

NATIONAL TRANSPORTATION SAFETY BOARD

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



July 06, 2021

MATERIALS LABORATORY FACTUAL REPORT

Report No. 21-032

A. ACCIDENT INFORMATION

Place : Moosic, Pennsylvania
Date : 09/20/2020
Vehicle : Piper PA-28R-180, N3790T
NTSB No. : ERA20LA322
Investigator : Timothy W. Monville

B. COMPONENTS EXAMINED

1. Number 2 cylinder with portion of fractured crankcase attached along the 4:00 to 8:00 position.

Base studs and hold down nuts from the number 2 cylinder (identified by its clock position)

1. 1:00 position—fractured stud with nut and portion of fractured stud cut from the crankcase
2. 2:00 position—fractured free-thru stud with nut and portion of fractured stud cut from the crankcase
3. 4:00 position—portion of a free-thru stud cut from the crankcase
4. 10:00 position—fractured stud with nut and portion of fractured stud cut from the crankcase
5. 11:00 position—fractured stud with nut and portion of fractured stud cut from the crankcase
6. Three unidentified cylinder hold down nuts.

C. DETAILS OF THE EXAMINATION

The number 2 cylinder assembly separated from the engine crankcase during flight. The purpose of this report is to document the fracture modes of the studs and base flange fretting scars.

As received images of the cylinder are shown in Figures 1-3 with key features annotated. In Figure 3, a clock position datum for the location of the studs is overlaid on the images.

A bottom view of the cylinder in Figure 4 shows a fractured portion of the crankcase that remained attached to the number 2 cylinder through clamping force provided by the 5:00, 7:00 and 8:00 studs.

The as-received base studs (anchored and free-thru) and hold down nuts retained during the engine teardown are shown in Figure 5. The stud pieces are numbered according to their installation clock position (see Figure 3 for reference).

The portion of crankcase that remained attached to the number 2 cylinder (see Figure 4) was removed as shown in Figure 6. The nut torque for the 5:00 and 7:00 studs was measured using an RS Technologies Model 962 Load and Torque Recorder with a 5 to 50 lb-ft transducer. The nut on the 8:00 stud was removed using a wrench and the nut torque was not measured. The approximate torque values are summarized in the table below.

Stud position	Tightening torque (lb-ft)	Loosening torque (lb-ft)
5:00	31.1	21.5
7:00	32.0	25.2

The fracture surface on the crankcase remnant was examined using a 5X to 50X stereo zoom microscope. The fracture features were consistent with overstress fracture in an aluminum casting. No injurious casting defects were noted on the fracture surface. As indicated in Figure 6, the threaded hole for the 4:00 free-thru stud position exhibited batter and mechanical attrition such that the threads were almost entirely worn away and the hole was enlarged.

Figure 7 shows the face of the base flange that mates with the crankcase. The clock positions of the mounting studs are noted in the figure as well as the clock position datums. Areas of darker discoloration on the face of the base flange are areas of material loss and oxidation typical of fretting wear scars.

The fracture surfaces on the stud remnants were examined using a 5X to 50X stereo zoom microscope (see Figure 5, pieces from stud locations 1:00, 2:00, 10:00, and 11:00). Figures 8-11 show digital microscope fractographs of the mating stud fracture surfaces. In all instances, diffuse-origin fatigue cracks initiated at the roots of the threads and propagated through about 70 to 80% of the diameter of the stud before succumbing to final overstress fracture.

Using a 5X to 50X stereo zoom microscope and a UV light source, the stud remnants were examined for the presence of an acrylic thread locking adhesive. Studs in the 8:00, 10:00, and 11:00 positions exhibited a thread locking compound on some of the threads engaged in the crankcase (see Figures 5 and 6).

