

REPORT 1508-3

- 1.0 SCOPE: This report describes the engine tear-down accomplished on the Lycoming IO-360-B1E S/N L-4412-51A from Pi-180 S/N 28R-30255 that had been involved in an engine failure accident.
- 2.0 BACKGROUND: The accident occurred at Haviland, Kansas on February 13, 2015 in night visual flight rules (VFR) conditions due to an inflight engine failure. Initial inspection by investigators revealed a massive hole at the upper rear of the crankcase with the #4 cylinder separated from the crankcase. The #4 cylinder was shipped to the NTSB laboratory where computed tomography (CT) images were developed to show the condition of the #4 cylinder and the section of the piston above the pin bosses that was still in the cylinder. The engine was shipped to Danbury Aerospace, Inc. (DAS) for a tear-down inspection that occurred on May 26, 2015.
- 3.0 ENGINE TEAR-DOWN: The engine was brought to the Danbury Aerospace, Inc. Titan Engine facility for the tear-down that was accomplished on May 26, 2015 and was directed by Mr. Ed Malinowski, NTSB.
- 4.0 TEARDOWN AND OBSERVATIONS:
 - 4.1 The engine was removed from the shipping crate, and damage to the engine crankcase was immediately obvious with a large hole in the crankcase between the #4 and #3 cylinders. The camshaft was separated behind the #3 & #4 intake lobe and the #4 connecting rod was severely bent with the piston pin still in the connecting rod small end. The camshaft showed severe impact damage with the aft section displaced toward the #4 cylinder (rear left side from back of engine) along with segments of the crankcase.
 - 4.2 The damage to the #4 connecting rod and the camshaft are consistent with the connecting rod and piston pin flailing in the engine and the connecting rod and piston pin hooking the camshaft as the crankshaft rotated the crankpin toward the #4 cylinder.
 - 4.3 The top right anchor thrubolt¹ shows some stretching and part of the fracture surface is separated in a flat pattern perpendicular to the length of the thrubolt. Some of the cylinder studs were missing, but one ½ inch stud was identified as from the #4 cylinder. A portion of the fracture surface of that stud is granular and is broken perpendicular to the length of the stud as shown in Photograph 6 in the Addendum (center fastener).

¹ The aft anchor thrubolts (studs) thread into the right side crankcase and extend through the #4 cylinder flange.

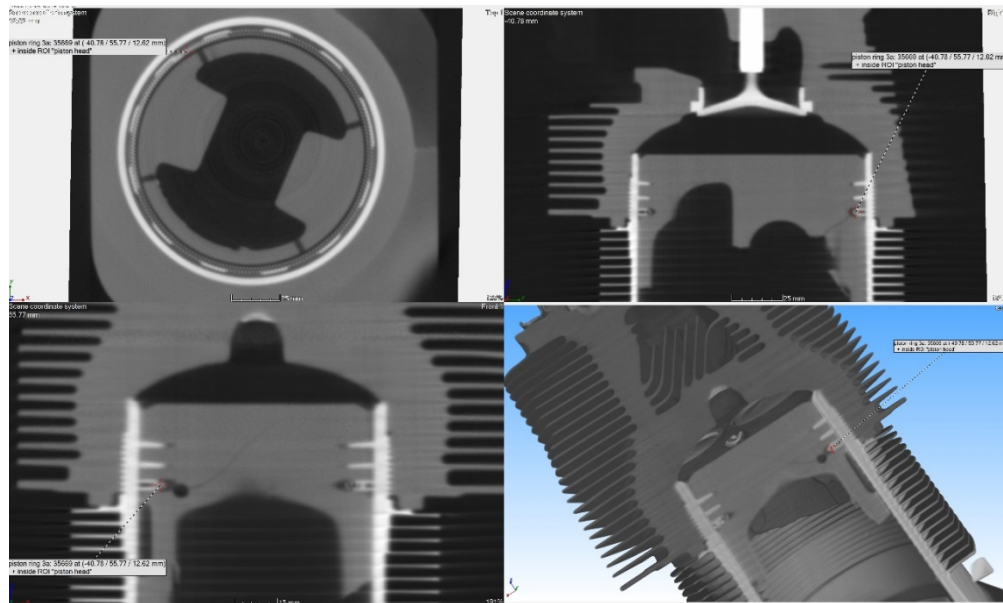
- 4.4 The Number 4 cylinder deck (upper broken out section) shows some fretting, with some more at the upper right anchor thrubolt. The body fit hole at the parting line on the broken out section of the crankcase above the #4 cylinder has significant deformation.
- 4.5 There were loose studs and nuts on the other cylinders, but these are considered to be caused by the very high energy crankcase fractures.
- 4.6 The #4 piston was fractured around the skirt and through the pin bosses. The skirt fracture surfaces show some evidence of progressive crack propagation. The remaining skirt portions showed some debris marks and some burnishing from loading against the bore.
- 4.7 The nut on one side of the #4 connecting rod was not tight as shown in Photograph #4. However, the rod cap fasteners experienced extremely high impact tensile loading, and the loose nut is considered to be the result of that impact. However, there was no evidence of bearing and crankshaft journal distress (Reference Photographs 13 and 15).
- 4.8 Cylinders #1 through #3 all showed some degree of bore glaze (coating of carbonized oil), but the worst was cylinder #3.
- 4.9 The #3 cylinder bore had score marks in line with the piston pin plugs. The piston pin plugs had damage, and one of them had a wear ridge around the outer periphery. There was additional damage to the #3 cylinder bore that could not be matched to geometry of the piston pin while it was in the operation position in the piston.
- 4.10 The #3 piston was broken away below the oil ring, and small pieces were in the oil sump along with some pieces from the #4 piston.

