



Engine Investigation Report

Rolls-Royce Model: 250-C20B
Engine Serial Number: CAE 832024
Aircraft Model: B206B
Registration Number: N211CS
Operator: West Valley Aviation
Accident Date: 1 March 2017
On-site Exam Date: 16 March 2017
Engine Exam Date: 13 June 2017
Report Date: 12 September 2017



Model 250-C20B/J


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Rolls-Royce

Report Enclosures:

Narrative

Appendix A, Aircraft / Engine Examination Photographs

Appendix B, Fuel Control Unit Test Results

Appendix C, Power Turbine Governor Test Results

Background Information:

According to the pilot, he was on an aerial application mission when he heard a loud bang and experienced an engine power loss. He was flying at 5 ft AGL and 70 mph performing a spray run when the power loss occurred. He immediately applied aft cyclic and lowered collective to flair and gain some altitude. He had to clear a drainage ditch to complete the autorotation and in doing so, bled off most of the main rotor RPM. As a result, he landed hard and the main rotor struck the tail boom. After landing, the aircraft began to shake violently so he shut down the engine, which continued to run. During the shutdown he rolled throttle up slightly to unload the idle detent button and the engine spooled up in response.

On-Site Airframe / Engine Observations:

The aircraft wreckage was removed from the impact site and stored in a hangar at the operator's facility until the examination. The wreckage was inspected on 16 March 2017 under the direction of the Fresno FAA FSDO inspector with investigators from Rolls-Royce and Bell Helicopters in attendance.

All of the engine mounts were intact. Linkages to both the Power Turbine Governor (PTG) and the Fuel Control Unit (FCU) were checked with no anomalies noted. The bleed valve was open and all external air, fuel, and oil line connections were at least finger tight. A pneumatic leak check was conducted using shop air with no leaks detected.

The aircraft was equipped with an inlet barrier filter which was dirty but not obstructed.

Air pressure was applied to the Pc inlet port of the bleed valve and the valve began moving with ~25psig pressure and closed fully with ~27psig pressure.

Both the N1 and N2 rotors turned freely and were continuous to the starter generator and main rotor respectively. No Foreign Object Damage (FOD) was noted on the first stage compressor blades, compressor inlet or fourth stage turbine wheel. The lower magnetic chip detector plug was removed to facilitate oil drainage and an appropriate amount of oil (~1/2 liter) was drained from the gearbox. Neither the upper nor lower chip detector displayed ferrous particles.

The aircraft mounted engine oil scavenge filter was examined with no significant debris observed. The bypass indicator was not extended.

Residual fuel was noted in all of the engine fuel lines. The aircraft mounted fuel filter was full of fuel which contained debris on the input (pre-filter) side. The engine mounted fuel filter was full of fuel which did not display contaminants and was normal in appearance and smell. The fuel nozzle primary and secondary orifices did not appear obstructed and the air shroud displayed normal carbon sooting.

One of the two aircraft boost pumps (the aft pump) was inoperative when tested individually. The fuel pump caution light was illuminated in the cockpit when master power was turned on. Approximately 6.5 gallons of fuel was drained and measured from the tank.

Engine Information:

An Allison M250-C20B gas turbine engine, S/N CAE 832024, powered the helicopter. The last documented engine inspection in the logbook was a 100hr inspection 65.5 operating hours prior on 15 February 2017 at an engine time of 12026.7 hours. No logbook discrepancies were noted.

Manufacturer	Allison
Engine Model	M250-C20B
Rating	420 Shaft Horsepower
Serial Number	CAE 832024
Engine Total Hours	12092.2 hours
Last Inspection	65.5 hours

Component	Serial Number	Part Number	TSO(hrs)	TSN (hrs)
Engine	CAE 832024	6887190		12092.2
Gearbox	CAG 34092	6894171	4084.6	12000.9
Compressor	CAC 38791	6890550	1241	7996
Turbine	CAT 35117	23038241	2230.6	5684
FCU	54799R	23070606	724.1	unk
PTG	28506	23065121	446.6	unk
Fuel Pump	T100839	6899253	48.5	unk
Fuel Nozzle	AG0777	M250-10603	298.5	unk
Bleed Valve	FF 57974	23053176	672.2	unk

Engine Investigation:

The engine investigation was conducted at Keystone Turbine Services (a Rolls-Royce authorized maintenance and repair center) under the supervision of the NTSB IIC on 13 June 2017. The engine was shipped without the magnetic chip detectors or fuel filter. The engine was inducted and a cursory inspection revealed no anomalies. It was installed on a test stand for performance evaluation.

