



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: February 24, 2012

In reply refer to: A-12-7

The Honorable Michael P. Huerta
Acting Administrator
Federal Aviation Administration
Washington, D.C. 20591

Since 2000, the National Transportation Safety Board (NTSB) has examined numerous Engine Components, Inc. (ECi) reciprocating engine cylinder assemblies that failed due to fatigue cracking that initiated in the root of the cylinder head thread, eventually resulting in loss of compression and/or separation of the cylinder head into two pieces.¹ These failures involved new assemblies installed on Lycoming and Teledyne Continental Motors (TCM)² engines, and many resulted in fatal accidents. Although the Federal Aviation Administration (FAA) has issued several airworthiness directives (AD) applicable to certain new ECi cylinder assemblies used on Lycoming and TCM engines to address this issue, similar fatigue failures in other new ECi cylinder assemblies installed on TCM engines have been identified but are not covered by an existing AD. Because fatigue cracking and separation of cylinder assemblies in piston-engine aircraft is a serious safety issue, this letter recommends corrective action for certain new ECi cylinders used on TCM engines.

Reciprocating engine cylinder assemblies consist of two major parts, the cylinder barrel and the cylinder head. ECi cylinder heads are manufactured from an aluminum alloy casting, and house the intake and exhaust valves, with their respective seats, guides, and spark plugs. ECi cylinder barrels are typically manufactured from an alloy steel forging and have a smooth bore that houses the piston. The cylinder head and barrel are joined by heating the cylinder head to about 650° F then screwing it onto the cylinder barrel until specific surfaces make contact. As the cylinder head cools and shrinks onto the cylinder barrel, an interference fit is produced, locking the parts together at the threads and at an adjacent plain diameter, which is commonly referred to as a shrink band (shrink bands are features on the barrel and in the cylinder head; see figure 2). On new cylinder assemblies, the barrel mounting flange and cylinder mounting holes in the flange are machined after assembly to ensure the cylinder's proper alignment on the engine case.

¹ Cylinder assemblies examined include those in connection with the following NTSB case numbers: ENG07WA032 (three cylinders), ENG07SA033, and WPR09SA476.

² Teledyne Continental Motors became Continental Motors, Inc. in April 2011.

In most of the cases examined by the NTSB, the fatigue cracks in the cylinder heads initiated at the root of the thread that was engaged with the first (uppermost) thread on the cylinder barrels, as shown in figure 1 and indicated by the yellow line in figure 2. The fatigue cracks propagated outwards through the cylinder head wall to emerge between the third and fourth or the fourth and fifth cooling fin, depending on the engine model. The fatigue cracks initiated at multiple locations, typically near the intake or exhaust valve side of the cylinder heads and, with engine use, propagated through the head thickness. Once the fatigue cracks propagated through the thickness of the cylinder wall, the cylinders lost compression, with a resulting reduction in or total loss of thrust. When the fatigue cracks reached a critical size, the cylinder heads fractured and separated at the fatigue location, with the lower portion remaining attached to the barrels, resulting in catastrophic engine failure.

