Hey there Vegistroke Faithful! Been kind of boring around here lately, and I know I have not helped that much since I have not been on here. Well the economy is flat, business is flat, and hasn't been much excitement, other than James breaking his collar bone. That guy will do anything to get out of work. :pointlaugh: I am not much of a conversationalist, can only really talk about techy geeky car stuff, so here is some techy geeky car stuff, er Truck stuff covering questions MANY MANY of you have asked me over the phone. Basically What is a "Powerstroke" and what is the best year to convert.

***Brief History*** So without going into too many boring details, but confusing all the same, "Powerstroke" is the Ford name for the engine developed by International, using State of the Art (for 1993) Caterpillar design Diesel Injection Technology known as HEUI, or **H**ydraulically actuated **E**lectronically controlled **U**nit **I**njector. This basic HEUI architecture was available in Ford F-250 through F-750 series trucks, and E series Vans from 1994 through 2007. In 2008 Ford again Jumped ahead of the competition in technology by going to Common Rail Injection (not new) using Piezo crystal injectors developed by Bosch. The use of the Piezo injector was the first by a Domestic automaker in any application, and had been previously used ONLY on high end European diesels. More on that later.

***HEUI*** Hydraulically actuated, Electronically controlled, Unit Injector. So what exactly does that mean? It means that from 1995 through 2007 ALL Ford light and medium duty diesel trucks did not have an injection pump. None, nada, zip. This is in fact one of the HUGE factors in favor of using a Powerstroke for biofuels. **It is impossible to cause a catastrophic failure by breaking the injection pump because it does not exist.** Each Injector is in fact its own Injection Pump. Although the design changed a bit between the 7.3 and the 6.0, the basic concept is the same. Each unit injector basically has two sections- One for fuel, and one for high Pressure engine Oil. Unless there is a mechanical failure the two fluids should never contact each other. The fuel provided by a low pressure fuel pump(~55psi), and the Engine Oil is delivered by a High Pressure Oil Pump(HPOP). The HPOP uses low pressure crankcase engine oil and pressurizes it to between 500 and 3000psi based on the duty cycle of the IPR(injection pressure regulator) that is controlled by the PCM(Powertrain Control Module). The delivery path to the engine for the fuel varies based on year with 3 primary designs we will discuss in later segments. But once the fuel reaches the engine itself, the rest is all the same. The engine is a V-block design with two cylinder heads and 8 cylinders. On the Left(Drivers) side you have cylinders 2,4,6,8 from front to back, and the right(passenger) side is numbered 1,3,5,7 front to back. In each head there are 4 large round holes that feed all the way down to the combustion chamber in almost a reverse cone shape. Those are the injector cups where the injectors are positioned in the head with the tip actually protruding into the top of the combustion chamber. Also in each head are two passageways that run the length of the head. And here is reason #1 why these engine make such excellent conversion candidates. The fuel rail is inside the head, and the fuel system is a deadhead design, meaning there is no return from the engine. That means the fuel moves relatively slowly through the head until it reaches the injector. During that time the oil is picking up heat directly from the motor. Some may argue this point but I have tested it over and over again. **So long as the engine is up to operating temperature it is IMPOSSIBLE to get cold oil to the injector**. Of the two passages in the head- One is for fuel, and the other is for high pressure oil. Reason #2 that the Powerstroke makes a great conversion candidate . Precise fuel pressure is rather unimportant. Again, yes I said **Precise fuel pressure in NOT important.** The fuel pressure only needs to

be enough to promote proper filling of the injector fuel cavity. Regardless of year, anything south of 50 psi and you may not get complete injector filling under load, anything north of 100 psi and you run the risk of interfering with correct injector operation. That leaves us with a nice liberal 50psi window for fuel pressure that will have no effect whatsoever on performance, power, emissions, mileage or anything else. This is **PART 3** of why Powerstrokes make such great conversion candidates. Fuel pressure requirements are very non-specific, More than enough, and less than too much. Where the magic happens is with the High pressure oil. Both the 6.0 and the 7.3 have a 7:1 intensifier piston that multiplies the pressure of the high pressure oil by 7 and transfers it to the low pressure fuel to create a maximum injection pressure of 21,000 psi for the 7.3 and 26,000 psi for the 6.0! That is a max of 3,000psi of HPO for the 7.3 and 3,770 for the 6.0. So to recap, high pressure engine oil pushes on a piston that then pressurizes and injects the fuel into the cylinder. So the viscosity of the fuel does not change the injection pressure at all in this type of system. It could be solid Crisco in the injector and it will still be delivered to the cylinder. However the ability of the injector to refill after that initial injection is a whole other story. Now that you know the basics of HEUI injection, we can cover the three basic generations of Powerstroke.

