

NATIONAL TRANSPORTATION SAFETY BOARD

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



February 25, 2021

MATERIALS LABORATORY FACTUAL REPORT

Report No. 21-006

A. ACCIDENT INFORMATION

Place : McMinnville, TN
Date : September 8, 2020
Vehicle : Piper PA28-181, N4166Z
NTSB No. : ERA20LA309
Investigator : Robert Gretz (AS-ERA)

B. COMPONENTS EXAMINED

No. 4 cylinder pieces, piston head, and piston pin.

C. DETAILS OF THE EXAMINATION

The no. 4 cylinder was submitted separated into 2 pieces, as shown in Figure 1. The separation occurred between the 3rd and 4th cooling fins. The following part markings were observed on the external surfaces of the cylinder:

AC1BUA197
1307FS2 295H18

A flat fracture with thumbnail-shaped arrest marks consistent with fatigue cracking, visible in Figure 2, was observed around approximately 180 degrees of the cylinder circumference (white dashed line, Figure 1). The fatigue cracking emanated from the vertical stiffener on the front of the cylinder between the 3rd and 4th fins (Figures 3 and 4). The fatigue cracking appeared to initiate at the start of the fillet between the vertical stiffener and the circumferential outer wall of the cylinder (yellow arrow, Figure 5). The remainder of the fracture surface was consistent with overstress.

The piston head and piston pin were also submitted, as shown in Figure 6. Dark colored carbon deposits consistent with combustion byproduct were observed on the flat top of the piston head. A light tan color was observed on the piston skirt consistent with staining from oxidized engine oil. Light wear marks were observed around the circumference of the piston pin from where it mated to the piston head.

The hardness of the cylinder material was measured on the designed flat on the intake side of the cylinder head near the barrel junction. The hardness of the cylinder

material measured approximately 59 HB/10mm/500kgf (converted from 19.9 HRA¹). The hardness specified on the manufacturer drawing was 60-75 HB/10mm/500kgf.

A portion of one cooling fin was sectioned from the cylinder and the chemical composition was determined using standardless semiquantitative energy dispersive spectroscopy² (EDS). The measured weight percentages of the cylinder cooling fin material are compared to the composition required in manufacturer material specifications in Table 1.

Element	Weight %	Specified
Magnesium	1.45	1.2 – 1.7
Silicon	0.01	0.00 – 0.60
Titanium	0.15	0.07 – 0.25
Chromium	0.24	0.15 – 0.25
Iron	0.47	0.00 – 0.65
Nickel	2.21	1.8 – 2.3
Copper	4.23	3.7 – 4.5
Aluminum	91.23	Remainder

Table 1: EDS measured weight percentages of cylinder cooling fin material.

Adrienne V. Lamm
Materials Engineer

¹ ASTM E140, "Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness".

² Thermo Scientific System 7 energy dispersive spectral imaging system with 60 mm UltraDry silicon drift detector and Norvar light element window on a Thermo Scientific Apreo 2 field emission scanning electron microscope.

