

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



ERA22FA126

MATERIALS LABORATORY

Factual Report 23-063

September 26, 2023

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A. ACCIDENT INFORMATION

Place : Lexington, North Carolina
Date : February 16, 2022
Vehicle : Beech 58, N58LF
NTSB No. : ERA22FA126
Investigator : Timothy Monville

B. COMPONENTS EXAMINED

#1 cylinder, piston, and piston pin from the right engine;
#5 cylinder and piston from the right engine;
#3 cylinder, piston, fuel injector nozzle and line from the left engine.
These parts were disassembled from a Teledyne Continental Motor IO-520-C(5) CCB engine.¹

C. EXAMINATION PARTICIPANTS

Senior Metallurgist Frank Zakar
 NTSB
 Washington, DC

Fire/Explosion Specialist Nancy McAtee
 NTSB
 Washington, DC

D. DETAILS OF THE EXAMINATION

#1 Piston and Cylinder from the Right Engine

Figure 1 show photographs of the as-received #1 cylinder, piston, and piston pin from the right engine. The piston was intact and the outer surface contained minor amounts of black combustion deposit. The head portion of the piston at the bevel edges showed evidence of minor erosion features; and the skirt portion showed evidence of minor longitudinal scoring marks (see figures 2 and 3).² The piston rings were intact. The surface of the wrist pin and the bore for the wrist pin showed no evidence of wear.

The inner surface of the combustion chamber for the #1 cylinder in the areas of the barrel portion contained evidence of circumferential scoring marks consistent with a machine polished surface with no evidence of longitudinal scoring or gouging³

¹ It is a six-cylinder, horizontally opposed aircraft engine.

² Scoring - marring or scratching of a smooth surface. It is most often caused by sliding contact with a mating member having a hard projection or embedded particle on its surface.

³ Gouge is a groove, cavity, or depression on the surface of an object.

marks. The head portion of the intake and exhaust valves were intact and showed no evidence of deformation. The exposed head portion of the intake valve (larger diameter) exhibited a dark film consistent with combustion deposit. The exhaust valve (smaller diameter) exhibited a lighter tint, minor grit blast-like, surface appearance compared to the intake valve. The inner top surface of the combustion chamber in many areas exhibited minor grit blast-like appearance.

#5 Piston and Cylinder from the Right Engine

Figures 4 and 5 show photographs of the as-received #5 cylinder and piston from right engine. The piston was intact and the head portion contained heavy black combustion deposit. The piston rings were intact and the skirt portion of the piston showed evidence of minor longitudinal scoring marks. The surface of the wrist pin and the bore for the wrist pin showed no evidence of wear.

The combustion chamber of the cylinder for the piston exhibited a mirror-like polished finish and the barrel portion of the combustion chamber showed no evidence of longitudinal scoring or gouge marks. The head portion of the intake and exhaust valves were intact and showed no evidence of deformation. The exposed head portion of the intake valve (larger diameter) exhibited a dark black-brown tint whereas the exhaust valve exhibited a light grey-blue tint.

The entry port for the injector nozzle contained a white and dry residue, see figure 5. A cotton tipped applicator at the end of a wood handle was dosed with acetone and then the cotton end was rubbed against the white residue. The residue at the end of the cotton swab was analyzed by Fourier transform infrared (FTIR) spectroscopy analysis. The result of the analysis is reported in Appendix 1.

#3 Piston, Cylinder, and Fuel Injector from the Left Engine

Figures 6 and 7 show photographs of the as-received #3 cylinder, piston, fuel tube and injector nozzle from the left engine. The piston was intact and the outer surface of the piston and inner surface of the cylinder (combustion chamber) exhibited appearance similar to those of the #5 piston and cylinder for the right engine.

