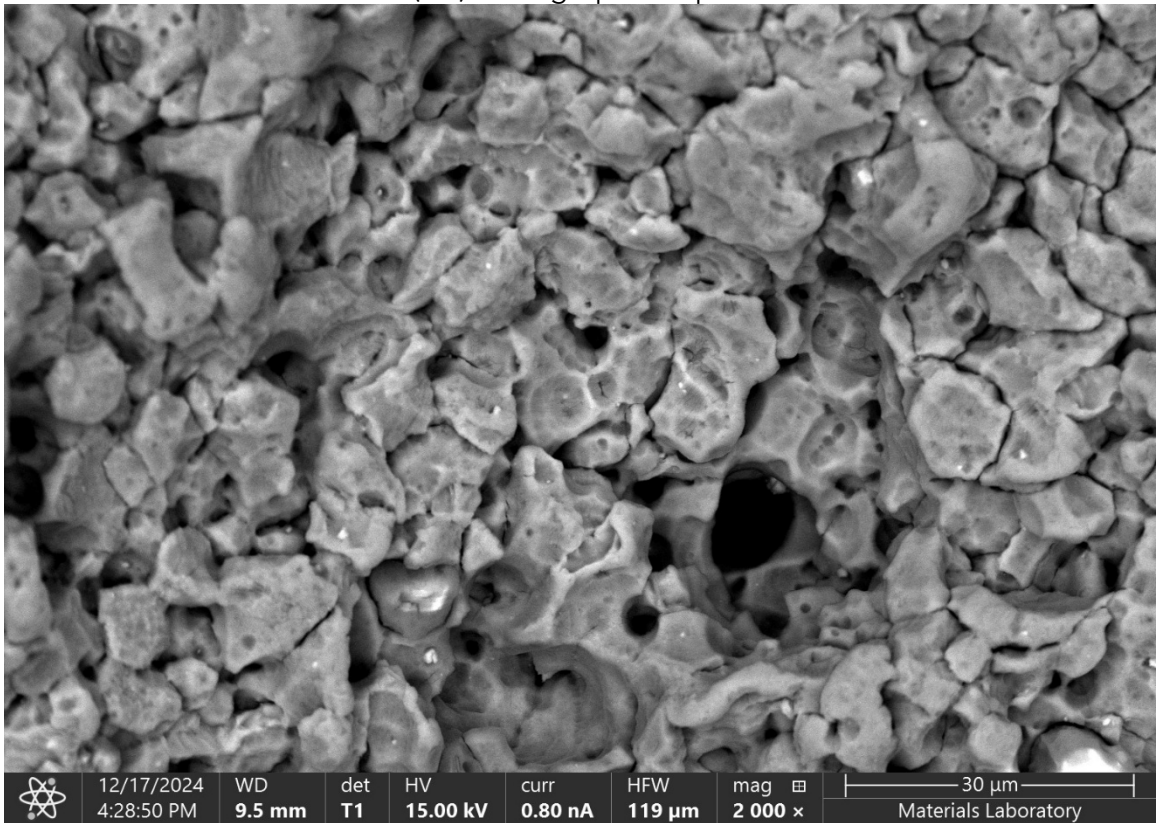


Figure 18. BE micrograph of intergranular fracture features on the lower rivet fracture surface.