Initially the engine started normally with no hesitation and accelerated to idle with a stabilized N1. Shortly thereafter the magnetic chip detector indications illuminated and, when inspected, both the upper and lower detectors presented chips and debris. Several subsequent test runs and troubleshooting efforts did not reveal the cause of the chip indications. A limited amount of engine performance data was collected during the various troubleshooting test runs but a full power calibration test was not achieved. Due to the possibility of engine and test stand damage, the engine run was aborted.

In order to troubleshoot the metallic debris generation, the engine was disassembled to gain access to the gearbox. The gearbox inspection revealed gouging on the forward face of a roller bearing separator. This roller bearing is the forward radial support bearing for the Power Takeoff (PTO) gear. It is likely that this damage occurred during preparation for the engine test when the adjacent double lip seal was replaced with a single lip seal to accommodate test stand vs. aircraft differences. It is suspected that the damaged bearing generated metal which caused the repeated magnetic chip indications during the engine testing. No other gearbox anomalies were noted during the teardown.

The PTG was tested on a certified bench in accordance with OEM overhaul limits and all serviceable limits were met.

The FCU was tested on a certified bench in accordance with OEM overhaul limits and an anomaly was noted. Specifically, a gasket on the torque shaft housing cover was not sealing properly due to under torqued screws. The safety wire on the screws was secure but the screws broke free with only 3-4 in-lbs. of applied torque (the specified assembly torque is 9-10 in-lbs.). The original gasket was refitted along with the same cover and screws, which were torqued to the specified values of 9-10 in-lbs. After gasket replacement, the unit was retested in accordance OEM overhaul limits and all serviceable limits were met. Logbook records indicate the FCU was last overhauled on 12 Aug 2015. The FCU was then removed after 511 operating hours and reinstalled the same day (27 Oct 2016) for "repair".

Service and performance engineering determined that the leaking gasket would cause a rich fuel delivery condition to the engine. The FCU bench test demonstrated that the leak was due to improper torque on the bolts securing the cover (and underlying gasket) over top of the torsion shaft, which is surrounded by FCU internal control air pressure (known as Px). The leaking gasket, which likely developed over time, would result in lower than expected Px values for a given compressor discharge pressure (referred to as Pc). This disparity between Px and Pc would grow as Pc pressure increases relative to a nominal FCU with no leakage. Therefore, the control would be richer at higher Ng speeds and thus produce higher power than normal. During operation the control system would compensate for this condition as the PTG would reset the FCU to reduce fuel flow in order to maintain the power turbine / main rotor speed at 100% (or the appropriate speed set by the pilot). Therefore, in a flying condition, the pilot would not notice any operational difference.

In order to determine the capability of the engine to produce power during the event, Rolls-Royce performance engineering used the limited amount of test data from the aborted engine test to plot the event engine performance versus an engine making minimum specified power. The results are depicted in Figure 1.

