

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



WPR22LA263

MATERIALS LABORATORY

Factual Report 24-020

05/14/2024

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A. ACCIDENT INFORMATION

Location: Bothell, WA
Date: 7/19/2022
Vehicle: Zenith STOL CH702
Investigator: Zoë Keliher

B. COMPONENTS EXAMINED

Portions of a flywheel assembly, alternator assembly, and crankshaft timing gear for a Jabiru 3300A engine.

C. DOCUMENTS EXAMINED

- Jabiru Engine Parts Book: 3300 Series, Revised Nov 2011

D. EXAMINATION PARTICIPANTS

Materials Engineer Brian Fuchs
 NTSB
 Washington, DC

E. DETAILS OF THE EXAMINATION

On July 19, 2022, a Zenith CH-701 lost power mid-flight as it approached its destination airport. The pilot was unable to restart the engines and attempted an off-airport landing on a vacant road. The plane struck high-tension power lines before falling to the road below. The owner arranged for removal of the plane from the accident site and an investigator performed an engine examination during October 11-12, 2023. The investigator discovered that the six bolts connecting the crankshaft to the flywheel assembly had failed. The flywheel assembly, alternator assembly, and crankshaft timing gear were submitted to the NTSB Materials Laboratory for further examination. It was found that magnetic forces between the alternator magnets (attached to the flywheel) and stator (attached to a mounting bracket) held the alternator and flywheel assemblies together. The investigator who performed the engine teardown confirmed that these pieces had not been separated for inspection prior to submission to the lab.

Figure 1 shows the flywheel and alternator assemblies as received. Radial splattering of a dark substance originating from the center spacer was visible across the face of the flywheel. Six broken bolts were visible on the front face of the flywheel. The planes of the bolt fracture surfaces were located at similar heights, either just above or just below the lip of the mating surface. The bolt fracture surfaces were

cleaned using acetone and a soft brush and were arbitrarily numbered 1 to 6 for identification purposes.

Figure 2 shows the crankshaft timing gear as received. The bolts would have passed through the six through-holes on the face and then threaded into to the crankshaft, as shown in Jabiru's assembly drawing (**Figure 3**). No significant damage was seen in the timing gear.

The stator ring and bracket were detached from the flywheel for further examination. The bracket shows galling wear in a circular pattern consistent with the location of the alternator ring when the two pieces were attached, shown in **Figure 4**. This is consistent with repeated contact and rubbing between the spinning flywheel assembly and bracket during engine operation.

Figure 5 shows the flywheel assembly after the stator and bracket were removed. The upper surface of the alternator ring shows galling wear where it was in contact with the stator bracket. The six fractured 5/16 inch hex-head bolts were backed out of their fully seated positions by approximately 0.25 inch. The bolts were loosely threaded into the holes, though communication and part drawings from Jabiru indicated that those holes were manufactured with a smooth bore. It is unclear if this was the final position of the bolts at the time of the failure or if they shifted during the subsequent crash or retrieval. Washers under the bolt heads were deformed in a manner consistent with bending forces and a crack was discovered in one washer, shown in **Figure 5C**.

Five of the six bolts were unscrewed from the flywheel for further acetone cleaning and examination; bolt 3 could not be unscrewed by hand. Examination of the bolt threads showed contact damage consistent with impingement on the walls of the through-holes, and complimentary wear resembling screw threading was visible in the through-holes, as pictured in **Figure 6**. It appeared that the contact damage in the through-holes was deep enough to explain why the bolts had to be unscrewed from their positions.

The bolt fracture surfaces were examined using a digital microscope and are shown in **Figure 7**. The surfaces on bolts 1, 2, 5, and 6 show similar characteristics. Ratchet marks (indicative of multiple fatigue initiation points) were seen at the base of the threads, indicated by white brackets. Fatigue crack progression marks were present across most of the face until final failure as indicated by a shear lip. These features are consistent with low stress bending-fatigue. Bolts 1, 2, and 6 also show evidence of secondary fatigue cracks intersecting the primary crack, with origins at the thread roots. Similar features were also observed on bolt 3. Contrasting to the relatively planar faces of the other bolts, bolt 4 (**Figure 7C**) has a pitched fracture surface with significant contact damage at the highest plane. Ratchet marks and crack

progression marks were visible at multiple points around the fracture surfaces, indicating fatigue initiating at the roots of several threads.

