

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



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MATERIALS LABORATORY

Factual Report 25-002

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A. ACCIDENT INFORMATION

Location: Madisonville, Tennessee
Date: June 8, 2024
Time: 10:08 eastern daylight time
14:08 coordinated universal time
Vehicle: Titan T-51, N512JA
Investigator: Leah Read, AS-ERA

B. COMPONENTS EXAMINED

Left landing gear wheel tubes and sleeves
Right landing gear wheel tubes and sleeves
Tail wheel assembly remnants

C. EXAMINATION PARTICIPANTS

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

D. SUMMARY

The right lower gear weldment fractured during landing from fatigue cracking that had initiated at multiple locations on the outer surface of the weld. The fatigue cracking propagated through the weld filler up to approximately 1.6 inches in circumference. The remainder of the fracture surface exhibited features consistent with overstress. The tailwheel link, which was also broken, fractured from tensile overstress.

E. DETAILS OF THE EXAMINATION

On June 8, 2024, an amateur-built Titan T-51 airplane sustained substantial damage when it was involved in an accident at the Monroe County Airport (MNV), Madisonville, TN. The airline transport pilot sustained minor injuries. The pilot stated that after landing, there was a “shimmy” from the tailwheel, and the airplane began to veer left. During an attempted recovery, the right wing collapsed to the pavement, spinning the aircraft to the left and resulted in it coming to rest off the side of the runway.

A postaccident examination of the airplane revealed the welded joint for the left and right main landing gear lower weldments had failed. The tailwheel and the fractured weldments were retained and sent to the National Transportation Safety Board Materials Laboratory for further examination.

A review of maintenance records revealed that the last annual inspection of the airplane and both engines was completed the day before the accident on March 29, 2024. On that date, the airframe's total time in service was 6,980.8 hours. The total time since the overhaul for both engines was 196.4 hours.

Figure 1 shows the remnants of the lower gear weldments, one from each side of the airplane (right and left). Both had fractured at the upper welds, connecting the legs to the upper sleeves. As shown in Figure 2, the oval fractures at the welds were consistent with the shape of the legs at this location. One area on the right landing gear leg exhibited features consistent with fatigue crack propagation, as detailed below.

Figure 3 shows the mating sides of the left gear fracture surfaces from the left gear weldment after cleaning in an ultrasonic bath with acetone. The leg side was sectioned about 2 inches from the fracture surface. There was some visible porosity in part of the weld, particularly on the right side of Figure 3. The fracture surfaces were within the weld filler and did not exhibit features consistent with fractures in either the sleeve or leg tube.

Similarly, the right landing gear leg weldment fractures, shown in Figure 4 after cleaning, also exhibited features consistent with the fracture located in the weld filler. The faces of the leg tube and sleeve exhibited parallel and erratic marks consistent with pre-weld grinding operations. On both mating surfaces of each fractured leg, there were areas of fractured weld material on top of the bare machined tube or sleeve surfaces.

Figure 5 shows a closer view of the portion of the weld that was positioned on the right side of Figure 3a. A part of the fracture surface exhibited a flatter morphology with a darker but more reflective luster. This area exhibited crack arrest marks, consistent with progressive cracking, later determined to be fatigue crack propagation. The circumferential length of this region, annotated in Figure 5, was 1.63 inches (41.5 mm) as measured using digital calipers.

The fatigue cracking exhibited ratchet marks indicative of multiple crack initiation sites, as demonstrated in Figure 6. In all cases, the crack initiation sites were located on the outer surface of the weld.

The mating fracture surfaces of the right weldment were examined using a field emission scanning electron microscope (SEM). A typical area of the fatigue cracking is shown in Figure 7. This part of the fracture surface exhibited striations, consistent with fatigue crack propagation. The direction of the striations was from the outer surface towards the inner surface. There were multiple regions with post-fracture damage, as indicated by areas of smearing annotated in Figure 7b. Figure 8 shows a closer view of the striations and the larger-spaced crack arrest marks.

As typified in Figure 9, dimpled rupture was observed outside the fatigue region. The dimpled rupture features were located along the dull, lighter areas in Figure 5. These regions also exhibited localized thinning near the fracture surfaces, along with cup-shaped or slanted fracture orientations. These features were consistent with subsequent overstress fracture during landing.

Two areas of the mating left gear weldment fractures were sectioned, vacuum cold-mounted in epoxy, polished, and etched with a 2% Nital solution. Figure 10 shows a montage of a cross-section through the mating fractures on the left weldment. The border of the weld is outlined on the leg and sleeve sides of the fracture, along with the heat-affected zones (which exhibited larger, more equiaxed grains). The fracture was located through the weld in this location, with the general crack propagation direction annotated from outside the weld surface inward. The weld exhibited satisfactory fusion and partial penetration in this location.

An area on the right toe of the weld in Figure 10 is highlighted in Figure 11. This location exhibited a small crack (~0.002 inches) at the interface between the weld and the heat affect zone (HAZ). This crack had initiated on the surface of the weld. No cracks were observed in the heat-affected zones or other features underneath the exterior surface.

Almost all of the fracture surfaces of the left gear weldment exhibited features consistent with overstress fracture. However, much of the right side of the fracture surface of this weldment (as positioned in Figure 4) had been obliterated by smearing. There were three small areas of thumbnail cracks, as illustrated in Figure 12. These areas exhibited fatigue striations when examined using an SEM. However, they were no longer than 0.05 inches in length.

The components from the tailwheel assembly are depicted in Figure 13. Of note was the tailwheel link had fractured. As shown in Figure 14, the fracture had occurred near the ball joint at the neck. The bearing inside the ball joint had jammed, and the face exhibited severe gouging on the side facing the reader in Figure 14b. The fracture surface of the link is shown in Figure 15.

Some plastic deformation in the form of thinning or necking was observed along the sides adjacent to the fracture surface. The edges of the fracture exhibited 45° slanted orientations and were generally cup-shaped. The fracture surface exhibited a rough texture, with two areas: a dull gray outer region and a reflective metallic inner region.

The fracture surface of the link was examined using a SEM. The boundary between the two fracture regions is highlighted in Figure 16, with the inner reflective region positioned in the lower half of the figure. The outer region of the link fracture surface exhibited dimpled rupture, as typified in Figure 17. The inner region exhibited

cleavage fracture, with isolated areas of dimpled rupture (see Figure 18). These features were consistent with tensile overstress fracture of the tailwheel link.

Submitted by:

