BOOST-A-PUMP THEORY EXPLAINED

There seems to be quite a bit of confusion among tuners and customers regarding fuel requirements for the 2003 Cobra and 2000 up Mustang GT utilizing "returnless" fuel systems when using the Kenne Bell supercharger. We'd like to take a moment to clear up some of this confusion. Since we get a lot of problem call backs specifically from customers who have chosen not to use our chip and/or Boost-A-Pumps with their kits, we feel it necessary to explain more in detail why you should use our complete kits; as we sell them, and use us as the Number One Source of information regarding our kits. Just because someone says they have chip tuning software does not make them an expert at tuning our supercharger kits.

There are a number of reasons why Ford chose to go to returnless fuel systems. One reason of course is cost, another deals with evaporative emissions, loss of octane and quality of fuel, and reducing temperature of the fuel (to help prevent boiling). There are others, but the main focus of this discussion is to assist in pointing out how to increase fuel requirements for elevated horsepower levels when using the Kenne Bell supercharger.

What is not so well understood by many tuners and customers is HOW to deliver the added fuel required. Kenne Bell has performed countless hours developing kits on vehicles using returnless fuel systems (both mechanical and feedback loop) at our dyno facility, on the street and at the track. We use high speed dataloggers and the same air/fuel monitoring equipment the OEMs use to collect reams of data on fuel pressures, flows, mass air flows, pump voltages and duty cycles, and air/fuel ratios to study their relationship with fuel delivery. We know what works. We've done the homework and collected the data.

We possess the in-house ability to fully tune all EECs to make them do what we want when we want.

HOW THE COBRA AND MUSTANG GT RETURNLESS FUEL SYSTEMS WORK

The fuel system is basically made up of the following:

1) Single Fuel Pump (Mustang GT), Dual Fuel Pumps (Cobra)

2) Fuel Pressure Feedback Sensor (both GT and Cobra)

3) EEC Feedback Loop Control

One main principle in delivering the correct amount of fuel relies on feedback from the Fuel Pressure Sensor mounted on the fuel rail. The EEC must monitor fuel pressure constantly and adjust the fuel pump duty cycle in relationship to manifold pressure (more on this later) to deliver the correct amount of fuel. Old return type fuel systems incorporated a mechanical fuel pressure regulator. The old style regulator has been replaced by software in the EEC, fuel pump driver module and fuel pressure sensor. Collectively, they now function as the "regulator".

The important thing often overlooked is that the nozzle outlet pressure of the injector MUST REMAIN CONSTANT against the forces of increasing/decreasing pressure in the manifold. Imagine a door you are trying to keep shut against the wind, but this door has no latch, so it's up to you to keep enough pressure applied to keep it shut as the wind against it increases or decreases. In order to keep the door in the same position, you would have to apply equal force on your side against the wind speed (force) trying to open it.

Now, what if you wanted to allow some air through the door, but you never wanted it to rush in faster or slower. The principle would still be the same as above with one exception: you would have to apply slightly more opposing force to the door at all times to keep the rush of air constant coming in as the wind changed.

Now, an example of what goes on in your manifold: Let's use an easy one. Suppose you have 10 psi boost inside your manifold. The injector (Ford) is rated at 39 psi operating pressure. What fuel pressure do you need to overcome the boost pressure in the manifold?

fuel rail pressure - manifold pressure = nozzle outlet pressure (or delta pressure).

In order to keep the delta (Ford's rated operating pressure) constant (39 psi), the fuel pressure in the rail would HAVE TO BE 49 psi at 10 psi boost, because 49 - 10 = 39.

Now, a not so easy one. If the idle pressure was 30 to 32 psi (typical on most Ford systems), how could you get 39 psi at the nozzle outlet in the manifold? Since the manifold now has vacuum and not boost, how can you produce 39 psi at the nozzle with only 30 psi in the rail?

You can do it because remember the most important thing: it's all about nozzle outlet pressure (delta). Because we read vacuum in inches, it's confusing (who's idea was that anyway?). Write this down: Every 1 psi of atmospheric pressure = 2.036 inches of mercury (Hg). So, if you are sitting there idling at 18 inches (Hg), how many psi would that be?

Inches of Hg / 2.036 = psi or 18 inches Hg / 2.036 = -8.84 psi (ahh, only this is NEGATIVE boost)

In order to keep the delta (Ford's rated operating pressure) constant (39 psi), the fuel pressure in the rail would HAVE TO BE 30 psi at 18 inches vacuum, because 30.12 - -8.84 = 39

(Note, gauges vary a little - if you see ~15 to 16 inches at idle, then you should see ~ 31 to 32 psi in the rail).

