

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594



January 19, 2018

MATERIALS LABORATORY FACTUAL REPORT

Report No. 17-088

1. ACCIDENT INFORMATION

Place : Safford, Arizona
Date : November 24, 2016
Vehicle : Cessna 182A, N6077B
NTSB No. : WPR17LA038
Investigator : Joshua Cawthra, AS-WPR

2. COMPONENTS EXAMINED

Parts of #5 cylinder and #6 cylinder

3. DETAILS OF THE EXAMINATION

On November 24, 2016, about 0850 mountain standard time, a Cessna 182A was substantially damaged during a forced landing following a loss of engine power near Safford, AZ. The commercial pilot and the three passengers were not injured. The pilot reported that during cruise flight, he noticed the oil pressure fluctuating and decided to return to the airport. Before reaching the airport, the engine lost power and the pilot initiated a forced landing. During the landing roll, the airplane struck two dirt berms and the nose wheel collapsed.

Post-accident examination of the airplane by a Federal Aviation Administration inspector revealed that the forward portion of the fuselage structure and engine firewall were structurally damaged. The wreckage was recovered to a secure location for further examination. The engine was a Continental O-470 series engine.¹ Components from the #5 and #6 engine positions were sent to the NTSB Materials Laboratory for examination.

3.1. Components from the #5 Cylinder Position

The components from the #5 engine position are shown in Figure 1, as received (except for a small bag of miscellaneous piston parts, shown later). All of the submitted pieces exhibited damage significant enough to deform the outer surfaces. Some of the pieces had been so damaged, they could not be readily identified. All of this damage was consistent with post-fracture damage while the engine was still running.

¹ The Continental O-470 is a family of six-cylinder, horizontally opposed, air-cooled aircraft engines developed for use in general aviation aircraft.

Figure 2 shows all the components submitted from the #5 connecting rod assembly. As shown in the figure, all of the pieces exhibited severe batter and deformation. The center of Figure 2 shows the remainder of the bushing and bearing pieces. These pieces had been so battered that they had folded in on themselves. No discernible features prior to this folding deformation could be observed.

Figure 3 illustrates the condition of the connecting rod bolts. Both bolts had fractured at midlength, consistent with where the faces of the cap and connecting rod mate. Both bolts exhibited necking adjacent to their fracture surfaces. The fracture surfaces were generally oriented 90° toward the bolt length and exhibited a rough texture and dull luster. These features were consistent with the bolts having fractured from tensile overstress.

Figures 4 through 6 illustrate the connecting rod body, as received. The markings on the connecting rod (Figure 4) stated "ATLAS 16 40742". As shown in the figures, the connecting rod was severely battered. The end facing the crankshaft had been battered into a "mushroom head" shape and the web of the rod had been deformed approximately 30° out of plane.

The most notable feature on pin side bore was the fracture at the neck yoke of the rod web, shown in Figures 5 and 6. A portion of the pin bore wall was sectioned away to observe the fracture surfaces. Figure 7 shows the connecting rod pin bore after this sectioning. As shown in the figure, the rod bore exhibited deformation consistent with having been twisted about the piston pin. The inner bore surfaces exhibited circumferential scoring marks. This surface also exhibited discernible rust, consistent with later exposure to water or humidity after the engine ceased functioning properly.

The fracture surface of the sectioned pin bore wall is shown in Figure 8. This fracture surface had been damaged by post-fracture batter and deformation. The areas adjacent to the fracture surface exhibited local thinning, or necking. The undamaged portion of the fracture surface exhibited a dull gray luster with rough surface texture. Examining this fracture surface using a scanning electron microscope (SEM) revealed dimple rupture. All of these features were consistent with fracture from overstress. In addition, examination of the mating fracture surface revealed similar features, with no indication of other fracture features.

The three portions of the connecting rod cap are shown in Figure 9. The cap had fractured in two places, and the previously curved cap had been deformed outward in an almost flat orientation. The fracture surfaces, along with the other surfaces of the cap, exhibited severe post-fracture damage in the form of batter, gouging, and scraping. The gouging marks on the inside bearing surface were consistent with either the cap being bounced around after fracture/separation or having an adjacent object impressed into the cap.

