

# National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



WPR23FA352

## **ENGINE TEARDOWN REPORT**

August 6, 2024

## TABLE OF CONTENTS

|                                        |    |
|----------------------------------------|----|
| A. ACCIDENT.....                       | 3  |
| B. PARTICIPANTS.....                   | 3  |
| C. SUMMARY .....                       | 3  |
| D. DETAILS OF INVESTIGATION.....       | 3  |
| 1.0 ENGINE EXAMINATION .....           | 4  |
| 1.1 Cylinders, pistons, valves.....    | 4  |
| 1.2 Crankshaft, camshaft, lifters..... | 10 |
| 1.3 Induction, airbox. ....            | 12 |
| 1.4 Exhaust .....                      | 13 |
| 1.5 Oil system .....                   | 14 |

## **A. ACCIDENT**

Location: San Pedro, California  
Date: September 25, 2023  
Time: 1250 Pacific Daylight Time  
Airplane: Sling 4 TSI, Registration N135WT

## **B. PARTICIPANTS**

|                   |                                                                                  |
|-------------------|----------------------------------------------------------------------------------|
| IIC               | Stephen Stein<br>National Transportation Safety Board<br>Federal Way, Washington |
| Party Coordinator | Jean d'Assonville<br>Sling Pilot Academy<br>Torrance, California                 |
| Technical Advisor | Jordan Paskevich<br>Rotech Flight Safety<br>Vernon, British Columbia             |

## **C. SUMMARY**

The engine was shipped to Rotech Flight Safety, Inc. in Vernon, British Columbia, Canada where it remained in storage until the engine disassembly, which took place on August 6 and 7, 2024. Examination of the engine revealed the presence of metallic fragments scattered throughout the engine case, exhaust system, airbox, turbo charger, and cylinders. Mechanical damage and gouges were observed on multiple pistons, most notably on cylinder 2 and 4 pistons. Both cylinder 4 valves were broken off at the valve stem and an unknown hardened black residue was noted on the cylinder 4 exhaust valve at the upper portion of the valve stem near the keepers.



**Figure 1: Engine on mount with firewall and engine mount removed**

## **D. DETAILS OF THE INVESTIGATION**

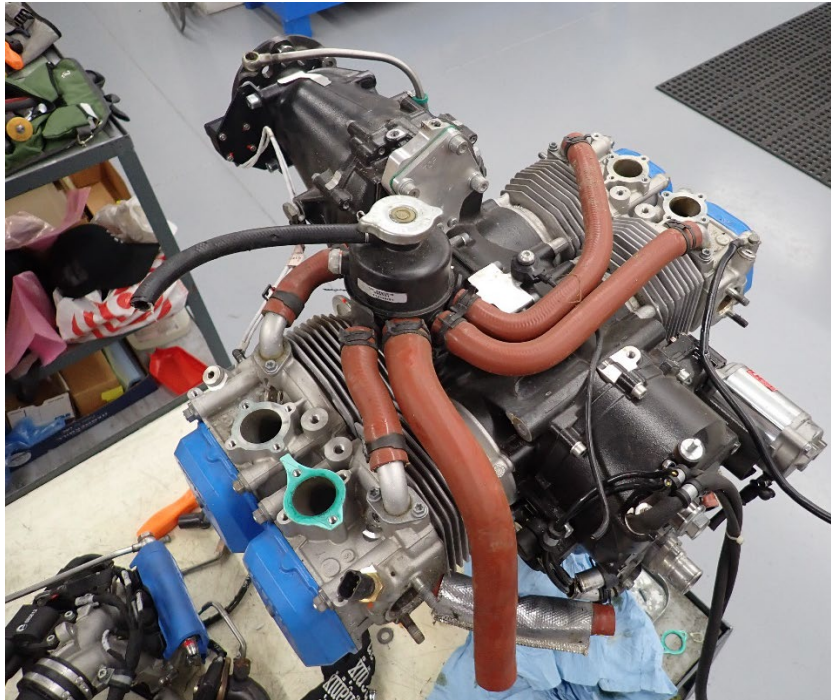
### **1.0 Engine Examination**

#### **1.1 Cylinders, pistons and valves**

The cylinders remained installed on the crankcase with all the securing hardware properly attached. Each cylinder and piston were removed and documented. Cylinder 4 exhibited extensive mechanical damage and gouging throughout the cylinder head (both spark plugs had been previously removed). The cylinder 4 piston also displayed extensive mechanical damage and gouging (consistent with the damage to the cylinder head interior). The no. 4 intake valve was separated and resting along the bottom of the cylinder wall with extensive gouge markings and deformation. The cylinder 4 exhaust valve was found inside the airbox heavily damaged and fragmented.

