

National Transportation Safety Board

Office of Research and Engineering

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MATERIALS LABORATORY

Factual Report 24-041

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A. ACCIDENT INFORMATION

Location: Prospect, Tennessee
Date: September 14, 2023
Time: 13:00 central daylight time
18:00 coordinated universal time
Vehicle: Cessna 182P, N8443M
Investigator: Ralph Hicks, AS-ERA

B. COMPONENTS EXAMINED

Remnants of rocker arm pin housing
Rocker arm
Rocker arm pin
Washers

C. EXAMINATION PARTICIPANTS

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

D. DETAILS OF THE EXAMINATION

On September 14, 2023, a Cessna 182P airplane was substantially damaged during an accident near Prospect, TN. The private pilot and one passenger sustained minor injuries. The pilot reported sudden engine vibrations and power loss about one hour into the flight. Unable to reduce these vibrations, the pilot attempted to land in a soybean field. After touchdown in the field, the nose landing gear struck a ditch, separated, and the airplane nosed over, coming to rest inverted. Federal Aviation Administration (FAA) inspectors responding to the scene found the wreckage with the fuselage and empennage substantially damaged. The wreckage was retained for further examination, and several components from the Continental O-470-S engine were sent to the NTSB Materials Laboratory for additional examination.¹

Figure 1 shows the components from the #6-cylinder position, as received. This figure includes one of the rocker arms, two washer/spacers, the arm shaft, and two housing boss fragments around the bores where the arm shaft had been positioned. One of the housing bore fragments was completely separated, while the other was still attached to the shaft via a hex bolt with safety wire through a bushing.

¹ The Continental O-470-S engine is a carbureted six-cylinder, horizontally opposed, air-cooled aircraft engine manufactured by Continental Motors, headquartered in Mobile, AL.

Figure 2 shows the rocker arm as received. The arm exhibited a rough surface texture and center part line, consistent with being die-cast. The bushing was still inside the rocker arm bore, as shown in Figure 2b. This figure also shows the part number on the side, which states, "534358." On the contact surfaces with the pushrod, any wear marks were centered and even. There were no indications of cracks on these surfaces and no plastic deformation present along the sides.

Figure 3 shows the rocker arm shaft and adjacent housing fragments from the top and fracture surfaces. Before receipt, these fragments had been labeled 'L' and 'R'. The right housing fragment was still attached to the arm and bushing by a hex nut with markings 'CP' and safety wire. The arm exhibited circumferential discoloration corresponding to the contact locations with the housing bores and the rocker arm bushing in its bore. Figure 4 shows the side view of this assembly remnant, with the housing having fractured at approximately the widest portion of the bushing diameter and the fracture surface being oriented flat.

The housing fragments were disassembled from adjacent components and cleaned in an ultrasonic bath of acetone to remove grease and other superficial surface contamination. Figure 5 shows the bore and fracture surfaces of the left or loose housing boss fragment. The bore exhibited longitudinal wear marks, along with some circumferential gouges on the lower portion of the figure.

Figure 6 shows the opposite faces of the left housing boss fragment. The side in Figure 6b exhibited the most prominent features, with a circumferential depression and triangular impact marks on the left corner.

The fracture surface of the fragment is highlighted in Figure 7. Overall, the fracture surface was rough and fibrous in texture and dull in luster. Like the right-side fragment fracture surfaces illustrated in Figure 4, this fracture surface was relatively flat and perpendicular to the bore, located along the widest part of the outer diameter.

Two triangular areas with darker hues were located along the corner with the bore at the bottom of Figure 7. These regions and the surrounding areas exhibited radiating linear features, consistent with those emanating from the inner corners along the bore at the bottom of Figure 7. One of these darker-colored regions is highlighted in Figure 8. The area along the bore exhibited outward deformation, located along regions of the circumferential gouges in the bore. Similar features were observed on one side of the right housing fragment, shown in the bottom center-left of Figure 9.