Erik M. Mueller
Materials Research Engineer

F. FIGURES

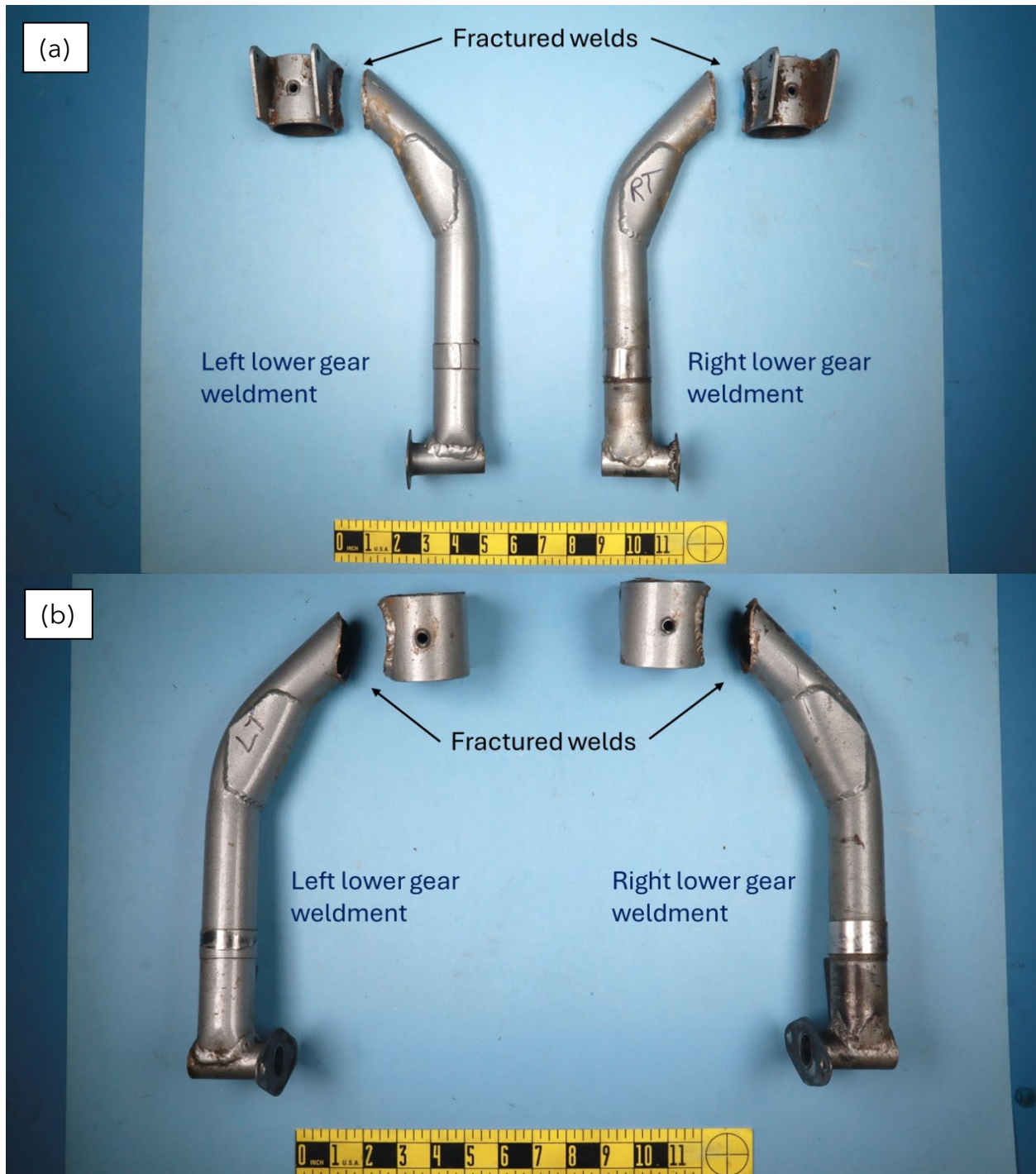


Figure 1. The (a) forward and (b) aft views of the landing gear remnants, as received.

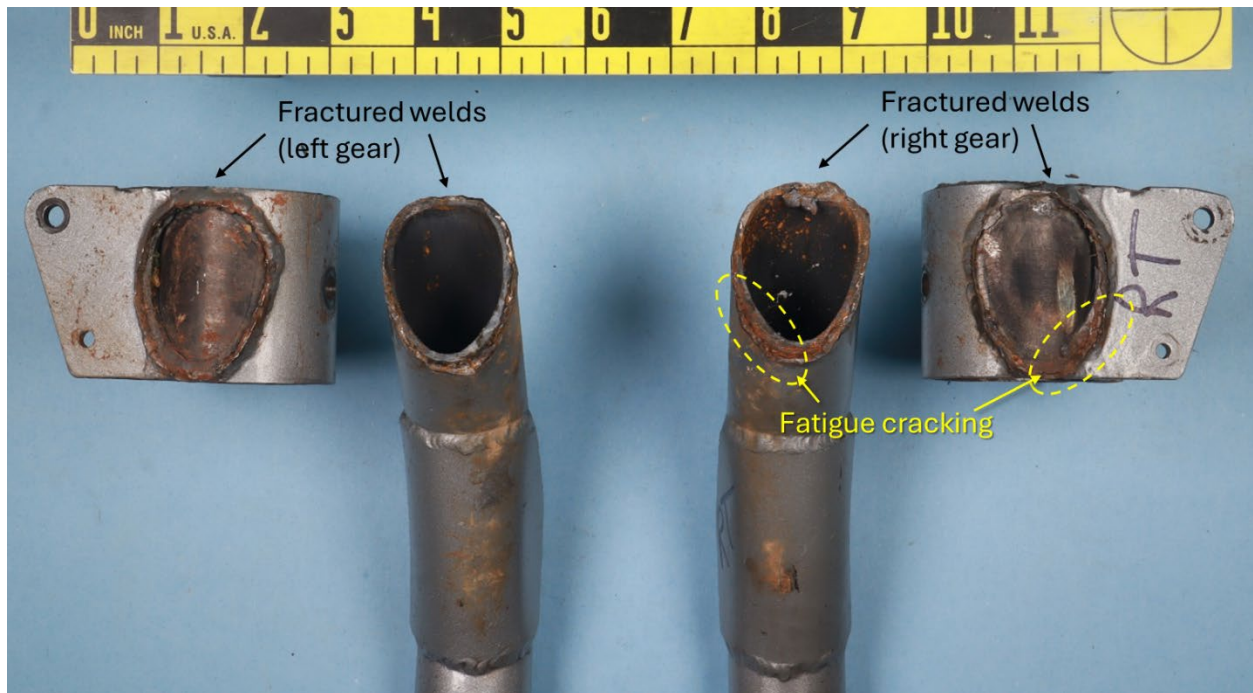


Figure 2. Views of the fracture surfaces of the legs at the weld with the strut sleeves.