5.0 FINDINGS

- 5.1 The structural failure of the #4 piston released the piston pin and connecting rod. The connecting rod with piston pin still in the small end bore hooked the camshaft and fractured it and the adjacent crankcase structure and displaced the severed rear section of the camshaft and adjacent crankcase structure toward the #4 cylinder (left rear position). This caused the engine to stop running.

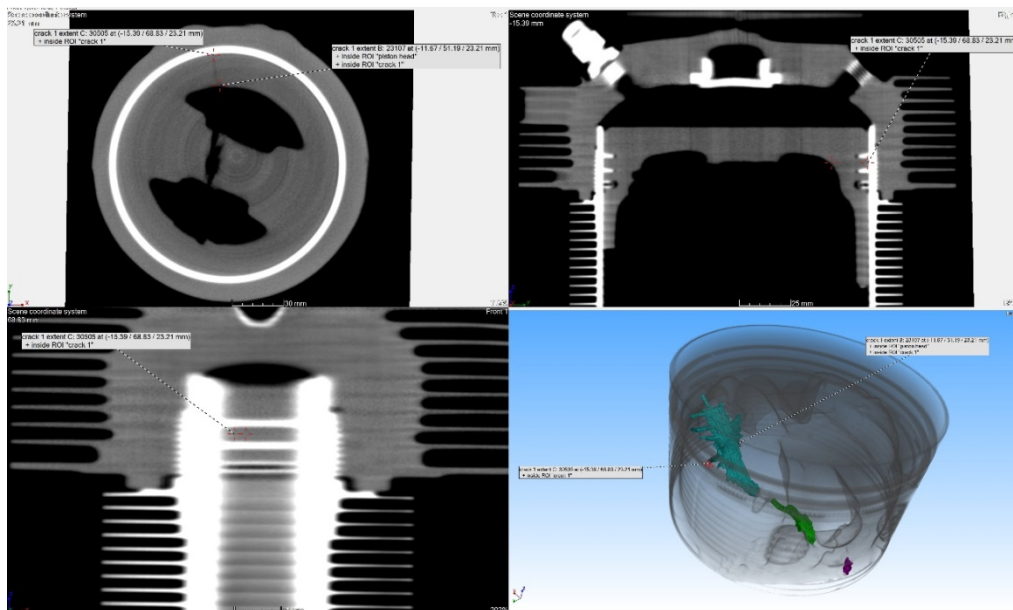
ADDENDUM

Photographs



Photograph 1

The #4 cylinder was shipped to the NTSB Laboratory where computed tomography (CT) images were made prior to removal of the piston during the engine tear-down. This photograph is an image of the #4 cylinder showing the upper portion of the piston that was still installed. The piston rings are visible and some fractures in the piston are also visible



