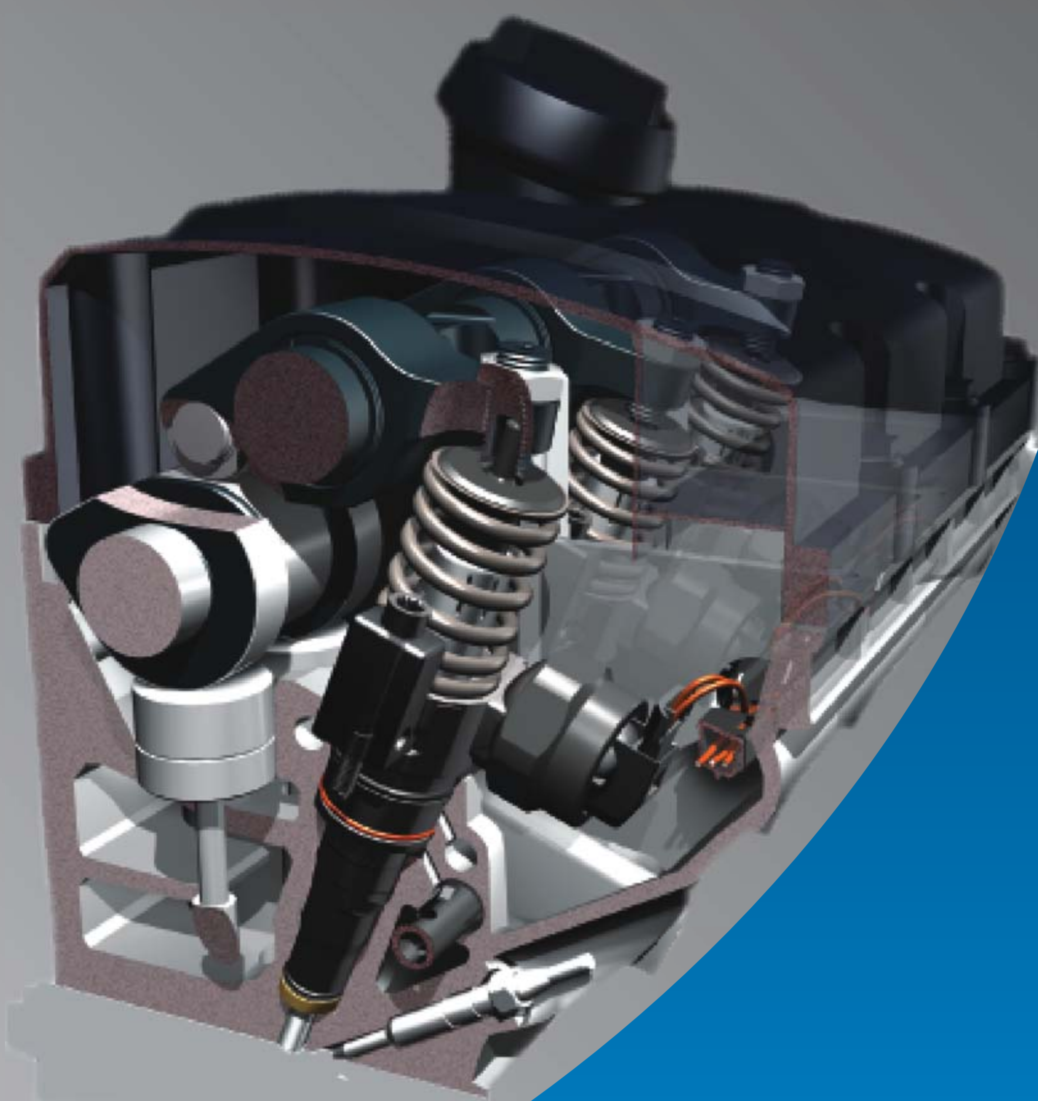
Service Training

Self-Study Program 821603

TDI Diesel



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Always check Technical Bulletins and the latest electronic repair information for information that may supersede any information included in this booklet.

Contents

Introduction 1

Fuel Supply 8

Pump Injection System.. 15

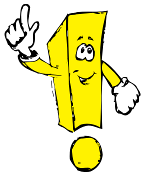
Engine Management.. 28

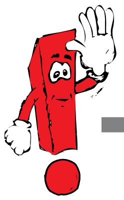
Glow Plug System.. 52

Functional Diagram 53

Service 55

Knowledge Assessment 59





This Self-Study Program covers information on Volkswagen TDI Technology.
This Self-Study Program is not a Repair Manual.
This information will not be updated.

For testing, adjustment and repair procedures, always refer to the latest electronic service information.

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History and Theory of the Diesel Engine

History

The diesel engine was developed as an alternative means of power other than steam. Similar to the gasoline engine, the operation is based on the Otto cycle.

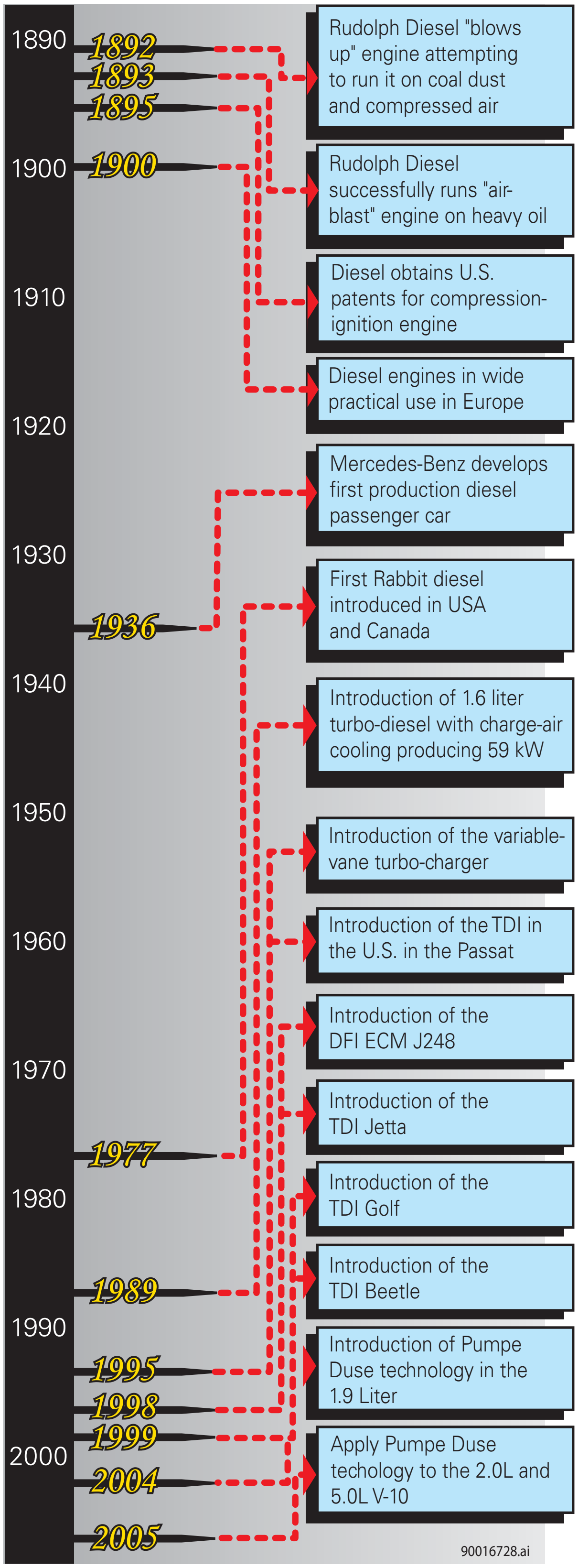
The diesel engine is a compression-ignition engine. This means that tightly compressed air and injected fuel are used to power the engine; no spark plugs are used in this type of engine.

Rudolph Diesel is given the credit for the compression-ignition engine. His first attempts used coal dust as the fuel. These attempts resulted in the engines exploding. After continuous failed attempts, Diesel switched to a liquid fuel. The liquid fuel worked, and in 1895, the compression ignition engine was patented in the U.S. and became known as the diesel engine.

Traditionally, diesels have been considered reliable, but massive and noisy engines. They lacked power and were difficult to start in cold weather. Diesel engines seemed to be best suited for industrial use, where they have succeeded as universal workhorses.

In an effort to explore all possibilities for cleaner, more efficient engines, Volkswagen has developed diesel engines that are practical for passenger car use.

Presently, the diesel is the only alternative engine capable of extraordinary fuel economy with a simple design devoid of complex emission controls.



Introduction

Theory

Diesel vs. Gasoline
The gasoline engine was being developed at the same time as the diesel engine. The gasoline engine quickly became more popular in automobiles because of its major characteristics:

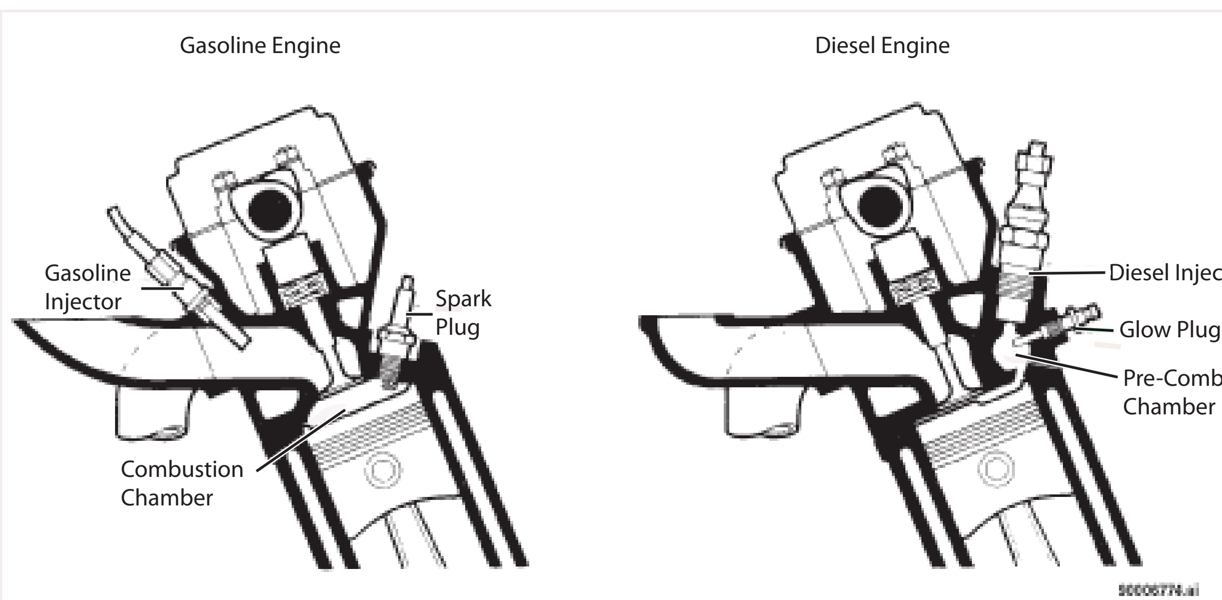
- Wide revolutions per minute (rpm) range
- Ease of starting
- Smooth and quiet operation
- Good acceleration

Even though the gasoline engine is more popular for automobile applications, diesel has some advantages:

- Low fuel consumption
- Less fire hazard
- Lower emission levels

Low fuel consumption is the most noticeable advantage. This is a result of a high air-to-fuel ratio, high compression ratio, and low pumping losses.

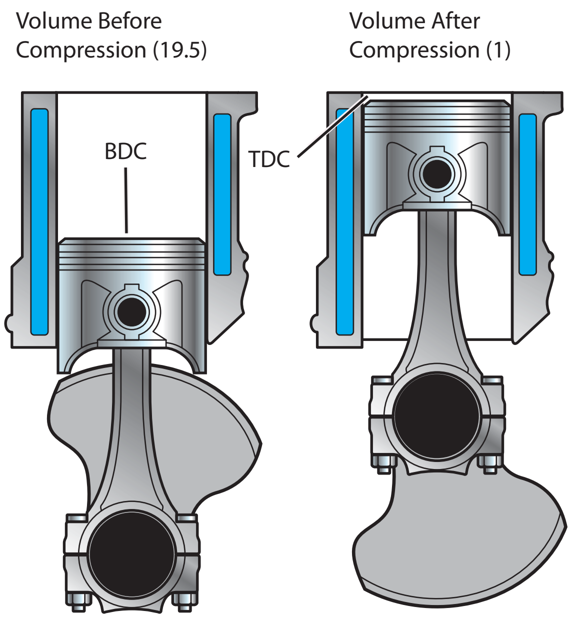
Air-to-Fuel Ratio
The air-to-fuel ratio is the amount of air and fuel needed for combustion. Gasoline engines need more fuel in comparison to air than diesel engines. Diesel engines can have ratios between 20 parts air to one part fuel, up to 100 parts air to one part fuel. This contributes to low fuel consumption.



Compression Ratio

The compression ratio is a comparison of cylinder volumes when the piston is at Top Dead Center (TDC) and at Bottom Dead Center (BDC). A high compression ratio, in theory, can result in more power produced. However, there are limitations that prevent extreme compression ratios. Gasoline does not burn efficiently at extreme compression ratios. Instead, it explodes and causes engine knocking.

Diesel engines use the heat created by compressing the air trapped in the cylinder to ignite the fuel. To do this, diesel engines use compression ratios as high as 25:1. Since there is a higher compression ratio, more power is produced on each stroke. More power per stroke also leads to more efficient fuel consumption.



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Pumping Loss

The energy used to pull air into the cylinder and to push out the exhaust is called pumping loss. Gasoline engines require more energy to pull the air in and to push the exhaust out because of throttle restriction. Diesel engines have no throttle restriction, so less energy is required. This low pumping loss also contributes to low fuel consumption.

Volatility

Another advantage is that diesel fuel is less of a fire hazard. Volatility, or ease of evaporation of a liquid, is low with diesel fuel. A low volatility rate, or slow evaporation, results in less of a fire hazard. This does not mean that diesel fuel is not volatile. Always handle diesel fuel with extreme caution because it is still highly flammable and dangerous.

Emissions

The diesel engine is not just efficient with fuel consumption, but also emission levels.

The Environmental Protection Agency (EPA) pays close attention to fuel economy and allowed emissions. Each year the fuel economy rating is raised, and every couple years the acceptable emissions level is lowered. With this careful watch on emissions, there has been a noticeable decrease in the amount of emissions produced.

Exhaust emissions may include:

- Nitrogen (N_2)
- Carbon Dioxide (CO_2)
- Water (H_2O)
- Oxygen (O_2)
- Sulfur Dioxide (SO_2)
- Particulates
- Hydrocarbons (HC)
- Oxides of Nitrogen (NOX)
- Carbon Monoxide (CO)

Not all of these components are harmful to the environment or people. N_2, CO_2, H_2O, and O_2 are all part of the air we breathe everyday. The remaining components, SO_2, particulates, HC, NOX, and CO can pose a threat to the environment and people. These components are constantly being watched and reduced.

One to two percent of the exhaust emissions from gasoline engines consist of these harmful components. However, less than one percent of the exhaust emissions from diesel engines consist of these harmful components.

SO_2 is produced as a result of sulfur in the fuel. Modern fuels are being refined to reduce the sulfur in the fuel. Particulates are the soot that exit the tail pipe. Typically, they are made up of a core and several other attached components. HC are found in unburned fuel and create ozone. NOX is created when the combustion temperature is above 2500°F (1371°C).

An unfavorable effect of more efficient fuel consumption is the production of more NOX. However, in diesel engines, the air-to-fuel ratio is high, so more fuel is burned and more CO_2 and H_2O are produced.

The diesel cylinder temperature does not need to be maintained as high as a gasoline cylinder. This lower temperature slows the formation of NOX, thus less is produced.

CO is in partially burned fuel. CO can be dangerous to people before it is released into the air. When in the air, it changes into CO_2 and is no longer harmful.

Differences and Characteristics of Diesel Fuel

Diesel fuel is made from petroleum, as is gasoline. When petroleum is refined, it is separated into three components: gasoline, middle distillates, and all remaining substances. Diesel comes from the middle distillates. The following will identify the characteristics and highlight important areas to know about diesel fuel.

Types of Diesel Fuel

Diesel fuel is available in two major grades: Number 1 (A) and Number 2 (B). The characteristics of each number determine the efficiency of the fuel. Number 2 diesel fuel is recommended for Volkswagen diesel vehicles because of its lubricating qualities. This is particularly important because the Volkswagen diesel injection pump uses diesel fuel as its sole source of lubrication.

Heat Energy

The combustion process burns fuel and releases heat energy. The amount of heat energy released is referred to as calories (British Thermal Units [BTU]). The calorie is derived from determining the heat energy required to raise the temperature of one gram of water 1°C (one pound of water 1°F).

One calorie will raise one gram of water 1°C. This heat energy is converted into power by the diesel engine. Diesel fuel has a higher calorie content than gasoline. More calories result in more power. This explains the fuel efficiency of diesel engines.

Specific Gravity

The specific gravity of a liquid is a measurement of the weight of the liquid compared to water. The specific gravity of water is one. Diesel fuel is lighter than water, but heavier than gasoline. If it is mixed with other liquids, the specific gravity will change. A hydrometer is used to measure specific gravity.

Specific gravity relates to the combustion process. Diesel fuel must be heavy enough to fill the entire combustion chamber before burning.

If the specific gravity is too low, the fuel starts to burn before the chamber is filled. This causes poor performance, increases engine noise, and may damage components. If the specific gravity is too high, fuel consumption may increase and engine power may decrease.

Wax Appearance Point (WAP)

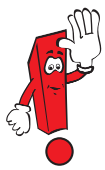
Climate and temperature affect diesel fuel more than gasoline. Diesel fuels contain paraffin, a wax material in middle distillate fuels. Paraffin acts the same as candle wax. After a candle is blown out, the temperature around the wick begins to cool. As the temperature drops, the candle wax begins to solidify. The paraffin acts the same in diesel fuel. The point when paraffin begins to solidify is the WAP, sometimes called the cloud point. Solidified paraffin collects and plugs fuel filters or lines. The WAP for Number 2 diesel fuel is approximately 20°F (-7°C). Refineries add flow improvers to lower this temperature. This is why you hear of summer and winter fuels.

Pour Point

The pour point is the point at which the fuel solidifies. This differs from the WAP in that the WAP points out when the wax solidifies, not the fuel. If the pour point is reached, the fuel stops flowing. The pour point for Number 2 diesel fuel is approximately 5°F (-15°C).

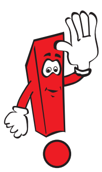
Blended Fuels

Pure Number 2 diesel fuel may not provide sufficient power in cold climates. Number 2 diesel fuel is often blended with 10 - 20 percent Number 1 diesel fuel to reduce the WAP and pour point in cold weather.



Caution: Number 1 diesel fuel does not have the lubricating qualities of Number 2. Using too much Number 1 can cause damage to the fuel system.

Additives also can be added to reduce the WAP and pour point. This is done most efficiently at the refinery. The true characteristics of diesel fuel are known before it leaves the refinery, and the proper additives can be added to achieve the desired characteristics.



Warning! Gasoline should never be used to alter the characteristics of diesel fuel.

Mixing gasoline and diesel fuel can result in an explosion. Because gasoline produces high volumes of vapor, the tank fills with fumes, which are highly volatile and can be easily ignited. The smallest electrical charge can cause an explosion.

Viscosity

The viscosity of diesel fuel affects the spray from the injector. Viscosity is the measurement of how resistant a liquid is to flowing. High viscosity equals more resistance and low viscosity equals less resistance. Diesel fuel needs a low viscosity so that a fine spray comes from the injector. However, if the viscosity is too low, the fuel does not provide enough lubrication. Temperature also affects viscosity. Colder temperatures result in higher viscosity. This is another reason for blending fuel.

Volatility

Volatility is the measurement of how easily a liquid changes into a vapor. Diesel engines need a fuel with a fairly high volatility. The higher volatility makes combustion easier.

Cetane vs. Octane

The cetane number is a rating of diesel fuel ignition quality or ability to spontaneously self-ignite. Cetane is actually a laboratory liquid with excellent ignition qualities. The cetane rating for diesel is determined by mixing cetane that has a rating of 100 with methylnaphthalene that has a rating of zero.

Methylnaphthalene does not ignite. The cetane and methylnaphthalene are mixed to imitate the performance of the fuel being tested.

The percentage of cetane in the mixture is the cetane rating. As the cetane rating increases, the faster the fuel self-ignites.

This is the opposite of octane. As the octane rating increases, the fuel resists self-ignition. Premium gasoline has a higher octane (CN) rating than regular, allowing it to be used in higher compression engines.

Volkswagen recommends a Number 2 diesel fuel with a cetane rating of 45. This is in line with commercially available fuel.

