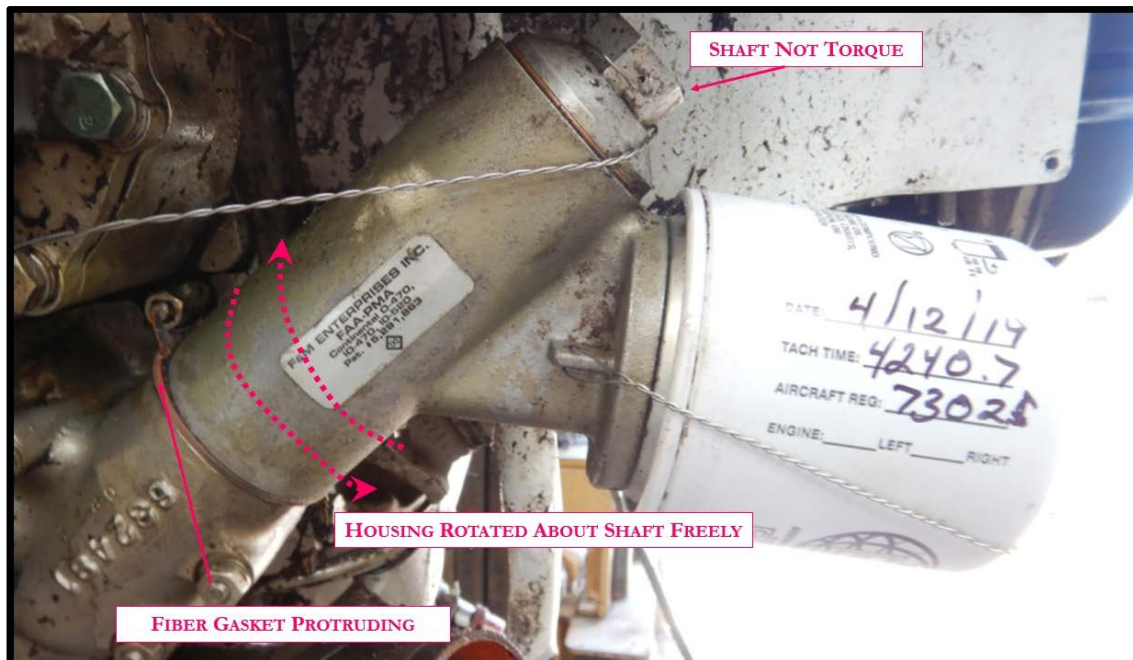


ACCIDENT WPR19FA126

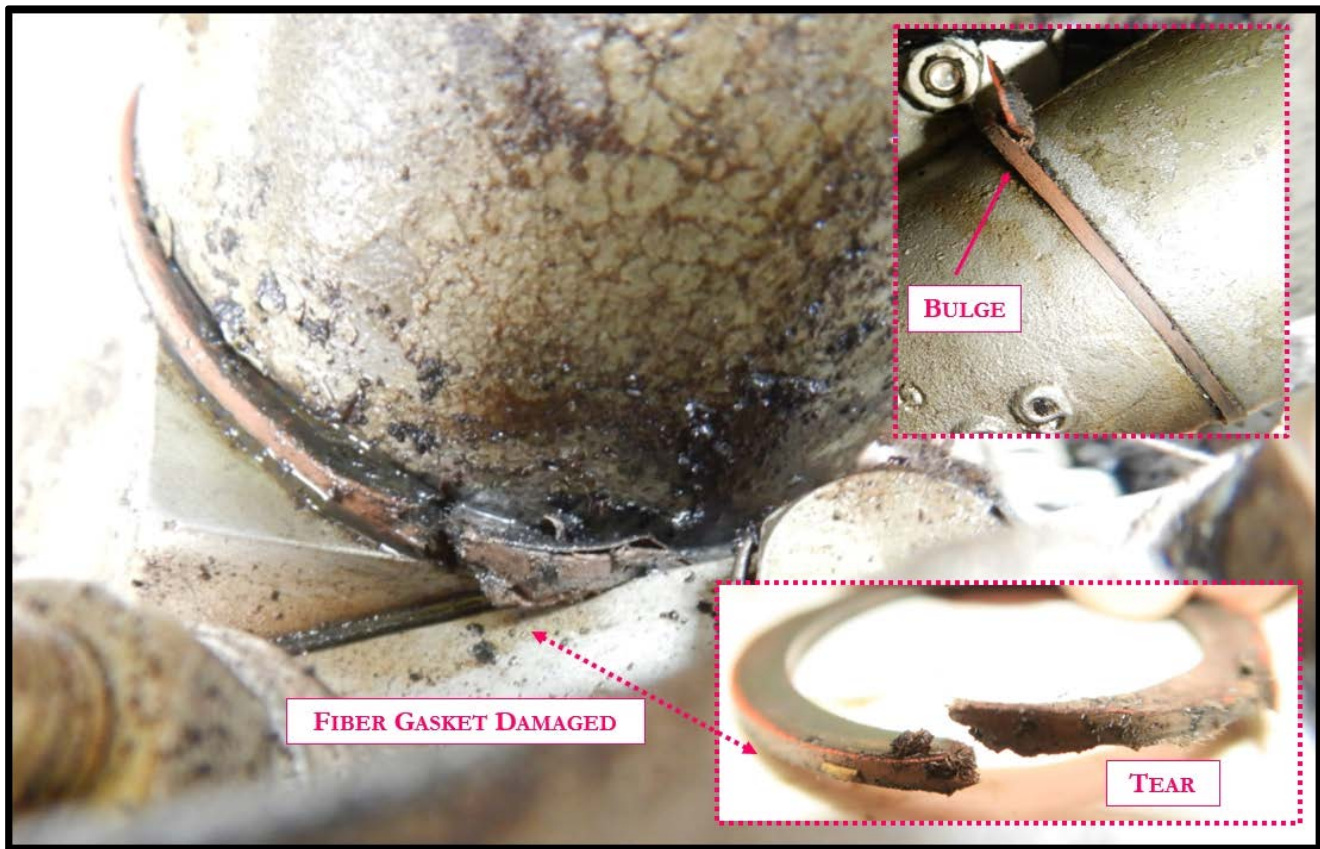
On May 01, 2019, about 1100 Pacific daylight time, a Cessna T182P airplane, N7302S, experienced a loss of engine power and collided with a power line while making an emergency landing to a grassy marsh in Mill Creek, California. The flight instructor and front-seated passenger sustained serious injuries; the rear-seated pilot-rated passenger was fatally injured. The airplane sustained substantial damage. The airplane was registered to and operated by Air Carriage, Inc. under the provisions of Title 14 Code of Federal Regulations Part 91 as a personal flight. Visual meteorological conditions prevailed and no flight plan had been filed. The flight originated from Chino Airport, Chino, California, about 1010.

An examination of the engine revealed signatures consistent with the engine experiencing a loss of power due to oil starvation. A further examination of the engine oil filter adapter, revealed that it was loose where the adapter housing could be rotated about the shaft. Investigators removed the safety wire and attempted to assess the breakaway torque of the adapter which was required to be 65 foot-pounds (ft/lbs). The torque was less than 20 ft/lbs, which was the force set on the torque wrench.



Picture 01: Oil Filter Adapter

A closer examination of the filter adapter revealed that the fiber gasket, located between the oil pump casting and the adapter housing was protruding with the outside edge extending beyond the castings. Removal of the adapter revealed that the fiber gasket was completely split.



