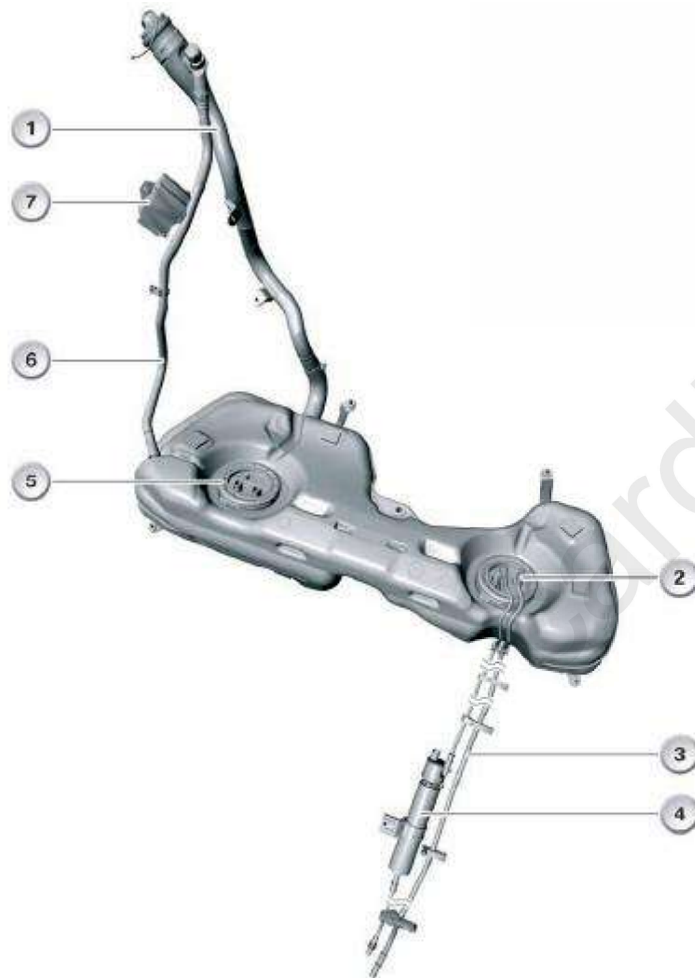


Fuel System

Fuel Supply Overview

As with current gasoline fuel injection systems, there is an electric fuel pump located in the fuel tank. The fuel pump supplies the needed low pressure fuel to feed the mechanical high-pressure pump.



Index	Explanation
1	Fuel filler neck
2	Left hand service opening
3	Fuel return line
4	Fuel filter with heating system
5	Right hand service opening
6	Filler vent
7	Electric fuel pump module (EKP)

The fuel tank is equipped with two chambers and, on modern vehicles, is made from plastic. The electric fuel pump on the diesel engines is driven by the EKP module.

Similar to BMW gasoline engines, the fuel system on the vehicles equipped with diesel engines share much of the same “low pressure” system components.

However, there are some distinct differences with the diesel engine.

These are:

- The system includes a fuel return line
- The breather system is significantly simpler
- There is no carbon canister (AKF) and no fuel tank leakage diagnosis module (DMTL)
- There is no pressure regulator
- The fuel filter is not located in the fuel tank.

The design layout of the fuel supply systems in the E70 and E90 are described in the following.

Fuel Tank

As with all modern BMW vehicles, the fuel tank is made from plastic and is installed in the optimum position to achieve the best possible weight balance in the vehicle.

To accommodate these needs, the fuel tanks must be designed in such a way so that there is room for the driveshaft to pass through with out interference.

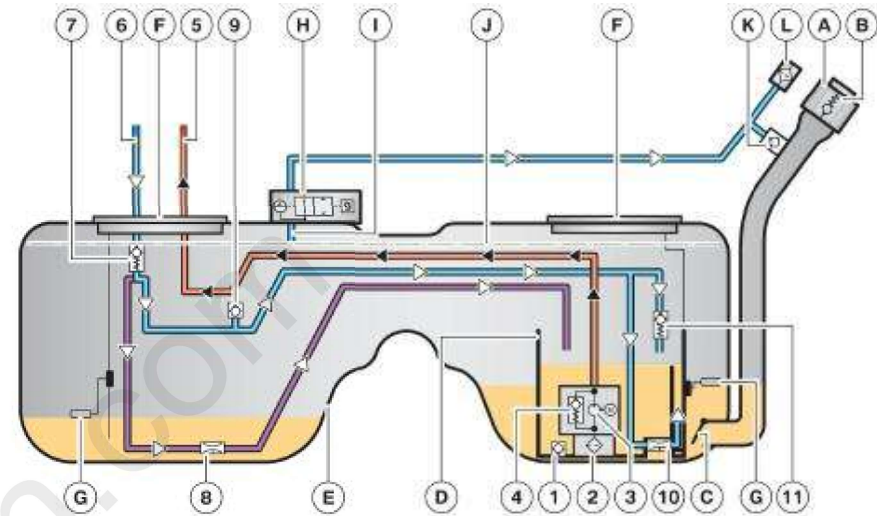
So, the fuel tanks in the diesel vehicles feature the familiar “double-chamber” configuration. This design feature accommodates two delivery units which are located in the right and left fuel tank halves.

The fuel pump (3) with intake filter (2) is a part of the right-hand delivery unit. The surge chamber including a suction jet pump (10) with pressure relief valve (11) and initial fill valve (1) as well as a lever-type sensor (G) complete this delivery unit.

The suction jet pump (8), lever-type sensor (G), leak prevention valve (7) and air inlet valve (9) belong to the left-hand delivery unit.

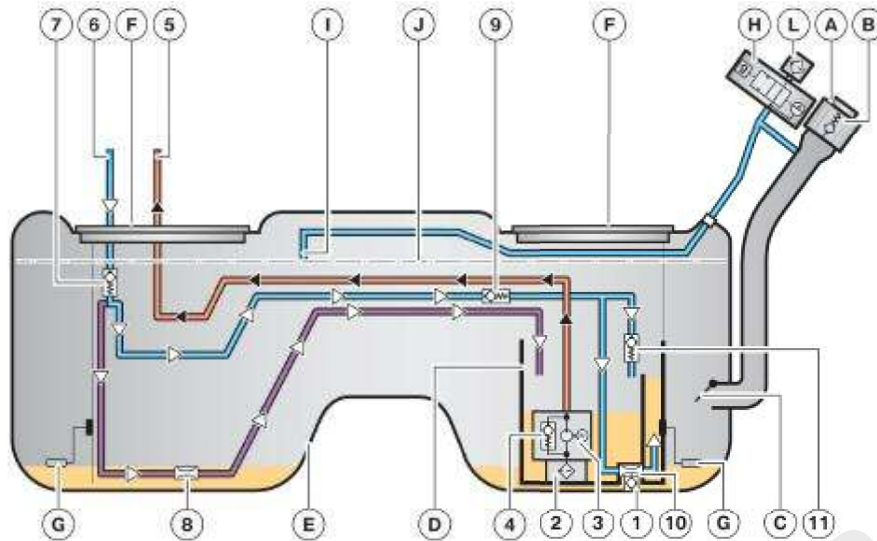
A line leads from the filler vent valve (H) to the filter (L). The fuel filler pipe is connected to this line via the non-return valve (K).