Carbon Residue

Because diesel fuel contains HC, carbon residue can be produced under certain operating conditions. The amount of carbon residue depends on the fuel quality and operating conditions. Engines that are idled for long periods tend to produce more carbon residue due to the lack of combustion efficiency at these engine speeds. Carbon residue that is allowed to build up can cause engine damage. The use of high-quality fuel can reduce these buildups.

Sulfur Content

Sulfur is a chemical in diesel fuel and the actual quantity of sulfur depends on the quality of the fuel. The sulfur is converted to Sulfur Dioxide (SO2) during combustion. SO2 is undesirable because it has acidic qualities that are harmful to the environment. Allowable sulfur levels in diesel fuels have been lowered in recent years.

Water Content

Water can be in diesel fuel that has been stored or distributed improperly. If the diesel fuel appears cloudy, water is most likely in the fuel.

Water in diesel fuel will corrode the fuel system. Rust particles from the corroding fuel system components get trapped in the fuel filter and clog the system.

When temperatures fall, the water in the fuel freezes and causes damage to fuel system components.

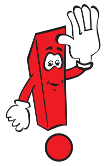
As previously mentioned, diesel fuel is the only lubricant for the fuel injection pump and fuel injectors. Water in the fuel reduces the lubrication quality and may damage these components. Water also invites bacteria to grow and poses a threat to the components.

Bacteria Content

Diesel fuel can be inviting to bacteria, particularly in warmer climates. The bacteria ingests the diesel fuel and excretes a corrosive substance. The substance also can clog the fuel system. Because bacteria may be living in diesel fuel, always wash your hands thoroughly and clean up your work area after handling the fuel.

Flash Point

The flash point of diesel fuel is the lowest temperature at which it can produce a flammable vapor. This temperature has little effect on the performance of the vehicle, but is important to fuel storage. If diesel fuel is stored at a temperature warmer than the flash point, fumes develop, and the fuel could be ignited easily.



Warning! Diesel engines return warm fuel to the fuel tank. This fuel is often above the flash point and can be explosive.

Fuel Storage

Storing diesel fuel properly is important. Improper storage may result in personal injury, poor engine performance, and component damage.

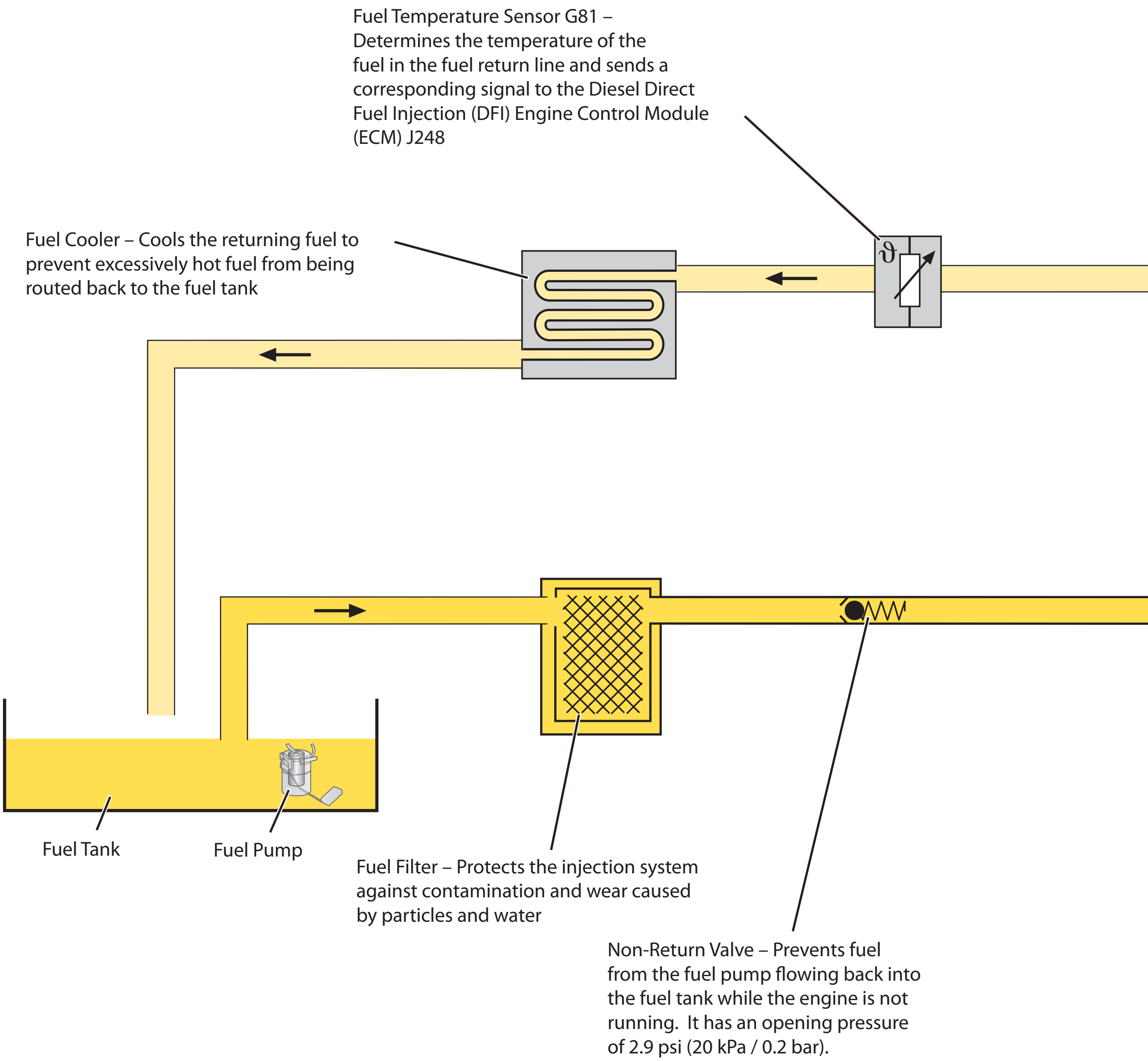
- Only store diesel fuel in approved containers
  - Certain materials, such as galvanized containers, react with diesel fuel
- Make sure all diesel storage containers are sealed and labeled properly
- Always use fresh diesel fuel
  - Although diesel fuel contains inhibitors to keep the fuel fresh, they lose their effectiveness over time
- Do not store diesel fuel in environments that can experience excessively hot or cold temperatures
- Do not add alcohol to diesel fuel
  - Alcohol lowers the flash point of the fuel

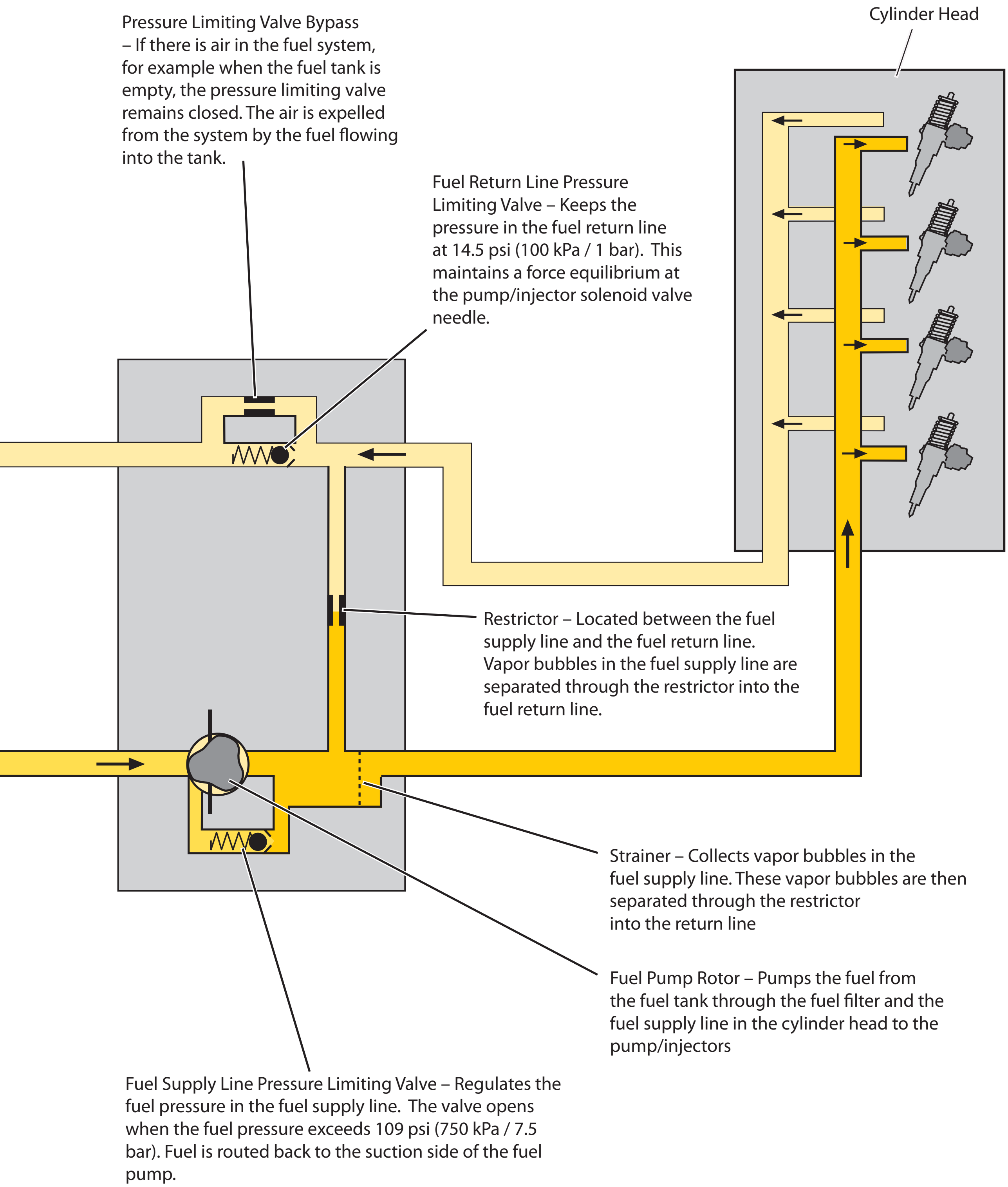
Fuel Supply

Fuel Supply System Overview

A mechanical fuel pump sucks the fuel out of the fuel tank through the fuel filter and pumps it along the supply line in the cylinder head to the pump/injectors.

The fuel that is not required for injection is returned to the fuel tank via the return line in the cylinder head, a fuel temperature sensor, and a fuel cooler.





Cylinder Head
Pressure Limiting Valve Bypass – If there is air in the fuel system, for example when the fuel tank is empty, the pressure limiting valve remains closed. The air is expelled from the system by the fuel flowing into the tank.
Fuel Return Line Pressure Limiting Valve – Keeps the pressure in the fuel return line at 14.5 psi (100 kPa / 1 bar). This maintains a force equilibrium at the pump/injector solenoid valve needle.
Restrictor – Located between the fuel supply line and the fuel return line. Vapor bubbles in the fuel supply line are separated through the restrictor into the fuel return line.
Strainer – Collects vapor bubbles in the fuel supply line. These vapor bubbles are then separated through the restrictor into the return line
Fuel Pump Rotor – Pumps the fuel from the fuel tank through the fuel filter and the fuel supply line in the cylinder head to the pump/injectors
Fuel Supply Line Pressure Limiting Valve – Regulates the fuel pressure in the fuel supply line. The valve opens when the fuel pressure exceeds 109 psi (750 kPa / 7.5 bar). Fuel is routed back to the suction side of the fuel pump.

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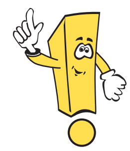
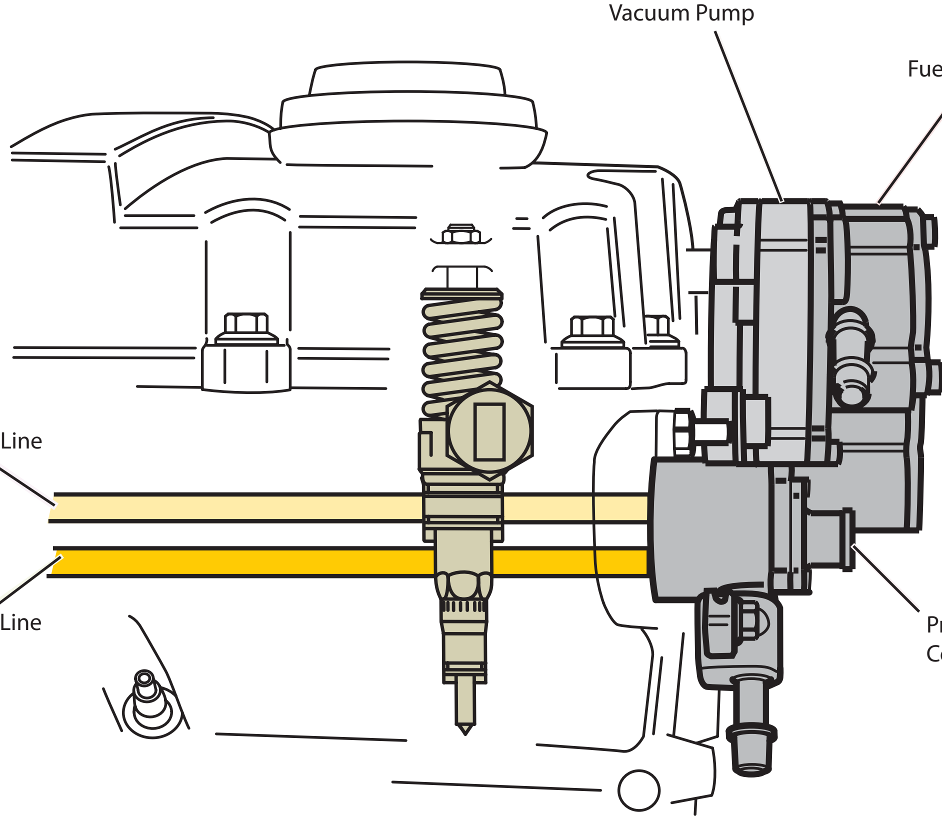
Fuel Pump

The fuel pump is located directly behind the vacuum pump at the cylinder head. It moves the fuel from the fuel tank to the pump/injectors.

Both pumps are driven jointly by the camshaft. They are collectively known as a tandem pump.



There is a fitting on the fuel pump for connecting pressure gauge VAS 5187 to check the fuel pressure in the supply line. Please refer to the Repair Manual for instructions.



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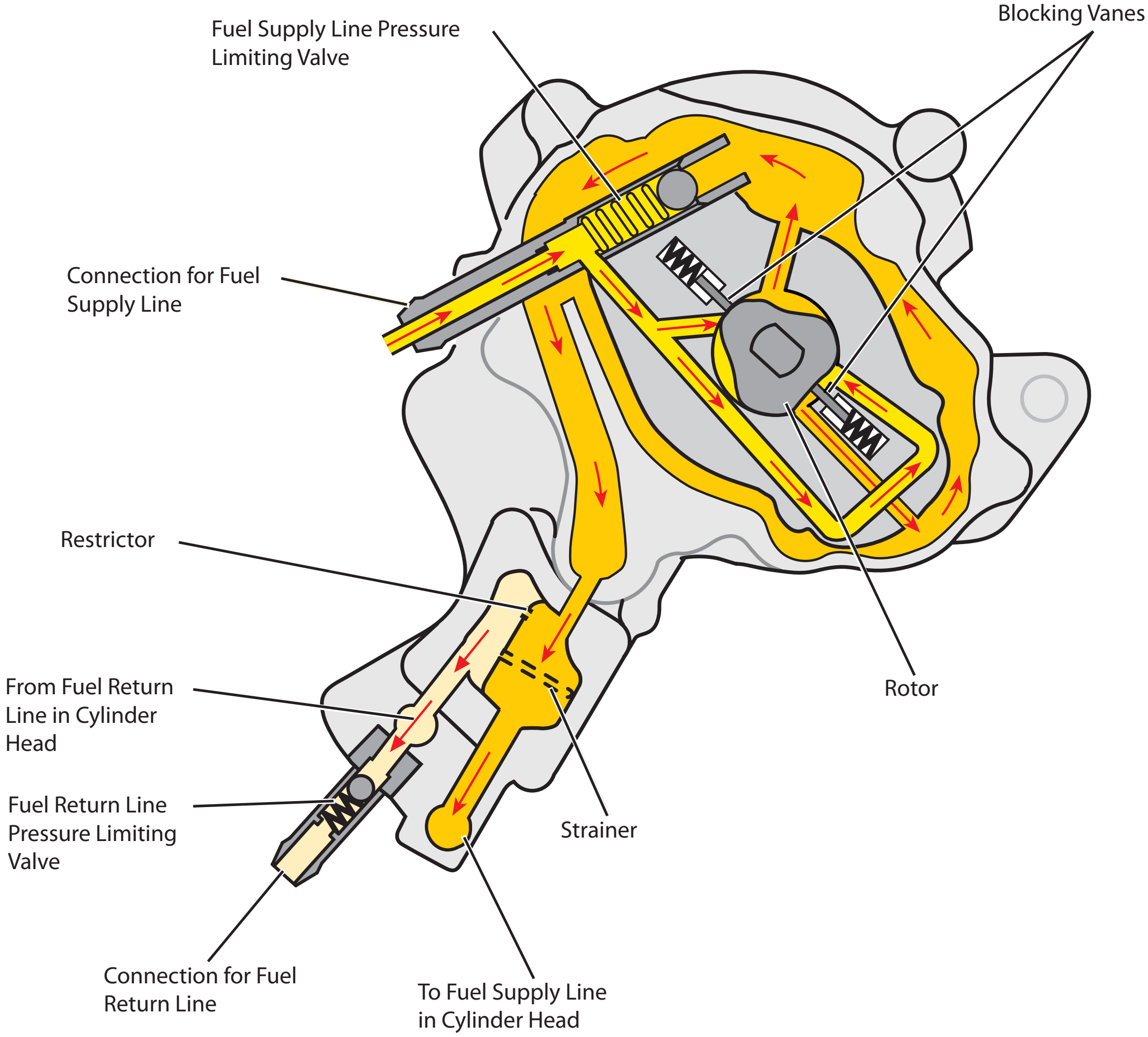
The fuel pump is a blocking vane-cell pump. The blocking vanes are pressed against the pump rotor by spring pressure. This design enables the fuel pump to deliver fuel even at low engine speeds.

The fuel ducting system within the pump is designed so that the rotor always remains wetted with fuel, even if the tank has been run dry. This makes automatic priming possible.



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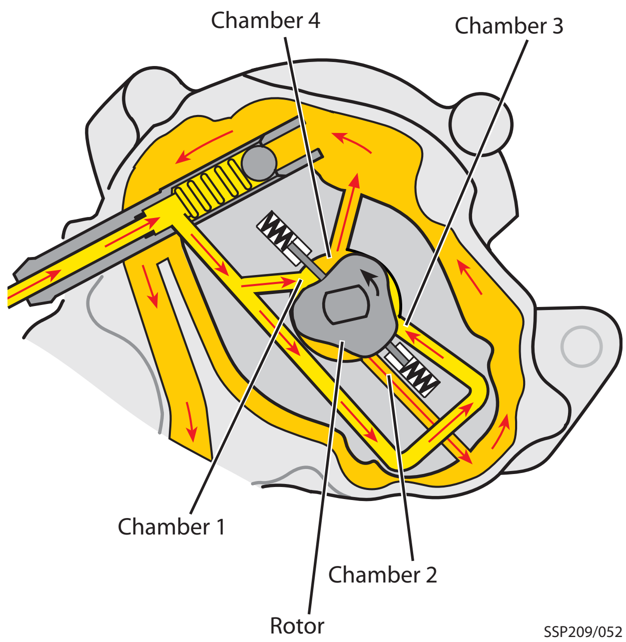
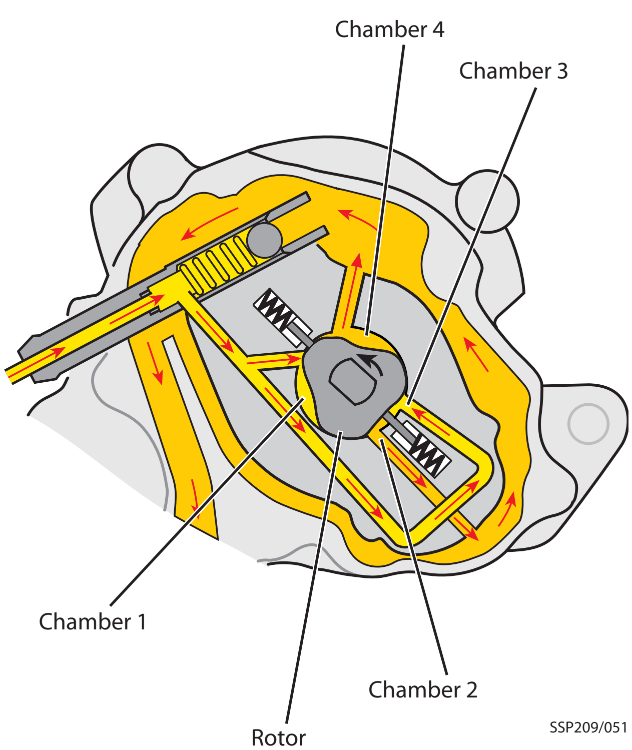
Fuel Supply





Function

The fuel pump operates by taking fuel in as the pump chamber volume increases and pushing the fuel out under pressure as the chamber volume is reduced.

