NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594

September 13, 2013

MATERIALS LABORATORY FACTUAL REPORT Report No. 13-024

A. ACCIDENT

Place	:	Effingham, SC
Date	:	September 25, 2012
Vehicle	:	Beech V35B, N11JK
NTSB No.	:	ERA12LA500
Investigator	:	Dennis Diaz, AS-ERA(ASH)

B. COMPONENTS EXAMINED

Propeller hub assembly, crankshaft, and connecting rod fragment

C. DETAILS OF THE EXAMINATION

On August 11, 2012, about 1310 EDT[1], a Beech V35B, N11JK, was substantially damaged during a forced landing following a loss of engine power near Effingham, South Carolina. The private pilot and the passenger were not injured. The propeller hub was found separate from the engine (TCM[2] IO-520-BB, S/N 551055) and the rest of the aircraft. Instrument meteorological conditions prevailed, and an instrument flight rules flight plan had been filed for the flight. According to the discussions with investigators, the propeller assembly was initially installed in May 2009, accumulating 249 service hours by March of 2012. The engine had accrued an additional 80 flight hours since the last maintenance performed in March 2012, with no records of propeller removal since that time. The assembly had been removed when the engine had undergone renovations to install additional equipment in July 2011. The hub assembly and crankshaft were sent to the NTSB Materials Laboratory for further investigation.

Figure 1 shows the propeller hub assembly, crankshaft, and other parts, as received. As can be seen in Figure 1a, two of the blades had broken off of the propeller hub assembly. The third blade had been sectioned off prior to shipment to the NTSB. The hub spinner shell exhibited a small dent in an area adjacent to the aircraft engine, showing cracking in the surface plating on the shell (but not the shell itself). Except for the aft hub section that mates to the crankshaft flange, no other indications of damage were observed externally on the hub assembly. The crankshaft exhibited material deformation and heat tinting on two of the connecting rod journals. A connecting rod had fractured approximately

[1] Eastern Daylight Savings Time.
[2] Teledyne Continental Motors, Mobile, Alabama

2.5 inches from the small end with the rod bushing. Additionally, photographic documentation of the engine during teardown revealed the engine case had fractured at the location of the broken connecting rod (not supplied to the Materials Laboratory). The fracture surface features of the case shown in the supplied photographs were consistent with failure by overstress.

The aft side of the propeller hub separated from the forward side of the crankshaft due to the failure of eight hub-mounting bolts. Figure 2 shows the aft side of the propeller hub assembly, as received. The spinner shell and bulkhead were removed from the hub assembly to examine the fractured bolt fragments. Figure 3a illustrates the fractured mounting bolts, which were labeled 1 through 8 for the purposes of this report. Figure 3b shows the corresponding bolt holes on the adjacent forward mounting flange of the crankshaft. Both the mating faces of aft of the hub and forward flange of the crankshaft show pairs of hemispherical-shaped wear marks at each bolt hole. The hemispherical marks are 180° degrees from each other at each respective hole, located along a circular path relative to each other.

Figure 4 and Figure 5 show the fracture surfaces of all eight bolts as viewed from the propeller hub side. All eight bolts exhibited two thumbnail crack features located 180° from each other, corresponding with the hemispherical wear marks on the hub case aft surface. The thumbnail cracks exhibited crack arrest marks emanating from the surface of the bolts. The regions of the fracture surfaces between the thumbnail cracks were generally rougher and of lower luster than the thumbnail regions. These fracture characteristics are consistent with failure from reverse bending fatigue. In this failure mode, fatigue cracks developed on opposite sides of the part until the cracks penetrated deep enough for the remaining cross-section in between to succumb to overstress. In general, the thumbnail portions of the bolt fracture surfaces were approximately half the bolt cross-sections. Bolt 7 exhibited the deepest fatigue crack penetration in the bolt cross-section.

The hub assembly was partially disassembled at the NTSB Materials Laboratory in order to remove the blades and gain access to the bolt fragments. The rest of the hub was fully disassembled by an external third party and returned to the Materials Laboratory for further analysis. None of the internal hub components, including the piston rod, spring, and plastic bushings, exhibited any indications of preexisting damage such as cracking or deformation. The internal parts appeared to be well greased, showing no signs of wear or excessive temperature exposure.

Figure 6 and Figure 7 illustrate damage to the crankshaft connecting rod journals for rods 6 and 4[3], respectively. The journal surface in Figure 6 showed plastic deformation in the form of smearing, batter, and cutting into the surface. Circumferential wear marks were present on the journal. The areas on the journal outside the plastically deformed center displayed indications of rust-colored oxidation. These features were consistent with high temperature exposure and wear due to interaction with an adjacent component, the

[3] TCM crankshafts journals are numbered from the rear of the engine to the forward. Main and cylinder journals are numbered independently.

connecting rod. The #4 piston connecting rod journal surface shown in Figure 7 showed circumferential wear, heat tinting, and oxidation consistent with high temperature exposure. In examination of the engine teardown photographs, the #4 piston connecting rod exhibited rust-colored oxidation on the rod cap, I-beam, and rod bolts adjacent to the crankshaft. These features are consistent with high temperature exposure.