Photograph 2

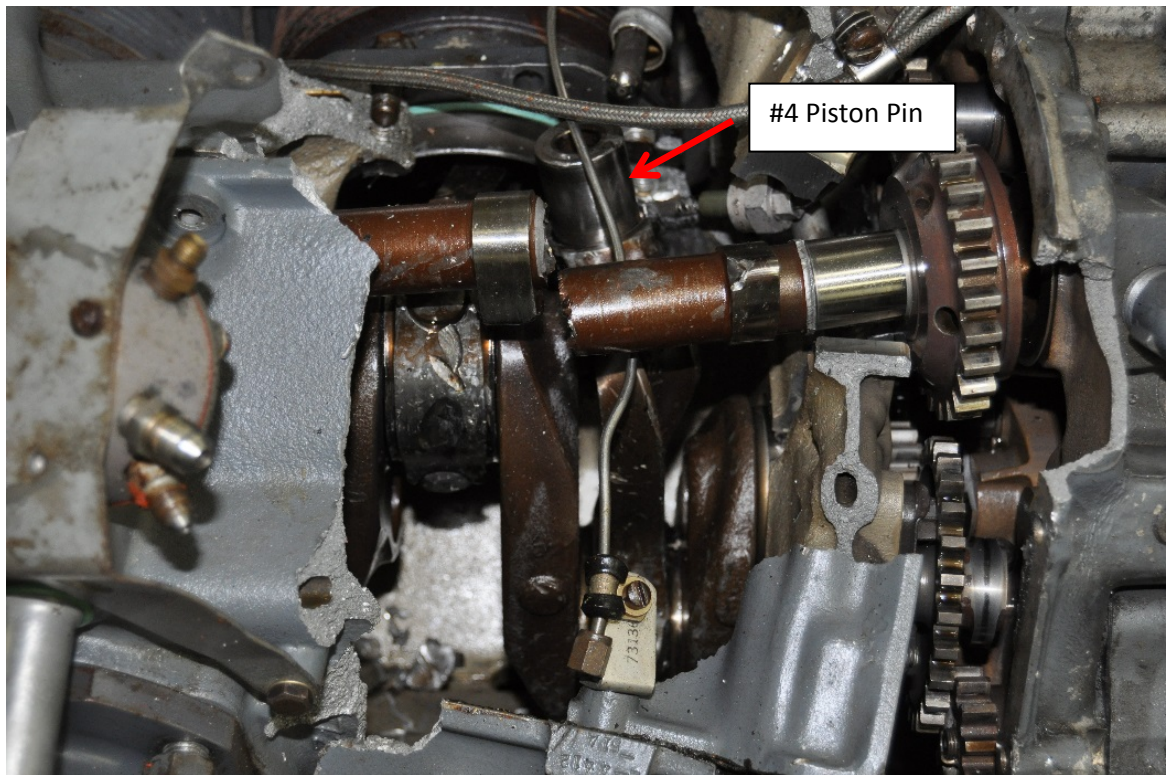
. This image shows cross sections and an image of cracks in the piston while it was still in the cylinder.



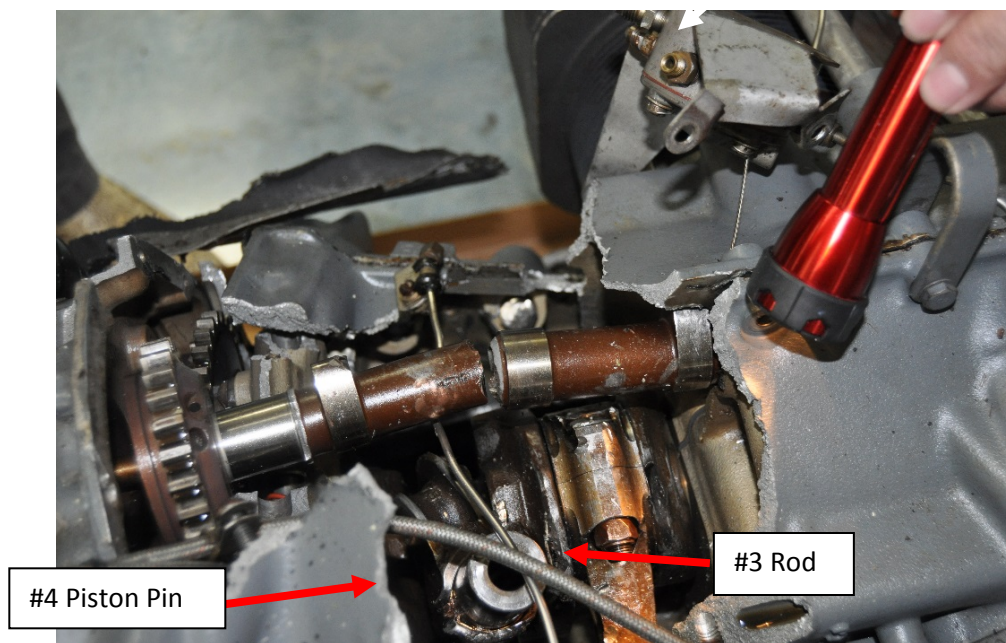
Photograph 3
Engine being installed on engine stand after removal from crate