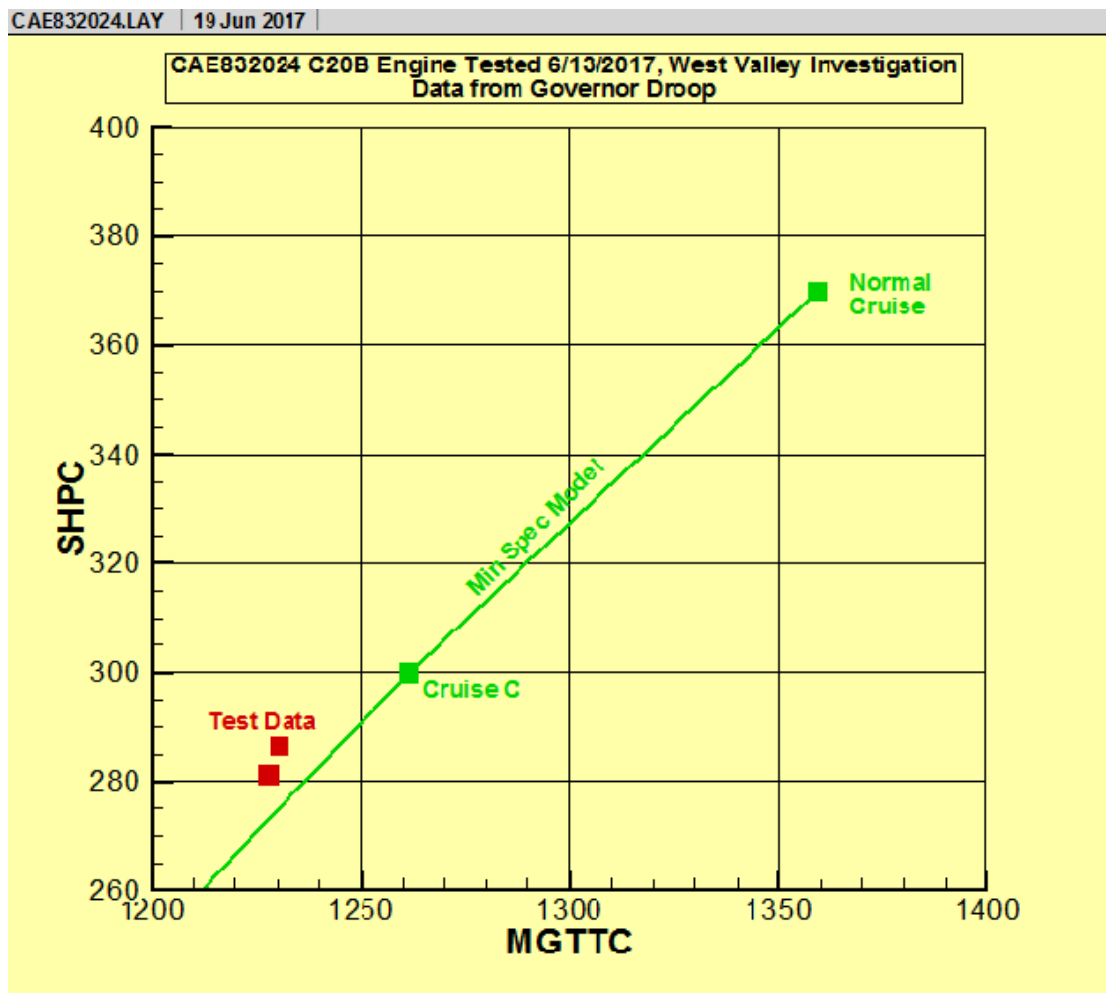


Figure 1. Event engine data points are depicted as red blocks.

Summary:

Although a full performance calibration engine test could not be performed due to repeated magnetic chip indications on the test stand, the engine started and generated some power prior to the commanded shutdown. Subsequent controls testing and engine inspection did not reveal a condition that would prevent the engine from normal operation during the event.

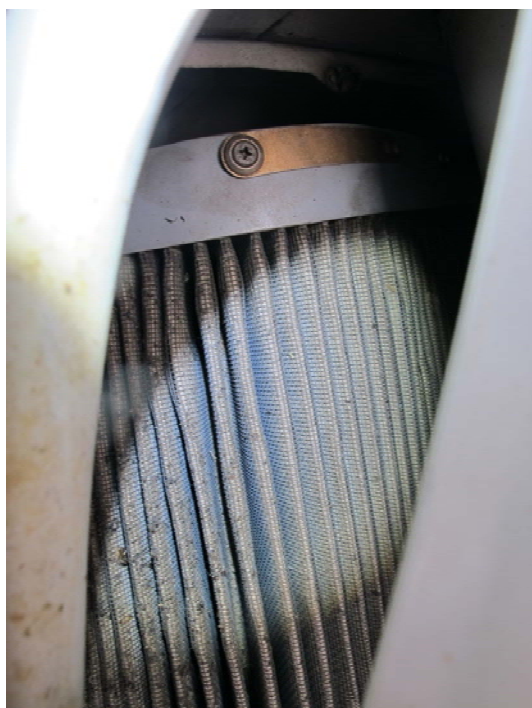
Appendix A, Aircraft / Engine Examination Photographs



