NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594

March 23, 2015

MATERIALS LABORATORY FACTUAL REPORT

Report No. 15-028

1. ACCIDENT

Place	:	Clay, AL
Date	:	February 14, 2014
Vehicle	:	Cessna 210L, N732EJ
NTSB No.	:	ERA14FA120
Investigator	:	Timothy Monville, AS-ERA

2. COMPONENTS EXAMINED

Dry vacuum pump

3. DETAILS OF THE EXAMINATION

On February 14, 2014, about 2221 central standard time, a Cessna 210L, N732EJ, crashed in a heavily wooded area near Clay, Alabama. The commercial pilot and one passenger were fatally injured. The airplane was destroyed. The airplane was registered to Southern Seaplane, Inc., and operated under the provisions of 14 Code of Federal Regulations (CFR) Part 135 as a non-scheduled, domestic, cargo flight. The flight originated from Jackson-Medgar Wiley Evars International Airport (JAN), Jackson, Mississippi, about 2109 CST, and was destined for Birmingham-Shuttlesworth International Airport (BHM), Birmingham, Alabama. The engine-driven vacuum pump was sent to the NTSB Materials Laboratory for investigation.

Figure 1 shows the pump and the mating drive gear coupling as received. The pump exhibited indications of damage consistent with impact damage—this included crushing of the pump housing, gouging and scarring of the pump, and tearing of the orange pump seals. The drive side flanges had fractured from the rest of the pump housing (see Figure 2).

The vacuum pump was radiographed before disassembly. Radiography revealed details of the attachment screws and inlet tubes, which exhibited no obvious indications of internal damage.

However, upon opening the pump, both the rotor and the six vanes were found fractured in multiple places with no obvious initiation site (see Figure 3). The rotor had fractured in a direction consistent with the deformation in the circumferential pump housing, as see in Figure 3. This face of the fractured rotor also exhibited a white dried substance, consistent with residual compounds from a dried fluid that had pooled in the pump.

The rotor was removed from the pump housing, and it is illustrated in Figure 4 and Figure 5. The opposite face of the rotor pieces exhibited a circular grinding pattern on the outside of the rotor. This wear pattern was consistent with the rotor having turned while in contact with the adjacent pump housing. In addition, circumferential wear marks were found on the outside surfaces of the fractured rotor. These witness marks were generally located on either edge of the rotor, consistent with contact while rotating. The fracture surfaces of the rotor pieces exhibited a rough morphology with a dull luster—these features were consistent with overstress failure of brittle materials.

The six vanes were removed and reconstructed using the largest remaining pieces. The vanes were labeled 1 through 6 for the purposes of this report, and they are illustrated in Figure 7. All of the vanes had cracked in multiple places. Each vane generally contained a primary crack that had progressed from one edge to the other, typically with branching cracks emanating from the primary crack. The fracture surfaces of the vane fragments exhibited a rough morphology with a dull luster, consistent with overstress failure of brittle materials. Horizontal and vertical sliding marks were present on the faces of the vanes. These marks were consistent with similar marks on the machined inside faces of the rotor pieces. The horizontal marks were consistent with sliding of the vanes that occurred during rotational operation of the rotor. Each of the vanes exhibited one flat vertical face and one rounded vertical face. The vane widths were measured using a micrometer, and are listed in Table I. All of the vanes exhibited a thickness of 0.8155 inches, with the exception of Vanes 1 and 6.

The pump housing is illustrated in Figure 8 and Figure 9, after pump disassembly. The circular housing had been deformed consistent with compressive crushing. One of the outer walls of the housing, adjacent to a through-bolt hole, had buckled inward. The interior face of the housing exhibited deep scarring consistent with contact with the rotor. Many of the interior scars exhibited features consistent with rotational wear. The dried white residue found on the rotor faces was present on the housing interior. The size of the one of the residue patterns was consistent with the size and shape of a rotor finger (see Figure 9).

Erik Mueller
Materials Research Engineer

Table I – Width of the vanes (in inches) measured after removal from the vacuum pump.

