

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594



May 8, 2017

MATERIALS LABORATORY FACTUAL REPORT

Report No. 17-041

1. ACCIDENT INFORMATION

Place : Franklin, Virginia
Date : December 10, 2016
Vehicle : EAB Lightning, N59JL
NTSB No. : ERA17LA067
Investigator : Timothy Monville, AS-ERA

2. COMPONENTS EXAMINED

No. 2 cylinder barrel and head
No. 2 piston with connecting rod

3. DETAILS OF THE EXAMINATION

On December 10, 2016, about 1215 eastern standard time, a privately owned and operated experimental amateur-built Lightning was substantially damaged when it impacted terrain in Franklin, Virginia. The commercial pilot sustained minor injuries and the passenger sustained a serious injury. The pilot stated that during initial climb, she felt a vibration that soon stopped. She continued the takeoff and noted that the exhaust gas temperature (EGT) readings were high, and the number 2 cylinder EGT had exceeded the maximum limit. When the airplane experienced a partial loss of engine power, the pilot stated that she returned to the airport keeping the throttle at full. On the return, the pilot stated she reduced the throttle after which the airplane impacted trees where it remained suspended.

The cylinder (barrel and head), along with the piston and the connecting rod, from the number 2 position in the Jabiru 3300 engine (S/N 33A1085) were retained and sent to the NTSB Materials Laboratory for further examination.¹ These components are pictured in Figure 1, as received.

The cylinder, normally affixed with four through-bolts on the outside of the barrel, had been disassembled, as received. The valves were still part of the cylinder assembly, along with the rocker arms. The face of the cylinder head is shown in Figure 2 and Figure 3. These surfaces exhibited flat, flaky compounds that adhered to all the inner surfaces. These compounds generally exhibited a brownish-yellow color, with a waxy luster.

¹ The Jabiru 3300 is a lightweight four-stroke, horizontally opposed six-cylinder air-cooled aircraft engine produced by Jabiru Aircraft, Bundaberg, Australia. The engine is used to power homebuilt and ultralight aircraft.

These compounds were examined using a scanning electron microscope (SEM). One such particle is illustrated in Figure 4. As imaged using backscattered electrons, these particles contrasted bright white against other examined particles, consistent with higher atomic mass elements.² Inspection using energy dispersive x-ray spectroscopy (EDS) found these particles to be consistent with lead oxides and lead bromide, as typified in Figure 5. These compounds were consistent with compounds that form after combustion of tetraethyl lead and 1,2-dibromoethane—the anti-knocking and lead scavenging additives in aviation gasoline (avgas).

The chemical composition of the cylinder was inspected using x-ray fluorescence (XRF). The composition was consistent with an AA 5086 aluminum alloy. As this alloy cannot be strengthened by heat treatment, hardness and conductivity testing was not performed.

Figure 6 shows damage to the inside of the cylinder barrel, which had been separated prior to examination. The inner surface damage manifested as wear scars. This was consistent with sliding wear from the adjacent piston crown and piston pin. The mating damage to the piston assembly is shown in Figure 7.

The sides of the piston exhibited material loss from wear and material spalling. The crown of the piston exhibited a rough surface, with erosion of the surfaces facing the cylinder head and barrel. These piston surfaces contained the same deposits found on the cylinder head (Figure 8). The most damaged corner of the piston, illustrated in Figure 9, allowed light to shine through the spalled regions. This cavity was consistent with gas blow-by of the piston past the oil rings. This piston damage was consistent with the damage on the inner surface of the barrel.

The high amount of lead-based compounds, rough texture and spalling of the piston, and sliding damage to the cylinder barrel were consistent with damage incurred from pre-ignition.³

Erik Mueller
Materials Research Engineer

² SEM micrographs produced using backscattered electrons display contrast that is associated with the atomic numbers of the elements in the micrograph. Materials containing elements with higher atomic numbers visually appear lighter relative to other materials containing elements with lower atomic numbers.

³ Pre-ignition in reciprocating engines is the uncontrolled firing of the fuel-air mixture in a combustion chamber prior to the occurrence of normal ignition.