Michael Budinski
Chief, Materials Laboratory Division

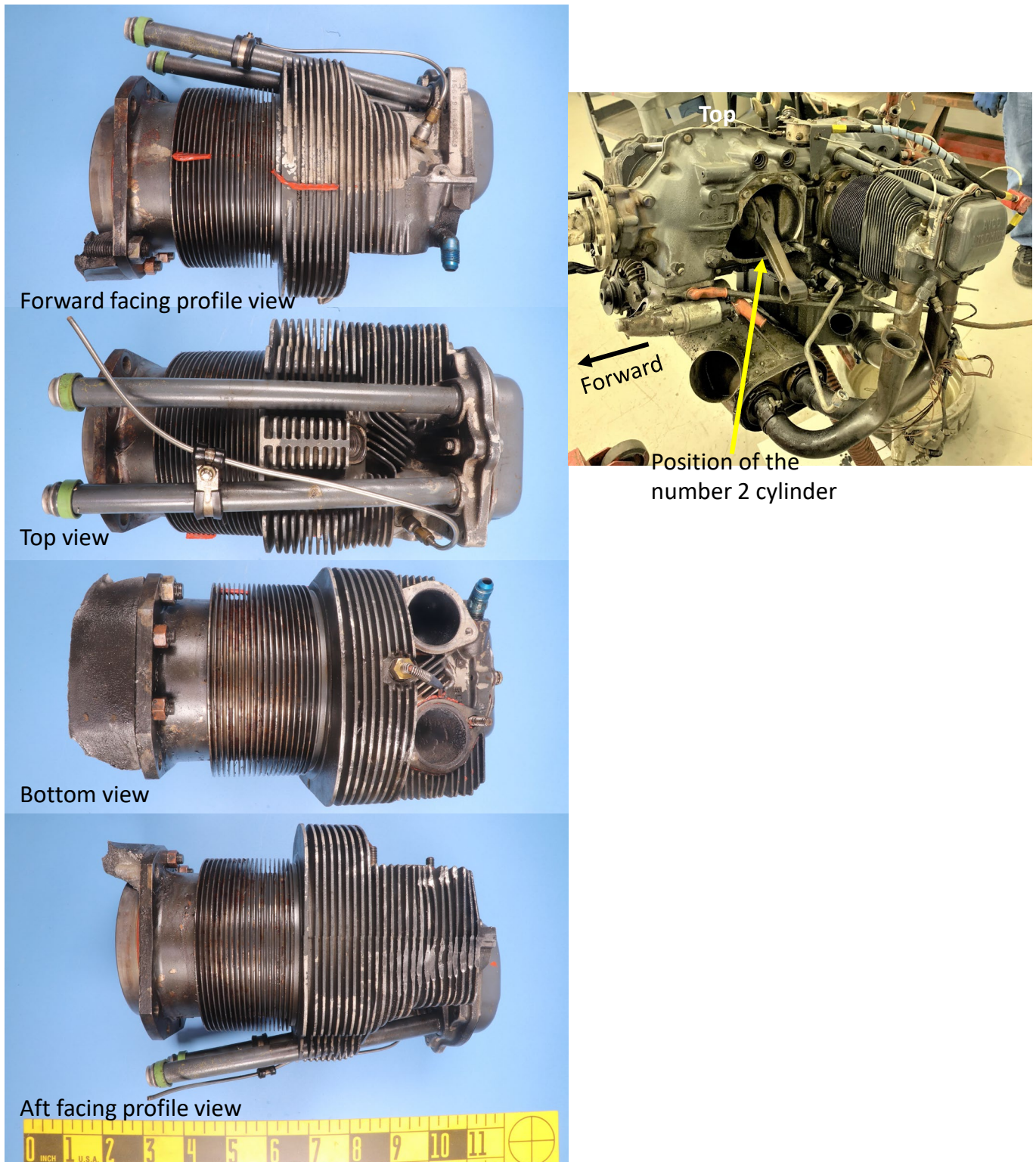


Figure 1 Top, bottom and profile views of the as-received number 2 cylinder.



Figure 2 Valve cover view of the as-received number 2 cylinder.