These fracture surfaces were examined using a field-emission scanning electron microscope (SEM). Figure 10 shows a typical view of the fracture surface in the triangular region of Figure 8. This region exhibited a generally flat orientation, with

repeating linear features and a layer of surface oxidation thick enough to obscure many underlying fracture features.

These features were consistent with fatigue striations. The area of these triangular regions adjacent to the bore corner exhibited multiple initiation sites, separated by perpendicular ratchet marks. These features were consistent with multiple fatigue crack initiation sites.

Outside of these triangular fatigue regions, the fracture surface exhibited contrasting features, as illustrated in Figure 12. These features included dimpled rupture and areas of flat, faceted fracture features. These patterns were consistent with subsequent overstress fracture of the casting material. There were also rounded and protruding features within voids found outside the fatigue cracks, as shown in Figure 12. Many of the features within this void exhibited rounded dendrite ends (Figure 13). These structures were consistent with solidification voids that would have been introduced during the casting process.

The composition of the fractured housing remnants was consistent with an aluminum-silicon casting alloy, as determined using energy dispersive x-ray spectroscopy (EDS). However, some areas contained inconsistent local compositions, as shown in Figure 14. In this figure, the lighter regions exhibited higher percentages of nickel, whereas the darker gray areas were primarily aluminum. The darkest areas in the figure were mainly silicon. These data were consistent with the segregation of alloying elements from the solidification process.

In summary, the housing fragments exhibited features consistent with fatigue that initiated at multiple sites along the bore surface that had been in contact with the arm. The remainder of the housing fragments were fractured from overstress, exhibiting features consistent with rapid fracture of an aluminum casting.

Submitted by:

Erik M. Mueller
Materials Research Engineer

E. FIGURES



Figure 1. The pieces submitted from the accident, including a rocker arm, two fractured sections of cylinder housing, the adjacent shaft bolted to the right fragment with safety wire, and two washer/spacers.



Figure 2. View of the rocker arm from (a) the underside with contact surfaces and (b) the side showing the casting markings and internal bushing.