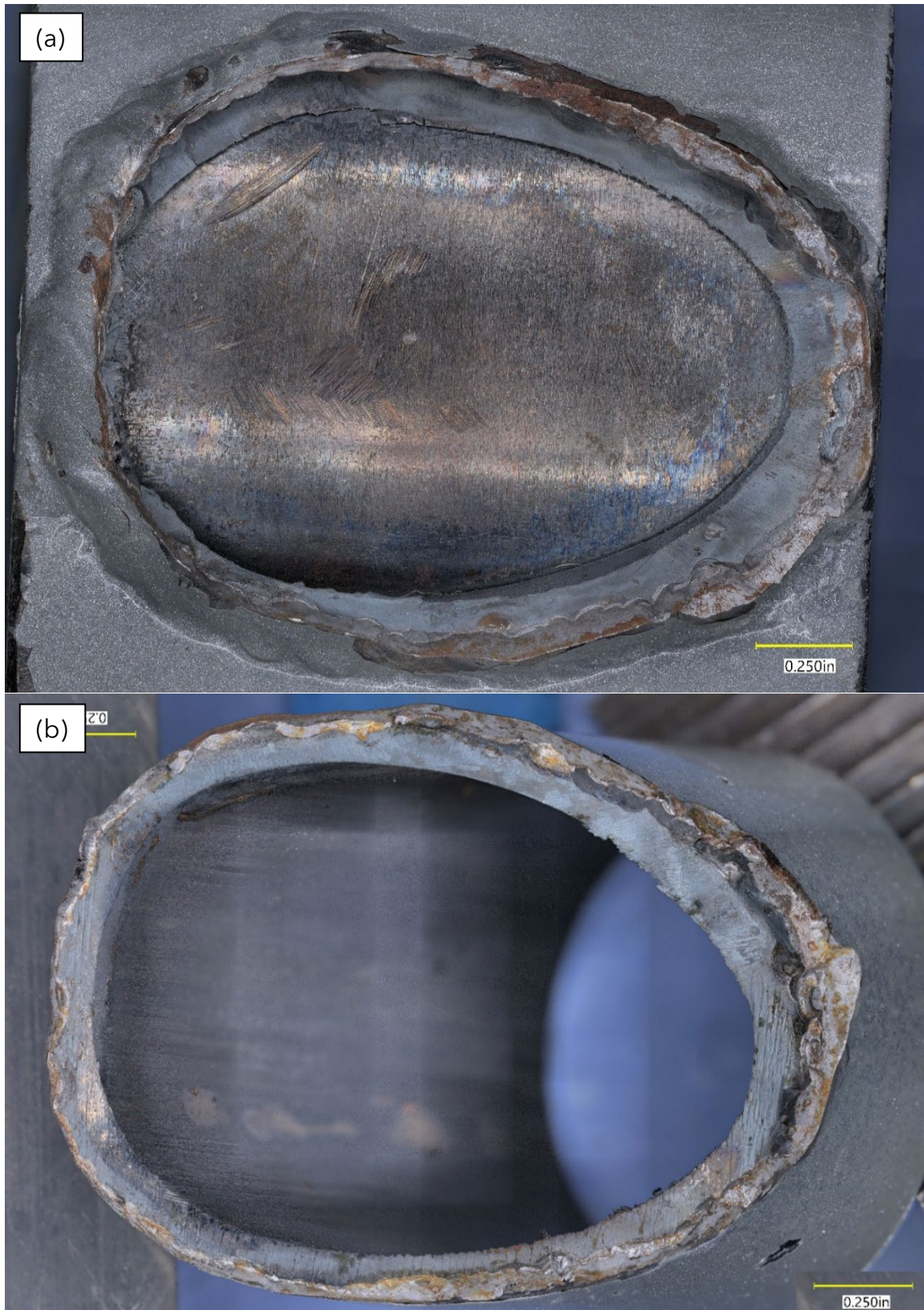


Figure 3. The fractured weld of the left gear, from (a) the sleeve and (b) the leg sides.

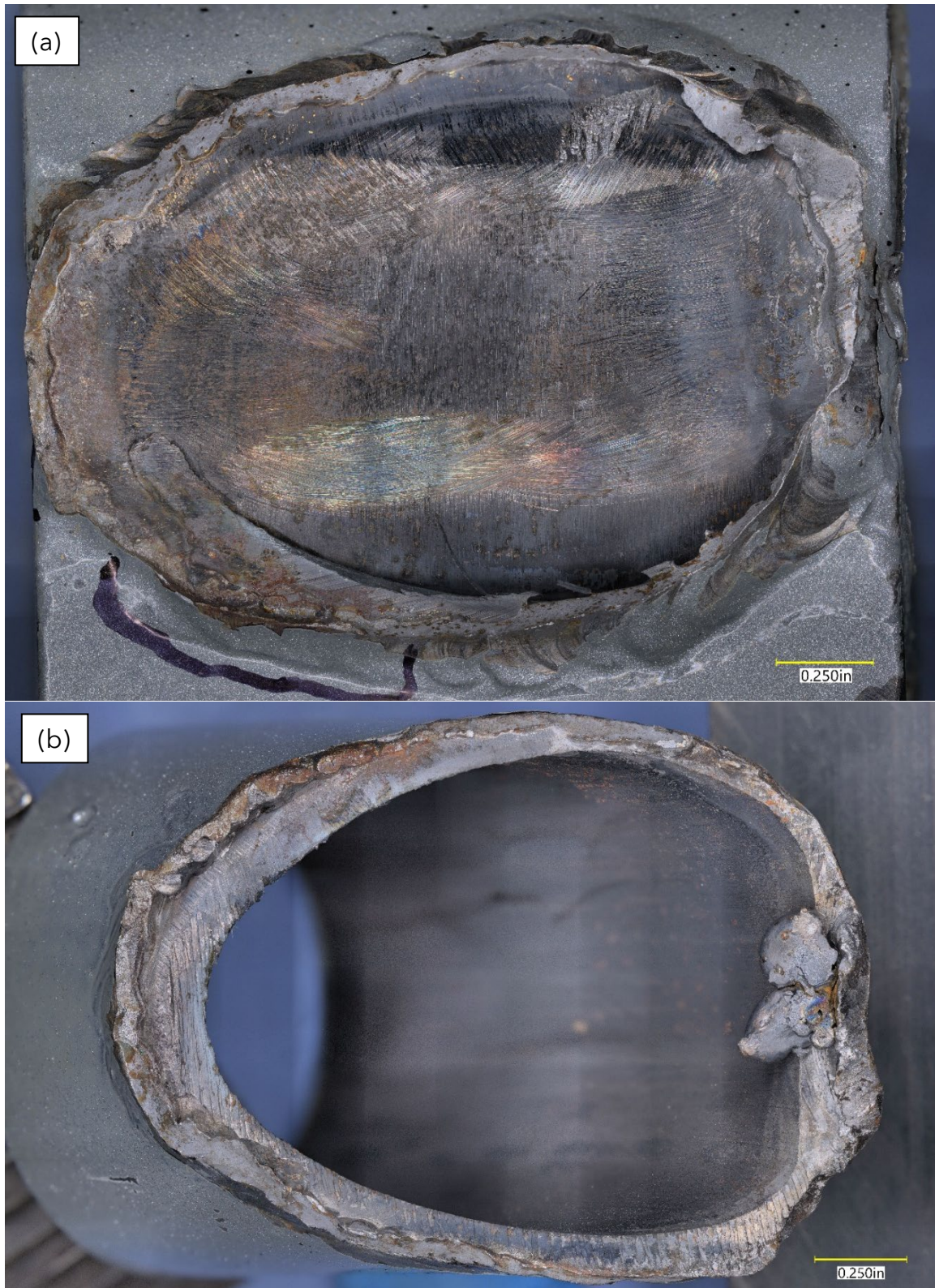


Figure 4. The fractured weld of the right gear, from (a) the sleeve and (b) the leg sides.