Figure 8 shows the #6 piston connecting rod from both sides. The rod had fractured along the I-beam approximately 2.5 inches from the small end of the rod. Figure 9 shows the rod fracture surface after being sectioned from the I-beam. Most of the fracture surface exhibited a dark color, with tortuous fracture surface. As illustrated in Figure 10, the fracture surface exhibited indications of heat tinting near one edge. This tinted area showed crack arrest features consistent with a small thumbnail crack.

The fracture surface was examined in a scanning electron microscope. While most of the fracture surface had been damaged, isolated areas within the thumbnail region exhibited features consistent with fatigue striations (Figure 11). No indications of other failure modes were found in this area. The fatigue thumbnail region had been oxidized enough to obscure much of the fracture features. All the areas outside of the thumbnail region exhibited dimple rupture features consistent with failure by overstress (see Figure 12). Across the entire fracture surface, small lead-based particles were found. These particles are consistent with additives in leaded aviation fuel.

Erik Mueller
Materials Research Engineer

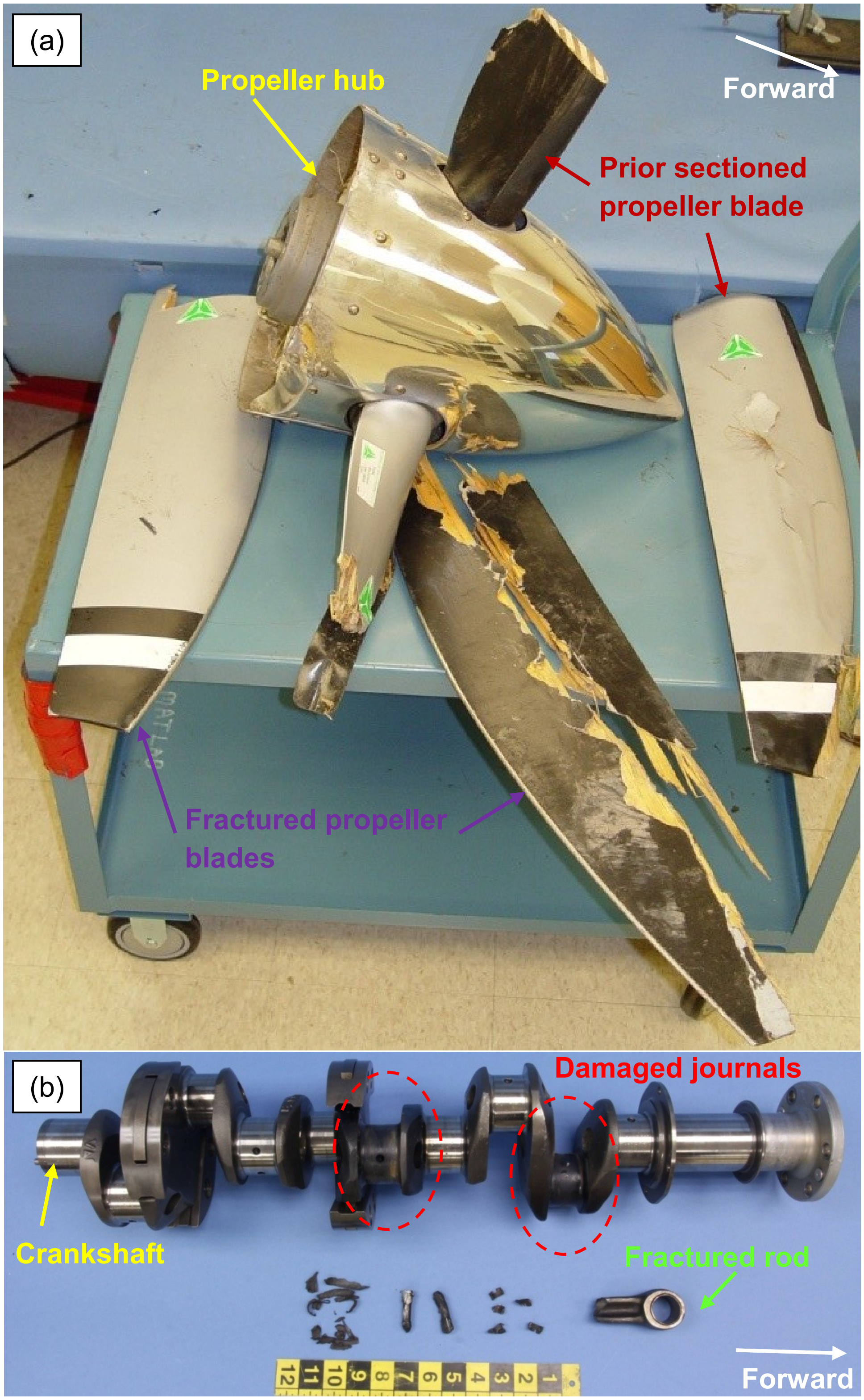

Figure 1 – The propeller parts as received, showing (a) the propeller hub and fractured blades and (b) the crankshaft, fractured rod and miscellaneous damaged parts.