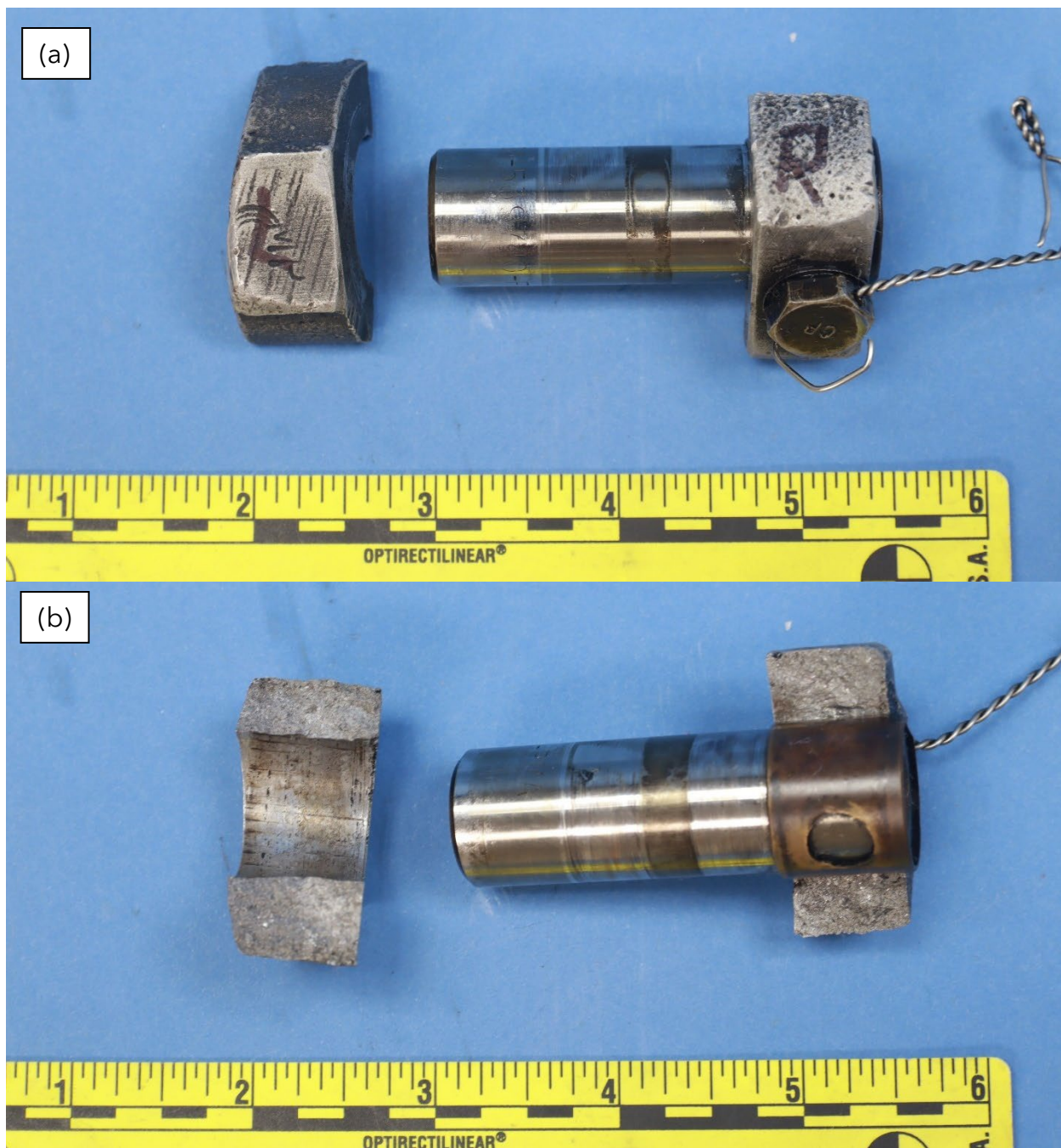


Figure 3. View of the rocker shaft and the housing fragments from (a) the top or exterior side and (b) the fracture surfaces on downward-facing sides.



Figure 4. End of the rocker arm shaft attached to a fractured cylinder housing fragment.

