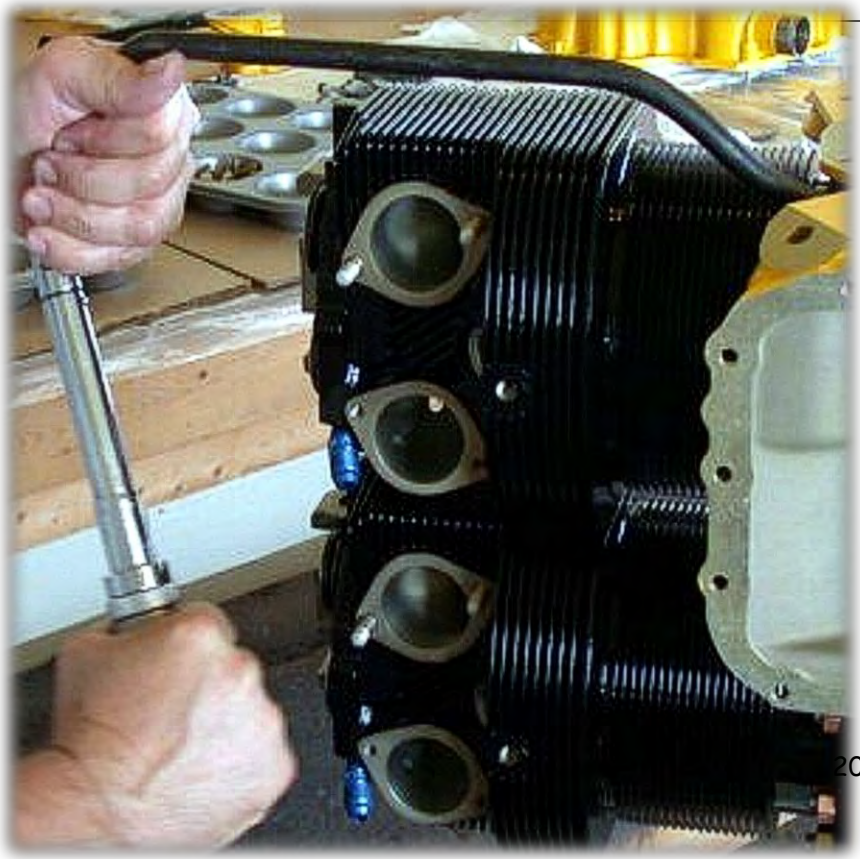
Cylinder Work: Risky Business



Your presenter…

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National Aviation Maintenance Technician of the Year (2008)

President — Savvy Aviation, Inc.

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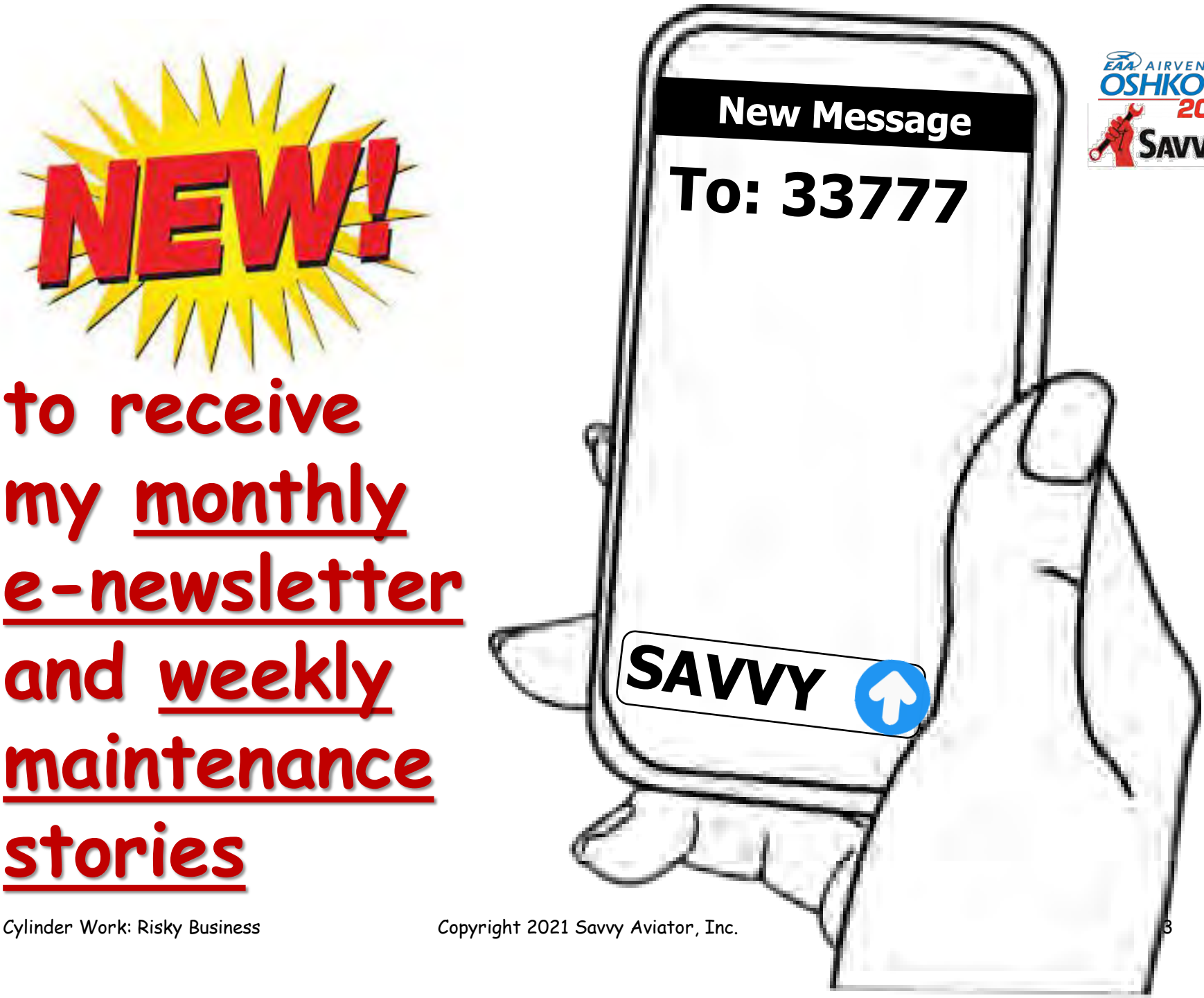