The fuel is drawn into two chambers and pumped out from two chambers. The intake and delivery chambers are separated from one another by the spring-loaded blocking vanes and the pump rotor lobes.

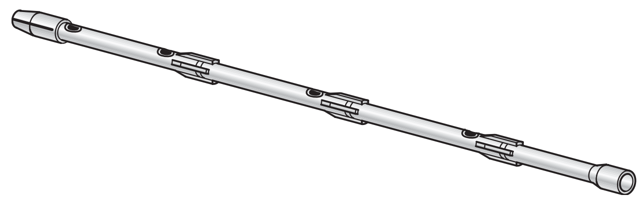
Fuel drawn into Chamber 1 is pushed out at Chamber 2. Fuel drawn into Chamber 3 is pushed out at Chamber 4.

The rotation of the rotor increases the volume of Chamber 1 while the volume of Chamber 4 is simultaneously reduced. Fuel is pushed out of Chamber 4 to the fuel supply line in the cylinder head.

The rotation of the rotor increases the volume in chamber 3 as it reduces the volume in Chamber 2. Fuel drawn in at Chamber 1 is forced out of Chamber 2 to the fuel supply line in the cylinder head.

Distributor Pipe

A distributor pipe is integrated in the fuel supply line in the cylinder head. It distributes the fuel evenly to the pump/injectors at a uniform temperature.



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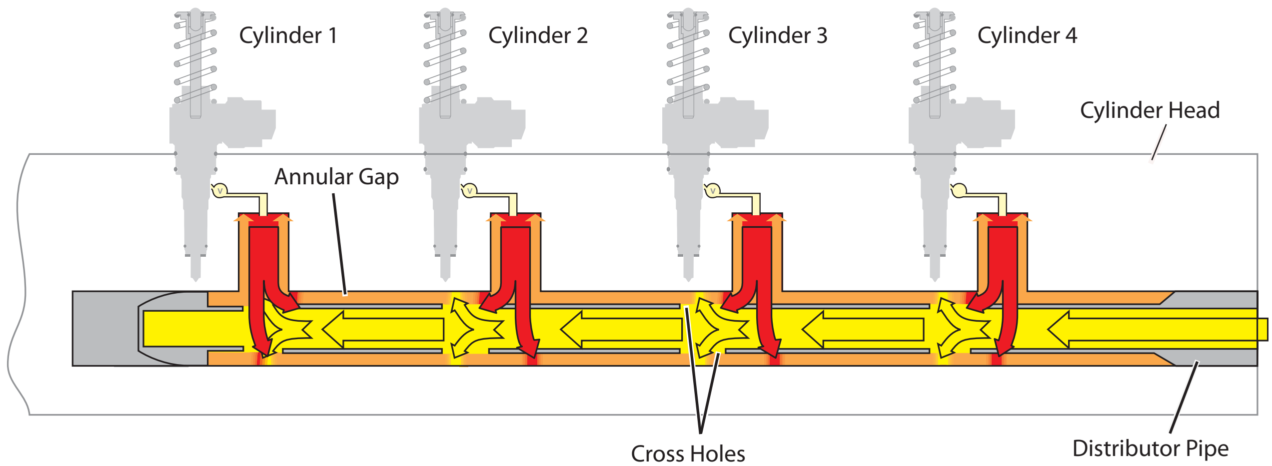

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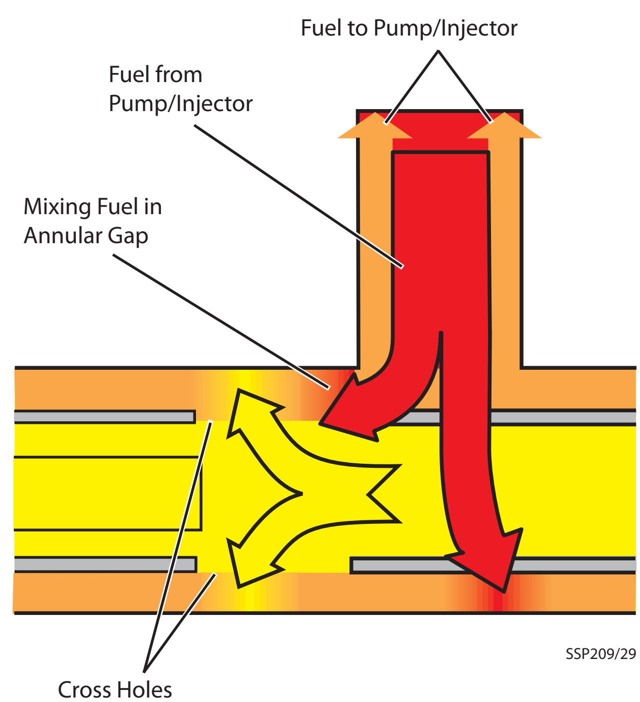
In the supply line, the fuel moves through the center of the distributor pipe toward Cylinder 1 at the far end.

The fuel also moves through the cross holes in the distributor pipe and enters the annular gap between the distributor pipe and the cylinder head wall.

This fuel mixes with the hot unused fuel that has been forced back into the supply line by the pump/injectors.

This results in a uniform fuel temperature in the supply line running to all cylinders.

All pump/injectors are supplied with the same fuel mass, and the engine runs smoothly.



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Fuel Cooling System

The high pressure generated by the pump/injectors heats up the unused fuel so much that it must be cooled before it returns to the fuel tank.

A fuel cooler is located on the fuel filter.

It cools the returning fuel and prevents excessively hot fuel from entering the fuel tank and possibly damaging the Fuel Level Sensor G.

Fuel Cooling Circuit

The heated fuel returning from the pump/injectors flows through the fuel cooler and its heat transfers to the coolant in the fuel cooling circuit that also flows through the fuel cooler.

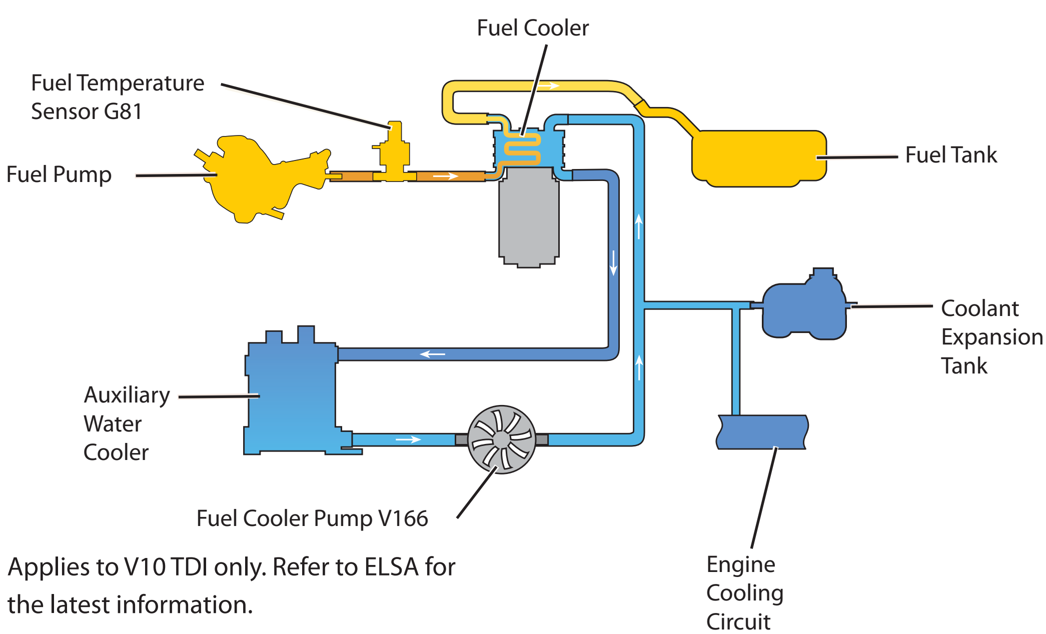
The auxiliary water cooler reduces the temperature of the coolant in the fuel cooling circuit by dissipating the heat in the coolant to the ambient air.

Fuel Cooler Pump V166 is an electric recirculation pump. It circulates the coolant in the fuel cooling circuit through the auxiliary water cooler and the fuel cooler. It is switched on by the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 via the Fuel Cooling Pump/Relay J445 at a fuel temperature of 158°F (70°C).

The fuel cooling circuit is largely separate from the engine cooling circuit. This is necessary because the temperature of the coolant in the engine cooling circuit is too high to cool down the fuel when the engine is at operating temperature.

The fuel cooling circuit is connected to the engine cooling circuit near the expansion tank. This enables replenishment of the coolant for fuel cooling at the coolant expansion tank. It also allows for changes in volume due to temperature fluctuation.

The fuel cooling circuit is connected so that the hotter engine cooling circuit does not have a detrimental effect on its ability to cool the fuel.



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Applies to V10 TDI only. Refer to ELSA for the latest information.

Pump/Injectors

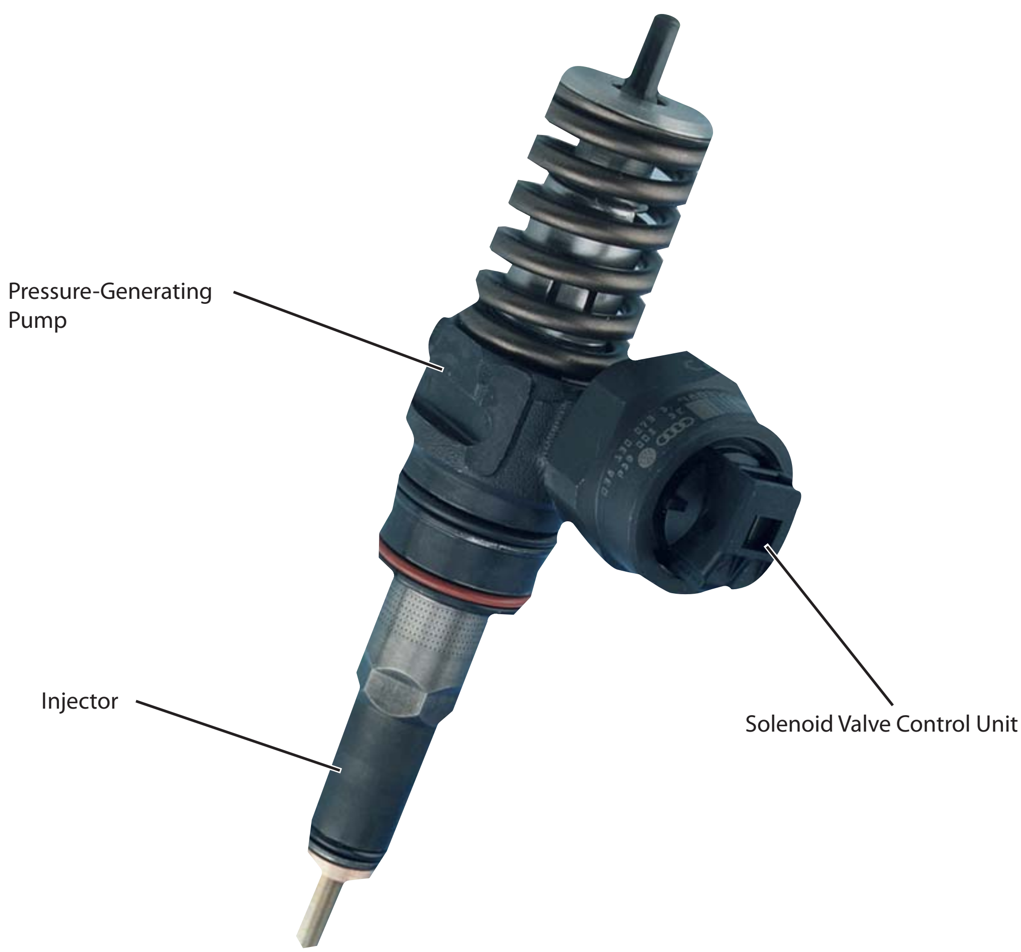
A pump/injector is, as the name implies, a pressure-generating pump combined with a solenoid valve control unit (Valves for Pump/Injectors, Cylinders 1 through 4, N240, N241, N242, and N243) and an injector.

Each engine cylinder has its own pump/injector.

This means that there is no longer any need for a high-pressure line or a distributor injection pump.

Just like a conventional system with a distributor injection pump and separate injectors, the new pump injection system must:

- Generate the high injection pressures required
- Inject fuel into the cylinders in the correct quantity and at the correct point in time



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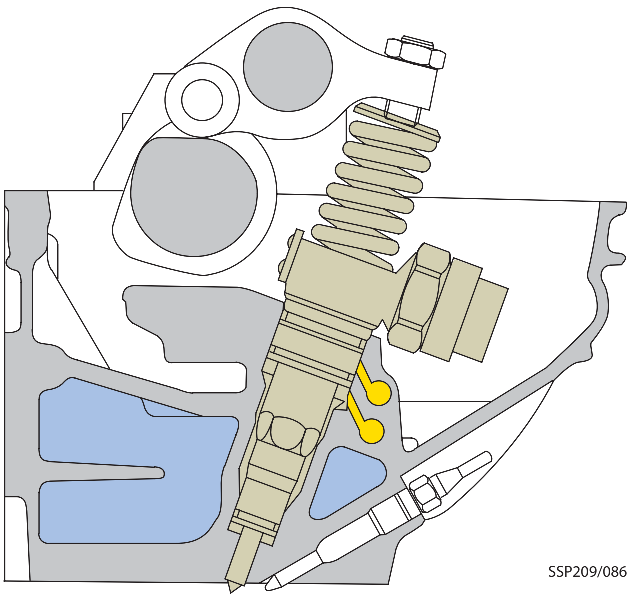
Pump Injection System



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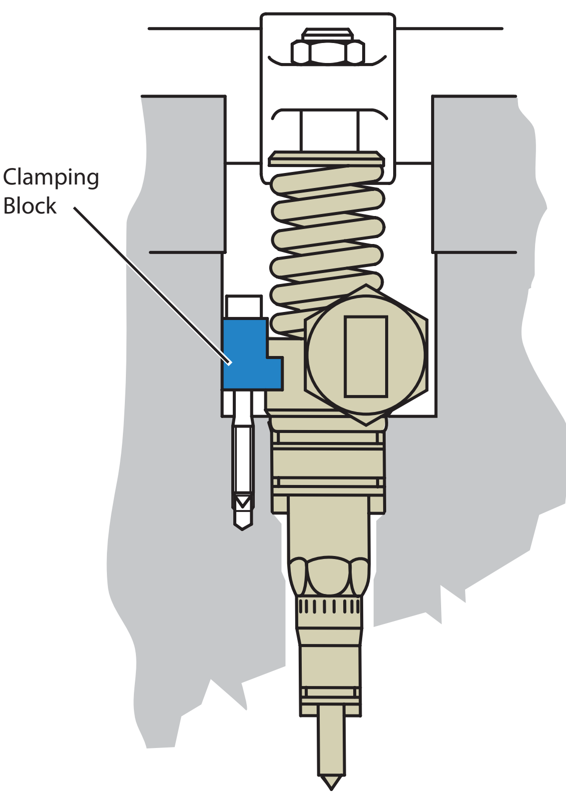
The pump/injectors are installed directly in the cylinder head.



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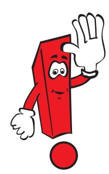
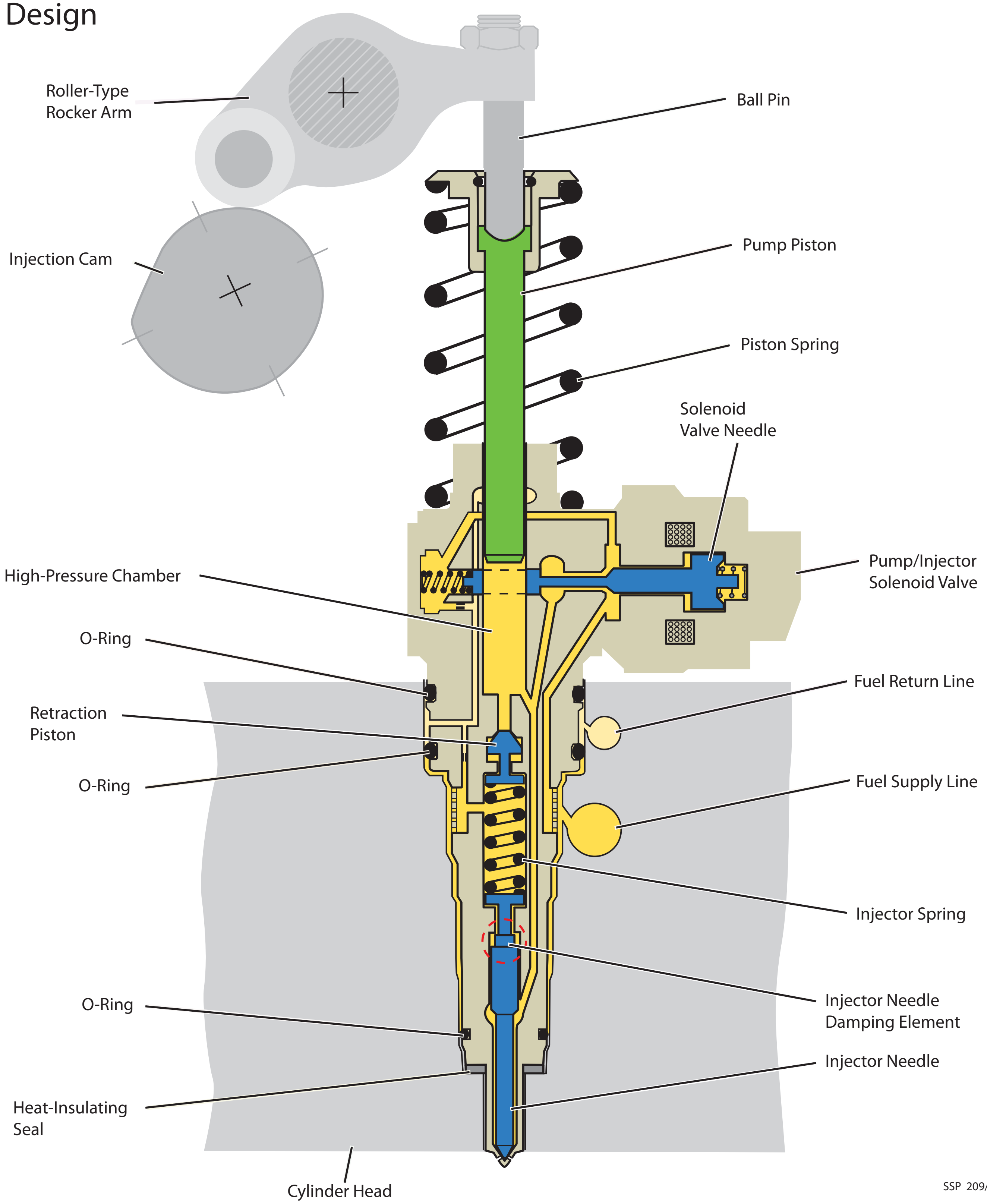
They are attached to the cylinder head by individual clamping blocks.



It is important to ensure that the pump/injectors are positioned correctly when they are installed. Refer to the Repair Manual for instructions.

If the pump/injectors are not installed perpendicular to the cylinder head, the fasteners can loosen. The pump/injectors or the cylinder head can be damaged as a result.

