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

January 6, 2014

MATERIALS LABORATORY FACTUAL REPORT Report No. 14-001

A. ACCIDENT INFORMATION

Place	:	Parkton, North Carolina
Date	:	December 16, 2012
Vehicle	:	Piper PA-28-160
NTSB No.	:	ERA13FA088
Investigator	:	Timothy W. Monville, AS-ERA

B. COMPONENTS EXAMINED

Engine-driven vacuum pump.

C. DETAILS OF THE EXAMINATION

Overall views showing many of the submitted pieces of the engine-driven vacuum pump are presented in figure 1. An inlet tube, forward and aft flange attachment screws, and two bags containing remains of the drive end coupling and drive finger sleeve are not shown. The pump was received in pieces as shown in figure 1. A teardown of the pump had been performed by the pump manufacterer with Federal Aviation Administration personnel present.

According to airplane mantenance records as reported by the NTSB investigator in charge, a Rapco, Inc., part number RA215CC vacuum pump was installed on August 19, 2003 at a tach time of 2,960.41 hours. At the time of the last annual inspection on January 27, 2012, the tach time was 3,558.40 hours, or an elapsed time of 597.99 hours. There was no record that the vacuum pump had been removed since installation in 2003.

The pieces of the vacuum pump showed oxidation and tinting consistent with significant heat exposure. The drive end coupling was completely destroyed from heat damage, and the bag of remains contained small charred remains. Charred remains of the drive end coupling were also found in the splined cavity of the drive shaft assembly. The labeled bag with the remains from the drive shaft assembly drive finger bushings contained a powdery gray substance.

The vanes and corresponding slots in the rotor were received numbered as shown in figures 1 and 2. The rotor was fractured, and the 5 submitted pieces of the rotor were labeled A through E for this report. Vane 5 was fractured at the interior forward corner of the vane as shown in figure 1. The other 5 vanes were all intact.

The pieces of the rotor were carefully reassembled as shown in figure 2, where the pieces and the vane slots are labeled with letters and numbers, respectively. The fracture patterns at the forward (inlet flange end) and aft (discharge flange end) surfaces were examined. A sequence of cracking can be determined from the crack intersections at the forward end. Where cracks form nearly perpendicular intersections, the crack that is straight across the intersection is the primary crack, and the crack that terminates at the intersection is the secondary crack. Using this sequencing technique, primary, secondary, and tertiary cracks were identified as shown in the upper image of figure 2.

Oblique views of the cracking pattern at the aft end of the rotor and in the center hole both with and without piece B in the image are shown in figure 3. The primary and secondary fractures and fractures extending between the center hole and vane slots 5 and 6 all intersected at an area of the center hole surface approximately 0.25 inch to 0.375 inch from the aft surface. Branching cracks (see unlabeled arrows in the upper image in figure 3) were observed emanating from both sides of the fracture in the area where the fractures intersected. The branching cracks were angled toward the aft face of the rotor. Some of the branching cracks also intersected the aft surface of the rotor and extended radially outward on the aft surface. The primary fracture plane had a plane normal that was oriented between the radial and axial directions.

Views of the mating sides of the secondary fracture in the rotor are shown in figure 4. Portions of the fracture surface on the secondary fracture and the radial fracture opposite from the secondary fracture had areas that appeared relatively dark, similar to adjacent surfaces of the center hole. The relatively dark areas were located adjacent to the forward face of the rotor, and dashed lines in the lower image in figure 4 indicate the boundaries of the relatively dark areas. Inspection using a stereo optical microscope did not reveal any cracks at the intersection between the aft face and the center hole of the rotor.

Circumferential score marks were observed on the interior surface of the rotor center hole (left image in figure 5) and on the center shaft on the aft flange (right image in figure 5. Unlabeled arrows in figure 5 indicate locations of the score marks. The marks on the rotor three relatively prominent marks were located 0.274 inch, 0.75 inch, and 0.985 inch away from the aft face, respectively. On the aft flange shaft, two marks were located 0.757 inch and 0.969 inch from the flange face, respectively.

