

NATIONAL TRANSPORTATION SAFETY BOARD

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



October 12, 2016

MATERIALS LABORATORY FACTUAL REPORT

Report No. 16-077

A. ACCIDENT INFORMATION

Place : Shawano, Wisconsin
Date : November 15, 2015
Vehicle : Lancair IV, N10UU
NTSB No. : CEN16LA043
Investigator : Michael Folkerts, AS-CEN

B. COMPONENTS EXAMINED

Two S6RSC-25P magnetos.

C. DETAILS OF THE EXAMINATION

An overall view of the right and left magnetos with fractured distributor gears is shown in figure 1. Prior to receiving the parts at the materials laboratory, the magnetos had been disassembled and tested with replacement distributor gears. The magnetos were received with the original distributor gears removed from the magnetos and the replacement gears installed. Many teeth were fractured from each distributor gear installed at the time of the accident as shown in closer views of the distributor gears presented in figures 2 and 3.

The magnetos had red-colored data plates that indicated they were type S6RSC-25P magnetos, Continental Motors part number 10-500556-101. The right magneto had serial number D09FA092, and the left magneto had serial number D09FA090. According to the airplane owner, the magnetos were installed on a Continental TSIO-550-E16B engine manufactured in 2009 and had 282 hours time in service since overhaul.

As viewed in figures 4 and 5 looking at the side of the distributor gear facing the coil, the distributor gears rotate in the counterclockwise direction under normal operation (see arrows indicating direction of rotation in each image). A timing mark on each gear, shown as a red mark at the root between two teeth, noted the location that should mesh with a chamfered tooth on the pinion gear. The distributor gears had 54 teeth, and for reference in this report, the teeth were numbered clockwise starting with the tooth on the clockwise side of the timing mark and ending with the tooth counterclockwise of the timing mark (see figures 4 and 5). Both gears shown in figure 4 and 5 had numbers "08" cast into the web, indicating the gears were manufactured in 2008.

The magnetos were each fitted with an impulse coupling. The impulse coupling assists with spark and timing during engine starting by inducing periodic accelerated rotation of the rotor assembly through a spring mechanism with a corresponding accelerated rotation of the distributor gear. The timing of the impulse on the distributor gear occurs at every 9th tooth (counting clockwise) starting with the position between teeth 8 and 9.

On the right distributor gear, 16 teeth (numbers 14 through 25 and 43 through 46) were fractured. An overall view of the fractured teeth from the larger of the two segments is shown in figure 6, and a closer view of a fracture surface displaying typical fracture features is shown in figure 7. The fracture features generally showed a relatively smooth area at the fracture initiation side of the tooth covering approximately $\frac{1}{4}$ to $\frac{1}{2}$ of the fracture area. Curving lines representing the fracture front were observed at the boundary of the smooth area. Hackle features and multiple curving crack front lines were present between the smooth area and the fracture termination.

Tooth fractures in the right distributor gear initiated at both the contact and the noncontact sides of the teeth. Teeth 14, 21 through 23, 25, and 43 had fractures initiating at the contact side, and teeth 15 through 20, 24, and 44 through 46 had fractures initiating at the noncontact side. Arrows in figure 6 indicate fracture propagation directions in each of the fractured teeth 14 through 25.

On the left distributor gear shown in figure 5, 8 teeth (numbers 13 through 19) were fractured. An overall view of the fractured teeth is shown in figure 8. The fracture features were generally similar to those observed on the right distributor gear, with a relatively smooth area at the fracture initiation side of the tooth covering approximately $\frac{1}{4}$ to $\frac{1}{2}$ of the fracture area, curving lines representing the fracture front at the boundary of the smooth area, and hackle features and multiple curving crack front lines between the smooth area and the fracture termination.

Tooth fractures in the left distributor gear initiated at both the contact and the noncontact sides of the teeth. Teeth 13 through 16 had fractures initiating at the contact side, and teeth 17 through 19 had fractures initiating at the noncontact side. Arrows in figure 8 indicate fracture propagation directions for the fractured teeth.

The left and right magnetos were disassembled, and replacement distributor gears that had been installed during testing of the magnetos were removed. The replacement gear from the right magneto had date code 11, and the replacement gear from the left magneto had date code 13. The replacement gears were a different color than the accident gears (see figure 10). The accident gears were darker with a brownish yellow color while the replacement gears had a yellowish white color.

The right and left distributor gears were analyzed using a ¹Varian IR600 Fourier-transform infrared (FTIR) spectrometer with a diamond attenuated total reflectance (ATR) accessory in accordance with ASTM E1252-98. Each distributor gear had an FTIR spectrum consistent with Nylon 6,6, consistent with the specified material for the gear.