**1994.5-1997** In 1994 you could get 3 different diesel options for your Ford. There was a 7.3 Non turbo Indirect injected (IDI), a Turbo IDI, and the coveted 7.3 Powerstroke Direct Injected Turbo Diesel. As previously mentioned in 1993 Caterpillar developed the HEUI injection system, and International, under license from Caterpillar created the Powerstroke engine for Ford. The International version was known as the T444E. International used their old 7.3 IDI engine as the starting point for the new DI 7.3, and carried over some of the same features such as the Water to oil heat exchanger mounted on the drivers side. This advanced engine at the time quickly became backbone of the Light and medium duty diesel market powering not only Ford Trucks and Vans, but Ambulances, Service vehicles, Busses, Box trucks, and Millions upon millions of vehicles.

FUEL DELIVERY The challenge In converting these years of Powerstroke is in the fuel delivery system. They use a two stage mechanical lift pump mounted in the engine valley between the heads. Fuel is fed directly from the tank to the low pressure side of the pump, then into the Fuel bowl where it passes through the filter, and back to the high pressure side of the pump, out the back and to the rear fuel ports on the engine. The return is fed out the front fuel ports, through the regulator attached to the side of the fuel bowl, and back to the tank. From a performance standpoint this is a great setup as it is a true regulated return. But from a conversion standpoint it creates several issues, Such as cross contamination, long purge times, lift pump reliability and the fact the the regulator recirculates a small amount of return fuel back into the fuel bowl. DFA solves those issues by simply eliminating the mechanical lift pump in favor of an electric one and updating the fuel system to mimic that of the 1999 and newer Powerstrokes, Or basically a deadhead design. It is a bit more work and cost, but reliability goes up, purge time goes WAY down, and cross contamination is eliminated. And we still use the OEM fuel filter for the diesel.

**1998**. This is a bit confusing for the uninformed. Officially there is no 1998 model year for the Heavy Duty Ford F-250-F-550 Series Pickup. This was the year that ford went to two different platforms for its

trucks- The light duty F-150 and the New Super Duty series of heavy duty work truck available as the F-250 up to F-550. Diesels were not available in the light duty F-150. Where this conversation is about diesel, we will only focus on the Super Duty platform. So if there was no 1998 MY, what was available in 1998? You had a few options. You could buy a 1997 OBS truck(Old Body Style) or the All New Early 1999 MY(Model Year) Super Duty. There were however 1998 MY E-series vans with the Powerstroke diesel. The 1998 E-series had the same updated Powerstroke engine that the 1999-2003 Super Duty would get with the electric lift pump.

**1999-2003**. These are among the Best, most reliable and heavy duty pickup trucks ever made. Ever. The Crew cab can fit a family of 6 easily. Even if they are 6'6" tall! The cabin space is simply perfect. The drive train is nearly bullet proof save for the transmission. And the 7.3? Well it really became something special during these years. The 7.3 has proven to be exceptionally reliable, and nearly indestructible, so long as you are not trying to make 500hp with them. The truck was released in 1998 as a 1999 model, but there are really two generations of 1999. There is the Early 99, made prior to 12/98, and then the late 99. The differences are subtle, but many. On the engine the Turbo is smaller, the intake is smaller, the turbo pedestal is different, The HPOP is different, Suspension is different, and some of the interior options are different. The trucks are most easily identified by the location of the powerstroke badge. The early 99's have the "V8 Powerstroke" badge on the Front fender, and the late 99-03 7.3 have the Powerstroke badge on the door. Generally speaking the late 99 trucks are more desirable to have, and the conversion process is slightly easier. In 2002 The Super Duty got clear headlights, a significant change in wiring and Gages, and finally ALL super Duty's (except the Excursion) got a real Dana 60 Front differential instead of the half breed Dana 50. The engine remains unchanged.

