



Continental Motors

ENGINE EXAMINATION REPORT

ENGINE MODEL	IO-550-N60B c TNIO-550 (via Tornado Alley Turbo STC)
ENGINE SERIAL NUMBER	1001700
AIRCRAFT MAKE & MODEL	Cirrus SR22
AIRCRAFT SERIAL NUMBER	3640
AIRCRAFT REGISTRATION	N744TC
FILE NUMBER	16-698

NAME	SIGNATURE	DATE
Nicole L. Charnon		11/15/2017

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EXAMINATION		ACCIDENT DATA	
DATE	11/14-16/2017	NTSB ACCIDENT #	WPR17LA137
FACILITY	Continental Motors	NTSB INVESTIGATOR	Howard Plagens
ADDRESS	2039 South Broad Street Mobile, Alabama 36615	FAA INVESTIGATOR	Richard Dilbeck
		ACCIDENT DATE	06/30/2017
		ACCIDENT LOCATION	Dixon, California

ENGINE INFORMATION

ENGINE POSITION	Single-Engine
TOTAL TIME	783.8
TIME SOH	N/A
TYPE & TIME SLI	11.9 hours since 50-hour inspection
BUILD DATE	01/22/2010
IN SERVICE DATE	03/29/2010

Significant logbook information:

The engine was shipped to Cirrus Aircraft on January 24, 2017 and underwent a Tornado Alley Turbo (TAT) turbo-normalized engine conversion via Supplemental Type Certificate (STC) SE10589SC. The engine was installed in the accident airplane on March 29, 2010. On March 19, 2012 at a total time of 264.2 hours, the #4 cylinder was replaced. On June 2, 2014, at a total time of 476.7 hours, the wastegate was replaced. On August 13, 2015 at a total time of 556.8 hours, the left exhaust stack was replaced and on July 21, 2016 at a total time of 651.9 hours the right turbocharger was removed and replaced with an overhauled unit. The last maintenance entry was for a 50-hour inspection that took place on May 18, 2017 at an engine total time of 771.9 hours. The flight meter at the time of the accident was 783.8 hours. Review of the work order for the turbocharger overhaul revealed that the turbocharger wheel was found to be serviceable and was reused. The overhauled turbocharger was installed 131.9 hours prior to the accident.

Report Summary:

Search Code(s):

15-12-40, 15-08-06, 15-08-48, 10-08-03, 57-11-03

The #3 and #4 connecting rods were fractured and separated from the connecting rod journals. The #4 connecting rod and connecting rod bearings and the crankshaft's #4 connecting rod journal displayed thermal discoloration consistent with oil starvation. The #2 connecting rod bearings also displayed incipient signatures consistent with lubrication distress. The #3 connecting rod and bearing were mechanically damaged. Approximately 2.0 quarts of oil was observed on the oil quantity dipstick following the event. Examination of the engine components and engine-related systems revealed no evidence of a pre-impact oil leak. Additionally, the right turbocharger was missing its turbine wheel and the shaft was fractured outboard of the turbine piston ring. The bearings displayed signatures consistent with lubrication interruption. The impeller contacted the inlet housing and the impeller blades displayed distortion in the opposite direction of rotation. Review of recorded engine data revealed that the oil pressure displayed a fluctuation followed by a steady reduction.

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The engine and engine-related systems were boxed and readied for shipment to John D. Ferguson at Clear Star Aviation as per AIG (Alberto Conrad) and NTSB (Howard Plagens) request.

INSPECTION WITNESSES

NAME	Nicole L. Charnon	NAME	Phillip Grice
ADDRESS	Washington, DC	ADDRESS	Mobile, AL
ORGANIZATION	Continental Motors	ORGANIZATION	Continental Motors
PHONE	[REDACTED]	PHONE	[REDACTED]
NAME	Lisa Jersild	NAME	Greg Eastburn
ADDRESS	Mobile, AL	ADDRESS	Mobile, AL
ORGANIZATION	Continental Motors	ORGANIZATION	Continental Motors
PHONE	[REDACTED]	PHONE	[REDACTED]
NAME	Howard Plagens	NAME	Brad Miller
ADDRESS	Palm Springs, CA	ADDRESS	Duluth, MN
ORGANIZATION	NTSB – Western Pacific	ORGANIZATION	Cirrus Aircraft
PHONE	[REDACTED]	PHONE	[REDACTED]

EXTERNAL ENGINE CONDITION

The engine was shipped to the factory with all the turbocharger components removed and placed in the crate, including the exhaust system. The top of the crankcase below the induction plenum displayed large holes in the vicinity of the #3 and #4 cylinders. The right turbocharger turbine wheel was missing.

External examination of the attached components did not reveal any signatures of a pre-existing oil leak. The engine was examined/documentated prior to its removal from the airframe. Review of the photographs taken during that prior examination did not reveal any signs of a pre-existing oil leak.

NOTE: Some photos included in this report come from the pre-engine-removal examination and are courtesy of Cirrus Aircraft's investigator.

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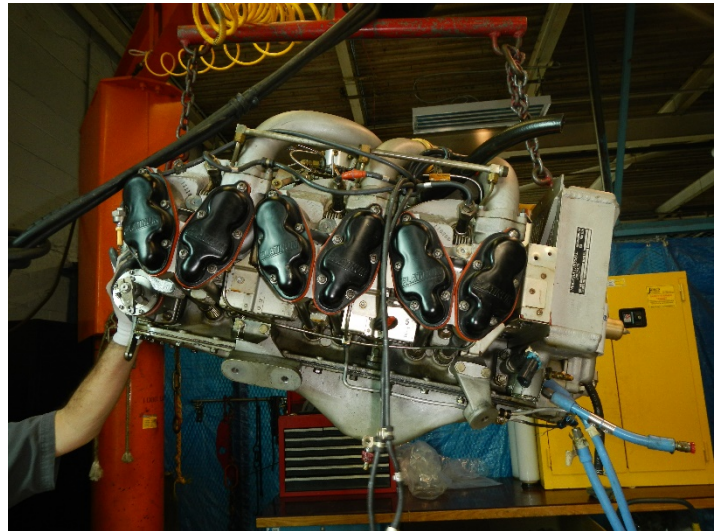
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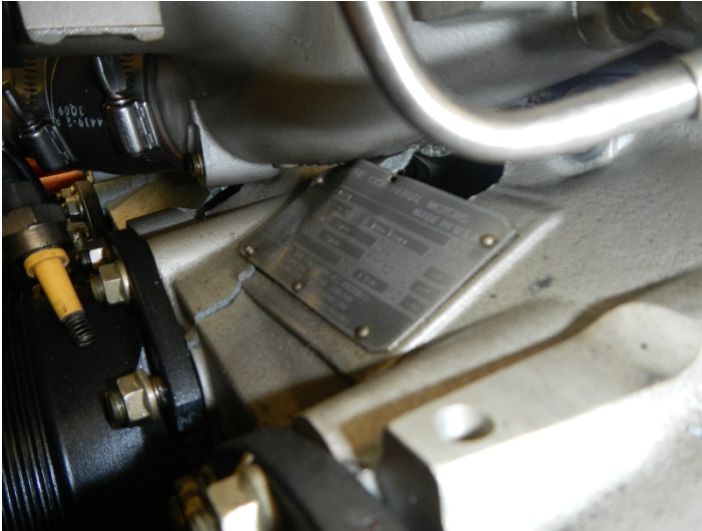
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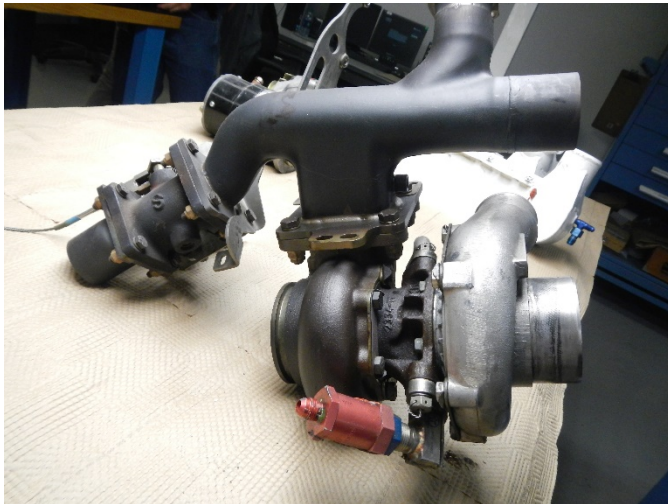
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ENGINE COMPONENT EXAMINATION

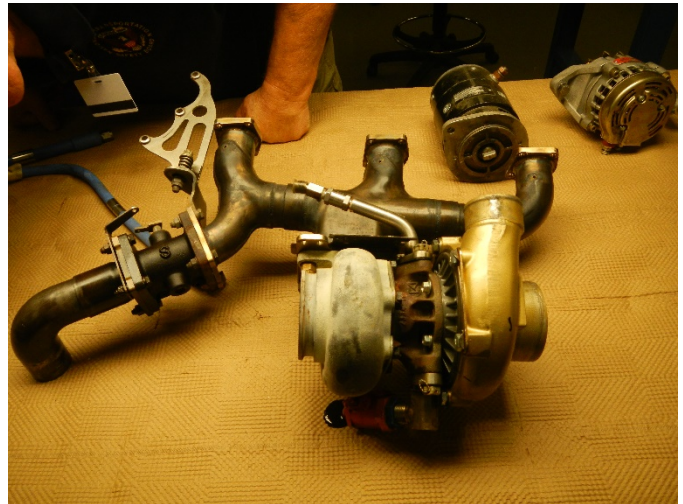
EXHAUST SYSTEM

Condition: The exhaust system was removed from the engine prior to shipment. There were no pre-impact anomalies noted with the exhaust risers or manifolds. The right side exhaust pipe was flattened at the exhaust end. The inside of the tailpipes were inspected using a lighted borescope. The right tailpipe displayed areas of circumferential scoring and gouging consistent with high rotational speed mechanical contact.

