

INVESTIGATION SUPPLEMENTAL MATERIAL

HISTORY OF FLIGHT

On September 12, 2021, about 1609 mountain standard time, a Cessna 177RG, N2085Q, was substantially damaged when it was involved in an accident near Lake Havasu Airport, Lake Havasu, Arizona. The pilot was fatally injured. The airplane was operated as a Title 14 *Code of Federal Regulations* (CFR) Part 91 personal flight.

The pilot was planning on making a long cross-country to Reno, Nevada in the next several days and the purpose of the accident trip was for him to get fuel for the Reno trip. The airplane was based in at Eagle Airpark in Bullhead City, Arizona and the pilot performed maintenance there earlier in the day including replacing the bushings on the nosewheel because he was experiencing a vibration on takeoff and landing. Thereafter, he departed about 1530 and landed at Lake Havasu about 1545. The pilot then purchased 24.8 gallons of fuel at the self-serve fuel tank which presumably topped off the fuel tanks to full as he intended.

Investigators reviewed video recordings, audio recordings, and flight track data covering the area of the accident during the time surrounding the accident using Federal Aviation Administration (FAA) provided Automatic Dependent Surveillance-Broadcast (ADS-B) data.¹ The airplane taxied to runway 14 and after performing a run-up, departed about 1608. Witnesses report that they observed the airplane takeoff down the runway at a slow groundspeed and noted that the engine sounded rough as though it was making partial power. The airplane did not ascend as expected and veered to the right of the centerline reaching 100-150 feet agl (see Figure 1 below). The ADB data shows the airplane accelerating down the runway up to a derived airspeed of 65 kts.



Figure 1: Security Camera Footage Showing Initial Right Turn

The airplane then pitched up to a nose-high attitude and made an aggressive left bank consistent with pilot attempting to make 180-degree turn back to the runway (see Figure 2 below). Witnesses observed the airplane's wingspan turn nearly perpendicular to the horizon and then stall with the left wing dropping toward terrain.

¹ <https://globe.adsbexchange.com/?icao=a1b2d1&lat=34.569&lon=-114.361&zoom=16.7&showTrace=2021-09-12&trackLabels×tamp=1631486980>



Figure 2: Security Camera Footage of Bank to the Left

At an undetermined time during the takeoff, the pilot made a transmission on the airport common frequency where he stated, “Lake Havasu traffic Cardinal 2085Q making a uh...” The next transmission was less than a second and all that could be heard is a high-pitch tone akin to a stall-warning horn.

WRECKAGE AND IMPACT

The accident site was located in the desert terrain about 830 ft from the end of runway 14 at an elevation of 790 feet msl. In character, the terrain was composed of dry, soft dirt with sparse brush. The wreckage was found distributed over a 200 ft distance on a median magnetic bearing of about 60°.

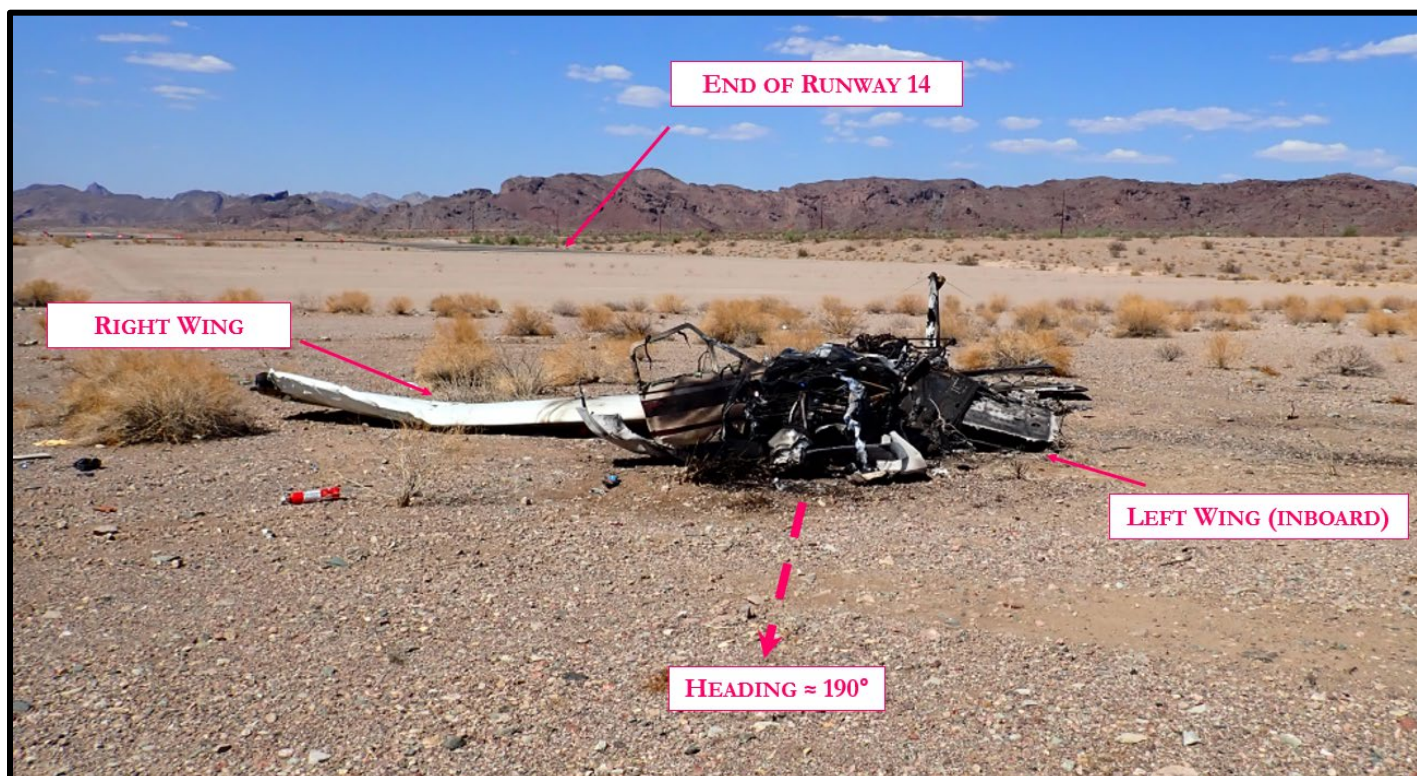


Figure 3: Main Wreckage at the Accident Site



Figure 4: Main Wreckage in Reference to the Runway

The main wreckage consisted of a majority of the airframe and engine, which had been consumed by fire with the exception of the right wing. The main wreckage came to rest on a heading of about 190°. The remaining wreckage was found in the debris field and adjacent to the main wreckage and principally consisted of the wing tip fragments, Plexiglas, and items loosely in the cockpit. The only item identified that could not be found at the accident site was an approximate 2-inch outboard portion of one of the propeller blades.

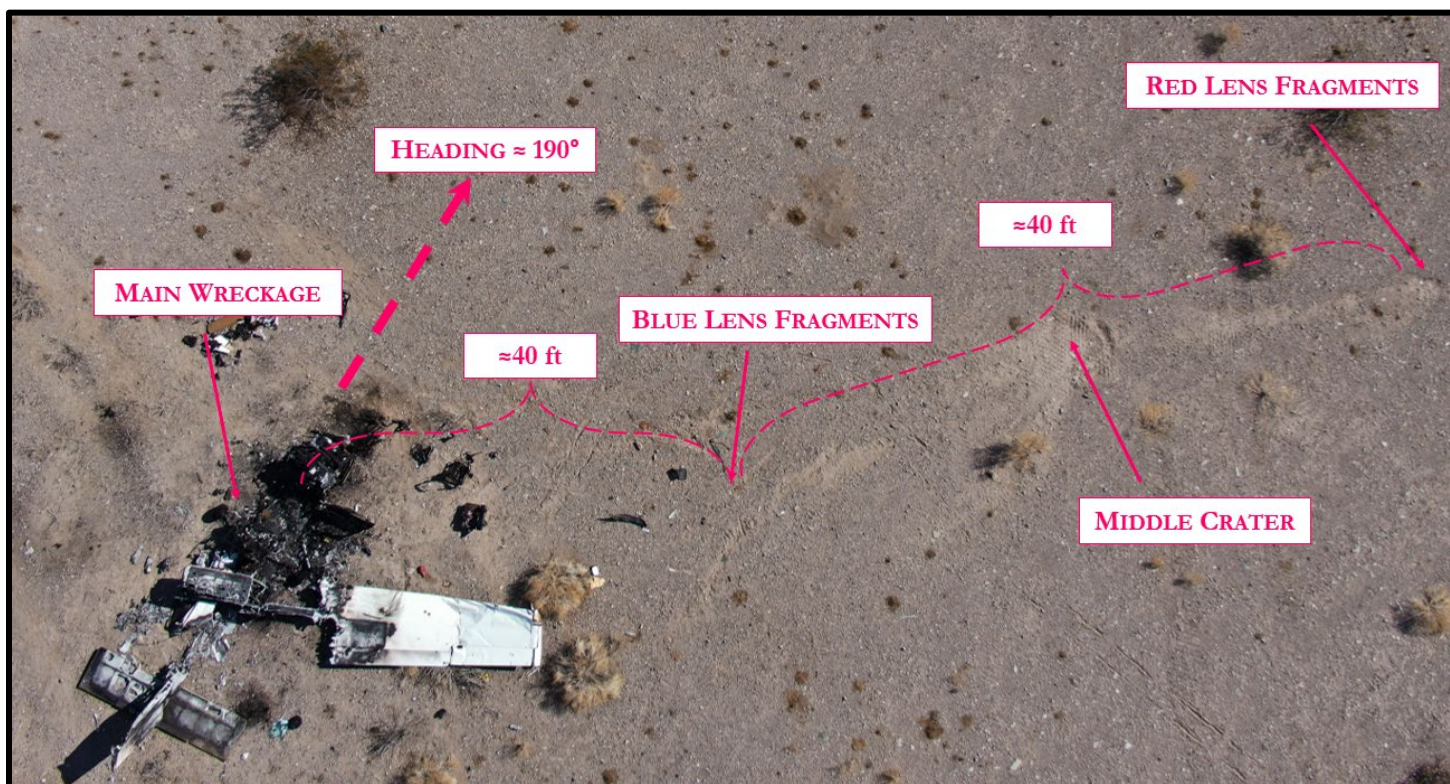


Figure 5: Main Wreckage in Reference to First Identified Point of Impact

The first identified points of contact consisted of disrupted dirt on the flat desert terrain making up the far east-southeast end of the debris field. The markings started as an indentation dirt with shards of red lens fragments imbedded within consistent with the left-wing tip impacting first. The crater was continuous for about 40 ft in the debris path and continued northeast toward the main wreckage with the end of the crater having blue/green lens fragments imbedded. A larger center indentation was found in between the ends of the crater with the red and green/blue lens fragments and had a large arc-shaped disruption of dirt consistent with a rotating propeller blade. The craters were consistent in size and orientation to that of the wings. The main wreckage was located about 40 ft from the blue/green lens fragments consistent with the airplane impacting in a nose low attitude and rotating about itself coming to rest on a heading of 190°.



