

# NATIONAL TRANSPORTATION SAFETY BOARD

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



December 10, 2014

## MATERIALS LABORATORY FACTUAL REPORT

Report No. 14-084

### A. ACCIDENT INFORMATION

Place : Tampa, Florida  
Date : December 20, 2013  
Vehicle : Cessna 210N, N5307A  
NTSB No. : ERA14LA076  
Investigator : Dennis Diaz (AS-ERA)

### B. COMPONENTS EXAMINED

Pieces of the #4 connecting rod assembly.

### C. DETAILS OF THE EXAMINATION

The submitted #4 connecting rod assembly pieces were from a Continental IO-520 engine. The assembly consisted of a connecting rod, a cap, and 2 bolts, all of which had fractured. Three (3) connecting rod pieces and 2 cap pieces were submitted, as shown in Figure 1. A section of the cap was missing. It was unknown if any portion of the connecting rod was also missing. Each of the bolts had fractured into 2 pieces, with the head ends wedged inside the mating connecting rod pieces and the threaded ends loose. A nut was still assembled onto the threaded end of one of the bolts.

Overall examination revealed that most of the pieces had post fracture damage that obscured the fracture surface features, with the exception of one cap piece (indicated by the red arrow in Figure 1) and the threaded ends of the bolts. The fracture surfaces of the cap and connecting rod pieces are shown in Figures 2 and 3.

All of the fracture surfaces were examined in more detail using a 5X to 50X stereo-zoom microscope. The examination revealed that one of the cap pieces was relatively intact and did not display deformation around the edges like the other cap and connecting rod pieces. The fracture surface of this cap piece is shown in Figure 4. The fracture surface was relatively flat with multiple thumbnail-shaped patterns that are consistent with fatigue. The fatigue crack thumbnails emanated from the inner and outer surfaces of the cap. Numerous ratchet marks<sup>1</sup> were observed perpendicular to the inner and outer surfaces, as indicated by the blue and red arrows, respectively. The blue and red dashed lines indicate unified crack fronts typical of final fatigue crack arrest

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<sup>1</sup> Ratchet marks are slight vertical steps in the fracture that link slightly offset planes of fatigue cracking at a fatigue origin area. Ratchet marks generally are aligned in the direction of cracking and taper off as distance from the origin is increased and a unified crack front is produced.

positions that emanated from the inner and outer surfaces, respectively. The features are consistent with fatigue initiating from the inner and outer surfaces of the cap and propagating inward. The fracture surface was comprised of 57% fatigue cracking initiating from the inner surface, 21% fatigue cracking initiating from the outer surface, and the remainder consistent with overstress.

Stereomicroscopic examination of the threaded ends of the bolts revealed necking<sup>2</sup> of the shank of the bolts adjacent to the fracture surfaces. The features on the bolt fracture surfaces were rough and grainy, and were surrounded by shear lips. The necking, rough fracture surfaces, and shear lips were consistent with overstress failure.

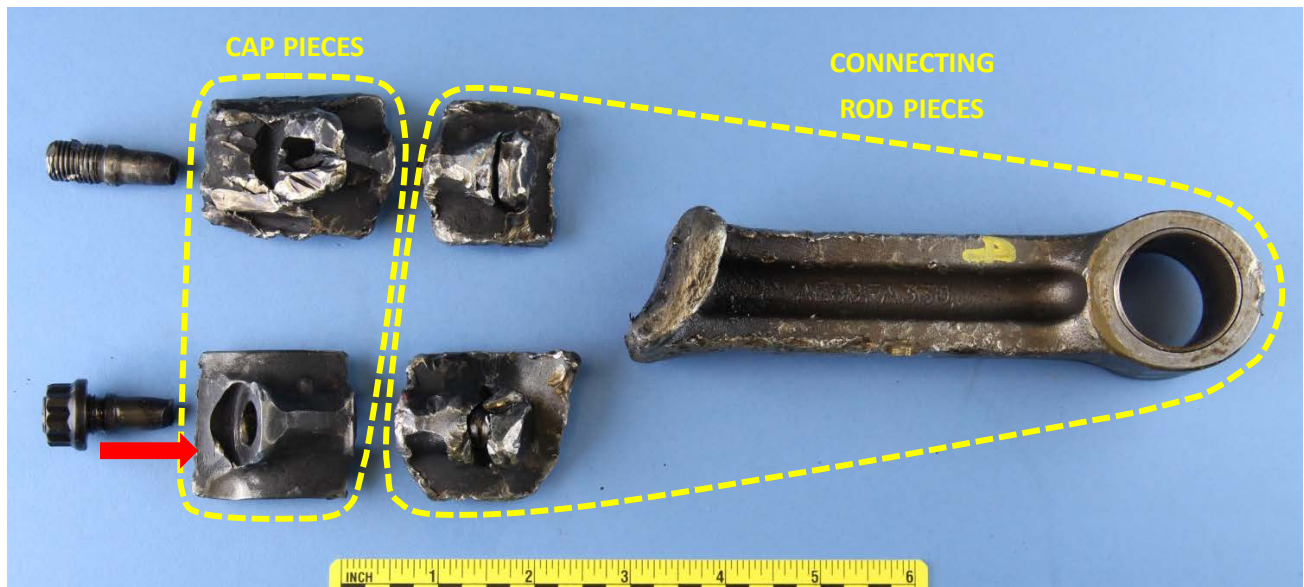
Representative connecting rod, cap, and bolt pieces were analyzed using a Thermo Scientific Niton XL3t-980 x-ray fluorescence (XRF) alloy analyzer. The alloy analyzer identified the material of the connecting rod and connecting rod cap as Grade 4340 alloy steel, and the bolt as Grade 8740 alloy steel. According to the manufacturer's engineering drawings, the alloys met the material composition requirements for the respective components.

