

OIL FILTER ADAPTER RESEARCH

On May 01, 2019 a fatal accident occurred in Mill Creek, California (WPR19FA126). The oil had egressed the engine at a high velocity from the F&M the oil filter adapter. Just over a month later, on June 10, 2019 another accident that occurred in Romana, California (WPR20LA166). The same teams responded to both accidents: Zoë Keliher (NTSB investigator-in-charge IIC), Michael Council (Continental Aerospace Technologies), and Henry Soderlund (Textron Aviation – Cessna).

OIL FILTER ADAPTER

ADAPTER FUNCTION

The purpose of the adapter was to enable the engine to use a conventional spin-on oil filter. As manufactured, the oil pump has a brass oil screen mounted to the casing and the filter adapter uses the oil screen bore to attach to the engine.

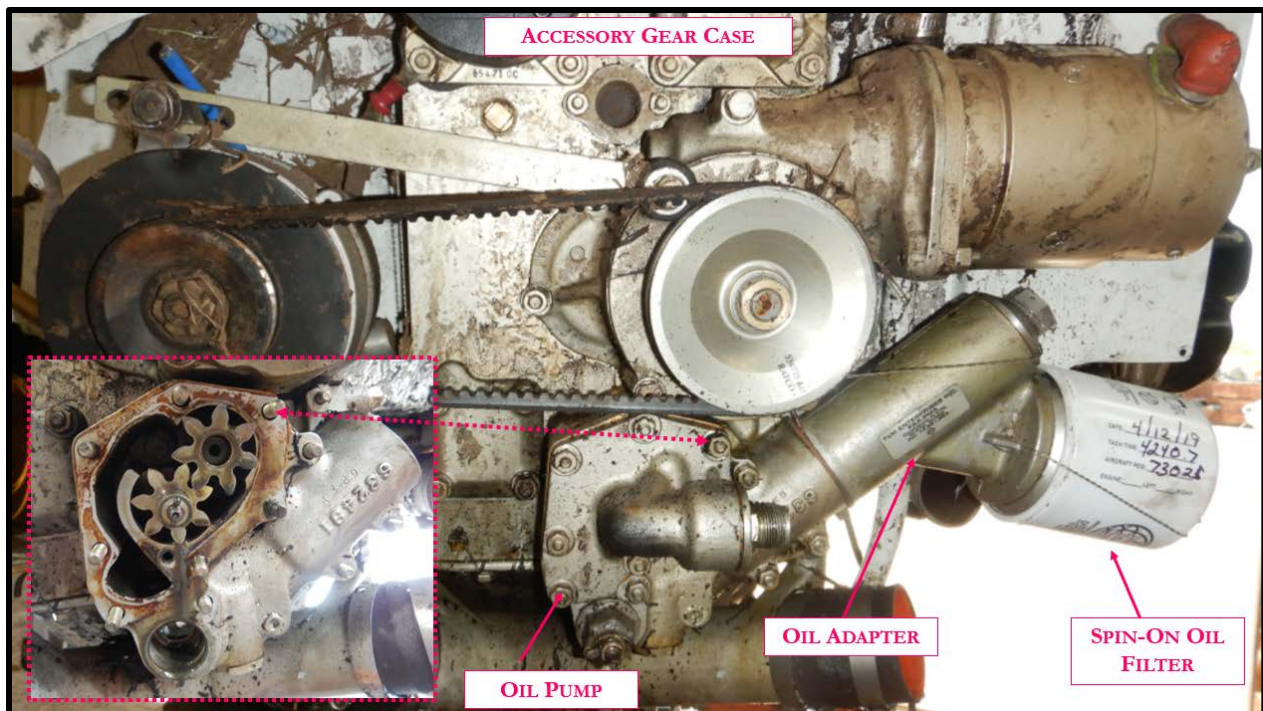


Figure 1: Oil Filter Adapter as Installed

According to the patent, the adapter included a tee casting (housing) and a hub (shaft) which was threaded to screw into the oil screen hole on the oil pump casting. The tee casting had a sleeve with a through bore and a mounting base with an end for receiving a spin-on oil filter. When installed, the hub was journaled into the bore of the sleeve and screwed into the oil screen hole, which had two oil passage openings. A crown (1-inch bolt head) at the outer end of hub secures the tee casting against the oil pump casing. Oil inlet and oil outlet passages are provided through the hub and the tee casting to circulate oil from the oil screen hole into the spin-on filter, and back into the oil screen hole from the spin-on filter.

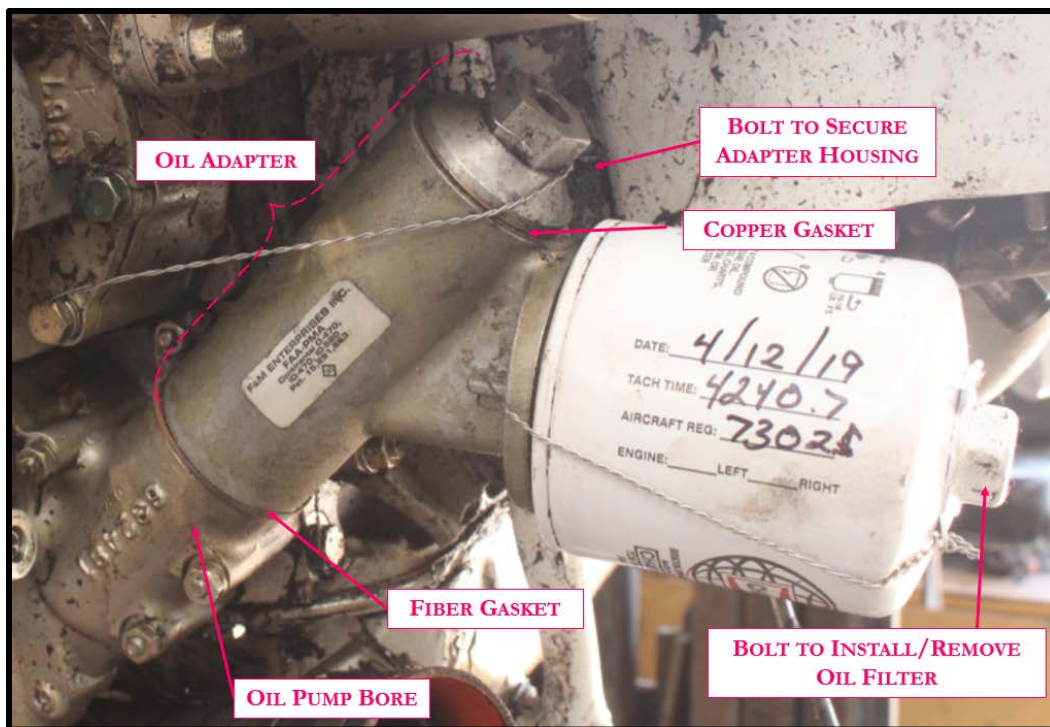


Figure 2: Oil Filter Adapter Assembly

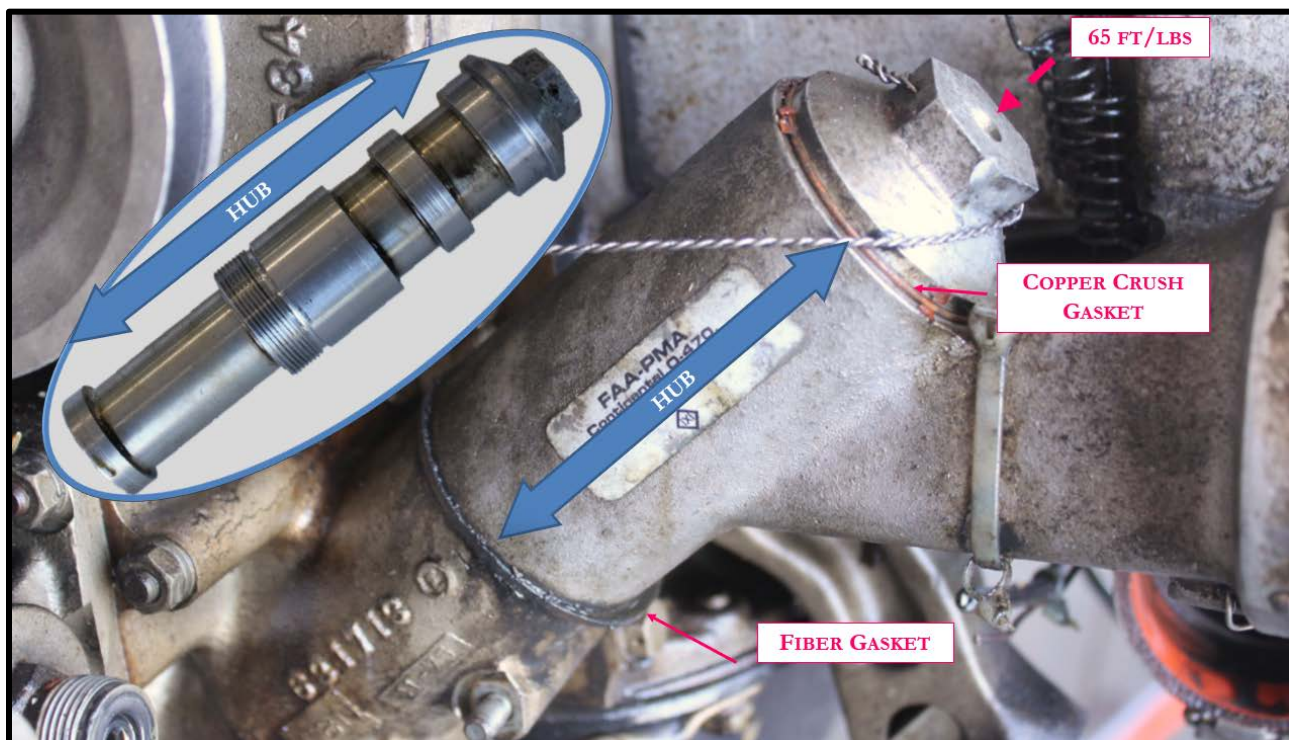


Figure 3: Oil Filter Adapter Showing Hub and Gasket

According to the patent, at the adapter sleeve housing inner flange (48), a metal seal (100) is positioned in the annular groove (66) of the hub (14). The purpose of the metal seal (100) it to prevent fluid leakage between the oil pump housing and the adapter sleeve housing at the inner flange (48). Additionally, the patent states that the annular groove (66) is sized and shaped to receive the metallic O-ring seal (100).

