

National Transportation Safety Board

Office of Research and Engineering

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MATERIALS LABORATORY

Factual Report 25-015

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A. ACCIDENT INFORMATION

Location: Marshall, Indiana
Date: September 11, 2024
Time: 12:12 eastern daylight time
16:12 coordinated universal time
Vehicle: Cessna 170A, N1249D
Investigator: Mitch Gallo, AS-CEN

B. COMPONENTS EXAMINED

Cylinder assembly
Fragment of engine case
Remnants of connecting rod and cap
Pushrods

C. EXAMINATION PARTICIPANTS

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

D. SUMMARY

The connecting rod fracture features were consistent with fatigue cracking that initiated at multiple locations on the outer surface opposite the inner bearing surfaces that mated the crankshaft. These cracks propagated through most of the rod yoke arm cross sections until the remainder subsequently fractured from tensile overstress. All other fracture surfaces were consistent with overstress fracture.

E. DETAILS OF THE EXAMINATION

On September 11, 2024, a Cessna 170A was substantially damaged during an accident near Marshall, IN. The pilot received minor injuries. The pilot stated that during cruise flight, there was a loud repeating banging sound and a loss of engine power, followed by an increase in engine temperature and decrease in oil pressure. Engine oil then sprayed onto the airplane windshield. As the airplane descended, the pilot looked for an area to perform a forced landing, then landed in a cornfield where the aircraft impacted the ground and nosed over. The airplane sustained substantial damage, including the wings, vertical stabilizer, and rudder. A postaccident engine examination revealed a hole in the crankcase above the number six cylinder assembly. The number six connecting rod was fractured near where it contacted the crankshaft. Several engine components were sent to the NTSB Materials Laboratory for additional examination.

Figure 1 shows the parts received by the Materials Laboratory. These included the cylinder, which still contained a jammed piston and connecting rod assembly, two pushrods, a fragment of the engine case, and the fractured remnant of the lower connecting rod.

The fracture surfaces of the engine case fragment exhibited rough, fibrous surface textures with dull hues. These features were consistent with overstress fracture.

The other fractured parts were the fragments of the connecting rod, which had separated from the rod neck but were connected to the rod cap by attachment bolts (see Figure 2). The upper portions of the connecting rod were still attached to the piston via a piston pin (inside the cylinder). The fracture surfaces of the connecting rod fragments are highlighted in Figure 3.

As shown in Figure 4, both fracture surfaces of the connecting rod remnants exhibited crack arrest marks, consistent with progressive cracking. There were also multiple ratchet marks, indicative of multiple crack initiation sites. The general crack growth direction is annotated on Figure 4. As shown in Figure 5, these initiation sites were located along the outer surface, facing toward the attachment bolt nuts (or opposite the inner bearing surfaces facing the crankshaft journal).

Most of these initiation sites had been damaged from post-fracture smearing, as typified in Figure 6a. However, three sites (towards the right in Figure 4) had not been battered, and they displayed river patterns and crack arrest marks emanating from the fracture edge (Figure 6b).

The fractured remnant in Figure 3a was disassembled from the connecting rod cap and then cleaned in an ultrasonic bath sequentially with acetone and an aqueous Alconox solution.¹ The fracture surface was then examined using a field emission scanning electron microscope (SEM).

Figure 7 shows a view of the surface exhibiting crack arrest marks. This figure reveals striations consistent with fatigue crack propagation. Much of the fracture surface had been damaged, as indicated by the flat smearing regions shown in Figure 8. The thin area of the fracture surface outside the fatigue cracking, as annotated in Figure 4, exhibited dimpled rupture, as illustrated in Figure 9.

The crack initiation region from Figure 6b is shown in Figure 10. This location exhibited smaller ratchet marks and small smearing areas on the fracture surface. There were no material defects at the initiation site, such as inclusions or pits.

¹ Alconox is a powdered cleaning detergent, containing primarily sodium bicarbonate and sodium alkylbenzene sulfonate, manufactured by Alconox, Inc., White Plains, NY.