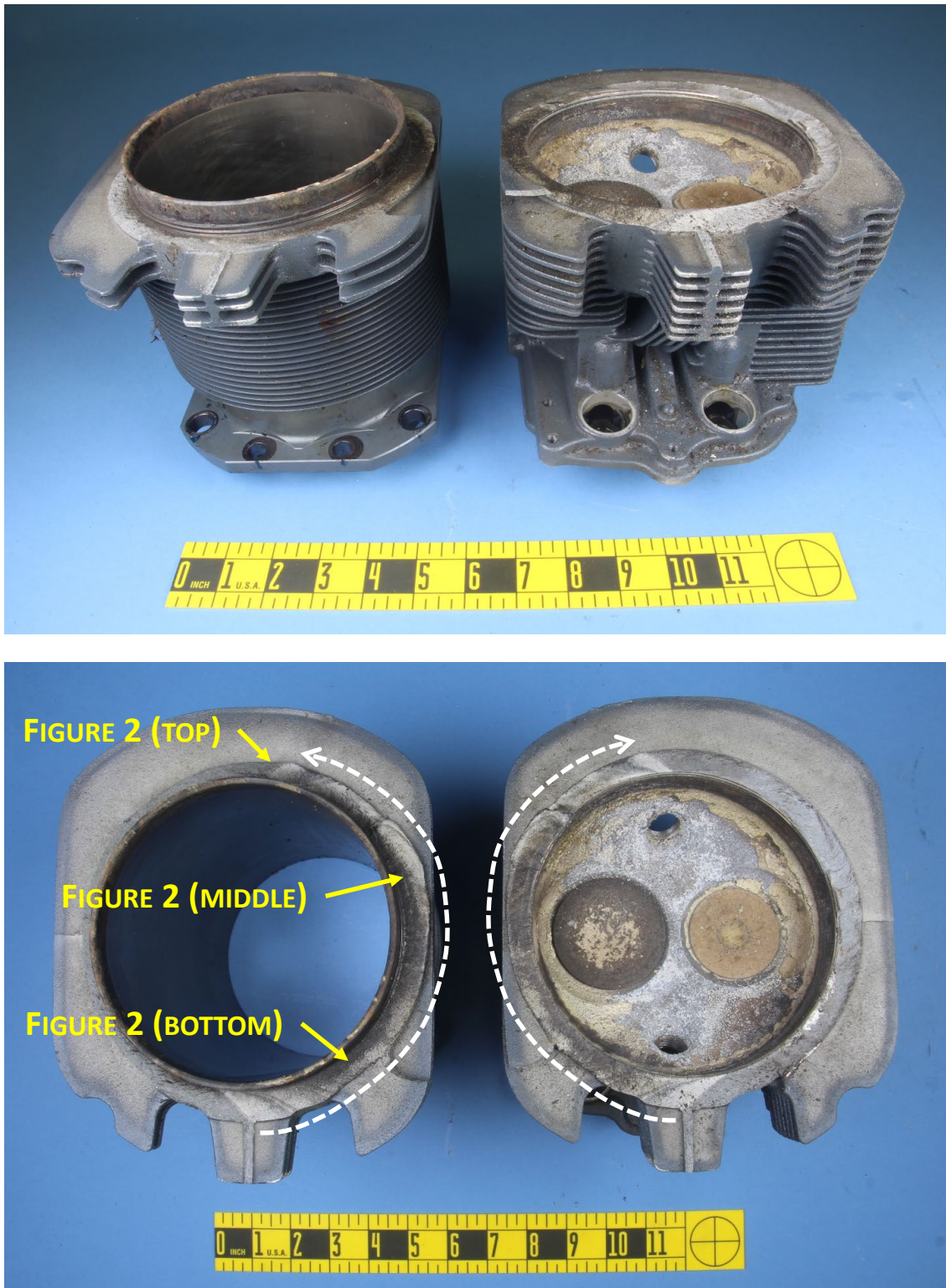


Figure 1: Overall photos of the separated no. 4 cylinder. The white dashed lines indicate the fatigue cracking on the fracture surface. The indicated areas on the bottom half fracture surface are shown in more detail in Figure 2.



Figure 2: Close-up photos of the fatigue cracking on the fracture surface on the bottom half of the cylinder. The yellow dotted line in the top image indicates the interface where fatigue cracking ended, and overstress began.

