

NATIONAL TRANSPORTATION SAFETY BOARD

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



June 3, 2014

MATERIALS LABORATORY FACTUAL REPORT

Report No. 14-032

A. ACCIDENT INFORMATION

Place : Paragould, Arkansas
Date : June 28, 2013
Vehicle : Zenith CH750, N699TX
NTSB No. : CEN13IA387
Investigator : Tim Sorensen, AS-CEN

B. COMPONENTS EXAMINED

Crankshaft piece, propeller flange, and propeller flange attachment hardware from a Jabiru 3300A engine.

C. DETAILS OF THE EXAMINATION

An overall view of the submitted components is shown in figure 1, where the forward faces of the propeller flange and the crankshaft piece are viewed in the image. Fractured ends of 5 of the 6 attachment bolts were retained in the propeller flange, and one of the bolts was missing completely. The head ends of 3 of the fractured bolts and 4 of the washers were recovered as shown in figure 1. According to information provided by the investigator-in-charge, the engine had 32 hours time in service since new.

A view of the aft face of the propeller flange at the crankshaft attachment area is shown in figure 2. The 6 holes for the propeller attachment bolts were arbitrarily numbered as shown in figure 2 for reference in this report. Heavy fretting damage was observed on the face that mated to the crankshaft flange. Fretting was most severe from hole 2 clockwise¹ to hole 5 and in the vicinity of hole 1.

The washers, shown in figure 1, had 12 radially-oriented step features on one of the faces and 40 radially-oriented step features on the opposite face consistent with a disk-type lock washer. Partial characters were marked on one side of one of the washers as shown in the close view in figure 3. The lower portions of the characters were obliterated by rubbing contact. However, the remaining upper portions of the characters were consistent with NORD LOCK. Impressions were observed on the clamping surfaces around the attachment holes on the forward face of the propeller flange corresponding to contact with the 40-step faces of the washers. Similar step

¹ Unless stated otherwise, clock references are described as viewed facing the forward direction.

features with approximately 40 steps were also observed on the clamping face on the underside of one of the 3 recovered attachment bolt heads. Remnants of step features were also observed on the clamping faces of the other two bolt heads, but the undersides showed substantial rubbing contact damage. Surrounding the step impressions on the forward face of the propeller flange, a circumferential contact mark consistent with the edge of a larger spring or cone-shaped washer was observed around each of the holes. According to Jabiru Aircraft Service Bulletin JSB 022-1, the standard washer for the propeller flange installation is a Belleville (cone or spring) washer.

An overall view of the forward face of the crankshaft piece is shown in figure 4. Attachment bolt holes are numbered for reference. Fretting damage was observed on the end face of the crankshaft corresponding to the damage observed on the flange. Based on feature matching between the crankshaft face and the mating face of the propeller flange, the bolt numbers shown in figure 4 correspond to the hole numbers on the flange as shown in figure 2.

Close views of the fracture surfaces of the attachment bolts are shown in figure 4. Two of the bolts had relatively smooth fracture features in a plane nearly perpendicular to the bolt axis, features consistent with fatigue. Brackets in figure 4 indicate the fatigue origin area. The fatigue origin areas were located on the side of the bolt clockwise from the bolt center. Ratchet marks² were observed at the origin area, consistent with multiple fatigue origins. Dashed lines indicate the fatigue boundaries. Fatigue cracks progressed through nearly the entire cross-section of bolt 3 and approximately 80 percent of bolt 1.

Bolts 2, 5 and 6 had smeared features or features on slant planes consistent with ductile overstress fracture. The bolt head ends shown on figure 1 had fracture features that mated to bolts 2, 5, and 6. Bolt heads 5 and 6 were joined by lockwire, and a fractured piece of lockwire was attached to bolt head 2. Bolt 4 was missing in its entirety.

Thread damage was observed in bolt holes 1, 3, and 4 in the crankshaft piece. The thread damage was located at the side of the hole that was counterclockwise from the bolt center (opposite the fatigue origin areas in bolts 1 and 3). Close views of the thread damage in holes 3 and 4 are shown in figure 5.

Deposits consistent with thread lock were observed in the threads of the fractured bolts and in the bolt holes in the crankshaft. A close view of thread lock in the threads of bolt number 6 is shown in figure 6. The thread lock had a red color. A close view of thread lock in the hole for bolt number 1 is shown in figure 7. Red thread lock was observed in this location as indicated. A yellow substance, also indicated in figure 7, was observed located between the red thread lock and the thread flank.

² A ratchet mark is a small step in the fracture surface formed when two adjacent fatigue cracks originate on slightly offset planes.