Likewise, no indications of mechanical defects, such as gouges or rub marks, were observed.

The chemical composition was examined using energy-dispersive x-ray spectroscopy (EDS). The composition was consistent with alloy steel. The hardness of the connecting rod was examined per ASTM E18.² The hardness averaged 31 HRC.

The connecting rod fracture surface was cross-sectioned, mounted, polished, and etched with a 2% Nital solution.³ Figure 11 shows a typical view of the section through the fracture surface, which was generally flat with no indications of secondary or branched cracking. The outer connecting rod surface did not exhibit any areas of additional cracking below the fracture.

The microstructure near the outer rod surface was finer than in the interior core (see Figure 12). Both exhibited features consistent with tempered martensite, which is typical for this material and its hardness.

Submitted by:

Erik M. Mueller
Materials Research Engineer

² ASTM E18 - *Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials*. ASTM International, West Conshohocken, PA.

³ 2% Nital - a mixture of 2% concentrated nitric acid (HNO₃) in ethanol (C₂H₅OH).

F. FIGURES



Figure 1. The cylinder, disconnected pushrods, and fractured connecting rod and engine case remnant.



Figure 2. Opposite sides of the fractured connecting rod.



Figure 3. The cap-side connecting rod fracture surfaces, of the (a) left fracture in Figure 2 and (b) the right fracture from Figure 2, which exhibited more post-fracture damage.

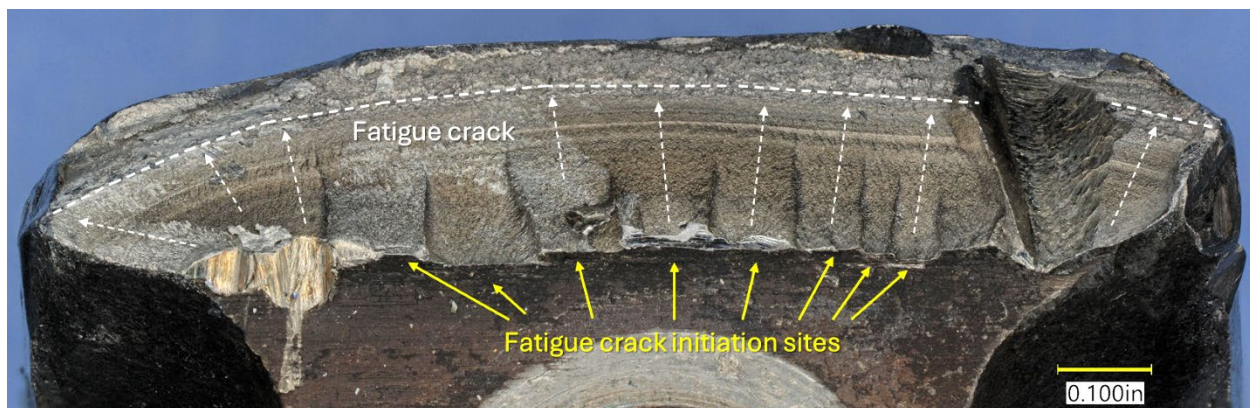


Figure 4. Montage of the left connecting rod fracture surface, annotated to show the region of fatigue cracking, crack growth direction, and several of the initiation sites.



Figure 5. Closer view of several of the initiation sites from the left of Figure 4, separated by vertical ratchet marks.



Figure 6. Closer views of (a) several of the crack initiation sites from Figure 5, and (b) a closer view of the central initiation site in 6a.