Vane Number	Width (inches)	Notes
1	0.7935	Inner face chipped and broken, max width reported.
2	0.8155	
3	0.8155	
4	0.8155	
5	0.8155	
6	0.8125	

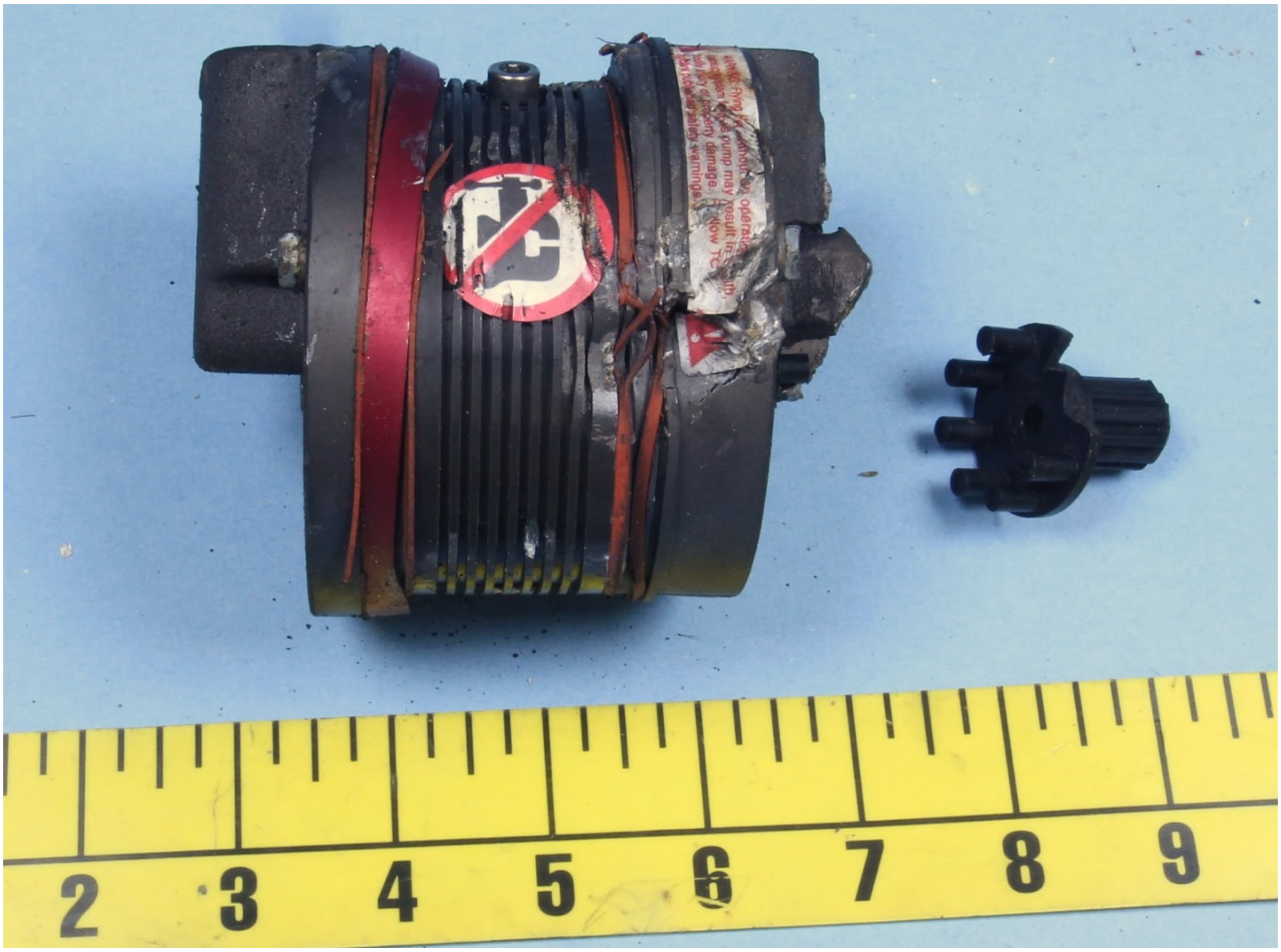

Figure 1 – The vacuum pump and drive gear coupling, as received.