Figure 1. Aircraft General



Figure 2. Tailboom Damage



Figures 3 and 4. Inlet Barrier Filter



Figure 5. Aircraft Warning Panel Indicating a Fuel Pump Issue



Figure 6. Aircraft Fuel Indicator Depicting Level of Fuel Found in Aircraft

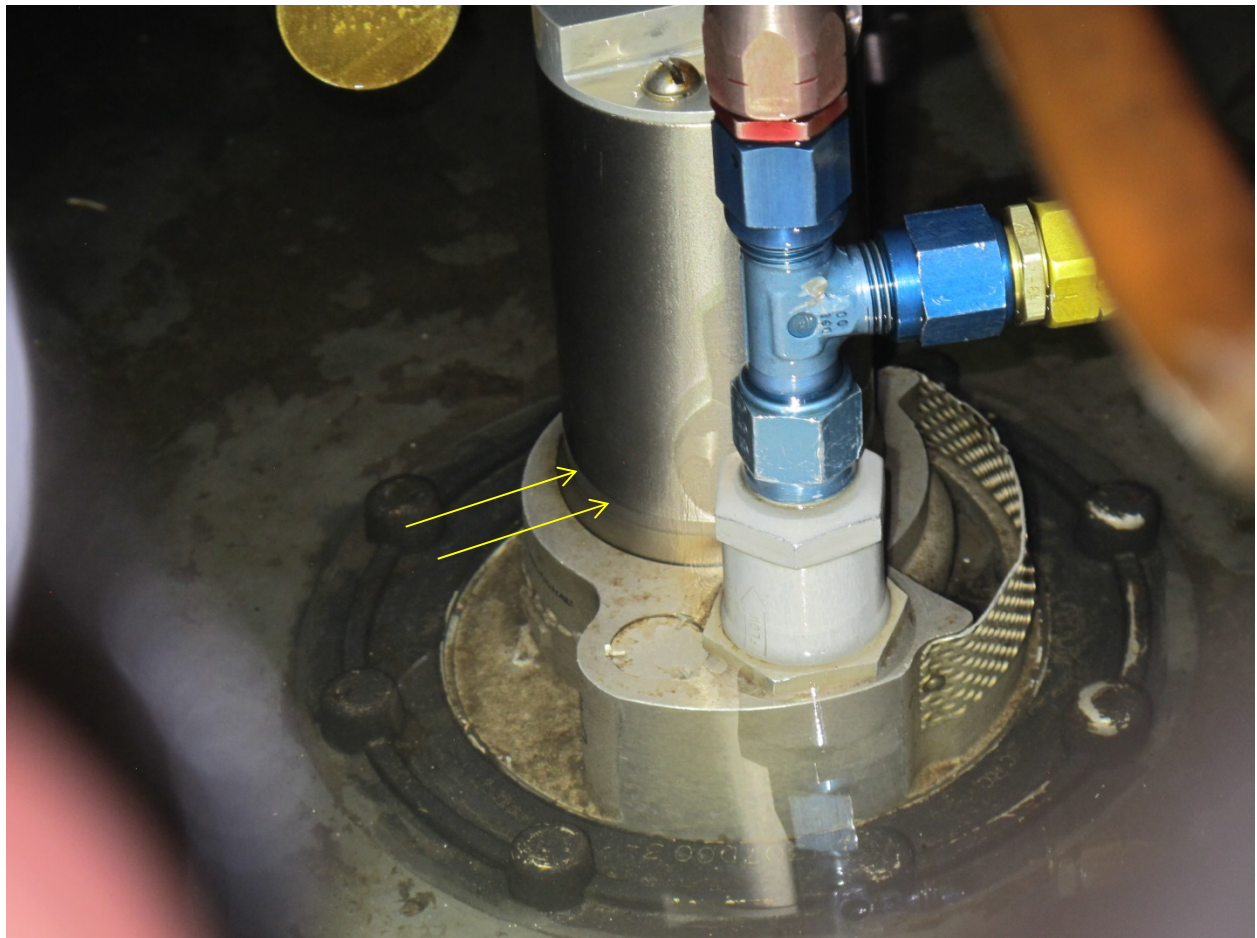


Figure 7. Aircraft Aft Boost Pump Installed in Fuel Cell. Arrows Indicate Fuel Level Found in Aircraft