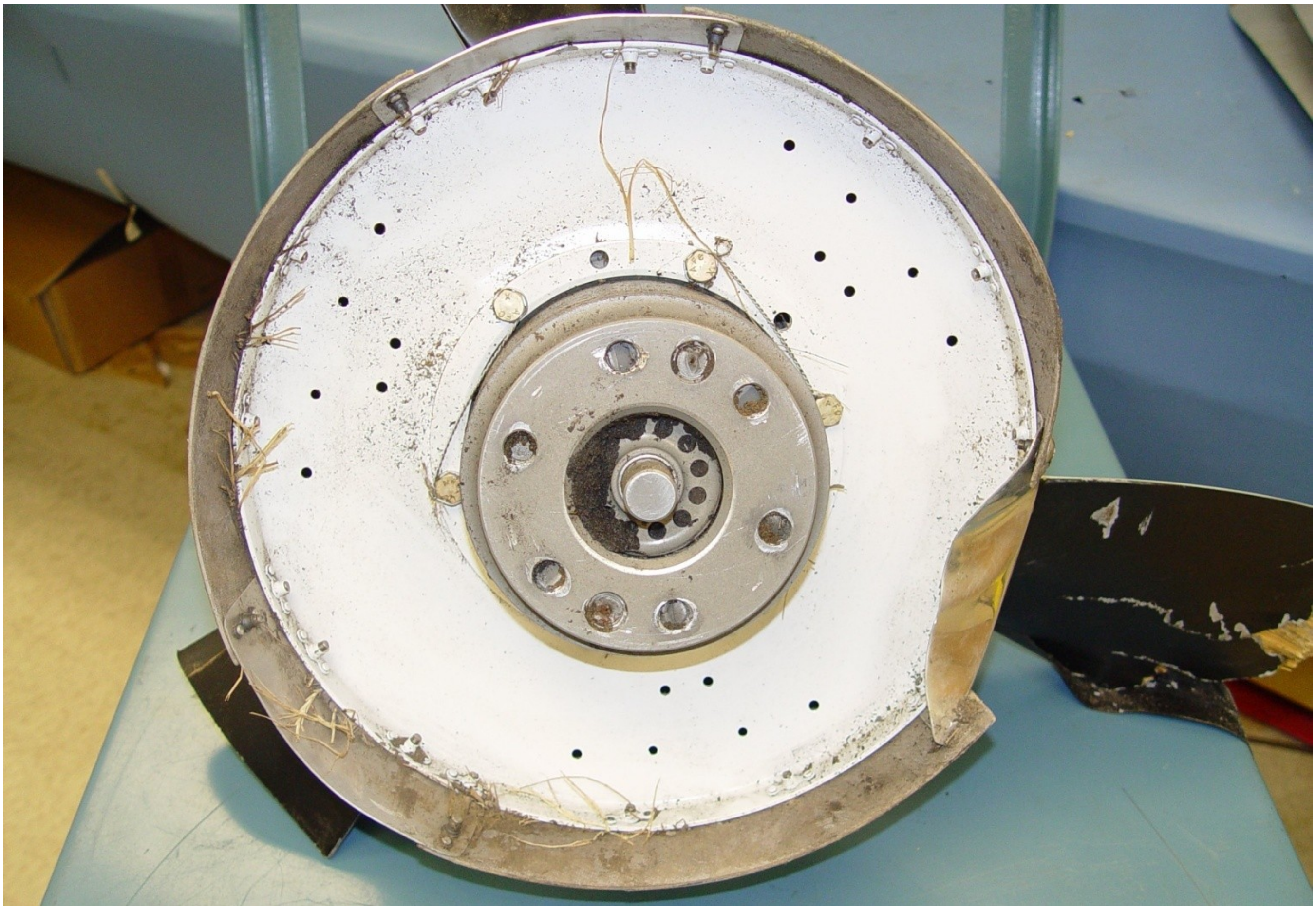
Figure 2 – The fractured bolts of the propeller hub as received, viewed aft-looking forward.