E70 Fuel Tank



Index	Explanation	Index	Explanation
A	Fuel filler cap	1	Initial fill valve
B	Pressure relief valve	2	Intake mesh filter
C	Non-return valve	3	Fuel pump
D	Surge chamber	4	Pressure relief valve
E	Fuel tank	5	Feed line
F	Service cap	6	Return line
G	Lever-type sensor	7	Leak prevention valve
H	Filler vent valve	8	Suction jet pump
I	Connection	9	Air inlet valve
J	Maximum fill level	10	Suction jet pump
K	Non-return valve	11	Pressure relief valve
L	Filter		

E90 Fuel Tank

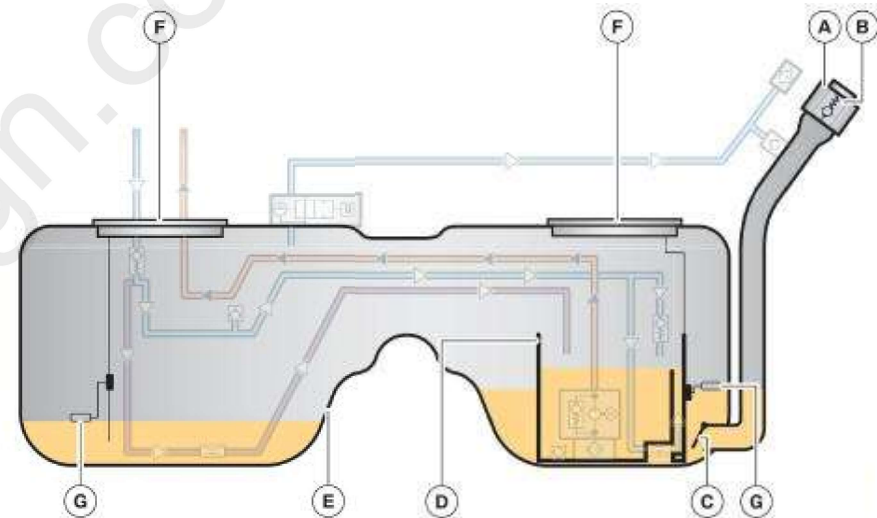


Index	Explanation	Index	Explanation
A	Fuel filler cap	1	Initial fill valve
B	Pressure relief valve	2	Intake mesh filter
C	Non-return valve	3	Fuel pump
D	Surge chamber	4	Pressure relief valve
E	Fuel tank	5	Feed line
F	Service cap	6	Return line
G	Lever-type sensor	7	Leak prevention valve
H	Filler vent valve	8	Suction jet pump
I	Connection	9	Air inlet valve (check valve)
J	Maximum fill level	10	Suction jet pump
L	Filter	11	Pressure relief valve

Fuel Tank Functions

A pressure relief valve (B) is integrated in the fuel filler cap (A) to protect the fuel tank (E) from excess pressure. A non-return flap (C) is located at the end of the fuel filler neck.

The non-return flap prevents the fuel from sloshing back into the fuel filler neck. The components in the fuel tank can be reached via the two service caps (F). The fuel fill level can be determined via the two lever-type sensors (G). The surge chamber (D) ensures that the fuel pump always has enough fuel available for delivery.

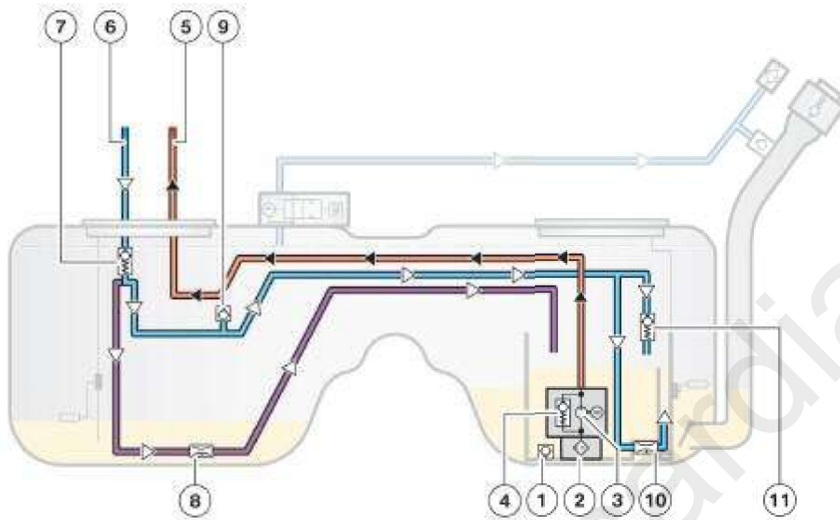


Index	Explanation	Index	Explanation
A	Fuel filler cap	E	Fuel tank
B	Pressure relief valve	F	Service cap
C	Non-return valve	G	Lever-type sensors
D	Surge chamber		

Fuel Delivery from Fuel Tank

In the event of the surge chamber being completely empty, the initial filling valve (1) ensures that fuel enters the surge chamber while refuelling.

The fuel reaches the fuel pump (3) via the intake filter (2), then continues through the delivery line (5) to the fuel filter. The fuel pump is located in the surge chamber. A pressure relief valve (4) is integrated in the fuel pump to prevent pressure in the delivery line from rising too high.



Index	Explanation	Index	Explanation
1	Initial fill valve	7	Leak prevention valve
2	Intake mesh filter	8	Suction jet pump
3	Fuel pump	9	Air inlet valve
4	Pressure relief valve	10	Suction jet pump
5	Feed line	11	Pressure relief valve
6	Return line		

As the engine switches off, the delivery line is depressurized but cannot run dry because, provided the system is not leaking, no air is able to enter it. In addition, after the fuel pump has switched off, the fuel pressure/temperature sensor is checked for plausibility.

Fuel that is required for lubrication and the function of high pressure generation flows back into the fuel tank via the return line (7). The fuel coming from the return line is divided into two lines downstream of the leak prevention valve (7). The non-return valve prevents the fuel tank from draining in the event of damage to lines on the engine or underbody. It also prevents the return line from running dry while the engine is off.

One of the lines guides the fuel into the surge chamber via a suction jet pump (10). The suction jet pump transports the fuel from the fuel tank into the surge chamber. If the fuel delivery pressure in the return line increases too much, the pressure relief valve (11) opens and allows the fuel to flow directly into the surge chamber.

An air inlet valve is used in the E70. The air inlet valve (9) ensures that air can enter the line when the engine is off, preventing fuel from flowing back from the right-hand half of the fuel tank to the left.

Instead of the air inlet valve (9) a non-return valve is used on the E90. The non-return valve ensures that, while the engine is off, fuel from the right-hand half of the fuel tank cannot flow back into the left-hand half. The return system remains completely filled with fuel.

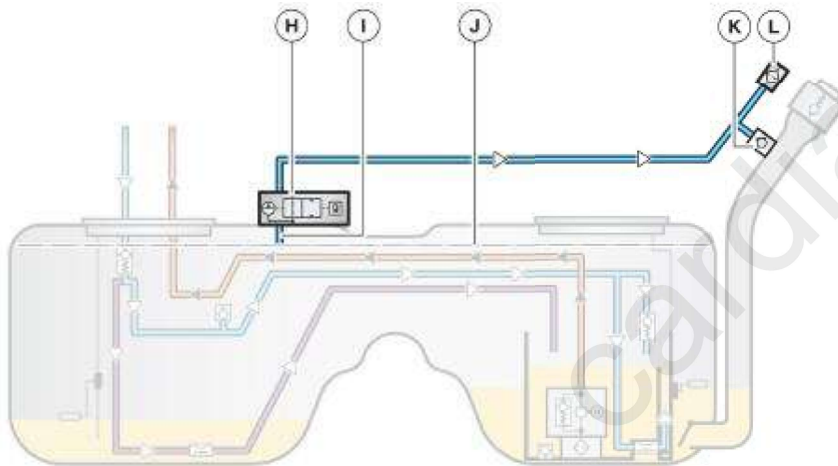
A further line branches off into the left-hand half of the fuel tank after the non-return valve (7) and transports the fuel into the surge chamber via the suction jet pump (8).