**Fuel Delivery**. Beginning in 1998 with the E-series Van and in 1999 with the Super Duty trucks, Ford went with an electric lift pump and a deadhead fuel design. The path of fuel flow is from the tank, through the electric lift pump on the frame under the drivers seat, to the Fuel bowl in the engine valley, through a simple poppet regulator, and back to the tank. This causes the fuel bowl to pressurize, forcing fuel through the filter, and out the two fuel lines on the passenger side of the fuel bowl to the OEM fuel feed ports on the engine. One feeds to the Passenger side rear(cylinder 7), the other to the Drivers side front(cylinder 2). The opposite ends of the fuel ports that was used on the earlier years has been plugged off. That means that fuel is only fed to the engine, but never returns from the engine. Tidbit- Factory spec for the fuel pressure is 54psi plus or minus 3. Typically I see anywhere from 60-70 psi on most trucks. But remember from earlier, anything north of 50 and south of 100 is adequate. This fuel system design while simple, had it's drawbacks as well. Mainly in that the firing order is 1,2,7,3,4,5,6,8. If you remember from earlier, the cylinder arrangement on the drivers side is 2,4,6,8, and fuel is fed into the rail by #2. That puts #8 at the "dead" end of the fuel rail. It is getting what fuel is left over from the other cylinders. Then to further complicate matters is that #6 fires immediately before #8. So #6 is further robbing #8 for fuel. This leads to a constant state of fuel starvation for #8. There are a few ways to combat this problem. Ford, devised the so called "Long Lead" injector. This was a futile attempt at incorrectly solving the problem by modifying an injector with a longer filling time. It didn't work. The aftermarket had some much more effective ways of dealing with this by either shimming the pressure regulator to increase fuel pressure therefore helping to overcome

restrictions to flow and allowing more fuel to #8, or the more expensive but better option which was the regulated return. Fuel was fed all the way through the head, and pressure was regulated after the injectors, not before. This ensured a much more stable fuel pressure for ALL injectors and eliminated any starvation issues. This resulted in a much quieter engine, smoother idle, and some gain power, maybe as much as 15hp on an otherwise stock truck. One other issue that was well known was that the Ford fuel system was known for getting air into the fuel either from the fuel line seals between the pump and tank, or from the fuel pickup in the tank itself. This air would get trapped in the heads with nowhere to go but through the injectors. Fortunately the injectors on the 7.3 were very robust, and the fuel starvation or the air did not have any real detrimental effect on the life of the engine or injectors. There are plenty of bone stock 7.3's with 500,000 miles or more on them. One other item of note that is really only for the horsepower junkies is that in 2001 Ford started using PMR process connecting rods instead of the Forged rods it had been using since 1994. Ideally the PMR rods have a higher tensile strength and greater hardness then the Forged rods, but they were also much more brittle, and when used with an unreinforced crankcase were more prone to breakage than the much more forgiving Forged rods. Rule of thumb is no more than 400hp with PMR's, and up to 500hp with the Forged.

**The End**. 2003 would mark the last year that you could buy a Ford truck with the coveted 7.3 Powerstroke ending a highly successful 10 year run that helped make the Ford Super Duty the undisputed champion of Reliable Hard working trucks. Federal emissions regulations, and increasing HP/TQ demands in the marketplace dictated the need for a newer, smaller, more efficient, more powerful, and more emissions friendly engine. And in 2003, the all new high tech 6.0 Powerstroke was released, becoming one of the biggest black eyes Ford Trucks have ever known.

**6.0 Powerstroke**. This engine was the future of Diesels. High tech and High Power. The all new 6.0 had Four Valves per cylinder, A variable Vane turbo that could provide maximum boost off idle, smaller more efficient HEUI injectors operating at up to 26,000 psi, Pilot Injection that made the motor super quiet for a diesel. The block was a two piece design now with the crank being held in place by the two halves of the block ensuring a super strong bottom end. And finally the old 4R100, formerly the E4OD that has been around since the 80's gets replaced with a modern 5 speed automatic made for diesel use, called the 5R110. The 5R110 was better in every way than the outgoing 4R100. These Transmissions had very few issues, if any. The same could not be said for the motor.