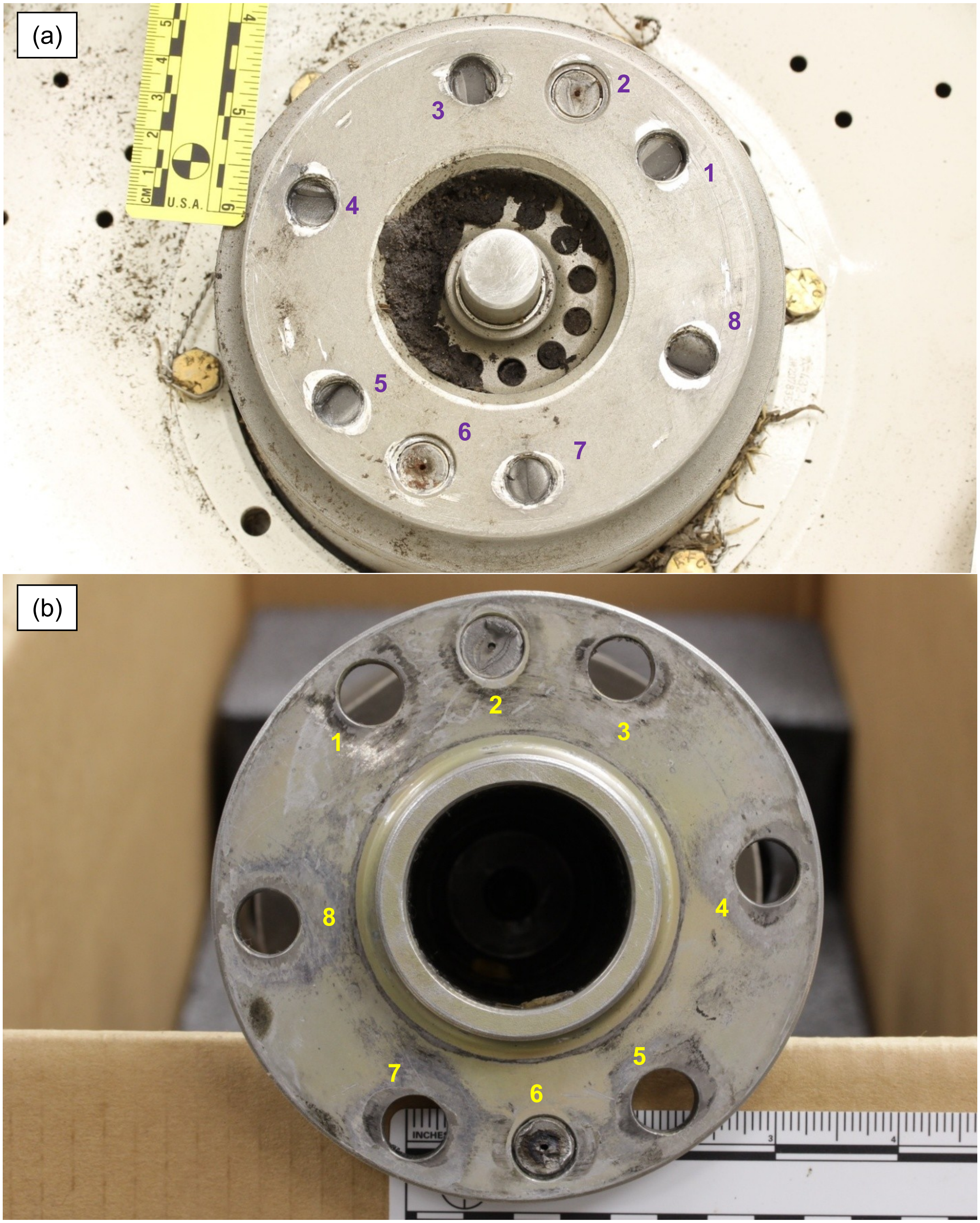

Figure 3 – The bolts fragments and bolt holes of the propeller assembly from (a) the hub side with the aft bulkhead removed and (b) the crankshaft side. The numbering system is used to identify the bolts in the investigation.