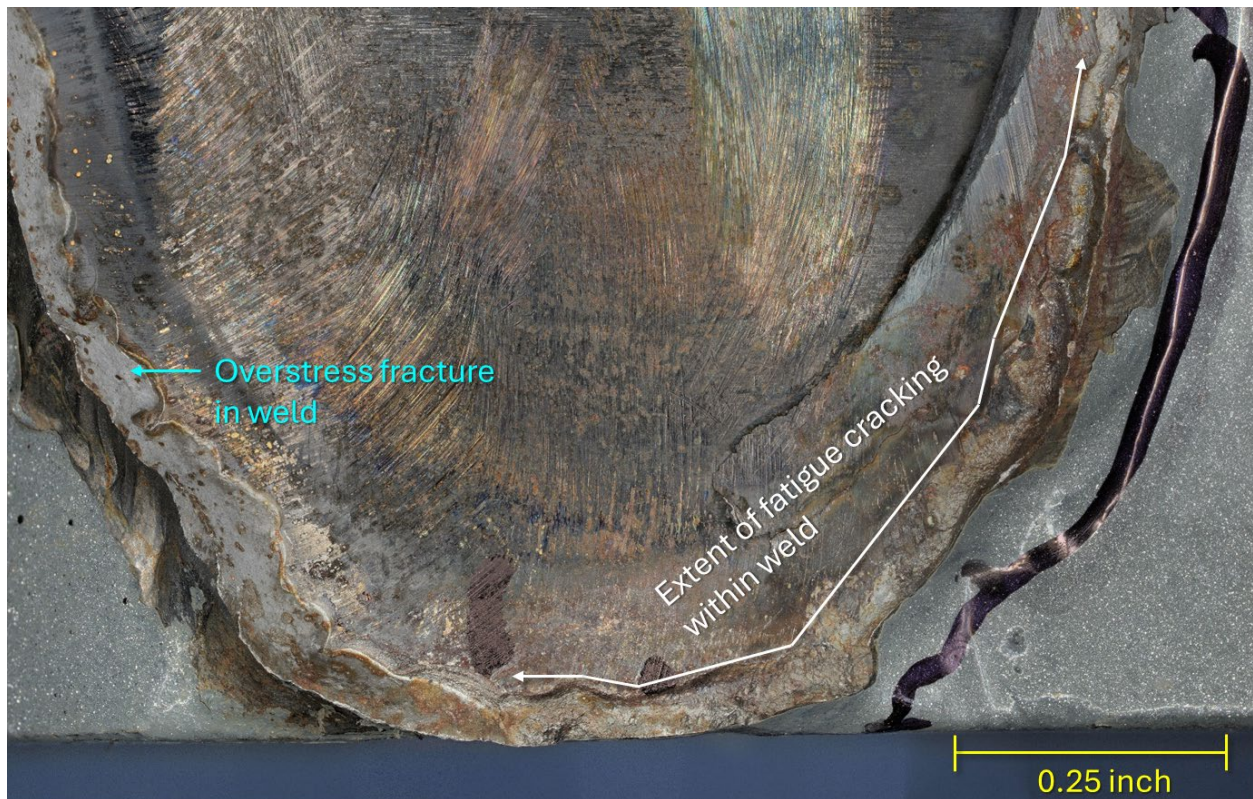


Figure 5. Closer view of the fatigue cracking (demarcated by the white line) from the fractured weld on the right landing gear sleeve.

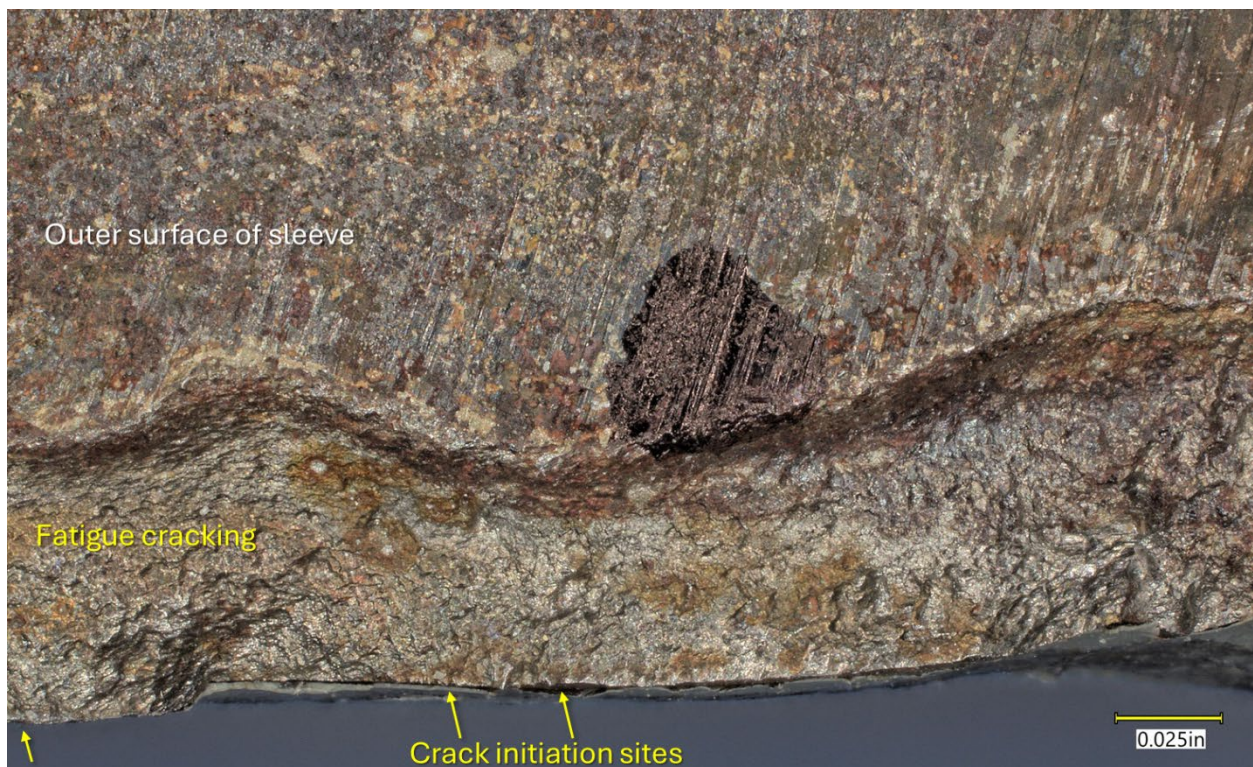


Figure 6. Crack initiation sites of the fatigue crack from the lower portion of Figure 5.