Figure 6: Artistic Representation of Possible Accident Sequence Consistent with Ground Disruptions

AIRFRAME

The Cessna 177RG single engine airplane was manufactured in 1974. It was equipped with a Lycoming IO-360-A1B6.



Figure 7: Picture of the Accident Airplane Prior to the Accident

FUSELAGE

The fuselage came to rest upright and was consumed by fire. An approximate 6 ft section of the inboard left wing was attached to the carry through spar and the aileron was consumed by fire. The outboard section was partially consumed by fire and only remains of the flap tracks could be found in the ashen remains; about 5 ft of the mid-section of the wing was completely consumed by fire. The fuel cap was affixed to the top of the inboard section.

The entirety of the right wing was present at the main wreckage. With the inboard section exhibiting the majority of the thermal damage. The outboard five ft sustained aft crush deformation to the leading edge with the severity near the wing tip. The fuel cap remained affixed to the wing with sooting present in a pooling pattern forward to the leading edge consistent with fuel escaping from the fuel tank during the post-crash fire. The flap and aileron control surfaces remained attached at their respective hinges and the control cables were continuous to the fuselage. The flap actuator jackscrew was examined by measuring the exposed threads, which totaled 2.2 inches. A representative from Textron Aviation stated that the position of the jackscrew was consistent to the flaps being extended about 10°.

The Textron Aviation representative confirmed flap cable continuity to the cockpit area; the flap indicator was in the 10° position. The aileron cable continuity was established from the control surfaces to the control yoke assembly.

The rudder control surface remained affixed to the vertical fin structure. The rudder cables were attached to the rudder horn, and continuity was established to the aft baggage compartment through a series of pulleys and runs through lightning holes; the ends were attached to their respective bell cranks at the rudder pedal mixing control bar.

The horizontal stabilizer and elevator remained attached to the empennage. The elevator was attached to the aft push-pull tube connect, which was partially consumed. The elevator cables were attached to their respective bellcrank arms and continuity was established in the aft baggage compartment through a series of pulleys and runs through lightning holes to the control yoke area. Elevator trim tab actuator was 1.2 inches which is consistent with 5 degrees tab up.

The right door tongue was out/engaged consistent with the door being closed at the time of impact; the left door was consumed by fire.

Fuel system continuity could not be established due to the amount of impact and thermal damage that the airplane had sustained. Fuel was present in the right wing tank and approximately seven gallons was drained into buckets; the odor and blue hue was consistent with 100LL AVGAS. The fuel selector valve was found in the "BOTH" position. No fuel was found in the fuel manifold.

The pilot's spouse stated that he always flew in the left seat. The left seat was partially consumed by fire and had sustained more bending forces than the right.

COCKPIT

The cockpit sustained thermal damage prohibiting investigators from obtaining any meaningful information from a majority of the gauges. The following information was garnered: The cowl flap handle was in the closed position; The Kollsman window for the altimeter was set for 29.73; The tachometer read 0665.7; the wing flap indicator was in the 10° position; the landing gear handle was in the down position; the throttle, propeller and mixture knobs were full forward. The key appeared engaged but the position could not be determined because of thermal damage. The auxiliary fuel pump switch was consumed by fire.

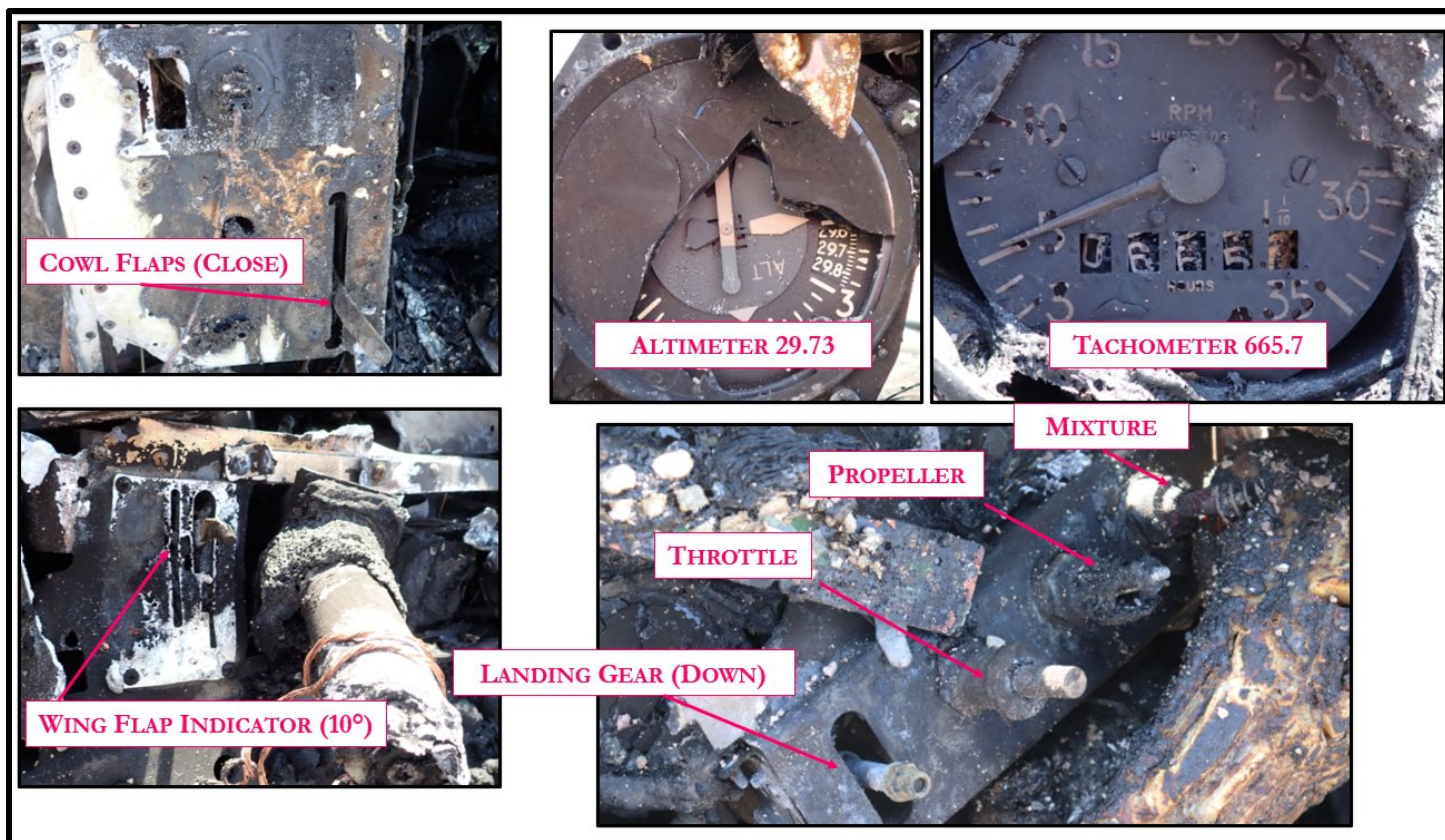


Figure 8: Cockpit Gauges

ENGINE

The Lycoming IO-360-A1B6D serial number RL-28054-51A, was intact. A post accident examination was conducted on September 15th and 16th, 2021, at the facilities of Air Transport in Phoenix, Arizona.

The crankshaft was rotated by hand utilizing the propeller. The crankshaft was free and easy to rotate in both directions. A compression test was performed on all cylinders, with the No. 1 cylinder showing the weakest compression around 60 psi and the remaining cylinders able to obtain over 65 psi. During the compression test of the Nos. 1 and 4 cylinders, investigators could hear faint hissing noise through the accessory gear mounting flange consistent air escaping the chambers. The complete valve train was observed to operate in proper order. Mechanical continuity was established throughout the rotating group, valve train and accessory section during hand rotation of the crankshaft. Clean, uncontaminated oil was observed at all four rocker box areas. The spark plugs were removed and according to the Lycoming representative, the electrodes were normal; No. 1 plugs were oil soaked.

A majority of the engine and its respective components were completely disassembled. The cylinders' combustion chambers and barrels showed light scratches, but there was no evidence of foreign object ingestion or detonation. The valves were intact and undamaged. There was no evidence of valve to piston face contact observed. The pistons were intact. The top compression rings (p/n 74241) on the Nos. 1 and 4 cylinders were fractured. There was evidence of deposits and coking in a majority of the ring lands. The piston skirts showed evidence of carbon build-up and wear with light scuffs/grooves oriented from the base to the crowns. There was evidence of blow-by with combustion signatures on the piston skirts on all cylinders, but the least damage was on the No. 3 cylinder. There was significant combustion deposits on the exhaust ports on the Nos. 1 and 4 cylinders and the piston face on the No. 2 cylinder. The No. 4 cylinder was different in appearance to the other cylinders with wrist pin boss having chamfered grooves surrounding it.