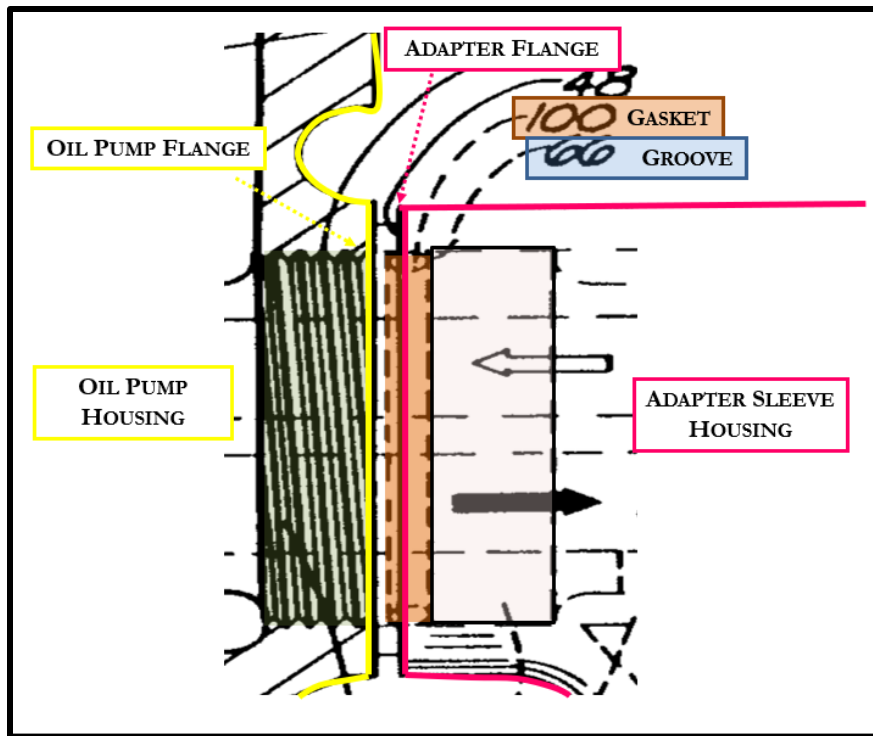


Figure 4: Patent Showing Adapter Sleeve and Annular Groove

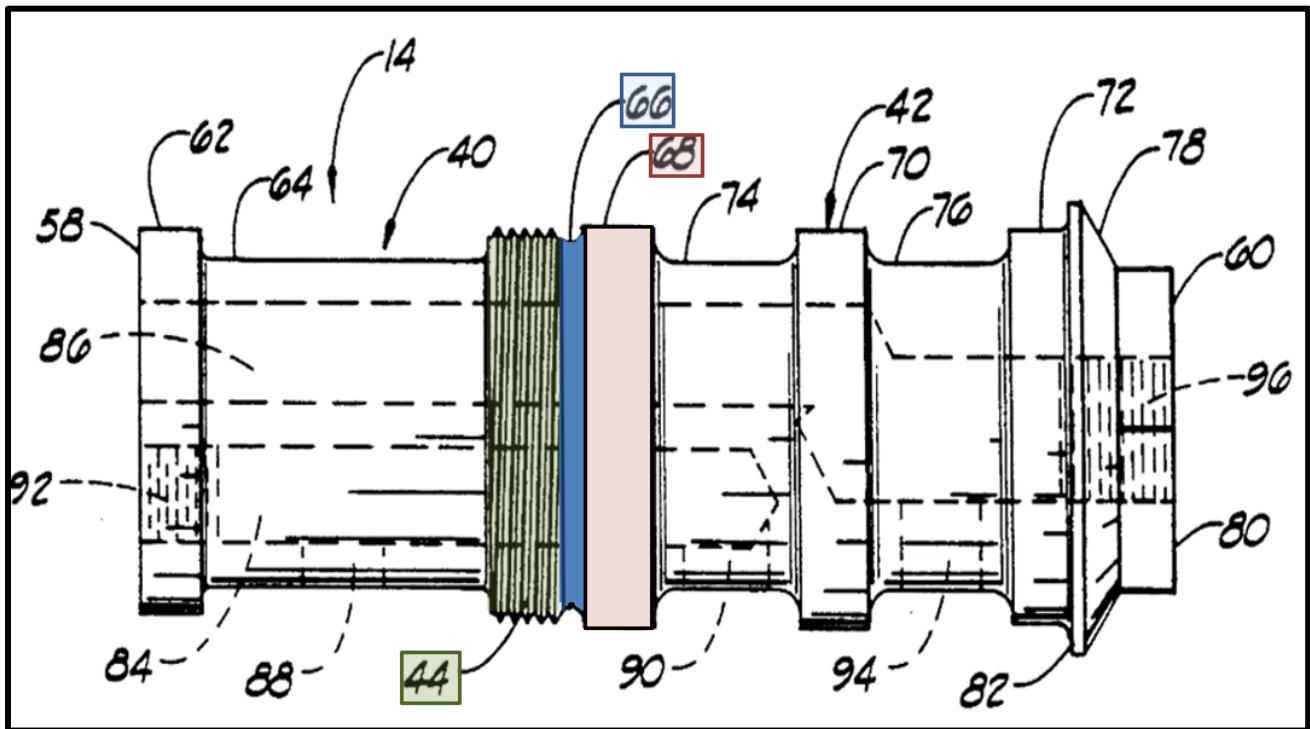


Figure 5: Patent Showing Hub

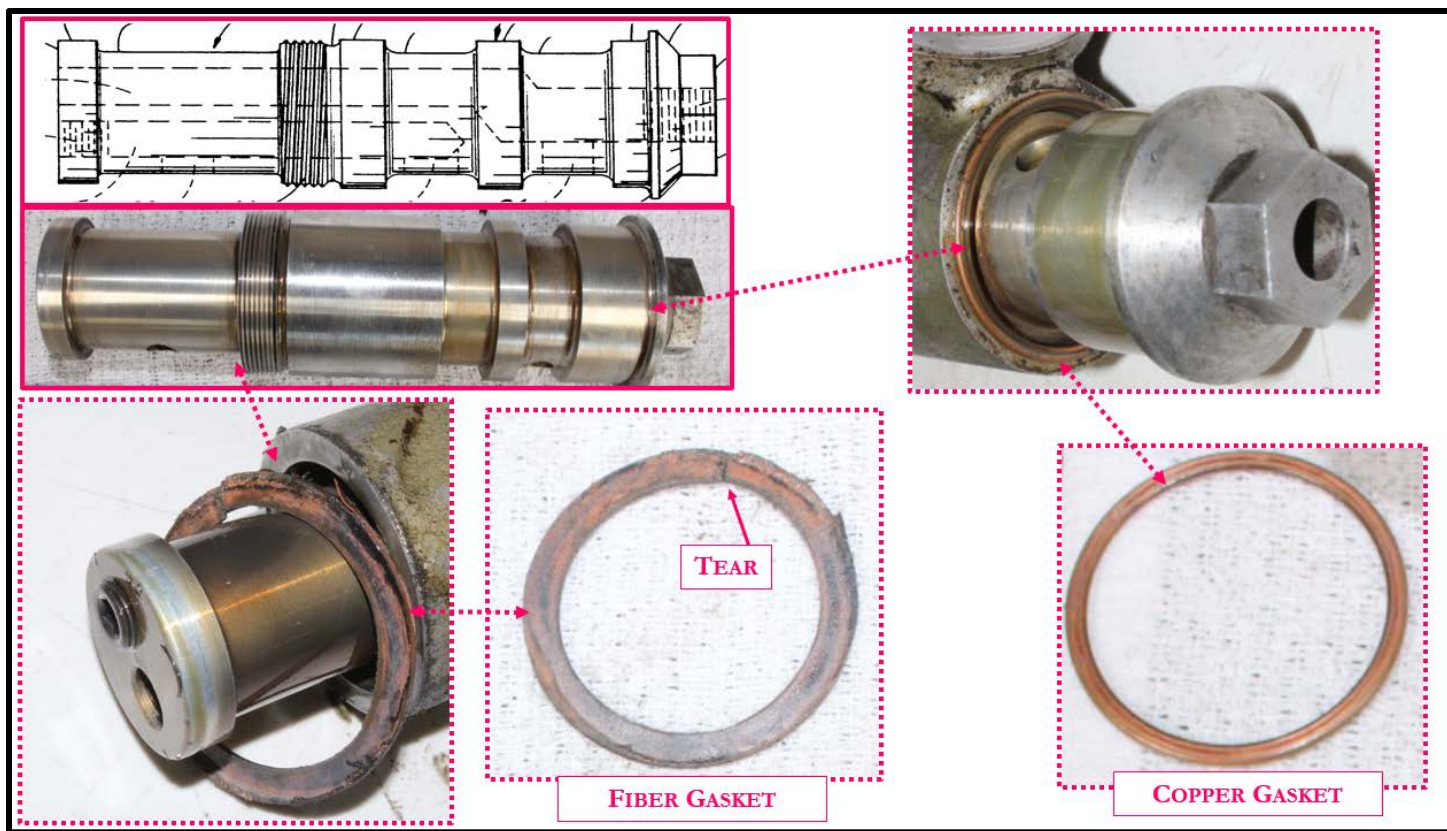


Figure 6: Oil Filter Adapter Shaft and Gaskets

GASKET

The tear in the fiber gasket was located on the flange closest to the forward by the cylinder. It is unknown which gaskets were on the accident airplanes, because the batch or lot number was not in the logbooks or stamped on the part.

Gaskets rely on both friction and compressive force (seating stress) to prevent gasket blowouts from occurring, which is a tearing in the fiber material consistent with the accident gasket. One of the signatures of uneven gasket compression is flange serration impression differences around the gasket, which in the oil filter adapter would likely be a crescent indentation in the gasket material from the circular flange shape of the adapter sleeve housing and the oil pump housing.

DESIGN

The fiber gasket, part number FM07¹, material was manufactured by Garlock as 3750 Leak-Guard² and cut by GPI or Corley Gaskets. The last order GPI received was in July 2013³ and sold to F&M in Texas.

The original copper gasket used by Continental for the oil screen was MS35769-48 (AN900-28)⁴ which had the following measurements: OD 2in, ID 1.75in, ring width 0.688in, thickness 0.094in.

¹ <https://www.aircraftspruce.com/catalog/eppages/fm-ofadap-gasket.php> (they have an 8130 showing Aero Accessories 2019)

² <https://www.garlock.com/sites/default/files/documents/en/Garlock%20Style%203750%20Spec%20Sheet%20-%20%28NA%29%202016-11%20EN.pdf>

³ According to Garlock the gasket shelf-life is 5 years

⁴ The AN900 annular gaskets are made from soft copper, which has been wrapped in a tubular 1/8-inch wide by 3/32-inch thick cross section around an asbestos core. As you examine one of the gaskets you will note one side is smooth and the other has the slot or split where the copper was formed around the core. This split side should always be placed against the surface that is not moved or rotated when the parts are assembled.

http://acversailles.free.fr/documentation/08~Documentation_Generale_M_Suire/Visserie/Joins/Copper_crush_gaskets.pdf

A representative from GPI stated that they procured the material directly from Garlock, ordering a 60” x 60” sheet of material and cut as many gaskets as possible from that sheet. The FAA had come to their facility twice to make sure they were in compliance with the certification and tagging of the die used to cut. He stated that the die used to cut the gaskets with labeled FM07 in measured: OD 2.25in, ID 1.745in, thickness 0.0625in. The last material used was the Garlock 3750 leak guard. He stated that F&M procured the following amount gaskets on these dates (the quantity is estimated based on the outer diameter of the gasket and size of sheet).

According to a Corley representative, the company is not FAA certified, nor have they ever been in contact with an FAA inspector.

The following gaskets were sold by both GPI and Corley Gaskets:

GPI		Corley Gaskets	
Date	QTY	Date	QTY
1/14/2010	576	2016	1600
10/19/2011	576	2017	800
8/17/2012	576	2018	1200
6/12/2013	576	2019	1200
7/19/2013	576		

Figure 7: Gaskets Ordered and Last Invoice Excerpt

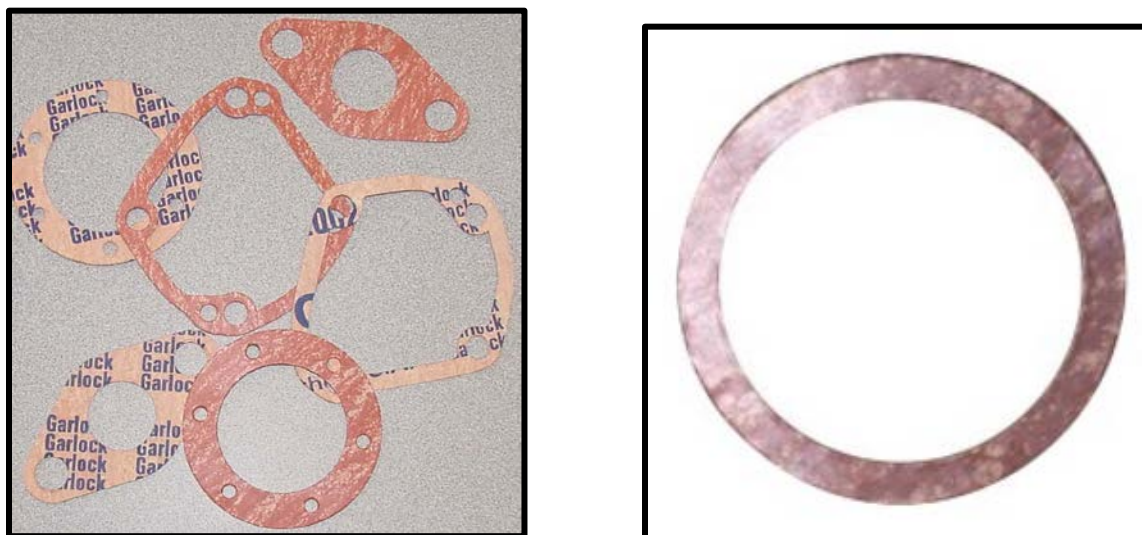


Figure 8: Gasket Material Provided by Garlock and Picture from Aircraft Spruce

According to Garlock engineers, “Compression can often vary significantly from one section of a gasket to another, indicating misaligned flanges, improperly supported pipes or uneven loading of the bolts. Overcompression can crush or cause splitting in some gaskets, which can be mistaken for chemical attack in rubber gaskets that have been installed in raised-face flanges.”⁵

And that “Even a small fragment of gasket left on a flange can make it impossible for the new gasket to conform properly, resulting in an immediate leak or a blowout.”⁶ Regarding chemicals interacting with the gaskets, “If the gaskets contain non-oil-resistant binders (i.e. SBR, EPDM, etc.), such lubricants can chemically attack them, soften the binders and reduce the crush strength of the gasket. Even when compatible with the gasket, these lubricants also reduce the friction between the gasket and flange faces causing them to extrude and eventually blowout.”

⁵ https://www.garlock.com/sites/default/files/files/technical_articles/Flow%20Control%20Article%20%289-16%29.pdf

⁶ <https://www.garlock.com/sites/default/files/documents/en/Gasket%20Removal%20and%20Installation%20-%20June%202018%20-%20TECHNICAL%20BULLETIN.pdf>

INFORMAL GASKET HISTORY

The owner of F&M passed away and the STC was sold to Stratus in 2015.

2016⁷: Their design used 2 copper crutch gaskets, one at base, and one at top nut. Crush gaskets do just that. They compress with cycles of tightening, vibration, and temperature cycles. The install manual says that filter adapter to be retorqued at 20 hours of operation, after gaskets compress. Tempest bought the design and certification from former owners and re-spec'd it.

They now specify new gaskets which can be bought as a set from Aircraft Spruce.

The new gaskets spec is a copper crush gasket at the top nut and a fiber gasket, not paper, at the base. This combination has about half the compression thickness of the two copper gaskets.

From what I've seen, there are at least three different gasket methods used on the F&M filters:

- 1) The earliest used two AN-900 copper crush washers.
- 2) Later used an upper AN-900 copper crush washer and a lower flat fiber gasket on a machined flat surface.
- 3) The latest and last used an upper AN-900 copper crush washer and a lower flat fiber gasket on a lightly knurled flat surface.

Aug 2012⁸: The F&M oil filter adapter is back on. I had to order a new gasket from them (\$15). I'm not convince it's much different from the one in the overhaul set. They're both paper gaskets. Their's is .032" thick and the one in the set is .030" thick.

Oct 2007⁹: in the beginning of the F&M history they did come with 2 crush gaskets but had leaks and the fiber gasket was developed. The early version used two commonly available copper crush washers and had a flat face where it mates to the accessory case. This version was known sometimes to leak. (The earliest installation instructions also failed to specify the proper torque and low torque was a contributing factor to leaks.)

FM Enterprises made minor changes to include a chamfer at the mating face (improved axial location), a composition gasket at the mating-face surface (improved sealing and vibration issues), provided installation torque specification, and advised to clean older engine cases of carbon in the threaded area (provide more accurate torque), solving the leak complaints.

Sept. 2006¹⁰: When I spoke with F&M regarding their system about a year ago, I was told they changed the fwd gasket (at accessory case) from an AN900 to the fiber type due to recurring reports of leaks at that interface. They also increased the torque to 65 lb/ft. It was also stated that the STC was not revised for the changes.

THREADS

The adapter threads are deeper in the bore than the original screen threads.

⁷ <https://www.beechtalk.com/forums/viewtopic.php?f=37&t=129444&start=60>

⁸ <http://n140tw.blogspot.com/2012/08/f-oil-filter-adapter.html>

⁹ <http://cessna170.com/forums/viewtopic.php?f=2&t=4998>

¹⁰ <http://www.cessna170.org/forums/viewtopic.php?f=2&t=3321>

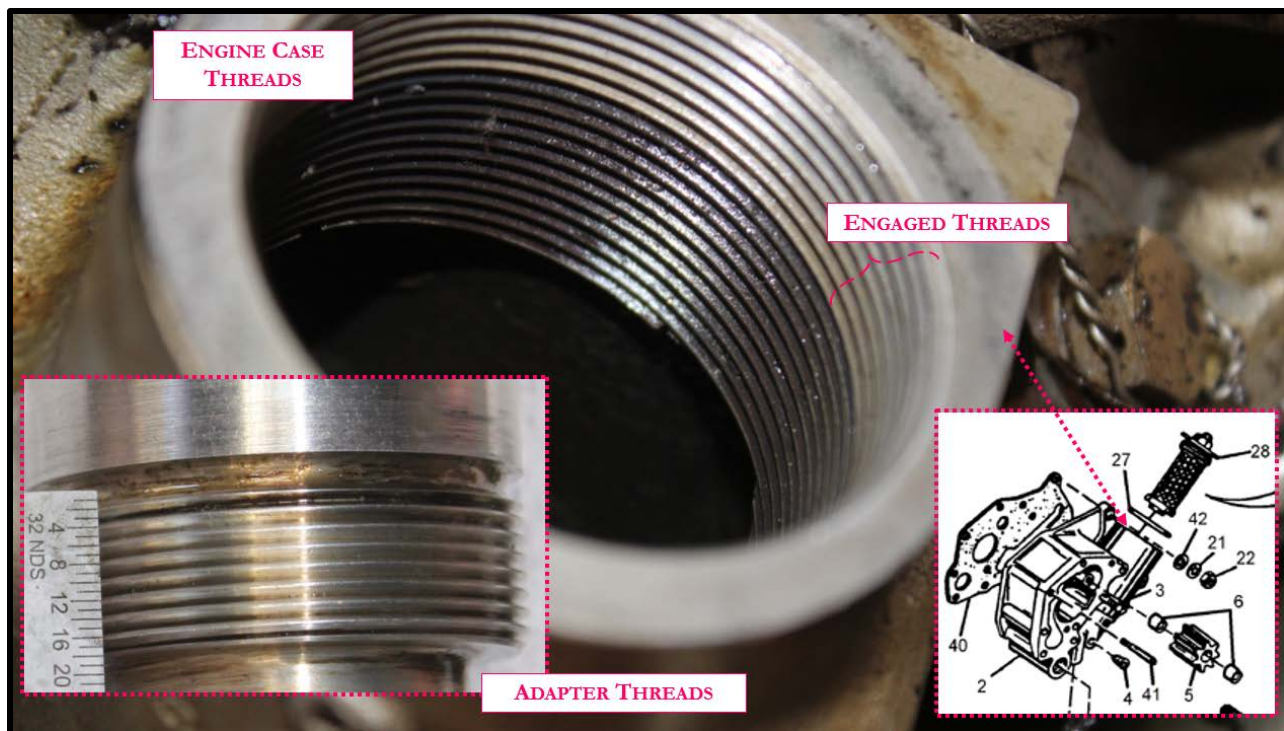


Figure 9: Oil Filter Adapter Threads



Figure 10: Oil Screen as Originally Sold

FORUMS

Excerpts: “some times the threads on the rear case need to have a thread chaser run down inside to clean up carbon build up.

Oct 2003¹¹: The guy at F&M did an outstanding job at customer support in my opinion. He is sending me the new gaskets and they will loan out the thread chaser for the cost of shipping. Hope this helps someone out there.