Picture 02: Oil Filter Adapter Fiber Gasket

OIL FILTER ADAPTER (C6LC-S)

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.¹

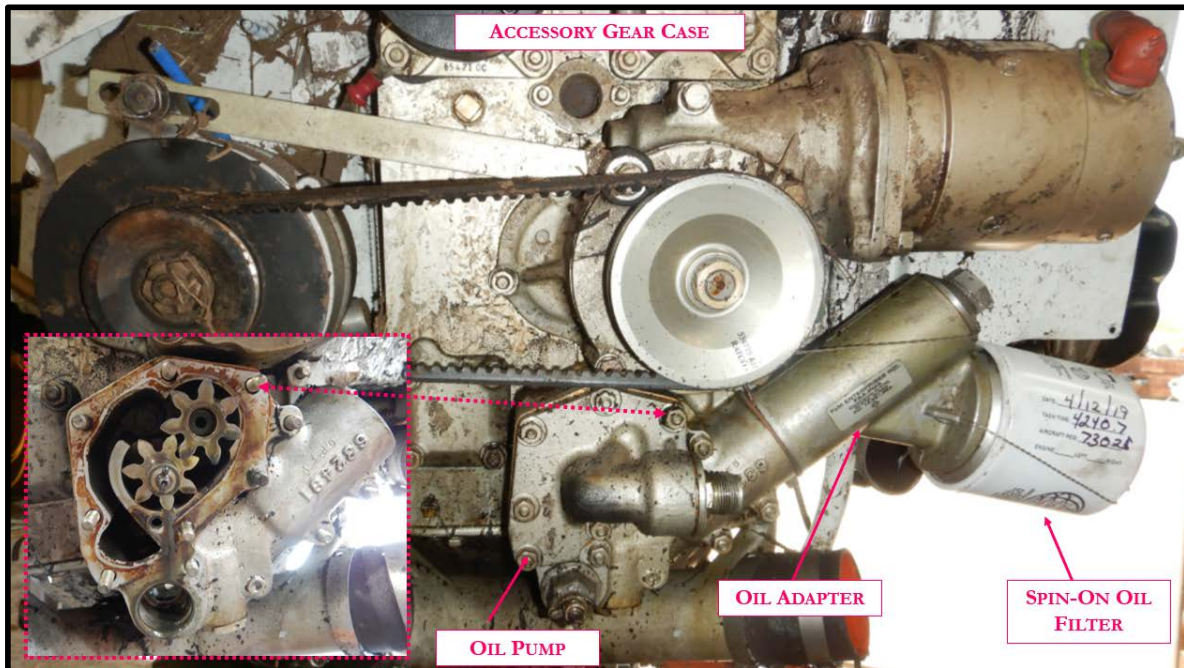
The maintenance records indicate that the oil filter was changed on seven occasions all of which were performed by the owner:

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

¹ It is likely that the history of the failed gasket will remain unknown.

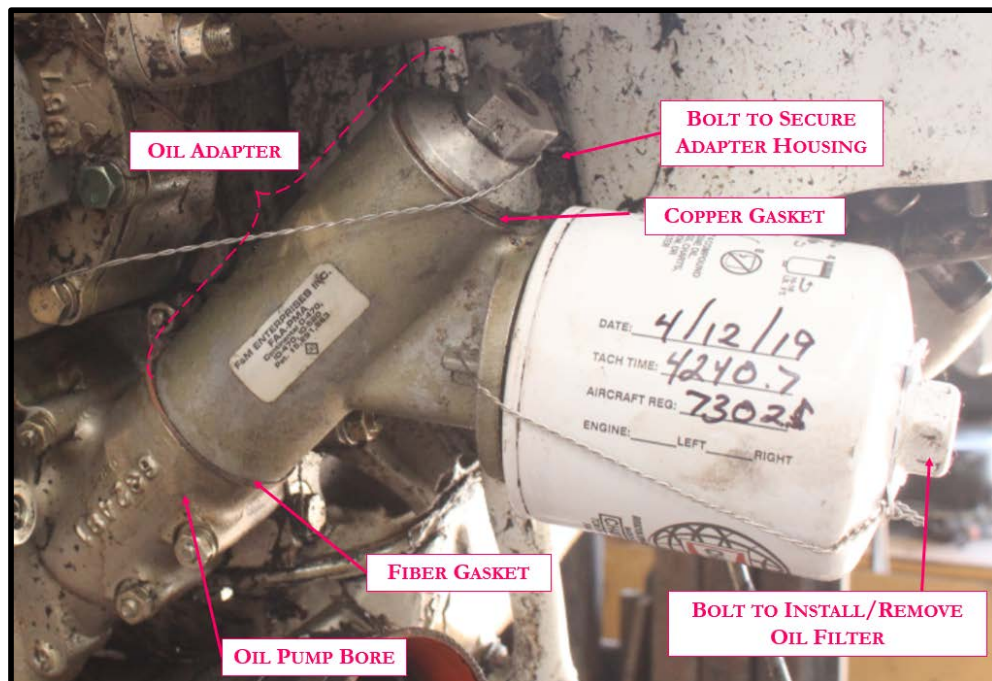
ADAPTER FUNCTION

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.

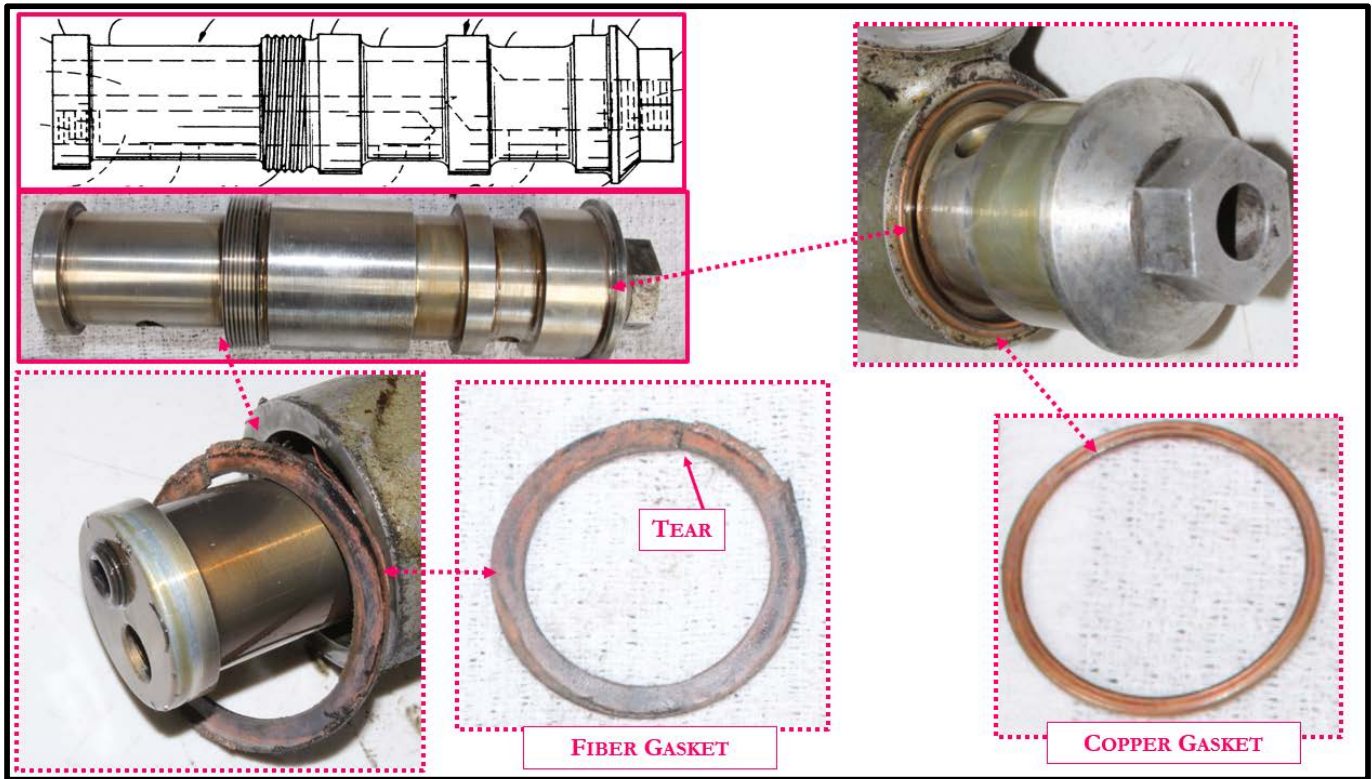


Picture 03: Oil Filter Adapter as Installed

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.



