

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



WPR23LA216

MATERIALS LABORATORY

Factual Report 23-091

October 25, 2023

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A. ACCIDENT INFORMATION

Location: Santa Monica, California
Date: June 5, 2023
Vehicle: Cessna 172R, N819KS
Investigator: Stephen Stein (AS-WPR)

B. COMPONENTS EXAMINED

Nose landing gear torque link and 2 bolts

C. EXAMINATION PARTICIPANTS

Specialist Adrienne Lamm
National Transportation Safety Board
Washington, D.C.

D. DETAILS OF THE EXAMINATION

During landing after flight, the nose landing gear on the subject aircraft experienced a shimmy immediately on contact with the runway. The shimmy intensified as the aircraft slowed; during slowdown, a metallic sound was reported by the pilot, who subsequently could not control the travel direction of the aircraft, resulting in the right wing striking the ground and the aircraft nosing over to land inverted. While performing a sweep of the runway after the accident, personnel discovered a bolt from the nose wheel torque link. Examination of the nose wheel torque link assembly determined the separated bolt was from the upper torque link. The torque link assembly was removed from the aircraft and, along with the separated bolt, was submitted to the NTSB Materials Laboratory in Washington, D.C. for examination. The submitted components are shown in Figure 1.

The separated upper torque link bolt was compared to the intact lower torque link bolt. The lengths of both bolts were measured; the upper torque link bolt separated through the shank approximately ¼ inch below the head. A bend was observed in the approximate middle of the remaining upper torque link bolt. A ridge of smeared material (red arrows, Figure 2) was noted on one side of the shank adjacent to the fracture surface. The ridge of material was located on the side opposite the direction of the bend in the bolt. Adjacent the fracture surface on the same side as the bend in the bolt the shank was deformed inwards and pushed slightly upwards, as highlighted by the white dotted line in Figure 2.

Figure 3 shows the fracture surface on the separated upper torque link bolt was flat with transgranular macro features. A lip of smeared material (red arrows) was noted on the fracture surface emanating from the ridge of material. On the opposite

side of the bolt, a ridge of material corresponding to the deformation of the shank was observed around the edge of the fracture surface (green arrows).

The fracture surface was sectioned from the upper torque link bolt piece, cleaned, and examined using a field-emission scanning electron microscope (SEM). Smearing damage obscured some areas on the fracture surface, but the undamaged areas had directional ductile dimples consistent with shear overstress. The dimples were observed across the entire fracture surface, as shown in Figures 4-7.

The illustrated parts catalog for the aircraft listed an AN4-31 bolt was to be used in the torque link assembly. Per specification, an AN4 bolt should have dimensional characteristics of ¼ inch diameter, with threads that conform to 28 UNF-3A profile. The diameter of the shank on both the intact lower torque link bolt and the separated upper torque link bolt measured ¼ inch. A thread gauge confirmed the thread profiles met 28 UNF.

Another portion of shank was sectioned from the remaining upper torque bolt piece. The cut surface was analyzed using an Olympus Vanta x-ray fluorescence (XRF) alloy analyzer and determined to have a composition consistent with 8620 steel.

AN4 28 UNF-3A bolts have a tensile stress area of 0.0364 in² and per specification should meet or exceed an ultimate tensile strength of 4,080 lbf at the thread root diameter.¹ Thus, the failure stress of the bolt should meet or exceed approximately 112 ksi, which corresponds to approximately 21 HRC hardness. Hardness measurements taken on the polished flats of the sectioned shank piece averaged 24 HRC.

The washers that were assembled to the intact lower torque link bolt appeared to be in good condition, with a shallow wear pattern on both faces. The washers that were assembled to the upper torque link bolt were rough with scrape marks, plating that had worn away, and had deformation. The lower torque link washers both measured 0.063 inches thick. One of the upper torque link washers was noticeably thinner than the other, as shown in Figure 8; one washer measured 0.62 inches thick and the other washer measured 0.31 inches thick.

Submitted by:

Adrienne V. Lamm
Materials Engineer

¹ Joseph Edward Shigley and Larry D. Mitchell, Mechanical Engineering Design, McGraw-Hill, Inc. 1958, page 361.

