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I'm just finishing up an over week long R&D on A vs C series 4 bar FPRs and the facts promise...

Posted by: VAP (1497) on 2009-10-06 15:24:25 | Advertiser

to raise an eyebrow or two 'round these parts. 42 pages of journal entries I'm trying to transcribe/make sense of the footnotes and entries as well as a ton of pictures to whet some whatles. 8 C series and 3 A series FPRs were dissected, cut up or torn apart to get pictures/measurements related to this.

I'd like to start posting it here later tonight but don't hold me to that. It could be early-to-mid-morning tomorrow as it could easily be a 10-15 or more post thread "just" on my part with an equal or perhaps even greater number of pictures.

I'll try to edit it to be as succinct/concise as possible without compromising on comprehensiveness. But no gettin around it being rather large. You've been warned!

Thread:

- o I'm just finishing up an over week long R&D on A vs C series 4 bar FPRs and the facts promise... VAP 2009-10-06 15:24:25 (90 views)
 - Lowe you a beer. Thanks for all of your hard work QuattroCakes 2009-10-06 17:52:04 (8 views)
 - More like we owe kegs of beer if this one pans out like it sounds it could...
 UrSobsessed 2009-10-06 18:04:39 (6 views)
 - I'll start making the popcorn.... e//S2 2009-10-06 15:48:35 (39 views)
 2nd that sir Julian_Bx2 2009-10-06 15:53:19 (6 views)

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A vs C FPR information...

Posted by: VAP (1497) on 2009-10-07 08:22:41 | Advertiser

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A common problem that occurs when using a fixed port rising rate FPR such as the "plug-in" Bosch we use is that fuel pressure cannot be effectively/efficiently controlled when the fuel pump volume being delivered is different or higher than came on the car as a "mated pair" or when a different FPR, even with identical pressure but with a smaller/larger return line orifice diameter is used other than what came on the car. The pump's volume as well as the FPR's return line metering orifice are specifically engineered to work with each other. Important to note at this point there is clear evidence to suggest ALL major manufacturers build fuel pumps that actually deliver 15-20% more fuel when new than they are rated to deliver. The reason for this is simple, ie; to compensate for pump deterioration over the pump's life as well as to compensate for things like dirty/clogged injectors et

When/if a different configurtion FPR or fuel pump than came on the car is used, the original balance is forfeited unless balance is restored via matching the components to each other. When an FPR is used that has the correct pressure rating but a smaller return line outlet orifice diameter than was originally designed, engineered and specified to work with a given fuel pump's

volume delivery specifications the balancing act between pump and regulator are compromised. The same thing occurs when a larger output pump is used with an FPR that was originally designed to work with a smaller displacement pump. Depending on the dynamics involved the result of this can run from mild/barely noticeable to extremely bad and/or anywhere in between. An FPR with too small an outlet diameter metering orifice with a stock/OEM pump or a higher-flowing pump with an OEM FPR create the same/identical issues as those relate to fuel return.

When using a larger displacement pump or an FPR with too small of a discharge/return line port, there is a large pressure spike at idle and with rapid deceleration/high intake vacuum because the smaller FPR return port orifice diameter cannot evacuate enough fuel through its metering orifice when the diaphragm is fully deflected off of its valve seat to the open position. This causes a continuous/ongoing rich condition at idle as well as a momentary rich condition during/after post-decelleration, which may lead to a rough idle quality for a few seconds until the rail pressure stabilizes (but of course it cannot stabilize at idle the way its supposed to because of either 1; the increased volume due to a larger displacement pump or 2: the reduced fuel return orifice diameter which compounds the issue further). Conversely, if the discharge/return port orifice is too large the rising rate/self-adjusting feature struggles due to diaphram "flutter" making precise responsive adjustments for the regulator almost impossible because the fuel flow out of the orifice is too rapid and the diaphram diameter and internal spring of the OEM FPR is too small and subsequently not sensitive or responsive enough to respond quickly or efficiently. The FPR beats itself to death trying to keep up.

