

National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594



WPR24LA194

MATERIALS LABORATORY

Factual Report 25-032

July 10, 2025

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A. ACCIDENT INFORMATION

Location: Roll, Arizona
Date: June 11, 2024
Vehicle: Cessna 150M, N3156V
Investigator: Albert Nixon, AS-WPR

B. COMPONENTS EXAMINED

Number 2 cylinder assembly including valves and pushrods, number 2 piston assembly, and intake and exhaust valves from cylinders 1, 3, and 4 of a Continental O-200-A engine.

C. EXAMINATION PARTICIPANTS

Specialist Matthew R. Fox, Ph.D.
NTSB
Washington, DC

D. DETAILS OF THE EXAMINATION

An overall view of the submitted components as received is shown in figure 1. The components included the number 2 cylinder assembly with pushrods, rocker arms, rocker shaft, valve springs and seats, valve spring seat locks (keepers), and valves disassembled from the cylinder as shown in figure 1. The number 2 piston assembly with partially removed piston pin was also received as shown in figure 1. Intake and exhaust valves from the numbers 1, 3, and 4 cylinders were also received, and all the valves are shown labeled with their respective cylinder number in figure 1.

The submitted components were from a Continental O-200-A engine. The engine reportedly had 3,182.5 hours time since new and 846.7 hours time since overhaul. According to the maintenance log books for the airplane, the engine was overhauled in February 2017, when new Superior part number SA10200-A20P cylinders were installed. Over 75 percent of the hours time in service since overhaul had been accumulated after February 2022.

The intake valve for the number 2 cylinder was fractured at the neck (where the stem met the head) and the stem was bent. The piston had impact marks consistent with intake valve head and stem contact, and cracks emanated from the valve head impact area. Piston rings were fractured in the area where the piston was cracked, and a fractured piece of a piston ring is shown next to the disassembled valve train components in figure 1. Intake valve impact damage was also observed on the internal surfaces of the cylinder head, and the inboard end of the intake valve guide was deformed to a D-shaped cross section. The number 2 pushrods were both rolled

on a flat table, and each rod rolled smoothly with no gaps consistent with straight rods.

The external surfaces of the cylinder head had a uniform yellow-gray color and showed no external evidence of tinting from high temperature exposure. However, the rocker box had black flaky deposits of coked oil, particularly around the exhaust valve guide. One valve inner spring and one valve outer spring, likely from the exhaust side, were also covered with coked oil deposits, and coked oil deposits covered the exhaust valve spring seat.

The intake and exhaust rocker arms for the number 2 cylinder are shown in figure 2 after oily deposits were wiped from the surfaces. Both rocker arms had a drive screw at the pushrod end of the rocker arm consistent with an oil channel between the pushrod and the rocker bushing. However, neither of the rocker arms had a drive screw or an oil orifice for valve stem lubrication at the rocker pad end.

The Continental Aerospace Technologies Standard Practice Maintenance Manual (SPMM) includes a section titled "Rocker Arm Identification" that shows differences between the intake and exhaust rocker arm part numbers 639614 and 639615, respectively, that are installed on Continental O-200-series engines.¹ Both rocker arms have oil channels with drive screws at the pushrod end, but the part number 639615 exhaust rocker arm also has an oil channel with a drive screw and orifice at the rocker pad end. According to the SPMM, the distinction is important. "Installing rocker arms in the incorrect position may cause oil starvation to the valve train and/or shorten cylinder life."

The rocker pads for both rocker arms are shown in figure 3. Both rocker pads were worn from contact with the valve tips, and the wear patterns corresponded to mating wear patterns observed on the respective valve tips. The pad for the rocker arm installed in the exhaust position was tinted dark around the worn area, and coked oil adhered to portions of the pad surfaces around the worn area. The wear on the intake rocker arm was deeper than the wear observed on the exhaust rocker pad. Within the worn area on the intake rocker pad, the wear was deeper around the edges than at the center, forming a convex shape to the wear pattern. The edges of the intake rocker pad were also worn from contact with the inside diameter of the intake valve seat.

A closer view of the number 2 intake valve, valve seat, and keeper halves is shown in figure 4. One of the keeper halves was loosely held within the valve spring seat and could not be separated from the seat when manipulated by hand. The inside diameters of both intake keeper halves were severely worn, and the locking tab for keeping the intake valve in place was missing on both halves. The outside

¹ Standard Practice Maintenance Manual, Section 10-6.14, Continental Aerospace Technologies, Mobile, Alabama (January 2023).

diameter surfaces were also worn, and corresponding wear was observed on the inside diameter of the valve spring seat. The inboard edges of the intake keeper halves were deformed outboard, deformation that contributed to trapping one of the keeper halves within the valve spring seat.