Impressions and heat tinting corresponding to features of the rotor were observed on the faces of the forward and aft flanges of the pump housing. The aft flange had heat tinting corresponding to features of the fractured rotor and vanes. An impression was noted on the aft flange corresponding to contact with the corner between the outer surface and vane slot 6 on rotor piece B. An impression was also observed on the forward flange corresponding to the edge of vane slot 2 on rotor piece B. No evidence of rotational sliding was observed at the impressions on the forward or aft flanges or the corresponding locations on the rotor. Aside from the impressions and

oxidation noted, the aft face of the forward flange and the forward face of the aft flange had a machined appearance with no visible gouges or scoring.

The pump housing interior surfaces were examined visually. The surfaces were oxidized, but appeared generally smooth with a machined finish.

The drive shaft bushing located in the forward housing flange had multiple relatively deep circumferential score marks. A view of the score marks in the drive shaft bushing are shown in figure 6, where unlabeled arrows indicated the three deepest marks.

Matthew R. Fox
Senior Materials Engineer

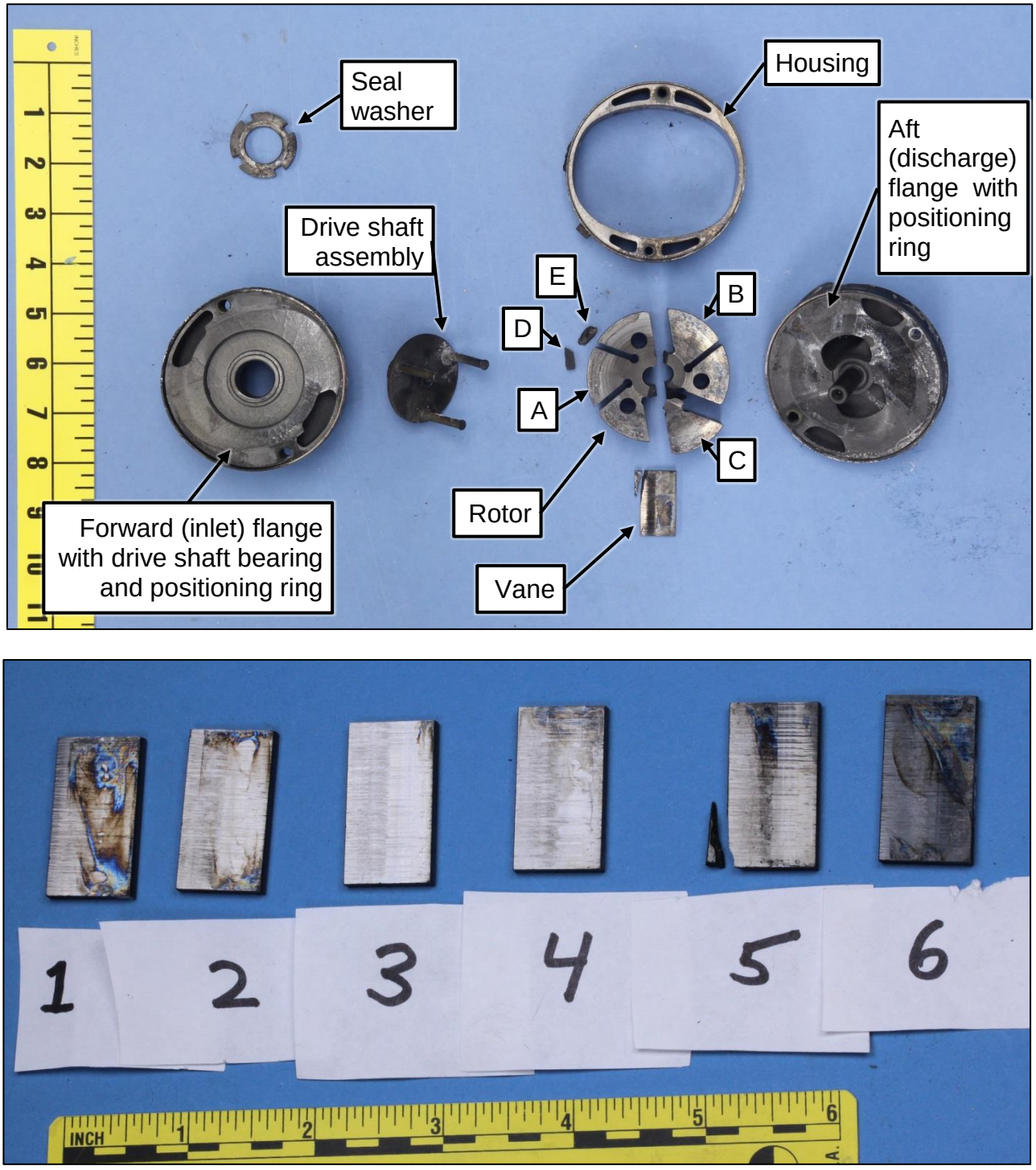

Figure 1. Overall views of submitted components from the vacuum pump assembly. Vanes in the lower image are labeled according to position number as designated during the pumb teardown. An inlet tube, flange attachment screws, and two bags containing the remains of drive end coupling and drive finger sleeve material are not shown.