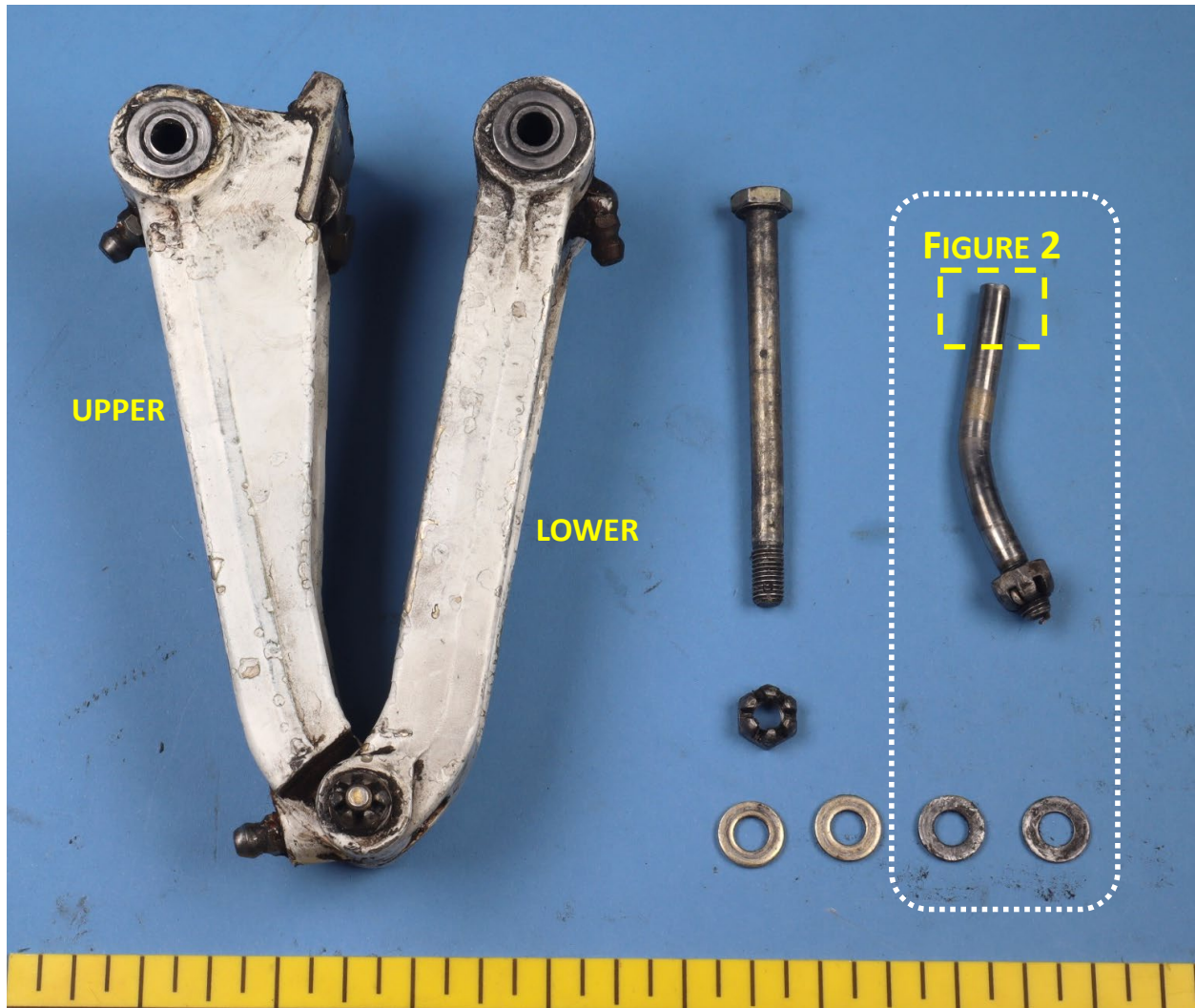


Figure 1. Macro photo showing the torque link assembly components. The white dotted line encircles the washers and separated bolt that mated with the upper torque link.

