TDI FAQ - TDIClub.com

I'd like to send out a thanks for Jon Bartlett for his time and effort in creating the original FAQ. This expanded version was compiled by GoFaster, Skypup, TooSlick, Jimmy, ThinkDiesel, and Jonathan Bartlett.

This is basically a summary for the frequently asked questions from the TDI Forums on Fred's TDI page (www.tdiclub.com). No guarantee is made for the accuracy of this document, so use at your own risk. Also these are peoples opinions, so please use your own common sense and judgment when reading these statements and others found in the TDI Forums.

History:

August 29, 1998: original by Jon Bartlett

January 16, 2000: updated by GoFaster, SkyPup, TooSlick, Jimmy, ThinkDiesel, and Jonathan Bartlett

June 21, 2002: Sections 7 & 8 updated by GoFaster.

September 30, 2002: Sections 6 updated by GoFaster.

For a more printer friendly version in Adobe Acrobate version download/view TDIFAQ.pdf.

Last updated: June 21, 2002

l. Bucks and snatches slightly at low speed when cold
m. Rattles, buzzes, and resonances from the exhaust system
n. Accidentally filled tank with gasoline - now what?
o. "Shuddering", "misfiring", "stumbling" at highway cruising conditions
p. "Surging" during acceleration; fluctuation of turbo boost pressure.
q. Hesitation upon moving away from a standstill or upon sudden application of accelerator pedal
r. Miscellaneous Strange Noises and Odd Behaviour

9) Non-Volkswagen TDi

10) AMTS. pour point temperatures for winter diesel

Back to Top

TDI FAQ

1) How It Works

Back to FAQ Index

----

1) How It Works

a. **Do I really need to read this?** - A recent question was:
"*...But do I really have to fuss with additives and titrations of kerosene and fret about cloud points and wax crystals and de-gunking my intercooler? Don't get me wrong, all that jazz is absolutely engaging and fascinating to my scientific mind, but in a conceptual and theoretical way; not one I actually want to get my hands dirty over (literally and figuratively).*" -(Victoria, Jan. 2000).

The answer is yes and no. This stuff is good to know and well worth the time to learn more usable knowledge. If this really isn't what you want, Peter Cheuk had some good advice:"

"One thing to keep in mind about these forums is that we are enthusiasts. Some of us are overzealous when it comes to our cars. Some of us are anal retentive . We maintain our cars better than we do our personal relationships (my wife suggested I sleep with the car a few times). I honestly think that the car can be treated like a gasoline car in most respects with the exception of pumping diesel instead of gas. Oil changes at the factory recommended 10,000 miles with synthetic oil and changing the fuel and air filters at 20,000 miles are the only maintainance that you will need to do until you need to have the timing belt changed. If you compare this engine to the darling of VW's fleet, the 1.8T, you will see that the TDI is cheaper and simpler to maintain, not to mention the economy of operation. I've done just that. "

So read on, expand your mind. You don't have to become a "motor head", but if you hang around with us too long you might just become one. - VW Derf

b. **General** - The TDI engine is a turbocharged and intercooled diesel engine with "direct injection" - that is, the fuel injector nozzle sprays directly into the main combustion chamber, rather than into a separate prechamber as was done with previous automotive diesel engines. This is similar to the way that bigger diesel engines have worked for

many years, but with countless improvements to refine the process and make it suitable for a passenger car engine. The result is an engine which is so refined in comparison to older passenger car diesel engines, that there really is no comparison.
Back to Top

c. **Improvements over Previous Diesels** - The TDI engine, compared with previous diesels from Volkswagen and others, offers the following benefits.
Electronic control of the fuel injection system means more power, less smoke, less noise, and even better fuel consumption. Both injection timing and quantity are electronically controlled on all Volkswagen TDI engines. Previous Volkswagen diesels have used mechanical regulation of the fuel injection system. The "cold start" handle familiar to drivers of older VW diesels has been eliminated, and the function that it served is now handled automatically by the engine controller.
Developments in turbocharger technology have culminated in the Garret VNT15 variable-geometry turbocharger on the latest 4-cylinder TDI models. This design gives faster response (less "lag" - although this was minimal even on the older models), and is capable of delivering boost starting at a lower engine speed and extending to a higher engine speed with less back-pressure of the exhaust flow. Turbo lag with the VW TDI engine is on the order of 0.25 second, which is not noticeable to the driver.
Electronically controlled emission control systems, including EGR (exhaust gas recirculation), reduce emissions of nitrogen oxides (NOx). Previous VW diesels did not include this function because the mechanical controls were not capable of providing adequate control.
Higher injection pressures and developments of fuel injector design mean less noise and lower exhaust emissions. Two-stage injector nozzles are used, to give a gradual pressure rise and minimize the diesel "knocking" sound.
The open-type combustion chamber has less heat loss than the older prechamber design. As a result, there is no need for glow plug operation at coolant temperatures above 9 degrees C, so starting can be immediate. In addition, there is no need for an engine block heater, which was an essential option for anyone with an older-design diesel in a cold climate.
Updated glow plug design compared to previous models reduces the glow period to about 10 seconds even at -10 degrees C.
The open combustion chamber allows the use of a lower compression ratio (18.5:1 or 19.5:1 depending on model, compared to about 22:1 or 23:1 on older designs). This reduces noise and vibration, and increases engine durability since the maximum pressure in the combustion chamber is reduced.
Back to Top

d. **Fuel System** - The features, components, and operation of the fuel system are as follows:
The fuel tank is made of plastic to eliminate any chance of corrosion, and is located under the floor in the area below the rear seat. There is an access cover to the top of the tank, held by three screws, under the right rear seat. This provides access to the "dip-tube" and level sensor sender unit It appears removable/replaceable without having to remove the tank. In the filler neck of the tank, in the 9 o'clock position is a little black button. This is a vent relief valve that can be pushed with the fuel nozzle when "topping up" the tank to squeeze in a few extra litres. The button is normally activated when the fuel cap is screwed on.
It should be noted that the vent valve is to prevent topping up. Overfilling the tank

could cause heat expansion to push fuel up the neck and create a spill. The vent keeps an amount of air in the tank until the cap is returned. The air in the tank moves up into the neck as the fuel in the neck moves down into the tank. Any expansion could now burp air instead of fuel. Topping up using the vent valve should be done only when the car will be driven long enough to consume a few litres of fuel before stopping the engine. Don't top off with the vent pressed and then park in the sun. For accurate fuel mileage calculations always use the same technique when refueling Either always "top up" by venting the expansion chamber, or never vent and stop refilling when the dispensing nozzle shuts off. That extra half gallon or two liters of fuel squeezed into the expansion chamber will make the trip consumption appear higher if this venting technique is used intermittently.

The fuel lines take fuel to and from the tank. These are two plastic lines, divided into approximately three sections each, running under the body of the car from the tank to engine compartment. Fuel is drawn from the tank through a suction line under the car, and into the fuel filter/water separator, which is located within the engine compartment. (Unlike with gasoline engines, there is no tank-mounted electric pump, and the low volatility of diesel fuel eliminates the need for any evaporative emission control components, thus simplifying the fuel system.) The fuel line sections attach to each other with "quick connect/disconnect" joints. Joints can be undone by pressing a small slim button on the joint itself. Joints are also potential places for leaks. The delivery line is colored all black and the return line is blue, but some pieces have simply a blue stripe painted on.

In the engine compartment, both lines attach to the fuel filter. The purpose of the fuel filter is to remove suspended particles of debris and water from the fuel supply. The entire filter should be replaced periodically, according to the maintenance schedule for your vehicle.

The supply line provides raw fuel from the tank to the input nipple of the filter. Filtered fuel is drawn by the injector pump from the output nipple via the clear section "sight-tube" line, visible by lifting the hood, between the fuel filter and the engine cover. The return line from the injector pump is also attached to the top of the filter via an inline "tee-piece", held in place on the filter by a spring clip. The tee-piece is a temperature sensitive valve that opens when the fuel temperature is below about 15 C / 60 F, and closes fully when above 25 C / 80 F - the purpose of this is to supply some heat to the filter during cold conditions, to resist the tendency for cold diesel fuel to "gel".

The flow path for fuel is modified at lower temperatures. The valve in the tee-piece of the return line opens, and some of the excess (and warm) fuel flows back into the filter, instead of returning to the tank. While this valve is open, a "rattling" noise, like bb's in a salt shaker, may be heard from the fuel filter. At very low temperatures, only the net fuel consumed by the engine is drawn from the tank. This has the effect of quickly warming, and hopefully un-gelling, the supply of fuel in the filter first. As this fuel warms the valve closes, and warm fuel is sent down the return line in exchange for cold (and possibly quite sluggish) fuel from the tank. In this way fuel in the tank is gradually un-gelled and warmed up.

Fuel is then drawn through a clear plastic hose from the fuel filter and into the fuel injection pump. There are three types of fuel injection systems currently in production, depending on the model, which will be discussed below. The pump delivers fuel in sequence to the injector nozzles under high pressure (900 bar or 13,500 psi on older models, even higher on newer models), and timed so that the injection event occurs in the vicinity of the end of the compression stroke. Injection timing and quantity are both controlled accurately by the engine controls, discussed in a later section. Excess fuel which is pumped into the injection system but not delivered to the engine at that time is returned to the tank through a separate line. In cold weather, this hot return fluid passes through the fuel filter as described above.

Most VW TDI models, including all sold in North America, use an electronically controlled Bosch VP 37 distributor-type injection pump which is mounted on the front of the engine and driven by the timing belt. This delivers fuel to separate injectors at each cylinder through high-pressure steel fuel lines. This system is used on the 1.9 litre 4-cylinder engines of both 90hp and 110hp, and is also used on the 2.5 litre 5-cylinder engine as well as the 2.5 litre V6 of 150hp. The latter engines have the injection pump mounted elsewhere on the engine but they work the same way. Inside the distributor-type pump, fuel is first drawn into a vane pump which pressurizes the pump housing to a low pressure, which is below the injection pressure. A single plunger rotates together with the input shaft but is also spring-loaded against a cam, so that the plunger moves in and out of a cylinder with ports in it. When the plunger is pulled back, fuel enters the cylinder via the fuel cutoff solenoid valve which is visible on top of the pump housing with a single wire going to it. When the plunger advances (4 times per plunger revolution in the case of a 4-cylinder engine), fuel is delivered through a passage in the plunger to whichever fuel line aligns with a port in the rotating plunger, thus fuel is delivered to the appropriate cylinders in sequence. Eventually, on each stroke, the plunger advances far enough that another port in the plunger is uncovered by the cutoff sleeve and any remaining fuel behind the plunger is bypassed rather than being injected into the cylinders. This sleeve is positioned in and out along the plunger so as to vary the quantity of fuel being injected, as directed by the engine controls. Injection timing is varied by rotating the cam profile that the plunger is pressed against; this is done by a small hydraulic cylinder controlled by a solenoid valve located on the bottom of the injection pump housing. Excess fuel which is not delivered to the engine is returned to the fuel tank through a return line.

Each injector contains a spring-loaded plunger which opens when the fuel pressure reaches a certain amount. The plunger then uncovers 5 injection orifices of extremely small diameter. The preload springs operate in two stages so that the initial injection occurs at a lower pressure, followed by the main part of the fuel at a higher pressure. This results in the fuel igniting progressively, thus reducing the noise level of the engine.

One of the improvements made on the A4 engines compared to previous models involved the increased fuel injection pressure from the injection pump with optimization of the fuel injectors. Manual transmission A4 TDI's have 800 bar (11,760 PSI) pump side pressure with 1100 bar (16,170 PSI) injection nozzle pressure. Automatic transmission A4 engines have 950 bar (13,965 PSI) pump side pressure with 1350 bar (19,845 PSI) injection nozzle pressure. To achieve this increase in pump and injection nozzle output pressures in the automatic transmission engines, the single injection pump plunger on the BOSCH pump was changed from 10mm to 11mm. This was required for emission purposes allowing the automatic version to inject the required quantity in the very limited time available at higher pressure, with a resulting 20% reduction in particulate emissions.

Other VW TDI models with the 1.9 litre 4-cylinder of 115 hp or 150 hp, and the 1.2 litre and 1.4 litre 3-cylinder engines, use a so-called "pumpe-deuse" (German) or "pump-nozzle" (English translation) system. In these engines, each cylinder has its own small high-pressure fuel pump which is actuated by the same camshaft that operates the intake and exhaust valves. Fuel is delivered to each pump-nozzle by a low-pressure pump serving the same function as the internal vane pump in the distributor-type system. As the engine cylinder approaches the end of the compression stroke, the main pump plunger advances, pressurizing the fuel. A solenoid valve adjacent to each pump-nozzle is normally open and bypasses the fuel. When the solenoid valve is energized, the bypass passage is closed and the fuel is forced to an extremely high pressure and through the injection nozzle. At the end of the required injection period, the solenoid valve de-energizes and any remaining fuel pumped by the plunger bypasses the nozzle. Thus, fuel is injected as long as the solenoid is energized, allowing full control of injection timing and duration. This system has the significant advantage of eliminating the separate high-pressure fuel lines from the pump to the nozzle because it is all built into a single unit, thus giving better control of the injection cycle.

Finally, some modern diesel engines use a "common rail" injection system. The concept is much like a conventional gasoline engine EFI system but the pressure involved is on the order of 1000 times higher. A single central high-pressure pump delivers fuel to a pressurized fuel line, and separate solenoid valves on each cylinder admit fuel into each injector. Although this sounds simple, it is extremely difficult to make it work due to the extremely high pressures involved. This system is used on the 180hp version of the 2.5 litre V6, and on the 3.3 litre V8.

Back to Top

e. **Air Intake System, EGR, PCV** - Air is drawn through a conventional air filter and into the so-called MAF, or mass-air-flow meter. A hot wire (older models) or hot film (later models) is contained inside this sensor and is maintained at a constant temperature. The electrical current which is required to maintain this temperature is an indication of how much airflow is passing over the sensing element. After the MAF, a hose connection comes from the valve cover where crankcase fumes are drawn into the intake air. From there, the intake air is drawn into the compressor of the turbocharger (see below) where it is compressed, but the compression process also increases the temperature of the air. The hot compressed air passes through a small heat exchanger known as the intercooler. When heat is removed, the density of the air increases, thus increasing the amount (by mass) of air which is drawn into theengine. The objective is to make the air going into the engine cylinders as dense as possible (pressurized and cooled) to allow maximum power output. From the intercooler, the pressurized and cooled air goes to the intake manifold where it is mixed with a proportion of exhaust from the EGR (exhaust gas recirculation) system for emission control purposes. (The EGR system is connected on the high-pressure side of both the exhaust and intake systems.) This mixture then goes into the engine cylinders. Unlike with a gasoline engine, there is no throttle in a diesel engine. Power output is governed using the fuel supply only. The lean air/fuel mixture is one of the reasons that the diesel engine is so efficient, and the lack of intake restriction due to absence of a throttle reduces pumping losses, and that is another reason that a diesel engine is more efficient when running under part load. The A4 engines have an added intake manifold flap to reduce shudder and compression pressures on diesel shutdown. Previous A3 TDI's did not have this feature.

Back to Top

f. **Engine** - The 4-cylinder engine uses a cast-iron block and an aluminum head with 2 valves per cylinder. Some newer designs (like the V6 model) use 4 valves per cylinder. Whereas gasoline engines use 4 valves per cylinder for better breathing at high engine speed, this is of little benefit to diesels. The main benefit of using 4 valves per cylinder in a diesel engine is to allow the injection nozzle to be located precisely in the center of the combustion chamber and mounted vertically - this gives better fuel distribution within the combustion chamber, hence more power and lower exhaust emissions. The displacement of all 4-cylinder models is 1.9L, 1896cc or 115.7 cubic inches. The bore (79.5mm) and the stroke (95.5mm) is the same on the A3 and A4 models. The compression ratio is 19.5:1 on the 90hp and 110hp models, and reduced to 18.5:1 on the 115hp model. The new engine used in the A4 models features a cast iron cylinder block, light alloy cylinder head and aluminum oil and a magnesium cylinder head cover. It also has the same piston oil spray nozzles as the earlier A3 TDI engines which spray oil against the bottoms of the pistons for added cooling. Both A3 and A4 engines have 5 main bearings on the crankshaft. Both the A3 and A4 engines have a single overhead camshaft driven by a toothed belt with semi-automatic belt tensioner. Both engines enjoy lightweight valve train with 2 valves per cylinder and reinforced exhaust valves for high temperature resistance. Both engines are transversely mounted with the new A4 engine featuring the new improved "Pendulum" type engine mounts for increased smoothness and freedom from vibration. The new A4 engine has a chain driven internal gear oil pump driven from the front of the crankshaft. The new A4 engine now has a camshaft driven vacuum pump. The A3 engine as a spin on cartridge oil filter down below the engine assembly next to the oil pan while the newer A4 version has a drop-in cartridge-type oil filter accessible from the top front of the engine bay. Both TDI models have radiator cooling added to their EGR valves to reduce the temperature of the EGR gases approximately 122 degrees Fahrenheit resulting in a 15% decrease in NOx emissions.
The use of a belt-drive for the camshaft on a diesel engine has been the subject of some criticism, because camshaft timing belts generally fail with no warning, and this failure has tremendous consequences. If this ever happens, the camshaft will stop immediately, while the crankshaft and pistons will keep going, driven forward by the still-moving car and still-turning drivetrain. It's guaranteed that the camshaft will stop with some valves open, and a piston will hit a valve ... crunch ... this leads to many expensive broken parts inside the engine. It is therefore crucial that the timing belt be replaced in accordance with the maintenance schedule! It should also be replaced any time there is doubt as to its condition, such as if an oil or fuel leak causes these fluids to contaminate the belt.
Gasoline engines can be designed so that even if the timing belt breaks, the valves will not contact the pistons, regardless of what position the camshaft stops in (a so-called non-interference engine). Not all gasoline engines are non-interference ... but they can be. This is impossible with a diesel engine because of the high compression ratio, and the small space between the piston and head in order to achieve that compression ratio. All 4-stroke diesel engines are therefore interference designs.
The new A4 engine has reduced crevice volume in the combustion chamber achieved with a new piston design. The new piston design has the top ring being moved to within 6mm of the piston crown, up from the previous 9mm of the A3 engines. This is a critical area of diesel piston design and assists in lowering the visible smoke output and the emissions through the oxidative 55mm catalytic convertor (A3 engines had 50mm oxidative catalytic convertors).

The A4 engine also enjoys a new oil pump, vacuum pump and water pump drive system with the elimination of the auxiliary drive shaft as found in earlier A3 engines. The familiar water pump thermostat housing that has been on the earlier VW 4-cylinder engine designs for the last 23 years is replaced with housings cast integral with the block and a plastic impeller pump. With the elimination of the intermediate shaft, the oil pump is moved up to the front of the engine and driven by chain from the crank. A spring loaded tensioner takes up any slack in the chain. The oil pump itself is a modern gerotor design, which pumps more oil using less power, has fewer moving parts and a smaller gear intermesh to minimize contact area and reduce friction. The modified oil circuit provides faster oil pressure build up, particularly during cold starts. The pressurized oil is controlled at the clean-oil end with the resulting faster build up of oil pressure which has a positive influence on less wear (shorter mixed friction time after starting). The vertical oil filter also assists with the ease of maintenance with a fully incineratable filter cartridge that is easy to access and easy to replace. A single oil pressure switch is used (the A3 models had two oil pressure switches, one high and one low) with an oil control valve mounted downstream of the oil filter. The new cylinder head cover also has an integrated oil separator to minimize oil consumption.

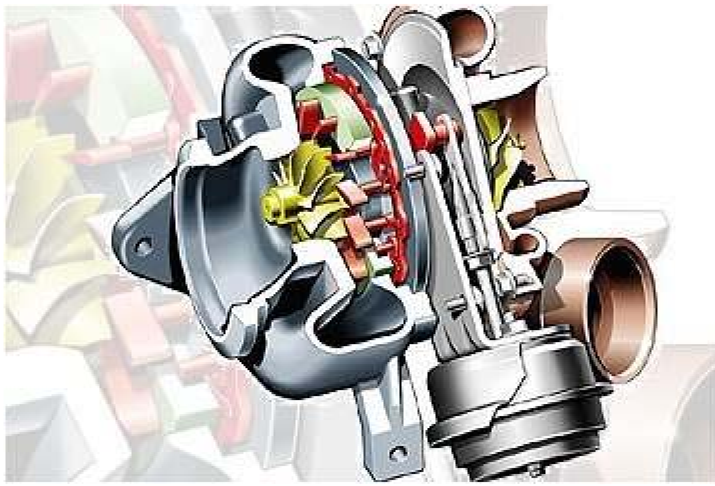
The new A4 engine also has a new lightweight cast aluminum oil pan using silicone sealant instead of a gasket on the previous A3 models. The oil pan is also bolted to the transmission housing to increase rigidity. The cylinder head cover is now cast in magnesium and uses a series of perimeter fasteners rather than the three center bolts on the A3 TDI design. There is no separate gasket on the cylinder head cover, instead the seal is bonded and positively located to give a more reliable seal. The wire mesh separator inside provides for better oil separation and increased crankcase breathing.

One of the biggest changes the A4 design includes is the new reinforced engine and transmission mount design, working on the principle of a pendulum. The engine is suspended from above on a bonded rubber transmission mount and rubber and hydraulically dampened motor mount, and located in the lower rear with a "pendulum support". This effectively dampens chassis shake, noise, vibration, and harshness and acts as a torque rod that reduces engine twist during hard acceleration. At rest, all three mounts are without any preload. Under acceleration or braking, the upper mounts twist while the lower pendulum mount dampens and restricts excessive movement.

Back to Top

g. **Turbocharger** - The function of the turbocharger is to increase the amount of air which enters the engine, thus allowing the power and torque to be increased tremendously compared to an engine without a turbocharger. It works rather like a miniature jet engine. A turbine is located in the exhaust from the diesel engine, and converts the pressure of the exhaust gases to mechanical work on a shaft. A compressor wheel is driven by this shaft, and draws air from the air intake, compresses it, and pressurizes the intake manifold of the diesel engine. The shaft of the turbine and compressor is mechanically independent of any connection to the rest of the engine - it spins freely on its own. The bearing on this shaft is lubricated by engine oil, fed by a separate oil line from the vicinity of the oil filter, and the oil drains into the crankcase through a drain pipe. The oil also serves to cool the turbine; there is no connection to the engine coolant.

Conventional turbochargers have the advantage of recovering part of the exhaust energy to increase the power of the main engine, but the disadvantage that they only operate under optimum conditions at a single engine speed - which, in the case of the 1.9 4-cylinder, is about 2000 rpm. Below that speed, there is not enough energy contained in the exhaust gases to allow the design level of "boost" to be achieved. Above that speed, there is too much energy in the exhaust, and the turbine tends to overspeed and generate too much boost. There are various ways of dealing with this - some models use a so-called "wastegate" which is the original design, and other models use a set of vanes in the turbine section to vary the angle and speed that the exhaust gases strike the turbine.



The A3 90hp engines use a conventional Garrett GT15 turbocharger with an internal wastegate. When the engine speed is below the optimum design speed for the turbo, the turbo does whatever it can, and the engine gets less boost than design ... nothing can be done about it. As engine speed increases, the boost level also increases because the extra exhaust energy spins the turbine faster. When the boost level starts to exceed a certain amount, the engine controls supply pressure to the wastegate actuator, which then bypasses part of the exhaust around the turbine. This causes less energy to be delivered to the turbine, so the boost level drops, and the engine controls operate so as to keep the boost level at the design level.

To improve performance in "off-design" conditions, the A4 engines (and the A3 110hp engines) use a variable-geometry Garret VNT15 turbocharger. There is no wastegate, and all of the engine exhaust passes through the turbine all the time. When the engine is running slowly, a set of vanes inside the turbine housing move, to direct the exhaust gases through the turbine at a shallower angle but a higher speed; this causes the turbine to spin faster, so that the turbo compressor can reach the design boost level sooner. As the engine runs faster and the amount of exhaust gases increase, the boost level starts going up; this is detected by the engine controls which act to move the vanes toward a more open angle. This allows less energy to be transmitted to the turbine wheel, so the boost level is reduced. Compared with the previous design, this arrangement allows the design boost level to be developed faster and at lower engine speeds, and allows more efficient operation with reduced exhaust back pressure at higher engine speeds.

Another design change with the new A4 engines is that the turbine housing is built into the exhaust manifold instead of being a separate piece, thus eliminating a potential leakage point.

For the 90hp engines, typical boost level at full load is 15 to 16 psi intermittently and

12 to 13 psi continuously.Back to Top

h. **Engine Controls** - All North American models use BOSCH's Motronic 5.9.2 electronic engine management systems. The TDI engine is a "drive by wire" design. There is no mechanical connection between the accelerator pedal and anything else. Pressing the accelerator pedal provides an input to the ECU (engine computer) indicating that more power is desired. The ECU takes into account accelerator pedal position and engine speed, then "decides" how much fuel is being requested by the driver. It compares this request with the signal from the MAF (airflow meter); if the MAF signal indicates that for whatever reason there is not enough airflow for the requested amount of fuel, the ECU cuts back the amount of fuel to prevent black exhaust smoke from being emitted. It is worth noting that if the accelerator and brake pedals are both depressed, the ECU detects the condition and brings the engine to idle speed as a safety feature, ignoring the accelerator input. (During "normal" driving this presents no obstacle, but enthusiastic drivers who can do racing-style "heel and toe" downshifts while braking may find that this safety feature thwarts their attempt to "match revs"...)
The result of this calculation is the desired amount of fuel to be injected. Within the distributor-type injection pump is a small electric motor which positions the fuel cutoff sleeve around the injection plunger; this changes the effective stroke of the plunger and thus varies the amount of fuel being injected. A position feedback device measures the actual position of this cutoff sleeve, thus giving the ECU precise control of the fuel quantity.
It is also necessary for the ECU to vary the injection timing for the best compromise between power, economy, and emissions. Injection quantity and engine speed are taken into account to determine the desired start-of-injection timing. A sensor located on injector number 3 (that's why this injector is bigger than the others and has a wire to it), in conjunction with a position sensor near the engine flywheel, allows the actual timing of the start-of-injection to be measured by the ECU. The ECU compares the actual start-of-injection timing, to a calculation of where the timing should be. A solenoid on the injection pump is energized or de-energized, depending on whether the measured injection timing is too far advanced, or too far behind. This operates a small hydraulic cylinder, which shifts the cam that the injection pump plunger rides against, thus altering the injection timing under closed-loop control.
The engine control unit also is responsible for operating the exhaust-gas recirculation system. Diesel engines have no throttle plate to limit the amount of intake air. This means that more oxygen is in the cylinders than can be used during fuel combustion. The high temperatures in the cylinder can combine this excess oxygen with nitrogen to form oxides of nitrogen (NOx). Recirculating exhaust with its partially depleted oxygen level back into the intake air lowers the combustion temperatures making it less possible to produce high quantities of NOx. If the ECU program determines, based on coolant temperature, altitude, engine speed and other variables, that operating conditions could lead to production of high levels of NOx, the ECU operates a solenoid which applies vacuum to the EGR valve, causing it to open. This causes the combustion temperatures in the cylinders to be reduced since the exhaust gas has less oxygen than the displaced fresh intake air. If the ECU program determines that conditions do not favor production of NOx, then the ECU acts in the other direction and closes the EGR valve. Too high a combustion temperature leads to formation of

NOx, too low leads to greater amounts of CO and "soot". The ECU regulates the EGR opening size to maintain this balance between too much and too little. On models equipped with the OBD-II system (i.e. North America), if the ECU cannot achieve the desired level of oxygen in the exhaust, the "check engine" light will come on.

The engine controls also operate the turbocharger, to regulate the boost pressure. On A3 models, a hose leads from the intake manifold to a pressure sensor located within the ECU. When the boost pressure exceeds a setpoint, a solenoid valve transmits boost pressure to the wastegate actuator, which then opens the wastegate, causing the boost pressure to come down - the control strategy is quite simple. On A4 models, the pressure sensor is located on the intake pipe coming from the intercooler. Control of the boost pressure is done by varying the position of vanes inside the turbocharger.

The glow plug system, used for cold starts, is also controlled by the ECU. When the "ignition" switch is turned "on" and the coolant temperature is below 9 degrees C, the glow plugs operate for a time which depends on the measured coolant temperature (i.e. about 10 seconds at -10 degrees C). The glow plug indication lamp on the instrument panel is an indication to the driver - "please wait". When this light goes off, the engine may be started. After it starts, the glow plugs operate for a period of time with the engine running, at engine speeds below 2500 rpm, in order to reduce emissions and improve engine operation during this time period. The glow plug indicator lamp does not operate during this stage.
In addition, some models have glow plugs in the coolant, to make the engine warm up faster, and to provide some heat to the passenger compartment sooner. These glow plugs operate for a period of time after the engine starts (without the glow plug indicator lamp).
Some may be under the impression that the glow plugs begin operating when the driver's door is opened. This is an "urban myth". The glow plugs do not operate until the key is turned "on".

Back to Top

Back to FAQ Index

TDI FAQ

2) General FAQ

Back to FAQ Index

----

2) General FAQ

a. **Types of TDI Engines** - Various cars use different engines which are generally described below. It should be noted that this document primarily focuses on the 90hp 4-cylinder engines, as these are the most common, and are the only ones seen in North America.

1.2 litre 3-cylinder 61hp - This engine is used in the "3-litre" (referring to fuel consumption of 3 litres per 100 km) versions of the VW Lupo, Seat Arosa, Audi A2, sold in Europe. The injection system uses the "pump-nozzle" or PD system, and the turbocharger is a variable-vane type.

1.4 litre 3-cylinder 75hp - Used in various Polo-based models sold in Europe. The injection system uses the "pump-nozzle" system, and the turbocharger is a variable-vane type.

1.9 litre 4-cylinder 90hp (A3 type) - used in various models sold until approximately 1998 in Europe and North America. Within this document we will call this the A3 engine even though it was also used in other models, because the most popular cars sold with this engine were the A3-chassis Golf, Jetta, and Vento sold from 1994 until early 1999. Not all model years were available in all markets, and this engine was replaced by the newer type (here called the A4 type) gradually over a period of years. Other models sold with this engine include the B4 Passat (1995 - 1997), VW Sharan minivan, and various Audi models.