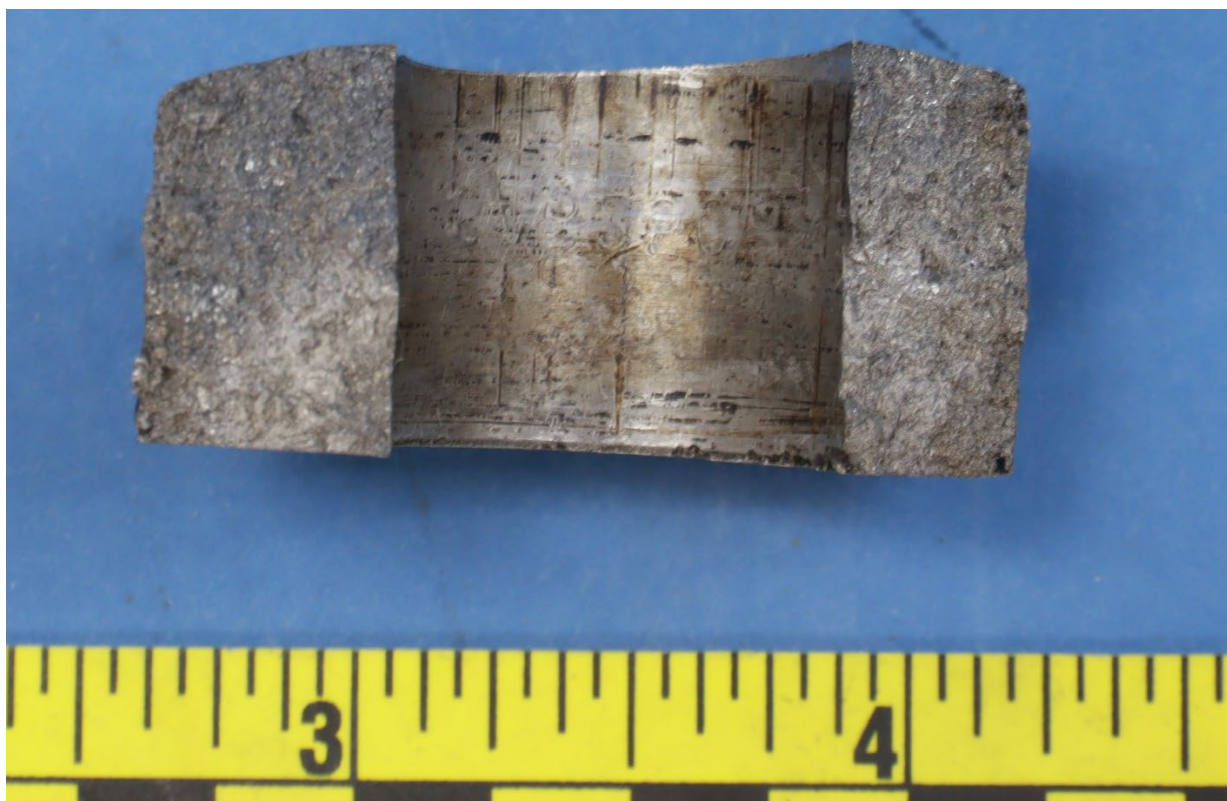


Figure 5. The fracture surfaces of the loose or left cylinder housing fragment.



Figure 6. The loose cylinder housing from (a) the outboard and (b) inboard faces.



Figure 7. View of the loose housing fragment fracture surfaces, after cleaning.



Figure 8. View of an inward corner of the left fracture surface in Figure 7, showing a darker triangular region on the fracture surface.

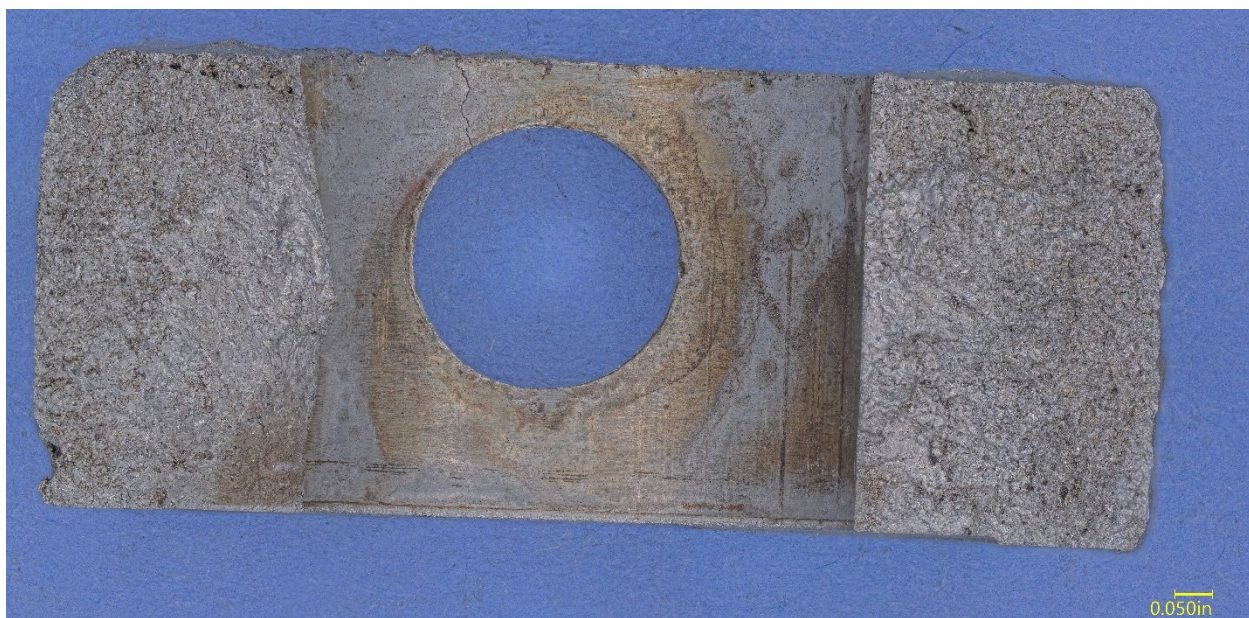


Figure 9. View of the fracture surfaces of the attached cylinder housing fragment, after disassembly and cleaning.