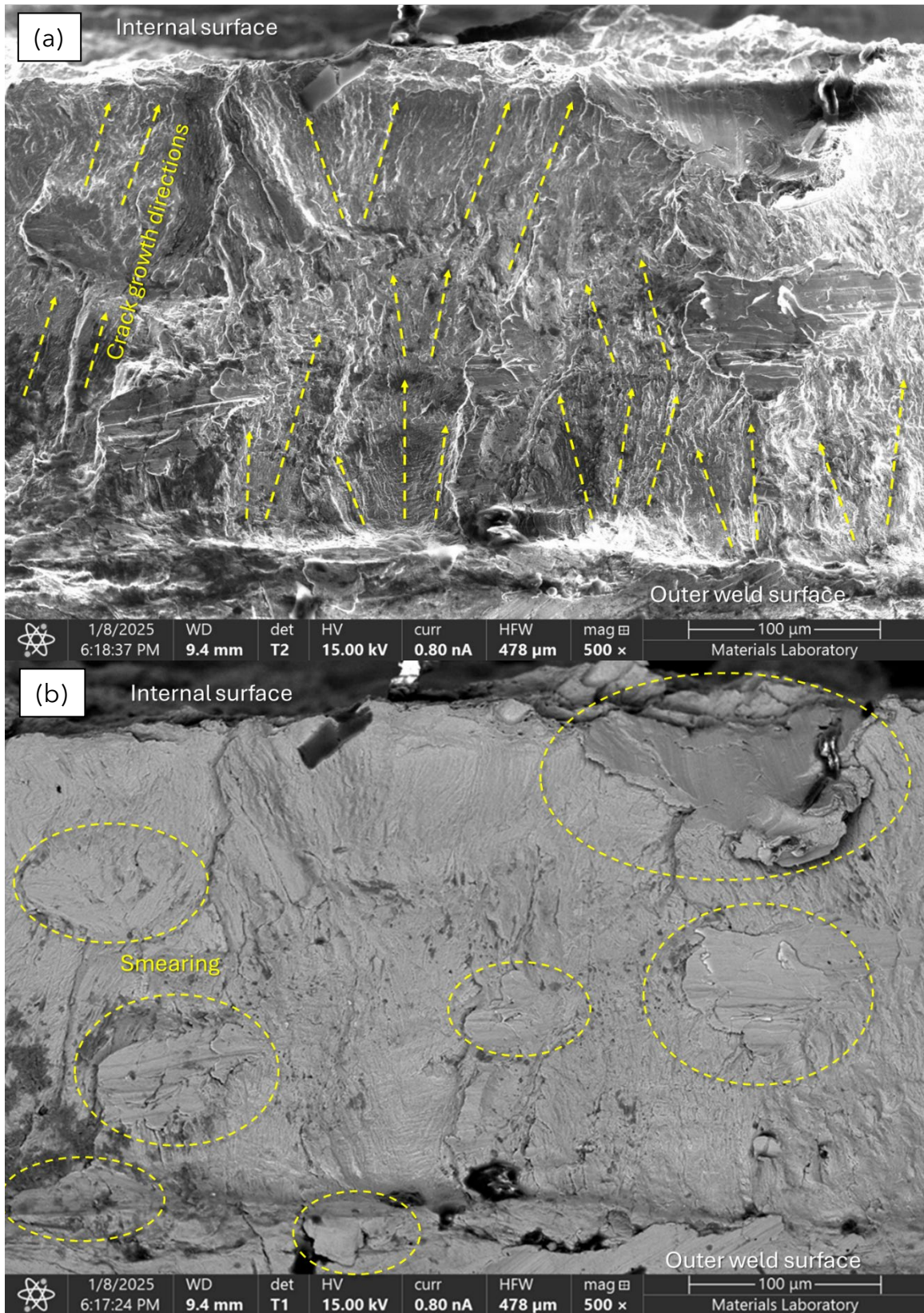


Figure 7. Secondary electron (SE) and backscattered (BE) micrographs of an area of the right leg weld fracture with fatigue cracking.

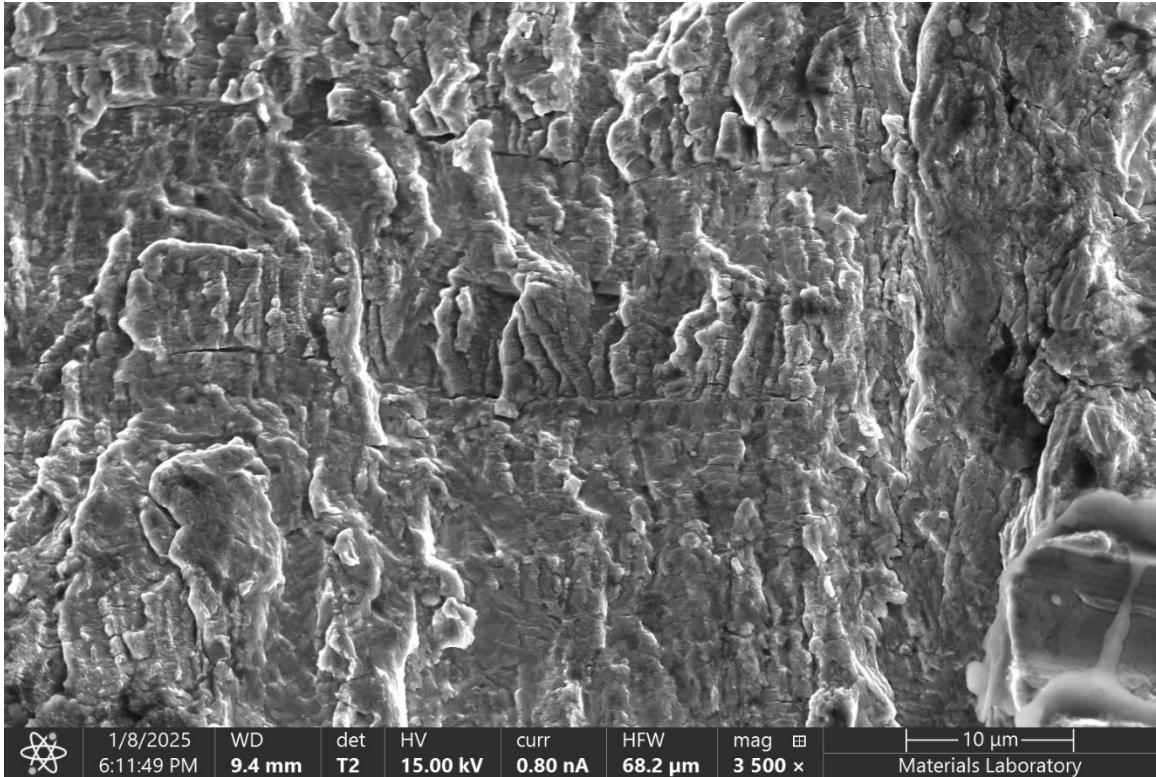


Figure 8. SE micrograph of fatigue striations on the right leg weld fracture surface.

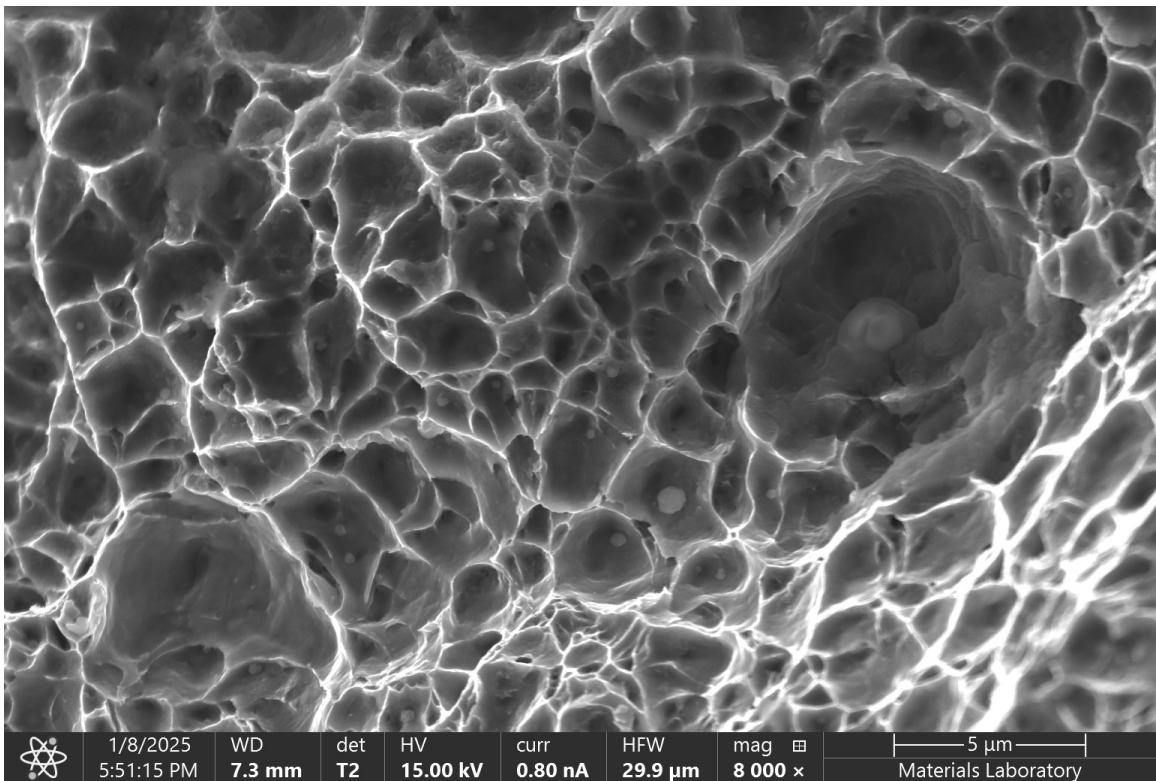


Figure 9. SE micrograph of dimpled rupture on the right leg weld fracture surface, outside the fatigue cracking.