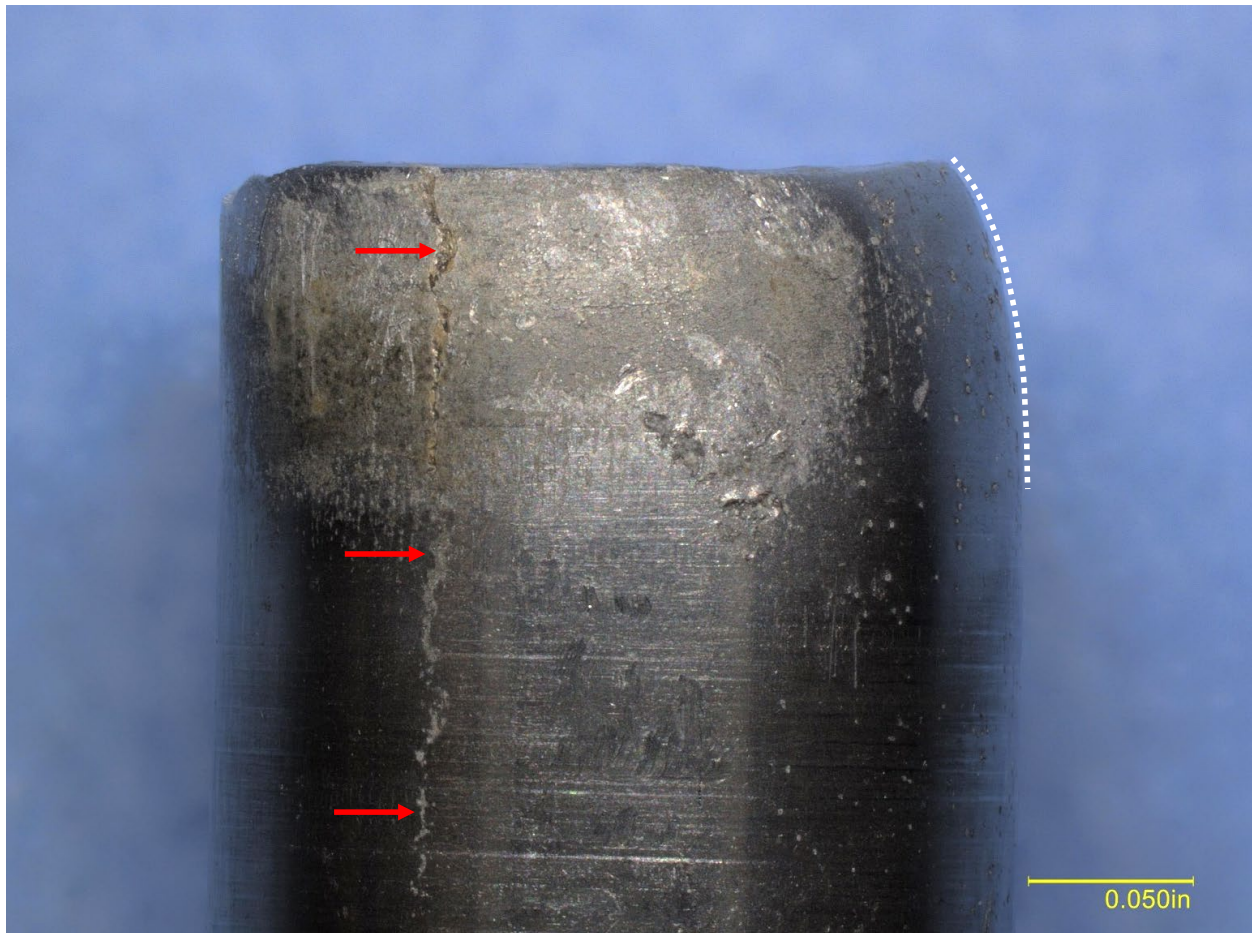


Figure 2. Digital microscope image showing the profile of the separated upper torque link bolt. The red arrows point to a ridge of smeared material on one side of the shank adjacent to the fracture surface. The white dotted line highlights an area of shank that was deformed inwards and pushed slightly upwards.