Submitted by:

Brian Fuchs
Materials Engineer

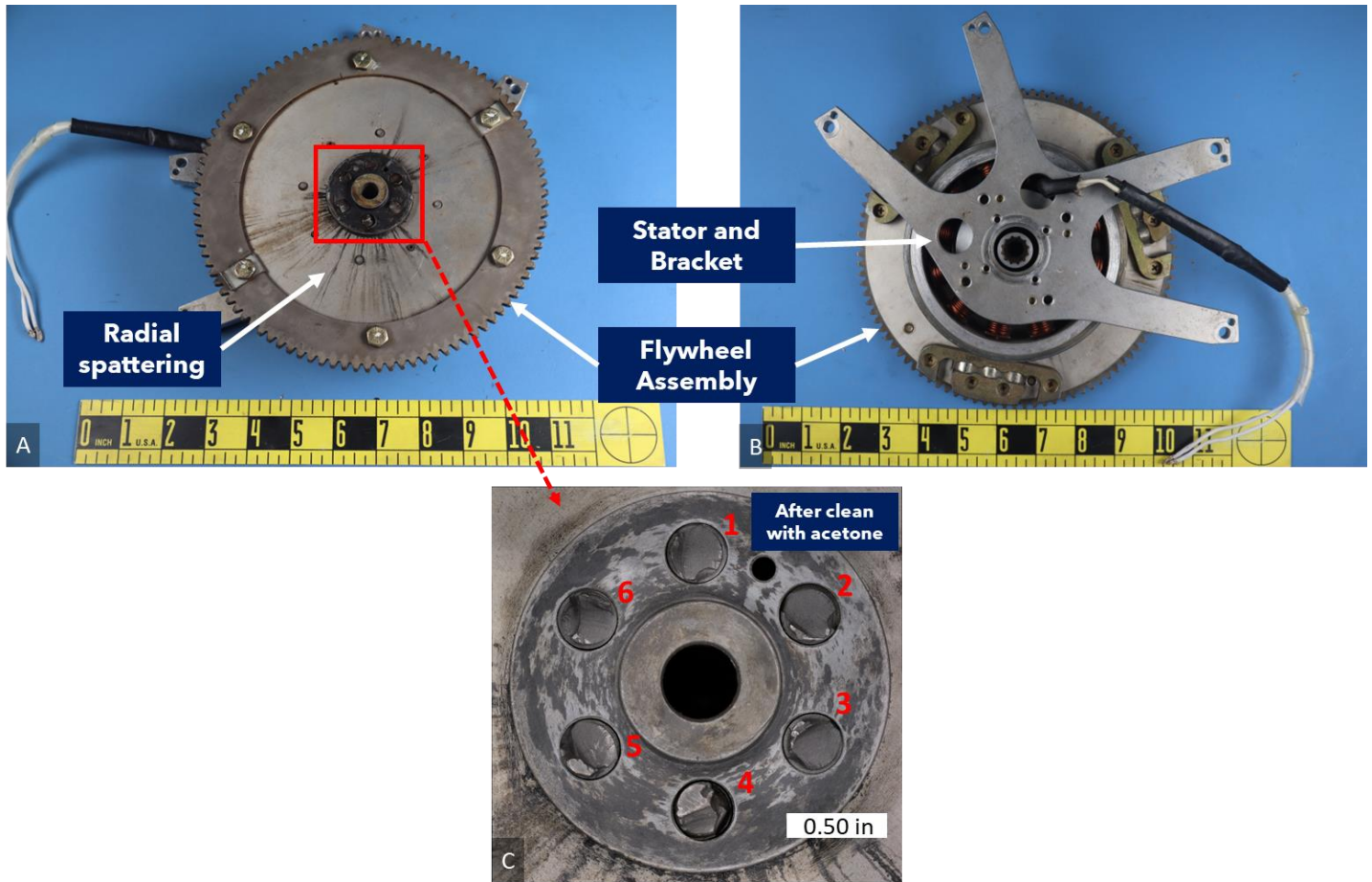


Figure 1. A) Front and B) rear side of the flywheel, alternator, and bracket as received. C) Fractured bolts in the flywheel assembly after cleaning with acetone.