Design

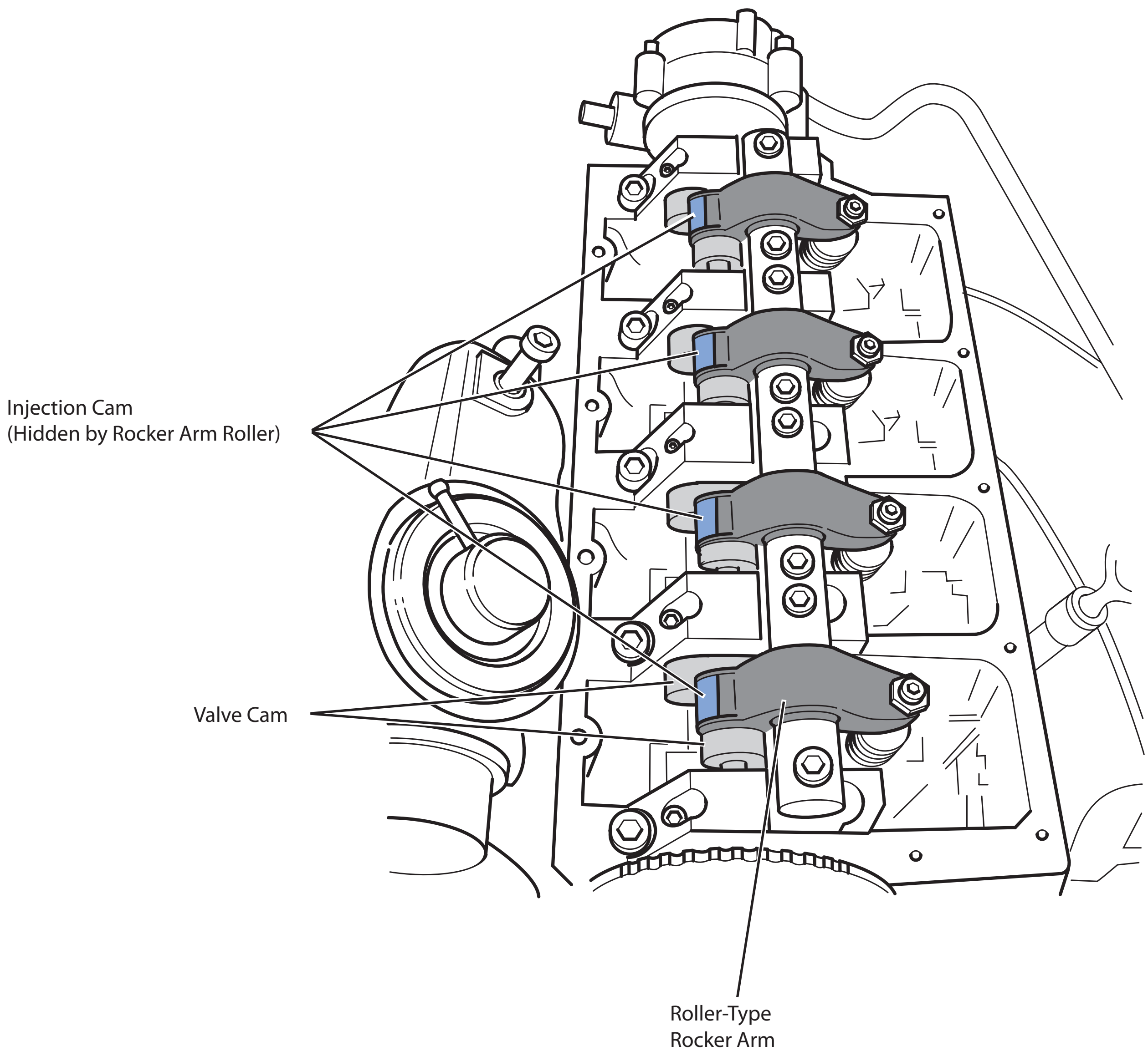


SSP 209/023

Drive Mechanism

The camshaft has four additional camshaft lobes for driving the pump/injectors.

They activate the pump/injector pump pistons with roller-type rocker arms.



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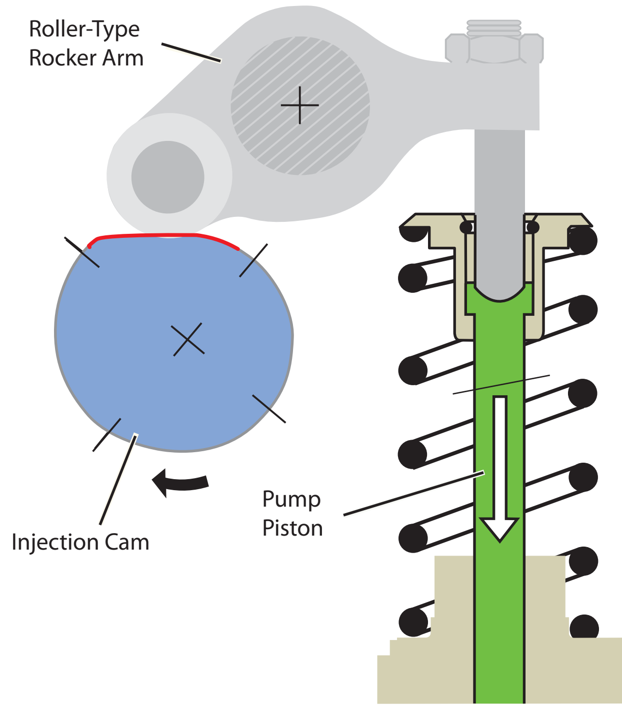
The injection cam lobe has a steep leading edge and a gradual slope to the trailing edge.

As a result of the steep leading edge, the pump piston is pushed down at high velocity. A high injection pressure is attained quickly.



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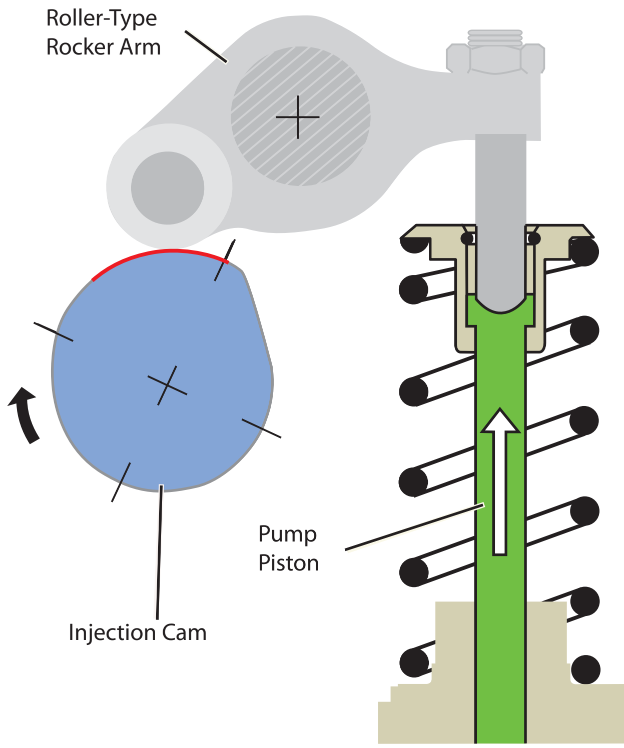
The gradual slope of the cam trailing edge allows the pump piston to move up relatively slowly and evenly. Fuel flows into the pump/injector high-pressure chamber free of air bubbles.



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Mixture Formation and Combustion Requirements

Good mixture formation is a vital factor for efficient combustion. To accomplish this, fuel must be injected in the correct quantity at the right time and at high pressure. Even minimal deviations can lead to higher levels of pollutant emissions, noisy combustion, or high fuel consumption.

A short firing delay is important for the combustion sequence of a diesel engine. The firing delay is the period between the start of fuel injection and the start of pressure rise in the combustion chamber. If a large fuel quantity is injected during this period, the pressure will rise suddenly and cause loud combustion noise.

Pre-Injection Phase

To soften the combustion process, a small amount of fuel is injected at a low pressure before the start of the main injection phase.

This is the pre-injection phase. Combustion of this small quantity of fuel causes the pressure and temperature in the combustion chamber to rise.

This meets the requirements for quick ignition of the main injection quantity, thus reducing the firing delay.

The pre-injection phase and the "injection interval" between the pre-injection phase and the main injection phase produce a gradual rise in pressure within the combustion chamber, not a sudden pressure buildup. The effects of this are low combustion noise levels and lower nitrogen oxide emissions.

Main Injection Phase

The key requirement for the main injection phase is the formation of a good mixture. The aim is to burn the fuel completely if possible.

The high injection pressure finely atomizes the fuel so that the fuel and air can mix well.

Complete combustion reduces pollutant emissions and ensures high engine efficiency.

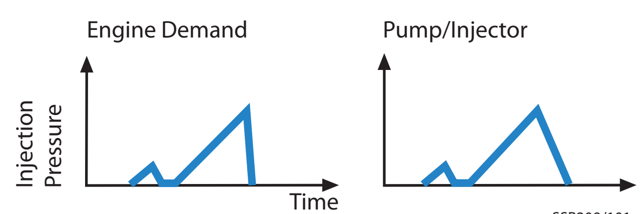
End of Injection

At the end of the injection process, it is important that the injection pressure drops quickly and the injector needle closes quickly.

This prevents fuel at a low injection pressure and with a large droplet diameter from entering the combustion chamber. Fuel does not combust completely under such conditions, giving rise to higher pollutant emissions.

Injection Curve

The pump injection system's injection curve largely matches the engine demands, with low pressures during the pre-injection phase, followed by an "injection interval," then a rise in pressure during the main injection phase. The injection cycle ends abruptly.



SSP209/101

Injection Cycle

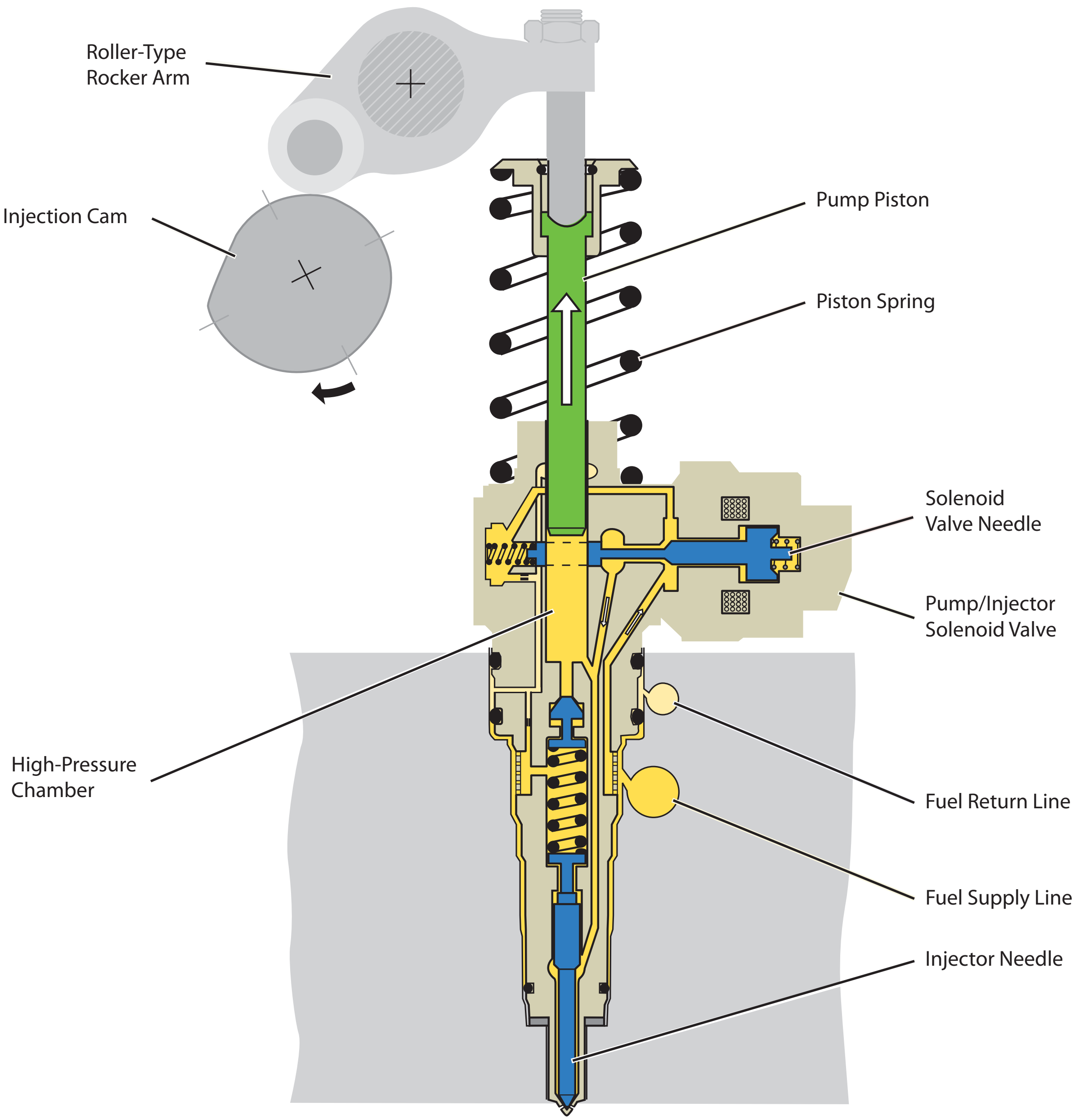
High-Pressure Chamber Fills

During the filling phase, the pump piston moves upward under the force of the piston spring and increases the volume of the high-pressure chamber.

The pump/injector solenoid valve is not activated. The solenoid valve needle is in its resting position.

The path is open from the fuel supply line to the high-pressure chamber.

The fuel pressure in the supply line causes the fuel to flow into the high-pressure chamber.



SSP209/024

Pre-Injection Phase Starts

The injection cam pushes the pump piston down via the roller-type rocker arm. This displaces some of the fuel from the high-pressure chamber back into the fuel supply line.

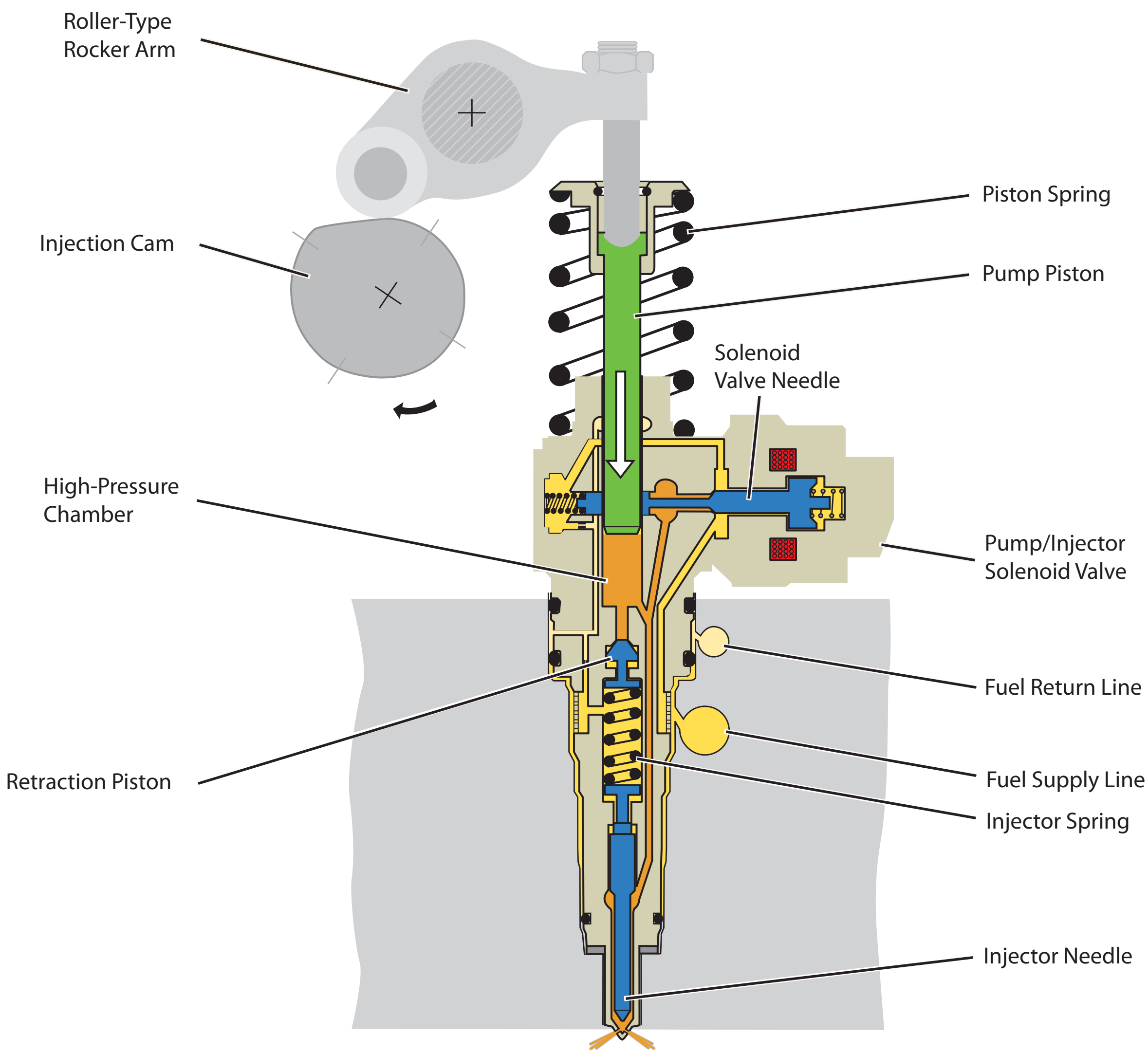
The Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 initiates the injection cycle by activating the pump/injector solenoid valve.

The solenoid valve needle is pressed into the valve seat and closes the path from the high-pressure chamber to the fuel supply line.

This initiates a pressure build-up in the high-pressure chamber.

At 2,611 psi (18,000 kPa / 180 bar), the pressure is greater than the force of the injector spring.

The injector needle is lifted from its seat and the pre-injection cycle starts.



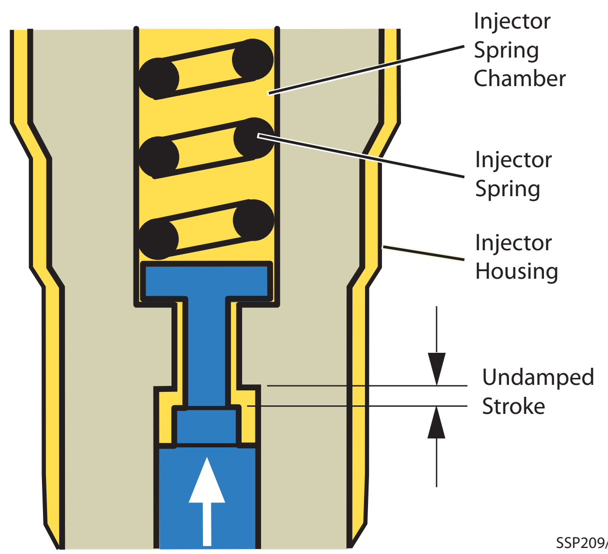
SSP209/025

Injector Needle Damping

During the pre-injection phase, the stroke of the injector needle is dampened by a hydraulic cushion. As a result, it is possible to meter the injection quantity exactly.

Function
In the first third of the total stroke, the injector needle is opened undamped.

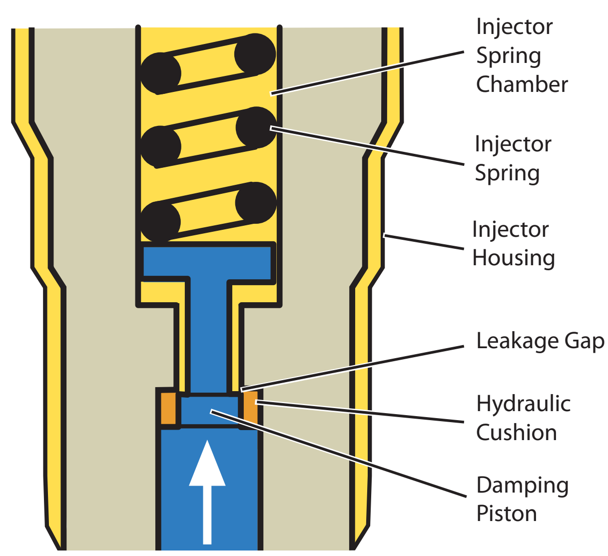
The pre-injection quantity is injected into the combustion chamber.



SSP209/035

As soon as the damping piston plunges into the bore in the injector housing, the fuel above the injector needle can only be displaced into the injector spring chamber through a leakage gap.

This creates a hydraulic cushion which limits the injector needle stroke during the pre-injection phase.



SSP209/036

Pre-Injection Phase Ends

The pre-injection phase ends immediately after the injector needle opens.