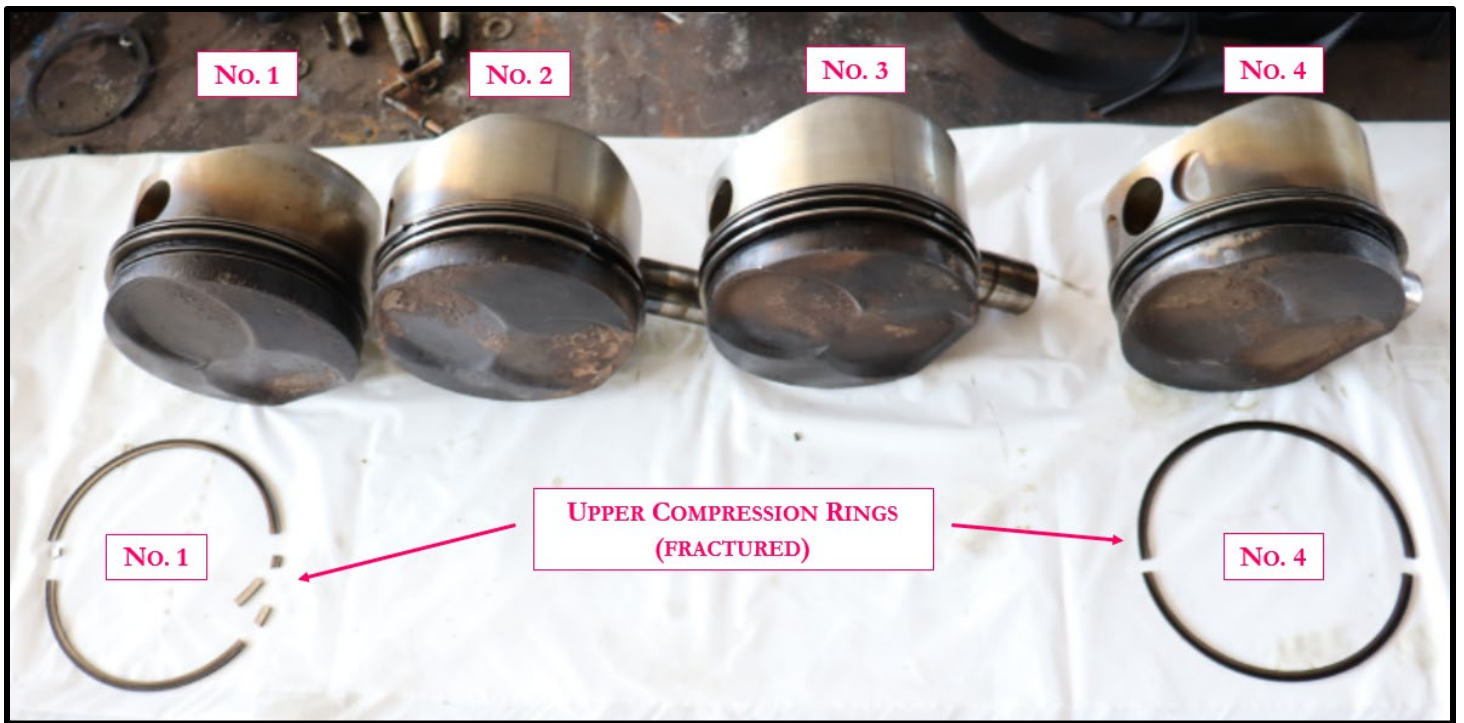


Figure 9: All Pistons (Showing Fractured Rings)

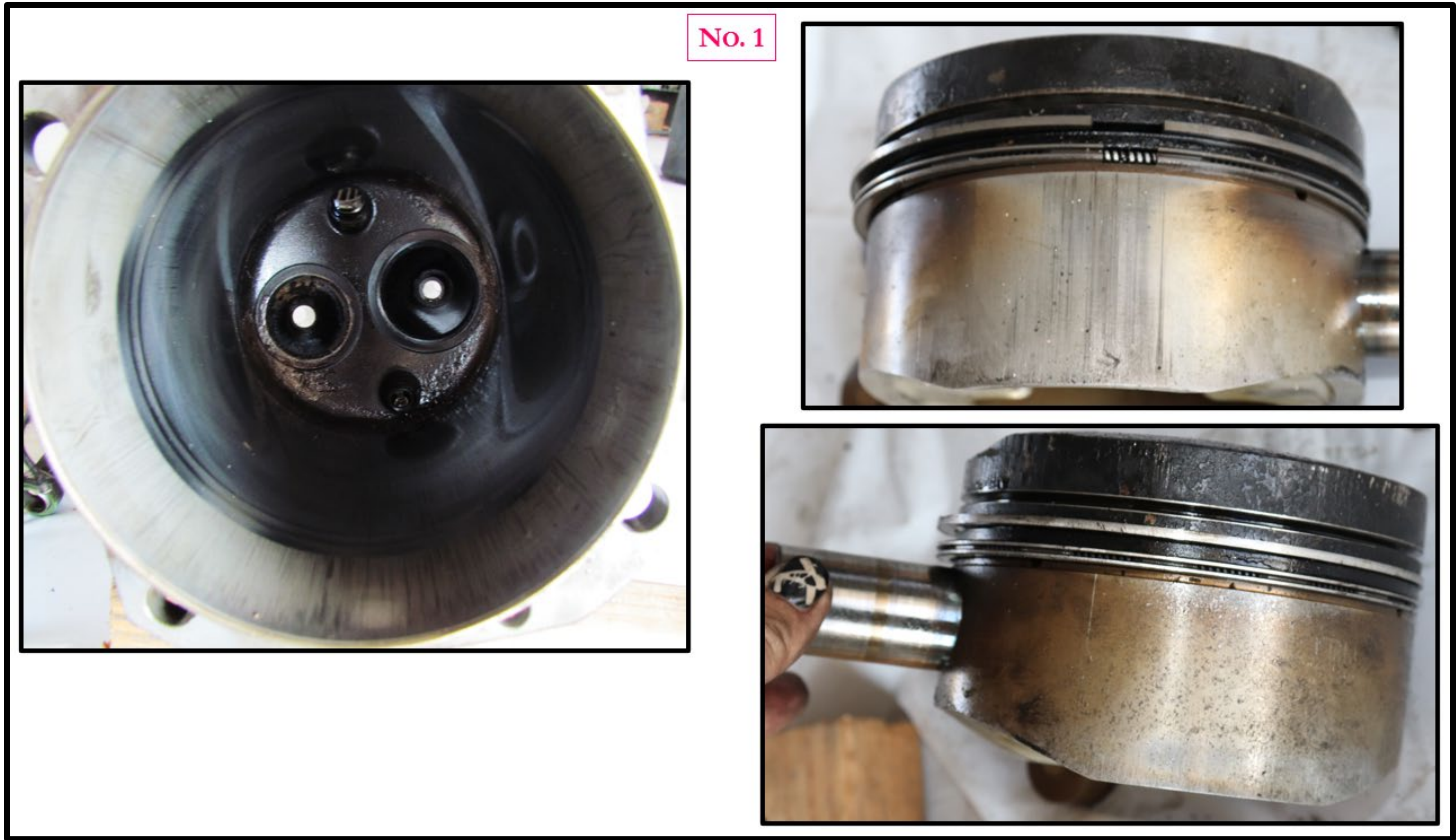


Figure 10: Cylinder No. 1 (Showing Cylinder Barrell and Piston Skirt Scuffs/Grooves)

No. 2

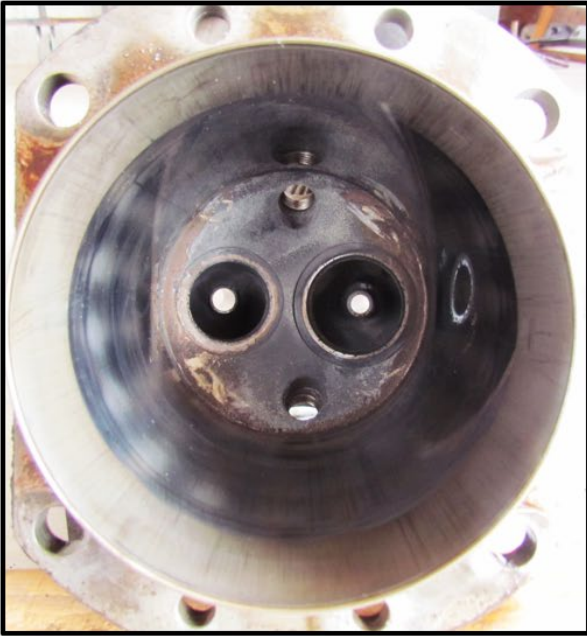


Figure 11: Cylinder No. 2 (Showing Cylinder Barrell and Piston Skirt Scuffs/Grooves)

No. 3



Figure 12: Cylinder No. 3 (Showing Cylinder Barrell and Piston Skirt Scuffs/Grooves)

No. 4



Figure 13: Cylinder No. 4 (Showing Cylinder Barrel and Piston Skirt Scuffs/Grooves)

Removal of the pistons revealed that the cam lobes and lifter² faces showed evidence of wear, necessitating complete disassembly. After separating the of the crankcase halves, investigators removed the lifters. There was severe spalling on the faces of all the intake lifters and the No. 3 exhaust lifter; there was also evidence of galling noted. On the remaining lifters there was evidence of wear with circular patterns and pitting.