The cylinder 4 valve rockers, keepers and washers were unremarkable. The intake valve could not be removed; the valve face had separated, the valve stem was bent

and the upper portion of the valve stem below the keeper displayed some mushrooming. The exhaust valve also could not be removed; the valve face had separated, the valve stem was loose and exhibited some play within the guide, and the upper portion of the valve stem below the keeper displayed a hardened black material.



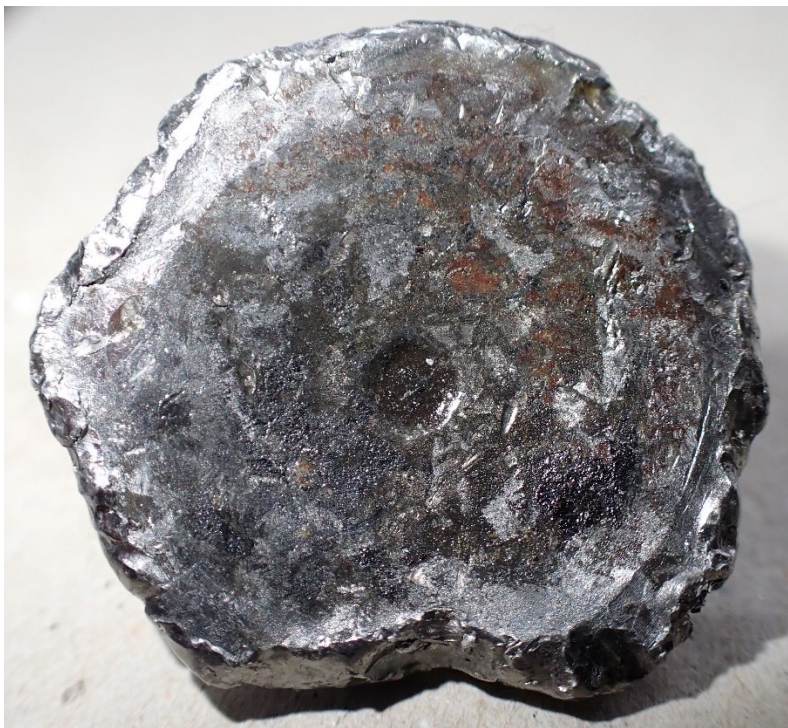
**Figure 2: Cylinders as installed in the engine (airbox removed)**



**Figure 3: No. 4 interior cylinder head and valve stems**



**Figure 4: Intake valve face circumference with deformation and gouge markings**



**Figure 5: Cylinder 4 exhaust valve face**



**Figure 6: Cylinder 4 upper portion of valve stem below keeper**



**Figure 7: Closeup of black hardened material on upper portion of exhaust valve stem below keeper**

The cylinder 2 piston face exhibited deep gouge marks along the circumference and shallow gouge marks towards the center with a trace amount of coolant and oil that had pooled at the bottom of the cylinder. A trace amount of coolant had also pooled within some of the cavities at the piston face. Fragments were also observed along the cylinder wall. Both valves (exhaust and intake) remained installed at the cylinder head, which displayed deep gouge marks near the top and bottom of the interior cylinder head and pitting at the center. The exhaust and intake valves displayed some pitting. The exhaust valve also displayed a circumferential white residue at the center. A piece of the cylinder skirt was embedded at the bottom of the interior cylinder

head.

Disassembly of the cylinder 2 valve assemblies did not reveal any mechanical anomalies with the rocker assembly, coils, keepers, washers, or push rods.



