

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



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MATERIALS LABORATORY

Factual Report 24-084

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A. ACCIDENT INFORMATION

Location: Fort Pierce North, Florida
Date: March 30, 2024
Time: 13:20 eastern daylight time
19:20 coordinated universal time
Vehicle: Piper PA-44-180, N595ND
Investigator: Leah Read, AS-ERA

B. COMPONENTS EXAMINED

Carburetor assembly

C. EXAMINATION PARTICIPANTS

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Office of Research and Engineering - Materials Laboratory Division
NTSB, Washington, DC

D. SUMMARY

The throttle lever teeth that were connected to the throttle arm assembly at the stop had worn to a degree that the lever could rotate intermittently without engaging. The throttle arm had fractured at one of the screw holes from torsional and bending overstress. The two fractured areas of the carburetor housing bosses fractured from overstress due to bending deformation of the throttle arm and fuel cutoff valve lever.

E. DETAILS OF THE EXAMINATION

On March 30, 2024, a Piper PA-44-180 sustained substantial damage when it was involved in an accident at the Treasure Coast International Airport (FPR), Fort Pierce, Florida. The flight instructor was fatally injured, and the private pilot was seriously injured. While practicing single-engine emergency procedures, the pilot was unable to bring the engine thrust back during a missed runway approach. The airplane stalled and impacted the ground. The airplane came to rest inverted on the airport ramp. The carburetor removed from the right engine showed the mixture was halfway between full rich and idle cut-off. The throttle control arm was secured to the throttle control arm lever via castle nut and cotter pin, but the serrated interface was not securely mated. This condition allowed the throttle arm lever to be fully rotated without moving the throttle arm. The throttle plate was in the fully closed position, and the throttle control assembly was impact damaged. The carburetor was sent to the NTSB Materials Laboratory for further examination.

A review of maintenance records revealed that the last annual inspection conducted on the airplane and both engines was completed the day before the accident on

March 29, 2024. At that time, the airframe total time in service was 6,980.8 hours. Total time since overhaul for both engines was 196.4 hours.

Figure 1 shows the carburetor assembly, as received. There were two areas of the housing that had fractured located at hollow bosses, as identified in Figure 1. These were near the fuel cut off assembly lever and the throttle shaft and lever arm assembly. Highlighted in Figure 1b, the levers at these fractured bosses also exhibited bending deformation. On the left side, the mixture control lever had been bent away from the housing, whereas the throttle lever and stop assembly on the right side had been bent back toward the carburetor.

The placard on the side of the carburetor stated the model number was HA-6 FF, with part number 10-6019. The serial number was 75958309. Another embossed marking on the side of the housing stated 10-B175.

Figure 2 shows the throttle side of the carburetor, showing the throttle arm and stop assembly attached to the circular valve (or plate) and the throttle lever arm on the right. Figure 3 shows a closer view of the interior of the carburetor, displaying the lever arm attached to the throttle valve with two screws. The screws were not oriented parallel to each other. The area of the arm surrounding the right screw had fractured (see Figure 4).

As illustrated in Figure 5, the arm around the right screw hole exhibited localized necking, or plastic thinning deformation around the hole. The arm had also fractured at this hole location, indicated by the vertical dark lines. Figure 6 shows a closer view of the arm as affixed to the throttle valve, via two screws. Figure 7 shows the right screw and the arm around it. The arm exhibited localized thinning deformation, or necking, adjacent to the screw.

The throttle arm was disassembled from the valve sequentially. Figure 8 shows the valve and arm after removal of the screws. This view demonstrates that the arm had fractured around the right screw hole, but was still intact on the left hole. The throttle valve plate was jammed into the position as received, and when removed, the inner surface of the housing revealed a black crescent witness mark, shown in Figure 9.

The arm assembly was removed from the carburetor, as is shown in Figure 10. Figure 11a shows the arm from the side, demonstrating the bending deformation of the shaft about the stop, pinned to the arm on the right in the figure. Figure 11b. shows the deformed arm from the opposite side, showing the outward bowing of the arm half that had fractured about the screw hole. The arm exhibited two fracture locations, which were oriented perpendicular to the arm longitudinal direction. Once the screw was removed, the fracture surfaces and near side of the arm on the near side of the slot shifted position, demonstrated in Figure 12.

Figure 13 shows a closer view of the side of the throttle arm that had been attached to the valve by the two screws. Figure 14 shows opposite side views of the throttle arm fracture surfaces, after disassembly. The material near the fracture surfaces exhibited necking. The surfaces also exhibited upward or downward shearing deformation, antiparallel to each other, consistent with up and down shearing deformation, as oriented in the figures.

The intact half of the arm on the far side of the slot was sectioned to allow examination of the fracture surfaces. One of the mating sides is shown in Figure 15. Much of the fracture surfaces exhibited flat, reflective regions, consistent with smearing from post-fracture damage. These smeared regions were mirrored on the mating sides, indicating contact and rubbing of these surfaces after fracture.

The areas that were undamaged were examined using a field emission scanning electron microscope (SEM). Figure 16 shows one of the fracture sides. The undamaged area exhibited dimpled rupture, as typified in Figure 17. These features were consistent with overstress fracture of the arm about the screw hole, in tensile, bending, and shearing directions.

Figure 18 and Figure 19 highlight the throttle arm stop, with a sawtooth-shaped face that mates with the throttle lever. When still assembled, the deformation in the throttle arm manifest as rightward-facing bending of the stop, consistent with a missing portion of the cylindrical housing boss (Figure 19). The throttle lever was still attached by way of bolt and nut, secured with a cotter pin. The interlocking teeth between the mating faces of the arm stop and the throttle lever were not settled, and they exhibited play and separate rotational movement intermittently when the lever was actuated. Figure 20 shows a closer view of the interlocking teeth while still assembled. In this position, the lever could move about the stop. The lever teeth, on the right side in Figure 20, exhibited rounding relative to the more pronounced points of the stop. Figure 21 shows the condition of the teeth when the lever is rotated to seat the teeth together.

Figure 22 shows a 90° view of the fractured housing and deformed throttle arm assembly. The slanted orientation of the fractured housing was consistent with outward deformation of the boss during fracture. This direction faces the reader in Figure 22, but was in the same direction as the outward bending of the throttle arm assembly and stop shown from the side in Figure 19.

Figure 23 shows the face of the throttle lever, with the teeth that had engaged the throttle arm stop teeth facing the reader. The crests of the teeth exhibited a silver-metallic color, in contrast with the golden color of the surface coating. The sides of the lever, shown from opposite 180° locations in Figure 24, demonstrate the rounding of the teeth along the crests.

Examination of the lever using a SEM revealed a loss of the outer coating in many areas of the crests. Energy dispersive spectroscopy (EDS) found the lever material to be consistent with alloy steel, and the coating to be consistent with cadmium. As shown in Figure 25 and Figure 26, the teeth exhibited circumferentially-oriented wear scars and gouges. The backscattered image demonstrated both removal of the outer coating material, as well as deposition of non-metallic material into the lever arm teeth (shown by the darker spots in Figure 26).

Digital calipers were used to measure several dimensions of the throttle lever. The inner diameter (hole) of the lever arm measured 0.374 inches, whereas the outer diameter measured 0.860 inches. The height of the teeth was also measured, and the height of the crests (from the back face) measured between 0.4585 and 0.4640 inches. This was a difference of 0.0055 inches, or 0.14 mm.

The last area of damage on the carburetor is shown in Figure 27. This shows the fuel cut off valve lever assembly, along with the surrounding subcomponents, which were still attached. The area of the housing near this lever had fractured, exhibited a slanted orientation with fracture surfaces that had features consistent with overstress. The rod joined to the opposite end of the lever had been deformed in an upward bending, as shown in Figure 27a.

Submitted by:

Erik M. Mueller
Materials Research Engineer

F. FIGURES

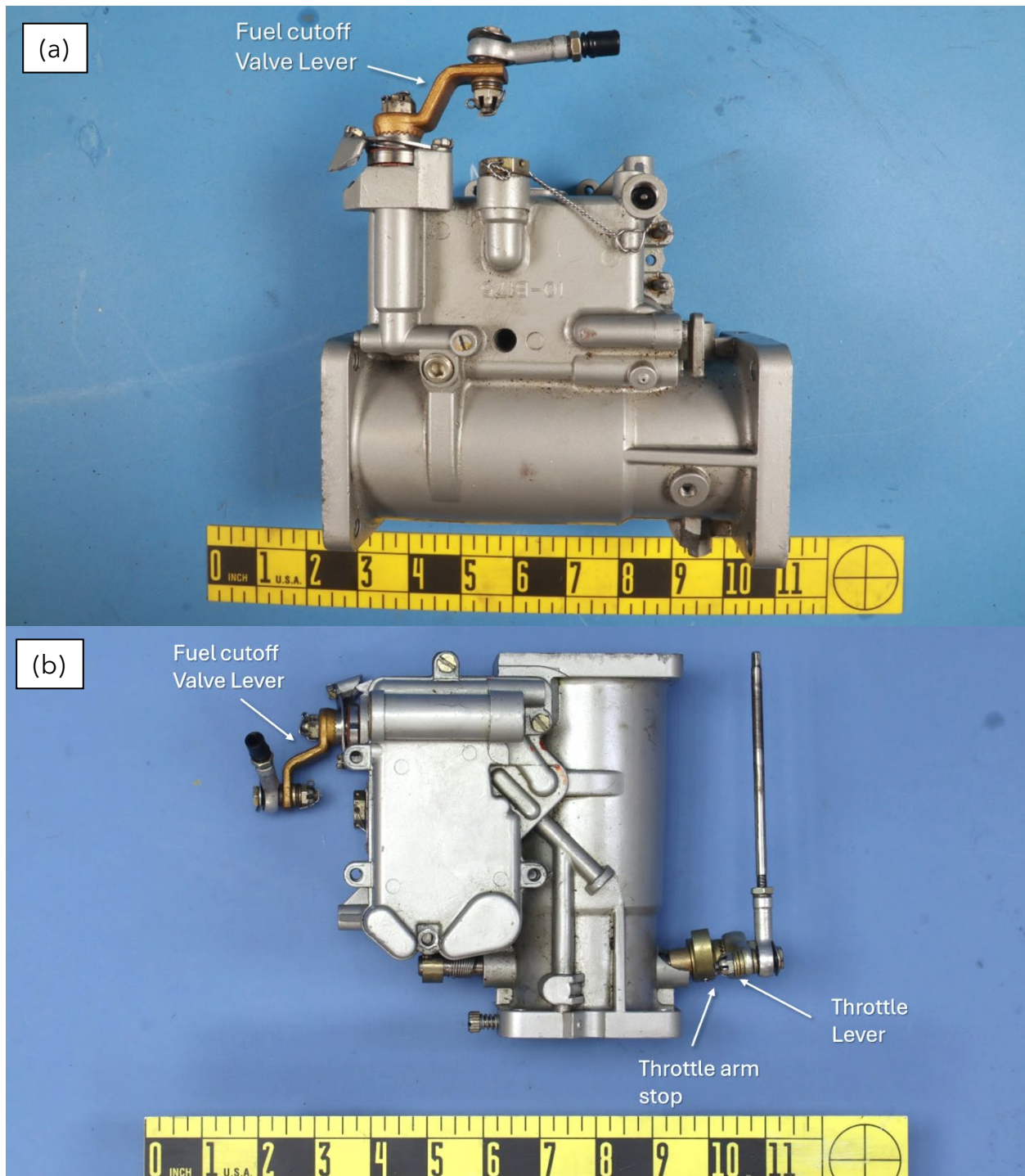


Figure 1. Rotated views of the carburetor from the housing, annotated to show some of the fractured locations.