¹¹ <http://cessna170.com/forums/viewtopic.php?f=2&t=499>

July 2010: As FM to also send you their cleanout tool. If there is ANY crud, carbon, damaged threads in the case, the FM Adaptor will not give the proper torque and may leak.

OTHER MANUFACTURES

According to the Air Wolf AFC-K008 Adapter¹² installation instructions:

******* WARNING (D) *******

On some Continental engines, you may find the 1-3/4"-16 UNF-3B threads in the oil pump/accessory case where the oil screen was located, to be damaged or not complete causing our CON-10 adapter to bind during installation. DO NOT FORCE our engine adapter into these damaged threads as galling WILL occur. A specially ground 1-3/4"-16 UNF-3B tap is available from Airwolf that usually will cleanup these threads.

Figure 11: From Air Wolf

OIL FILTER ADAPTER (C6LC-S) -- WPR19FA126

ACCIDENT ADAPTER HISTORY

The Continental Motors O-470- S, serial number 1032759, was a factory remanufactured engine installed on February 21, 2017 at an engine time of 341.9 hours since last major overhaul. The engine was equipped with an F&M Enterprises Inc. engine oil filter adapter, model C6LC-S (s/n 60399). The filter adapter was installed on the engine under FAA Supplemental Type Certificate (STC) SE09356SC. According to the owner, he installed the oil filter adapter upon receipt of the engine in February 2017. There were no documents regarding the installation of the adapter, but in an interview with the owner, he stated that he removed the adapter off the prior engine. The FAA records indicated that engine that was removed, O-470-S (s/n 464449), had the STC installed June 16, 2006. The owner stated that the adapter was off an engine for about one month and could not recall the procedures he used to install the adapter, but thought he would have looked at the manufacturer's instructions and replaced any seals.¹³

The maintenance records indicate that the oil filter was changed on seven occasions all of which were performed by the owner:

Date	TSMOH	Tach	Performed By
4/18/2017	20.4	3928.6	Owner
6/24/2017	55.6	3963.8	Owner
9/20/2017	103.2	3963.8	Owner
3/24/2018	167.7	4075.9	Owner
7/7/2018	218.1	4126.3	Owner
8/31/2018	267.5	4175.7	Owner
4/26/2019	332.5	4240.7	Owner

OIL FILTER ADAPTER (C6LC-L) -- WPR19LA166

The engine was equipped with an F&M Enterprises Inc. engine oil filter adapter, model C6LC-L (s/n 10706L).

ENGINE

The Continental Motors IO-520-FcA, serial number 240902-R, was a Millennium overhauled engine installed in June 2003 at an airplane total time of 1,119 hours and engine total time of 1,767.7. Continuity was established from the throttle, mixture, and propeller controls in the cockpit to their respective arms in the engine compartment.

¹² STC SA00079NY <http://www.airwolf.com/aw/products/remote-mount-oil-filter-kits/remote-oil-filter-kits-continental-engines>

¹³ It is likely that the history of the failed gasket will remain unknown.



An external examination revealed there was a hole in the upper right crankcase a few inches wide in diameter. There was a larger hole in the upper left crankcase and the top of a separated connecting rod was lodged in this hole. Turning the propeller resulted in the engine being able to turn about 270 degrees before binding internally. Removal of the upper spark plugs revealed that the faces were slightly dark, but according to the Continental representative, were in normal condition. An electronic borescope inspection disclosed that all intake and exhaust valves were intact and exhibited normal combustion signatures.

OIL ADAPTER EXAMINATION

An external examination revealed that the filter adapter was loose, and the adapter housing could be rotated about the shaft.¹⁴ The crown head of the shaft and the oil filter screen bolt head both remained saftied. There was a concentration of oil in the area of the adapter and adjacent firewall. The nut on the hub had several wear marks, consistent with a tool slipping on the nut. There was an older zip tie around the adapter arm that held two wires. The plastic and wear was consistent with the tie wrap being installed several years prior, and the location of the wrap end was position near the nut, where the installation/removal of the nut was prohibited by its position.¹⁵

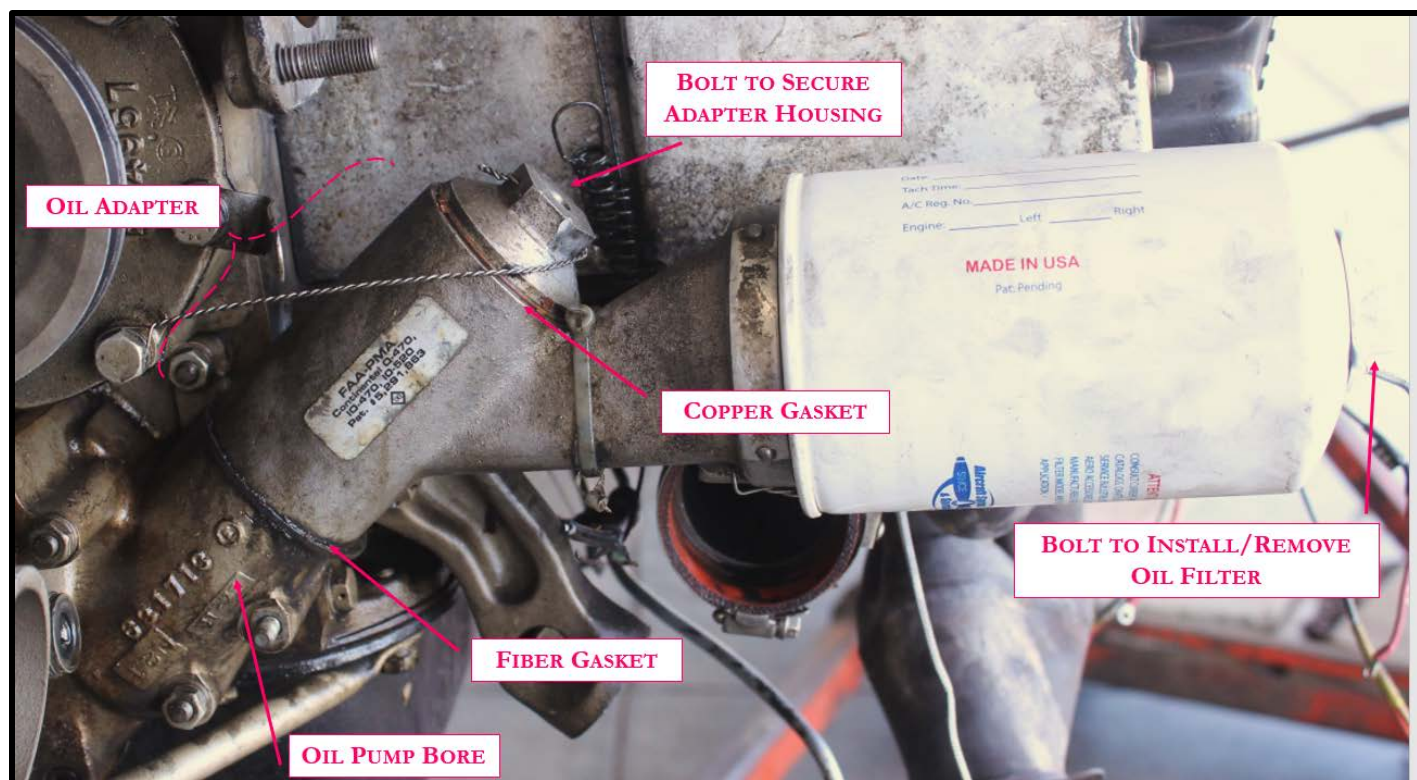


Figure 12: Oil Filter Adapter as Installed on Oil Pump Bore

¹⁴ See <https://www.flickr.com/photos/136005688@N02/28283176785/in/set-72157668173219294/> for example

¹⁵ This conflicts with the mechanic's statement that performed the last annual inspection that he recently re-torqued the adapter.

A closer examination revealed that the fiber gasket, located between the oil pump casting and the adapter was protruding with the outside edge extending beyond the castings. Additionally, a tear could be seen in the gasket where the adapter housing abutted the engine case. Investigators removed the safety wire and attempted to assess the breakaway torque of the adapter. A torque wrench was used to determine that the breakaway torque was 9 foot-pounds

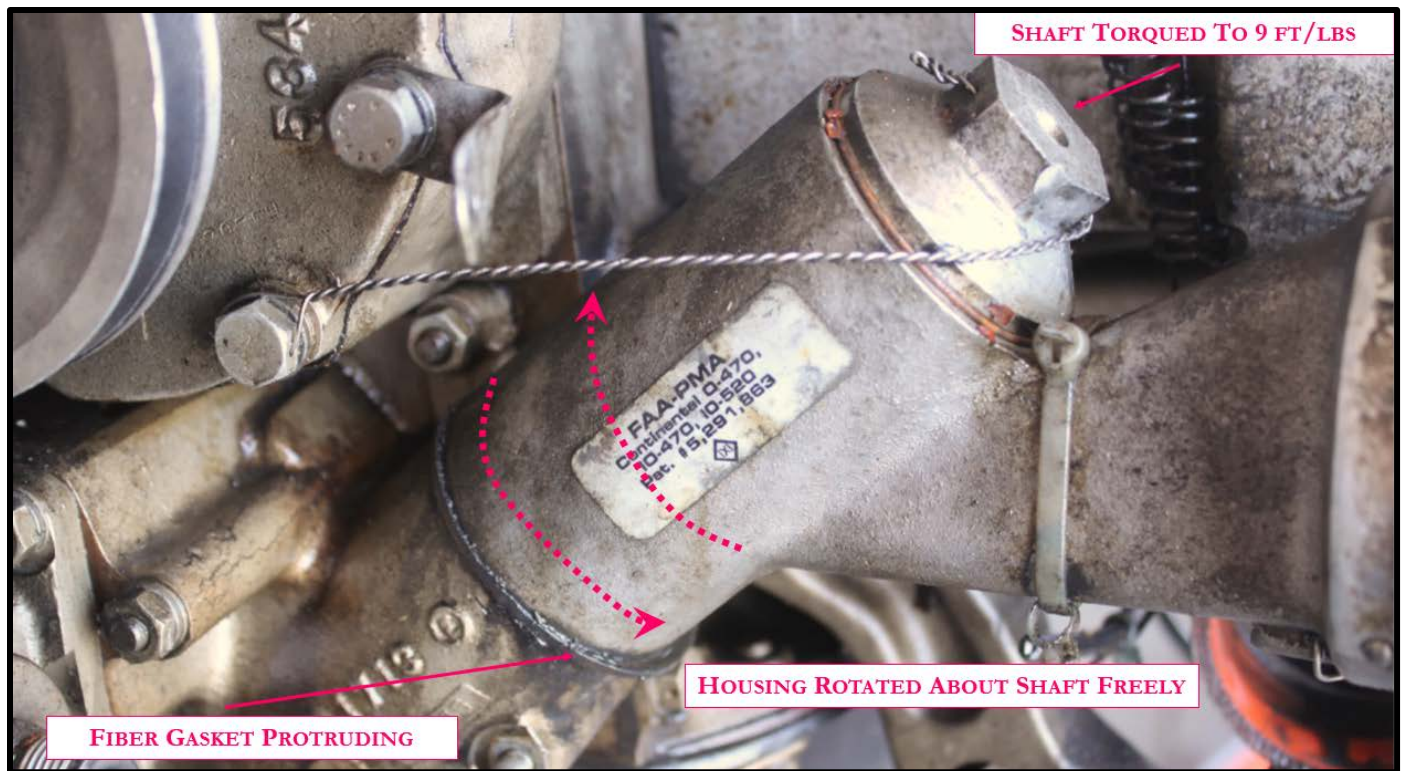


Figure 13: Oil Filter Adapter Could be Rotated Freely

Removal of the adapter revealed that the fiber gasket was completely split and contained several lips where it appeared the gasket had been pinched between the engine case and the adapter housing. The copper crush gasket was intact.