Left



Right



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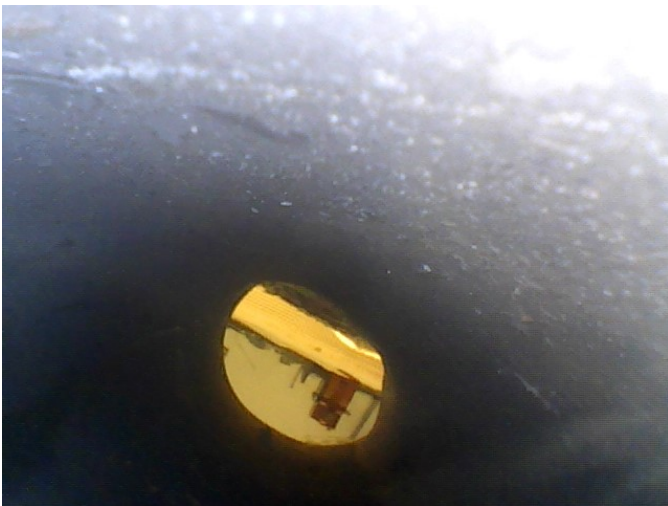
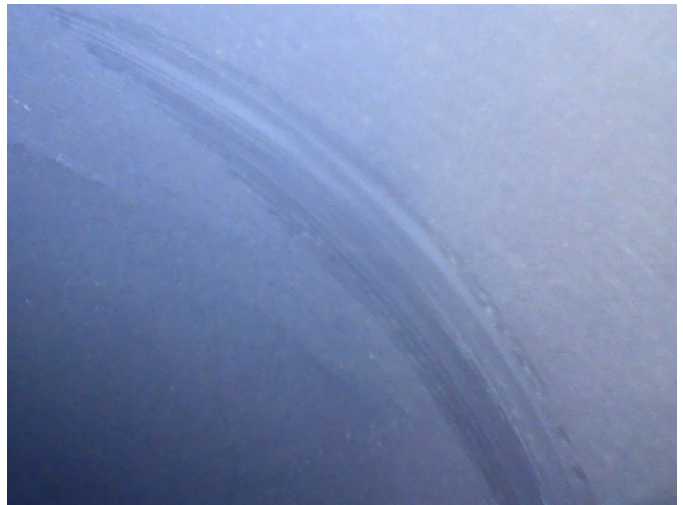
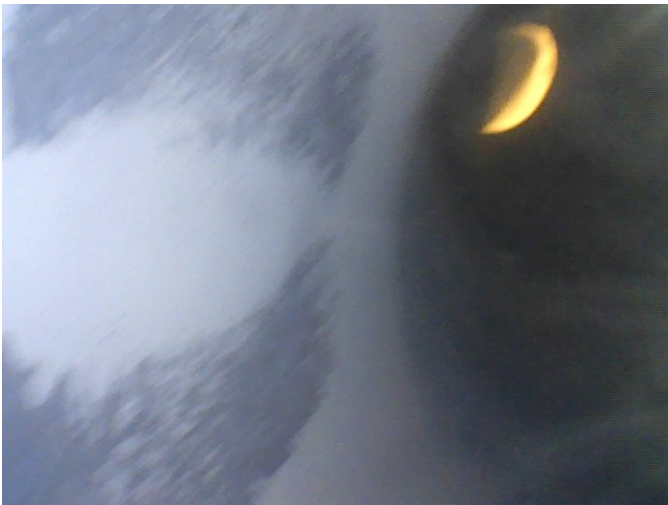
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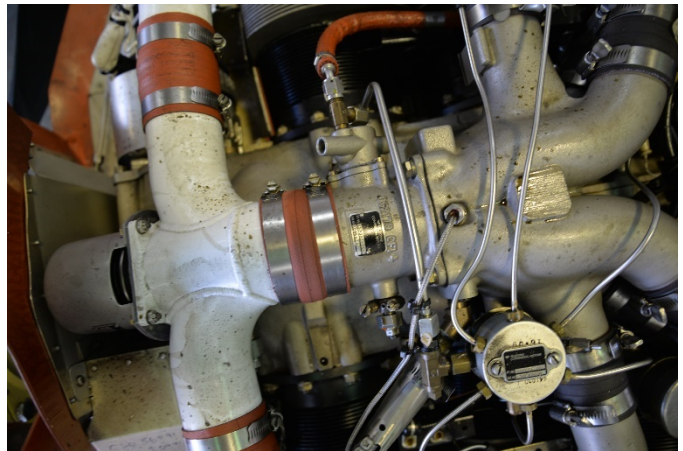
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INDUCTION SYSTEM

Condition: The throttle body, intake plenum, and intake tubes remained in place on the engine. The intake tubes and intercoolers were removed prior to shipping. There were no pre-accident anomalies noted with the intake system components. Photographs of the engine while it was installed in the airframe revealed oil splatter on the intake system components, consistent with the liberation of the connecting rods from the crankcase.



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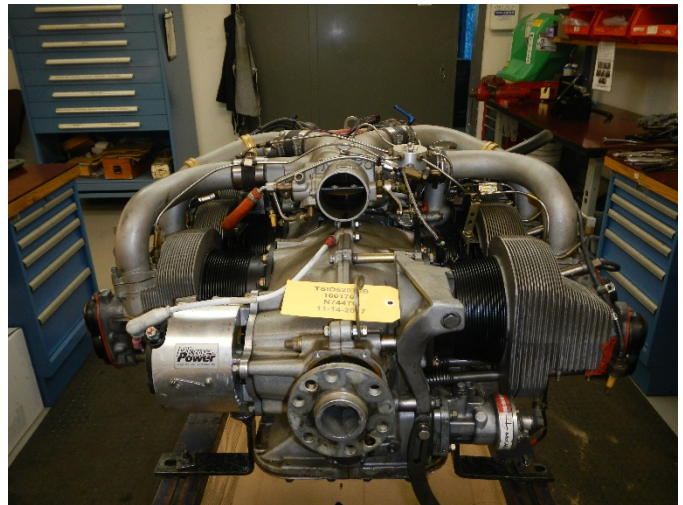
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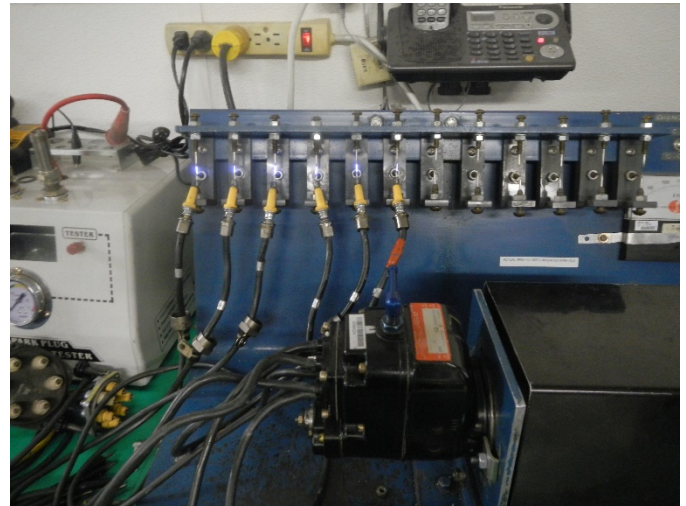


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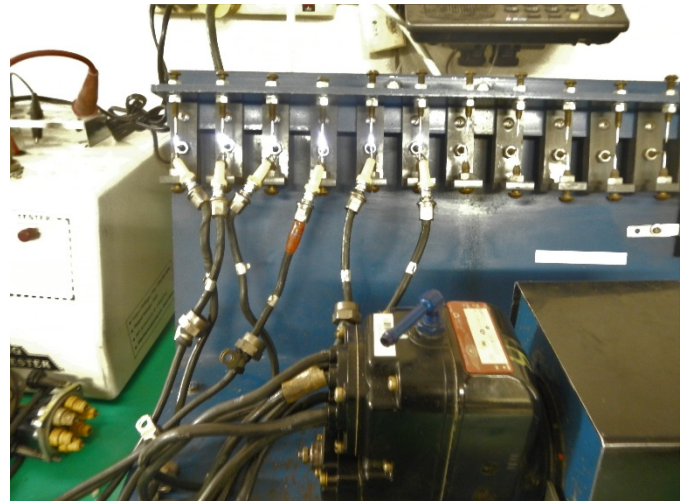
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IGNITION SYSTEM

LEFT MAGNETO	Manufacturer: Continental Motors S6RSC-25P	P/N: 10-500556-101	S/N: D09IA024
Condition:	The magneto remained secured to the topside of the engine with no pre-accident anomalies noted. The ignition harness remained in place. The magneto, with the harness still attached, was removed and placed on a test stand. The magneto was functionally tested through various speeds and it produced a spark across a 7-mm gap in firing order. No pre-accident anomalies were noted with the unit.		



RIGHT MAGNETO	Manufacturer: Continental Motors S6RSC-25P	P/N: 10-500556-101	S/N: D09KA076
Condition:	The magneto remained secured to the topside of the engine with no pre-accident anomalies noted. The ignition harness remained in place. The magneto, with the harness still attached, was removed and placed on a test stand. The magneto was functionally tested through various speeds and it produced a spark across a 7-mm gap in firing order. No pre-accident anomalies were noted with the unit.		



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IGNITION HARNESS

Manufacturer: Continental Motors

P/N: Not Recorded

S/N: Not Recorded

Condition: The ignition harness remained secured to the magnetos and each terminal remained secured to its respective sparkplug. The harness was used during the functional testing of the magnetos and no pre-accident anomalies were noted.

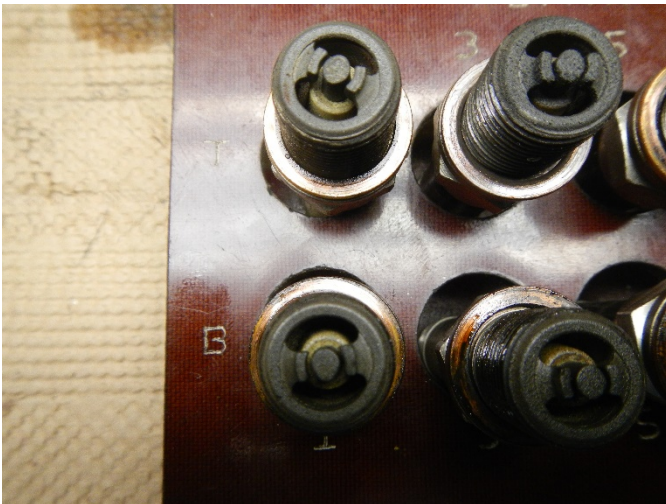


SPARK PLUGS

Manufacturer: Tempest

P/N: URHB32E

Condition: The sparkplugs displayed a normal worn condition with no signs of lead or carbon fouling. The #4 bottom sparkplug contained debris that was consistent with loose combustion deposits. No pre-accident anomalies were noted.