The injection system uses a distributor-type pump. On cars with transverse engines, the A3 engine can be distinguished from the later type by the spin-on oil filter on the front of the engine facing down at an angle, the air filter housing is at the right front corner of the car, and the two black plastic pipes to the intercooler lead towards the left front corner of the car. There are other differences, but these are the most easily visible.

The turbocharger is a conventional wastegate type.

1.9 litre 4-cylinder 110hp (A3 type) - used on the same models as the 90hp but not available in all markets - in particular, not available in North America. Visually it is almost impossible to tell apart from the A3 90hp engine, except for the red "I" in the TDI badges used on the car in various places. The engine itself is identical to the 90hp model.

The turbocharger is a variable-vane type, and the injection system uses a distributor-type pump which looks the same as that of the 90hp model. Obviously there are differences in the ECU, and in the plumbing and controls for the turbo, since the turbo is not the same as for the 90hp model.

1.9 litre 4-cylinder 90hp (A4 type) - used in various models available in Europe and North America from 1998 on, this gradually replaced the previous engine as the car models were changed. Within this document we will call this the A4 engine because the most common application is the A4-chassis Golf, Jetta, Bora, New Beetle, and various models from Seat and Skoda using the same chassis.

The injection system uses a distributor-type pump. The oil filter is a cartridge type, and sits in a vertical container on the front of the engine towards the left of the car. On cars with transverse engines, the air filter housing is at the left side of the engine compartment and the two black plastic pipes to the intercooler lead towards the right front corner - exactly the opposite of the arrangement used on the previous model.

On North American models, the turbocharger is a variable-vane type. On European models, the turbocharger is a conventional wastegate type. The North American A4 engine is essentially a Euro 110hp A4 engine but with engine controls optimized for emissions rather than performance.

1.9 litre 4-cylinder 110hp (A4 type) - virtually identical in appearance and specification to the 90hp except for the engine controls; cars using this engine have a red "I" in the TDI badges. Not available in North America.

1.9 litre 4-cylinder 115hp "PD" - again similar to the A4-type engine but with the "pump-nozzle" injection system. Although the peak power is only slightly more than the 110, maximum torque is much higher and the engine has lower exhaust emissions. VW intends to gradually replace the 110hp models with this engine. Not available in North America, reportedly because the exhaust emission controls used on this engine cannot be used with fuels containing greater than 50 parts per million of sulfur, whereas at this writing (1999) fuels in North America can have as much as 500 parts per million.

Models with this engine have badges with a silver "T" and red "DI".

The injection system is the "pump-nozzle" type, and the turbocharger is a variable-vane type. The lack of the injection pump mounted on the front of the engine is the obvious visual difference.

1.9 litre 4-cylinder 150hp "PD" - Few details are available at this writing. Models with this engine apparently will have badges with "TDI" in all red.

2.5 litre 5-cylinder - used in various larger models available in Europe. The injection system uses a distributor-type pump.

2.5 litre V6 150 hp - used on various Audi-based models (including the VW Passat) starting in 1998. Has 4 valves per cylinder, and uses a distributor-type injection pump. The advantage of using 4 valves per cylinder for a diesel engine is not so much for better breathing, as it is to allow the injection nozzle to be located precisely in the center of the combustion chamber and oriented vertically.

2.5 litre V6 180 hp - differs from the 150 hp model only in the use of common-rail injection instead of the distributor-type pump.

3.3 litre V8 - used on the Audi A8 available in Europe.

b. **Cold Starts** - This is one of the big questions that non-TDI drivers have: How well will it start in cold weather? The answer is that they behave quite well. Volkswagen was confident enough in the cold-starting ability of this engine that there is no engine block heater designed to suit the TDI engine. For those living in truly cold places - we're talking Edmonton or Winnipeg cold, those in balmy Boston have nothing to worry about - there are ways of making the block heater designed for the previous 1.9 turbodiesel fit this engine, it's not easy but it can be done.

Diesel engines operate on a principle of compression ignition, rather than a spark ignition as in a gasoline fueled engine. The air within the Diesel engine's cylinder is compressed much more tightly than a gasoline engine, usually 2 to 2 1/2 times more tightly. This high compression heats the squeezed air to a temperature that causes the Diesel fuel to burn as soon as it is injected. Cold temperatures suppress the tendency for self-ignition of the Diesel fuel. "Glow plugs" are used to create a hot spot within the cylinder to help force ignition. The glow plugs are small electric heaters which are turned on before the starter is operated. The amount of time required for these heaters to obtain a sufficient temperature to ensure ignition depends on the engine's temperature. When the coolant temperature is above 9 C, the glow plugs may not come on prior to starting. On cold winter nights, they may take several seconds to heat up (7 to 10 seconds is typical).

Many measures have been taken to ensure reliable starts in cold weather, but there are some factors beyond the control of the car. More than one person accustomed to gasoline engines has merrily hopped into the car during cold weather, stuck the key in the ignition and turned it all the way to the "Start" position (which prevents the glow plugs from operating!!!) and then wondered why the car acts up. The proper procedure is to switch the key to the "On" position and wait for the yellow glow plug lamp to go out before cranking the engine. The amount of time you have to wait ranges from none whatsoever (if the coolant temperature is above 9 degrees C), to about 10 seconds (if the car has been sitting outside in -10 C for some time). If this is done, the engine normally starts with perhaps a second of cranking, even at -10 C. Owners have reported starting their engines at temperatures below -30 C, which is about -20 F. Better make sure the battery is healthy, at those temperatures - but that's no different from any other car.

The other factor beyond the control of the car, is the quality of the fuel. In Canada, diesel fuel must be provided to stations "winterized" to expected outdoor temperatures as low as -45 C in some areas. The most common source of problems is when one purchases fuel at an out-of-the-way station, which may go months between refills of their underground tank. Prudent and experienced diesel drivers go to stations that have lots of traffic during cold weather, to avoid getting a tank full of summer diesel in the dead of winter.

The problem with summer diesel is that it "gels" or "crystallizes" below a certain temperature. The TDI engine is capable of operating at temperatures below what could normally be expected for a given fuel, because the fuel filter is heated by fuel being returned from the injection system. If fuel gels up in the filter, the engine will generally start, but won't have power to do much other than idle for a few minutes until the fuel filter warms up ... but at least you'll get going. It will only handle so much, though, and the car will not run in -20 C with summer diesel fuel. Under very cold start-up conditons (and this means in the -30 C range), you may need to wait for several minutes with the engine idling before driving off to allow the fuel to be warmed. Otherwise, power will be impaired or the engine may stall as the injector pump will be starved for fuel. Because of the long range of a TDi, when you are driving from a warm to a cold climate it may be prudent to fill up with winterized fuel in the destination area before the system cools down. If you are in the unfortunate situation of a completely gelled fuel system and the car will not start, the only cure is place the car in a warm garage for a few hours.

For extra insurance, diesel fuel anti-gel additives are available at truck stops and many auto parts stores. There are some additives which can be added "after the fact" to a fuel tank which is already gelled, and during extremely cold spells it is highly recommended to carry a container of anti-gel additive in the car. Using a portion of gasoline or kerosene in cold weather, as a substitute for an anti-gel additive, is not recommended, because these fuels do not have the proper lubricating characteristics and cetane number.

It is normal to have somewhat reduced power and slightly higher fuel consumption when using winterized diesel fuel.

c. **Warm-up** - Because the TDI engine is so efficient, it puts less heat into the cooling system than comparable gasoline engines. A TDI engine will not reach operating temperature by idling. There is no point starting the car a few minutes before you plan to use it in order to have a warm interior - it isn't going to happen. Heated seats are definitely a worthwhile option for those living in a cold climate!

The best way to warm up a TDI engine is to start up and GO, after minimum essential warm-up. It's generally recommended to drive gently for the first few minutes, until the temperature gauge approaches the normal range. When done this way, the warm-up period is not too different from that of a gasoline engine.

If one gets stuck in traffic with a cold engine, now there's a dilemma, because the engine won't generate enough heat to warm up. If this happens, one suggestion has been to introduce some electrical load to make the engine work a little harder, like the headlights, rear-window defroster, and heated seats if you have them.

d. **Shifting Gears** - Much has been made about what the best shift point is for maximum economy. It is known that the engine "likes" running at around 2000 rpm, and the turbo starts kicking in at about 1500 and is going full tilt by 2000. The author prefers shifting at about 2500 rpm during normal acceleration, then when cruising speed is reached, selecting a gear which puts the revs between 1500 and 2000.

For absolute maximum acceleration with a stock engine, shift at about 4000 rpm, because power drops off quickly beyond this. There is little to be gained by shifting at 4000 compared to shifting at 3500.

For those not accustomed to manual transmissions, the TDI engine is among the easiest to learn with. The engine quickly and automatically builds up torque if the idle speed starts dropping, and the engine doesn't race away like mad upon the slightest touch of the accelerator pedal like many gas engines do. It's possible to smoothly let out the clutch and start off from a stop, then shift to second, and then to third, without touching the accelerator, and the car will pull it!

For those who don't want to shift for themselves, there is limited availability of an automatic transmission with the TDI engine.

e. **Performance** - It has been said that "people buy horsepower, but drive torque". This statement completely describes why the TDI engine is so easy to live with during day-to-day driving, despite the seemingly low horsepower rating!

A typical multivalve 2-litre gasoline engine may have its maximum horsepower (perhaps 120 or so) at 5500 to 6000 rpm, and its maximum torque (perhaps 120 lb-ft or so) between 3500 and 4000 rpm, and is probably geared to run about 2700 rpm at 100 km/h. In top gear at highway speed, the engine is below its peak torque, and probably makes around 51 hp at that speed. A downshift is usually needed to make a quick pass, or to get up a steep hill. If the car has an automatic transmission, the torque converter will probably unlock going up moderate hills, in order to get the engine closer to its peak torque.

With the TDI engine, maximum horsepower (90) is available at 3750 to 4000 rpm, and maximum torque (155 lb-ft) is available at just 1900 rpm. The engine runs 2100 rpm at 100 km/h and makes about 62 horsepower at that speed. Hey, that's more than the gas engine ... by quite a bit, too! Thus, no downshift is required to make a pass or to climb virtually any highway grade. And if the car has an automatic, it won't unlock the torque converter, because peak torque is right there already.

If you enter a drag race between these two cars, the gas car will probably win, because drag racing is about horsepower-to-weight ratio and little else. But who drives like that every day? Most people don't. Even people who think they do - usually don't.

For what it's worth, owners report 0 to 60 mph times with a stock car ranging from about 10.5 to 12 seconds (mostly depending on the weight of the car) and top speeds well in excess of what one ought to be doing on North American highways. In other words, not too different from the performance of a 2-litre gas engine in a similar car. The cars that the VW TDI is installed in were all designed to handle autobahn cruising at 160 km/h (100 mph) with ease and all models will exceed that easily, so if you're buying a diesel in the hope of reducing the number of speeding tickets you get, you'd better find a different excuse!

And for those so inclined, there are ways to significantly boost the performance of a TDI engine, discussed elsewhere in this document. These modifications don't change the basic character of the engine - it makes both more power and more torque - and they generally have little effect on fuel consumption unless you use the extra power all the time. One owner has reduced the 0 to 60 mph time of his New Beetle TDI to a hair over 7 seconds through suitable modifications - nothing exotic.

f. **Noise, Vibration, and Smell** - If you're comparing the TDI to diesels of yore, there is no comparison. It compares more favorably with 4-cylinder gasoline engines. It's a little louder at idle with a little more vibration transmitted to the passenger compartment (and it's worse when cold) but hardly intrusive, especially after it is warmed up. It's actually quieter at highway speed than equivalent gas engines, because it's turning slower, just 2100 rpm at 100 km/h. It's especially quieter during rapid acceleration when a gas engine would be buzzing away at 5000 rpm while the TDI is loafing along at 3000.

Diesel noise and clatter are well isolated from the passenger compartment and can only really be heard with the windows down. Most true diesel-heads roll the windows down just to hear the engine!

Diesel exhaust smell is noticeable outside the car after starting a cold engine, but is considerably reduced compared to older diesel engines. Fuel smells are only an issue when refueling, and only if the pump is messy and covered with diesel fuel. You don't want to get diesel fuel on your hands. In most cases, it's possible to refuel without spilling any without special precautions, but some owners suggest carrying some latex gloves in the car if you have to deal with a messy filling station.

g. **Longevity and Reliability** - These are well-known strong points of diesel engines. There is the issue of the timing belt, which must be changed religiously at the specified intervals, or else. Aside from that, VW diesels have proven to be very durable over the long haul. Some members of this forum tend to be "anal" about oil changes and stuff ... but in a way, that's as it should be, because diesel owners are generally in it for the long haul.

   The diesel engine has certain factors acting strongly in its favor, compared to modern gasoline engines. The engine itself is very heavily constructed due to the compression ratio. Lower exhaust temperatures than a gasoline engine extend the life of the exhaust valves and the turbocharger. No spark plugs, no ignition coil, no distributor, no plug wires, and diesel engines aren't fussy about air/fuel ratio the way gasoline engines are. Although the TDI has its share of electronics and sensors, virtually all of those sensors are "non contact" sensors that work either by magnetic fields, or by solid state electronics - i.e. the sensors have no components to wear out. And the TDI lacks what is among the most unreliable components of every modern gasoline engine ... there are no oxygen sensors in the exhaust system. It does have a glow-plug system (and some owners have had the relay conk out) but this system is far simpler than the ignition system of a gasoline engine.

h. **Fuel Consumption** - This is another strong point of diesel engines. The TDI engine uses about 60% as much fuel as an equivalent 4-cylinder gasoline engine. In Canada, diesel fuel is less expensive than gasoline, so fuel costs can be expected to be a little over half that of a similar gasoline car. Using current fuel costs of C$0.65 per litre for gasoline and C$0.60 per litre for diesel, and 8.0 L/100 km for the gasoline car versus 4.8 L/100 km for the diesel car, you save $2.32 every 100 km. Payback of the extra cost of about C$1500 comes in about 65,000 km, which is less than two years for many long-distance travelers and about three years for the average driver. Maintenance costs are assumed to be about equal (which is about right) and this doesn't take into account the fact that, at least in Canada, it is virtually guaranteed that at the end of that payback period, the diesel car will be worth MORE than the gas car ... possibly by more than the original difference in price! (Example; at this writing (late 1999), the going rate for a 1996 Passat VR6 with say 100,000 km is about C$15,000 while the going rate for a 1996 Passat TDI is about C$18,000...)

In the USA, the situation is not quite as favorable, because of generally lower fuel prices, and because diesel is relatively higher priced compared to gasoline, compared to Canada. You can do calculations similar to the above for your area.

Besides strictly economics, there are those who prefer the characteristics of a diesel engine, regardless of the payback period!

i. **Fuel Availability** - In most areas, about one fuel station out of three or four has diesel fuel, and diesel is always available at truck stops along major highways. With the low fuel consumption, and the same size tank that the gas cars use, the TDI cars have an impressive range, easily 1000 km (600 miles) or more. Availability of fuel is not an issue, although as mentioned elsewhere, it's wise to fill up at stations with a lot of diesel traffic, especially during cold weather.

   Your VW has a fuel nozzle capable of accepting the nozzle at large big-rig pumps, although you'd better set the pump at the lowest feed rate possible to prevent a splash-back!

j. **Maintenance Costs** - The cost of maintaining a TDI is not much different from maintaining a similar gasoline-powered vehicle. You need to be a bit careful with oil changes, because you need to use oil meant for diesel engines, so this item tends to cost a little bit more. There's obviously no need to do anything about spark plugs, plug wires, distributor, or anything like that, so this cost item is eliminated. The air filter needs to be changed once in a while, same as for a gas engine. The fuel filter also needs changing, and it costs a bit more than one for a gas engine, but it's only once every 50,000 km or so - not a big deal.

   The only pricey regular maintenance task is getting the timing belt changed. After considerable indecision, VW seems to have settled on a change interval of 90,000 km / 55,000 miles, but check the owners manual for your particular vehicle as it may vary. This is little different from the change interval specified for most gas engines, but for some reason the job costs more on a TDI. Do not try to skimp on this. Use the genuine parts; change the tensioner too; change the serpentine belt and the V-belt at the same time. If you buy a used TDI, then you can either get a piece of paper proving the belt was changed at a certain mileage and believe it (or not), or figure on getting the belt changed to make sure. If it can't be proven that the timing belt was changed, then assume it needs to be done. DO NOT EVER neglect this!

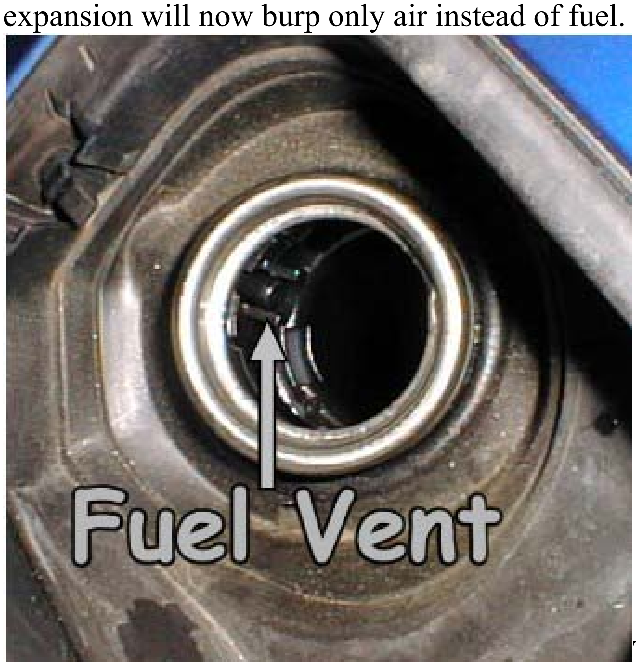
   Some owners have reported being charged exorbitant costs for a "tune-up". Don't be suckered into this. Find out exactly what the repair shop proposes to do in the "tune-up", because there is very little to tune up. Most places will simply do an oil change, and change the air filter and possibly the fuel filter. Rarely will such a "tune-up" include cleaning the air intake screen or the intercooler. Any owner with even slight mechanical ability is capable of taking care of every one of these tasks with the possible exception of changing the fuel filter, and the price for a "tune-up" should reflect this. Sometimes repair shops will attempt to cover up their lack of diesel knowledge by specifying countless replacement items which don't really need to be replaced. Injectors, glow plugs, whatever.

As for unscheduled maintenance, who knows, time will tell. There are forum members at or beyond 200,000 km / 120,000 miles and still going.

k. **Can I use a remote car starter?** - In general, the answer is "No", because remote car starters generally do not have provision for the glow plug waiting period in cold weather. Also, some manual transmission models do not have a switch interlock to prevent starting with the transmission in gear.

l. **Where do I find a good mechanic?** - Boy, if we can find an answer for this ... Normal maintenance on the TDI engine is not beyond the capability of any competent mechanic. Even changing the timing belt can be done by any mechanic who has half a clue. Unfortunately, there are many mechanics out there who don't have half a clue. Some of them even work at VW dealerships. Problems with mechanics doing things wrong are not isolated to the TDI. All modern car engines are extremely sophisticated and some repair jobs - particularly "Check Engine light"-type repairs - should be left to either a competent dealer, or to a mechanic who specializes in the repair of that particular brand of vehicle.
Talk to other TDI owners in your area, and find out where they go. IF you have an electrical or "Check Engine"-type problem, make sure the shop you take it to has the computerized equipment capable of monitoring OBDII engine controls.

m. **Venting** - In the filler neck of the tank, in the "9 o'clock"" position is a little black button. This is a vent relief valve that can be pushed with the fuel nozzle when "topping up" the tank to squeeze in a few extra litres. The vent valve is designed to prevent overfilling the tank. Overfilling could cause heat expansion to push fuel up the neck and create a spill. The vent keeps an amount of air in the tank until the cap is returned. The installation of the fuel cap presses the vent button and allows air in the tank to move up into the neck as the fuel in the neck moves down into the tank. Any expansion will now burp only air instead of fuel.



Topping up using the vent valve

should be done only when the car will be driven long enough to consume a gallon or so before stopping the engine. Don't top off with the vent pressed and then park in the sun. For accurate fuel mileage calculations always use the same technique when re-fueling. Either always "top up" by venting the expansion chamber, or never vent and stop refilling when the dispensing nozzle shuts off. That extra half gallon or two liters of fuel squeezed into the expansion chamber will make the trip consumption appear higher if this venting technique is used intermittently.

n. **Things you may not know, but should**

- It is not recommended to let the TDI engine idle for extended periods of time. Aside from wasting fuel, causing unnecessary emissions, and not accomplishing anything (the engine won't warm up at idle anyway), the turbocharger depends on having a certain minimum level of boost pressure to maintain the condition of the seals. Extended periods of idling may cause a certain amount of oil consumption, and the oil consumption may clog the catalytic converter. Some owners who have let their engine idle for a long time report the engine running poorly for some time afterward. And no, you don't need to worry about what's going to happen if you get stuck in a traffic jam now and again, it's not THAT serious. Just don't start the engine 20 minutes before you want to leave in the morning every day, in the false hope of having a warm interior.
- Old diesel mechanics may suggest mixing ATF with the fuel to lubricate the injection pump. DON'T DO IT! This may cause damage to the catalytic converter. Proper additives are available to accomplish this, although even those are probably not really necessary.
- Old hands may also suggest mixing a portion of gasoline with the fuel in cold weather to prevent wax buildup. The owners manual cautions against this procedure. Use proper additives which are meant for the job, if necessary at all.
- Another questionable practice involves disposing of used motor oil by blending it with diesel fuel. This is another thing which sounds likely to damage the catalytic converter. Besides, used motor oil contains extremely fine particles of solids which may be fine enough to get through the fuel filter and into the injection pump and injectors, where they cannot possibly do anything good, and are a lot more likely to do something bad.

Back to Top

Back to FAQ Index

TDI FAQ

3) Fuel

Back to FAQ Index

----

3) Fuel

a. **Specifications -** The recommended fuel for the TDi models of Volkswagens sold in North America is Diesel fuel number 2. This is the usual type of Diesel fuel sold at retail fueling stations. Nearly one in four gasoline stations in North America also sells Diesel fuel.
Back to Top

b. **Cetane -** Diesel fuel is rated in cetane number (roughly analogous to gasoline octane). The common cetane rating is 40 to 45 in North America. A higher cetane rating number indicates a "premium" grade which is not required for the Volkswagen TDi. The use of a higher cetane fuel may increase performance and mileage, but generally costs more per gallon. Decide for yourself if the cost increase is offset by improvements in performance and mileage.
Back to Top

c. **Winterized** -Diesel fuel number 2 loses its ability to flow at temperatures below 20F (-7C.). This is caused by wax separation, and is commonly termed "gelling". The thicker wax component of the fuel may be blocked by the fuel filter although it can flow through the larger diameter fuel lines. The fuel filter in the Volkswagen TDi is heated to reduce this tendency. The heater permits the use of Diesel fuel number 2 down to a temperature of -10F (-24C). Most fuel companies "winterize" the fuel sold during winter months in cold climates. This winterized fuel resists gelling at low temperatures. The winterized fuel does not provide the same level of performance as the summer fuel, so your mileage will likely drop while using it. Be aware that the refueling range of the TDi may permit travel from a warm climate to an extremely cold one on one tank of fuel. It is recommended to fill up with winterized fuel before stopping the engine for a long time in a cold environment.

Under warm conditions diesel behaves much like gasoline, i.e. it appears as a liquid, stinks, but is heavier and less volatile. As its temperature drops some of its less desirable properties become apparent. Diesel fuel consists of many different hydrocarbon molecules of varying characteristics, and of special interest is the temperature some solidify and become wax. The appearance of wax crystals is called "clouding", and the temperature at which this happens in a particular blend is referred to as "the cloud point". Oil companies adjust the cloud point to suit the various climatic conditions in different locations and the time of the year. The same brand name may be different in Maine from the product sold in New York and in Florida. Lowering of the cloud point is generally done by addition of heavier (higher boiling range) components (Napthalenes and aromatics) and other additives, but this also reduces fuel energy and consequently mileage suffers. Winter fuel is less economical and lighter than heavier summer fuel. As the temperature drops further, some hydrocarbons continue to remain liquid, but others form wax. The net result of very low temperatures (-50F?) is that what was liquid fuel at +50F can resemble a thick gel. Further information on diesel fuel can be located at the following web site:
www.chevron.com/prodserv/bulletin/diesel/L1_toc_rf.htm

www.shell.ca/oshell/diesel.htm
Back to Top

d. **Low sulfur** - Lower sulfur content fuel is becoming more common as the limits of sulfur dioxide and other acid rain producing emissions tighten, and as it becomes necessary for manufacturers to use emission control components that do not tolerate sulfur in the exhaust from the engine.
There is a somewhat mistaken impression that sulfur in the fuel acts as a lubricant for injector pumps, and this impression stems from an older chemical process to remove sulfur which also removed other chemical compounds in the fuel that were completely unrelated to the sulfur but which turned out to be important to the lubricating properties of the fuel. These refinery processes have been changed to remove the sulfur while still allowing the fuels to meet standards for lubricity, and in addition, the fuel pumps in current production have been designed to operate with the current low sulfur fuel. Volkswagen does not specifically make mention of guidelines regarding diesel fuel lubricant additives for the TDi.
Ultra-low sulfur diesel fuel (ULSD) can be used in all current production diesel engines without any problems. As a bonus, the exhaust emissions of current production engines should improve slightly without changing anything in the engine, simply by consistently using ULSD.
North American standards allow 500 parts per million of sulfur, which is considered

"low sulfur" only by previous standards which were much higher. Modern "low sulfur" fuel sold elsewhere in the world contains 50 parts per million or less. Lower sulfur content in the fuel allows engine designers to use more advanced emission control components. .
Back to Top

e. **Non-taxed (off road)** - Diesel fuel sold for use on roadways in the U.S. is subject to the Federal Highways Fuel Tax. Diesel fuel for stationary and commercial marine engines is not subject to this tax. The non-taxed fuel is dyed to indicate that tax has not been paid. The dye is concentrated so that even a small amount of dye will mark a large quantity of fuel. Home heating oil is the same as Diesel and is also dyed. Evidence of dye in road use vehicles can result in hefty fines. The color of the fuel can be seen through the translucent fuel lines to and from the fuel filter. (The situation is similar in Canada).
Back to Top

f. **Bio-diesel** - Bio-diesel is produced from currently grown vegetation without the intervening eons for partial fossilization. The fuel produced from this source reportedly produces even lower emissions. The current supply is scarce and there are very few locations which currently offer it for retail sale.
Back to Top

g. **Additives** - Additives are available to correct a host of implied deficiencies in fuel content. Volkswagen specifically mentions additives for use in its gasoline fueled vehicles, however Volkswagen makes no mention on the use of additives for the Diesel fueled vehicles. This lack of mention may be interpreted as you wish.
Back to Top

h. **Refueling** - Refueling at automotive service stations is the same as with a gasoline fueled vehicle. Refueling at stations which primarily service the trucking industry is slightly different. The pump nozzles are a larger diameter to permit quicker filling of the large truck tanks. The filler neck of the TDi will accept this large nozzle. The faster fill rate allowed by the large nozzles may overcome the TDi venting abilities and could cause splash back, or excessive foaming of the fuel. Filling at less than the full speed will avoid these problems. Filling at truck stations has advantages during seasonal changes. The storage tanks at truck stations is likely to be depleted and refilled at a higher frequency than the automotive station. The changes of fuel blends for weather conditions are more likely to be up to date when the turn over is higher.
Back to Top

Back to FAQ Index

TDI FAQ

4) Oil

Back to FAQ Index

---

4) Oil

a. **Specifications** - The oil specified for use in the Volkswagen TDi for current models meets the "API Service CG-4" rating. This mark means that the oil has been tested for use in Diesel (C = compression ignition) engines to meet the requirements of a test level called "G" in a 4-stroke engine. The oil may also have been tested for use engines fueled by gasoline, methanol, propane, or other fuels ignited by a spark plug (S = spark ignition). The "S" ratings (SG, SH, SJ, etc.) have no bearing on the suitability of the oil to protect a Diesel fueled engine from the special demands imposed by the higher compression ratios and the tendency for all diesel engines to place soot in the oil.

   Since there is little difference internally between the earlier and later engines, it is only prudent to use oil meeting the latest standards, even in the earlier models. The latest standard is CH-4, and the one previous to that is CG-4. Many oils which have CG-4 printed on the packaging actually meet CH-4, but due to the time taken to use up old packaging, it is only the labeling which is not up to date.
   Back to Top

b. **Semi and full Synthetic** - According to a service bulletin, Volkswagen recommends the use of synthetic oil in the TDI engine. Herein lies the dilemma, as if you take your Volkswagen to a dealer for service, they may try to use an oil which is not CG-4 rated and isn't really a full synthetic. There are a limited number of oils on the market in North America which satisfy the following criteria: CG-4 or CH-4 rating, full synthetic, viscosity 5w30 or 5w40. These oils are suitable for VW's full recommended oil change interval and the viscosity range is suitable for all climates in North America. Contrary to what dealers may tell you, neither Mobil 1 nor Castrol Syntec fulfill all of these requirements - and that information is right on the bottle.

The information in this section refers to API service classes which are North American standards. Different standards for engine oils are used in Europe and elsewhere. It should be noted that since this vehicle was developed in Europe, it is much easier to determine whether a European engine oil is suitable. Any synthetic oil meeting the specification VW 505.00 is suitable for use with this engine with the full recommended oil change interval. The VW 505.00 is the manufacturer's own specification, but in North America this specification is rarely seen, so we must rely on the API grades.