A ¼-inch thick sheet of nylon 6,6 formed into 24-inch by 48-inch panels was purchased from a commercial vendor. Using a handheld bandsaw, a shape approximately matching a tooth profile was cut from the sheet, and a small round file was used to round the corner at the base of the “tooth”. The resulting specimen is shown in figure 11, where arrows indicate the orientation of the long direction of the sheet. The specimen in figure 11 was placed in a vice, and the side of the “tooth” was impacted with a chisel and hammer. The resulting fracture surface is shown in figure 12. The fracture showed relatively smooth features across most of the fracture surface with curving fracture front lines and hackles toward the terminal side of the fracture.

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¹ American Society for Testing Materials E1252-98: *Standard Practice for General Techniques for Obtaining Infrared Spectra for Qualitative Analysis*, ASTM International, West Conshohocken, PA (2013).

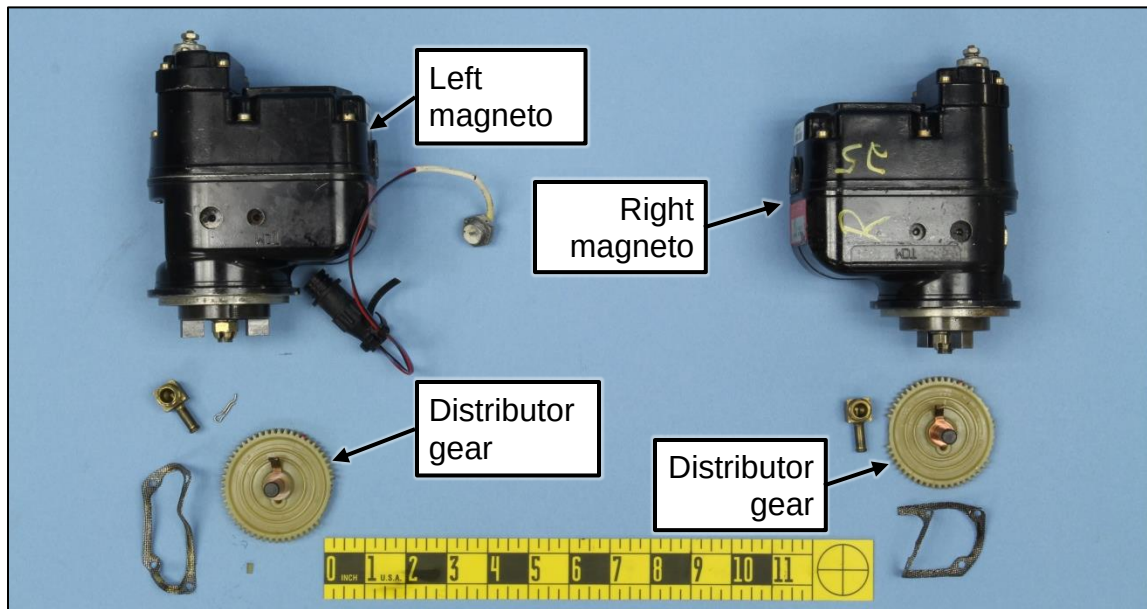


Figure 1. Overall view of the submitted left and right magneto assemblies with fractured distributor gears.

