

Lancair 235/320/360 Main Gear Over-Center Link Design Improvement

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Figure 1, The Main Gear Over-Center Link on a Lancair 360

I am always on the look-out for long term wear issues in our planes. One system I closely examine every annual is the over-center link on the main landing gear. I remove the parts, disassemble, clean, and measure the hole dimensions and the resulting play in the joint. For some 22 years wear stayed down around .001". One year wear jumped to .003 unexpectedly. The bearing surfaces have never run dry so perhaps some sort of fine abrasive was introduced in the prior year. Whatever the cause, there are a few weaknesses in the original design. The first is that the bearing material is the aluminum part itself. This makes the link a wear item. The second thing I noticed during the prior annual is that one of the press fit bearings had loosened. I had seen this on other planes. Below are photos taken by one very lucky owner. The bearing had loosened and the link slipped off. It was just hanging on to the bolt head. Note: This installation is supposed to have a large washer under the bolt head to prevent disassembly in the event of a loose bearing.



Figure 2, An Over-Center link that slipped off the bearing

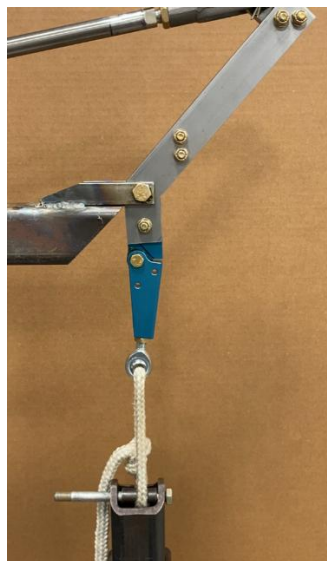
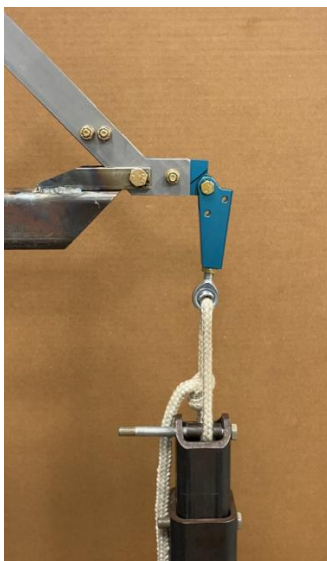
One theory that could explain the loosening of the interference fit on the bearing over time involves the very small cross section produced when the hole for the roll pin is drilled. If the remaining cross section yields (stretches) in the slightest it will loosen the grip on the bearing. For this size bearing the interference is approximately 0.001". The hoop stress is substantial and the material cross section up against the bearing is only .049" thick in the stock part.



Figure 3, The roll pin hole greatly reduces the local material cross-section

I addressed these two issues with some design changes.

I machined some custom high strength journal bearings that would make the bolt the sacrificial wear element. I used close tolerance bolts (AN174 series) and sized the bearings to only have a 0.001" clearance. This was followed by durability testing on the bearing material using two different approaches. For the first approach I assumed regular maintenance, i.e. regular cleaning and lubrication. For the second approach I assumed no maintenance was being performed. I further assumed 270 flights a year for 10+ years. For the first run I removed the bolt every 270 cycles, cleaned and lubricated the joint with Aeroshell 5 grease, then reassembled.



A pneumatic ram cycled the OC-link through 90 degrees of motion. Two buckets filled with concrete weighing 104 and 140 lbs were used as the load.

Figure 4, Test Fixture used for durability testing

The second approach involved performing the entire 10 year duration with no maintenance. In total 3,000 cycles were run without cleaning or re-lubricating. To ensure a concentration of the wear, the bolt was restrained such that it could not rotate in the assembly i.e. the same area of the bolt and bearing would make contact for each cycle. The result showed that all measurable wear occurred on the bolt. Replacing the bolt restored the original 0.001" clearance.



Figure 5, High strength bearings installed in new Over-Center Links

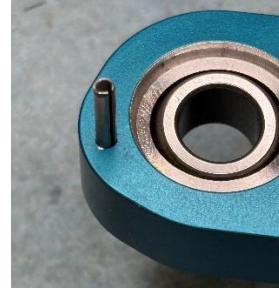


Figure 6, Area around roll pin increased to prevent local yielding

New Over-Center links were fabricated to accommodate the three small journal bearings. While the new links are made of a stronger 7075 aluminum alloy, a slight bump out was added so that the bushing volume would not reduce the material cross section. Similarly, material was added where the roll pin hole is drilled to maintain the same nominal material cross section.

The prototype was again run through durability testing. The bearings performed just as before. I ran 5,400 cycles straight through with no cleaning or relubrication. The bolt showed signs of wear as before while the bearings were unaffected. When the bolt was replaced with a new one, operating tolerance were restored to 0.001".



Figure 7, Complete Set of new Over-Center Links

This new design approach both reduces free-play in the joint and extends the life of the part indefinitely. The wear item is now an inexpensive AN bolt.