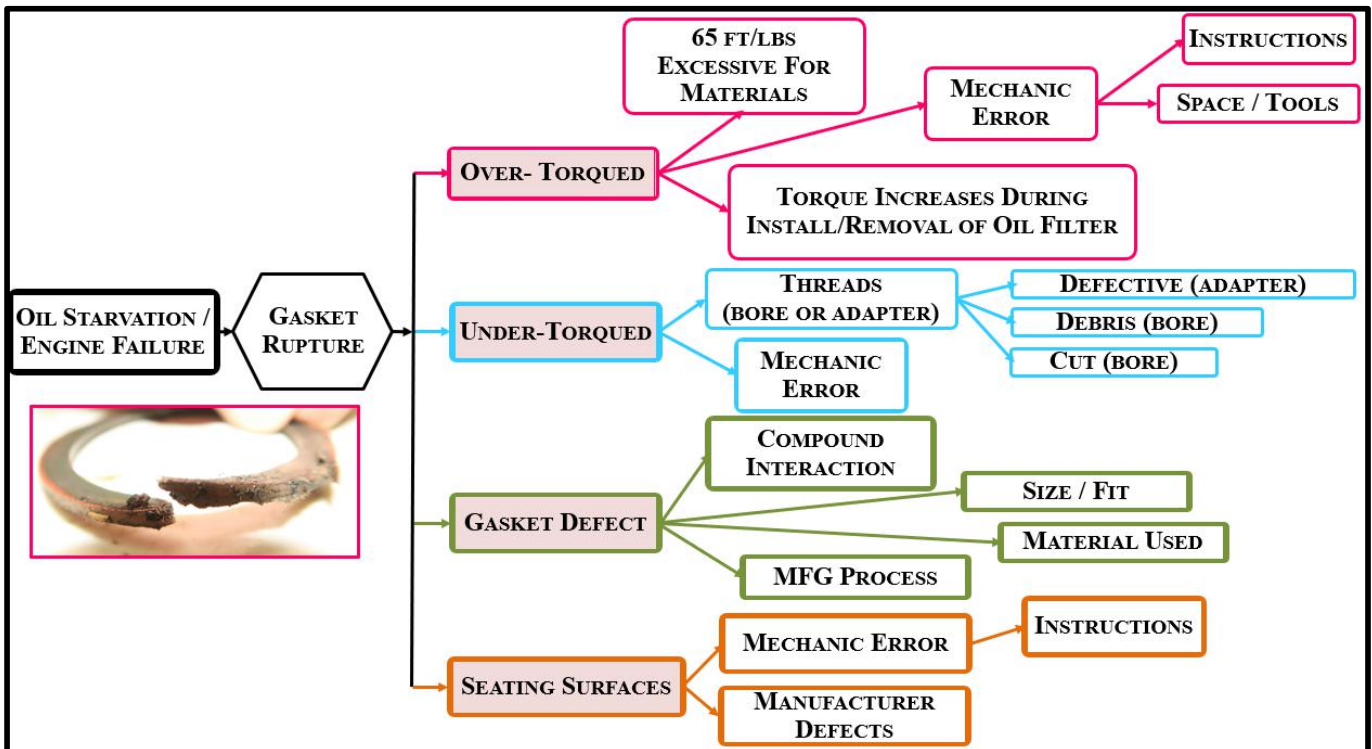
Picture 04: Oil Filter Adapter Assembly



Picture 05: Oil Filter Adapter Shaft and Gaskets

GASKET FAILURE

The tear in the fiber gasket was located on the flange closest to the forward by the cylinder. In a discussion with the FAA, Cessna, Continental, and NTSB the parties discussed the methods in which the gasket could have ruptured:



Picture 06: Fault Tree of Possible Failure Origins

GASKET

DESIGN

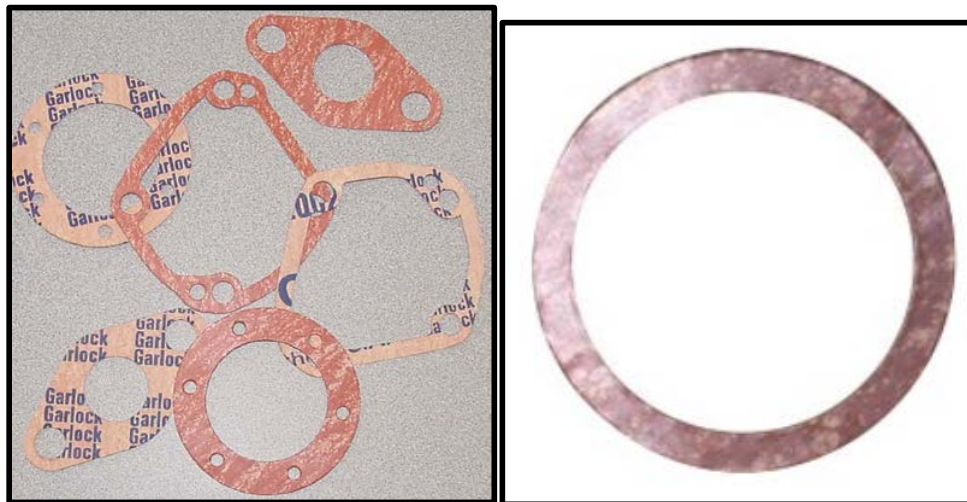
The fiber gasket, part number FM07², was manufactured by Garlock as 3750 Leak-Guard³ and cut by GPI. The last order was in July 2013⁴. The original gasket used by Continental for the oil screen was MS35769-48 copper gasket⁵ (AN900-28): OD 2in, ID 1.75in, ring width 0.688, thickness 0.094.

GPI would contact Garlock to order 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. He stated that the die used to cut the gaskets with labeled FM07 in measured 2-1/4" OD x 1.745" ID and 1/16" thick. 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):

Quantities					Item ID	Pricing
Ordered	Allocated	Remaining	UOM	Qty	Item Description	UOM
Delivery Instructions: CALL WHEN READY						
1	1.000	0.000	0.000 EA	C	FM07 GSKT, 3750 GARLOCK 1/16in DIE 4C1	EA
3	1.000	0.000	0.000 EA		399062253750 GSKT, MTL 3750 LEAKGARD 1/16 X 60 X 60 MFR: GARLOCK CUT AS MANY AS POSSIBLE OF THE FM07 GASKETS PER DIE FROM SHEET WE NEED TO GET A CERTIFICATE OF CONFORMANCE FOR THESE SHEETS	EA

Date	Qty
1/14/2010	576
10/19/2011	576
8/17/2012	576
6/12/2013	576
7/19/2013	576

Picture 07: Gaskets Ordered and Last Invoice Excerpt



Picture 08: Gasket Material Provided by Garlock and Picture from Aircraft Spruce

² <https://www.aircraftspruce.com/catalog/eppages/fm-ofadap-gasket.php> (they have an 8130 showing Aero Accessories 2019)

³ <https://www.garlock.com/sites/default/files/documents/en/Garlock%20Style%203750%20Spec%20Sheet%20-%20%28NA%29%202016-11%20EN.pdf>

⁴ According to Garlock the gasket shelf-life is 5 years

⁵ 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/Joints/Copper_crush_gaskets.pdf

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.”⁶ 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.”⁷ 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.”

STC HOLDER GUIDANCE HISTORY

The FAA provided a timeline of revisions F&M made to the Instructions for Continued Airworthiness (ICAW) FM2007-01. In pertinent parts the following timeline could be established from the revision timeline:

09.05.2007: Initial release

05.09.2011: Added: CAUTION - The oil filter adapter must be installed using new gaskets. Operate the engine and check for leaks following installation of the oil filter adapter and whenever replacing gaskets. Verify proper lockwire installation.

10.08.2013: Added: Section 8.1 Gaskets with requirement "New gaskets are to be installed anytime the oil filter adapter as sy is removed and re-installed. Replace gaskets at 300 hours or 3 yrs whichever occurs first.