Figure 10 illustrates the pieces of the piston pin, as received. Both endcaps of the pin had fractured away, but only one of the cap remnants was received. The outer surface

of the pin exhibited batter and gouge marks, as well of surface rust consistent with post-fracture exposure to water or humidity. The mating fracture surfaces of the pin and pin endcap fragment are shown in Figure 11. Both fracture surfaces had been extensively damaged, consistent with post-fracture impact. No discernible information could be obtained from examination of the fracture surfaces.

The piston is shown in Figures 12 through 14. The majority of damage to the piston was present on the underside of the part to the skirt flanges, shown in Figures 12 and 14. The crown or head of the piston facing the cylinder interior exhibited some combustion deposits, but there were no features consistent with severe wear, impact, or thermal damage. The underside of the piston exhibited small gouge and batter marks, consistent with impact with multiple metallic pieces.

The lower portions of the piston, including those surrounding the piston pin boss, had fractured into many multiple pieces, collected and illustrated in Figure 15. All of the fracture surfaces examined exhibited features consistent with overstress failure of aluminum castings—rough and tortuous surfaces, dull luster, and no indications of pre-existing cracks or discontinuities. The oil and guide rings were found relatively undamaged.

Examination of the chevron marks and river patterns on the piston fracture surfaces found that they were consistent with fracture beginning from the inside of the piston. These general directions are annotated on Figure 12. Many of the fracture features were consistent with having emanated from the piston pin boss.

3.2. Components from the #6 Cylinder Position

The components from the #6 engine position are shown in Figure 16, as received. While all the submitted pieces exhibited damage significant enough to deform the outer surfaces, this damage was less than those observed on the components received from #5 engine position. This damage was consistent with post-fracture damage while the engine was still running.

Figure 17 shows the connecting rod components, as received. The markings on the web of the connecting rod stated, "ATLAS 17 40742". The connecting rod components had been damaged with batter and other post-fracture damage, but the degree of damage was less than that of the components of the #5 connecting rod.

The bolts from the connecting rod are shown in Figure 18. Both bolts had fractured at midlength, consistent with where the rod and cap mate. The areas on the bolts adjacent to their fracture surfaces thinned down, or necked. The fracture surfaces themselves exhibited a 45° slant. These features were consistent with fracture from tensile overstress.

Figures 18 through 20 show the condition of the connecting rod cap. From Figure 18, the cap had been deformed, consistent with having been bent inward about the uppermost point in Figure 18. Figure 19 shows the inside bearing surface of the rod cap—this surface was relatively undamaged, exhibiting no indications of significant wear or

damage. The top or exterior of the cap is shown in Figure 20. One of the bolt fragments was still present and lodged into one of the bolt holes. All the surfaces in this view exhibited deformation and batter. Most notably, a large 1 inch smear was present on the apex of the rod cap, consistent with contact with an adjacent component.

Figure 21 shows the connecting rod, as received. The crankshaft side of the connecting rod had fractured near the yoke neck. The pin side of the rod arm was relatively undamaged. The bushing was still present inside the pin bore of the rod.

Figure 22 shows the inner bearing surface of the connecting rod that had faced a crankshaft journal surface. This surface exhibited some wear marks, consistent with sliding in a lateral direction. In addition, some material smearing outward of the bearing surface was present on the left side of Figure 22.

The fracture surface of the rod arm remnant is shown in Figure 23. The fracture surface was generally dull in luster, with post-fracture iron oxide (rust) corrosion and smearing damage on the outer regions of the fracture surface. Examination of the undamaged portions of the fracture surface using an SEM revealed dimple rupture, consistent with overstress.

Figure 24 shows the remnants of the crankshaft side bearing materials from the connecting rod. These pieces had been severely deformed and fractured in several places. However, there were no indications of material thinning or exposure of the underlying babbitt material on the bearing. These features were consistent with the bearing having deformed and fractured after engine failure began.

Figures 25 through 27 show the #6 piston, as received. This piston was less damaged than the #5 piston. The underside had exhibited one primary fracture along a skirt flange, as seen in the top of Figure 25. The top of the piston, shown in Figure 26, exhibited two regions with smeared material, consistent with impact or rubbing of an adjacent component, or post disassembly handling. Examination of the side of the piston found little additional damage, excepting the aforementioned piston skirt fracture (Figure 27). The compression and oil control rings were in place and undamaged.