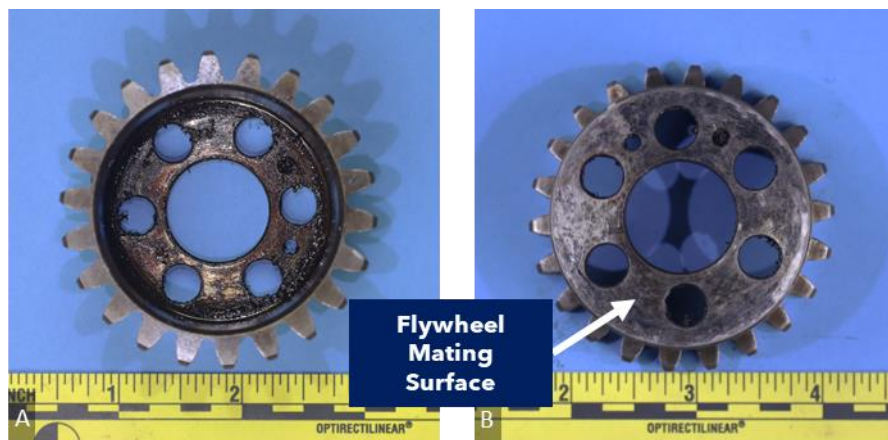


Figure 2. A) Front and B) rear side of the crankshaft timing gear as received.