Bench binocular microscope of the fuel injection nozzle revealed the outer threads and exposed port of the injection nozzle were covered with a black deposit. The fuel injector nozzle was disassembled. Light was illuminated through one end of the nozzle while the other end was inspected with a bench binocular microscope. Light passed through the nozzle and there was no evidence of foreign matter blocking the nozzle. The fuel injector nozzle was ultrasonically cleaned with Alconox, a commercial detergent. Post-cleaning binocular microscope examination of the fuel

injector nozzle revealed the crown portions of the outer threads were intact and showed no evidence of shearing (thread stripping).

Submitted by:

Frank Zakar
Senior Metallurgist

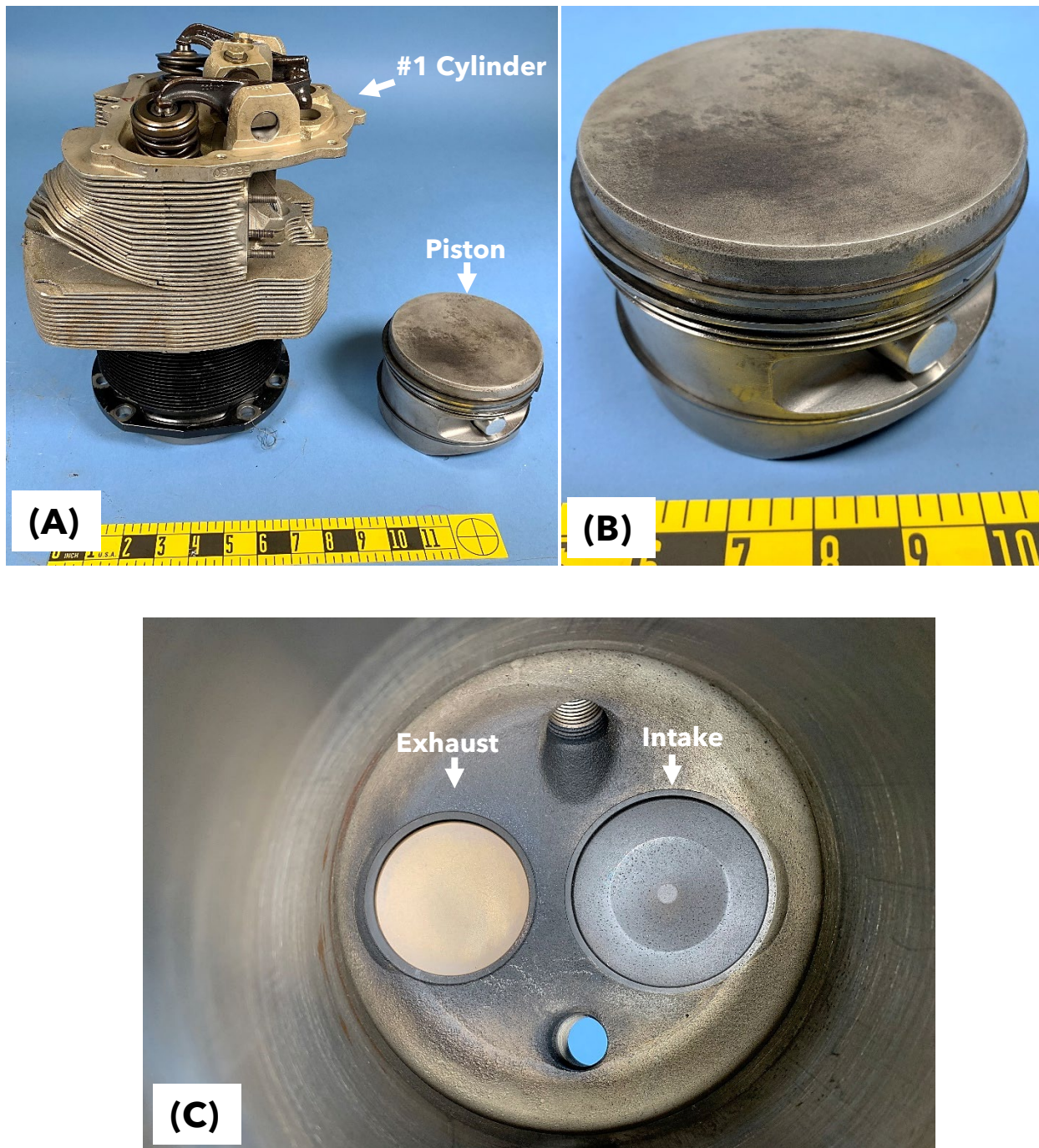


Figure 1. Overall view of (A) the #1 cylinder and piston with piston pin from the right engine; (B) oblique view of the piston; and (C) internal view of the cylinder combustion chamber showing the head portion of the intake and exhaust valves.

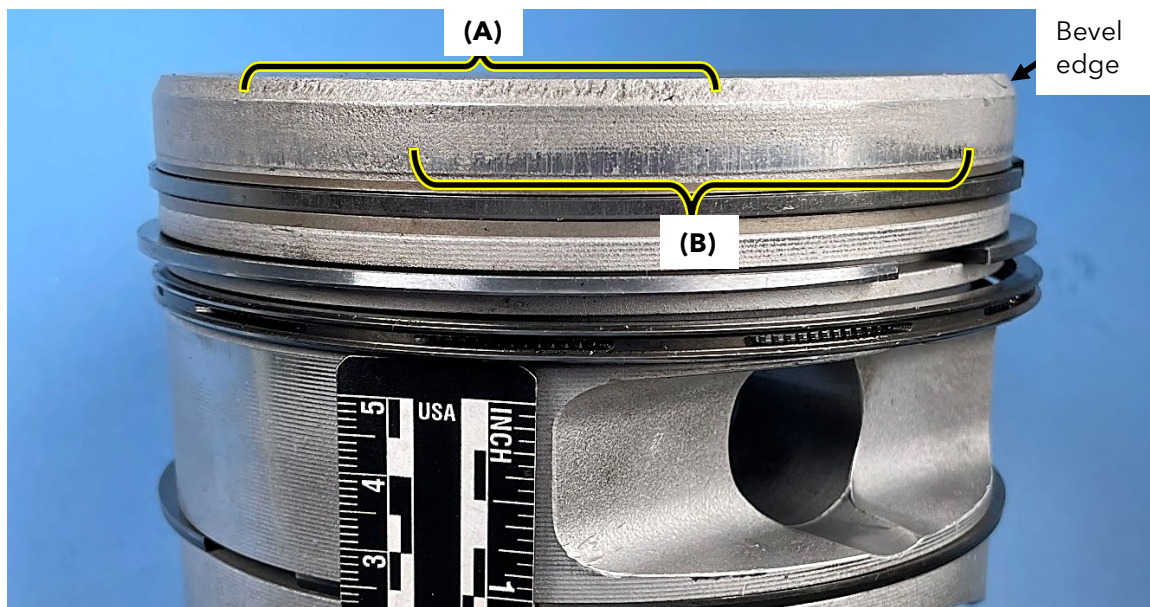


Figure 2. Side view of the piston from the right engine's #1 cylinder showing mechanical damage at the bevel edge of the head, such as (A) minor erosion features, and (B) minor axial scrape marks.