At an unknown date, F&M sent owners replacement gaskets with the following instructions:

1. **Verify contents of package**
 - 1- AN-900-28 copper gasket
 - 1- "Leak-Gard" fiber gasket
2. **Remove the oil filter adapter from engine.**
3. **Remove the fiber gasket from the oil filter adapter body.**
4. **Separate the oil transfer cylinder from the oil filter adapter body.**
5. **Clean any residual fiber gasket material from the oil filter adapter body and accessory case.**
6. **Remove the copper gasket from the oil transfer cylinder.**
7. **Install the new copper gasket (*with the open side of the copper gasket facing the flange of the oil transfer cylinder*) onto the oil transfer cylinder.**
8. **Lightly coat the oil transfer cylinder with engine oil and slide the oil transfer cylinder into the oil filter adapter body.**
9. **Slide the fiber "Leak Gard" gasket onto the oil transfer cylinder.**
10. **Install the oil filter adapter in accordance with F&M Enterprises' "Oil Filter Adapter Installation Instructions". Torque the oil filter adapter to 65lbs/ft.**
11. **Install safety wire in accordance with F&M Enterprises' "Oil Filter Adapter Installation Instructions".**
12. **Install the oil filter, in accordance with the oil filter manufacturer's installation instructions.**
13. **Add oil as necessary to assure proper oil quantity, start the engine, and check for oil leaks around the oil filter adapter and oil filter. If no leaks are detected, verify the correct oil quantity and replace the cowl.**
14. **After 10 hours of operation re-torque the oil filter adapter to 65lbs/ft and safety wire in accordance with F&M Enterprises' "Oil Filter Adapter Installation Instructions".**

Picture 09: Excerpt from F&M

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

Stratus Tool Technologies issued ICAW ST001 in 08.02.2017 stating in pertinent part:

At each oil change and each 100 hour or annual inspection:

- Inspect the oil filter adapter for oil seepage. If oil seepage is detected, replace the fiber and copper gaskets on the transfer cylinder with new gaskets... Use of a torque wrench is mandatory when installing or reinstalling the filter adapter. Safety-wire the transfer cylinder to an appropriate safety-wire location on the engine accessory case.

⁶ https://www.garlock.com/sites/default/files/files/technical_articles/Flow%20Control%20Article%20%289-16%29.pdf

⁷ <https://www.garlock.com/sites/default/files/documents/en/Gasket%20Removal%20and%20Installation%20-%20June%202018%20-%20TECHNICAL%20BULLETIN.pdf>

- Check and verify that the body does not move (rotate around the transfer cylinder) when 10 to 20 pounds of force is applied to the body in a manner that would tend to rotate it around the transfer cylinder. If the body rotates around the transfer cylinder, remove the safety-wire and tighten the adapter... Use of a torque wrench is mandatory when tightening the transfer cylinder. Safety-wire the transfer to an appropriate safety-wire location on the engine accessory case.
- Always install new fiber and copper (where used) gaskets each time the filter adapter is removed and reinstalled on the engine.

Stratus Tool Technologies issued Installation Instructions ST003 on 04.06.2017 stating in pertinent part:

- Insert the transfer cylinder into the bore of the adapter body and place the fiber gasket onto the transfer cylinder. **DO NOT USE GASKET COMPOUND ON THIS GASKET OR ON THE OIL FILTER ADAPTER. THIS GASKET MUST BE INSTALLED DRY.**

-Apply engine oil to the oil pump housing threads.

-Thread the transfer cylinder into the oil pump housing. Temporarily install the oil filter onto the adapter body. Check for at least 3/8-inch clearance between the oil filter case other items in the engine compartment. Using a torque wrench, tighten the transfer cylinder to 65-foot pounds of torque...

-ATTENTION: THE OIL FILTER ADAPTER TRANSFER CYLINDER MUST BE RE-TIGHTENED TO 65 FOOT POUNDS OF TORQUE BETWEEN 8 AND 12 HOURS OF OPERATION AFTER INSTALLATION OR ANY TIME THE ADAPTER IS REMOVED AND REINSTALLED. USE OF A TORQUE WRENCH IS MANDATORY PER THE ICA.

FORUMS

2016⁸: Their design used 2 copper crush 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 2012⁹: 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 2007¹⁰: 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. 2006¹¹: 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.

⁸ <https://www.beechtalk.com/forums/viewtopic.php?f=37&t=129444&start=60>

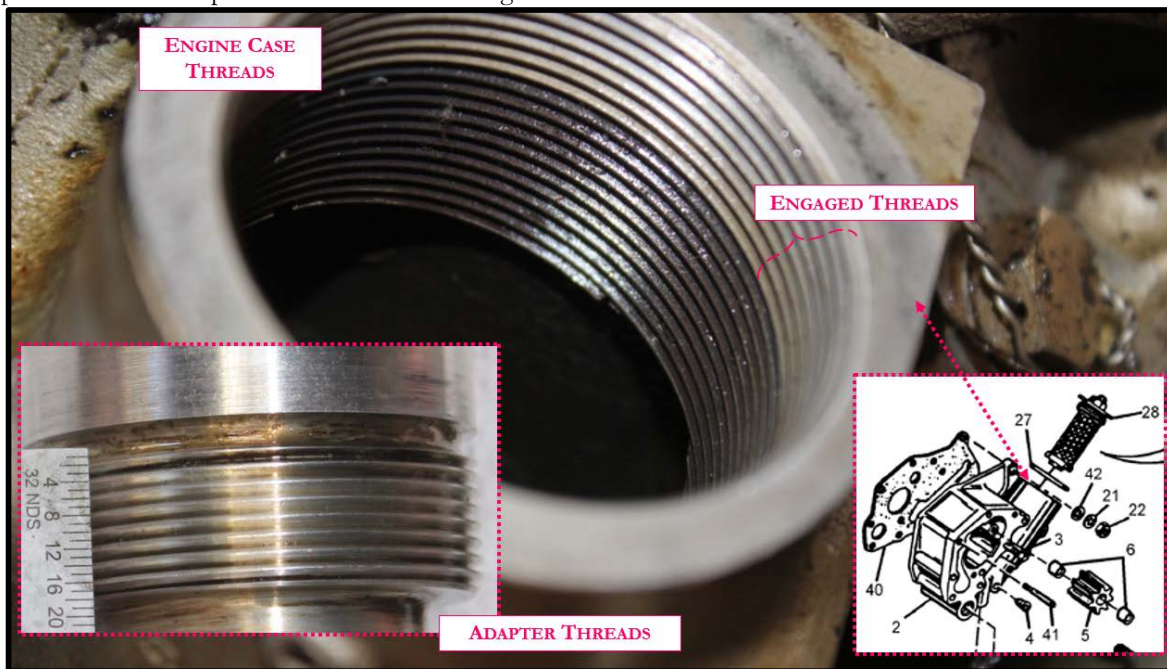
⁹ <http://n140tw.blogspot.com/2012/08/f-oil-filter-adapter.html>

¹⁰ <http://cessna170.com/forums/viewtopic.php?f=2&t=4998>

¹¹ <http://www.cessna170.org/forums/viewtopic.php?f=2&t=3321>

THREADS

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



Picture 10: Oil Filter Adapter Threads



Picture 11: Oil Screen as Originally Sold

FORUMS

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

Oct 2003¹²: 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.

¹² <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 Adapter¹³ 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.

Picture 12: From Air Wolf

ADAPTER DESIGN

FORUMS

Oct 2018¹⁴:

- 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 2017¹⁵: 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 2018¹⁶: 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

¹³ STC SA00079NY <http://www.airwolf.com/aw/products/remote-mount-oil-filter-kits/remote-oil-filter-kits-continental-engines>

¹⁴ <https://backcountrypilot.org/forum/oil-filter-adapters-22444>

¹⁵ <http://cessna170.com/forums/viewtopic.php?f=2&t=4998>

¹⁶ Frank 817-475-6096 <http://cessna170.org/forums/viewtopic.php?f=24&t=14431>

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.