Erik M Mueller
Materials Research Engineer



Figure 1 – The components of the #5 engine position (less the connecting rod shaft), as received.



Figure 2 – The received pieces of the #5 connecting rod, cap, and bolts.



Figure 3 – Closer view of the bolts from the #5 connecting rod, as received.



Figure 4 – The web and camshaft bearing of the #5 connecting rod, as received.



Figure 5 – The #5 connecting rod, rotated 90° from Figure 4.



Figure 6 – The #5 connecting rod, side opposite of the one in Figure 4.



Figure 7 – The pin side of #5 connecting rod, after sectioning the fractured bore half away.

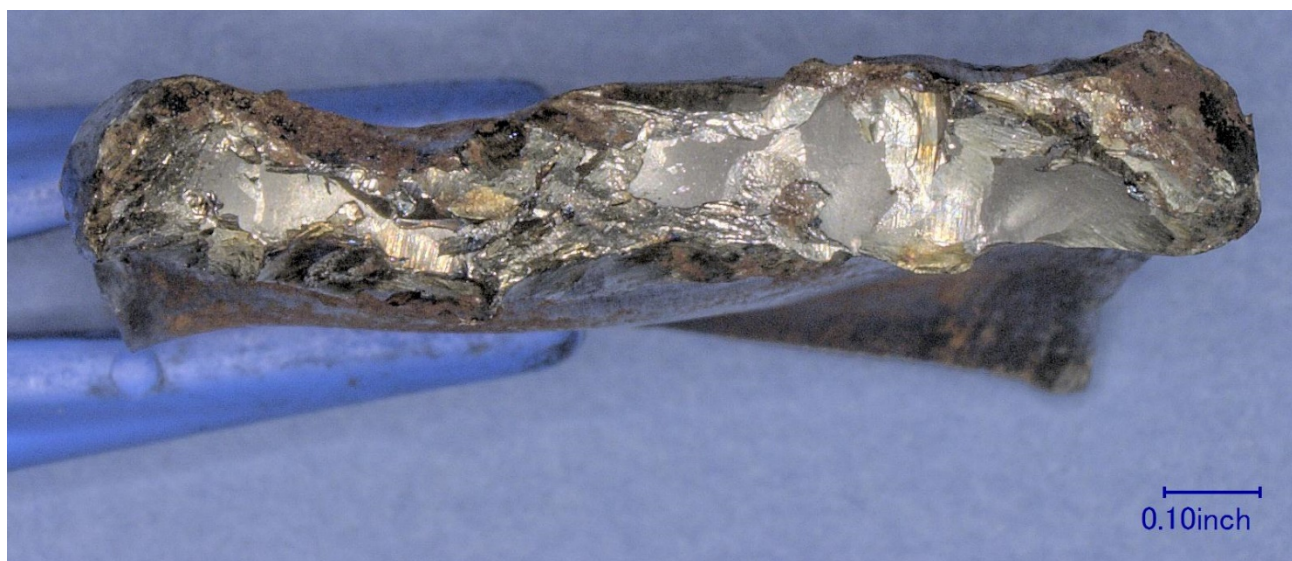


Figure 8 – The fracture surface of the sectioned bore half from the #5 connecting rod pin side bore.



Figure 9 – The inside bearing surfaces of the #5 connecting rod cap.



Figure 10 – The pieces of the piston pin from the #5 piston.