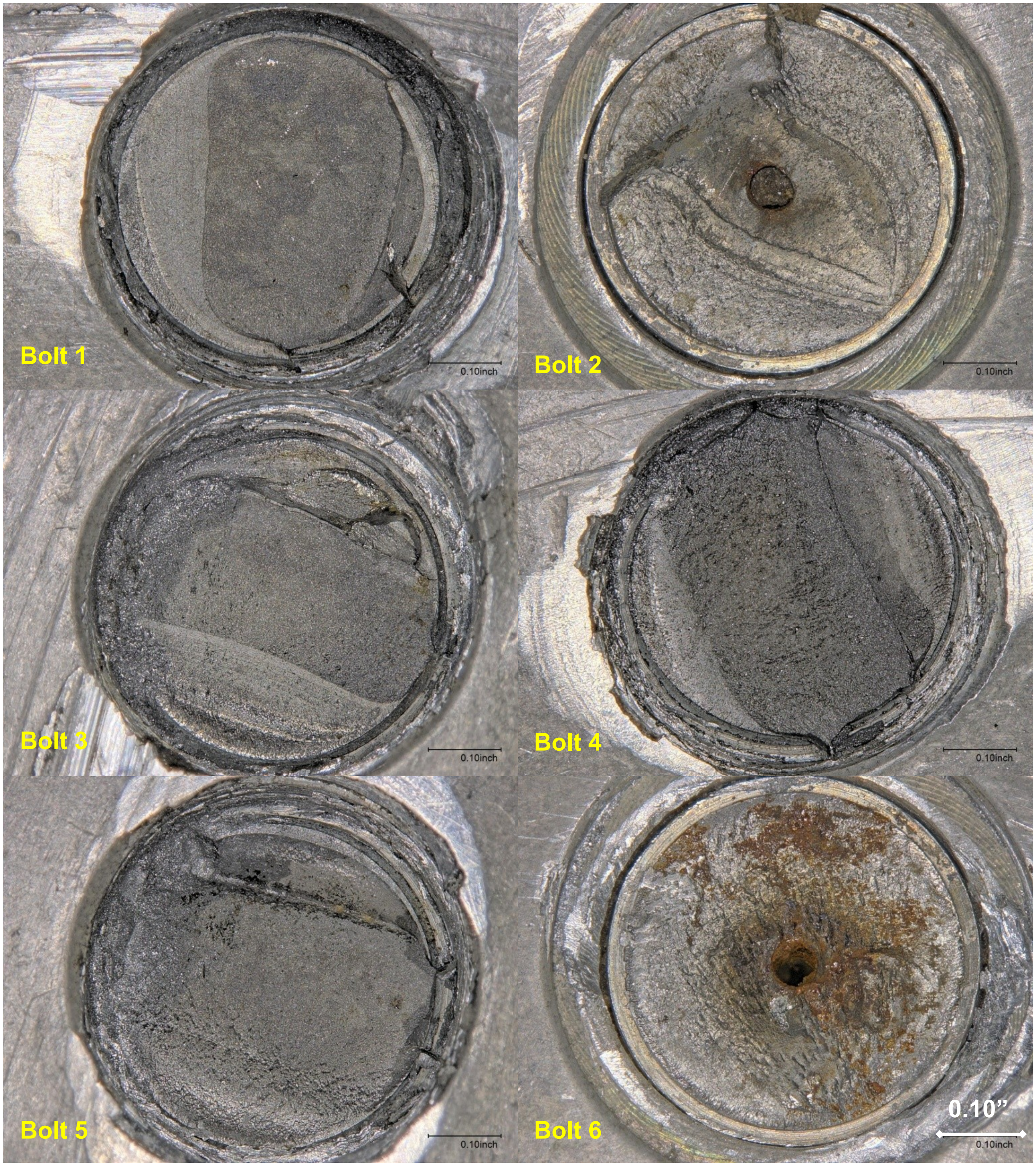

Figure 4 – Fracture surfaces of bolt fragments 1 through 6. Each fracture surface exhibited patterns indicative of reverse bending fatigue.

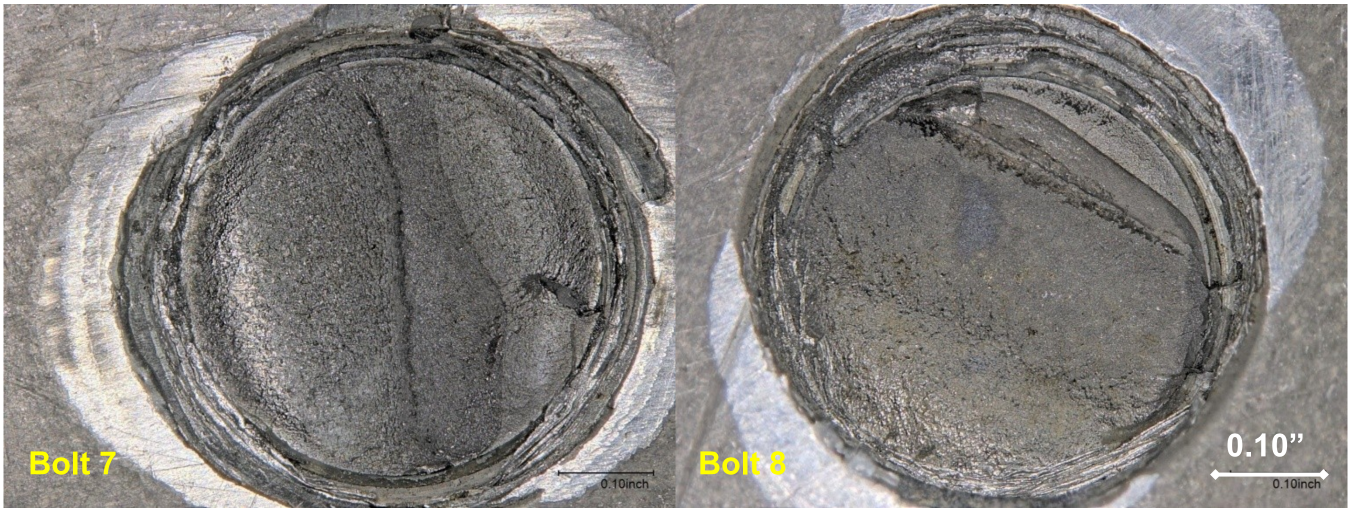

Figure 5 – Fracture surfaces of bolt fragments 7 and 8. Each fracture surface exhibited patterns indicative of reverse bending fatigue.