1 Top & Bottom



3 Top & Bottom

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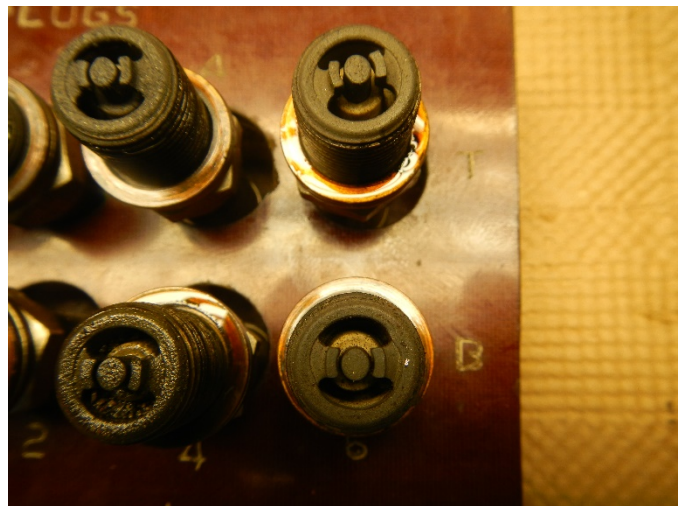
5 Top & Bottom



2 Top & Bottom



4 Top & Bottom



6 Top & Bottom

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FUEL SYSTEM

FUEL PUMP

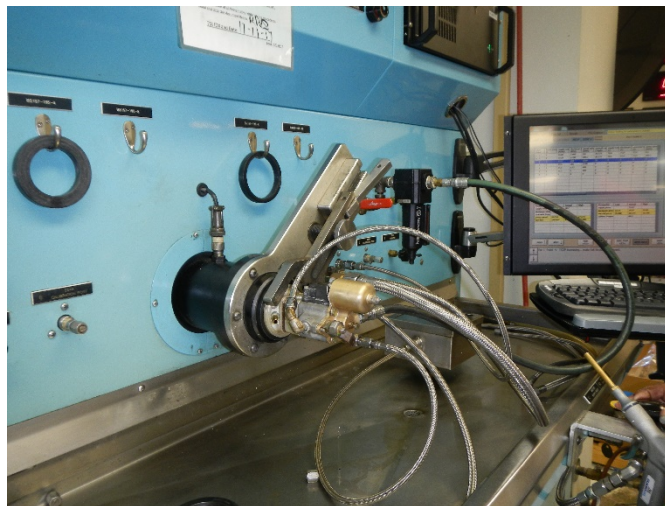
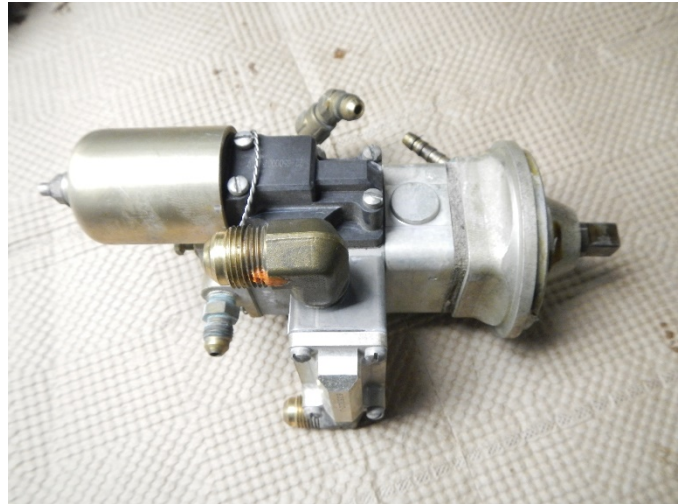
Manufacturer: Tornado Alley
Turbo

P/N: ETI-SR22-2-12

S/N: GP5655

Condition:

The fuel pump remained secured to the backside of the engine and the fuel lines remained in place. The fuel pump was placed on a production test stand and run through various test parameters for an equivalent pump model. Since it was a modified pump for an STC-modified engine, it did not meet Continental Motors production specifications throughout the entire test range. However, the pump was functional with no pre-accident anomalies noted. A leak was observed at the diaphragm area, but no fuel staining was observed on the housing.



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THROTTLE BODY METERING UNIT

Manufacturer: Continental
Motors

P/N: 653353-8A1

S/N: A09KA249

Condition:

The throttle body remained attached to the topside of the engine with no pre-event anomalies noted. The unit was placed on a production test stand and run through various test parameters for an equivalent pump model. Though the fuel metering unit did not meet all of the specified test specifications, the differences can be attributed to in service adjustments. The throttle body and fuel metering unit proved functional throughout the tested ranges.



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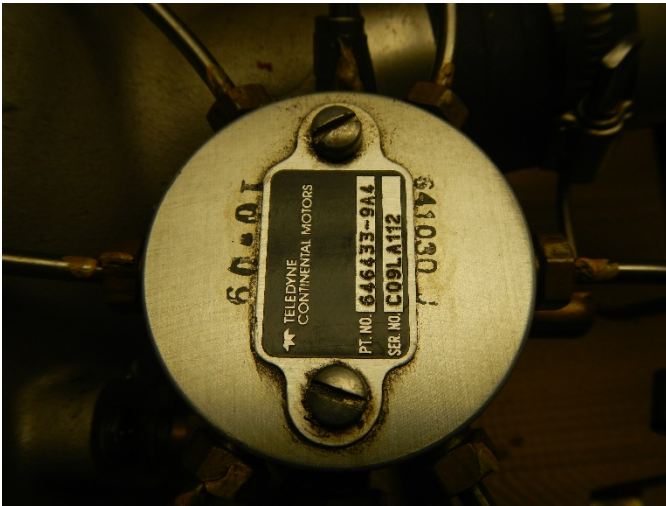
PAGE 15 of 47**FUEL MANIFOLD
VALVE**Manufacturer: Continental
Motors

P/N: 646433-9A4

S/N: C09LA112

Condition:

The fuel manifold valve remained secured on the topside of the engine with all fuel lines attached. The unit was tested on a production test stand throughout various test parameters. The unit metered fuel throughout the test, though it did not meet production specifications. The differences could be attributed to the nozzle jets installed with the STC modification.

**FUEL NOZZLES
AND LINES**

Manufacturer: GAMI

Condition:

The injectors remained attached to the fuel injection lines. There were no pre-accident anomalies or blockages noted. The nozzles were tested during the flow test of the fuel manifold valve with no pre-accident anomalies noted.

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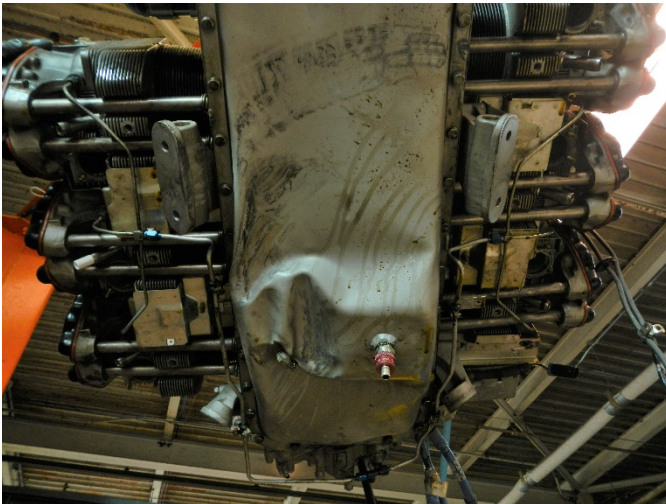
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LUBRICATION SYSTEM

NOTE: The external oil lines used for the turbocharger system were examined/documentated prior to engine removal from the aircraft. All the lines remained attached to their respective systems with no evidence of an oil leak.

OIL SUMP

Condition: The oil sump remained intact and attached to the bottom side of the engine, but it displayed a small puncture in an area relating to significant deformation damage. Photographs taken prior to engine removal from the airframe show a little over 2 quarts of oil registered on the oil dipstick. Approximately 1.5 quarts of oil was drained from the sump after it was shipped to the factory. The sump contained fractured crankcase components, lifters, multiple connecting rod pieces, a piston pin, and connecting rod bearings.



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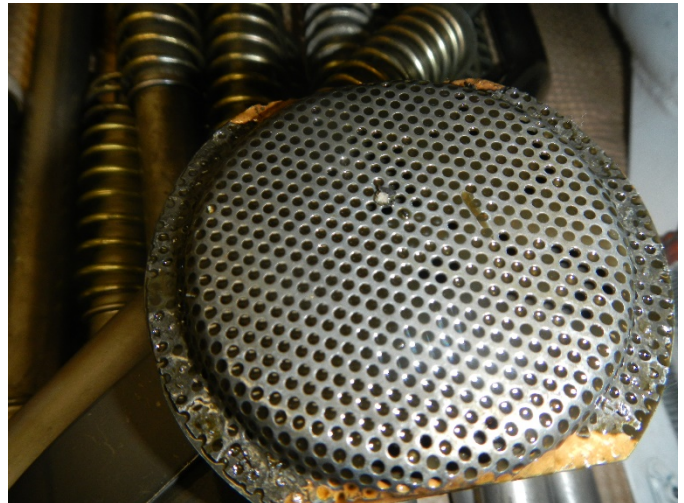
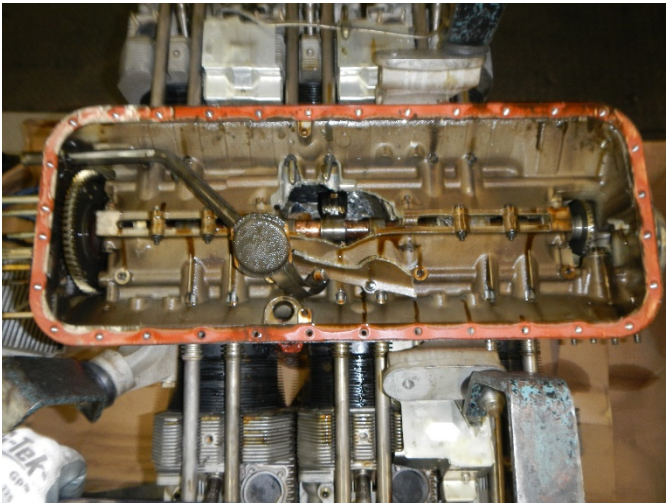
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OIL PICKUP TUBE & SCREEN

Condition:

The oil pickup tube and screen remained intact, but the tube was deformed like the sump. The screen contained some small metallic particles, but it did not appear blocked.