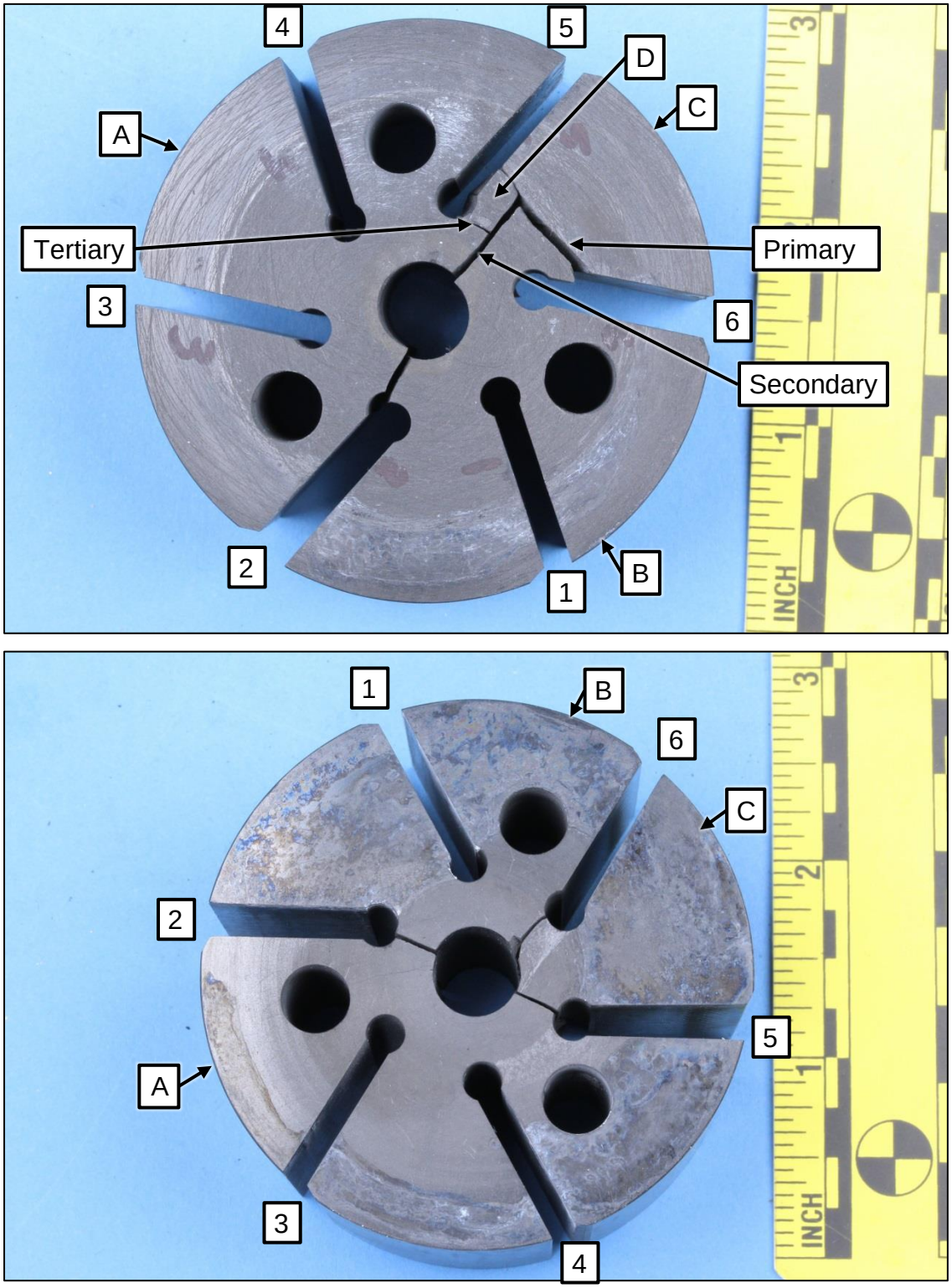

Figure 2. Overall views of the forward face (upper image) and aft face (lower image) of the rotor. Vane slots are shown as numbered during the teardown. Pieces A through D are labeled as shown in figure 1.