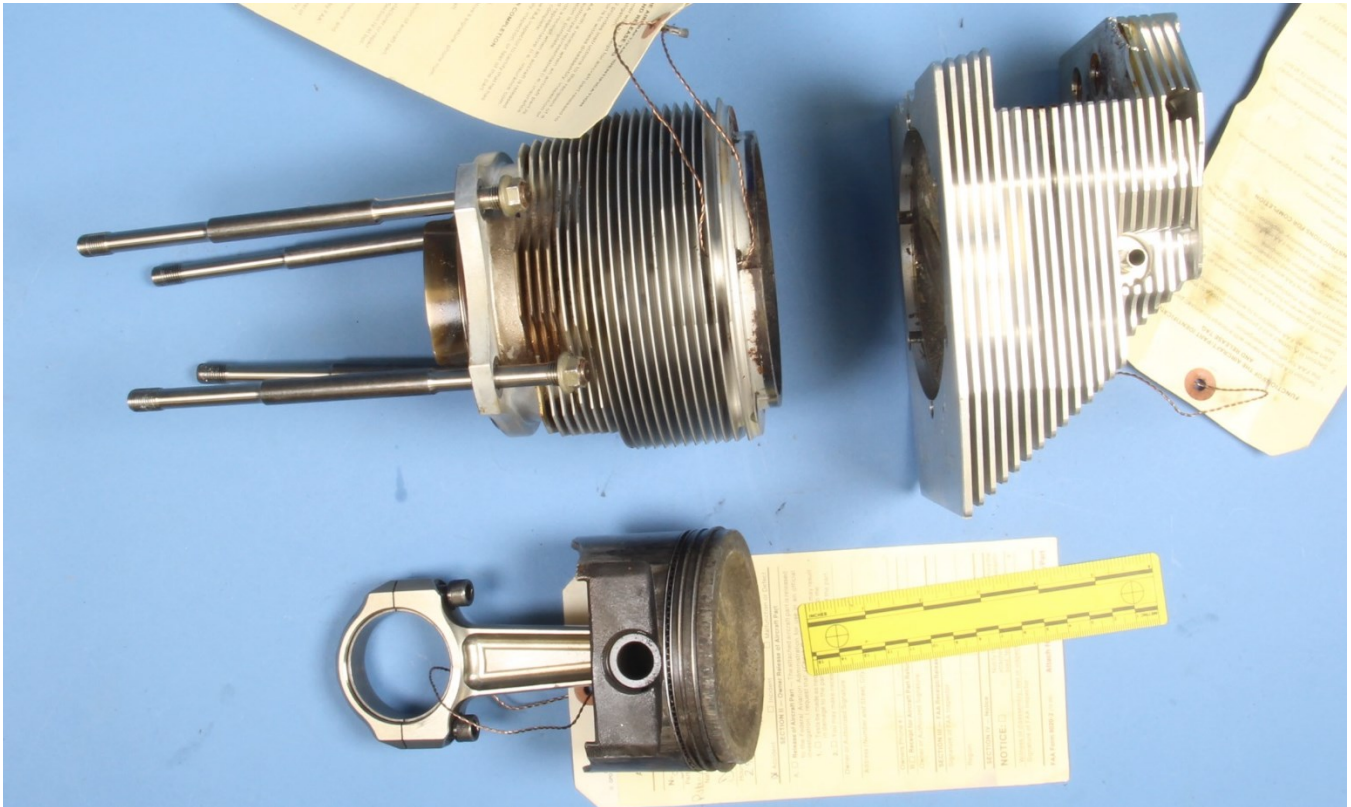


Figure 1 – The components from the engine, as received.



Figure 2 – View of the cylinder head with the valve faces, as received.



Figure 3 – A closer view of the cylinder head, showing adherent lead-based compound deposits (brownish-yellow) on the valve faces and cylinder surfaces.