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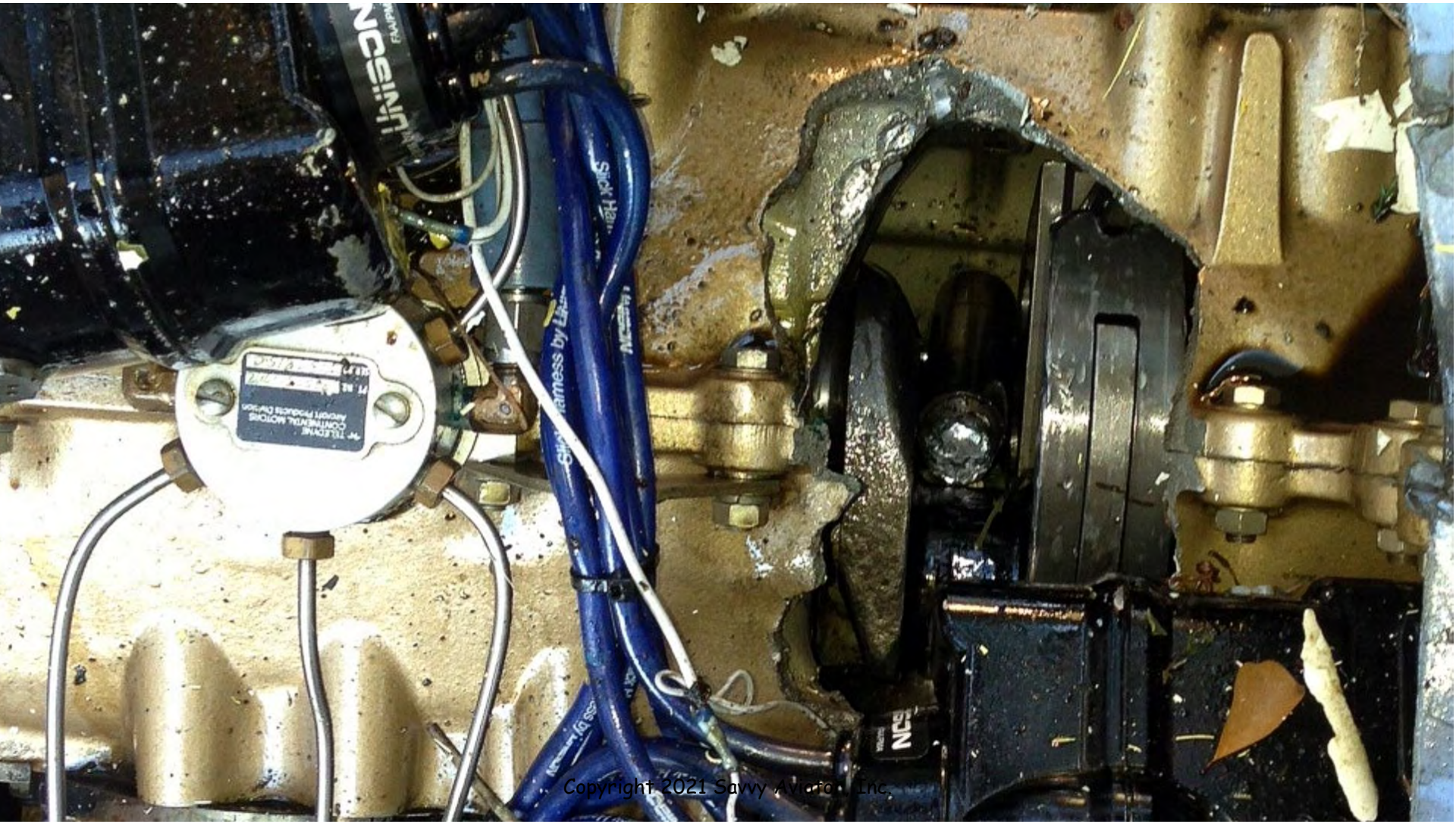
Why it's is nearly impossible to install a cylinder properly when the engine is on the airplane

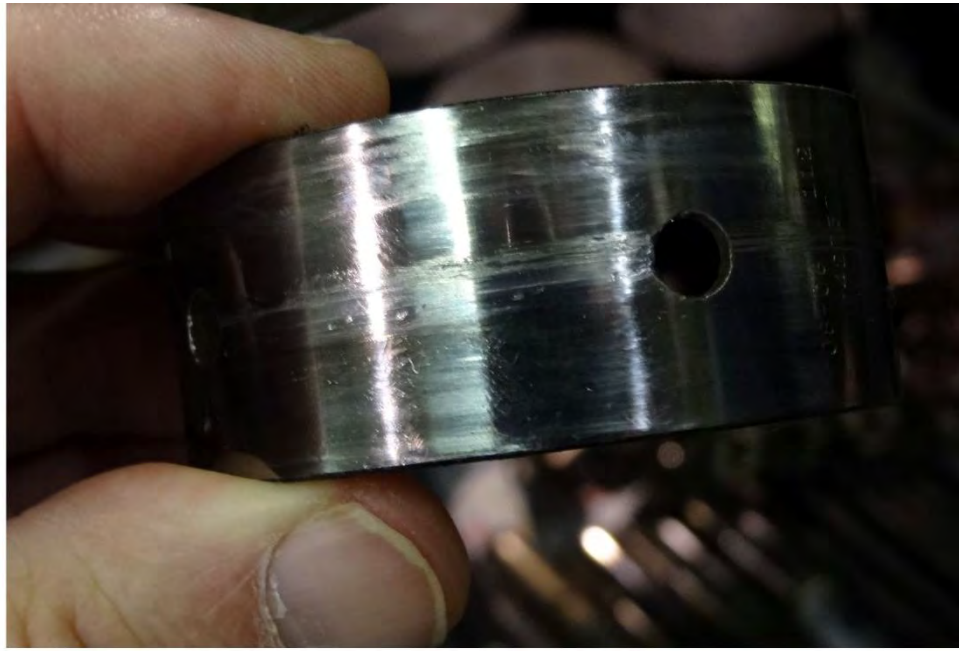
Cylinder replacement—especially replacement of multiple cylinders at once—is a procedure that needs to be executed perfectly

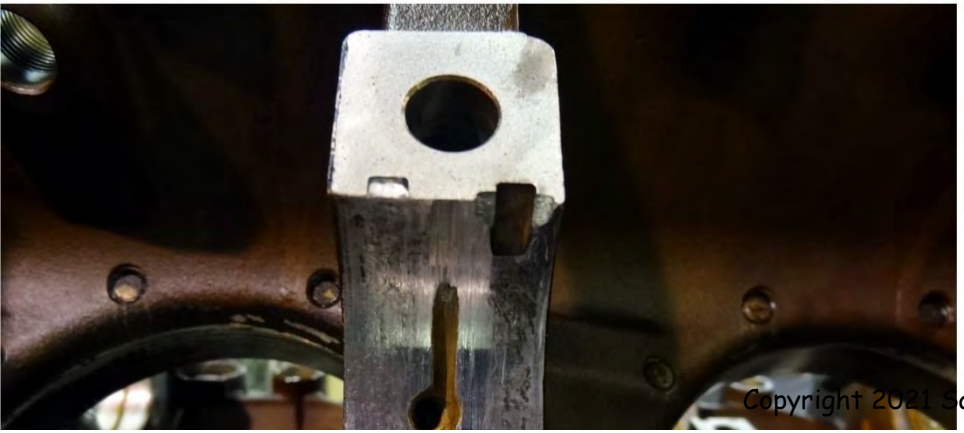
If it isn't, there can be dire consequences