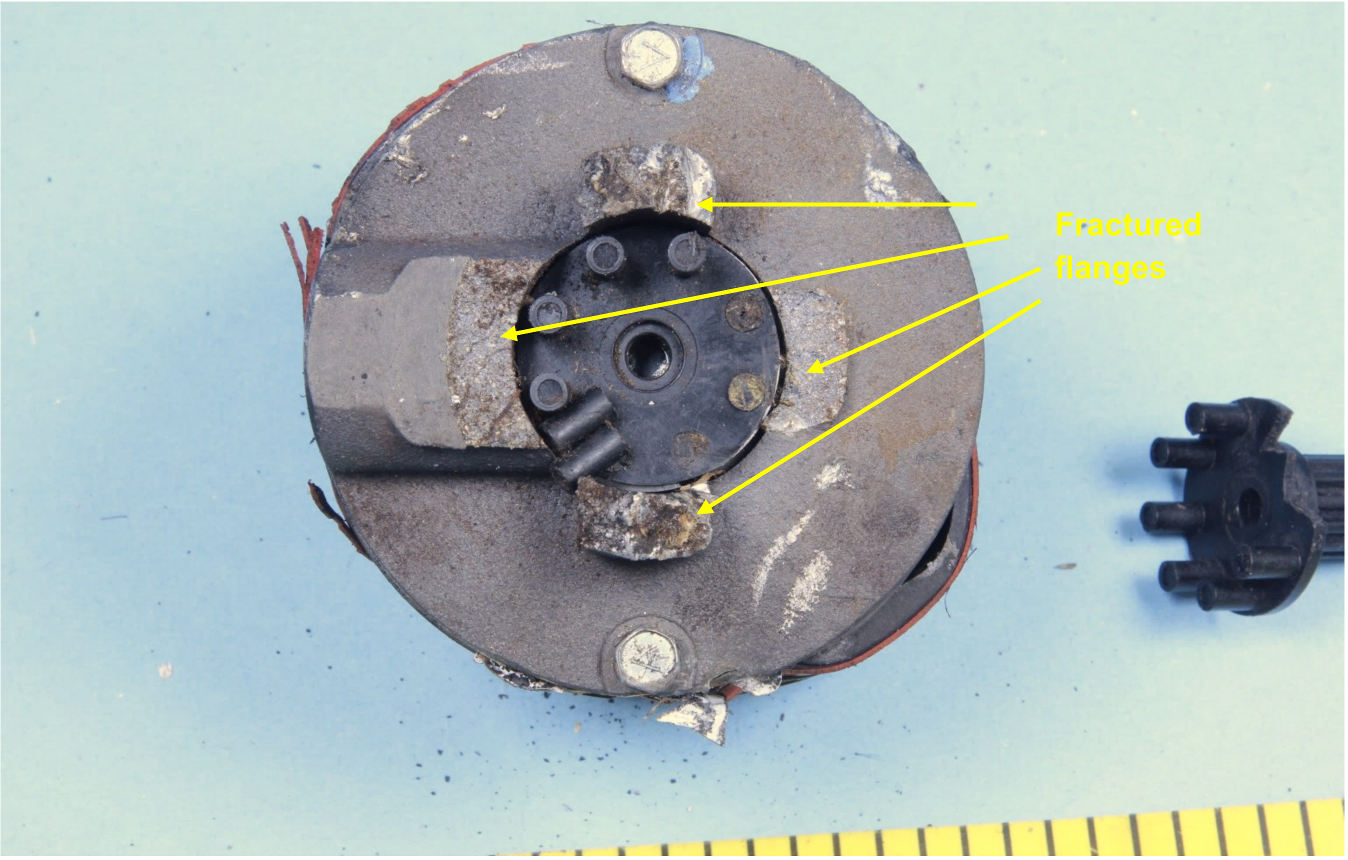

Figure 2 – The pump housing, view from the drive or inlet side, showing fractured flanges.


Figure 3 – The interior of the vacuum pump, after removal of the drive side housing cover (shown Figure 2).

Figure 4 – The fractured rotor pieces, after removal from the pump housing.