Larger, precision stand-alone FPRs get around this by offering replaceable return line metering orifice ports from say .040" to .200" diameters in .010" - .020" incremental diameters to allow the FPR to be tailored to respond precisely to the pump's volume output as well as other variables inherent in any/all fuel delivery systems. And those existing metering orifice diameters can be tailored more precisely with the use of twist drills for even smaller diameter increases. The system as-is is very good offering long life and relatively good when used with OEM pump that closely matches to return line metering orifice. But that is lost if/when the C-series FPR is installed in place of the A series FPR that came on the car. And when higher output pumps are used everything changes again. Not so much with an A series FPR but DRAMATICALLY with a C series FPR. Add a 5 bar FPR and guess what? Yep, even bigger changes. The thing to remember here is that the FPR and fuel pump are the symbiotic relationship in the fuel delivery system. Pressure-wise, any 4bar FPR would work. But volume-wise things can NEVER be the same once a C series FPR is swapped into the system that originally came with a .140" diameter return outlet that now has to "make-do" with an .086" diameter outlet. Something it struggles with given its 45.4% smaller! And that goes double if say an 044 pump is used with a newer C-series FPR!! The fuel pump and FPR were sized for each other originally and without much regard to anything else in the fuel delivery system.

Yes, there does seem to be latitude in what is acceptable and/or tolerable but a 45.4% reduction in fuel return design with the accompanying idle, off-idle and decelleration issues is simply too much for the C-series FPR to swallow (pun intended).

Thread:

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Does "cannot evacuate enough fuel " mean that you think the fuel rail is not always 100% full? Posted by: **UrS4boy** (137) on 2009-10-07 10:18:53 In Reply to: <u>A vs C FPR information...</u> posted by **VAP** on 2009-10-07 08:22:41

Sorry Mance, maybe I just read that wrong. I believe the fuel rail is always 100% full and the transient condition is NOT fuel levels in the rail but too much pressure, e.g. after going from fully throttle/high boost to closed throttle/idle, as you described.

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Posted by: UrS4boy (137) on 2009-10-07 10:51:37 In Reply to: speaking "only" of the FPR return outlet metering diameter... nothing to do with "rail" posted by VAP on 2009-10-07 10:21:50

the fuel rail, through the fuel rail, through the FPR and back through the return line (up to the fire wall)? As you said, the system is symbiotic, i.e. not just one component, they all act together as a piece.

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In Reply to: Okay. What do you think of my previous suggestion of testing the fuel system from the firewall, to posted by **UrS4boy** on 2009-10-07 10:51:37

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crazy by all means, test it!

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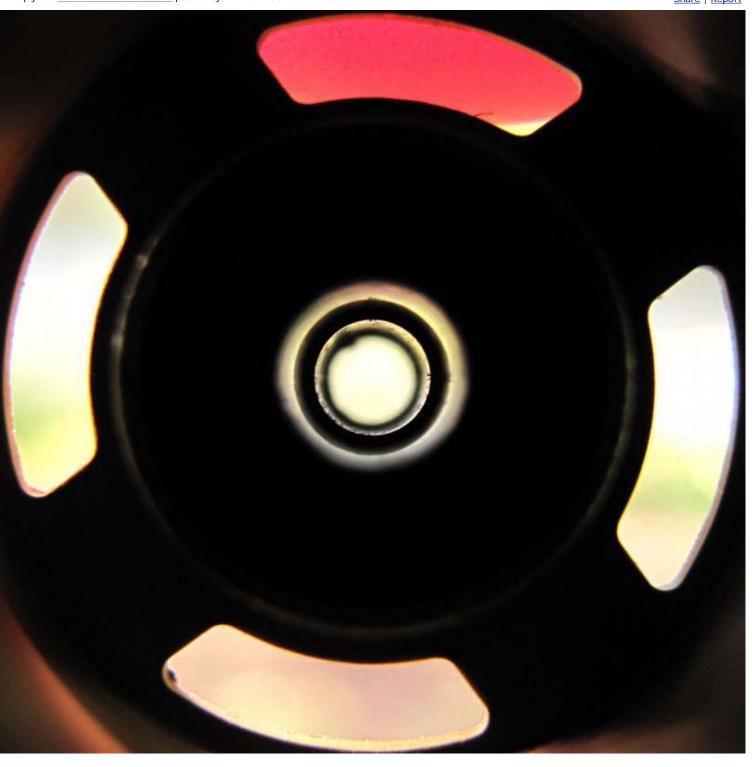
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A view down-the-bore of a 4 bar C-series FPR from seat-to-outlet...

Posted by: **VAP** (1497) on 2009-10-07 09:09:14 | **Advertiser** In Reply to: A vs C FPR information... posted by **VAP** on 2009-10-07 08:22:41

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This pic shows the 3-step metering orifice outlet in the C-series FPR. My gut feeling is this was originally designed to allow Bsch to make a single FPR then to allow purchasers to open the outlets up based on specs needed for a particular engine. But somehow Bosch never got this info out or gave up on the concept and just decided to go with a "one-size-fits-all" application which would be perfect on some cars, "close" on other and MILES from some. There's no other plausible/reasonable explanation for this setup.