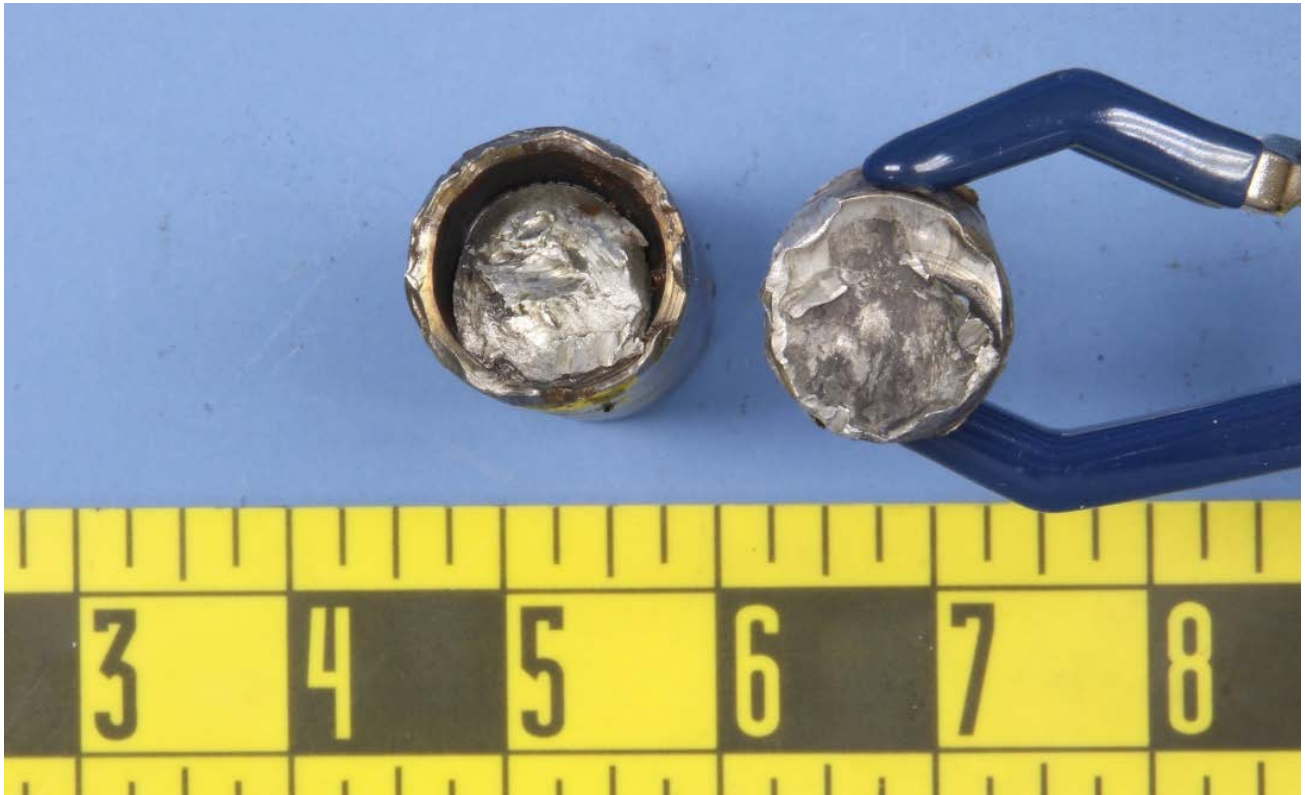


Figure 11 – The battered fracture surfaces of the #5 piston pin pieces.