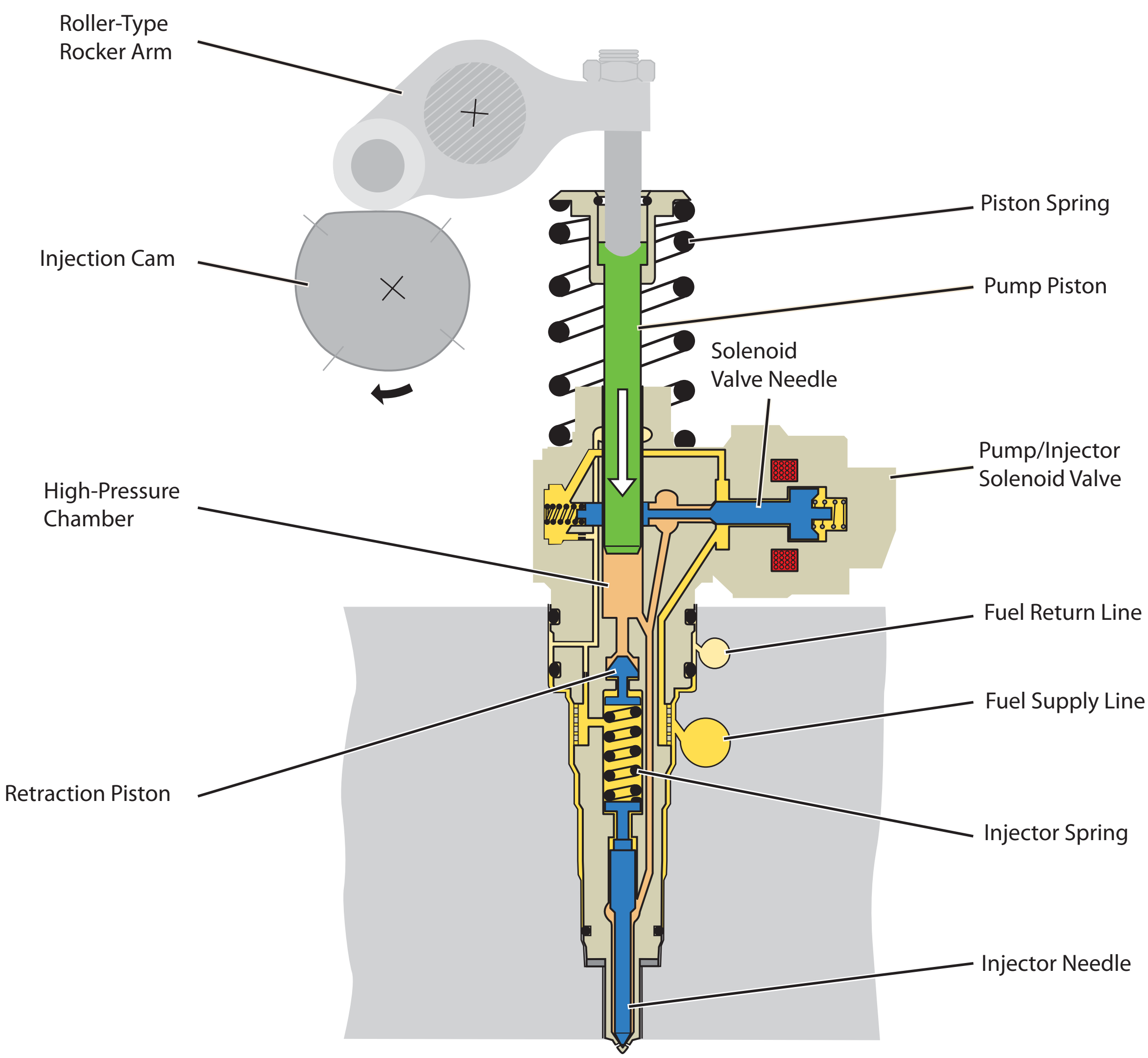
The rising pressure causes the retraction piston to move downward, thus increasing the volume of the high-pressure chamber.

The pressure drops momentarily as a result, and the injector needle closes.

This ends the pre-injection phase.

The downward movement of the retraction piston pre-loads the injector spring to a greater extent.

To re-open the injector needle during the subsequent main injection phase, the fuel pressure must be greater than during the pre-injection phase.



SSP209/026

Main Injection Phase Starts

The pressure in the high-pressure chamber rises again shortly after the injector needle closes.

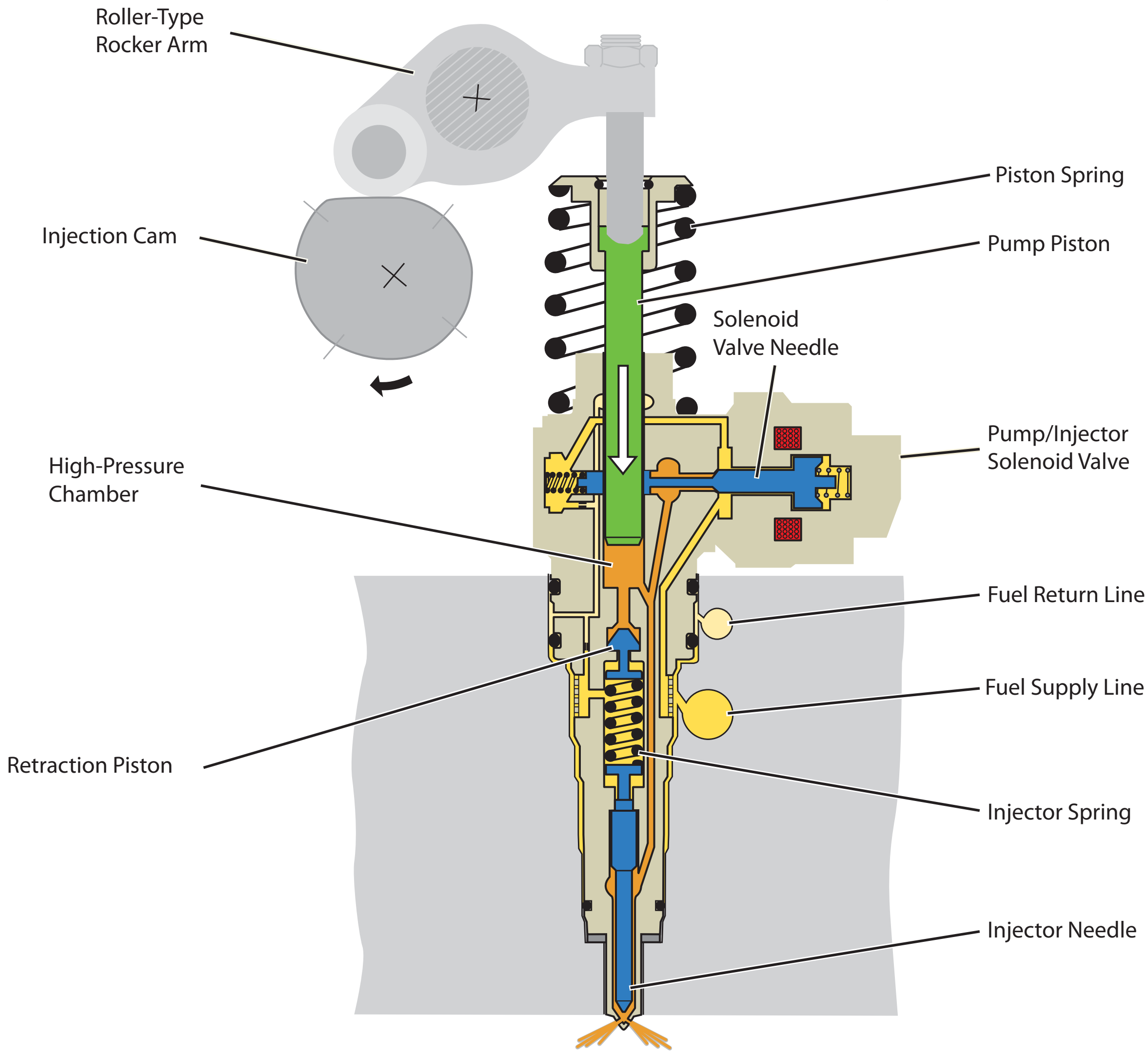
The pump/injector solenoid valve remains closed and the pump piston moves downward.

At approximately 4,351 psi (30,000 kPa / 300 bar), the fuel pressure is greater than the force exerted by the pre-loaded injector spring.

The injector needle is again lifted from its seat and the main injection quantity is injected.

The pressure rises to between 27,121 psi (187,000 kPa / 1,870 bar) and 27,846 psi (192,000 kPa / 1,920 bar) because more fuel is displaced in the high-pressure chamber than can escape through the nozzle holes.

Maximum fuel pressure is achieved at maximum engine output. This occurs at a high engine speed when a large quantity of fuel is being injected.



SSP209/027

Main Injection Phase Ends

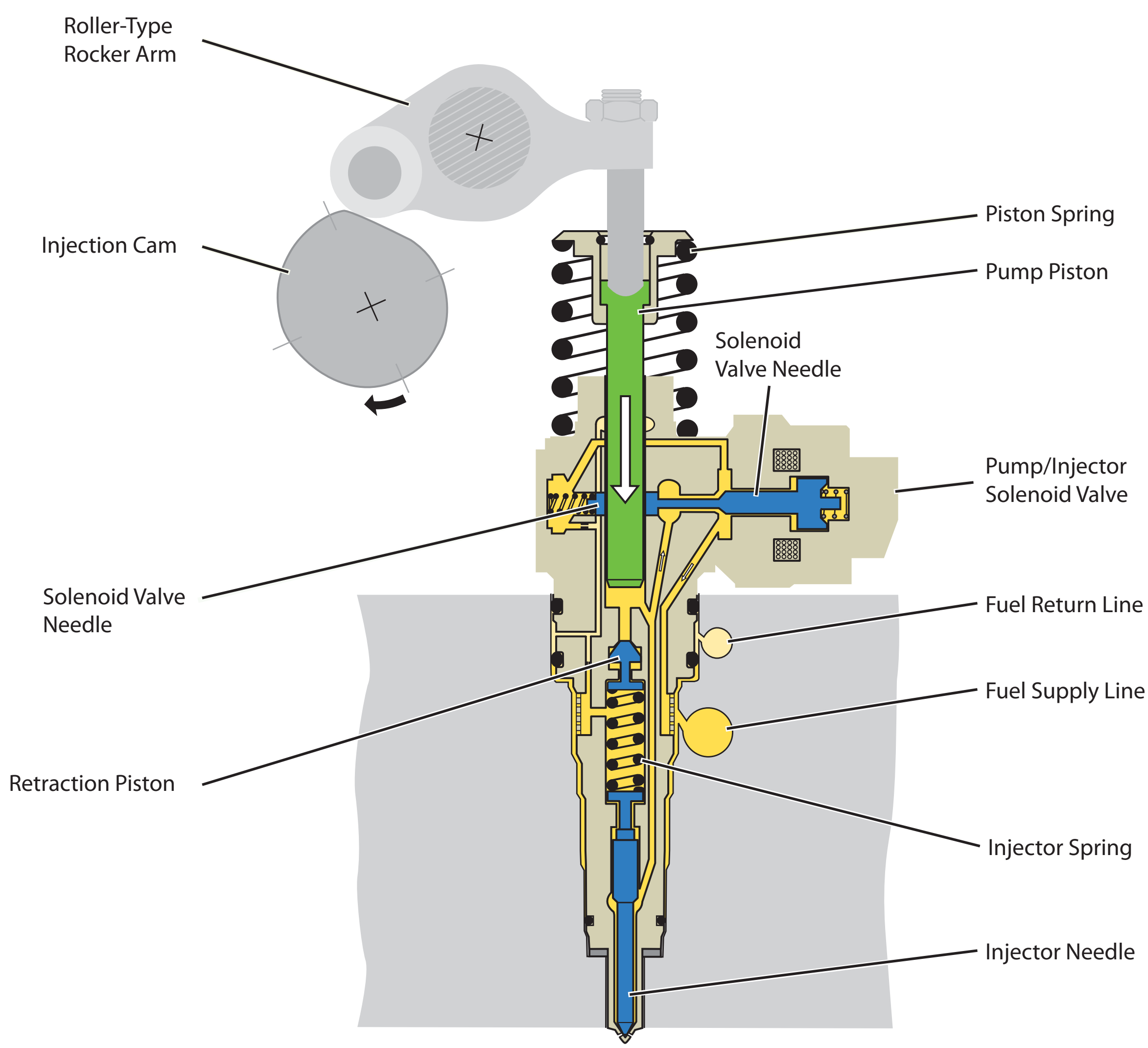
The injection cycle ends when the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 stops activating the pump/injector solenoid valve.

The solenoid valve spring opens the solenoid valve needle, and the fuel displaced by the pump piston can enter the fuel supply line.

The pressure drops.

The injector needle closes and the injector spring presses the bypass piston into its starting position.

This ends the main injection phase.

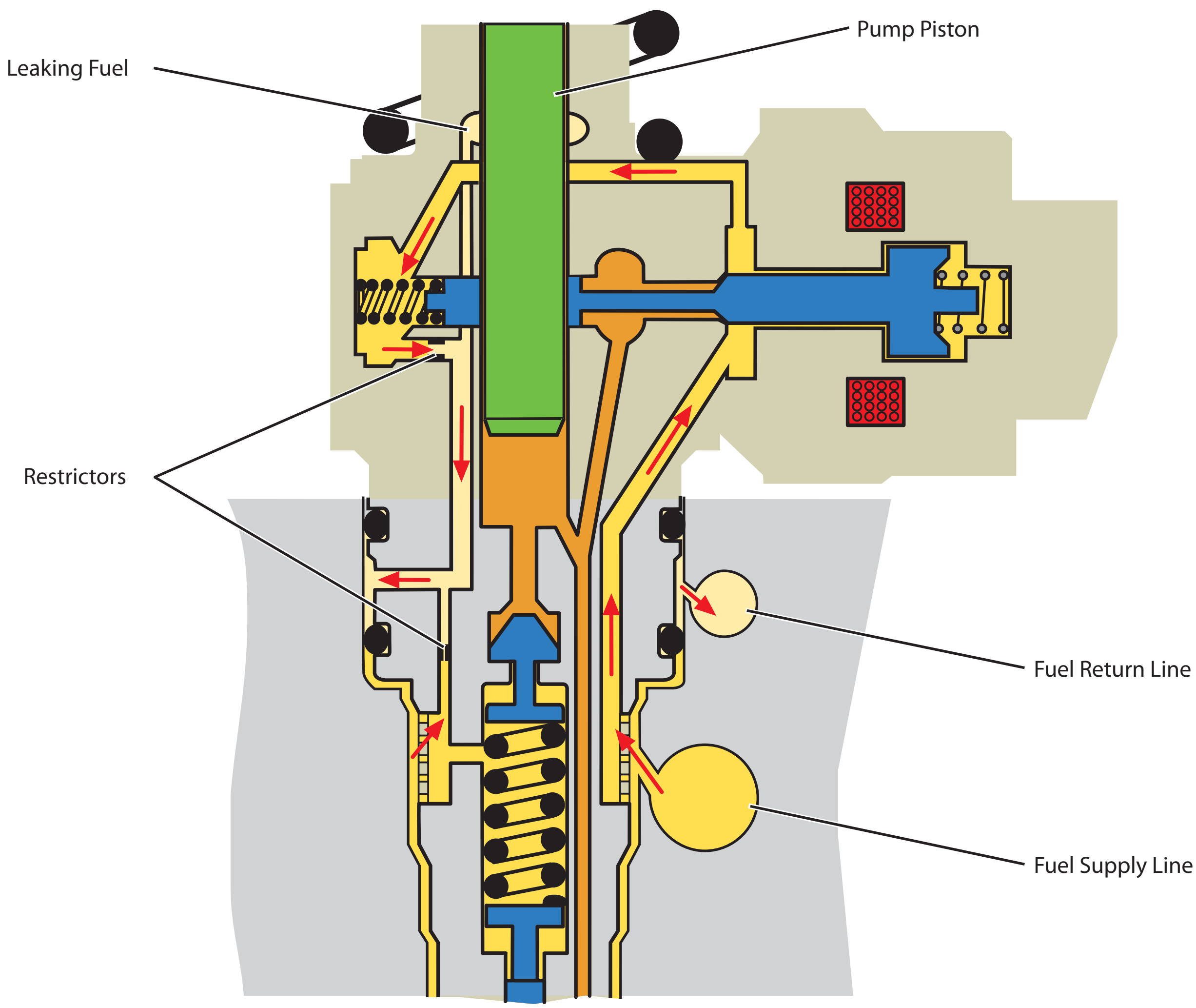


SSP209/028

Pump/Injector Fuel Return

The fuel return line in the pump/injector has the following functions:

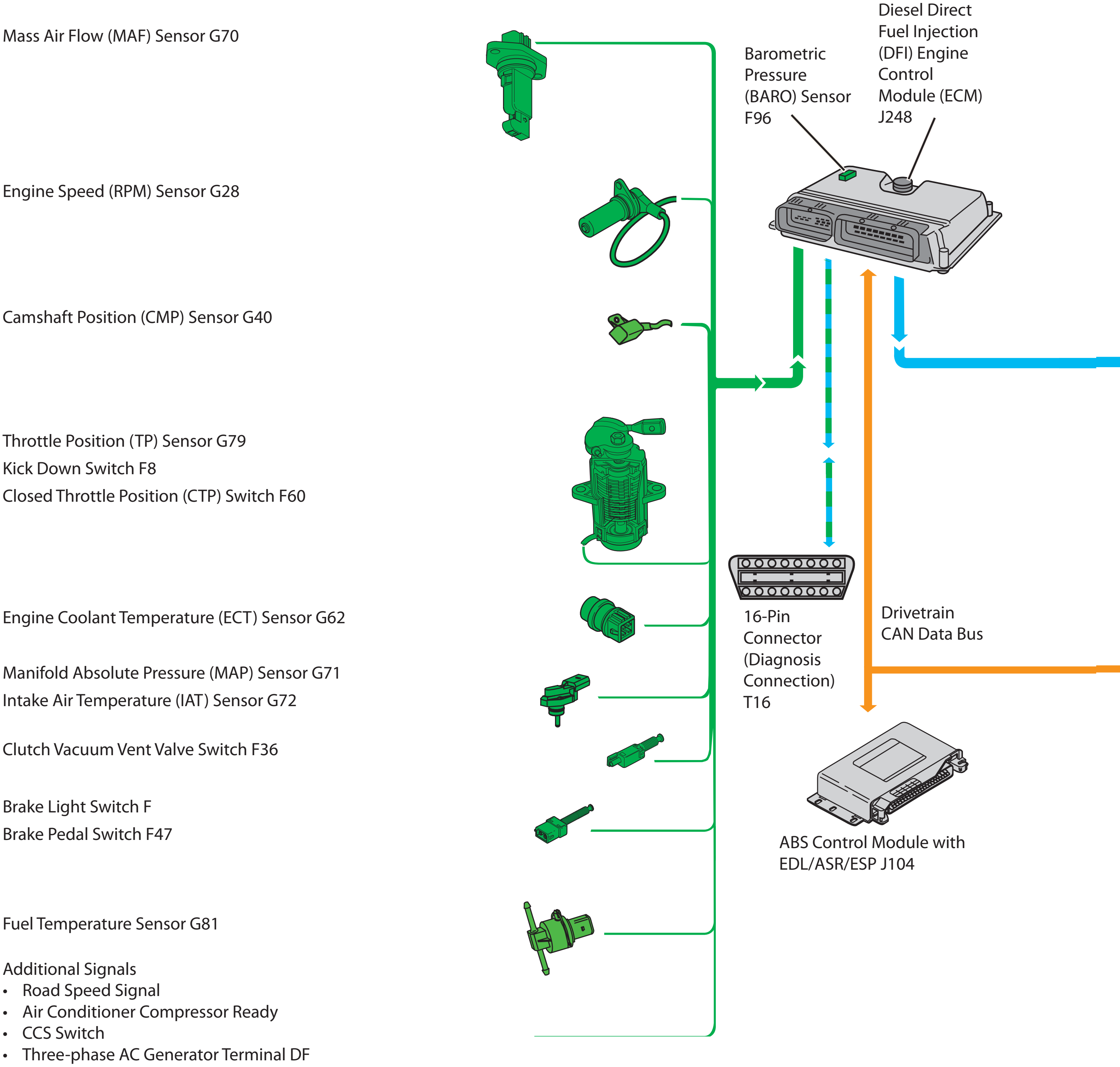
- Cools the pump/injector by flushing fuel from the fuel supply line through the pump/injector ducts into the fuel return line
- Discharges leaking fuel at the pump piston
- Separates vapor bubbles from the pump/injector fuel supply line through the restrictors in the fuel return line