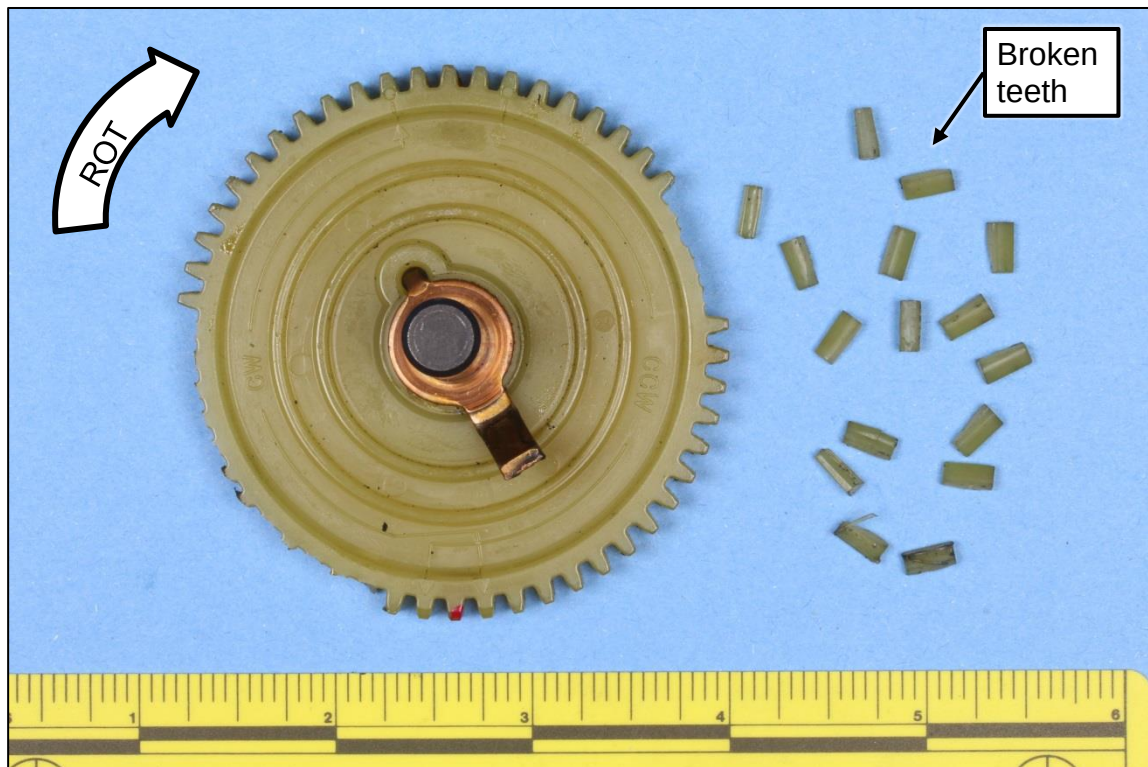


Figure 2. Closer view of the distributor gear assembly from the right magneto showing the side of the gear facing the distributor block with the pieces of broken teeth.

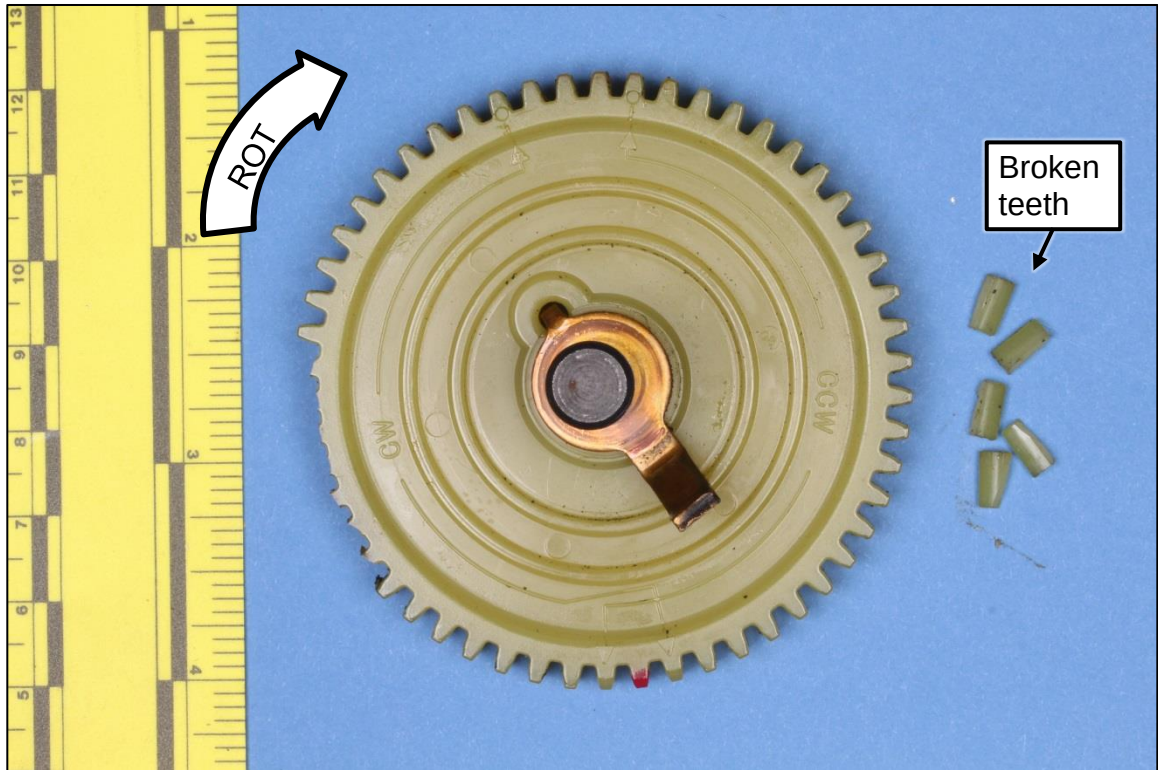


Figure 3. Closer view of the distributor gear assembly from the left magneto showing the side of the gear facing the distributor block with the pieces of broken teeth.