The average hardness of the connecting rod, connecting rod cap, and bolt was determined to be 29.7 HRC, 38.5 HRC, and 37.1 HRC, respectively. According to the manufacturer's engineering drawings, the hardness measurements for the connecting rod and connecting rod cap met the material requirements. The hardness measurement for the bolt was slightly below the range specified in the material requirement, which is 38-42 HRC.

Adrienne V. Lamm  
Materials Engineer

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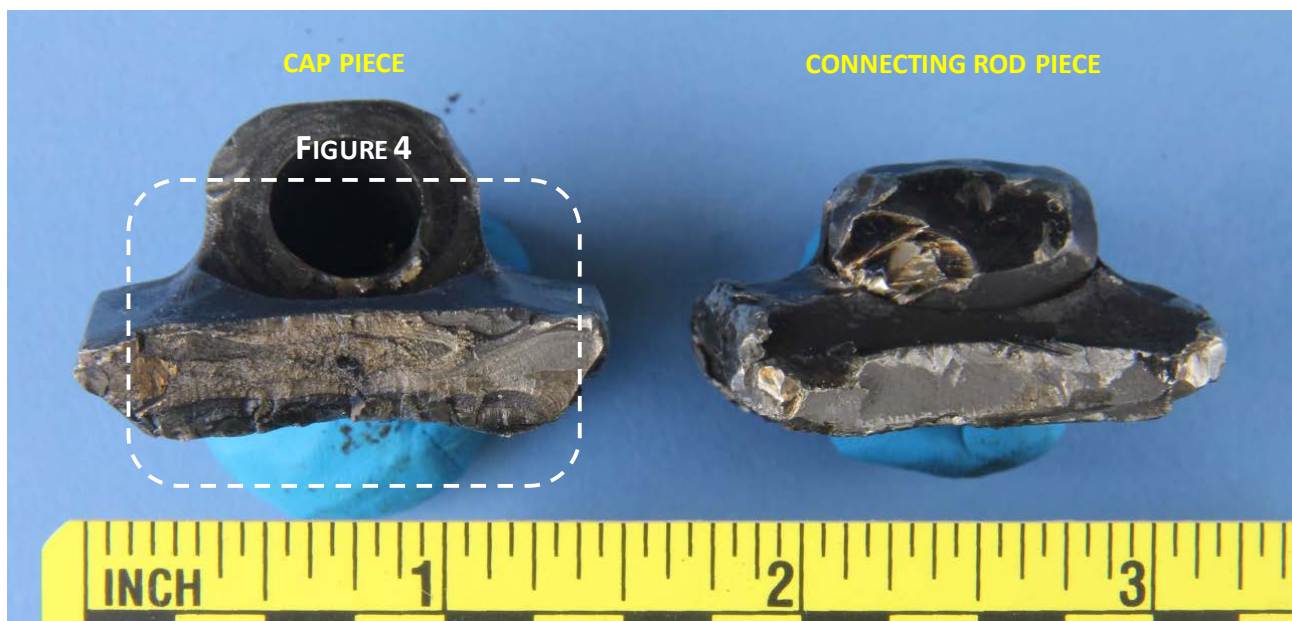
<sup>2</sup> Necking is the reduction in cross-sectional area of a component due to localized deformation, and is typically associated with uniaxial tension or stretching.