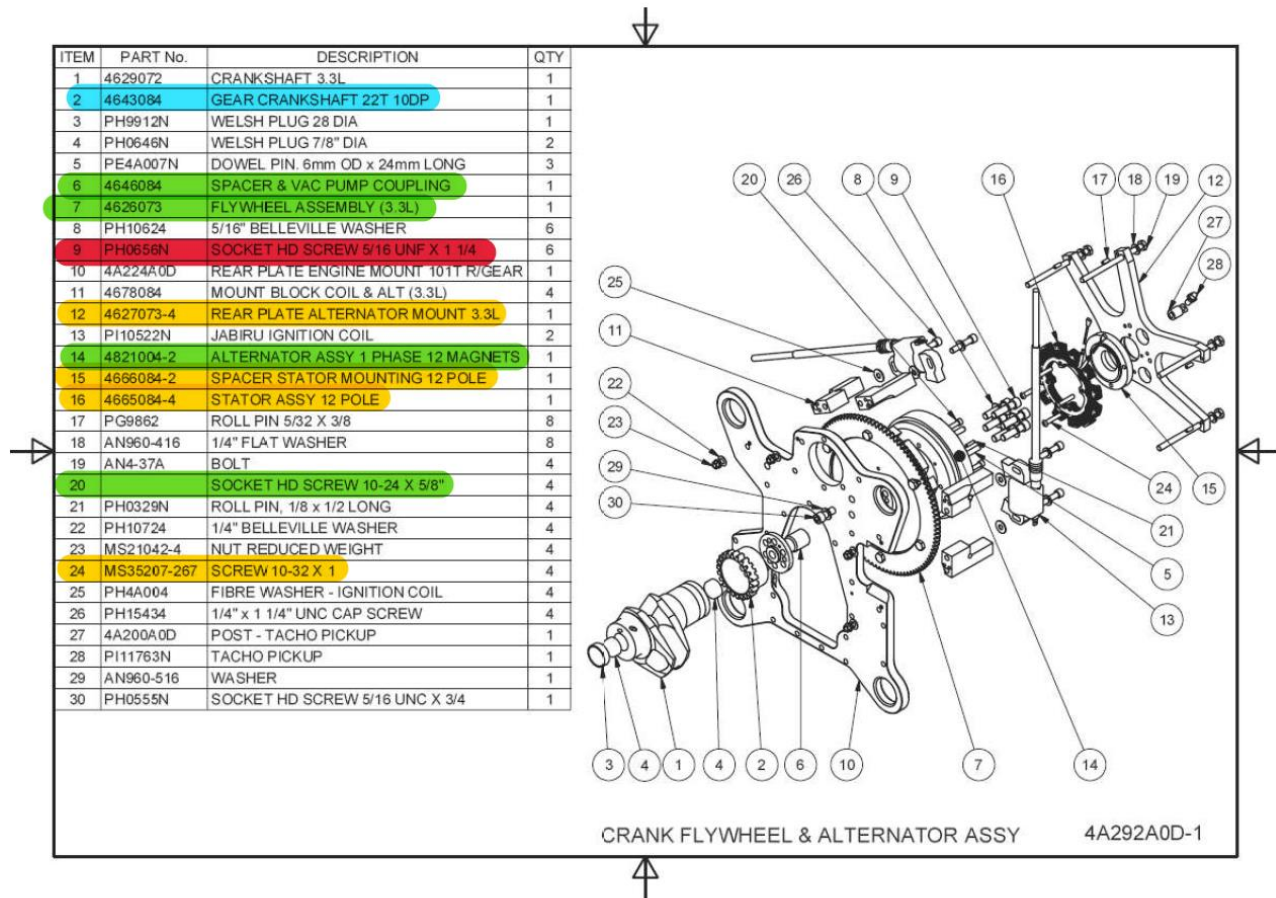


Figure 3. Drawing of crankshaft, flywheel, and alternator assembly in with similar configuration to accident vehicle. Highlighted text indicates parts in the assembly. Blue is the crankshaft timing gear, green are parts in the flywheel assembly, orange is the stator and bracket assembly, and red are the failed bolts. Note that this image is from a newer design revision than the accident vehicle, as the accident vehicle did not include the three dowel pins and accompanying holes in the crankshaft assembly. Adapted from "Jabiru Engine Parts Book: 3300 Series," p. 19.

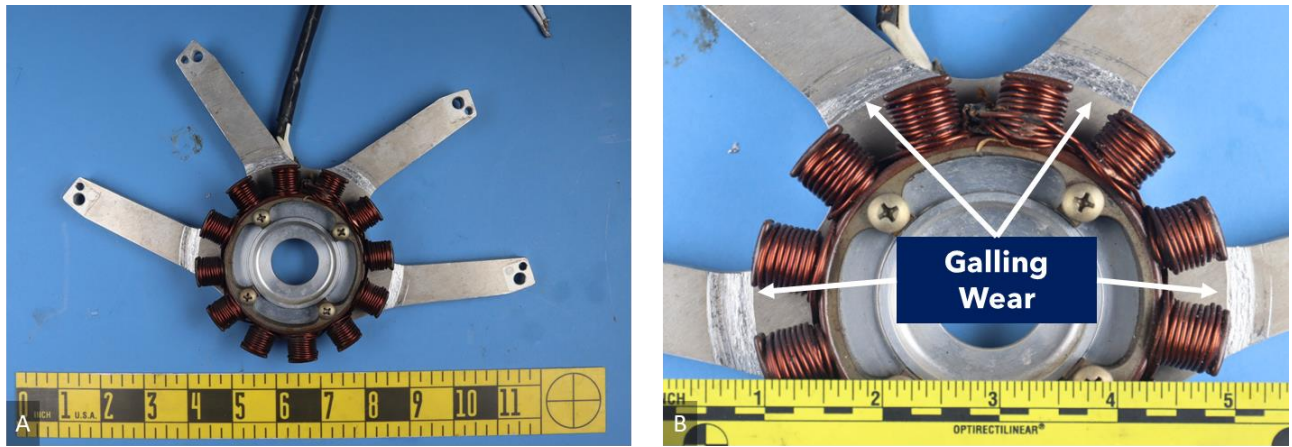


Figure 4. A) Front side of the stator and bracket after removal. B) Closer view of galling wear on the bracket