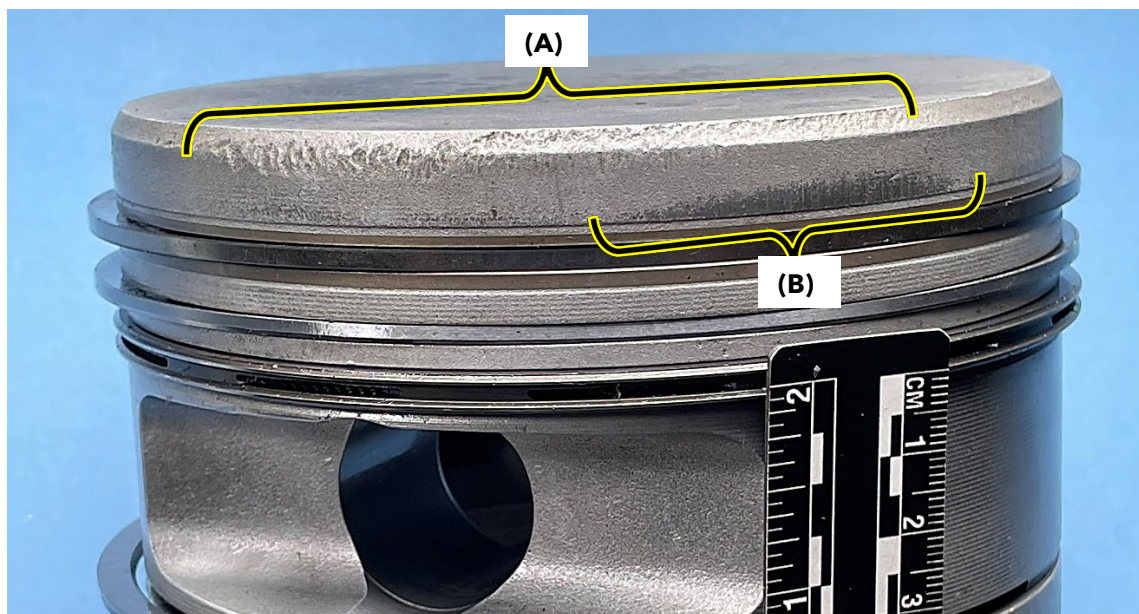


Figure 3. Side view of the piston from the right engine's #1 cylinder showing mechanical damage at the bevel edge of the head, such as (A) minor erosion features, and (B) minor axial scrape marks; from an area located nearly diametrically opposite shown in figure 2.