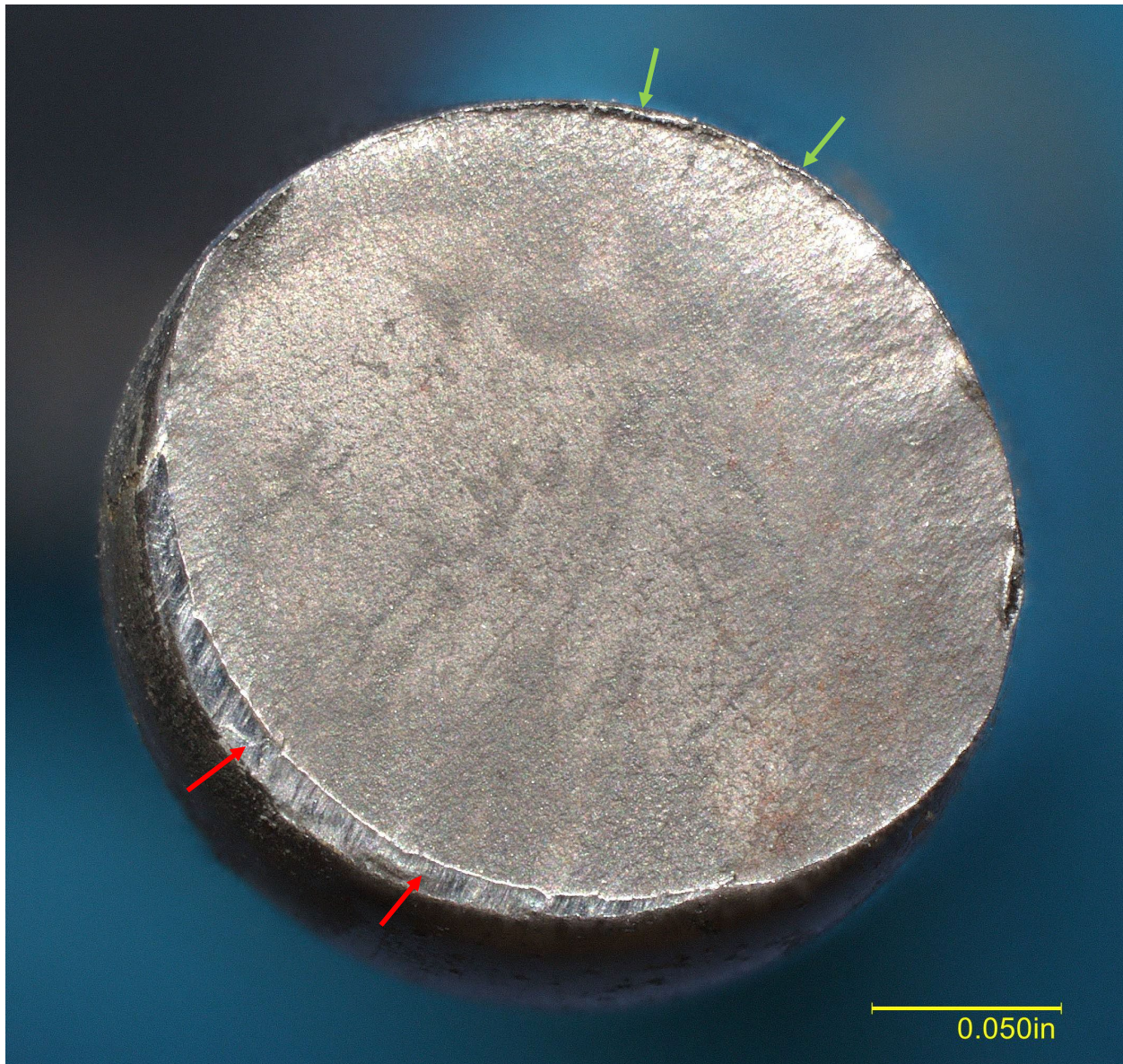


Figure 3. Digital microscope image showing the fracture surface on the separated upper torque link bolt. The red arrows point to a lip of smeared material on one side of the fracture surface. The green arrows point to a ridge of material corresponding to the deformation of the shank observed around the edge of the fracture surface.

