NOSTRUM

HIGH PERFORMANCE

SUBARU FA20DIT HIGH PRESSURE FUEL PUMP DEALER TUNING GUIDE

SUBARU FA20F BB PUMP KIT PART #: H136-0571

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SUBARU FA20F

TUNING GUIDE INSTALLATION INSTRUCTIONS

BMW N55 3.L KIT PART #: H086-0715

FA20F DIT FUEL SYSTEM OVERVIEW & DEALER TUNING GUIDE

The FA20F engine found in the 2015+ Subaru WRX is Subaru's first Direct-Injected (DI) gasoline engine. Unique to DI fuel systems is their high operating pressure: ~2200 psi in the FA20F's case, allowing fuel to be injected directly into the engine's combustion chamber. To achieve that fuel pressure, the engine utilizes a high pressure fuel pump in addition to the conventional in-tank low pressure pump.

The low-pressure side of the system includes an in-tank pump capable of ~185LPH at 60 psi, feeding the high-pressure fuel pump (HPFP). The HPFP then pressurizes that fuel up to 2200psi in the fuel rail. This is done with an internal cam-driven piston.

The piston in the HPFP moves a constant volume of fuel per stroke, determined by the surface area of the piston and the stroke of the fuel lobe on the camshaft. Delivered fuel quantity is controlled by a solenoid valve which returns excess fuel back into the low pressure side of the pump. Additionally, the fuel pump contains an internal pressure bypass valve: this bypass valve is a mechanical device built into the body of the HPFP and is pre-set at the factory to open at pressures above ~2600psi. This means that no matter what, fuel pressure cannot increase past the point where the bypass valve opens. There is some natural variability in the exact pressure the bypass valve will activate for a range of production pumps.

WHAT IS THE NOSTRUM HIGH PERFORMANCE FUEL PUMP?

The Nostrum HPFP is brand new, fully tested OEM style pump rebuilt with various upgraded parts, the most important of which being a piston and cylinder that have 40% more surface area than the OEM pump. This means that for every pump stroke the Nostrum HPFP can supply 40% more fuel to the injectors than the factory pump! Our pump is built with only ethanol compatible materials to ensure longevity when running ethanol blends up to E100. It is a direct bolt-on component that installs in the factory location and requires no tuning in order to function.

LIMITATIONS OF THE STOCK FUEL SYSTEM

The HPFP is driven by the camshaft meaning that, the pump speed and its ability to move fuel increases and decreases with engine speed. Therefore, the capacity of the HPFP is lowest at low engine speeds and highest at high engine speeds. If a loss of fuel rail pressure is observed at low RPMs it's likely that the maximum capacity of the HPFP has been exceeded at that engine speed. Conversely, the low pressure fuel pump (the in-tank electric pump) operates independently of engine speed and has a constant maximum flow rate of approximately 185 liters per hour. If fuel rail pressure drops at high RPMs when horsepower, and thus fuel demand, are at their highest, the maximum capacity of the low pressure pump has been exceeded. In order to take full advantage of the Nostrum HPFP you need to upgrade your in-tank fuel pump to at least a 300 LPH unit.

Nostrum does not currently offer an in-tank pump upgrade, however some customers currently utilize the Deatschwerks DW300C kit: This kit will supply sufficient fuel flow, however it can be prone to fuel pressure drop caused by the O-rings not sealing properly or O-ring complications after installation. The kit includes three O rings with the instruction to either cut the spacer off the stock fuel pump or stack all three O rings to create a spacer: *We recommend using the spacer, since O-Rings are not meant to be stacked and that configuration is known to cause leaks.*

We have also noted that the provided O-rings do not appear to be ethanol compatible and they can degrade over time. Nostrum always recommends monitoring low side fuel pressure, before the HPFP inlet, on any upgraded system in order to verify that the in-tank pump is maintaining adequate fuel pressure to the HPFP.
This recommendation is particularly important for this specific pump upgrade.
If you are unsure how or what to use for this, please feel free to ask and we can recommend parts.