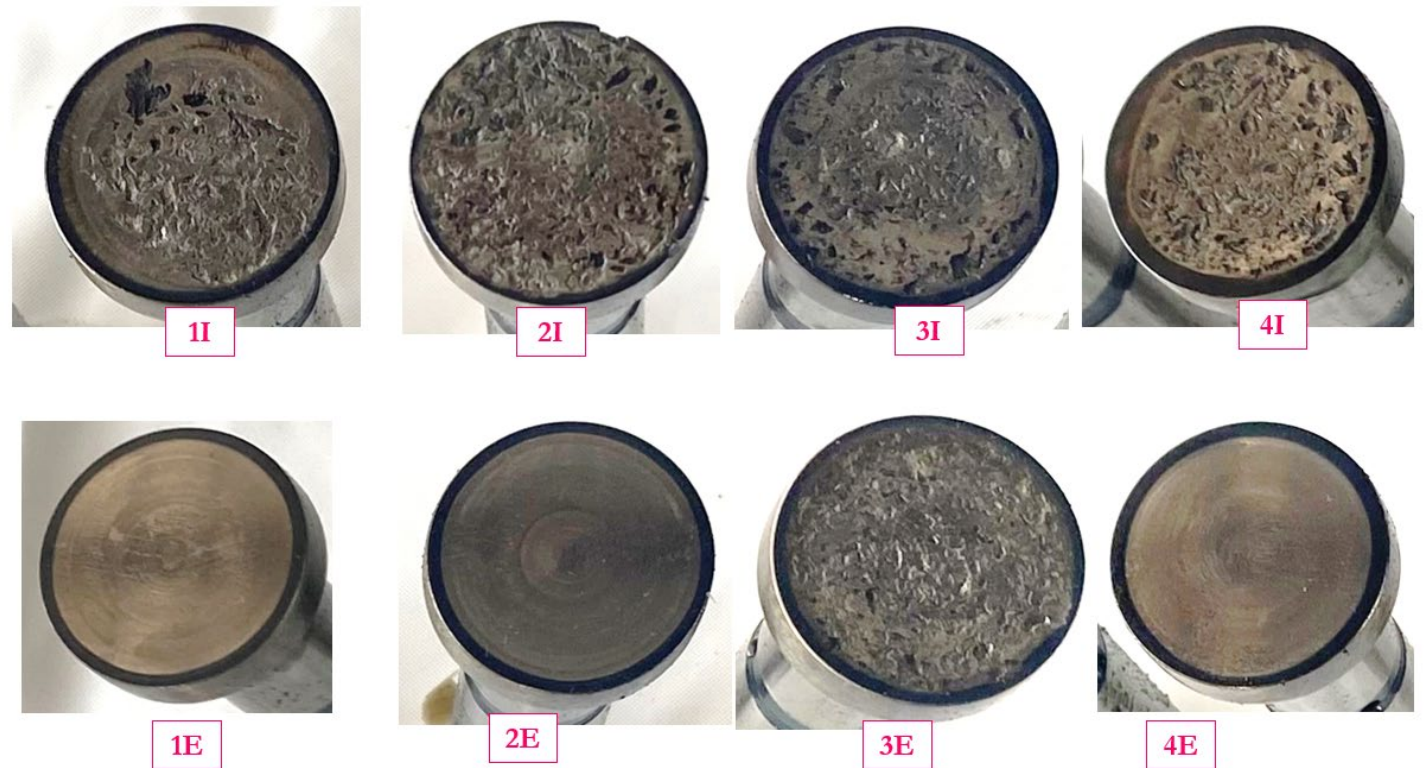


Figure 14: Lifter Faces (Showing Intakes on the top and Exhausts on the bottom)

² Part number, 72877, is referred to as a cam follower, hydraulic tappet, or lifter. In this report, they will be known as lifter.

The lifter on the No. 4 exhaust valve had a tear in the base of the body. This is consistent with the valve failing to close or too much wear on the cam lobe that the push rod becomes loose and the hydraulic socket is allowed to come out of the lifter body. If the socket cocks at an angle when the lobe returns back around, the socket would be able to get pressed against the body of the lifter and break it.

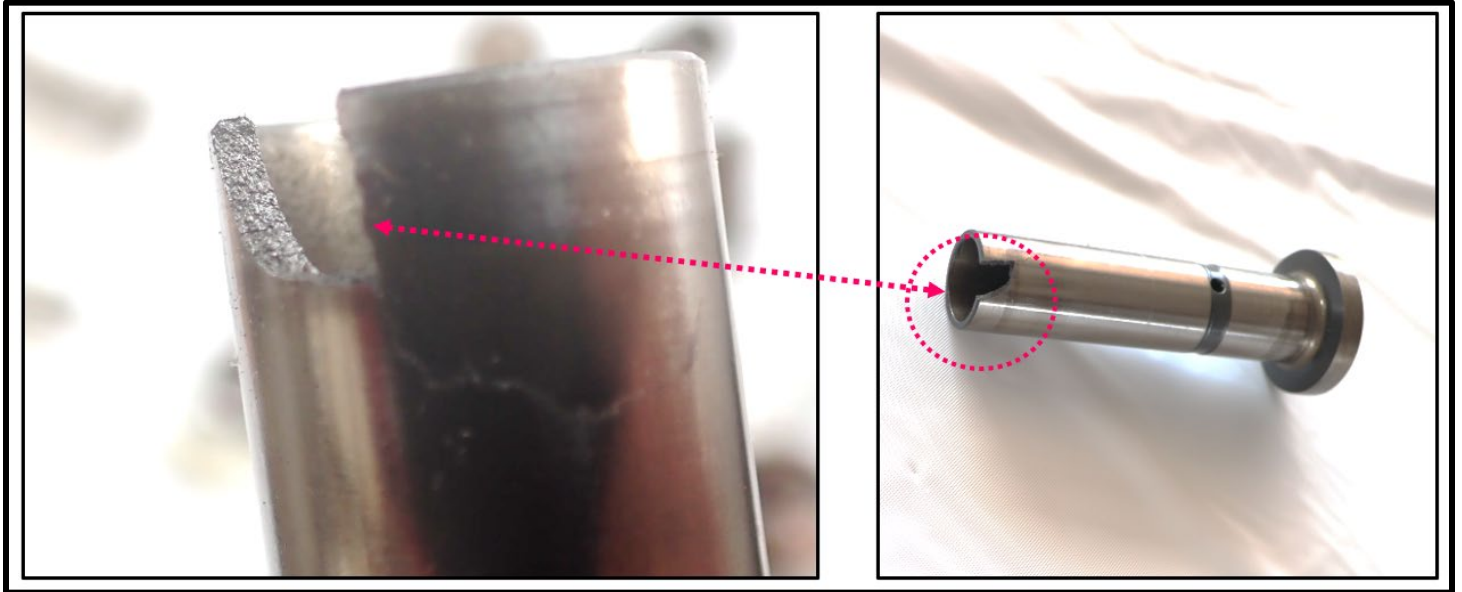


Figure 15: Lifter Body

The camshaft revealed signatures of excessive wear on the cam lobes including, rounding of the lobes, pitting and material deformation observed on the lobes.

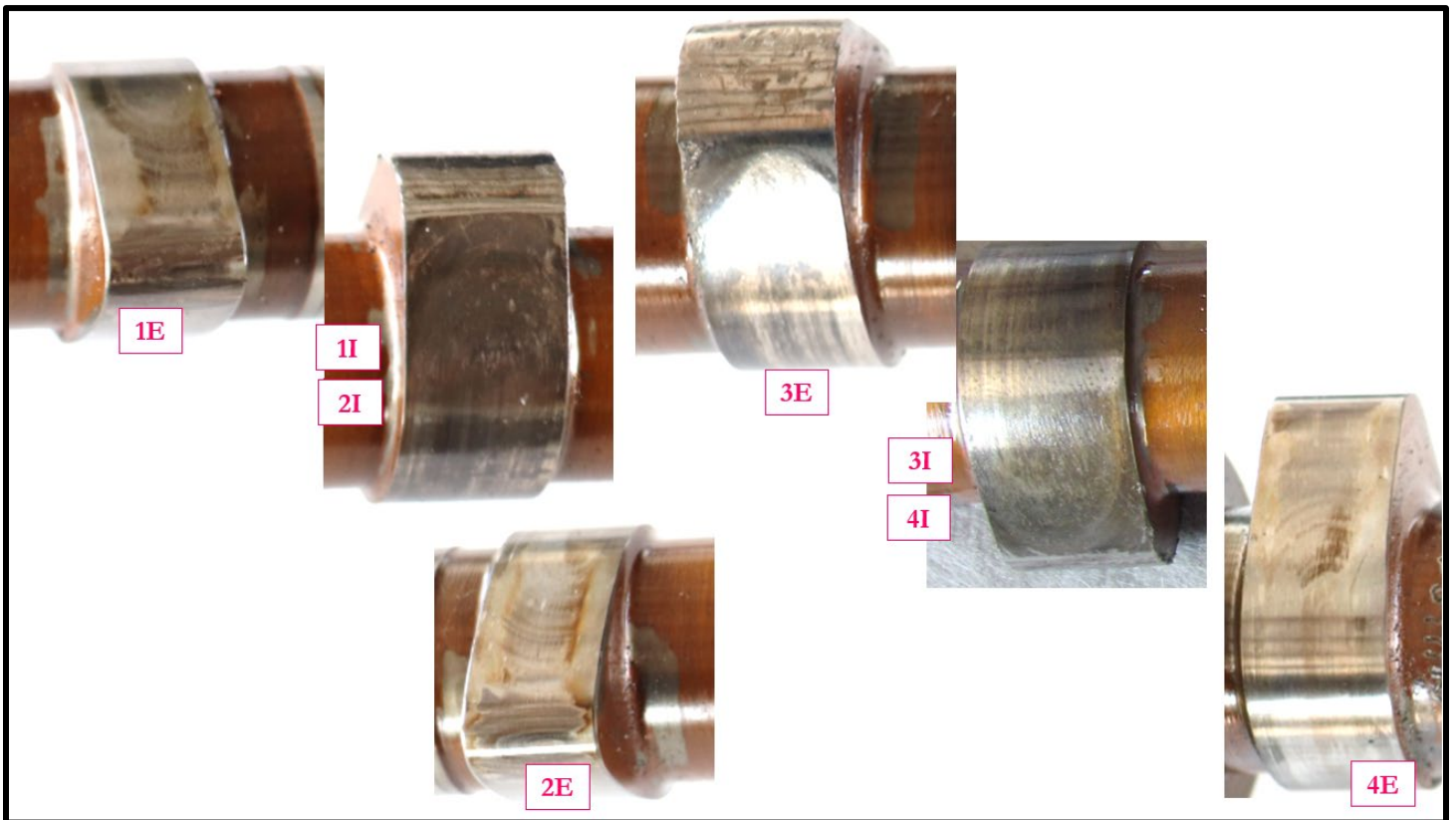


Figure 16: Camshaft Lobes

The valve springs showed on the No. 4 cylinder showed wear as did the lower seat. The rocker arm had a horizontal mark above the toe, consistent with it making contact with the upper valve seat. The No. 1 cylinder valve springs additionally showed wear.