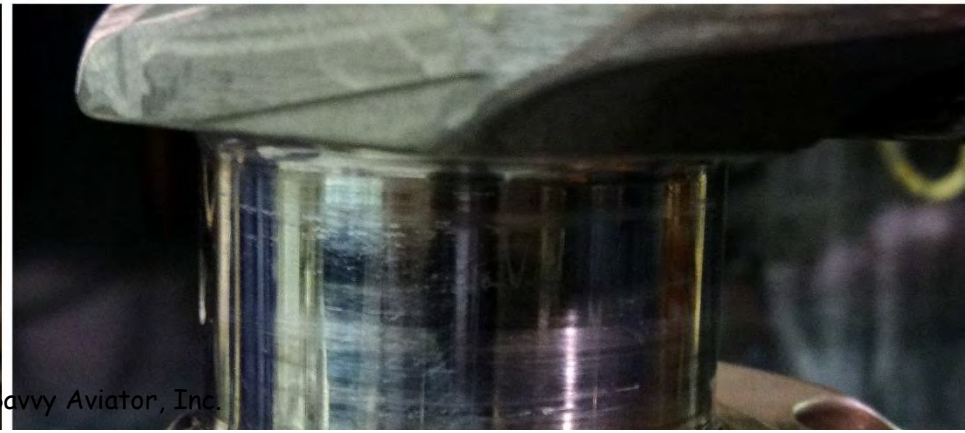
Beech Bonanza



Cirrus SR20



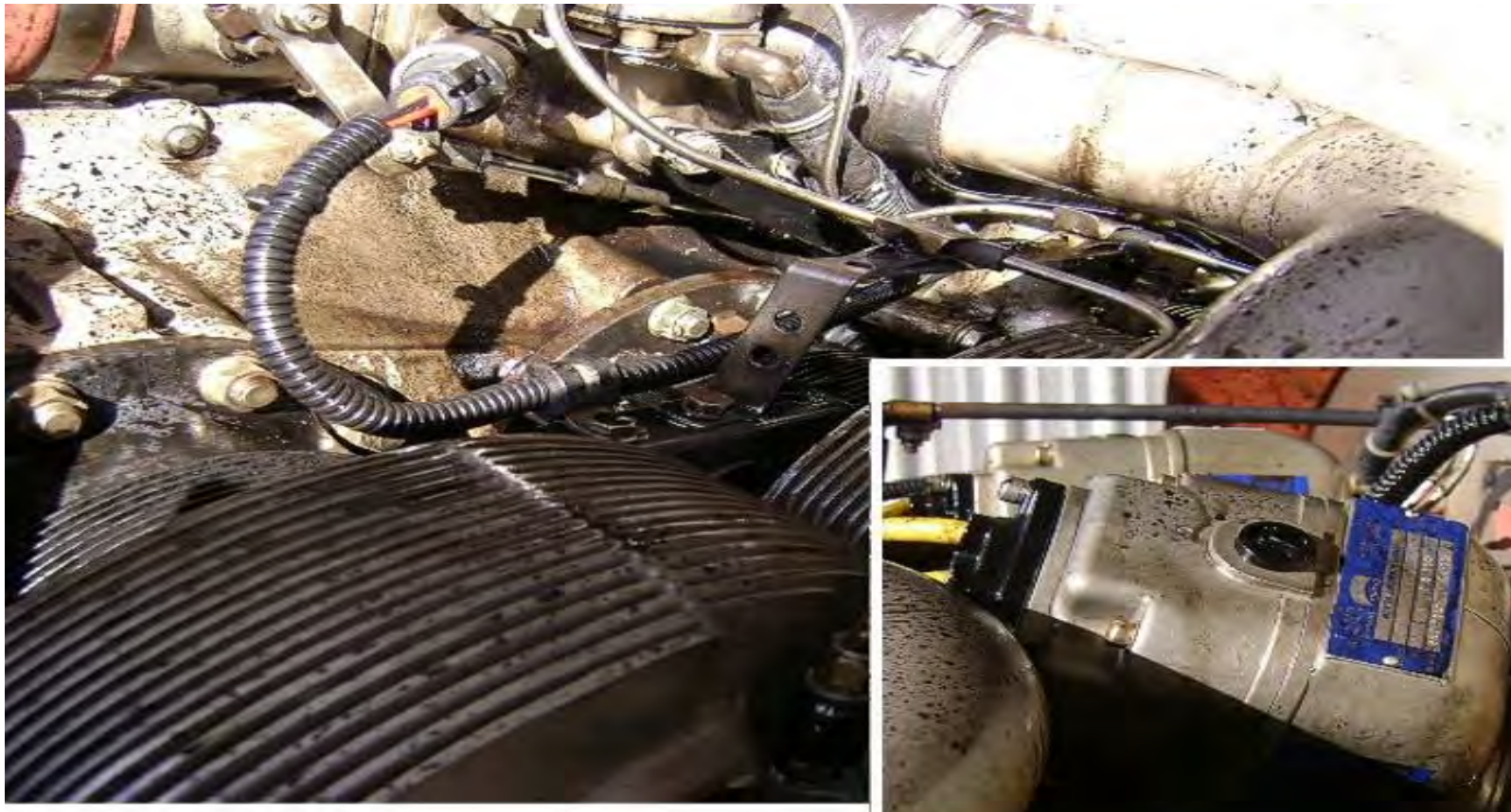




Beech Bonanza

Cessna 206

Cirrus SR22



Yet it's a procedure that most career general aviation A&Ps perform routinely without apparent concern

Why aren't these mechanics nervous?

Yet it's a procedure that most gener A&Ps routin appar

Undoubtedly because they believe they always perform it properly…

…and that only careless or incompetent mechanics screw it up

…se…

…mechanics nervous?

Roger D. Fuchs, DER

U.S. Department of Transportation
Federal Aviation Administration

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Reposing special trust and confidence in the integrity, diligence, and discretion of

Roger D. Fuchs

impartial judgment to merit special public responsibility, I hereby designate as

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with authorization to act in accordance with the regulations and procedures prescribed by the Federal Aviation Administration relating to this designation.