According to Jabiru Aircraft JSB 022-1, if the flange has been removed, then the screw threads in the crankshaft must be cleaned using a 3/8" UNF tap to remove leftover retaining compound from the threads. The threads of the attachment bolts and the crankshaft holes are to be cleaned using Loctite 7471 activator. After drying, Loctite 620 must be applied to the threads of the bolt and the crankshaft. In the general notes, JSB 022-1 cautions Loctite 620 is used because of its high temperature tolerance, and other compounds may lose significant strength at operating temperatures. According to the Technical Data Sheet for Loctite 620,³ the uncured appearance for Loctite 620 is a green liquid.

A sample of the red thread lock was removed from the bolt shown in figure 6 and analyzed using a Varian IR600 Fourier-transform infrared (FTIR) spectrometer with a diamond attenuated total reflectance (ATR) accessory in accordance with ASTM E1252-98 (American Society for Testing Materials E1252-98: *Standard Practice for General Techniques for Obtaining Infrared Spectra for Qualitative Analysis*). The resulting spectrum for the sample was consistent with a methacrylate ester.

Matthew R. Fox
Senior Materials Engineer

³ Henkel Corporation, March 2012.

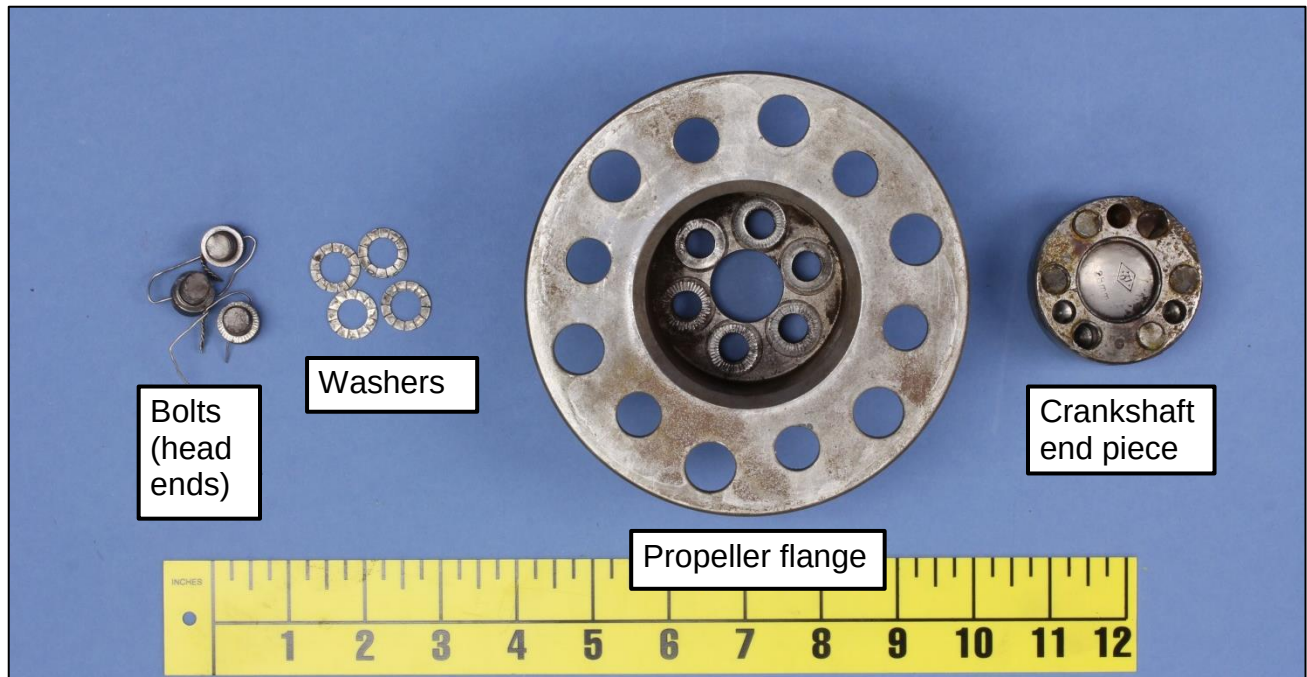


Figure 1. Overall view of the submitted components.