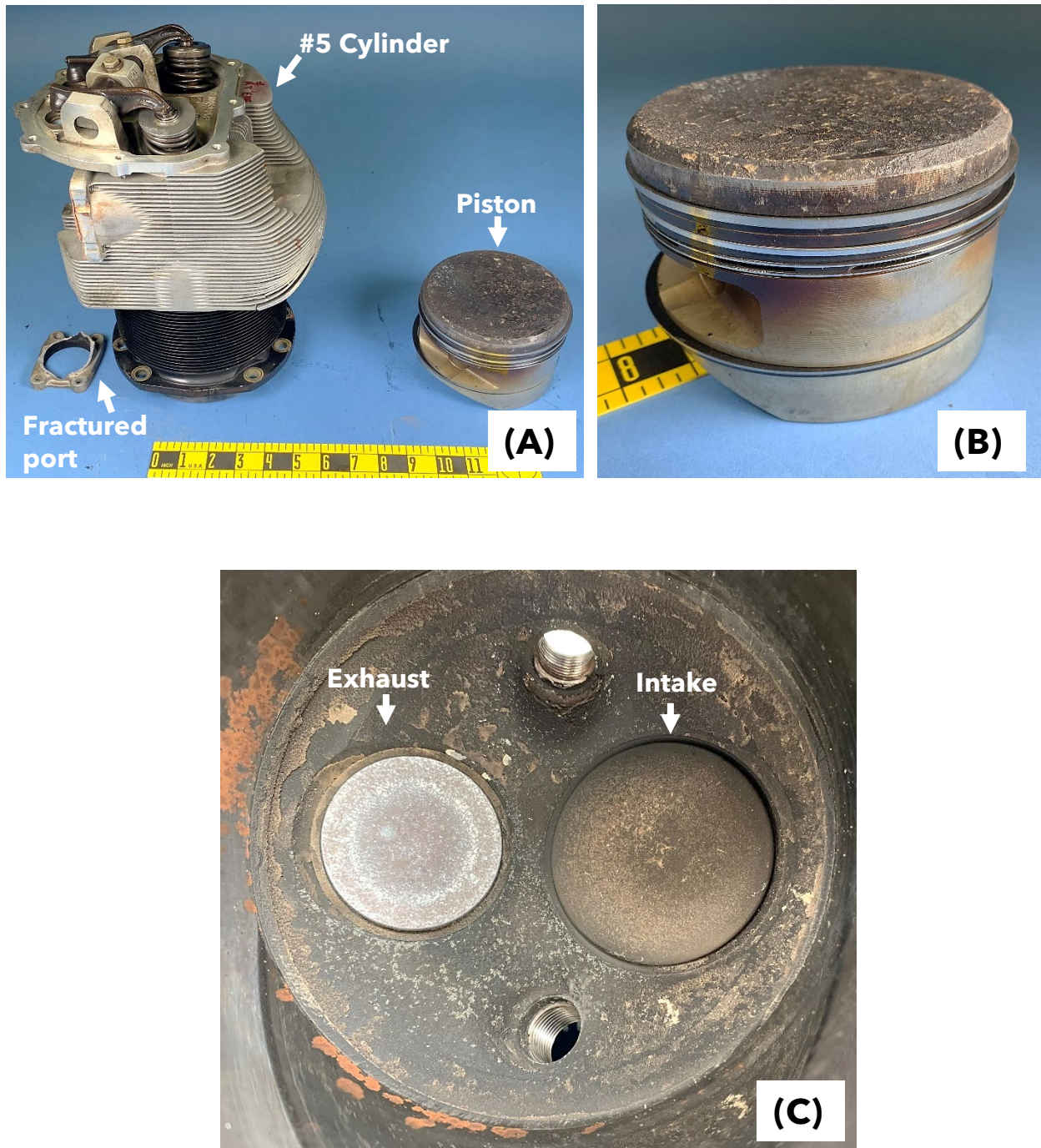


Figure 4. Overall view of (A) the #5 cylinder, fractured port from the exhaust/intake port, and piston without piston pin from the right engine; (B) oblique view of the piston; and (C) internal view of the cylinder combustion chamber showing the head portion of the intake and exhaust valves.



Figure 5. View of the #5 cylinder showing white residue at the entry port for the injector nozzle.