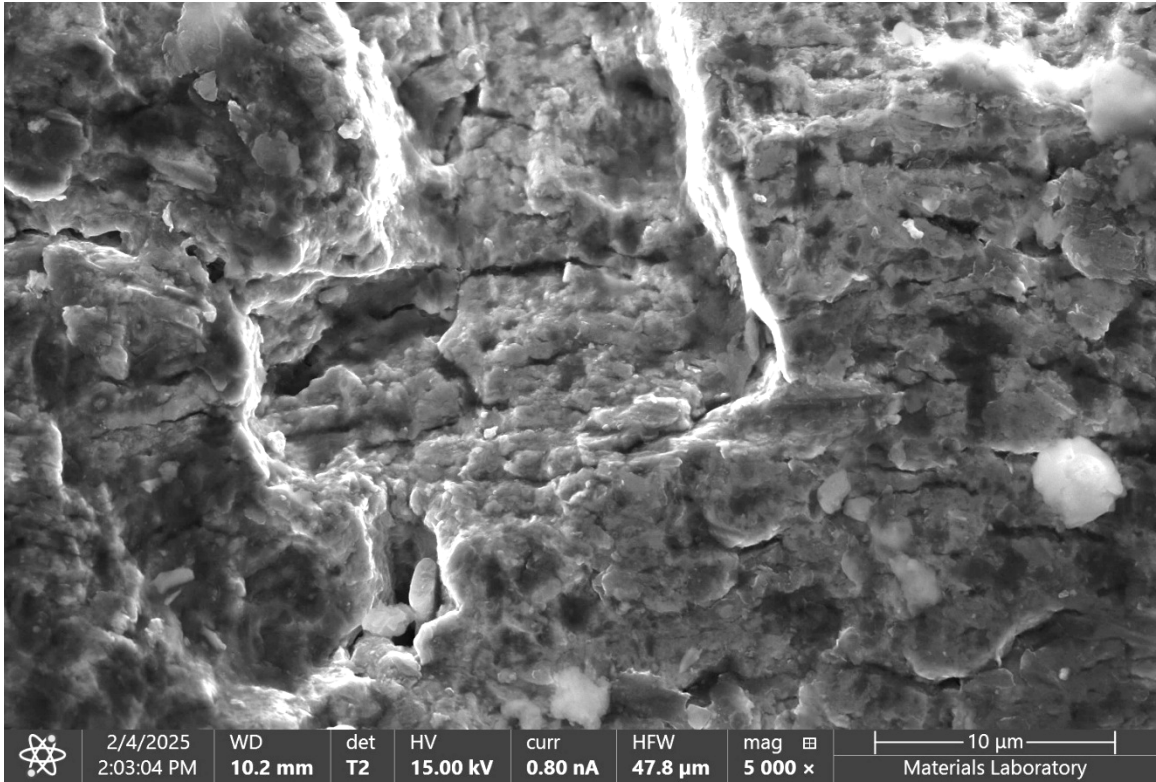


Figure 7. Secondary electron (SE) micrograph of fatigue striations on the rod fracture surface.