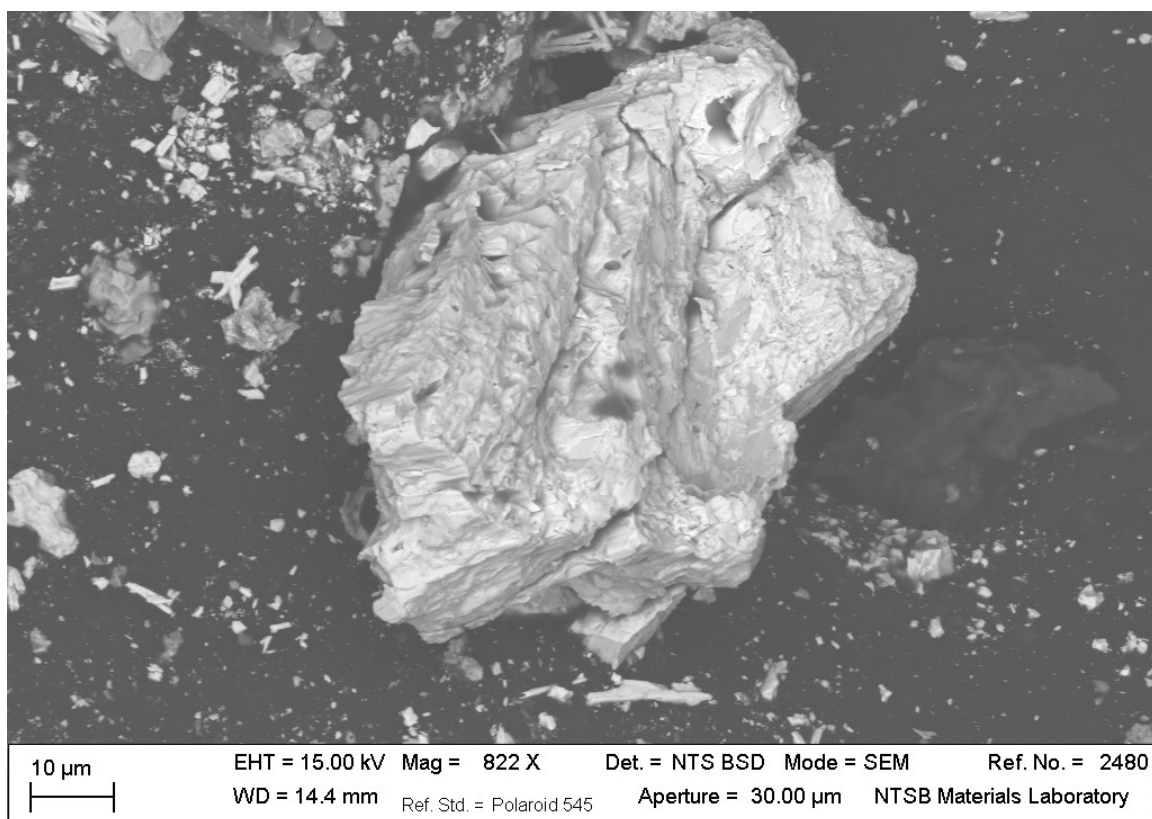


Figure 4 – Backscattered electron (BE) micrograph of a lead-based compound on the cylinder head.

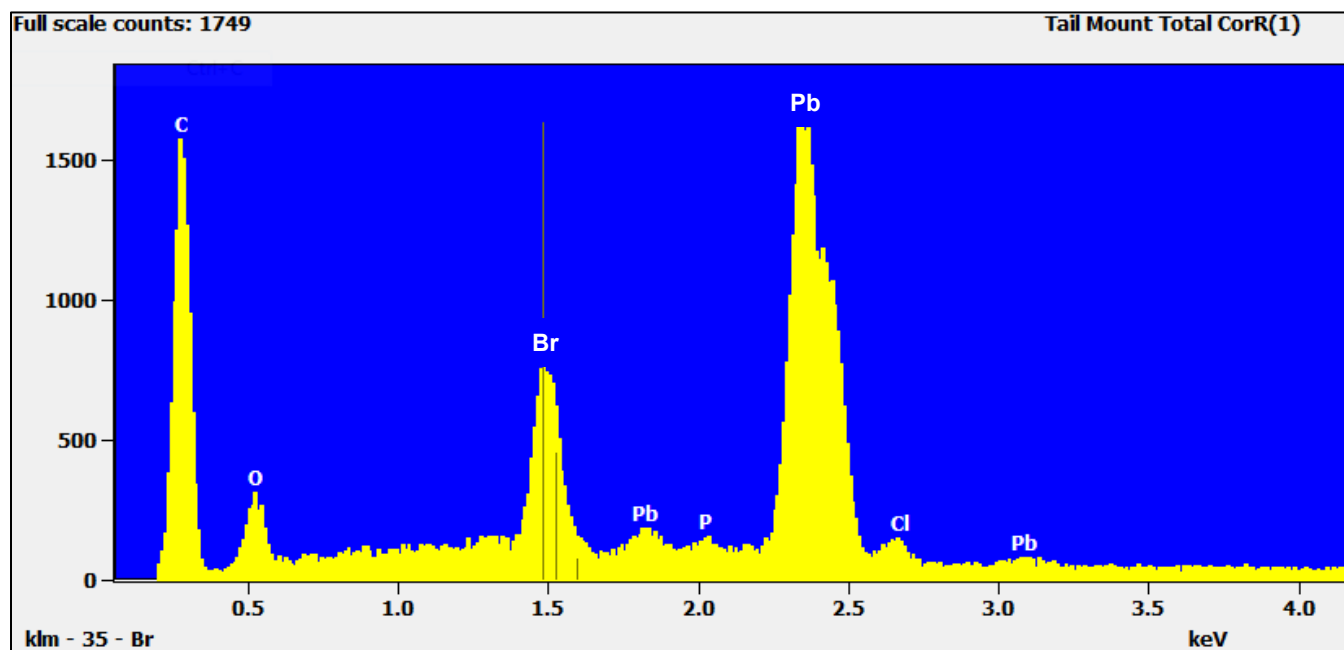


Figure 5 – Energy dispersive spectroscopy (EDS) spectrum of the particle shown in Figure 4.



Figure 6 – Angled view of the interior of the cylinder barrel, showing sliding wear and rough erosion scars on the surface.



Figure 7 – Closer view of the blow-by damage on the corner of the piston crown.



Figure 8 – View of the face of the piston crown, showing deposits, and erosion damage about the periphery.



Figure 9 – View of material loss due to wear on a corner of the piston crown, showing where blowby occurred past the oil rings.