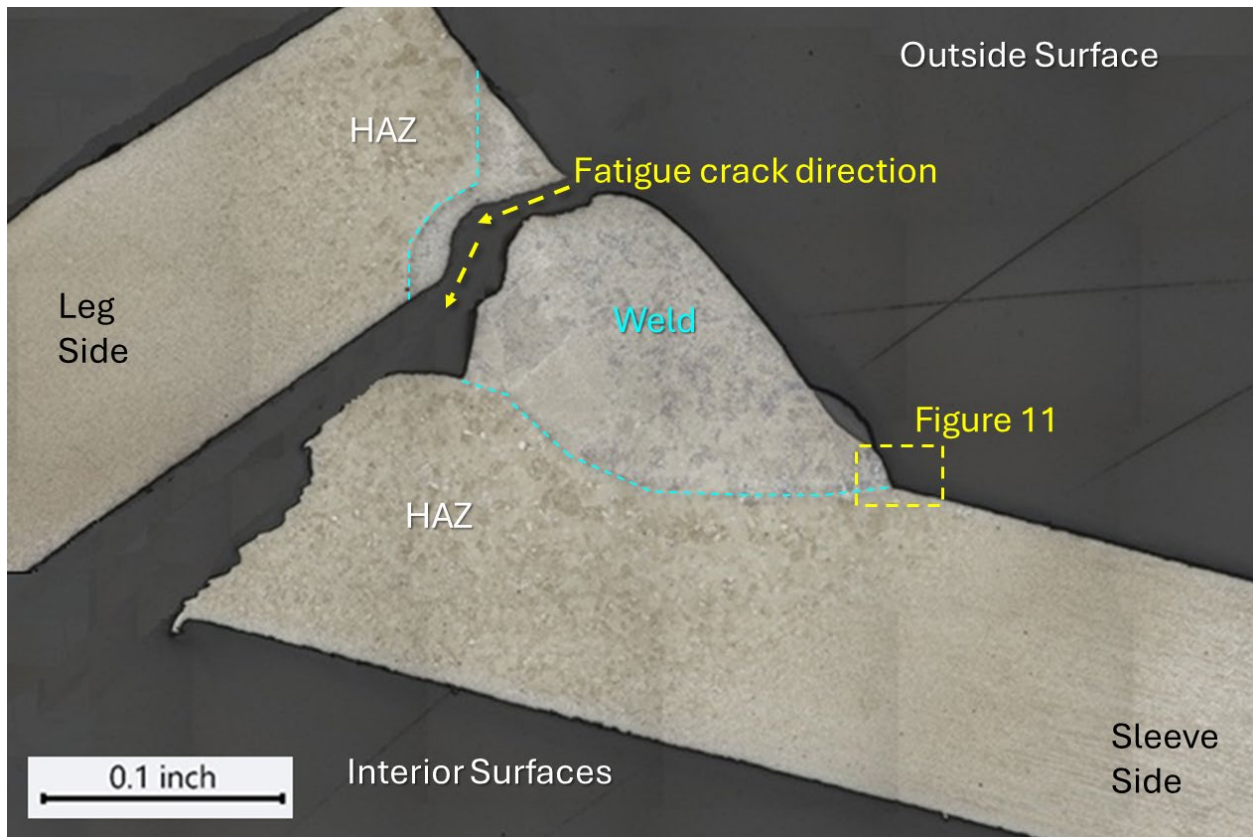


Figure 10. Montage of bright-field (BF) optical micrographs of a cross section of the reconstructed fractured weld through the mating sides of the left landing gear weld, showing areas of the weld, heat affected zones (HAZ) and the mating fracture surfaces which exhibited fatigue cracking features (~25X, etched 2% Nital).

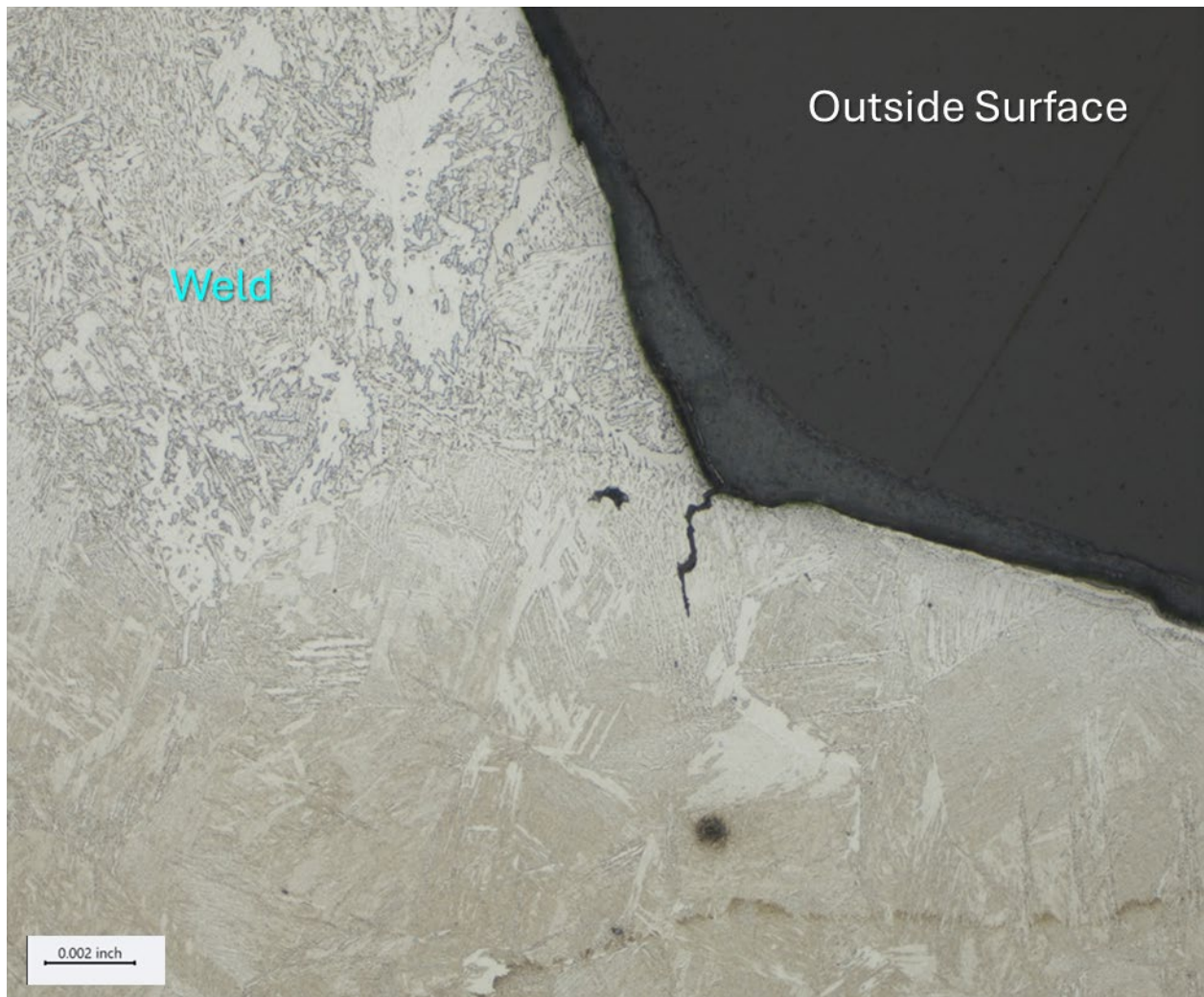


Figure 11. BF optical micrograph of a crack at the toe of the weld from Figure 10 opposite that fracture surface (located off image towards left) (~200X, etched 2% Nital).