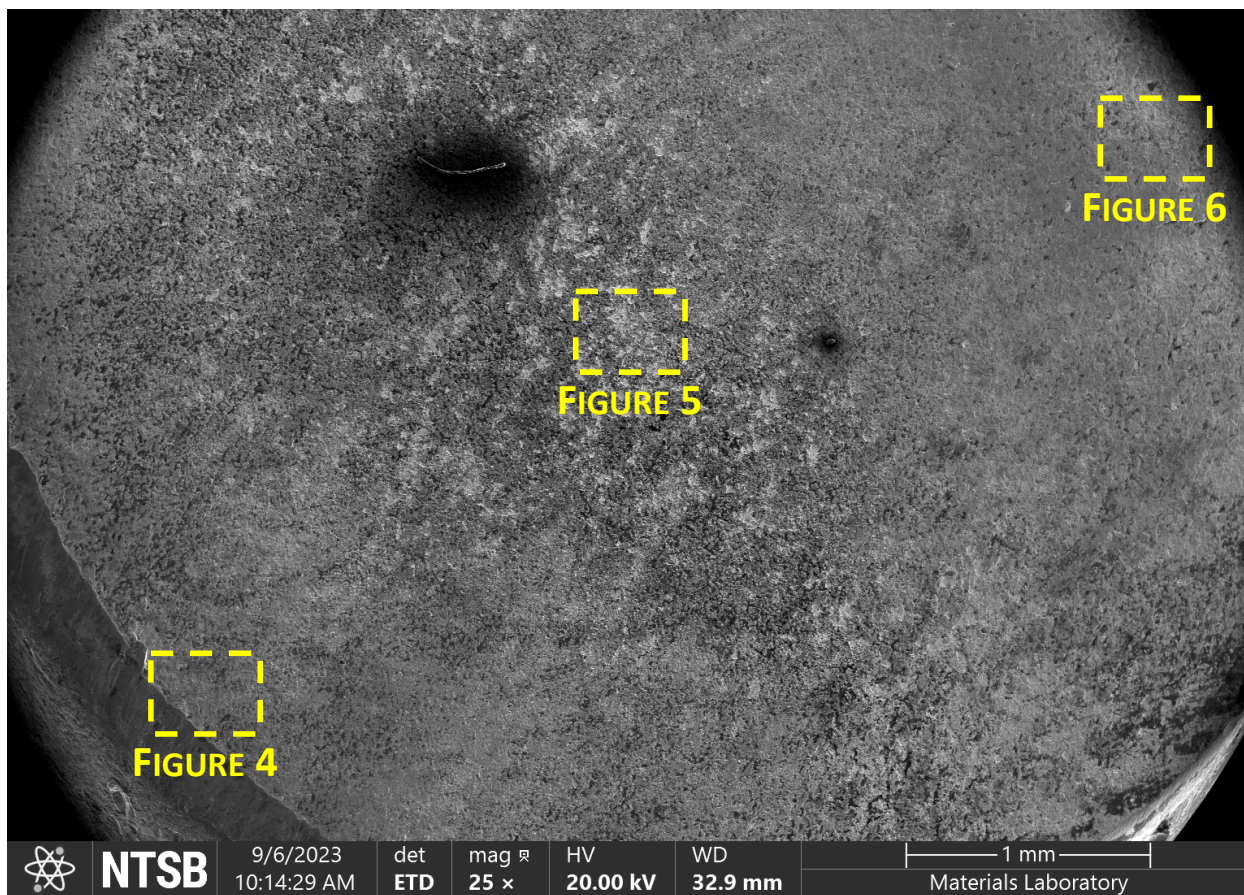


Figure 4. Secondary electron (SE) SEM image showing the fracture surface on the separated upper torque link bolt. Higher magnification