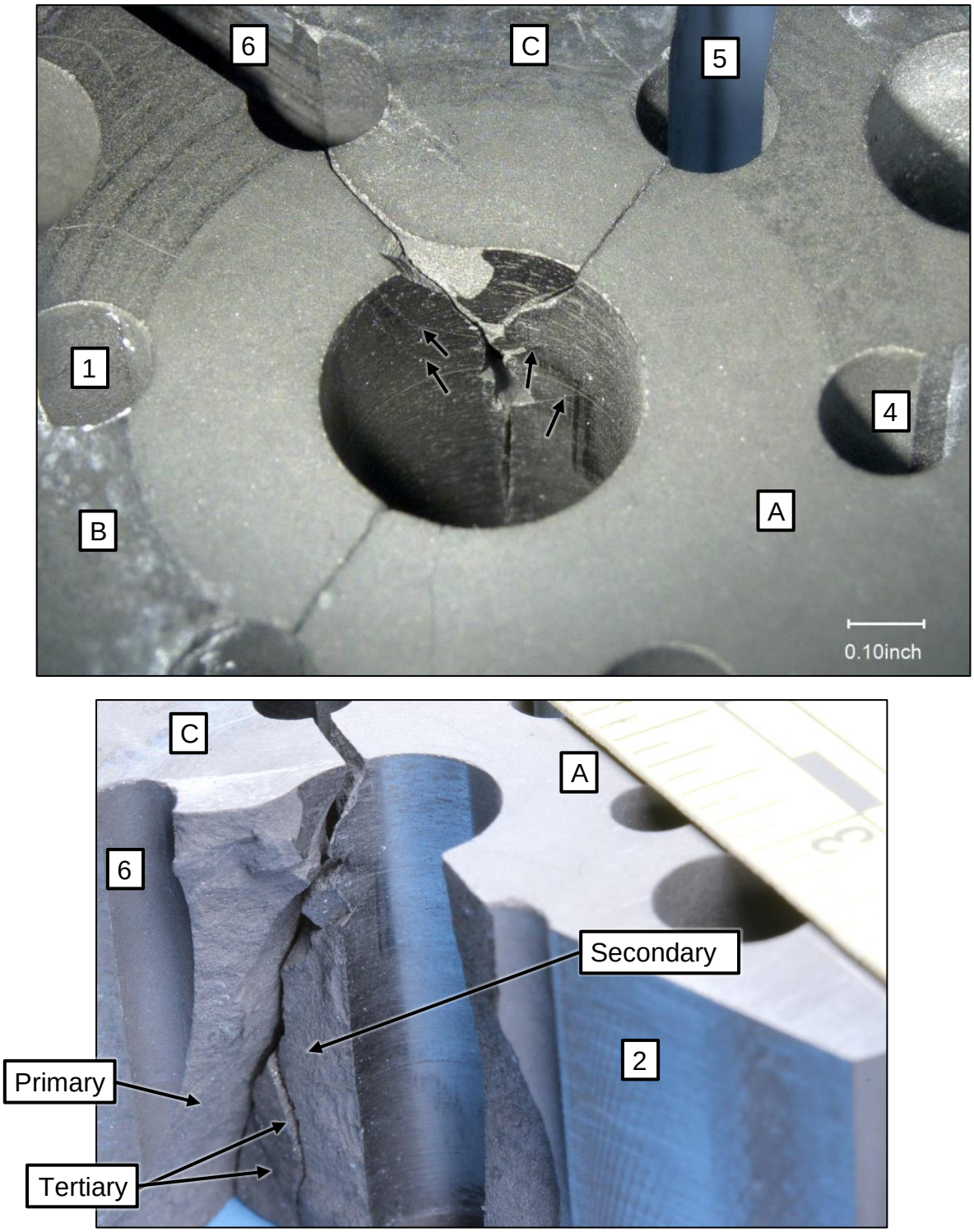

Figure 3. Close views of the fracture paths at the center of the rotor viewed at an oblique angle looking forward with all fractures placed in close proximity (upper image) and with piece B removed (lower image). Unlabeled arrows in the upper image indicate branching cracks emanating from both sides of the fracture.