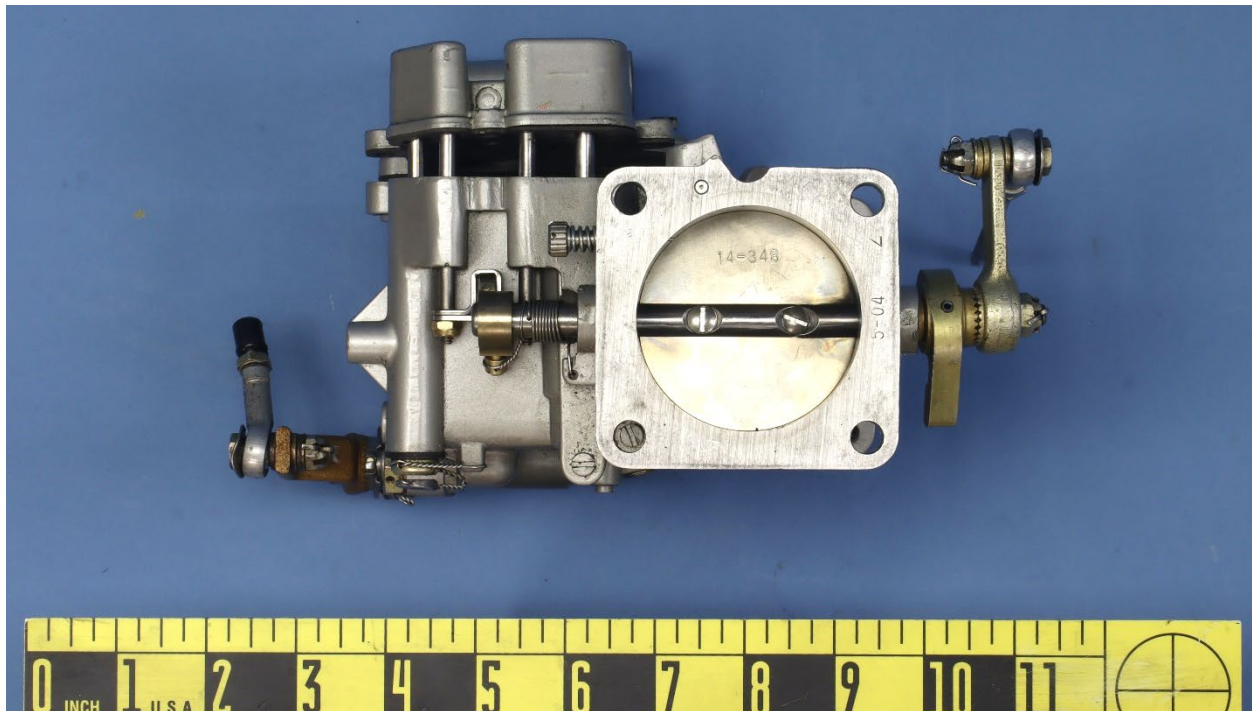


Figure 2. View of the carburetor, rotated to show the fuel cutoff valve assembly on the left, and the throttle lever and throttle arm assembly on the right.

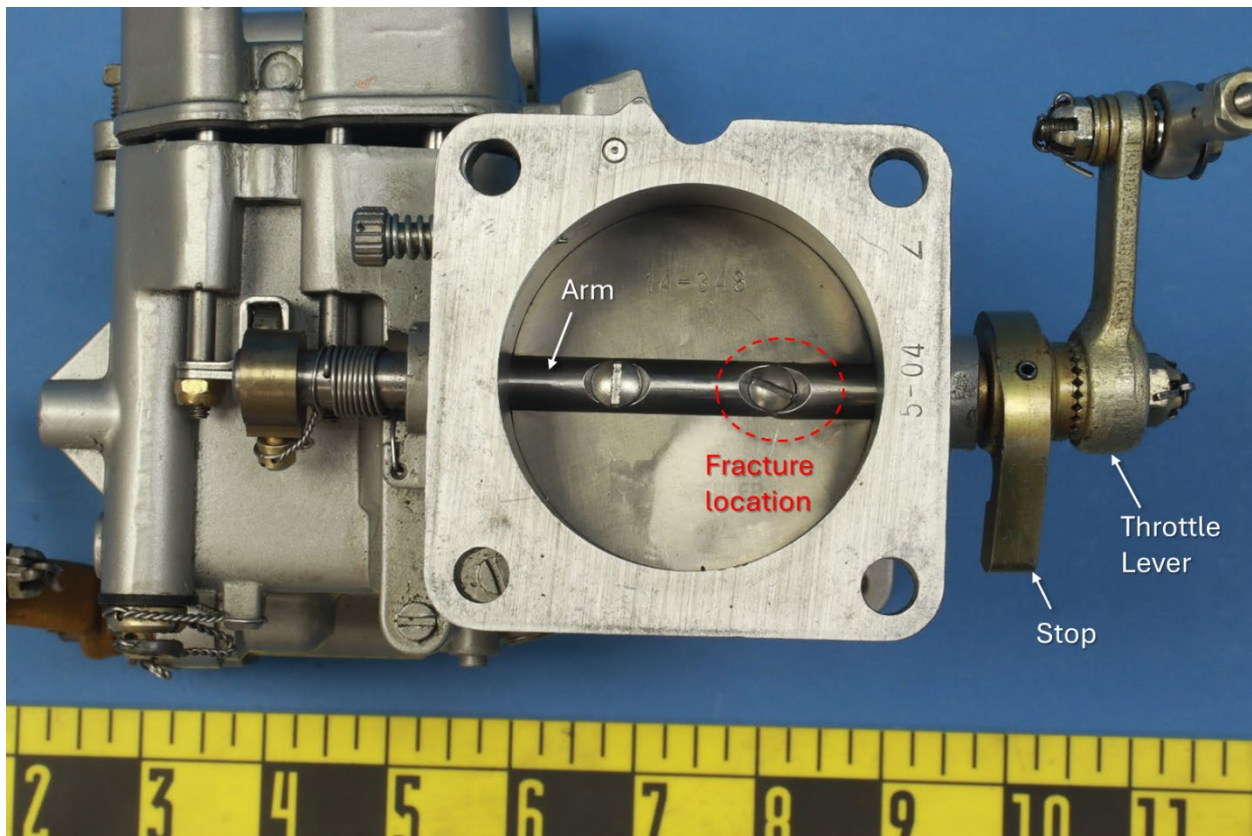


Figure 3. Closer view of Figure 2, showing the fractured throttle shaft and the disengaged teeth from the throttle lever (right).

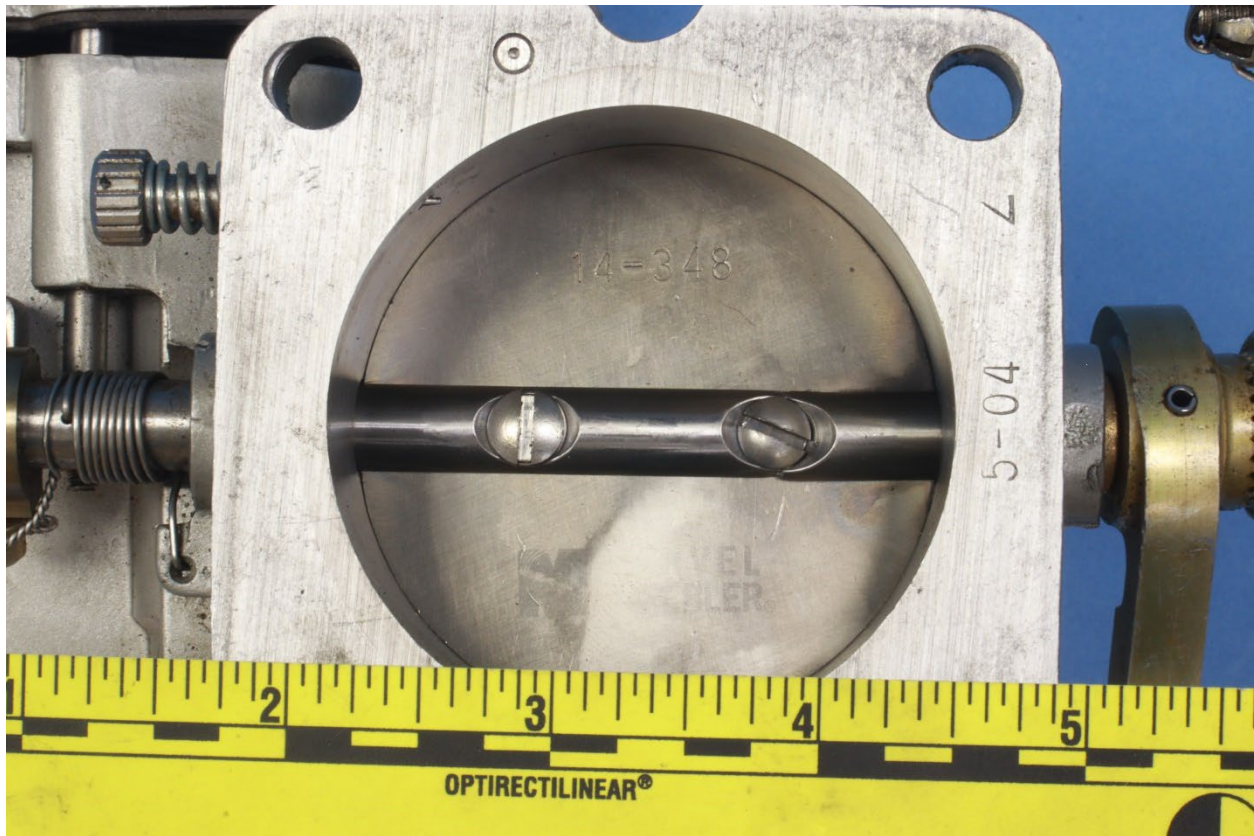


Figure 4. Closer view of the valve and throttle arm assembly in the body assembly interior.