images of the fracture surface in the areas highlighted are shown in subsequent images.

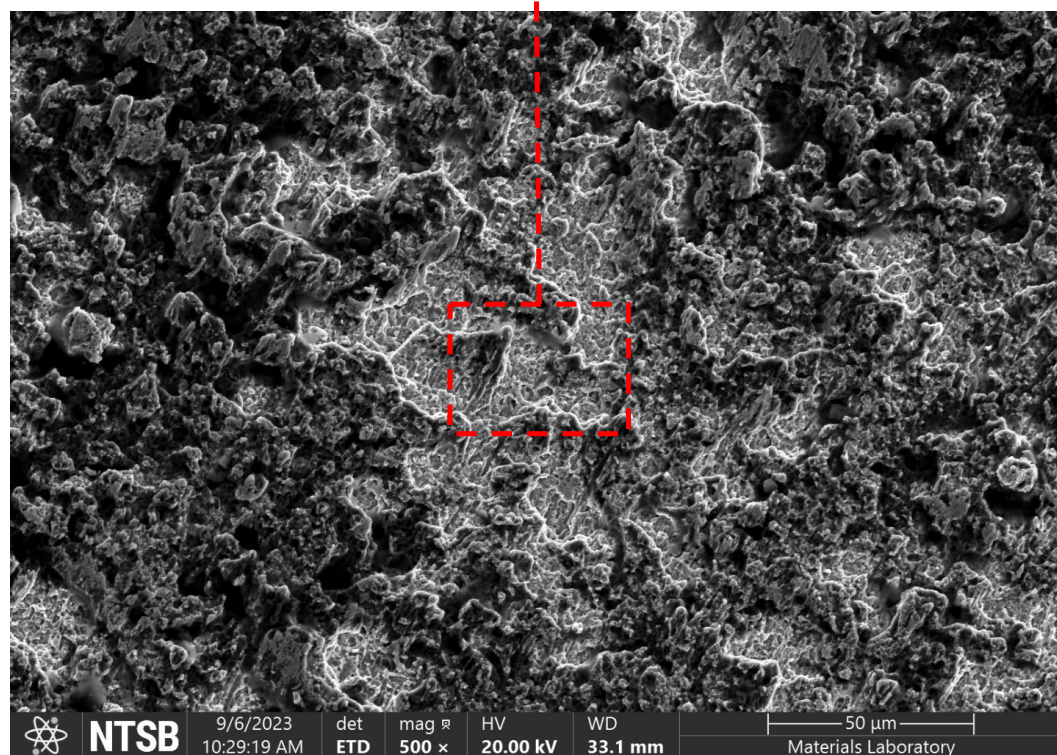
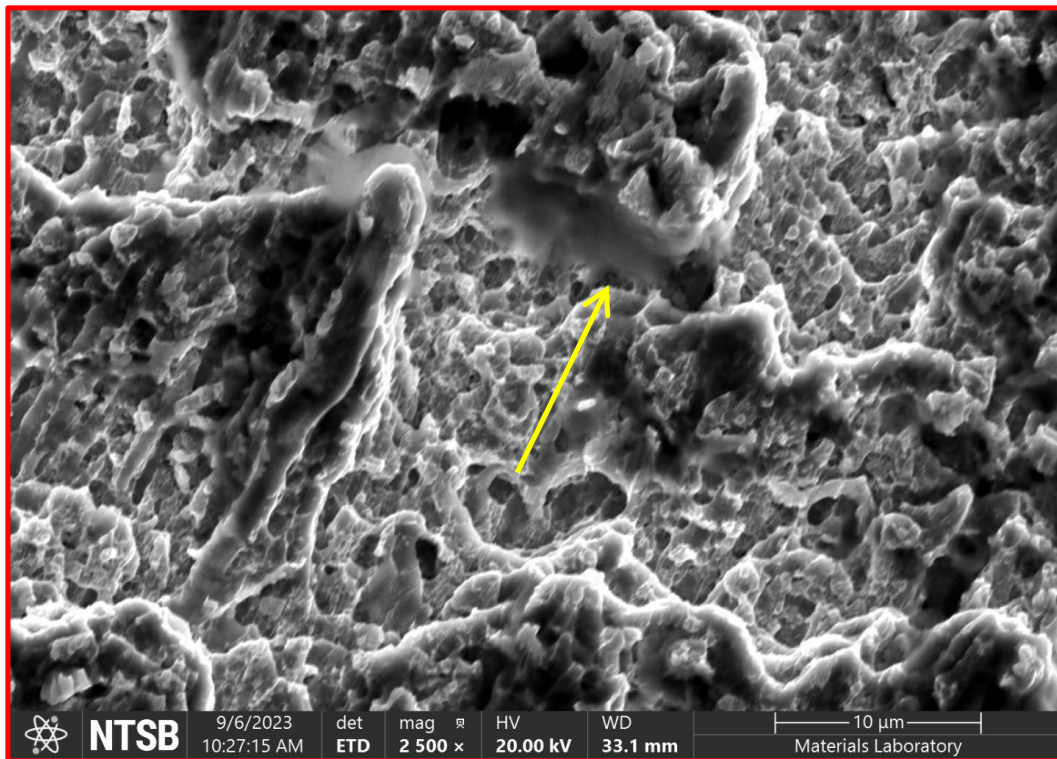