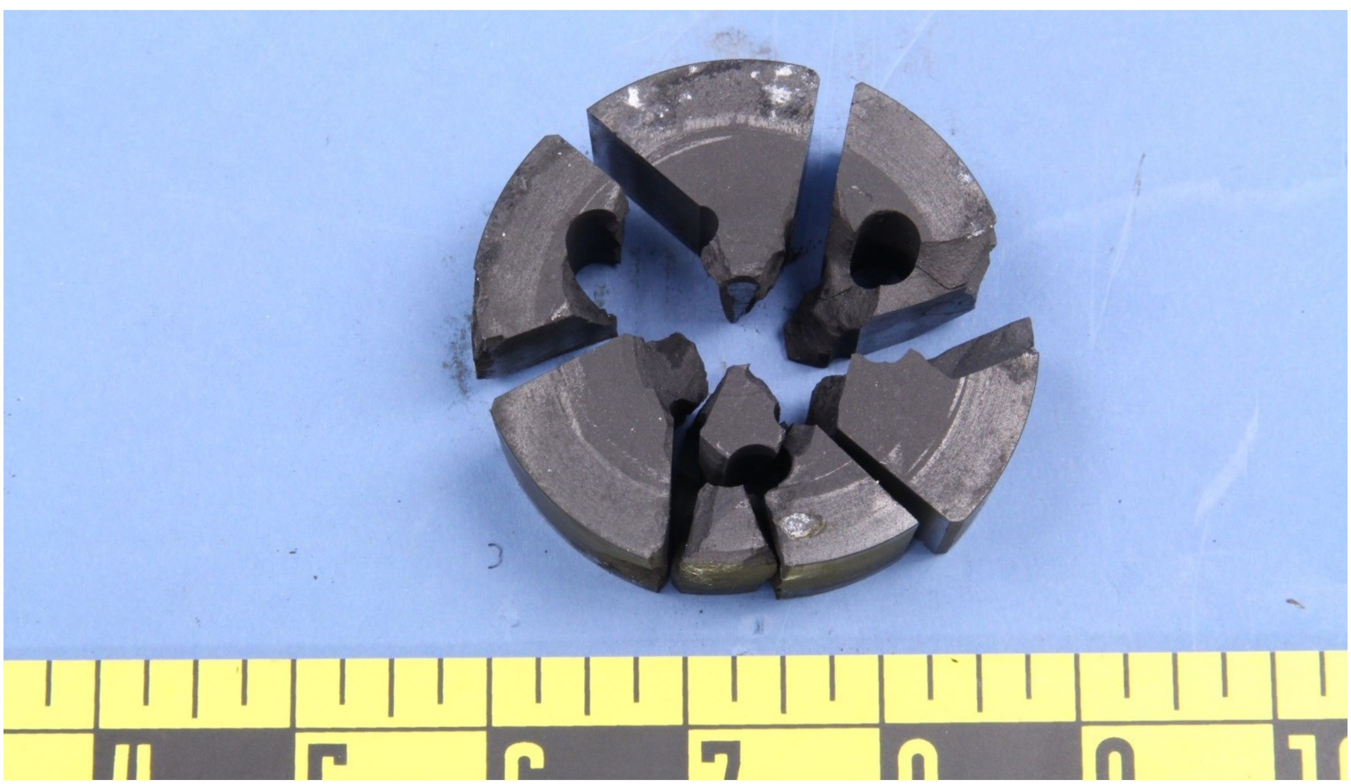

Figure 5 – The fractured rotor pieces, after removal from the pump housing, opposite side of that Figure 4.

