WolfKatz Engineering LLC Fuel Rail, Pump and Injector Testing Final Report:

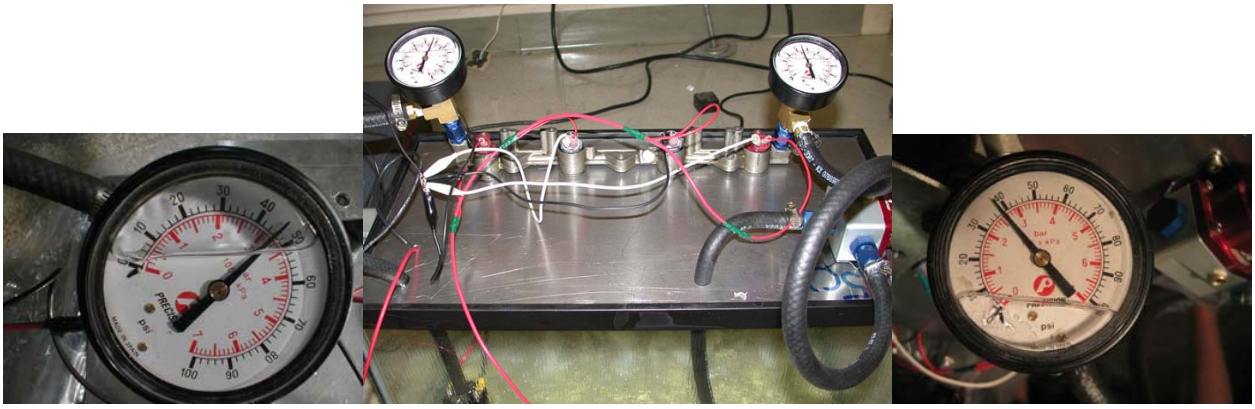
First off, here are the main conclusions of the testing:

- You should not run a larger fuel pump with the stock Gen II MR2 Turbo (3S-GTE) fuel rail.
- You should not run any fuel rail with 550's with the stock Gen II 3S-GTE fuel pump above 10 PSI boost. The stock fuel pump cannot keep up above 52 psi of line pressure.
- The Gen II 3S-GTE factory FPR, supply lines, and return lines can handle a larger fuel pump without problems.
- Both the Supra pump and the Walbro pump (255 lph) can keep up with 850 cc/min injectors.

The rest of the report:

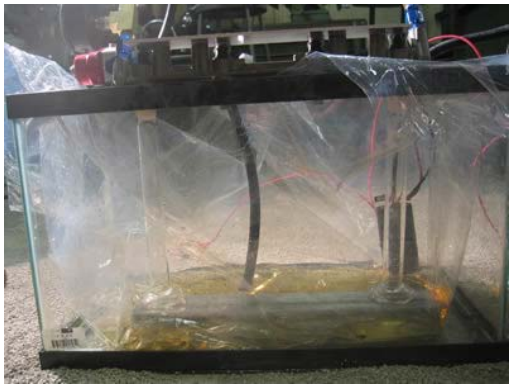
The Setup:

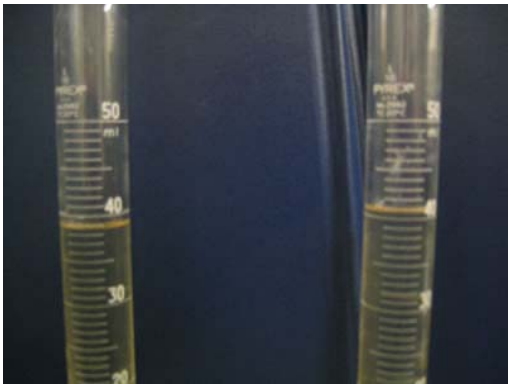
The test setup involves a fish tank, pressure gauges, a power supply, a fuel pump, and a fuel pressure regulator. The setup, while simple in design, can show exactly how each rail performs. The pump is placed inside the fish tank. It then sends the rail through hose up to the fuel rail which is mounted in a custom made plate sitting on top of the fish tank. The FPR is connected to the outlet end of the rail and the return is sent back into the fish tank. Pressure gauges are mounted direction to the inlet and outlet of the fuel rail. All four injectors in the rail are connected to a simple switch. When this switch is thrown, the injectors open. Various rails, injectors, pumps and pressures can be tested using this setup. If a sizeable pressure difference shows up between the inlet and outlet of the rail, there is a flow difference and thus a mixture difference. A mixture difference can lead to a blown cylinder and a ka-boomed engine. The larger picture is of the experimental setup. For each experiment, pictures of the inlet and outlet rail pressures were taken simultaneously with two cameras. The left picture is the inlet pressure, the right the outlet pressure (these pictures for 550's in the stock rail at 40 psi base pressure from the Supra pump).