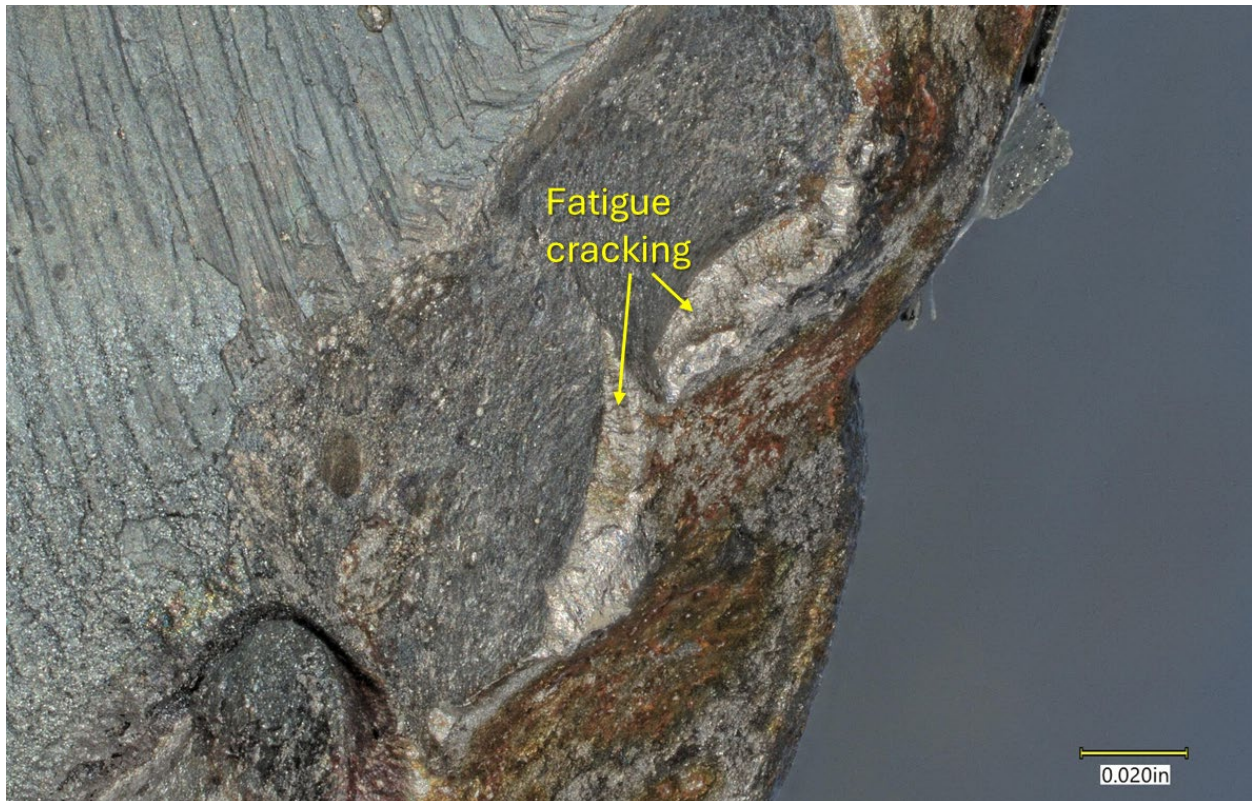


Figure 12. Isolated fatigue cracks on the left landing gear weld fracture (leg side).



Figure 13. View of the components submitted from the tailwheel assembly.



Figure 14. View of (a) the tailwheel link body and (b) a closer view of the fractured neck near the ball joint.

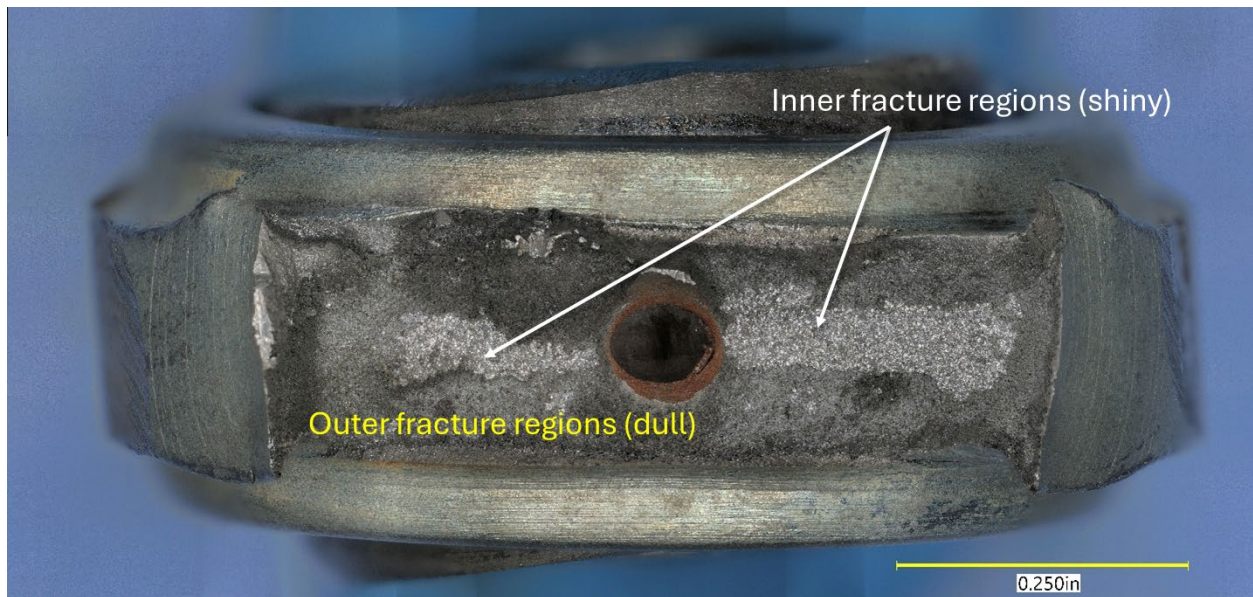


Figure 15. The fracture surface of the tailwheel link, viewed from the ball joint side.