Oils which are suitable for the full recommended oil change interval in all climates include, but aren't limited to:

Mobil Delvac 1, 5w40 (full synthetic, a reformulated version of Mobil 1 which is intended for diesel engines)

Chevron Delo 400, 5w40 (full synthetic version)

Shell Rotella T (full synthetic version, not to be confused with Rotella SB synthetic blend or regular Rotella T non-synthetic)

Amsoil Series 3000, 5w30 (full synthetic, CH-4 rated)

Amsoil High Performance, 10w40 (full synthetic, CH-4 rated)

Amsoil semi-synthetic 15w40 (CH-4 rated and high quality, but almost as expensive as the full synthetic, and higher viscosity at low temperatures)

Redline, synthetic version (make sure you get the type meant for diesel engines, with the CG-4 or CH-4 rating)

There are intermediate classes of oils in between full synthetic oils and conventional oils. These include synthetic blends, and so-called "Group III" hydroisomerized oils, and are also available in viscosity ranges suitable for all climates. They include:

Shell Rotella SB (synthetic blend)

Petro-Canada Duron, various viscosity's (Group III, various grades available, ensure CG-4 or CH-4 rating on the bottle)

Castrol Syntec 5w30, 5w40 (Group III - note that this oil is frequently recommended by VW dealers but is NOT rated CG-4 or CH-4, and isn't a full synthetic - which calls into question what the dealer is telling people ... this forum is generally of the opinion that Castrol Syntec is not the best choice for this engine)

In warm weather, a good-quality non-synthetic oil meant for diesel engines with CG-4 or CH-4 ratings may be used. They're not suitable in cold weather due to reduced cold-pumping properties, and it's prudent to shorten the oil change interval because non-synthetic oils may not resist breakdown at high temperatures as well as the synthetic oils (remember that turbocharger). These oils are much easier to find. These include:

Mobil Delvac 1300, 15w40

Shell Rotella T, 15w40

Chevron Delo 400, 15w40

Beware of other brands that claim to be diesel-rated or turbo-rated, but are actually just plain cheap. Use the good stuff. If you doubt this, ask transport truck drivers that own their rigs what they use. Chances are it will be Delvac or Rotella.

In cold weather, if CG-4 or CH-4 rated synthetic oil cannot be found, regular Mobil 1 rated CF in viscosity grades 0w30, 5w30, or 10w30 may be used, but with a shortened oil change interval because this oil doesn't have as much capability to handle soot.

So what's the deal if something else is used besides the expensive and sometimes hard-to-find 5w40 full-synthetic CH-4 rated oil?

Conventional oils that are meant for diesels are usually viscosity SAE 15w40. That's okay in warm weather, but not in cold weather. You want oil to reach that turbocharger as soon as possible after a cold start, and it takes longer to get there if the oil won't pump easily. Synthetic oils have many advantages over conventional oils, not the least of which is better cold pumping characteristics, and hence the common 5w40 viscosity grades.

It is possible to get some non-synthetic oils with viscosity's such as 0w30, 5w50, etc. In non-synthetic oils, these can only be achieved by heavy use of viscosity-index modifiers, a type of additive, whereas synthetic oils can easily achieve a viscosity range like 5w40 with little or no use of viscosity-index modifiers. For various reasons we'd rather not get into, it's better to have the viscosity right in the base stock, than to tinker with the viscosity using additives.

Oils that lack the CG-4 or CH-4 rating don't have the same level of anti-foaming and soot-dispersing capability. The best quality diesel-engine oils deal with it and render the soot as harmless to the engine as possible. Oils that don't meet the CG-4 or CH-4 ratings can't handle as much soot, so you need to change them sooner.

Finally, cheaply made oils (not the same as cheaply priced ...) usually won't have the same resistance to breakdown at high temperatures, that good quality oil does. High temperatures are found in the turbocharger. When oil breaks down at high temperature over a period of time, it "cokes" or builds up deposits in the high-temperature area, which then restrict lubrication. Bye-bye, turbo. There has been one reported turbo failure which was traced to lubrication failure. Do a search of the forums for "turbo failure" to find out what oil he was

using...
Back to Top

c. **Additives** - Volkswagen specifically recommends not to use oil additives. The use of additives may adversely affect your warranty. After the warranty period expires there is nothing to prevent the use of your choice of additives, although members of this forum "in the know" indicate that there is generally more to be lost than gained.

   Many oil additives contain PTFE, also known as Teflon, and touted under many other different names after the manufacturer of Teflon filed a lawsuit to prevent oil-additive companies from using that name. PTFE is a solid. The job of the oil filter in your engine is to collect solid particles down to about 10 microns in size. Where's that solid PTFE going to end up? In the oil filter. Which may cause the filter to plug prematurely, causing the bypass valve to open, and now your engine is running on unfiltered oil. Not good.

   Other oil additives are nothing but ultra-thick substances that increase the viscosity of the oil in an attempt to reduce the leakage rate around seals that have seen better days ... better off to just change the seal. This may help reduce oil consumption on a knackered engine which is on its last legs and is not worth rebuilding, but it can do no good for an engine which isn't leaking or burning oil.

   There are some oil additives which contain real anti-wear additives, such as ZDDP (zinc di-horrible-chemical-name phosphate). ZDDP is a useful additive when used in the right concentration, and in combination with other additives. Good diesel motor oils already contain the right amount of ZDDP and other additives, more is not necessarily better. Why risk it with home-brewed additive concoctions when you can just buy the right oil that has been engineered with a balanced additive package?
   Back to Top

d. **Oil consumption** - Engine oil consumption rates will depend on the viscosity or weight of the oil, engine speeds, weather, road conditions and other factors. Volkswagen has mentioned these variables in declining to state a "normal" consumption rate. Higher speeds and a new engine will tend to consume more oil than lower speeds and an engine which has been broken-in.
   Back to Top

e. **Where to get** - For the picky owner interested in only the best, it can be difficult to find oil that meets the recommended criteria. In the USA, Mobil has a find-a-dealer page at www.mobil.com and in Canada, Mobil is distributed at Husky truck stops, among others.

   The most common diesel-engine vehicles on the road (in North America) are ... big trucks. Those big rigs have big diesel engines, so if you want to find products and lubricants for diesel engines, go where the big rigs go. Truck stops, and bulk lubricant-supply places.
   Back to Top

f. **I just changed the oil, and it's still black. Why?** - Diesel motor oil usually turns black in absolutely no time, because diesel engines pump soot into the oil. It's totally normal and it's a fact of life with a diesel engine. As long as the oil in the crankcase is the right stuff (rated CG-4 or CH-4 and good quality, not cheap stuff) it will handle it. Don't worry about it.
Back to Top

g. **Can I get the oil changed at a quick-lube place?** - Yes, but ... Make sure you know what's going into your engine. A recommended procedure is to BUY YOUR OIL SOMEWHERE ELSE, so that you can read the label on the container and know exactly what it is. See the section above for recommended oil types. Bring YOUR OWN JUG of fresh oil to the oil change place and watch the mechanic pour it into your engine. Also be aware that many (most?) quick-lube places do the job in a hurry and thus overfill the oil. The oil capacity of the crankcase is such that one 4-litre jug will put the oil level pretty close, without overfilling it.

Back to Top

h. **Synthetic oil is too expensive. Can I mix it with regular oil?** - In an emergency on the road when you need a litre of oil added to get home, by all means do it. As a routine matter, oil experts advise against mixing types and brands. Each type of oil has a certain additive package which is meant to work a certain way, and it will be less effective if diluted with something else. Besides, by using that expensive full synthetic, oil change intervals can be longer, so it's really no more expensive - and it's less hassle - in the long run.

Back to FAQ Index

TDI FAQ

5) Emissions

Back to FAQ Index

---

5) Emissions

a. **TDi vs. gasoline** - The TDi emissions levels are among the lowest ever for Diesel powered engines. All TDi powered Volkswagens sold in the US meet so-called "Tier 1" emission limits. The TDi is often "cleaner" overall than gasoline powered cars. CO2 emissions are about 20% less than a conventional gasoline powered engine. CO, HC and NOx emissions are less than previous Volkswagen Diesels. Diesel fuel has lower evaporative emissions than gasoline. Diesel fuel also requires less energy intensive refining than gasoline.

   Diesel engines generally emit higher amounts of NOx and particles than equivalent gasoline powered cars, even though CO and HC emissions may be lower, and total emissions are lower due to much better fuel consumption. The current TDI Volkswagens emit slightly lower than the Tier 1 limits for NOx and particles, but the CO and HC emissions are far below the Tier 1 limits and well below the emissions of the equivalent gasoline engine.

   The emission levels from diesel engines tend to remain more-or-less constant throughout the useful life of the engine, whereas gasoline engines have many more emission-related components which deteriorate and lead to higher and higher emissions as the engine gets older.

   Volkswagen has made continuous progress on emissions through the years, and 2000-model TDI engines emit far less than the 1996 models first available here. Further progress has been made in Europe with new fuel-injection and emission-control technology, but for various technical and market-related reasons, this technology is not available here.
   Back to Top

b. **Bio-Diesel** fuel is available in limited geographical areas. The fuel is produced from a recently grown crop of vegetation (often soybean) and is produced without the partial fossilization and the passage of millennia. The emission levels of the bio-diesel is lower than the more common petroleum Diesel.
   Back to Top

c. **California and New York issues** - The state of California places limits on the "fleet average" emissions of auto manufacturers. Currently, a manufacturer can only sell a certain proportion of "Tier 1" vehicles in relation to the number of "LEV" or low-emission vehicles. Certain other states have copied the California legislation. Volkswagen has stated that the withdrawal from sale of 2000-model TDI vehicles from certain states is due to these reasons. Furthermore, California has declared diesel exhaust to be a toxic air contaminant, although other studies dispute this conclusion. The situation in New York is the same.
   Back to Top

d. **The future - Tier 2**- The USA will be phasing in "Tier 2" emission limits over the next few years. These emission limits are considerably stricter than the Tier 1 limits, and existing TDI engines emit more than the allowable NOx and particles under the Tier 2 limits. On the other hand, the USA will also be phasing in requirements for truly "low sulfur" fuels, which may open up additional options for the auto manufacturers, since sulfur contained in fuel prevents the use of catalysts that can deal with NOx and particles more effectively than at present. Also, the North American auto manufacturers have a number of diesel engines of their own under development. Whether the improvement in emissions technology will outpace the tightening of regulations, is presently anybody's guess. It has been noted elsewhere that by the year 2007, proposed emission limits in certain geographic areas cannot be met by any known diesel technology. If the USA, through its own legislation, shuts out the use of engine technology that cuts consumption of petroleum by 40% and emission of greenhouse gases (CO_2) by a similar amount, it will be a tragic loss. CO_2 emissions are directly in proportion to fuel consumption, there is no escaping this fact.
   Back to Top

e. **Emissions testing** - In most areas with emission testing, diesel-powered light-duty vehicles are only subjected to an "opacity" test, which simply notes how "opaque" (i.e. black) the exhaust is. The clean-running characteristics of the TDI engines virtually ensures that they will pass this test, unless they are running so badly that the owner could not help but notice. In some areas, diesel-powered vehicles are exempted from emission testing altogether. Emissions testing regulations vary from one area to another and change with time. Some areas may do full testing, including testing for NOx, in which case the condition of the EGR system, presence or absence of aftermarket equipment such as "chips" or "boxes", and the general condition of the engine, will all make a difference.
   Back to Top

Back to FAQ Index

TDI FAQ

6) Performance

Back to FAQ Index

---

6) Performance

Disclaimer: While considerable effort has been made to make the information provided in this section as complete and accurate as possible, it does not and cannot cover all possible situations. The authors cannot accept any responsibility for any damages which may occur from the use or mis-use of this document, nor can the authors accept any responsibility for any damages which may result from personal injury or property damage which allegedly may be caused by the use or mis-use of this document. No responsibility is accepted for missing or incorrect information. Those who intend to modify their vehicle shall accept all responsibility for performing the work which may be described below. If you have any comments or suggestions for additions or revisions, please contact the site administrator.

Any mention of specific brand names, manufacturers, vendors, etc. shall not be considered an endorsement, neither in favour nor against. In cases where particular products or services are available from a limited number of sources, we have listed some of these sources purely to enable the reader to be able to find the products or services in question, not as an endorsement, and this doesn't mean that such products or services aren't available elsewhere. In cases where products or services are widely available, we have generally NOT listed any specific sources.

The following sections of this document are organized as follows. First, a general introduction to the operation of a diesel engine is provided so that the concepts behind various modifications can be understood. Next, various modifications are discussed one at a time, and within each section where appropriate, information is provided concerning the benefits, disadvantages, cost, any necessary cautions that may be associated with it which are specific to that particular modification, suggested modifications to go along with this modification to enhance its effectiveness, and finally the "bang for the buck" factor. The final sections discuss issues other than engine-related performance.

Throughout this document, you will see references to VAG-COM. Many diagnostic and calibration procedures cannot be performed without a VW specific diagnostic scan tool. VAG-COM is a reasonably priced software and cable that allow any Windows based computer to be used to communicate with the vehicle's on-board diagnostic system. Generic OBD-II code scanners (such as those which may be found at independent garages that do not specialize in VW/Audi) will normally NOT be sufficient - you need a VW specific scan tool. For more information about VAG-COM and to purchase a copy for yourself, see www.ross-tech.com - highly recommended.

This thread identifies VAG-COM users who may be willing to help:
http://forums.tdiclub.com/NonCGI/ultimatebb.php?ubb=get_topic;f=17;t=000768

Here's a database of VAG-COM users who might be able to help you:
http://www20.brinkster.com/beowulf9/tdi/vagcom/

Know which model you have. If you have a '96 or '97 Passat TDI in North America, you have a B4 chassis with what is known in this document as an A3-style engine, and you have a Garrett GT15 turbocharger. If you have a '97 through early '99 Jetta TDI in North America, you have an A3-style engine and you may have the Garrett GT15 turbocharger but more likely you have a KKK K03-006 turbocharger. If you have a New Beetle TDI, or a '99.5 or later Jetta or Golf TDI in North America, you have an A4-chassis vehicle, and you have a Garrett VNT-15 turbocharger.

The engine code number can be found on the build sheet which is typically near the spare tire on the floor of the trunk. In North America, engine code 1Z means 90hp A3-style engine with Garrett GT15 turbocharger and Pierburg MAF (mass air flow sensor). Engine code AHU means 90hp A3-style engine with KKK K03-006 turbocharger and Pierburg MAF. ALH means 90hp A4-style engine with Garrett VNT-15 turbocharger and Bosch MAF. European models don't necessarily correspond in specifications, engine codes, and model years (you're on your own, as far as figuring out what type of turbo and MAF sensor you have).

Finally, if you are reading this section because of a feeling that your vehicle is down on power, make sure it isn't because there is something wrong with it! Refer to the "Troubleshooting" section of this TDIFAQ.

a. **A General Introduction to Diesel Engine Performance with a Historical Perspective** - The diesel engine operates by drawing air into the cylinders without any fuel (unlike a gasoline engine). The air is compressed much more than is the case with a gasoline engine, then near the point where the piston reaches the end of its compression stroke, fuel begins to be injected at high pressure. Within about a millisecond after fuel injection begins, the fuel ignites in the hot, highly compressed air. Combustion continues as fuel continues to be injected until some time after the piston begins moving down again, then the hot gases push the piston down the power stroke. Then the exhaust valve opens and pushes the spent gases out of the cylinder. This is the basic operating principle behind the 48hp 1.5 litre diesel engine used in the 1976 VW Rabbit ... hardly a performance vehicle.

   The more fuel you inject, the hotter the gases are during the expansion stroke (up to a point ...), the more power you get. But in order to burn fuel and transform it into heat, you also need air. If you inject too much fuel ... rather than more power, you get black smoke. Continue adding fuel beyond that point (which actually occurs over a range of air/fuel ratio, it's not a sharply defined point), and the smoke just gets blacker and blacker.

   Enter the turbocharger, the device which has transformed the modern diesel engine into something capable of being much more interesting than in the old days, by cramming more air into the cylinders and allowing more fuel to be burned before reaching the limits imposed by black exhaust smoke. In the mid eighties, VW fitted a turbocharger to their diesel engine (which now displaced 1.6 litres), bumped up the fuel delivery a bit, and increased power output to 68hp. There was an "ecodiesel" version sold in the USA, which had the turbo but not the increased fuel delivery, in the interest of less smoke from the exhaust ...

   How to improve on the turbocharged diesel engine? Enter the intercooler. Turbochargers increase the pressure of air, but in the process of compression, the air gets hot. The intercooler removes some of that heat, thus increasing the density of the intake air even if the pressure is kept the same. Then the fuel delivery can be bumped up a bit more. There was a version of the earlier turbo diesel engine sold in Europe with an intercooler and increased fuel delivery, with a useful performance boost.

   The saying goes that "there is no replacement for displacement", so in 1993, the displacement of the VW 4 cylinder turbo diesel engine was increased to 1.9 litres, and the standard turbocharged but non-intercooled version developed 75hp.

   But around the same time, a revolution in thermal efficiency and exhaust emissions was about to take place: the electronically controlled direct-injection VW diesel engine, the TDI. Something not mentioned in the first paragraph, is that for a wide variety of reasons, automotive diesel engines have historically been "indirect-injection" ... the fuel is injected near the top of compression stroke into a small chamber adjacent to the main cylinder and the burning mixture then expands into the main chamber, a process which controls the noise level but has a certain amount of heat loss. VW adapted direct injection to their diesel engines, and controlled the noise level and exhaust emissions using sophisticated electronic controls. The turbulence necessary to mix fuel and air within scant milliseconds is achieved using a bowl-shaped chamber in the top of each piston (the bottom of the cylinder head is completely flat). The extreme heat generated by combustion - capable of cracking or melting pistons if not controlled - is dealt with partly by careful design of the injector nozzles, the pistons, and the electronic controls; partly by reducing overall cycle temperature and pressure through the use of the intercooler; partly by oil-spray jets aimed at the bottom of each piston.

Back to Top

b. **Limiting Factors to Diesel Engine Power Output** - The same limiting factors apply to hot-rodders as to original manufacturers, although they may differ in importance for each application.

1. Exhaust smoke. Too much fuel without enough air, especially fuel that is injected long after the piston starts going down ... and you get excessive black exhaust smoke. The standard tuning of a 90hp TDI engine is extremely under-fueled ... there is a rather large safety factor against black exhaust smoke. But it's easily possible to reach the smoke limit by going too far with modifications that add fuel. The amount of exhaust smoke is affected not only by the air/fuel ratio, but also by the timing of the END of the fuel injection period. Fuel which is injected early, and especially that which comes in within a few crank degrees after the end of the compression stroke, has more time to mix with air and burn properly than fuel which is injected late.

2. Exhaust temperature. The more fuel you add, and the longer that fuel injection continues after the piston starts moving down, the higher the exhaust temperature gets. (This response is NOT the same as for a gasoline engine.) Too high, and the exhaust turbine of the turbocharger suffers a meltdown. (Design limits for steady state "turbine inlet temperature" are 750 C / 1382 F for the GT15 and KO3 turbochargers, and 850 C / 1562 F for the VNT15. The author suggests a healthy margin below that.) The deductive reader has already observed that proper injection timing is critical for both smoke and exhaust temperature.

3. Peak cylinder pressure. It's tempting to crank up the boost pressure and advance the injection timing to get rid of smoke, and to a certain extent, this approach is possible. But the design limit for cylinder pressure is within reach, and both of these factors increase the peak cylinder pressure. Too much cylinder pressure, and you'll get blown head gaskets, bent or broken connecting rods, cracked pistons, and who knows what else. Peak cylinder pressure is affected by the boost pressure (more correctly, by the absolute intake manifold pressure), the compression ratio, and the timing of the start of fuel injection. Every 2 degrees of timing advance results in 15 bar (about 10% compared to stock) more cylinder pressure. So you want to run no more boost pressure than necessary to control smoke and exhaust temperature, and no more timing advance under load than necessary for optimum efficiency and to control smoke. At sea level, be very cautious about using more than 18 psi boost pressure and/or more than 12 degrees BTDC timing advance at full load and 3000 rpm ...

4. Piston temperature. Adding more fuel increases piston temperature. Advancing the injection timing under load increases piston temperature ... more reason for using no more

timing advance than necessary. Lowering intake temperature drops it a bit. Increasing boost pressure drops the temperature (because the extra air is diluting the heat due to combustion). Lowering the oil temperature drops the piston temperature a bit (remember those piston-cooling oil-spray jets).

5. Turbo compressor "surge" and "choke" limitations. This is a very complex topic, but to put it into simplified terms, each blade of a turbo compressor acts like a miniature airplane wing. What happens if you try to fly an airplane at a speed which is too low? The wing "stalls", and if uncontrolled, the airplane falls out of the sky. What happens if you ask for too much boost pressure while the amount of flow through the compressor is too low (i.e. too high *turbo* speed but too low *engine* speed)? The compressor wheel goes into "surge" which has harmful effects ... it may be a factor in breaking the shaft of the turbocharger (which has happened on VNT15 turbochargers! - this risk is not zero). The bottom line is that you don't want to reach full boost pressure (18 psi at sea level) until about 2000 rpm, and you want no more than about 6 psi boost pressure at 1500 rpm, to avoid compressor surge. The "choke" limitation of turbochargers limits the flow rate at the TOP end of the operating range, but it won't be an issue in this application unless you are asking for WAY more boost pressure than the turbo and engine can cope with.

6. Mechanical limitations. The device inside the injector pump which controls the amount of fuel being delivered can only go to a certain maximum position before a fault will be detected and the ECU will ruin your day by going into a safe "limp mode" condition.

7. Drivability limitations. The engine control module contains a program for maintaining a steady engine speed at idle and during part-load constant-speed conditions. If the response characteristics of the system are changed too much (e.g. by increasing fuel delivery), unstable operation can occur, which the driver will feel as an extremely annoying shuddering. Aftermarket fuel-adding devices that have an "on/off" characteristic (as opposed to a smooth response to increasing engine load) WILL result in extremely annoying abrupt response.

BOTTOM LINE ... When selecting the engine's operating parameters, whoever is responsible for doing so must have some basic understanding of these limitations! Some popular modifications are "cookie cutter" and these limitations have been dealt with to the extent possible at the design stage. In other cases, YOU are on your own and are responsible for proper calibration of the engine's operating parameters. Where possible, the sections below contain at least a little bit of information to get you started, if this is the case.

The complete engine, turbocharger, intake system, fuel system, emission control system, sensors, and electronic controls must be thought of as a complete integrated system. Changes to one area may have side-effects on other areas which require compensation to make the complete system operate correctly ... and sometimes compensation and/or moderation are required in order to prevent either gradual or catastrophic failure.

Back to Top

c. **Before You Modify** - Make sure your vehicle is in healthy condition!

Before you make a serious investment in something to drastically increase performance beyond stock, check all maintenance items to ensure that your car is in tiptop mechanical condition. There is little point in modifying an engine which is suffering from years of neglect. Pay special attention to the air intake and the intercooler, as these can have a very significant adverse effect on performance if neglected. Make sure all sensors and control devices are operating within proper calibration. (MAF sensors on some models are prone to failure, which will cause serious loss of performance, and sometimes the hoses and solenoids involved with the boost control system malfunction, which will also cause major performance issues even if the problem is a $3 hose. See the Troubleshooting section of this TDIFAQ.)

If your car is more than a couple of years old, restoring it to stock performance level may satisfy your needs. If it doesn't, and you still feel the need for speed and elect to hop up your engine, we recommend using only the best synthetic oil available, and following a religious maintenance schedule of ensuring that the air intake and the intercooler are always in perfect condition. This will minimize the possible adverse effect on engine durability, and ensure that you have the performance you paid for.

Back to Top

d. **Common questions and answers before proceeding further** -

Q. *Is it going to affect my warranty?*

A. ANY modification that you make to the engine or its control systems could provide grounds for a manufacturer or aftermarket warranty supplier to deny a warranty claim.

Q. *Is my engine going to blow up?*

A. Whatever modification you choose, if it is done in moderation and properly set up, the likelihood of serious problems is very low (but not zero). In the later parts of this section that discuss individual modifications, wherever possible, we have provided some information to get you started on proper set-up of whatever it is that you are doing.

Q. *Is it going to use more fuel?*

A. Typically, properly-done modifications to a diesel engine DO NOT significantly increase fuel consumption unless the "extra" power is being requested all the time ... normally not possible in North American driving conditions. It should remain within a few percent one way or the other. The reason is that under part-load conditions that account for the vast majority of normal operation, most properly-done modifications do not significantly change the way the engine operates.

Q. *Can I get <generally some ridiculously large number> HP from this engine?*

A. The standard response for anyone involved in motor racing is this: "Speed costs money. How much do you have?" And it's not a linear relationship, either ... more like exponential. Keep in mind the limiting factors discussed in an earlier section. READ IT AGAIN. A conservative approach to engine tuning, using proven methods and components, will create little or no side effects if done properly. A more aggressive approach requires a certain amount of re-engineering of the vehicle and perhaps accepting some loss in long-term durability. Before setting a lofty horsepower goal, ask some questions. What are you going to be using the vehicle for? What are the essential minimum requirements for it to fulfill that role? What potential benefit is there to going well beyond those requirements and can the resulting expense and potential loss of durability be accepted?

It doesn't take 180 horsepower to cruise at 100 km/h ... or even 180 km/h. A bone stock 90hp engine will do that without any worries. It doesn't take 180 horsepower to do zero to 100 km/h in 8 seconds, either. So set realistic goals. Don't just pick a horsepower number for the sake of having it. For a daily driver vehicle, the overall results of a reasonable and conservative approach will be more satisfactory and less costly to achieve.

Q. *Do I need to change how I maintain the vehicle?*

A. All of the big power adders (chip, box, injectors) add more fuel, and if you use the extra power frequently, there will be an increased amount of soot added to the engine oil. It is advisable to shorten the oil change interval in these situations, and due to the potential for more stress and more heat loading, don't even think about using anything other than synthetic oil of the proper viscosity grade and specification approvals for your vehicle. It's also advisable to keep the air intake system in optimum operating condition, considering all components including air intake screen (if present - consider removing it), air filter, intercooler, and intake manifold.

Q. *Is it going to increase exhaust emissions? Will I fail my annual inspection?*

A. It may or may not affect exhaust emissions, but if properly set up, it is unlikely that the result will be a failed annual inspection. In most locations in North America, light duty diesel vehicles are either not subject to periodic emissions inspection at all, or are only subject to an exhaust opacity ("blackness") test. There may be a visual check that emission control components are in place and appear to be functioning. It takes a very poorly-running TDI engine to fail an exhaust opacity test, regardless of modifications (but see next paragraph). The possible need to pass a visual inspection should be considered before making modifications that are highly visible under the hood, and the procedures used for your local inspection should be considered prior to committing to a large expenditure.

Exhaust opacity tests at idle (most locations), or 2500 rpm no load, or at any constant cruising speed, are easy to pass. If your local jurisdiction does a dynamometer test at full load (most don't) that's a bit tougher, but even so, if your vehicle is properly set up it's not normally a problem. In the sections below, we have attempted to warn about configurations that might be prone to excessive exhaust smoke under load.

Q. *The text in this document says I have to make other changes along with what I want to do. Do I REALLY have to do all that? Why can't I simply do what I want to do and nothing else?*

A. In cases where other changes are recommended, if language such as "It will be necessary to ..." is used, then typically those changes really are necessary in order to prevent a bad side-effect, or at least to reduce the magnitude of the bad side-effect. In most cases, these recommendations are made based upon experience. You may find that if you try to skip steps, sooner or later you'll find out why those other changes were recommended ... hopefully not in the form of a shattered turbocharger or broken connecting-rod ...

Q. *It says in this document that [some combination of modifications] is too much, or that [some setting] is too much. Why?*

A. Typically - past experience, judgment, known limitations, known design documentation, calculations and extrapolations from similar but slightly different variations, and on and on ...

Q. *Why not just import a European model that already has more power?*

A1. For Canada - This CANNOT be done legally. You CANNOT register a vehicle in Canada which was not originally built to North American standards unless it is more than 15 years old. If the vehicle was not originally built to North American standards, Transport Canada WILL NOT allow the vehicle to be registered for the road. You CANNOT modify a vehicle to meet North American standards to satisfy Transport Canada - it has to be built to North American standards originally when it rolled down the original manufacturer's production line. And they don't make anything other than a 90hp TDI to North American standards (as of 2003 model year). Refer to www.riv.ca and link to the import regulations.

A2. For USA - There are authorized vehicle modification facilities that are capable of modifying certain vehicles (not all) to meet North American safety standards, but if it is fitted with an engine that hasn't got EPA's approval, that's going to be a big problem. For all reasonable and practical intents and purposes, it is impossible to import a vehicle into the USA and legally register it for the road if that vehicle was not originally built to North American standards by the original manufacturer (or it is more than 15 years old).

A3. General - Most vehicle registration systems are only concerned with the VIN (Vehicle Identification Number) - the chassis number. They typically don't pay attention to the engine number. There is a theoretical possibility that a drivetrain could be imported somehow (complete with ALL sensors, wiring, electronics, and accessories - typically these aren't the same as North American models) and put into a North American vehicle. No doubt this process isn't legal due to the use of an engine which has not gone through the EPA / Transport Canada approval process, but suppose somehow one finds a way around that. Now you have a vehicle in North America that has parts on it - including some scheduled maintenance parts, like the timing belt - that cannot be obtained through normal channels. You've now spent loads of money, and nobody will know how to fix it, and nobody will be able to get parts for it. And what happens a few years down the road when something better finally comes along? What little resale value is left owing to the difficulty of servicing goes right out the window. FORGET IT.

Back to Top

e. **Discussion of Popular Engine Modifications -**

The following sections discuss popular modifications, starting with the modifications that are most common and WORK, and moving down to modifications that are less common and/or only helpful in conjunction with other alterations, and finally to some things that are either useless, or risky, or extremely expensive for what the benefit is, or require a high degree of skill and/or knowledge to do properly.
Back to Top

1. **The Chip (Chipping)**

   Popular manufacturers available in North America are Upsolute (www.upsolute.com) and Wetterauer (www.chip-tuning.com). Since all operating parameters of these engines are electronically controlled and their operation is governed by a memory chip in the engine ECU (electronic control unit), this modification consists of installing a different program on one or more "chips" contained within the engine ECU to alter the engine's operating parameters. Typically, these chips will slightly increase the maximum turbo boost pressure, considerably increase the maximum quantity of fuel delivered, and may slightly advance the start-of-injection timing under load, but with little or no effect on calibration at part-load conditions.

   Installation: On A3 and B4 vehicles, the affected chips are "socketed" to the main board, so it is possible for an aftermarket chip to be purchased and installed by a moderately competent do-it-yourself mechanic following the manufacturer's instructions. On later models (New Beetle, '99.5-on New Golf and Jetta) the affected chips are soldered to the circuit board and can only be serviced using highly specialized tools, generally only by the vendor of the chip. It is recommended that this task be left to the vendor of the chip in question, in all cases.