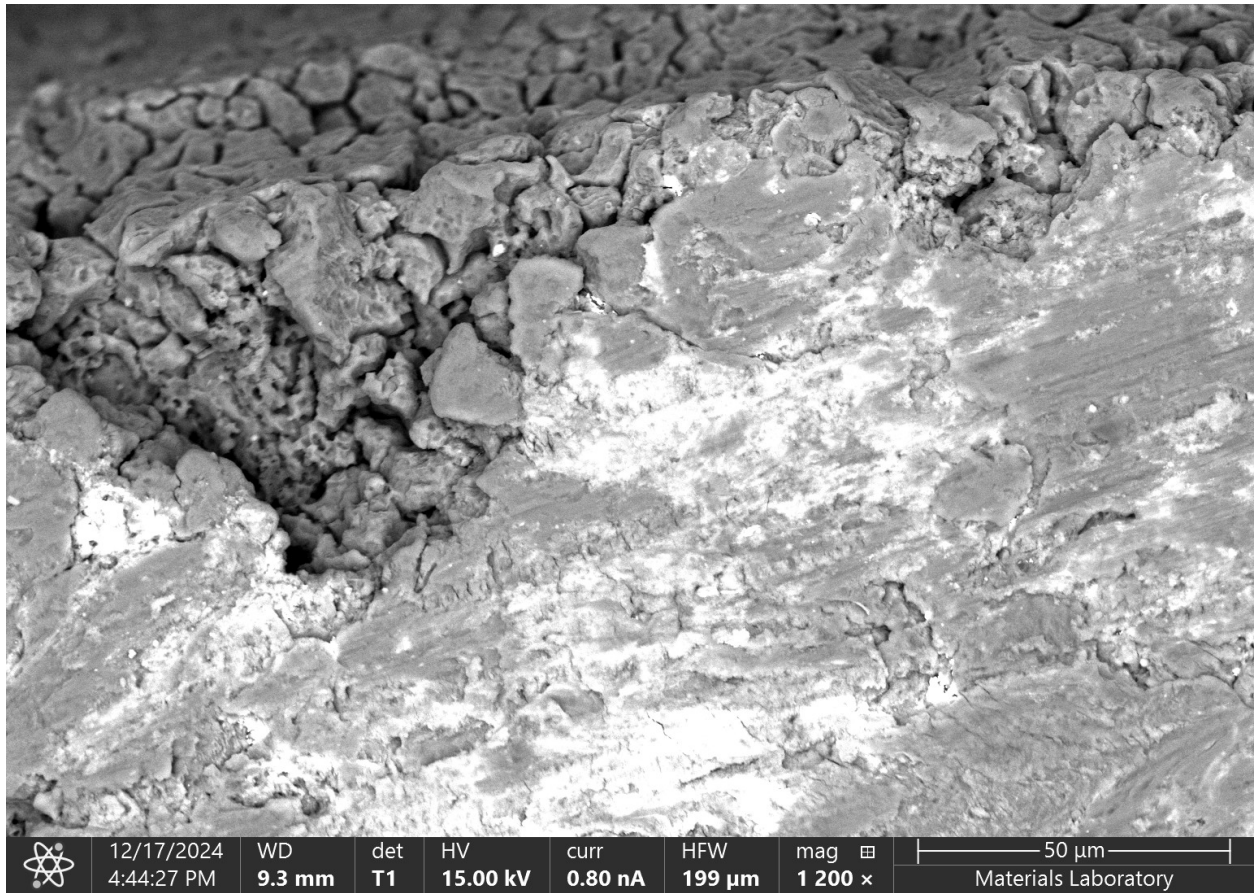


Figure 19. BE micrograph of smearing damage and wear streaks on the intergranular fracture features of the lower rivet.