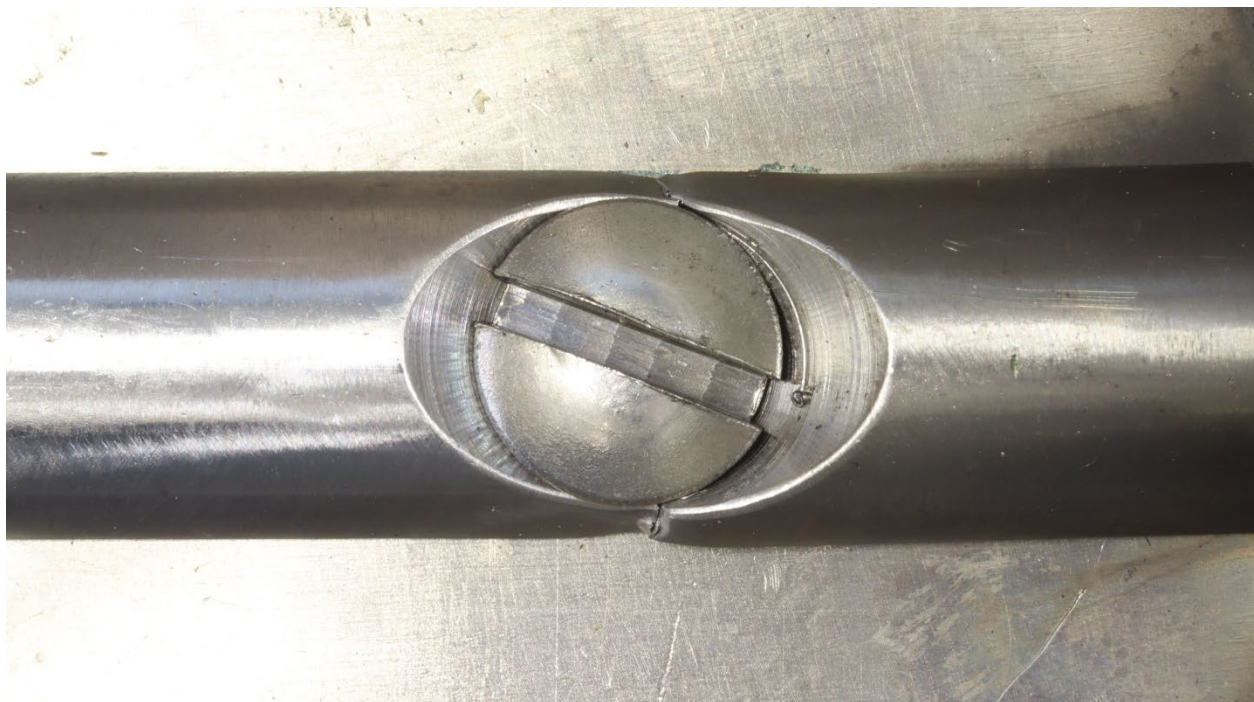


Figure 5. View of the fractured shaft and position of the screw, as received.



Figure 6. View of the throttle arm, as received when still attached to the valve plate.

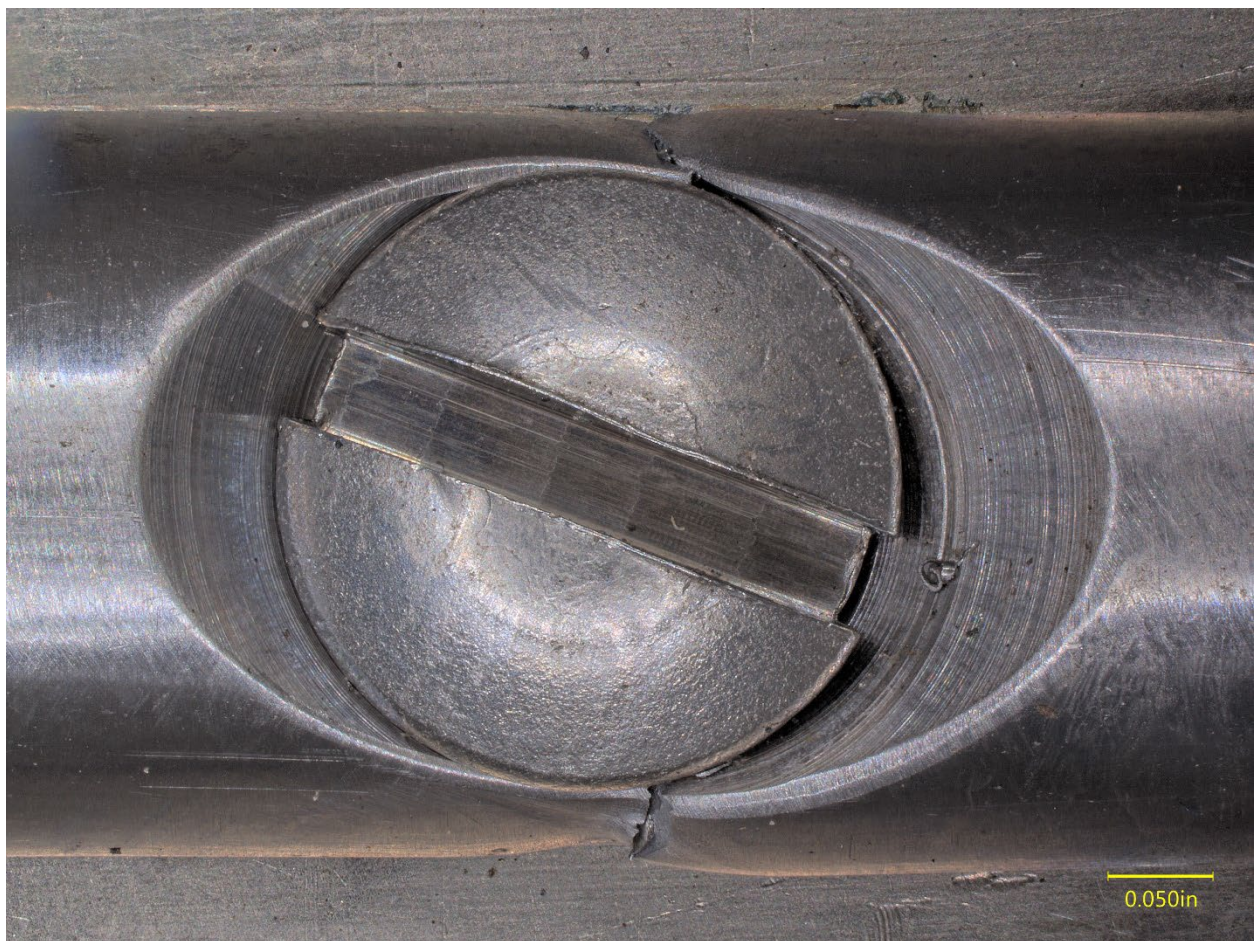


Figure 7. View of the fractured arm around the right throttle valve screw in Figure 10.

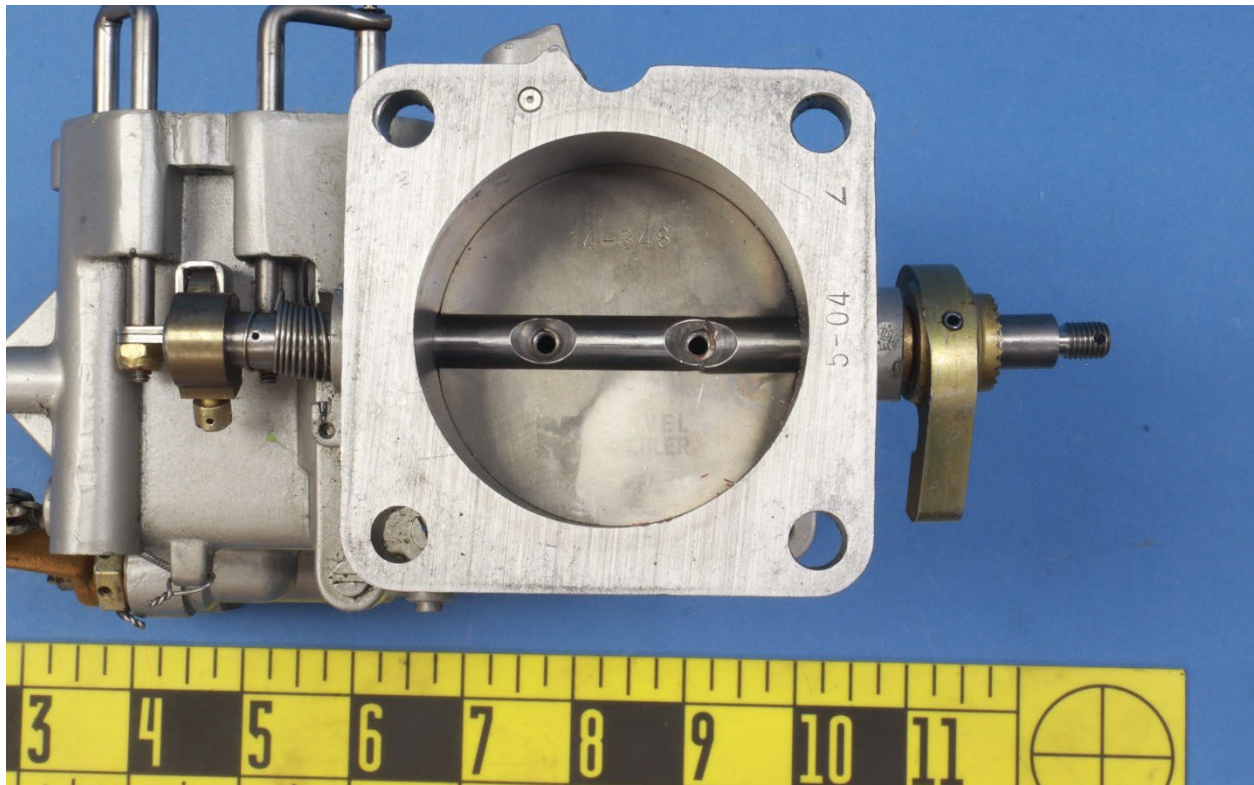


Figure 8. View of the throttle arm assembly inside the carburetor, after removal of the screws.



Figure 9. Angled view of the interior of the carburetor housing, after removal of the throttle arm assembly and plate, showing the circular witness mark in the bore from the plate edge.