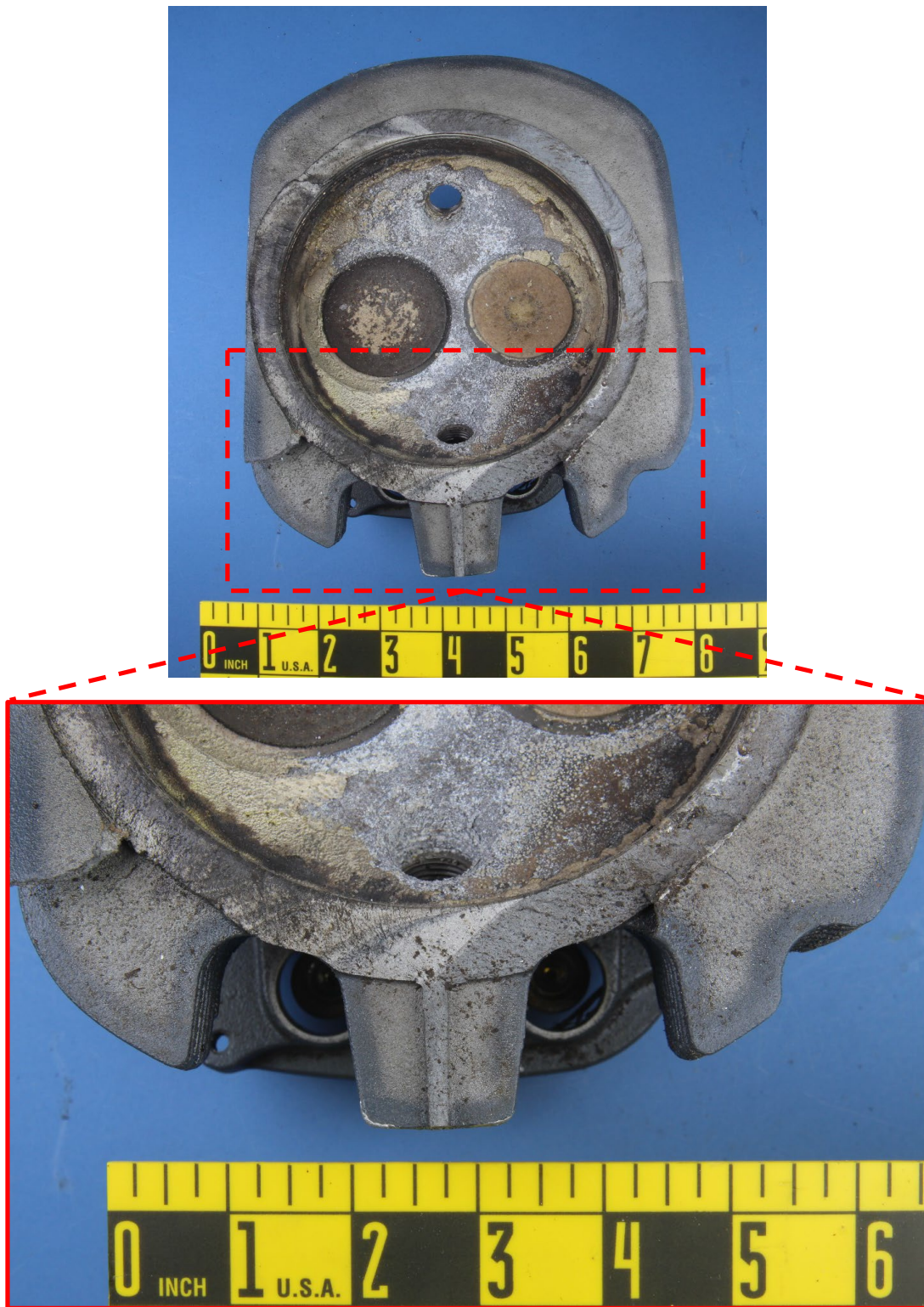


Figure 3: Overall and close-up photos of the fracture surface on the top half of the separated cylinder.