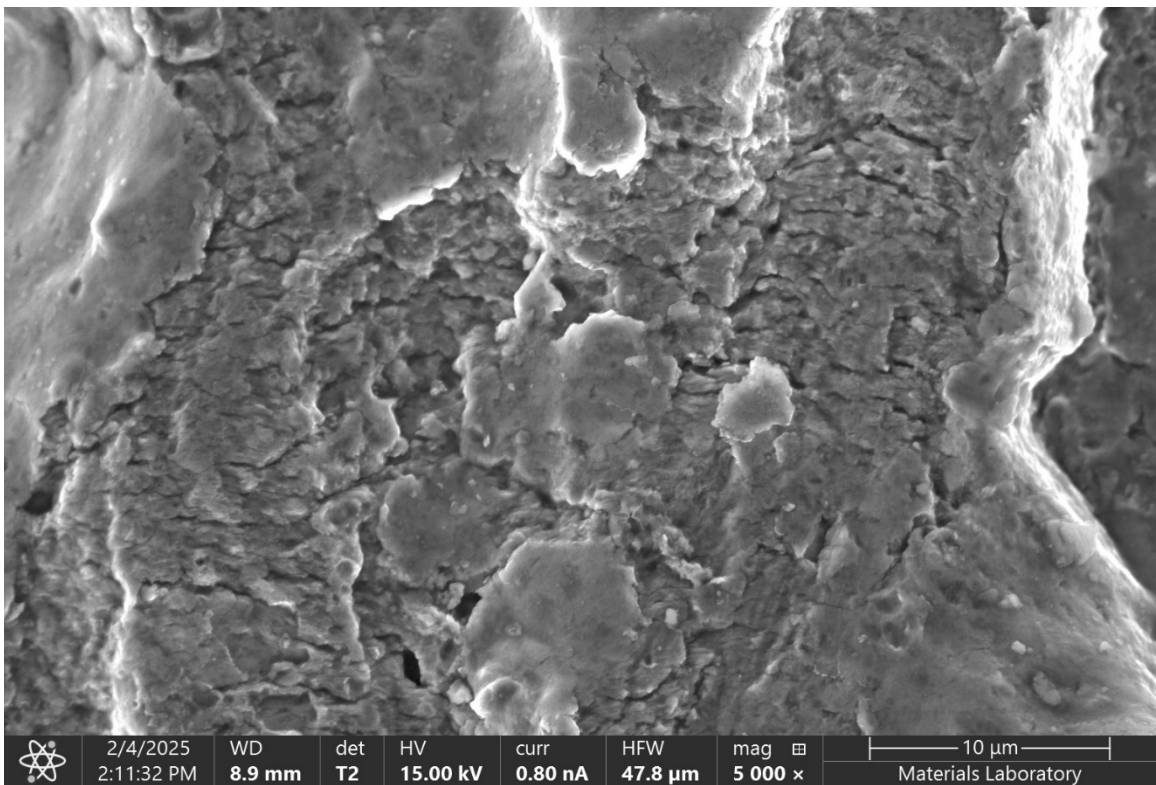


Figure 8. SE micrograph of striations amidst smearing damage, near the crack initiation area.