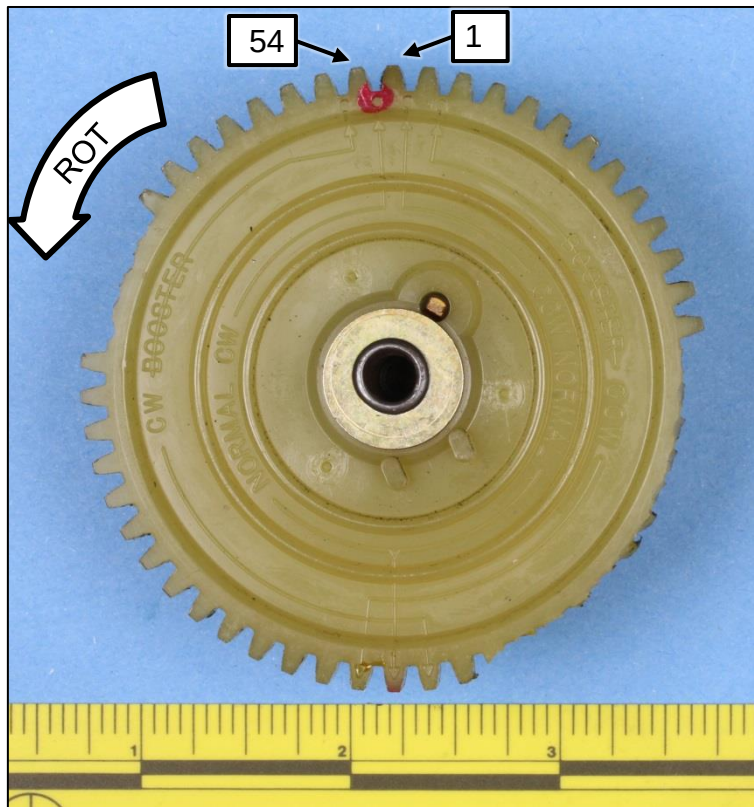


Figure 4. Right distributor gear showing the side facing the coil. Teeth were numbered clockwise starting at the timing mark as shown.

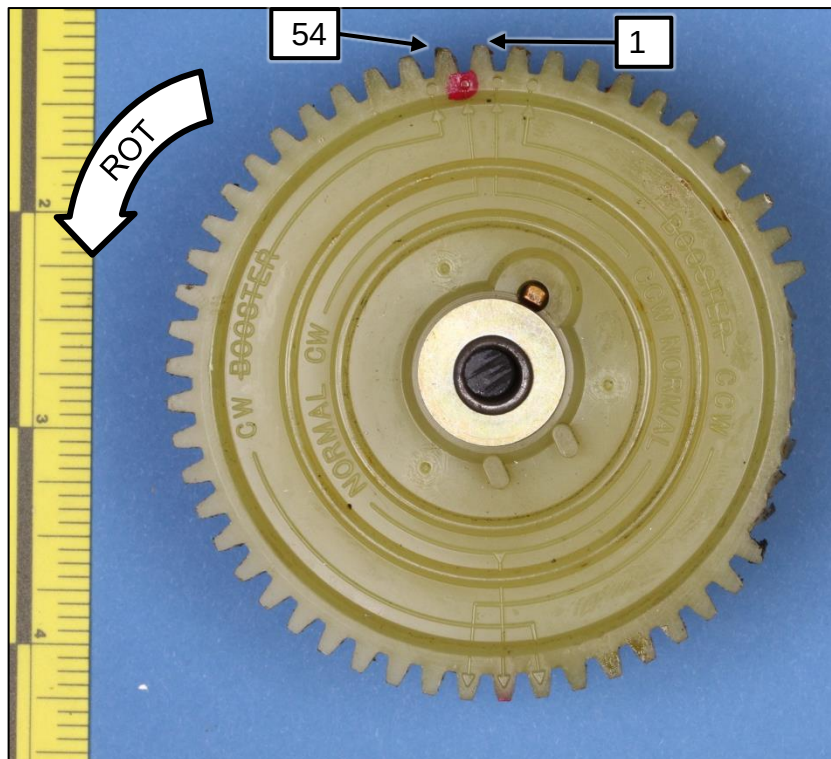


Figure 5. Left distributor gear showing the side facing the coil. Teeth were numbered clockwise starting at the timing mark as shown.