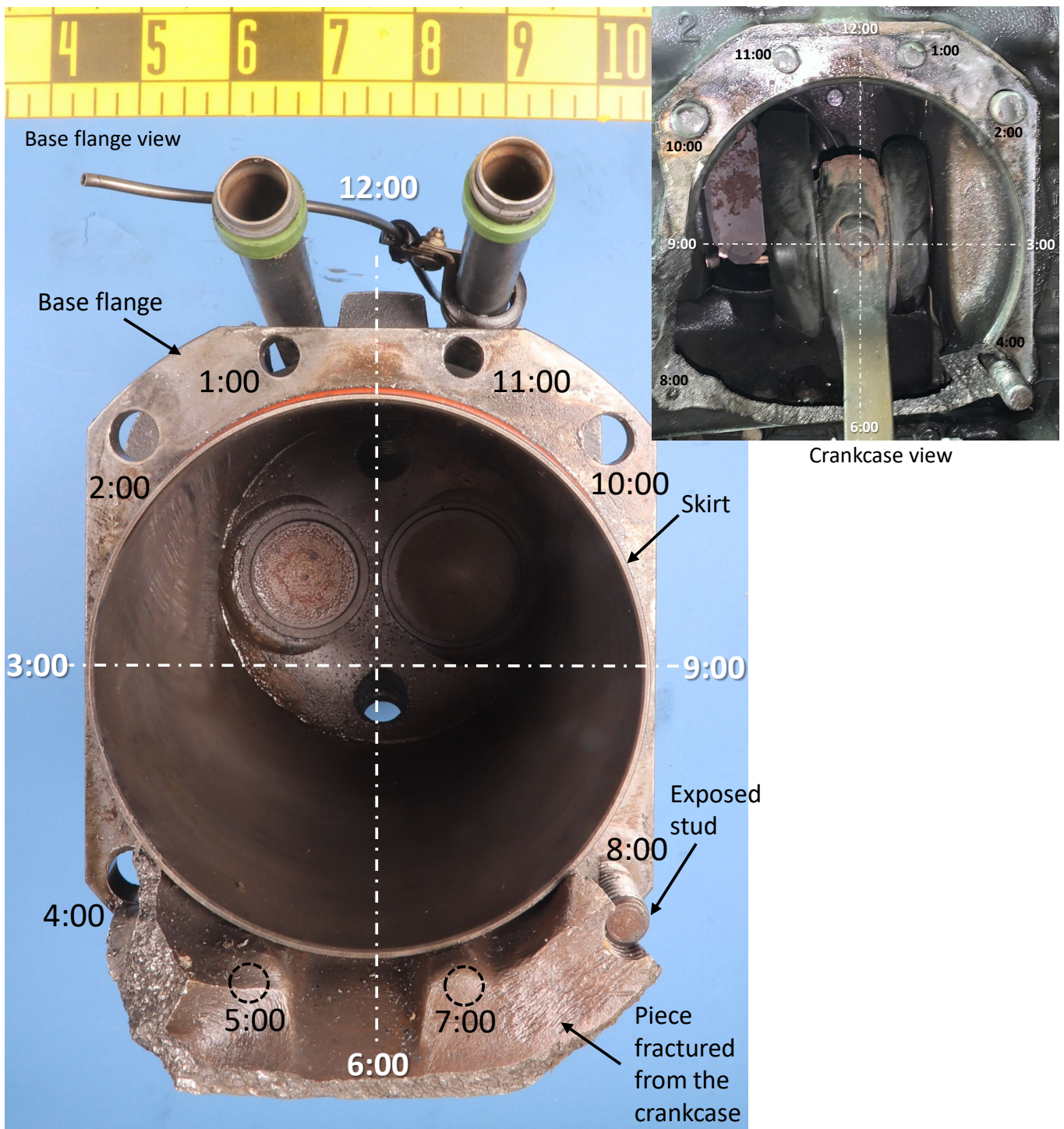


Figure 3 Base flange view the of the as-received number 2 cylinder. The stud positions are annotated in the image based on clock positions.



Figure 4 Bottom view of the cylinder shows a fractured portion of the crankcase that remained attached to the cylinder through clamping force provided by the 5:00, 7:00 and 8:00 studs.