But if I go with my "gut" then there's a work-around for virtually every engine spec'd for this 4 bar FPR that comes very close to matching engines that specify this FPR as the OEM regulator.

Pic above is shot from inside-out. That is to say the 1st/largest black surround is the FPR's valve seat metering outlet orifice. Followed by a short "ring of light" which represents the diameter at that step. Then another black annular ring that is the 2nd step. Then another black ring and circle of light representing the 3rd step and final outlet diameter.

More on those specs in the following post.

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Depends. If only going up to .125" outlet thats a cake-walk and only cost 4-\$5....

Posted by: VAP (1497) on 2009-10-07 13:36:26 | Advertiser

In Reply to: Can we send our old "A series" to you for drilling? posted by UrSoccer_mobile® on 2009-10-07 12:38:08

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for the drill bits and ANYONE can do it in 2 minutes flat! And it'll be included as part of the fuel rail upgrade "if" desired. Going larger than .125" pretty much locks me into being the only one with the capabilities at this time but is also included with the fuel rail modifications if desried. Based on my flow results using a pump and CNC'd alloy manifold I'm thinking the .125" diameter "may" even work better than the A series FPR on cars with new/old OEM fuel pumps. However, I also think the .125" outlet orifice is too small once an 044 fuel pump is installed. And I question its need and/or benefit at less than +/- 575WHP once the fuel rail starts to flow. Time will tell on that one.

Doing FPRs as an aside to or separate from fuel rails is something I'll take a look at later, after I've started shipping modified rail assemblies.

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 - o Depends. If only going up to .125" outlet thats a cake-walk and only cost 4-\$5.... VAP 2009-10-07 13:36:26 (22 views)

 - Specifications of the 3-stepped C-series FPR VAP 2009-10-07 09:28:56 (57 views)
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Specifications of the 3-stepped C-series FPR

FPR from seat-to-outlet... posted by VAP on 2009-10-07 09:09:14

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In an effort to find a work-around for the C-series FPR to make it a far more efficient design for a wide array of engines/pumps I needed to measure the inside diameters of the 3 steps to find out if they could be easily modified and turns out those internal bores are indeed matched to a specific set of drill bits available lending further credibility to the prospect that just maybe these were originally designed to be modified to an engine/pump specific diameter by "someone" after they left Bosch but before they were installed as a one-size-fits-all application.

The above pic is my journal entry of the C-series 4 bar FPR outlet diameters as well as the length of each diameter within the FPR outlet stem. Interesting to note these correspond EXACTLY to a 1/8" (.125"). #36 (.106") and the outlet bore is a #44 drill bit (.086").

The length of each of the 2 stepped diameters below the seat diameter is in numbers on right of drawing

The diaphram is represented by the blue line and the valve seat incorporated into the diaphram is green while the pressure regulating spring is in red.

Thread:

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    Avs CFPR information... - VAP 2009-10-07 08:22:41 (123 views)

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How to get a 4 bar C-version FPR 45.4% closer to the A-series on a DIY basis...

109-10-07 10:06:16 | **Advertiser** ne 3-stepped C-series FPR posted by **VAP** on 2009-10-07 09:28:56 In Reply to: Sp

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The work-around to get a better-suited C-series FPR is rather easy. It'll require 2 drill bits, ie; a number 36/.106" drill bit and an 1/8" (.125") drill bit and an electric/cordless drill

Step 1: drill the OEM FPR .086" outlet bore to .106" diameter with the #44. It's only .221" deep and you'll easily know once you've entered the larger step as the drill gun will free-spin instead of "drilling."

Step 2: Now drill with the 1/8" drill bit about .231" deeper than you went with the previous drill bit. Again the drill will free-spin once its reached the .125" outlet orifice seat diameter. While its ok if the drill bit touches the seat at this point DO NOT continue to drill past when the drill starts to free-spin.