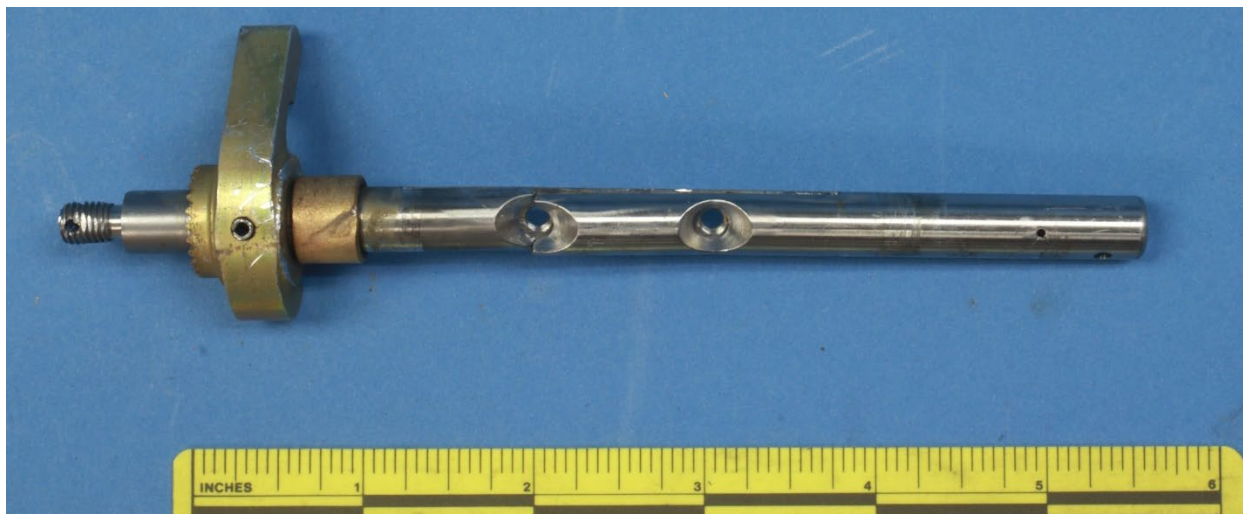


Figure 10. The throttle arm and stop assembly, after disassembly from the carburetor body assembly.

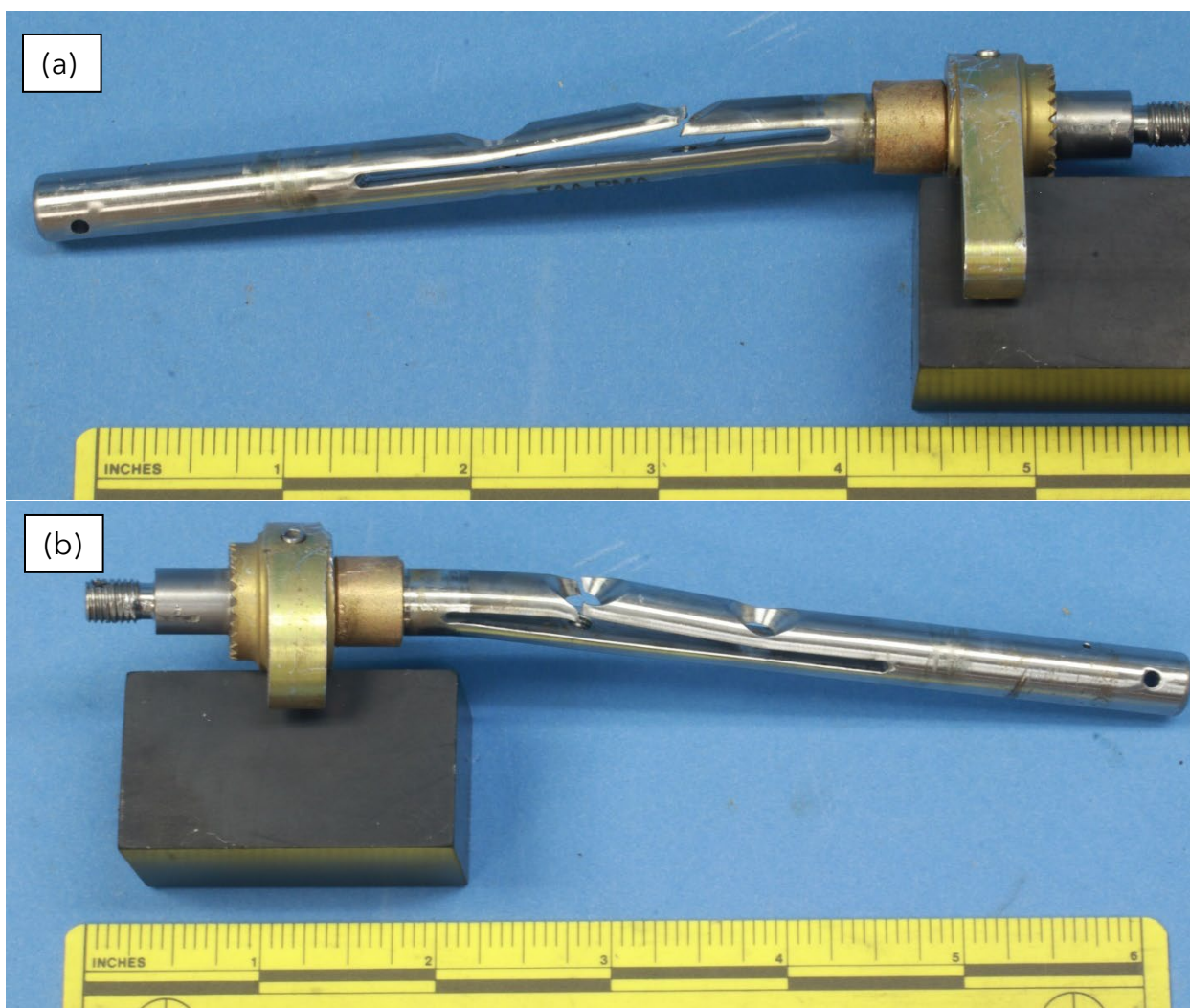


Figure 11. Side view of the fractured and deformed throttle arm and stop assembly.

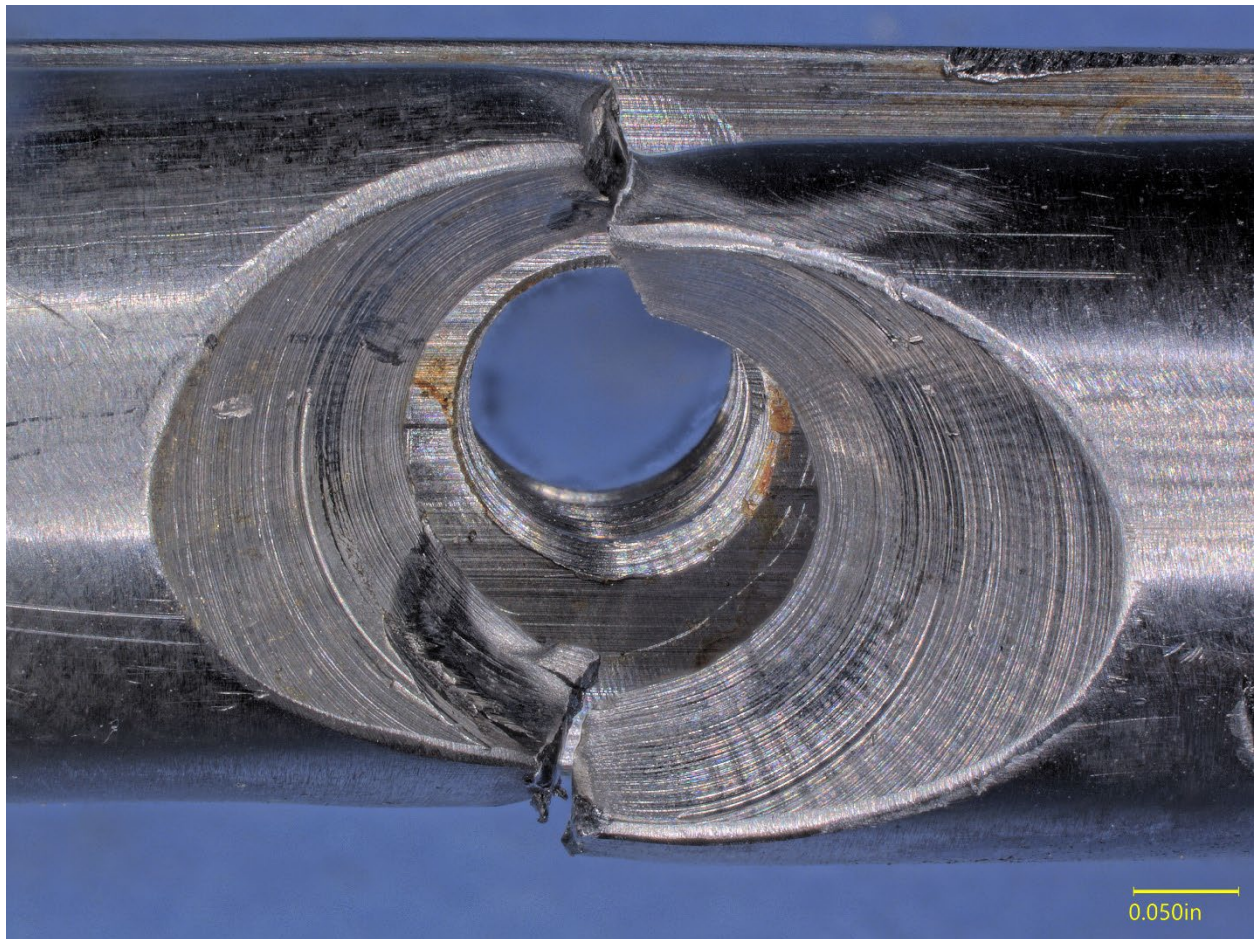


Figure 12. View of the fractured area of the throttle arm from Figure 11, after disassembly from the valve.

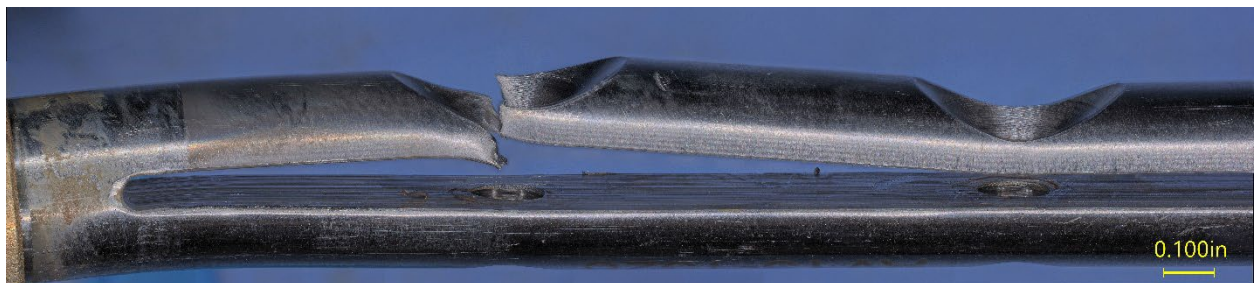


Figure 13. Side view of the throttle arm, showing the upward bending of part of the arm and shearing deformation and necking about the filaments around the screw hole.