   Advantages: Easy, since you don't have to do it yourself. No home calibration or adjustment is necessary (although the fuel injection timing must be properly set to avoid excessive exhaust smoke). Suitable for someone who wants more power but knows very little technically about how the vehicle operates. Completely invisible to the eye, and to electronic scan tools unless the user of the scan tool knows specifically what to look for and is specifically testing for it. There is a large power gain, instantly noticeable when driving the vehicle. All vehicle diagnostic and sensor-checking functions remain intact.

   Disadvantages: For later models, it is difficult (but possible) to reverse the modification should the need arise. For earlier models, reversing the modification is straightforward due to the socketed chips. It's hardly an issue ... you'll never want to go back to stock anyway. You are your own warranty.

   Cost factor: US$300 - US$500 range

   Cautions specific to this modification: Injecting more fuel using the stock injectors inherently extends the injection period later in the power stroke, so exhaust temperature will go up during prolonged operation at greater than the stock power output. Due to richer air/fuel and extended injection period, the tendency is towards more smoke in the exhaust, but normally the chip manufacturers stay within limits of exhaust smoke that are acceptable to most people and within limits of acceptable exhaust temperature. The vehicle will be more sensitive to fuel quality and proper setup of the injection timing for exhaust smoke. Set injection timing within specifications per shop manual but close to the "advanced" limit in order to ensure that the pump has enough capability to provide sufficient timing advance under load, otherwise exhaust will be smokier than necessary and the exhaust temperature will be higher than necessary. *DO NOT* use the "adaptation" settings in VAG-COM to provide more timing advance than the chip already specifies.

Suggested modifications in parallel: Turbo boost gauge; exhaust gas temperature gauge if vehicle is used for trailer towing or for prolonged operation near maximum speed and load; larger oil cooler. De-restricted intake and exhaust systems won't hurt.

"Bang for the Buck": If in doubt, DO IT!

What if I want more? A chip can be made to work with the next size bigger injectors, although it may take some effort (see later section). If any problems arise because of this, you are on your own to solve them. Clutch slippage, turbo damage, and high exhaust temperature are potential issues if modifications go far beyond that of a chip. Some people have run tuning boxes together with a chip, but this defeats the safety margins that the chip and box programmers have each individually built in, and there is a high probability that the maximum fuel delivery of the injector pump will be reached, causing all sorts of drivability and "check engine" problems. Dyno testing has found limited benefit from chip and box together ... typically there is more clutch-destroying torque, but little more peak power.

Back to Top

2. **Tuning Boxes**
   There are too many different suppliers of "tuning boxes" to list here. In some cases, the same device is sold under different names. They vary from simplistic passive electrical circuits to microprocessor-controlled devices. Some have multiple adjustments to allow calibration to different operating conditions and some are "plug and play" with no adjustment possible. All tuning boxes operate by altering the communication between the fuel injection pump and the engine ECU so as to increase fuel delivery under certain conditions. Typically, tuning boxes will considerably increase the maximum amount of fuel delivered at full load, will not change the steady-state boost pressure, and may or may not have some effect on injection timing.

   Installation: Plug-and-play types are easy for the do-it-yourself mechanic following the manufacturer's instructions. Generally, unplug the large electrical plug at the injector pump, plug the box in so that it is now "in between" the two parts of the injector pump's electrical plug. Most boxes require one wire to be spliced into the wiring harness of the vehicle, either at the MAF sensor, the accelerator pedal position sensor, or the manifold air pressure sensor. Soldering may be required to do this, or the box manufacturer may provide suitable plugs to allow it to be done without disrupting stock wiring harnesses. Adjustable types may require experimentation following installation in order to get the settings right ... if you have a non-standard configuration, expect this calibration to take a lot longer than actually installing the device. PLEASE ASK QUESTIONS RELATED TO A SPECIFIC UNIT TO THE VENDOR OR SEARCH EXISTING THREADS ON THE FORUMS to avoid creating unnecessary forum traffic.

Advantages: Relatively easy installation, possible for the do-it-yourself mechanic. Some types have fine-tuning adjustments which can either be left alone or customized to a given application. Plug-and-play types are suitable for someone who wants more power but knows very little technically about how the vehicle operates. The modification is readily visible but easily removed should the need arise. Electronic scan tools may not display correct sensor values due to the way the box modifies some stock signals in order to perform its job. There is a large power gain, instantly noticeable when driving the vehicle, but typically gains are smaller than achieved by a chip. All vehicle diagnostic and self-checking functions remain intact but the accuracy of some sensor displayed values may be affected - easily solved by temporarily removing the box from the system.

Disadvantages: The modification is readily visible but easily removed should the need arise. On boxes that require a spliced or soldered wiring harness connection, that connection (even if unplugged) is going to be more or less visible (depending on where you put it) and not easily removed. Some tuning boxes have been known to cause drivability problems and "check engine" lights under certain conditions. Sometimes the adjustable boxes can be adjusted to eliminate these faults, but not always. You are your own warranty. Boxes with multiple adjustments allow fine-tuning to arrive at an optimum setting, but having the ability to adjust something inherently means that there are far more possible ways to get it wrong rather than right. But boxes with no adjustments cannot be adjusted if they don't work in your particular application. PLEASE ASK QUESTIONS RELATED TO A SPECIFIC UNIT TO THE VENDOR OR SEARCH EXISTING THREADS ON THE FORUMS to avoid creating unnecessary forum traffic.

Cost factor: US$200 - US$400 range

Cautions specific to this modification: Injecting more fuel using the stock injectors inherently extends the injection period later in the power stroke, so exhaust temperature will go up during prolonged operation at greater than the stock power output. Due to richer air/fuel and extended injection period, the tendency is towards more smoke in the exhaust, but normally the box manufacturers stay within limits of exhaust smoke that are acceptable to most people and within limits of acceptable exhaust temperature. The vehicle will be more sensitive to fuel quality and proper setup of the injection timing for exhaust smoke. Set injection timing within specifications per shop manual but close to the "advanced" limit in order to ensure that the pump has enough capability to provide sufficient timing advance under load, otherwise the exhaust will be smokier and exhaust temperature will be elevated. *DO NOT* use the "adaptation" settings in VAG-COM to provide more timing advance than the box already specifies.

Suggested modifications in parallel: Exhaust gas temperature gauge, if vehicle is used for trailer towing or for prolonged operation near maximum speed and load; larger oilcooler. De-restricted intake and exhaust systems won't hurt.

"Bang for the Buck": Generally very good, but beware of potential problems, especially if you are trying to use the box together with another major power-adding modification. Power gains are typically going to be less than that of a chip, due to the inability of currently available tuning boxes to do anything about the boost pressure.

What if I want more? Some people have run tuning boxes together with a chip, but this defeats the safety margins that the chip and box programmers have built in, and there is a high probability that the maximum fuel delivery of the injector pump will be reached, causing all sorts of drivability and "check engine" problems. If you see yourself wanting more power than the box provides on its own, then this may not be the best way to go, because if you want to burn more fuel then you need more air, and boxes available to this date do not affect the boost pressure. Using a tuning box together with bigger injectors may or may not work, but it typically isn't the best way to go unless the box is specifically set up for the bigger injectors, because neither box nor injectors specify more intake air than standard, and you'll need more air if you want more power rather than black smoke.

Back to Top

3. **Bigger Injectors**

If you have a vehicle with a 90hp TDI and 5-speed manual transmission, you have injectors with 0.184mm orifices. If you have a 90hp TDI with automatic transmission in North America, you have injectors with 0.158mm orifices and a higher-pressure injector pump so as to push the same amount of fuel through these smaller injectors (for emissions reasons, at a cost of increased stress on the components and increased engine noise). The European 110hp model has what are known as 0.205mm injectors, and the European "Multivan" 150hp 5-cylinder TDI has what are known as 0.216mm injectors. All of these injectors are dimensionally interchangeable, so it is possible to install injectors one or even two sizes larger in place of the original ones. This will increase fuel delivery without the engine ECU knowing a thing about it, and it will do it without pushing the limits of the injector pump, nor will it extend the duration of the injection period - and not extending the duration is better for smoke, power, exhaust temperature, and efficiency.

Larger injectors are available in North America from www.dieselgeek.com (USA) or www.autobraun.com (Canada). Refer to the "Allowable combinations" table below before committing yourself to anything. You cannot order these parts from a North American VW dealer.

For the 90hp 4-cyl 5 speed injectors (known as 0.184 injectors) here are the

part numbers you'll need (upgrade for automatics in North America only):
(Qty 3) - 028 130 202 P (there may be a suffix on the end indicating that it is reconditioned)
(Qty 1) - 028 130 202 Q (there may be a suffix on the end indicating that it is reconditioned)

For the 110hp 4-cyl injectors (known as 0.205 injectors) here are the part numbers you'll need:
(Qty 3) - 028 130 201 T (there may be a suffix on the end indicating that it is reconditioned)
(Qty 1) - 028 130 201 S (there may be a suffix on the end indicating that it is reconditioned)

For the 150hp 5-cyl T4 Multivan injectors (known as 0.216 injectors - biggest commercially available) here are the part numbers you'll need:
(Qty 3) - 074 130 201 K (possibly with a V on the end indicating reconditioned rather than new)
(Qty 1) - 074 130 202 R (possibly with V on the end)

Don't worry about reconditioned versus new. Reconditioned injectors contain all new working parts inside a re-used housing, and are quite a bit less expensive. Also don't worry about the opening pressure of the injectors, it affects the idle settings a bit but not much else.

Installation: This modification is not recommended for people who don't have good vehicle wrenching ability and troubleshooting skills. Professional installation might be possible, but if you're not comfortable doing this installation yourself, then you probably don't have the required skills and knowledge to troubleshoot and correct any problems or side-effects that may occur. The mechanical part of the installation is fairly straightforward, but you will need VAG-COM to recalibrate some functions in the ECU (easy if you have it ... www.ross-tech.com), and some engine/injector/ECU combinations will require physical modifications to the turbo boost control system in order to get more air into the engine without blowing something to smithereens. To install the injectors, remove the clamps that tie pairs of injector lines together, loosen lines 1 and 4 at the pump end and remove them at the injector end. (Note the relatively low torque, not counting the initial "crack" to break the fitting loose.) Remove the clamps that hold injectors 1 and 4 down. Remove the drain-back hoses from injectors 1 and 4. Remove injectors 1 and 4 by applying a twisting action with a 15mm wrench while pulling up on the injector. Clean soot out of the seating surface in the hole in the cylinder head. Stick a new copper sealing washer to the new injectors with a dab of grease on the washer, slip them in, and torque the clamps to 20 lb.ft. Re-install all injector lines and tighten the lines at the pump. (Do not overtighten these fittings!) Start the engine (it will run on two cylinders at first) - run it for 5 seconds after the idle smooths out. Then repeat this process for injectors 2 and 3, remembering to deal with the electrical plug for #3, and transfer the drain-back fitting from the old #3 injector to the new one. Following completion of this, connect VAG-COM, and re-calibrate the EGR per section 7.j of this

TDIFAQ, and re-calibrate the fuel delivery at idle to about 3 mg/stroke if you have a stock ECU and you only went up one injector size, or to the leanest possible setting (i.e. biggest reported number that can be achieved within specs) if you went up two injector sizes with a stock ECU or if you went up one injector size with a chipped ECU. On vehicles equipped with a VNT15 turbo, you should back off the initial response of the turbo to avoid dangerous operating conditions at low engine RPM and high engine load - see item 4b on boost control system modifications later in this document.

Advantages: Larger injectors are unique among the major power adders in that they inject a larger amount of fuel within the same amount of crankshaft rotation, and thus, for a given power delivery, they keep smoke and exhaust temperature to the minimum while also avoiding the increase in peak cylinder pressure caused by over-advanced start-of-injection timing. Given that the 110hp VW TDI engine is almost identical to the 90hp except for larger injectors, and that the 190hp "race TDI" developed by VW Motorsport uses even larger injectors but roughly the same injection timing and duration as stock, this method would appear to be the one favored by the engineers who develop the VW TDI. All injectors other than 0.216 look the same other than the part number, so the modification is invisible to the eye, and in the case of the 0.216 injectors, it takes a knowledgeable eye to spot a minor difference. This modification is transparent to electronic scan tools. Power gain will range from mild to wild depending on how big you go, but will be easily noticeable when driving the vehicle. All vehicle diagnostic and sensor-checking functions remain intact although the reported fuel delivery will no longer be accurate since the ECU has no way of knowing about the extra fuel being injected.

Disadvantages: Beyond the start we've given you in the "installation" section and the "Allowable Combinations" section below, you're on your own for ironing out any hiccups that may occur and not breaking something expensive in the process. You are your own warranty. You might need a different setting for reported fuel quantity at idle if you run into shudder problems (leaner - i.e. larger reported quantity - tends to reduce shuddering). Some ECU and chip and injector combinations may have shudder problems that cannot be resolved without going to a different chip, and not all combinations have been tested by someone. For example, the Upsolute chip for the '96 Passat "BK" ECU is not at all compatible with 0.216 injectors and (to my knowledge) has not been tested with 0.205 injectors, but the stock chip for the same ECU is OK with 0.216 injectors if AND ONLY IF reported idle fuel quantity is set at 6.4 mg/stroke. For the '97 Passat and Jetta, the Upsolute chip is compatible with the 0.205 injectors, although you'll need more boost pressure than the chip specifies. For the later models, no compatibility issues have been reported as far as drivability is concerned - but see the "Allowable combinations" table below.

Cost factor: US$550 - US$700 range, and you had better have VAG-COM (www.ross-tech.com - about US$200).

Cautions specific to this modification: Since the ECU doesn't know about the extra fuel, it's up to you to either find settings that control exhaust smoke and exhaust gas temperature (if possible), or drive in a way that doesn't cause issues (not a good solution to require this to be done). READ THE "ALLOWABLE COMBINATIONS" SECTION CAREFULLY FOR YOUR PROPOSED SETUP. Most of that is based upon experience, and if you skip steps, sooner or later you're likely to find out why those other modifications are recommended. On A4-chassis 5-speed vehicles, going 2 injector sizes up with stock ECU or 1 size up with chipped ECU is likely to cause clutch slippage ... figure on an upgraded clutch. On automatic transmission vehicles, beware of exceeding the transmission torque limits, which are not known at this writing, but whoever finds out is in for an expensive lesson. On vehicles with VNT15 turbo and manual transmission, beware of high-load operation at low engine revs (see turbo discussion in "Limiting Factors" above, and item 4b - boost control system modifications - below).

Suggested modifications in parallel: Better clutch on A4-chassis manual transmission, if modifications more aggressive than 1 size bigger injectors with stock chip are done. Better final drive and differential (Quaiffe or Peloquin with bolted ring gear - only possible on manual transmission). Refer to the "Allowable Combinations" section below, for additional changes that may be necessary for specific installations. Refer to item 4b (boost control system modifications) as well. A larger oilcooler may also be a good idea

"Bang for the Buck": Pretty good, if you're capable of sorting out the ECU issues with VAG-COM and sensor tweaks, and you don't skip steps, and you don't try to do something that cannot be done. Lousy, if you bit off more than you can chew, or if you have no clue about sorting out those issues, and end up going back to stock or buying more parts in order to get a more conservative setup that's more suitable for normal use. The difficulty of sorting out these issues will depend on how wild you choose to go ... the wilder you go, the tougher the issues are going to be to deal with. See "Allowable combinations" discussion below.

What if I want more? Install a better intercooler and max out the fuel delivery, provided that your ECU will allow it without causing unacceptable shudder. Custom chip programming. Bigger turbo (which won't do anything without custom chip programming). Lower compression ratio (which you had better do if you go much beyond 18 psi boost pressure). Quaiffe or Peloquin final drive. Better bring lots of money ...

Allowable combinations of injectors and other modifications

This section is formatted as "If you are starting with ... then you can install ... provided that you also do ... subject to the following risks ...". See elsewhere in this FAQ for the "also recommended" modifications. ECU recalibration information is in the Maintenance Procedures section of this FAQ. Boost bleed for A3 and B4 vehicles is discussed in a later section (can't do it that way on an A4). Mechanical boost controllers are discussed in the Troubleshooting section of this FAQ under the topic "Fluctuation of boost pressure". It is highly recommended that a boost gauge be installed in the vehicle, for any situation where the corrective measures listed involve changing anything related to turbo boost control.

On A4-chassis vehicles, it is possible to fit an automatic's 11mm injector pump to a vehicle with a manual transmission. This document doesn't explicitly address this possibility, largely because it is an expensive modification and has only been done on a very small number of vehicles. If you propose to do this, then for purposes of interpreting the following data, pretend that fitting an 11mm pump in place of a 10mm pump is like installing injectors that are one size larger. (11mm pump with 0.184 injectors is like a 10mm pump with 0.205 injectors, etc.) If you have an A3 or B4 vehicle, the A4-chassis injector pump's wiring harness is not compatible, although we've heard that it is possible to make it work given enough effort. The 11mm pump is only available in A4-chassis form and can therefore only be fitted to an A3 or B4 with considerable difficulty due to the wiring differences.

Fuel system and engine control components from "pump-duese" engines are not at all compatible with the distributor-pump engines. This discussion pertains only to the 90hp distributor-pump engines as sold in North American specification through model year 2003. The 110hp distributor-pump engine already has 0.205 injectors as standard.

If you are starting with an A3 or B4 with stock chip and no tuning box, you can install 0.205 injectors provided that you recalibrate the EGR system so that maximum possible intake air is specified, and if you experience rough idling or shuddering at light load, recalibrate reported injection quantity at warm idle to around 3.0 mg/stroke. There shouldn't be any difficult issues to resolve. Power gains will be moderate ... probably a bit less than a chip with stock injectors, but this solution more closely resembles VW's official solution for the 110hp model (see "Advantages" above). Only install a tuning box if it is specifically suitable for use with this chip and injector combination.

If you are starting with an A3 or B4 with stock chip and no tuning box, you can install 0.216 injectors provided that you recalibrate the EGR system so that maximum possible intake air is specified, and recalibrate reported injection quantity at warm idle to around 5 to 7 mg/stroke (shuddering and drivability problems will probably be limiting factors - larger reported quantity helps both issues), and you install a bleed on the pressure sensing line that goes to the ECU so that the resistance upstream (to sensing line) and downstream (to atmosphere) of the ECU sensing port is about equal, and you install a mechanical boost controller in parallel with the standard N75 system calibrated to 17 psi maximum boost pressure which experience has been found is sufficient to adequately control exhaust smoke - fine-tune up or down if required, without exceeding 18 psi boost pressure. Tuning boxes will probably not work in this application - if you're having trouble controlling shuddering and/or exhaust smoke, adding more fuel is the last thing you want to do. There shouldn't be any issues beyond those discussed here. This configuration has been tested (author's vehicle), and has proven to work very well after the initial hiccups were ironed out, with acceleration tests showing power slightly greater than that of a chip with stock injectors in the same vehicle, *BUT* you need to be capable of dealing with the side effects!

If you are starting with an A3 or B4 with Upsolute or Wetterauer chip and no tuning box, you can install 0.205 injectors provided that you recalibrate the EGR system so that maximum possible intake air is specified, and recalibrate reported injection quantity at warm idle to around 5 to 7 mg/stroke (fine tune for shudder and/or exhaust smoke), and you install a bleed on the pressure sensing line that goes to the ECU so that the resistance upstream (to sensing line) and downstream (to atmosphere) of the ECU sensing port is about equal, and you install a mechanical boost controller in parallel with the standard N75 system calibrated to 18 psi maximum boost pressure which is the maximum allowable. You'll be fighting hard to control exhaust smoke with this configuration, and it may not be possible to completely solve the problem. A bigger intercooler, although costly, is really what is required. Although similar configurations have been tested on several vehicles, long term durability under high load conditions is not proven, since the power output will considerably exceed standard and is well beyond that of a chipped engine with stock injectors. Do not use any type of tuning box in this application - you've already got too much fuel. Clutch problems are likely ... see elsewhere in this TDIFAQ. Drag-racers should upgrade the final drive and differential. Remember, YOU ARE YOUR OWN WARRANTY.

If you are starting with an A3 or B4 with Upsolute or Wetterauer chip, don't even think about 0.216 injectors unless you're prepared for internal engine work to lower compression, a slightly larger turbo (but not too much!) such as a VNT17, custom intercooler, upgraded clutch, upgraded final drive, extra oil cooling, probably custom ECU programming to deal with all the issues that will occur. This will cost thousands of dollars to get right. Long term durability under high load conditions is not likely to be very good. We know of one engine with a similar configuration, having about 150hp to the wheels (roughly double the stock figure!), which suffered cracked pistons after about 80,000 km of admittedly hard driving.

If you are starting with an A4 5-speed manual with stock chip and no tuning box, you can install 0.205 injectors provided that you recalibrate the EGR system so that maximum possible intake air is specified, and if you experience rough idling or shuddering at light load, recalibrate reported injection quantity at warm idle to around 3.0 mg/stroke. There shouldn't be any difficult issues to resolve ... you're basically changing a 90hp into a 110hp. Power gains will be moderate, probably a bit less than using a chip ... but see "Advantages", above. Only install a tuning box if it is specifically intended for use with this chip and injector combination. Since you are your own warranty, it's worth checking whether you are getting boost pressure too close to the "surge" regime and making adjustments if required ... see separate section 4b below.

If you are starting with an A4 5-speed manual with stock chip and no tuning box, it seems likely that you can install 0.216 injectors provided that you recalibrate the EGR system so that maximum possible intake air is specified, and recalibrate reported injection quantity to a value that has yet to be determined but within the specification range of 2.2 to 9.0 mg/stroke (probably higher in the range) to control exhaust smoke. This combination hasn't been tested to this author's knowledge, but based on the A4's stock boost pressure being quite close to the final configuration of a B4 test vehicle with these injectors, it should work out with a bit of fine tuning. Exhaust smoke will likely be marginal at full load, though. It is strongly advised that the initial response of the turbocharger be de-tuned to avoid "surge" operation, per section 4b below, to preserve the turbocharger. Clutch problems are possible with this arrangement ... see elsewhere in this TDIFAQ. Tuning boxes will probably not work in this application - the smoke situation will be marginal, so adding more fuel won't help.

If you are starting with an A4 5-speed manual with Upsolute or Wetterauer chip and no tuning box, you can install 0.205 injectors provided that you recalibrate the EGR system so that maximum possible intake air is specified, and recalibrate reported injection quantity at warm idle to around 4 mg/stroke (fine tune for exhaust smoke), and make the turbo negative VNT adjustment indicated in section 4b below - DO NOT skip this step, it is vital to the life of your turbo. Although similar configurations have been tested on several vehicles, long term durability under high load conditions is not proven, since the power output will considerably exceed standard. Do not use any type of tuning box in this application - you've already got too much fuel. Clutch problems are almost a certainty ... see elsewhere in this TDIFAQ. Drag-racers should upgrade the final drive and differential. Remember, YOU ARE YOUR OWN WARRANTY.

If you are starting with an A4 5-speed manual with Upsolute or Wetterauer chip, don't even think about 0.216 injectors unless you're prepared for internal engine work to lower compression, a slightly larger turbo (but not too much!) such as a VNT17, custom intercooler, upgraded clutch, upgraded final drive, better oil cooling, custom ECU programming to deal with all the issues that will occur. This will cost thousands of dollars to get right. Long term durability under high load conditions is not likely to be very good.

If you are starting with an A4 automatic with stock chip and no tuning box, you can install 0.184 injectors provided that you recalibrate the EGR system so that maximum possible intake air is specified, and if you experience rough idling or shuddering at light load, recalibrate reported injection quantity at warm idle to around 3.0 mg/stroke. Only install a tuning box if it is specifically intended for use with this chip and injector combination. There shouldn't be any difficult issues to resolve.

If you are starting with an A4 automatic with stock chip and no tuning box, you should be able to install 0.205 injectors provided that you recalibrate the EGR system so that maximum possible intake air is specified, and recalibrate reported injection quantity at warm idle to around 3.0 mg/stroke, possibly a larger number if exhaust smoke proves to be an issue. This particular combination, at the time of this writing and to the knowledge of this author, has not been tested. Do not use any type of tuning box in this application, it will be marginal on exhaust smoke without adding still more fuel.

If you are starting with an A4 automatic with stock chip, don't even think about the 0.216 injectors, it will smoke too much.

If you are starting with an A4 automatic with Upsolute or Wetterauer chip and no tuning box, you can install 0.184 injectors provided that you recalibrate the EGR system so that maximum possible intake air is specified, and recalibrate reported injection quantity at warm idle to around 3.0 mg/stroke, or possibly slightly greater if exhaust smoke proves to be an issue. Do not use any type of tuning box in this application, it will be marginal on exhaust smoke without adding still more fuel. This configuration has been tested on quite a few vehicles with no known issues at this writing. Long term durability of the automatic transmission in this application is not known.

If you are starting with an A4 automatic with Upsolute or Wetterauer chip, don't even think about 0.205 or 0.216 injectors unless you have a transmission rebuild in the budget ... in addition to all the other things you'll need to control the exhaust smoke.

Back to Top

- **4a. Boost Control System Modifications - A3 and B4 cars with GT15 or KO3 turbochargers -**
  This discussion must be separated into two parts due to the completely different operating characteristics of the wastegate-type turbochargers from the VNT-type turbochargers. This first subsection focuses on the wastegate-type turbochargers.

  The purpose of these modifications on the wastegate-type turbochargers is to increase the steady-state boost pressure while greatly reducing the overshoots and fluctuations of boost pressure that are characteristic of the stock boost control system. This modification is only useful if other modifications (e.g. injectors) have been made that result in unacceptable exhaust smoke with the stock boost pressure. It is not to be done unless there is smoke from the exhaust and other causes of smoke (wrong injection timing, bad injectors, bad MAF sensor, EGR calibration problems) have been ruled out.

  We can take no responsibility for what you do to your own car. Be aware that if you choose to do this, you are on your own. If you blow something up, you did it, not us. This modification can be made very cheaply but BE CAREFUL! It's very easy to blow something up by using too much boost pressure. Don't even think about messing with this unless you first install a boost gauge so you can watch what's happening. On the A3 models, the red hose in the engine compartment is boost pressure straight from the compressor discharge - easy to tap a pressure gauge into. To avoid false readings, the gauge connection should be made adjacent to the turbo or manifold before any signal-modifying bleed devices or mechanical boost controllers.

The boost pressure is controlled using a sensor which is inside the ECU. There is a small black hose which attaches to the intake manifold just where the intake manifold turns down towards the engine. (Make sure you're looking at the elbow that turns down towards the engine itself, not the one that turns down and goes into the turbocharger!) If you trick the engine computer into seeing less boost than there really is, then the engine computer will control it to a higher level. This is only useful if you have done other things that increase fuel delivery, and you need more air to control smoke and exhaust temperature as a result.

For a detailed discussion on this matter, follow this link:
http://forums.tdiclub.com/cgi-bin/ultimatebb.cgi?ubb=get_topic&f=4&t=000529

It has been found advisable to use a mechanical boost controller in parallel with the stock boost control system if you do this. Refer to the Troubleshooting section of this FAQ, under the symptom "Fluctuation of boost pressure".

Do not operate the standard turbocharger at more than 18 psi boost pressure at sea level. (This must be de-rated in proportion to barometric pressure at higher altitudes.) Do not operate an engine with a stock compression ratio at higher than 18 psi boost pressure under any circumstances.

Installation: Straightforward for the knowledgeable do-it-yourself mechanic. Professional installation isn't really feasible, because most mechanics won't have a clue about how this is going to work and won't want to chance it.

Advantages: For vehicles that have higher fuel delivery than stock, this provides a method of controlling the smoke, and the mechanical boost controller provides control of the boost spikes and fluctuation that are characteristic of the stock boost control system.

Comments: Only worth doing on a highly tuned vehicle.

Disadvantages: A boost gauge is MANDATORY if modifications are done to the stock boost control system, and the driver is well advised to pay attention to that gauge, since these modifications remove the built-in safety features of the electronic control system. You are your own warranty. Remember ... no more than 18 psi boost pressure, under any circumstances!

Cost factor: Next to nothing for the bleed device, $35 for the mechanical controller from www.dawesdevices.com - and figure on another $100 or so for a boost gauge and a place to put it.

Cautions specific to this modification: YOU are responsible for making sure that you don't do something destructive to your vehicle.

Suggested modifications in parallel: This is only appropriate for a highly tuned vehicle with chip and injectors, that needs close to the limit of boost pressure (18 psi) in order to control exhaust smoke. A larger oilcooler may also be a good idea

"Bang for the Buck": Good.

What if I want more? Since this modification is only appropriate for a vehicle that already has more and is smoking badly as a result ... you already have more..
Back to Top

4b. Boost Control System Modifications - A4 cars with VNT turbochargers
This discussion must be separated into two parts due to the completely different operating characteristics of the wastegate-type turbochargers from the VNT-type turbochargers. This second subsection focuses on the VNT-type turbochargers.

4b.1. Foreword and Disclaimer

This section discusses modifications intended to *prevent* turbo damage, so NOT doing anything about it may actually be the more dangerous scenario. Nevertheless, we can take no responsibility for what you do to your own car. Be aware that if you choose to do this, you are on your own. If you blow something up, you did it, not us. BE CAREFUL! It's very easy to blow something up by using too much boost pressure. Don't even think about messing with this unless you first install a boost gauge so you can watch what's happening.

The purpose of these modifications is NOT to increase the steady-state boost pressure (which is already higher than the older vehicles use, and very close to the safe upper limit if the vehicle is "chipped") but rather to control the fluctuations of boost pressure characteristic of the stock boost control system, and to REDUCE the amount of boost pressure at low engine speeds in the interest of preserving the turbocharger by avoiding operation in the "surge" regime. This will actually *reduce* responsiveness at low engine speeds, but it is a necessary step to preserve the life of the turbo, if other modifications which increase fuel delivery at low engine speed have been done. These modifications are only useful if other modifications (e.g. injectors) have been made that result in either unacceptable exhaust smoke or power fluctuation due to fluctuations in boost pressure that the stock boost pressure control system cannot control, or unacceptably high boost pressure at engine speed below 2000 rpm. The VNT turbo must not reach full boost pressure until above 2000 engine rpm, and should preferably produce no more than about 6 psi boost pressure at 1500 rpm, to avoid operating the compressor in the highly damaging "surge" regime. Turbo manufacturers recommend staying at least 10% clear of operation in the surge regime.

