

NATIONAL TRANSPORTATION SAFETY BOARD

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



September 3, 2020

MATERIALS LABORATORY FACTUAL REPORT

Report No. 20-023

A. ACCIDENT INFORMATION

Place : North Garden, Virginia
Date : August 8, 2019
Vehicle : Cessna R172, N1609V
NTSB No. : CEN19LA258
Investigator : Daniel Baker, AS-CEN

B. COMPONENTS EXAMINED

Crankcase accessory cover
Two oil pump gears
Pieces of an oil pump drive gear
Oil pump cover
Tachometer drive connector

C. DETAILS OF THE EXAMINATION

On August 8, 2019 at 0955 EDT, a Cessna R172K airplane, N1609V, impacted terrain near North Garden, Virginia, following a total loss of engine power. The pilot reported he was flying at 9,500 ft mean sea level (MSL) when "Oil Pressure" displayed on the primary flight display. He estimated he made it about 8 miles and the engine seized. He performed an emergency landing to a field. The pilot received minor injuries. The airplane was substantially damaged.

An internal view of the as-received crankcase accessory cover and closer views of the integral oil pump housing, identified by the unlabeled black arrow, are shown in figure 1. The base and sidewalls of the oil pump housing exhibited some evidence of circumferential scars consistent with abrasive wear. Typical examples observed are indicated with yellow arrows. There were also three indentation marks around the housing sidewalls which spanned from the base of the housing to the top of the sidewall, parallel to the gear axes, as indicated by the red arrows. The indentation mark spacing was consistent with the internal gear teeth tip spacing. The internal surface of the accessory cover had areas of local mechanical damage as highlighted by yellow dashed lines.

Figure 2 shows a photograph of the other components that were received, including a piece of the oil pump drive gear (23 teeth), the internal oil pump drive gear (6 teeth, with extended hub bosses), the mating shaft piece of the 23 tooth oil pump drive gear (retained in the hub of the 6 tooth drive gear), the internal oil pump driven gear (6 teeth, constant width), the oil pump housing cover, and the tachometer drive connector (attached to the shaft piece of the oil pump drive gear).

The internal surface of the oil pump housing cover exhibited fine circumferential scratches at interface surfaces with the internal gears. There was also one indentation mark on the surface of the drive gear side that matched the profile of a drive gear tooth. Through cracks were evident between the large and small fastener holes and between the small fastener hole and the edge of the part nearest the indentation mark.

The 23-tooth oil pump drive gear was marked "649506" on the flat side¹. Approximately nine of the teeth exhibited compressive mechanical damage consistent with misalignment and mechanical contact with other components. It was evident this gear was made with an integral shaft portion which extended from the gear hub. The shaft portion separated from the web of the gear near the transition radius in the area indicated by unlabeled black arrows. The shaft portion was retained within the internal drive gear hub and its threads were engaged with the tachometer drive connector. The tachometer drive connector was unfastened from the fractured shaft which was then carefully removed from the gear hub for further evaluation. At the shaft-to-web transition, the shaft diameter was reduced by a machined flat-bottom groove that exhibited a rougher surface finish than the larger diameter bearing surface of the shaft, which was smooth and uniform. The reduced diameter section of the shaft extended approximately 0.15 inches from the radiused shoulder to the fracture surface and exhibited lateral deformation relative to the shaft axis, consistent with a ductile bending or shear fracture mode. The oil pump drive gear fracture surfaces were cleaned using soapy water and a soft bristled brush followed by a water rinse and ultrasonic acetone cleaning prior to further evaluation.

X-ray fluorescence (XRF) spectroscopy, using an Olympus Vanta-VCR hand held XRF alloy analyzer, was performed on the fractured gear and a high concentration of iron with lesser concentrations of manganese, nickel, chromium, silicon, molybdenum, sulfur, and phosphorous were detected which was consistent with a low-alloy steel material typically used for gear components. A relatively large concentration of lead² was also detected.