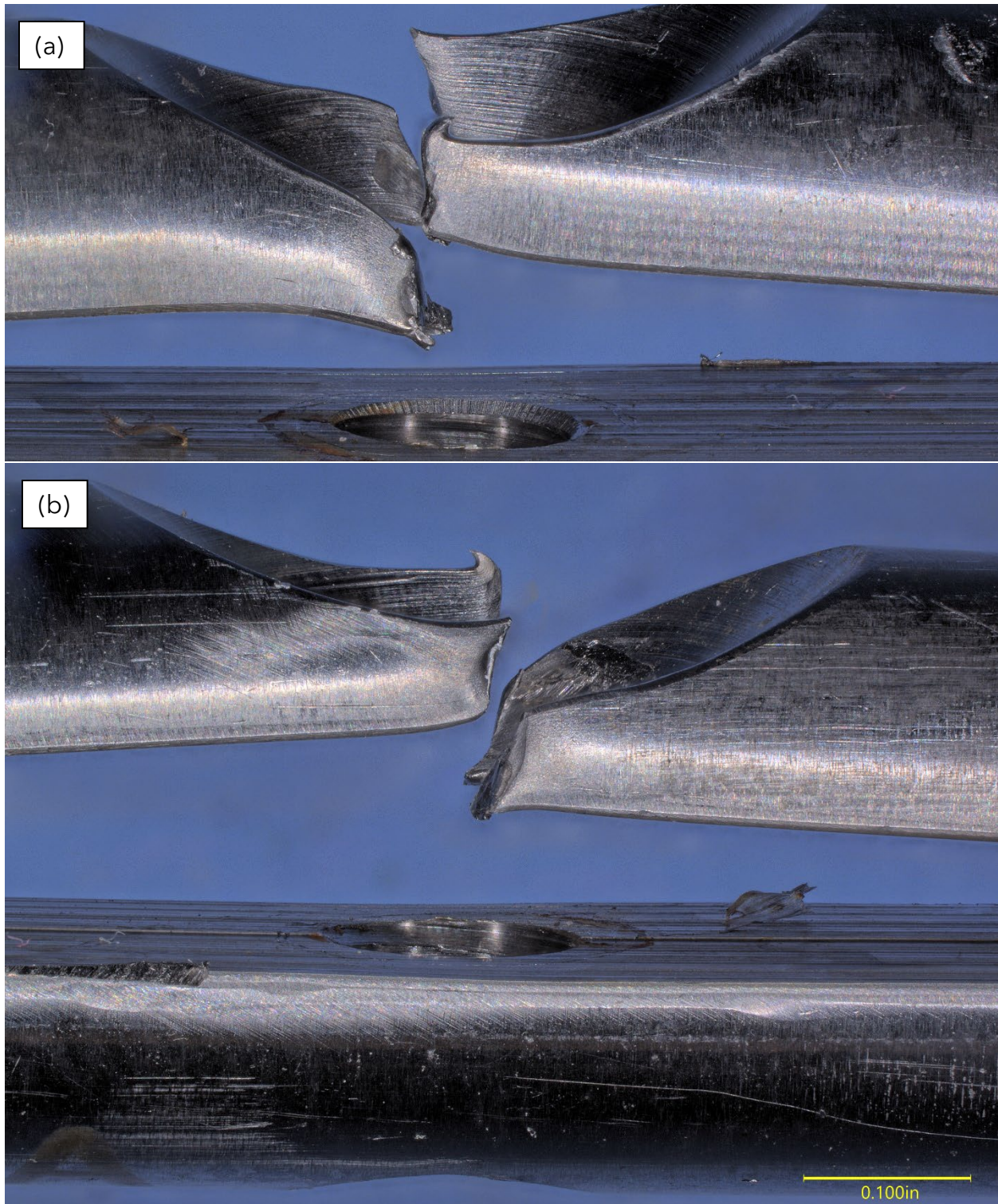


Figure 14. Side views of the fractured arm half, viewed from opposite sides.

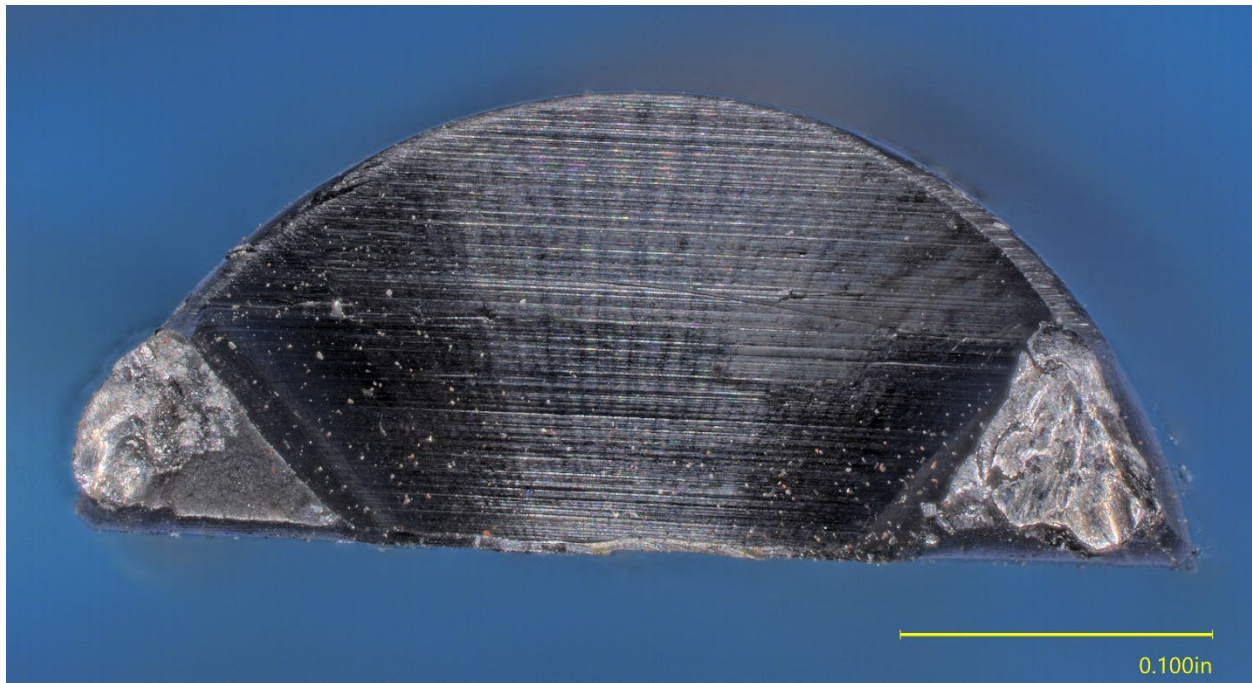


Figure 15. Direct view of two of the fractured filaments of the upper throttle arm.

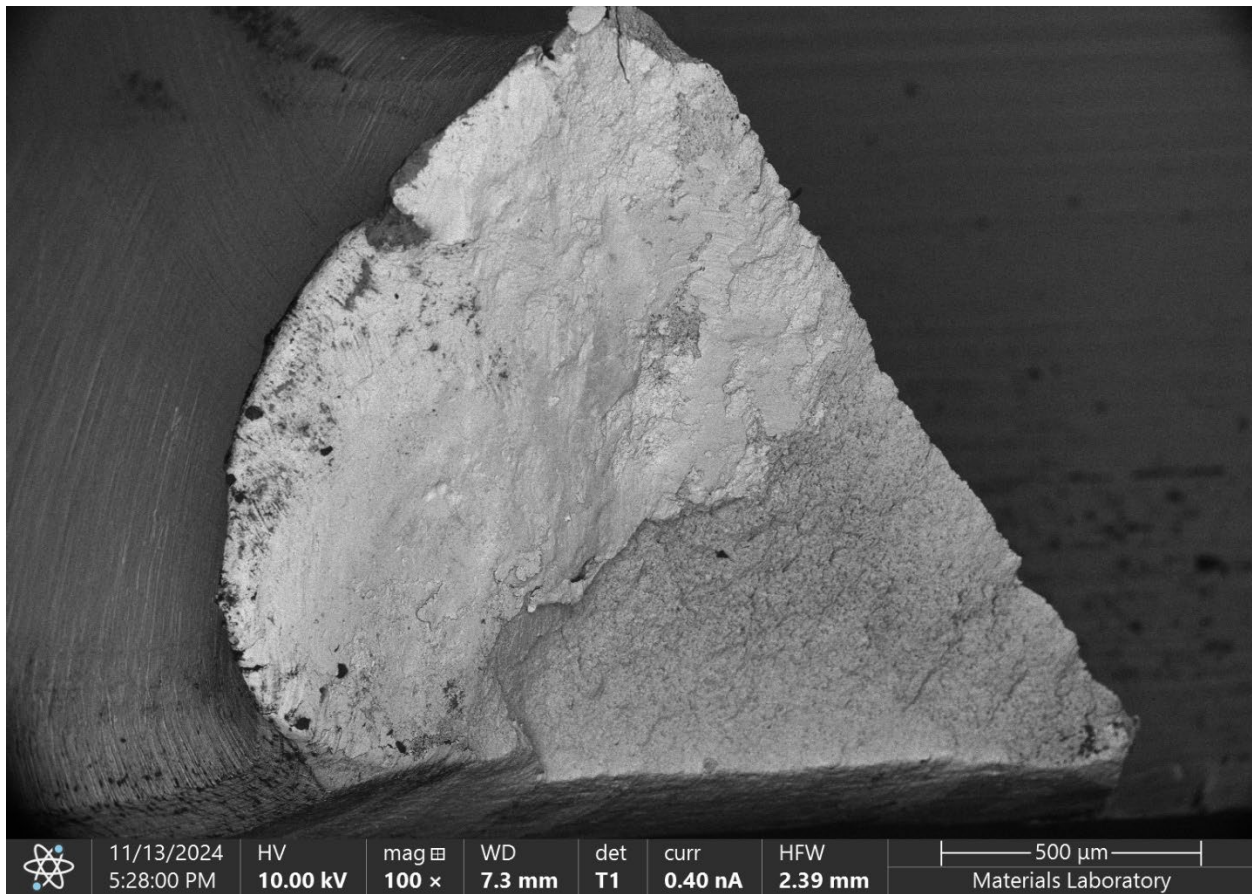


Figure 16. Backscattered electron (BE) micrograph of the left filament surface in Figure 15.