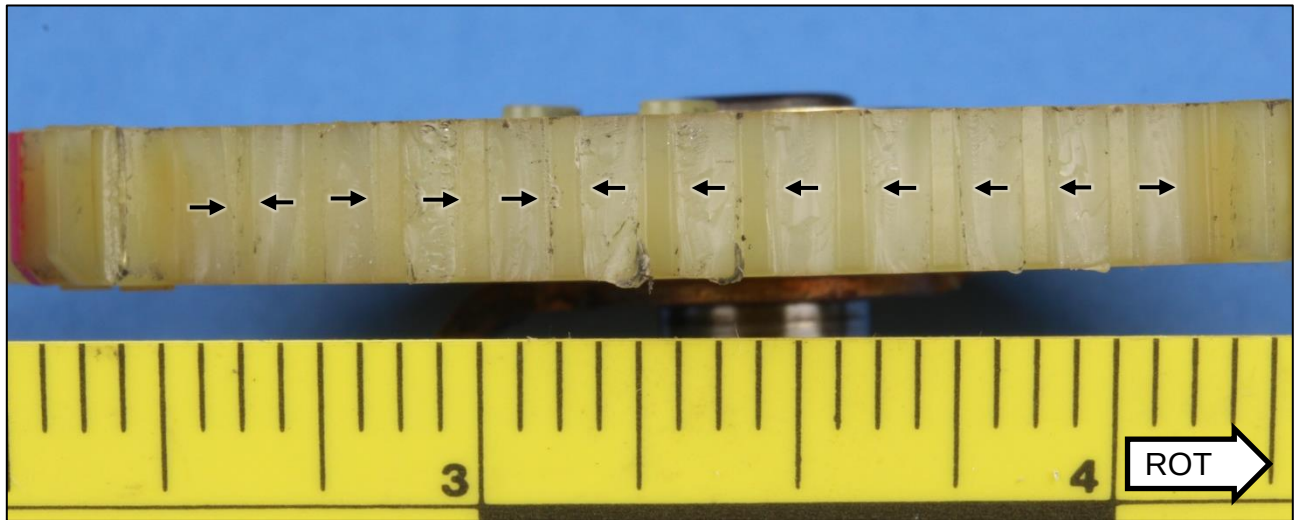


Figure 6. View of fracture features of the larger segment of broken teeth on the right distributor gear. Unlabeled arrows indicate the general direction of fracture propagation in each tooth.

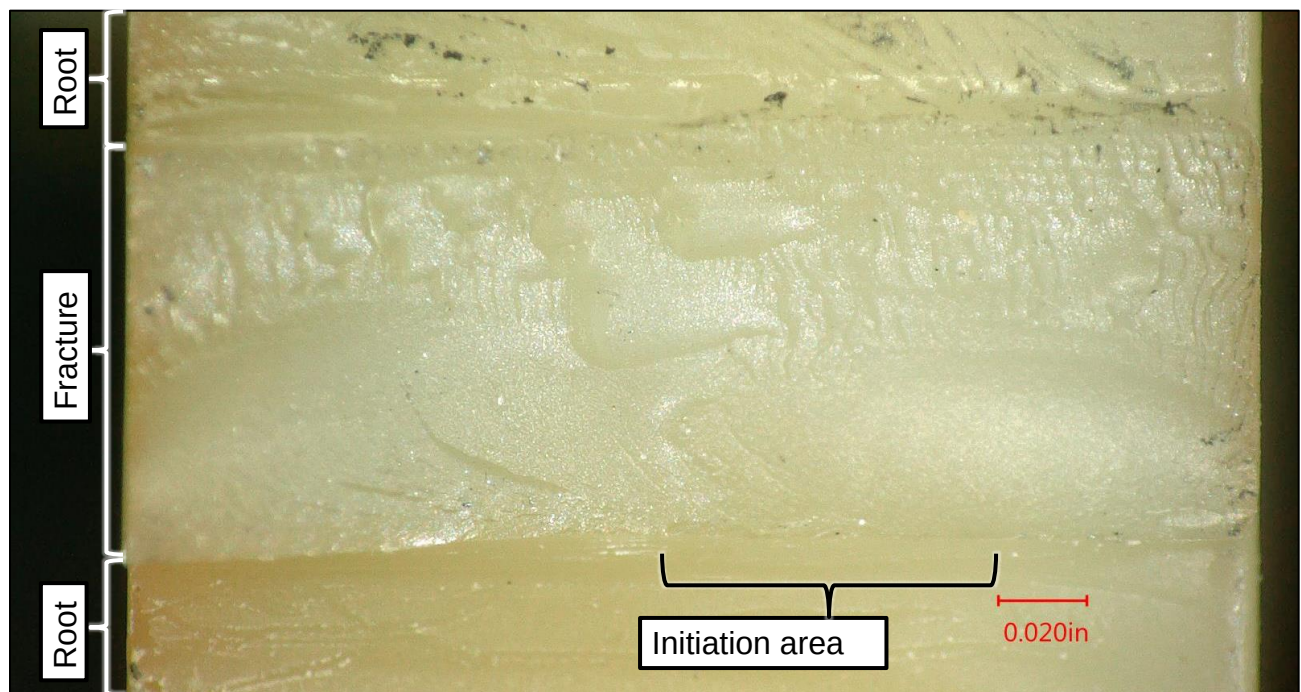


Figure 7. Close view of a tooth fracture surface from the right distributor gear.