The setup varied only slightly when flow measurements were taken. Two graduated cylinders were attached to the upstream (pump side) injector and the downstream (FPR side) injector. The

injectors were then opened for a set amount of time thus filling up the two graduated cylinders. The flow difference between the two cylinders could then be measure. The setup including the cylinders is shown below left. After the cylinders are removed from the tank the measurements could be recorded. A typical example is shown below right.





Data Sets:

Below are two data sets. The first set is pressure data. Tests were done using a Gen IV Supra Pump, a Gen II RX7 Pump, and a Stock 3S-GTE Gen II MR2 T pump. The Side Feed injectors tested included stock MR2 T Gen II 440's, Supra Gen IV 550's, MR2 T Gen III 540's (1996-1999 in Japan), and Blitz 850's. One test was also performed on the eXtremeBoost Top Feed rail with 84lb injectors. Side feed rails tested included the WolfKatz Side Feed Fuel Rail (and a Blem version of this rail that has a different outlet fitting, which is a bit more restrictive, as it's only difference), the stock Gen II MR2 Turbo rail, the Stock Gen III MR2 Turbo Rail (1996-1999 in Japan), a Center Feed Dual Return Rail, and two varieties of the Dual Feed Center Return Rail (one with a 12 mm center hole and one tapped to 1/8" npt). Both an aftermarket FPR and the stock FPR were tested. Each configuration was also tested at both the base fuel pressure around 40 psi and a pressure around 65 psi that represents ~25 psi of boost. A pressure measurement was recorded with the injectors closed and the injectors wide open (static). Below is a table of the results.

	Fuel Rail	*Injectors*	*Fuel Pump*	*FPR*	*Base Pressure Setting (psi)*	*Pressure drop with injectors open (psi)*	*Pressure drop with injectors closed (psi)*
1	Center Feed M12	550	Supra	Aeromotive	39.5	2	3.5
2	Center Feed M12	550	Supra	Aeromotive	64	0	2
3	Dual Feed 1/8 NPT	550	Supra	Aeromotive	40.5	2	3.5
4	Dual Feed 1/8 NPT	550	Supra	Aeromotive	64	0	0
5	Dual Feed M12	550	Supra	Aeromotive	40	3	4
6	Dual Feed M12	550	Supra	Aeromotive	66	0	1
7	Dual Feed M12	850	Supra	Aeromotive	40	2	3
8	Dual Feed M12	850	Supra	Aeromotive	66	0.5	1.5
9	eXtremeBoost Top Feed	84	Supra	Aeromotive	40.5	0.5	1
10	eXtremeBoost Top Feed	84	Supra	Aeromotive	65.5	1	0
11	Stock Gen II	440	RX7	Aeromotive	40	3	6