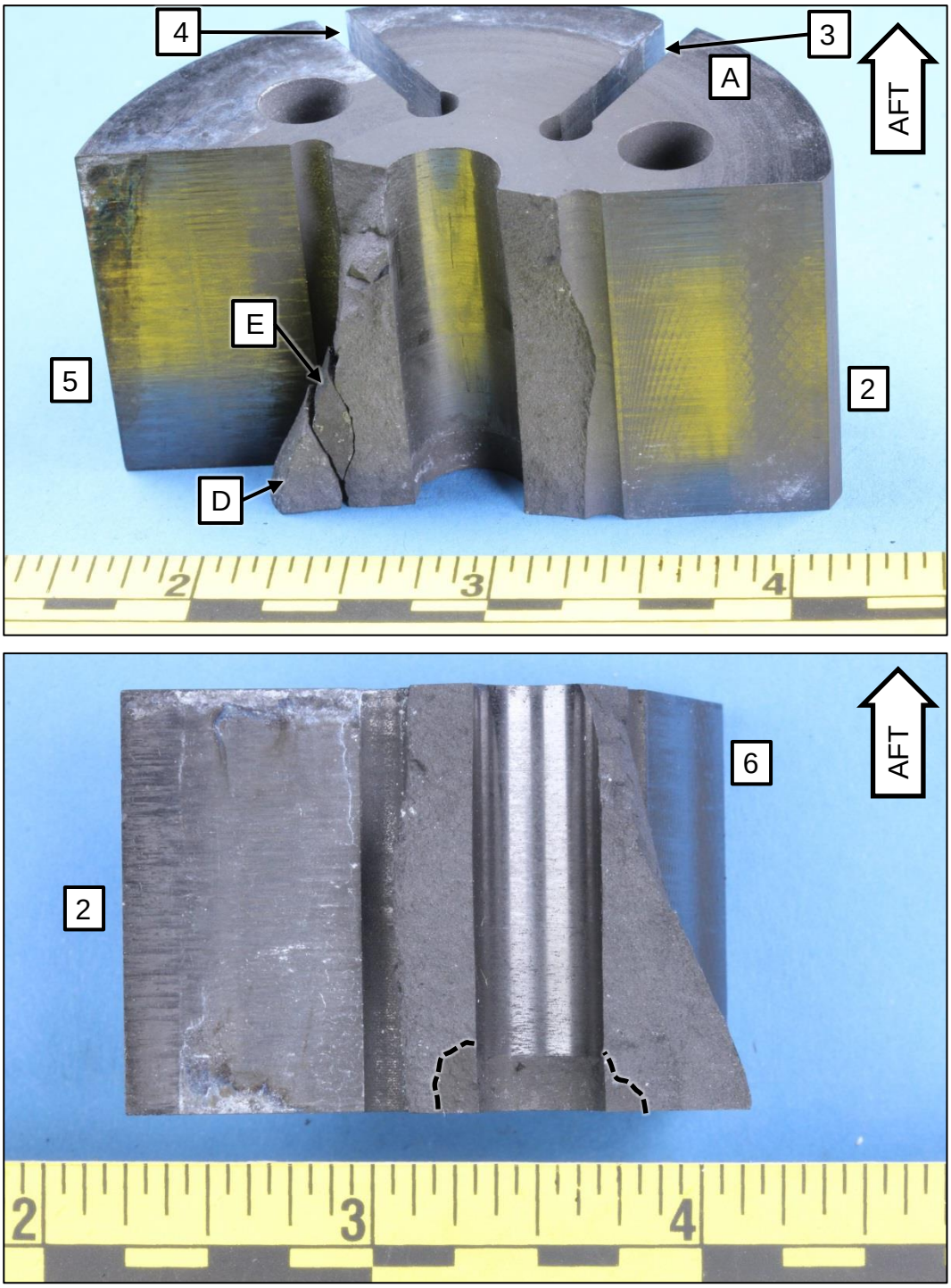

Figure 4. Views of the secondary fracture surfaces on pieces A, D, and E (upper image) and the mating side on piece B (lower image). Dashed lines in the lower image indicate areas that appeared darker relative to the rest of the fracture surface.