May 2012¹⁷: 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 2010¹⁸: 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.



Picture 13: Prior Accident

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.

¹⁷ <http://www.cessna172club.com/forum/ubbthreads.php?ubb=showflat&Number=174856>

¹⁸ <http://cessna170.com/forums/viewtopic.php?f=24&t=4998&sid=a84cc990532006fe8316e034d6c2cb91&start=45>



Picture 14: Prior Accident

CEN13FA044 (Cessna 310) -used 2 copper gaskets

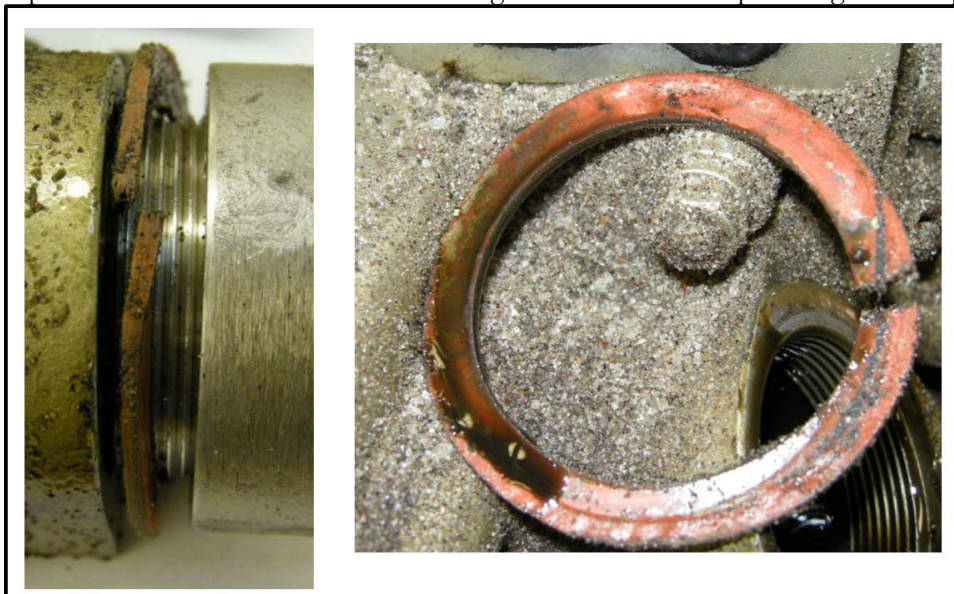
The pilot's failure to maintain airplane control after he shut down the right engine in flight due a loss of oil pressure... the mechanic's improper assembly and installation of the right engine's oil filter adapter, which resulted in a loss of oil to that engine.



Picture 15: Prior Accident

ERA10LA335 (Cessna 210)

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



Picture 16: Prior Accident

WPR09LA422 (Cessna 210)- Nearly the same accident

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.



Picture 17: Prior Accident

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.

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.

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.”

POSSIBLE FAILURE #1

HYPOTHESIS

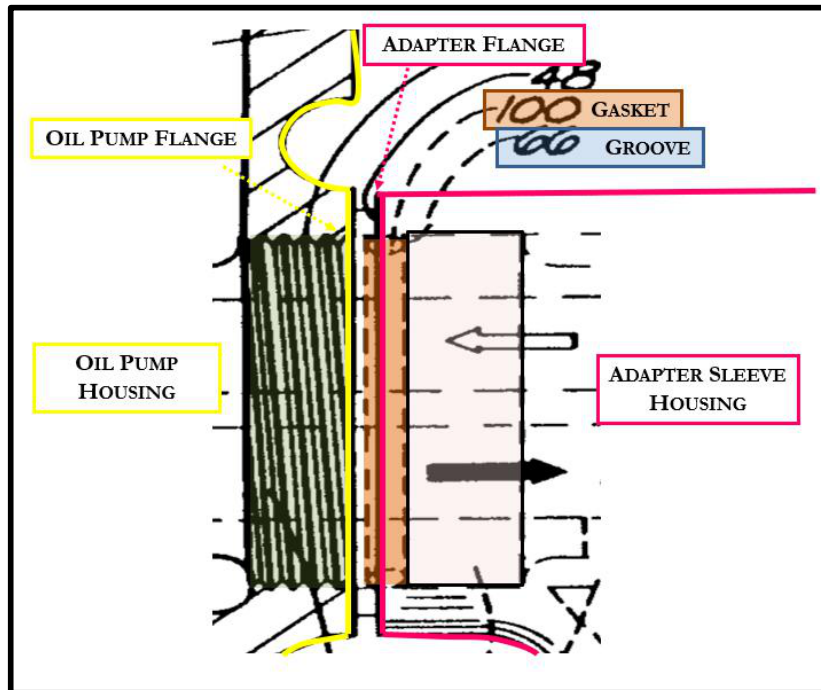
The inner diameter (ID) of the fiber gasket is large enough for the mechanic to slide it over the threads of the hub. The mechanic would then seat it against the housing for the oil adapter where it is positioned around the annular groove. The annular groove is sunken (depth currently unknown) which theoretically would make the gasket susceptible to being misaligned between the flanges during the installation. The estimated oil pump flange surface width is 0.5 in (but likely less in other areas) and the fiber gasket width is 0.505 in, which gives little margin for proper seating. If misaligned the seating surface area would be reduced and the potential of even gasket compression.

Need: all measurements of oil pump housing and oil filter adapter; better pictures of prior failures.

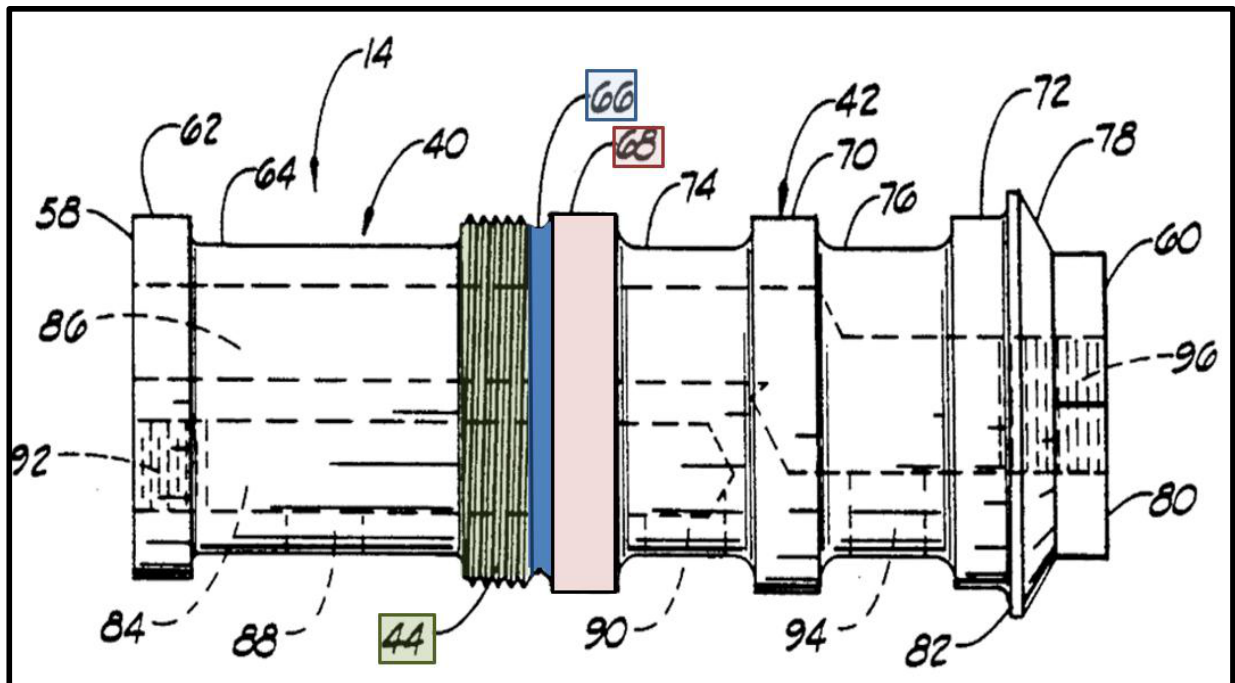
RESEARCH

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.

