NTSB

SAFETY ALERT

National Transportation Safety Board

Take Time to Torque

★ ***Apply proper torque to prevent accidents*** ★

The problem

- From 2009 to 2015, over 45 accidents and incidents have occurred that resulted from maintenance personnel applying improper torque to engine fasteners (bolts and nuts) during engine maintenance activities. The application of improper torque led to internal engine damage and subsequent engine failures and accidents or incidents (see figures 1 and 2).
- Applying too little or too much torque can cause a bolt to fail and/or the nut and bolt threads to become stripped, which allows the fastening hardware to loosen.

Figure 1. Cylinder with a finger-tightened nut that is not properly torqued.

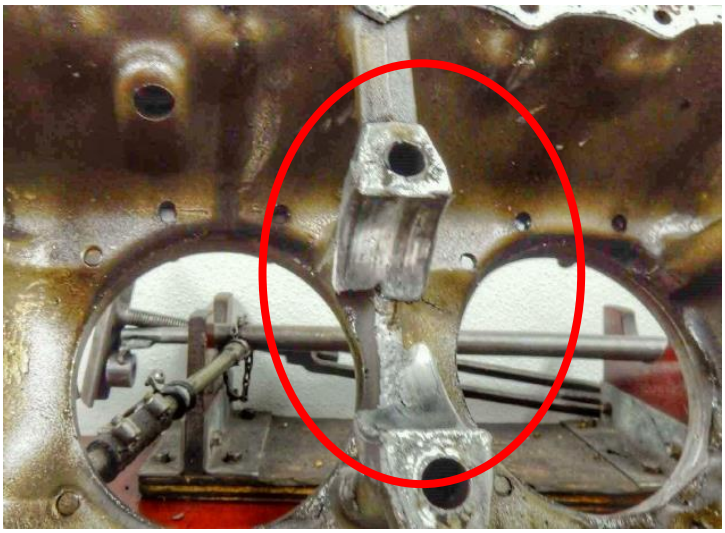

Figure 2. Internal damage to another engine resulting from the application of improper torque.

Why is it important to apply the proper torque values?

- Allows the structure or assembly the fasteners are holding together to develop its full design strength.
- Prevents the exceedance of the design limitations of the structure or hardware.

- Reduces the possibility of excessive wear of the fasteners and parts being held.
- Ensures that each fastener carries the load for which it was designed and that the load is evenly distributed between the fasteners.

REMEMBER — NOT TOO LOOSE, NOT TOO TIGHT:

ENSURE THE TORQUE IS JUST RIGHT!

Related accidents

Unfortunately, the circumstances of many recent accidents are remarkably similar to those of previous accidents. This suggests that some maintenance personnel are not taking advantage of the lessons learned from such accidents that could help them avoid making similar mistakes. The following accident summaries illustrate some common—and preventable—maintenance-related accident scenarios:

- An in-flight crankshaft failure occurred 231 hours after maintenance personnel had removed and reinstalled the Nos. 3 and 4 cylinders. The pilot and passenger were seriously injured during the forced landing. Postaccident examination showed that the torque on the cylinder flange nuts and through bolts was below factory specifications. It was determined that maintenance personnel's application of insufficient torque during installation of the engine cylinders led to the loosening of the components, loss of lubrication, failure of the crankshaft, and the subsequent loss of engine power. (ERA15LA338)
- An engine crankshaft failed in flight, which resulted in a subsequent hard, forced landing, the commercial pilot sustaining serious injuries, and one passenger sustaining minor injuries. The pilot's mechanic had replaced four engine cylinders about 4 months earlier. Postaccident examination revealed that the engine cylinder through bolts on the Nos. 1 through 5 cylinders were significantly undertorqued, and the crankshaft was fractured. The mechanic's failure to properly torque the engine through bolts allowed the bearings to move and led to the in-flight failure of the crankshaft. The pilot had observed "an excessive amount of metal" in the oil filter when changing the oil and filter before beginning the accident flight but assumed that the debris was chrome from the overhauled cylinders as a result of "break-in." Airport personnel who had observed the pilot perform the maintenance expressed concerns about the metallic debris, but the pilot chose to finish the oil change and continue with the accident flight, not realizing the risk of imminent engine failure. (ERA14LA193)
- The commercial pilot, who was conducting a skydiving flight with four passengers on board, was forced to conduct an off-airport landing to a highway after a total loss of engine power during climbout. One passenger sustained minor injuries. Disassembly and examination of the engine revealed that the crankshaft had fractured near the No. 2 main bearing surface, and areas adjacent to the No. 2 bearing on the inside of the engine case exhibited rotational scoring, indicating bearing movement. It was determined that maintenance personnel applied insufficient torque to the cylinder through bolts during replacement of the No. 2

cylinder 19 days before the accident. The insufficient torque allowed the bearings to move and led to the eventual failure of the crankshaft. (ERA15LA263)

What can maintenance personnel do?