Figure 8. Debris in Aircraft Mounted Fuel Filter Bowl

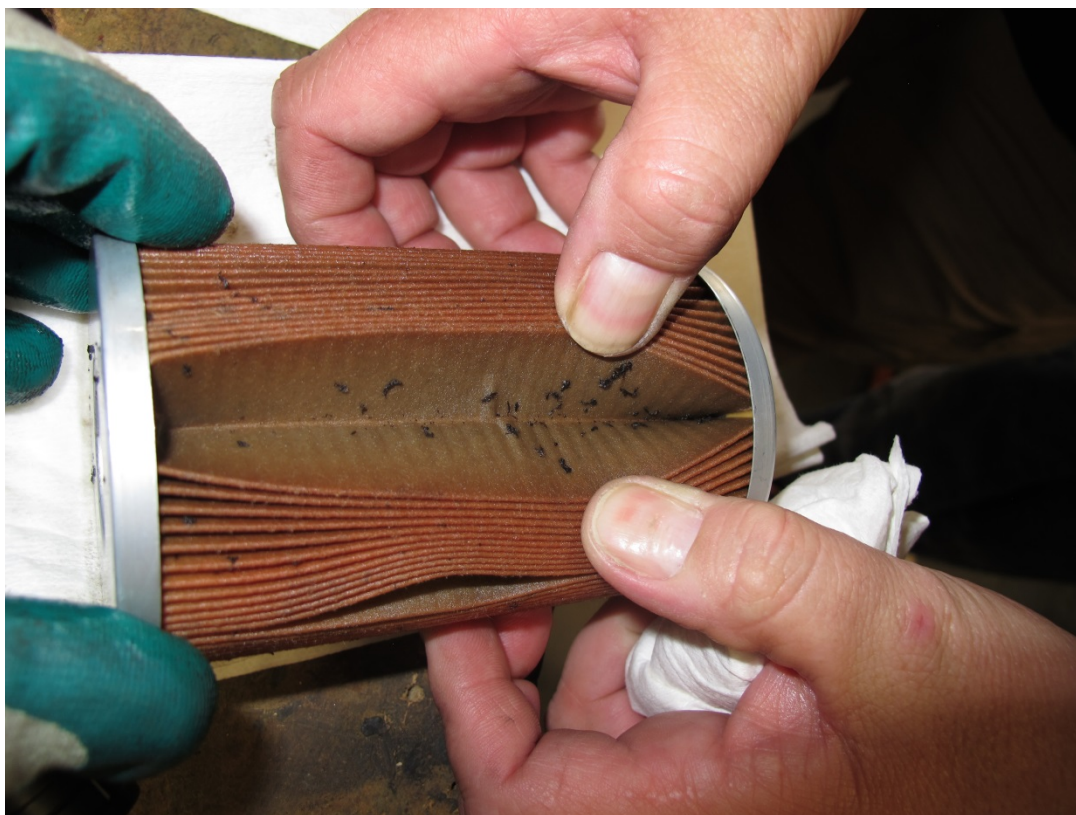


Figure 9. Debris in Aircraft Mounted Fuel Filter Element



Figure 10. Engine Mounted Fuel Filter Bowl

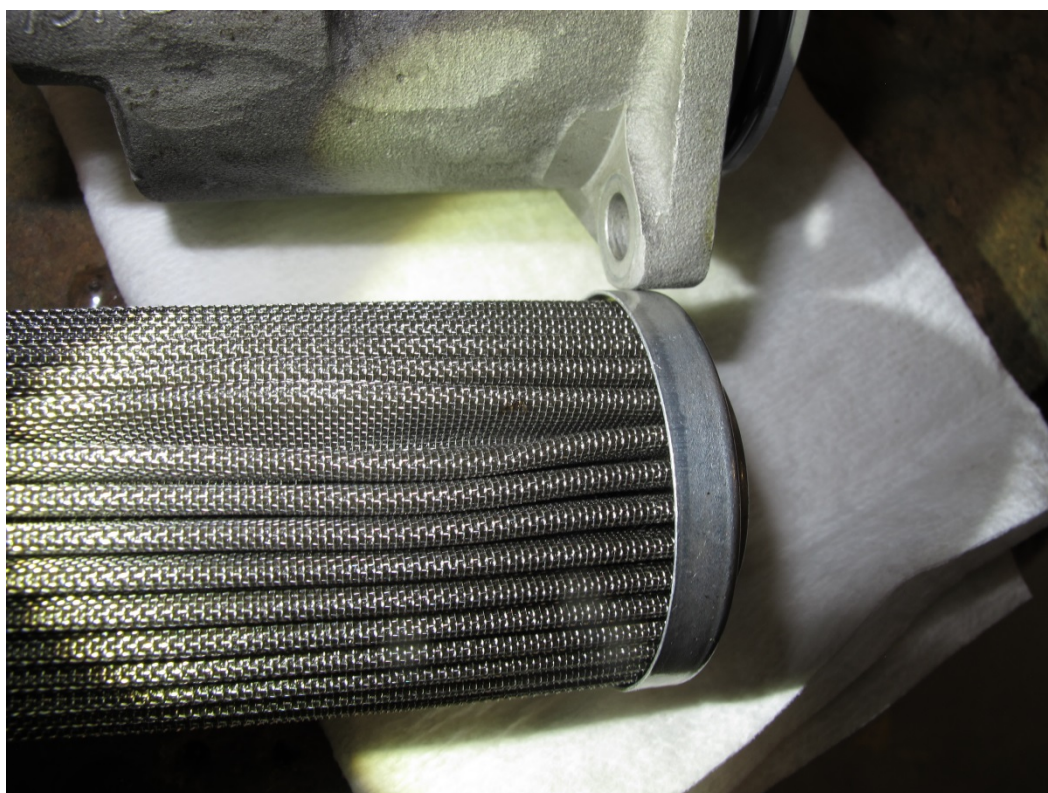


Figure 11. Engine Mounted Fuel Filter Element