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) is 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).

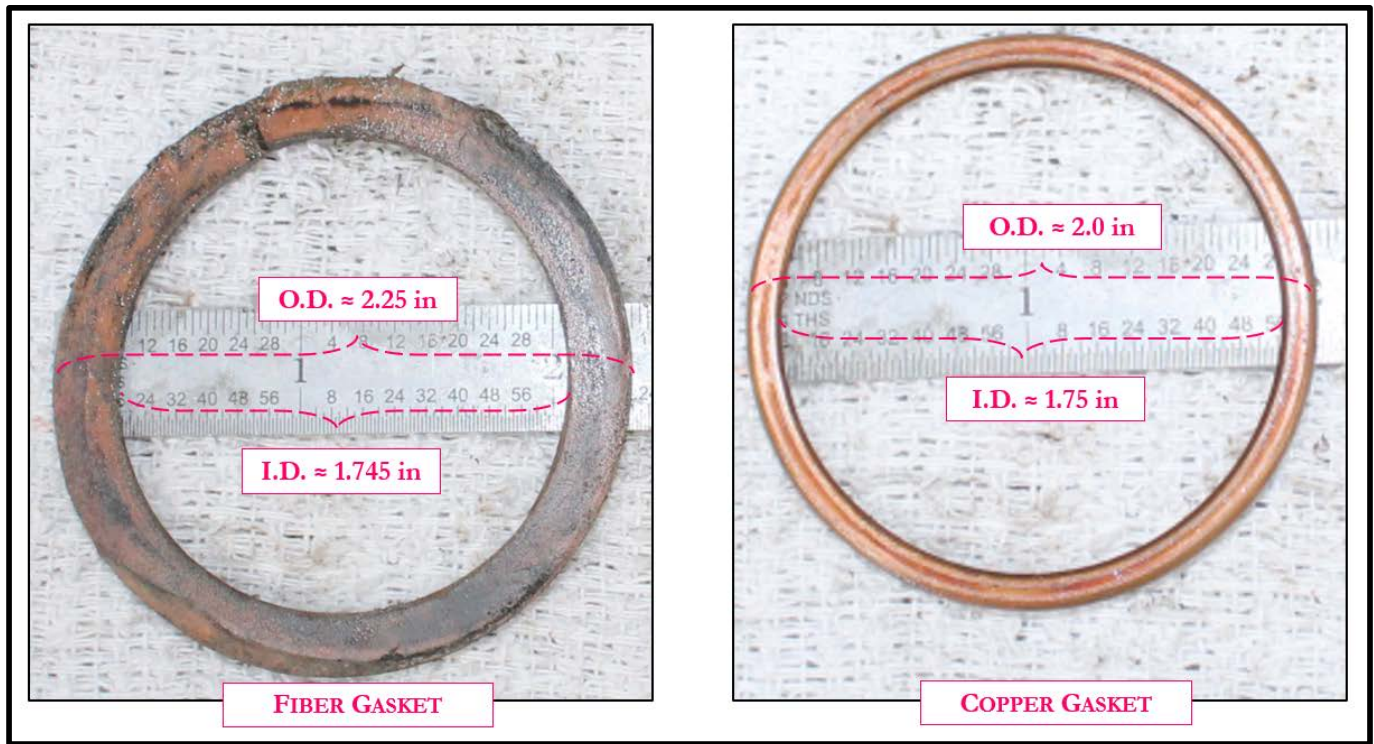


Picture 18: Patent Showing Adapter Sleeve and Annular Groove

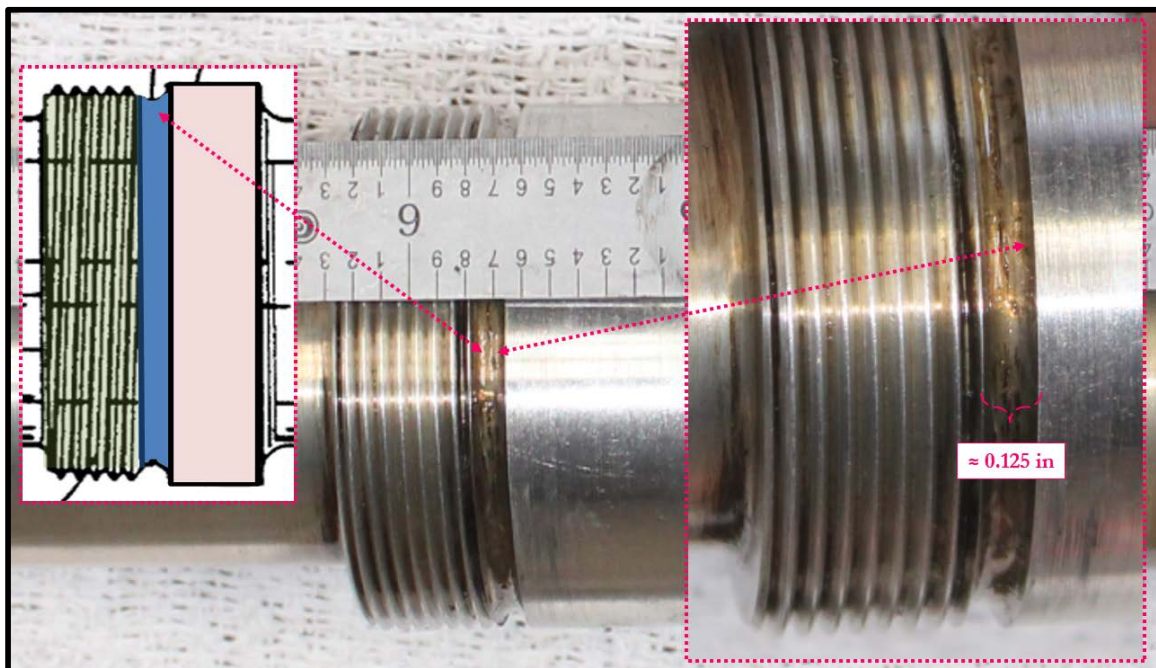


Picture 19: Patent Showing Hub

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.