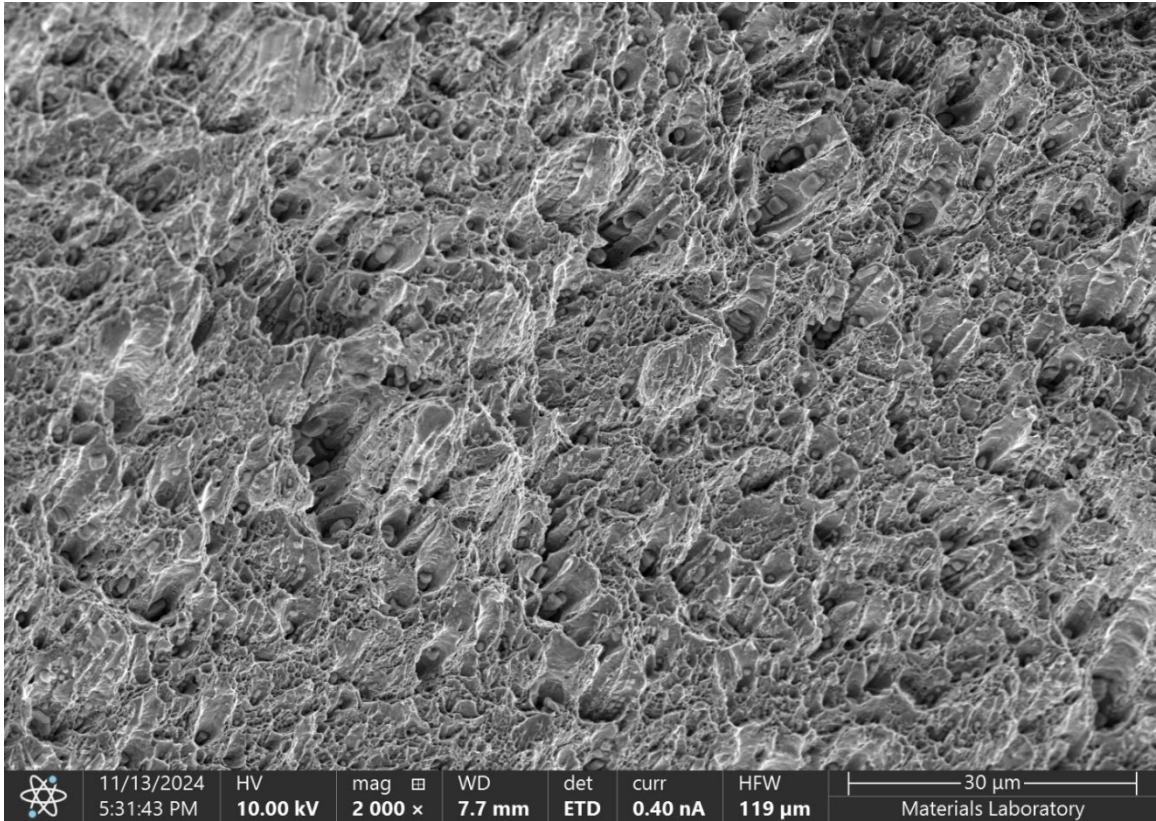


Figure 17. Secondary electron (SE) micrograph of dimpled rupture on the fracture surface in Figure 16.

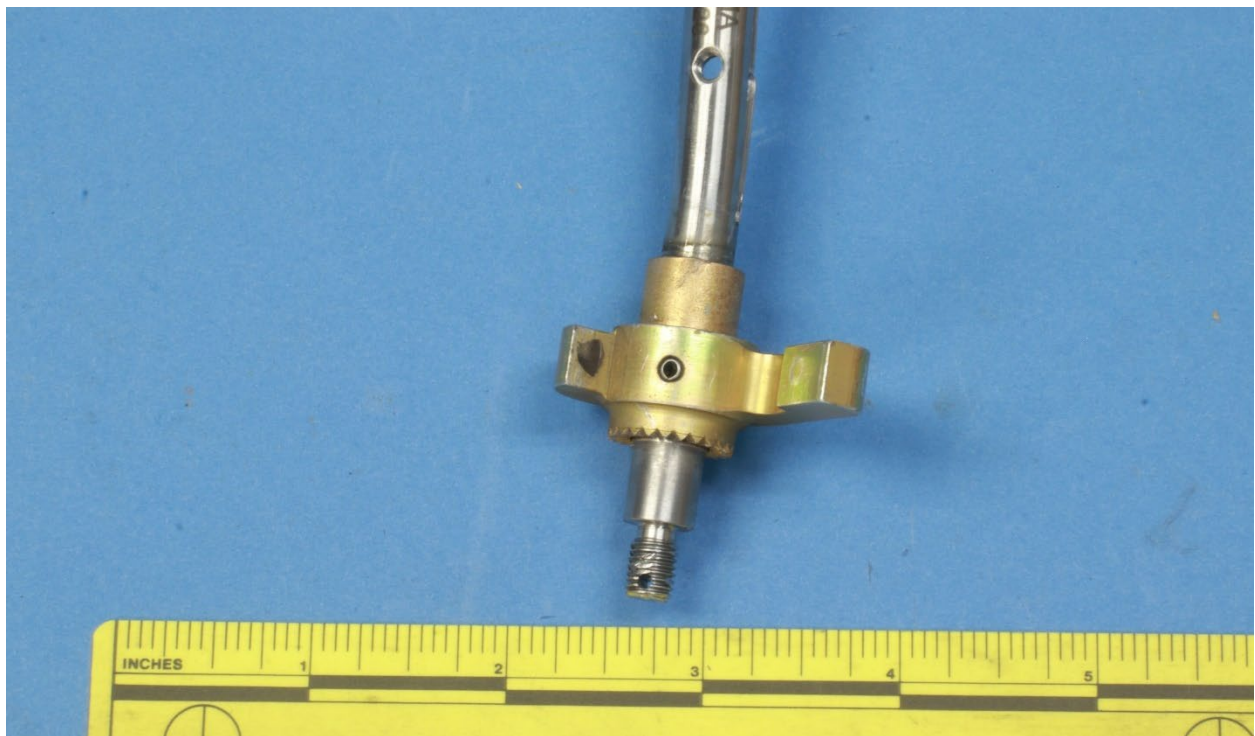


Figure 18. The end of the throttle shaft with the stop end.

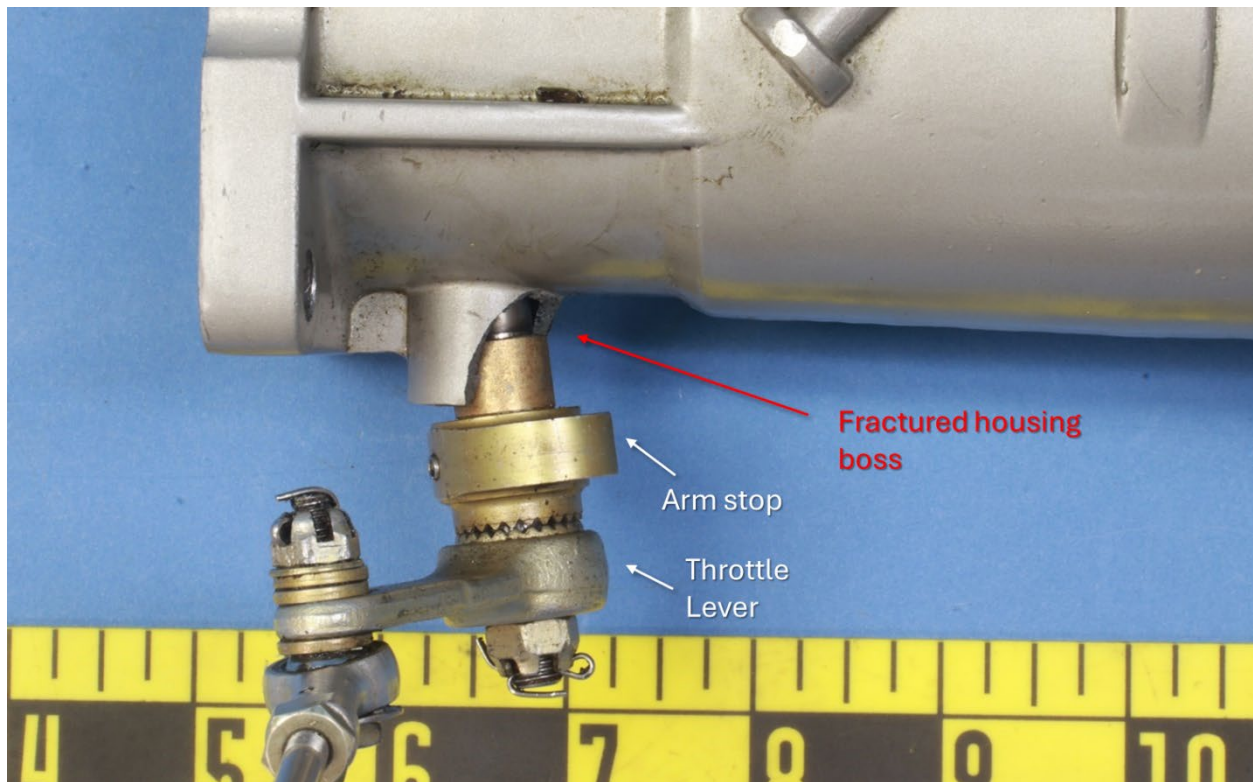


Figure 19. The joint of the throttle arm stop and lever arm, showing rightward deformation and the boss housing fracture.

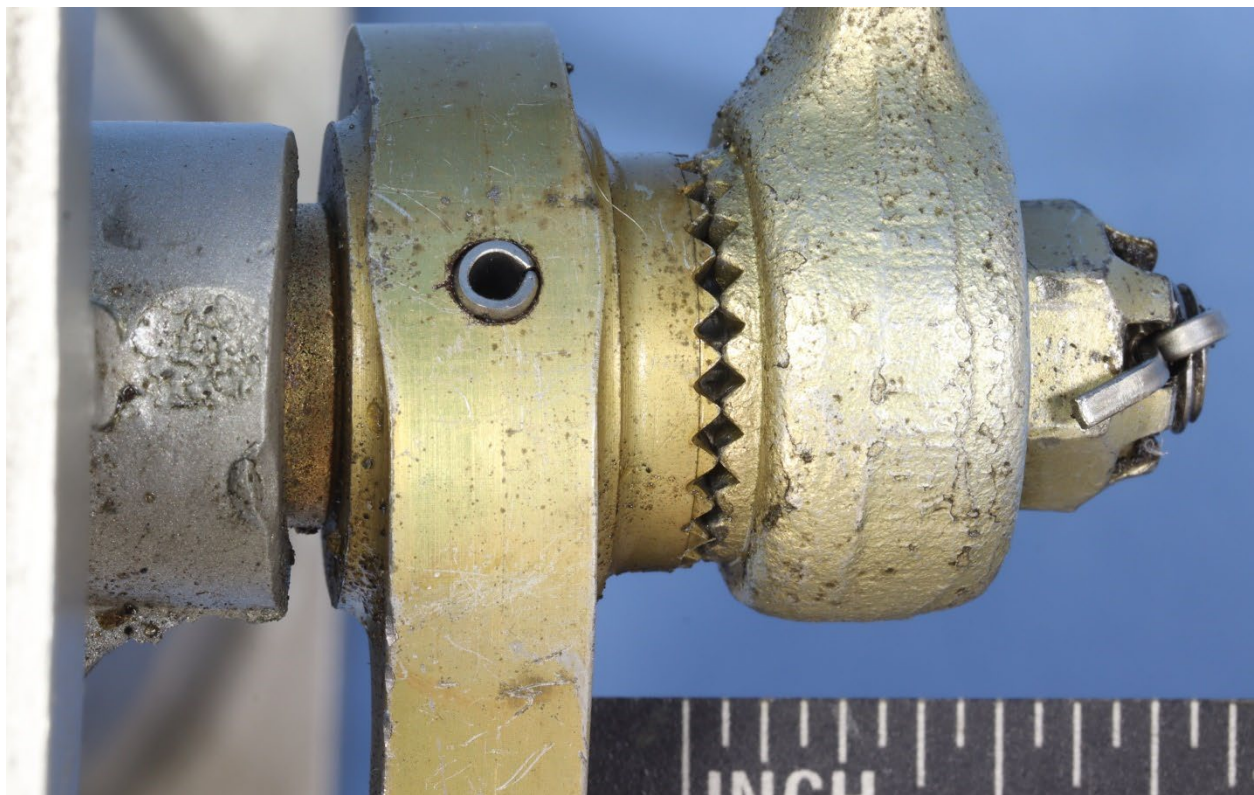


Figure 20. View of the engagement teeth between the throttle lever (right) and stop (left).