Air Supply and Extraction

Fuel ventilation is ensured by means of the filler vent valve (H). The filler vent valve is located in the fuel tank and uses the connection (I) to determine the maximum fill level (J). The filler vent valve contains a float that buoys upwards on the fuel when the vehicle is refuelled and blocks the filler ventilation. The fuel rises in the fuel filler and the fuel nozzle switches off. The fuel rises in the fuel filler and the fuel nozzle switches off.

A roll-over valve is also integrated in the filler vent valve to block the ventilation line when a certain angle of incline is reached and prevents fuel from draining out if the vehicle were to roll over.

The non-return valve (K) prevents fuel from escaping via the ventilation when the vehicle is refuelled. During operation, air can flow into the fuel filler pipe and the fuel can flow from the fuel filler pipe into the tank.



Index	Explanation	Index	Explanation
H	Filler vent valve	K	Non-return valve
I	Connection	L	Filter
J	Maximum fill level		

The filter (L) prevents dirt or insects from entering the ventilation and blocking the line.

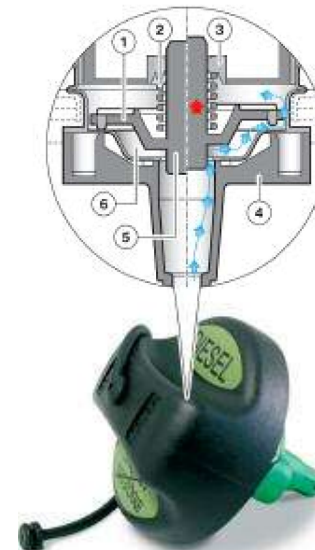
If the ventilation line does become blocked, fuel consumption during operation would cause negative pressure and the fuel tank would be compressed and damaged.

Fuel Filler Cap

The fuel filler cap contains a pressure relief valve to ensure that, if there is a problem with fuel tank ventilation, any excess pressure that may form can escape and the fuel tank is not damaged.

If excess pressure forms in the fuel tank, this causes the valve head (1) and with it the entire pressure relief valve (5) to be lifted off the sealed housing (6). The excess pressure can now escape into the atmosphere. The excess pressure spring (2) determines the opening pressure.

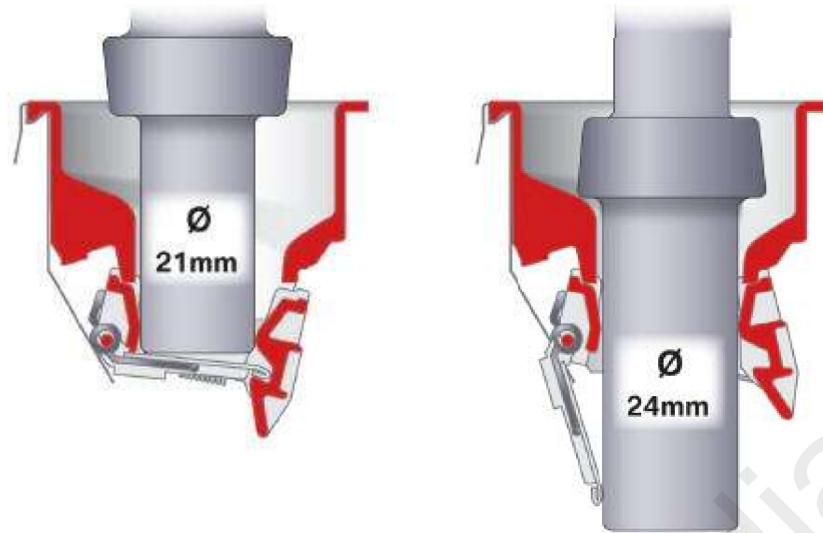
The excess pressure spring uses a defined pressure to push the pressure relief valve onto the sealed housing and is supported by the brace (3).



Index	Explanation
1	Valve head
2	Excess spring pressure
3	Brace
4	Bottom section of housing
5	Pressure relief valve
6	Sealed housing

Misfueling Protection

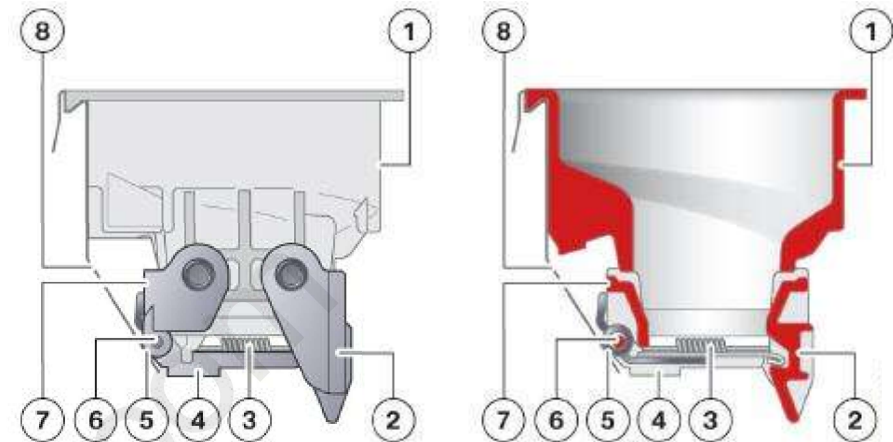
A mechanical system has been developed in order to help prevent a mis-fueling situation. To make sure that the diesel vehicles are only refueled with the proper diesel fuel, a mechanical flap has been added to the fuel filler neck.



As the following illustrations show, only a fuel nozzle with a diameter of approximately 24 mm can fit. If the diameter is approximately 21 mm, the flap (4) does not open as the hinged lever (7) and the locking lever (2) cannot be pushed apart.

If a diesel fuel nozzle is inserted, this pushes the locking lever (2) and the hinged lever (7) at the same time. The hinged lever is pushed outwards against the tension spring (3) and releases the flap (4). This is only possible, however, if the hinged lever cannot move freely and is also locked in position by the fuel nozzle.

To open the protection against incorrect refuelling feature in the workshop, a special tool is required.

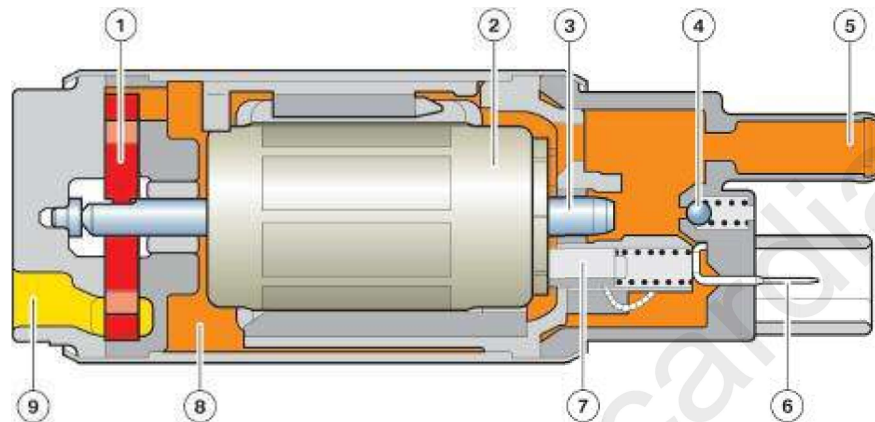


Index	Explanation	Index	Explanation
1	Housing	5	Torsion spring
2	Locking lever	6	Rivet
3	Tension spring	7	Hinged lever
4	Flap	8	Ground strap

Fuel Pump

Today's diesel vehicles are fitted with electric fuel pumps to deliver the needed fuel to the high pressure pump. The electric fuel pump is designed to deliver a sufficient amount of fuel to lubricate and cool the injectors and the high-pressure pump and to satisfy the maximum fuel consumption of the engine.