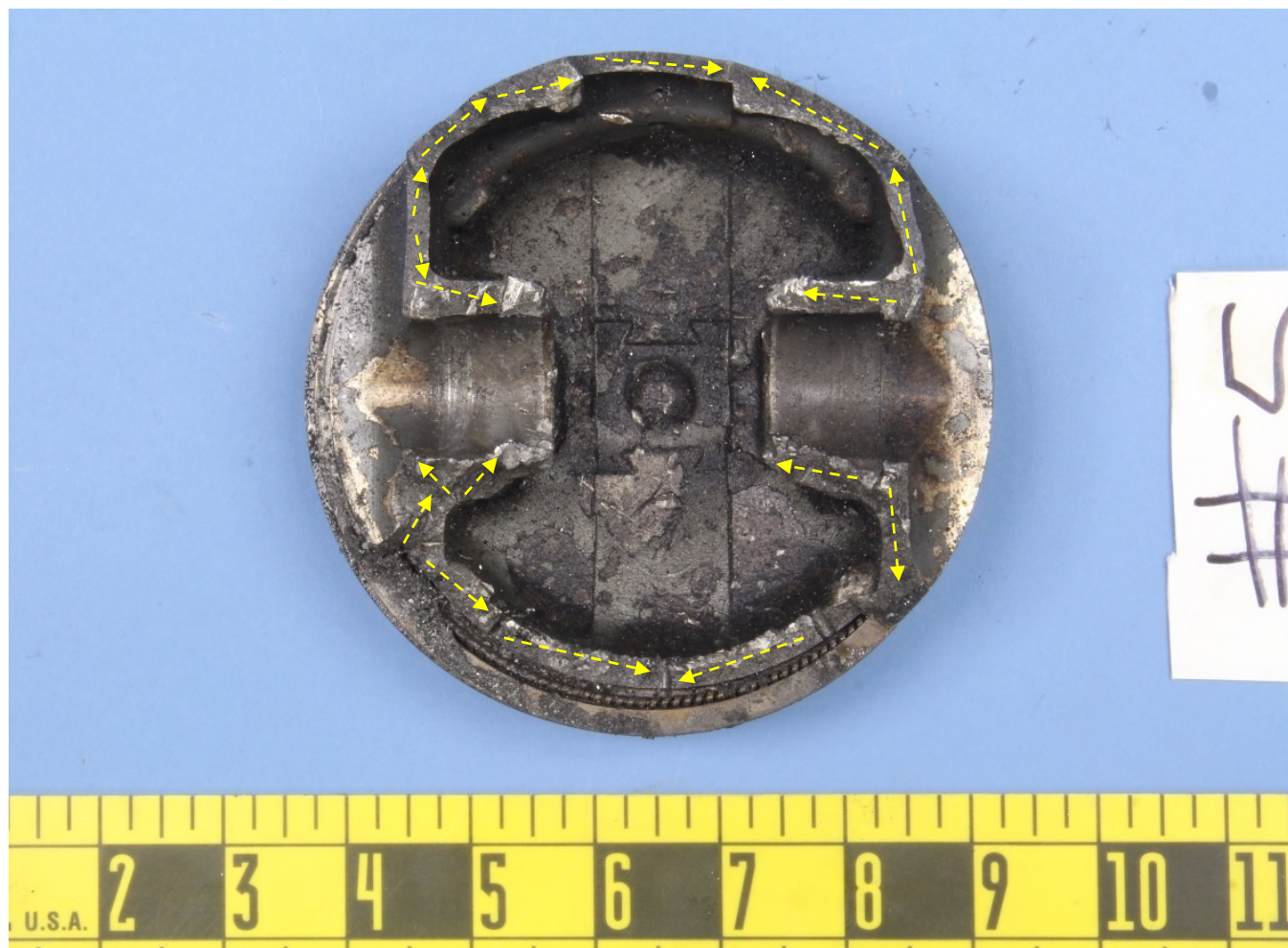


Figure 12 – The underside of the #5 piston crown, showing fracture surfaces of the skirt. The yellow dashed arrows indicate the direction of overstress fracture, based on the radial and chevron marks on the fracture surfaces.



Figure 13 – The top of the #5 piston, which had faced the interior of the #5 cylinder.



Figure 14 – The sides of the #5 piston, showing the damage about the pin boss from (a) the pin boss side and (b) rotated 90° from Figure 14a.



Figure 15 – The miscellaneous piston pieces from the #5 piston.



Figure 16 – The components of the #6 engine position, as received.



Figure 17 – The received pieces of the #6 connecting rod, cap, and bolts.



Figure 18 – Closer view of the bolts and cap from the #6 connecting rod, as received.