Photograph 4
Checking cylinder flange nut torque during disassembly



Photograph 5.
View of damage from #4 cylinder position.



Photograph 6
View of damage from #3 cylinder side.



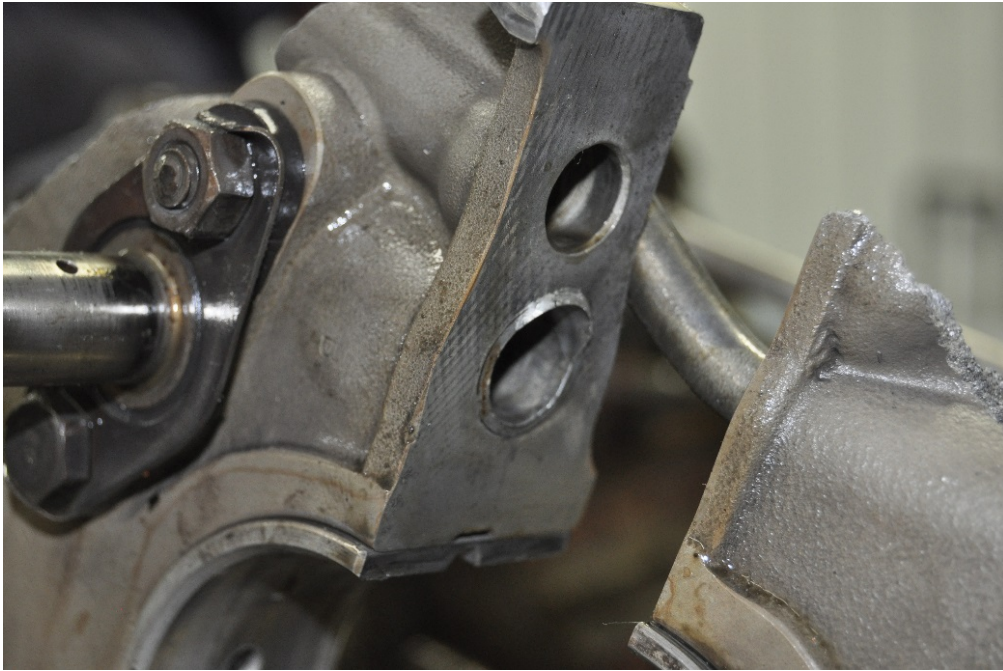
Photograph 7

Upper #4 cylinder thru-stud showing marks on the diameter, some necking and fracture surface with a majority of the fracture perpendicular to the loading (along length).