Since the A4 cars do not have any small-diameter hoses which carry boost pressure, it will be necessary to install a suitable fitting to access boost pressure. This fitting should preferably be located as close as possible to the turbo compressor outlet, such as on the lower intercooler pipe ... remove the pipe from the vehicle to install the fitting there. In order to facilitate future removal of this pipe for timing belt changes, use some sort of quick-connect

detachable fitting to your new boost signal hose.
Back to Top

4b.2. Test Procedure for Turbo Calibration - Low Speed Regime

If you have an automatic transmission, you don't need to worry about operating the turbo in the "surge" regime. At full engine load, the transmission will either downshift to a lower gear or unlock the torque converter, and in either case, the engine speed will be above the critical zone. Nevertheless, it may be worth performing a test similar to what is described below, and confirm that the transmission downshifts if floored at 2000 rpm in top gear before the boost pressure reaches 18 psi, and downshifts if floored at 1500 rpm in top gear before boost pressure reaches 6 psi in response to smooth application of pedal.

On manual transmission vehicles, to test whether you have a potential "compressor surge" issue, install a boost gauge, and then in 5th gear on level ground, preferably at an altitude of not more than 1000 metres, abruptly floor the accelerator at 1900 rpm and note the boost response. Ideally, it should smoothly rise to a peak which is not more than 18 psi somewhere near 2000 rpm. Try tramping the pedal to the floor at engine speeds between 1900 and 2100 rpm. It should never exceed 18 psi in this speed range. Not even for a split second. If it passes the tramp-the-pedal test, try accelerating through that speed range starting at slightly lower speeds and try it in different gears - confirm that initially after flooring the pedal, the boost pressure is lower than its eventual peak when below 2000 rpm, and that the peak is not reached until 2000 rpm. If it passes THAT test, reduce speed to 1500 rpm, and see if you can get more than 6 psi boost at 1500 rpm (don't floor it at this speed unless a few initial tests at part load suggest that you can floor it without exceeding that pressure). If it ever exceeds 6 psi at 1500 rpm or 18 psi at 2000 rpm, or if the peak boost pressure - whatever it is set to - is reached before 2000 rpm (never mind what happens at higher engine speeds), then you have a potential "compressor surge" issue, and you should consider performing the "negative VNT adjustment". Turbo manufacturers recommend staying 10% clear of the surge regime, and if you get it so that it passes these tests no matter what you try, you'll be around 10% clear of the surge line. (Don't be surprised if a bone-stock TDI fails this test procedure ... no chip no tuning box no injectors no nothing. Stock calibration is extremely close to the surge regime and normal production tolerances may put it into the surge regime.)
Back to Top

4b.3. VNT Linkage Adjustment

To slow down the rate of boost pressure rise at low engine speeds, using a 10mm wrench and suitable hand tools, release the locknut of the VNT linkage (located above the diaphragm housing on the turbo) and adjust it 1 turn in the direction of lengthening the linkage, then re-tighten the locknut. YOU ARE NOW YOUR OWN TURBO WARRANTY. (If your vehicle was hot-rodded such that this modification was needed, you were already your own turbo warranty anyway, but hopefully the turbo is less likely to blow apart now.)

NEVER NEVER NEVER shorten the length of this linkage to less than it was stock. Attempting to increase the boost pressure at low engine speeds, or attempting to get the turbo to accelerate to full boost faster (which will cause a massive overshoot) is asking for a blown turbo. It has happened, so don't neglect this possibility!!
Back to Top

4b.4. Test Procedure for Boost Control System Response

After performing the above procedures, to test whether you have a potential "spike" issue, in high gear at 2500 rpm, abruptly floor the accelerator and note the boost response. In the ideal world, it'll go smartly to the boost setpoint (which is not more than 18 psi) and stay there, but in reality with the stock boost control system, you'll get some overshoot. If it overshoots and fluctuates wildly before settling down, you need to do something to control boost spikes. If it survived this test at 2500 rpm, try it at 3000 rpm. Remember that 18 psi is the safe limit for continuous operation at sea level and this must be de-rated in proportion to barometric pressure at higher altitudes. If you're scared by what you see (and if you drive like that!), you need to do something to control boost spikes!

A mechanical boost controller in parallel with the stock boost control system can be installed as per the Troubleshooting section of this FAQ, under the symptom "Fluctuation of boost pressure". It is critical that any vent hole in this boost controller be soldered closed to prevent a vacuum leak, and this boost controller will ONLY work in parallel with the stock boost control system so as to eliminate spikes. It cannot be used to raise the boost pressure beyond standard. Do not operate the standard turbocharger at more than 18 psi boost pressure at sea level. Do not operate an engine with a stock compression ratio at higher than 18 psi boost pressure.

Installation: VNT adjustment is straightforward for the home mechanic but you're playing with something that costs several thousand dollars to replace - that's the scary part. Boost controller and boost gauge installation is more involved due to the need to partially disassemble things in order to install the fitting and gauge, and get the boost controller calibrated. Professional installation may be possible but ordinary garage mechanics probably won't want to touch it. If your vehicle has side curtain airbags and a "double DIN" radio, you're going to have a tough time finding a place for a permanent boost gauge.

Advantages: For vehicles that have higher fuel delivery than stock, this provides a method of controlling the boost spikes and fluctuation that are characteristic of the stock boost control system, in order to avoid potentially dangerous operation of the turbo in the "surge" regime, and in order to avoid potential overspeed of the turbo or engine damage due to overboost conditions.

Comments: A boost gauge is MANDATORY if modifications are done to the stock boost control system.

Disadvantages: You are your own warranty.

Cost factor: Nothing for the VNT adjustment, $100-ish for the gauge and fittings, $35 for the mechanical controller from www.dawesdevices.com - note that the installation will be non-standard per "Troubleshooting - Fluctuation of Boost Pressure" section of this TDIFAQ.

Cautions specific to this modification: YOU are responsible for making sure that you don't do something destructive to your vehicle. But if you have done other modifications, be aware that NOT doing this may be more dangerous than doing it.

Suggested modifications in parallel: None as a result of this, but this modification is recommended as a result of other changes.

"Bang for the Buck": Good, if you need it to control issues caused by other modifications and it saves your turbo. Lousy, if you're doing it for the sake of doing it, or if you bugger something up and break something expensive.

What if I want more? Since this modification is only appropriate for a vehicle that already has more ... you already have more.
Back to Top

5. Air Intake System Modifications

The stock air filter element can be replaced with an oiled-cotton (e.g. K&N) or oiled-foam (e.g. Pipercross, Amsoil) filter element in the standard filter box, or the entire airbox can be replaced with either a "cone" filter that draws air from within the engine compartment, or an enclosed-type high-flow filter that draws air from outside the engine compartment. The "snow screen" in the duct leading to the airbox (A4-chassis) or in the base of the airbox (A3, B4) can be removed at no cost and no side effects other than transferring responsibility for cleaning the air to the air filter which is responsible for doing that anyway. The snorkel on the intake side of a B4 airbox can also be removed with no side effects. On models where removing the snorkel would make a difference between drawing air from within or from outside the engine compartment, either leave the snorkel there so as to draw in cold air, or make other provisions for getting outside air into the area. If you alter the intake, MAKE SURE that potential water splash and rainwater issues are dealt with at least as effectively as the stock setup.

Installation: "Panel" filters are no more difficult to install than a standard air filter. "Cone" filters and cold-air intake systems frequently require installation of support brackets which should be done according to manufacturer's instructions. However, all of these filters require specific methods of periodic cleaning and re-oiling, which if not done correctly, will result in reduced filtration efficiency (dirt getting past the filter and into the turbo and engine). On foam-type filters, always use a "sticky" filter oil (Amsoil has a good one) which must be worked into the full depth of the foam using fingers. You need a sparse coating of the filter oil but it must be completely dispersed throughout the entire filter media to be effective. IMPORTANT NOTE: Regardless of the type of air filter chosen, make 100% sure that it is sealed against leakage of unfiltered air!! A leaky gasket around the outside of an otherwise good air filter WILL let more dirt into the engine than the entire filter element itself, so be careful about installation - REGARDLESS of what type of air filter is used!

Advantages: Not having to periodically replace the standard paper filter element (but you still have to periodically clean the replacement filter element). On some models where the standard airbox is difficult to deal with (B4 Passat!) the cone filters are easier to install in a way that ensures that there are no leaks of unfiltered air.

Comments: Performance gains are fairly small at best ... some would argue that they are non-existent.

Disadvantages: If not maintained correctly, dirt can get into the engine. The same is true of ANY air filter including the stock one, but aftermarket types are designed to be cleaned and re-oiled periodically, and this must not be ignored or done improperly. If installed in a way that has any gaps around the filter element, dirt can get into the engine, although this is equally true of the standard filter element. You are your own warranty.

Cost factor: Nothing (snorkel / screen removal, to US$20ish (panel filter) to US$200 range for fancier systems.

Cautions specific to this modification: Make absolutely sure that oiled-type filter elements are properly maintained. Check periodically for any evidence of contamination due to leakage of unfiltered air. This is good practice regardless of the type of filter element used.

Suggested modifications in parallel: Doesn't really matter.

"Bang for the Buck": Good due to no cost (for removal of restrictions in the stock system) to rather poor due to limited power gain and higher cost (cone filters and fancy air intake systems). If you don't properly maintain the washable-type filter elements, they can be bad news for your turbo and engine ... just as failure to periodically replace standard paper air filter elements.

What if I want more? Do something that increases fuel delivery ...
Back to Top

6. Exhaust Modifications

It has been found that the noise level of a TDI engine is acceptable without any muffler at all. It is possible to cut out the standard mufflers (one or both of them) and replace them with either straight pipe sections or "resonators" or straight-thru low restriction performance-type mufflers. Alternatively, the entire system can be replaced aft of the catalytic converter. Some have experimented with the downpipe between turbo and catalyst, but with mixed results.

Installation: Welding required - not normally for the do-it-yourself mechanic.

Advantages: The less restriction you have downstream of a turbo, the lower the exhaust temperature will be, and the quicker the turbo will accelerate to deliver boost pressure. On Passat TDI's, which have a poorly-designed stock exhaust system, modifying the exhaust system can get rid of that annoying resonance at 1200 and 2400 rpm, with a bit of experimentation. An additional flex pipe downstream of the catalyst is reported to be successful.

Comments: Performance gains are fairly small to non-existent. Leave the catalyst in place, it has minimal impact on power (no more than 1 horsepower) - this is worth saving the environment for.

Disadvantages: Some authorities have legal requirements that a vehicle must have a muffler, so one may have to incorporate something that at least looks like a muffler even if it doesn't really do anything, to keep the authorities happy.

Cost factor: US$40 for replacing mufflers with straight pipe, to US$600 for a complete stainless steel "cat-back" exhaust system.

Cautions specific to this modification: It might take some experimentation to get rid of resonance at certain engine speeds which will vary depending on configuration.

Suggested modifications in parallel: Doesn't really matter. De-restricting the exhaust is a good thing to do on highly-tuned vehicles that need all the help they can get to reduce the exhaust temperature.

"Bang for the Buck": Rather lousy. In view of limited to non-existent horsepower gains, but theoretical improvement in exhaust temperature ... the less you spend on this, the better.

What if I want more? Do something that increases fuel delivery ...
Back to Top

7. Intercooler Modifications, Intercooler Duct Modifications

Cooler air going into the engine means that other modifications that increase fuel delivery can be done, or if the exhaust is smoky at full load, the denser air will help turn some of that smoke into power. It's not worth doing if the vehicle is in an underfueled state of tune.

Installation: Typically, extremely difficult custom fabrication - not normally for the do-it-yourself mechanic. It may be possible to find boost pipes available in kit form, but such a kit isn't likely to include the intercooler. The stock boost pipe from turbo to intercooler on an A4-chassis (located below and to the extreme right of the engine, below the front pulley) looks suspiciously restrictive.

Advantages: Anything that reduces the air intake temperature of a turbo engine closer to ambient temperature is a good thing, especially on highly-tuned vehicles. Anything that enables normal boost pressure to be developed with less work required of the turbocharger is also a good thing, although the pressure drop caused by the intercooler and ductwork is insignificant so actual measurable difference will be very small to nonexistent.

Comments: Only worth doing on a highly tuned vehicle. The standard intercooler is already 65% - 70% efficient which is fine for the stock state of tune, and even for quite a bit beyond that.

Disadvantages: High cost and the likely need to have the vehicle out of service for some time during the installation. You are your own warranty.

Cost factor: If you have to ask ... you probably can't afford it.

Cautions specific to this modification: Make sure that the intercooler piping arrangement can absorb the normal movement of the engine and drivetrain, and make sure the intercooler piping arrangement doesn't complicate required maintenance access. Make sure the intake air temperature sensor is downstream of the intercooler.

Suggested modifications in parallel: This is only appropriate for a highly tuned vehicle with chip and injectors, that needs close to the limit of boost pressure (18 psi) in order to control exhaust smoke.

"Bang for the Buck": Poor, in view of high cost. Should note that some people have installed a vent in the fender liner behind the intercooler, which costs next to nothing but has questionable benefit. If you do this, make sure it has slotted vanes angled such that dirt and debris flying off the front wheel doesn't hit the backside of the intercooler.

What if I want more? Custom intercooler work isn't appropriate for anything short of a highly tuned vehicle with chip and bigger injectors at a minimum, in which case, you've already got more.
Back to Top

8. Advancing the Injection Timing

There is a misunderstood impression that more timing advance can produce more power. The correct statement is that the *optimum* amount of timing advance will produce the most output, and anything more or less will have adverse effects. Every 2 degrees of timing advance beyond the so-called "minimum advance for best torque" raises peak cylinder pressure by about 15 bar (about 10% increase from stock) and raises piston operating temperature by an unknown amount. Both of those are headed towards holes in pistons if taken too far.

There are two different "injection timing" settings. There is a mechanical adjustment procedure which involves setting the proper mechanical timing of the pump based upon information from VAG-COM's "group 0 basic settings" display, following the procedure in the shop manual. There is also an ECU adaptation channel which can be adjusted using VAG-COM. These procedures are NOT INTERCHANGEABLE and have completely different effects. The mechanical adjustment procedure following the shop manual (and preferably setting the timing within specs but in the upper range of the graph in the shop manual) is the right thing to be doing. Never touch the adaptation channel ... always leave this at stock specifications.

Installation: Not really an "installation". The correct mechanical adjustment procedure for the pump requires VAG-COM, the shop manual (for specification chart and proper procedure) and a selection of wrenches and sockets. Don't adjust it if it's already within specs, and very small adjustments make a big difference. The incorrect VAG-COM adaptation method only requires VAG-COM, but you shouldn't be doing it anyway, so forget that the possibility exists.

Advantages: Setting the injector pump mechanical adjustment so that it is close to the top of the specification range (but still within specs) ensures that under conditions when maximum timing advance is requested (e.g. full load), the pump can actually deliver the requested amount of timing advance. If it can't deliver maximum advance under those conditions, the result will be more smoke, higher exhaust temperature, and reduced efficiency. Proper mechanical timing also makes the engine easier to start under moderate temperature conditions, since under those conditions, the automatic timing adjustment mechanism is not operating. The (non-recommended) VAG-COM adaptation method increases requested timing advance under all speed and load conditions. Advance too much and run the engine too hard ... and the result will be severe engine damage, so don't do it!

Disadvantages: There are no disadvantages to having the injector pump's mechanical timing exactly where it should be! But for the VAG-COM adaptation adjustment ... You are your own warranty, and this is something that is headed towards holes in pistons.

Cost factor: Next to nothing, if you do it yourself and have VAG-COM. (Some models require the bolts at the injector pump sprocket to be replaced, which will cost a couple of bucks.)

Cautions specific to this modification: To do the proper mechanical adjustment, you need to know which way to turn a wrench and have the required "mechanic's common sense". If you don't know which way to turn a wrench, then leave the work to someone else. You shouldn't be doing the VAG-COM adaptation method due to the possibility of severe engine damage.

Suggested modifications in parallel: Irrelevant.

"Bang for the Buck": Irrelevant, you should have the mechanical pump timing correct anyway. BAD NEWS, for the VAG-COM adjustment method, due to potential engine damage.

What if I want more? Do something that actually accomplishes something ...
Back to Top

9. Bigger Turbo

It's tempting to think that installing a bigger turbo will result in more boost pressure and hence more power. Problem is ... it doesn't work that way! The turbocharger boost pressure in these vehicles is electronically controlled. The engine gets the boost pressure it wants, as long as everything is operating as it should. Changing the turbo doesn't change the electronic setpoint, so unless the turbo is installed along with suitable reprogramming of the electronics, the benefit will be ZERO.

Also, turbochargers which are too large for the engine will result in weaker low-end and mid-range response. So if a bigger turbo is installed without doing anything else, the result will be poorer bottom end response and no difference in top end response!

Installation: Typically, extremely difficult, unless in the form of a kit which is complete with the required different exhaust manifold, downpipe, intake connections, and lubrication connections, in which case it is simply difficult. If you are on your own for any of the auxiliary components, custom fabrication will be required. It should be noted that complete turbo assemblies (including the exhaust manifold) from other models of TDI engines will go in a lot more easily. Keep in mind that the manifold arrangement on a transverse-engine car isn't the same as that on a longitudinal-engine car, to the extent that the assemblies cannot be interchanged directly because they won't directly fit into a vehicle that has the engine sitting the other way.

Advantages: Good thing to do on a highly tuned vehicle that needs more boost pressure than the stock turbo can safely deliver ... but ...

Disadvantages: In order to properly take advantage of a bigger turbo, not only do you need reprogramming to make it work, but also the compression ratio of the engine needs to be reduced by some means in order to control peak cylinder pressure. And that's on top of the fuel delivery modifications that are the only reason for considering a turbo swap in the first place. $ $ $ $!!!

Cost factor: To do properly ... EXPENSIVE!!!

Cautions specific to this modification: You are SERIOUSLY your own warranty for this situation! Reliability of such a highly tuned engine isn't likely to be very good if the extra power is used frequently or for extended periods.

Suggested modifications in parallel: Everything. Otherwise, you're wasting your money.

"Bang for the Buck": Awful, if you do this and you didn't have to for other reasons. Still pretty lousy in view of high cost, if done properly.

What if I want more? Are you crazy???
[Back to Top](#)

10. Camshafts

This is a largely unproven area. Given that diesel engines cannot have much of a valve overlap period (the stock cams have NO overlap), and that the low-revving characteristics normally warrant conservative camshafts, there isn't likely to be much overall benefit. Cams that "breathe" better at the higher engine speeds where horsepower measurements are made typically result in a loss of low-end and mid-range response, so consider your driving habits and be wary of claimed high gains in an engine speed range that you don't use. One thing is for sure: this isn't the place you want to START modifying a diesel engine. Start with something that increases fuel delivery, instead. And only consider camshafts if the exhaust smoke situation warrants better breathing at high revs and yet is OK down low, but you're at the limit of the turbo.

Advantages: Unknown - unproven as of 9/02.

Disadvantages: Unknown - unproven as of 9/02. Camshafts that have later exhaust valve closing or earlier intake valve opening compared to the stock cam will have less margin of error in the alignment between crankshaft and camshaft. In more severe cases - i.e. if there is more than even the slightest amount of overlap - valves will hit pistons. Camshafts that have higher lift than stock will put more stress on the valve springs - but it's unknown whether that's a significant issue or not with this engine, due to lack of experience. Camshafts that have much later intake valve closing will typically have a loss of low-end and mid-range power offsetting gains in top-end power. This also causes a lower effective compression ratio during starting, so don't go too far, or else ...

Cost factor: Unknown - probably a few hundred dollars.

Cautions specific to this modification: TDI camshafts that will work with the stock pistons must always have a specified exhaust valve closure several degrees BEFORE top dead centre (i.e. before the official end of the exhaust stroke) and the intake valve opening must not happen until several degrees

AFTER top dead center (i.e. after the intake stroke has already begun) - based upon measuring the timing at 1mm lift. The stock intake valve timing is 16 degrees ATDC opening / 25 degrees ABDC closing for 189 degrees duration at 1mm lift. Beware of non-standard methods of specifying timing and duration ... often aftermarket cams will have the timing referenced to the fully closed position rather than the standard 1mm in order to "pump up the numbers" while in reality the cam is a lot more conservative than it first appears.

Suggested modifications in parallel: Different cams are probably only appropriate for an engine that's underfueled (no smoke) in the low rpm range, and overfueled (smoke) at higher engine speeds. (This is actually a common scenario.) In other words, it shouldn't be the first thing to tackle. It should be one of the LAST things after doing all sorts of other things to increase fuel delivery. And if it's suspected that an engine is overfueled at high revs and needs more air, make sure the problem isn't a clogged intake manifold or wrongly set static injection timing ...

"Bang for the Buck": Unknown.

What if I want more? Unknown.
[Back to Top](#)

11. Blow-off valves or BOV or similar

Since people insist upon asking about these devices, they need to be discussed ... The purpose of a "blow-off valve" or "diverter valve" on a gasoline engine is to give boost pressure someplace to go when the throttle plate is abruptly closed, to prevent operating the compressor in the "surge" regime. Since a diesel engine doesn't have a throttle plate, a gadget like this serves absolutely no purpose and has no business anywhere on a diesel engine. "But I like the cool noise ..." Too bad, this discussion is focused on things that WORK. Even if you manage to find some way to make such a device work, the noise of people "in the know" laughing at you because they realize that it has absolutely no place on your engine will drown out the noise that the device itself makes.

Installation: Impossible. Cannot be made to work even if you insist upon it.

Advantages: None.

Disadvantages: Won't work. People who actually know how a diesel engine works will laugh at you for even considering it. You are your own warranty.

Cost factor: Too much, all things considered.

Cautions specific to this modification: Won't accomplish anything.

Suggested modifications in parallel: Irrelevant.

"Bang for the Buck": One hundred percent total waste of time and money.

What if I want more? Do something that actually accomplishes something ...
Back to Top

12. Nitrous Oxide

Not normally suitable for a diesel engine. Since diesel engines normally run lean (except when belching black smoke!) adding more oxidizer isn't going to accomplish anything. If the engine is over-fueled due to extensive other modifications, then this might help power output ... for a little while, until something breaks.
Back to Top

13. Propane Injection

Although it has been done (search forums), this subject won't be discussed here due to the high risks associated with propane injection. The risks are not only in terms of reliability and durability, but also drivability (most have simple "on/off" controls which cause very abrupt response - very unpleasant to live with on a day-to-day basis) and most importantly, the safety of yourself and others in the vehicle due to the compressed flammable gas storage and the fuel lines containing pressurized flammable gas.
Back to Top

14. Sensor Tweaks and Various Home-grown Mods
You are SERIOUSLY on your own if you try any of this. These links are provided because the information is out there and the questions get frequently asked, not necessarily because any or all of them are good or bad. Many of these, if done correctly, can be useful, while the same idea wrongly implemented will wreak all sorts of havoc. YOU ARE YOUR OWN WARRANTY. If you try one of these stunts but get it all wrong and bugger up your vehicle, don't come running to us, and don't go running to the dealer to get them to straighten you out.

Water injection (poor man's intercooler):
http://forums.tdiclub.com/cgi-bin/ultimatebb.cgi?ubb=get_topic&f=4&t=002533&p=

The famous fuel-delivery wiring harness modification:
http://forums.tdiclub.com/cgi-bin/ultimatebb.cgi?ubb=get_topic&f=4&t=001893&p=

Faking out the manifold pressure sensor to raise boost on an A4-chassis that has a remote boost pressure sensor outside the ECU ... read ALL of the following before trying this stunt:
http://forums.tdiclub.com/cgi-bin/ultimatebb.cgi?ubb=get_topic&f=4&t=004077&p= (right idea, but doesn't tell you which wire to splice ...)

http://forums.tdiclub.com/cgi-bin/ultimatebb.cgi?ubb=get_topic&f=4&t=004059&p= (... but this one does, and contains appropriate warnings)
http://forums.tdiclub.com/cgi-bin/ultimatebb.cgi?ubb=get_topic&f=4&t=003627&p= (a few reasons for not bothering to try it ...)

Faking out the manifold pressure sensor to raise boost on an A3 or B4 that has the boost pressure sensor inside the ECU and connected to the intake manifold with a rubber hose:
http://forums.tdiclub.com/cgi-bin/ultimatebb.cgi?ubb=get_topic&f=4&t=000529
Back to Top

15. Turbo Timers

Strictly speaking, these aren't performance items, but they are sometimes seen as aftermarket items on turbocharged gasoline engines. The purpose is to give the engine a prescribed period of idling so that the turbocharger can be cooled by the engine oil (and coolant, in many cases) that circulates through it. (It has NOTHING to do with waiting for the turbocharger to "spin down". That takes a quarter of a second.)

Diesel engines have lower exhaust temperature than gasoline engines. At anything less than full load, the temperature is FAR lower. It is low enough that the turbochargers in these vehicles do not have a connection to the engine coolant system - only to the lubricating oil. Under most conditions, there is no need to wait for the turbocharger to cool down, and hence, no need for a turbo timer.

The only potential exception is if you are towing a trailer or operating the vehicle at close to top speed (i.e. 160+ km/h) on the highway or climbing the side of a mountain pedal to the metal. But in most cases, you don't just come straight off such full load conditions and stop. You trickle through neighborhood streets, or you wander through a parking lot in search of a spot. Usually this is more than enough time even if you're driving the car hard. And if it DOES take less than a minute measured from the time you first take load off the engine (still coasting out on the road) until you get to a parking spot ... just let it finish that minute at idle.

You don't need a turbo timer.
Back to Top

f. Trailer Towing Issues

Torque versus Power - Power is the rate at which the torque is produced (pound-feet per second or Newton meters per second). If two objects produce the same torque, the faster rotating object has more power. Towing a trailer typically involves getting a heavy trailer moving from a low speed, and pulling up steep hills with minimal slowing down, and for these applications, you need torque.

The TDI, like all diesels, is better suited for producing torque than producing power. The force driving the engine's pistons downward is the expansion of the air/fuel mixture within the cylinders. A greater expansion means more force on the piston. The extra compression ratio available allows a larger percentage of expansion than gasoline does. This greater expansion produces more force to push the piston downward (torque).

Diesel fuel does not burn as rapidly as the more volatile gasoline. The relatively slower expansion limits the maximum piston speed and this results in a lower maximum engine speed (rpm). The lower engine speed limits the power (torque times rpm).

The TDi engine produces far more torque than a comparable gasoline fueled engine, but only up to the engine speed that approaches the air/ Diesel fuel expansion rate limit (about 3800 to 4000 rpm). The similarly sized gasoline fueled engine can rotate faster than this Diesel limit, and as a result has a higher power rating above this speed.

Towing capacity of TDi powered Volkswagens is not described consistently in owners manuals. Some owners manuals indicate that the towing capacity has not been tested, others indicate that trailer towing is not possible for technical reasons, others give a small towing rating. Consider that some - possibly all - European 90hp models are given a towing rating of 600 kg (1320 lbs) without trailer brakes, or as much as 1200 kg (2640 lbs) if the trailer has brakes and the maximum slope does not exceed a certain (fairly generous) amount, and provided that certain cooling-system modifications are done (which are already present, on vehicles equipped with air conditioning).

Forum members have towed trailers weighing as much as 1500 lbs without problems, even in summer and without any cooling system changes. Obviously the performance envelope is reduced in every way, and be prepared for a big penalty in fuel consumption. For highway driving, the frontal area of a trailer is a major concern. Obviously it's sensible to make sure that the car is in good shape considering engine, tires, and brakes. Take it easy while driving with a trailer behind - this is prudent for both safety and longevity of the tow vehicle. Don't mash the pedal to the floor and leave it there.

The greater torque of the TDi produces a superior tow vehicle engine when compared to the gasoline powered equivalent. This does not mean that greater weights may be towed, only that the same weight can be towed with more ease. The guidelines for towing with a gasoline powered Volkswagen can be used as a reference for towing with the TDi. The additional weight of the trailer will mean more usage of the turbocharger and hotter turbocharger temperatures. Be sure to allow additional time for the turbocharger to cool before shutting off the engine.

Vehicles whose performance has been increased (see previous sections) will on the one hand be considerably more pleasant to drive while towing, but on the other hand, caution is necessary so as not to exceed heat-related limits on the turbocharger, engine oil, and the engine itself. It's best to use either a boost gauge or an exhaust temperature gauge so as to remain within the limits of the engine's standard power output most of the time, and only use the extra power for short periods of acceleration. Be particularly cautious on long uphills; it's tempting to use the extra power to maintain full highway speed, but this might not be healthy for your turbocharger or your engine oil. An auxiliary engine oil cooler may be advisable, or perhaps simply temporarily removing the plastic pan beneath the engine to permit more air circulation.

Due to the much greater likelihood of running close to full load for extended periods of time, trailer towing vehicles should always be conservatively tuned ... not tuned right to the edge of blowing to bits.
Back to Top

g. Fuel Consumption

High fuel economy claims are often subject to ridicule and accusations of miscalculation, deceit, or violation of basic laws of physics. Low mileage lamentations are often accompanied by accusations of fraudulent misrepresentation by the manufacturer and questions regarding possible defective or misadjusted components. Both of these types of comments are prevalent among those who drive the TDi. These engines are so efficient with fuel that a small percentage change in mileage results in a large numerical change in miles per gallon.

The TDi equipped Volkswagens are sold throughout the world. Different mileage calculations are used in other locations and may not convert to equivalent numbers. In North America, mileage is often specified as miles per gallon. The UK may also refer to miles per gallon. Be aware that the quantity of fuel contained in a "gallon" depends on the type of gallon, US or Imperial. The more common consumption rate used elsewhere in the world is liters per 100 kilometers. When comparing expenses remember that "dollar" is the name of currency in Australia, Canada, New Zealand, and the USA. The exchange rate fluctuates between these currencies. The conversion of one measurement to another gives additional opportunity for errors. When comparing someone else's set of figures to yours bear in mind that their driving style, wheel alignment, weight, acceleration techniques, braking habits, climate, preferred cabin temperature, tire pressure, etc., etc., are different than yours. These are some of the reasons for the disclaimer "your mileage may vary". Bear in mind that no matter what your TDi's mileage, it is better than it would be if you were using a gasoline engine in the same car under the same conditions.