TUNING OF THE HIGH PERFORMANCE FUEL PUMP

As mentioned previously, the Nostrum HPFP does not require any tuning in order to work. **However, we have found that the maximum potential of the pump can be achieved using the following tuning parameters.**

Fuel Pressure Target

It is recommended that the fuel pressure target (fuel rail pressure is the principle input variable for the pump algorithm) not be increased much beyond stock values. The HPFP's built-in mechanical bypass will relieve any pressure above ~2600 psi. This bypass valve ensures that any fuel pressure control issue does not result in fuel pressures beyond what the fuel injectors can open at, or even pressures that could potentially fail fuel system components. Although the HPFP pressure relief valve is designed to a 180 bar target set point, the production variation of the set point (pump to pump variation) and the pressure pulsations (from the piston action), the safe fuel rail pressure target is 150 bar (2175 psi).

See the following section on "Pressure Recommendations for Subaru FA20F High Pressure Fuel Pump" for more details.

In the case that you want to explore fuel rail pressure targets beyond 150 bar, please recognize that you are pushing the pump pressure relief into its range of actual operation. We recommend treading carefully when attempting to command fuel pressures much in excess of the factory's 150 bar (2175psi) and watching for signs that you may be hitting the fuel pump bypass, such as an inability to reach target pressure or maintain stable pressure under load.

The pump will be noticeably louder when trigger the pressure relief. Furthermore, constant stress on the internal bypass can fatigue the spring ultimately causing it to open at lower pressure and further lowering the maximum pressure of the pump. In extreme cases, constant operation against the bypass could cause failure of the pump.

Start of Injection

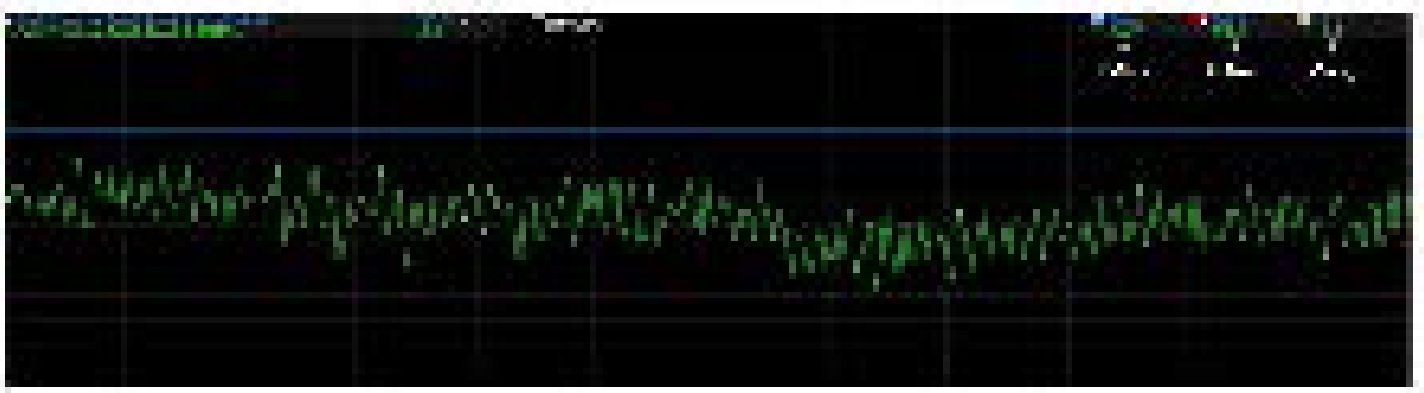
One method to increase the fuel flow capacity of the stock injectors is to start opening them sooner. The duration for which the injector is open is called the "injection duration" or "pulsewidth", and it is calculated by the ECU. If the pulse width is too long for a given engine speed, it will attempt to extend into the start of combustion. To avoid damaging the injectors the ECU will override the signal and close them early. This will cause your AFR to lean out, potentially
damaging your engine. The time at which the injectors are opened is called "start of injection", and if they're opened too early, fuel will be injected during the exhaust stroke and a lot of smoke can result.

We have found that it is possible to advance start of injection up to 70 degrees earlier than stock at high engine speeds before smoke becomes an issue. This will give you the maximum fueling from your FA20DIT injectors until an upgrade becomes available.

PRESSURE RECOMMENDATIONS FOR YOUR SUBARU FA20 NOSTRUM HIGH PERFORMANCE HIGH PRESSURE FUEL PUMP

Every single high pressure fuel pump has a pressure relief valve. The pressure relief valve is set to a specific pressure so that the pump won't go past this point and build up excessively high pressures by accident.