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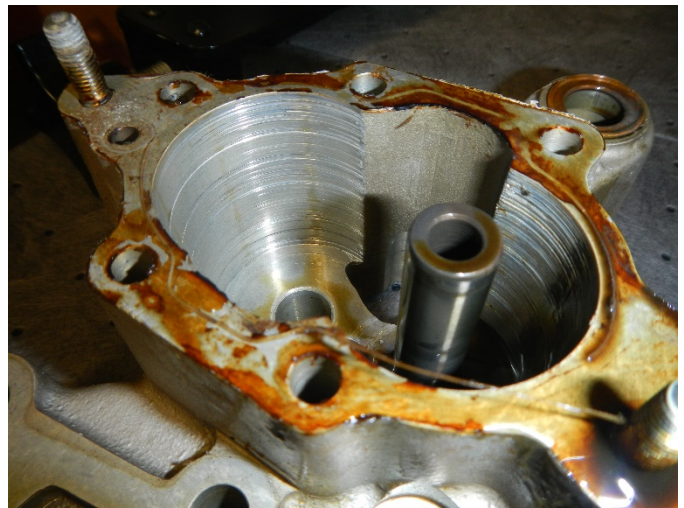
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OIL PUMP

Condition:

The oil pump remained secured to the backside of the engine with no external anomalies or oil leaks noted. Disassembly of the pump revealed evidence of hard particle passage with circumferential scoring noted on the pump walls. The oil pressure relief valve face displayed some pitting consistent with material between the valve face and valve seat.

The scavenge pump remained secured to the backside of the starter adapter with no external anomalies or oil leaks noted. Disassembly of the scavenge pump revealed residual oil coating all the components with no signs of hard particle passage on any of the scavenge pump components.



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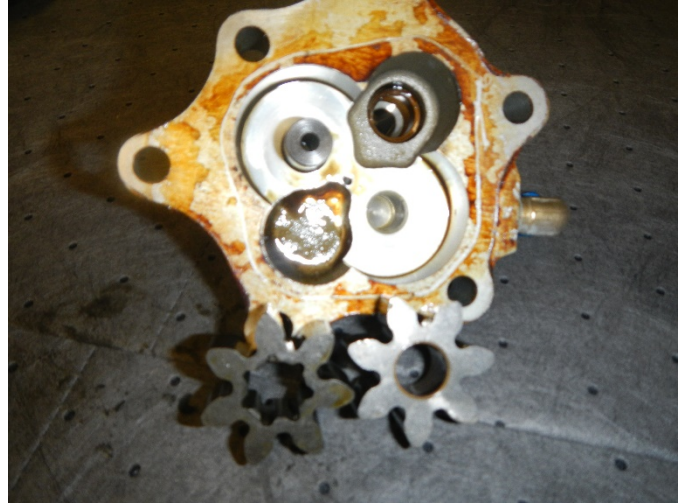
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OIL FILTER

Manufacturer: Tempest

P/N: AA48108-2

Condition:

The oil filter remained attached to the adapter and safety-wire secured it in place. There were no signs of pre-event oil leaks. The oil filter was removed and cut open. Metal contaminants were found throughout the filter's pleats.



OIL COOLER

Manufacturer: Niagara

P/N: 654585

S/N: K08-7057-399

Condition:

The oil cooler remained attached to the engine with no pre-accident anomalies noted.

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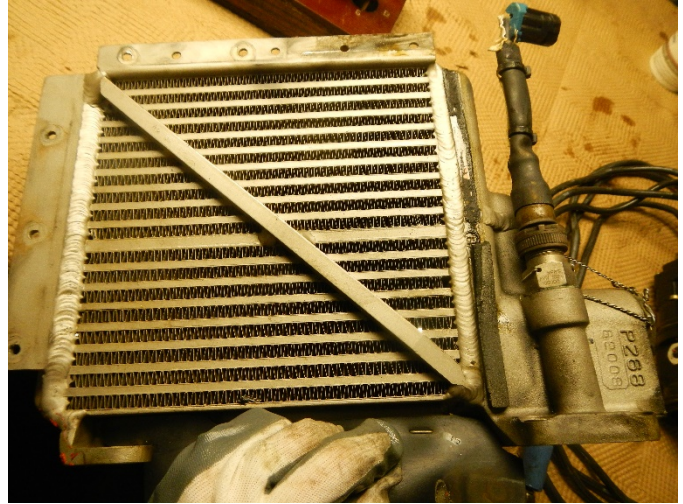
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CYLINDERS

CYLINDER #1

Condition: The cylinder remained secured to the engine and the original torque putty was present on the cylinder attaching hardware. There were no pre-accident anomalies noted with the cylinder components.



CYLINDER #3

Condition: The cylinder remained secured to the engine and the original torque putty was present on the cylinder attaching hardware. The cylinder skirt had to be cut due to mechanical damage that interfered with the crankcase cylinder bay. There were no pre-accident anomalies noted with the cylinder components.



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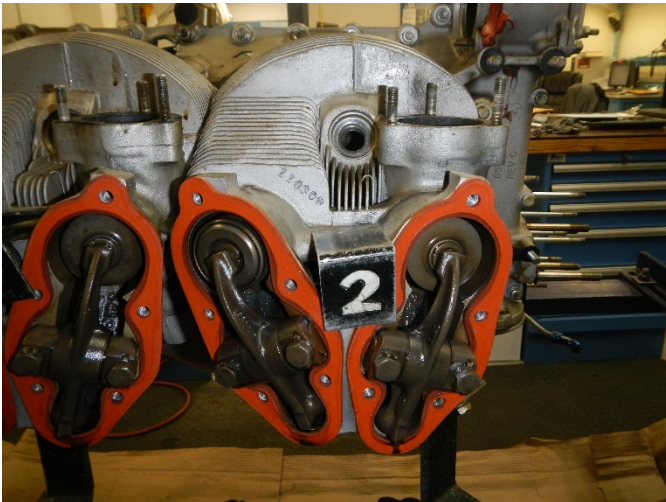
CYLINDER #5

Condition: The cylinder remained secured to the engine and the original torque putty was present on the cylinder attaching hardware. There were no pre-accident anomalies noted with the cylinder components.



CYLINDER #2

Condition: The cylinder remained secured to the engine and the original torque putty was present on the cylinder attaching hardware. There were no pre-accident anomalies noted with the cylinder components.



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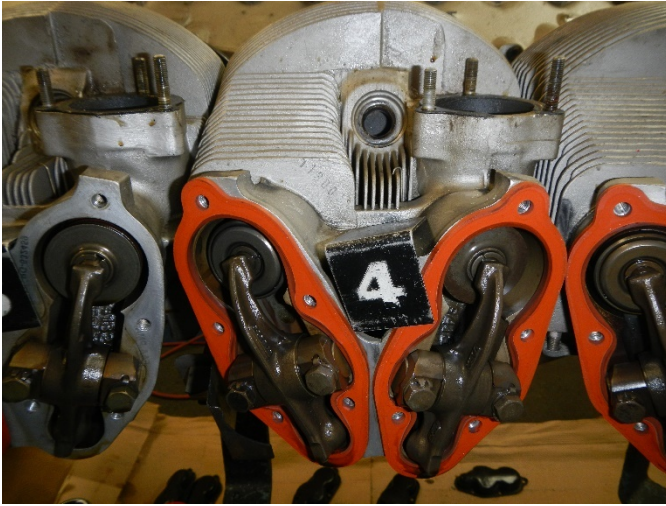
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CYLINDER #4

Condition: The cylinder remained secured to the engine and the original torque putty was not present on the cylinder attaching hardware. The cylinder skirt had to be cut due to mechanical damage that interfered with the crankcase cylinder bay. There were no pre-accident anomalies noted with the cylinder components.



CYLINDER #6

Condition: The cylinder remained secured to the engine and the original torque putty was present on the cylinder attaching hardware. The cylinder skirt had to be cut due to mechanical damage that interfered with the crankcase cylinder bay. There were no pre-accident anomalies noted with the cylinder components.



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#1 PISTON, RINGS AND PIN

Condition:

The piston face displayed normal combustion deposits and did not display any signs of pre-accident anomalies. The piston skirt displayed some scoring damage and light mechanical damage was noted.



#3 PISTON, RINGS AND PIN

Condition:

The piston face displayed two crescent shaped impact marks consistent with a valve strike. However, the face displayed normal combustion deposits with no signs of piston erosion. The piston skirt was fractured below the oil control ring land and the piston pin was separated.



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#5 PISTON, RINGS AND PIN

Condition:

The piston face displayed normal combustion deposits and did not display any signs of pre-accident anomalies. The piston skirt displayed some scoring damage and light mechanical damage was noted.



#2 PISTON, RINGS AND PIN

Condition:

The piston face displayed normal combustion deposits and did not display any signs of pre-accident anomalies. The piston skirt displayed some scoring damage and light mechanical damage was noted.



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#4 PISTON, RINGS AND PIN

Condition: The piston face displayed two crescent shaped impact marks consistent with a valve strike. However, the face displayed normal combustion deposits with no signs of piston erosion. The piston skirt was fractured below the oil scraper ring and the piston pin boss was mechanically damaged. The fractured connecting rod remained attached to the piston pin.



#6 PISTON, RINGS AND PIN

Condition: The piston face displayed normal combustion deposits and did not display any signs of pre-accident anomalies. The piston skirt displayed some scoring damage and light mechanical damage was noted.