The automatic transmission used in these vehicles increases fuel consumption by about 20% compared to the manual transmission.
Back to Top

h. Suspension

The suspension components used on these vehicles are common to other 4 cylinder VW models which use the same chassis. A wide variety of aftermarket components are available for most VW vehicles, and a large number of aftermarket shops deal with these components. As a result, only general recommendations will be discussed here.

People who wish to modify suspension fall into two groups: those who want to lower the vehicle so as to achieve a certain appearance, and those who wish to improve the handling performance of the vehicle. For various reasons, these objectives typically do not coincide with each other: modifications which lower the vehicle usually have an adverse effect on handling.

Lowering a VW Golf-chassis-based vehicle is BAD, for the following reasons.

The angle of the lower control arms on the front MacPherson strut suspension is such that if the vehicle is lowered, it will tend to send the camber of the front wheels in the wrong direction in response to body roll. These lower control arms should always have the pivot point at the outer ball joint closer to the ground than the pivots which attach to the chassis, when the vehicle is at static ride height. If this is not the case, the geometric roll center of the vehicle can be below ground level which will tend to INCREASE body roll, the camber of the front wheels will go in the wrong direction when body roll is encountered, and the steering geometry will be adversely affected.

The reduced amount of suspension travel above static ride height before hitting the bump-stops necessitates the use of springs with a stiffer spring rate, with adverse effects on ride quality. This forces the use of dampers with more damping, again adversely affecting ride quality. You cannot have lowered suspension together with improved ride quality ... if an attempt is made to preserve original spring and damping rates while lowering the suspension, the ride quality will still be adversely affected due to the frequency with which the suspension hits the bump-stops ...

There is marginal ground clearance below the oil pan, and on later models, that oil pan is cast aluminum and is prone to fracturing. If that happens ... you need a tow truck. And you'll have to worry much more about the bottom of the front bumper striking curbs.

Now that this issue has been dispensed with, what can be done to improve handling?

These vehicles are typically set up to understeer strongly. Better wheels and tires will help a lot (wide variety available, see www.tirerack.com or any of a large number of other sources), but what is really needed to reduce understeer is greater rear roll stiffness. The end with greater roll stiffness tends to slide first. To shift grip away from the rear and towards the front, while increasing overall roll stiffness to reduce body roll, add an additional rear antiroll bar.

BEWARE, understeer is built into the vehicle for the benefit of drivers who don't know how to control oversteer. If you install a rear antiroll bar, and a situation occurs where the vehicle oversteers and the driver doesn't manage to control it ... don't say you weren't warned. You're the one who chose to do it. Also remember that even if YOU feel that you can control an oversteer situation, family members or other people driving the vehicle may not be able to.

Better dampers, and springs with a slightly greater spring rate, will improve turn-in precision, at some cost in ride quality. Don't install stiffer springs on stock dampers. You need more damping to control motions resulting from the greater spring rate. Firmer dampers and stock springs is fine within reason.

The author's vehicle has Bilstein HD struts and shocks on stock springs and no additional antiroll bar, with performance tires 10mm wider than standard on rims 1" larger diameter than standard, with a profile 10 points lower than standard (in other words, conventional "+1" sizing). This arrangement is well suited to this vehicle's daily-driver mission where the outer limits of adhesion aren't normally tested, but it gives very noticeable improvement in turn-in and steering feedback, and raises the ultimate amount of grip available without compromising the margin of stability associated with the built-in understeer of the vehicle.
Back to Top

i. Brakes

The brakes used on TDI equipped vehicles are standard VW components used in a wide variety of vehicles. There are a large number of aftermarket shops that handle VW performance parts, which can be a help in this area. It is normal to only upgrade the front brakes of front-wheel-drive vehicles, since the rear brakes only handle a relatively small proportion of the braking loads. The drum brakes used on the rear of A3 Jetta TDI models are not a limiting factor in brake performance.

Retrofit of ABS to a vehicle which was not originally equipped with it, is for all rational intents and purposes, impossible. There are too many components which are different between a vehicle equipped with ABS and a vehicle not so equipped.
Back to Top

j. Driveline

1. Clutch

For the A3 and B4 cars, if an upgraded clutch proves to be necessary as a result of engine upgrades, the VR6 clutch assembly is a direct replacement, and any aftermarket clutch that is suitable for a VR6 application is also suitable for a TDI application.

For the A4 cars, a VR6 or VR6-compatible clutch assembly can be installed if the flywheel is replaced with a flywheel from a 4-cylinder G60 engine.

Upgraded clutch parts are available in the USA from www.dieselgeek.com and elsewhere.
Back to Top

2. Final drive and differential

The weakest link in the O2A (for A3 and B4 cars) and O2J (for A4 cars) 5-speed manual transmissions involves the final drive and differential assembly. Vehicles with performance engine modifications, which may experience hard drag-racing-style launches, wheelspin that results in wheel hop, and similar actions which place the greatest stress on the final drive assembly, should have the final drive and differential upgraded to reduce the chance of having problems in this area. Quaiffe or Peloquin final drive units employ a "torque biasing differential" that improves grip in slippery conditions while eliminating the spider-gear cross-shaft which is a weak point in the stock differential. These final drive units should be bolted to the final drive ring gear with high-strength bolts, usually available as part of the final drive kit. Installation of such components is best left to experts in manual transmissions.

Be aware of the possibility that some earlier models may use a different style of half-shaft mounting arrangement compared to other models that use a similar transmission. There have been a few situations where apparently the half-shaft mounting arrangement of an O2J transmission was found on what is otherwise an O2A transmission. Consult with experts in VW manual transmissions, such as wherever you intend to purchase the unit from or whoever you are planning to get to install it.

The CV or constant-velocity joints on the half-shafts are the next weakest link, but not much can be done. If you do hard launches from a standing start ... be prepared for shortened CV joint life.
Back to Top

Back to FAQ Index

TDI FAQ

[7) Maintenance]

Disclaimer: While considerable effort has been made to make the information provided in this section as complete and accurate as possible, it does not and cannot cover all possible situations. The authors cannot accept any responsibility for any damages which may occur from the use or mis-use of these procedures, nor can the authors accept any responsibility for any damages which may result from personal injury or property damage which allegedly may be caused by the use or mis-use of these procedures. No responsibility is accepted for missing or incorrect information. Those who use these procedures shall accept all responsibility for performing the work which may be described below. If you have any comments or suggestions for additions or revisions, please contact the site administrator.

References within this document to "left" or "right" always refer to the orientation viewed from the driver's normal seating position. Throughout this document, you will see references to VAG-COM. Many diagnostic and calibration procedures cannot be performed without a VW specific diagnostic scan tool. VAG-COM is a reasonably priced software and cable that allow any Windows based computer to be used to communicate with the vehicle's on-board diagnostic system. Generic OBD-II code scanners (such as those which may be found at independent garages that do not specialize in VW/Audi) will normally NOT be sufficient - you need a VW specific scan tool. For more information about VAG-COM and to purchase a copy for yourself, see www.ross-tech.com - highly recommended.

This thread identifies VAG-COM users who may be willling to help:
http://forums.tdiclub.com/NonCGI/ultimatebb.php?ubb=get_topic;f=17;t=000768

Here's a database of VAG-COM users in North America who might be able to help you:
http://www20.brinkster.com/beowulf9/tdi/vagcom/

Know which model you have. If you have a '96 or '97 Passat TDI in North America, you have a B4 chassis with what is known in this document as an A3-style engine, and you have a Garrett GT15 turbocharger. If you have a '97 through early '99 Jetta TDI in North America, you have an A3-style engine and you may have the Garrett GT15 turbocharger but more likely you have a KKK K03-006 turbocharger. If you have a New Beetle TDI, or a '99.5 or later Jetta or Golf TDI in North America, you have an A4-chassis vehicle, and you have a Garrett VNT-15 turbocharger.

The engine code number can be found on the build sheet which is typically near the spare tire on the floor of the trunk. In North America, engine code 1Z means 90hp A3-style engine with Garrett GT15 turbocharger and Pierburg MAF (mass air flow sensor). Engine code AHU means 90hp A3-style engine with KKK K03-006 turbocharger and Pierburg MAF. ALH means 90hp A4-style engine with Garrett VNT-15 turbocharger and Bosch MAF. European models don't necessarily correspond in specifications, engine codes, and model years (you're on your own, as far as figuring out what type of turbo and MAF sensor you have).

7) Maintenance

Back to FAQ Index

a.

Engine Oil and Filter Maintenance -Your owners manual contains a recommended change interval for normal driving conditions, which is either 12,000 km / 7500 miles (older models), or 16,000 km / 10,000 miles (newer models). Some forum members have used oil analysis to determine a suitable change interval. There have been cases where, using synthetic oil rated CH-4, the 10,000 mile / 16,000 km interval was appropriate. There have been other cases where shorter intervals were warranted, generally using oils which were either not synthetic or did not have the CG-4 or CH-4 rating.

Based on the available information from oil analysis, an oil change interval under normal conditions of 16,000 km / 10,000 miles (or 1 year whichever comes first) is recommended when full-synthetic 5w30 or 5w40 oil meeting CG-4, CH-4, or CI-4 standards is used, as per the owner's manual. Note that owners manuals may not refer to the latest specifications for certain types of oils. Oil specification CI-4 supercedes CH-4, which already superceded CG-4 some time ago. Oils conforming to CH-4 or CI-4 (latest standards) may (and should!) be freely substituted for the owner's manual requirements for older specifications, without question.

If semi-synthetic, synthetic blend, or Group III oil is used which meets CG-4, CH-4, or CI-4 standards, an oil change interval under normal conditions of 12,000 km / 7,500 miles (or 6 months, whichever comes first) is recommended.

For conventional non-synthetic oil which meets CG-4, CH-4, or CI-4 standards, or for any oil meeting older standards such as CF, an oil change interval under normal conditions of 8,000 km / 5,000 miles (or 6 months, whichever comes first) is recommended. Castrol Syntec recommended by many dealers falls into this category, as it is a Group III oil meeting the CF standard. Mobil 1 also falls into this category as it meets only the CF standard, not CH-4.

ACEA B3 or B4 rated oils are also acceptable, at least for 2001 model year vehicles. In North America, the ACEA B3 and B4 rating is found on some *W-40 (and *W-50) oils that are not marketed as diesel engine oils (the latter would normally have the API CH-4 rating). They may be marketed as "oils for European engines" or some such.

API CF is not the same as API CF-4. Many more oils carry the API CF rating, compared to the number of oils that carry the API CF-4, CG-4, or CH-4 rating, but these are not suitable for TDI use unless they also carry another appropriate rating, such as ACEA B3 or B4.

If conventional oil of 15w40 viscosity is used, expected weather conditions also need to be taken into account, as the cold pumping ability of this oil is much less than that of the recommended 5w40 viscosity.

In the case of adverse driving conditions, such as trailer towing, mountain driving, driving under hot or dusty conditions, or driving consisting of mostly short trips, the oil change interval should be reduced.

Some forum members have installed oil bypass filtration units which continuously remove particles smaller than can be removed by conventional filters. Oil analysis indicates that these can safely extend oil change intervals far beyond what is conventional.

With the A3-type engine in a B4 Passat, removal of the lower engine pan is not necessary to change the oil. The drain plug is located at the rear of the oil pan, facing down at an angle, and is easy to reach. The oil filter is another matter, it's notoriously difficult on A3/B4 cars but it's possible to do from above. On a 1996 B4 Passat, there is a radiator hose blocking access, but this can be pulled out of the way without disconnecting it. A conventional strap-type oil filter wrench can be worked into position on the filter to remove it. Some oil spillage onto the lower engine pan is unavoidable. Before installing the new filter, pre-fill it with fresh oil, to minimize the amount of time that the engine runs without oil pressure. Then, the hard part is getting the new filter started on the mounting threads, because you can't see what you're doing, there's hardly room to feel your way, and you don't want to spill that brand new expensive synthetic oil now contained in the filter! With enough persistence, it can be done.

With the A4 models, the filter is a cartridge type, and is a snap to change, but the lower engine pan has to come off for access to the drain plug. You win some, you lose some!

Leaving the lower engine pan off, to facilitate oil changes, isn't recommended. The lower pan performs several functions. It isolates a certain amount of noise, it keeps more heat within the engine compartment, it protects many components from debris thrown up from the road.
Back to Top

b. **Fuel Filter / Water Separator Maintenance** -Diesel fuel is filtered through a combination filter and water separator. The water collection chamber is in the lower portion of the unit, and the filter medium is in the upper portion. There is a drain in the bottom of the water separator to permit removal of any accumulated moisture without the need to remove the unit.

This drain should be opened to drain any collected water at periodic intervals. The entire unit of filter and separator should be replaced periodically. The capacity of the filter/separator is relatively large in comparison to typical gasoline filters. It may be desired to pre-fill the new unit with Diesel fuel before installation to minimize starting hesitation.

The change interval for the fuel filter is either 48,000 km / 30,000 miles, or 32,000 km / 20,000 miles, depending on model. Consult your owners manual for your specific vehicle.

The filter is a cylinder-shaped housing with hoses going into the top, easily visible at the extreme right of the engine compartment. It's possible to change the filter yourself. Make sure you have a supply of suitable clamps before you start the job, and also find some way to pre-fill the filter housing completely with diesel fuel before hooking everything up again, otherwise you'll have an awful time getting the engine to keep running until all the air is worked out of the system.

> 7.b.1 Using pliers, pinch and slide hose clips away from filter (about 1 1/2in from hose ends) of fuel feed lines. Fuel feed is traceable back to a black line from the tank.
>
> 7.b.2 Use needlenose pliers and pull out (sideways, towards engine) return line clip for tee-piece. The tee-piece pulls straight up out of filter. The return line line is traceable back to a blue line from the tank. Wrap the tee-piece with a clean cloth or paper towell to protect from dirt.
>
> 7.b.3 Push (do not pull!) feed lines off the filter nipples (flat screwdriver blade helps). Wrap the ends with paper towells to protect from dirt. Use a Phillips screwdriver and release fuel filter clamp (vertical screw beside filter), holding filter from slipping down. Observe the positioning of the filter nipples.
>
> 7.b.4 Gently lift filter straight up out of the car. Do not tip, as fuel may spill.
>
> 7.b.5 To drain the filter, on the bottom of the filter should be a knurled knob. Hold over a glass jar and unscrew (counter clockwise viewed from bottom) slowly. There is a nipple here where you can attach a short drain hose to avoid spilling. Try to contain drained fuel to a glass jar (old widemouth jam jar). This way you can see if there was water in filter. Drain about two ounces of fuel, and look for water droplets (may appear as beads, as water and diesel do not mix).
>
> Note that if you are draining and not replacing the filter, it is not necessary to disconnect the hoses; the filter can be unclamped and lifted up enough to access the knurled knob. THIS KNOB IS VERY FRAGILE. Don't break it off if you are going to be re-using the filter!
>
> Some analysis of the quantity of water in the filter is in order. It is determined by several factors, e.g. condensation in the tank, use of fuel treatments, and especially by your fuel supplier. If you buy fuel from the same place all the

time, it may be usefull to check for water after say the first 5000kms as a safeguard to see what your supplier is giving you. If you see lots of water you may want to change to a different supplier. Stay well away from old barrels found lying in a field.

7.b.6 Set the old one aside and get the new one out now and install. Watch the orientation of the nipples. Tighten clamp you loosened in step 3 above.

7.b.7 Before you plug back on the return line tee-piece, it is wise to prime the filter with some CLEAN diesel fuel, and/or some straight fuel system cleaner. Failure to so do may result in a long cranking time before the engine starts, especially at lower temperatures.

7.b.8 Replace hoses, clamps and clip, then test engine.

7.b.9 Once engine is running, look at the "sight tube", i.e. clear line from filter to engine (if so equipped) - you may see air bubbles. They should almost dissappear, but there will still be a few after running for a while.

Note: If you have a gross amount of air bubbles, there may be an air leak in the fuel supply side (or the tee-piece), and it may impact engine performance. Check hose fittings, connectors, especially the return line plastic Tee-fitting (has an O-ring) where it plugs on to the filter with the retaining spring clip.

Back to Top

c. **Air Filter and "Snow Screen" Maintenance** - The air filter should be replaced at 30,000 mile / 48,000 km intervals or not more than 2 year intervals. When checking or replacing the air filter, also inspect the screen on the intake of the airbox and clean if necessary (see below).

   In some areas, due to high levels of airborne contaminants, the "snow screen" will become clogged so quickly (resulting in power loss) that it becomes a considerable hassle. Many owners have removed these screens permanently with no ill effect other than slightly more frequent need to clean the main air filter element. The total frequency of maintenance may be considerably lower without the screen than with it in place ...

   On A3/B4 models, the air filter housing is at the right front corner of the car. To access it, first remove the plastic cover between the top of the airbox and the headlight (it just pops out). Unplug the electrical connector at the airflow meter (between top of airbox and the large flexible hose). Pull the clear plastic fuel lines out of the clamp that holds them. Release the four clamps for the airbox cover and pull the airbox cover away to expose the filter element, which can then be removed for inspection. Unbolt and remove the screen which is bolted into the lower section of the air filter housing, and either clean it or don't bother re-installing it. This screen is very prone to clogging and some owners have found that it is better to leave the screen out and accept the (possibly) slightly greater frequency of servicing the main air filter.

Re-assembly is the reverse, but don't forget to plug the airflow meter in again, and make sure the air filter element is properly seated in the housing at all edges and corners!

On A4 models, the air filter housing is on the left side of the engine compartment. Release the clamps, pull the cover off, and the filter element is right there. Cleaning the screen requires removal of the lower section of the airbox from the vehicle and then removal of the duct which leads to the air filter housing intake.
[Back to Top]

d. **Timing Belt Inspection and Replacement** - - The TDI engine uses a toothed belt to drive the camshaft. The choice of a belt rather than a chain was made for noise considerations. A Diesel engine is normally louder at idle than a gasoline engine. A direct injection Diesel is louder yet due to the lack of a pre-chamber that tends to suppress some noise. Minimizing noise sources was a high priority and a belt drive for the camshaft is much quieter than a chain drive. All rubber belts will fail eventually, as will chains. Chains, prior to their failing, become more noisy, looser, and in general give warning to their deterioration. Belts remain nearly silent and tight right up to their sudden failure. When the camshaft drive belt breaks, the camshaft stops turning and the valves stop moving. The valves that are open stay open. The pistons continue moving up and down as the engine coasts to a stop. It is almost a certainty that a high compression engine, like a Diesel, will have the pistons travel in a stroke that overlaps the stroke of the valves as they move open and close. The camshaft normally controls the opening and closing of the valves to occur only when the piston is clear. If the valves are open and do not move closed when the piston reaches the top of its stroke, the piston will strike the valve and damage the valve and the piston. The repair cost of this damage is often several thousand dollars. Although timing belt replacement is not an inexpensive operation, replacing the belt long before its likely failure is inexpensive in comparison to the cost of a failure. The replacement interval varies depending upon model but is generally 96,000 km for manual transmission models for the 2001 and prior model years, and 64,000 km for automatic transmission modeis for the 2001 and prior model years, and 128,000 km for 2002 model year regardless of transmission. The 2002 model has an updated belt and tensioner design which may be retrofitted to A4-chassis models of prior years to take advantage of the extended change interval provided that both the belt and tensioner are replaced. The extended-life belt and tensioner cannot be fitted to the older A3 or B4 engines because the belt is a different length and will not fit.

The timing belt should be inspected at every oil change interval for evidence of any abnormal wear conditions. This is easily done by unclipping and removing the upper timing belt cover and performing a visual inspection. If any of the following conditions are noted, the belt and tensioner must be replaced immediately without driving the vehicle any further:
- More than 1 or 2 mm gap between either edge of the belt and the base of the flange on the front and rear of the tensioner roller - indicating that the belt is mis-tracking and is wearing at the edges.
- Excessive wear on any of the edges of the belt, indicating mis-tracking.
- Evidence of cracks on the outer surface of the belt, indicating that the rubber material is deteriorating.
- Evidence of oil, fuel, or other fluids on the belt. These cause deterioration of the belt materials.
- Excessive wear on the teeth of the belt.
- If the belt has been on the vehicle for in excess of the time or mileage specified in the

owner's manual, the belt and tensioner must be replaced with new components regardless of the result of any visual inspection.

For A3 and B4 vehicles, instructions for performing a timing belt change can be found here: http://www.tdiclub.com/articles/A3-TimingBelt

For A4-chassis vehicles, instructions for performing a timing belt change can be found here: http://www.tdiclub.com/articles/A4-TimingBelt (PDF version)
Back to Top

e. **"Supplementary injector" on 1996 Passat TDI models - North American specification only-** The 1996 Passat TDI models in North America were the subject of a technical service bulletin (TSB) regarding the engine control module (ECM). The TSB instructed the VW dealer network to replace the ECM and if necessary, the injectors, with a newer version of each. The new version of the ECM and injectors were used as original equipment from mid 1996 onward. Some, not all, TDI engines from before this time were experiencing this failure. This TSB was not a recall and the replacement of the affected components was covered under warranty terms in most instances. The most common complaint is that, after a period of highway driving (15 - 20 minutes), then stopping, smoke would be emitted upon acceleration away from the stop.

   Investigation by members of this forum have traced the problem to the "supplementary injector" which some models were equipped with. Under certain operating conditions, an injector located in the exhaust system sprays extra fuel into the exhaust to keep the catalyst warmed up. Although the official VW documentation insists that this system is only present and functional on models with automatic transmission (which were never actually produced), experience has shown that the system operates on the manual transmission models as well. This system proved to be extremely unreliable, and later models are not equipped with it. VW had great difficulty getting the early models to pass emission requirements, and hence the expensive replacement components listed above.

   Fortunately for the backyard mechanic, the "supplementary exhaust injector" can be bypassed easily at negligible cost. To determine if your car has this system, locate the fuel filter on the right side of the engine compartment, and locate the two clear plastic hoses nearby. The smaller of the clear plastic hoses ends in a black "T", and one of those branches goes back to the top of the fuel filter and the other branch goes forward and down, to the exhaust injector solenoid mounted on the back of the airbox. The line coming out of this solenoid can be followed through a clip on the timing belt cover and then into a fitting on the exhaust downpipe.

   To disable the "supplementary exhaust injector" system, pull the hose which faces forward off the "T" at the end of the smaller of the clear plastic hoses. Plug the hose by jamming a wood screw or some other suitable object into the hose, then reconnect it to the "T" (to prevent a fuel leak). No more "supplementary exhaust injector". This modification will not cause a "check engine" code to be set and there are no known adverse side effects.

Back to Top

f. **Intercooler Cleaning** - With thanks to many members of this forum who first discovered this problem and then contributed many ideas on what to do about it, here's a recommended procedure.

You will need a drain pan, a pail, some liquid dish detergent, and a fuel container with 2 litres of kerosene or other suitable solvent - don't use gasoline, or anything which will attack rubber. You will also need some vise-grips to hold the clamps open, and some channel-lock-type pliers for opening the clamps in the first place. Alternatively, buy some gear-type clamps that you can deal with a lot easier than the standard spring clamps, which are a hassle.

Locate the two black plastic pipes which go from the top of the engine down to the intercooler (which is at the left front on an A3, or the right front on an A4). Also locate the hose connection at the bottom of the intercooler and make sure you can get it open (just enough to drain fluid, you don't need to disconnect it completely) before starting.

At some suitable location, disconnect both pipes to the intercooler. Identify the pipe which goes straight down to the bottom of the intercooler. (On some models, the other pipe has some low spots in it which will trap liquids, you don't want to pour anything down that pipe.) Pour the kerosene into the intercooler and let it sit for a while. If possible, agitate the liquid once in a while by blowing into the pipe that goes to the bottom of the intercooler by some means. After 15 minutes or so, put the drain pan under the intercooler, and drain the liquid out. Chances are, it will be black! Don't pour this crap into your fuel tank, use it to fill your camp stove or something.

Now, close the bottom pipe, and squirt some dish detergent down into the intercooler. Measure out 2 litres of hot water, and pour that into the intercooler. Let that sit for a while, and agitate it by blowing into the pipe if possible. Then drain that out. Chances are, that will be murky, too!

Inspect the system for any low spots that would trap liquid, and get the liquid out of there by whatever means are needed, before you start the engine. Make ABSOLUTELY SURE there's no standing liquid anywhere inside, then reconnect everything.

You should be aware that the CCV (crankcase vent) system is the reason for the gunk accumulating in the intercooler in the first place. The CCV hose goes from the round black housing on top of the valve cover and into the air intake pipe. Pull that hose off the black CCV housing and check for sticky black gunk inside. If you don't want to have to clean the intercooler again, and if it's legal where you live to not have a CCV system, then you can connect a 3/4" PVC hose to the black PCV housing and run the hose to somewhere (keep it away from moving parts and from the exhaust system), and plug the end of the hose that normally hooks up to the PCV housing with a 3/4" pipe plug and a hose clamp. In most areas, this setup is not legal for on-road use, so you'll just have to periodically clean the intercooler to maintain peak performance.

Here is another writeup on Intercooler Cleaning:
http://www.tdiclub.com/articles/Intercooler_Cleaning/

[Back to Top](#)

g. **Intake Manifold and EGR Cleaning -** This vehicle is equipped with a CCV (crankcase vent) system and an EGR (exhaust gas recirculation) system. Oily fumes from the CCV system can combine with carbon particles from the EGR system to form a black sticky tar in the intake system. This eventually starts restricting the amount of airflow into the engine, resulting in gradual power loss as the vehicle ages and the intake clogging becomes worse. In rare cases a MIL ("check engine" light) may be tripped, with an intake manifold pressure control code set, but normally this does not happen and no codes are set. Operating conditions, fuel quality, oil quality, driving habits, and general condition of the engine all have some effect on how long the intake system survives before clogging up. It can be prevented (see section 7.8 below) and this recalibration is highly recommended for all TDI owners.

But if you didn't do that, and your vehicle is suffering from lack of power at higher engine speeds at all times, you need to clean the intake manifold. The following procedure is generic to all TDI vehicles. Individual vehicles may differ slightly.

Don't even THINK about cleaning the intake manifold without removing it from the vehicle ... engines don't like breathing solid particles.

CAUTION: This is an involved procedure. None of the steps are particularly difficult but the procedure requires diligent attention to how everything is disassembled in order that reassembly proceeds smoothly. Read the entire procedure before deciding upon whether to attempt it yourself. If you are not comfortable with the procedure, then arrange for it to be done by someone qualified. Expect to pay for several hours of shop time in that case, because that's what will be required.

7.g.1 Remove the top engine cover. Since it may be necessary to access some bolts from underneath the vehicle, support the front of the vehicle securely on safety jack-stands and remove the lower engine cover.

7.g.2 Disconnect the small-diameter black vacuum hose from the silver EGR diaphragm.

7.g.3 On A3 and B4 vehicles, remove the screw that attaches the upper and lower intercooler pipes, unplug the temperature sensor located on the upper intercooler pipe, disconnect the small diameter hose from the upper intercooler pipe, unclamp both ends of both pipes and remove them from the vehicle.

7.g.4 On A4 vehicles, unclamp and disconnect the upper intercooler pipe from the intake manifold adjacent to the EGR diaphragm and valve, and remove the rubber elbow from the vehicle.

7.g.5 On A3 and B4 vehicles, remove the bolt that attaches the turbo intake pipe to the intake manifold. Release the hose clamp that attaches the turbo compressor outlet pipe to the turbo outlet, and pull the metal turbo compressor outlet pipe out of the vehicle. Cover the turbocharger so that no dirt can get into it.

7.g.6 On vehicles not equipped with an EGR gas cooler, unbolt the EGR transfer pipe at both ends (exhaust manifold and EGR valve), and remove it from the vehicle. On vehicles equipped with an EGR gas cooler, unbolt and remove the EGR pipe from the exhaust manifold to the cooler, then unbolt and remove the EGR pipe from cooler to EGR valve, then unbolt the EGR cooler from the back of the intake manifold. Some of these bolts may require access from underneath the vehicle. Then swing the EGR cooler out of the way. The coolant hoses may be left attached to the EGR gas cooler.

7.g.7 On A4 vehicles, disconnect the linkage at the anti-shudder valve and unbolt the solenoid and actuator assembly, and detach the EGR / antishudder housing from the intake manifold. It may prove easier to leave the solenoid and actuator devices connected to the vehicle but hanging loose. Remove the EGR / anti-shudder valve assembly from the vehicle.

7.g.8 Remove the 6 bolts which secure the intake manifold to the engine. It will be necessary to bend a heat shield on the exhaust manifold out of the way to remove the 2 right-most bolts; this can be done with carefully-placed hits with a hammer on a long screwdriver. On some models, it will be necessary to remove the oil feed line to the turbocharger in order to access one of the bolts. The fitting at the turbocharger will probably be seized and will let go with a sharp "crack" upon applying firm pressure. Use a wrench which fits well over the fitting so that it doesn't slip. Cover the oil feed to the turbo, and protect the oil pipe, so that no dirt can enter either component.

7.g.9 Remove the intake manifold from the vehicle after confirming that nothing else is in the way.

7.g.10 The intake manifold can be cleaned out by a number of methods. Paint remover, acetone, and other solvents can be used to soften the goop. (Do this away from anything that may be damaged by the nasty solvents and away from any ignition sources due to their flammable vapours!) A high-pressure washer is useful. Bead-blasting has also been used but make sure all the beads are out of there before re-installing the manifold on the engine.

7.g.11 Debris also accumulates in the inlet ports of the cylinder head, but these are very difficult to clean without getting too much debris into the engine. One method that has been suggested involves placing cotton balls just inside the ports, cutting a bevel in the crud so there is not such an abrupt transition, and sucking the balls and cut-off bits of crud out with a shop vacuum.

7.g.12 Assembly is generally the reverse of removal. If you had to remove the turbo oil feed line, make sure you reconnect it, and don't over-tighten the fitting at the turbo. It will not be possible to get a torque wrench on most fasteners, so use common sense when re-installing the bolts. You don't need a new intake manifold gasket.