Now you know what your fuel pressure should be at all times under all conditions: vacuum or boost! If you have 15 psi boost, then you better have 54 psi in the rail, right? What if the vacuum was 10 inches? Then you better have 34 psi in the rail (10 / 2.036 = -4.91, or 34.09 - -4.91 = 39).

Another way to look at it is vaccum or boost + 39 = desired fuel rail pressure (-4.91 psi + 39 psi = 34.09 psi).

This is where the EEC plays the important role: How does it determine what the fuel pressure in the rail needs to be at all times? The EEC could monitor manifold air pressure (MAP) and adjust the fuel pressure up this way, right? Not without a fuel pressure sensor also. That would cost more to have both. So, Ford does it this way: they already know what the fixed (delta) nozzle pressure must be at all times, right? 39 psi. How could you monitor manifold pressure (MAP) and fuel pressure at the same time with only one sensor? Many people believe the EEC "infers" what MAP is via TPS and mass air flow - NOT! Some people say the fuel pressure sensor also is a MAP sensor - NOT!

The fuel delivery strategy needs only to monitor and adjust fuel pressure as long as a reference to vacuum / boost is applied to the fuel pressure sensor diaphragm! This is how it is done. Remember the door? If the manifold pressure is opposing the pressure from the fuel rail, and the EEC knows to add 39 psi at all time to the feedback pressure, could it be done? YES!

How does the EEC actually control the pressure? By Pulse Width Modulating (PWM) the fuel pump, very similar to how an injector is pulse width modulated. The principle again is fairly simple: build a pump that you know can overcome the maximum fuel delivery requirements of the engine at the maximum pressure and flow rate, then slow the pump down to keep the pressure where you want it during all other conditions. *Note: Have you noticed how "slowing down" and "speeding up" pumps has become standard practice on modern fuel systems - just like Kenne Bell, The Innovators has been doing with our Boost-A-Pump. Don't be afraid of this new technology - we've been doing it for over six years.*

There's no real magic here: the EEC switches the voltage to ground more rapidly or slowly (duty cycle) dependent upon demand (pressure feedback from the rail sensor). Now for the kicker: Re-read the above paragraph: "...build a pump that you know can overcome the maximum fuel delivery requirements of the engine at the maximum pressure and flow rate..." Hmm... we added 50%+ more power and guess what? The pump isn't going to make it even at the fastest duty cycle. We'd like to show what happens to the pump PRESSURE and VOLTAGE once you've reached 100% duty cycle and the EEC wants to deliver more fuel, but it CAN'T (see FIG 1).

The interesting thing here is many tuners think they can "play with" the pressure or raise the duty cycle. NOPE. Once you're at 100% folks, that's it. You only have two choices: 1) increase the existing pump's output (flow) at the same given pressure or 2) install a bigger pump. BTW: merely increasing a pump's pressure DOES NOT , WILL NOT, CANNOT INCREASE ITS OUTPUT IN FLOW.

Another humorous one is "We'll just put some bigger injectors in. That'll fix 'er". NOPE. The pump is DONE, FINITO, KAPUT. Installing bigger injectors doth not maketh thy pump bigger.

Now, if you are Kenne Bell, you have the best of all worlds. We can install the Boost-A-Pump and allow the pump to operate much more efficiently, output more flow at the same pressure as before (up to 50%) AND then install bigger injectors, AND control the pump duty cycle with our chip!

<u>Without the Boost-A-Pump, bigger injectors and increasing the pump duty cycle is not an option provided the pump was already at 100% duty cycle at WOT</u>.