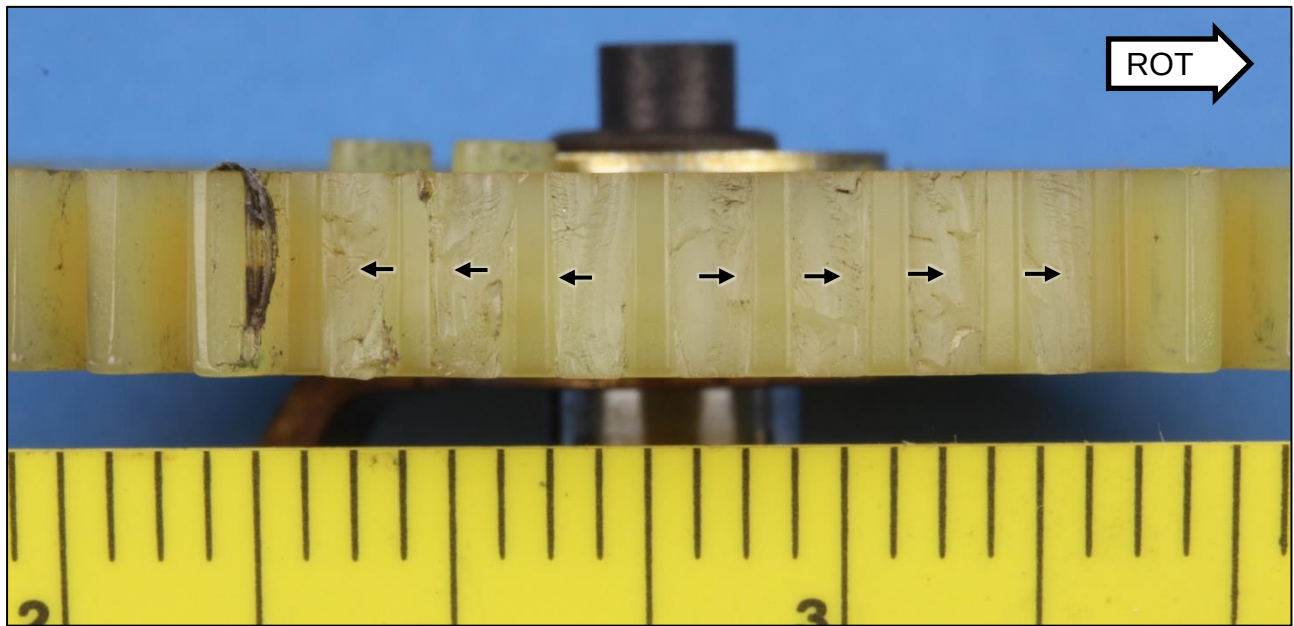


Figure 8. View of fracture features of broken teeth on the left distributor gear. Unlabeled arrows indicate the general direction of fracture propagation in each tooth.