It has to deliver the fuel at a defined pressure. That means that when the engine is idling or running at medium power, the fuel pump delivers several times more than the amount of fuel required. The fuel pump delivers approximately three or four times the volume of maximum possible fuel consumption.



Index	Explanation	Index	Explanation
1	Impeller	6	Electrical connection
2	Driveshaft	7	Sliding contacts
3	Electric motor	8	Pressure chamber
4	Pressure relief valve	9	Intake section
5	Pressure connection		

The electric fuel pump is located in the fuel tank. There it is well protected against corrosion and the pump noise is adequately soundproofed.

The fuel pump on BMW diesel engines may either be a gear pump, a roller-cell pump or a screw-spindle pump. The following fuel pumps are used on USA vehicles:

- E70 - Screw spindle pump
- E90 - Gear pump (rotor type)

The operating principle of each of these types of pump is described below. The pump itself is driven by the drive shaft (2) of the electric motor (3). The electric motor is controlled by the electrical connection (6) and sliding contacts (7).

Passing first through the intake filter and then the remainder of the intake section (9), the fuel enters the impeller (1). The fuel is pumped through pressure chamber (8) on the electric motor, past the pressure connection (5) and onwards to the fuel filter and engine.

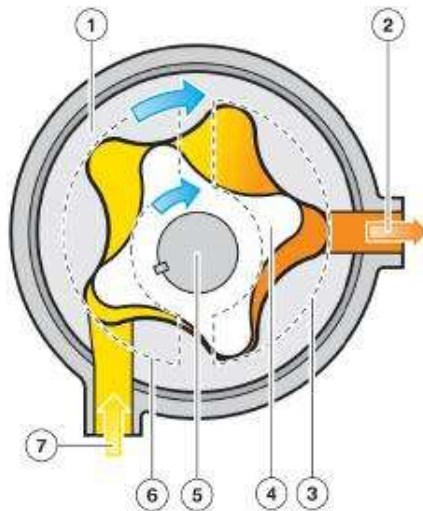
If the fuel delivery pressure increases to an impermissible value, the pressure relief valve (4) opens and allows the fuel to flow into the surge chamber.

Fuel Pump - E90

On the E90, the fuel pump is a gear type pump. The gear pump is comprised of an outer rotor (1) with teeth on the inside, and an inner rotor (4) with teeth on the outside. The inner rotor is driven by the drive shaft (5) of the electric motor. The outer rotor is propelled by the teeth of the inner rotor and thus turns inside the pump housing.

The inner rotor has one tooth fewer than the outer rotor, which means that, with each revolution, fuel is carried into the next tooth gap of the outer rotor.

During the rotary motion, the spaces on the intake side enlarge, while those on the pressure side become proportionately smaller. The fuel is fed into the rotor pump through two grooves in the housing, one on the intake side and one on the pressure side. Together with the tooth gaps, these grooves form the intake section (6) and pressure section (3).

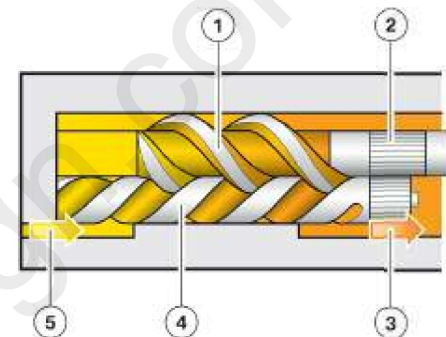


Index	Explanation
1	Outer rotor
2	Fuel delivery to engine
3	Pressure section
4	Inner rotor
5	Driveshaft
6	Intake section
7	Fuel from tank

Screw-spindle Pump - E70

With the screw-spindle pump, two screw spindles intermesh in such a way that the flanks form a seal with each other and the housing. In the displacement chambers between the housing and the spindles, the fuel is pushed towards the pressure side with practically no pulsation.

In this way, the screw spindles pump fuel away from the fuel tank (5). The fuel is then fed to the engine (3) through the pump housing and the fuel delivery line.



Index	Explanation
1	Driveshaft screw spindle
2	Gearwheel
3	Fuel delivery to the engine
4	Screw spindle
5	Fuel from tank

Low Pressure Fuel System - E90

The low pressure fuel systems differ between the E70 and E90. The E90 is a “speed regulated” system which means that the fuel pump speed is regulated by the EKP module based on request from the DDE.

The fuel pump will be activated with the “ignition on” signal. If the engine is not started, the fuel pump will be switched off after a defined time period. When the engine is switched off, the fuel pump is switched off as well.

■ Fuel Temperature Sensor

The fuel temperature sensor is located in the fuel feed line just before the high pressure pump.

The sensor consists of a temperature dependent resistor with which works on the NTC principle.

The fuel temperature sensor registers the fuel temperature just before the high pressure pump. The fuel temperature sensor is installed on the low pressure side of the fuel system.

The density of the fuel changes as temperature changes. The DDE requires the fuel temperature for the purpose of precisely calculating the start of injection and injection quantity.

The fuel temperature sensor consists of a temperature-dependent measuring resistor made from semiconductor material that is integrated in a housing. The measuring resistor has a negative temperature coefficient (NTC).

The digital diesel electronics compares the measured voltage with a characteristic curve that assigns a corresponding temperature to each voltage value.

The various sensors and actuators are required for ensuring effective operation of the fuel system and engine. Apart from ensuring compliance with legal requirements, these components are also responsible for providing outstanding engine performance and the associated acoustics.

Fuel temperature sensor - E90



■ Fuel Filter Heating - E90

On the E90, the fuel filter heater is not controlled directly by the DDE. A pressure switch and a temperature sensor are located in the fuel filter housing.

The fuel heater only works with the ignition switched on and when both of the following conditions are fulfilled:

- Temperature drops below a defined value
- A defined fuel delivery pressure is exceeded due to cold, viscous fuel.

If the filter is clogged, a corresponding signal is sent via a diagnosis line to the DDE. This is the case when, despite a sufficiently high temperature, the fuel pressure upstream of the filter does not drop.

The conditions for fuel filter heater operation are as follows:

- The fuel heater is switched ON when - the fuel pressure is greater than 6 bar AND the fuel temperature is less than 2°C.
- The fuel heater is switched off when - the fuel pressure is less than 5.5 bar for a duration of greater than 5 minutes OR
- the fuel temperature is greater than 12°C OR
- during the starting process if the electronics in the fuel filter detect a battery voltage of less than 7.5 V for longer than 0.2 seconds.

The fuel heater is not activated by the DDE control module. However, the fuel heater reports a detected filter blockage via the signal DIAG_DKH to the DDE control module. The DDE control module then stores the fault.

Low Pressure Fuel System - E70

The low pressure fuel system on the E70 is a “pressure regulated” system which uses the signal from the fuel pressure sensor located in the low pressure fuel line.

The fuel pump operates with "ignition ON". If the engine is not started, the fuel is switched off at a specific pressure. When the engine is running, the fuel pump is regulated on-demand by the EKP module in response to a load signal from the DDE in order to ensure a uniform fuel pressure at the inlet to the high-pressure pump.

The functions of the low pressure fuel system are integrated into the DDE control module. The DDE uses the pressure information from the combined fuel pressure-temperature sensor to determine the current actual pressure in the low pressure system.

In order to maintain the approximate delivery pressure of 4.8 to 5.0 bar, the DDE uses a number of input variables. The input variables relevant to determining the adjusting value are:

- Actual pressure in the pre-supply system
- Engine speed
- Injection volume

The adjusting value is sent from the DDE to the EKP module in the form of a CAN message.

■ Fuel Pressure-temperature Sensor

The fuel pressure-temperature sensor consists of two independent sensors combined in one housing.

The fuel temperature sensor is required to precisely calculate the start of injection and injection quantity. The fuel pressure sensor registers the fuel pressure upstream of the high pressure pump. This fuel pressure is required for the purpose of controlling the fuel pump in the fuel tank.