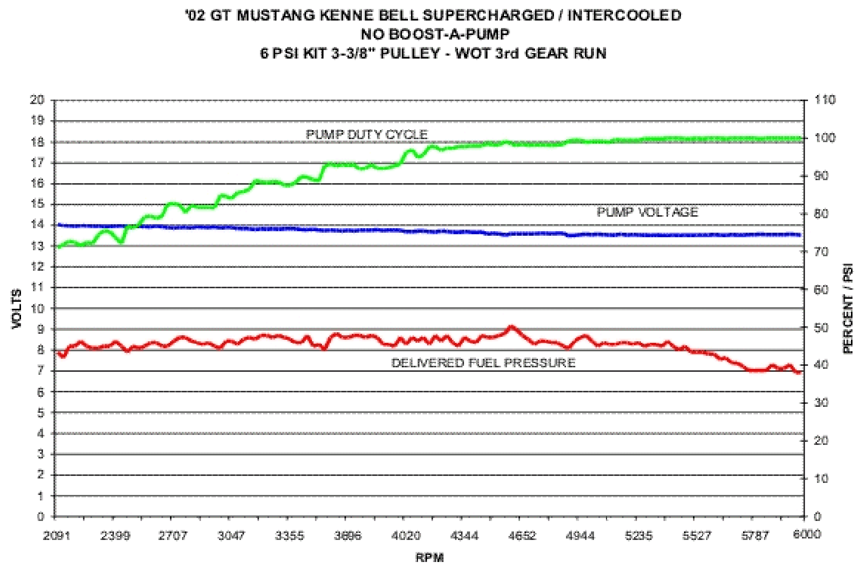

FIG 1.

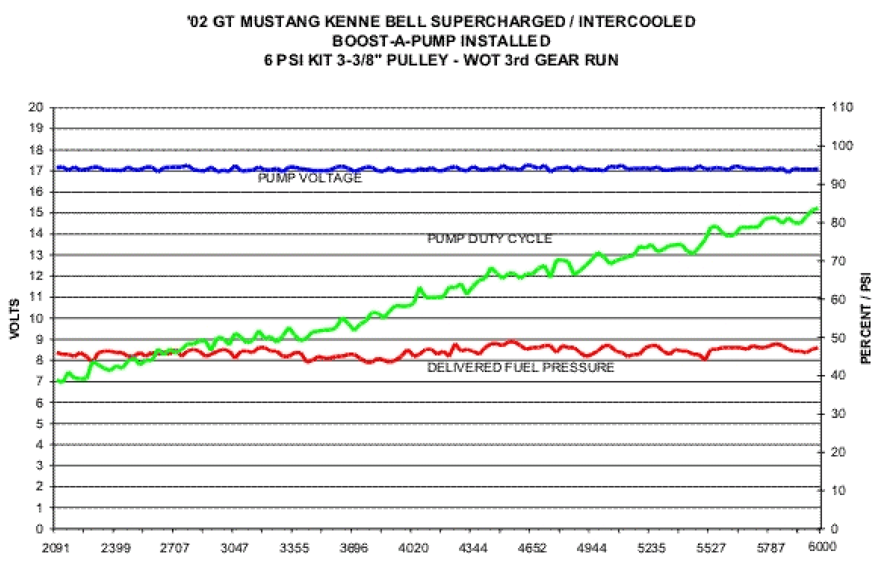

FIG 2.

In conjunction with our chips, we developed the Boost-A-Pump to safely increase the work of the stock pump to deliver up to 50% more fuel. Note how the pressure begins to drop off at higher RPM in FIG 1. as well as voltage delivery to the pump (these are directly related to flow). Look at FIG 2. to see the effect of fuel delivery with the Boost-A-Pump. Note how 100% Duty Cycle is never reached. Beautiful! ***The pump <u>works much less</u> and <u>outputs much more</u> fuel.***

BOOST-A-PUMP FACTS - It's All About Pain, Time and Money.

MYTH: "THE BOOST-A-PUMP ISN'T RELIABLE"

FACT: We have thousands of these units in the field working flawlessly, without a single failure that was not due to an installation error. They have been implemented in virtually all of our kits and have been in use daily traveling hundreds of thousands of miles since 1996.

MYTH: "WE CAN JUST INSTALL BIGGER PUMP(S)"

FACT: Shops make money by installing extras. They do not make money when installing the Boost-A-Pump because it's included in the kit installation price. That's a lot of extra time *(and your money)* to install bigger pumps in the tank when it's not necessary.

MYTH: "WE CAN TUNE IT - DON'T USE THEIR CHIP"

FACT: Shops make money by "tuning". Some do not realize they can't make it work without the Boost-A-Pump and our chip together.

MYTH: "THAT EXTRA VOLTAGE WILL HURT YOUR PUMP"

FACT: The installation of our Boost-A-Pump will actually increase pump life by reducing its workload. BTW: the Boost-A-Pump only increases the voltage when required under boost conditions. It is a passive system otherwise.

We want to make sure everyone understands: you can install bigger pumps and get basically the same result, but why? It's absolutely unnecessary and it's painful, time consuming and will cost more. Also, our intention is not to "knock" people who are out there trying to make a living at installing aftermarket products or providing tuning services. This message is a service directly to our customers to aid them in making the right decisions which way to go when installing Kenne Bell Superchargers.

Thanks.

Kenne Bell