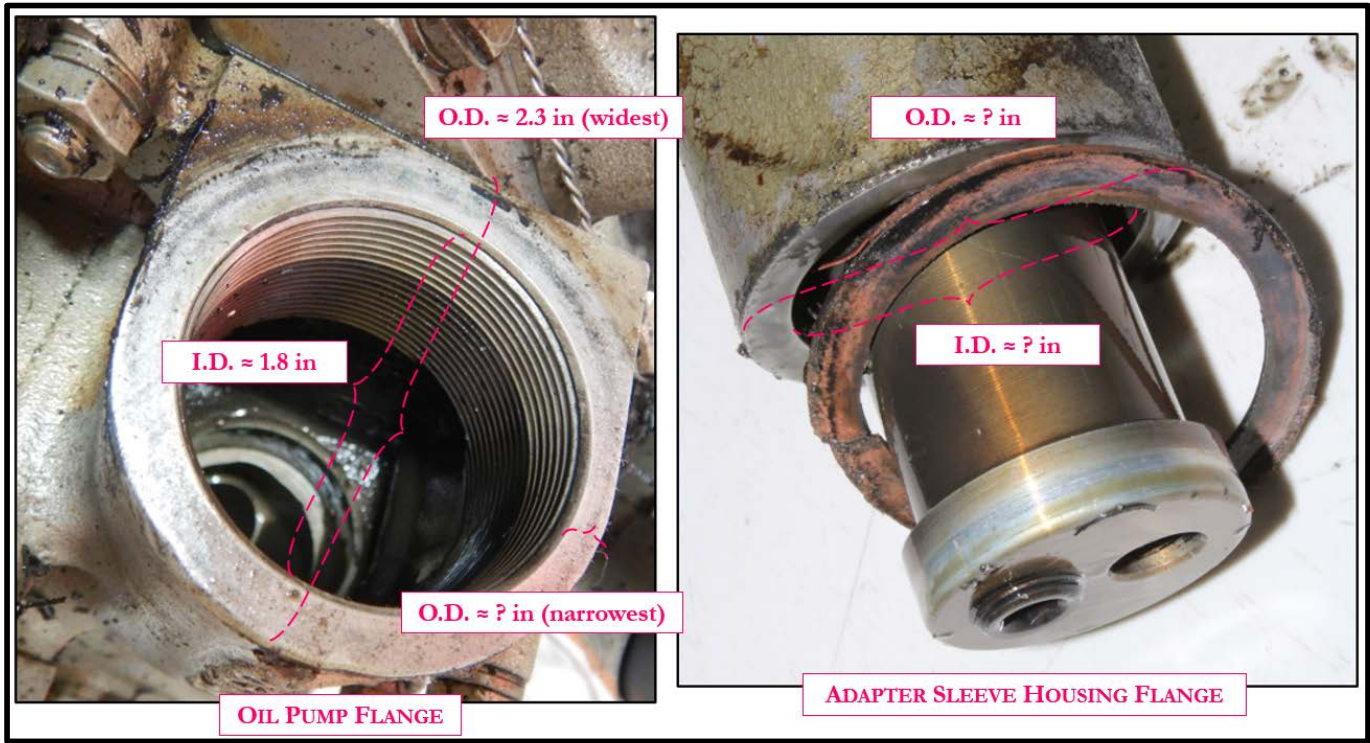


Picture 20: Measurements of Fiber vs. Copper Gasket



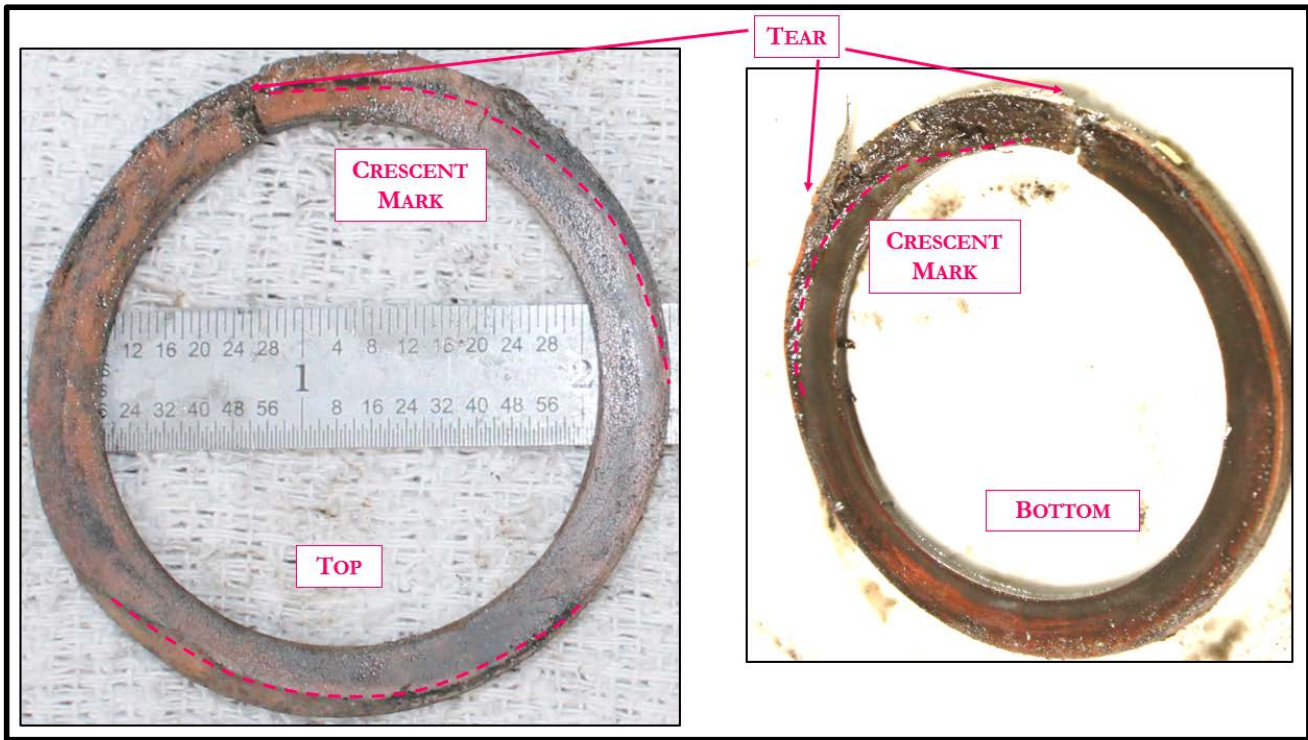
Picture 21: Measurements of Annular Groove

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.



Picture 22: 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.



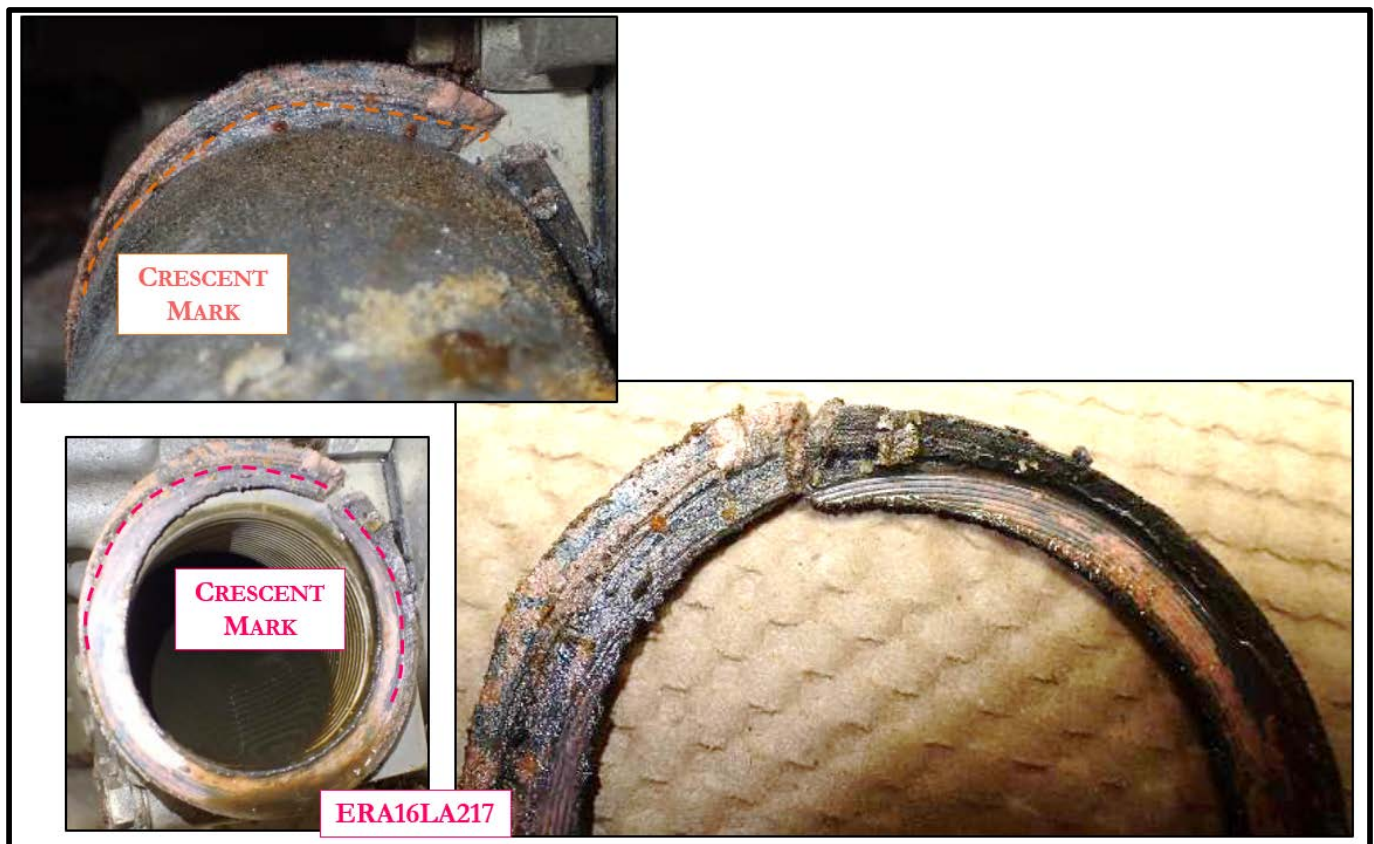
Picture 23: Gasket Showing Impressions/Marks