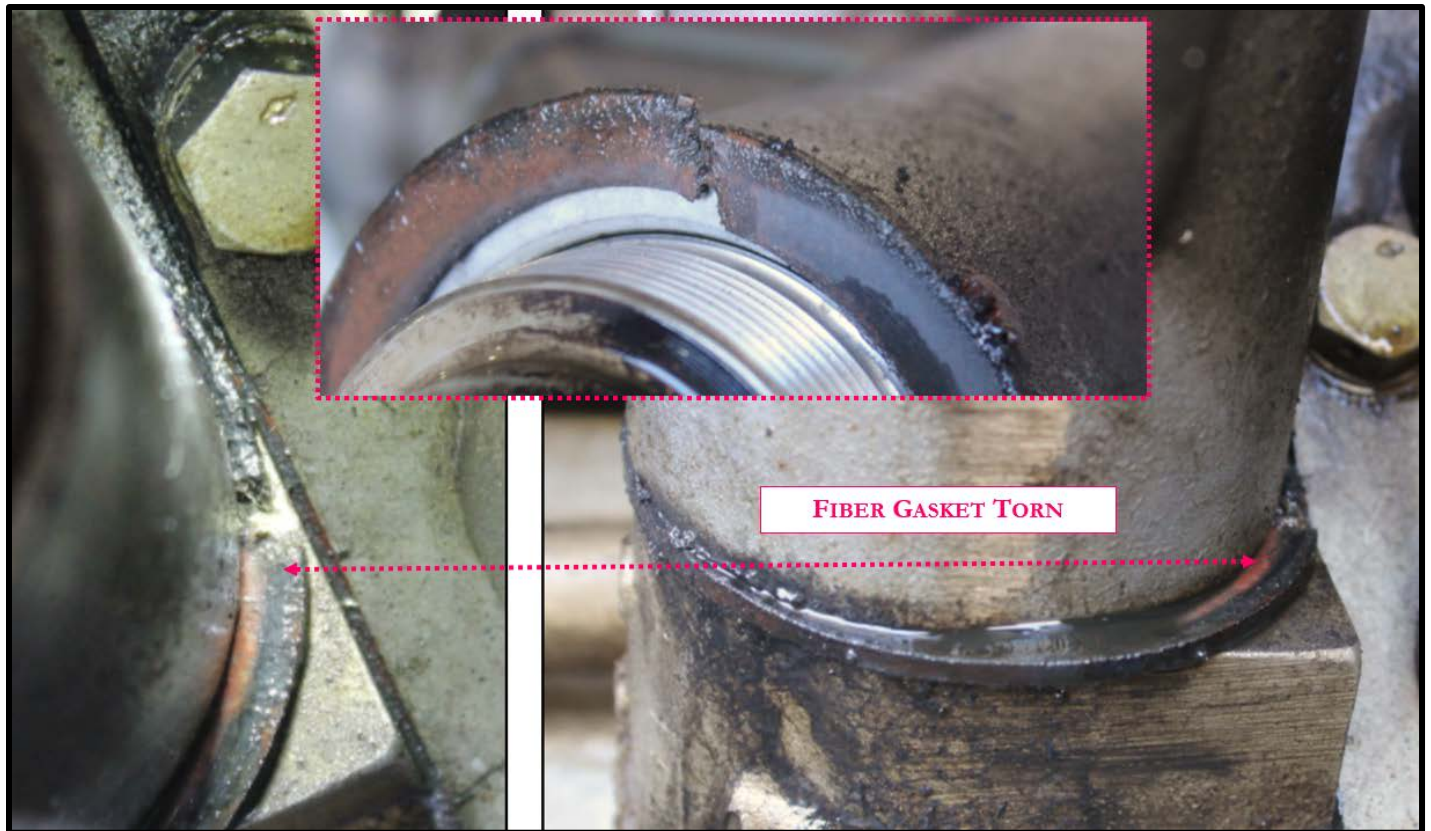


Figure 14: Fiber Gasket

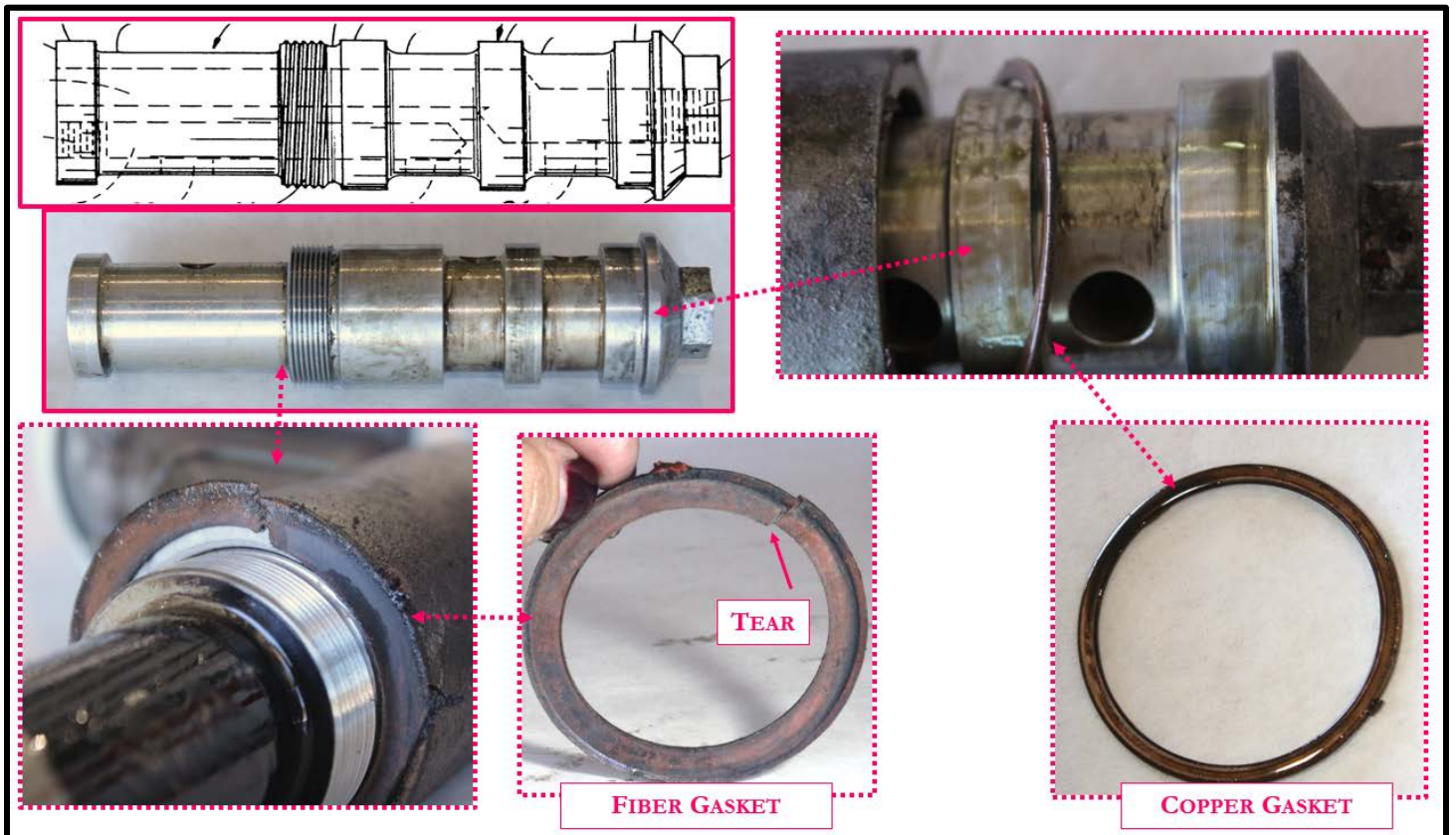


Figure 15: Shaft Showing Gaskets

The threads on the upper area of the hub, adjacent to the annular groove were rough.

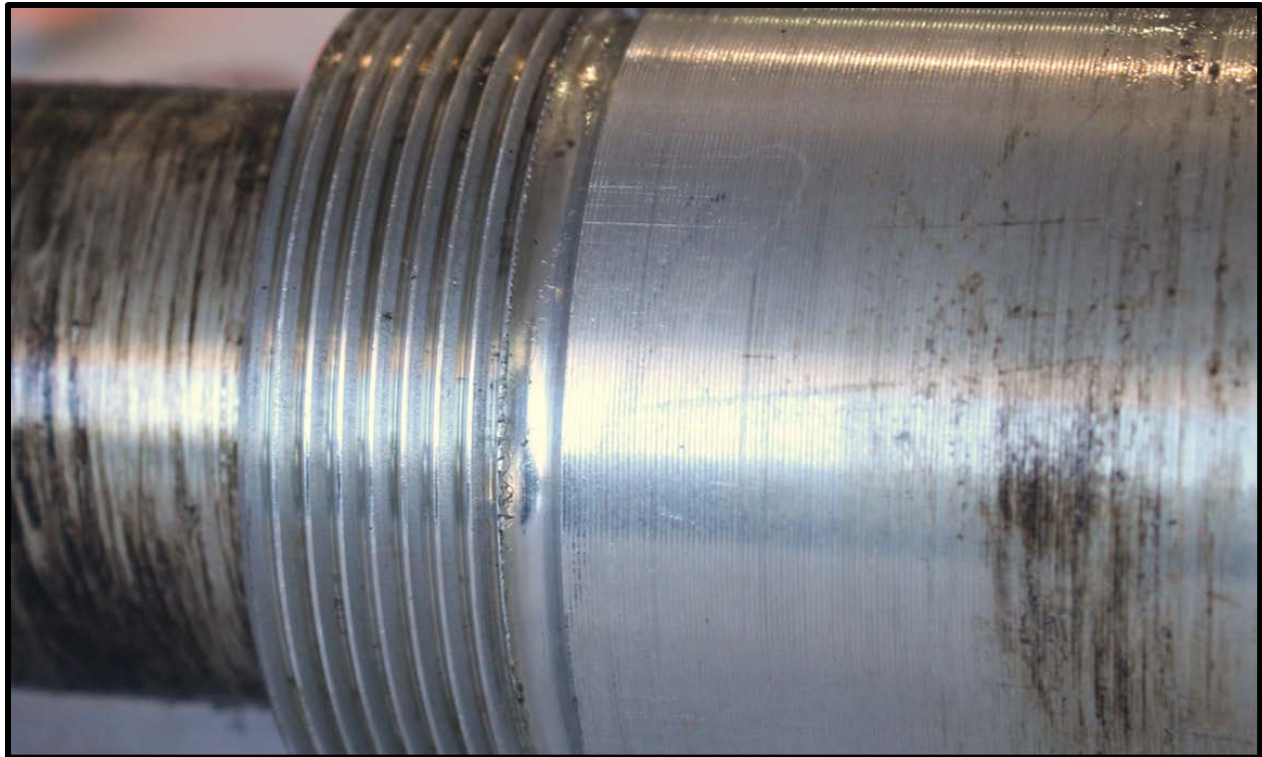


Figure 16: Threads on Hub

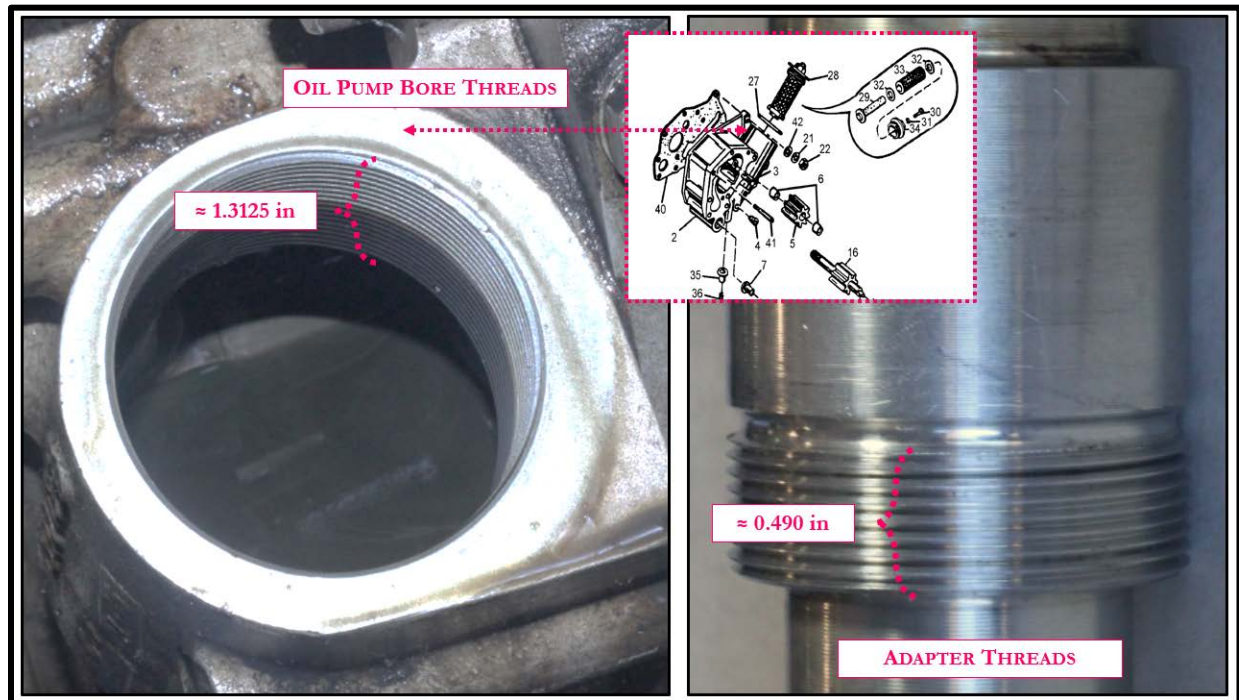


Figure 17: Threads of Oil Pump and Adapter

FUNCTIONAL TESTING

After measuring and photo documenting the oil filter adapter assembly, a new fiber and copper gasket were used to install the oil filter adapter on the engine, using a calibrated torque wrench. A mechanic installed the adapter while investigators captured the installation on video.¹⁶ When sliding the fiber gasket over the hub threads, there was light scraping due to the tight fit of about 0.022 inches as measured with a feeler gauge. Despite numerous components

¹⁶ See Videos 1a, 1b, 2a, 2b showing two installations from 2 different angles.

being removed (e.g., the starter), the mechanic had only about 8 inches of space to torque the adapter. The limited space prohibited the mechanic from being able to visually discern the alignment of the fiber gasket.¹⁷



Figure 18: Clearance to Install Adapter with All Components Installed

The mechanic had great difficulty torquing the adapter where the entire adapter body would rotate prior to reaching 65 ft/lbs. After great effort, the mechanic was able to torque the adapter to 65 ft/lbs, with the body having shifted. Even with that amount of torque, the adapter could still be moved by applying force to the oil filter or adapter body.¹⁸ It was not possible to torque it tight enough to prohibit movement.

¹⁷ The clearance between the hub and the fiber gasket was about 0.031 inch clearance.

¹⁸ See Video 3 showing movement of the filter after adapter is torqued to 65 ft/lbs.

MEASUREMENTS

Measurements taken during examination.