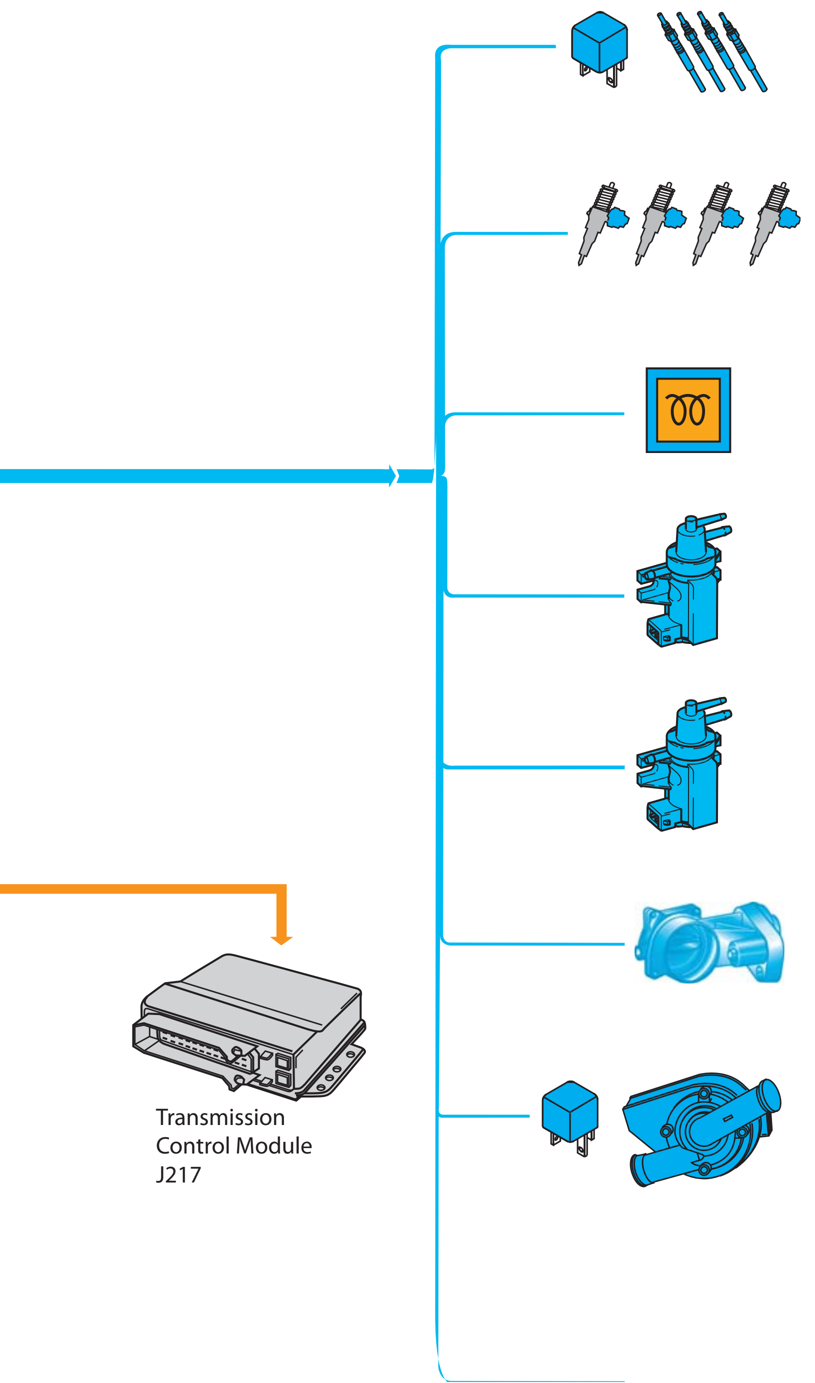
SSP209/096

1.9-liter TDI Engine EDC 16 System Overview

Sensors



Actuators



Glow Plugs (engine) Q6

Glow Plug Activation Control Module J370

Valve for Pump/Injector, Cylinder 1 N240
Valve for Pump/Injector, Cylinder 2 N241
Valve for Pump/Injector, Cylinder 3 N242
Valve for Pump/Injector, Cylinder 4 N243

Glow Plug Indicator Light K29

EGR Vacuum Regulator Solenoid Valve N18

Wastegate Bypass Regulator Valve N75

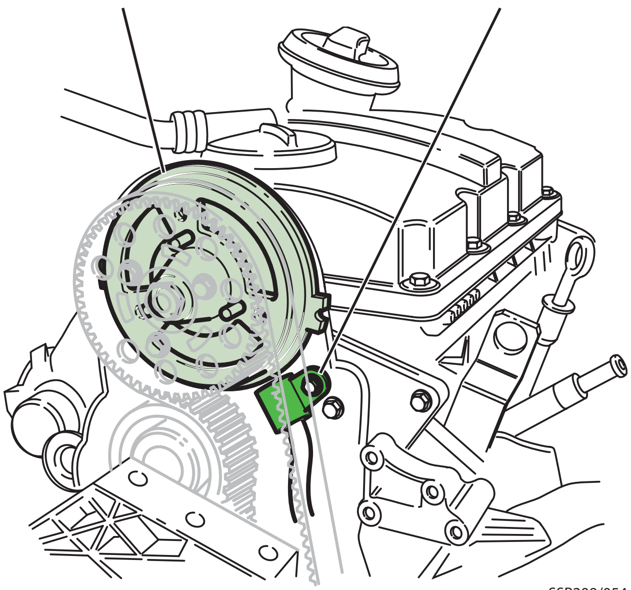
Intake Flap Motor V157

Fuel Cooling Pump/Relay J445

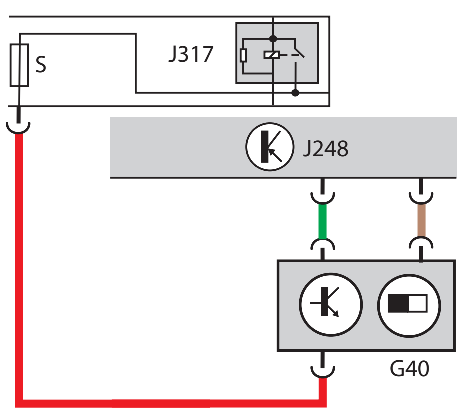
Fuel Cooler Pump V166
(V10 TDI Only)

Additional Signals
- Coolant Auxiliary Heater
- Engine Speed
- Cooling Fan Run-On
- Air Conditioner Compressor Cut-Off
- Fuel Consumption Signal

SSP209/053



SSP209/054



SSP209/055

Sensors

Camshaft Position (CMP) Sensor G40

The Camshaft Position (CMP) Sensor G40 is a Hall-effect sensor.

It is attached to the toothed-belt guard below the camshaft gear.

It scans seven teeth on the camshaft sensor wheel attached to the camshaft gear.

Signal Application
The Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 uses the signal that the Camshaft Position (CMP) Sensor G40 generates to determine the relative positions of the pistons in the cylinders when starting the engine.

Effects of Signal Failure
In the event of Camshaft Position (CMP) Sensor G40 signal failure, the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 uses the signal that the Engine Speed (RPM) Sensor G28 generates.

Electrical Circuit

G40	Camshaft Position (CMP) Sensor
J248	Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM)
J317	Power Supply Relay (Terminal 30, B+)

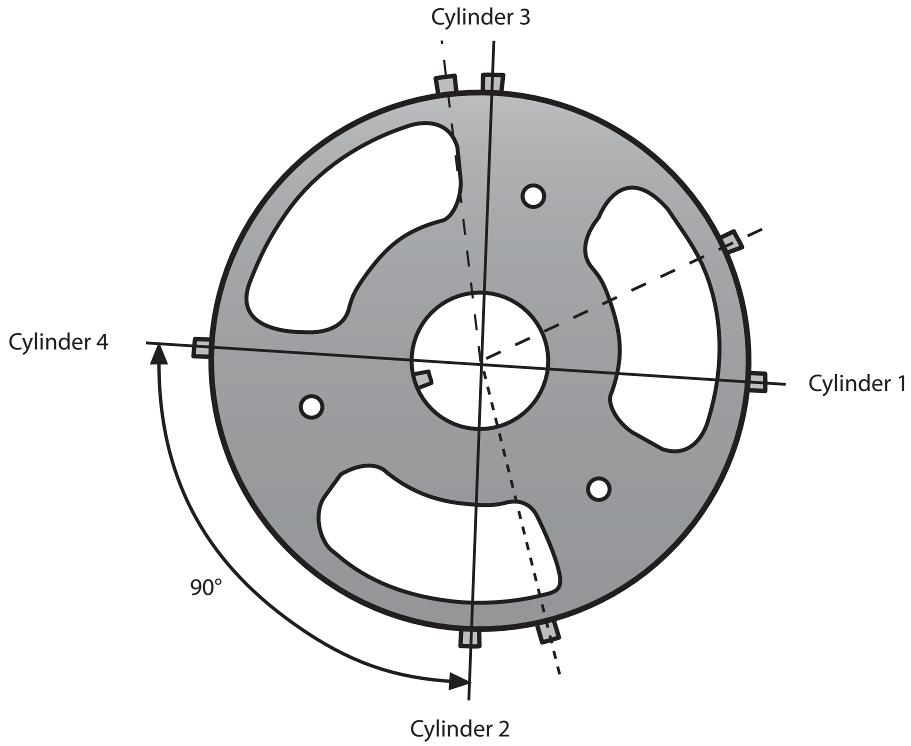
Cylinder Recognition when Starting the Engine

When starting the engine, the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 must determine which cylinder is in the compression stroke in order to activate the correct pump/injector valve. To achieve this, it evaluates the signal generated by the Camshaft Position (CMP) Sensor G40, which scans the teeth of the camshaft sensor wheel to determine the camshaft position.

Camshaft Sensor Wheel

Since the camshaft executes one 360-degree revolution per working cycle, there is a tooth for each individual cylinder on the sensor wheel. These teeth are spaced 90 degrees apart.

To differentiate between cylinders, the sensor wheel has an additional tooth with different spacing for each of cylinders 1, 2, and 3.



SSP209/094

Function

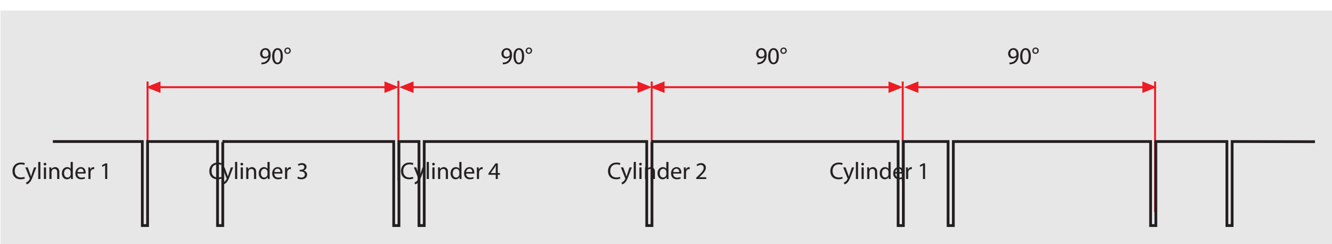
Each time a tooth passes the Camshaft Position (CMP) Sensor G40, a Hall-effect voltage is induced and transmitted to the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248.

Because the teeth are spaced at different distances apart, the induced voltage occurs at different time intervals.

From this, the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 determines the relative positions of the cylinders and uses this information to control the solenoid valves for pump/injectors.

Refer to "Quick-Start Function" (page 34).

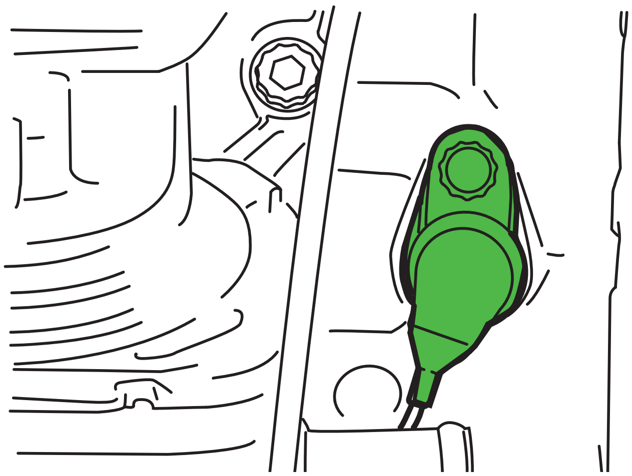
Signal Pattern, Camshaft Position (CMP) Sensor G40



SSP209/095a

Engine Speed (RPM) Sensor G28

The Engine Speed (RPM) Sensor G28 is an inductive sensor. It is attached to the cylinder block.

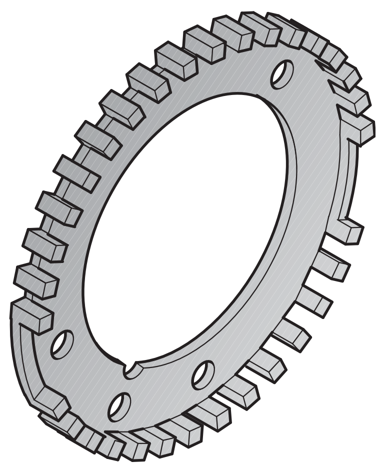


SSP209/056

Engine Speed Sensor Wheel

The Engine Speed (RPM) Sensor G28 scans a 60-2-2 sensor wheel attached to the crankshaft. This means that the sensor wheel has 56 teeth with two gaps the width of two teeth each on its circumference.

These gaps are 180 degrees apart and serve as reference points for determining the crankshaft position.



SSP209/085

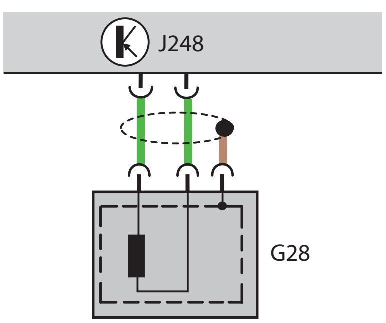
Signal Application
The signal generated by the Engine Speed (RPM) Sensor G28 provides both the engine speed and the exact position of the crankshaft.

The injection point and the injection quantity are calculated using this information.

Effects of Signal Failure
If the signal of the Engine Speed (RPM) Sensor G28 fails, the engine is switched off.

Electrical Circuit

G28	Engine Speed (RPM) Sensor
J248	Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM)



SSP209/057

Quick Start Function

To allow the engine to be started quickly, the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 evaluates the signals generated by the Camshaft Position (CMP) Sensor G40 and the Engine Speed (RPM) Sensor G28.

The Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 uses the signal that the Camshaft Position (CMP) Sensor G40 generates to determine the relative positions of the pistons in the cylinders when starting the engine.

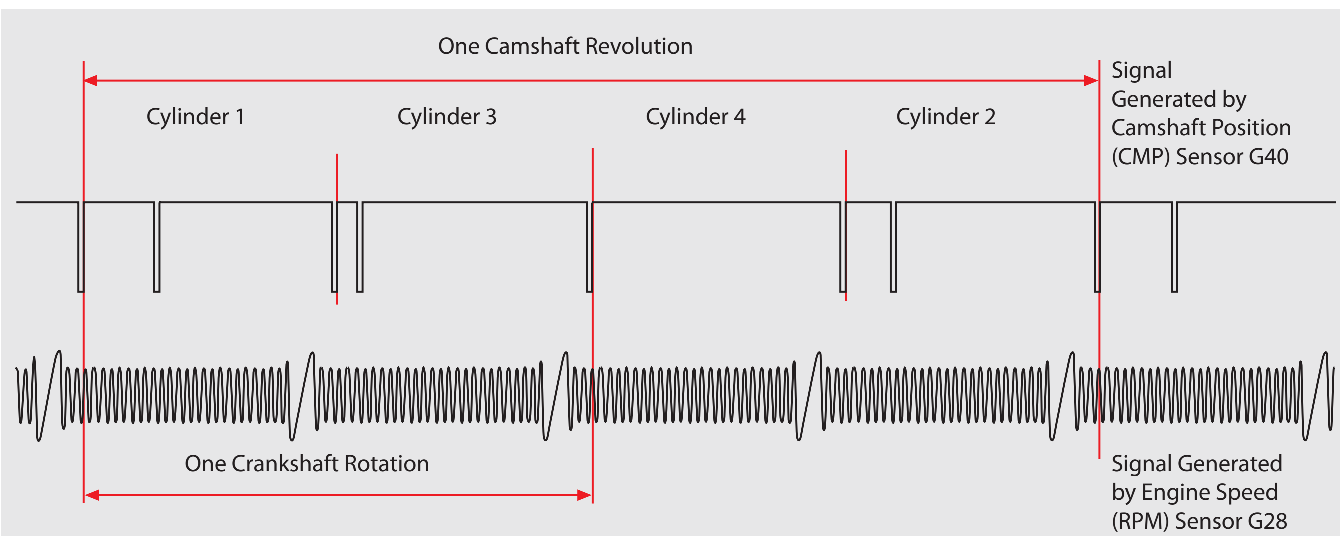
Because there are two gaps on the crankshaft sensor wheel, the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 receives a usable reference signal from the Engine Speed (RPM) Sensor G28 after only half a turn of the crankshaft.

By interpreting the signals from these two sensors, the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 determines the position of the crankshaft in relation to the camshaft and thus the positions of the pistons in the cylinders at an early stage.

With this information, it can activate the correct solenoid valve at the proper time to initiate the injection cycle in the next cylinder to reach the compression stage.

The quick start function enables an early engine start because synchronization with the first cylinder is not required.

Signal Pattern, Camshaft Position (CMP) Sensor G40 and Engine Speed (RPM) Sensor G28

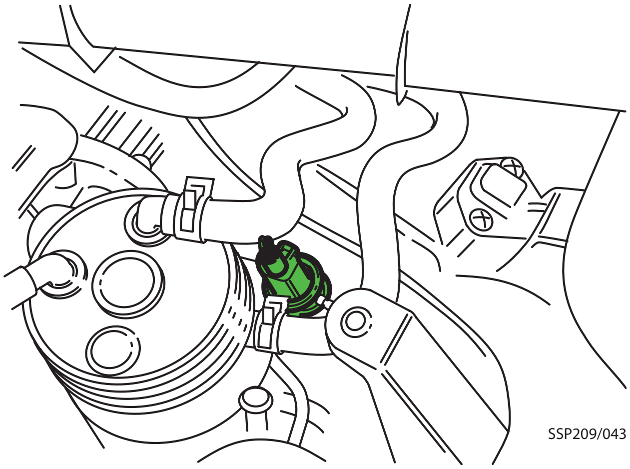


SSP209/095

Fuel Temperature Sensor G81

The Fuel Temperature Sensor G81 is located in the fuel return line between the fuel pump and the fuel cooler. It determines the current temperature of the fuel at that point.

The Fuel Temperature Sensor G81 has a negative temperature coefficient. The sensor resistance decreases with increasing fuel temperature.



SSP209/043

Signal Application

The signal generated by the Fuel Temperature Sensor G81 is used by the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 to determine the fuel temperature.

This signal is needed to calculate the start of injection point and the injection quantity so that allowance can be made for the density of the fuel at different temperatures.

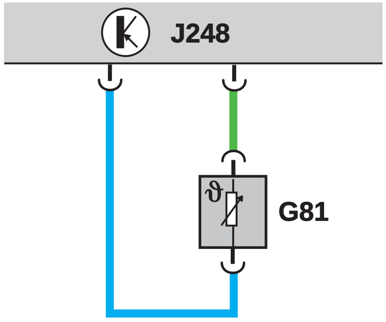
This signal is also used to determine the timing for switching on the fuel cooling pump.

Effects of Signal Failure

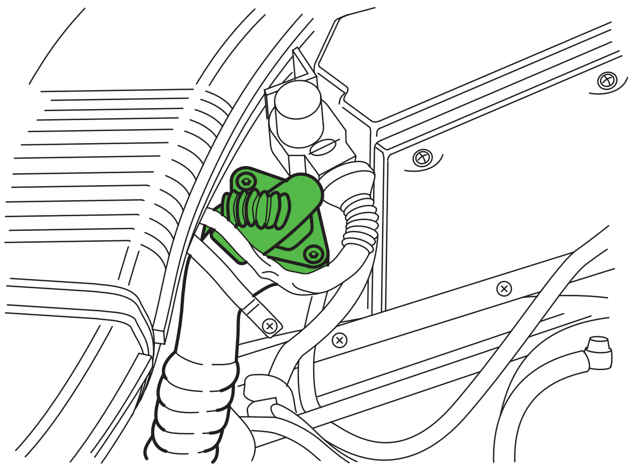
In the event of Fuel Temperature Sensor G81 signal failure, the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 calculates a substitute value from the signal generated by Engine Coolant Temperature (ECT) Sensor G62.

Electrical Circuit

G81	Fuel Temperature Sensor
J248	Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM)



SSP209/058



SSP209/044

Mass Air Flow (MAF) Sensor G70

The Mass Air Flow (MAF) Sensor G70 with reverse flow recognition is located in the intake pipe. It determines the intake air mass.

The opening and closing actions of the intake valve produce reverse flows in the induced air mass in the intake pipe.

The Mass Air Flow (MAF) Sensor G70 recognizes and makes allowance for the returning air mass in the signal it sends to the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248.

The air mass is accurately measured.