At this point the bore diameter comes within .015" of matching the original A-series FPR and will work far more efficiently and tons closer to the original FPR specs

Yes, there is a way to get the C-series FPR back up to the A-series OEM return flow spec and even beyond but this is beyond the means of the average DIYer as it takes special tools to offset the diaphram sealing ring off it's seat as well as removing the mesh on the FPR underside which is a VERY tricky endeavor indeed without breaking and should ONLY be attempted on a new FPR not unused. Any attempt at doing this without hearing the instructions will absolutely result in a broken drill bit and FPR. Even if you try it 7 times. Ask me how I might KNOW that ;-)

Pic above shws OEM A-series FPR on left w/.140 metering outlet. 2 C-series FPR's on right with middle C-series being modified to .125" outlet diameter using the above procedure.

I'll cover this in a subsequent post later today

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A vs C FPR information... - VAP 2009-10-07 08:22:41 (123 views)

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Getting a C-series FPR up to and beyond A-series return fuel flow specifications...

er to the A-series on a DIY basis... posted by VAP on 2009-10-07 10:06:16

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Here's where things get a little tougher. In order to do this the FPR's inlet mesh that's designed to keep rail sediment out of the FPR sealing seat provision and to prevent that material from being returned to the fuel tank MUST be remved. Due to the brass stem that retains the mesh screen having a flat on its underside makes getting the mesh off VERY difficult. If the FPR is new you have a better chance. Once that plastic mesh body has been used for awhile the plastic becomes heat-fatigued, brittle and prone to breakage before it can be removed. I've actually ground my own tools to do this with but only have 100% success rates with a new FPR. And those that are 1 year old maybe 70% success. After that its 50/50 even on VERY good day!

In the above pic you can see the diaphram and sealing mechanism used to seal against the outlet metering orifice sleeve that mates against the sealing seat in the lower half of the FPR. The diaphrammounted sealing provision is simply an 8mm spherical ball bearing that has a 5mm "flat" ground on it. This allows the actual ball bearing seat to move radially/orbitally to maintain a flat sealing seat against the outlet metering orifice. Without the spherical ball the diaphram composition would not allow the seat to fully seal 360* around its circumference. The ball bearing compensates for that by staying "flat" against th orifice outlet no matter what the diaphram is doing.

The drill bit sticking out of that diaphram is what happens if you try to bore your FPR outlet beyond .125". The pressure adjusting spring pressing against the diaphram and sealing ball takes near 25lbs of effort to overcome and lift the ball seal off it's seat. Try doing that by pushing the drill at 25+lbs and the ball seal bearing will tilt and drive the drill bit into the spherical race, break the drill bit and ruin the sealing seat in the outlet orifice. FPR is toast! Doesn't matter who ya know or where ya go this is going to happen EVERY time!!

The work-around I've found is to CNC a pressing die that fits within the 4 inlet slots around the FPR base that goes down into the lower half of the FPR and can raise the diaphram off its seat via its center locating disc under the spherical race. That disc is shown to the right of the diaphram in above pic. The 4 black spots on that disc show the footprint that the pressing die makes on that disc when it makes contact. And you can see the bearing "flat" that seals against the outlet orifice. You can see the black die "feet" just to the right of that inserted into the lower FPR body.

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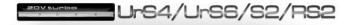
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Same pic as above but side-view. Next up I'll show ya how it all comes together to allow...

9-10-07 12:05:40 | **Advertiser** PR up to and be<u>yond A-series return fuel flow specifications...</u> posted by **VAP** on 2009-10-07 11:58:04

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matching or surpassing A-series FPR return fuel flow specs.

o Avs C FPR information... - VAP 2009-10-07 08:22:41 (123 views)

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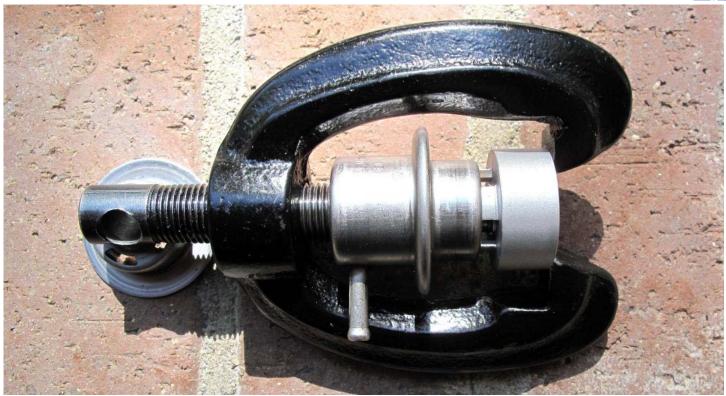
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By installing a C-series FPR with the pressing die into an ordinary puller I'm able to deflect....