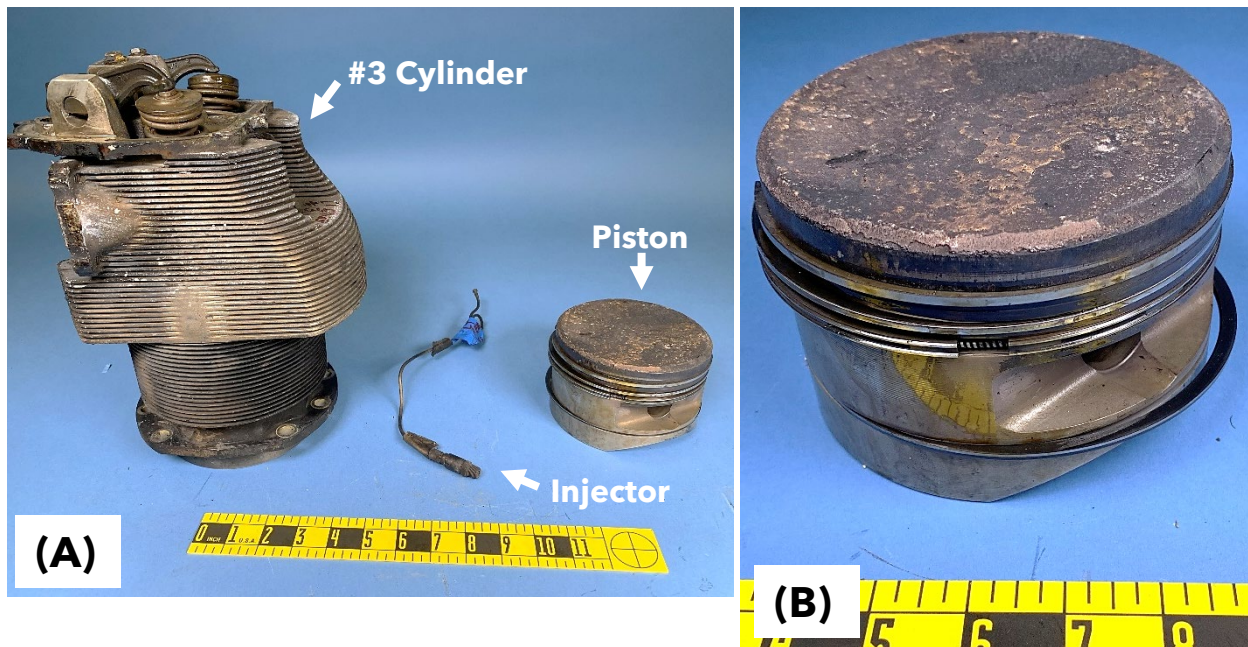


Figure 6. Overall view of (A) the #3 cylinder, piston without piston pin, and fuel injection nozzle with tube, from the left engine; (B) oblique view of the piston; and (C) internal view of the cylinder combustion chamber showing the head portion of the intake and exhaust valves.

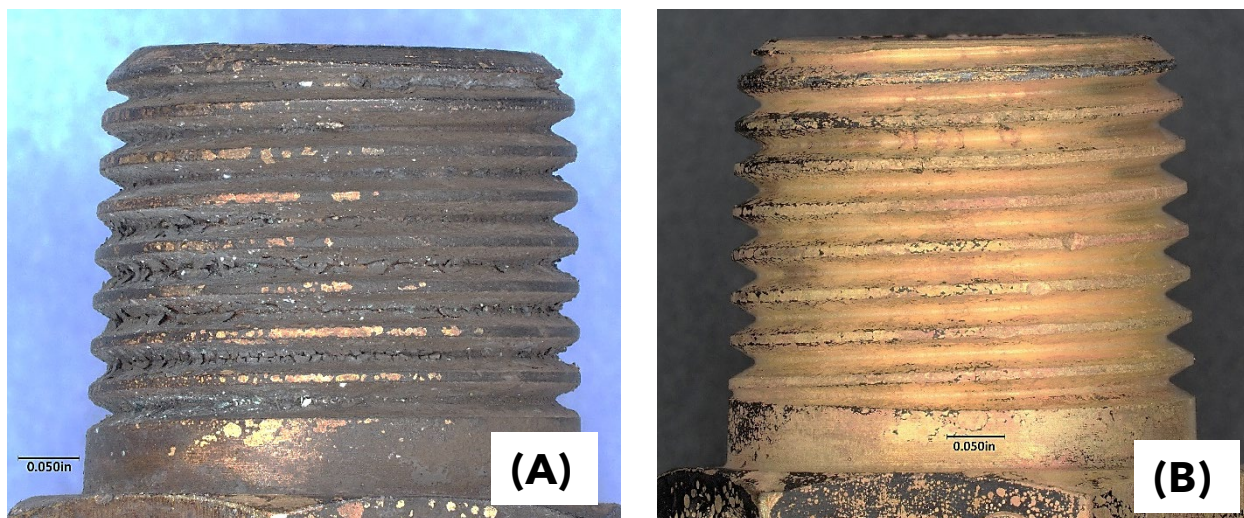
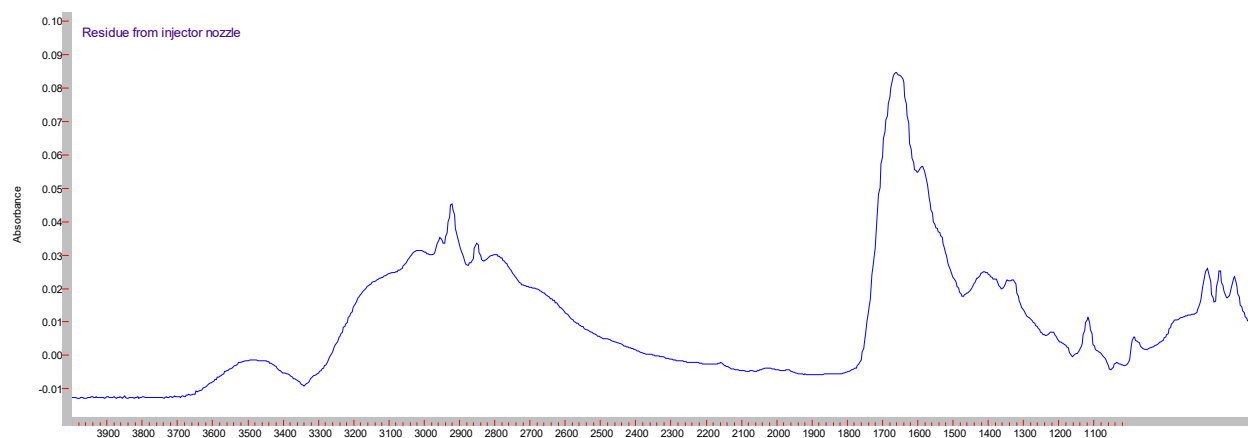