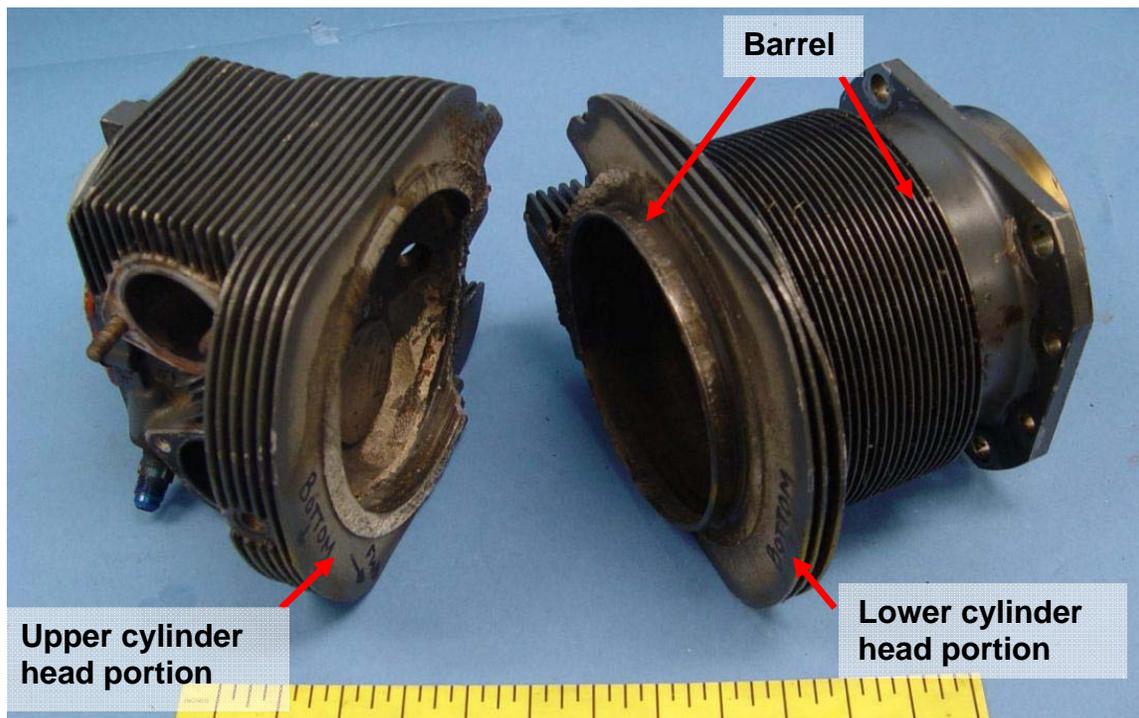


Figure 1. Photograph of a fractured cylinder assembly.

Beginning in 2004, ECI and the FAA issued several bulletins and directives to address these fatigue failures. After 34 reported fatigue failures of ECI cylinders, the FAA issued AD 2004-08-10, effective May 2004, to require replacement of certain ECI cylinder assemblies on TCM model 520 and 550 series engines. The AD identified a manufacturing discrepancy that occurred between September 2002 and May 2003 (S/N 1044-7708), which resulted in an inadequate cylinder head wall thickness and an over-hardened condition that would reduce the fatigue strength of the aluminum cylinder head.

In August 2006, ECI issued Mandatory Service Bulletin (MSB) 06-2 instructing operators to perform repetitive inspections for leaks and cracks on cylinder assemblies between S/N 7709 and 33696 and to replace any discrepant cylinders. Affected assemblies were produced between September 2002 and November 2005 with inadequate cylinder head wall thickness on the exhaust side. At least 21 head separations have been reported for this group of cylinders, and the

NTSB has investigated several of these, including those documented in NTSB case number ENG07SA033. The fatigue initiated on the exhaust side of the cylinder head, between the 14th and 16th cooling fins, and propagated inwards toward the valve seat. The FAA issued Special Airworthiness Information Bulletin (SAIB) NE-07-09R1 in March 2007, detailing the importance of performing the inspections called for in ECI MSB 06-2, but did not require the inspections.

