U.S. Department
of Transportation
**Federal Aviation
Administration**

Aviation Safety

Federal Aviation Administration
Flight Standards District Office
2725 Skyway Drive, Suite 1
Helena, Montana 59602-1213
[redacted]

March 3, 2020

Mr. Stephen Stein
Aviation Accident Investigator
National Transportation Safety Board
505 South 336th Street, Suite 540
Federal Way, WA 98003d

Dear Mr. Stein:

On February 25, 2020, I completed the inspection of a Lycoming O-360-A4N, serial number L23343-36A engine installed on a Cessna 172Q, Registration number N96145, involved in an accident on January 17, 2020. The inspection was to determine if the engine failed due to an anomaly described by the accident pilot as a 'grinding' sound emanated from the engine accompanied with a loss of engine RPM prior to impacting the ground.

The team performing this investigation consisted of a FAA certificated Mechanic with both airframe and powerplant ratings, a representative from Textron Aviation with assistance and oversight provided by myself, an FAA safety inspector. The aircraft and engine were disassemble to allow inspection of the following systems or components; oil wetted internal engine component, fuel system, ignition system, valve-train, fuel delivery and filtration components, propeller components, and cylinder compression values. The report contains photographs, in a separate file. The associated file contains photographs that add value to this report. In some instances, given the photographic equipment at-hand, image quality lacked the appropriate resolution to capture the objects features; therefore, they are not included but described in detail in the report. This report includes Concluding Observations, which are not by any means an attempt to provide causal factors to the accident. The FAA inspector included this section as a means to communicate the composite observation of the team following completion of the inspection. The concluding observations encapsulate in words what the inspection found within the sum of all the system and components inspected.

Should you have any questions, please contact me, directly by phone at [redacted], or by e-mail: [redacted]

Sincerely,

[redacted]

John M. Cosenza
Aviation Safety Inspector

Engine Historical Data

On May 23, 1996, Custom Airmotive Inc. overhauled the engine and converted it from a O-360-A4**M** to a O-360-A4**N** they also completed all applicable Airworthiness Directives (AD). The engine data plate displayed the appropriate conversion data plate. The Engine records indicate adherence to scheduled inspections cycles, oil changes and maintenance as well as completing recurrent ADs. The engine records indicate extensive repair or preventive maintenance during subsequent annual or 100-hour inspections. A second engine Overhaul occurred on August 31, 2017 at 2970 (Hobs) due to a crack in the engine case below the number 2 cylinder. During this overhaul, Aircraft Specialties Services Inc. performed an NDT inspection and refurbished the Crankshaft, drive gears, connecting rods and rocker arms. Additionally, a new camshaft, lifter bodies, and Lycoming cylinder kit was installed. The magnetos were overhauled at this time as well. Also replaced were all seals, connecting rod bolts and other hardware associated with the overhaul. In accordance with the overhaul manual, PN 60294-7 and parts illustrated manual, PN PC-306-3. Following the second overhaul, the owner followed the 100-hour /annual inspection schedule appropriately. The total indicated aircraft hours at the time of the accident was 3593 hours – approximately 623 hours between overhaul and accident.

Inspection Results – Lycoming O-360-A4N, SN: l23343-36A

General condition prior to disassembly – The impact caused substantial damage to the propeller and lower front engine area, including the carburetor, air filter, heater box and supporting structures. Some components within this area were detached or missing (see images 1, 2). The carburetor was removed from the engine by cutting the throttle, heat, and mixture cables. All accessories and attached components were secure and showed no signs of improper installation. Although the engine did not contain oil or fuel at the time of inspection, there was evidence of failed or leaky seals installed between components and the engine case. A small section of the Starter Ring Gear broke away from the AFT rim of the pulley channel, apparently caused by contacting the engine case during impact. There is corresponding rotational marks on the engine case corresponding to the size and location of the pulley (see images 3-14).