Back to Top

h. **Solving the "Slow-down Shudder" and Other Shudder Issues - Recalibrating the Fuel Quantity at Idle -** A VW specific scan tool such as VAG-COM is required for this procedure. With the engine warmed up and running at idle in neutral with all major accessories such as air conditioning turned off, connect the scan tool cable and start the scan tool software. Select engine control module. "Login" using 12233 as the access code. Select "adaptation" and go to adaptation block 1. Note that the display shows a default adaptation value of 32768 and shows the amount of fuel being delivered in milligrams per stroke. (If it does not show this, you are either on the wrong screen, or you have an older ECU that differs slightly - see next paragraph.) The specification range for reported fuel delivery at idle is 2.2 to 9.0 mg/stroke and they normally run best between 3.0 and 5.0 mg/stroke (highly tuned non-stock engines may differ - you'll have to experiment in that case). If you see a number smaller than your desired range, enter an adaptation number that is slightly smaller (say 100 units smaller than where it is now) and "test", to see the effect. Adjust the adaptation number up or down as required to achieve a reported fuel injection quantity as close as possible to your target. It is only possible to adjust within a very limited range using this method but experience has found that it doesn't take much change to make a big effect in the shuddering. Once you get a proper setting, "save" it.

Note for '96 Passat and possibly other older ECU variations: The adaptation numbers are in a different range, and you won't be able to get feedback on what you are doing on the same screen. You'll have to flip between "measuring blocks" group 1 and "adaptation" block 1 to see what's going on.

Physical adjustment of the upper section of the pump is also possible to recalibrate the fuel quantity but it is strongly recommended that the adaptation method be used first. The physical adjustment method requires the use of a special tool to loosen the special security bolt on the injection pump, then the other 3 bolts that secure the top 2 sections of the pump to the housing (you can leave the upper cover in place - it's movement at the second split that you are after). In addition, this method still requires the use of VAG-COM to ensure that the injection quantity remains in the proper range. THIS METHOD IS NOT RECOMMENDED FOR BEGINNERS. It is a "last resort" to solve an engine that persists in not running correctly despite all other attempts, and which has had major surgery performed on the injector pump, and even then, ONLY if a VAG-COM check finds that the pump is out of OEM specifications (2.2 to 9.0 mg/stroke at warm idle in neutral with all accessories off). CAUTION: Improper physical adjustment of the pump is capable of causing an "engine run-away" condition which will result in severe engine damage. ALWAYS ensure that if a physical adjustment is done, that the adaptation setting for group 1 is at factory default and that after completion of all work, the reported quantity at idle is within factory specifications.

Back to Top

i. **Engine Power Supply Relay a.k.a. "Relay 109" Replacement -** this is a very inexpensive part - about $20, and it is easy to replace yourself. On older models, it is located on the fuse panel, which is behind a cover on the bottom left corner of the instrument panel. The cover can be removed without tools and the relay can be pulled out of the fuse panel (note the location on the panel and the orientation of the pins on the relay for reference during installation of the new relay). On later models, it is located on the relay panel, which is behind a cover left of the steering column behind the instrument panel, which will require a Torx screwdriver to remove. Once the panel is removed, the replacement procedure is the same as for the older models.

Back to Top

j. **Avoiding the Need for Intake Manifold Cleaning - Recalibrating the EGR System -** this vehicle is equipped with a CCV (crankcase vent) system and an EGR (exhaust gas recirculation) system. Oily fumes from the CCV system can combine with carbon particles from the EGR system to form a black sticky tar in the intake system. This eventually starts restricting the amount of airflow into the engine, resulting in gradual power loss as the vehicle ages and the intake clogging becomes worse. In rare cases a MIL ("check engine" light) may be tripped, with an intake manifold pressure control code set, but normally this does not happen and no codes are set. Operating conditions, fuel quality, oil quality, driving habits, and general condition of the engine all have some effect on how long the intake system survives before clogging up. It can be prevented and this recalibration is highly recommended for all TDI owners.

   A VW specific scan tool such as VAG-COM is required for this procedure. With the engine warmed up and running at idle in neutral with all major accessories such as air conditioning turned off, connect the scan tool cable and start the scan tool software. Select engine control module. "Login" using 12233 as the access code. Select "adaptation" and go to adaptation block 3. Give the accelerator pedal a quick "blip" to ensure that the EGR remains turned on for the next minute while you perform the following steps. Note that the display shows a default adaptation value of 32768 and shows approximately 250 +/- 20 mg/stroke of air intake volume. (If it does not show this, you are either on the wrong screen, or you have an older ECU that differs slightly - see next paragraph.) If all is well, enter 33768 as the new adaptation value, and select "test". Note that the displayed air intake volume changes, usually to about 370 mg/stroke. The specification limit is 370 mg/stroke, so if you want to remain within OEM shop manual specifications for emission control reasons, you might have to enter a number slightly smaller than 33768. (If you don't care about road-legal NOx emission limits then leave it at 33768.) If all is well and you have a seting that you are happy with which results in an intake air volume of 370 mg/stroke or just a hair less, enter "save". Now your intake manifold either will never clog, or will take so long that the engine will wear out first.

   Note for '96 Passat and possibly other older ECU variations: The adaptation numbers are in a different range, and you won't be able to get feedback on what you are doing on the same screen. The EGR adaptation number for a '96 Passat with the original "BK" ECU is 188 rather than 33768 and you'll have to go back to "measuring blocks" group 3 to see the effect before "saving" the new setting.

   Back to Top

k. **Setting the Injection Timing - Injector Pump Mechanical Adjustment** - A VW specific scan tool such as VAG-COM is required for this procedure. It cannot be done by any other method. The mechanical adjustment technique used for previous generations of VW diesels, which used a mechanical fuel pump without electronic control, is not suitable for the electronically controlled TDI injector pump.

   With the engine warmed up and idling, connect the diagnostic tool, and select the engine control module. At this point, one of two different procedures is necessary, depending upon whether you have the proper factory service manual for your particular vehicle.

   If you have the factory service manual, select "Measuring Blocks", group 0, then select "Basic Settings". The glow plug indicator lamp will begin flashing at this time (this is normal). Do

NOT forget to go into "Basic Settings" because this procedure is completely invalid if measurements are taken outside of "basic settings". Take note of the 2nd and 9th numbers in the display. Locate the chart in the factory service manual which shows the proper relationship between these two numbers. Go across the chart with the 9th number then up the chart with the 2nd number and make sure it is within the shaded area. It has been found through experience that these engines have better cold starting characteristics if the setting is within the upper half of the shaded area. If it is good ... don't do anything further. If the second number is below the recommended range, you need to make a mechanical "advance" adjustment (see below). If the second number is above the recommended range, you need to make a mechanical "retard" adjustment (see below).

If you don't have the factory service manual, select "Measuring Blocks", and go to group 4. Do NOT use "basic settings" for this method. The displays show the requested injection timing, the actual measured injection timing, and the duty cycle of the advance solenoid. At warm idle in neutral, requested timing should be between 0.4 and 2.0 degrees BTDC. If the actual timing is not more than roughly 3.0 degrees BTDC, and the duty cycle of the advance solenoid is not more than 10%, the timing is good ... don't do anything further. If actual timing is more than 3.0 degrees BTDC, you need to make a mechanical "retard" adjustment. If the duty cycle is more than 10%, you need to make a mechanical "advance" adjustment.

If you have an A3 or B4, you need to rotate the body of the injector pump "forward" to retard the timing and "backward" to advance the timing. Stop the engine. Remove the upper timing belt cover. Rotate the engine by hand (shifting trans into 5th gear and pushing the whole car works) such that the two nuts at the rear and bottom of the injector pump flange can be reached through the access holes in the pump pulley. Loosen these two nuts by 1 turn, loosen the bolt at the top front of this flange 1 turn (accessed from outside, not within the pulley). Loosen the bolt located at the opposite end of the pump below the four injector lines. With a 17mm wrench, loosen by 1/2 turn the injector lines on the end of the pump. Now you can rotate the entire pump housing in the required direction (make VERY SMALL adjustments) then tighten and reassemble everything and recheck the timing.

If you have an A4, you need to remove the upper timing belt cover and adjust the relationship between the inner and outer parts of the injector pump pulley. To advance the timing, the inner part of the pulley (together with the pump shaft) needs to move "forward" with respect to the outer part of the pulley. To retard the timing, the inner part needs to move "backward" with respect to the outer part. The 3 bolts which secure the two parts of the pulley together may or may not be "stretch bolts" that must be replaced every time you do this ... so it's a good idea to get 3 new bolts just to be sure. Make all the adjustments using the original bolts, then replace the old bolts with the new bolts and torque them one at a time.

Back to Top

l. **MAF sensor - checking and replacement** - With VAG-COM, confirm that in measuring blocks 3 with the engine at warm idle in neutral with all accessories off, the requested and actual airflow rates closely match each other (specifications: 230 to 370 mg/stroke) until the engine has been idling for a couple of minutes, after which the reported airflow should increase to approximately 480 (plus or minus about 30) mg/stroke. At 3000 rpm full load (test can only be done while driving) the reported air intake quantity should be at least 800 mg/stroke. If your sensor does not pass these tests and the intake system is known not to be excessively clogged, replace the MAF. The Pierburg MAF cannot be used as a replacement for a Bosch, but a Bosch MAF for a 2.0 gasoline engine vehicle will work fine in a TDI and may be a lot less expensive...

Back to Top

Back to FAQ Index

TDI FAQ

8) Troubleshooting

Disclaimer: While considerable effort has been made to make the information provided in this section as complete and accurate as possible, it does not and cannot cover all possible situations. The authors cannot accept any responsibility for any damages which may occur from the use or mis-use of these procedures, nor can the authors accept any responsibility for any damages which may result from personal injury or property damage which allegedly may be caused by the use or mis-use of these procedures. No responsibility is accepted for missing or incorrect information. Those who use these procedures shall accept all responsibility for performing the work which may be described below. If you have any comments or suggestions for additions or revisions, please contact the site administrator.

The following sections are grouped based upon the "major symptom". Within each section, subsections describe possible causes that could cause the major symptom. These symptoms are approximately listed in descending order of probability based on the experience of forum members (in other words, the most likely causes are listed first). In many cases, the subsection will be preceded by one or more questions or test procedures. It is crucial to find out the answers to each of these questions and test procedures so that you do not get led astray!

Troubleshooting is like detective work. It will frequently be necessary to list a number of possible causes, then systematically go through these possible causes while ruling them out one by one, until the actual problem area is located.

Finally, within each subsection, a description of how to repair the problem is either provided, or referenced elsewhere. Where applicable, advice is given on how to prevent the problem from happening again.

References within this document to "left" or "right" always refer to the orientation viewed from the driver's normal seating position.

Throughout this document, you will see references to VAG-COM. Many diagnostic and calibration procedures cannot be performed without a VW specific diagnostic scan tool. VAG-COM is a reasonably priced software and cable that allow any Windows based computer to be used to communicate with the vehicle's on-board diagnostic system. Generic OBD-II code scanners (such as those which may be found at independent garages that do not specialize in VW/Audi) will normally NOT be sufficient - you need a VW specific scan tool. For more information about VAG-COM and to purchase a copy for yourself, see www.ross-tech.com - highly recommended.

This thread identifies VAG-COM users who may be willling to help:
http://forums.tdiclub.com/NonCGI/ultimatebb.php?ubb=get_topic;f=17;t=000768
Here's a database of VAG-COM users in North America who might be able to help you:
http://www20.brinkster.com/beowulf9/tdi/vagcom/

Know which model you have. If you have a '96 or '97 Passat TDI in North America, you have a B4 chassis with what is known in this document as an A3-style engine, and you have a Garrett GT15 turbocharger. If you have a '97 through early '99 Jetta TDI in North America, you have an A3-style engine and you may have the Garrett GT15 turbocharger but more likely you have a KKK K03-006 turbocharger. If you have a New Beetle TDI, or a '99.5 or later Jetta or Golf TDI in North America, you have an A4-chassis vehicle, and you have a Garrett VNT-15 turbocharger.

The engine code number can be found on the build sheet which is typically near the spare tire on the floor of the trunk. In North America, engine code 1Z means 90hp A3-style engine with Garrett GT15 turbocharger and Pierburg MAF (mass air flow sensor). Engine code AHU means 90hp A3-style engine with KKK K03-006 turbocharger and Pierburg MAF. ALH means 90hp A4-style engine with Garrett VNT-15 turbocharger and Bosch MAF. European models don't necessarily correspond in specifications, engine codes, and model years (you're on your own, as far as figuring out what type of turbo and MAF sensor you have).

[Back to FAQ Index]

---

8) Trouble Shooting

a. **Preventing Future Problems (to the extent possible) :**
This section documents procedures and operating practices that will hopefully prevent many of the problems described later on from ever happening.

Perform the scheduled maintenance on schedule! The required schedule is in your owner's manual. Don't assume that particular driving habits will allow any service interval to be extended beyond what the owner's manual recommends. Consider doing *more* maintenance than officially scheduled. Particular attention needs to be paid to all fluid levels, fuel / air / oil filters, and timing belt replacement. Timing belt replacement interval is 96,000 km for all manual transmission models of 2001 and previous model years, 64,000 km for all automatic transmission models of 2001 and previous model years unless the 2002 model belt and tensioner have been installed, and 128,000 km for 2002 models and beyond. The 2002 model timing belt and tensioner can be retrofitted to A4-chassis vehicles (manual or automatic) provide that both the belt and tensioner are replaced with the new designs. They cannot be retrofitted to earlier A3-type engines because the belt is a different length.

Use the fluid types recommended in the owner's manual and in the factory service manual. The "G12" VW coolant is specially designed to be compatible with the seals, hoses, and cooling jacket materials used in VW vehicles - don't assume that other pink or reddish fluids are the same. Likewise for the power steering fluid, the brake fluid, and the special automatic transmission fluid (do NOT ever use a Dexron-type fluid in later model VW automatic transmissions!). The best bet is to buy these fluids at a VW dealer. Yes, the VW power steering fluid is 10 times more expensive than generic power steering fluid. Why should you use it? Price out a new rack and pinion mechanism ...

Regarding engine oil ... your owner's manual recommends 5w40 oil which conforms to one of several specifications, all of which are specific to diesel engines.

There have been issues with intake manifolds clogging due to the combination of oily fumes (originating from the CCV or crankcase ventilation system) with soot from the EGR (exhaust gas recirculation) system. These problems can be virtually eliminated by ensuring that the EGR system is operating at the minimum allowable level. The adjustment procedure is in section 7.h of this FAQ. The only side effect of this alteration will be somewhat increased NOx emissions under certain operating conditions but the change will not affect the ability of the vehicle to pass emission tests (#1, the adjustment remains within factory specifications, #2, most emission test procedures for diesel vehicles do not measure NOx). DO NOT change any of the other adaptation values unless their effects are precisely known and considered. Specifically, changing the adaptation value for injection timing in group 4 to other than factory default may cause severe engine damage so DON'T TOUCH adaptation group 4! (Every 2 degrees of timing advance raises peak cylinder pressure approximately 15 bar (about 10%) and raises piston temperature by an unknown amount, so it's best to leave this alone.)

Some manual transmission vehicles exhibit a slight "shudder" upon returning to idle speed after coasting down from higher speed. An adjustment procedure is in section 7.i of this FAQ. Deviation towards a smaller reported injection quantity has been associated with this "slow-down shudder". Deviations towards a higher reported injection quantity have been associated with lack of power. It can be adjusted to some extent by adjusting adaptation channel 1 using VAG-COM so that the reported injection quantity is as close to within the 3.0 to 4.0 range as can be achieved.

Finally, DON'T BABY IT. Don't drive around with the pedal right on the floor all the time, either. But don't baby it and don't lug it. Give it some load once in a while. Give it some revs. This seems to "exercise" the VNT mechanism and help in keeping the exhaust system from getting clogged up with carbon.

Back to Top

b. **Engine will not start, or engine is difficult to start:**
Question: Will the engine start at all? If the engine will start occasionally, or after an extended period of cranking, go to section 8.b.2 - Difficult starting. If the engine cannot be started at all, go to section 8.b.1 - Engine will not start.
b.1 Engine will not start.

Test procedure, step 1: Have the transmission in neutral (or park, if automatic transmission). Have the clutch pedal pressed completely to the floor throughout this procedure (if manual transmission). Watch the instrument cluster at the location of the "glow plug" and/or "check engine" lights. Insert the ignition key into the ignition switch, and turn it to "run" (not start). Do the "check engine" and "glow plug" indicator lights come on? If they do not, go to section 8.b.1(a) - No electrical power to engine electronics. If the indicator lights come on as they do normally, continue to the next step in the test procedure, below.

Test procedure, step 2: Wait for the "glow plug" indicator to turn off, then turn the key to "start". Does the engine rotate ("crank", "try to start", "make noise")? If it does, go to section 8.b.1(b) - Engine cranks but does not start. If the starter motor does not operate, go to section 8.b.1(c) - Starter motor does not operate.

b.1(a) - No electrical power to engine electronics.

PRECAUTION: Problems listed in this section can NOT be identified by the vehicle's "on board diagnostics" system. They will typically NOT set any "trouble codes" in the ECU.

- Are all other electrical systems (such as lighting systems) "dead", in addition to the electronics? If so, the battery may be completely discharged. It will be necessary to remove the battery from the vehicle and have it recharged out of the vehicle, and replaced with a new one if the battery is found to be faulty. AVOID "BOOSTER / JUMPER STARTING" ANY LATE MODEL VEHICLE (not just this one). THE ELECTRONICS ARE VERY, VERY EXPENSIVE TO REPLACE IF YOU "FRY" SOMETHING.

- If all other electrical systems are also weak or dead but the battery is good, the problem may involve a corroded or loose battery cable connection. Check the connections at the battery terminals as well as at the ground straps and chassis ground connections (these are located near or under the battery on most models). It will be necessary to make the connection good (e.g. by sanding the contact surfaces) and re-install the connection, coating it with a suitable dielectric grease to prevent further corrosion. HINT: At the battery cables, before securing the clamp nut, place a socket centered over the battery terminal and large enough to fit around the outside of the battery post but securely flat on the terminal, then tap the socket lightly with a hammer to "seat" the terminal before securing the clamp nut.

- "Relay 109" failure - this is the relay which provides power to all of the engine electronics. Failure of this relay will NOT typically set any "trouble codes" in the ECU. The only method of isolating the problem is to replace the relay. Refer to Section 7.j of this FAQ for replacement procedure.

- Ignition switch fault. If replacing the relay doesn't solve the problem, this is the next most likely problem.

- Security system fault (if so equipped).

b.1(b) - Engine cranks but does not start.

- Electrical problem. Perform the test procedure at section 8.b.1 to determine whether the engine electronics are receiving power. Refer to section 8.b.1(a) if there is no power to the engine electronics.

- Weak or partially discharged battery. The starter motor must crank the engine at about 300 RPM for the engine to start. If cranking speed is low, have the battery load tested out of the vehicle, and serviced / recharged / replaced as required.

- Corroded electrical connections at the battery terminals, starter motor power wire, ground strap (located near or under the battery on most cars), ground strap at engine block side. See similar symptom under 8.b.1(a).

- Weak starter motor. The starter motor must crank the engine at about 300 RPM for the engine to start. If the cranking speed is low, but the battery checks out OK and all battery post and cable terminals are OK (see 8.b.1(a)), then the starter motor needs to be removed from the vehicle and serviced. The starter motor can be serviced by any reputable auto electric shop; look in your local phone book.

- Incorrect or insufficient fuel in the fuel tank. Diesel engines will not operate on gasoline, water, or air.

- Incorrect fuel injection timing. See inspection and repair procedure at section 7.k.

- Anti-shudder valve not opening. See description of this same symptom under section 8.b.2 - Difficult starting.

- All of the potential causes of difficult starting can also cause complete failure to start, if the condition is sufficiently severe. See section 8.b.2 - Difficult starting.

- Air in the fuel system - especially if maintenance has just been performed. Check the clear plastic lines for air bubbles, and see if the bubbles move when you crank the engine. If air bubbles are found, check all fuel hose connections and ensure that the white plastic "T" that fits into the top of the fuel filter is properly seated with the O-rings securely in place. Refer to section 7.b.

- Fuel filter clogged or filled with water. Refer to section 7.b.

- Poor compression due to worn-out engine.

- Major mechanical failure. Remove the timing belt cover and check whether the timing belt is still there and properly tensioned, and still has teeth on it all the way around ...

- Fuel injection pump problem - inoperative or worn out. See description at section 8.b.2 - Difficult starting.

- (Only applies if the ambient temperature is below freezing and the engine has been outside in below-freezing conditions for several hours.) Improper starting procedure. Drivers accustomed to gasoline engines might be turning the key all the way to "Start" without waiting for the glow plugs. Proper starting procedure is to turn the key to "ON", wait for the glow plug light to go off "for good" (some models have a brief flash before the "real" glow plug delay), and then turn the key to "START" to crank the engine.

- (Only applies if the ambient temperature is below approximately -10 C.) Fuel not sufficiently "winterized". There are some additives which claim to de-gel a fuel system which is already gelled up, but they won't solve the problem of thawing out the injection pump and the fuel filter. The only way you're going to get started is to get some heat into the injection pump and the fuel filter by some suitable means - hair dryer, or whatever. To prevent this from happening again, fill up with fuel which is either known to be winterized, or use an anti-gelling additive which is available at truck stops to prevent precisely this problem.

- (Only applies if the ambient temperature is below approximately -10 C.) Wrong oil viscosity, too heavy for ambient temperature, causing cranking too slow to allow the engine to start. Use the oil viscosity recommended in your owner's manual, which is 5w40 (this viscosity is only available as a synthetic engine oil).

- (Only applies if the ambient temperature is below freezing and the engine has been outside in below-freezing conditions for several hours.) Glow plugs or glow plug system inoperative. If the temperature is above freezing, this is not the problem - the glow plug system is not required for starting the engine with the coolant temperature above approximately 5 degrees C. If the temperature is below freezing and the engine has been outside for several hours, but the glow plug delay period is abnormally short, the coolant temperature sensor may be faulty. This fault will NOT cause a MIL or "check engine" light and will NOT set any ECU trouble codes. Checking the calibration of the coolant temperature sensor requires that the vehicle be left outside for several hours and then connected to VAG-COM. Confirm that the temperature displays in VAG-COM "measuring blocks" are approximately outside temperature before starting the engine. If they are not, replace the faulty temperature sensor. The coolant temperature sensor can also be resistance checked out of the vehicle, per the procedure in the factory shop manual, but given the hassle of removing the sensor from the vehicle and checking it, it may make more sense to simply replace the sensor with a new one (it's not expensive). Troubleshooting a faulty coolant temperature sensor without either VAG-COM or information from the factory service manual is not possible.

To get the vehicle going with a bad coolant temperature sensor, unplug the electrical connection to the coolant temperature sensor (which will force the glow plugs to operate for the maximum period) until the engine is running. The coolant temperature sensor is located on a coolant pipe towards the left side of the cylinder head and the wiring connection is on a bracket nearby.

This vehicle is equipped with a monitoring system for the glow plugs. If problems develop with a glow plug, the power supply wiring to the glow plug, or the activation relay for the glow plugs, the MIL or "check engine" light will come on and a "glow plug monitoring" code will be set in the ECU. If problems develop with the coolant temperature sensor, the MIL will probably NOT come on (see above).

b.1(c) - Starter motor does not operate.

- Are all other electrical systems "dead" in addition to the electronics? If so, see similar, under section 8.b.1(a).

- Corroded or loose battery cable connection. See similar, under section 8.b.1(a).

Optional test procedure which will make subsequent troubleshooting much easier: Obtain a DC voltmeter, or a 12-volt test light with suitable probes. At the starter motor, note that there are 2 cable connections, one small, one big. There should be 12 volts between the big cable connection and the engine block at all times. (If not, there is a problem with the battery itself, or the wiring between the battery and this terminal.) Have an assistant switch the key to "start" while pressing the clutch all the way to the floor (manual) or with the selector in "Park" or "Neutral" (automatic). There should be no voltage between the small terminal and the engine block normally, but this should go to 12 volts when the key is in the "start" position with the clutch pedal pressed to the floor (manual) or selector in "Park" or "Neutral" (automatic). If there is power to both large and small terminals, and yet the starter motor does not operate, the starter is faulty, and requires a rebuild which can be done by any automotive starter/alternator shop in your local area.

- Clutch interlock switch fault (manual transmission - if so equipped). On most models, the clutch pedal must be depressed all the way to the floor before the engine can be started. If this is being done, and the starter still will not operate, the switch may be faulty. Check switch and wiring for proper operation and good connections and repair/replace as necessary.

- Gear position interlock switch fault (automatic transmission - if so equipped). The starter motor will not operate unless the selector is in "P" or "N". If this is the case, and yet the starter still will not operate, the switch may be faulty. Check switch and wiring for proper operation and good connections and repair/replace as necessary.

- Faulty starter motor. Refer to the test procedure described above. If the starter does not operate, but the battery checks out OK and all battery post and cable terminals are OK (see 8.b.1(a)), then the starter motor needs to be removed from the vehicle and serviced. The starter motor can be serviced by any reputable auto electric shop; look in your local phone book.

- Ignition switch fault.

- Security system fault (if so equipped).

b.2 Engine is difficult to start, requires a long period of cranking before starting, etc.

- Weak or partially discharged battery. The starter motor must crank the engine at about 300 RPM for the engine to start. If cranking speed is low, have the battery load tested out of the vehicle, and serviced / recharged / replaced as required.

- Corroded electrical connections at the battery terminals, starter motor power wire, ground strap (located near or under the battery on most cars), ground strap at engine block side. See similar symptom under 8.b.1(a).

- Weak starter motor. The starter motor must crank the engine at about 300 RPM for the engine to start. If the cranking speed is low, but the battery checks out OK and all battery post and cable terminals are OK (see 8.b.1(a)), then the starter motor needs to be removed from the vehicle and serviced. The starter motor can be serviced by any reputable auto electric shop; look in your local phone book.

- Air in the fuel system - especially if maintenance has just been performed. Check the clear plastic lines for air bubbles, and see if the bubbles move when you crank the engine. If air bubbles are found, check all fuel hose connections and ensure that the white plastic "T" that fits into the top of the fuel filter is properly seated with the O-rings securely in place. Refer to section 7.b.

- Fuel filter clogged or filled with water. Refer to section 7.b.

- Incorrect fuel injection timing. Further evidence of incorrect timing include excessive smoke from the exhaust once the engine eventually starts, and reduced power, and higher than normal fuel consumption. See inspection and repair procedure at section 7.k.

- Faulty or poorly calibrated fuel injectors or injector pump. IF you have VAG-COM, get the engine going, and confirm that the amount of fuel delivery at idle is within specifications. Refer to section 7.i of this document for adaptation procedure.

- Anti-shudder valve problems. If you have an A3 or B4, this isn't the problem, because you don't have one. The anti-shudder valve is located at the entrance to the intake manifold right next to the silver round EGR diaphragm at the right rear of the engine compartment (attached to the engine). To the right of this is a device operated by a linkage facing the rear - this is the anti-shudder valve. Operate the mechanism by hand and make sure it moves freely and is spring-loaded to the open position. If you unclamp and remove the flexible air intake hose located right next to this, you can look inside and readily see whether the "throttle butterfly" is operating as it should.

- Poor quality fuel.

- (Only applies if the ambient temperature is below freezing and the engine has been outside in below-freezing conditions for several hours.) Improper starting procedure. See 8.b.1(b).

- (Only applies if the ambient temperature is below approximately -10 C.) Fuel not sufficiently "winterized". See 8.b.1(b).

- (Only applies if the ambient temperature is below approximately -10 C.) Wrong oil viscosity, too heavy for ambient temperature, causing cranking too slow to allow the engine to start. Use the oil viscosity recommended in your owner's manual, which is 5w40 (this viscosity is only available as a synthetic engine oil).

- (Only applies if the ambient temperature is below freezing and the engine has been outside in below-freezing conditions for several hours.) Glow plugs or glow plug system weak or inoperative. See 8.b.1(b).

- (Only applies if the ambient temperature is below freezing and the engine has been outside in below-freezing conditions for several hours.) Faulty coolant temperature sensor causing non-operation of glow plugs. See 8.b.1(b).

Back to Top

c. **Engine stalls randomly without warning and may or may not restart :**
- See "Relay 109" at section 8.b.1(a).

Back to Top

d. **MIL ("Check Engine") light is on while driving, or "glow plug" light is flashing while driving:**

- In ALL cases, if a MIL is on or flashing, a trouble code will be set in the ECU which can be read by a VAG-COM or other scan tool connected to the on-board diagnostic system. The knowledge of this trouble code will greatly assist in narrowing down the problem area.

- Do the engine "check" light and "glow plug" light intermittently come on for brief periods while driving? If so, see "Relay 109" at section 8.b.1(a). The relay may be losing electrical power for fractions of a second, which are enough for the engine electronics to think that you switched the key off then on.

- If the "glow plug" light is flashing while driving, check your brake lights! The brake light circuit is monitored by the engine electronics and this is the warning signal used in this case (among others). Burned out brake light bulbs will cause this symptom, as will a faulty or improperly adjusted brake light switch or a blown fuse for the brake lights.

- If the MIL is accompanied by a reduction in engine power, proceed to section 8.e below, with particular attention paid to the sections concerning the MAF sensor and wiring (most likely cause).

- MIL accompanied by difficult starting and/or smoke from the exhaust and/or a reduction in power and/or an increase in fuel consumption, especially after work has been done involving the timing belt or the injector pump, may indicate fuel injection timing grossly out of adjustment. Resetting the injection timing requires the use of a VW specific scan tool, there is NO alternative procedure. Refer to section 7.k of this document.

- MIL which may or may not be accompanied by a reduction in power may indicate a malfuctioning EGR system (e.g. sticking EGR valve, sticking EGR solenoid valve, disconnected or improperly routed vacuum hose related to EGR system, clogged intake manifold, MAF sensor problems - all of these components are involved with the EGR system). These problems will set a trouble code that can be read by a VAG-COM, with the trouble code indicating an EGR control system deviation (or similar). Note: see section 7.g for intake manifold cleaning procedure, see section 7.h for EGR adaptation procedure to prevent a recurrence. If despite cleaning the intake manifold and confirming that the EGR valve is operating smoothly, the problems likely involve the EGR solenoid valve or the MAF sensor.

