Supercharge! Chapter 6

SUPERCHARGING YOUR VOLVO CHAPTER SIX: "THE FUEL PRESSURE IS ON"

by Greg Sievert

In the last issue, I discussed the set-up of the drive belts and pulley system for the supercharger. With that complete, I was able to fire up the car and run it for the first time in supercharged mode. To do that involved fitting a switch in the centre console to engage and disengage the supercharger electromagnetic clutch (similar to the clutch on the A/C compressor). Ultimately we will devise a control system to automatically engage and disengage the supercharger, possibly a subject for a future chapter in the saga. In this issue, I'll talk about some of the issues encountered with the fuel system, and what was done to mostly overcome these issues.

Figure 1: Standard Fuel Pressure Regulator on 1988 B230F Engine

With any type of forced induction (turbo or supercharger), it's not just extra air that you need to pump into the engine. Without extra fuel, the engine would run extremely lean, and you not only would lose power, but you'd also fry your engine in a matter of minutes. The lean mixture would lead to overheating and excessive pre-ignition knocking or "pinging" that eventually would put holes in your pistons and an even bigger hole in your bank account. Knowing this, I still decided to take the car for a spin with no mods to the fuel system just to see how well the LH Jetronic fuel system could cope with extra air.

With the LH system, the computer measures all the air going into the engine via the mass airflow sensor. This device uses a heated wire and bridge circuit to determine the volume and hence mass of oxygen entering the engine at any given time. From this, the computer injects the correct amount of fuel into the engine according to maps and calculations within the computer to give the best possible running conditions. With the LH system, there is also an oxygen sensor in the exhaust stream. This allows additional fine-tuning of the fuel mixture via a feedback loop, so the computer can correct for things such as engine wear and other environmental factors.

Another important feature of the LH system is the fuel pressure regulator (see Figure 1), which receives a vacuum signal from the inlet manifold. When running at low engine load (highway cruising or deceleration, the engine vacuum is high, which reduces fuel pressure. Consequently, when the engine is under heavy load (full acceleration, etc.) the inlet manifold vacuum decreases, increasing the fuel pressure. In the 1988 240 with LH injection, base fuel pressure is in the 36 PSI range at idle. When the engine goes into boost (with turbo or supercharger), the stock fuel pressure regulator increases fuel pressure at a 1:1 ratio with boost (for example, if you have 3 PSI of boost, fuel pressure would increase by 3 PSI due to the fuel pressure regulator's feed signal from the inlet manifold).

What I found when first tuning the car in supercharged mode is that the car ran quite well under low boost conditions at low RPM. However, when the RPM and boost levels increased, the fuel mixture ran into the lean area, and pinging was observed. Not good! I filled the tank with high-octane fuel, which reduced the pinging a bit, but the fuel mixture meter that I had fitted to the engine still showed lean running conditions under boost and mid RPM. Still not good! What to do? Somehow, I needed to get extra fuel into the engine.

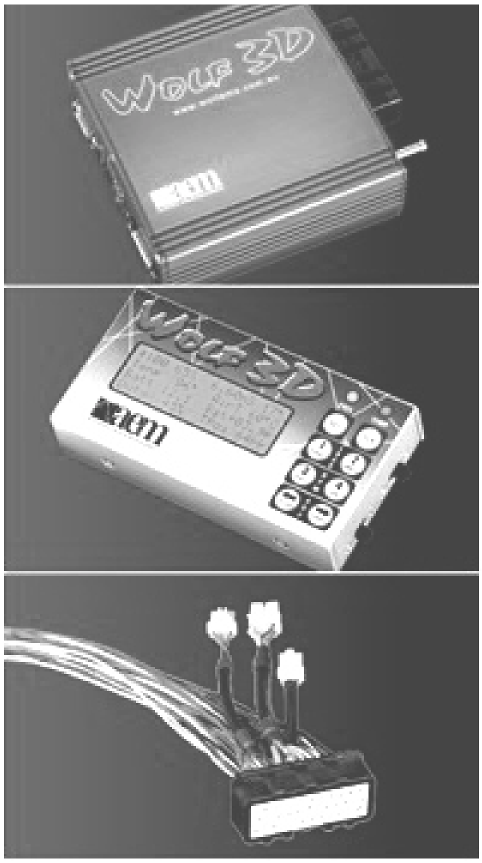

Figure 2: Aftermarket Fuel Injection Control System (Courtesy Wolf Engine Management Systems)

There are many options for increasing fuel flow to the engine. One option often taken when people boost an engine is to fit an aftermarket fuel injection control system (See Figure 2). With this option, the fuel maps can be customised to provide extra fuel under boost. This option is not cheap. Aftermarket engine management systems are over $1000, and are likely to require time on a dyno to develop the fuel/air maps for proper running under all load conditions. You're never going to be able to do as good a job as the Volvo engineers, as they probably spent millions of dollars and thousands of hours perfecting the engine control system to ensure smooth, reliable running and starting under all conditions.

A second option is larger injectors. Unfortunately, this results in extra fuel being injected into the engine all the time, which means the stock computer might have trouble adjusting. This would result in a rich running condition most of the time, wasting fuel and polluting the environment. This option is often used in conjunction with an aftermarket computer system to give the best results.