The tip end face of the number 2 intake valve was smooth as shown in figure 5(a). The middle portion was worn more extensively than the surrounding area, forming a concave surface profile across the central portion of the surface. The outer edges around the circumference of the tip face were rounded from wear. In the keeper contact area near the tip of the stem, the surfaces were tinted black. The fracture through the stem adjacent to the head was irregular and on slant planes, features consistent with overstress fracture. A close view of the valve seat contact face is shown in figure 5(b). The contact face was worn, leaving a step on the contact face as indicated in figure 5(b).

Views of the number 2 exhaust valve are shown in figure 6. The tip end face had a circular contact pattern that was smooth from wear, and the edges at the outer circumference were rounded. Isolated pits with rounded edges were also observed on the tip end face. Thick coked oil deposits were observed at the tip end of the valve stem between the stem's shoulder and the tip end face. Keeper contact faces showed pitting and wear consistent with fretting damage. Corresponding wear was observed on the exhaust keeper halves including worn contact surfaces on the outboard sides of the locking tabs mostly near the longitudinal edges (split faces) of the keeper halves.

The valve stem had a dark tint extending up to 2.5 inches from the head end face. Substantial pitting damage was observed on the stem between 1.5 inches and 2.2 inches from the head end face as indicated in figure 6(a). The valve seat contact area mostly had a black, glazed appearance as shown in figure 6(b). The contact area for the valve seat appeared uneven around the circumference. Isolated areas of dark gray deposits and radially-oriented streaks were also observed on the valve seat contact area around the circumference.

On the intake valves from cylinders 1, 3, and 4, the tip end faces generally had a smooth, worn appearance with circular wear patterns. However, the number 4 intake valve tip had two areas of linear rocker pad contact marks consistent with at least two instances of interrupted valve rotation. Isolated pits with rounded edges were also observed on each of the tip end faces. Remnants of linear grinding marks likely from original manufacture were observed at the outer edge of the tip end face on valves 1 and 3.

Each of the intake valves from cylinders 1, 3, and 4 had circumferential gouges and adjacent linear scrape marks near the tip end of the valve stem. Gouged and scraped areas on the number 4 intake valve stem are shown in figure 7(a and b).

Thick black deposits were observed on the stem side of the head on each of the intake valves from cylinders 1, 3, and 4. A view of typical deposits on the number 4 intake valve are shown in figure 7(c). Flattened deposits were also observed on the valve seat contact surfaces on each valve, including the number 4 valve seat contact face shown in figure 7(c). On the number 4 intake valve, the deposits on the valve seat contact face were also associated with radial flow lines. Tan deposits were observed on portions of the head end face of the number 4 intake valve that were not observed on other intake valve heads.

On the exhaust valves from cylinders 1, 3, and 4, the tip end faces generally had a smooth, worn appearance with a circular wear pattern. Isolated pits with rounded edges were also observed. The outer edges of the number 3 valve tip end face were slightly rounded.

Coked oil was observed between the stem shoulder and the tip end face on each of the exhaust valves from cylinders 1, 3, and 4. The keeper lock contact areas on the outboard sides of the keeper grooves were slightly worn on each of the exhaust valves. Additionally, fretting contact damage was observed at the keeper contact surfaces on the number 4 exhaust valve.

Dark tinting was observed on the numbers 1, 3, and 4 exhaust valve stems up to 2 inches, 1.75 inches, and 1.7 inches from the head end face, respectively. Pitted areas were observed within the dark tinted areas on each of the exhaust valves. Longitudinally-oriented black streaks were observed near the outboard end of the dark tinted areas on the numbers 1 and 3 exhaust valve stems.

The numbers 1, 3, and 4 exhaust valve seat contact faces all had a black glazed appearance. Isolated areas of dark gray deposits and radially-oriented streaks were also observed around the circumference on each of the exhaust valve seat contact areas. The head end face of the number 4 exhaust valve had a roughly circular pattern of black, red, orange, and yellow colors from the middle to the outer edges which differed from the more uniform dark colors observed on the other exhaust valve end faces.

The intake and exhaust valve guides in the number 2 cylinder assembly were cleaned by dragging a cloth through the guide. After cleaning, the valve guide inside diameters were measured using a telescoping bore gauge at multiple axial positions along the lengths of the guides. The outside diameters of the number 2 valve stems were measured using a micrometer near the tip on both valves and in the pitted area on the exhaust valve. Results of the measurements are listed in table 1.