I'll show va how it all comes together to allow... posted by VAP on 2009-10-07 12:05:40

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the spherical ball off its seat. That in turn allows me to now drill/ream the existing outlet bore to even greater-than-OEM diameters. The cautions with this of course are that if compressed to much you risk pulling the diaphram out of its clamped-together retaining provision between upper and lower compartments. Secondly and again if compressed too far you risk stacking the spring solid which "could"

Since I knew by dissection exactly how far I can go that allows me to get everything up high enough with risking collateral damage I just applied the distance needed to the thread-count and hit the mark perfectly. Basically 2.0 turns from hand tight puts me exactly where I need to be to get things drilled/reamed without stacking the spring solid (coil-bind) or pushing the diaphram out of its retainer.

And obviously, you can see here why thet plastic encapsulated mesh must be removed. But there's another reason as well. "If" you could drill the return bore larger it would have to be done with the sealing seat raised. If you drill with the sealing seat raised you fill up the pressure chamber with the chips you got when drilling. This would undoubtedly find its way on to the sealing seat and create a leak that affected both fuel line pressure as well as return fuel volume out of the FPR. You'd be worse off than before you started. With the mesh removed and after drilling I can blow it out up inside there with brake cleaner aerosol and compress air assuring a clean environment and seat-to-seal leak-free mating surface.

Next up the "business end" of this asembly..

- o A vs C FPR information... VAP 2009-10-07 08:22:41 (123 views)
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With the FPR and die in a clamp I'm able to now drill/ream to the desired diameter...

g die into an ordinary puller I'm able to deflect.... posted by VAP on 2009-10-07 12:33:08

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This shows the business end of the arrangement. I've purposely matched ID of the die to match the ID of the FPR housing where the small o-ring and outlet stem is held/sealed. This allows me to keep everything square and on-axis without it being such a fiddly affair

Once fuel return line bore diametersbores are drilled to desired spec everything is blown out with compressed air, aerosol brake cleaner and compressed air again then ultrasonically cleaned before reinstalling the mesh so there's zero chance for ANY particulate debris or shavings to remain inside.

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o A vs C FPR information... - VAP 2009-10-07 08:22:41 (123 views)

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Just some fun I had with FPR's during this research...

In Reply to: With the FPR and die in a clamp I'm able to now drill/ream to the desired diameter... posted by VAP on 2009-10-07 12:46:52

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I wanted to experience the same or similar results in my car to what you guys might experience by purchasing a C-series FPR to replace a bad/faulty A-series FPR when that time comes (and rest assured, its COMING;-) So I built myself one with an .052" return line orifice diameter by silver-soldering the .086" outlet orifice closed then re-drilling to .052". That's the same percentage reduction you guys get ding'd when swapping an A-series for a C-series.

WOWSERS!! Idled fatter-n-a-pig with black sooty/puffy smoke billowing out and rail fuel pressure sky-rocketed to 72psi from my set pressure at idle of 56 psi (I have a fuel pressure gauge mounted in my fuel rail to monitor this stuff). Accelerated much slower than usual and at night with car headlights behind me I could see voluminous black smoke coming from the tailpipes when cruising that increased dramatically at WOT. Boy, I had NO problem whatsoever noticing something was H-U-G-E-L-Y outta wack! Knew it within a split second of starting the car. It was many things but "subtle" wasn't in the 1st 3 to 4,000 thoughts that raced immediately across my mind!!

In this pic the OEM A series FPR with standard .140" outlet diameter is at upper left. Next to it is a C-series modified to .155" outlet diameter (I "think" .160" diameter is as large as I can safely go with these before risking losing the small-o-ring groove cap at the very tip. The rest of em are marked for outlet diameters. All of em ran dramatically better individually than the .052" one but next I want to test the intermediate step bore that's .106" diameter (.020" larger than the OEM C-series FPR outlet diameter) which I'll do by redrilling the one I silver-soldered and re-test.

Now if I could just get my hands on a 5 bar FPR without having to buy one just to see if its outlet is larger/different than the A series 4 bar unit.