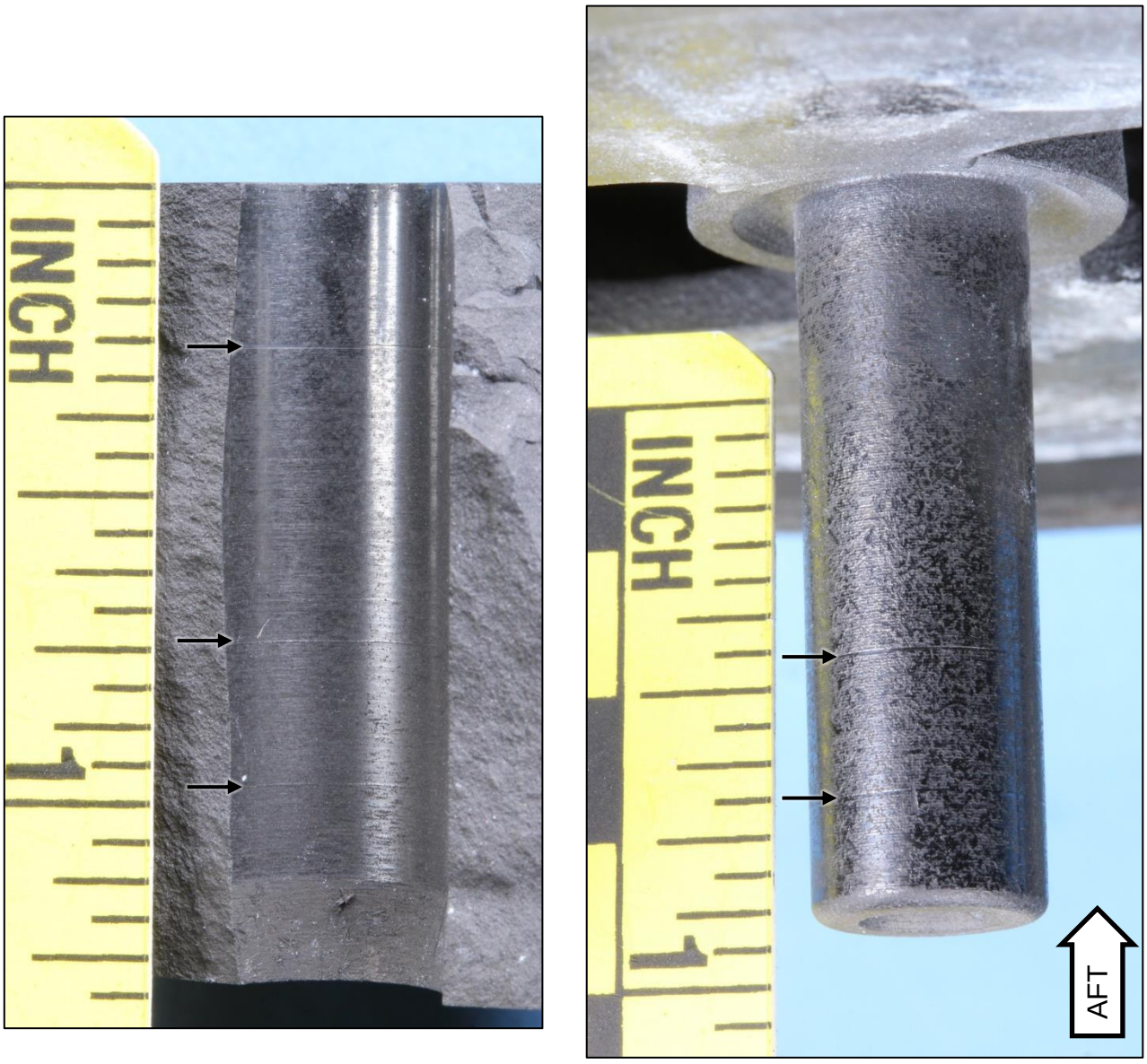

Figure 5. Circumferential score marks on the rotor center hole (left image) and the rotor shaft (right images. Unlabeled arrows indicate score marks.