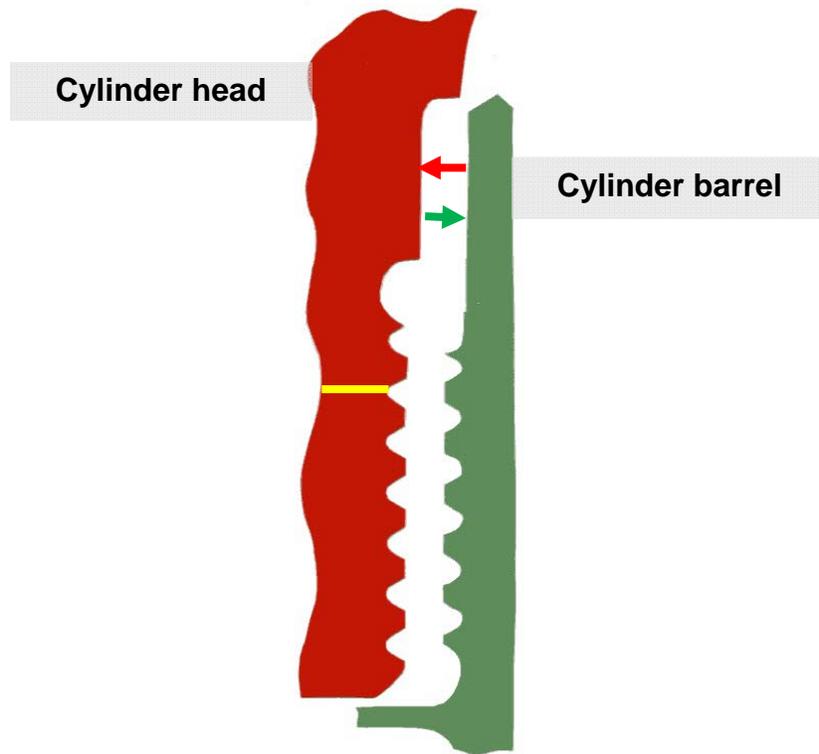


Figure 2. A sectional view of an ECI cylinder head and barrel, showing the location of fatigue cracking (yellow line) and shrink bands (red and green arrows).

ECi has also informed the NTSB of at least eight cylinder head fatigue failures in the group of cylinder assemblies produced between October 2005 and October 2009 (S/N 33697-52884) for installation on TCM engines that are currently not covered by any corrective bulletin or directive. Including these eight failures, at least 29 cylinder head fatigue failures have been reported and confirmed for new ECI cylinder assemblies with serial numbers between S/N 7709 and 52884 for installation on TCM engines.

NTSB and FAA representatives formed a task force in 2005 to study fatigue failures of cylinder heads, which at that point included domestic and foreign failures. In 2006, the task force visited several facilities, including ECI, and observed the entire manufacturing process, from casting of the cylinder heads to cylinder assembly. The NTSB continued examining failed cylinders and updating the FAA's aircraft certification office responsible for oversight of ECI. Following a meeting of NTSB, FAA, and ECI representatives in October 2006 to discuss the cylinder head fatigue failure issue, ECI designed and manufactured a fatigue test fixture that

simulates the cylinder head temperature and pressure cycles experienced by a cylinder on an operating engine. After running numerous tests, ECi changed the manufacturing process for its cylinder assemblies in October 2009 to provide an increased interference fit at the shrink band and between the cylinder head and the cylinder barrel threads but remaining within the limits of the approved design.

During a meeting in January 2011 between ECi, the FAA, and the NTSB, ECi produced data on the cylinder assembly failures and recommended that the FAA issue an AD to mandate inspection and replacement of any discrepant cylinders; however, the FAA has not taken the recommended action for those cylinders not currently covered by an AD. Since the design improvement in October 2009, there have been no reported cylinder head fatigue failures on ECi cylinder assemblies installed on TCM model 520 and 550 engines. Although ECi's changes to the manufacturing process may increase the fatigue strength of new production cylinder heads, a large population of potentially discrepant cylinder assemblies remains in service without any required corrective action.

Therefore, the National Transportation Safety Board makes the following recommendation to the Federal Aviation Administration:

Require repetitive inspection of Engine Components, Inc. cylinder assemblies produced between May 2003 and October 2009 (serial numbers 7709 through 52884) installed on Teledyne Continental Motors model 520 and 550 engines and removal of these cylinder assemblies once they reach the engine manufacturer's recommended normal time (hours) in service between overhauls.
(A-12-7)

In response to the recommendation in this letter, please refer to Safety Recommendation A-12-7. If you would like to submit your response electronically rather than in hard copy, you may send it to the following e-mail address: correspondence@ntsb.gov. If your response includes attachments that exceed 5 megabytes, please e-mail us asking for instructions on how to use our secure mailbox. To avoid confusion, please use only one method of submission (that is, do not submit both an electronic copy and a hard copy of the same response letter).

Chairman HERSMAN, Vice Chairman HART, and Members SUMWALT, ROSEKIND, and WEENER concurred in this recommendation.

[Original Signed]

By: Deborah A.P. Hersman
Chairman