Pick your poison. International who designed the 6.0 had already been using them in their fleet very successfully. However the consumer light truck market was different than the commercial truck market. Ford didn't dare release a new engine that couldn't match or better the competitors HP and TQ numbers. And of course it had to be quieter as well. This required a higher RPM, a different turbo, and modified injectors from the original International design the meet the requirements. The engine had already been through substantial testing and validating, so changing a few items shouldn't cause much problem. Ford and International couldn't have been more **WRONG!** Injectors started failing on the showroom floor causing hydro-locking, cylinder washing and often complete engine failure . Something to do with the pilot injection to make the engine quieter. Then the head gaskets

started leaking. The Main Seals leaked very quickly. Then the actuator for the variable vane turbo started getting stuck from soot. Next the EGR coolers started leaking or failing altogether, besides the EGR valve becoming stuck. High pressure oil pumps had a high rate of failure. And the list went on. Before the end of the year Ford had more TSB's (Technical Service Bulletins) for repairs and problems then Chevy and Dodge Combined. Not all motors failed. Some never had a problem, and the ones that ran, ran extremely well. But probably on the order of 1 in 10 had major repairs that needed to be performed. Approximately 3 in 10 had minor issues that had to be addressed. Probably the most problem prone motor to be released since the Chevy 350 diesel. Quickly Ford started reprogramming the trucks cutting back the power, eliminating pilot injection, reducing throttle response to help minimize coking of the EGR and Turbo, and some other stuff. This resulted in fewer problems, but the trucks didn't run well at all. The pulling power was gone, mileage went down, they were every bit as noisy as the 7.3, and still had rampant EGR problems. In 2005 the engine was nearly completely overhauled. The injectors were redesigned, the heads were redesigned, the Turbo had already been revised, the EGR cooler was reworked, the seals upgraded, and the programming figured out. This resulted in dramatically more reliable engines that had the power they were supposed to. And instead of 1 in 10 having problems, that number went down to closer to 1 in 1000 with major issues. And even then the major issues were typically turbos, egr's and HPOP's. The injectors were much more reliable, but still sensitive to low fuel pressure. So injectors were only an issue if proper maintenance and filter changes were not adhered to, or if someone got a bad batch of diesel. EGR valves still would stick somewhat regularly, but the after market had by then come up with a bypass, or simply turned the EGR off electronically. This not only prevented EGR issues, but actually improved fuel mileage slightly. The EGR was strictly for emissions and was not required for the engine to run correctly.

To get back on track, the injectors were one of the critical components for converting the 6.0. Many people and companies attempted to convert the 6.0 to run on oil, and failed. There were a few reasons for this. First the OEM fuel system has two filters- One on the Frame at the fuel pump also known as FCM, or Fuel conditioning module. This housed the primary fuel filter, fuel pump, thermal fuel recirculation valve, and water separation. From there the fuel traveled to the secondary filter bowl on the engine. This fuel bowl is similar in operation to that of the 7.3. There is a simple poppet valve regulator that pressurizes the fuel bowl to about 54psi forcing the fuel through the filter through two fuel lines and to the injector fuel rails. Except in this case the fuel is fed through the front of the engine using 12mm Banjo Fittings. There are fittings at the opposite ends of the fuel rails, but like the 7.3 they are plugged. This is still a deadhead fuel system, and again like the 7.3, on the drivers side the fuel is fed through the front, and deadheaded at the back, at #8 injector. The fuel starvation issue isn't as bad since the fuel rails have a larger volume that better deal with the deadhead design. At least until you get into the higher horsepower applications. When trying to feed oil through the OEM fuel system filter plugging was a major problem. It is nearly impossible to keep enough heat in the oil for the oil to make it past both filters without waxing and eventual plugging. Then of course once the filters plug, switching back to diesel does no good. It is too late at that point. The engine loses fuel pressure, you are stuck, and there is a very likely chance your injectors are ruined from the low fuel pressure. There is only one way to successfully convert the 6.0 to run on 100%

SVO with no problems. And that is a completely separate pressure based fuel system designed to handle the viscosity of the oil and ensure that the injectors never lose pressure. The DFA Vegistroke is the only system currently that operates that way. And because of that we have converted hundreds of 6.0's without issue. In fact we have some 6.0's out with over 100,000 miles on oil already!