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CRANKCASE ASSEMBLY

CRANKCASE

Casting
Number:

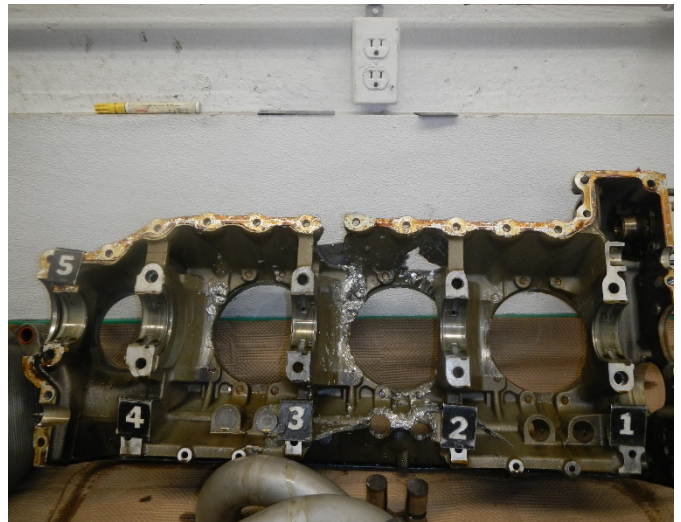
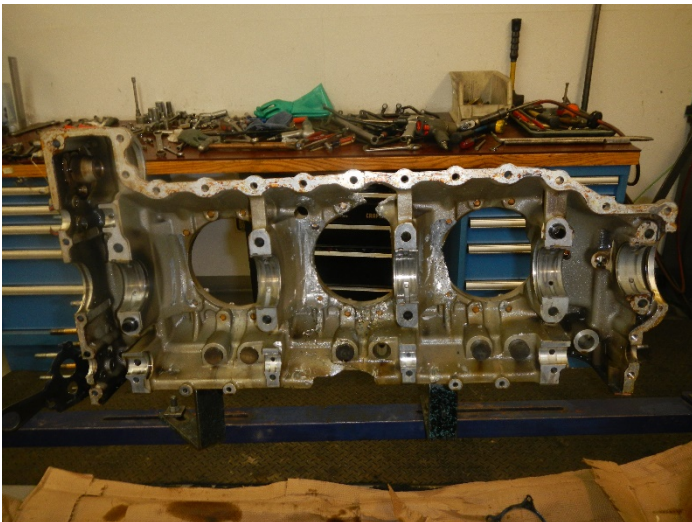
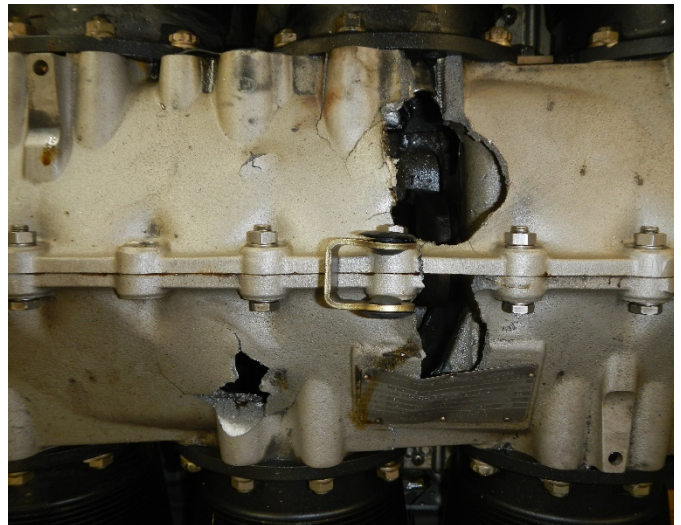
1-3-5: 655433

2-4-6: 655434

S/N: R09LA300

Condition:

The crankcase halves remained attached and displayed three holes on the topside that were in line with the #3 and #4 cylinders. A few of the cylinder attaching studs for the #3 and #4 cylinders were mechanically damaged/missing. The break-away torque for the cylinder through-bolts and deck studs was measured during disassembly. There were no pre-event anomalies noted with the undamaged items. Mechanical damage was noted in all the cylinder bays and the #3 and #4 lifter bosses. The oil passages that fed the crankshaft and connecting rod journals were visually examined when the case halves were separated. No blockages were noted.



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MAIN BEARINGS

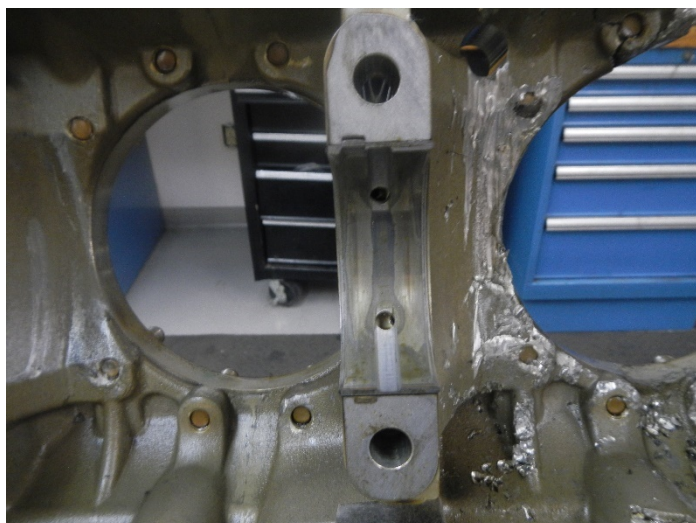
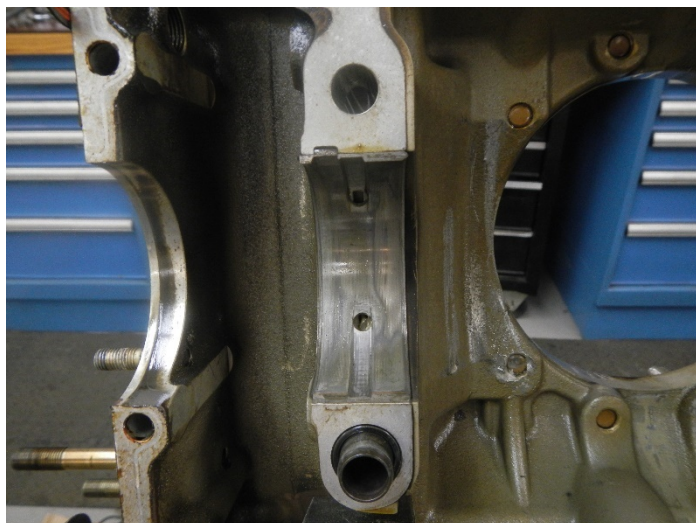
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4-5 653547

Date Code: 1-3 10/09
4-5 11/08

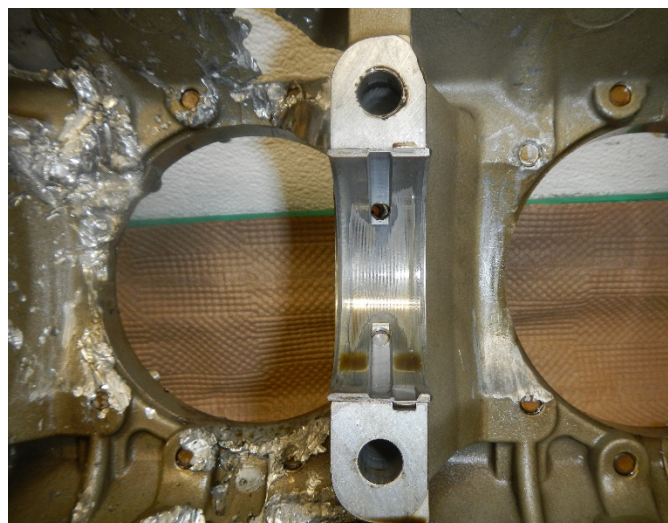
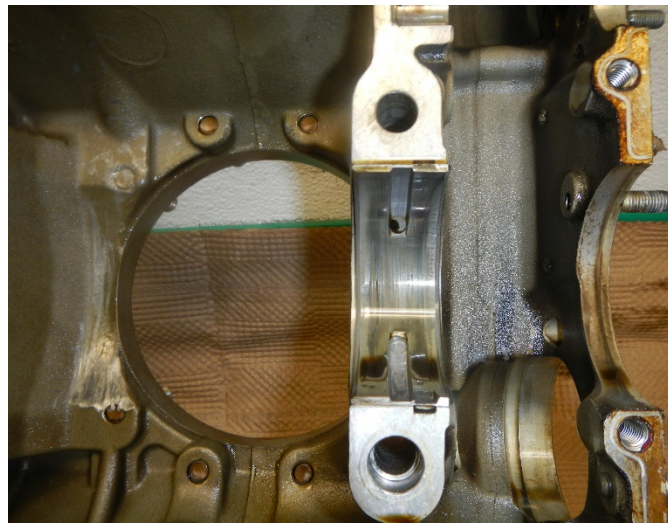
Condition:

The main bearings remained in place with no signs of pre-event anomalies noted. The photographs below depict the left and right bearing halves from 1 through 5.