The fuel pump is also switched off when the engine is turned off and the fuel feed is depressurized. After the fuel pump has been shut down, the digital diesel electronics checks and evaluates the plausibility of the fuel pressure sensor. If a fault is detected, the corresponding fault code is stored in the fault code memory of the digital diesel electronics.



The integrated fuel temperature sensor is identical to the fuel temperature sensor used in the E90. The fuel pressure sensor is also integrated in the housing. Both the fuel pressure sensor and the fuel temperature sensor features two separate connections in a common connector housing that has four pins.

The fuel pressure sensor consists of resistors mounted on a diaphragm. The one side of the diaphragm has contact with the fuel so that the fuel pressure acts on the diaphragm.

The greater the pressure, the more the diaphragm is deflected. The resistors on the diaphragm change their resistance in response to the mechanical stress. A bridge circuit and electronic signal processing circuitry in the sensor amplify the bridge voltage, compensate for temperature influences and linearize the pressure characteristic curve.

The output voltage for the digital diesel electronics is in the range between 0 and 5 volts. As for the temperature sensor, a characteristic curve is stored in the digital diesel electronics that assigns a corresponding pressure to each voltage value.

■ Fuel Filter Heating - E70

The fuel filter heating operation is somewhat different in the E70. The E70 has a pressure-controlled fuel supply system. In this system, the fuel filter heater is actuated by the DDE. The DDE communicates with the filter heater via the signal S_KSH.

A combined fuel pressure and temperature sensor upstream of the high pressure pump is used. If required, the fuel filter is heated with an electrical heating element. The DDE switches the fuel filter heating on under the following conditions:

- Temperature drops below a defined value
- The required fuel pressure is not reached despite increased power intake of the electric fuel pump.

The DDE recognizes a clogged filter when the target pressure upstream of the high pressure pump is not reached despite a sufficiently high fuel temperature and high current consumption of the electric fuel pump.

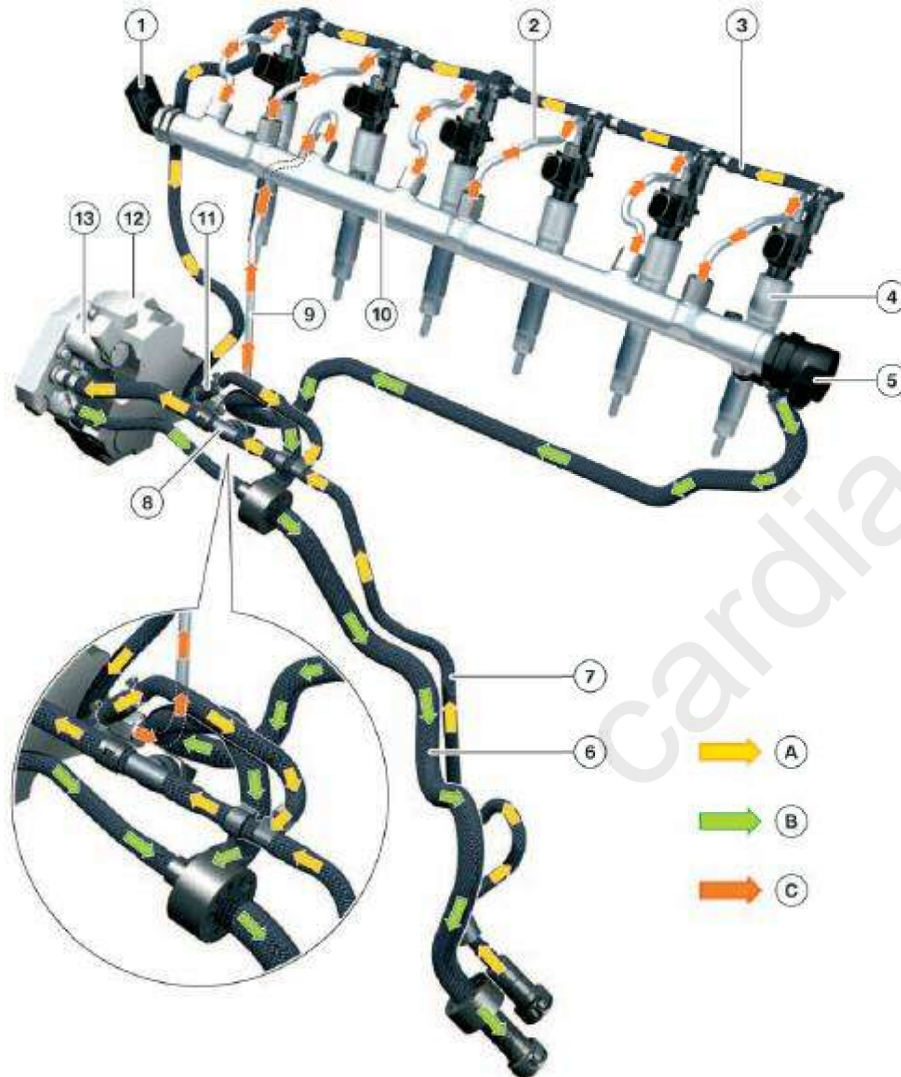
The electrical power output of the fuel pump is higher than the stored adaptation value "electric fuel pump" plus an offset for more than 3 seconds. The offset is determined from a characteristic map and depends on the engine speed and fuel injection rate.

The fuel filter heating is switched off again under the following conditions:

- Activation time > 5 min or
- Fuel temperature > 8°C or
- Battery voltage is less than 9 volts for more than 30 seconds

High Pressure Fuel System

The high pressure fuel system is mostly identical in design and function as compared to the European version. However, some components have been adapted to the different fuel specification.



Index	Explanation	Index	Explanation
A	Fuel feed (low pressure)	6	Return line
B	Fuel return	7	Feed line
C	Fuel high pressure	8	Fuel temperature (or temp/pressure)
1	Fuel rail pressure sensor	9	High pressure line
2	High pressure line	10	Fuel rail
3	Leakage line	11	Restrictor
4	Piezo injector	12	High pressure pump
5	Fuel rail pressure control valve	13	Volume control valve

These components are:

- High-pressure pump
- Fuel rail
- Fuel injectors.

These adaptations are restricted to different coatings and materials on the inside.

Fuel Injectors

Compared to a piezo fuel injector on a gasoline engine, the diesel injector operates quite differently. The concept of piezo electricity is the same, but applied in a different manner.



On a gasoline engine, the piezo element is used to physically operate the injector pintle in an outward motion. Due to the very high pressures used in a diesel engine, the piezo element cannot be used to directly actuate the pintle. The pintle on a diesel fuel injector moves inward (away from the combustion chamber).

Instead, the piezo element is used to trigger a relay valve in the actuator module. The injector is then hydraulically “imbalanced” which causes the pintle to open via the fuel rail pressure.

The piezo-element (2) is located inside the actuator module (5). When controlled, it produces the movement necessary to open the relay valve.