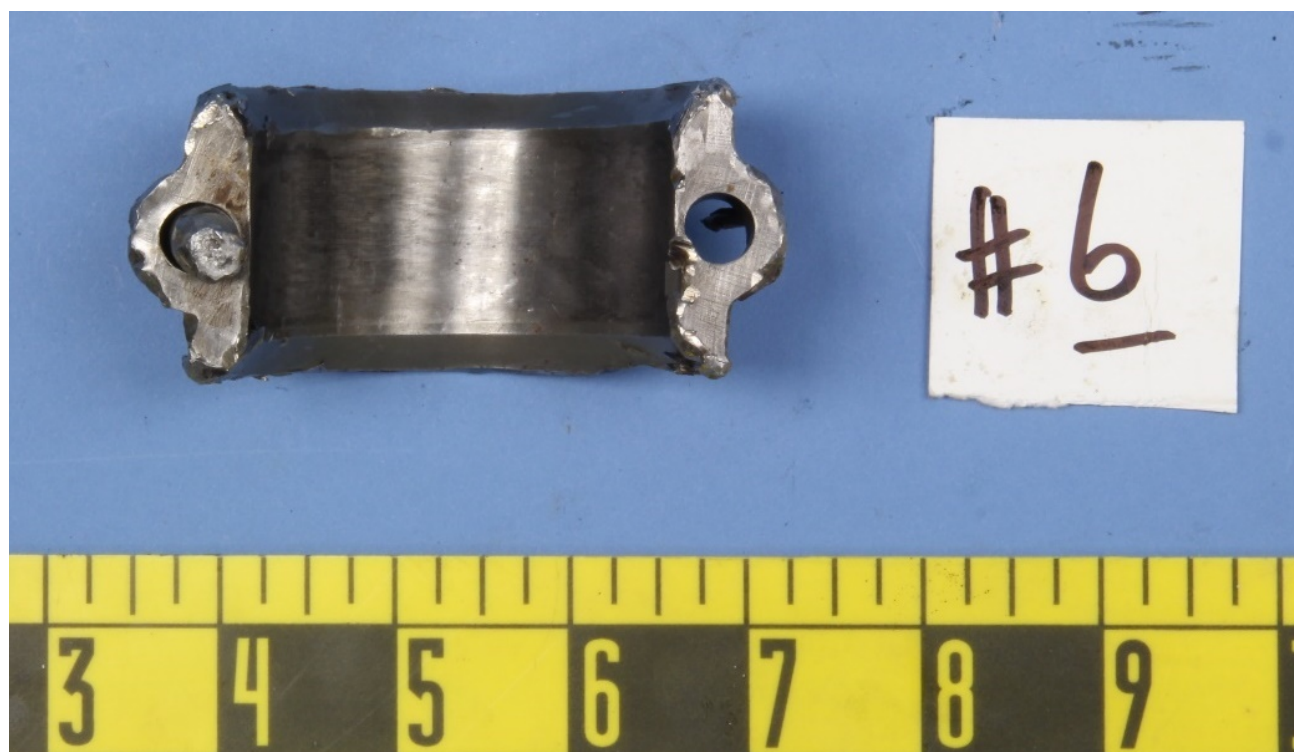


Figure 19 – The inside bearing surface of the #6 connecting rod cap.



Figure 20 – The outside of the #6 connecting rod cap, showing batter.



Figure 21 – The pieces of the #6 connecting rod.

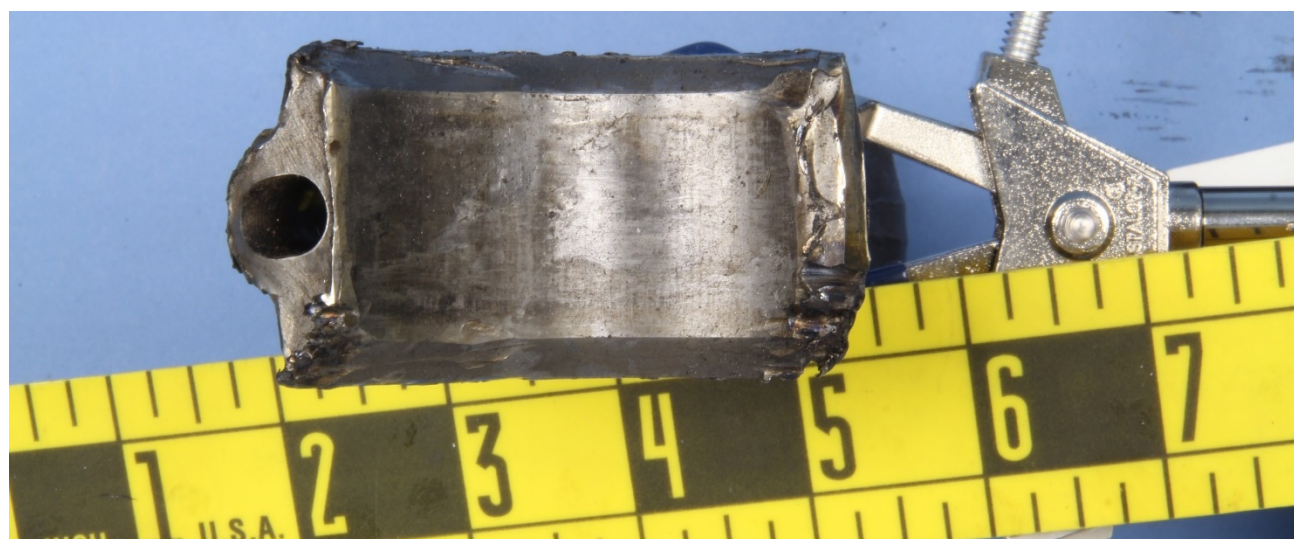


Figure 22 – The inner bearing surface of the #6 connecting rod, facing left in Figure 21.