Figure 17: No. 4 Intake Rocker Arm and Valve Springs

The main bearings showed evidence of wear and several areas of wiping. There semi-circular wear patterns on the mating internal bearings. The crankshaft had light circumferal scoring.



Figure 18: Main Bearings

The rotator caps all showed a round pattern, consistent with normal operation. The rocker arm faces showed overall wear that was not concentrated to a certain area. The push rods did not appear bent and blowing air through one side, expelled air through the other, indicating there were no blockages.

The single-shaft, dual-magneto remained securely clamped at its respective mounting pad and had been thermally damaged due to the effects of the post impact ground fire. The ignition harnesses were secure at each magneto. The magnetos were removed for examination. The magnetos sustained varying degrees of thermal damage that rendered the unit inoperative and therefore, could not be functionally tested. Magneto to engine timing could not be ascertained.

OIL

The oil filter and suction screen were secure at their respective mountings. The oil filter and suction screen were removed and examined. The oil filter was cut open to expose the filter media. Visually there was no evidence of pre-mishap metal contamination observed in the filter pleats, but a microscopic inspection revealed small metal particles. There were several small pieces of metal in the suction screen.

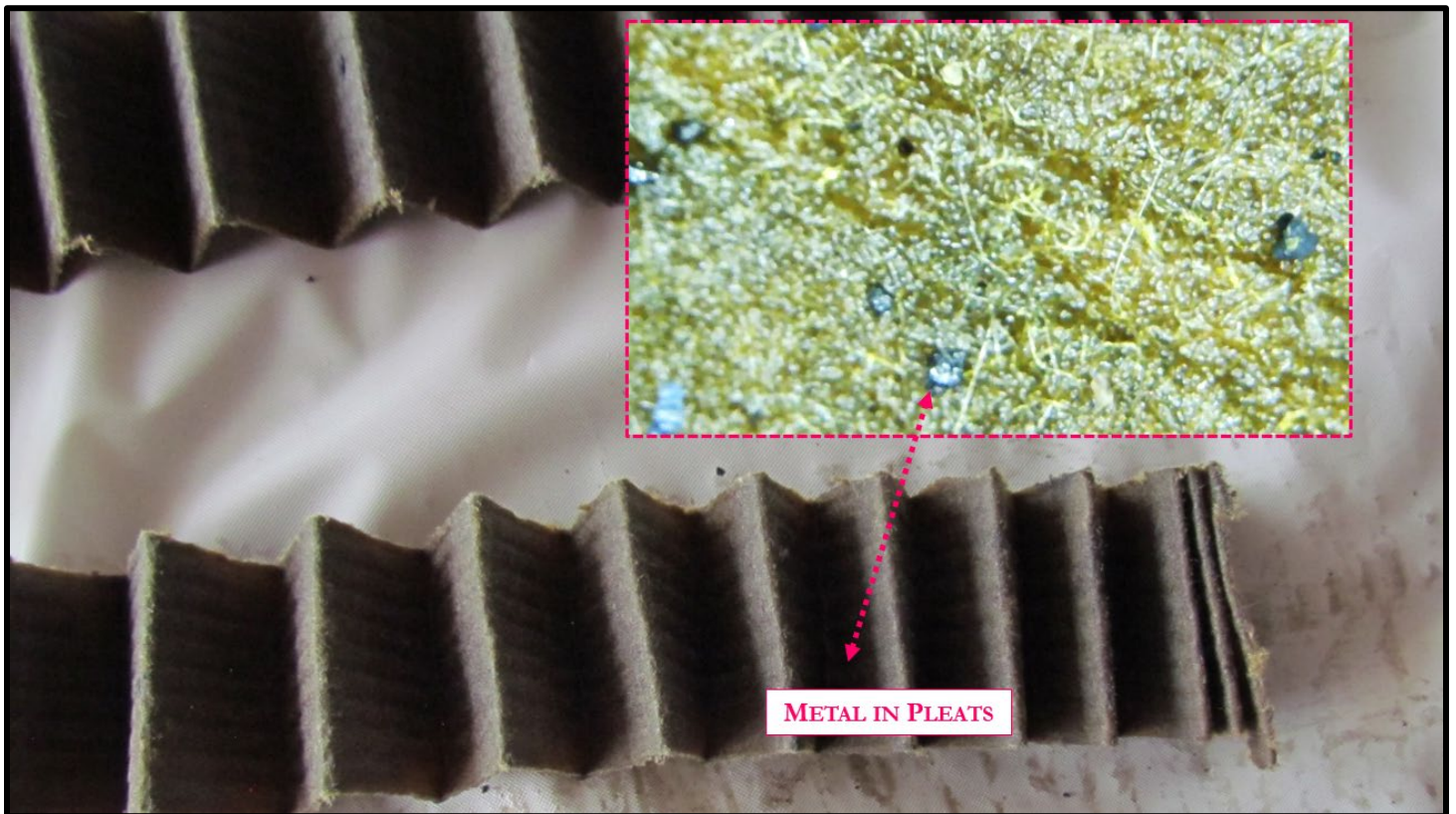


Figure 19: Microscopic Metal Particles Found in the Pleats of Oil Filter

The oil pump was removed and light scoring was found in the housing and on the gerotor gears.

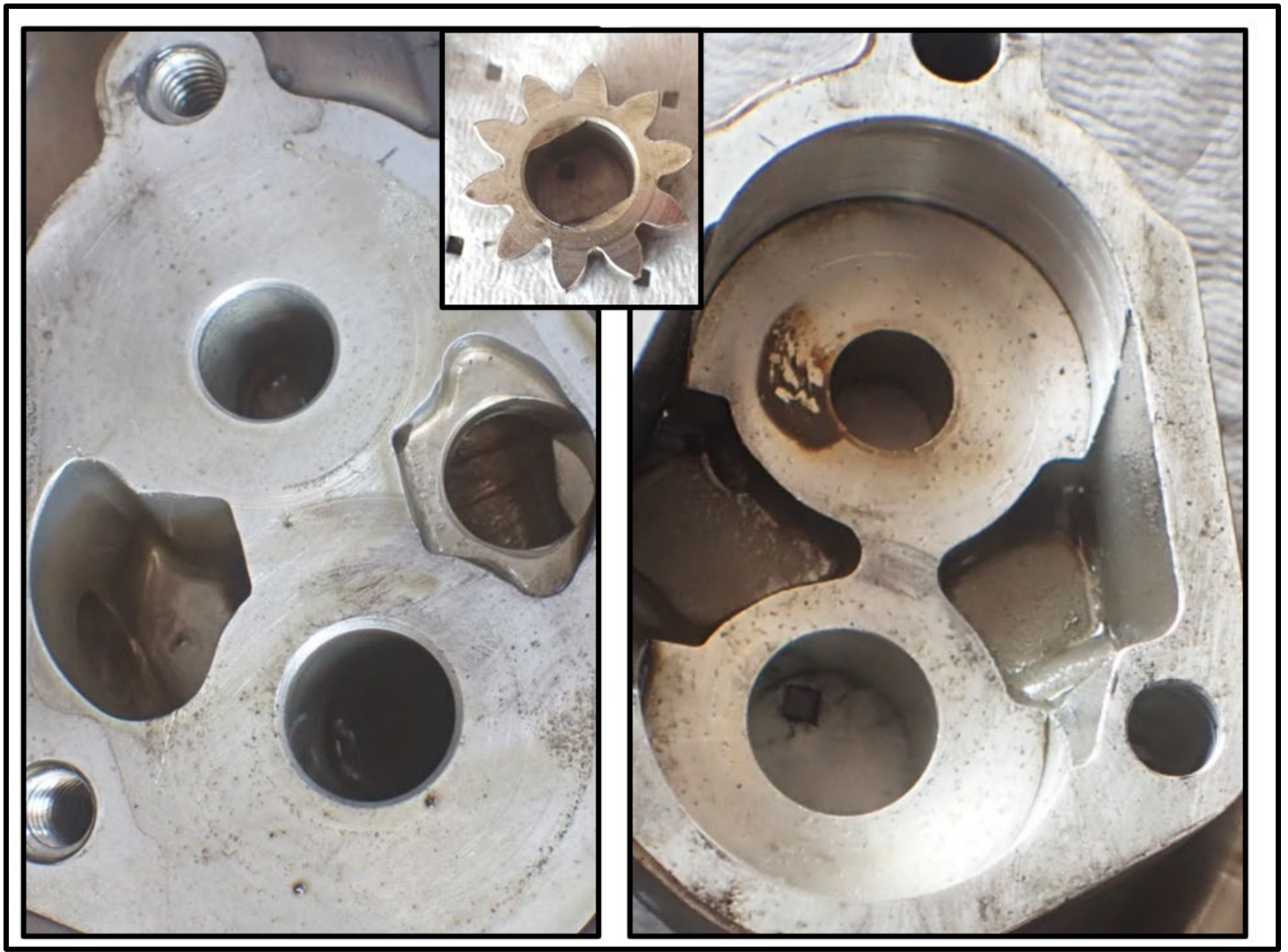


Figure 20 Oil Pump

PROPELLER BLADES

The propeller, a McCauley B2D34C207, was overhauled in September 2020. The blades remained attached to the hub. The blades had sustained impact damage, exhibiting chordwise scratches and leading-edge gouging.



Figure 21: Propeller Blades

The accessory case mounted propeller governor was securely attached at the mounting pad with the pitch control rod securely attached at the control arm. The control arm position could not be determined due to impact forces. The governor, McCauley model C290D3-T12 was removed for examination. The drive remained intact and but could not be rotated by hand due to impact forces. The gasket screen was free of visible contamination. The propeller gasket screen utilized a metal backing plate LW-12347, IAW Lycoming SI-1438A.

FUEL SYSTEM

Investigators drained the right wing fuel tank, recovering about 8 gallons of fluid consistent in color and odor to that of 110LL Avgas. The fuel selector was positioned on the “BOTH” tank selection. Damage to the electric fuel pump prohibited it from being functionally tested. The gascolator was consumed by fire.