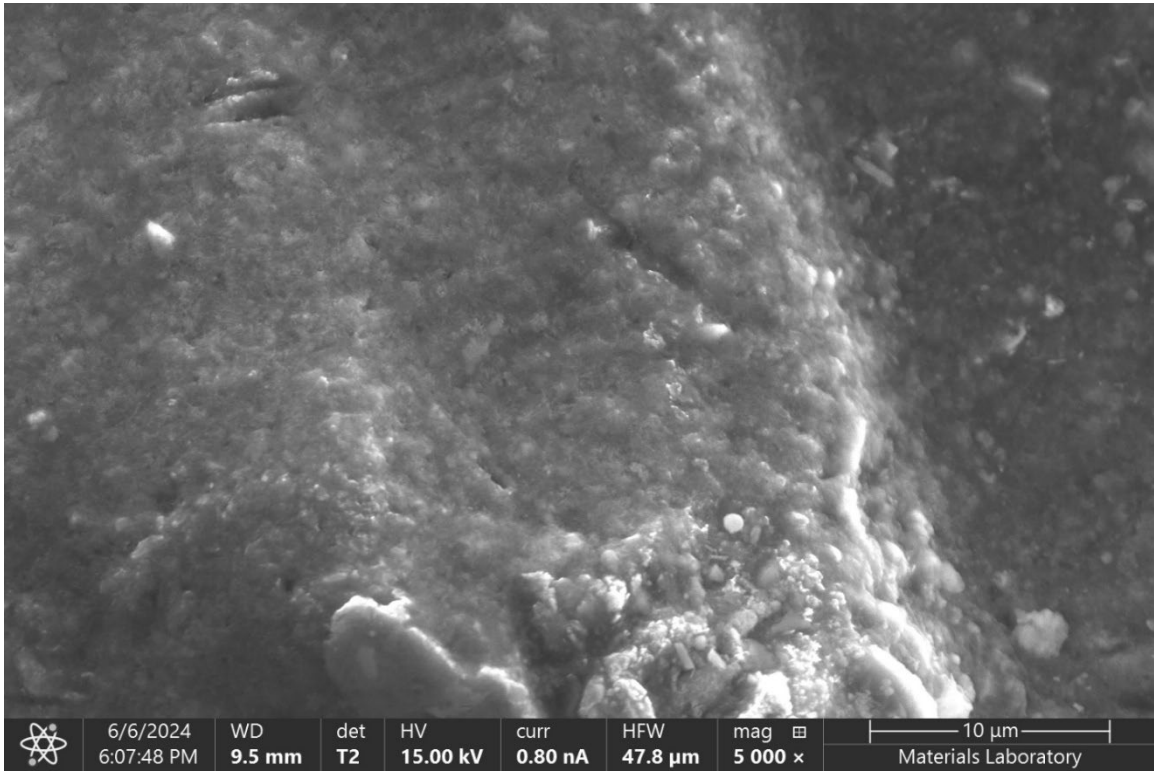


Figure 10. Secondary electron (SE) micrograph of fatigue striations, covered by an oxidation layer on the surface.