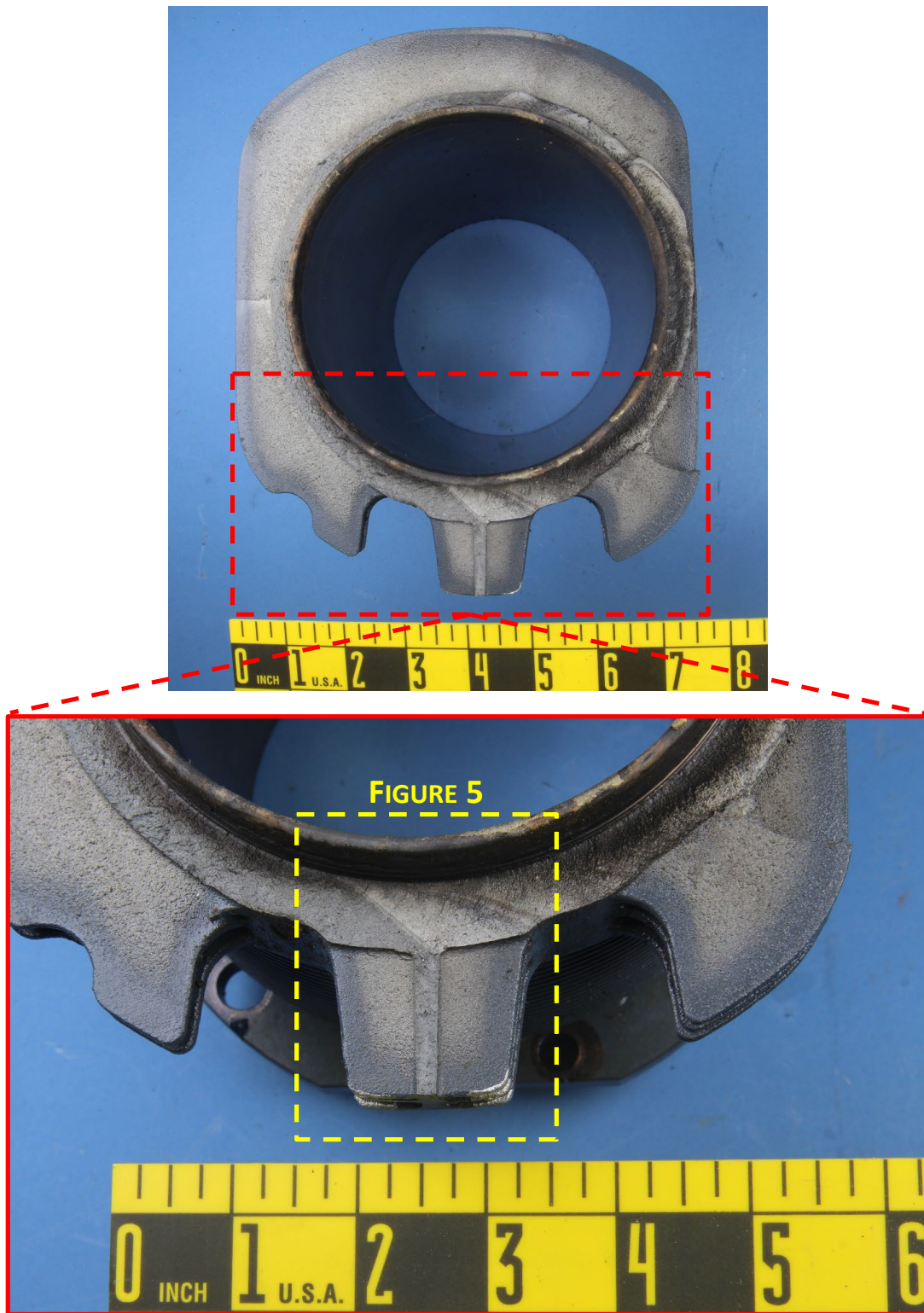


Figure 4: Overall and close-up photos of the fracture surface on the bottom half of the separated cylinder. The indicated area is shown in more detail in Figure 5.



Figure 5: Close-up photo of the fracture surface on the bottom half of the separated cylinder. The yellow arrow points to the location of fatigue cracking initiation at the start of the fillet between the vertical stiffener and the circumferential outer wall of the cylinder.



Figure 6: Overall photos of the piston head and piston pin.