12	Stock Gen II	440	RX7	Aeromotive	66	2	2
13	Stock Gen II	440	Stock	Aeromotive	40.5	4	7
14	Stock Gen II	440	Stock	Aeromotive	66	1.5	2
15	Stock Gen II	440	Supra	Aeromotive	40	13	17
16	Stock Gen II	440	Supra	Aeromotive	66	7	14
17	Stock Gen II	550	Stock	Aeromotive	40.5	2.5	5.5
18	Stock Gen II	550	Stock	Aeromotive	62.5 set / **52**	1	1.5
19	Stock Gen II	550	Supra	Aeromotive	40	8	14
20	Stock Gen II	550	Supra	Aeromotive	66	2	10
21	Stock Gen II	850	Supra	Aeromotive	40	6	11
22	Stock Gen II	850	Supra	Aeromotive	66	4	8
23	Stock Gen III	540	Supra	Aeromotive	40	2	4
24	Stock Gen III	540	Supra	Aeromotive	66	1	2.5
25	Stock Gen III	850	Supra	Aeromotive	40	1.5	6
26	Stock Gen III	850	Supra	Aeromotive	66	1.5	2.5
27	WolfKatz	550	RX7	Aeromotive	30	0.5	NR
28	WolfKatz	550	Stock	Aeromotive	40.5	0.5	1.5
29	WolfKatz	550	Stock	Aeromotive	65	0.5	0
30	WolfKatz	550	Supra	Aeromotive	40	2	4
31	WolfKatz	550	Supra	Aeromotive	66	1	2
32	WolfKatz	550	Supra	Stock	43	2.5	4
33	WolfKatz	850	Supra	Aeromotive	40	2.5	3.5
34	WolfKatz	850	Supra	Aeromotive	66	2	2
35	WolfKatz	850	Supra	Stock	51	2	3
36	WolfKatz	850	Supra	Stock	76	1.5	0
37	WolfKatz Blem	550	Supra	Aeromotive	40	3.5	4.5
38	WolfKatz Blem	550	Supra	Aeromotive	66	2	1
39	WolfKatz Blem	850	Supra	Aeromotive	40	2	4
40	WolfKatz Blem	850	Supra	Aeromotive	66	0.5	1

Pressure drops shown in “orange” represent a case where one should be aware of possible issues that may arise. Pressure drops shown in “red” should be avoided at all times. As you can see, there are very large pressure drops in the Stock Gen II rail when a larger fuel pump is fitted. Remember that the stock Gen II fuel system reduces the fuel pump voltage at low pressures (off boost) and thus the number 13 data is higher than what would be seen in the car.

Here are the lessons learned:

- The stock rail is barely compatible with its own stock pump. It appears Toyota engineered in an electronic fix to the mechanical limitation.
- The stock 3S-GTE fuel pump cannot support larger fuel injectors above ~10 psi of boost. The test shown in number 18 shows that the pressure topped out at 52 psi when the injectors were held wide open.
- A larger fuel pump (Supra or Walbro) most certainly require an upgraded fuel rail. All of the red values show the significant limitation of the stock rail.
- The Gen III rail needs no help, it has been appropriately re-designed.
- The stock supply lines, return lines and regulator all work fine with all pumps and can keep up with the Blitz 850 cc/min injectors.
- The WolfKatz Fuel Rail is thus the only ‘bolt in’ option that works with the stock FPR requiring no machine work to solve the restrictive fuel rail problem.

- The top feed system tested worked fine, but is not compatible with the stock supply line, return line, and regulator.