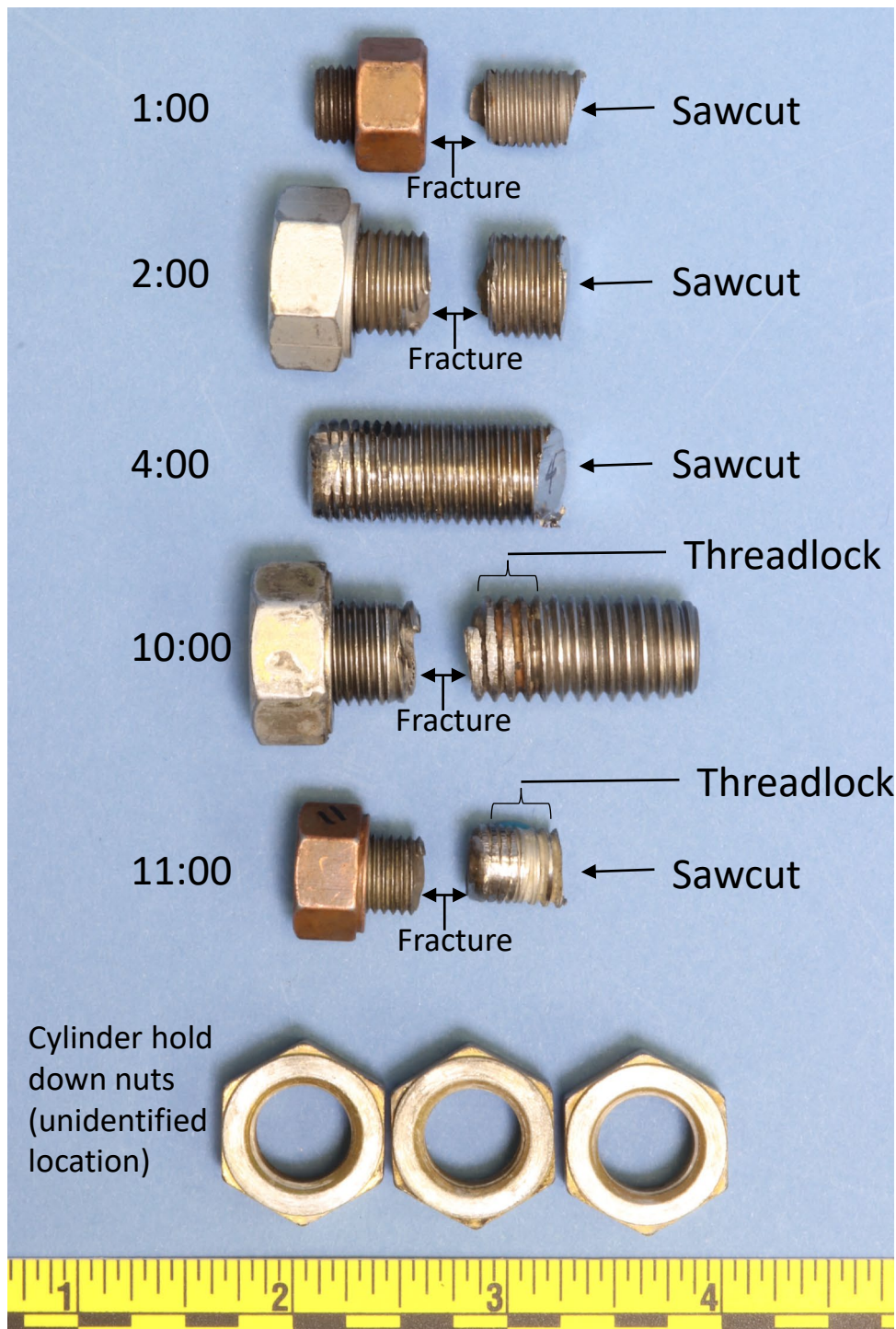


Figure 5 The as-received stud pieces with base nuts. In some instances, the lower portion of the stud was saw-cut from the crankcase. Three hold down nuts were submitted but the locations were not identified.