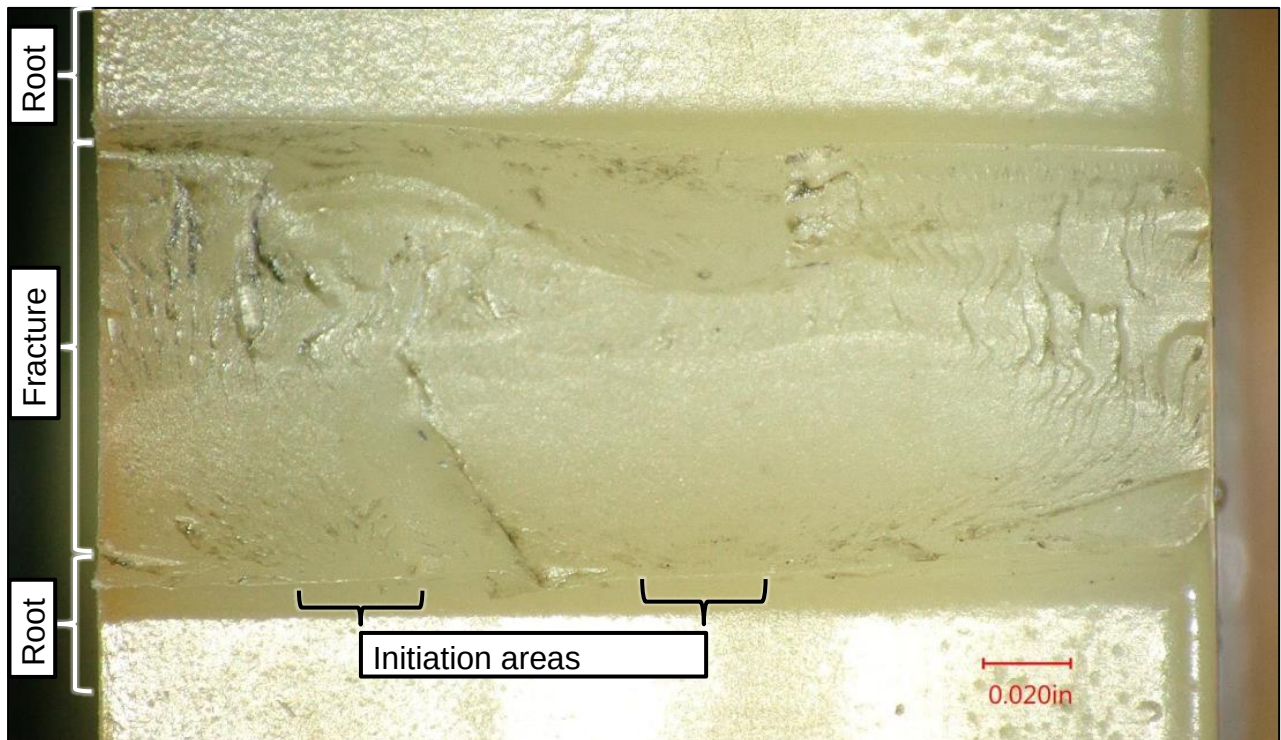


Figure 9. Close view of a tooth fracture surface from the left distributor gear.

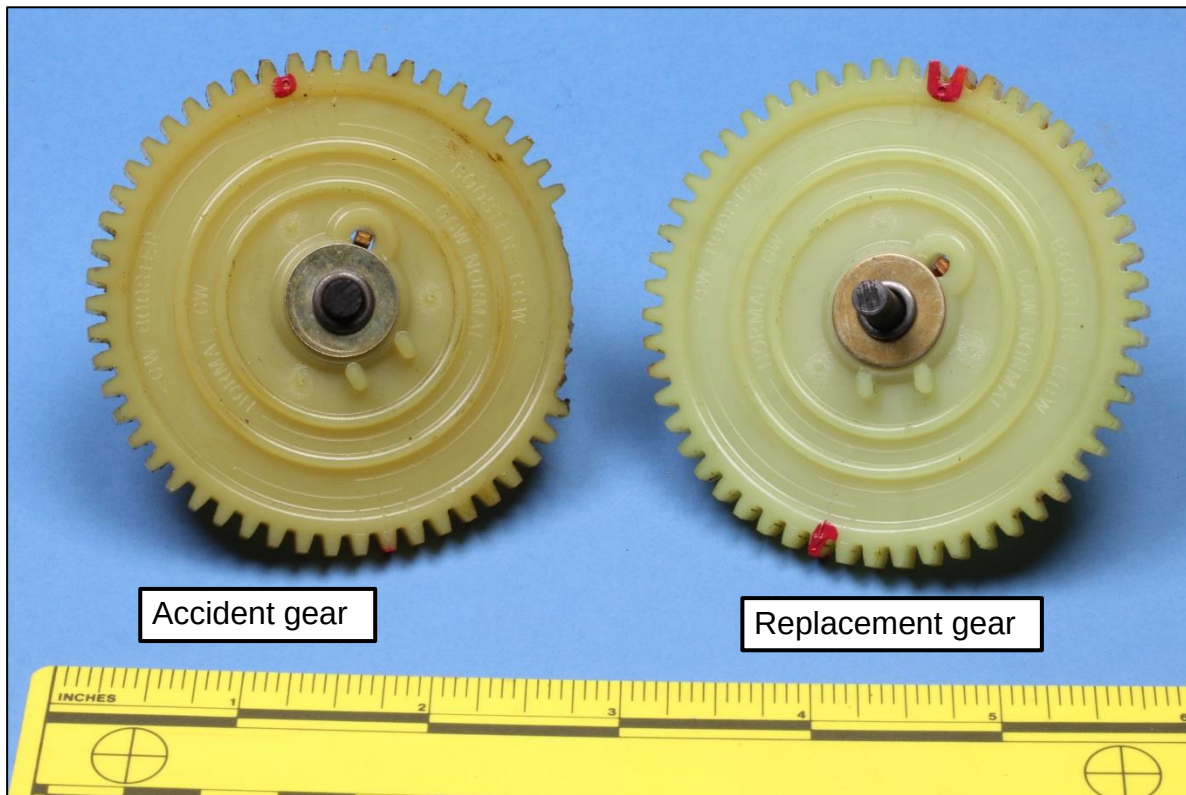


Figure 10. Gear that was installed in the left magneto at the time of the accident (left) and the replacement gear that had been installed during testing of the magneto (right).