Figure 12. Fuel Nozzle



Figure 13. Lower Magnetic Chip Detector



Figure 14. Upper Magnetic Chip Detector



Figure 15. Compressor Inlet



Figure 16. Engine General

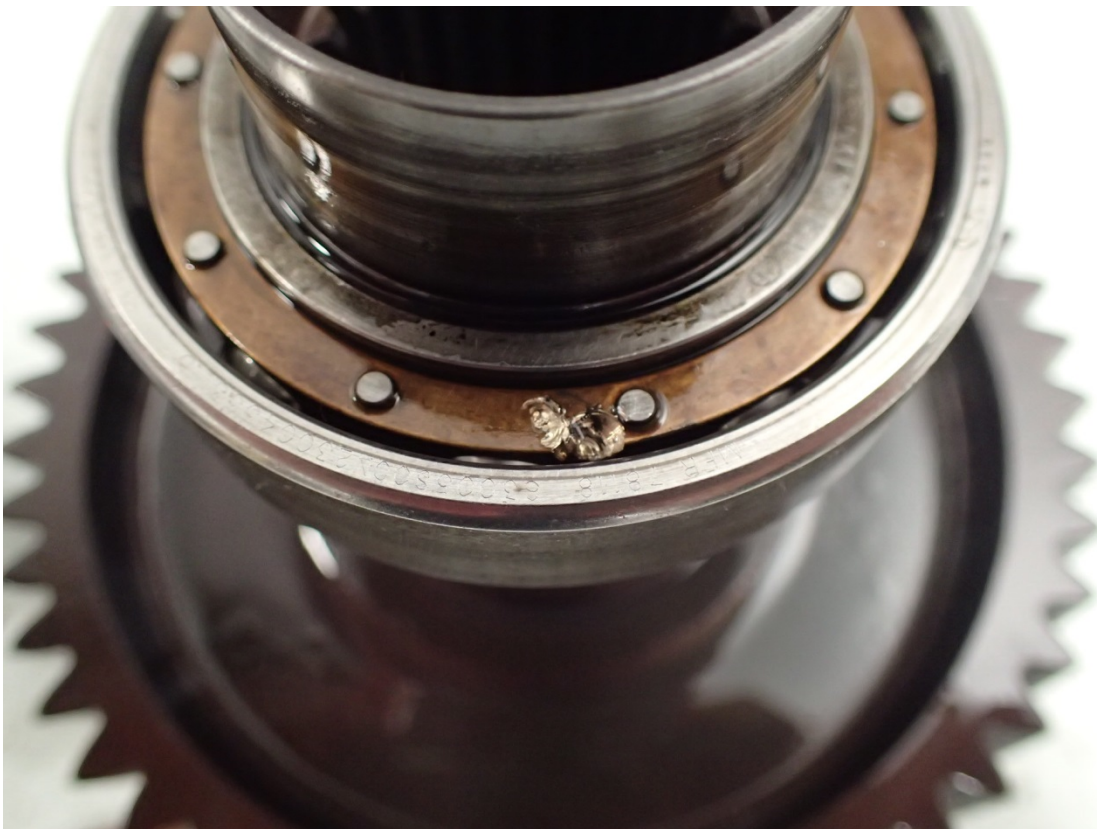


Figure 17. PTO Gear Bearing Separator Damage



Figure 18. Fuel Control Unit Px Cover