Figure 7. Side view of the fuel injection nozzle from the #3 cylinder of left engine in the (A) as-received condition and (B) after cleaning.

APPENDIX 1

**Results of FTIR Analysis for the White Residue
Found at the Entry Port for the Injector Nozzle
of the #5 Cylinder**

The surface outside of the fuel injector nozzle was swabbed using a white cotton swab. This sample was examined using a Fourier Transform Infrared (FTIR) spectrometer with a diamond attenuated total reflectance (ATR) accessory in accordance with ASTM E1252-98 (American Society for Testing Materials E1252-98: *Standard Practice for General Techniques for Obtaining Infrared Spectra for Qualitative Analysis*). The spectrometer was used to collect and process infrared wavelength absorbance spectra of the unknown material(s). The FTIR spectrum from the sample is shown below.



The spectrum for the material contained the following combination of spectral peaks corresponding to particular functional groups found within molecular structure of the material. The presence of a broad peak at $\sim 3480\text{ cm}^{-1}$ is indicative of an oxygen-hydrogen (O-H) stretching bond. Another broad peak $\sim 3000\text{ cm}^{-1}$ is indicative of a nitrogen-hydrogen (N-H) stretching bond. The presence of a triplet peak at $\sim 2920\text{ cm}^{-1}$ $\sim 2850\text{ cm}^{-1}$ and $\sim 2800\text{ cm}^{-1}$ is indicative of a carbon-hydrogen (C-H) single stretching bond. A peak at $\sim 1660\text{ cm}^{-1}$ is indicative of a carbon-oxygen (C=O) stretching double bond. A broad medium peak at $\sim 1580\text{ cm}^{-1}$ is indicative of a nitrogen-hydrogen (N-H) bending bond. A single peak at $\sim 1415\text{ cm}^{-1}$ is indicative of a carbon-hydrogen₂ group bending bond. A single peak at $\sim 1330\text{ cm}^{-1}$ is indicative of a carbon-oxygen (C-O) bending bond. A weak peak $\sim 1200\text{ cm}^{-1}$ is indicative of a carbon-nitrogen (C-N) stretching bond. A peak at $\sim 1100\text{ cm}^{-1}$ is indicative of a carbon-oxygen-carbon (C-O-C) bond. A peak at $\sim 620\text{ cm}^{-1}$ is indicative of a nitrogen-hydrogen (N-H) out-of-plane bending bond. The spectrum was consistent with a carboxyamine or a mixture of materials containing amines and carboxylic acids. A spectral library search was performed on the swab sample spectrum. No matches were found, however, there were similarities to several surfactants (which often contain amines) as well as other amines and carboxylic acids. Common additives to aviation gasoline used for deposit control, antioxidants and anti-corrosion control often contain these types of materials. The material on the surface of the cylinder was likely the residue left when the fuel evaporated.