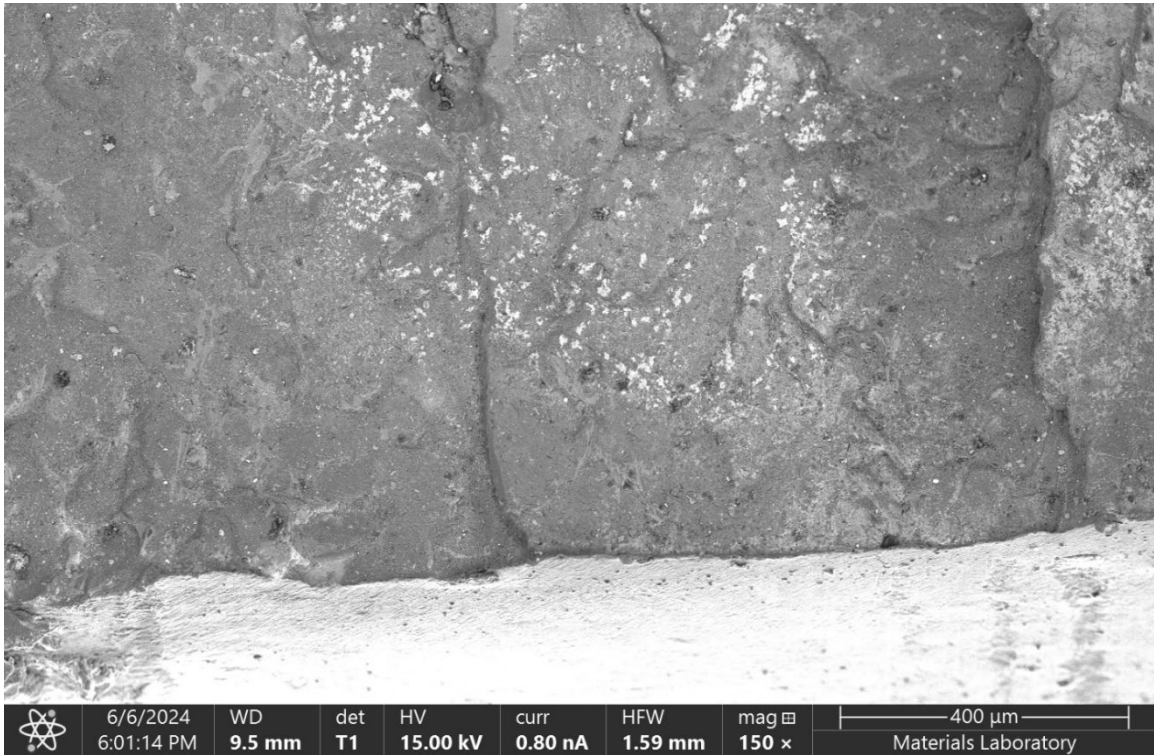


Figure 11. Backscattered electron (BE) micrograph of two individual crack initiation sites along the bore corner.