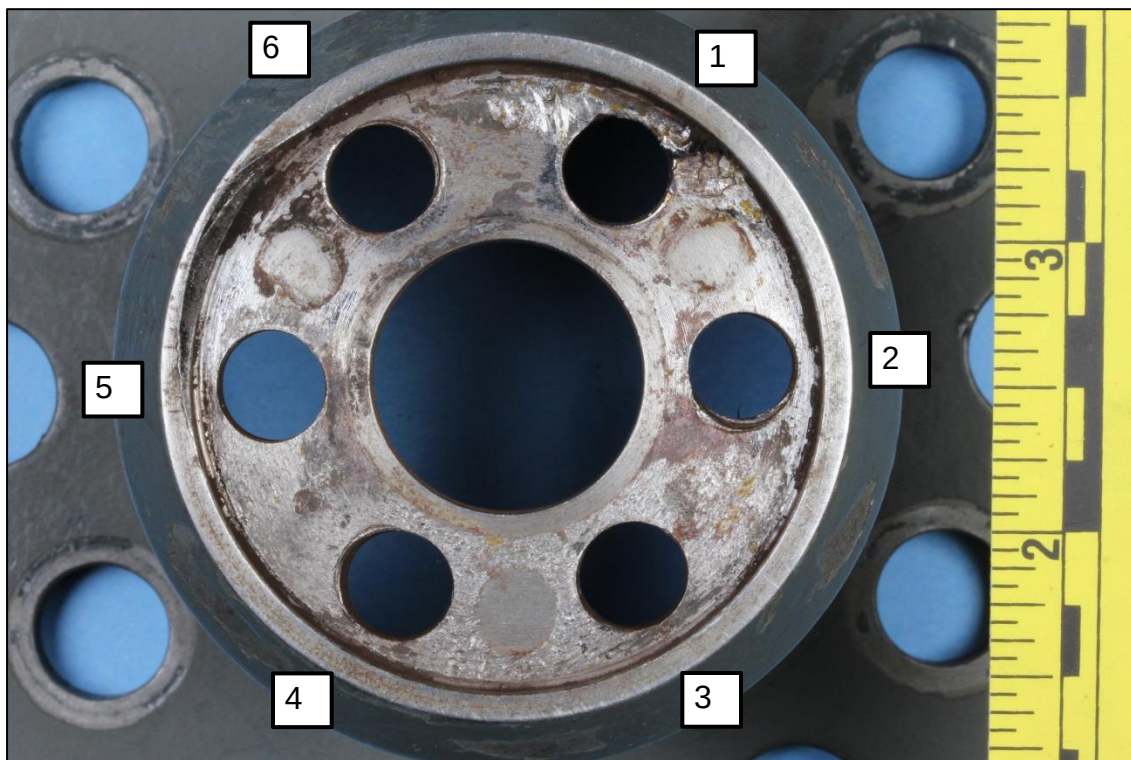


Figure 2. View of the aft face of the propeller flange where it mated to the crankshaft. Attachment bolt holes are numbered for reference.



Figure 3. Close view of one of the washers showing the upper portions of characters consistent with NORD LOCK as indicated with arrows.