LEFT



RIGHT



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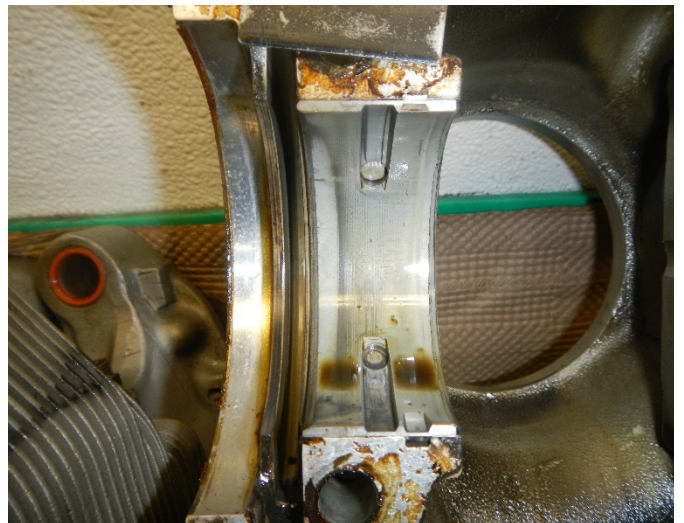
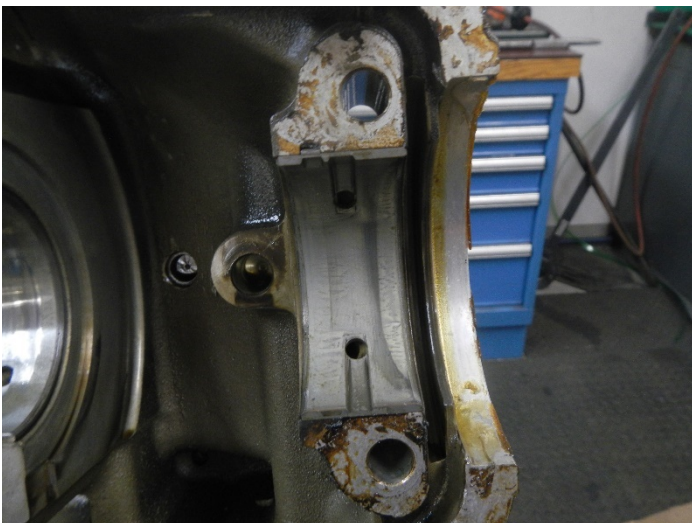
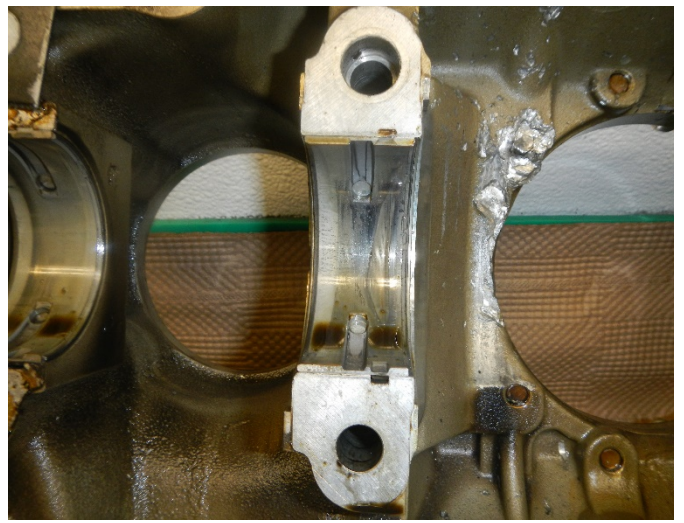
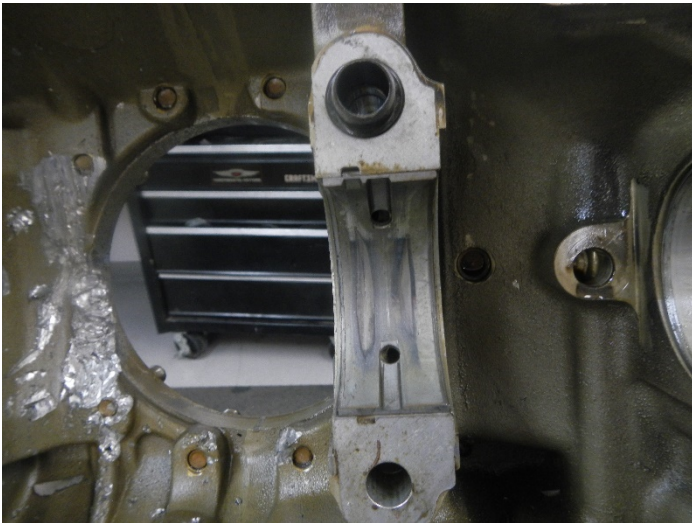
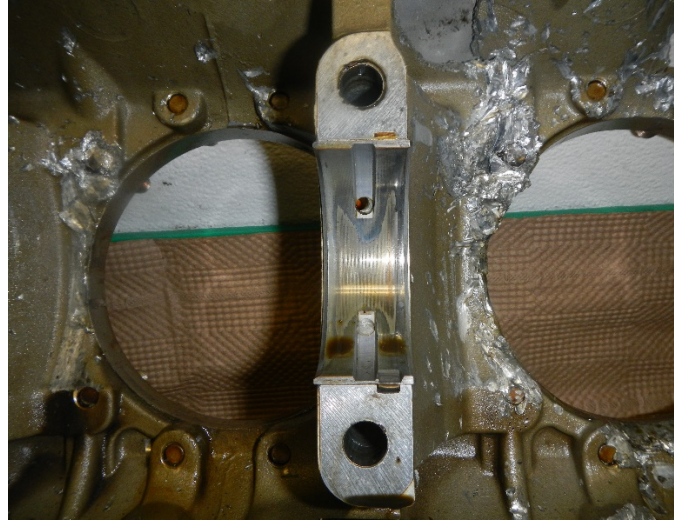
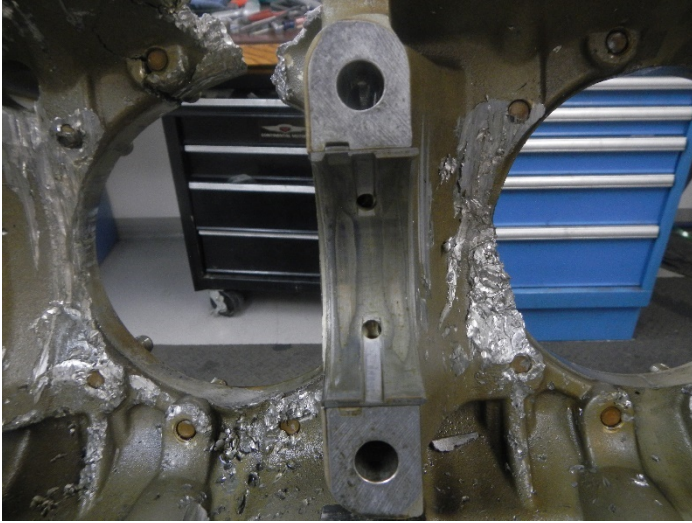
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CRANKSHAFT ASSEMBLY

CRANKSHAFT

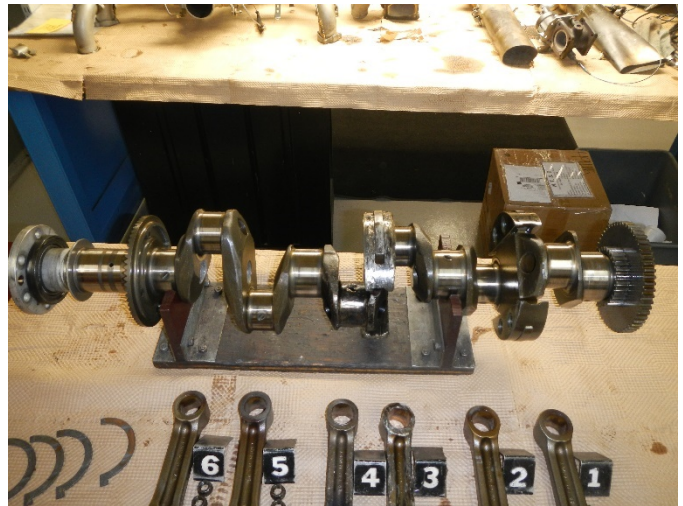
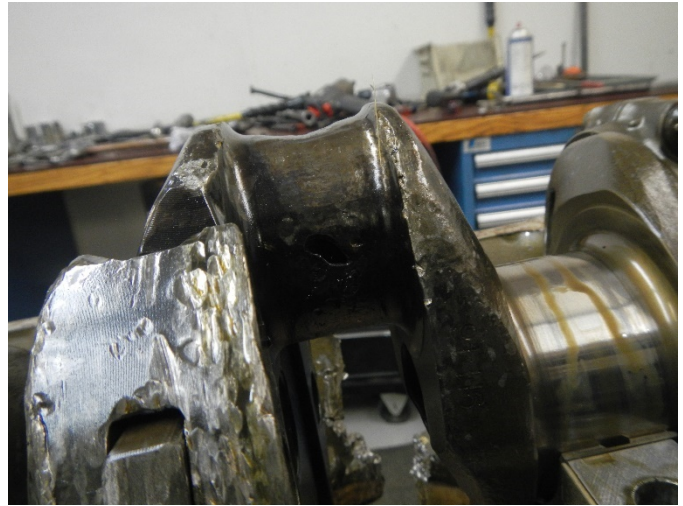
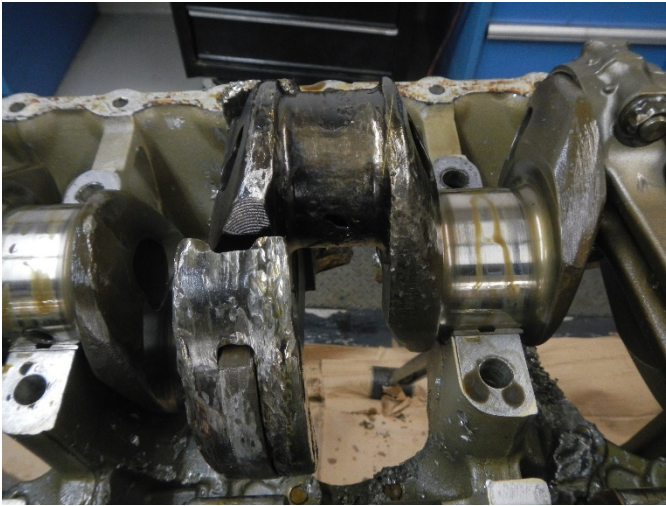
Forging Number: 649878

S/N: N09IA146

Heat code: KRH

Condition:

The crankshaft was intact, but sustained mechanical damage to the counterweights, hangar blades, and crankshaft cheeks from the fractured #3 and #4 connecting rods. The #4 connecting rod journal was thermally discolored and displayed deformation damage. The oil feed tube for the #4 connecting rod was clear and free from obstructions. The crankshaft gear remained intact and secured in place.



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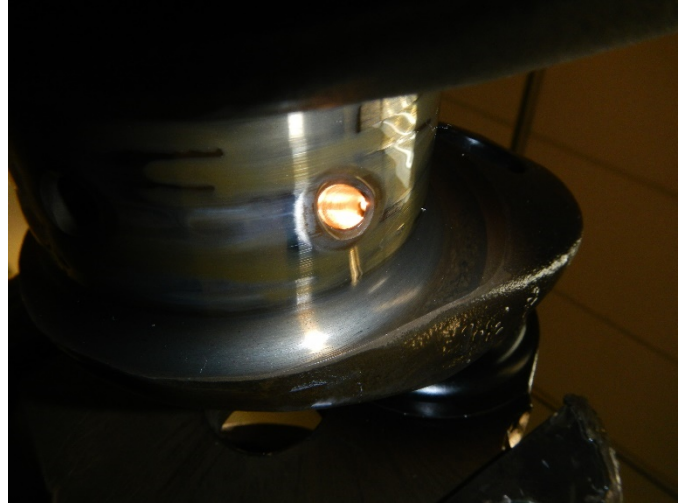
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TRANSFER COLLAR

Condition:

The transfer collar remained in place with no pre-accident anomalies noted.



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INTERNAL TIMING

Condition:

The internal timing was properly set.



#1 CONNECTING ROD

P/N: 655932A3

Forging or Serial Number: AE09HA514

Condition:

The connecting rod remained secured to the crankshaft with no pre-accident anomalies noted.

#1 CONNECTING ROD BEARING

P/N: 642328

Date: 10-08

Condition:

The bearing remained in place and did not display any pre-accident anomalies.



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#3 CONNECTING ROD

P/N: 655932A3

Forging or Serial Number: AE09HA395

Condition: The connecting rod was fractured and separated from the crankshaft and its piston pin; it was located in the oil sump. The rod displayed mechanical damage that distorted the rod cap and rod shoulders. There were no signs of thermal discoloration.

#3 CONNECTING ROD BEARING

P/N: 642328

Date: 10-08

Condition: The bearing was mechanically damaged and found in the oil sump.



#5 CONNECTING ROD

P/N: 655932A3

Forging or Serial Number: AE09HA470

Condition: The connecting rod displayed mechanical damage to its rod cap, but the rod remained intact and attached to the crankshaft.