Figure 5. SE SEM image showing the fracture surface on the separated upper torque link bolt in the area indicated in Figure 4. The yellow arrow indicates the direction of shear stress that resulted in the observed directional ductile dimples.

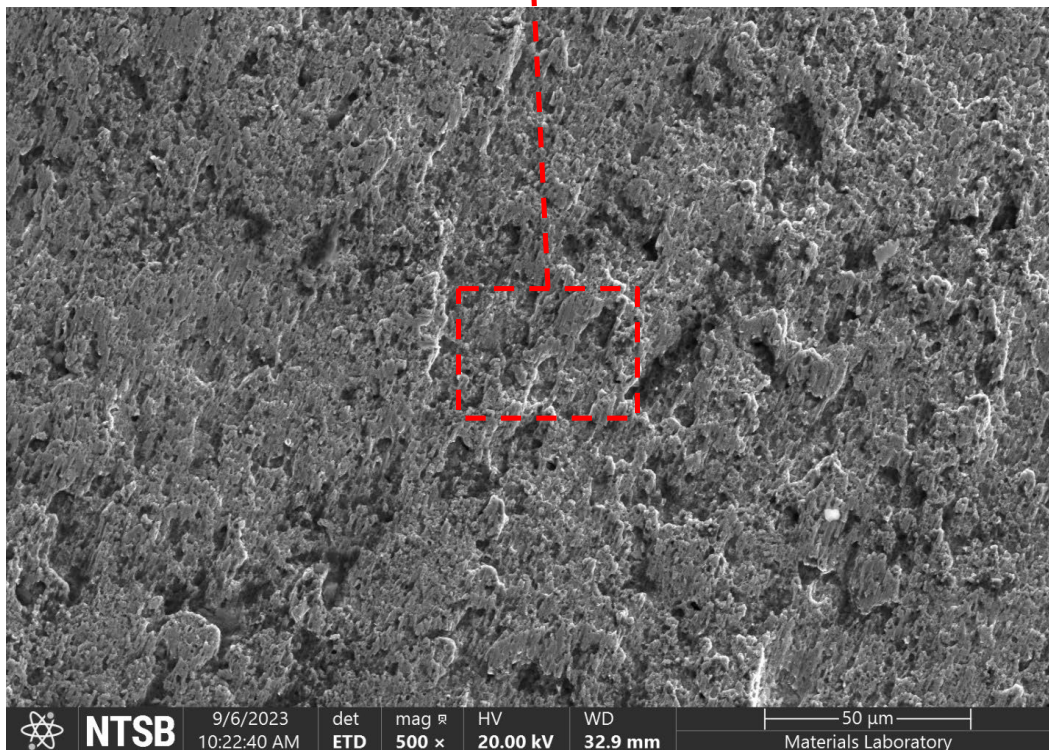
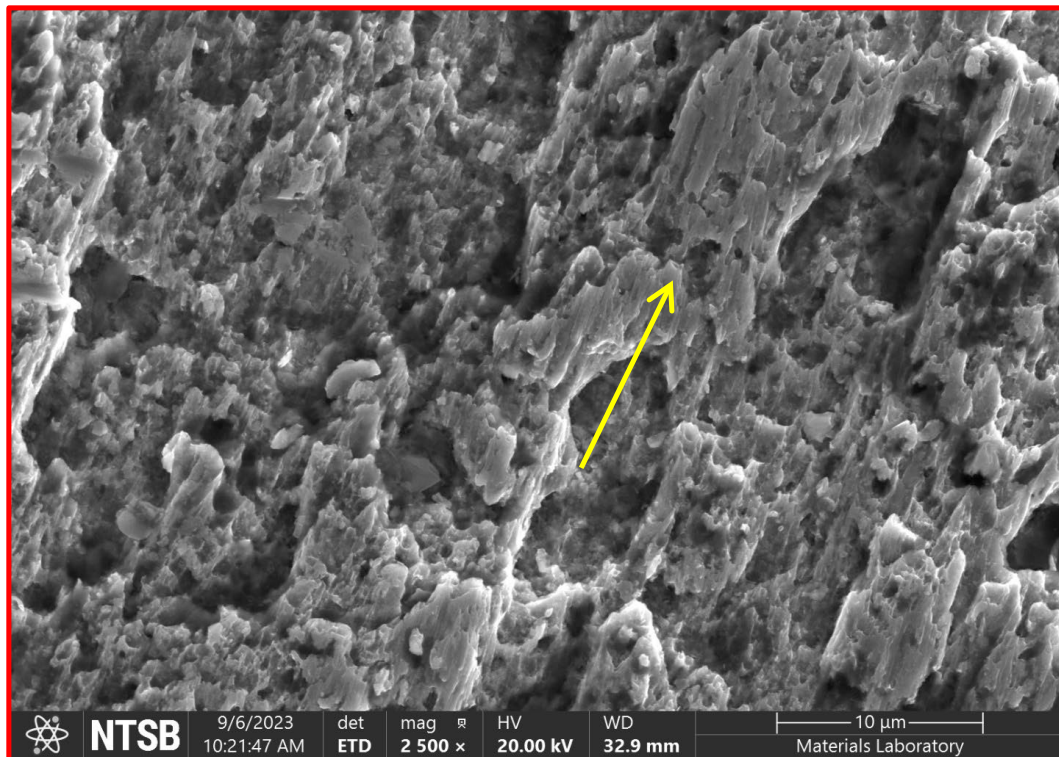


Figure 6. SE SEM image showing the fracture surface on the separated upper torque link bolt in the area indicated in Figure 4. The yellow arrow indicates the direction of shear stress that resulted in the observed directional ductile dimples.