Component Inspection

Engine Fuel Filter, Main (Gascolator) – The filter screen was clean, free from damage and corrosion. No breaks in the mesh were visible and it securely fastened to the housing assembly. The only notable damage were tool marks on the inlet tube’s lower surface. The fuel bowl contained a hard substance at the base of the bowl, which appeared to be a sealant of some type intentionally applied to prevent leaks or as part of corrosion repairs

Carburetor, Marvel Schebler, Model MA4-5 – the carburetor was detached from the engine mounting point along with the air filter and heater box. The NTSB will perform a more detailed inspection of this component to determine if AD 63-22-03 effected this carburetor and for other indications of in-flight failure. The AD calls for inscribing a “V” on the data plate. Although a ‘V’ is on the data plate, it is unclear if it is in the correct location indicating accomplishment of the AD (see images 18-20).

Fuel Pump – Removed for further inspection by the NTSB to verify it provided fuel in a quantity and volume to maintain engine operation. No visible leakage or external defects/damage noted (see image 21 – 21A).

Fuel Distribution – Inspection of the fuel lines leading from each wing tank, through the selector valve, then to the fuel strainer appeared to be operative and debris free. When transferring air through the system/lines, the following occurred when the Fuel Selector Switch is set to one of four settings, OFF, BOTH, LFT or RT:

OFF: no air transferred to the Fuel Filter.
BOTH: Air transferred through the Fuel Filter when introduced at the LFT or RT fuel line.
LFT: Air transferred through the Fuel Filter when introduced at the LFT fuel line and with some restricted / reduced flow airflow from the RT fuel line.
RT: Air transferred through the Fuel Filter when introduced at the RT fuel line and with some restricted / reduced airflow from the LFT fuel line.

The flow in air, albeit restricted, from the opposite sides fuel line, indicates fuel would pass through it to the engine, regardless of the Fuel Selector Switch position. The switch was set to BOTH prior to the engine exhibiting a loss of RPM and its associated noise.

Wing Fuel Tanks - Each wing tank appeared to be free of debris. Each fuel cap O-ring was in serviceable condition and free of cracks; nor was it brittle or warped that may lead to fuel syphoning during flight. The relief valve, a small rubber like flap, was also in good condition, securely fastened, and flexible which appeared to be capable of allowing the introduction of air into the tank during fuel depletion. The fuel lines in each tank, as well as the vent line, were free of debris and transferred air without restriction. Each finger screen was free of debris.

Magnetos – timing of the left magneto was 23 degrees and Right at 25 degrees of Top Dead Center. Rotating the propeller produced sharp and audible "Clicks" from each magneto indicating the rotational components, crank and associated gears, actuated each magneto. Results of each magneto's ability to provide an electrical impulse is as follows:

No. 1 leads – the top lead produced a blue spark but was inconsistent with each click or the magneto. The bottom lead, when removed from the spark plug, fell apart with the main contactor point falling out of the lead housing. The No. 1 bottom lead did not produce a consistent spark and when it did spark, the color was more yellow than blue.

No. 2, 3, & 4 – both top and bottom plug leads discharged a crisp blue spark, which coincided with the click of the associated magneto.

Valve Train actuation – All rocker arms, and push rods actuated in equal ranges of operation during the rotation of the propeller. Return springs were secure with no apparent broken springs or any alignment differences in valve components. Rocker Arm pins and retaining buttons were in good condition with no scoring, heat damage, or indication of oil starvation

Spark Plug Condition – Inspection for damage and carbon deposits are as follows:

Plug No. 1 Top – Fouled and corroded with carbon and rust. The rust may be a result of the aircraft's position, inverted, for a period of time that allowed water or other moisture to build up in the top of the cylinder. The shape of the cathode indicated wear or excessive cleaning and was not the typical oval shape. The anodes were worn and did not follow a consistent gap around the cathode (see image 22A).

Plug No. 1 Bottom – Severely fouled and filled water oil and fuel, possibly from being in the same position as described in Plug 1 Top. No real visible gap between the anode and cathode (see image 22B).