A third option, and the one I chose for the Volvo project, is to use a rising-rate fuel pressure regulator. This nifty device basically fools the computer (as it is totally independent of the computer system). What it does is increase the fuel pressure when boost pressure is increased. Remember how I mentioned the stock fuel pressure regulator did the same thing, at a 1:1 ratio? Well, with a rising-rate regulator, ratios as high as 10:1 can be achieved! For example, the base fuel pressure may be 36 PSI. If you have a 10:1 rising-rate regulator, the fuel pressure will rise by 10 PSI for every 1 PSI of boost (hence at 3 PSI boost you'd have about 66 PSI of fuel pressure). The computer just keeps opening and closing the injectors at the rate it thinks is adequate, and when you get into boost, the higher fuel pressure results in more fuel being injected for every opening of the injector. Magic! Well, not quite - it's just the basics of Mechanical Engineering.

Figure 3: Vortech Super Fuel Management Unit

I looked around at various fuel pressure regulators, and in the end bought a used one from fellow member Ross Gilmore, who didn't need it for his V8 project car. This regulator is a Vortech SFMU (Super Fuel Management Unit) (See Figure 3) that has many adjustment features on it. There are various springs and disks that can be used to tune the rate of pressure increase, and the base pressure is adjustable as well (See Figure 4 for example of rising rate fuel pressure curves). The unit is placed in the return fuel line downstream of the stock regulator. The function of both the stock and new regulators is that they provide a controlled blockage of the fuel returning to the tank, resulting in pressure in the line at the injectors. I have the Vortech SFMU temporarily mounted in the engine bay as I have yet to decide how to permanently mount it (see Figure 5). I'll probably eventually make up a bracket to hold it either to the firewall or the front shock tower.

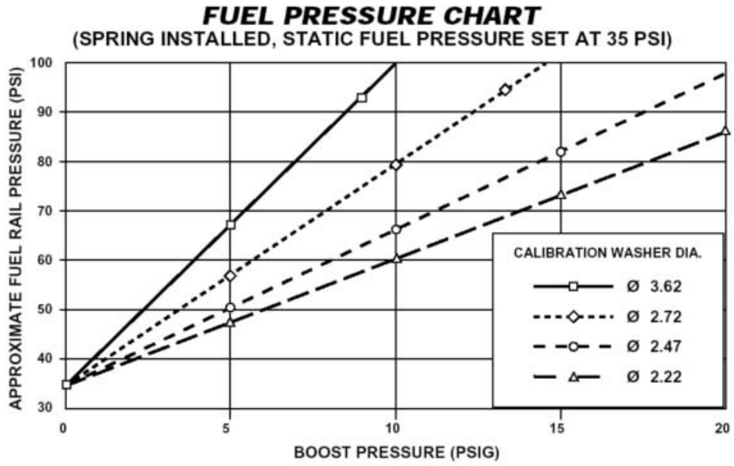

Figure 4: Vortech Fuel Pressure Curves (Courtesy Vortech)

I fitted the Vortech regulator to the Volvo with the heaviest spring in the kit, and tested the fuel pressure using my hand-held vacuum/boost pump. What I found was that it was very difficult to achieve a 10:1 rising rate, as advertised by the specs of the Vortech unit. This could be attributable to several things. I narrowed it down to either insufficient fuel flow or an inadequate spring in the regulator. The first item would require a higher-output fuel pump, and the second was fixed by fitting the ultra-heavy spring from Vortech (special order from the USA).

Even before fitting the heavy spring and higher-flow pump, I saw a big improvement with the driveability of the car. Although there was a slight delay where the car ran lean under boost, the regulator kicked in and provided extra fuel and mid-RPM under boost. I still had a lean-running condition at high RPM under boost. So, I fitted a higher-flow fuel pump (from a 760 with B28E). This made a big difference, and in conjunction with the heavy spring in the Vortech unit, I am now able to achieve the correct fuel mixture at all but the highest RPM under the highest boost conditions. Ideally, you would want to run slightly rich under boost, but the computer automatically runs the car at stoichiometric conditions. This is true even for the 740 turbos with LH Jetronic, so I see no real problems with it. The main differences with my setup are that I am running much lower boost (less than 5 PSI) and a much higher compression ration (9.5:1 vs. about 8:1 in the B230FT). The result is a quicker launch off the line, but it runs out of power at the higher RPM's compared to the 740 turbo. I find it a lot better around town than the 740 turbo, but a bit lacking in all-out passing power on the freeway. Don't get me wrong - it's a huge difference between having the supercharger on and with it off, but it's nothing like the kick-in-the-pants of a turbo.

Future steps towards ensuring a correct mixture even at high RPM under boost will be to add an extra injector that is automatically controlled to kick in when the boost level and RPM hit specified values. I already have a few injectors to play around with, and we're in the process of developing a small computer control system to engage and disengage the supercharger by monitoring engine RPM, manifold vacuum & boost, and throttle position. More on this in future instalments.

Until next time, happy motoring! Any questions or comments, feel free to Email me at gsievert@tpg.com.au

Regards,

Greg

Figure 5: SFMU in 240 Engine Bay