The mechanical fuel pump remained attached to the engine at the mounting pad; it was free of internal mechanical malfunction and could be operated by hand. The diaphragm was burned. Investigators disassembled the fuel servo; the plastic area underneath the ball of the regulator stem was melted. There was a light dusting of metallic material on the diaphragm.

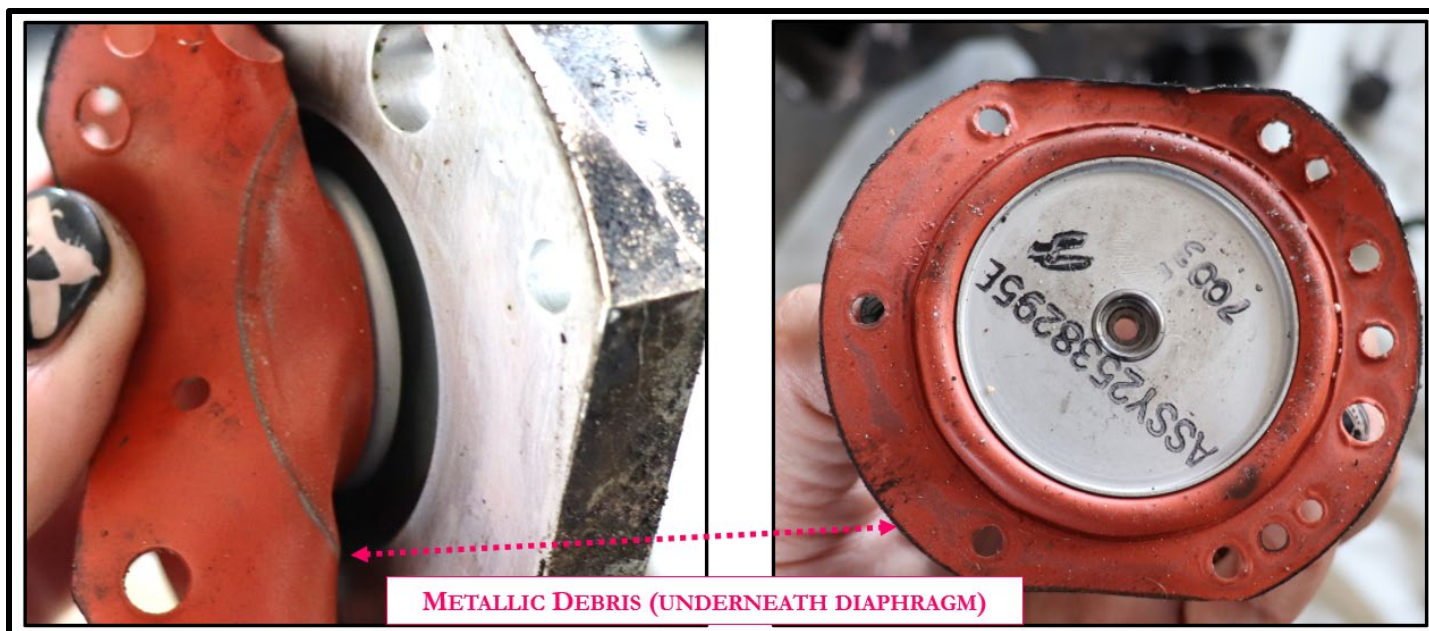


Figure 22: Fuel Servo Regulator Diaphragm

The fuel flow divider (manifold) remained secure at the mounting bracket situated at the top of the engine. The fuel lines remained secure at each flow divider fitting and fuel injector at each cylinder. Disassembly of the flow divider revealed there was no fuel present. There was no evidence of internal mechanical malfunction or obstruction to fuel flow. The diaphragm remained intact and undamaged.

The fuel injection nozzles remained secure at each cylinder with the respective fuel line attached. The nozzles were removed and appeared free of visible contamination or obstruction to flow.

RECORDS

The tachometer at the accident site 665.7. The last annual inspection was recorded as being completed on July 16, 2021 at 640.0 hours, equating to 25.7 hours prior to the accident.

The logbooks indicated that the Lycoming-overhauled engine was installed with 0.0 hours in March 2018 at a total airplane time of 2,176.3 hours. In December 2004 at an engine time of 534.7 hours the camshaft and lifters were replaced. The pilot purchased the airplane in 2017 at a total time of 2,706.5 hours, equating to 979.5 hours since the engine was overhauled. The logbooks indicated that on March 1, 2020 at an airplane total time of 3,412.2 hours the No. 1 cylinder was replaced with an overhauled assembly; this equated to 75.1 hours prior to the accident. The last recorded maintenance was the annual inspection on July 16, 2021 at 1,190.9 hours since overhaul.

ENGINE LOG	
DATE	N2085Q
TIME	MARCH 1, 2020
IO THS	7114.2 5906
REMOVED ALTERNATOR SENT TO PEARLAND ALTERNATOR FOR OVERHAUL AND REINSTALLED, REMOVED AND REPLACED # 1 CYLINDER AND PISTON WITH OVERHAUL CYLINDER ASSYMBLY BY J&J AIRPARTS INC. SEE YELLOW TAG PART# LW 12993 NI DATED NOV 27, 2019, DRAINED OIL SERVICED WITH 7 QTS OF PHILLIPHS 20W 50 OIL, REMOVED AND REPLACED FILTER WITH NEW TEMPEST 48103-2 OIL FILTER AND RESAFTIED, INSTALLED CYLINDER IAW CONTINENTAL IO-360 OVERHAUL MANUEL, RAN ENGINE FOR 2 MINUTES, OPS GOOD NO LEAKS DETECTED, BROKE IN CYLINDER IAW CONTINENTAL BREAKIN PROCEDURES, NO OTHER MAINTENANCE PERFORMED AT THIS TIME	

Figure 23: Record for When the No. 1 Cylinder was Replaced

AIRCRAFT LOG			
VOR Receiver operation checked in accordance with FAR 91.25			REMARKS
Date	Bearing error	Place	Signature
7/11/2021	N2085Q	Tach 640.0 TT3461.2	TTSN 1190.9
Prop 20.5 SOH - Cleaned engine compartment, area below floors in cabin, and interior of tail section IAW Service manual D991-13-RAND-100-10/75 (SM) sect. 2-30. Ran engine up to operating temp, checked compression 1 62/80, 2 62/80, 3 78/80, 4 72/80. Performed borescope inspection valves and cylinders, All locked good. Cleaned, gapped, and inspected plugs, all OK, rotated per Lycoming recommendations and reinstalled, drained oil, replaced oil filter w/ Tempest 48103-2, added 7 qts Phillips XC20-SOW oil, 1 pint CamGuard. Cut open oil filter and inspected, no metal found. Replaced air filter w/ Bracket BA-5705. Ran engine, oil pressure and temps normal, no leaks. Replaced vacuum system filter. Serviced wheel bearings IAW Cessna Service Manual section 2-22, lubricated all pulleys, bearings, and other points as specified in SM sect. 2-40. Serviced fuel strainer IAW SM sect. 12-50. Checked shimmy dampener and nose strut IAW SM Sect. 2-26, all OK. Under supervision Repaired cracks in cowl flaps IAW SM Sect 17. Performed Lycoming S.I. 1425A. removed carbon deposits from exhaust valve guides/stems. Serviced right and left brake levers, replaced all O-rings, reinstalled, checked for leaks, all OK. Bled brakes and tested IAW SM sect. 12-50, all OK. Replaced all O-rings and seals in Left downlock actuator IAW SM sect. 5-56/5-57. Reinstalled, checked operation, all OK. Replaced exhaust tube cross-over PN 2054019-1 w/ serviceable part. Replaced Altimeter with Cessna/United Instruments MDL 5934P-1, SN J1847. No change in weight. Checked static system for leaks. No problem found. Performed test flight, all systems operating properly. Gary VanDyke, Owner, PPL 2832040 <i>A+O Donald Walters</i> 7/19/2021 7/16/2021 TACH Time 640.0 T Time 3461.2 I CERTIFY THIS AIRCRAFT HAS BEEN INSPECTED I-A-W AN ANNUAL INSPECTION AND WAS DETERMINED TO BE IN AIRWORTHY CONDITION Donald J. Walters [Redacted Signature] A copy of this Insp. Report CAN BE OBTAINED AT 2127			

Figure 24: Last Annual Inspection Record from Airframe Logbook

Tach: 2713.7 Eng. Total: 534.7 Lyc IO-360 A1B6D S/N: RL20854-51A Engine was removed and torn down for cam and lifter replacement. Engine assembled I.A.W. Lycoming O.H. Manual. Installed all new main bearings, cam, lifter bodies, hydraulic units and new oil squirt nozzles. All cylinders inspected and found compliant with Lycoming Service Instruction 1485A - Exhaust valve guides with higher chrome content. Cylinders honed and installed all new rings, pistons and P/N 72198 piston pin plugs. Engine assembled with all new gaskets and seals. All parts were genuine Lycoming. Engine installed on airplane with all oil hoses flushed and blown out, new oil cooler, propeller flush, prop governor overhauled. New 215CC vacuum pump installed and new E-Z Heat pad P/N 442 installed. Other accessories reinstalled as removed. Engine was run-up, leak checked and test flown. -End-	MAINTENANCE RELEASE The Aircraft and/or Component identified herein was Repaired and Inspected in accordance with current Federal Air Regulations and was found Airworthy for return to service. Pertinent details of the repair are on file at this Agency, under Work Order No. <u>7703</u> Date <u>10 Dec 04</u> Signed <i>[Redacted Signature]</i> (Signature of Authorized Individual) for MICHIGAN AVIATION CO. - CRS No. KL2R956K COUNTY INTL AIRPORT - WATERBURY, VT
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Figure 25: Last Change of the Camshaft and Lifters

According J&J Airparts, they provided two overhauled cylinders to the pilot: one on January 17, 2020 and the other on October 06, 2020.