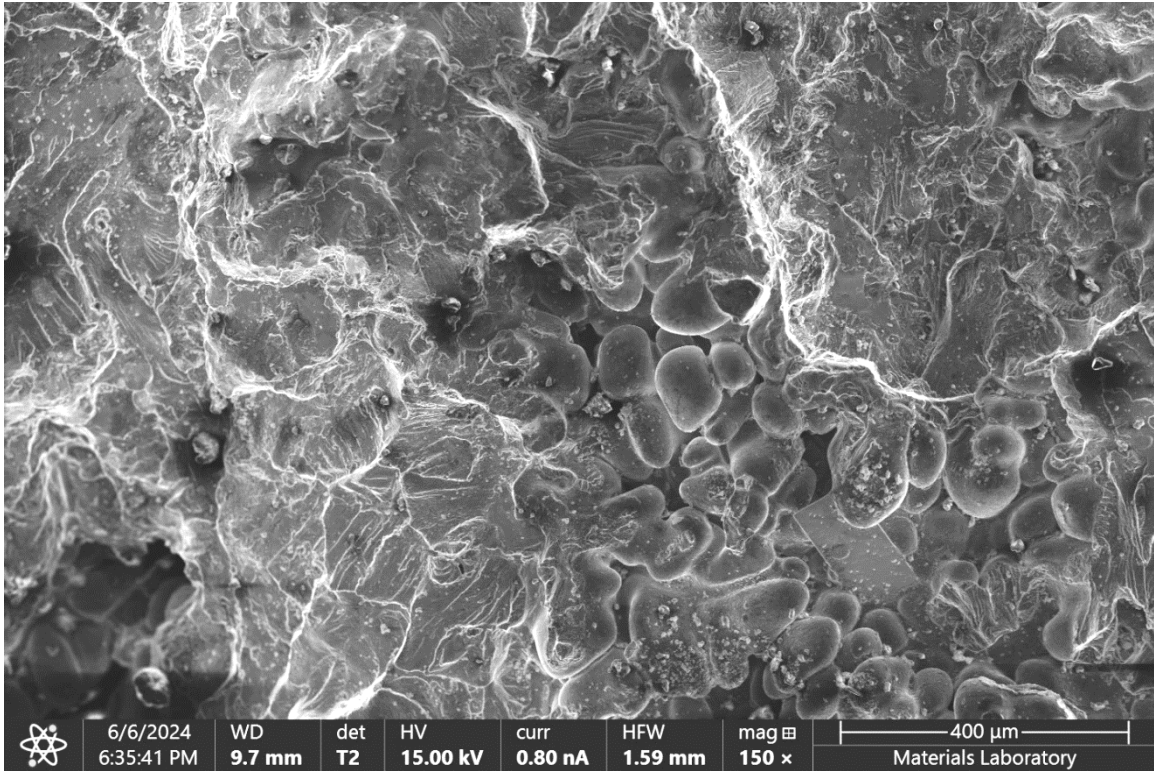


Figure 12. SE micrograph of dendritic features in the fracture surface of the housing fragment.