The Subaru FA20 pump has the pressure relief valve set at 180 bar. The general recommendation is to always run 30 bar under the pressure relief setpoint. We have demonstrated this by requesting a 200 bar (blue line – fig. 1) pressure in our high pressure pump test bench, but only getting an average of 181 bar (green line – fig. 1).



The reasoning behind this recommendation is that if you run close to the pressure relief set point, you can damage the valve because it would be constantly activated with the pressure variation. The damage to the valve will result in the pressure relief setpoint to decrease overtime.

Even if you are targeting a pressure under the pressure relief setpoint, you may be triggering the pressure relief valve intermittently because of the natural pressure variations a pump can produce (a typical pump will go ~ 17 bar over and under the target, as shown in fig. 2).

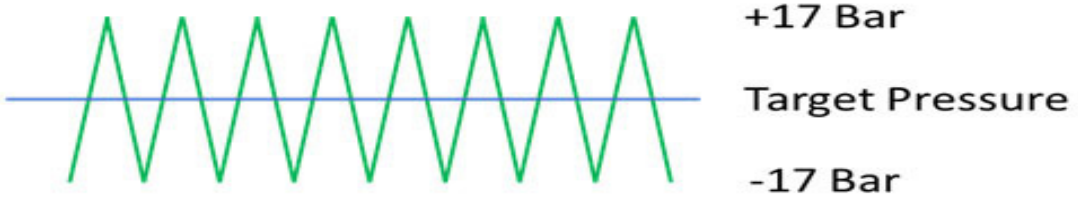


Fig 2 – Typical variation in pressure around a pressure target

Another good reason to keep your FA20 High Pressure Fuel Pump running to a maximum pressure of 150 bar is that the flowrate of the pump decreases once you pass 150 bar, as we can see in fig. 3:

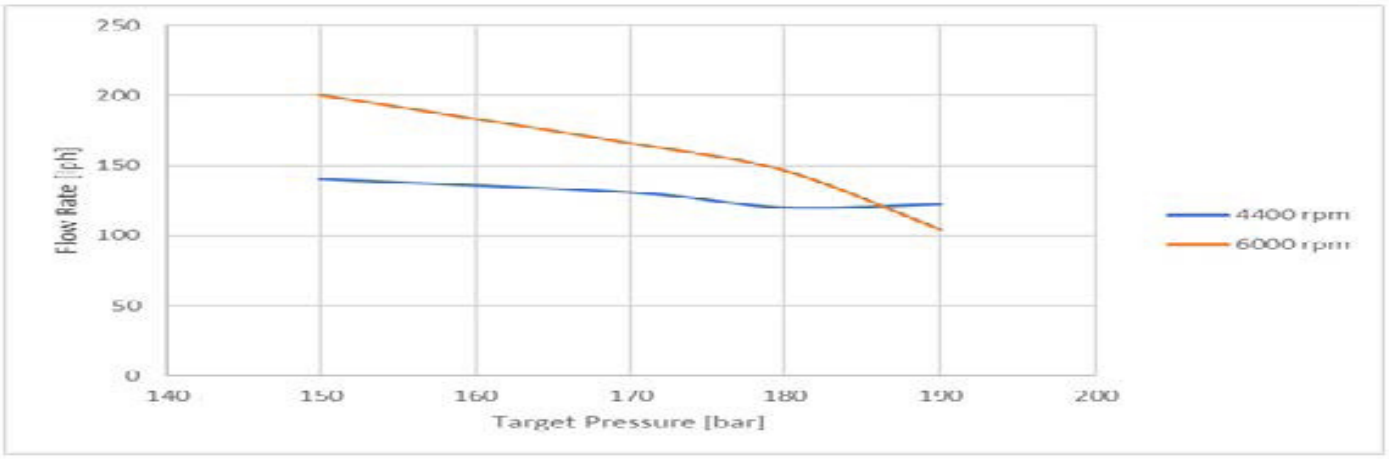


Fig 3- Target Pressure vs Flow Rate

We came to this conclusion by running several tests on our High Pressure Pump Test Bench, which consisted on setting different target pressures starting at 150 bar up to 190 bar and then registering the flow rate for all the different target pressures.

We ran the same tests for two different engine speeds (4400 rpm & 6000 rpm), and we obtained the same results – flow rate of the high pressure fuel pump decreases as pressure increases after 150 bar.