Plug No. 2 Top – Showed normal wear and was in good condition. Cathode was more round in shape with consistent gap between the anodes (see image 23A).

Plug No. 2 Bottom – Showed excessive wear with a wider gap between the anode/cathode than No. 2 Top plug with a darker carbon coloration indicating a normal to slightly cold ignition (see image 23B).

Plug No. 3 Top – above normal wear or excessive cleaning as the cathode appeared to be smaller in diameter towards the top of the cathode than the other plugs and more square on the surfaces not facing the anode. The gap between the anode/cathode was not consistent with other plugs (see image 24A)

Plug No. 3 Bottom – Similar to No. 3 Top plug; however, the gap was wider than No. 1. Additionally there were cylindrical deposits on the surface of the outer ring of the anode (see image 24B).

Plug No. 4 Top – Worn cathode and wide gap between the anode. Similar cylindrical deposits on the surface of the anode as with plug No. 3. Cathode shape was smaller in diameter at the top of the portion of the cylinder than at the base nearer the ceramic insulator (see image 25A).

Plug No. 4 Bottom – Wet in appearance but may be due to the position of the aircraft described in Plug No., 1. Same wide gap, cathode shape and wear as No. 4 Top with the cylindrical deposits apparent on the ceramic insulator (see image 25B).

Spark Plug electrical impulse check – each plug was test for conducting an electrical impulse; the results are as follows:

Plug 1 Top – conducted impulse on one anode lug only.
Plug 1 Bottom – No impulse conducted (cleaned plug prior to testing).

Plug 2 Top – conducted impulse on both anode lugs.
Plug 2 Bottom – Same as 2 Top.

Plug 3 Top – Conducted impulse on one anode lug.
Plug 3 Bottom – Conducted impulse on both anode lugs.

Plug 4 Top – Conducted impulse on one anode lug.
Plug 4 Bottom – Same as 4 Top.

Cylinder Bore Scope – Prior to performing the compression check, the inspectors used a borescope to inspection each cylinder. All cylinders **BUT** the No. 1 cylinder appeared to be normal - no noticeable scoring, heat damage (interior or exterior) or discoloration; each appeared to be well oiled as evidenced on the oil ring and traces of oil on cylinder walls or piston skirts. The No. 1 cylinder appeared was filled with water or some liquid. Subsequent removal of cylinder No. 1 found rust near the valves, which supported the findings of sludge deposits and rust on the spark plug (see image 28 - 29). The remaining cylinders were normal in appearance. The only notable difference between each cylinder was in the removal of the connecting rod pin from the piston on cylinders No. 3 and 4. The pin in each cylinder required extensive force (hammer and brass drift pin) to remove each piston pin and piston pin button. However, once disassembled, there was no evidence of excessive wear, heat damage or stress, discoloration or oil starvation.

Cylinder Compression Check – The table below is the compression history of the accident engine following the overhaul of August 31, 2017. The last row of readings is that of this accident inspection/testing:

	Cylinder Number				
	1	2	3	4	Date - Hrs
PSI	80	79	79	79	5/1/2018 - T = 3028
	80	79	79	79	10/16/2018 - T = 3161
	79	79	78	79	2/12/2019 - T =3289
	80	78	78	79	5/3/2019 - T = 3414
	78	78	78	79	10/25/2019 - T = 3542
	68	28	66	78	Post-Accident – T = 3593

Low readings on Cylinders; 1, 3, & 4 may be due to possible debris on the valve seats due to the inverted position and carbon dislodging during impact. A test of the Cylinder No. 2 valve seats indicated abnormal displacement of the exhaust valve seat. Tests consisted of pouring a solvent into the exhaust and intake ports then cylinder then checking for seepage within the cylinder. The first round of solvent identified a leaky exhaust valve (see image 26). Following actuation of the valves on cylinder No. 2, the debris dislodged from the valve surface reducing leakage (see image 27). The test allowed an equal time for each leak test. Inspectors used Cylinder No. 2

as it produced a reading outside a normal range. Although the remaining cylinders produced lower than normal readings, historically, they were still within a standard passing / operational range of 60 – 80 psi.