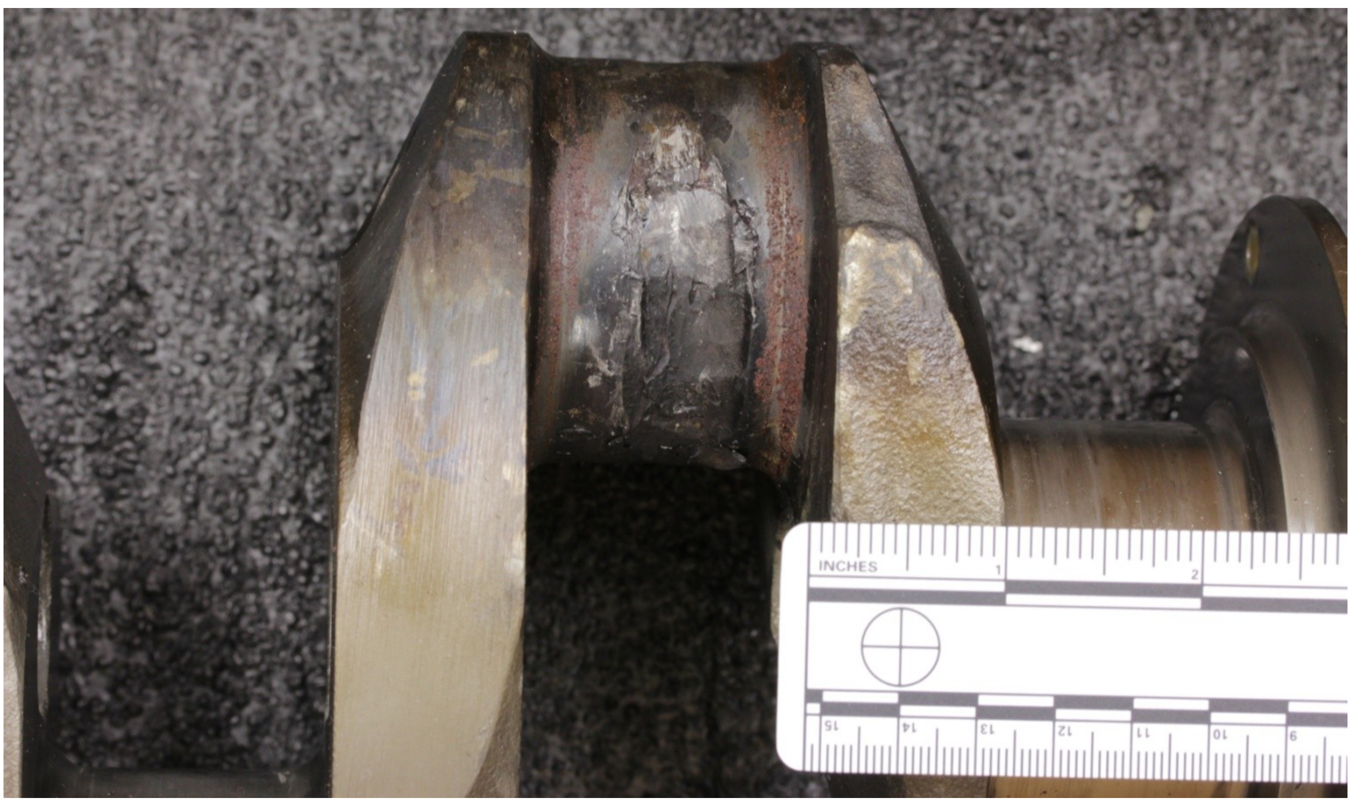

Figure 6 – Damage on the crankshaft at the #6 connecting rod bearing journal, showing indications of heat tinting and material deformation.

Figure 7 - Damage at the #4 connecting rod crankshaft bearing journal location, showing indications of heat tinting and material deformation.