Table 1. Number 2 Cylinder Valve Guide and Valve Stem Diameter Measurements

Component	Diameter	Axial Location	Intake Measurement (inch)	Exhaust Measurement (inch)
Valve guide	Inside	Near outboard end	0.3445	0.4406
Valve guide	Inside	Middle	0.3436	0.4403
Valve guide	Inside	Near inboard end	Not measured (damaged)	0.4430
Valve stem	Outside	Near tip	0.3422	0.4324
Valve stem	Outside	Pitted area	Not applicable	0.4294

The cylinder head was marked with "SA10200", consistent with a cylinder made by Superior Air Parts for the Continental O-200 engine. According to Superior Service Letter L92-01G, the SA10200 cylinder should be maintained using the original equipment manufacturer instructions.² Therefore, results listed in table 1 were compared to values in the Table of Limits for the Continental O-200 engine provided by a representative of Continental Aerospace Technologies. The Table of Limits included minimum and maximum diameter values for new valve guides and valve stems, and service limits for the valve in guide diametral clearance.

While the outside diameter of the number 2 intake valve stem was within the range of values for a new intake valve stem as listed in the Table of Limits, both measurements of the outside diameter of the number 2 exhaust valve stem were below the lower limits for diameters of either exhaust valve stem listed in the Table of Limits (two part numbers were listed).³ Referencing the valve guide measurements, the inside diameter of the number 2 intake valve guide at the middle axial position was within the specified range listed in the Table of Limits for a new valve guide bore, but the inside diameter at the outboard end exceeded the maximum value. The inside diameter of the number 2 exhaust valve guide exceeded the maximum value of a new exhaust valve guide bore at all three measured positions.

² Service Letter L92-01G, *Subject: Installation, Operation, and Maintenance for SA10200 Cylinder Power Assemblies*, Superior Air Parts, Coppell, Texas (2005).

³ Since these parts had been used in service, comparisons to the diameter limits for new parts are provided for reference only. Comparison to service limits for diametral clearance is discussed in the next paragraph.

Using the measured values listed in table 1, the diametral clearance was calculated by subtracting the valve stem outside diameter from the valve guide inside diameter at each measurement position. If no stem diameter measurement was taken at a given axial position, the clearance was calculated using the stem diameter measured near the valve tip. By calculation, the stem to guide clearance values for the number 2 intake valve were 0.0014 inch and 0.0023 inch, which were both less than the corresponding service maximum value listed in the Table of Limits. The three stem to guide clearance values for the number 2 exhaust valve ranged from 0.0082 inch to 0.0111 inch, all of which exceeded the corresponding service maximum value listed in the Table of Limits.

Submitted by:

Matthew R. Fox, Ph.D.
Chief Technical Advisor, Materials Laboratory



Figure 1. Overall view of the number 2 cylinder assembly including disassembled components from the valve train, number 2 piston assembly, and intake and exhaust valves for the remaining cylinders as received.



Figure 2. Side view of the intake and exhaust rocker arms from the number 2 cylinder.



Figure 3. View of the rocker pads on the intake and exhaust rocker arms for the number 2 cylinder.



Figure 4. Number 2 intake valve, keepers, and spring seat.

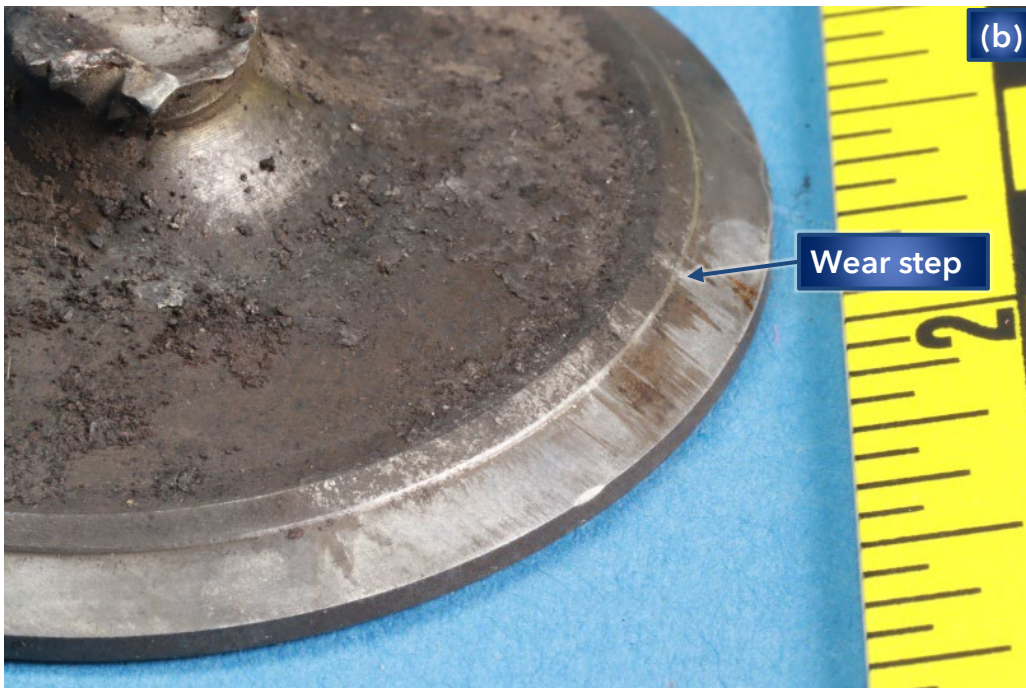


Figure 5. (a) Number 2 intake valve tip end face and (b) valve seat contact face.