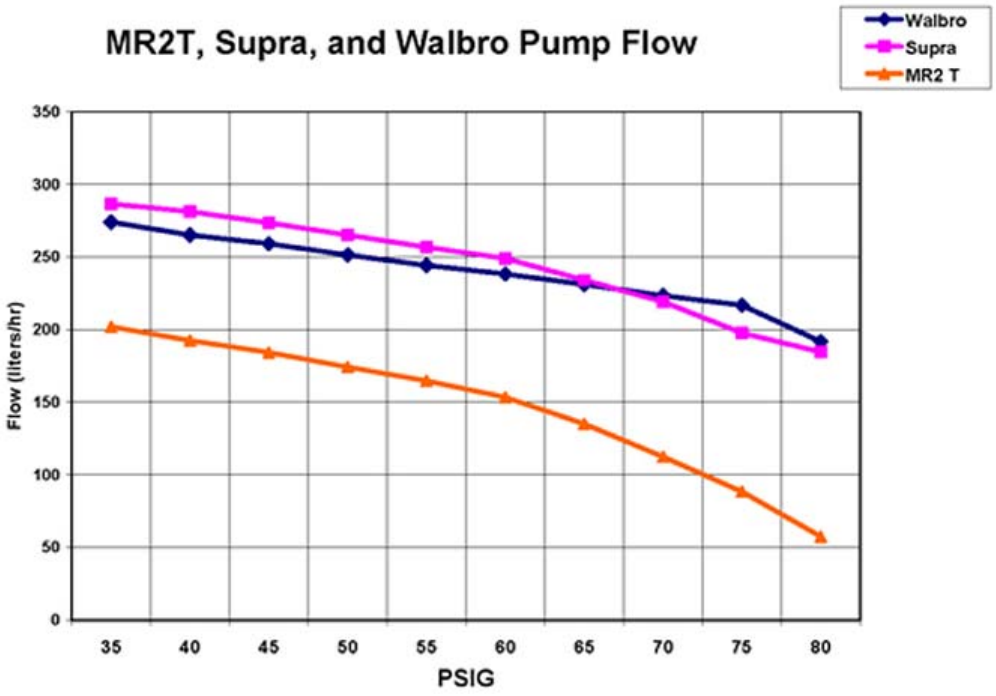
The second table shows the data from the flow testing. The data taken in these tests is correlated to the pressure drops measured above. These tests were done to confirm that the pressure drop method was practically sound (we know it works with fluids theory).

Fuel Rail	Injectors	Fuel Pump	FPR	Percentage Difference
Stock Gen II	440	RX7	Aeromotive	4.0
Stock Gen II	440	Supra	Aeromotive	5.1
Stock Gen II	550	Supra	Aeromotive	5.1
WolfKatz	550	Supra	Aeromotive	1.1
WolfKatz	550	Stock	Aeromotive	0.7

Thus, the pressure drop is a valid way to gauge mixture differences across the cylinders.

Other Information:

We also compiled some test data on the various fuel pumps available for in tank swaps into the Gen II MR2. The chart below shows the flow differences between the stock 3S-GTE pump and the two most popular swap choices: the Supra Gen IV pump and the 255 lbh Walbro. Since very few of us will ever go over 70 psi of fuel pressure (in fact, most aftermarket FPR's won't go above this pressure), both of these pumps will work fine for our purposes. The Supra pump is quieter, but draws more current.



Also, below is a picture showing the two modified stock rails that were tested along with a completely stock rail. The purpose of this picture is to show the difference between the 12 mm hole, the 1/8 npt hole and the stock hole. It is my feeling that the 12 mm hole leaves very little material for threading and should be avoided. Keep in mind that this modification of the stock rail does not save money over buying the WolfKatz Fuel Rail and you lose the ability to run a cold start injector.

The 12 mm hole is the one on the bottom and the stock rail is the one on the top. The M12 fitting (blue one) is show next to the 1/8" npt fitting in the bottom left corner of the picture.

We also performed a flow test on a 15' long, 5/16" diameter hose (similar to the stock supply line) to decide if there would be a pressure drop between the pump and the inlet of the fuel rail. The test was performed using the Supra fuel pump. There was a negligible pressure drop present as shown in the next picture.

The pressure drop is so slight that it is within the error of the gauges. Thus the hose does not have a large effect on the system.

We also played around with a new stock fuel filter and found it to be completely fine for use with larger fuel pumps. In fact, these filters have even less resistance than the hose!

Conclusions:

In closing we learned a few important things. Gas fumes make you dingy at two in the morning … But seriously, be careful when modifying the fuel system on your Gen II MR2 Turbo or STS 185 All-Trac Celica. The rail is very restrictive and should be replaced as soon as your fuel requirements outgrow your stock injectors. Best of luck with your project!