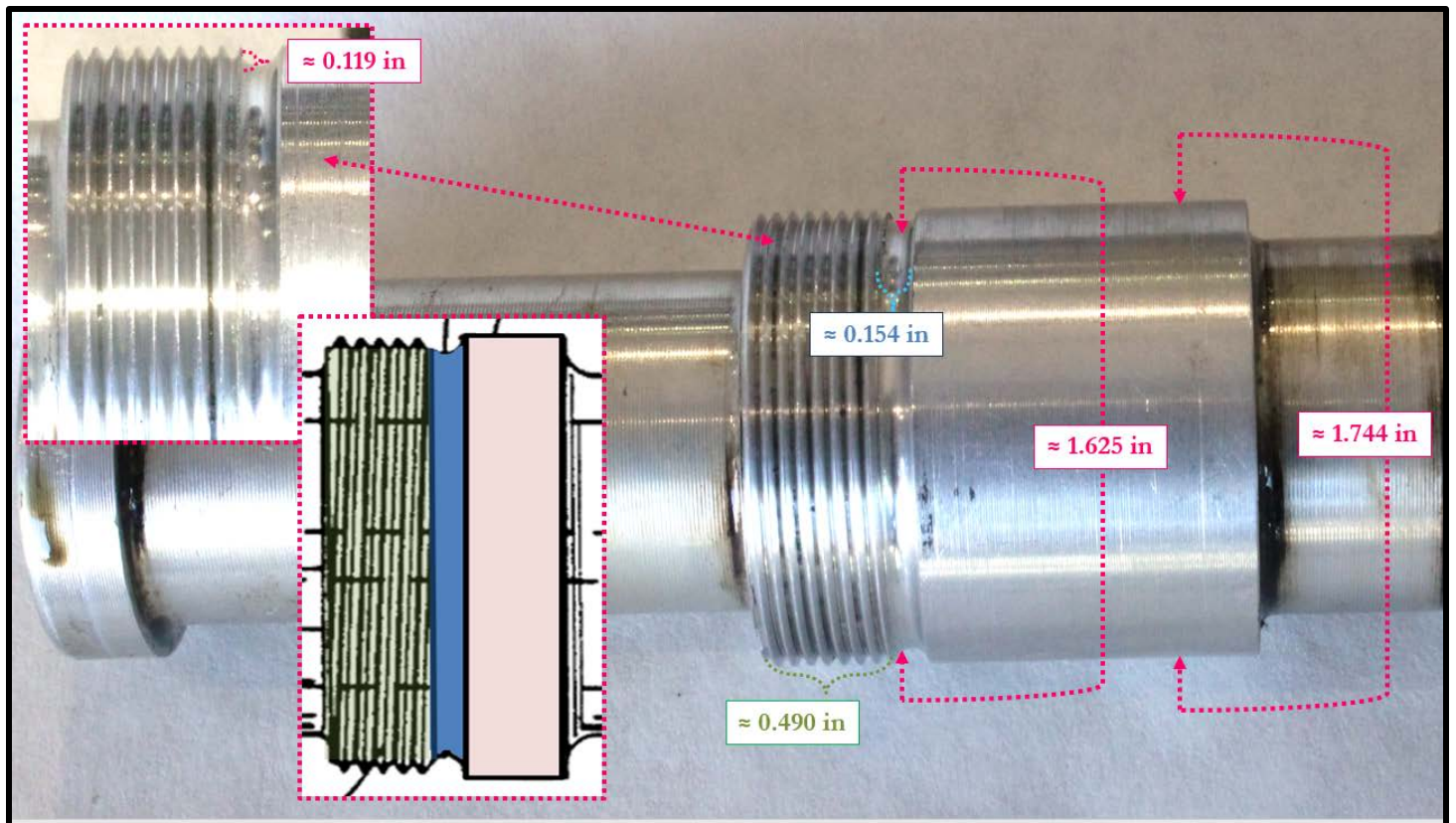


Figure 19: Hub Measurements



Figure 20: Fiber Gasket Measurement Comparison

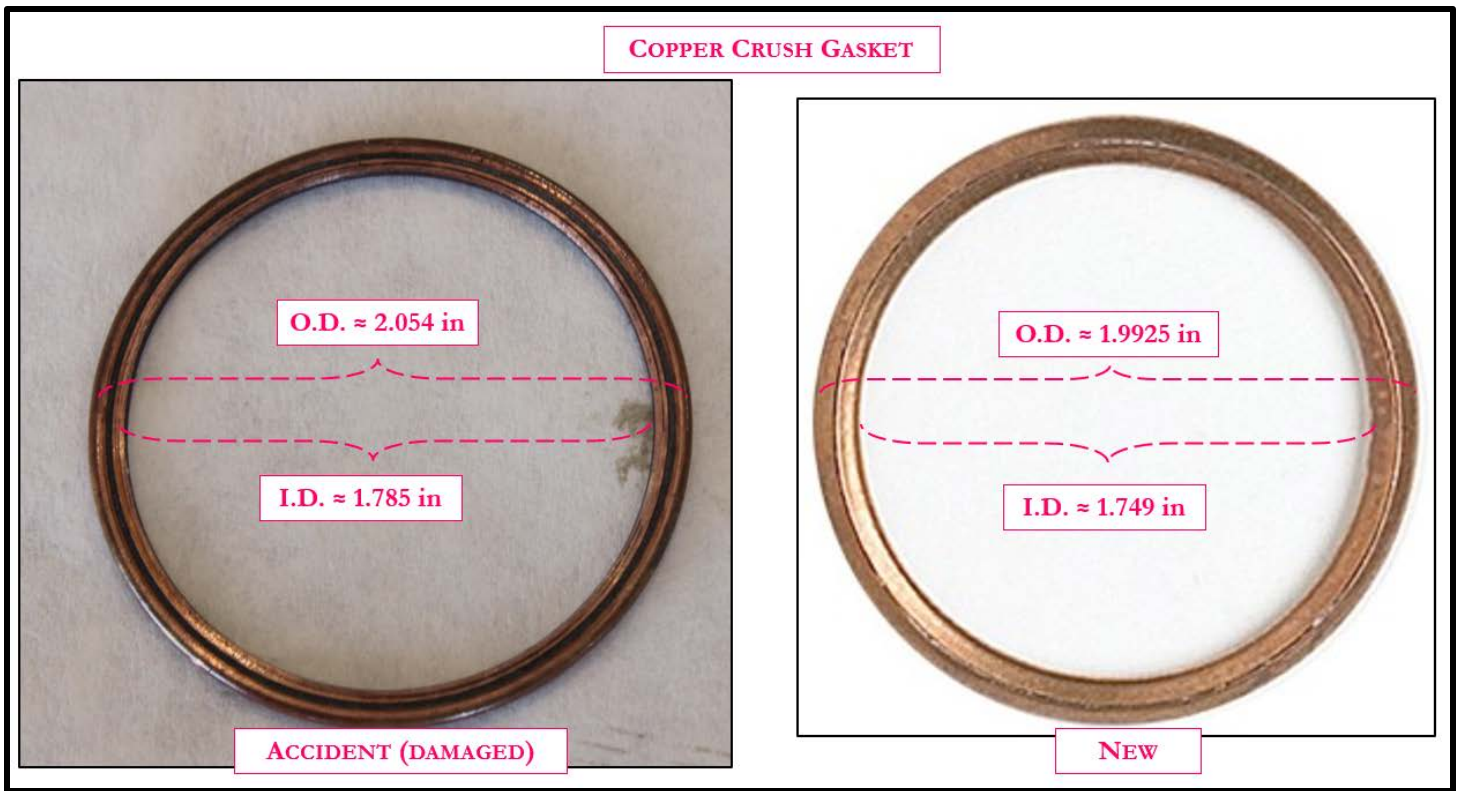


Figure 21: Fiber Gasket Measurement Comparison

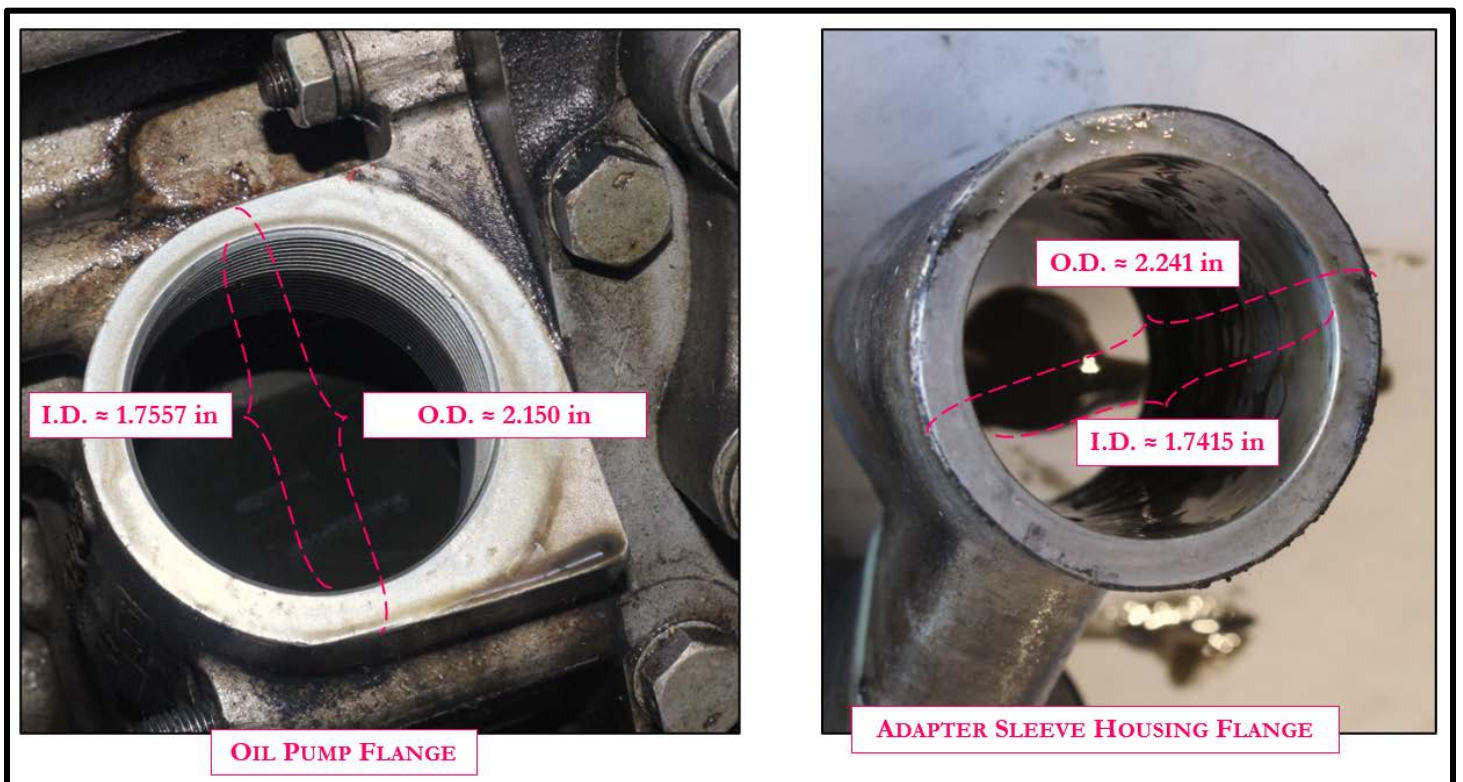


Figure 22: Oil Pump Flange and Adapter Housing Measurement Comparison

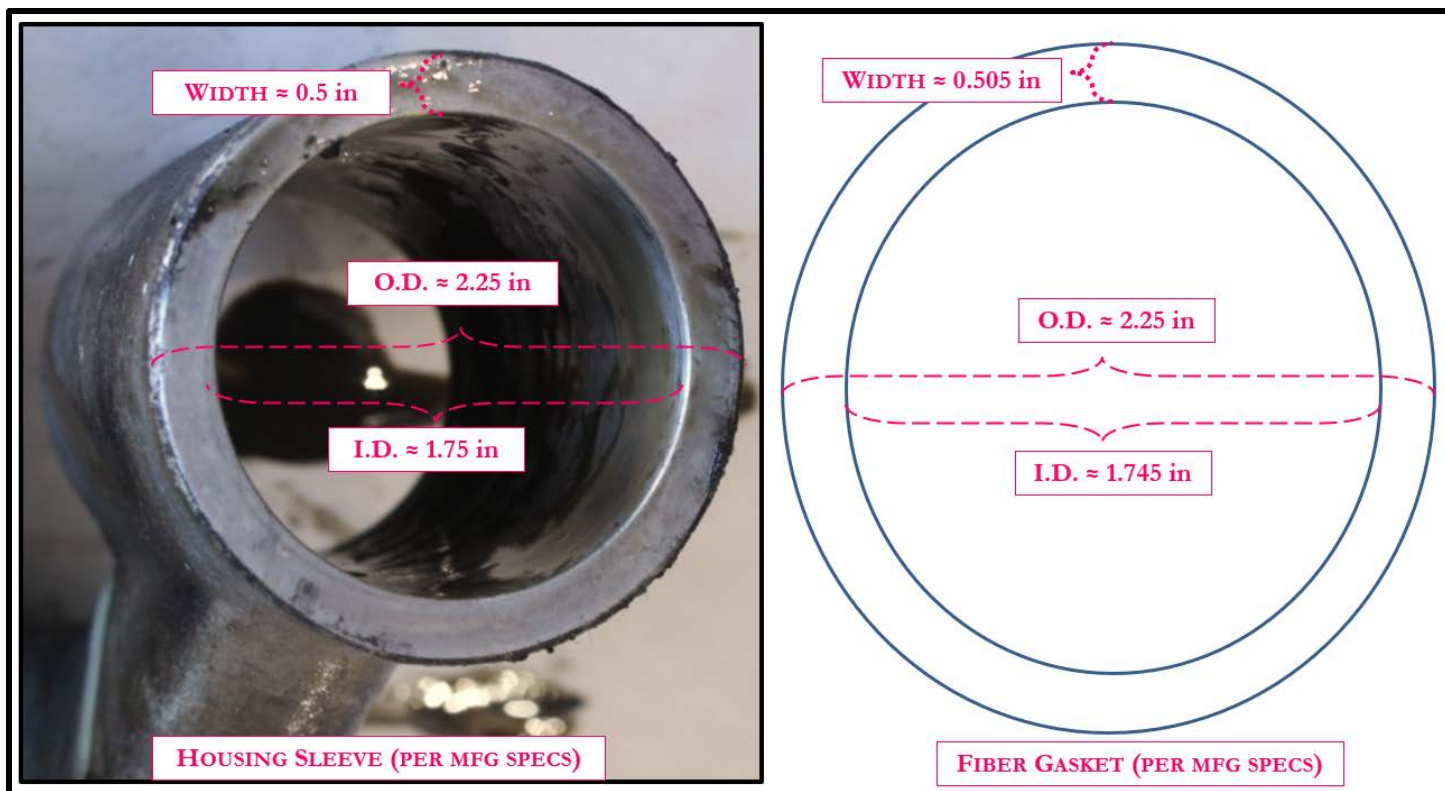


Figure 23: Adapter Housing Measurement Comparison to Fiber Gasket

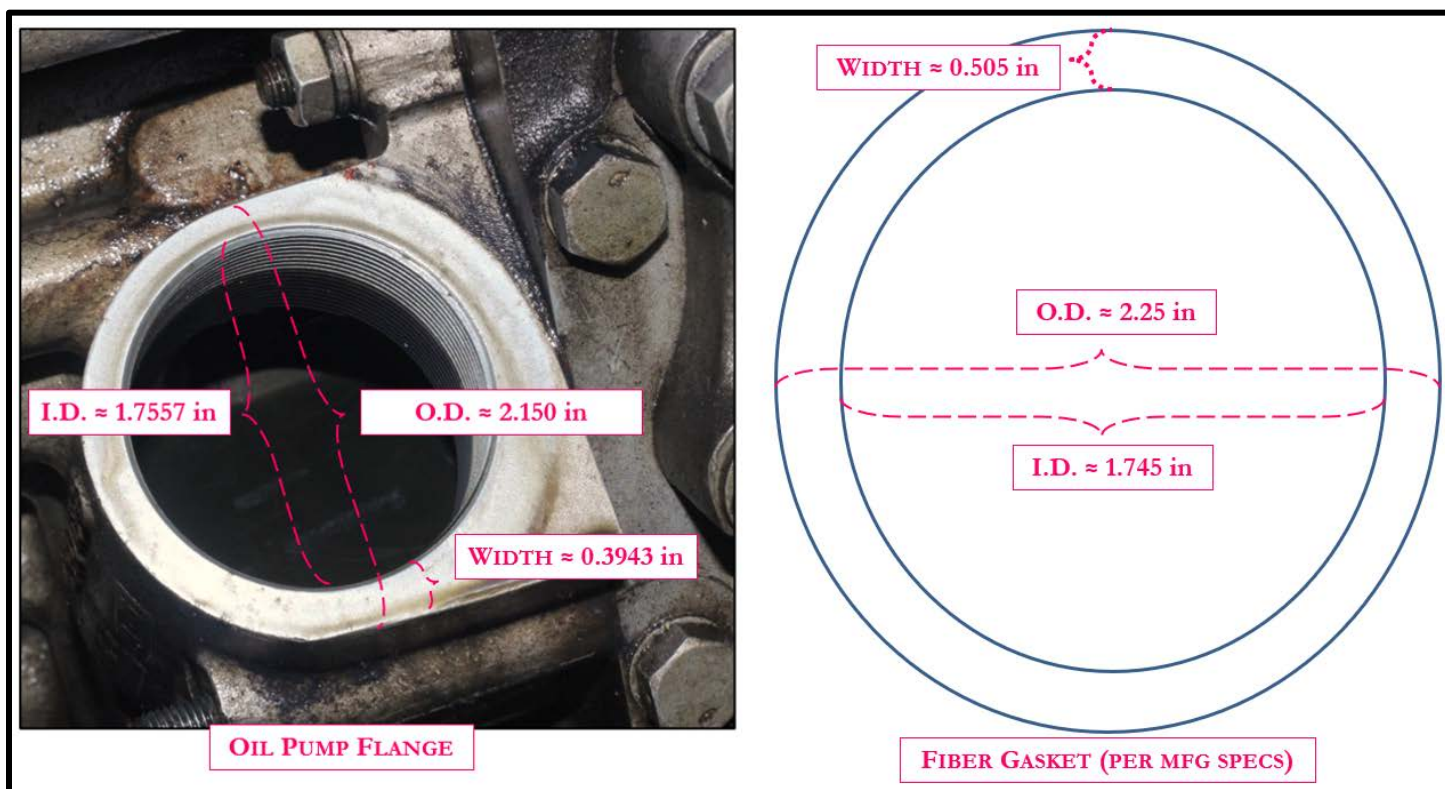


Figure 24: Oil Bore Measurement Comparison to Fiber Gasket

ACCIDENT ADAPTER HISTORY

The Continental Motors IO-520-FcA, serial number 240902-R, was a Millennium overhauled engine installed in June 2003 at an airplane total time of 1,119 hours and engine total time of 1,767.7. At the examination the tachometer read 2,747.88 (17.2 hours since last maintenance) and an engine time of 1,435.9.

Pro Air Aviation

Registration : N 3997Y [REDACTED] Date: 05/03/2019
Manufacture: Cessna

Model : C 210 D Lakeside, CA 92420 Tach/Hobbs: 2730.66
[REDACTED] ph TTSN: 1611.66
Work Order #: 7629

Engine: IO 520-FcA S/N: 240902-R

All routine maintenance and service completed per an ANNUAL inspection.
Drained oil, replaced oil filter, Serviced engine with 11 QTS. Of Phillips 50w OIL.
Cleaned and inspected all spark plugs, Cleaned and inspected All fuel injectors.
Inspected magneto to engine timing, inspected and pressure tested exhaust system for
leaks, none found. Compression check as follows: #1.67 /80, #2.70 /80, #3.70 /80,
#4.68 /80, #5.66 /80, #6.68 /80. Replaced air induction elements with new. Washed
Engine and cowl, test run normal. I certify that this ENGINE has been inspected I.A.W.
AN ANNUAL Inspection and was determined to be in airworthy condition. AD's Current
through bi-weekly issue: 2019-09.

[REDACTED]

Colin Skinner A/P IA.

The engine logbooks indicated that the engine was installed on the airframe in June 2003. The engine was subjected to a propeller strike in October 2001 and January 2005.