Issued at Lakewood, [illegible] *[illegible] of the Administrator*

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Manager, Systems and Equipment Branch

DER

000-5 (4-84)

"My concern comes out of decades of experience with Continental engines, particularly the design of crankcases, main bearings, fasteners and assembly practices…"

"All my experience indicates that there is a major risk to safety and airworthiness when performing cylinder replacement on mid- to high-time engines, NOT as a result of improperly performed maintenance actions…"

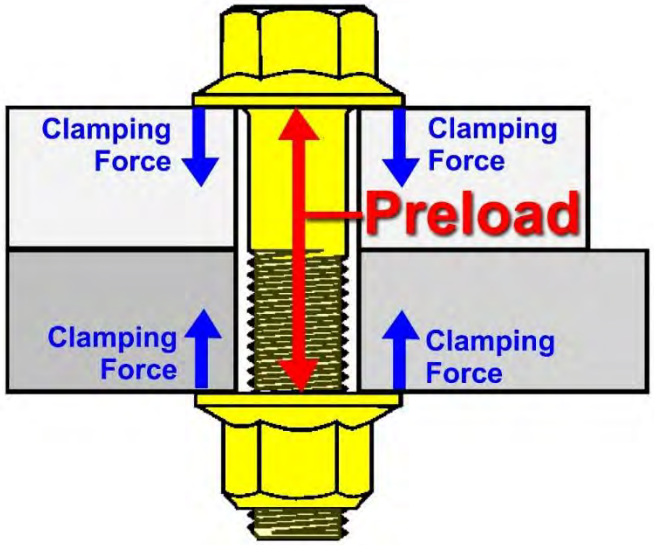
"…but rather as the result of maintenance actions by experienced mechanics who are attempting to perform properly according to the manufacturer's recommendations as published."

Fuchs contends that there's a significant risk that an engine might come apart after cylinder replacement (especially a top overhaul) even when the work is performed exactly as prescribed by the manufacturer

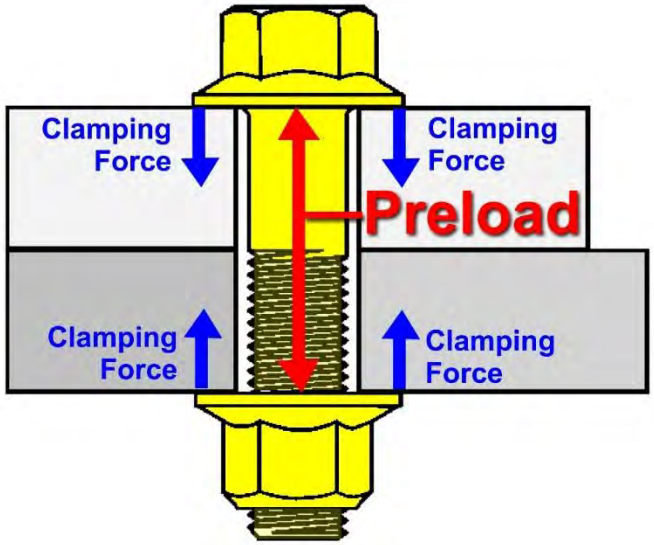
OMG!

How can this be?

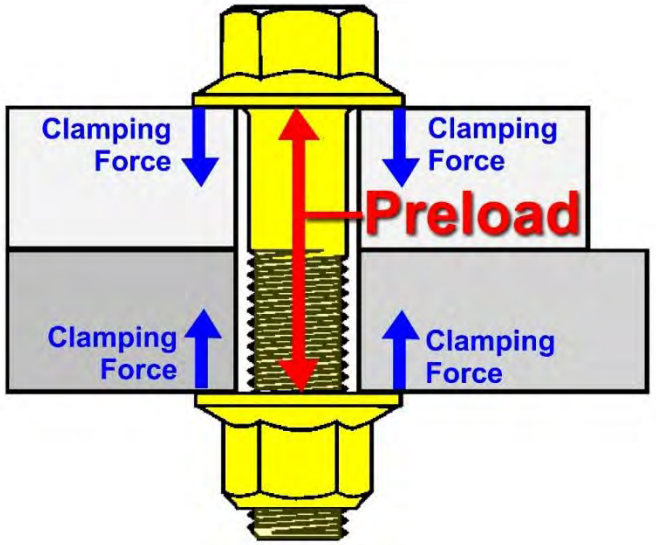
According to Fuchs, the root cause of spun bearings, thrown rods and separated cylinders is simply "failure to achieve sufficient preload in the assembled fasteners."



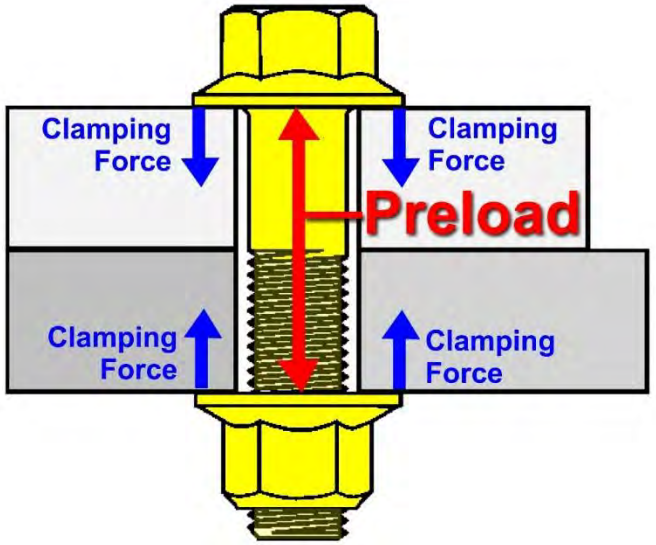
Having sufficient preload is the key to a strong and reliable bolted joint that will not loosen, break or shift under load