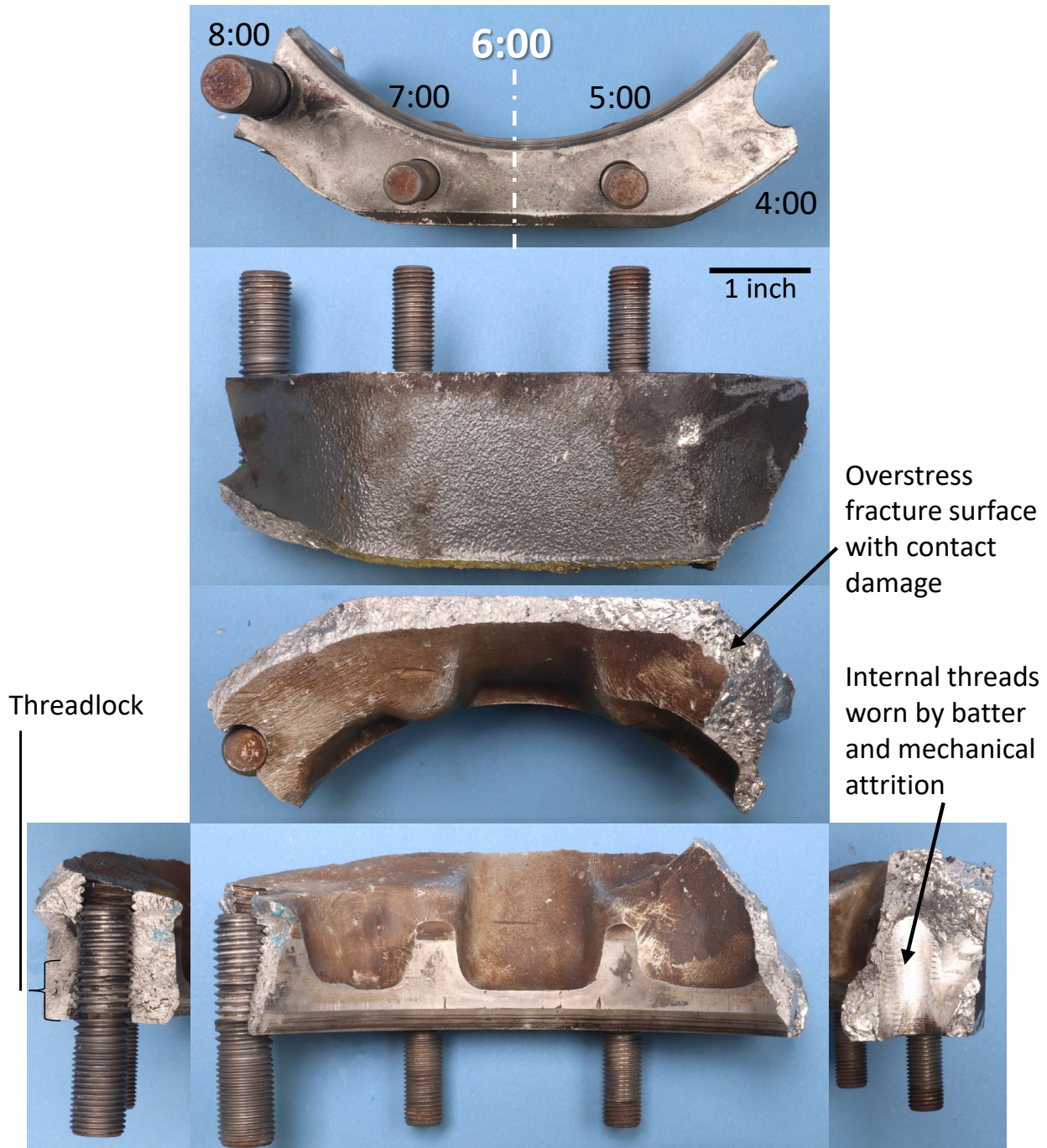


Figure 6 Images of the fractured portion of crankcase with three studs that was attached to the number 2 cylinder base flange.