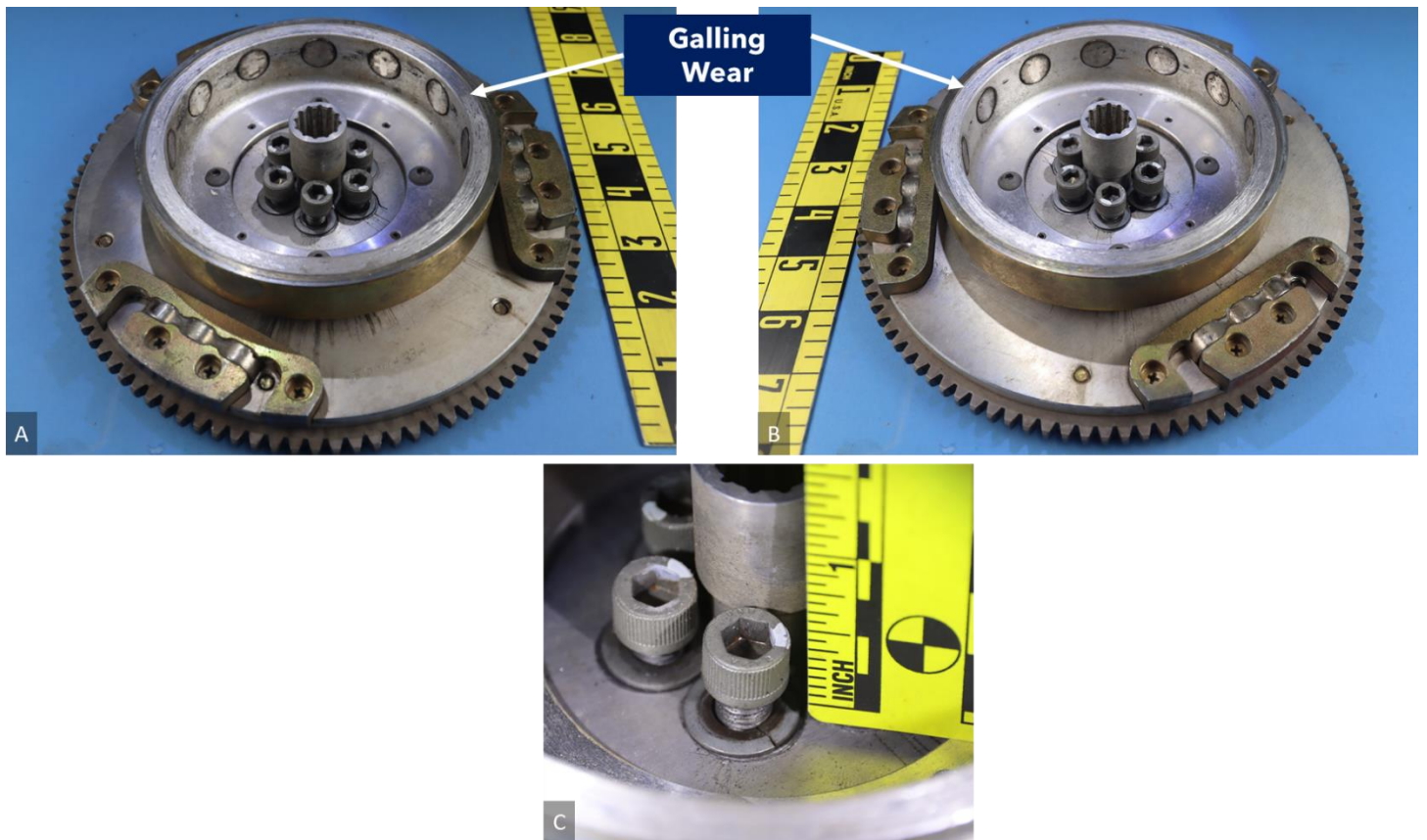


Figure 5. A, B) Opposing views of the rear of the flywheel assembly showing the backed-out bolts. C) A closer view of a backed-out bolt (4) with a cracked washer underneath the head.

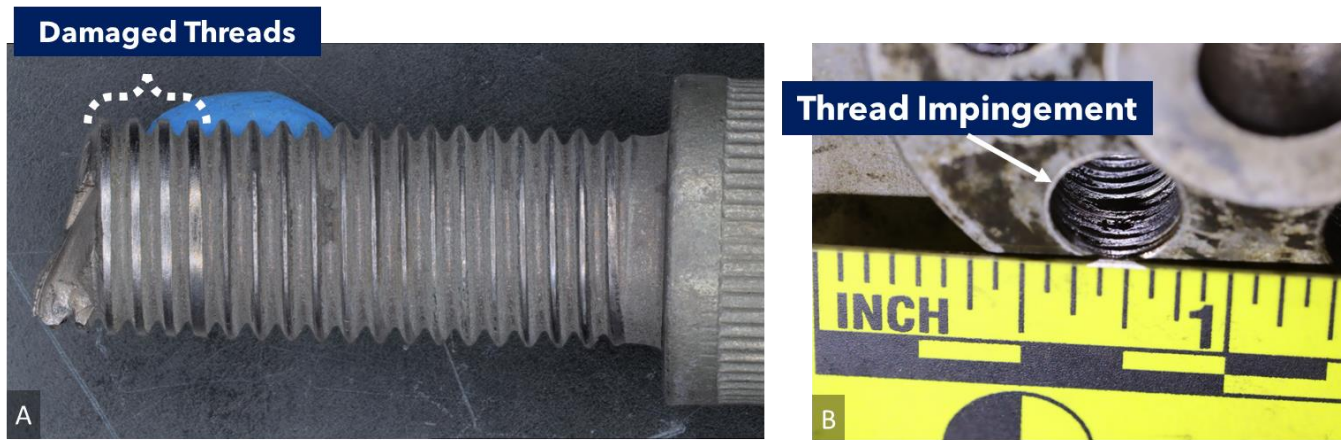


Figure 6. A) Thread showing contact damage near the fracture surface on bolt 6. B) Thread impingement on a through-hole in the spacer.