Piston and Rings – all piston and rings were in good condition with no signs of heat damage, excessive wear or scoring.

Crank and Connecting Rod Inspection – a visual inspection of the connecting rods and crank did not identify any indication of catastrophic failure of any internal components; nor was there any indication of oil starvation, discoloration due to heat stress, surface damage/scoring or any other physically noticeable damage. There was oil pooled in the bottom of the case and no visible cracks in the case. No movement of the crank by pulling or pushing on the propeller was noticeable. Movement of the connecting rods around the crank appeared to be normal with less than a millimeter gap between the connecting rod journals and crank web. There was no movement along the radial axes of the connecting rod journals. Connecting rod bushings showed no signs of discoloration due to heat damage, oil starvation, or scoring. The bushings were not of the year range to be included in AD 17-16-11, and did not move laterally within the connecting rod small end. The I-Beam (rod webbing) did not show any visible signs of damage or inner component contact and appeared to move freely around the crank when rotated (full 360 degrees) (see images 30 – 35).

Propeller – The propeller contacted the ground during the accident. The ground at the time was the grass area to one side of the runway. There was approximately 3-4 inches of snow on the grass and the ground was frozen. A section of one propeller blade detached and recovered by the salvage company. The second blade showed signs of impact with a typical inward curled tip. The recovered tip also had an inward curl, 45-degree fracture angle and metal scale like structure on the face of the fracture. The NTSB will receive the propeller section for further analysis.

Propeller Mounting – The propeller was removed to ensure it was installed correctly and to verify damage to the crank flange mirrored the damage of the propeller. The Flange was out-of-round consistent that of the propeller as well as the associated mounting components. During removal of the mounting bolts, two of the bolts had a break value of 150-inch pounds, roughly 150 under the lowest torque value required during installation. The spinner bulkhead was damaged but not in a way consistent with impact. The bulkhead had cracks adjacent to three bolts, which showed characteristics of vibration or over-torqueing the attachment bolts (see image 40 – 42).

Oil Filter – The oil filter was cut open and inspected for metal from internal components, NONE present (see image 36 – 39). Due to the lack of visible evidence, the engine operated without a sufficient amount of oil or the continuous oil supply to oil wetted components, the inspection team did not disassemble the engine to inspect the oil pump.

Airframe – the recovery team separated the wings from the airframe to facilitate transportation. The Textron inspector verified continuity of all flight controls cables to their associated control surface. Also checked was continuity of the throttle, mixture, and carburetor heat cables; all but the carb-heat check good. The carb-heat lever appeared to be broken at the lock, which prevented movement.

Concluding Observations

The inspection of this engine discovered no signs of latent or catastrophic failure. The inspection did not reveal any improperly installed components. All oil wetted parts appeared to receive enough lubrication to sustain engine operation long enough to enable a normal landing given the aircrafts proximity to the airport. The same conclusion regarding fuel flow and engine operations is also true. All internal components appear undamaged and functional aside from damage, which may only be apparent through run-out inspections or NDT analysis. Although the number 1 cylinder appears to partially operational at best, it alone would not incapacitate the engine without leaving visible damage to internal components. The loss of one complete cylinder's function would create a rough running engine, but would enable operation with enough power to land safely. The associated vibration and possibly noise may cause an increased level of stress upon the pilot but nothing more to the engine. The only aspect of this inspection which could not be clearly evaluated is the air filter and air induction system; there were not enough remaining components to ascertain its ability to provide efficiently provide air to sustain engine operations. The pilot provided no indication of a loss of power indicative of a fouled induction system – give the report of an unfamiliar noise along with a decrease in engine power RPM and not necessarily engine power.