Signal Application

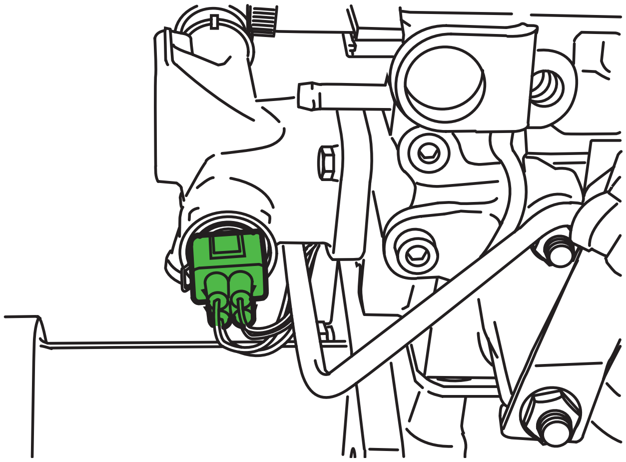
The Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 uses the measured values from the Mass Air Flow (MAF) Sensor G70 to calculate the injection quantity and the exhaust gas recirculation rate.

Effects of Signal Failure

If the signal from the Mass Air Flow (MAF) Sensor G70 fails, the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 uses a fixed substitute value.

Engine Coolant Temperature (ECT) Sensor G62

The Engine Coolant Temperature (ECT) Sensor G62 is located at the coolant connection on the cylinder head. It sends information about the current coolant temperature to the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248.



SSP209/60

Signal Application
The Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 uses the coolant temperature as a correction value for calculating the injection quantity.

Effects of Signal Failure
If the signal from Engine Coolant Temperature (ECT) Sensor G62 fails, the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 uses the signal generated by the Fuel Temperature Sensor G81 to calculate the injection quantity.

Accelerator Pedal Sensors

The accelerator pedal sensors are integrated into a single housing and connected to the pedal by mechanical linkage.

- Throttle Position (TP) Sensor G79
- Kick Down Switch F8
- Closed Throttle Position (CTP) Switch F60

Signal Application
The Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 can recognize the position of the accelerator pedal from this signal.

In vehicles with an automatic transmission, the Kick Down Switch F8 indicates to the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 when the driver wants to accelerate.

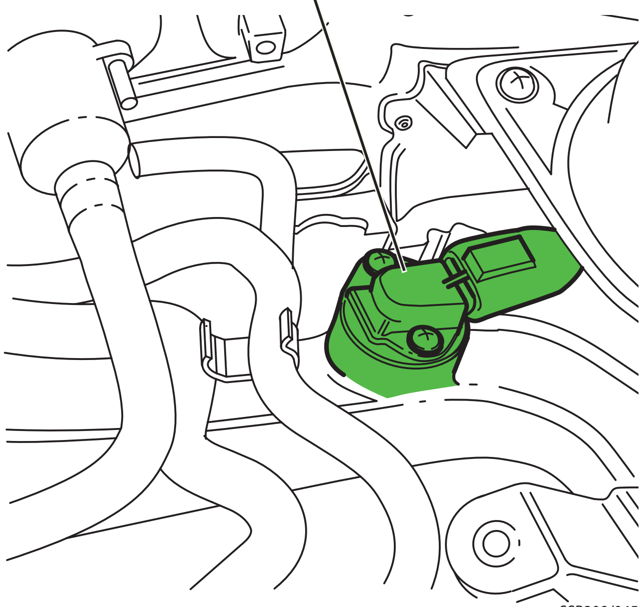
Effects of Signal Failure
Without the signal from Throttle Position (TP) Sensor G79, the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 is unable to recognize the accelerator pedal position.

The engine will only run at an increased idling speed.

Intake Manifold Sensors

The intake manifold sensors are integrated into a single module and installed in the intake pipe.

- Manifold Absolute Pressure (MAP) Sensor G71
- Intake Air Temperature (IAT) Sensor G72



Manifold Absolute Pressure (MAP) Sensor G71

Signal Application
The Manifold Absolute Pressure (MAP) Sensor G71 supplies a signal that is required to check the charge pressure (boost pressure).

The Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 compares the actual measured value with the setpoint from the charge pressure map.

If the actual value deviates from the setpoint, the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 adjusts the charge pressure via the Wastegate Bypass Regulator Valve N75.

Effects of Signal Failure
The charge pressure can no longer be regulated.

Engine performance drops.

Intake Air Temperature (IAT) Sensor G72

Signal Application
The Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 uses the signal generated by the Intake Air Temperature (IAT) Sensor G72 as a correction value for computing the charge pressure.

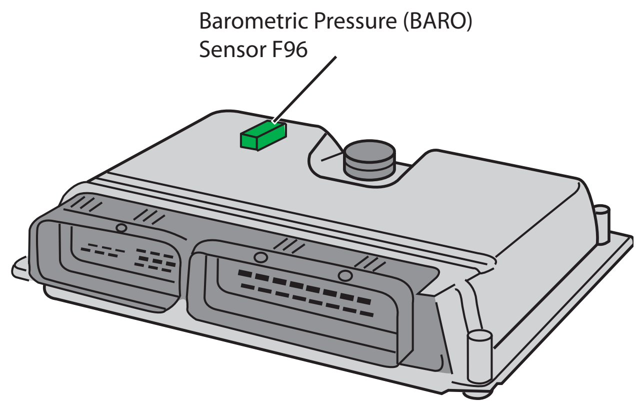
The Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 can then make allowance for the effect of temperature on the density of the charge air.

Effects of Signal Failure
If the Intake Air Temperature (IAT) Sensor G72 signal fails, the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 uses a fixed substitute value to calculate the charge pressure.

This can result in a drop in engine performance.

Barometric Pressure (BARO) Sensor F96

The Barometric Pressure (BARO) Sensor F96 is located inside the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248.



SSP209/061

Signal Application
The Barometric Pressure (BARO) Sensor F96 sends the current ambient air pressure to the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248. This value is dependent on the vehicle geographical altitude.

With this signal the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 can carry out an altitude correction for charge pressure control and exhaust gas recirculation.

Effects of Signal Failure
Black smoke occurs at altitude.

Clutch Vacuum Vent Valve Switch F36

The Clutch Vacuum Vent Valve Switch F36 is located at the foot controls on vehicles with manual transmissions.

Signal Application
The Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 determines from this signal whether the clutch is engaged or disengaged.

When the clutch is engaged, injection quantity is reduced briefly to prevent engine shudder when shifting gears.

Effects of Signal Failure
If the signal from the Clutch Vacuum Vent Valve Switch F36 fails, engine shudder can occur when shifting gears.

Brake Pedal Sensors

The brake pedal sensors are integrated into a single module that is mounted on the brake pedal bracket.

- Brake Light Switch F
- Brake Pedal Switch F47

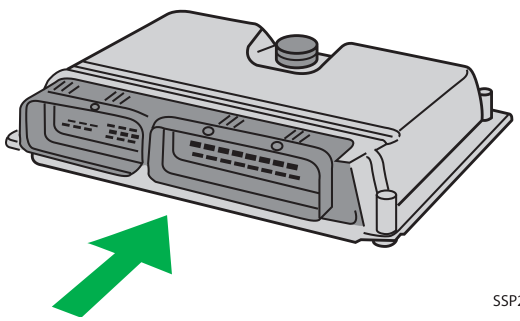
Signal Application
Both switches supply the Diesel Direct Fuel (DFI) Injection Engine Control Module (ECM) J248 with the “brake activated” signal.

The engine speed is regulated when the brake is activated for safety reasons, since the Throttle Position (TP) Sensor G79 could be defective.

Effects of Signal Failure
If one of the two switches fails, Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 reduces the fuel quantity delivered.

Engine performance drops.

Additional Input Signals



SSP209/083

Road Speed Signal

The Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 receives the road speed signal from the vehicle speed sensor.

This signal is used to calculate various functions, including cooling fan run-on and engine shudder damping when shifting gears.

It is also used to check the cruise control system for proper functioning.

Air Conditioner Compressor Ready

The air conditioner switch sends Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 a signal indicating that the air conditioner compressor will shortly be switched on.

This enables the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 to increase the engine idle speed before the air conditioner compressor is switched on to prevent a sharp drop in engine speed when the compressor starts up.

Cruise Control Switch

The signal generated by the cruise control switch tells the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 that the cruise control system has been activated.

Three-phase AC Generator Terminal DF

The signal supplied by generator terminal DF indicates the load state of the three-phase AC generator to the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248.

Depending on available capacity, the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 can switch on one, two, or three Coolant Glow Plugs Q7 of the coolant auxiliary heater via the Preheating Coolant, Low Heat Output Relay J359 and the Preheating Coolant, High Heat Output Relay J360.

Control Area Network (CAN) Data Bus

The Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248, the ABS Control Module with EDL/ASR/ESP J104, and the Transmission Control Module (TCM) J217 interchange information along a CAN Data bus.

Actuators

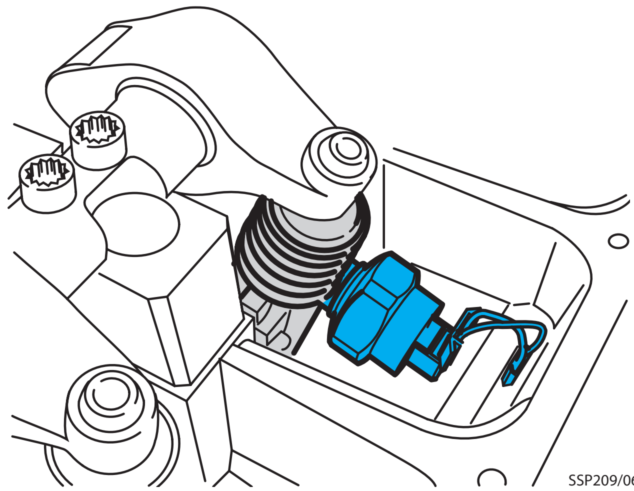
Pump/Injector Solenoid Valves

The 1.9-liter TDI engine with the new pump injection system uses four pump/injector solenoid valves:

- Valve for Pump/Injector, Cylinder 1 N240
- Valve for Pump/Injector, Cylinder 2 N241
- Valve for Pump/Injector, Cylinder 3 N242
- Valve for Pump/Injector, Cylinder 4 N243

The pump/injector solenoid valves are attached to their pump/injectors with a cap nut.

The Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 regulates the start of injection points and injection quantities of the pump/injectors by activating their solenoid valves at the appropriate times.



SSP209/064

Start of Injection Point

As soon as the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 activates a pump/injector solenoid valve, the magnetic coil presses the solenoid valve needle down into the valve seat and closes off the path from the fuel supply line to the high-pressure chamber of the pump/injector.

The injection cycle then begins.

Injection Quantity

The injection quantity is determined by the length of time that the solenoid valve is activated.

Fuel is injected into the combustion chamber as long as the pump/injector solenoid valve is closed.

Effects of Failure
If a pump/injector solenoid valve fails, the engine will not run smoothly and performance will be reduced.

The pump/injector solenoid valve has a dual safety function.

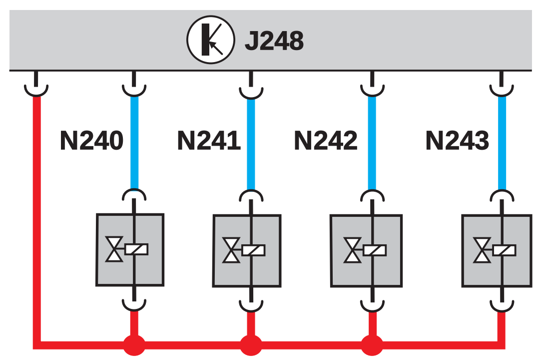
If the valve stays open, pressure cannot build up in the pump/injector.

If the valve stays closed, the high-pressure chamber of the pump/injector can no longer be filled.

In either case, no fuel is injected into the cylinders.

Electrical Circuit

J248	Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM)
N240	Valve for Pump/Injector, Cylinder 1
N241	Valve for Pump/Injector, Cylinder 2
N242	Valve for Pump/Injector, Cylinder 3
N243	Valve for Pump/Injector, Cylinder 4



SSP209/065

Pump/Injector Solenoid Valve Monitoring

The Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 monitors the electrical current that actuates the solenoid valves at the pump/injectors.

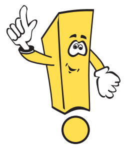
This provides feedback to the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 of the actual point in time when injection begins.

The Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 uses this feedback to regulate the Beginning of Injection Periods (BIP) during subsequent combustion cycles and to detect malfunctions of the pump/injector solenoid valves.

Start of injection is initiated when the pump/injector solenoid valve is actuated.

Actuating current applied to a pump/injector solenoid valve creates a magnetic field. As the applied current intensity increases, the valve closes; the magnetic coil presses the solenoid valve needle into its valve seat. This closes off the path from the fuel supply line to the pump/injector high-pressure chamber and the injection period begins.

As the solenoid valve needle contacts its valve seat, the distinctive signature of an alternately dropping and rising current flow is detected by the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248. This point is called the beginning of injection period (BIP). It indicates the complete closure of the pump/injector solenoid valve and the starting point of fuel delivery.

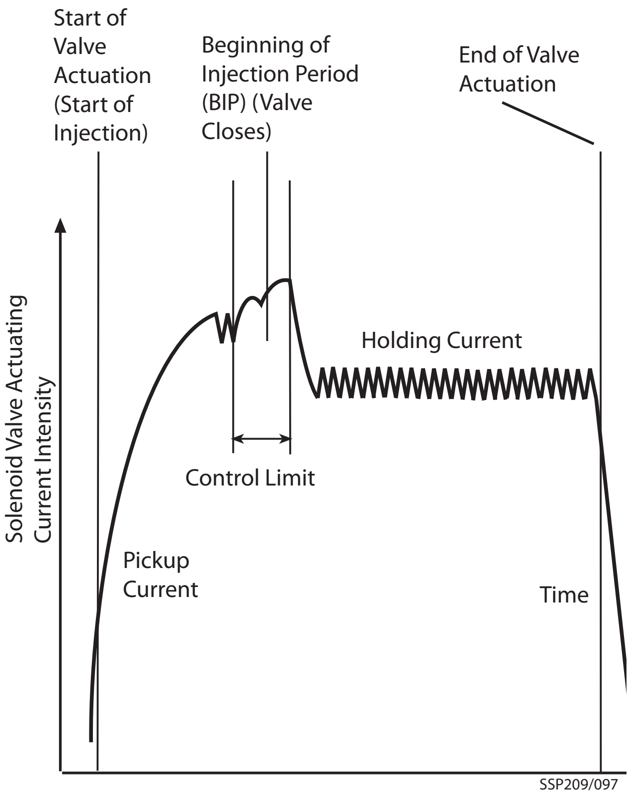


"Start of Injection" is the point in time when the actuating current to the pump/injector solenoid valve is initiated.

"Beginning of Injection Period (BIP)" is the point in time when the solenoid valve needle contacts the valve seat.

With the solenoid valve closed, a holding current is maintained at a constant level by the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 to keep it closed. Once the required time period for fuel delivery has elapsed, the actuating current is switched off and the solenoid valve opens.

Current Pattern - Pump/Injector Solenoid Valve



The actual moment at which the pump/injector solenoid valve closes (BIP) is used by the Diesel Direct Fuel Injection Engine Control Module J248 to calculate the point of actuation for the next injection period.

If the actual BIP deviates from the mapped details stored in the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248, it will correct the point of valve actuation (start of injection) for the next combustion cycle.

To detect pump/injector solenoid valve faults, the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 evaluates the BIP position from the current flow pattern. If there are no faults, BIP will be within the control limit. If this is not the case, the valve is faulty.

Effects of failure

If a fault is detected at the solenoid valve, start of injection is determined based on fixed values from the control map.

Regulation is no longer possible and performance is impaired.

Example

If there is air inside the pump/injector, the solenoid valve needle has a low resistance when it closes. The valve closes quickly and the BIP is earlier than expected.

In this case, the self-diagnosis indicates the following fault message:

"BIP below control limit"

Intake Flap Motor V157

The Intake Flap Motor V157 is located on the intake manifold It operates the intake manifold flap in the intake pipe. This stops the engine shuddering when the ignition is turned off.

Diesel engines have a high compression ratio. The engine shudders when the ignition is turned off because of the high compression pressure of the induced air.

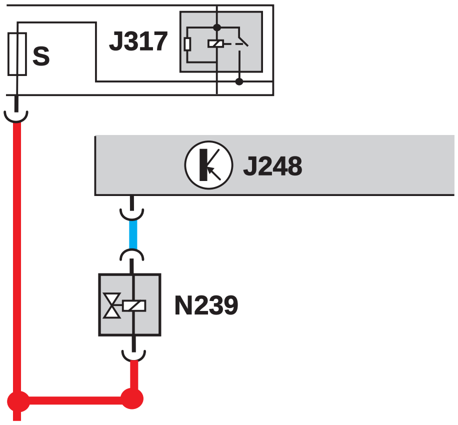
The intake manifold flap interrupts the air supply when the engine is turned off. Little air is compressed and the engine runs softly to a halt.

Function
When the engine is turned off, the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 sends a signal to the Intake Flap Motor V157, closing the intake manifold flap.

The Intake Flap Motor V157 is equipped with a 3-wire potentiometer which serves as a position sensor. This allows operation during engine cruise to partially close the intake, creating a venturi effect in the intake manifold to increase EGR flow.

Effects of Failure
If the Intake Manifold Flap Change-Over Valve N239 fails, the intake manifold flap stays open.

The tendency of the engine to shudder when switched off will increase.



SSP209/070

Electrical Circuit

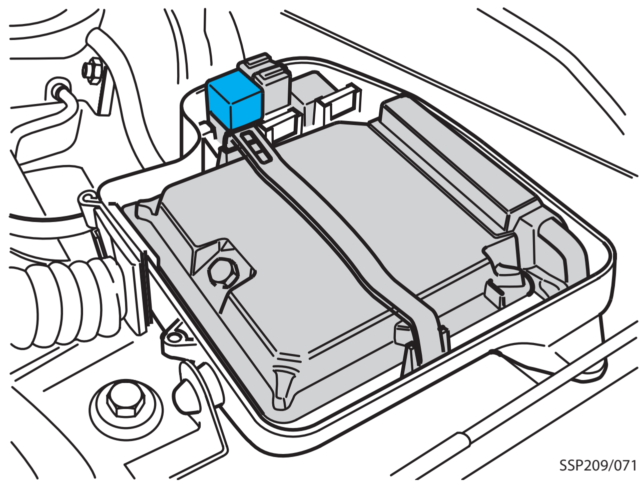
J217	Transmission Control Module
J248	Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM)
N239	Intake Manifold Flap Change-Over Valve
S	Fuse

SSP209/069

Fuel Cooling Pump/Relay J445

The Fuel Cooling Pump/Relay J445 is located on the engine control module mounting bracket.

It is activated by the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 at a fuel temperature of 158°F (70°C) and switches the working current for the Fuel Cooler Pump V166.



SSP209/071

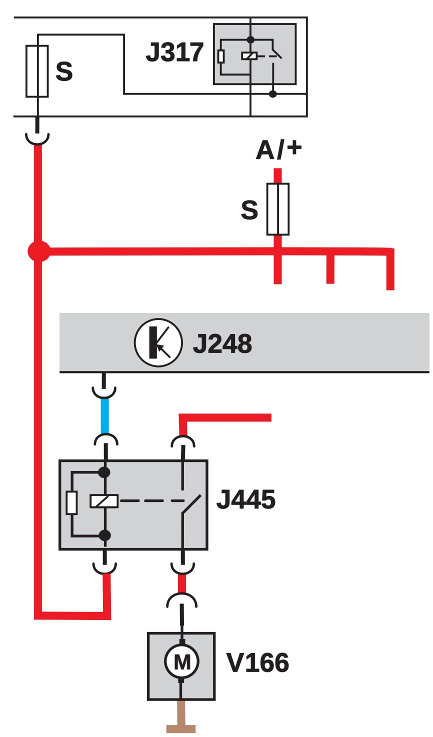
Effects of Failure

If the Pump, Fuel Cooling J445 Relay fails, the heated fuel flowing back from the pump/injectors to the fuel tank will not be cooled.

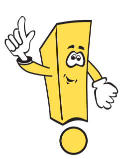
The fuel tank and the Sender for Fuel Gage G can be damaged.

Electrical Circuit

J248	Diesel Direct Fuel Injection Engine Control Module
J317	Power Supply Relay (Terminal 30, B+)
J445	Fuel Cooling Pump/Relay J445
S	Fuse
V166	Fuel Cooler Pump

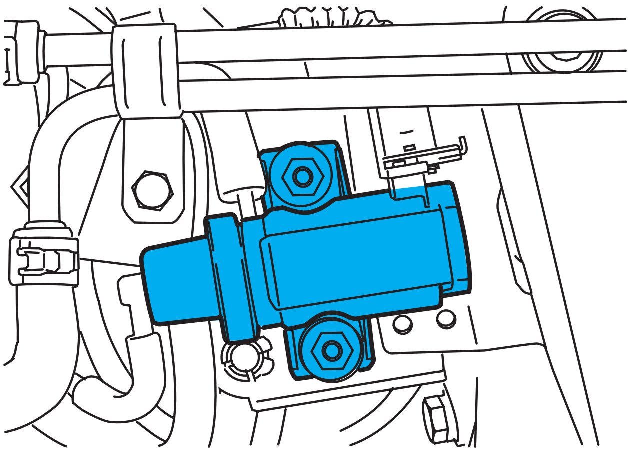


SSP209/072



The Output Check Diagnosis function in the self-diagnosis can be used to check whether the Fuel Cooling Pump/Relay J445 has been activated by the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248.