& visually inspected removed oil filter. Very clean. (7925) Torqued oil filter adapter (not Cessna) to 500 in/lbs & safety wired with .040. (9010) Completed post inspection leak checks. (9030) Completed local flight check 03/27/04 for oil filter adapter leak check. Little Flyers WO# 3712 Roger A. Stern A&P [REDACTED]

A logbook entry in January 2007 states that the mechanic retorqued an oil filter adapter at a tach time of 1554.77 hours.

¹⁹ The FAA inspector collected the recent logbooks from the pilot, preventing the investigation team from being able to review them prior to and during the examination.

✓ 7925	OIL FILTER
1.	Repositioned oil filter adapter and torqued to 65 ft/lbs, safety wired. RS
2.	Re-torque oil filter adapter after 10 hrs.

Figure 27: Other Entries

SIMILARITIES OF GASKETS

Based on the patent, forum discussions, and changes in F&M instructions, it is likely that the oil filter adapter was originally designed and sold with two AN900 copper crush gaskets. The original Continental oil screen required copper gasket MS35769-48 (OD 2.0 in, ID 1.75 in, ring width 0.688 in, thickness 0.094 in), which is likely the same gasket that was used for the adapter. GPI stated that fiber gaskets supplied to F&M were OD 2.25 in ID 1.745 in, ring width 0.505 in, thickness 0.063 in. The annular groove was 0.125 in wide and the depth is unknown.

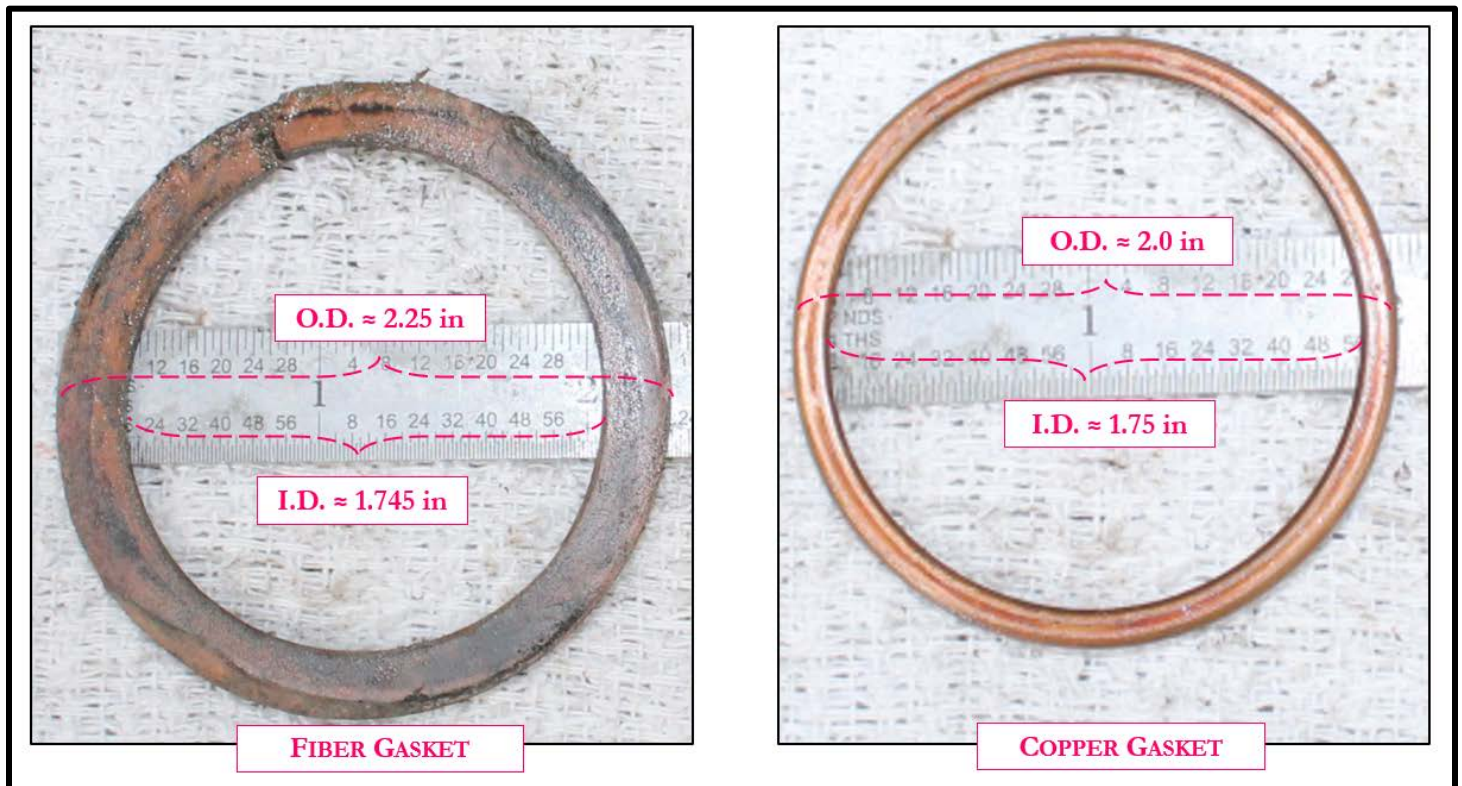


Figure 28: Measurements of Fiber vs. Copper Gasket

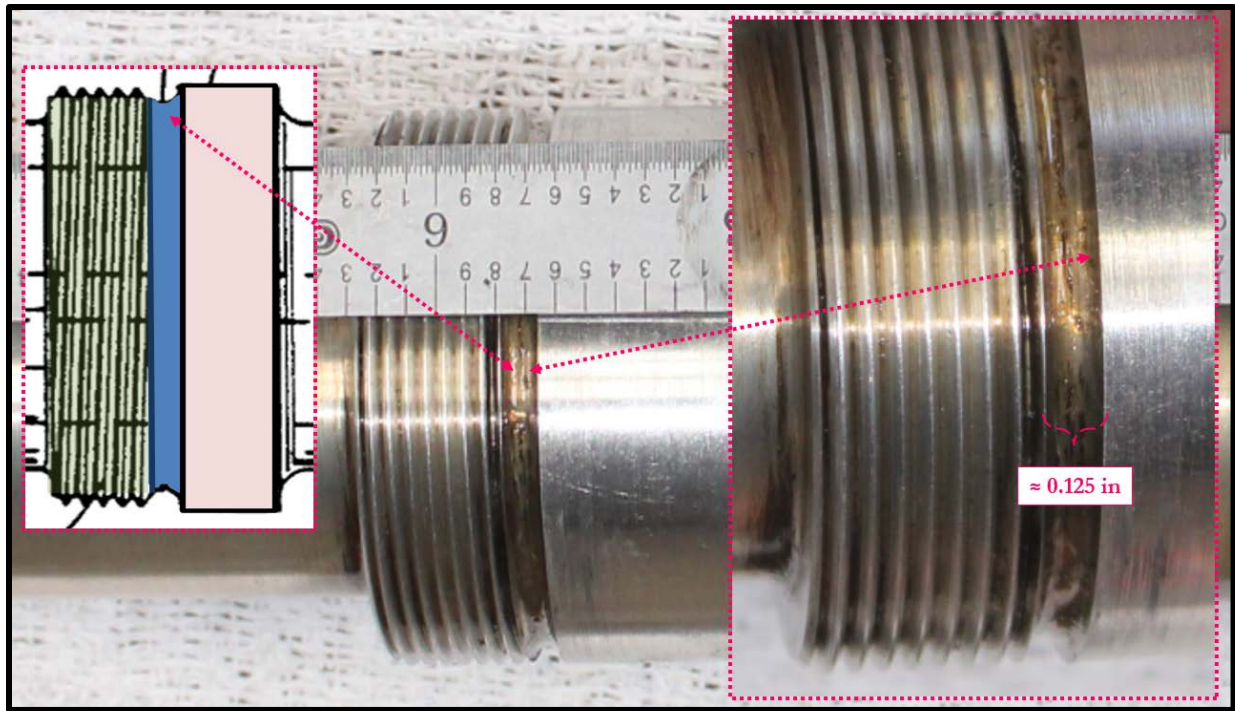


Figure 29: Measurements of Annular Groove

The oil pump housing flange measured about 2.3 in at the widest portion and the flange width thickness varied; the narrowest portion, where the bottom lip was the thinnest, gave an unknown OD and ID, but the OD is presumably less than 2.3 in. The width of the flange then is an estimated 0.5 in. The oil adapter sleeve housing flange OD and ID are unknown.

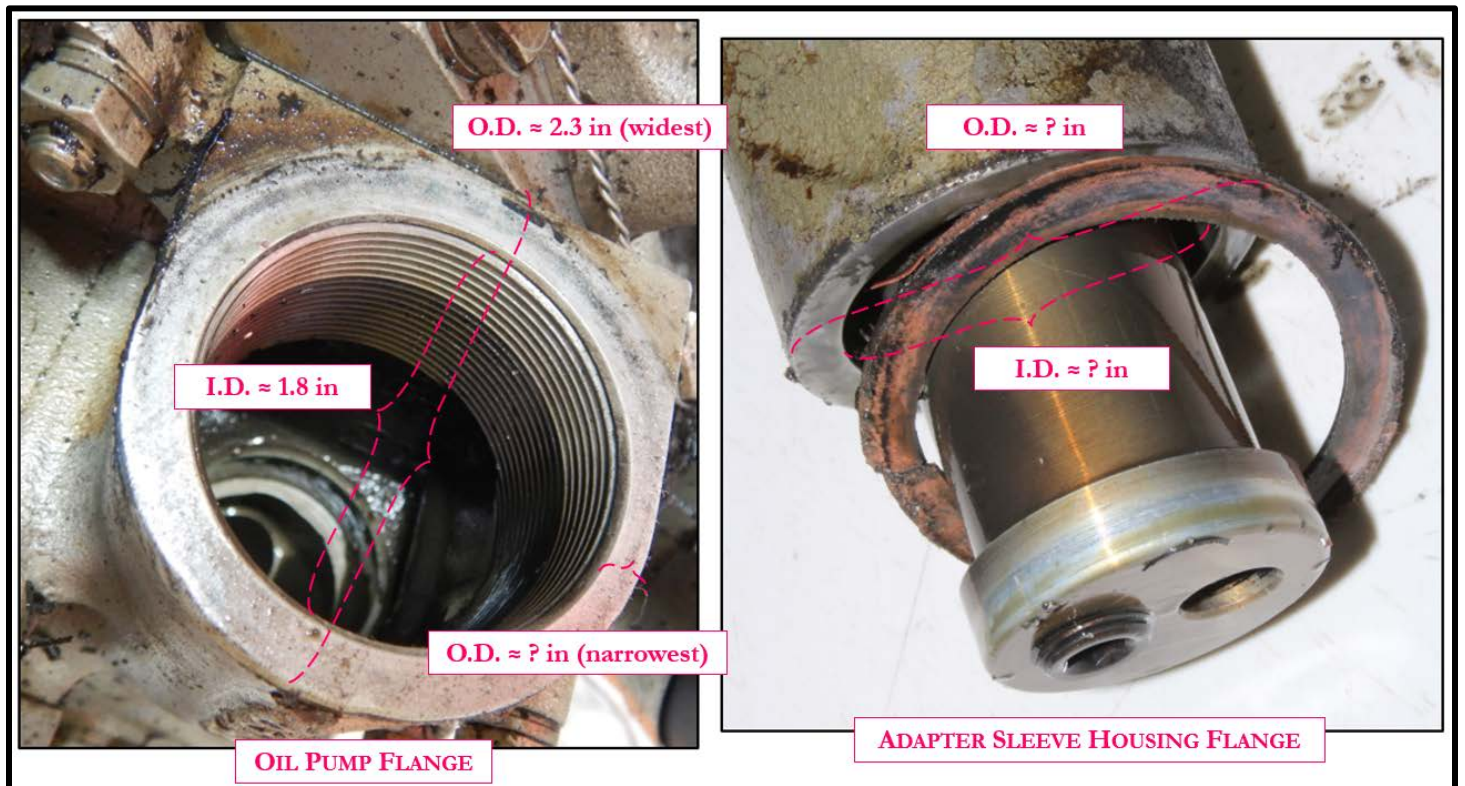


Figure 30: Measurements of Flange on Oil Pump and Adapter Sleeve Housing

The gasket had numerous impressions and markings consistent with the crescent shape of the flanges.

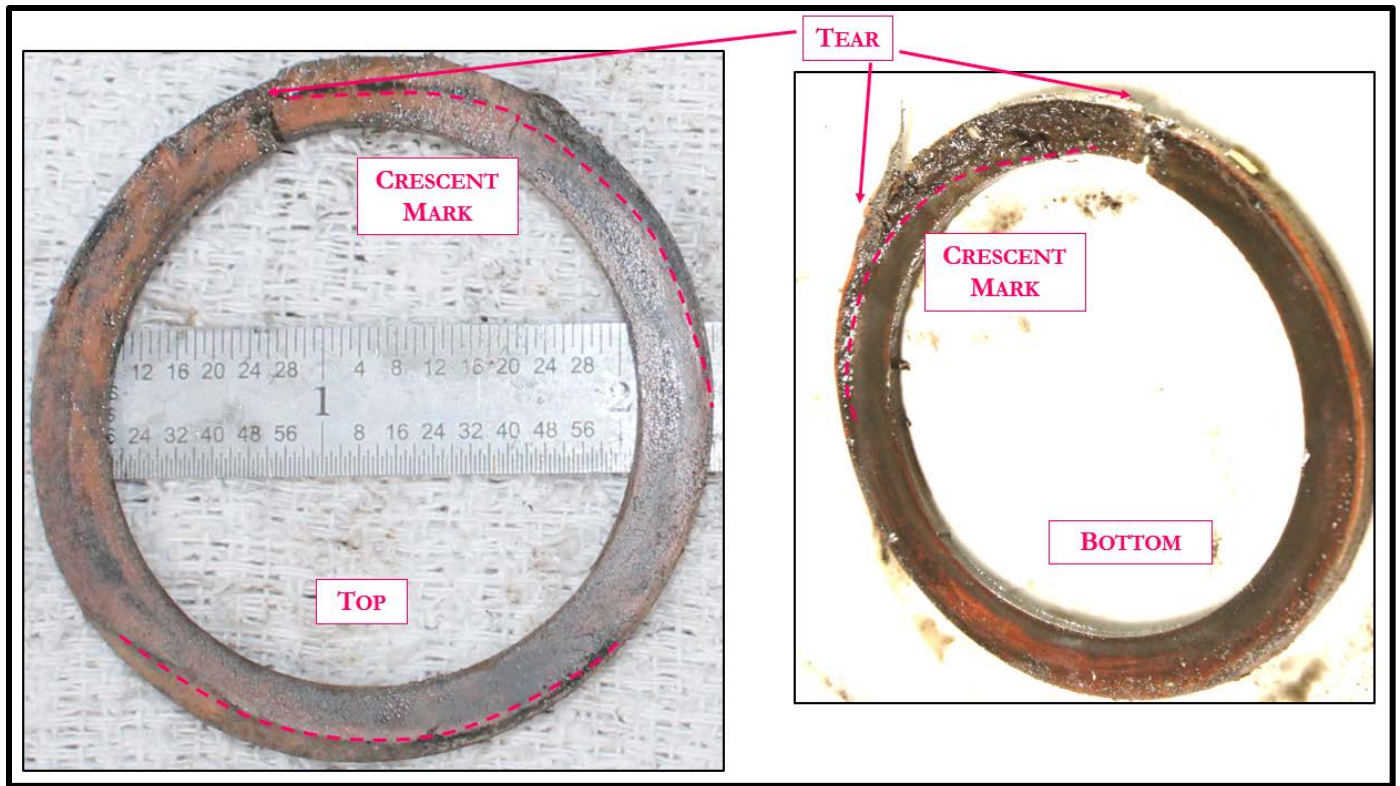


Figure 31: Gasket Showing Impressions/Marks

PRIOR ACCIDENTS

A review of pictures of prior accidents revealed that there were crescent marks similar to the accident mark. Better quality photographs are currently be searched for.