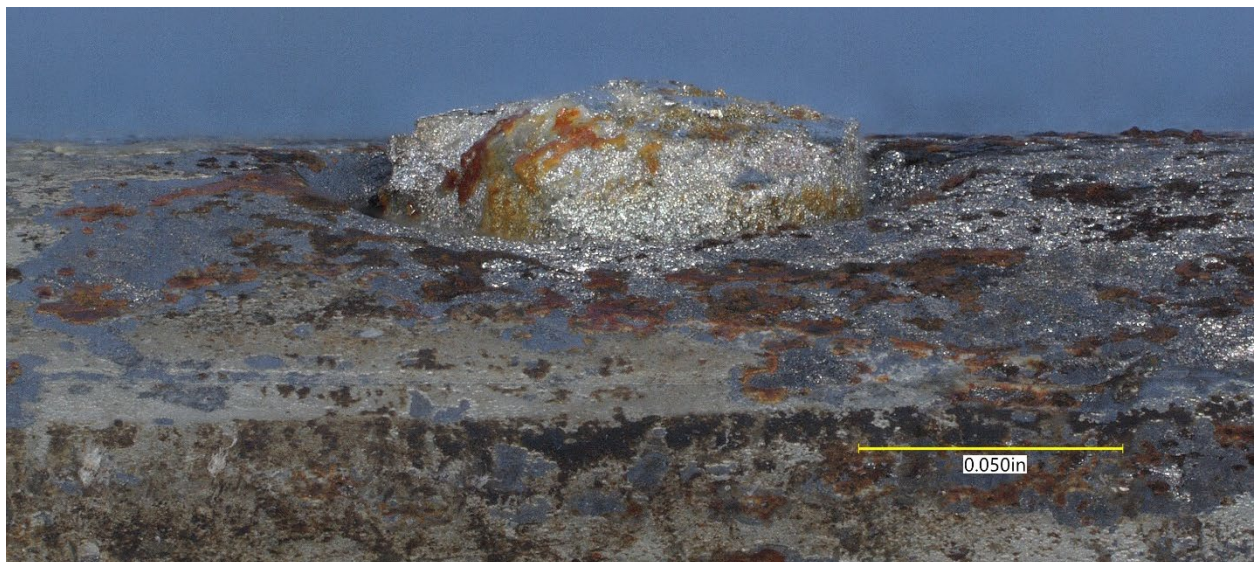


Figure 20. Side view of the lower rivet fracture in the valve stem flange, after repeated cleaning iterations.

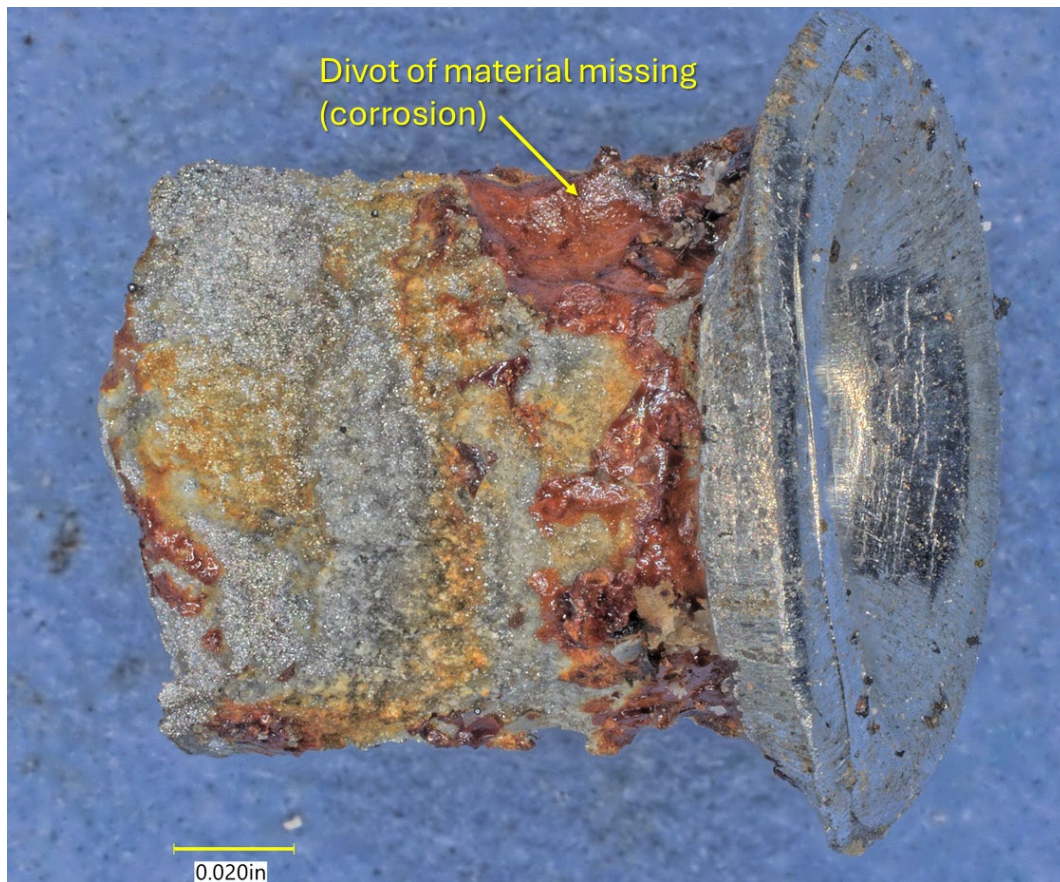


Figure 21. Side view of the lower rivet, after cleaning and removal from the flange.



Figure 22. Sectioned and opened rivet hole at the location of the lower rivet.