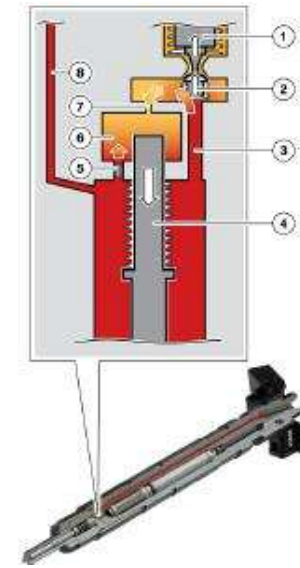
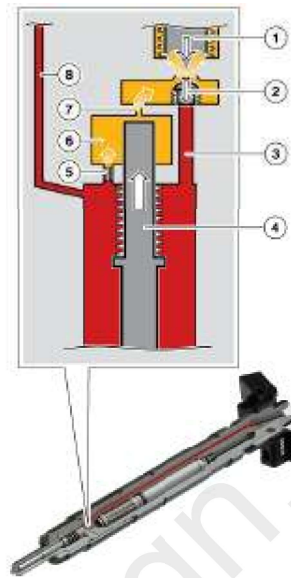
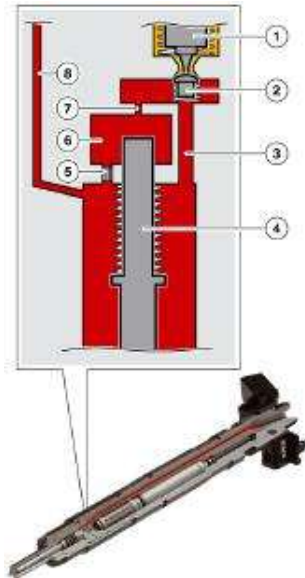
Circuited between the two elements is the coupler module (6), which functions as a hydraulic compensating element, e.g. to compensate for temperature-related length expansions.

When the fuel injector is controlled, the actuator module expands. This movement is transferred to the relay valve (7) by the coupler module. When the relay valve opens, the pressure in the control chamber (1) drops and the nozzle needle opens.

The benefits of the piezo-fuel injector are that they offer a considerably faster control response, which results in greater metering accuracy. In addition, the piezo-fuel injector is smaller, lighter and has a lower power consumption.

Index	Explanation	Index	Explanation
1	Control chamber	5	Actuator module
2	Piezo element	6	Coupler module
3	High pressure supply	7	Relay valve
4	Supply duct to the nozzle	8	Nozzle needle

Piezo Injector Operation



Index	Explanation
1	Coupler module
2	Control valve
3	Bypass
4	Nozzle needle
5	Restrictor
6	Control volume
7	Outlet
8	Supply duct to nozzle

■ Injector Opening

If the fuel injector is activated by the DDE, the piezo-element presses the control valve (2) down against the spring force via the coupler module (1) and closes the bypass (3). The fuel from the control volume (6) can then flow across the outlet (7) and the control valve.

The pressure in the control volume drops and the nozzle needle (4) is opened by the fuel delivery pressure.

■ Injector Closing

If the injector current feed is set by the DDE, the piezo-element contracts and the coupler module is pressed back by the spring force.

The spring in the control valve closes the valve and clears the bypass. Fuel now reaches the control volume via the bypass, outlet (7) and restrictor (5) and presses the nozzle needle down. The injector is closed and injection is finished.

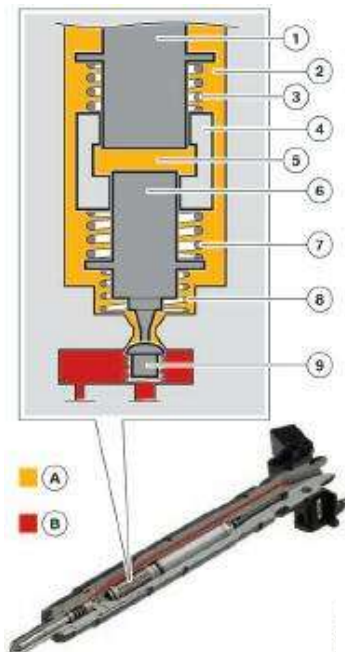
■ Coupler Module

The hydraulic coupler is surrounded by diesel fuel at a pressure of approximately 10 bar. The piezo-element acts on the upper plunger (1).

Lower plunger (6) rests on control valve (9). The force of spring (7) and of spring (8) is set in such a way that, when closed, the piezo element and control valve (9) are connected free of play via the coupler module.

The upper plunger (1) presses against coupler chamber (5) when the piezo-element is activated.

The force of the piezo-element is increased since plunger (1) has a larger diameter than plunger (6). Plunger (6) opens the control valve (9). When the coupler chamber is pressurized during activation, a small leakage quantity escapes via the clearance in the plunger guide into fuel return (2).



Index	Explanation
A	Fuel feed
B	High pressure fuel
1	Plunger
2	Fuel return
3	Spring
4	Coupler
5	Coupler chamber
6	Plunger
7	Spring
8	Spring
9	Control valve

After injection or after the piezo-element has been switched off, the springs (7 and 8) balance out the play created by the leakage quantity and fuel is again drawn via the clearance in the piston guide into the coupler chamber. This balancing out process takes place so fast that the coupler chamber is completely filled again by the next injection cycle.

A return pressure of approximately 10 bar is required for this purpose, which is achieved by the restrictor in the fuel return of the fuel injectors. The control valve is not operated and no fuel is injected when no pressure is applied in the fuel feed.

■ Leakage Oil

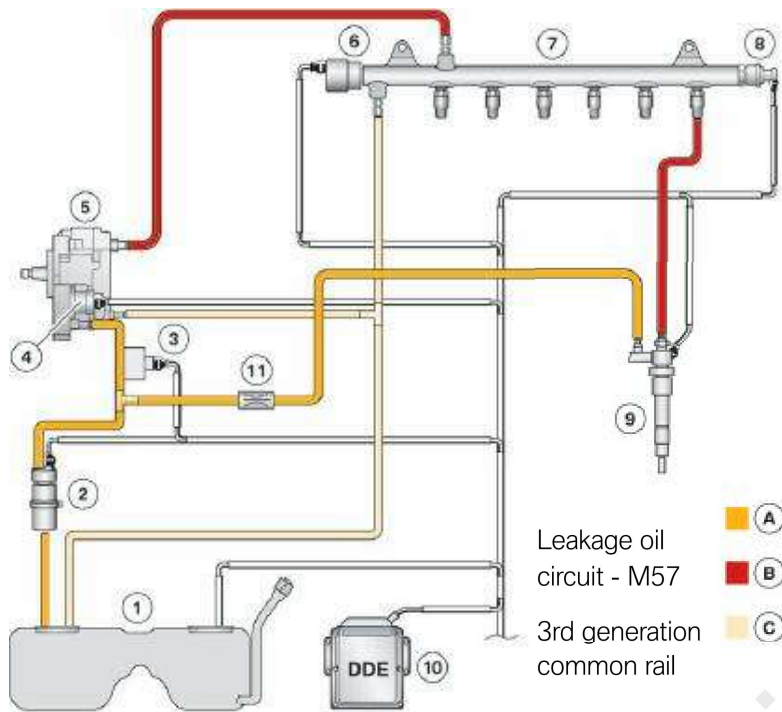
The piezo injectors require a certain amount of backpressure in the leakage circuit in order to operate properly. So, the leakage circuit on the 3rd generation common rail differs from the earlier versions.

In past versions (such as 1st and 2nd generation common rail), the leakage oil circuit drained into the fuel return line.

However, since the piezo injectors operate differently than the earlier solenoid valve injectors, the leakage circuit has been redesigned.

A certain amount of leakage oil occurs in the diesel fuel injectors due to the design of the system. The reason for this is that the relay valve in the piezo-fuel injector needs a certain back pressure to work correctly. The relay valve requires about 10 bar to be present in the leakage circuit to prevent injector malfunctions.

In order to maintain this pressure, a restrictor (11) has been installed between the injector(s) and the low pressure feed to the HP pump.



Index	Explanation	Index	Explanation
A	Fuel feed	5	High pressure pump
B	Fuel high pressure	6	Rail pressure control valve
C	Fuel return	7	Fuel rail
1	Fuel tank	8	Fuel pressure sensor
2	Fuel filter and filter heating	9	Piezo fuel injector
3	Fuel temp (and pressure) sensor	10	DDE
4	Volume control valve	11	Fuel restrictor

■ Restrictor

The restrictor has a .2 mm orifice which increases the pressure in the fuel return of the fuel injectors. The operating pressure in the leakage oil circuit is about 10 bar.