**To recap**- The 6.0 PowerStroke can be converted to run on oil successfully without more than normal maintenance or failures if done with a quality pressure based fuel system that will ensure the injectors never lose pressure. The system does not help prevent other engine issues such as EGR coking and sticking, head gasket issues, cylinder washing from bad injectors, etc.

**The Rest Of the Truck**. The chassis has not had a major overhaul since its introduction in 1999, however almost nothing remains unchanged. Even the frame itself is considerably different. However the exterior dimensions remain unchanged from 1999-2009. Why mess with perfection? In 2005 besides some pretty serious interior changes the Truck got a facelift with a new grill, bumper, and integrated crystal headlights/turn lamps. This look is in my opinion one of the best looking trucks Ford ever made. And the good news for those with older trucks is that these parts are a direct bolt on that can be done in a matter of a few hours. 2005 was the first year that the heavy duty trucks would get a coil spring front suspension that helped ride considerably and turning radius.

6.4 A new Era of Uncertainty. For 2008 model year Ford released the latest and LAST International designed motor- The twin turbo 6.4l common rail, piezo injector high tech motor. Even though the basic construction itself is the same as the 6.0, Everything that was an issue with 6.0 was addressed. First the fuel system. This would mark the first time that HEUI injection would not be used for the Powerstroke. The fuel system is now a common rail injection system using a first in the industry Piezo injector. These crystal based injectors have such a quick reaction time that they can be fired 5 times per combustion stroke!! The injection system is nothing short of sensational and completely different from the Cummins or Isuzu(Duramax) systems which both rely on CPS injection pumps and very similar style injectors. Other issues addressed besides the injection was the reputation for weak headgaskets. The heads were revised and headbolts were upsized from 14mm to 16mm and no longer hold the rocker arm fulcrum. The EGR cooler was significantly revised and more than doubled in size for cooler exhaust temps into the intake and less EGR failures. Due to the dual turbos AND variable vane the torque curve is incredible making over 500lb-ft from 1300 rpm to 3300 rpm. Reliability has been improved from last to on par with the others. In fact the 6.4 has had fewer issues than the new 6.7 Cummins engine. The only real issue of concern was radiators cracking on the early trucks, but that was easily fixed with a quickly installed factory coolant pressure bleed port to prevent excessive cooling system pressure. The only real downside to the new motors is the EPA mandated emissions control, AKA DPF(diesel Particulate filter). This exhaust filter traps ALL soot in the exhaust. Cool factor is that after 30,000 miles in our 08 there is not even a hint of anything black in the tailpipe. Downside is that it is a massive restriction in the exhaust system making the engine work harder to make the same power and also uses extra fuel to "regenerate" or burn all the soot in the filter thereby cleaning it. This reduces the fuel economy considerably to the point that

most average about 12-13 not towing anything. Removing the DPF and reprogramming can net a MPG increase of 7-10mpgs. And unlike the days of the E4OD and 4R100, the 5R110 “Torqueshift” transmission is about as bulletproof as any transmission Ford has ever made. Transmission problems are so infrequent that it is not worth mentioning. So it would appear that Finally Ford and International have hit a home run with this new motor, not counting the EPA mandated stuff that affects all three manufacturers. Well no. As a direct result of the 6.0 engine debacle(and other factors as well) Ford and international could never reconcile their differences and ended their long time partnership. So that means Ford is currently finishing up on inhousing their own design of Diesel engine codenamed “Scorpian”. This will be available for the 2011 model year giving the 6.4 a run time of a whopping 3 years. Even the heavily troubled 6.0 was in use for 5 model years in trucks and is still being used in Vans and other equipment. The new 6.7 promises to be a simpler fuel system and hopefully a simpler conversion. But only time will tell!