**Figure 8: Cylinder 2 piston face**



**Figure 9: No. 2 cylinder head and valves**

The no. 1 cylinder head contained some loose metallic fragments along the circumference and also some dark debris at the top of the exhaust valve near the top spark plug porthole. Both the intake and exhaust valves exhibited normal concentric burn patterns. The piston face exhibited normal burn signatures at the top and bottom of the piston at the spark plug firing positions. A dark material consistent with the debris near the exhaust valve was located at the top of the piston face. A trace amount of oil and coolant had pooled at the cylinder wall.

Disassembly of the cylinder 1 valve assemblies did not reveal any mechanical anomalies with the rocker assembly, coils, keepers, washers, or push rods.



**Figure 10: No. 1 cylinder head and valve faces**



**Figure 11: Cylinder 1 piston face inside cylinder**

The cylinder 3 piston face displayed normal burn signatures at the face with burn patterns at the top and bottom consistent with the spark plug positions. The intake and exhaust valve remained installed within the cylinder head and both showed concentric burn patterns consistent with normal wear. Some pitting was observed inside the interior cylinder head.

Disassembly of the cylinder 3 valve assemblies did not reveal any mechanical anomalies with the rocker assembly, coils, keepers, washers, or push rods.



**Figure 12: Cylinder 3 piston, cylinder head, and cylinder**



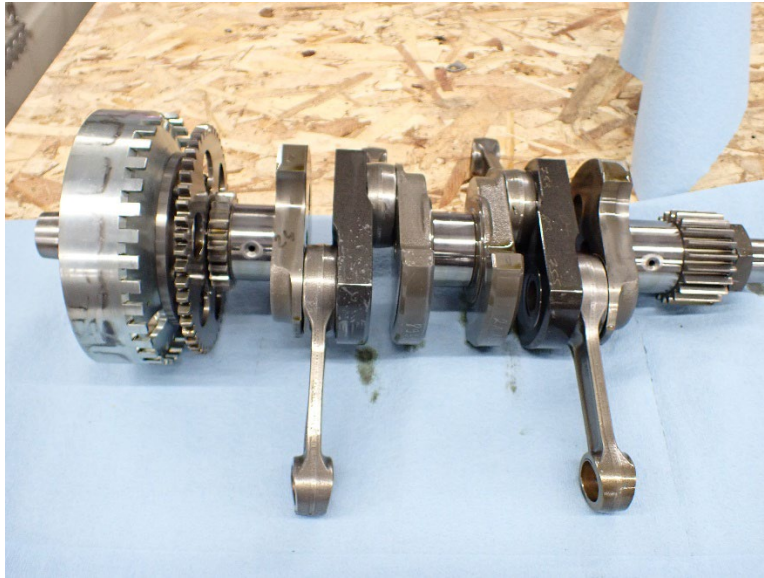
**Figure 13: Cylinder 3 piston face**

## **1.2 Crankshaft, camshaft, lifters**

Crankshaft and camshaft continuity to the accessory case was achieved after the cylinders and pistons were removed when the propeller flange was rotated using a hand tool. The connecting rods were all installed at their respective connecting rod journals and the counterweights and crankwebs were in place. The main journals appeared normal and the bearings exhibited some scoring with normal wear and some of the bearings had evidence of foreign object contact. The cylinder 4 connecting rod displayed gouge marks at the rod bushing. The camshaft lobes were normal and unremarkable.

The hydraulic lifters were all normal in appearance with no evidence of pitting, butterflying, or evidence of severe wear. Each of the hydraulic lifters were soft when

pressed at the push rod socket with the exception of the cylinder 4 exhaust, which would not depress with a hand tool. Disassembly of the cylinder 4 exhaust lifter did not reveal any anomalies.