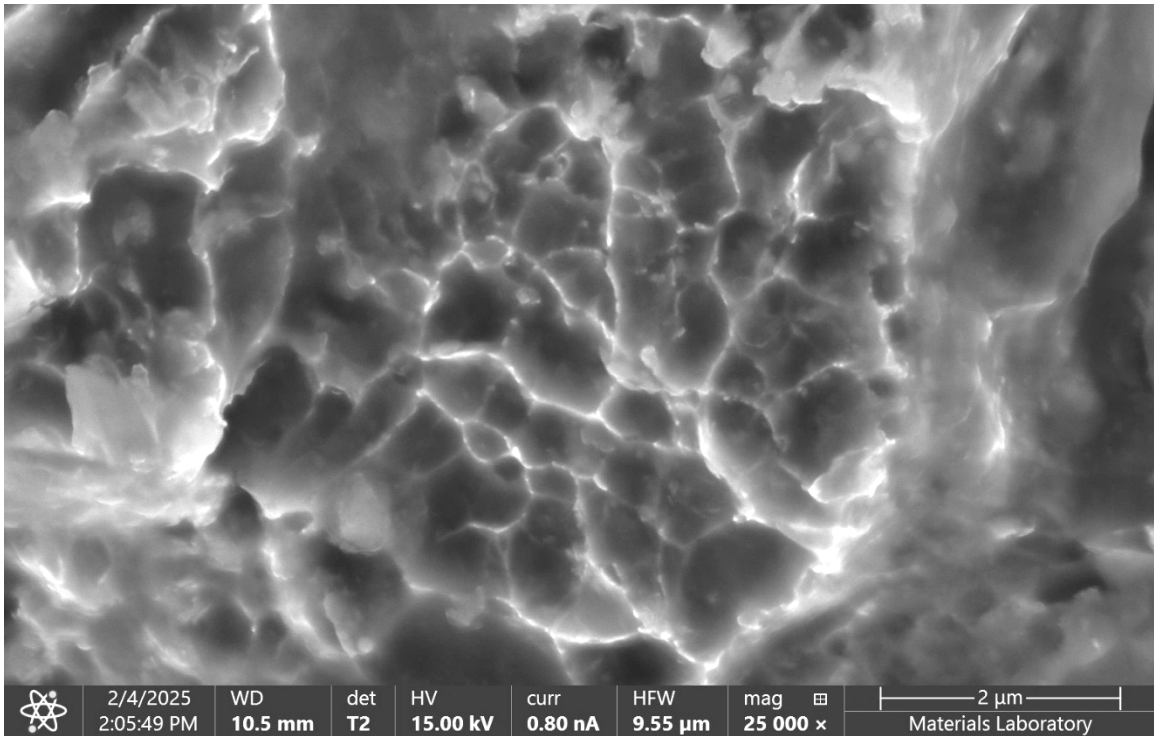


Figure 9. SE micrograph of dimpled rupture on the connecting rod fracture regions outside of the fatigue cracking.

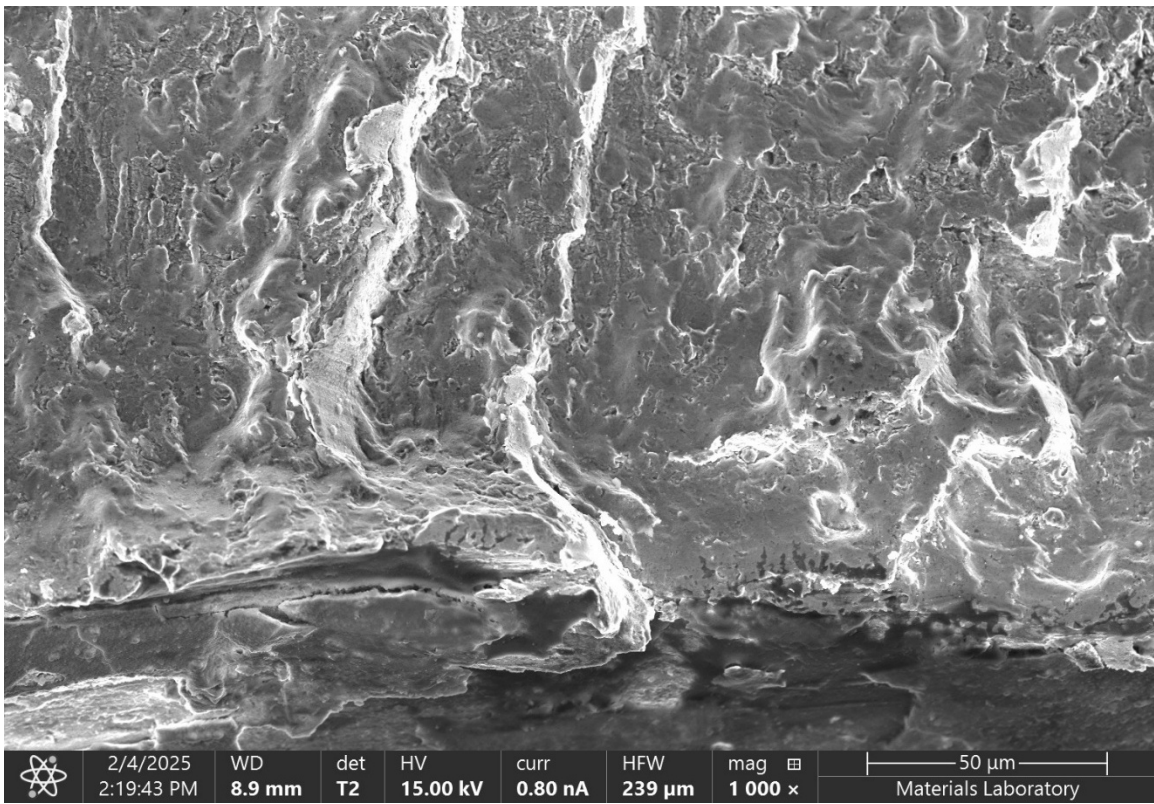


Figure 10. SE micrograph of undamaged crack initiation sites on the fracture surface edge.