#5 CONNECTING ROD BEARING

P/N: 642328

Date: 10-08

Condition: The bearing remained in place and displayed distortion in areas that were mechanically deformed on the rod cap.



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#2 CONNECTING ROD

P/N: 655932A3

Forging or Serial Number: AE09HA512

Condition: The connecting rod remained attached to the crankshaft and the piston pin. The rod sustained mechanical damage to the I-beam toward the piston pin end.

#2 CONNECTING ROD BEARING

P/N: 642328

Date: 10-08

Condition: The bearing remained in place, but displayed incipient oil starvation signatures. The oil passage to the bearing was clear.



#4 CONNECTING ROD

P/N: 655932A3

Forging or Serial Number: AE09HA464

Condition: The connecting rod was fractured and separated from the crankshaft but remained attached to the piston pin. The connecting rod displayed multiple fractures and thermal discoloration consistent with oil interruption.

#4 CONNECTING ROD BEARING

P/N: 642328

Date: 10-08

Condition: The thermally discolored remains of the bearing were found in the oil sump. The pieces were discolored black and sustained significant distortion and fragmentation. The oil passage to the bearing was clear.



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#6 CONNECTING ROD

P/N: 655932A3

Forging or Serial Number: AE09HA487

Condition:

The connecting rod displayed mechanical damage to its rod cap, but the rod remained intact and attached to the crankshaft.

#6 CONNECTING ROD BEARING

P/N: 642328

Date: 10-08

Condition:

The bearing remained in place with no sign of thermal discoloration.



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CAMSHAFT & LIFTER ASSEMBLY

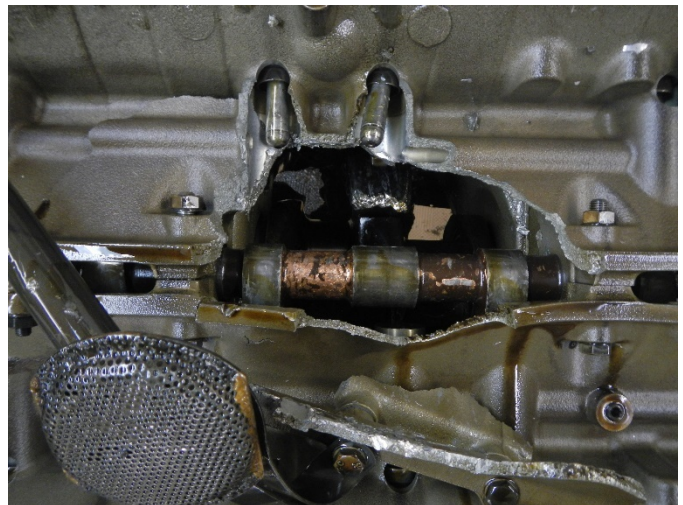
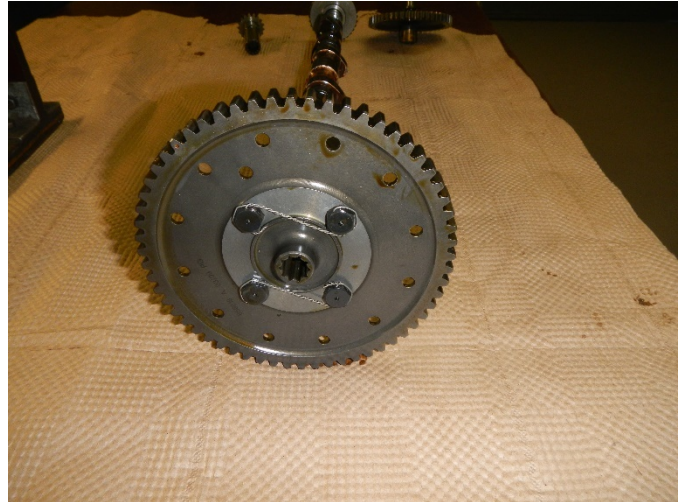
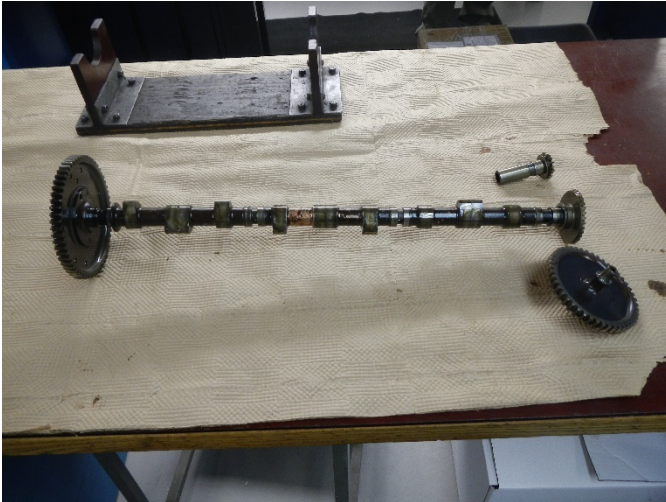
CAMSHAFT & LIFTERS

P/N: 654084K

S/N: 38284

Condition:

The camshaft sustained mechanical damage in an area that coincided with the fractured connecting rods. The #3 lifter housing area was fractured and lifters were not in place. There were no pre-accident anomalies noted with the lifter faces or camshaft lobes. The camshaft and beveled gear remained in place with no pre-accident anomalies noted.



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ACCESSORIES

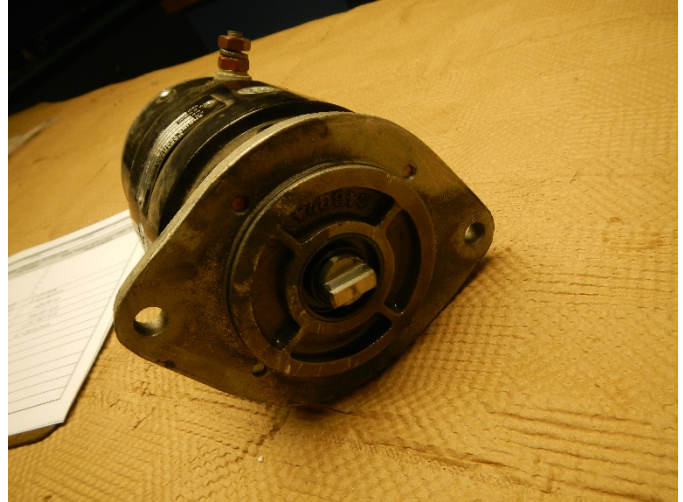
STARTER

Manufacturer: Hartzell
Engine Technologies

P/N: 646275-1R

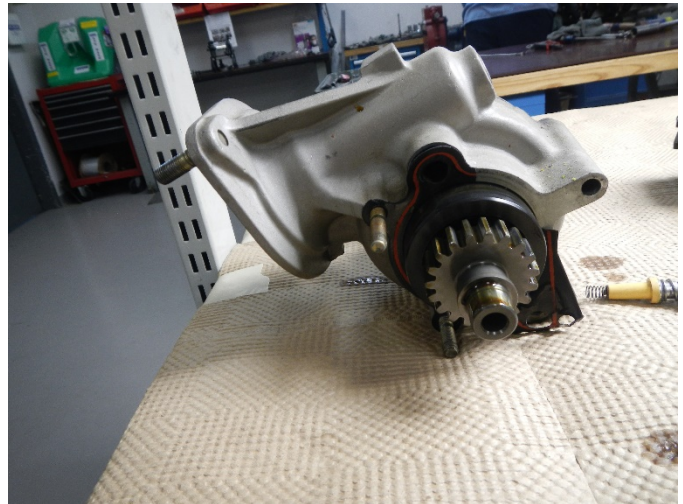
S/N: H-O091366

Condition: The starter motor remained in place with no pre-accident anomalies noted. The starter shaft rotated freely during manual manipulation.



STARTER ADAPTER

Condition: The starter adapter remained in place on the backside of the engine with no external signs of operational distress. Removal of the unit revealed no pre-accident anomalies.



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ALT/GEN #1

Manufacturer: Plane Power

P/N: C28-150

S/N: 150-144409

Condition:

The alternator remained secured to the front right side of the engine with no pre-accident anomalies noted.



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ALT/GEN #2

Manufacturer: Hartzell
Engine Technologies

P/N: 657199H

S/N: H0111017

Condition:

The belt-driven alternator was removed prior to shipment and no pre-accident anomalies were noted with the unit.



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TURBOCHARGER COMPONENTS

NOTE: The examination of the turbocharger components took place at Hartzell Engine Technologies' (HET) facility in Montgomery, Alabama on November 16, 2017. The photographs that follow each components condition description were taken at the Continental Motors and HET facilities.

TURBO #1	Manufacturer: Kelly Aerospace	P/N: 466304-0003	S/N: LIL00112
Condition:	The left turbocharger remained secured to the exhaust transition but the transition was removed from the engine prior to shipment. Oil was observed in the impeller inlet and on the outside of the turbine wheel housing. Residual oil drained from the bearing. The impeller wheel rotated freely with a coinciding rotation of the turbine when manually manipulated. The bearing oil supply inlet screen and check valve were tested and inspected. The check valve unseated with 14 psi of air pressure applied, and the inlet screen was found clear. The turbocharger was disassembled at the HET facility. There was no evidence of foreign object damage on the compressor or turbine wheels and the housings did not display any pre-event anomalies. The turbine and compressor bearings were removed and the oil holes were clear and unobstructed. The turbine bearing displayed some discoloration and circumferential wear on its OD. See the HET examination report for more information.		