PRIOR ACCIDENTS

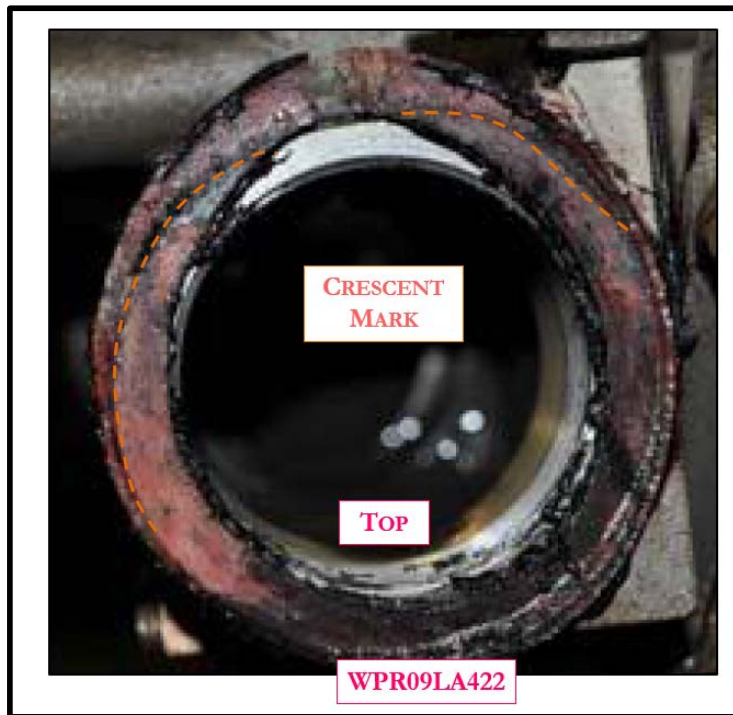
A review of pictures of prior accidents revealed that there were crescent marks similar to the accident mark. Better quality photographs are currently be searched for.



Picture 24: Prior Accident Gasket Showing Impressions/Marks



Picture 25: Prior Accident Gasket Showing Impressions/Marks



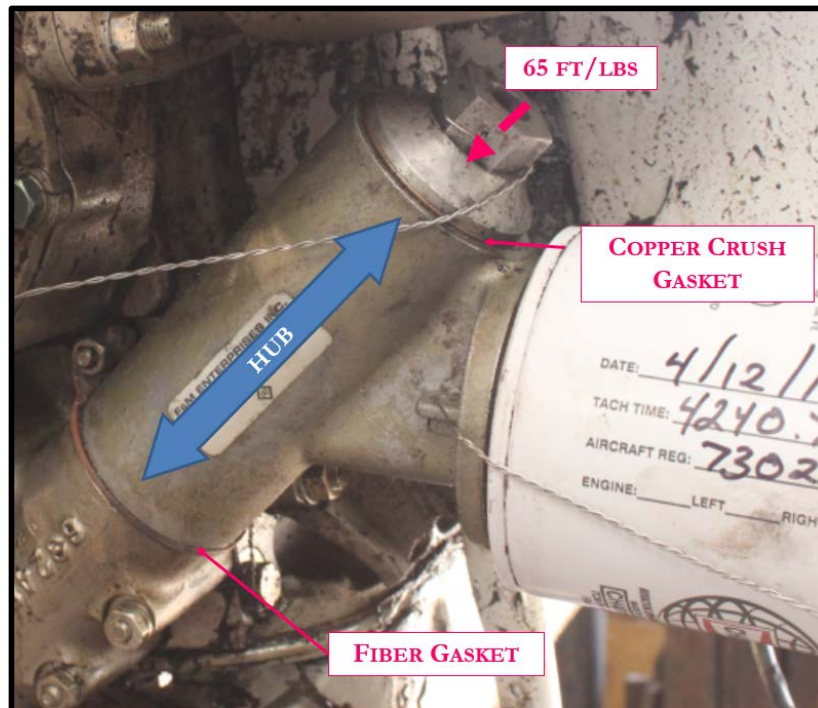
Picture 26: Prior Accident Gasket Showing Impressions/Marks

POSSIBLE FAILURE #2

HYPOTHESIS

The 65 ft/lbs of torque applied to the adapter head is very different than 65 ft/lbs because of the copper crush gasket.

Need: determine what torque the fiber gasket is seated with in light of the copper crush gasket being present.



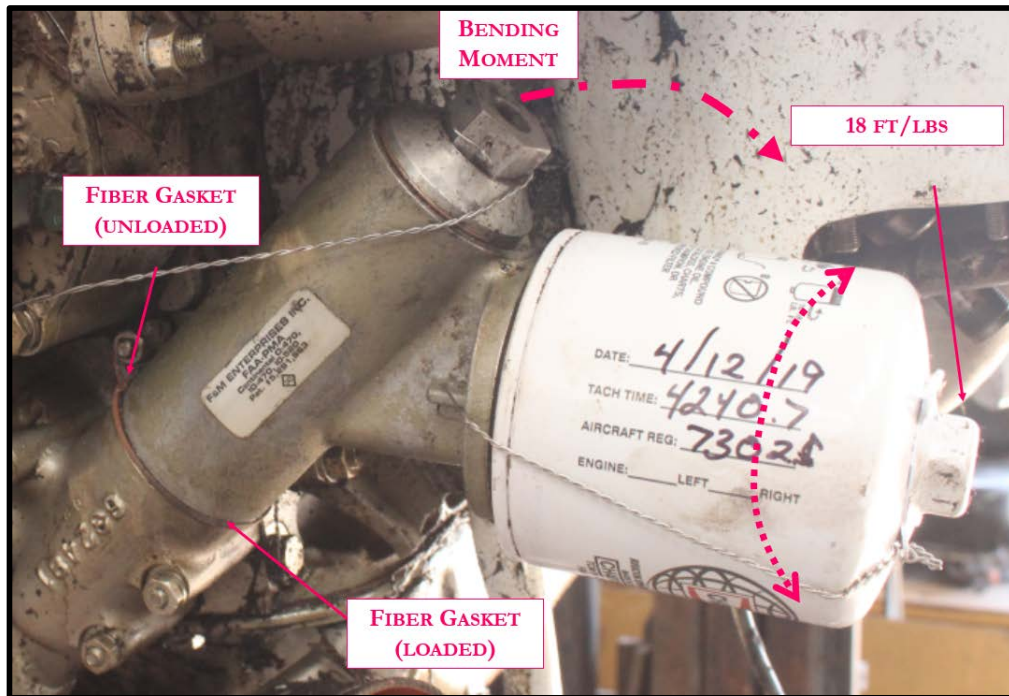
Picture 27: Torque Applied to Adapter Hub

POSSIBLE FAILURE #3

HYPOTHESIS

The loads applied to the gasket from the removal/installation of the oil filter and the long arm of where the oil filter is located (with constant vibration) result in uneven compression of the gasket which lead to blowout.

Need: determine loads on gasket during various conditions and factor in bending moment. Finite Element Analysis would be best.



Picture 28: Loads on Gasket

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