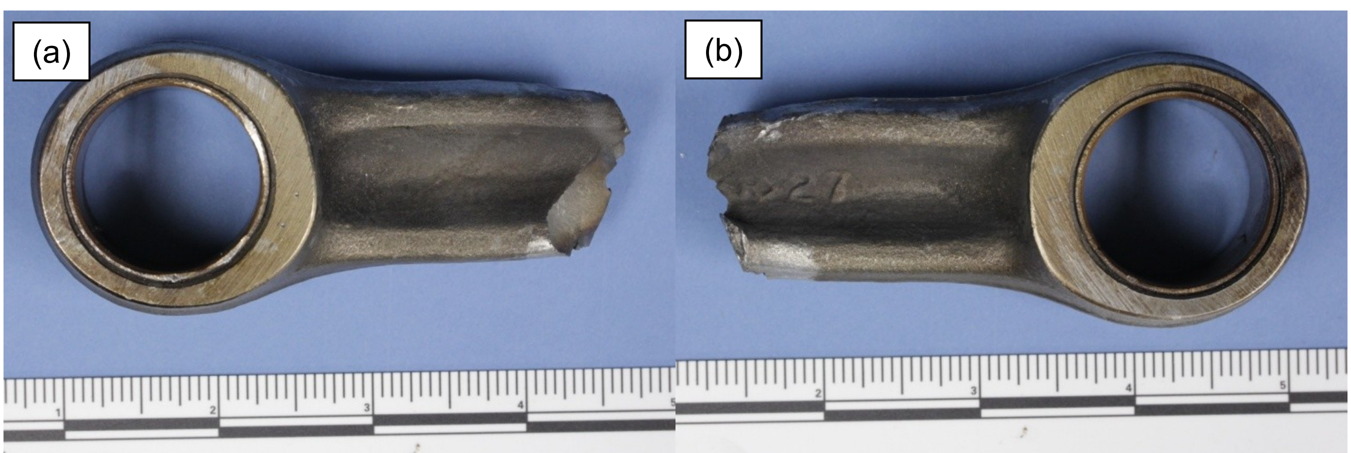

Figure 8 – The fractured connecting rod end as seen from both sides (a) and (b).

Figure 9 – Fracture surface of the fractured rod, after sectioning from the main part fragment.

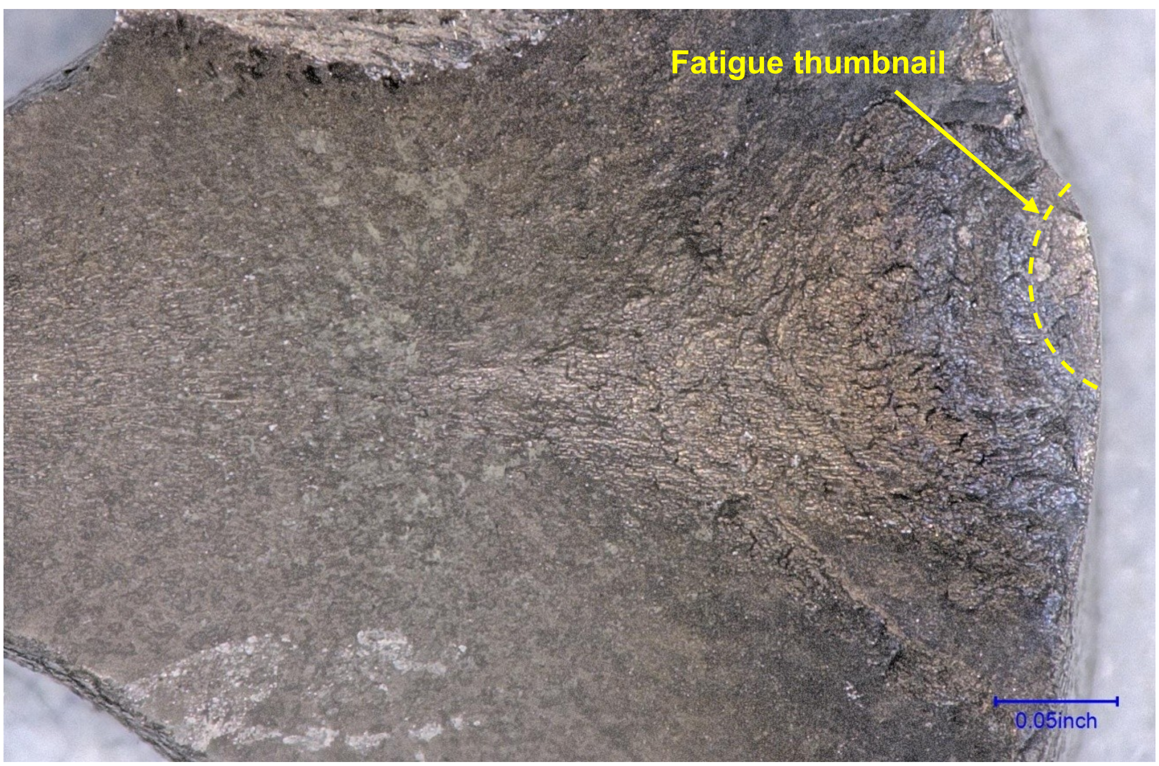

Figure 10 – Closer view of the fracture surface from Figure 9, showing a small thumbnail on the edge of the part.