Wastegate Bypass Regulator Valve N75



SSP209/075

The engine has a variable turbine geometry for optimally adapting the charge pressure to the actual driving conditions.

To regulate the charge pressure, the vacuum in the vacuum unit for turbocharger vane adjustment is set depending on the pulse duty factor.

The Wastegate Bypass Regulator Valve N75 is activated by the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248.

Effects of Failure
If the Wastegate Bypass Regulator Valve N75 fails, the vacuum unit reverts to atmospheric pressure.

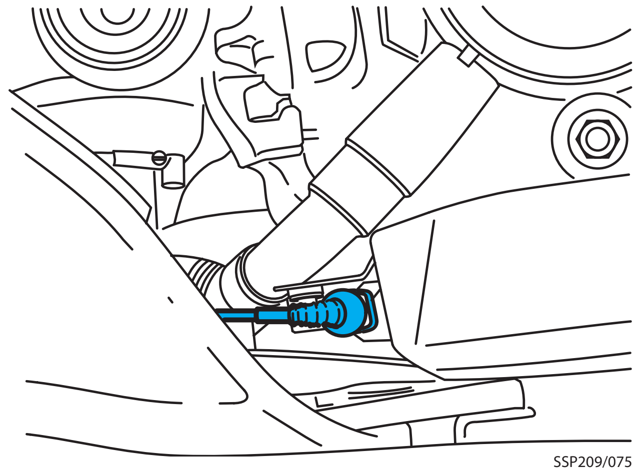
As a result, charge pressure is lower and engine performance is impaired.

EGR Vacuum Regulator Solenoid Valve N18

The EGR Vacuum Regulator Solenoid Valve N18 enables the exhaust gas recirculation system to mix a portion of the exhaust gases with the fresh air supplied to the engine.

This lowers the combustion temperature and reduces the formation of oxides of nitrogen.

To control the quantity of exhaust gases returned for combustion, the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 activates the EGR Vacuum Regulator Solenoid Valve N18 with duty cycles based on internal control maps.



SSP209/075

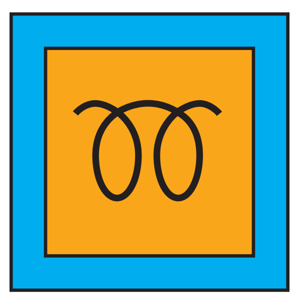
Effects of Failure
Engine performance is lower and exhaust gas recirculation is not assured.

Glow Plug Indicator Light K29

The Glow Plug Indicator Light K29 is located in the instrument cluster.

It has the following tasks:

- It signals to the driver that the pre-starting glow phase is in progress
  - In this case, it is lit continuously
- If a component with self-diagnostic capability becomes faulty, the warning lamp flashes

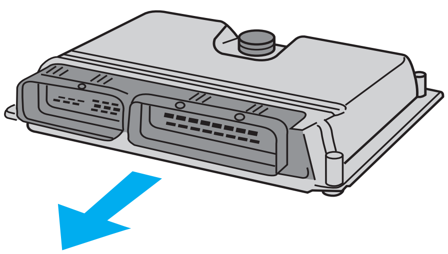


SSP209/077

Effects of Failure
The Glow Plug Indicator Light K29 comes on and does not flash.

A fault message is stored to the fault memory.

Additional Output Signals



SSP209/084

Coolant Auxiliary Heater

Thanks to its high efficiency, the 1.9-liter TDI engine with pump injection system develops so little heat that sufficient cabin heat output may not be available in certain circumstances.

In countries with cold climates, an electrical auxiliary heater is used to heat the coolant at low temperatures.

The coolant auxiliary heater is comprised of three Coolant Glow Plugs Q7. They are installed to the coolant connection on the cylinder head.

The Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 uses the coolant auxiliary heater signal to activate the relays for low and high heat output.

Either one, two, or all three Coolant Glow Plugs Q7 are switched on depending on the available capacity of the three-phase AC generator.

Engine Speed

This signal provides information on engine speed for the tachometer in the instrument cluster.

Cooling Fan Run-on

The run-on period of the cooling fan is controlled according to a characteristic curve stored in the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248.

It is calculated from the current coolant temperature and the load state of the engine during the previous driving cycle. The Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 uses this signal to activate the cooling fan relay.

Air Conditioner Compressor Cut-off

To reduce engine load, the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 switches the air conditioner compressor off under the following conditions:

- After every starting cycle (for approximately six seconds)
- During rapid acceleration from low engine speeds.
- At coolant temperatures in excess of 248°F (120°C)
- In the emergency running program

Fuel Consumption Signal

This signal provides information on fuel consumption for the multifunctional display in the instrument cluster.

Glow Plug System

The glow plug system makes it easier to start the engine at low outside temperatures. It is activated by the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248 at coolant temperatures below 48°F (9°C).

The Glow Plug Relay J52 is activated by the Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM) J248. The Glow Plug Relay J52 then switches on the working current for the Glow Plugs (engine) Q6.

Function
The glow process is divided into two phases, the glow period and the extended glow period.

Glow Period

The glow plugs are activated when the ignition is switched on and outside temperature is below 48°F (9°C). The Glow Plug Indicator Light K29 will light up.

Once the glow plug period has elapsed, the Glow Plug Indicator Light K29 will go out and the engine can be started.

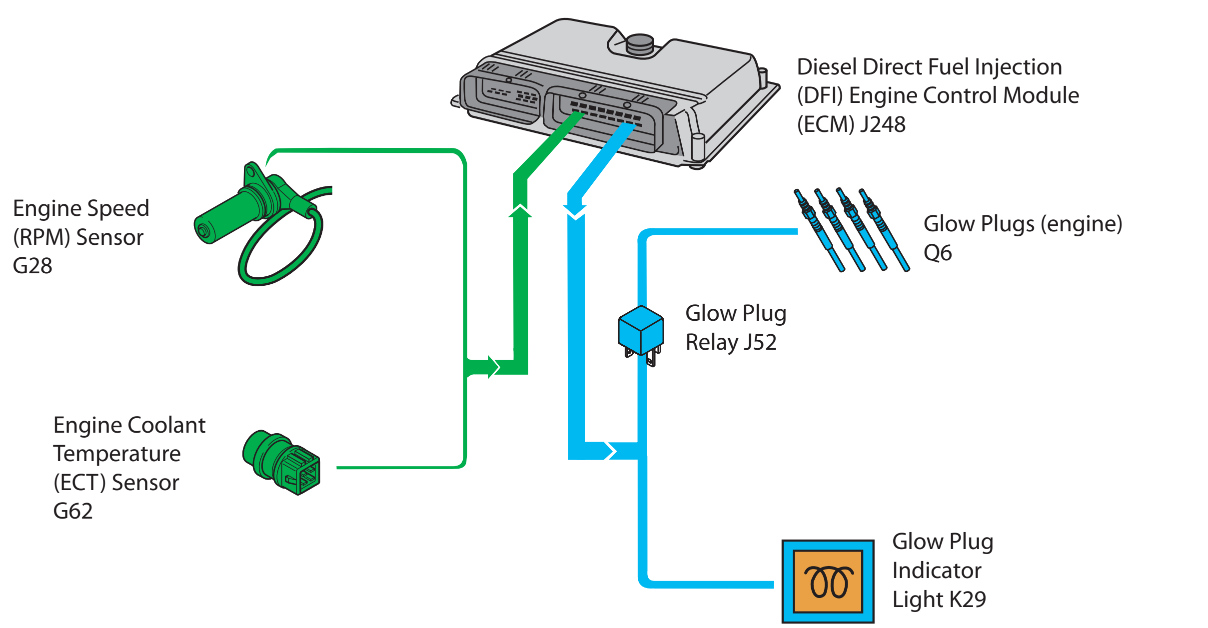
Extended Glow Period

The extended glow period takes place whenever the engine is started, regardless of whether or not it is preceded by a glow period.

This reduces combustion noise, improves idling quality and reduces hydrocarbon emission.

The extended glow phase lasts no more than four minutes and is interrupted when the engine speed rises above 2500 rpm.

Glow Plug System Overview



EDC 16 Functional Diagram for 1.9-liter TDI Engine

Components

E45	Cruise Control Switch
F	Brake Light Switch
F8	Kick Down Switch
F36	Clutch Vacuum Vent Valve Switch
F47	Brake Pedal Switch
F60	Closed Throttle Position (CTP) Switch
G28	Engine Speed (RPM) Sensor
G40	Camshaft Position (CMP) Sensor
G62	Engine Coolant Temperature (ECT) Sensor
G70	Mass Air Flow (MAF) Sensor
G71	Manifold Absolute Pressure (MAP) Sensor
G72	Intake Air Temperature (IAT) Sensor
G79	Throttle Position (TP) Sensor
G81	Fuel Temperature Sensor
J52	Glow Plug Relay
J248	Diesel Direct Fuel Injection (DFI) Engine Control Module (ECM)
J317	Power Supply Relay (Terminal 30, B+)
J359	Preheating Coolant, Low Heat Output Relay
J360	Preheating Coolant, High Heat Output Relay
J445	Fuel Cooling Pump/Relay
N18	EGR Vacuum Regulator Solenoid Valve
N75	Wastegate Bypass Regulator Valve
N239	Intake Manifold Flap Change-Over Valve
N240	Valve for Pump/Injector, Cylinder 1
N241	Valve for Pump/Injector, Cylinder 2
N242	Valve for Pump/Injector, Cylinder 3
N243	Valve for Pump/Injector, Cylinder 4
Q6	Engine Glow Plugs
Q7	Coolant Glow Plugs
S	Fuse
V166	Fuel Cooler Pump

Additional Signals

A	Brake Lights
B	Fuel Consumption Signal
C	Engine Speed Signal
D	Air Conditioner Compressor Cut-Off
E	Air Conditioner Compressor Readiness
F	Road Speed Signal
G	Cruise Control Switch Voltage Supply
H	Cooling Fan Run-On
K	Diagnosis and Immobilizer Wire
L	Glow Period Control
M	Drivetrain CAN Data Bus (Low)
N	Drivetrain CAN Data Bus (High)
O	Three-phase AC Generator Terminal DF

Color Coding

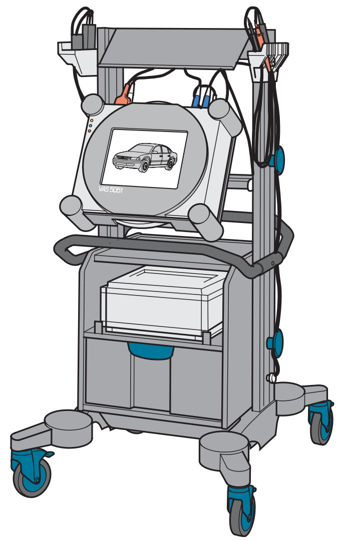
- Input Signal
- Output Signal
- Positive
- Ground
- CAN Data Bus
- Bi-directional

use fold-out document

Self-Diagnosis

The following functions can be read out using a VAS Scan Tool:

001	Identification
004	DTC memory content
005	Output Diagnostic Test Mode (DTM)
007	Coding
011	Measured values
012	Adaptation
015	Access authorization
017	Safety
020	Special function
022	End output



SSP209/082

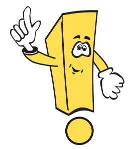
Function 004 – Interrogate Fault Memory

The color coded components are stored to the fault memory by the self-diagnosis function.

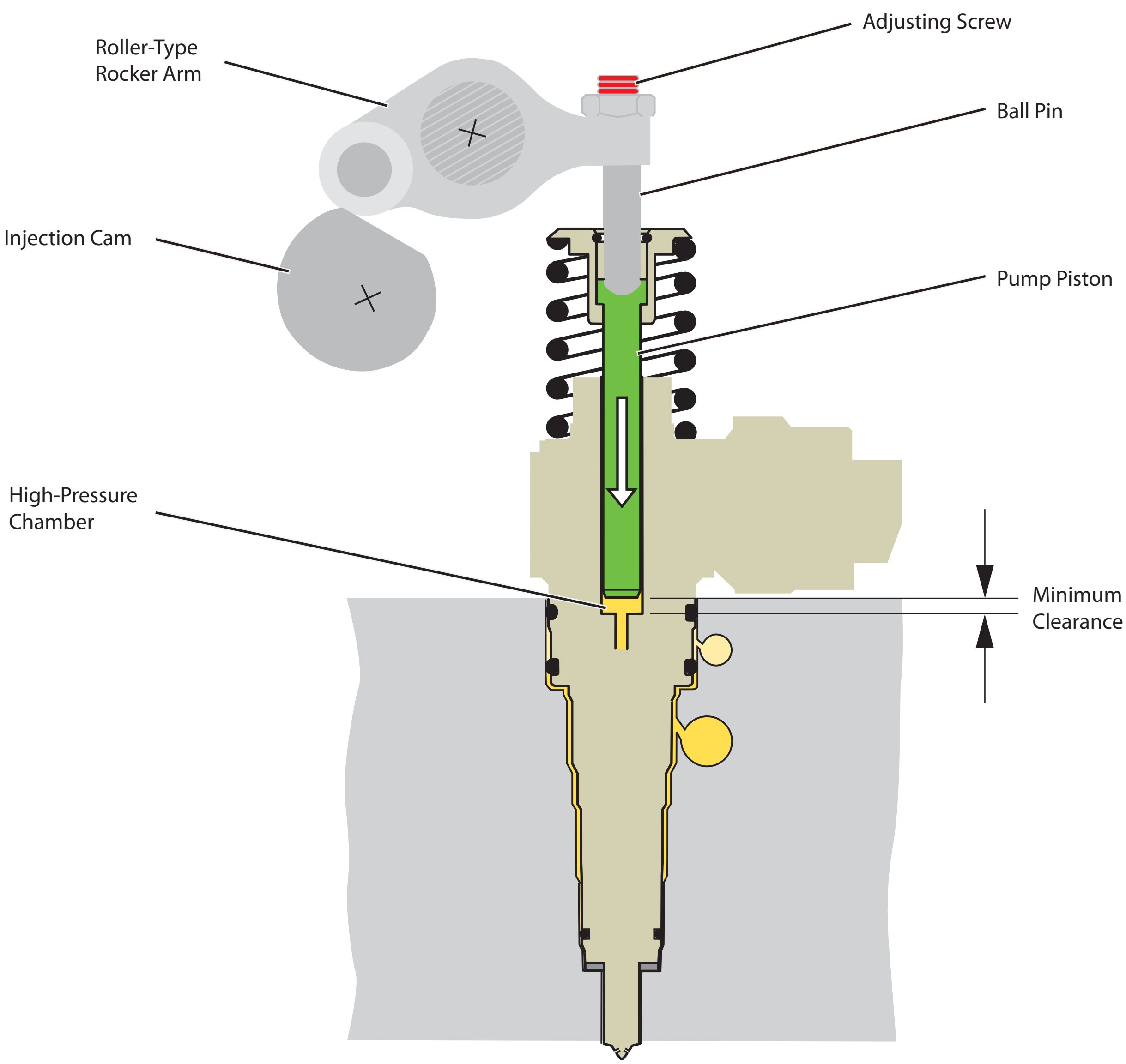
Pump/Injector Adjustment

After installing a pump/injector, the minimum clearance between the base of the high-pressure chamber and the pump piston must be adjusted at the pump/injector adjusting screw.

This adjustment prevents the pump piston from knocking against the base of the high-pressure chamber due to heat expansion.

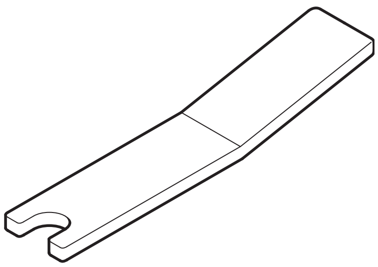


For a complete description of this adjustment procedure, refer to the Repair Manual.



SSP209/098

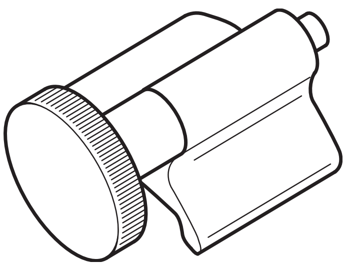
Special Tools



SSP209/090a

Marking Plate

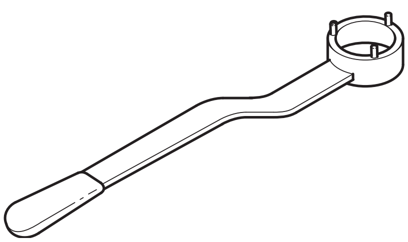
T 10008
Holds the hydraulic toothed belt tensioner in place when installing and removing the toothed belt.



SSP209/090b

Crankshaft Stop

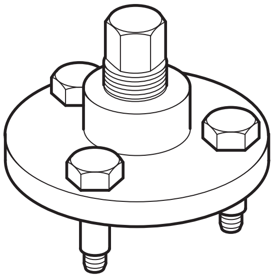
T 10050
Holds the crankshaft in place at the crankshaft gear when adjusting the port timing.



SSP209/090c

Camshaft Gear Counter-holder

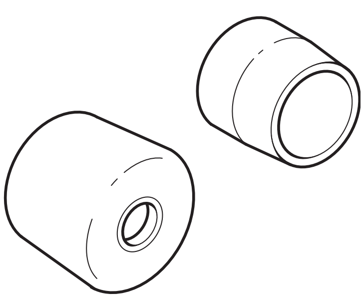
T 10051
Camshaft gear installation.



SSP209/090d

Camshaft Gear Puller

T 10052
Camshaft gear removal from the tapered end of the camshaft.



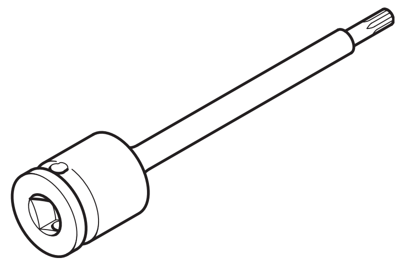
SSP209/090e

Crankshaft Sealing Ring Assembly Fixture

T 10053
Guide sleeve and compression sleeve for installing the crankshaft sealing ring.

Socket Insert

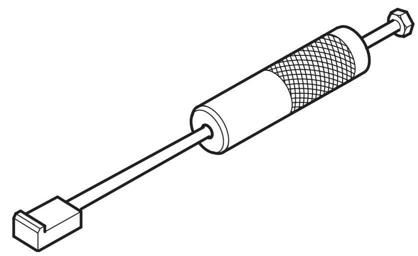
T 10054
Pump/injector clamping block fastener installation.



SSP209/090f

Pump/Injector Puller

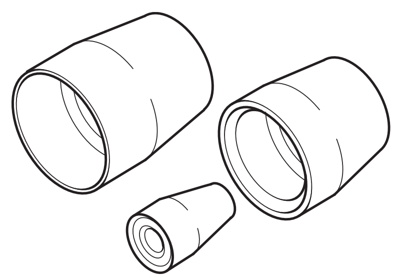
T 10055
Pump/injector removal from the cylinder head.



SSP209/090g

Pump/Injector O-Ring Assembly Sleeves

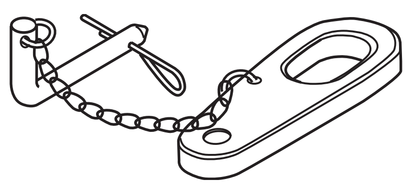
T 10056
O-Ring installation on the pump/injectors.



SSP209/090h

Shackle

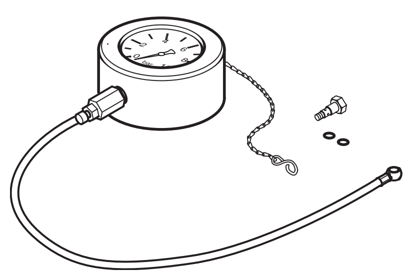
T 10059
This shackle is used to remove and install the engine in the Passat. The engine is moved into position using this shackle in combination with lifting gear 2024A.



SSP209/090k

Pressure Gauge

VAS 5187
Fuel pressure measurement at the supply line to the fuel pump.



SSP209/090i

An on-line Knowledge Assessment (exam) is available for this Self-Study Program.

The Knowledge Assessment may or may not be required for Certification.

You can find this Knowledge Assessment at:

www.vwwebsource.com

For Assistance, please call:

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Certification Program Headquarters

1 – 877 – VW – CERT – 5

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