**Figure 14: Crankshaft with counterweights, crankwebs, and connecting rods**



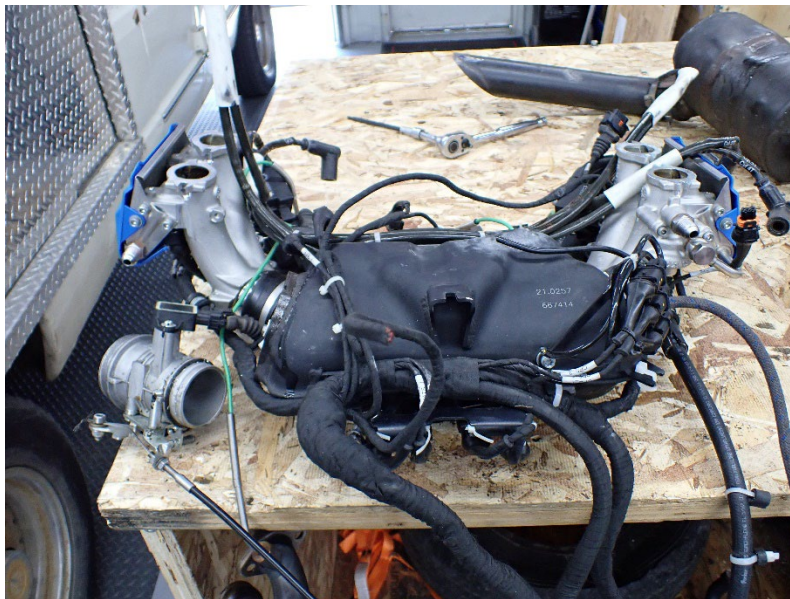
**Figure 15: Cylinder 4 connecting rod damaged bushing**



**Figure 16: Camshaft**

### **1.3 Induction, airbox**

The induction tubes were attached at each cylinder with their securing hardware in place. Each tube contained metallic fragments. The airbox contained numerous large metallic fragments including the cylinder 4 exhaust valve.



**Figure 17: Airbox and induction**



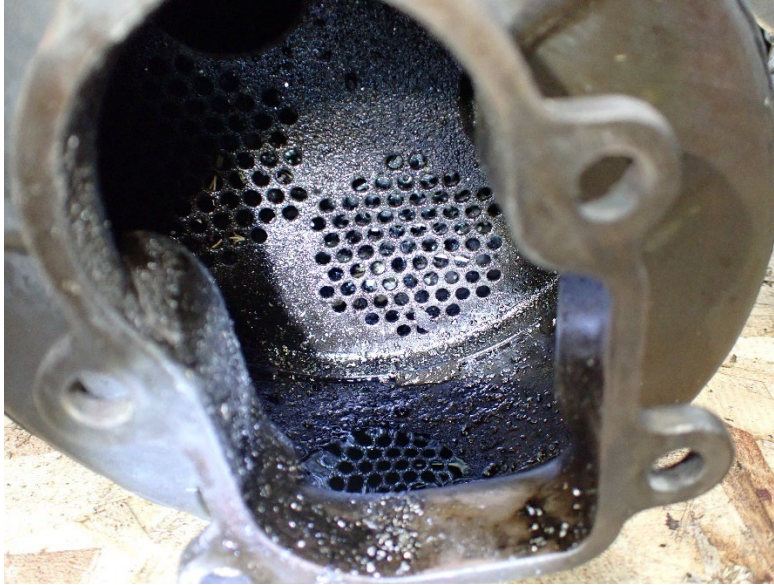
**Figure 18: Metallic fragments inside airbox**

#### **1.4 Exhaust system and turbo**

The exhaust system was partially damaged from the accident sequence. The cylinder 1, 2, and 4 exhaust tubes had been disconnected previously when the airplane was examined in Phoenix, Arizona. The cylinder 3 exhaust tube remained attached to the cylinder head. The exhaust muffler was unremarkable and exhibited some organic debris inside the internal baffling. The turbo impeller spun normally by hand and some metallic debris was observed within the turbo.



**Figure 19: Muffler**



**Figure 20: Interior muffler at baffling**

## **1.5 Oil system**

The oil system components all remained attached securely to the engine and there was no evidence oil seepage. The oil cooler remained connected to the oil sump and oil pump and was damaged during the accident sequence, but was otherwise unremarkable. The dry sump oil tank was connected and undamaged (this oil tank contained coolant, oil and metallic fragments during the wreckage examination in Phoenix). A return oil line from the crankcase to the dry sump was undamaged. The scavenger lines were connected from the oil pump and crankcase and remained securely attached to the oil sump. The oil pump rotated freely by hand.

Submitted by:

Stephen Stein  
Senior Aviation Accident Investigator