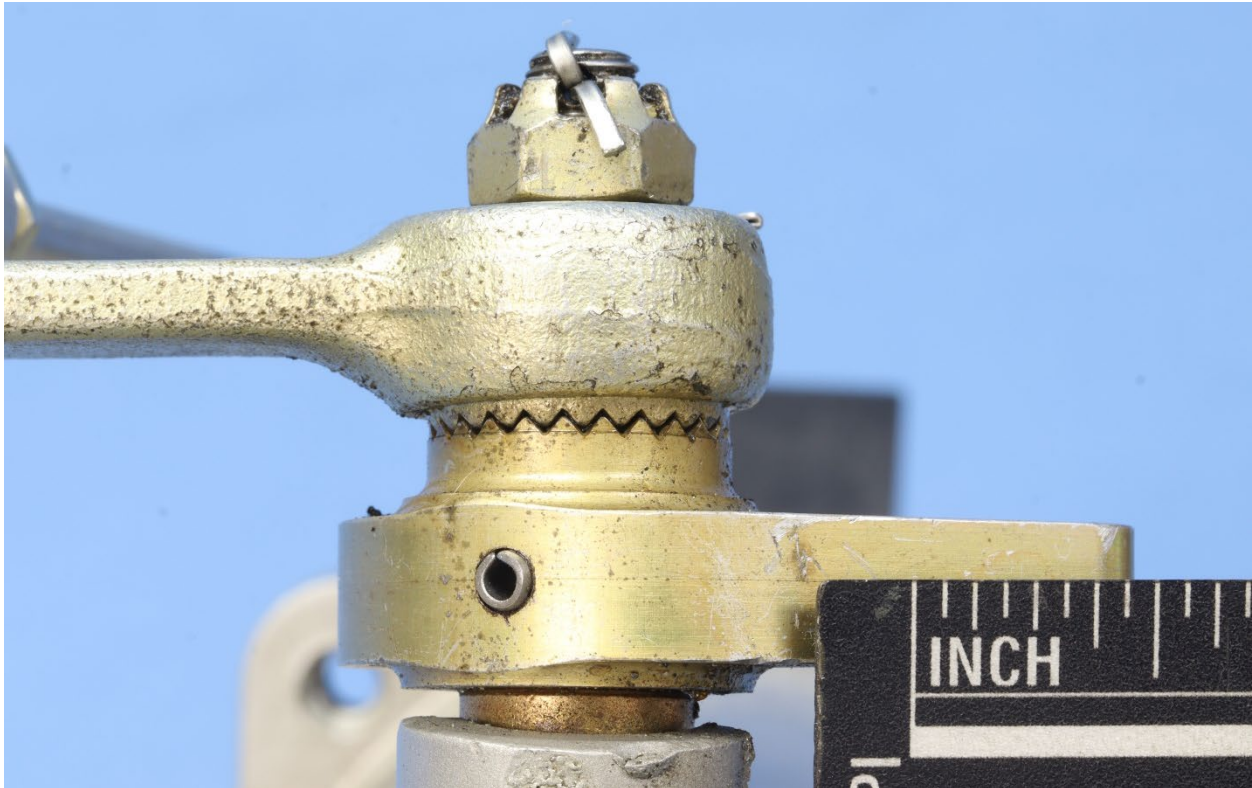


Figure 21. Side view of the stop and lever teeth after rotation to full engagement.

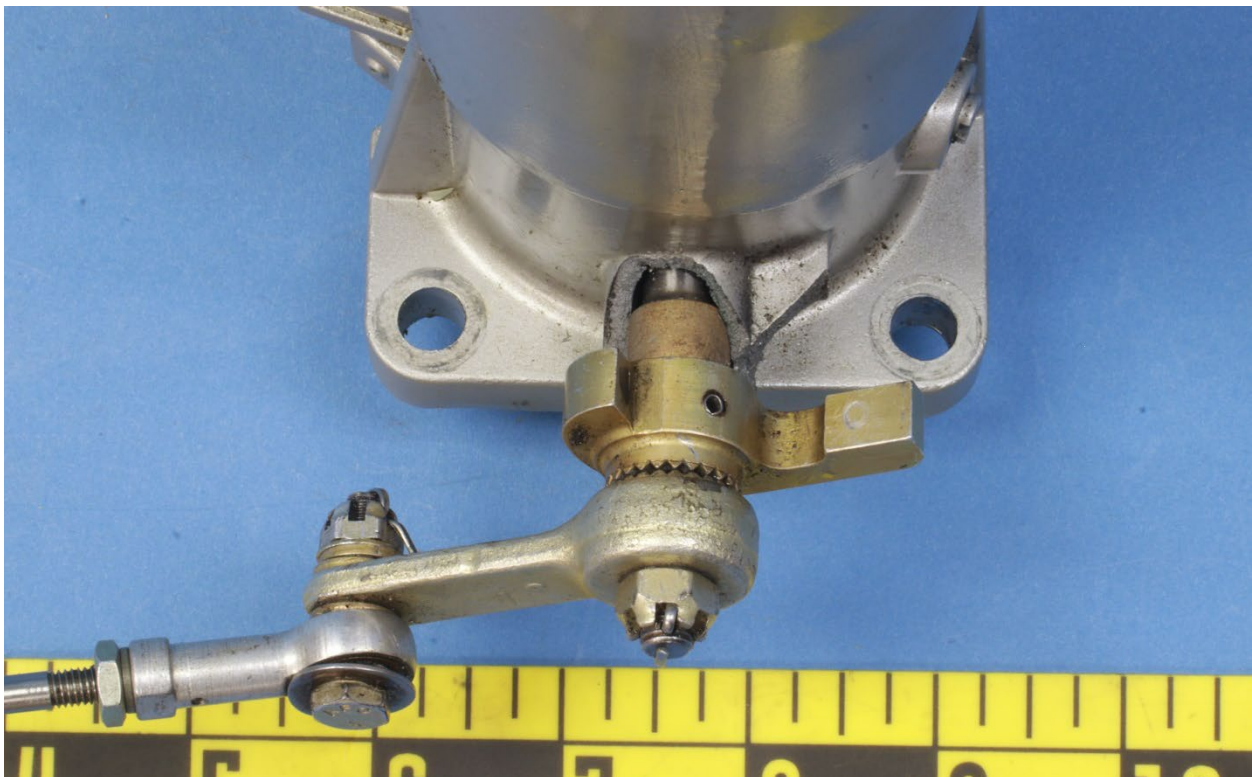


Figure 22. Angled view of the throttle arm stop and lever, as received, showing the upward bend and housing fracture.



Figure 23. View of the teeth on the throttle lever, after disassembly and cleaning.

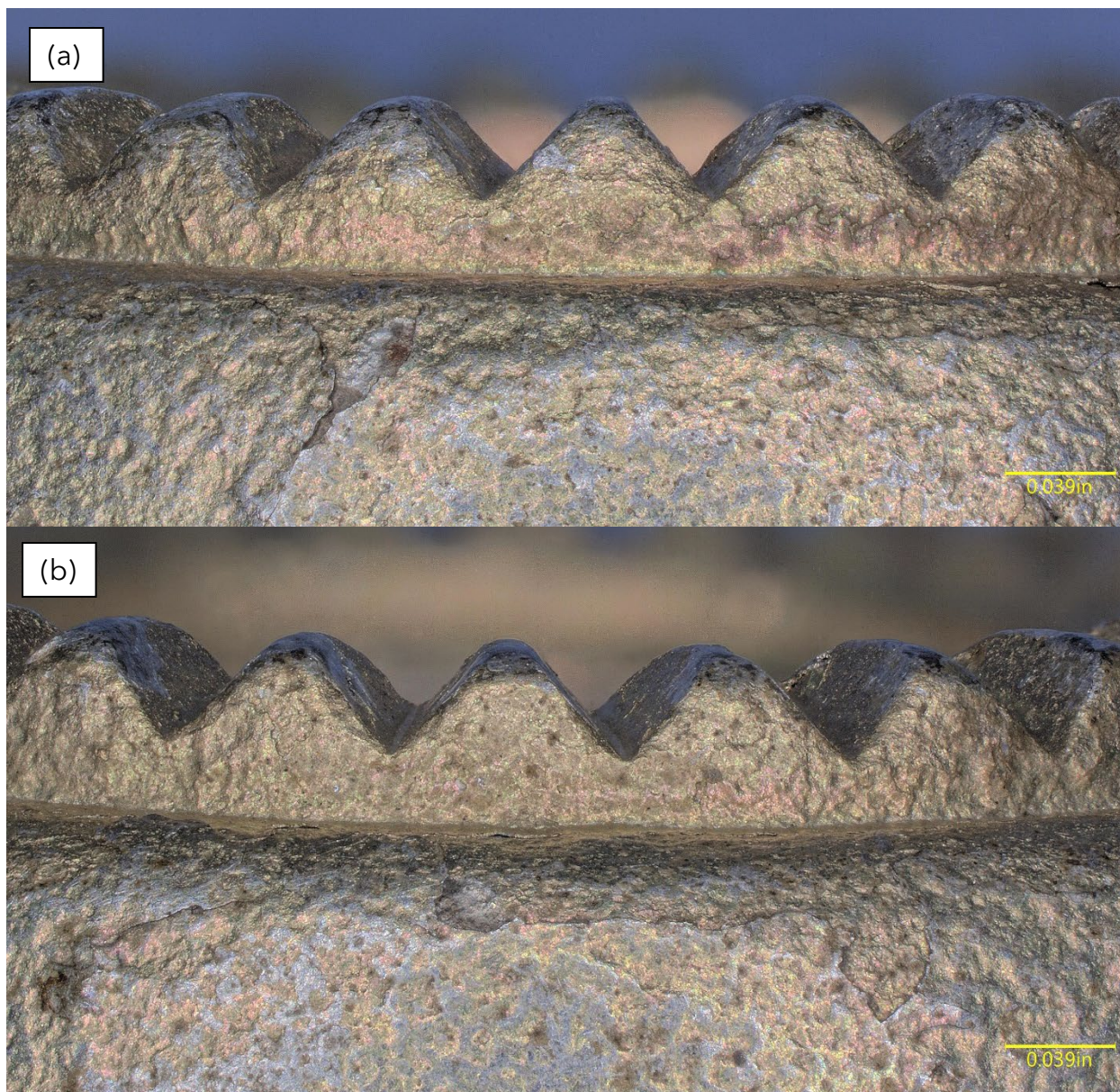


Figure 24. Side views of the throttle lever teeth from (a) the top of Figure 24 and (b) the bottom, showing rounding on the crests.