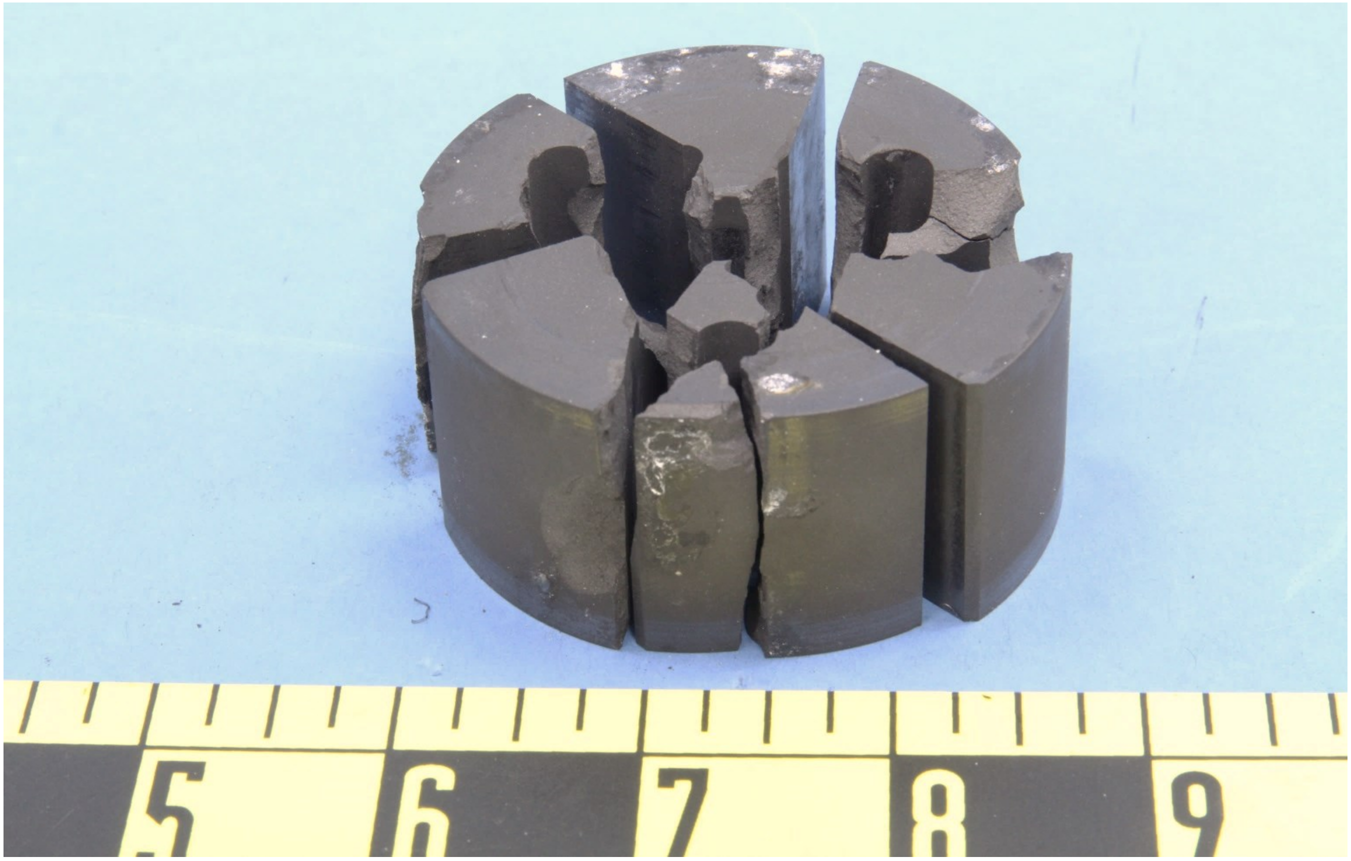

Figure 6 – The side of the fractured rotor, showing smoothed areas and circumferential wear marks.