OIL RECORD(S)

The pilot sent a sample of his oil for analysis to Blackstone Laboratories, the most recent of which was September 09, 2021 at an engine time of 1,217 hours equating to 3 days prior to the accident or about 2 flight hours. The sample had not been run before the accident occurred. The slip that the pilot included with the oil analysis stated that the No. 2 cylinder was replaced 74.1 hours ago with an overhauled unit. There was also a note about the oil fill tube leaking at the base and that was fixed at this oil change. The lab note stated that the sample showed excess engine wear. Considering the recent work and long oil run, we would not have automatically suspected a major problem because some of the high wear could have been from break-in, and long oil runs will cause more metal to show up naturally. Since we suggested checking for oil filter metal in 2019, we would have likely done the same here."

ELEMENTS IN PARTS PER MILLION	MI/HR on Oil	68	UNIT / LOCATION AVERAGES	34	30	5	5	6	UNIVERSAL AVERAGES
	MI/HR on Unit	1,217		1,141	1,006	622	604	575	
	Sample Date	9/9/2021		9/15/2019	6/24/2017	10/8/2012	10/29/2010	12/19/2007	
	Make Up Oil Added	10 qts		3 qts	5 qts				
	ALUMINUM	23	3	32	12	2	2	1	6
	CHROMIUM	61	2	64	35	2	2	2	3
	IRON	148	12	43	26	9	6	10	22
	COPPER	35	4	19	3	3	3	3	6
	LEAD	3606	1385	1921	3468	798	651	522	3478
	TIN	2	1	1	0	0	1	2	1
	MOLYBDENUM	2	0	0	0	0	0	0	0
	NICKEL	5	0	1	1	0	0	0	2
	MANGANESE	2	0	1	0	0	0	0	0
	SILVER	0	0	0	0	0	0	0	0
	TITANIUM	0	0	0	0	0	0	0	0
	POTASSIUM	0	0	0	1	0	0	1	1
	BORON	0	0	2	0	1	0	0	1
	SILICON	10	6	23	4	9	7	9	5
	SODIUM	2	0	1	2	1	0	0	1
	CALCIUM	40	0	64	69	0	0	0	26
	MAGNESIUM	0	0	1	2	0	0	0	1
	PHOSPHORUS	28	102	36	75	137	116	118	608
	ZINC	4	6	4	4	2	0	1	3
	BARIUM	0	0	0	0	0	0	0	0
Values Should Be*									
PROPERTIES	SUS Viscosity @ 210°F	99.3	86-105	87.4	100.8	86.2	88.3	88.8	
	cSt Viscosity @ 100°C	20.20	17.0-21.8	17.34	20.55	17.05	17.57	17.68	
	Flashpoint in °F	455	>430	445	430	490	510	500	
	Fuel %	<0.5	<1.0	<0.5	TR	<0.5	<0.5	<0.5	
	Antifreeze %	-		-	-	-	-	-	
	Water %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Insolubles %	0.4	<0.6	0.5	0.4	0.4	0.2	0.3	
	TBN								
	TAN								
	ISO Code								

Figure 26: Oil Analysis from 3 Days Prior to the Accident

On the report prior to the most recent, taken in September 2019, the laboratory commented that there was elevated levels of metal. The report stated that if work had not been done recently on the engine, the amount of aluminum, chrome, and iron would indicate piston, ring, and steel wear. The analysis further stated that there was “even enough chrome to show a ring problem.”

According to an employee at ASL, the amount of Camgaurd to be used is 1.6oz per quart of oil. He said in the oil analysis is should be at LEAST over 100 with Phosphorus and if it is lower than the pilot is heavily diluting it with adding oil as it is burning. According to the logbooks, the airplane had 23 hours on the engine between the oil change and when the pilot sent in the oil analysis. The mechanic noted that he completed an oil change and added 7 qts of Phillips XC20W50 oil and 1 “can” of Camgaurd, which presumably was 16 ounces.

DATE	DURATION	ACCUMULATED TOTAL TIME		REPAIRS --- ADJUSTMENTS	SIGNATURE	LICENSE NUMBER
		HOURS	10THS			
2021	7/16/2021			T. TIME S/NEW 1190.9 Following work completed This DATE Changed oil + filter Added 7QT Phil. XC 20W50 Add LEAN OF CAM Guard, Cleaned Sump Screen Cleaned Fuel Screen + Gascoiler Screen DIFF Press Test AS Follows: #1 60/80 #3 76/80 #2 58/80 #4 70/80 ELT Batt Due Feb 20-2025 Static Test June 2022		

Figure 27: Excerpt of the Engine Logbook Showing Last Annual Inspection

FUEL RECORD

Transaction Detail Screen							
Sold To Name:		DESERT SKIES EXECUTIVE AIR TERMINAL			Settlement Number:		
Sold To Number:		0010087659			Settlement Date:		
Ship To Name:		DESERT SKIES EXECUTIVE AIR TERMINAL			Batch Number:		
Ship To Number:		0000846448			Batch Date:		
EPOS Number:		1000049310					
Transaction Type:		POS Sale/Return					
Invoice #	Inv. Date	Inv. Time	Card Type	Acct Nbr	Gross Amt	Non-Settled	
008453	12-Sep-21	08:17:00	Visa				
008454	12-Sep-21	13:20:00	American Express				
008455	12-Sep-21	13:58:00	American Express				
008456	12-Sep-21	14:04:00	American Express				
008457	12-Sep-21	14:32:00	Visa				
008458	12-Sep-21	16:36:00	Visa				-26.1
008459	12-Sep-21	17:57:00	Visa				-24.8 Gal
Total:							22.0

Figure 28: Fuel Records

PILOT INFORMATION

GARY L VAN DYKE³

Pilot Certificate (PRIVATE PILOT ASEL INSTRUMENT), was a 64-year-old male. This pilot reported civil flight experience that included 1343 total and 30 hours in last six months as of exam dated 2/4/2020. This pilot was 76 inches tall and weighed 248 lbs. at the time of the last exam. The last exam was conducted by Aviation Medical Examiner (AME) 9490. This pilot was issued a Third Class Medical Certificate with the following limitation: "Must wear corrective lenses".

Written by the pilot from "Pilot's of America" forum.

³ <https://www.linkedin.com/in/gary-vandyke-a2226510b>



GaryV
Pre-takeoff checklist
Gone West

Joined: Dec 22, 2016
Messages: 469
Location: Bullhead City, AZ

Display name: GaryV

I fly a 1974 Cardinal RG that I've owned since 2013.

I work with a skilled IA/A&P and do owner assisted maintenance and annuals. That is I do as much of the work as my IA will approve under his supervision and oversight. I enjoy doing the work and he ensures that I do it right and that I don't miss something critical.

My average maintenance cost has been around \$2000 a year including oil changes every 25 hours. My 'surprises' include a vacuum failure (about \$700) a couple of years ago and a failed alternator this year. Replacing the alternator came out to around \$800. I found out last week that killing the battery due to the alternator failure finished off the battery. Replacing the battery added another \$300. The alternator / battery failure will jump my maintenance cost to around \$3500 this year. That's by far my most expensive year so far.

I average between 100 and 125 hours a year so I consider the cost to be pretty reasonable for a plane that averages 165 mph TAS on just under 10-gallons an hour. With my wife and I (and way more stuff than I think we need to carry, we can do 5-hour legs (just over 800 miles no wind) and still have an hour's reserve fuel. The AngelFlights I do usually carry two full size passengers and I can still fly 4-hour legs with reserves.

I believe that the keys to my results have been active membership and participation in the Cardinal Flyers Ownership group, great support from pilots on POA, and a focus on properly maintaining the plane including fixing any glitch as it's discovered.

I suspect that a similar focus with most other planes would yield similar results. Take personal responsibility for overseeing how your plane is cared for and you're likely to be OK.

I'm 6'4" and 225 lbs. I like the RV-6 but for my mission the 177RG is a better fit.

The pilot's logbook indicated he had amassed the following total time since July 2021.

Total	SEL	Complex	Actual	Simulated	Dual	X-C	Night	Solo	PIC
1787.5	1745.9	584.9	182.3	356.9	119.8	1078.2	212.3	1327.2	1332.6
0.4	0.4	0.4						0.4	0.4
2.5	2.5	2.5		1.7	2.5				2.5
0.4	0.4	0.4						0.4	0.4
1790.8	1749.2	588.2	182.3	358.6	122.3	1078.2	212.3	1328	1335.9

Figure 29: From Pilot's Logbook

The pilot's spouse stated that they purchased the airplane in 2013. They lived in Texas and had recently moved to Bull head City, Nevada in October 2020. They had recently made a three-week cross country flight where he flew the accident airplane over 50 hours. During the trip the pilot had to replace the alternator because the airplane was not starting. Additionally, after the trip the pilot replaced a cylinder because the engine was "not acting right." After replacing the cylinder he had problems with the vacuum system and determined that there was a plug that was not sealed. The vacuum problem was diagnosed from the instruments not working correctly. After plugging that port the problem seemingly resolved itself. He flew the airplane approximately two times after that maintenance.

On the day of the accident, the pilot went to his hangar around 0900 (an approximate 25 minute drive from his residence) and planned to do maintenance on the nose wheel and fly to get fuel in Lake Havasu. She estimated the pilot finished the maintenance around 1515 and departed shortly thereafter. The pilot was planning to fill the fuel tanks for their upcoming trip to Reno, Nevada and there was no fuel available at the home base airport. She estimated the pilot had refueled at Lake Havasu on 3 to 4 occasions.

She noted that the pilot was replacing the nose ger bushings because the airplane had been vibrating on takeoffs and landings. The pilot would often perform his own maintenance. He would fly with a knee board and an ipad in front of him. After asking leading questions, she stated that the pilot would normally manipulate a lever during takeoff which was assumed to be the flaps. She additionally said that she had heard the stall horn on serval occasions which the pilot said that they did not need to worry about on takeoff.