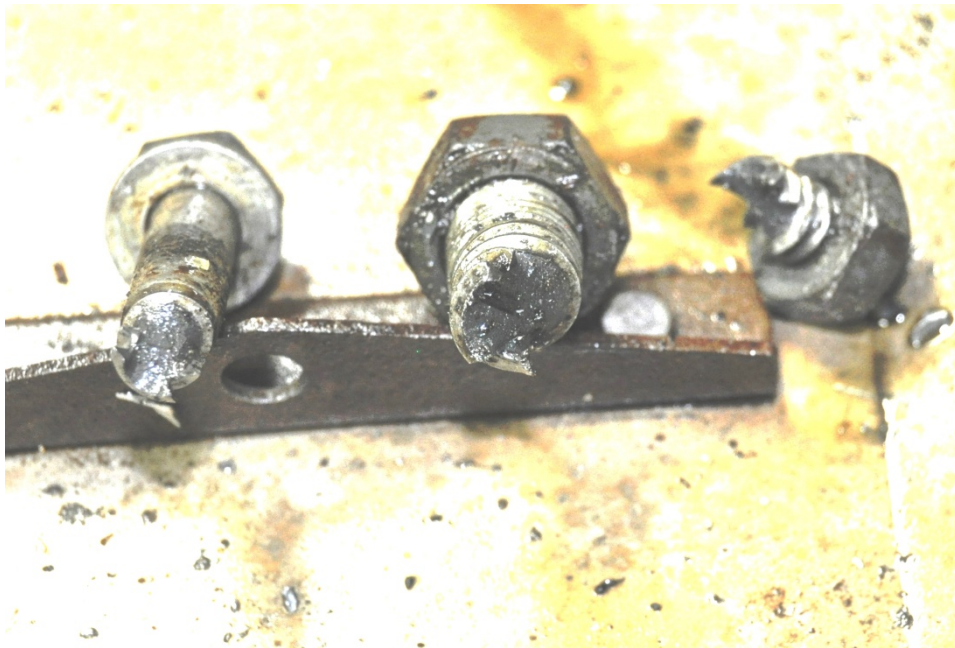
Photograph 8

Lower #4 cylinder anchor throbolt. Fracture surface is angled to the length of the throbolt.



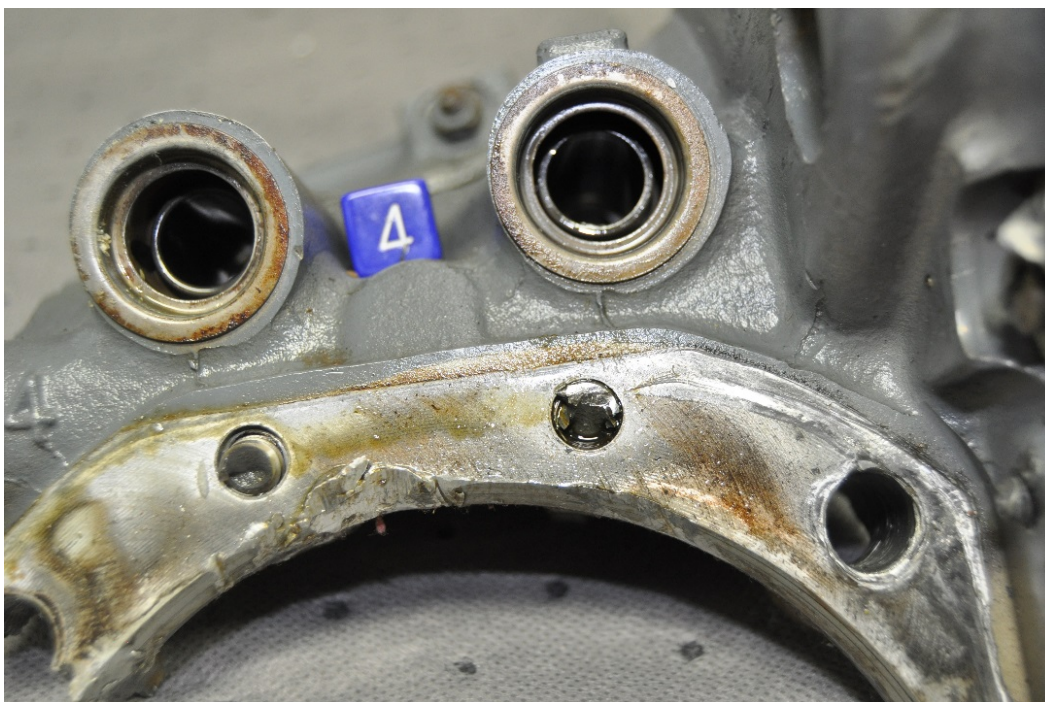
Photograph 9

Crankcase parting line at #4 cylinder anchor stud hole. Some parting line fretting and distortion around and in the anchor thru-bolt hole are visible.



Photograph 10

#4 cylinder deck stud in the middle.



Photograph 11

#4 deck section showing fretting and wear at the upper thru-stud.