Figure 23 – The fracture surface of the #5 connecting rod pin bore near the yoke neck, which mated with the fracture surface in Figure 22.

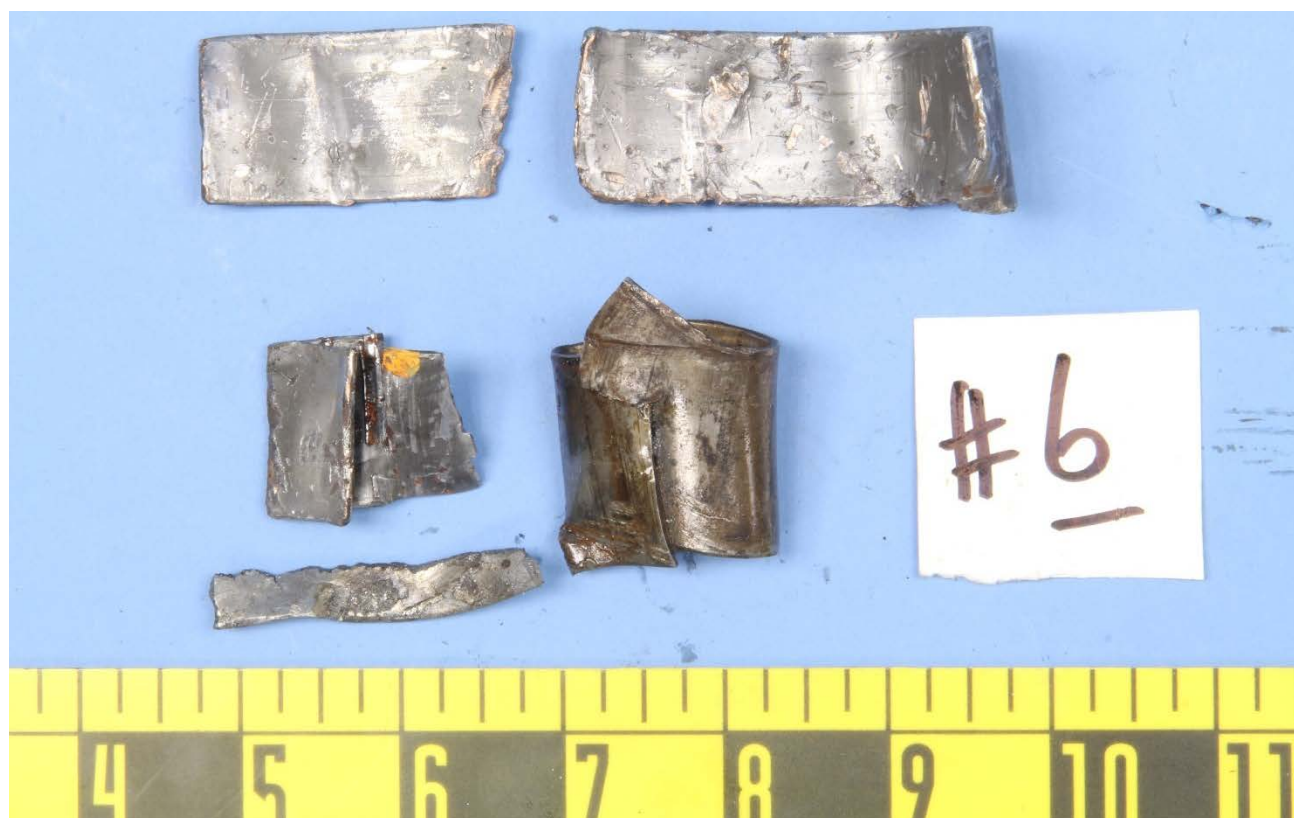


Figure 24 – The pieces for the bearing from the #6 connecting rod.



Figure 25 – The underside of the #6 piston.



Figure 26 – The top of the #6 piston crown.



Figure 27 – The #6 piston viewed from (a) the pin boss side and (b) rotated 90° from Figure 27a.