Figure 3 shows a photograph of the gear side of the fracture surface as well as a higher magnification scanning electron microscope (SEM) image of the area highlighted by the yellow box. A circumferential band surrounding the fracture surface was a lighter and shinier shade of brown than the darker brown color of the rest of the part. The outer edge of the band matched the profile of the chamfered hub surface of the internal drive gear. The fracture surface exhibited a relatively flat, dull, and rough surface morphology with a relatively large shear lip feature between the 11 and 1 o'clock positions as oriented in the figure 3 photograph. The shear lip feature spanned between the shaft inner diameter (ID) and outer diameter (OD) and was oriented approximately 45 degrees relative to the gear shaft axis. This shear lip feature was consistent with the location of final separation of a ductile bending (mode I) or shear (mode II) fracture mode. Between the 2 and 6 o'clock positions, there was significant smearing damage over majority of the fracture surface. A flatter and smoother

¹ Teledyne Continental® Aircraft Engine Critical Service Bulletin, CSB 96-5, issued 11 April 1996 identifies oil pump drive gears with part number 649506 be replaced with the applicable replacement gear at next scheduled maintenance interval, not to exceed 100 hours, on the affected new, rebuilt, and overhaul engine models identified. Also affected are field replacement parts purchased from Teledyne Continental Motors from 27 March 1990 to 1 December 1991.

² The internal combustion engines used in general aviation still use leaded fuels and lead may contaminate the surface of parts that are exposed to combustion products.

area of the fracture surface near the OD of the shaft was observed just past the 6 o'clock position and was examined more closely using SEM which revealed radial features emanating perpendicularly from the gear shaft OD near the gear shaft radius. These features resembled ratchet marks³ and were consistent with multiple fracture origins. Smearing damage over majority of the fracture surface obliterated many of the fine fracture features and no evidence of fatigue striations were found. Some areas of the fracture surface near the shaft OD exhibited intergranular fracture features which were consistent with separation of a case-hardened alloy steel component. Areas examined between the shaft inner and outer diameter that were less obliterated by smearing damage showed microvoid coalescence consistent with monotonic overstress separation.

Michael Meadows
Materials Engineer

³ 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.