Index	Explanation
1	Connection from injector leakage line
2	Filter
3	Restrictor (.2mm)
4	Filter
5	Connection to low pressure line

The fuel flowing from the piezo-fuel injectors via the fuel return connection (1) initially passes through a filter (2), through restrictor (3) and then through a further filter (4) to connection (5) back into the fuel feed to the high pressure pump.

There is a filter (2 and 4) on either side of restrictor (3) as the restrictor has no specific direction of flow. The filters ensure that the actual restrictor (3) does not become clogged.

Fuel Injector Volume Adjustment

Piezo-fuel injectors not only bear the hydraulic tolerances but also information concerning the stroke characteristics of the injector. This is a separate classification for the injector voltage calibration.

This information is necessary due to the individual voltage requirement of each fuel injector. The fuel injector is assigned to a voltage requirement class. This replaces the seventh digit of the numerical combination on the injector for hydraulic adjustment.

A piezo-fuel injector therefore has only six characters for the hydraulic adjustment (due to a more precise manufacture of the piezo-fuel injectors) and a seventh character for the injector voltage adjustment.



Index	Explanation
1	7 Character code for adjustment
2	Voltage adjustment

Volume Adjustment

If the digital diesel electronics detects engine speed fluctuations, the actuation period of the fuel injectors is corrected based on these engine speed fluctuations. The volume adjustment adapts the injected volume of all cylinders with respect to each other.

Zero Volume Adaptation

The zero volume adaptation is a continual learning process. This learning process is required to enable precise pre-injection for each individual fuel injector. Accurate metering of the very low pre-injection volume is necessary for the fulfilment of exhaust emission regulations.

Zero volume adaptation must be carried out on a continual basis due to the volume drift of the fuel injectors.

At each cylinder, a small amount of fuel is injected during overrun mode. This volume continues to increase until a slight increase in engine speed is detected by the digital diesel electronics.

The digital diesel electronic is thus able to detect when the respective cylinder begins to work. The volume of fuel injected during zero volume adaptation is used by the digital diesel electronics as a value for the characteristic map of pre-injection.

Zero volume adaptation takes place alternately from one cylinder to the next during the overrun phase at engine speeds from 1500 to 2500 rpm and with the engine at operating temperature.

Zero volume adaptation has no influence on fuel consumption as only very small quantity of fuel (about 1 mm^3) is injected at one cylinder at a time.

Mean Volume Adaptation

The mean volume (quantity) adaptation is a learning process in which the air/fuel ratio (lambda value) is corrected by the adjustment of the air mass or exhaust gas recirculation. Unlike the other processes, this process affects all fuel injectors equally rather than the individual fuel injector.

An injection volume averaged across all cylinders is calculated from the lambda value measured by the oxygen sensor and the air mass measured by the hot-film air mass meter. This value is compared with the injection volume specified by the digital diesel electronics.

If a discrepancy is detected, the air mass is adjusted to match the actual injection volume by an adjustment of the exhaust gas recirculating valve. The correct lambda value is set in turn.

The mean volume adaptation is not an "instantaneous" regulation but an adaptive learning process. The injection volume error is taught into an adaptive characteristic map that is permanently stored in the EEPROM of the control unit.

Replacing the following components will require a reset (clearance) of this mean volume adaptation characteristic map:

- Hot-film air mass meter
- Fuel injector(s)
- Rail pressure sensor

It is possible to reset the characteristic map with the BMW diagnosis system.

NOTES

PAGE



Workshop Exercise - Fuel Supply System

1. Fill in the chart below while performing the test module for the EKP:

Item	Value
Voltage, fuel pump	
Current, fuel pump	
Specified delivery rate	

2. Carry out the service function for bleeding the fuel system.

When would this procedure be required?

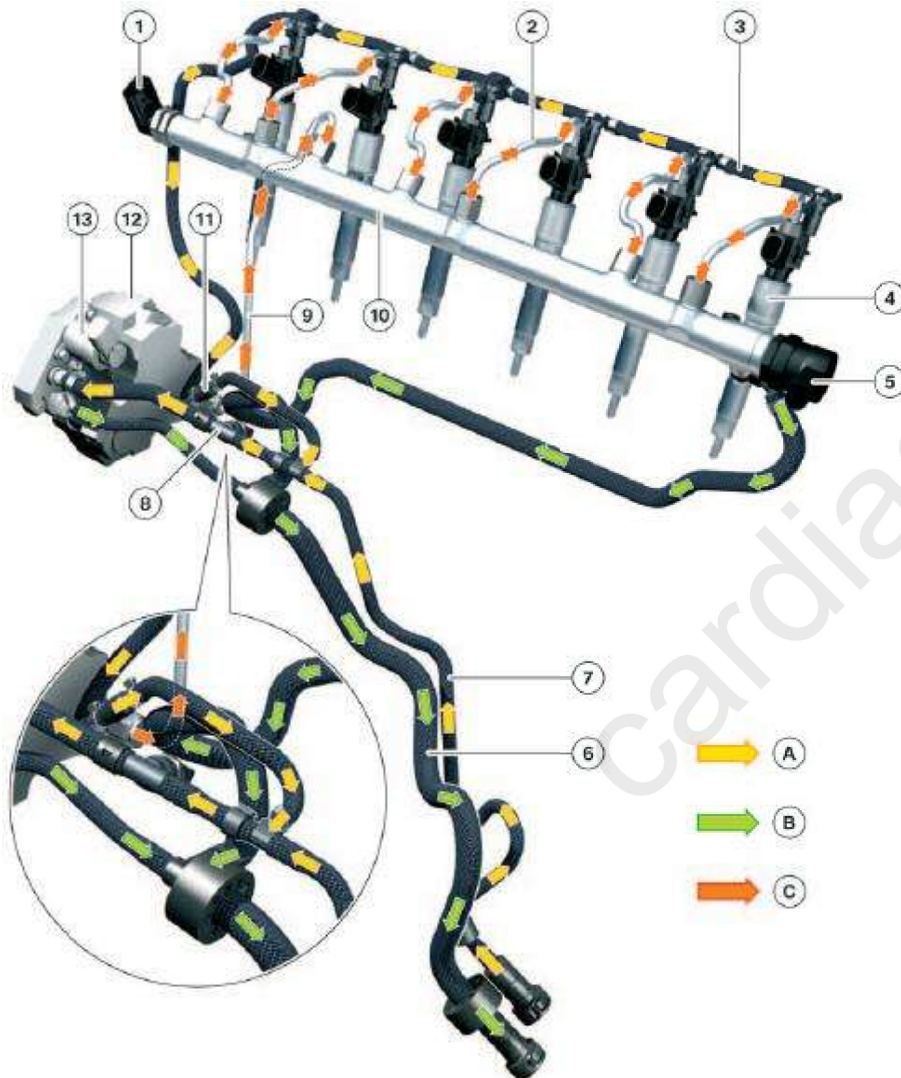
3. Carry out the plausibility test for the fuel pressure/temperature sensor:

Item	Value
Fuel temperature	
Fuel pressure (E70 only)	



Workshop Exercise - High Pressure Fuel System Component Location / Identification

1. Complete the chart by filling in the functions for the listed components, then locate on the vehicle:



Index	Explanation	Function/Purpose
A	Fuel feed (low pressure)	
B	Fuel return	
C	Fuel high pressure	
1	Fuel rail pressure sensor	
2	High pressure line	
3	Leakage line	
4	Piezo injector	
5	Fuel rail pressure control valve	
6	Return line	
7	Feed line	
8	Fuel temperature (or temp/pressure)	
9	High pressure line	
10	Fuel rail	
11	Restrictor	
12	High pressure pump	
13	Volume control valve	



Workshop Exercise - High Pressure Fuel System

1. Using the “read measured values” test modules in service functions, please complete the following table:

	Cold	Hot
Engine speed		
Coolant temperature		
Rail pressure, actual		
Rail pressure, target		
Injection volume, mg		

2. With the engine at operating temperature, please complete the following table regarding the rail pressure.

Engine speed	Rail pressure (actual)	Activation pressure, control valve	Activation, volume control valve
Idle			
1000 rpm			
2000 rpm			
3000 rpm			



Workshop Exercise - High Pressure Fuel System

3. *Disconnect the rail pressure sensor and note the substitute value.*

Substitute value - _____

Is there any change to engine operation?