- Apply torque values provided in the applicable aircraft and engine maintenance manuals. If the engine manufacturer has recommended torque values in its engine specifications, use those specified values.
- Use a calibrated torque wrench to measure the amount of twisting force applied to a nut or bolt (see figure 3). Verify that your wrench is calibrated and check that the wrench is not damaged to ensure continued accuracy.
- Follow manufacturer guidance about whether to use lubricants on fasteners.
- Use smooth, even pulls when applying torque pressure.
- Conduct a postmaintenance check after applying torque to fasteners to ensure that the correct amount of torque was applied. If possible, have someone else independently check the torque values using a different wrench.
- Also use torque seal to verify that the applied torque has not changed and to visually confirm which fasteners have been torqued (see figure 4).
- Beware of leaving hardware that has been only finger tightened. Once you start the process, make sure you complete it. Set a reminder if you need to step away before completing the torqueing process.

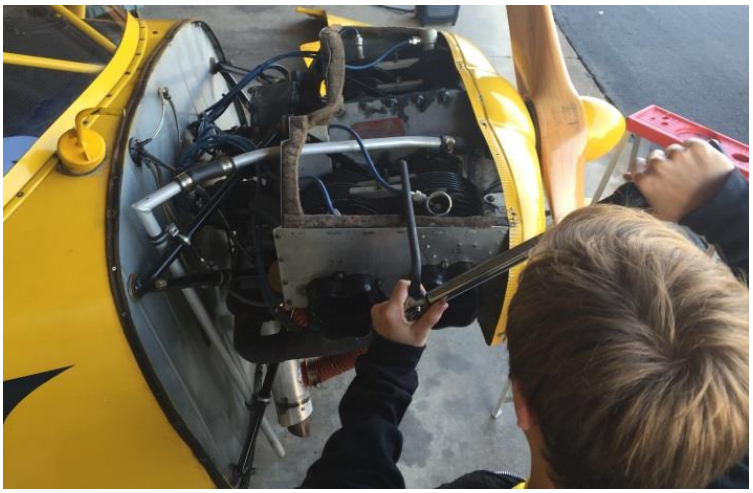

Figure 3. Mechanic applying torque to through bolts.

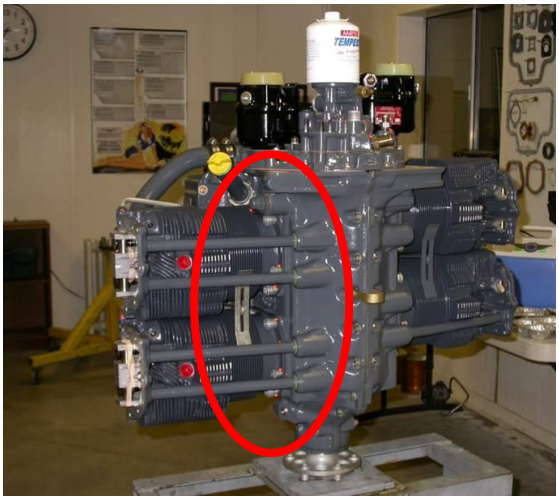

Figure 4. Engine on stand showing torque seal on fasteners.

Interested in more information?

If the engine manufacturer has not provided the specific torque values to be used, reference Federal Aviation Administration Advisory Circular (AC) 43.13-1B, "Acceptable Methods, Techniques, and Practices - Aircraft Inspection and Repair," chapter 7, section 3, which provides general information about torque application and, in table 7-1, shows the recommended standard torque values to be used for nuts and bolts.

Also, figure 7-2, shows how to calculate the corrected torque values for various torque wrench adapters.

GA Maintenance Alert: Safety and Security of Components provides general tips to maintenance personnel on how they can ensure that airplane components are properly secured and emphasizes the importance of following written procedures and mitigating human factors, such as fatigue and time constraints, when performing maintenance activities. This GA maintenance alert and others can be accessed from the FAA Safety Team website at www.faasafety.gov.

The Aircraft Owners and Pilots Association article, Torque Time, provides detailed information about the basic concepts related to torque, why it is important, and when, where, and how to apply it properly.

The NTSB's Aviation Information Resources web page, www.ntsb.gov/air, provides convenient access to NTSB aviation safety products. The reports for the accidents referenced in this safety alert are accessible by NTSB accident number from the Aviation Accident Database link, and each accident's public docket is accessible from the Accident Dockets link for the Docket Management System. This safety alert and others can be accessed from the Aviation Safety Alerts link.