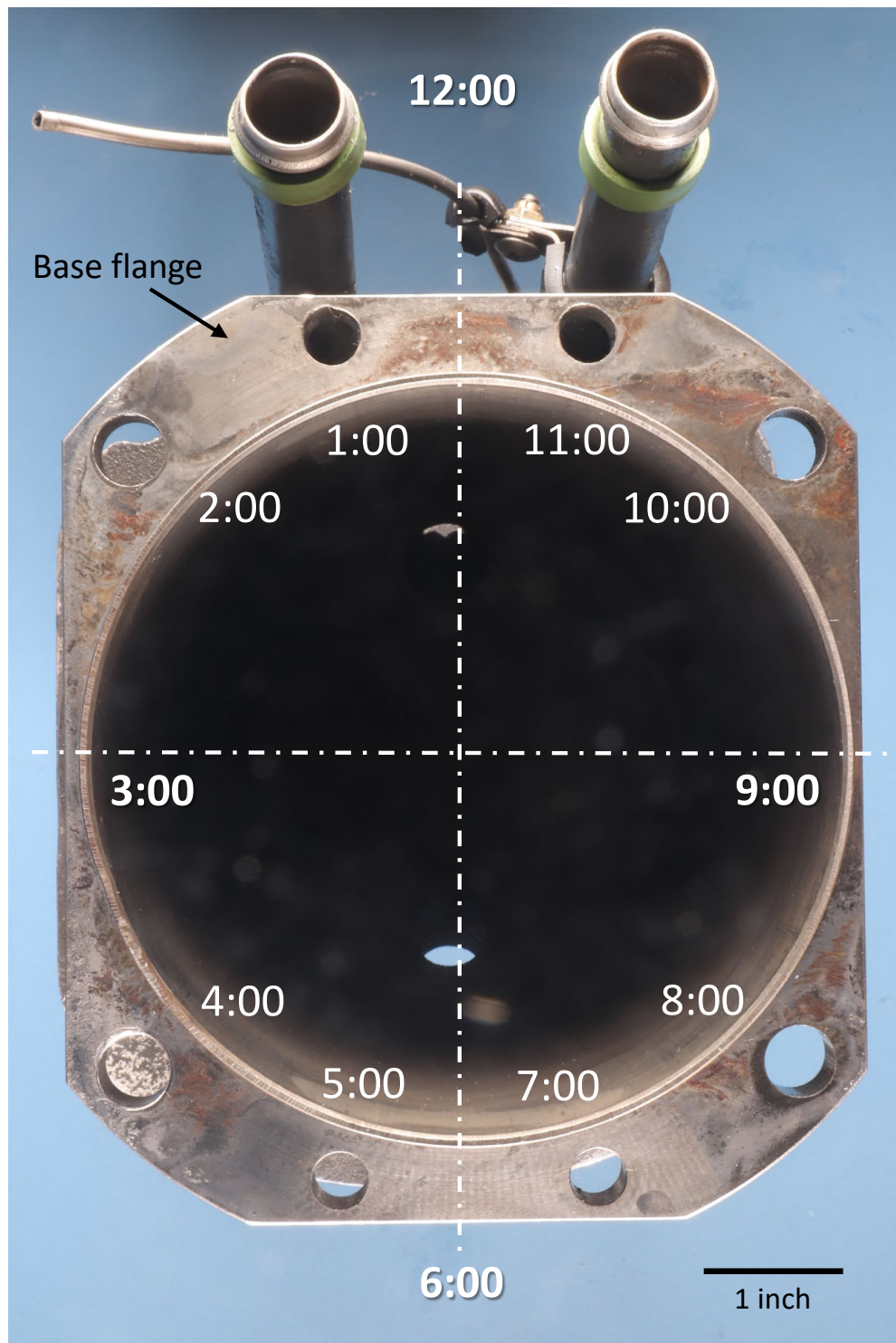


Figure 7 Image of the number 2 cylinder base flange face that mates with the crankcase. The dark regions are areas of material loss and oxidation indicative of fretting wear.



Figure 8 Fracture surfaces on the mating halves of the stud in the 1:00 position. Annotations indicate the general region of fatigue crack initiation and direction of propagation.