Thread

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O Avs C FPR information... - VAP 2009-10-07 08:22:41 (123 views)

O Does "cannot evacuate enough fuel " mean that you think the fuel rail is not always 100% full? - UrS4boy 2009-10-07 10:18:53 (25 views)

Speaking "only" of the FPR return outlet metering diameter... nothing to do with "rail" □ - VAP 2009-10-07 10:21:50 (12 views)

O Okay. What do you think of my previous suggestion of testing the fuel system from the firewall, to - UrS4boy 2009-10-07 10:51:37 (23 views)

□ "believe" I said the FPR & pump are symbiotic and not the "system." But if it's driving you... - VAP 2009-10-07 10:55:57 (33 views)

□ "believe" I said the FPR & pump are symbiotic and not the "system." But if it's driving you... - VAP 2009-10-07 10:55:57 (33 views)

□ Eventually, you "might" see my point. In the meantime, carry on. Good stuff. □ UrS4boy 2009-10-07 11:18:38 (12 views)

□ A view down-the-bore of a 4 bar C-series FPR from seat-to-outlet... □ VAP 2009-10-07 0:09:14 (66 views)

□ Can we send our old "A series" to you for drilling? - UrSoccer_mobile © 2009-10-07 12:36:88 (15 views)

□ Depends. If only going up to .125" outlet thats a cake-walk and only cost 4-$5... - VAP 2009-10-07 13:36:26 (22 views)

□ Specifications of the 3-stepped C-series FPR □ VAP 2009-10-07 09:28:56 (88 views)

□ How to get a 4 bar C-version FPR 45.4% closer to the A-series on a DIY basis... □ VAP 2009-10-07 10:06:16 (45 views)

□ Getting a C-series FPR up to and beyond A-series return fuel flow specifications... □ VAP 2009-10-07 10:06:16 (45 views)

□ Same pic as above but side-view. Next up I'll show ya how it all comes together to allow... □ VAP 2009-10-07 12:35:08 (38 views)

□ By Installing a C-series FPR with the pressing die into an ordinary puller I'm able to deflect... □ VAP 2009-10-07 12:35:08 (38 views)

□ With the FPR and die in a clamp I'm able to now drill/ream to the desired diameter... □ VAP 2009-10-07 12:36:40 (29 views)

□ I wish i still had that 5 bar FPR in the pic i posted last week. Great research... □ VAP 2009-10-07 13:26:50 (52 vie
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quattroworld.com Forums: Just some fun I had with FPR's during this rese...

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Speaking of FPRs...

Posted by: kday (680) on 2009-10-07 09:34:32

VAP's post reminded me of this picture I took a while ago of my adjustable FPR taken apart. Looks pretty easy to replicate if you have a lathe and a stock FPR.



```
94 S4
96 A6q Avant
90 Miata
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Thread

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o Speaking of FPRs... □□□ - kday 2009-10-07 09:34:32 (143 views)

o Resized for the whiners: □□□ - EDIGREG 2009-10-07 11:34:34 (83 views)

o um... do you have a bigger picture? □□ - ImQuattro® 2009-10-07 10:18:52 (9 views)

o Yeh. That one only covers two States (MA and NH). Is there a three state version? □□ - UrS4boy 2009-10-07 10:52:45 (8 views)

o Sorry, It's an old camera. That's as big as it gets. □ - kday 2009-10-07 11:07:03 (10 views)

o lol □□ - urs6ville 2009-10-07 12:28:11 (1 view)

o is that the one where the nut jammed up? - a4kquattro 2009-10-07 10:15:10 (26 views)

o Yeah... you can see the stripped threads on the smaller screw. - kday 2009-10-07 11:08:36 (18 views)
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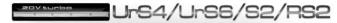
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Resized for the whiners:

Posted by: **EDIGREG** (112) on 2009-10-07 11:34:34 In Reply to: <u>Speaking of FPRs...</u> posted by **kday** on 2009-10-07 09:34:32





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All messages | Search Forums | Return to UrS4/UrS6/S2/RS2 Posted by: **a4kquattro** (<u>181</u>) on 2009-10-07 10:15:10 In Reply to: <u>Speaking of FPRs...</u> posted by **kday** on 2009-10-07 09:34:32 the threads look ok, what was ultimately wrong with it?

is that the one where the nut jammed up?

Marc Swanson 95.5 S6 Avant 90 CQ 3.6 V8TT

o Yeah... you can see the stripped threads on the smaller screw. - kday 2009-10-07 11:08:36 (18 views)

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Yeah... you can see the stripped threads on the smaller screw.

Posted by: **kday** (680) on 2009-10-07 11:08:36 In Reply to: <u>is that the one where the nut jammed up?</u> posted by **a4kquattro** on 2009-10-07 10:15:10

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I just replaced that piece with the larger screw and it works fine (though it looks silly).

94 S4 96 A6q Avant 90 Miata

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