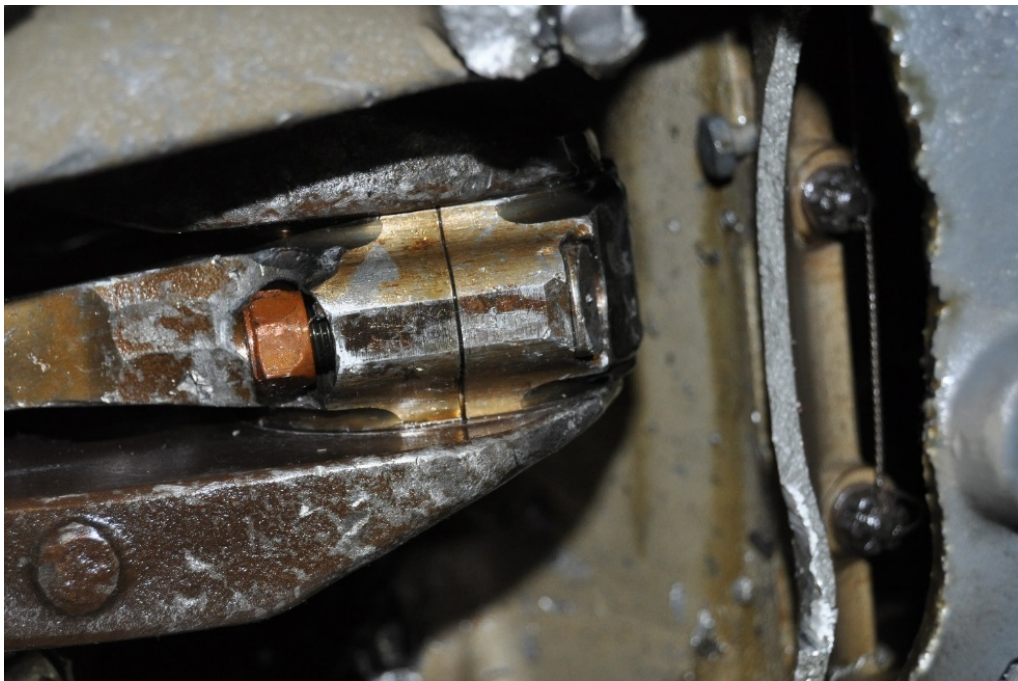


Photograph 12

#4 piston before removing during engine tear-down



Photograph 13
Outside view of #4 piston

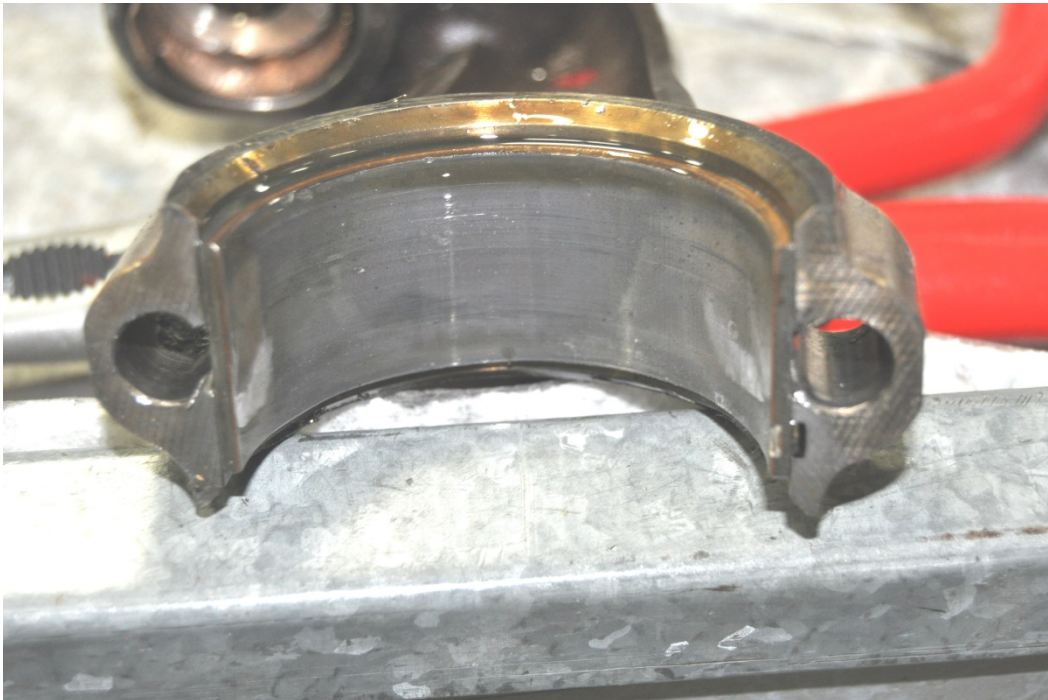


Photograph 14
#4 connecting rod bolt and loose nut. After the nut was removed, the bolt revealed deformed threads from the failure event.



Photograph 15

#3 connecting rod still installed on the crankshaft. No significant damage to the crankshaft bearing journals.



Photograph 16

#4 upper connecting rod bearing with normal wear pattern for time in service



Photograph 17

The threads on the rod bolt are stripped and there is some damage to the thrust faces of the #4 connecting rod



Photograph 18

Interior of the #3 piston with the piston pin in place



Photograph 19