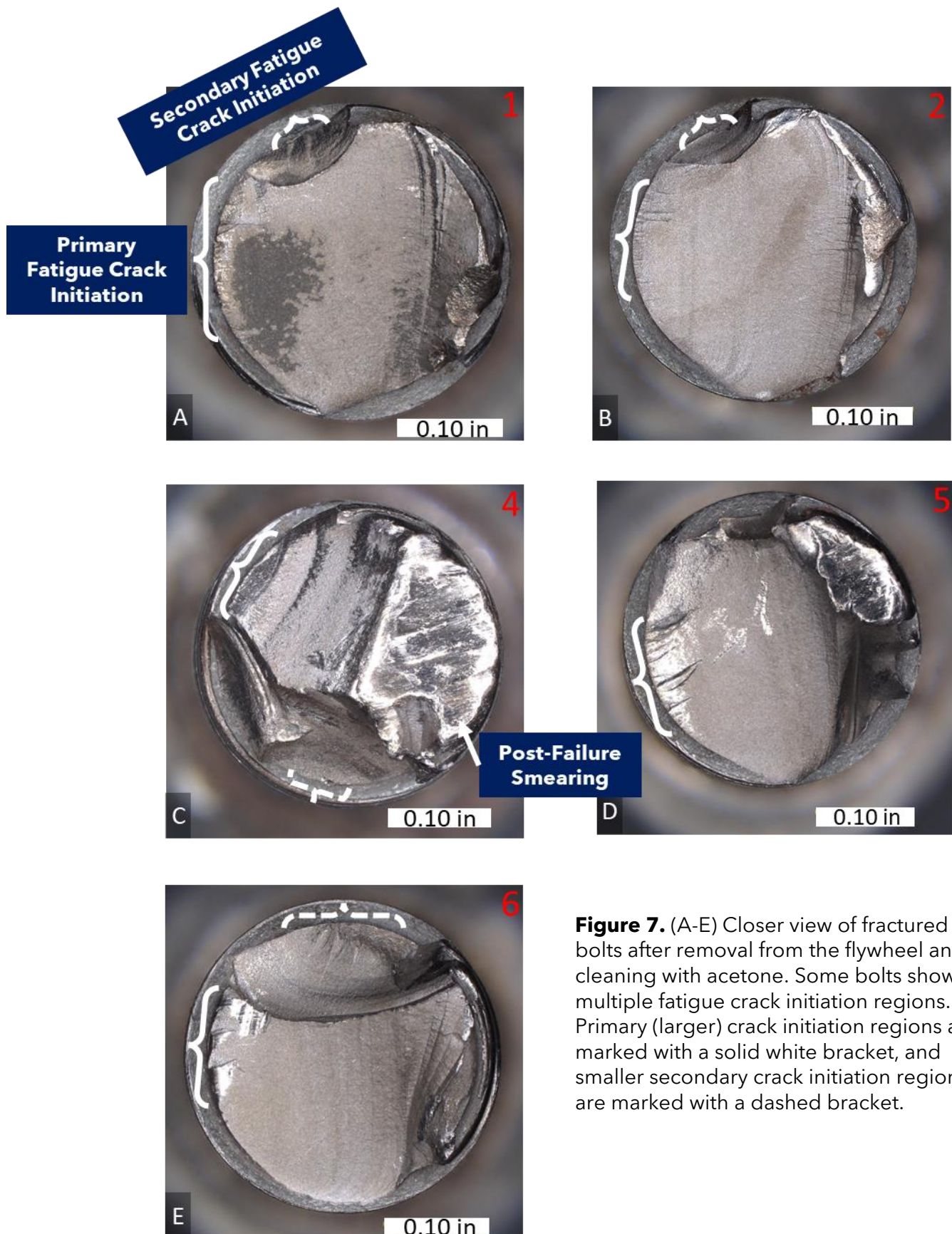


Figure 7. (A-E) Closer view of fractured bolts after removal from the flywheel and cleaning with acetone. Some bolts show multiple fatigue crack initiation regions. Primary (larger) crack initiation regions are marked with a solid white bracket, and smaller secondary crack initiation regions are marked with a dashed bracket.