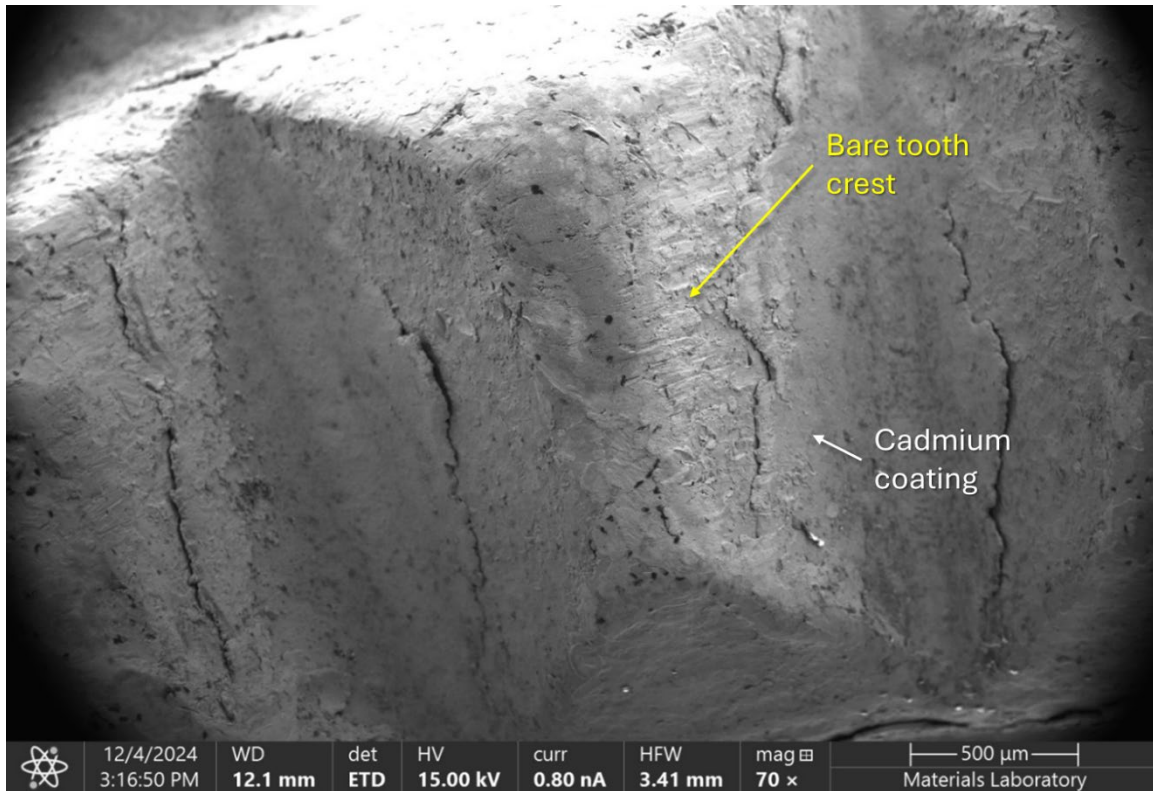


Figure 25. SE micrograph of a worn lever tooth crest, showing spalling of the Cd coating.

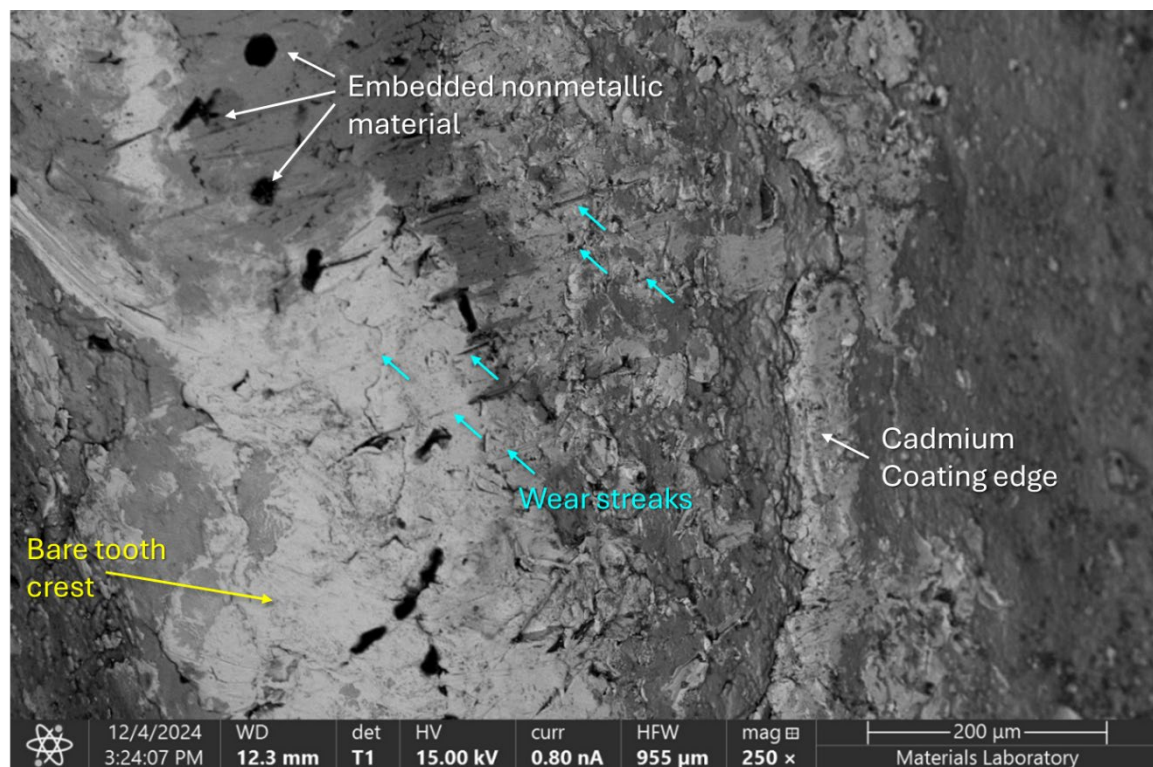


Figure 26. BE micrograph of the side of the tooth crest in Figure 26, showing missing surface coating and wear scars and localized deformation.

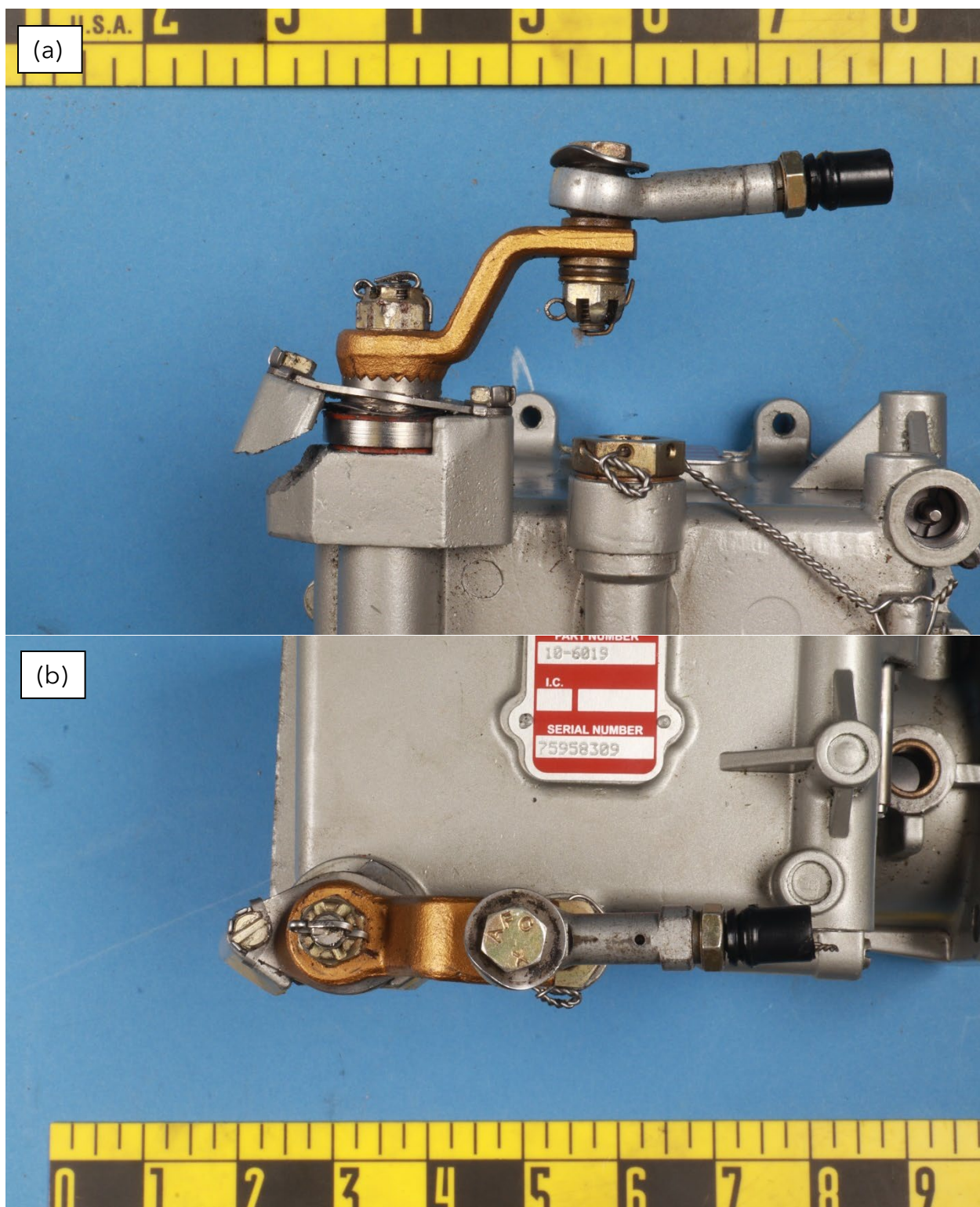


Figure 27. Views from (a) the side and (b) the top of the fuel cut off valve lever assembly, showing fracture of the housing where the retainer is affixed via a screw.