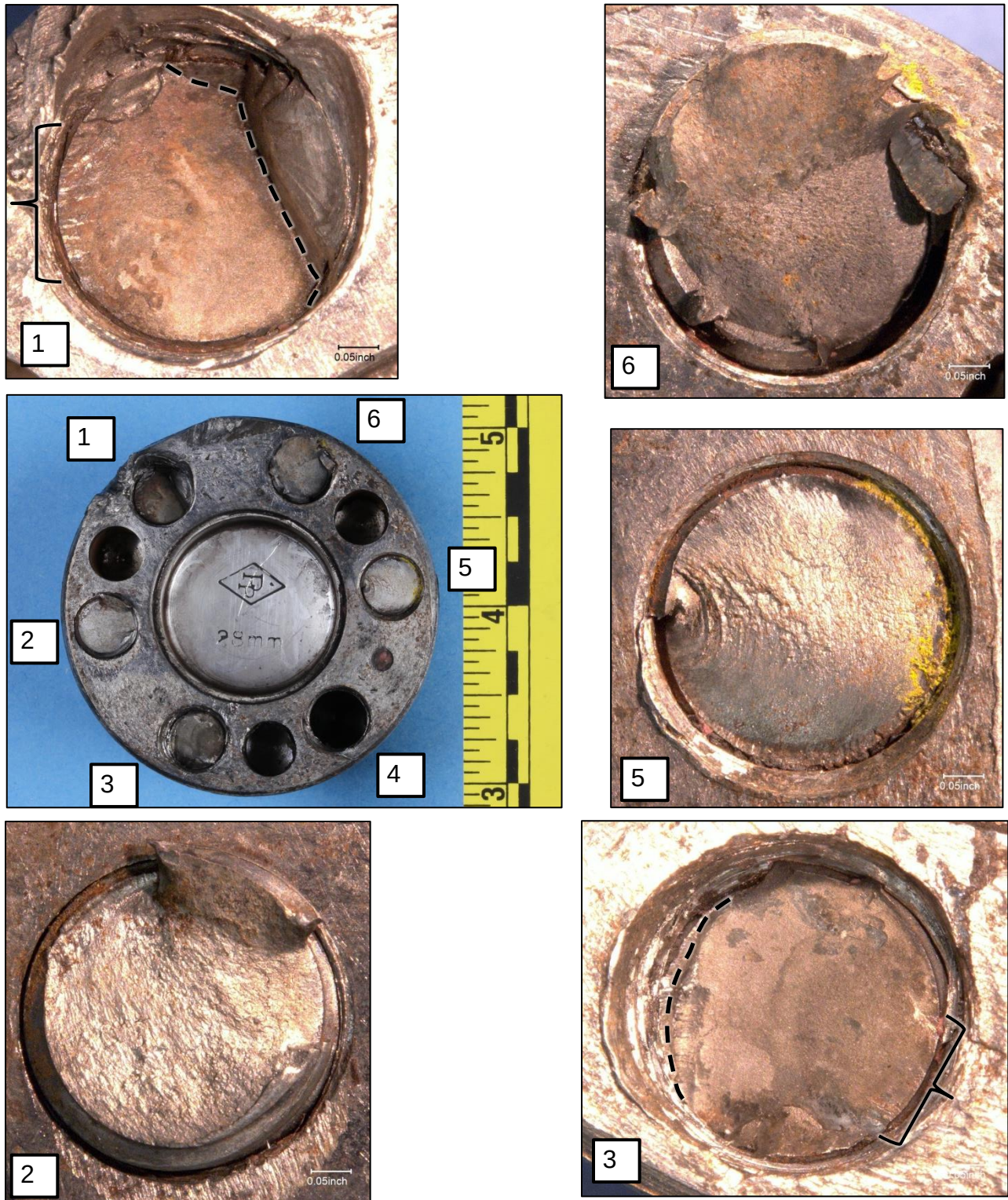


Figure 4. Overall view of the crankshaft end piece with close views of attachment bolt fracture features. Brackets indicate fatigue origin areas and dashed lines indicate fatigue boundaries in bolts 1 and 3.



Figure 5. Close view of thread damage at bolt hole 4 (upper image) and 3 (lower image) on the crankshaft piece.



Figure 6. Red-colored thread lock observed in the threads of fractured attachment bolt number 6.

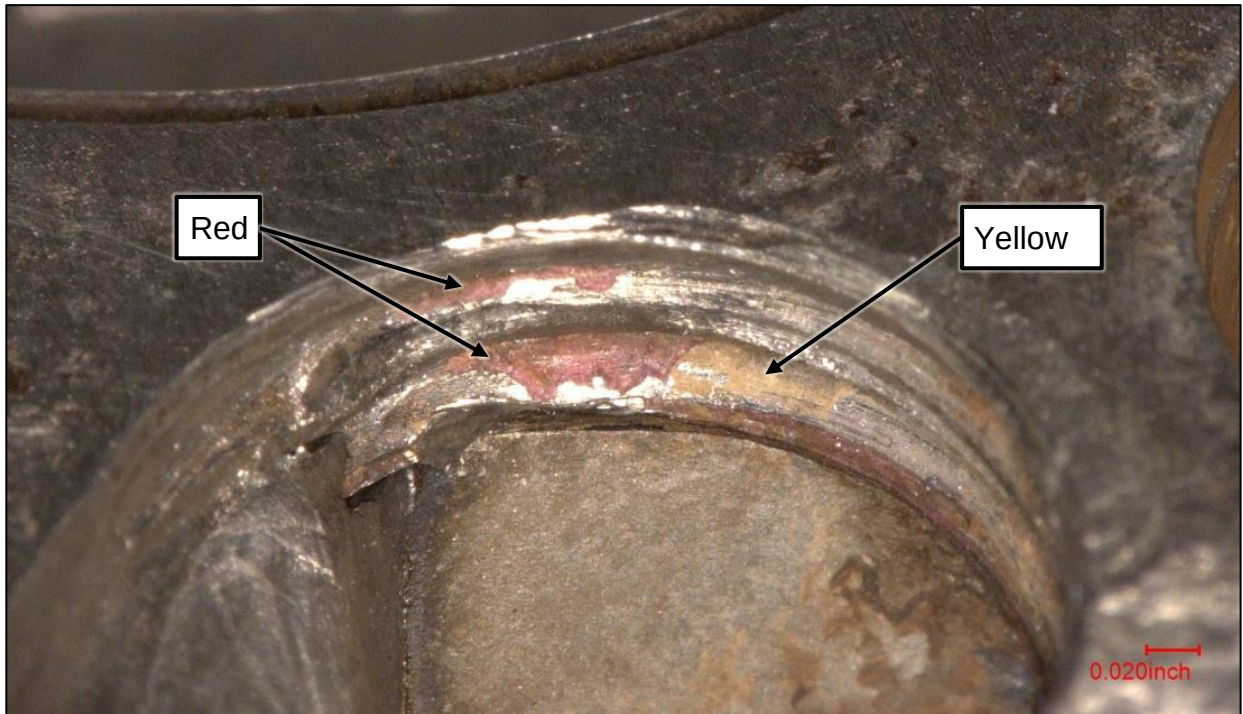


Figure 7. Red-colored thread lock over a yellow substance in the threaded hole for attachment bolt 1.