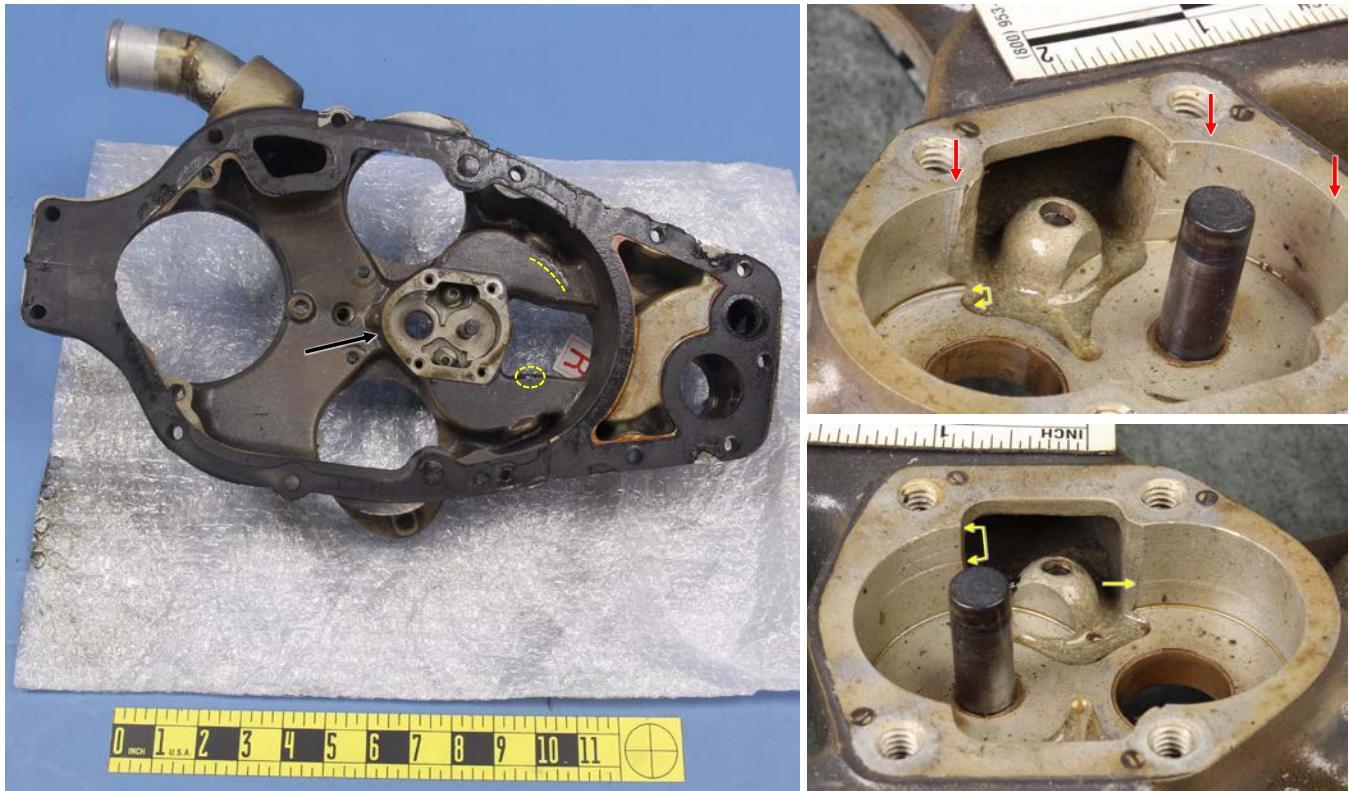


Figure 1: An internal view of the accessory case cover is shown on the left, the black arrow indicates the oil pump housing location. The yellow dashed lines highlight areas of mechanical damage. Closer views of the oil pump housing are shown on the right. The red arrows indicate indentation marks observed on the housing sidewalls that were consistent with internal gear teeth spacing. Examples of circumferential scars observed on the sidewalls and base of the housing are highlighted with yellow arrows.