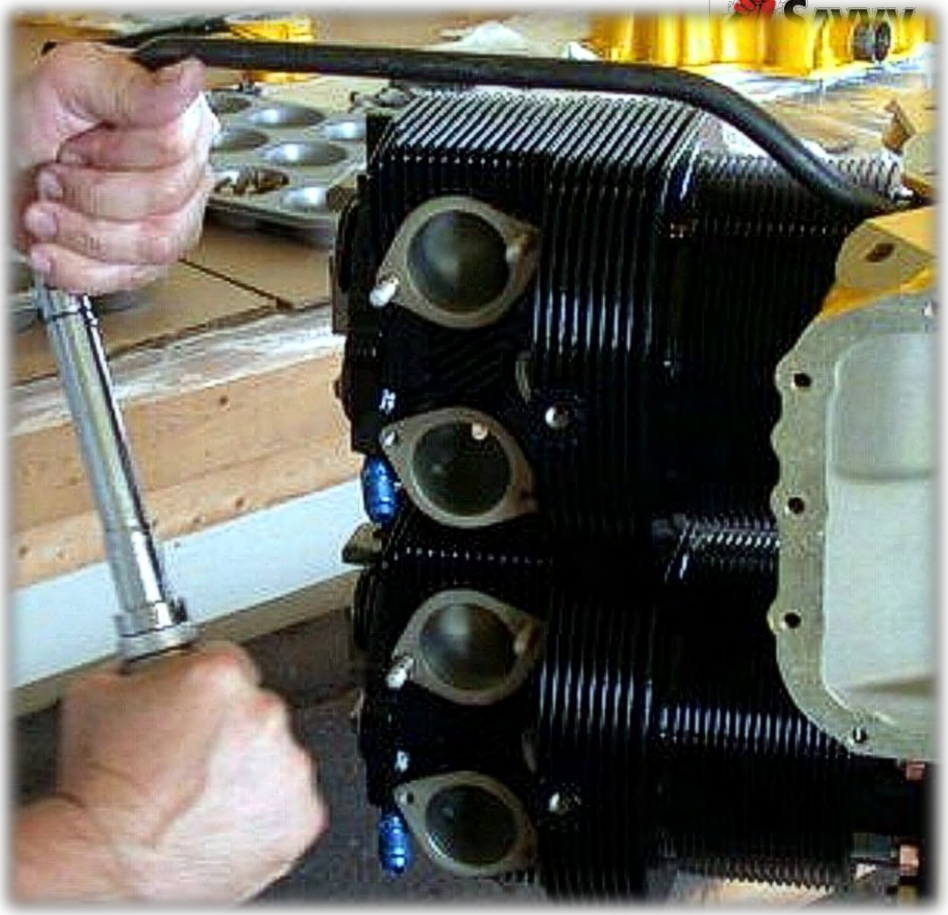
In order for a bolted joint to be stable under cyclic repetitive stress, the preload on the fasteners must be greater than the maximum stress that is trying to pull the joint apart



Unless this condition is met, the joint will shift under load and the fasteners will ultimately fail from repetitive stress fatigue



So, how do we obtain the desired preload when installing a cylinder?

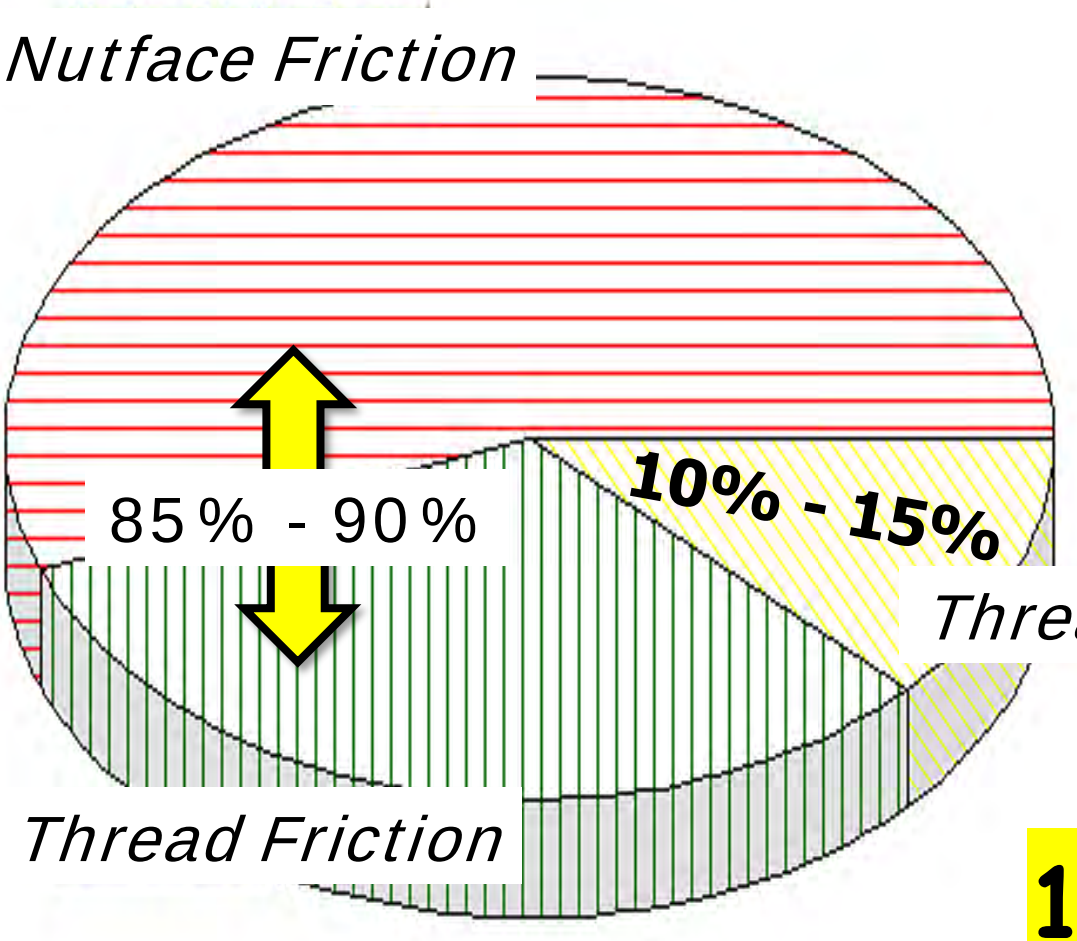


In a perfect world we'd tighten the cylinder base nuts so that the deck studs stretched by about .005" and the through bolts stretched by about .035"…

In the real world, mechanics have no practical way of measuring the stretch of the deck studs and through bolts, so they are forced to rely on **using a calibrated torque wrench**…