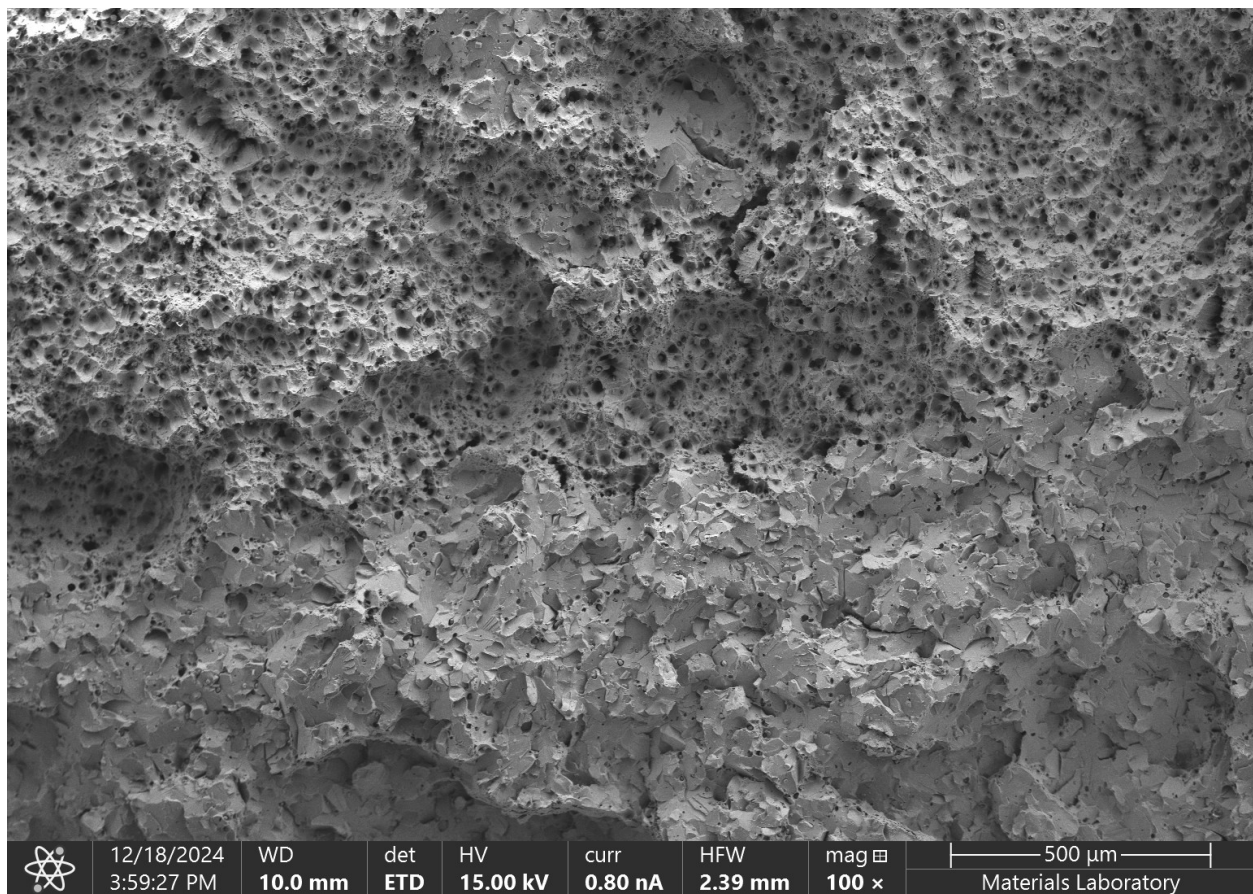


Figure 16. SE micrograph of the transition area of the tailwheel link fracture surface.

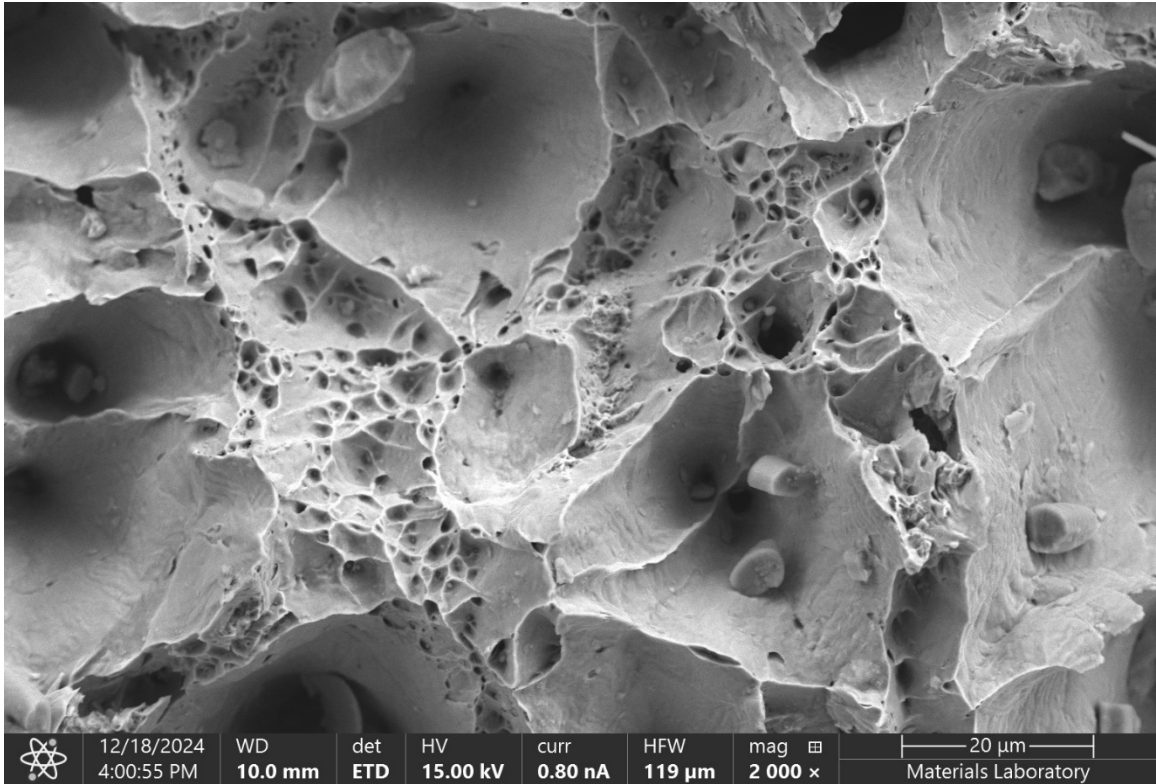


Figure 17. SE micrograph of dimpled rupture in the outer areas of the tailwheel link fracture surface.

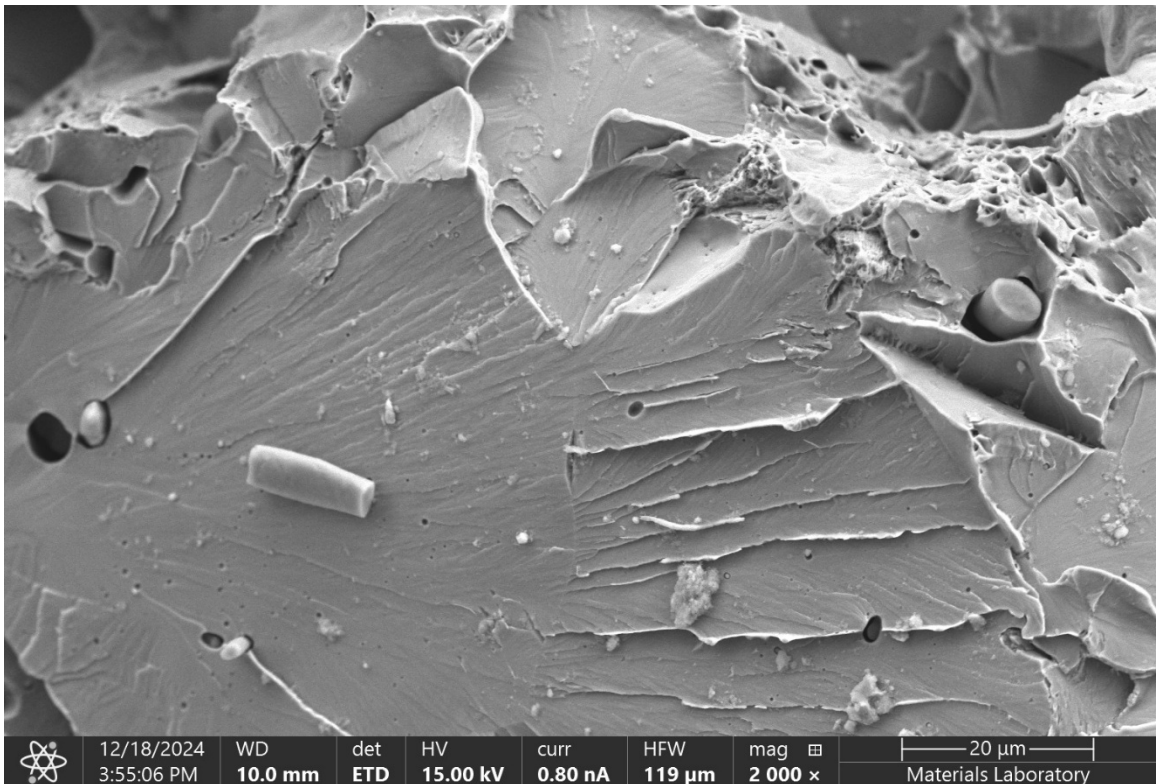


Figure 18. SE micrograph of cleavage in the inner areas of the tailwheel link fracture surface.