Figure 32: Prior Accident Gasket Showing Impressions/Marks ERA10LA335

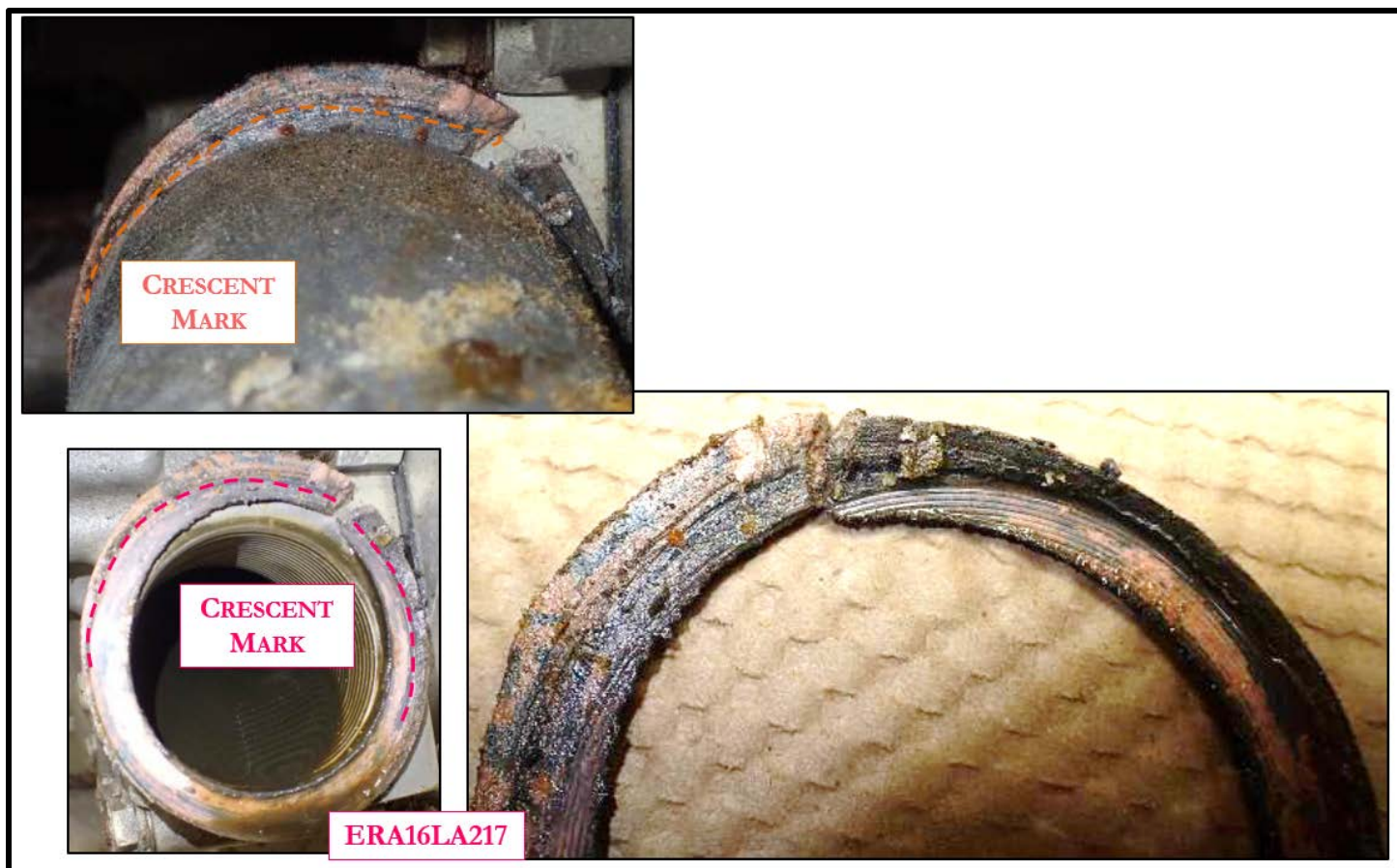


Figure 33: Prior Accident Gasket Showing Impressions/Marks ERA16LA217

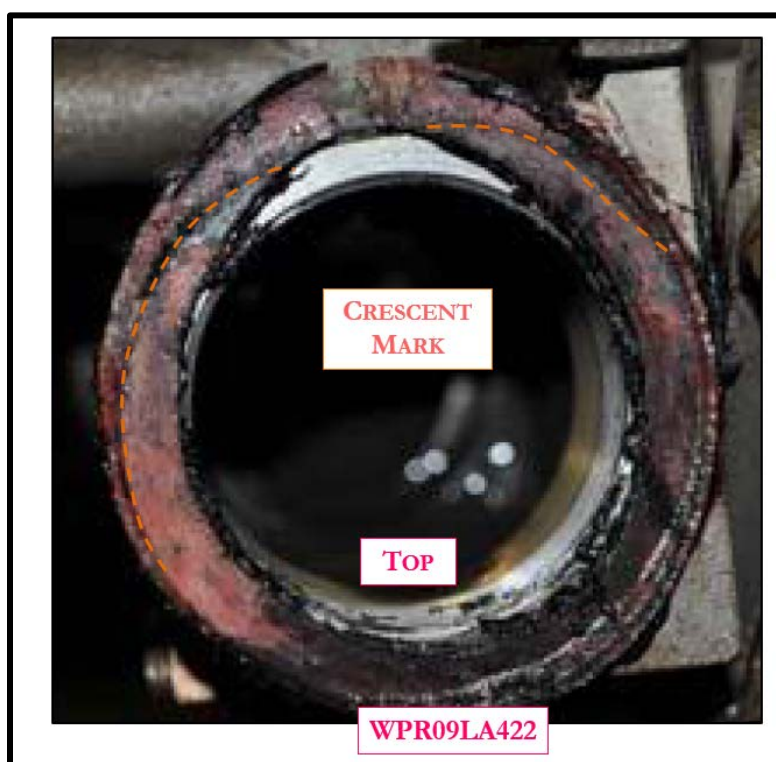


Figure 34: Prior Accident Gasket Showing Impressions/Marks WPR09LA422

FORUMS

Oct 2018²⁰:

- The Tempest is fine. You just have to make sure you don't loosen the adapter when unscrewing the filter."
- It's just a matter of being careful when you unscrew the filter off the Tempest.

Oct 2017²¹: After running both types, quite frankly I think I like the Cessna filter adapter better. (YMMV of course!) It uses a jam nut on the adapter against the sump which makes it easier to hold the adapter in the correct orientation while torquing. The large hex jam nut on the Cessna adapter is easier to torque than the smaller square aluminum boss on the F&M. In my experience, the jam nut on the Cessna adapter is also much less likely to allow the adapter to loosen at the sump when removing the filter, a likely source of leaks. I end up having to re-torque the F&M about every other time I change the oil, a real PITA. Also, the Cessna filter has only one seal, an o-ring under the jam nut, as opposed to the crush washer and fiber seal on the F&M.... I'm not sure if the jam nut on the Cessna adapter does a better job of holding the adapter in place, or if its the fact that the F&M filter is further below the centerline of the hole in the case, and angled further back, causing more torque on the adapter while removing the filter...

I torqued the adapter to the spec in the instructions, using a crow's foot and accounted for the (slightly) increased arm. I've never had it leak or loosen on it's own. It's tough to keep the crow's foot on the square lug, pull the torque wrench, AND keep the adapter from spinning in place. Definitely a two-person job. It might be easier with some sort of special tool that would self-align on the square lug. Can you post a pic of the tool you use? (Maybe while you're at it, post of a pic of if/how you safety the adapter to the engine.)

As for removing the filter, no matter where you pull from, SOME loosening torque will be imparted to the adapter because the axis of the filter is not perpendicular to the axis of the adapter.

- My F&M filter adapter will loosen if I'm not careful to torque the filter in a way that is in a different rotational plane then the filter adapter. And I use DC-4 and a torque wrench when installing the filters and a wrench on the end of the filter to remove it.

-I do pay attention to avoid any rotational forces placed upon the adaptor. It's important to only "spin" the filter...not to place stress upon the adaptor. If one pulls on a filter-wrench to impart an un-screwing spin on the filter in such a way that a starboard-to-port (or vice-versa) torque is imparted to the adaptor...then I can see where it might move the adaptor. I avoid any sideways push/pull on the unit by insuring my efforts to un-screw the filter are effected only on the filter....not the adaptor. (I also used a Pratt & Whitney square socket to install my adaptor rather than a crow's foot.) Never torque the filter more than 18ft/lbs. Most folks overtighten oil filters.

Nov 2018²²: I have had an F&M oil filter adapter on my engine since 2003 and for a good portion of that time, when I remove the filter, the adapter moves a bit. I probably should have re-torqued the adapter, but other than when Bruce provided me with a custom built/custom painted (GREEN :mrgreen:) socket to do the torque, I haven't done so and didn't have leak issues--that is until recently when I had the entire lower half of my firewall covered in oil (probably a tablespoon full, but a little goes a long way). I removed the adapter and the fiber gasket appears to be the culprit, I hope. I ordered a gasket kit from Spruce for \$14.95 and am hoping with it and a proper torque that leak will be history. For anyone needing the gasket kit, with your part number they will send a new crush washer P# AN900-28 and a leak guard fiber gasket (no part #). Hope this may be of help to others.

²⁰ <https://backcountrypilot.org/forum/oil-filter-adapters-22444>

²¹ <http://cessna170.com/forums/viewtopic.php?f=2&t=4998>

²² Frank 817-475-6096 <http://cessna170.org/forums/viewtopic.php?f=24&t=14431>

May 2012²³: Hi all I had the same problem with same gasket, but mine blew out at touch down and found after taxi to fuel pump quart and a half oil left at shut down.(followed oil stream back from fuel pump to about touch down point) F&M sent new gaskets and instructions to re-torque after 10 hours service... I had the engine torn down and it is toast. The guy guessed I flew the plane for about 10 minutes with no oil. (which is pretty accurate)

Nov 2010²⁴: I had the local FBO install the FM adapter on my 1948 170A. My partner last changed the oil and it appears the adapter twisted slightly so that the oil filter now contacts the battery box. I am unable to squeeze a sheet of paper between the box and the filter. Has this happened to anyone else? I realize the adapter needs to be clocked just so in order to prevent this and my guess is that the combination of crush gasket and fiber washer make this happen.

- After fighting to stop my F&M oil filter adapter from springing leaks every time someone touched it, I've decided the best way to stop the #\$\$% thing from leaking is to take it off the engine, clean all oil residue from it, and place it in a sealed plastic bag on a shelf.

HISTORY OF FAILURES

NTSB REPORTS

ERA16LA217 (Beech P35) – Nearly the same accident-

A total loss of engine power due to inadequate maintenance of the oil filter adapter, which resulted in an oil leak and subsequent oil starvation to the engine.



Figure 35: Prior Accident ERA16LA217

ERA14LA436 (Bellanca) -used 2 copper gaskets

The improper installation of the oil filter adapter at an unknown time, which resulted in an oil leak and subsequent oil starvation to the engine.

²³ <http://www.cessna172club.com/forum/ubbthreads.php?ubb=showflat&Number=174856>

²⁴ <http://cessna170.com/forums/viewtopic.php?f=24&t=4998&sid=a84cc990532006fe8316e034d6c2cb91&start=45>

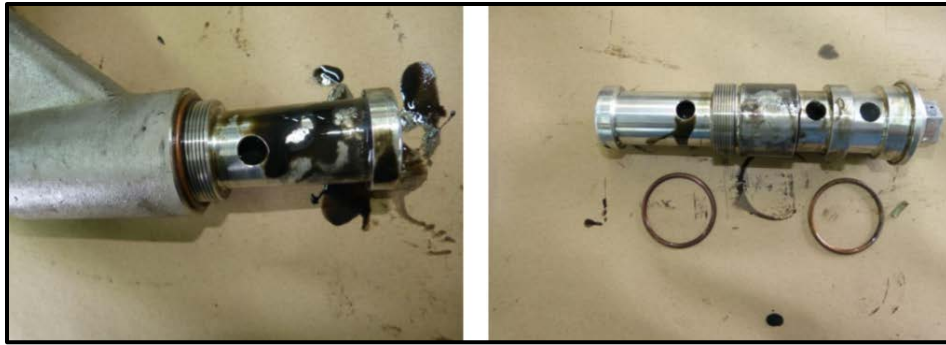


Figure 36: Prior Accident ERA14LA436

CEN13FA044 (Cessna 310) -used 2 copper gaskets

The pilot's failure to maintain airplane control after he shut down the right engine in flight due a loss of oil pressure... the mechanic's improper assembly and installation of the right engine's oil filter adapter, which resulted in a loss of oil to that engine.



Figure 37: Prior Accident CEN13FA044

ERA10LA335 (Cessna 210)

The loss of engine power due to the failure of the oil filter gasket and the subsequent engine oil depletion.

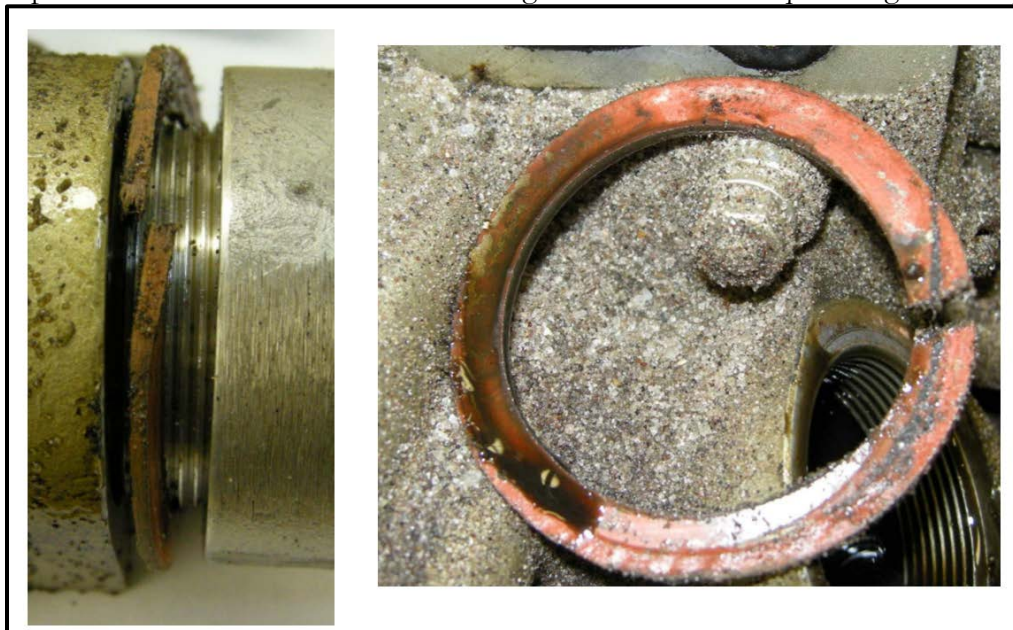


Figure 38: Prior Accident ERA10LA335

WPR09LA422 (Cessna 210)- Nearly the same accident findings

A total loss of engine power due to the displaced oil filter adapter gasket, which resulted in an oil leak and oil exhaustion. Contributing to the accident was the unsuitable terrain for a forced landing.



Figure 39: Prior Accident WPR09LA422

NYC04LA210 (Cessna 172)

The failure of the oil filter adapter seal, which resulted in a loss of oil pressure, and subsequent catastrophic engine failure, and forced landing.

CEN13LA056 (Cessna 210):

The total loss of engine power due to the loss of oil to the engine. Contributing to the accident was maintenance personnel's improper installation of the engine oil filter adaptor, which resulted in the loss of oil to the engine.



Figure 40: Picture 18: Prior Accident CEN13LA056

Possible ERA16LA158 Although the engine oil and oil filter were changed the day before the accident flight, no correlation could be made between that event and the reported loss of engine power. Because the airplane and engine were not recovered and could not be examined, no determination could be made as to the reason(s) for the sudden loss of oil pressure, smoke, and then subsequent total loss of engine power.