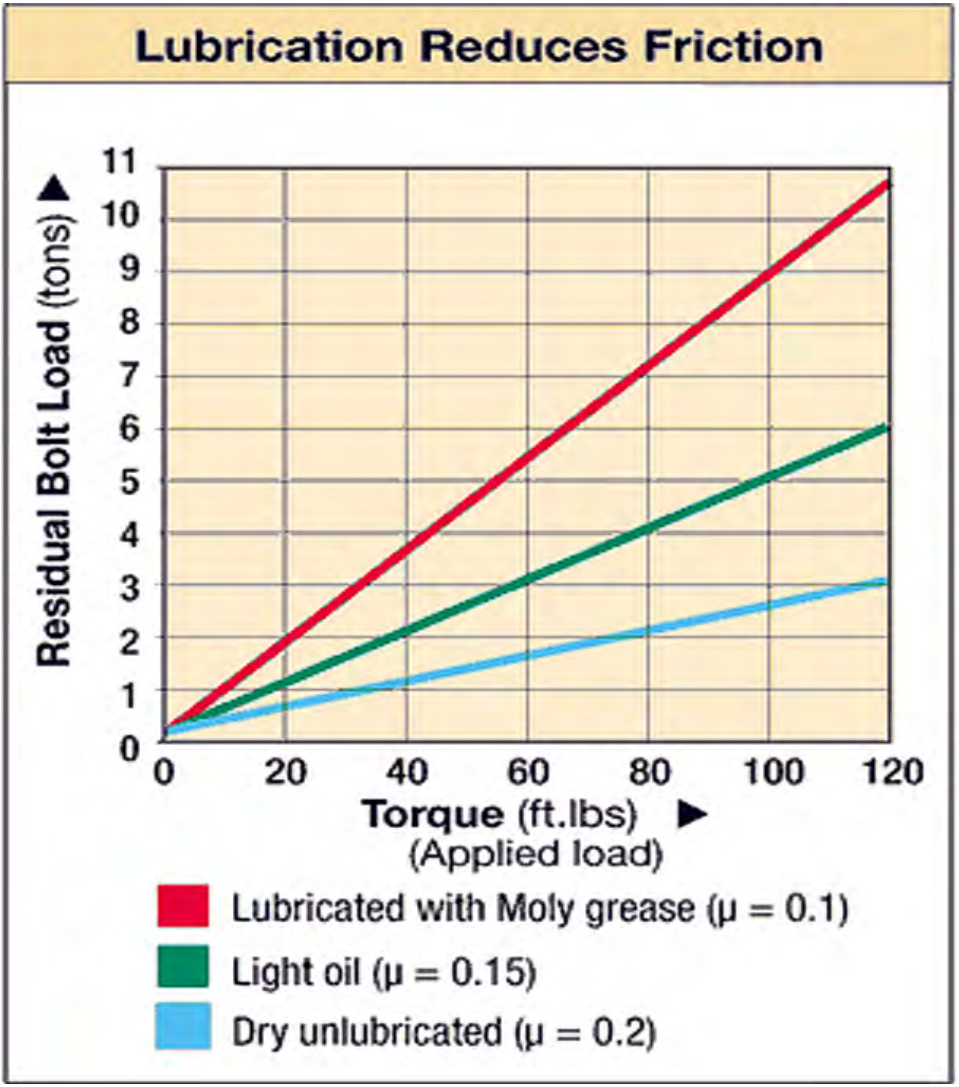
This turns out NOT to be a very reliable method…

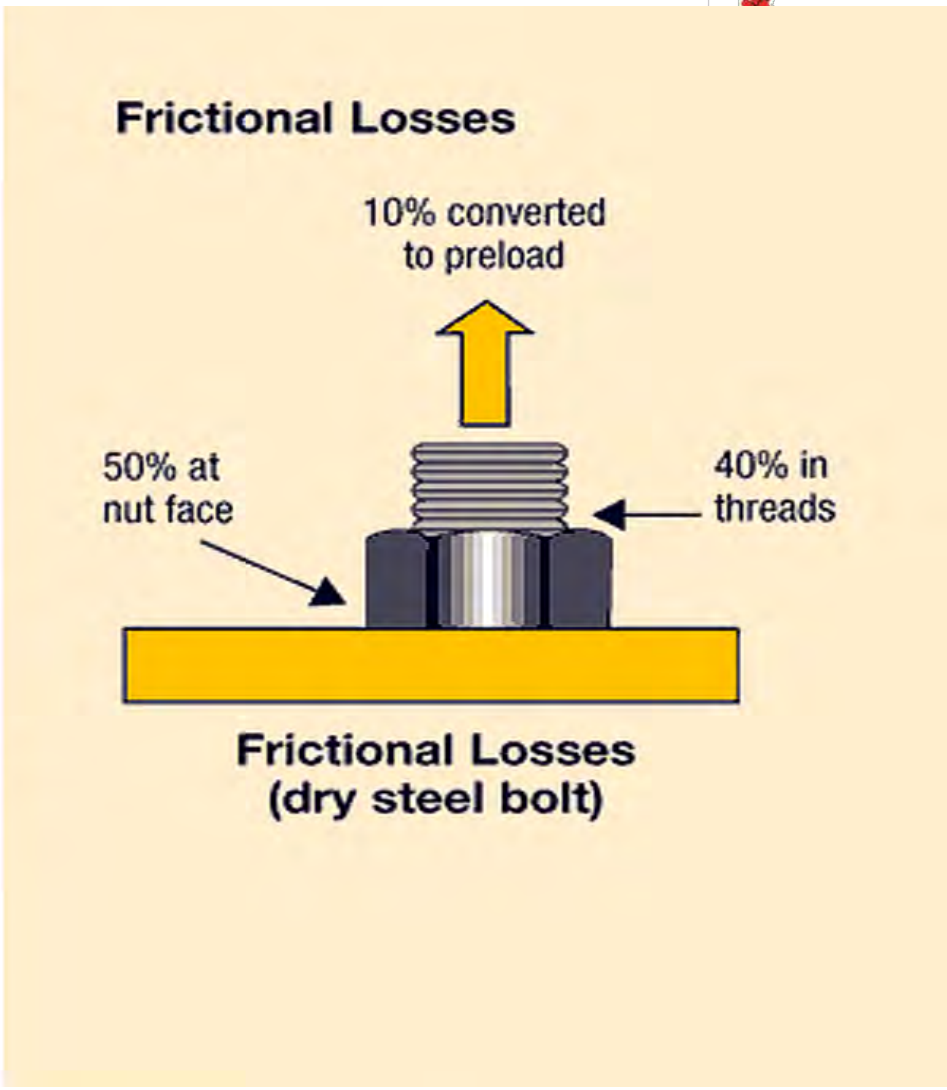
The amount of fastener preload generated by torquing a nut to a specified torque value can vary quite a bit…



85% to 90% of applied torque is dissipated overcoming friction

Only 10% to 15% generates preload





The "wet" torque method works adequately during initial engine assembly at the factory or engine overhaul shop when the engine is mounted on an assembly stand and all the bolts, studs and nuts are brand new…

…but it works far less well when cylinders are being replaced in the field with the engine still mounted in the airplane


Obstacles to Achieving
Proper Preload

1.The fasteners aren't new

When engine is assembled at the factory or by a good overhaul shop, the through bolts and deck studs are brand new, with cad-plated threads in perfect condition

The cad plating is very slippery, but very thin (8µm) and relatively soft

1. The fasteners aren't new

When cylinders are replaced in the field…

- through bolts and deck studs are never replaced
- hold-down nuts are often reused at the mechanic's discretion.
- threads of through bolts, deck studs and hold-down nuts may be worn or damaged

2.Fasteners may not be adequately lubricated

Both Continental and Lycoming say cylinder fasteners are to be torqued "wet"

- Continental calls for using 50-weight engine oil
- Lycoming suggests using a 90/10 mixture of engine oil and STP