The bore of the #3 cylinder shows evidence of blow-by during operation and scar marks from the piston pin plugs.



Photograph 20

#3 cylinder piston pin plugs



Photograph 21

Close up of the #3 piston. There is a wear pattern at the top of the upper ring land, some mashed aluminum found between the top and second compression rings.



Photograph 22

Upper #3 cylinder deck segment. There appears to be a residue along the edge of the cylinder flange



Photograph 23

Another view of the #3 cylinder bore showing the glazed bore with distress indications



Photograph 24

View of the #1 cylinder combustion chamber. The combustion chamber shows some metal splatter around the spark plugs.

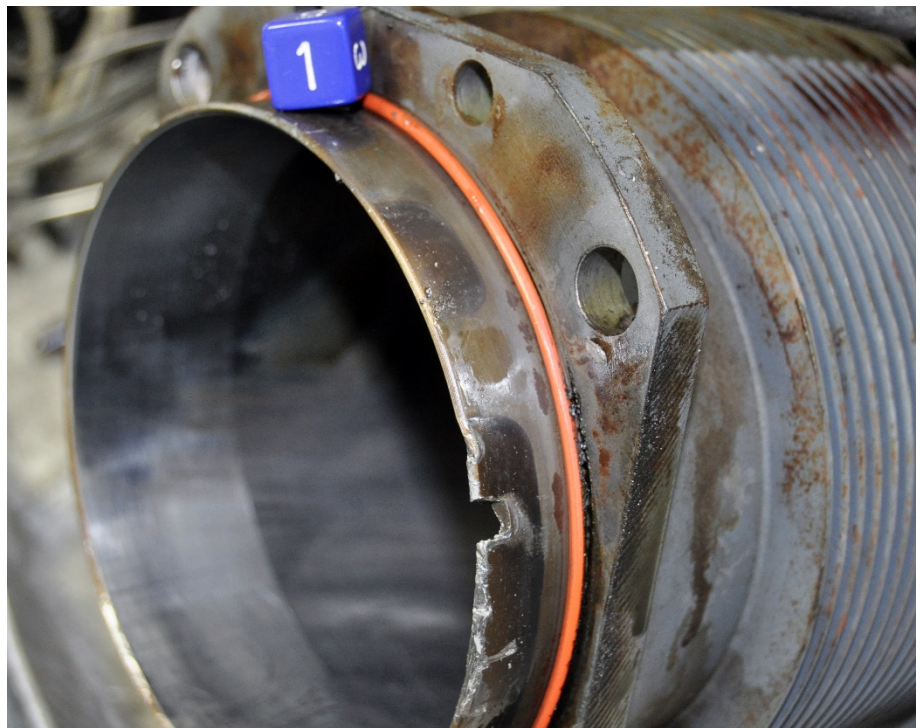


Photograph 25

View of the #1 cylinder bore showing a more normal bore condition with some bore glaze.