- MIL which comes on after approximately 30 seconds of starting the engine, but which is not associated with any apparent driveability problems but which MAY be associated with difficult cold starting, may indicate a problem related to the glow plug or the glow plug circuit. If you get a "glow plug monitoring" fault upon investigation with VAG-COM, remove the wiring harness from the glow plugs and measure the resistance between each glow plug terminal and the engine block. All four should be the SAME and in the 0.5 to 1.0 ohm range. If you find that one or more glow plugs are either outside this range or are different from the others, consider replacing ALL FOUR glow plugs with new ones. The resistance of the glow plugs must match very closely and since it changes as the plugs get older, one must change all four to ensure that they start out with the same resistance and will all have the same pattern of aging. Also check the main glow plug fuse (it's visible under a small clear plastic cover somewhere in the engine compartment - typically either near the battery or on the firewall). If there are no apparent faults with the fuse or the glow plugs, the most likely problem involves poor electrical connection between the harness and the glow plugs - try sanding / cleaning these contacts or replacing the harness (not expensive). The official service procedure calls for replacing the glow plug relay but it has been found that an exceedingly large majority of the time, the relay is not at fault.

- There are many other potential causes for a MIL, but rest assured that a loose fuel cap is not one of them! Gasoline engine vehicles have a monitoring system for the fuel tank venting arrangement but diesel engine vehicles DO NOT HAVE this system.

- If a MIL is on, and there are no readily apparent other symptoms of malfunction, the ONLY method of finding the cause involves connecting the vehicle to a suitable scan tool. IT IS NOT POSSIBLE TO OBTAIN ECU CODES WITHOUT A SUITABLE DIAGNOSTIC SCAN TOOL. Nor is it possible to reset fault codes without first fixing the underlying cause and then resetting the code using a suitable diagnostic scan tool. Get VAG-COM, it's well worth the small investment.

- Finally, do not interpret MIL codes as "gospel" indicating that the sensor pointed to by the code is at fault. The trouble code only indicates the general problem area. Before condemning a particular sensor, check the wiring and electrical connections.

Back to Top

e. **Engine lacks power - "No Boost" - "No Turbo" - "Can't hear turbo":**
Precaution: DO NOT jump to conclusions when attempting to identify the cause of having no power. Don't automatically assume that your turbocharger is broken!

Question: Is the power loss intermittent (OK some of the time, weak at other times) or is it weak all the time? If it is intermittent, see 8.e.1 - Intermittent power loss. If it is weak all the time compared to a similar vehicle which is known to be in a similar state of tune but operating properly, see 8.e.2 - Constant power loss.

e.1 Intermittent power loss - Low engine power under some conditions, but runs well at other times

Note: Getting any codes that may be set your ECU (using VAG-COM) will be a major help in isolating the problem. Codes may be set without necessarily illuminating the MIL ("check engine") light.

- Manifold pressure sensor problems. This only applies to A3 and B4 models (i.e. older models - if you have a New Beetle or a '99.5 or later Golf/Jetta, don't even bother reading this section, you have a completely different setup). There is a black hose which connects at one end to the intake manifold and at the other end to the MAP (manifold air pressure) sensor at the ECU. (The ECU is located underneath a black plastic trim panel that also covers the windshield wiper linkage.) The rubber hardens up and leaks at both end connections, resulting in the ECU not seeing a proper pressure signal and causing "limp mode". Replace the hose with a 5 foot length of 5/64" windshield washer hose (about $4 at an auto parts store). It is not even worth investigating whether the hose is at fault, just replace it.

- MAF (Mass Air Flow) wiring harness problems. Did you change the air filter and forget to plug in the sensor? Some vehicles may have aftermarket modifications which involve the wiring harness leading to the MAF sensor ... are these aftermarket devices operating properly with electrical connections all good? Diagnosis of any problems that may exist with such aftermarket modifications is beyond the scope of this document and troubleshooting may be best performed by removing the device in question from the system.

- MAF (Mass Air Flow) electrical plug problems. If your vehicle has a Bosch MAF (see below) there is a technical service bulletin for replacement of earlier-style wiring connectors with a new design having larger electrical contacts.

- MAF (Mass Air Flow) sensor problems. The MAF sensor is located immediately adjacent to the air filter housing. Question: Look at the nameplate on the sensor. Is your MAF sensor manufactured by Pierburg (all A3's and B4's, some European A4's, i.e. all earlier models) or Bosch (most A4's i.e. all later models)? The Pierburg MAF is extremely reliable and is unlikely to be the source of the problem. The Bosch MAF prior to model year 2002 has a poor reliability history. Many owners have had to replace this sensor multiple times (and this is regardless of the type of air filter used). Refer to section 7.1 of this document.

- Turbo control system not operating properly. Clogged, leaking, disconnected, or improperly connected hoses that are involved with controlling the turbo boost pressure will create havoc. Check condition and routing, and replace if necessary.

- Turbo VNT mechanism sticking. This only applies to vehicles with a VNT-15 turbocharger ... most A4-chassis models including all A4-chassis models sold in North America, and all 110hp models (A3 or A4 chassis) sold elsewhere. (DON'T READ THIS if your car has a GT15 or K03 turbocharger because they operate in a COMPLETELY different manner.) Locate the diaphragm housing which operates the VNT mechanism (has a single hose going to it, extreme rear of engine compartment, buried down near the bottom right rear of the engine, hose connection faces STRAIGHT DOWN). Locate (by feel with a finger) the linkage rod which points straight up out the center of that diaphragm housing. While feeling this rod, have someone start the engine, and note whether the linkage rod moves - it should. Upon stopping the engine, the linkage rod should move back after a few seconds. If the linkage rod does not operate as described, get a vacuum tester (any auto parts store) and apply vacuum to the VNT diaphragm to see if you can get it to move. If it's seized up, there's your problem. NOTE: To prevent this from happening, DON'T BABY THE

VEHICLE when you are driving it, and consider recalibrating the EGR system to reduce the amount of soot build-up in the exhaust.

- Turbo wastegate mechanism sticking. This only applies for those with a GT15 or K03 turbo. If you have a later model, you have a VNT mechanism rather than a wastegate, so see above. The wastegate opens under pressure rather than vacuum. Using a pressure gauge which reads to 30 psi, verify that when you floor it at 2500 rpm, the turbo boost pressure rises to a peak and then drops to about 0.8 - 0.9 bar (12 - 14 psi). Sometimes the wastegate diaphragm gets clogged up with oil from the crankcase ventilation system, and some owners have had success by replacing the red and blue hoses with new clean hoses and cleaning gunk out of the diaphragm housing as best as possible. You're on your own for doing this procedure. To prevent it from ever happening, arrange for the crankcase fumes to not get into the engine air intake ...

- Turbo boost control solenoid valve problems - this is also known as the N75 valve. If you have VAG-COM, and a trouble code of "intake manifold pressure control" is being set, and the problem is NOT a sticky VNT mechanism (see above), the N75 valve may be sticking, clogged with debris, or faulty. It can be removed from the vehicle and the paths through the valve checked by blowing through the various connections with the valve first de-energized, and then energized with 12 volts. Alternatively, obtain a vacuum gauge and "T" it into the hose that goes from the N75 valve to the VNT vacuum diaphragm, and confirm that the vacuum varies under different load conditions while driving. If found to be faulty, some have had success by blowing solvent through the valve to remove any deposits, but replacement with a new one may be the best option.

- Fuel cut-off valve O-ring unseated - especially if the idle speed is intermittently higher than normal. With the engine cover removed, the fuel cut-off valve is located on top of the injection pump just above where the four steel lines go into the end, and has a single wire going to it. Remove this valve (disconnect the wire first!) and make sure the black O-ring is all the way against the body of the valve, then re-assemble.

- Vehicles which have modified engine control systems, especially if a chip and a tuning-box are used together, may experience a phenomenon which has been called "warp field collapse": at full load and generally higher engine speeds, the engine will abruptly go into a reduced-power mode. Investigation of trouble codes with a VAG-COM will generally find a code set which is related to the quantity adjuster upper limit. The problem is that too much fuel is being requested! The solution is to back off the requested amount of fuel, generally through de-tuning the tuning box which hopefully has some manual adjustments that can be made.

e.2 Constant power loss - Vehicle is always sluggish compared to another similar vehicle in a similar state of tune

- If power loss happens below operating temperature and it's OK warmed up, this behavior is normal to some extent.

- If the power loss is accompanied by an excessive amount of exhaust smoke, check all the pipes involved with the air intake system for leaks! A leak on the high-pressure side of the turbo compressor will cause this problem. On later models, the pipe from the turbo compressor outlet (bottom of turbo) to the intercooler is particularly vulnerable because the clamp is awkward to reach and difficult to install properly, so it's prone to blowing the pipe off the turbo. You'll have to remove some lower engine covers to see this pipe properly.

- Dragging brakes, underinflated tires, excessive weight carried in vehicle, slipping (worn-out) clutch, transmission problems which are beyond the scope of this document, etc.

- Incorrect injection timing. See inspection and repair procedure at section 7.k.

- MAF sensor or wiring problems. See procedures described under section 8.e.1.

- Intake manifold clogged. See repair procedure at section 7.g, and see section 7.h for recalibration procedure to prevent this from ever happening.

- Air intake clogged. Inspect air filter and airbox intake screen as described in section 7.c of this document.

- Air entering fuel system. Check the clear plastic lines for air bubbles, and see if the bubbles move when you crank the engine. If air bubbles are found, check all fuel hose connections and ensure that the white plastic "T" that fits into the top of the fuel filter is properly seated with the O-rings securely in place. Refer to section 7.b.

- Intercooler blocked externally. Inspect intercooler for external blockage by leaves or other debris - visible by looking at the intercooler, under the bumper on the left side (A3 cars) / right side (A4 cars), and clean as necessary.

- Intercooler clogged internally. Follow the intercooler cleaning procedure in section 7.f of this document.

- Fuel filter clogged. Replace with a new one per section 7.b of this document. If desired, inspect the old one by cutting it open. If failure was premature, find cause of debris entering fuel system. Your VW has a plastic fuel tank, the debris cannot be from corrosion of your car's fuel tank.

- Poor quality fuel. Fill up at a different station next time.

- Fuel cut-off valve O-ring trouble. See repair procedure described under section 8.e.1.

- Accelerator pedal position sensor malfunction. Check for fault codes with VAG-COM.

Back to Top

f. **Fuel consumption seems high:**

- Consumption normally increases noticeably in cold weather, both due to efficiency loss in cold weather, and due to lower energy content of winterized fuel.

- Incorrect use of manual transmission - unnecessary high engine revs, jack-rabbit starts, and so forth affect fuel consumption of any vehicle.

- High proportion of city driving or short trips affect fuel consumption adversely in any vehicle.

- New engine not broken in. The TDI engine seems to take longer to break in than gasoline engines.

- Automatic transmission models have about 20% to 25% higher fuel consumption than those with manual transmission.

- Brakes dragging.

- Low tire pressure.

- Clogged injectors, if older vehicle.

- General lack of maintenance. Dirty air filters, clogged exhaust system, etc.

- Improper modifications to the turbo and/or boost control system in an attempt to get more performance, which result in excessively high boost pressure under light load conditions (and thus, excessively high exhaust back-pressure, and hence the drag on the engine).

Back to Top

g. **Oil consumption seems high:**
- Engine not broken in. Oil consumption is normally higher during the break-in period.

- Most owners report normal oil consumption of one litre over several thousand km.

- CCV (crank case vent) trouble. Check for restriction in the air filter or intake system which could be causing abnormal amounts of oil to be sucked in through the CCV system, or pressurized out of other openings due to restriction in the CCV system.

- It is NORMAL for a small amount of oil to get into the air intake system through the CCV (crankcase vent) hose, which then contaminates the turbo compressor and all intercooler pipes including the intercooler itself, and continues on to contaminate the intake manifold. Refer to sections 7.f (intercooler cleaning), 7.g (intake manifold and EGR cleaning). CONSIDER THE POSSIBILITY THAT OIL FOUND IN THE INTAKE SYSTEM IS *ALL* COMING FROM THE CRANKCASE VENT BEFORE CONDEMNING THE TURBOCHARGER!!!!

- Oil leaks. See next section.

- Turbocharger seal problems. This failure is extremely rare on vehicles that have seen their proper oil changes using the proper type (synthetic oil rated CG-4 minimum!) and viscosity of oil.

- Internal engine problems, due to leaking rings or valve stem seals.

Back to Top

h. **Oil leaks onto ground :**
- On A3 cars, it's impossible to change the oil filter without spilling a bit of oil, and if the old filter happens to drop before it comes out of the car due to the difficulty of getting the filter out, the oil in the filter will make a much bigger mess. If the oil filter is changed without removing the lower pan, this oil will gradually work its way to the back of the pan and may drip off from there.

- Oil may be leaking from the drain plug, especially if the gasket on the drain plug wasn't replaced.

- Oil which is sitting on the outside of the turbocharger is NOT coming from the INSIDE of the turbocharger, so don't panic! Oil on the outside of the turbo is either coming from a leak at the oil feed fitting on top of the turbo, or it's coming from a leak at the valve cover gasket and running down the manifolds to end up at the "low spot" which of course is the turbocharger, or it's coming from a leak elsewhere in the engine compartment and landing on the turbocharger. Oil is NOT getting to the outside of the turbo from the inside, because seal failures result in oil either getting inside the intake system (but see notes on crankcase ventilation system in section 8.g), or down the exhaust pipe.

- Check the valve cover gasket for leaks, especially if the car just came out of a timing belt job.

- If it is found that the front crankshaft seal leaks, it is very important that the timing belt be replaced besides the obvious replacement of the leaking seal. A thorough cleaning of that area of the engine should be done, so that no oil gets on the new timing belt. Oil causes the belt material to deteriorate.
Back to Top

i. **Smokes on cold start-up:**
- It's normal for diesel engines to smoke a little bit after start-up in very cold conditions. The smoke goes away as the engine warms up. This is mentioned in the owner's manual.

- Coolant temperature sensor problems. Using VAG-COM, leave the car sit for several hours and confirm that all of the temperature sensors read approximately ambient temperature after turning on the key but before starting the engine.

- Excessive smoking accompanied by rough running after a cold start may indicate problems with the glow plug system. See 8.b.2 and glow plug system at 8.d.

- Incorrect fuel injection timing. See section 7.k.

- Poor quality fuel. Use the best stuff you can find, in cold weather.

- Worn or clogged injectors. Using VAG-COM, check that the injectors are balanced to each other in measuring blocks.

Back to Top

j. **Smokes under full acceleration:**
- For the older models, and for engines which have been "hot-rodded" by various means, some smoke under full acceleration may be normal. To minimize or eliminate it, check the following items.

- Check the air filter and intake system as described elsewhere.

- Incorrect fuel injection timing. See section 7.k.

- Injectors may be clogged. Try using a good-quality diesel fuel injector cleaner at the next fill-up.

- Poor quality fuel. Try filling up at a different station to see if that has any effect. Biodiesel has been reported to reduce the amount of exhaust smoke.

Back to Top

k. **Smokes from exhaust under other conditions:**
If you have a 1996 Passat TDI, and you are experiencing bluish or greyish smoke from the exhaust after decelerating from extended periods of highway driving, disable the supplementary injector system per section 7.e of this document.

Back to Top

l. **Bucks and snatches slightly at low speed when cold :**
- Many owners of earlier models report a slight stumbling at 1200 to 1500 rpm in the higher gears, when the engine is cold. The problem goes away when the engine warms up. It seems to be normal, but verifying that the reported fuel injection quantity at idle is within the specified range (2.2 to 9.0 mg/stroke) or ideal range if possible (3.0 to 5.0 mg/stroke) and adjusting it as close as possible to the ideal range helps. Refer to adaptation discussion in section 7.i of this document.
Back to Top

m. **Rattles, buzzes, and resonances from the exhaust system:**
- Many B4 (1995 to 1997) Passat models have a resonance in the exhaust system at

1200 rpm, and a lesser one at 2400 rpm. Several possible causes have been described but the problem appears to be inherent in the design.

- Some owners have reported that the downpipe (flex pipe) has become clogged with carbon build-up, thus causing noise to be transmitted through the rest of the exhaust system. In some cases this component has been replaced under warranty. In other cases, the problem was addressed by removing the flex pipe from the car and working it back and forth to loosen up the deposits.

- Some have had one of the mufflers (there are two) come apart internally, thus requiring replacement.

- Exhaust hangers can harden up and/or work loose over time, thus transmitting much more noise to the passenger compartment. These components are easily replaced.

- If this happens out of warranty, some owners may consider this to be an excuse to buy a performance aftermarket "cat-back" exhaust system. This might be the only way to eliminate the flaws in the standard system. The TDI engine is not loud even when operating with no muffler at all.

- Several owners have had success with getting a muffler shop to install an additional flex pipe downstream of the catalyst.

- Deteriorated engine mounts can increase the amount of noise and vibration transmitted into the vehicle.

Back to Top

n. **Accidentally filled tank with gasoline - now what?**
- If the tank was mostly filled with diesel, and the gasoline is a smaller proportion so that the engine still runs, the best remedy appears to be to buy a container of injector lubricant additive and cetane boost additive, and "overdose" it to protect the injection pump. Fill the tank completely with diesel to dilute the gasoline as much as possible, and keep driving. In the interest of protecting the engine, it would be prudent to avoid high engine speeds or high engine loads until the gasoline is sufficiently diluted.

If the tank has more gasoline than diesel fuel in it, the engine won't run on that mixture. It will be necessary to drain the tank and re-fill it with diesel. If the car was driven to the point of stalling, it will also be necessary to drain the injection pump housing and replace the fuel filter, and re-prime both of these with diesel fuel.

The expense and aggravation caused by all this should be a sufficient reminder to not do it again.
Back to Top

o. **"Shuddering", "misfiring", "stumbling" at highway cruising conditions:**
- Fuel pump delivered quantity may be out of specification (or if your vehicle is modified, it may require a different setting than standard which will have to be determined by experiment). Refer to section 7.i of this document.

- Some vehicles may have had a device fitted in the electrical circuit from the MAF sensor to the ECU, which tricks the computer into thinking that the EGR system is operating when in fact, it is disconnected in order to avoid intake clogging, thus avoiding a MIL or "check engine" light. Malfunction of this device can cause shuddering under certain speed and load conditions. Check security of electrical connections associated with this device, if the vehicle is so equipped. Calibration of the vacuum switch may have some effect. Rather than installation of this device (which is not legal for on-road use), it is recommended that the EGR system be recalibrated according to section 7.g of this document such that the EGR is operating at the minimum level that the original specifications will allow - i.e. that the amount of intake air is at the maximum that the original specifications will allow, which is 370 mg/stroke at warm idle in neutral with all major accessories off.

- EGR valve, or EGR solenoid valve, may be sticking. See sections 7.h (recalibration), 7.g (cleaning).

- If the vehicle is modified beyond stock, the modifications may be such that the ECU in the vehicle is not compatible with the modifications. In some cases, modifications to greatly increase the amount of fuel delivery have resulted in shuddering. Some compensation may be possible by recalibrating the fuel pump per section 7.i of this document. You want a larger reported amount of fuel delivery at idle than standard in this case - this is actually a "leaner" pump, because the actual amount of fuel required to keep the engine going is not changing but you are telling it that it is delivering more (bigger number) than it really is ... i.e. it is actually delivering less than it is telling the ECU. But in extreme cases, the only solution to the shuddering may involve un-doing some of the modifications so that the ECU is capable of dealing with the situation.

- "Relay 109" may be in the early stages of failure. See section 8.b.1(a).

- MAF sensor may be dirty. Check calibration per section 7.l of this document. If the sensor is indicating proper readings, do not do anything further with it! On A4 cars, this sensor is very prone to failure. On A3/B4 cars, obtain some non-residue electronics cleaner and spray it at the sensor element WITHOUT EVER TOUCHING THE SENSOR ELEMENT. Check the security of the intake system. Make sure there are no leaks past the air filter element, and if an aftermarket air filter element is used, ensure that it is properly oiled with a very sparse but evenly-distributed coating of high-tack "sticky" air filter oil. Over-oiling may be a contributing factor to dirty MAF sensor elements.

- Problems may involve the wiring harness to the fuel pump, especially if non-OEM accessories such as tuning boxes or other wiring harness modifications are found. Check security of electrical connections.
Back to Top

p. **"Surging" during acceleration; fluctuation of turbo boost pressure:**
- The standard control system for the turbo boost pressure may be electronic with high-tech sensors, and it may depend on a sophisticated map inside the ECU, but fast response to changes in load conditions is not one of its strong points. It is normal upon sudden application of load at higher engine speeds for the boost pressure to "spike"

beyond its eventual setpoint, then drop down below the ECU-requested boost pressure, then settle to a stable value after more fluctuations. This behaviour may be more pronounced on vehicles that have been modified beyond stock form. The standard "mapping" in the ECU is very conservative, partially in order to mask this behaviour, but those insisting upon better performance than stock will want to fully utilize the turbocharger's capacity while not overstressing it.

- In some cases, turbo boost fluctuation problems have been traced to problems with the N75 valve (see 8.e.1), or contamination in the hose from N75 to the turbo wastegate diaphragm (GT15 / K03 turbo only - does not apply to VNT15). If oily residue is found in the hose from N75 to wastegate diaphragm, removing and cleaning out these components may help. This oily residue is coming from the crankcase vent (CCV).

- In other cases, generally on modified vehicles, it may be necessary to use an aftermarket mechanical boost controller in addition to the standard electronic system in order to obtain a satisfactory solution. www.dawesdevices.com has a nice simple adjustable mechanical boost pressure regulator.

- If you have a GT15 or K03 turbo, install a "T" fitting into both the blue and red hoses at any convenient location (the Passat has existing hose connectors near the upper right corner of the firewall that can easily be replaced with T fittings without cutting any stock hoses). Solder the small vent hole in the mechanical boost controller closed. Connect the boost controller so that the inlet connects to the T fitting that you spliced into the red hose, and the outlet (90-degree hose connection in this case) connects to the T fitting that you spliced into the blue hose. Temporarily "T" a boost gauge into the hose connection at the intake manifold so that you can perform calibration. Then adjust the boost controller so that the peak boost pressure is no more than the electronically-controlled steady boost pressure, and your boost control problems will be solved. Don't run the GT15 or K03 turbochargers at higher than 18 psi boost pressure at sea level, and this should be reduced in proportion to barometric pressure at higher altitudes.

- If you have a VNT15 turbo, it will be necessary to use the "higher pressure" version of the boost controller (different spring). Remove the lower intercooler pipe from the vehicle, and install a suitable fitting to supply boost pressure to your boost gauge and boost controller. Solder the small vent hole in the mechanical boost controller closed. The inlet of the boost controller connects to the fitting that you just installed. Connect the outlet to a "T" that you need to install on the hose that connects to the VNT vacuum diaphragm. Temporarily connect a pressure gauge into the supply hose to the boost controller so that you can perform calibration. Then adjust the boost controller so that the peak boost pressure is no more than the electronically-controlled steady boost pressure. Don't run the VNT15 turbocharger at higher than 18 psi boost pressure at sea level.

Back to Top

q. **Hesitation upon moving away from a standstill or upon sudden application of accelerator pedal:**

- Improper use of manual transmission - engine speed too low. The turbocharger is not operating near its best efficiency until the engine speed is above 2000 rpm, and below 1500 engine rpm, not much boost pressure is available. If you are going to require fast acceleration, downshift so that the engine speed is above 2000 rpm before giving it full load. Do not be tempted to make modifications that result in increased boost pressure at engine speeds below 2000 rpm - it's bad for the turbocharger. (Search forums for "compressor surge".)

- EGR valve, or EGR solenoid valve, may be sticking. See sections 7.h (recalibration), 7.g (cleaning).

Back to Top

r. **Miscellaneous Strange Noises and Odd Behaviour**:
- A "swish" or "whoosh" that happens about 2 seconds after switching the engine off, is the anti-shudder valve operating normally. Don't worry about it. Worry when it STOPS making that noise. A3's and B4's don't have this valve, so they don't make this noise ... in those cases, the engine makes a mighty shiver that can be felt throughout the car when you switch off the key. That's NORMAL in those models, it's what happens with 19.5:1 compression ratio and it's why the later models have that anti-shudder valve!

- A clicking noise within the engine compartment, which may be present even if the engine is not running but the key is in the "run" position, is the EGR solenoid valve and boost pressure control solenoid valve (a.k.a. N75 valve) clicking away merrily. Both of these devices continuously switch from "on" to "off" all the time the key is on, and they make a clicking noise. Worry when they STOP clicking.

- During engine warm-up, occasional clicking noises coming from the vicinity of the relay panel near the base of the steering column are normal. These noises come from the glow plug control relay switching on and off in response to various conditions. The clicks may be associated with a brief change in the brightness of lights throughout the vehicle, which are caused by switching the very high current load of the glow plugs on and off. This is all normal.

Back to Top

TDI FAQ

9) Non-Volkswagen TDi

Back to FAQ Index

---

9).Non-Volkswagen TDi

a. TDi vehicles are sold world wide by several manufacturers of motor vehicles. Only Volkswagen presently sells TDi vehicles in the US Some of the other manufacturers of TDi vehicles include: Rover, from England ; Renault, Peugeot and Citroen from France; Seat from Spain; and Audi from Germany. Audi, VW, Seat and Skoda are all part of the Volkswagen group.

Back to Top

Back to FAQ Index

The ASTM pour point temperatures for winter diesel

Hello TDI Fans,

Here is a table of the ASTM pour point temperatures for winter diesel. The numbers are taken from the ASTM map of the USA for "Tenth Percentile Minimum Ambient Temperatures For The United States (except Hawaii)". I still can't find the Canadian National Standards Board maps for Canada.

All temperatures are in Celsius. Some states have more than one pour point. The divisions are on a longitude or latitude line and is marked by degrees. If the division is longitude, the degrees will be marked east and west. If the division is latitude, the degrees will be marked north and south. Except California, it is divided into four sections that do not follow any geographical lines (they just got to be different out there). California's divisions are called, North Coast, South Coast, Interior, and Southeast. The coast sections and the interior are divided by the Sierra Nevada Mountains. The coast sections split around Pismo Beach. To define Southeast, find Indio on I-10. Now imagine a straight line north through Indio from Mexico to Nevada. Alaska is divided into three sections at latitudes 72, 62, and 56 degrees.

The diesel fuel in your state is suppose to be blended to the temperatures listed. If your January temperatures do not drop much below -5C, then there is slim chance blended diesel is sold in your state. If a cold front moves in that will bring temperatures close to the pour points or exceeds them, then there is risk for fuel jelling. Most fuel retailers sell diesel fuel that will at least meet the listed pour points. Because of the way diesel fuel jells, a new system for rating winter diesel is being developed. The pour points are not realistic because the test does not take into account that fuel has to pass through a fuel filter. Diesel fuel can have a very high level of jelling and still pass the pour point test. A test called 'Cold Flow Plugging Point' or CFPP measures the fuel's ability to flow through a fuel filter. Cold flow performance to pass the CFPP test will be 2C degrees maximum above the ASTM D-975 tenth percentile numbers. These numbers should be incorporated into existing standards by late 1998. Winterized fuel meeting CFPP numbers should be on the market for late 1998.

		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
AL		4	-3	-6	-7	-3	-2
AK	**72S**	-25	-37	-45	-49	-47	-43
AK	**62S**	-11	-13	-18	-32	-32	-29
AK	**56S**	-4	-11	-16	-19	-13	-12
AZ	**34N**	-4	-12	-14	-17	-16	-12
AZ	**34S**	7	0	-2	-4	-3	-1
AR		2	-4	-7	-11	-7	-3
CA	**(SC)**	6	-6	1	-1	0	2
CA	**(NC)**	4	0	-2	-2	-1	-1
CA	**(IN)**	2	-3	-4	-7	-6	-6
CA	**(SE)**	1	1	8	-11	-7	-5
CO	**105W**	-8	-18	-25	-30	-24	-16
CO	**105E**	-2	-12	-14	-19	-15	-12
CT		-1	-7	-16	-17	-16	-9
DE		2	-3	-10	-11	-10	-6
FL	**29N**	7	1	-1	-3	-1	-4
FL	**29S**	14	7	3	3	5	7
GA		3	-2	-6	-7	-6	-2
HI							
ID		-4	-13	-18	-21	-18	-13
IL	**40N**	-1	-9	-19	-21	-13	-11
IL		1	-7	-16	-17	-15	-8
IN		-1	-7	-16	-18	-16	-9
IA		-2	-13	-23	-28	-22	-16
KS		-2	-11	-15	-19	-14	-13
KY		1	-6	-13	-14	-11	-6
LA		5	-1	-3	-4	-2	1
ME		-3	-10	-23	-26	-26	-18
MD		2	-3	-10	-12	-10	-4
MA		-2	-7	-16	-18	-17	-10
MI		2	-11	-20	-23	-23	-18
MN		-4	-18	-30	-34	-31	-24
MS		3	-3	-6	-6	-4	-1

MO		1	-7	-14	-16	-13	-8
MT		-7	-18	-24	-30	-24	-21
NE		-3	-13	-18	-22	-19	-13
NV	**38N**	-7	-14	-18	-22	-18	-13
NV	**38S**	8	0	-3	-4	-2	1
NH		-3	-8	-18	-21	-21	-12
NJ		2	-3	-11	-12	-11	-6
NM	**34N**	-2	-11	-14	-17	-14	-11
NM	**34S**	4	-4	-8	-17	-7	-3
NY	**42N**	-3	-8	-21	-24	-24	-16
NY	**42S**	-1	-5	-14	-16	-15	-9
NC		-1	-7	-10	-11	-9	-5
ND		-4	-20	-27	-31	-29	-22
OH		-1	-7	-16	-17	-15	-9
OK		1	-8	-12	-13	-8	-7
OR	**122W**	0	-4	-5	-7	-4	-3
OR	**122E**	6	-11	-14	-19	-21	-9
PA	**41N**	-3	-8	-19	-20	-21	-15
PA	**41S**	1	-6	-13	-14	-14	-8
RI		1	-3	-12	-13	-13	-9
SC		5	-1	-5	-5	-3	-2
SD		-4	-14	-18	-27	-24	-18
TN		1	-5	-9	-11	-9	-4
TX	**31N**	3	-6	-9	-13	-9	-7
TX	**31S**	9	2	-1	-3	-1	2
UT		-2	-11	-14	-18	-14	-8
VT		-3	-8	-20	-23	-24	-15
VA		2	-3	-9	-11	-9	-4
WA	**122W**	0	-3	-3	-7	-4	-3
WA	**122E**	-2	-8	-11	-18	-11	-8
WV		-3	-8	-15	-16	-14	-4
WI		-4	-14	-24	-28	-24	-18
WY		-4	-15	-18	-26	-19	-16

Back to FAQ Index