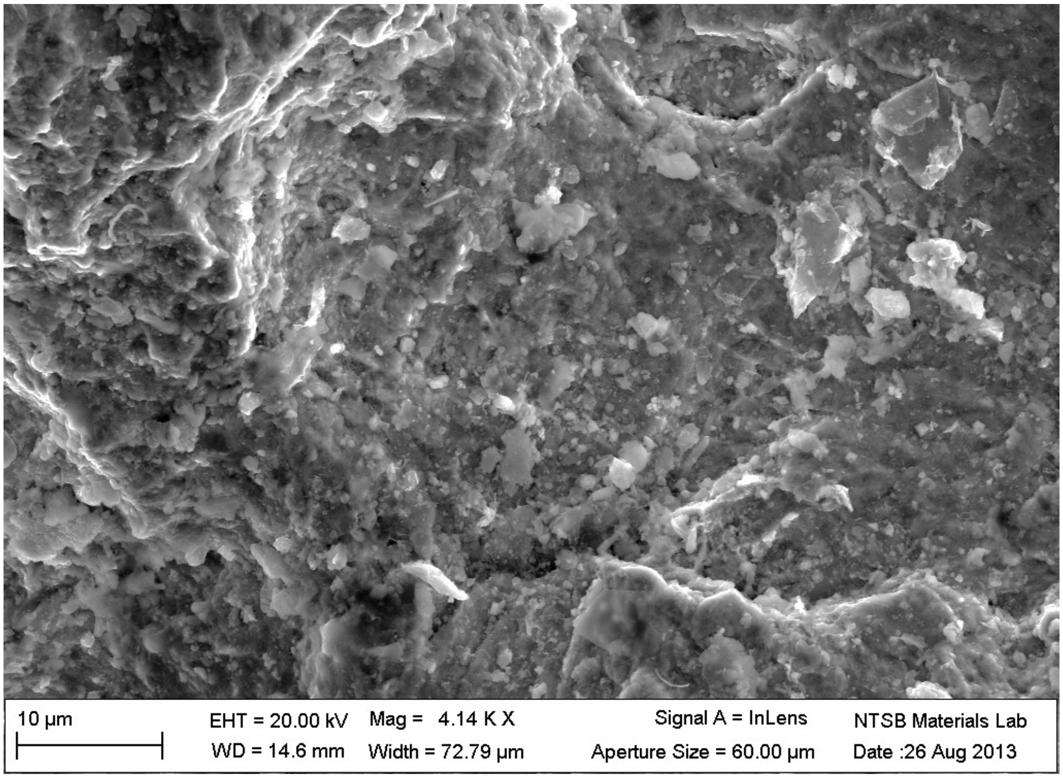

Figure 11 – Secondary electron (SE) micrograph of the thumbnail area identified in Figure 10, showing faint fatigue striations.

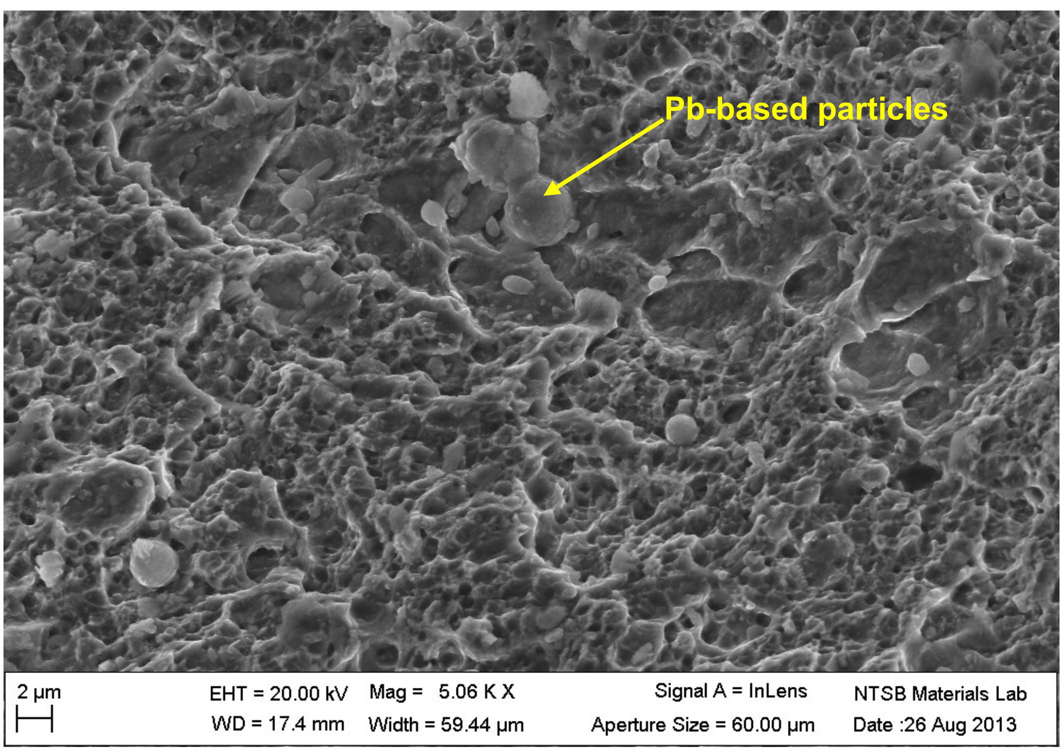

Figure 12 – SE micrograph of dimple rupture, indicative of overstress, typical of what was found on the rod fracture surface outside of the thumbnail area.