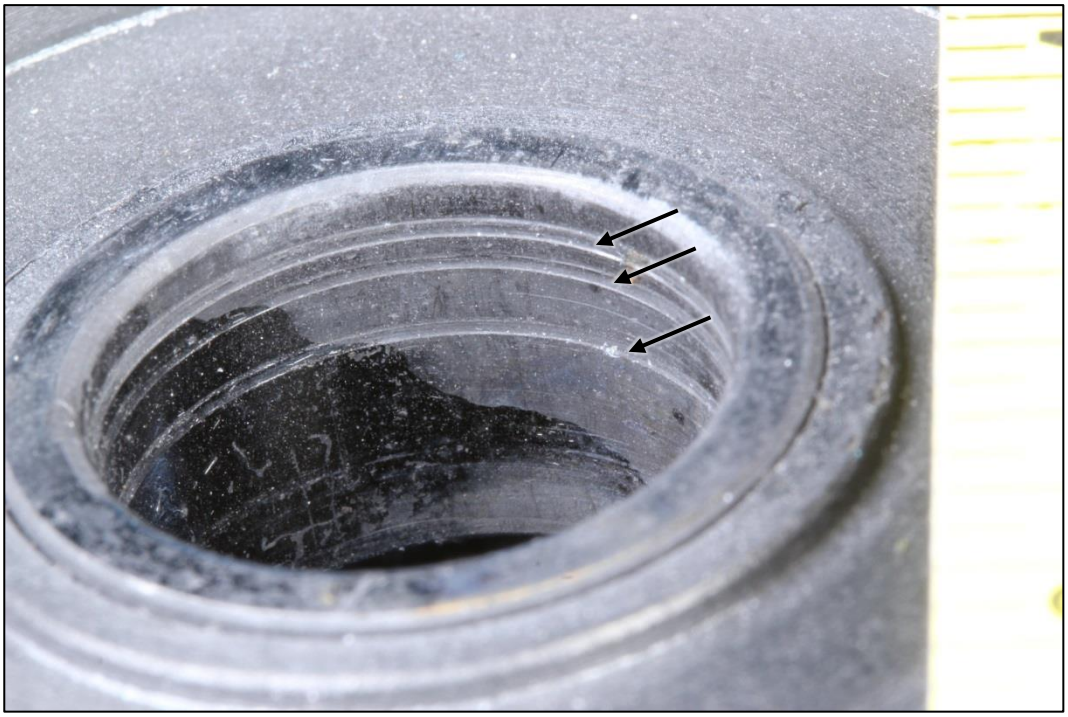

Figure 6. Circumferential score marks in the drive shaft bearing.. Unlabeled arrows point to the score marks.