2.Fasteners may not be adequately lubricated

To achieve proper preload, the lubricant needs to be liberally slathered onto both the fastener threads and the nut face area

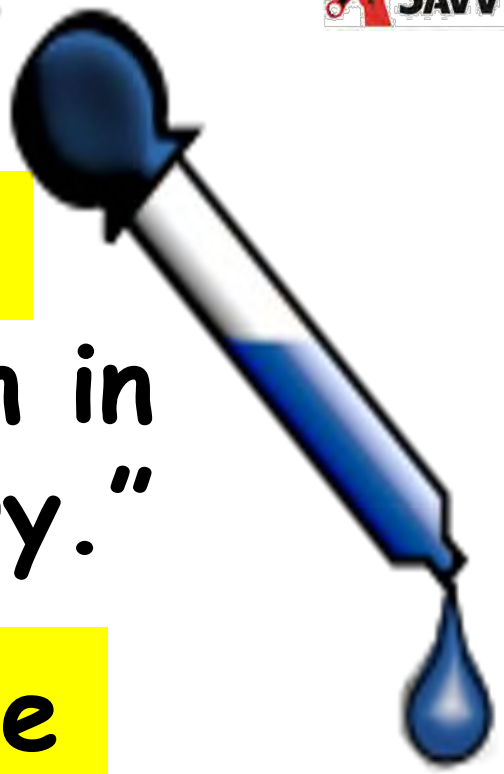
2.Fasteners may not be adequately lubricated

According to Fuchs, "Mechanics are generally reluctant to use much oil on threads and nut faces during cylinder assembly" because it "conflicts with their innate desire for tidy-looking engines…"

2.Fasteners may not be adequately lubricated

"I find use of too little lubricant rather common in the maintenance industry."

"It's a very serious issue when assembling used fasteners."



3.The lubricant is rather poor

Fuchs also points out that plain 50-weight engine oil (e.g., Aeroshell W100) is a lousy thread lubricant because it lacks synthetics and anti-wear additives that would make it much slipperier

3.The lubricant is rather poor

Add this to the likely loss of slippery cad-plating from the worn fastener threads, not to mention the possibility of thread damage, and it's anybody's guess whether proper torque will result in proper preload

4. Wrench access is limited

Both Continental and Lycoming call for cylinder hold-down nuts to be first tightened to 50% of final torque, and then torqued to 100% of final torque

4. Wrench access is limited

Consistent results can only be obtained if the final tightening sequence is performed using a single continuous motion of the torque wrench

4. Wrench access is limited

If the movement of the wrench is interrupted, the "click" from the wrench that signifies that the specified torque has been achieved will occur too early

4. Wrench access is limited

While it's usually easy enough to do this properly on an engine stand with unobstructed access, it's almost impossible to do when the engine is mounted in the airplane

5. Manufacturer instructions leave a lot to be desired

- Don't emphasize liberal lubrication
- Don't emphasize non-reuse of nuts
- Don't emphasize thread condition inspection of studs and through bolts

5. Manufacturer instructions leave a lot to be desired

Most importantly, fail to provide specs for tightening fasteners using the torque-angle method

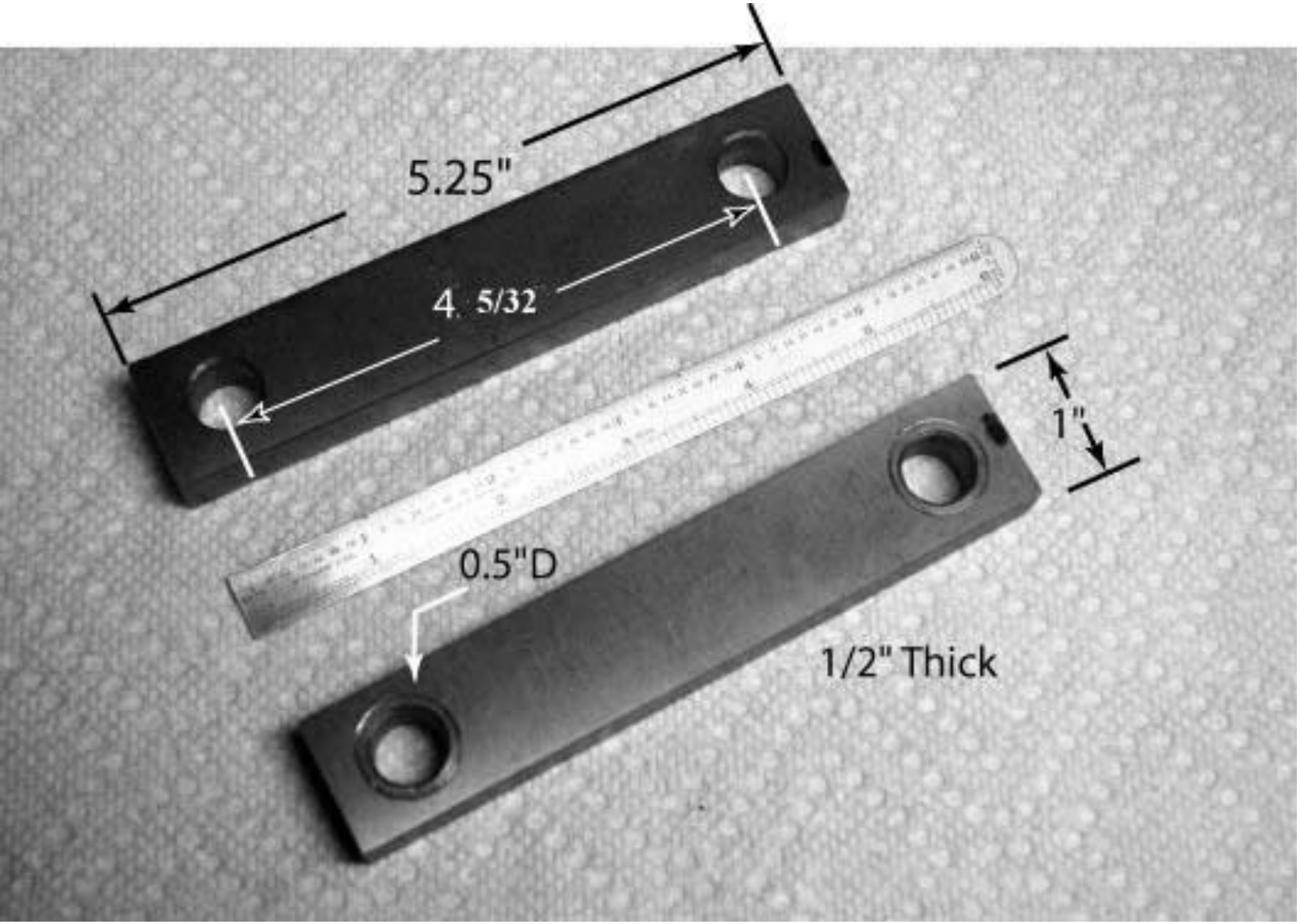
5. Manufacturer instructions leave a lot to be desired