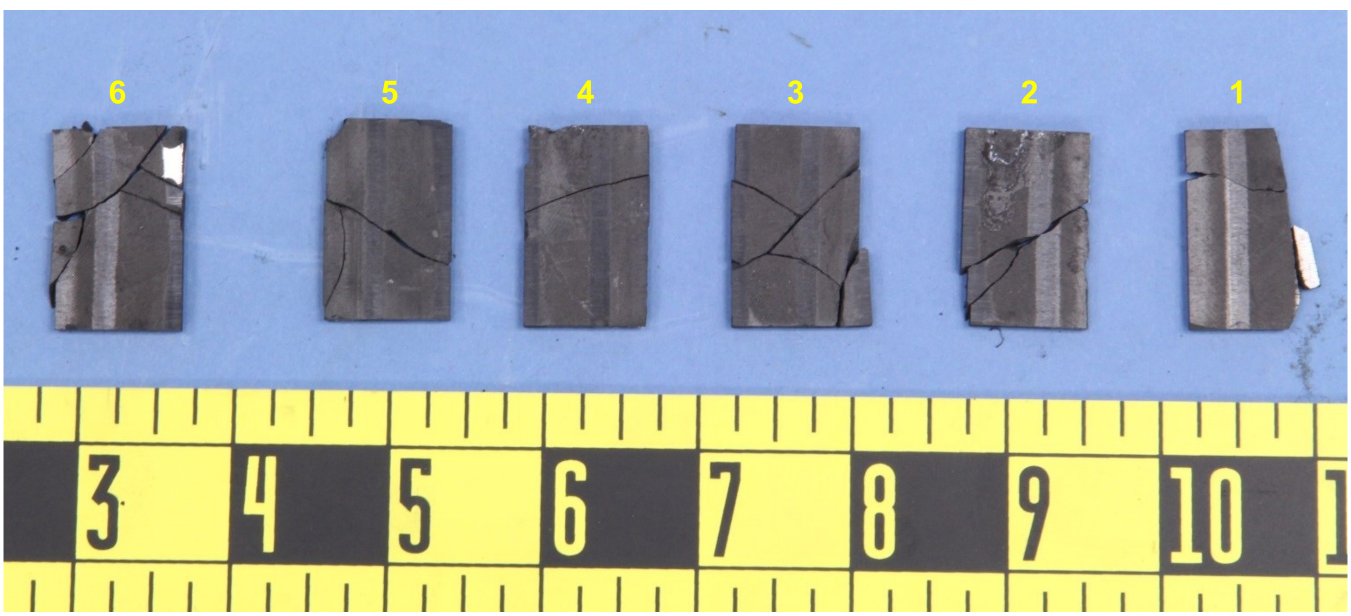

Figure 7 – The fractured vanes, after removal from the pump housing. The vanes were labeled 1 through 6 for the purposes of this report.

Figure 8 – The crushed pump housing.

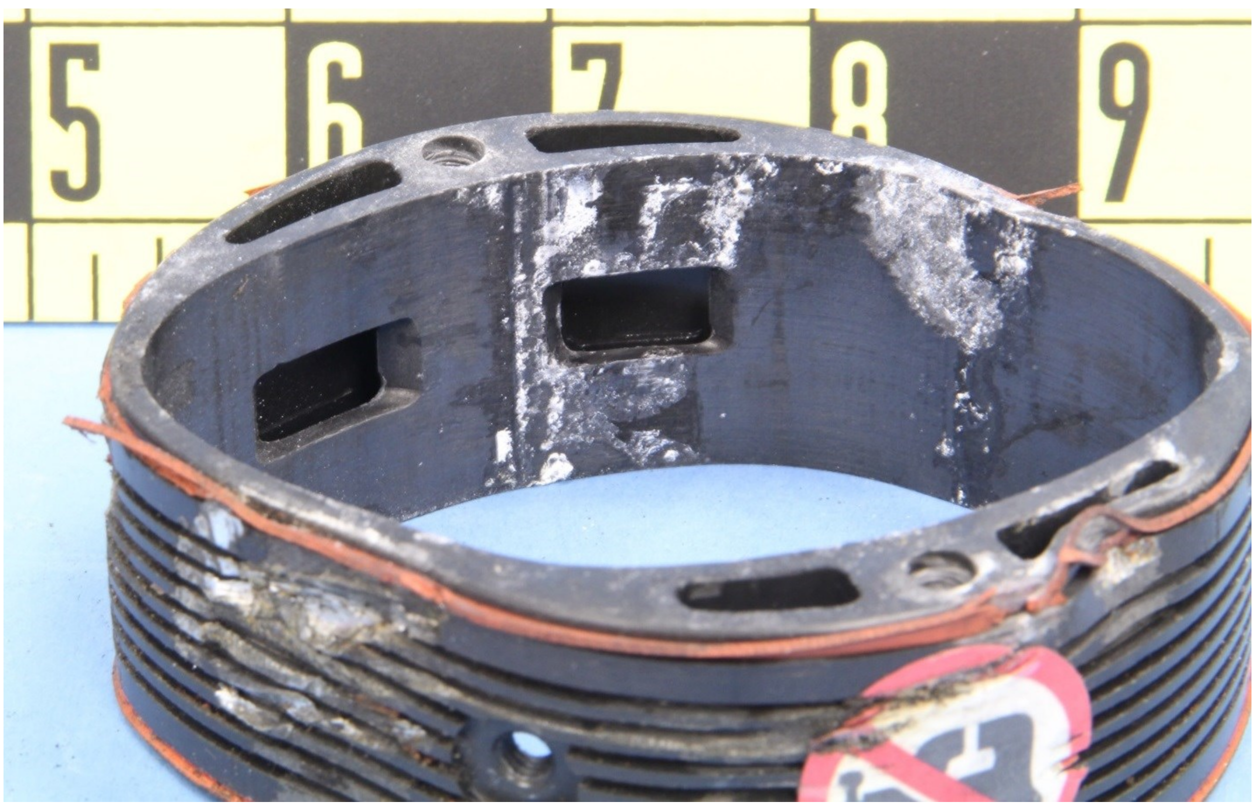

Figure 9 – Interior view of the crushed pump housing, showing witness marks of the mating rotor piece, circumferential wear marks and gouging, and indications of dried residue from pooled fluid.