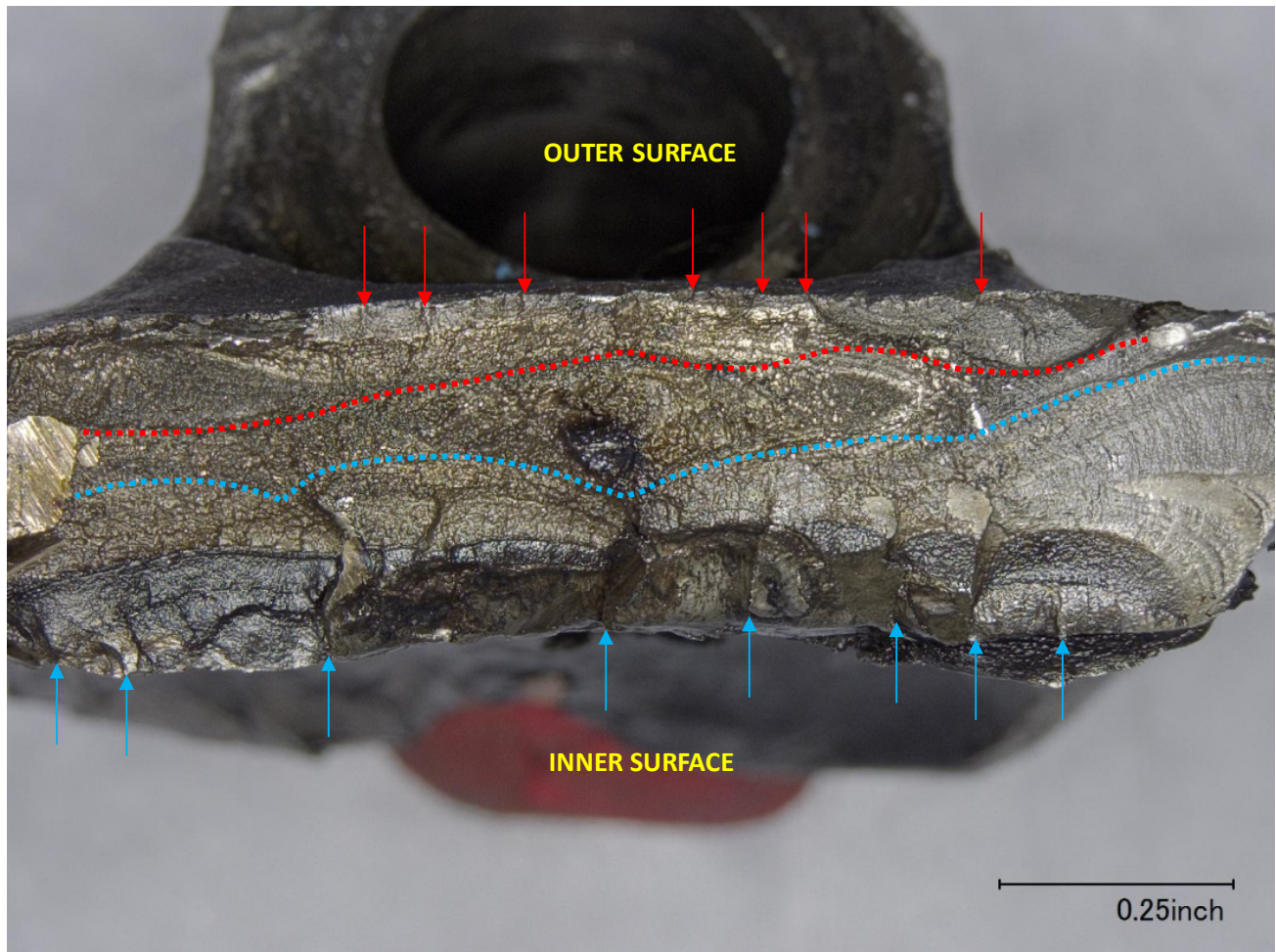
**Figure 1:** Overall photo of the submitted connecting rod, connecting rod cap, and bolt pieces. The red arrow indicates the fracture surface on the cap piece that is shown in more detail in Figure 4.



**Figure 2:** Close-up photos of the fracture surfaces on the connecting rod and cap pieces shown in the top of Figure 1.



**Figure 3:** Close-up photos of the fracture surfaces on the connecting rod and cap pieces shown in the bottom of Figure 1. The fracture surface on the cap piece in the indicated area is shown in more detail in Figure 4.



**Figure 4:** Close-up photo of the fracture surface on the cap piece that was shown in Figure 3. The fracture surface had multiple fatigue crack thumbnails emanating from the inner and outer surfaces. Ratchet marks perpendicular to the inner and outer surfaces are indicated by the blue and red arrows, respectively. Blue and red dashed lines indicate unified fatigue crack fronts that emanated from the inner and outer surfaces, respectively.



**Figure 5:** Close-up photo of the fracture surfaces on the bolt pieces with the threaded ends.