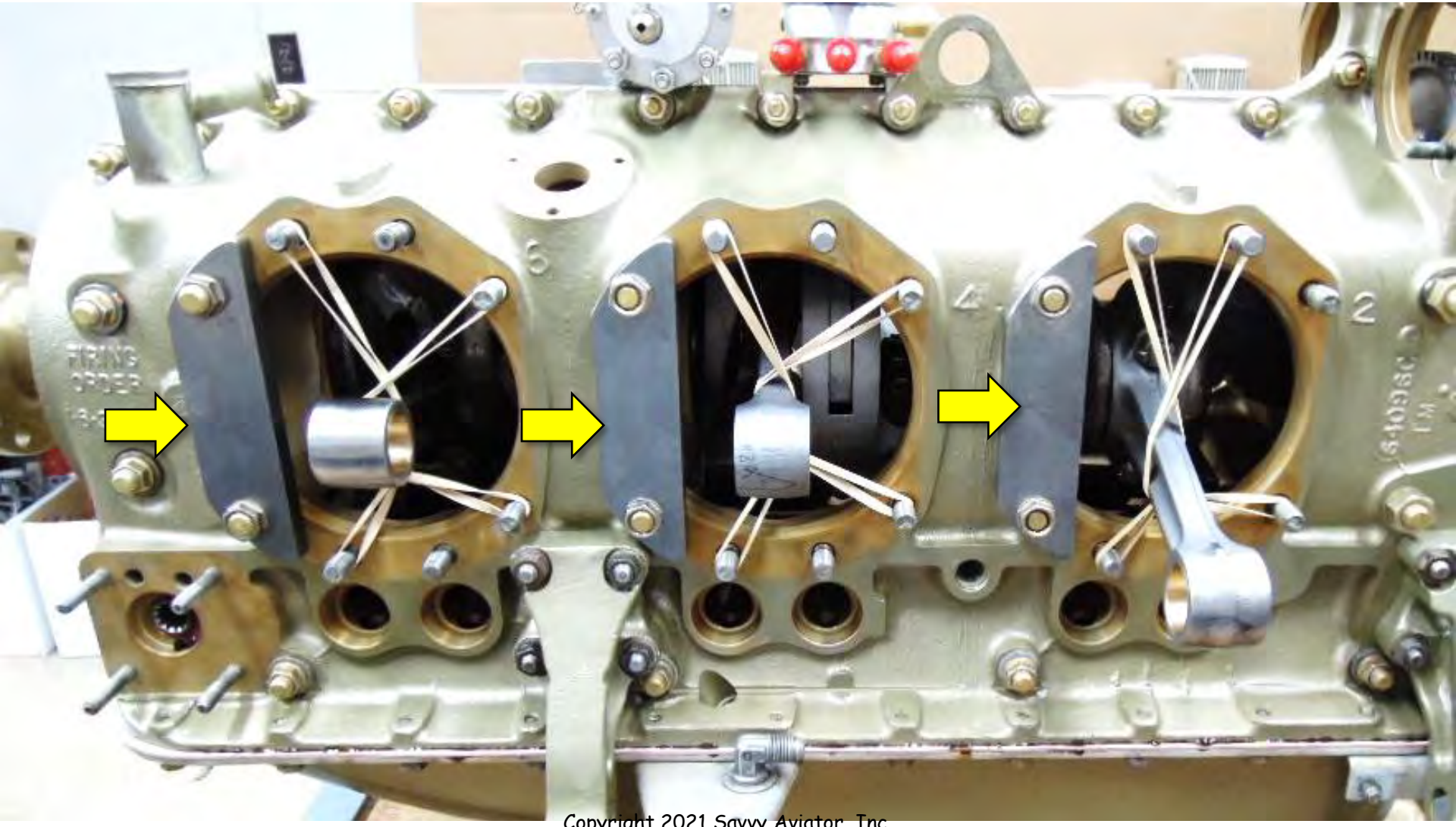
Also fail to emphasize the importance of using torque plates when multiple cylinders are removed

5 ...cturer instructions le... ...o be emp... the importance of using **torque plates** when multiple cylinders are removed

Torque what?

They never said anything about that in A&P school!





Key Takeaways…

- Don't pull cylinders if you can possibly avoid it
- Avoid top overhauls
- Use torque plates
- Use Torque Seal
- Re-check torques after 50 hours

Key Takeaways…

When cylinder removal is unavoidable, make absolutely sure your A&P follows all the techniques mentioned in this webinar to mitigate the risk

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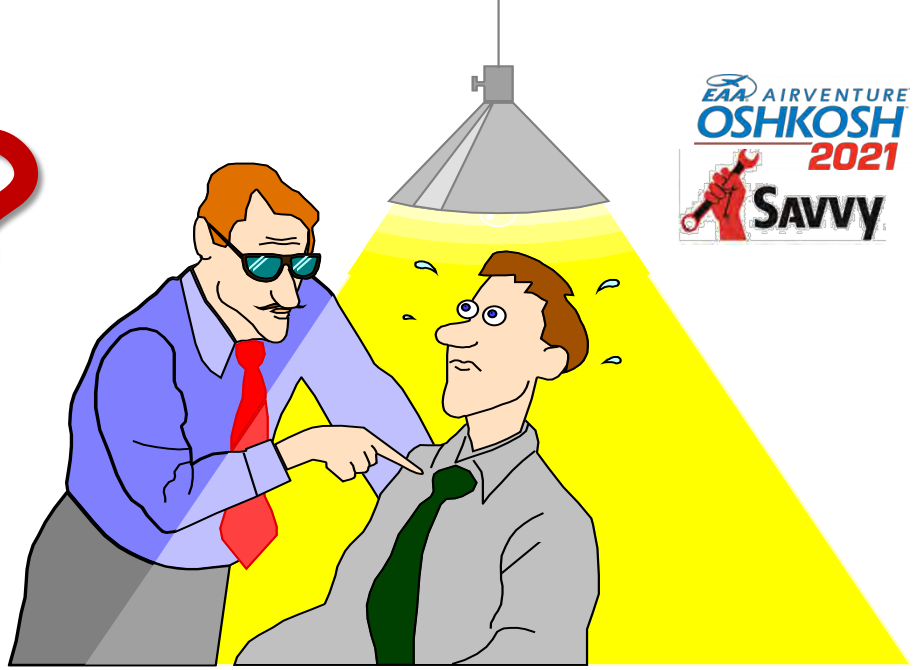

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