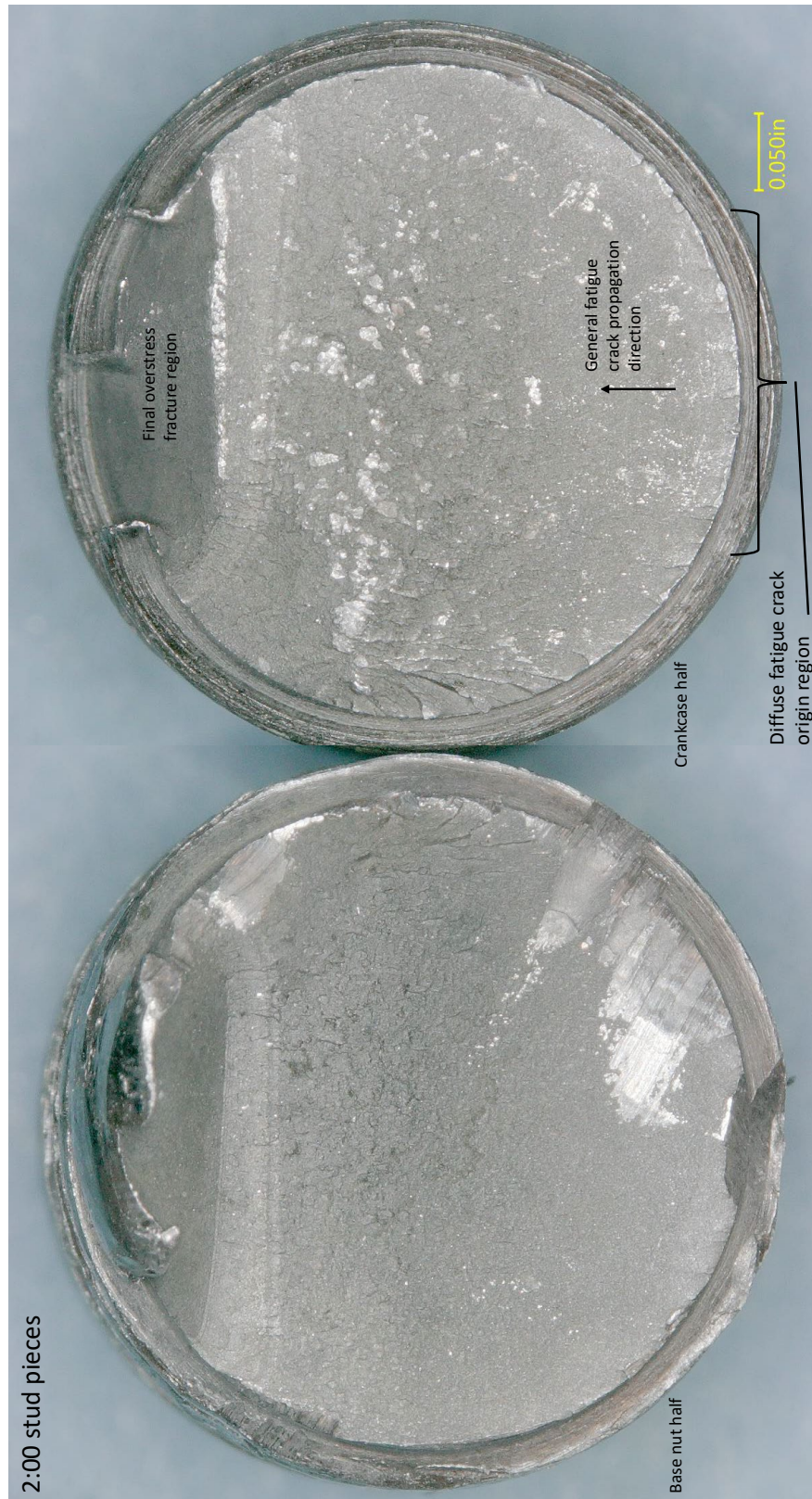


Figure 9 Fracture surfaces on the mating halves of the free-thru stud in the 2:00 position. Annotations indicate the general region of fatigue crack initiation and direction of propagation.



Figure 10 Fracture surfaces on the mating halves of the stud in the 10:00 position. Annotations indicate the general region of fatigue crack initiation and direction of propagation.



Figure 11 Fracture surfaces on the mating halves of the stud in the 11:00 position. Annotations indicate the general region of fatigue crack initiation and direction of propagation.