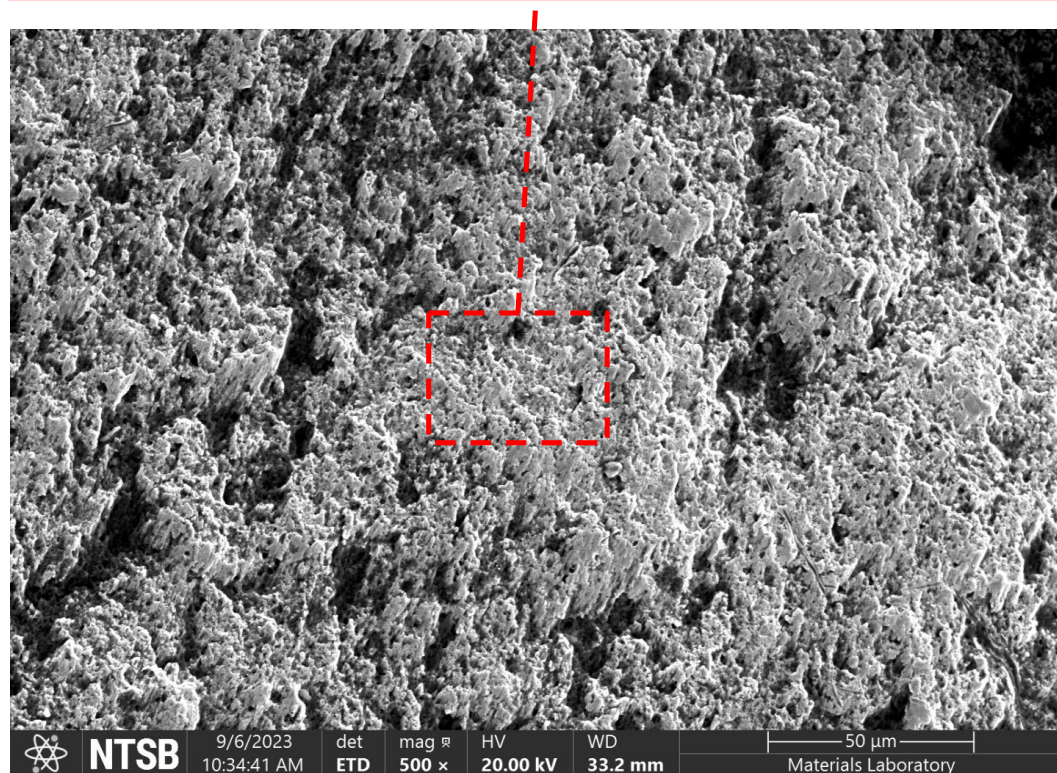
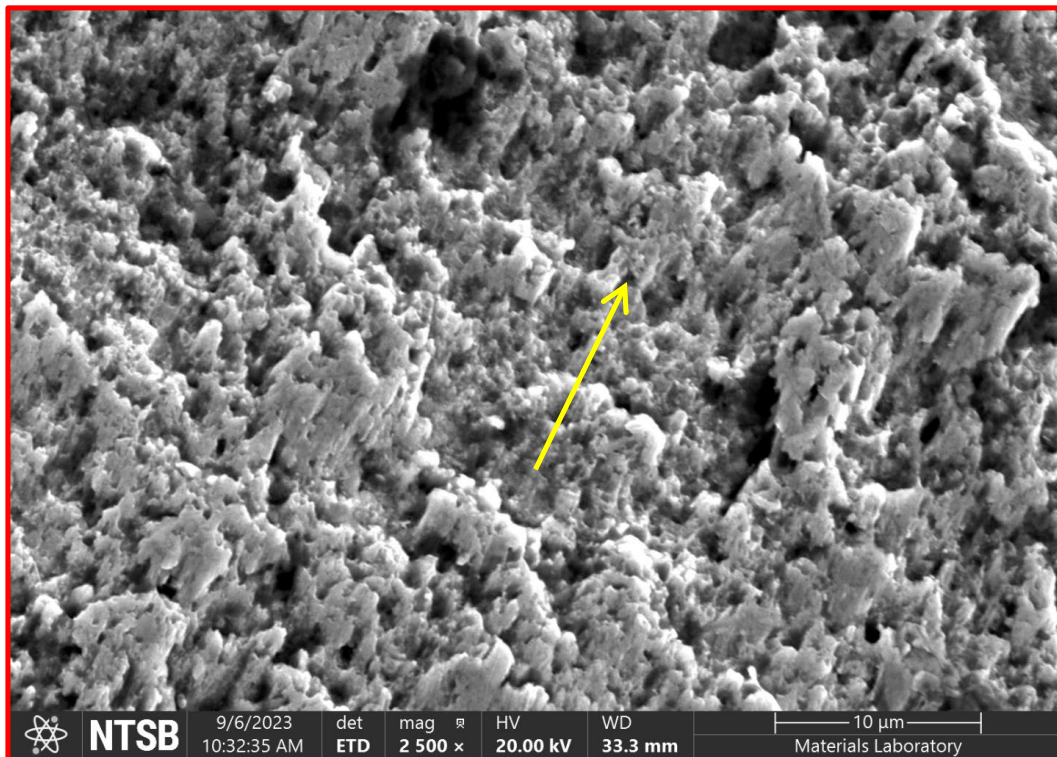


Figure 7. SE SEM image showing the fracture surface on the separated upper torque link bolt in the area indicated in Figure 4. The yellow arrow indicates the direction of shear stress that resulted in the observed directional ductile dimples.



Figure 8. Digital microscope image showing the profile of the washers that had been assembled to the upper torque link bolt.