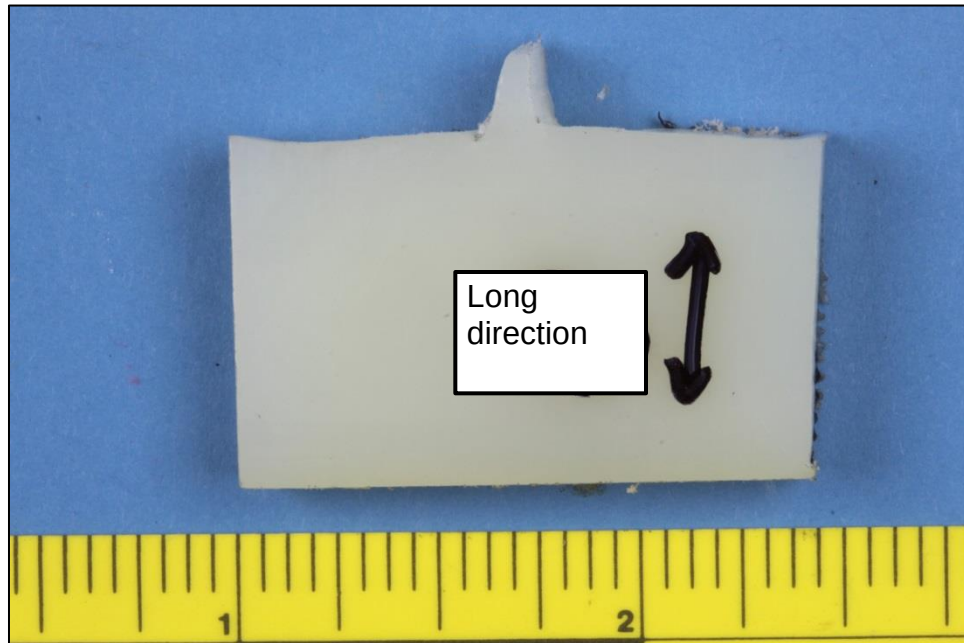


Figure 11. Overall image of a laboratory impact specimen roughly fabricated into the approximate shape of a gear tooth in a $\frac{1}{4}$ -inch thick sheet of nylon 6,6. Arrows on the specimen indicate the long direction of the original 24-inch by 48-inch sheet.

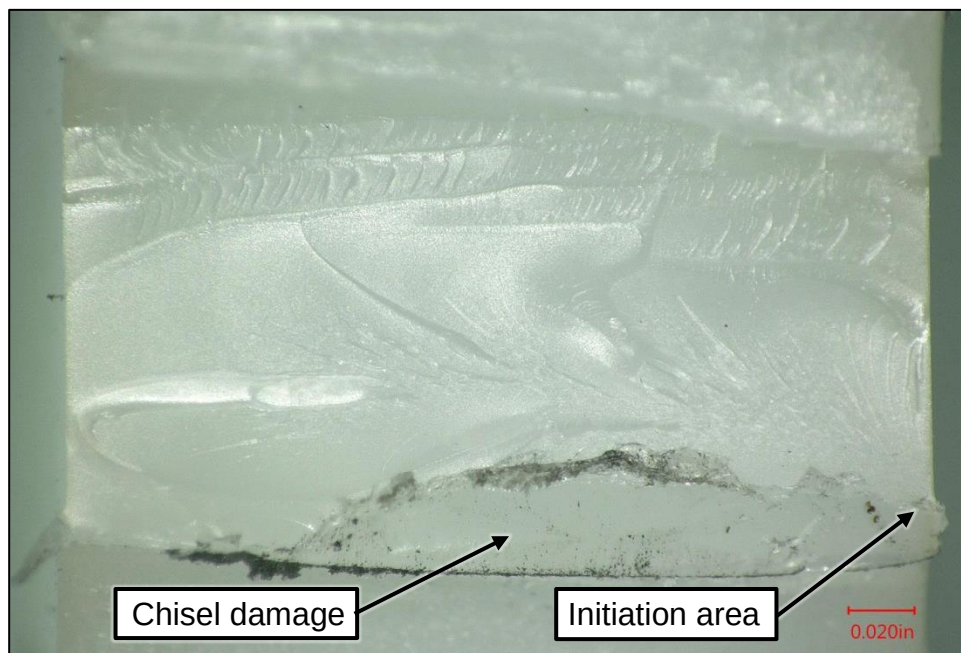


Figure 12. Fracture surface on the specimen in figure 11 after impact applied using a hammer and chisel.