Photograph 26

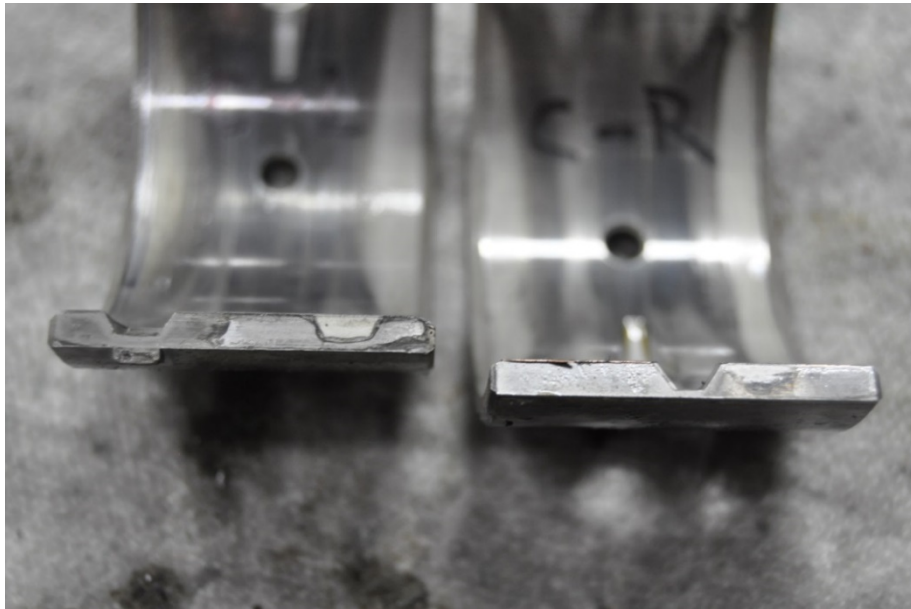
Another view of #1 cylinder.
Note the residue at the
cylinder base seal (O-Ring).





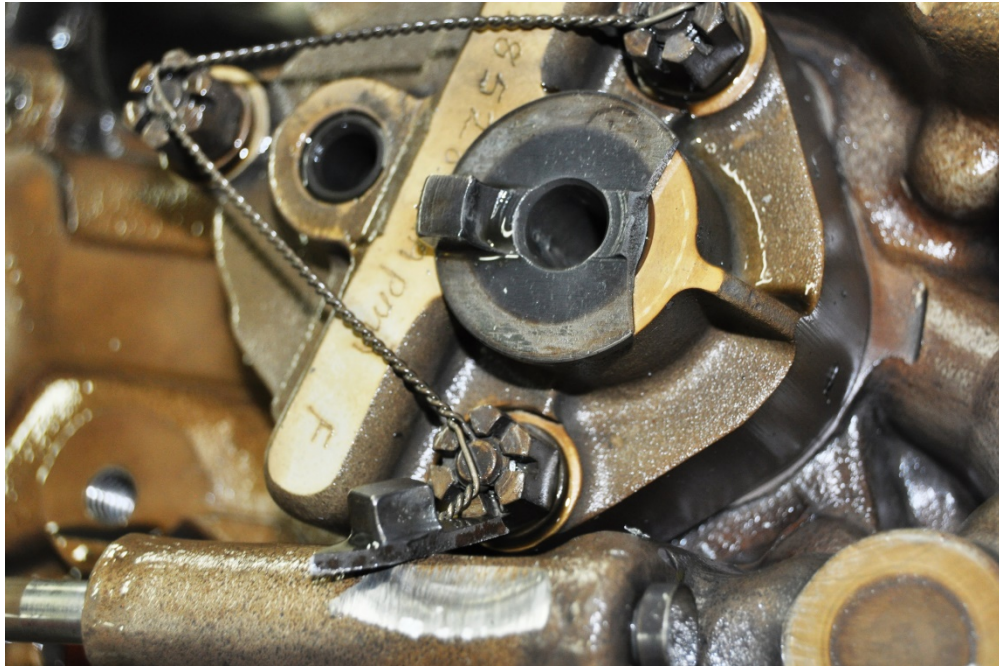
Photograph 27

Center main bearings: Normal appearance on backs for the time in operation



Photograph 28

Center main bearings show normal wear. The condition of the bearings shows that the failure sequence progressed from root cause to engine stoppage before debris was circulated through the bearings



Photograph 29
View of oil pump housing and drive shaft with broken tang.



Photograph 29
Interior of oil pump with no indications of significant debris circulating through the pump.