WEATHER INFORMATION

4:04 PM	111.5 °F	53.8 °F	15 %	East	1.5 mph	2.7 mph	29.89 in	0.00 in	0.00 in	2	767.7 w/m ²
4:09 PM	111.6 °F	54.8 °F	16 %	NW	1.1 mph	2.3 mph	29.89 in	0.00 in	0.00 in	2	758 w/m ²
4:14 PM	111.7 °F	53.1 °F	15 %	NW	2.7 mph	4.3 mph	29.89 in	0.00 in	0.00 in	2	749.7 w/m ²
4:19 PM	112.1 °F	53.1 °F	15 %	WNW	0.9 mph	2.0 mph	29.89 in	0.00 in	0.00 in	2	738.6 w/m ²
4:24 PM	112.5 °F	52.2 °F	14 %	WSW	0.6 mph	1.4 mph	29.89 in	0.00 in	0.00 in	2	729.6 w/m ²
4:29 PM	112.9 °F	54.4 °F	15 %	SW	2.0 mph	3.1 mph	29.89 in	0.00 in	0.00 in	2	718.5 w/m ²
4:34 PM	113.0 °F	52.1 °F	14 %	West	2.4 mph	4.1 mph	29.88 in	0.00 in	0.00 in	2	703 w/m ²

Figure 30: Weather Information

ADDITIONAL INFORMATION

From Sky Ranch Engine Manual: Operation, failure, repair, piston aircraft engines Paperback – January 1, 1991
by John Schwaner:

Lifter Body Damage

The lifter body could be damaged from:

- 1) Excessive clearance in the rocker arm
- 2) Bent push rod bent (usually as a result of a tight guide or sticking valve)
- 3) Part failure
- 4) Rocker shaft cover falling off allowing the rocker arm to exit

Spalling

Under the right conditions, a fatigue crack initiates at the surface of the cam follower. The crack propagates parallel to the surface for a short distance before turning or branching. A pit forms when the crack grows to an extent that it separates a piece of the surface material. If several pits grow together to form larger pits, it's called a 'spall'. Spalling is a metal fatigue failure and not a "wear" type of failure. If the lubricant film is insufficient to prevent metal-to-metal contact, the oxide layers that protect the lobe surfaces may be broken through. Intense frictional heating generated by the combination of high sliding velocity and intense surface pressure causes the bare metal surfaces to weld together. This type of damage is called "scuffing". Scuffing is more likely to occur upon start-up or after overhaul when the surfaces have not yet been smoothed by running in. Scuffing is a wear type of failure. Proper surface conditions are essential to prevent fatigue pitting and scuffing failure. Two common causes for cam-shaft lobe failure due to improper surface conditions are:

Spalling

The lobes of the camshaft, and the tappets that they continually operate against, have always been subject to wear. Someone recently stated that in recent years, there has been an unacceptable rise in the occurrence of spalling tappets and worn cam lobes. Is this a factual statement? Perhaps it may help if we take a look at one or two of the causes of wear on these parts. From this, we may reach a conclusion about why this statement could possibly be true today. Corrosion is a known cause of tappet and cam lobe wear. The engines of aircraft that are not flown regularly may be extremely vulnerable to corrosion. When the film of oil drains from the interior parts of the engine after it has been run, those parts become prey to the chemical changes that are caused by moisture, acids and oxygen.

Tappets from engines which have not been operated for long periods have been closely examined. Under a microscope, it is not unusual to find microscopic pits on the face of the tappet. This is the beginning of trouble. Starting with these very tiny pits, tiny particles of rust also affect the cam lobes. Once started, the process is not likely to stop until the wear reaches a point where these parts are doing an unacceptable job. Some people might question the assertion that engines can attract unusually large amounts of moisture: brief operating periods, low engine oil operating temperatures and condensation all contribute. It might be very surprising to take an engine which has flown 15 to 25 hours over the course of four to six months and drain the oil into a clear container. The amount of water which settles to the bottom is likely to be more than one would expect. Also remember that combustion causes acids to collect in the oil. When these are not removed by regular oil changes, the acids, as well as the moisture, will promote the growth of microscopic pitting which eventually leads to excessively worn tappets and cam lobes. Another factor in the unacceptable rise of tappet spalling in general aviation engines may be the product that is put into many of those engines at overhaul. To reduce the costs of overhaul, there is an increasing tendency to put reground camshafts and tappets into these engines. Although camshafts may be reground, there is a very strict limit on the amount of grinding which can be tolerated. Grind too much, and the hardened surface of the cam lobe is gone. After this kind of grinding, the cam may look great, but it will be wearing on the soft metal which was once protected by a hardened surface. Lycoming does not recommend the use of reground tappets under any circumstances, but many engines overhauled in the field today come back to the owner with reground tappets and camshaft. In some cases at least, these items are nothing more than good-looking junk. Because of the high percentage of refurbished used parts that go into many overhauls, and the many airplanes that sit for long periods without being flown, there could be more tappet spalling today than in the past. These are some of the reasons why the statement that there has been an unacceptable rise in spalled tappets and worn cam lobes in recent years might just be true. Ask about the parts which are going into your overhaul. It may be less expensive to pay for new parts at the time of overhaul than it is to pay for replacing worn-out parts before your engine has reached its expected TBO.

Piston Rings

Besides sealing against gas and oil, piston rings transfer heat from the piston to the cylinder barrel. Blowby past the ring belt raises the temperature of the piston. The piston, which has a large heat receiving surface called the piston dome, transfer heat to the cylinder wall through the piston rings. Cooling fins on the cylinder barrel transfers heat to the atmosphere. Combustion gases blowing past the piston compression rings prevent them from transferring piston heat to the cylinder wall. As piston temperatures increase, the oil on the piston and in the ring grooves thickens as the more volatile components of the oil vaporize. At approximately 450°F, the oil begins runaway oxidation and turns to carbon. The oxidized oil in the ring groove causes the rings to stick. Ring breakage occurs when the compression rings stick and are prevented from going back into the ring groove and subjected to side loading on the cylinder wall. If the compression rings stick in the ring groove in the compressed state, massive blowby of combustion gases occurs. This pressurizes the crankcase, causing oil to blow out the engine breather. Oxidized oil on the cylinder wall clogs the oil control ring expander and prevents oil from draining from the cylinder wall through the oil control ring and into the crankcase. Oil consumption will then rise dramatically.

After cylinder repair, the cylinder rings must be seated for proper oil control. If you have excessive oil consumption, you might be told this is normal and that the rings haven't seated". This may or may not be the case. Even though the rings have not seated, you should not have blowby past the ring belt. If your oil is black and you have oil blowing out the engine breather, it's not because the rings have not seated. The rings should hold compression right

Blowby

Another power loss condition is that of blow-by — or oil blowing by the piston rings and getting into the combustion chamber in more than desirable amounts. It occurs with broken or worn piston rings, scored cylinder walls and bell-mouthed exhaust valve guides. Oil in the combustion chamber fouls spark plugs and reduces their efficiency. It also lowers the octane rating of the fuel and causes a loss of power, particularly at takeoff or climb. If the engine is not close to its normal overhaul life, then a top overhaul would be in order if more than one cylinder showed this condition. Power loss from valve leakage may not be noticeable to the pilot while in flight. If an exhaust valve becomes burned and deteriorated at the edge of the head, it may cause an engine miss in flight. But leaking intake valves are difficult to detect during flight. The latter either get irregularly seated and cause a compression loss, or they can also cause a loss if they get tuliped from preignition. A good differential compression check will pick up most of these discrepancies except for some occasions of broken rings. However, any oil in the combustion chamber from broken rings would, in addition, call for a visual inspection with a borescope or a gooseneck light.

Oil Filter Analysis

Oil Filter Analysis eo0co Proper inspection of the oil filter is the best method of detecting camshaft or cam follower spalling and failure. Cut the oil filter open and wash and rinse the filter media care- fully into a bucket of clean solvent. The washing shifts particles into the bucket. Using a clean magnet, work it around in the solvent solution. Ferrous metal particles in the solution will adhere to the magnet, allowing inspection. A visual inspection of the cam followers is warranted if the end of the magnet is covered with metal slivers. You will not detect early signs of cam follower damage by taking the filter media out of the can and spreading it out on the table. There is not enough at this stage of failure to be visible in the folds of the filter. Oil pressure forces the small slivers of metal into the filter media where they are not visible. A magnet concentrates the small amount of metal, making it visible. Unless the examination of the oil filter is done correctly, you will not get a reliable analysis. 0g o b Dirt, Silica and Silicon Emission Spectroscopy Oil Analysis has proven to be a popular method of inspecting your engine oil for abnormal levels of contaminants. A proper interpretation of the results is needed to make the analysis useful. What this type of oil analysis does well is report the amount of wear metals in the oil. Two occurrences where wear metals may be excessive: 1. Component or lubricant failure is causing metal-to- metal contact wear (two body wear). 2. Wear is being created by dirt (abrasives) in the engine (three body wear).

II. Spectrographic Oil Analysis:

NOTE

Spectrographic oil analysis does not replace recommended maintenance practices, such as oil filter, pressure screen, suction screen content inspection, cylinder differential pressure compression checks, and boroscopic examination, however, Lycoming does encourage the use of spectrographic oil analysis at every oil change as a method of monitoring engine component wear rate. Refer to the latest edition of Lycoming Service Letter No. L171. Use the recommended procedures to insure that the oil sample is free of outside contaminants.

1. In accordance with the latest edition of Lycoming Service Letter No. L171, collect an oil sample and submit it for analysis by a qualified facility. Lycoming recommends using a Spectrographic oil analysis facility that specializes in aircraft engines, and also using the same facility for each analysis, due to the differences in laboratory testing standards.

NOTE

Typically, the first oil analysis of a new, rebuilt, or newly overhauled engine will indicate higher concentrations of metal. After an initial break-in period, metal content should decrease rapidly to a level that remains essentially constant.

2. If an oil analysis report indicates elevated levels of aluminum (above 30 parts per million for non-turbocharged engines; above 40 parts per million for turbocharged engines) or iron (above 100 parts per million for non-turbocharged engines; above 130 parts per million for turbocharged engines), contact a technical representative at the Lycoming Factory Product Support Department.
3. If in a continuing program of oil analysis, results show a trend toward an increase in aluminum or iron content, inspect contents of the oil filter and suction screen in accordance with the procedures in Part I, Oil Filter/Suction Screen Inspection.

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