Figure 6. (a) Number 2 exhaust valve with (b) a close of the valve seat contact face.

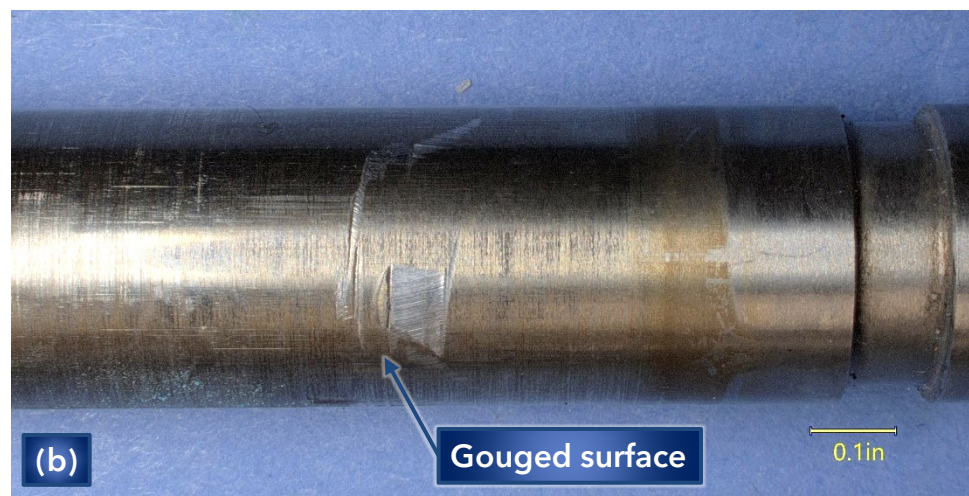
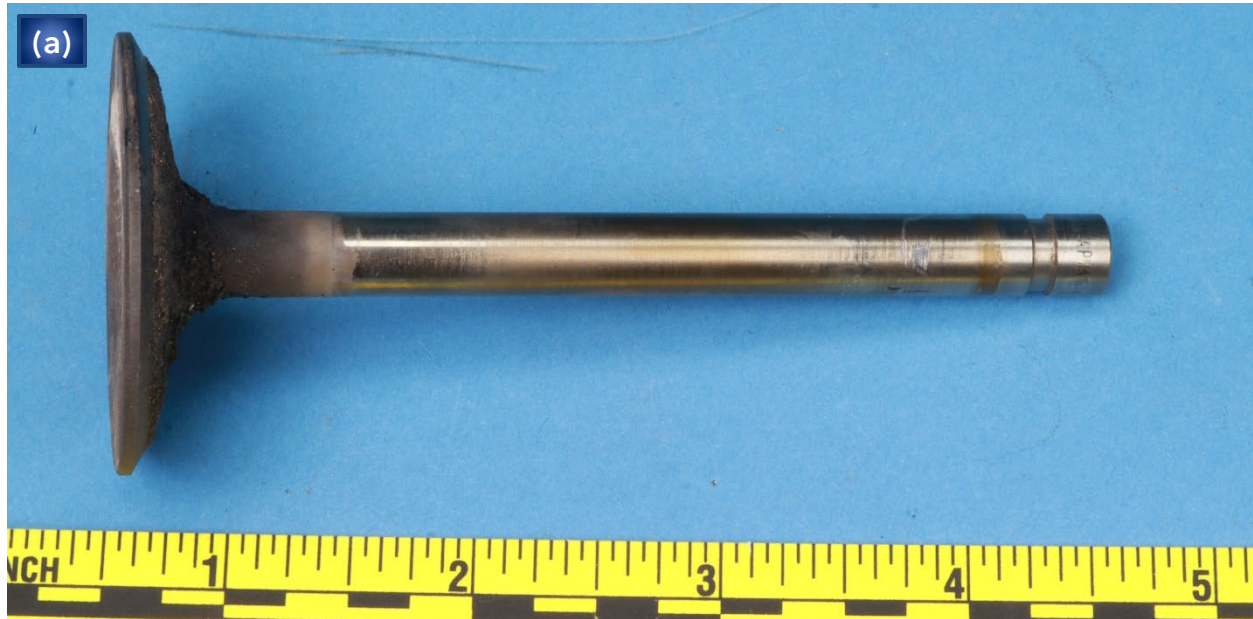


Figure 7. Number 4 intake valve (upper image) with closer views of a damaged area on the valve stem (middle image) and deposits on the stem side of the valve head including on the valve seat contact face (lower image).