4. *Complete the test module for the rail pressure regulation valve. Record the resistance values in the chart below:*

Nominal value	Actual value

5. *Disconnect the volume control valve. Does the engine run? Explain why or why not?*

6. *Disconnect the pressure control valve? Does the engine run? Explain why or why not?*

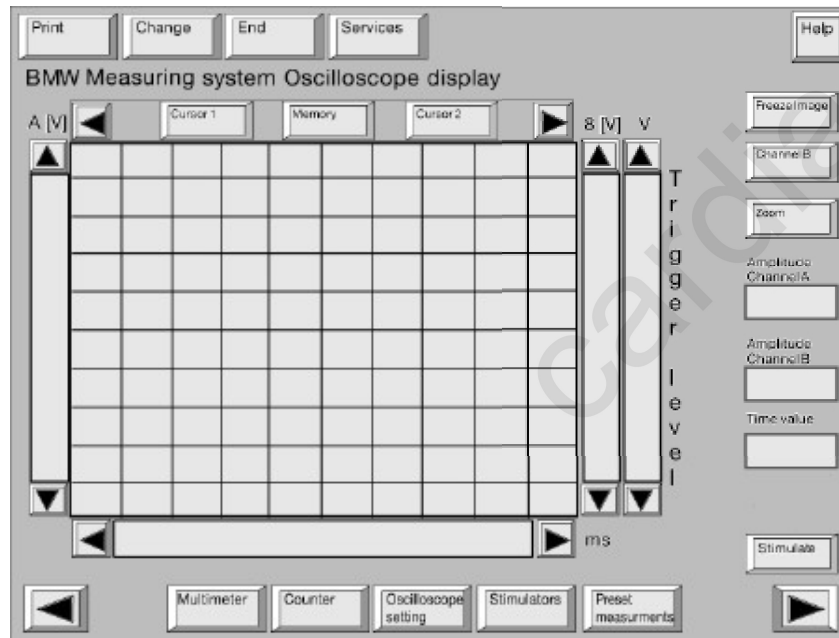


Workshop Exercise - High Pressure Fuel System

7. Perform the test module for the high pressure pump and complete the following chart:

Amplitude (maximum)	Period duration

While performing above test module, obtain the oscilloscope pattern for the high pressure pump. Draw the pattern on the scope illustration provided.



Item	Value
Test connections (MFK)	
Frequency settings	
Voltage level	
Trigger level	

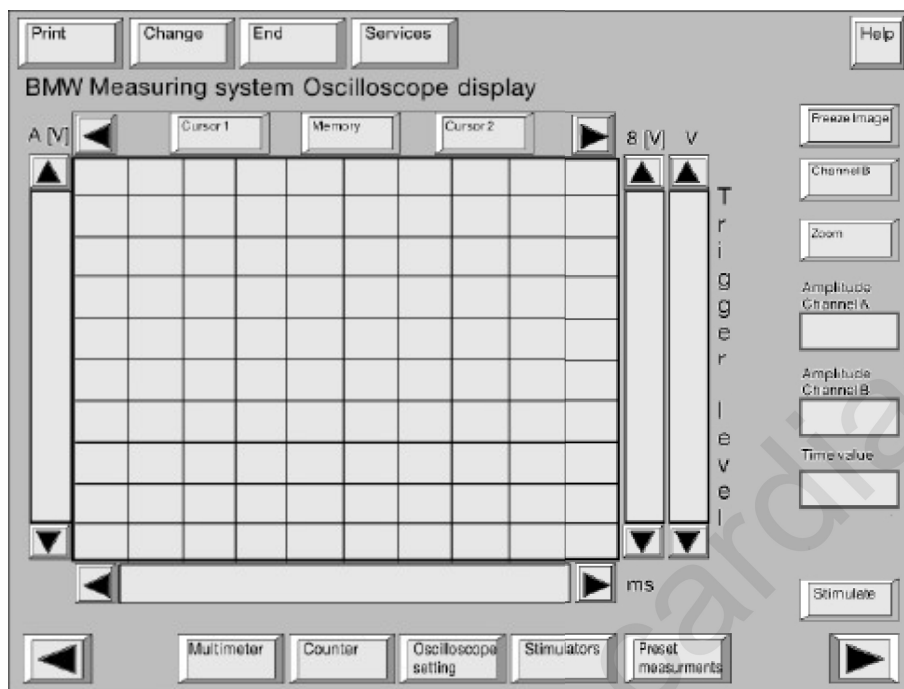


Workshop Exercise - High Pressure Fuel System

8. Obtain an oscilloscope pattern of the piezo injector and sketch your result below:

WARNING!!!

High voltage may be present.



Record Settings in the chart below:

Item	Value
Test connections (MFK)	
Frequency settings	
Voltage level	
Trigger level	

9. Measure the resistance values of all injectors and record below:

Injector 1	Injector 2	Injector 3	Injector 4	Injector 5	Injector 6



Workshop Exercise - High Pressure Fuel System

10. Perform the test module/service function for the fuel injectors and complete the following table with the correct classification numbers and compare to those on the vehicle:

Cylinder number	Classification
1	
2	
3	
4	
5	
6	

What type of fuel injectors are used in the M57D30T2 engine?

NOTES
PAGE



Classroom Exercise - Review Questions

1. Which of the components listed below direct fuel to the return circuit for the operation of the siphon jet in the fuel tank? (circle those that apply)

Leakage line	Volume control valve
Rail pressure control valve	Restrictor
Fuel injectors	Fuel filter
2. In order to refuel a BMW diesel vehicle, there is a flap in the fuel tank to prevent misfueling. What is the correct diameter of the diesel fuel nozzle which is necessary to operate the misfueling flap? (circle one)

19 mm 21 mm 24 mm 34 mm
3. Which of the following components is **NOT** used on a diesel fuel system? (circle those that apply)

Electric fuel pump	Charcoal canister	Fuel filter
EKP module	Siphon jet	DM-TL
4. In order for the piezo injector to operate correctly, the pressure in the leakage circuit must be: (circle one)

100 bar or greater	Approximately 10 bar
3 to 5 bar	100 millibar
200 bar	1 bar +/- 100 millibar
5. In order to maintain the adequate pressure in the leakage line, a _____ is installed after the fuel injectors. (circle one)

check valve	non-return valve	restrictor
solenoid	bypass valve	coupler
6. For the US version of the diesel, which of the following fuel system components has been adapted to meet the US specific fuel specifications? (circle all that apply)

High pressure pump	Fuel filter
Volume control valve	Leakage line
Electric fuel pump	Fuel injectors
Fuel rail	Fuel filter heater



Classroom Exercise - Review Questions

7. Complete the following chart by checking the box for either E70 or E90 where it applies:

Component/System	E70 Xdrive35d	E90 335d
Screw-spindle fuel pump		
Gear-type (rotor) fuel pump		
Speed controlled low pressure fuel system		
Pressure controlled low pressure fuel system		
Fuel temperature/pressure sensor		
Fuel temperature sensor		
Low pressure EGR system		
High-pressure EGR system		
SCR system		
Diesel particulate filter		
Low pressure EGR cooler		
High pressure EGR cooler		