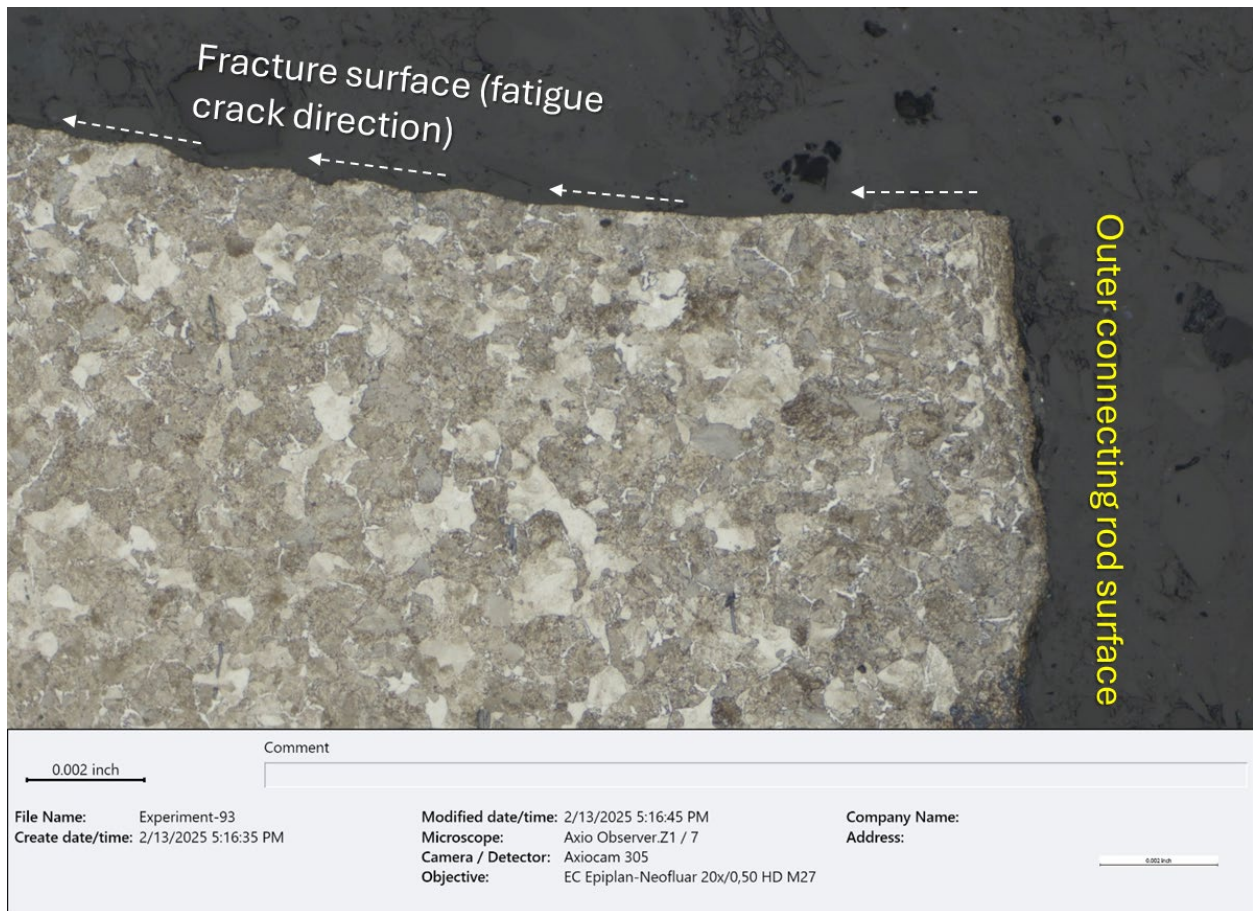


Figure 11. Bright-field (BF) optical micrograph of a cross section of the fracture surface through the initiation region (~25X, etched 2% Nital).



Figure 12. BF optical micrograph of a typical area of the connecting rod microstructure, located away from the fracture surface (~625X, etched 2% Nital).