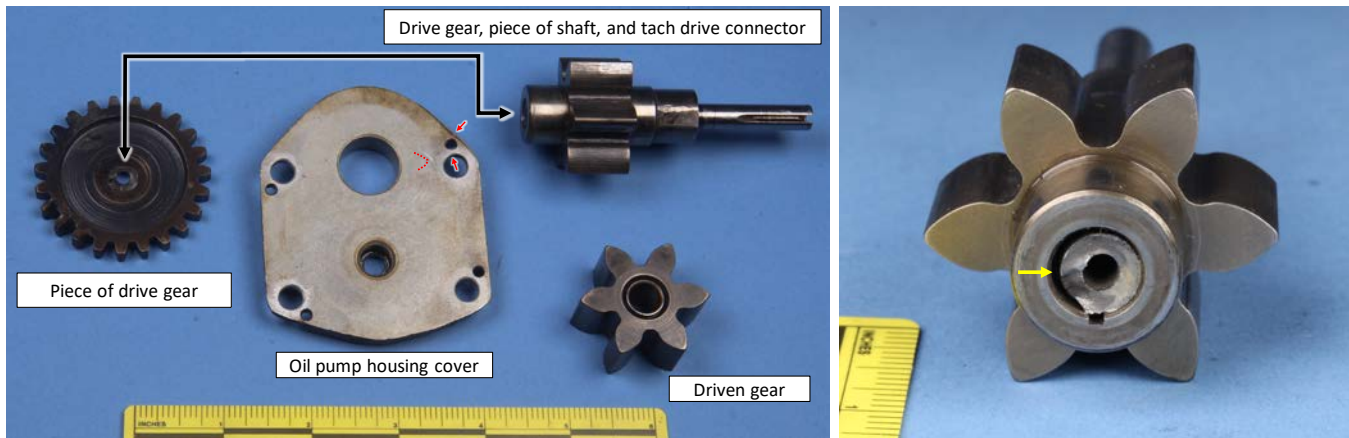


Figure 2: The oil pump gears with tachometer drive connector still attached, and the internal surface of the oil pump housing cover are shown in the photograph on the left. The red dashed line highlights an indentation mark on the cover that matched the tooth profile of the 6-tooth drive gear. Two red arrows indicate the location of through-cracks observed between the fastener holes and edge of part. The black arrow indicates where the drive gear separated from an integral shaft which is designed to pass through the largest hole of the cover. A closer view of the drive gear shaft fracture surface is shown on the right. Lateral deformation of the shaft relative to the gear axis was observed and is represented by the yellow arrow.

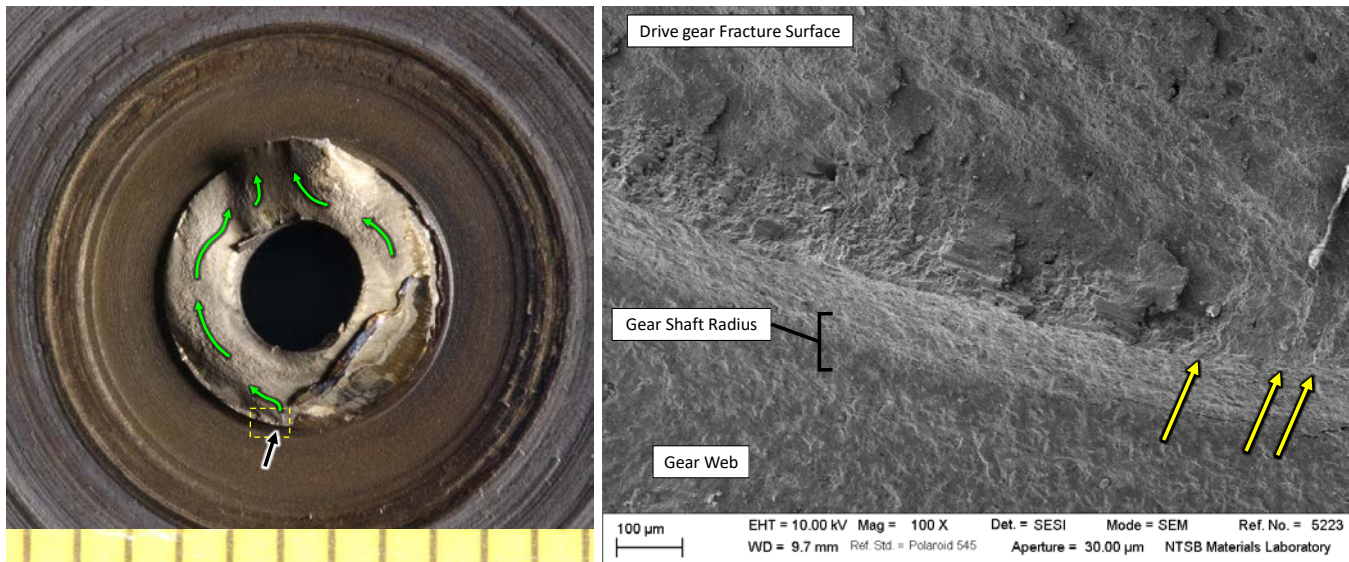


Figure 3: A photograph of the drive gear fracture surface is shown on the left. Scale markings are 1/16 inches. The area spanning from approximately the 2 to 6 o'clock positions exhibited significant spearing damage, but an apparent origin is highlighted by the black arrow and fracture propagation direction is shown with green arrows. A scanning electron fractograph of the area in the photo identified by the yellow box is shown on the right. Features near the shaft outside diameter that resembled ratchet marks are identified by the yellow arrows and were consistent with multiple fracture origins. Green arrows in the photograph indicate approximate direction of crack propagation which terminated near the 12 o'clock position at a shear lip feature.