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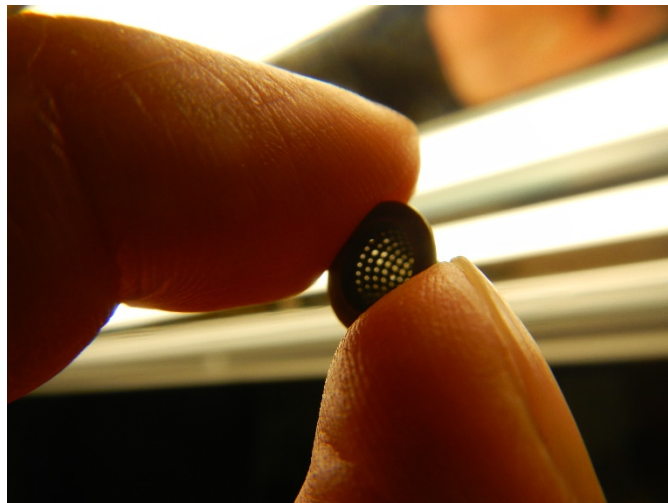
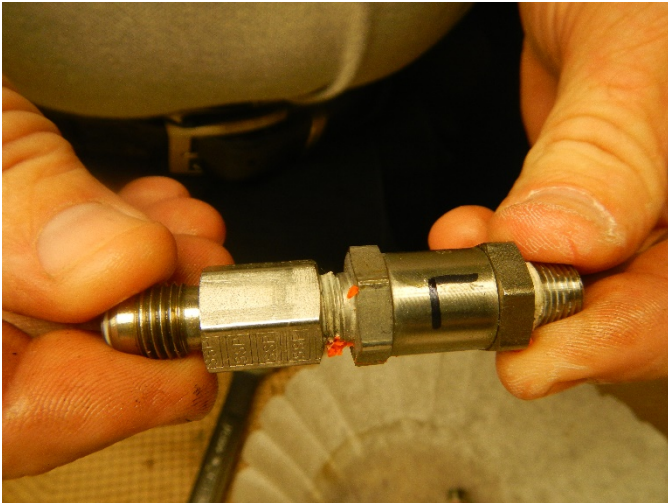
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TURBO #2

Manufacturer: Kelly
Aerospace (overhauled by
ATC)

P/N: 466304-9003

S/N: IBL00293

Condition:

The right turbocharger remained secured to the exhaust transition but the transition was removed from the engine prior to shipment. The turbocharger's turbine wheel was missing and there was little-to-no rub or contact damage noted on the turbine wheel housing (it should be noted that a normally sized turbine wheel would not be able to exit the unit without interfering with the housing). The turbine housing was discolored with what appeared to be a pale colored exhaust residue; however, the source of the discoloration was not determined. There was an area on the housing's exhaust tailpipe mating flange that was similar in appearance, as noted with the red bracket in the second photograph. The v-band coupling remained with the tailpipe and was removed from the turbocharger prior to shipment.

The impeller and impeller housing displayed damage consistent with rotational contact. The bearing oil supply inlet screen and check valve were tested and inspected. The check valve unseated with 15 psi of air pressure applied, and the inlet screen was found clear. Disassembly of the unit revealed that the bearings' oil holes contained displaced bearing material and both the turbine and compressor bearings were worn. The bearing housing lubrication passages were clear. The turbine wheel was separated from the turbine shaft at the outboard edge of the piston ring groove. The piston ring remained in place. There was no evidence of oil leakage in the turbine housing. See the HET examination report for more information.



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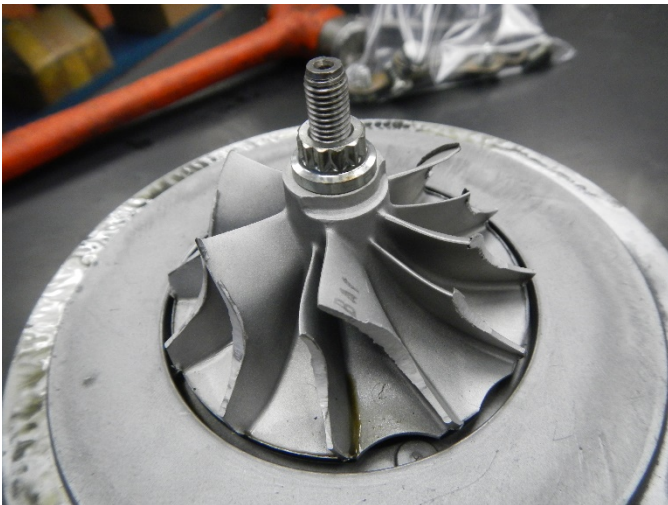
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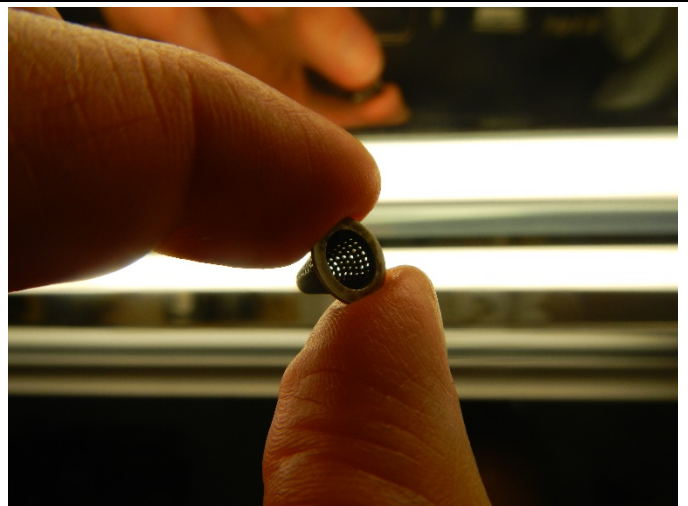
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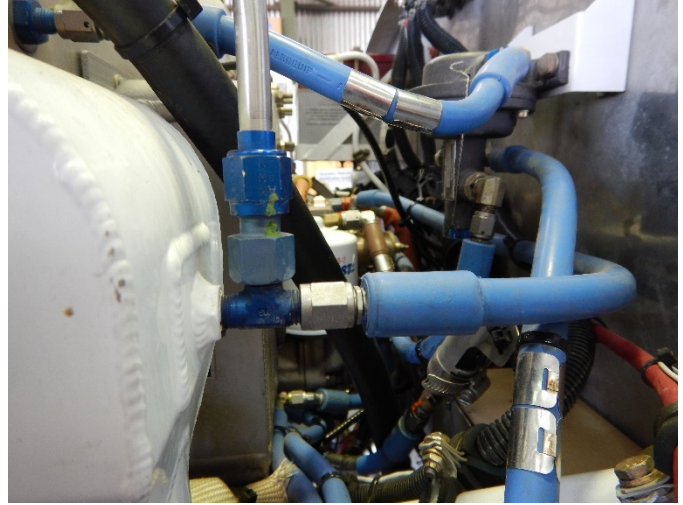
TURBO CONTROLLER

Manufacturer: Kelly Aerospace

P/N: 470688-0005

S/N: MIN00110

Condition: The controller was removed prior to shipment. The oil lines to and from the controller remained attached with no signs of pre-event oil leaks. NOTE: The photographs below were taken prior to engine removal from the aircraft.



WASTEGATE

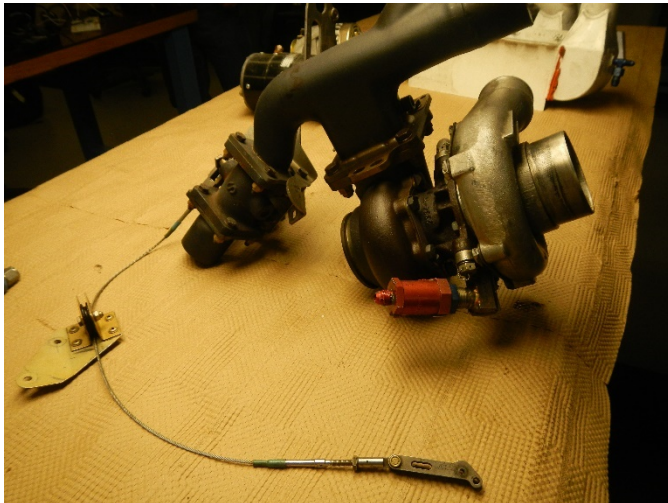
Manufacturer: Kelly Aerospace

P/N: 470842-0004

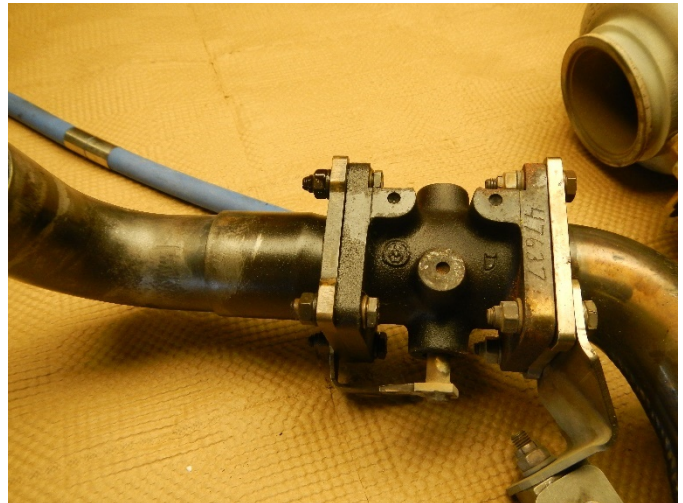
S/N: NEN00150

Condition: The wastegate and wastegate controller remained with the left turbocharger exhaust system. The wastegate interconnect cable for the right turbocharger exhaust system remained attached to the left wastegate control linkage. The left wastegate was functionally tested at HET facility with no pre-accident anomalies noted.

Left



Right



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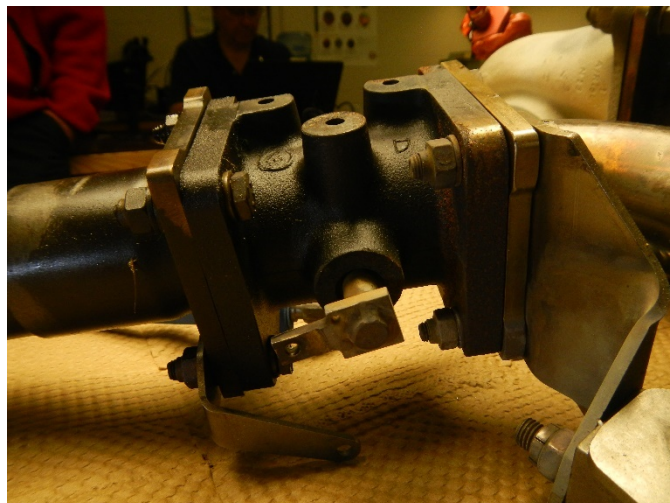
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OVERBOOST VALVE

Manufacturer: Kelly Aerospace

P/N: 470944-0017

S/N: LLN00147

Condition:

The overboost valve remained attached to the previously removed intake system components. It was functionally tested at the HET facility with no pre-accident anomalies noted.



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PROPELLER

PROPELLER GOVERNOR

Manufacturer: McCauley

P/N: C290D3R/T23

S/N: 090250

Condition:

The propeller governor remained attached to the front left side of the engine with no pre-accident anomalies noted. The governor was removed and the inlet screen was clear. Manual rotation of the drive shaft resulted in free rotation of the pump with residual oil observed in the housing.