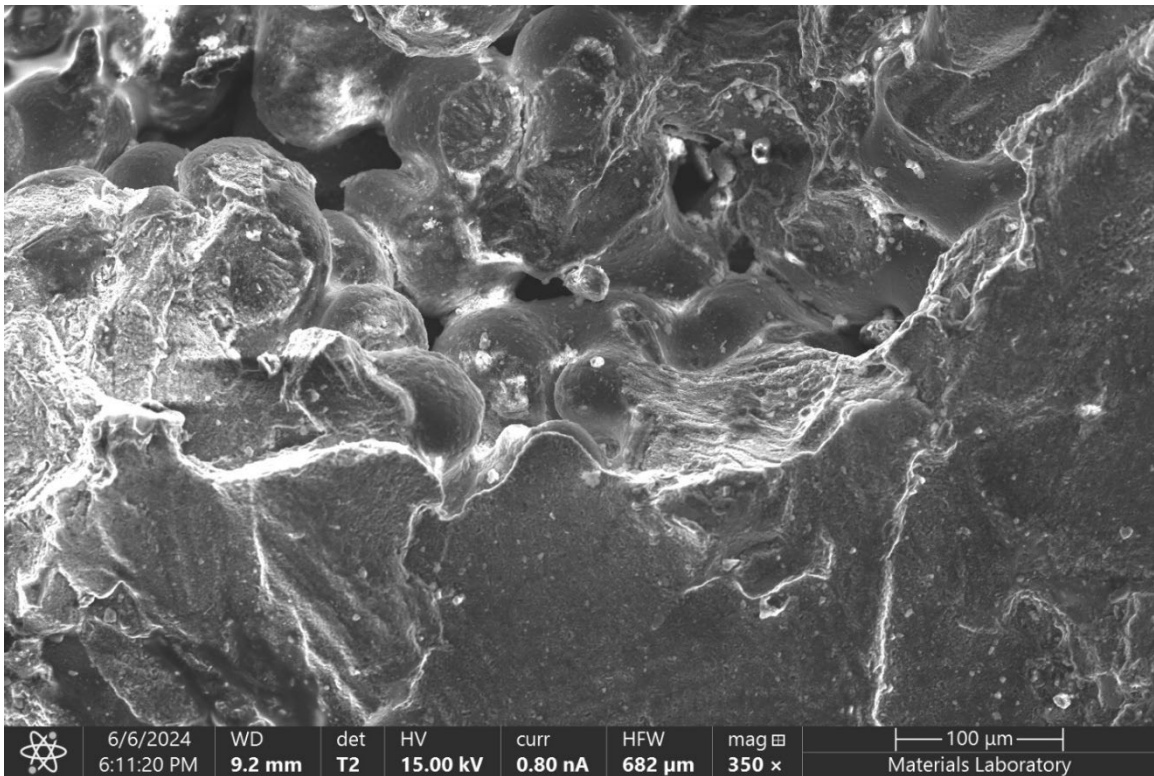


Figure 13. SE micrograph of dendritic features in a solidification void in the fracture surface.

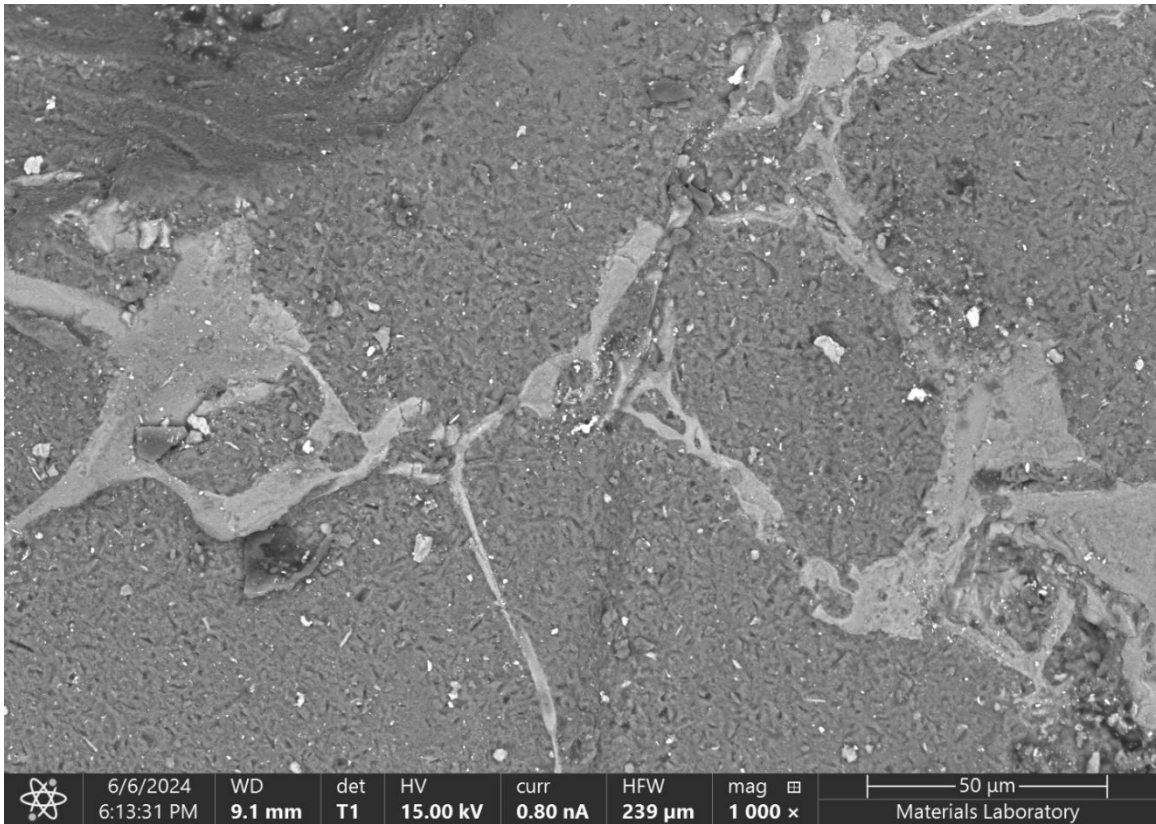


Figure 14. BE micrograph of different hue intensities consistent with interdentritic material observable on the fracture surface.