ERA19LA017 (Cessna 182)

The improper torque application on the oil filter adaptor by maintenance personnel, which resulted in a loss of lubrication and a catastrophic engine failure.

SERVICE DIFFICULT REPORT (SDR) DATABASE

According to the FAA there are “13 SDRs related to oil filter adapters, five of those can be identified as belonging to Cessna; which already has an AD on their adapters. For the purpose of our risk-assessment we will conservatively assume all of the remaining 8 adapters belong to F&M.”

NTSB

For WPR09LA422, the IIC stated that there was a displacement of the oil filter gasket, but he could not definitively determined what precipitated the displacement. He thought it was most likely due to improper maintenance when the adapter wasn’t torqued correctly during install.

For CEN13FA044, the IIC the adapter was not properly safety-wired to the engine as per the installation instructions in the STC and was loose. There were two copper crush rings (gaskets) were found on the oil transfer cylinder. According to the STC, only one copper crush ring was to be used and a fiber leak-guard gasket was to be used at the base of the adapter. Additionally, the IIC determined that the copper crush ring did not exhibit the signatures or dimensions that would be created if it had been installed at the proper torque value. The mechanic admitted to not torqueing the filter in accordance with the STC.

For ERA16LA217, the IIC did not see the problem as systemic because the “mechanic did not replace the gasket at the regular interval per the maintenance instructions, which ultimately lead to the oil coming out of the engine.” The maintenance required the gasket to be replaced every 300 hours or 3 years, whichever occurred first; the maintenance records indicated that the oil filter adapter was installed about 4.5 years before the accident.

PAST INSTANCES OF PROBLEMS BEING BROUGHT TO NTSB ATTENTION

In September 2014 a representative from Continental emailed the IIC of ERA14LA436, an accident that involved an oil filter adapter that had two copper crush gaskets installed rather than one fiber and one copper gasket. At that time the representative made the IIC aware that at least four similar accidents had occurred in the past; at this time Continental also notified the ACO of the event.

FAA RESPONSE

Continental sent the FAA ACO a report of a gasket failure in 2014.
Stratus was reissued the STC in 2015.

05.06.2019

FAA Atlanta ACO notified of WPR19FA126 and the Continued Operational Safety Program Manager labeled the adapter as “a priority 1 issue.” They stated that they were “very interested with the frequency of the events and the corrective action that is being considered for this issue.”

OTHER ADAPTERS

CESSNA OIL FILTER ADAPTER

In July 1996 the FAA issued an Airworthiness Directive (AD), AD 96-12-22, for Cessna Aircraft Company oil filter adapter assemblies. It stated:

This action requires inspecting the oil filter and adapter assembly (or torque putty, if installed) for oil leakage and proper installation of the adapter retaining nut and fretting of associated threads (security), and replacing any oil filter adapter assembly with security problems; applying torque putty between the engine filter adapter assembly, nut, and oil pump housing (unless already equipped with torque putty); and repetitively inspecting the torque putty for misalignment, evidence of oil leakage, or torque putty cracks, and reinspecting the oil filter and adapter assembly threads if misalignment, evidence of oil leakage, or torque putty cracks are found.

At the time of issuance, the FAA estimated that 70,000 airplanes in the U.S. registry incorporate one of the affected engine oil filter adapter assemblies. The engines effected were Continental Motors: O-200, O-470, IO-470, TSIO-470, O-520, IO-520, TSIO-520, GTSIO-520, IO-550, TSIO-550.

INDUSTRY

BEECH TALK: A thread started on BeechTalk in October 2016 warning owners of gasket failures.

2016

Stu Taylor

The gasket between the engine and the F&M oil filter adapter failed on a recent flight taken by two of my partners. Fortunately it failed within a few minutes of landing and they were not forced to make an emergency or off airport landing. Had they taken a planned longer flight we are 100% certain they would have suffered an inflight engine failure and could have easily lost their lives. There is no mention of the gasket as an ongoing maintenance item in the 2011 F&M installation and maintenance instructions. Our adapter was installed many years ago and I can't see where gaskets were ever replaced. The plane is less than 10 hours out of annual so we really want to know if there could be any contributing conditions. C6LC-L

Dave Pasquale :I recently found one that was loose. <https://www.flickr.com/photos/136005688...ist-K6hF64>
It was leaking but no more than a seep. The correct gaskets were installed. The crush gasket was barely compressed. It seemed after replacing the gaskets that the center part of the adapter was bottoming out in the engine before fully compressing the crush gasket. I have spoke with Greg Ehrlich at Tempest about this issue several times. He said that they have changed the gasket material and to only use the tempest gasket sets. He added that they have not had a failure with any of the newer gasket sets only with the older gaskets produced by F&M.

Bill Hale: On my engine, at 2200 smoh the oil pressure dropped to zero at start and it was traced to this plug with its crush washer being loose.

Gilbert Frudd: I know of a local guy that had this exact issue and I don't want this to sound like I'm trying to be a jerk, but his problem was solved by putting the factory screen back in. I am aware of all the benefits of a paper filter, but sometimes peace of mind is a good thing too.

James W Shoemaker: I've had the same issue on a previous Baron. My neighbor had the same on his Bonanza. In both instances, the issue occurred just a few hours after a difficult filter change. I'm convinced that this adapter has an inherent design flaw. With the filter being mounted on a "Y", you can create a rotational force at the base of the adapter when removing the filter, especially if it was slightly over torqued during installation. Just a slight movement can cause the gasket to fail.

Daniel Katz: That's exactly what happened to me. Compression on the fiber gasket is lost and you will have a leak. If you let it go farther, the vibration will pinch the gasket at the 6 o'clock position and break it completely. The result will be a pinhole leak where 8 quarts of, pressurized, oil will leak out within about 5 minutes. The oil was EVERYWHERE on the belly of the airplane. Does anyone else think an AD is warranted here?

Curtis Kooiman: I had leveled out at 8000ft, noted low oil pressure and dropping. Immediately diverted and landed without incident. Had 1qt left in the engine... the rest was on the belly and on the ground. The F&M adapter is loose and can be rotated by hand. 33 hours since it was installed.

Jeffrey Beauboeuf: My friend was flying and started monitoring his oil temp and pressure, the oil smell didn't go away, he looked down and his oil pressure was decreasing. He was directly over an Ag strip that he has landed on his entire life, he pulled off the power, made a 360 and landed. He shut the engine down, got out, saw oil all over the side and bottom of his airplane. We pulled the cowl and soon discovered the fiber washer hanging out at the base of the engine oil filter adapter.

Rip Quinby: posted this before, and I'll post it again, just to be a nuisance. From my experience, there were three (3) different sealing methods used on the F&M adapters. The first used two (2) copper crush washers. The second used one (1) copper crush washer and one (1) paper gasket on a smooth gasket surface. The third used one (1) copper crush washer and one (1) fiber reinforced gasket on a knurled sealing surface. As far as I can tell, the part number of the adapter itself never changed, but the three (3) different sealing methods ARE NOT INTERCHANGEABLE!!! If you try to seal a style #1 adapter using a style #3 gasket set, it will fail. If you try to seal a style #3 or #2 adapter using style #1 seals, it will fail. If you try to seal a style #2 adapter with a style #3 gasket it will fail. If you try to seal a style #3 adapter with a style #2 gasket, it MIGHT work, if the adapter machining tolerances were on the high side.

2017

Chuck Waldrop: When I shut down and got out I found oil pouring out of the nose gear well and the belly was a solid river of oil. Fortunately I was only two quarts down so I must have sprung my leak in the latter part of the flight. It was coming from the oil filter adapter which was on the plane when I bought it 11 years ago.

2019

Last week, the gasket on my F&M Enterprises Oil Filter Adapter on my IO-470-C failed - it was literally torqued in half. I lost most of my oil before I shut the engine down and glided in for landing. No damage - temps never rose, pressure was maintained, and the oil analysis came back completely normal - more than 5 quarts were left on shutdown. Anyway, F&M is very clear on the 300 hours/3 year replacement - and, on the torque values and process.

Rand OConnor: On takeoff and climb out tower notified me that I was either losing fuel or smoking. I did an immediate 180 and landed. After shutting down it was apparent it was oil I was spraying. A seal on the spin on oil filter unit gave out and I was spraying oil on the exhaust. I lost 4 quarts in that short flight.

2020

Nigel Beek: Went through this problem in July, changed oil on both engines on the B55- went for Test flight shot an ILS going missed see faint trail of oil on left flap. Thought funny, didn't spill any oil then the faint trail of white smoke opened cowl flap it went away ; closed it came back. Just then it clicked Oil leak - secured engine and landed to find gasket had split. Engine was down to 5 qts.

Stephen Voth: I'm looking for a replacement for an F&M Oil Filter Adapter on my IO-470N. I had to make an emergency landing due to it loosening and dumping 4 quarts of oil. I don't trust it and will not reinstall this on my plane.

Gary Plewa: after a 45 minute test flight I found oil leaking from the crush washer at the top and more importantly, signs that the fiberglass reinforced washer at the bottom was being pushed out.

2011

Agghopp:²⁵ We retorqued the adapter and today I called F&M. Here is what I learned from the owner. Bob bought the company 12 years ago and worked to find a solution to the leaky adapter issue. He knows all about the constant leaks and he developed a fiber gasket for the engine side and a crush ring for the firewall side that fixes the problem. Says he 100% guarantees this will fix the problem.

\$15 for gasket, crush ring & instructions. It uses 65 ft lbs of torque, which is a higher value than the old one said to use. He told me the problem was that the old method used two crush rings, but with that method, it was impossible to get both crush rings to compress at the same time which caused deformity and lack of seal on one end or the other.

According to Bob, the key is to install his upgrade kit and then after 10 hrs, retorque it and safety wire it and you'll be good to go. He also mentioned that it is important during install to read the instructions carefully and make sure the OPEN side of the crush ring is facing the firewall. It has very sharp edges that meet up with a flange on that end and you don't want it trying to dig into the metal on the case if installed backwards.

TESTING AT TELEDYNE CONTINENTAL MOTORS

On Thursday, August 15, 2019, a series of tests were performed at the Continental Motors, Inc. (CMI) facility on CMI engine model, O-470-S1B, with F&M oil filter adapters installed from both the Ramona and Mill Creek accidents. To test the impact of damaged fiber gaskets on adapter function, various types of imperfections were induced on the gaskets and then installed with the adapter onto the engine. The effects of adapter function at varying torque values was also tested.

In summation of the findings, investigators were unable to simulate the fiber gasket blowout that was seen in the accidents adapters. However, when the hub was not torqued and the housing could be moved about the shaft with minimum force, oil was observed leaking from the area where the adapter housing meets the engine case. When the adapter was properly torqued and the adapter housing was rotated by force (much less force required when oil was on the gasket) the rotation would result in the gasket having a crescent impression in the outer material, similar to the accident gaskets. The new gaskets used for testing were noted to have a lip on the inner diameter which the STC holder stated was a signature consistent with the die cutting into the material.

Test Run #1 (Ramona Adapter, Surface Ding on Fiber Gasket):

- Ramona adapter installed with a surface ding on the fiber gasket
- Adapter was torqued to 65 ft-lbs
- 10 minute engine run
- 180 deg F oil temperature @ shutdown
- No oil seepage noted
- Force on oil filter and body did not cause rotation around the adapter cylinder

Test Run #2 (Ramona Adapter, Surface Ding on Fiber Gasket):

- Breakaway torque applied to the installed Ramona adapter
 - Adapter @ unknown torque
- 5 minute engine run
- 184 deg F oil temperature @ shutdown
- No oil seepage noted
- Adapter removed. Fiber gasket showed signs of non-uniform compression (lip) with a very small imperfection noted on the ID section of the fiber gasket.
 - It was later identified that all new fiber gaskets had this same feature present

Test Run #3 (Ramona Adapter, Inside Nick on Fiber Gasket):

²⁵ <http://www.cessna172club.com/forum/ubbthreads.php?ubb=showflat&Number=48180>

- Ramona adapter was re-installed with ID nicked fiber gasket and torqued to 65 ft-lbs
- 5 minute engine run
- 175 deg F oil temperature @ shutdown
- Oil seepage (slight) noted from fiber gasket; seepage also noted at the re-used copper gasket location
- Force on the oil filter and body (much greater than 20 lbf) caused rotation around the adapter cylinder

Test Run #4 (Ramona Adapter, Inside Nick on Fiber Gasket):

- Breakaway torque applied to the installed Ramona adapter
 - Adapter @ unknown torque
- 5 minute engine run
- 182 deg F oil temperature @ shutdown
- Oil seepage noted (from both fiber and copper gaskets)
- With minimal force applied to the oil filter and body, the body rotated around the adapter cylinder
- Breakaway torque was measured at 22 ft-lbs

Test #5 – no engine run performed (Ramona Adapter, Oil Soaked Fiber Gasket):

- Ramona adapter re-installed with oil soaked gasket and same crushed copper gasket
- Adapter torqued to 65 ft-lbs
- With minimal force applied to the oil filter and body, the body rotated around the adapter cylinder
 - Continued back and forth rotation to examine effect on fiber gasket
 - Breakaway torque was measured at 25 ft-lbs
 - Adapter was removed; Pinching/lip at OD of fiber gasket was visible

Test Run #6 – (Mill Creek Adapter, Channel Cut Across Fiber Gasket):

- Mill Creek adapter installed with channel cut fiber gasket
- Adapter torqued to 65 ft-lbs
- 5 minute engine run
- 167 deg F oil temperature @ shutdown
- No oil seepage noted
- Breakaway torque was measured at 46 ft-lbs

Test Run #7 – (Mill Creek Adapter, Folded/Bent Fiber Gasket):

- Mill Creek adapter installed with folded/bent fiber gasket
- Adapter torqued to 65 ft-lbs
- 5 minute engine run
- 177 deg F oil temperature @ shutdown
- No oil seepage noted

Test Run #8 – (Mill Creek Adapter, Folded/Bent Fiber Gasket):

- Mill Creek adapter remained installed with folded/bent fiber gasket
- Body was rotated around the adapter prior to engine run
- Engine re-run for 5 minutes
- 188 deg F oil temperature @ shutdown
- No oil seepage noted

Test Run #9 – (Mill Creek Adapter, Folded/Bent Fiber Gasket):

- Mill Creek adapter remained installed with folded/bent fiber gasket
- Adapter torque was set to 30 ft-lbs
- Engine re-run for 5 minutes
- 190 deg F oil temperature @ shutdown
- No oil seepage noted

Test Run #10 – (Mill Creek Adapter, Folded/Bent Fiber Gasket):

- Mill Creek adapter remained installed with folded/bent fiber gasket
- Adapter torque was set to 20 ft-lbs
- Engine re-run for 5 minutes
- 188 deg F oil temperature @ shutdown
- No oil seepage noted

Test Run #11 – (Mill Creek Adapter, Folded/Bent Fiber Gasket):

- Mill Creek adapter remained installed with folded/bent fiber gasket
- Adapter torque was backed off and finger tightened
- Engine re-run for 5 minutes
- 180 deg F oil temperature @ shutdown
- Significant oil seepage noted
- Approximately 1.5 quart oil loss over 5 minute run

Test Run #12 – (Mill Creek Adapter, New Fiber and Copper Gaskets):

- Mill Creek adapter re-installed with new gaskets (fiber and copper)
- Adapter torqued to 65 ft-lbs
 - The torque was then backed off, with the body being intentionally rotated around the adapter cylinder with a wrench; attempt to induce gasket signatures (lip, tear, etc.)
 - The adapter cylinder eventually rotated freely
- 20 minute engine run
- 198 deg F oil temperature @ shutdown
- Steady oil leakage observed through both fiber and copper gasket locations
- 0.5 to 0.75 quart oil loss over engine run