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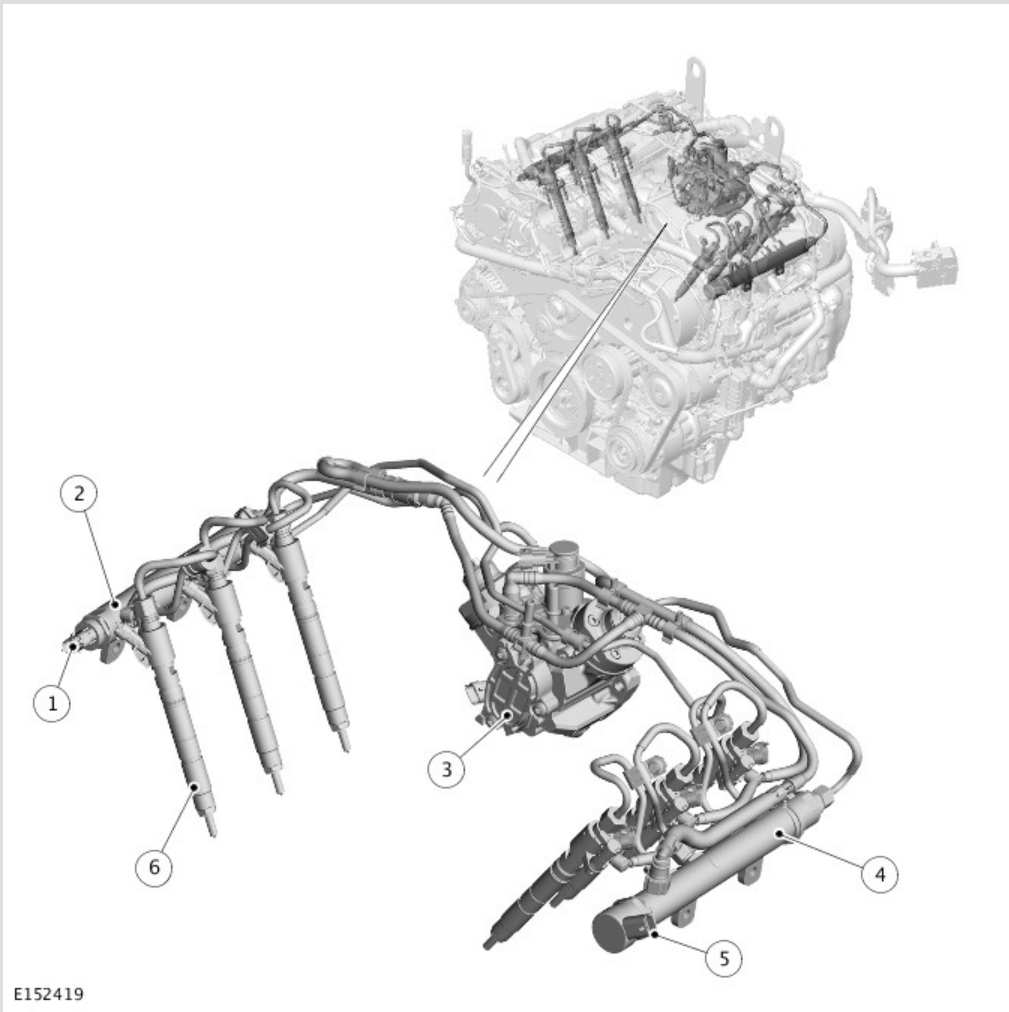
2017.0 DISCOVERY (LR), 303-04

FUEL CHARGING AND CONTROLS - TDV6 3.0L DIESEL

DESCRIPTION AND OPERATION

COMPONENT LOCATION

TDV6 3.0L DIESEL



ITEM	DESCRIPTION
1	Fuel Rail Pressure (FRP) sensor
2	Fuel rail - Bank 1
3	High Pressure (HP) fuel pump - With internal transfer pump
4	Fuel rail - Bank 2
5	Fuel rail Pressure Control Valve (PCV)
6	Fuel injector (6 off)

OVERVIEW

The TDV6 3.0L diesel engine is equipped with a High Pressure (HP) common rail fuel injection system. A HP fuel pump delivers a uniform level of pressure to the shared fuel lines (the fuel rails), which serve all six fuel injectors. Pressure is controlled to the optimum level for smooth operation.

The fuel injection system supports a pre and pilot injection depending on engine operating conditions. This reduces combustion noise levels, more commonly referred to as 'diesel knock'.

Fuel injection pressure is generated independently of engine speed and fuel injection events.

The fuel injection timing and volume are calculated by the Powertrain Control Module (PCM), which then energizes the appropriate piezo actuated injector.

The fuel injection system has the following features:

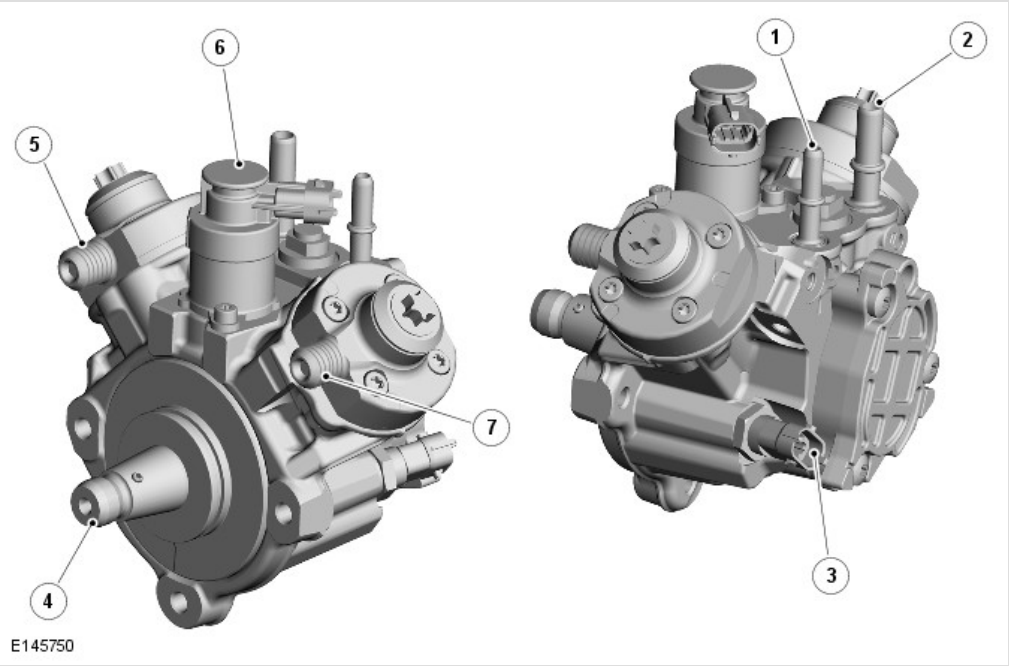
- High fuel injection pressures of up to 2000 bar (29007 lbf/in²) for greater atomization of fuel (increasing performance and lowering emissions)
- Variable injection to optimize combustion in all engine operating conditions
- Low tolerances and high precision throughout the life of the system.

The system features the following components:

- HP fuel pump
- Fuel rails
- HP and Low Pressure (LP) fuel pipes
- Fuel injectors.

DESCRIPTION

HIGH PRESSURE FUEL PUMP



ITEM	DESCRIPTION
1	Low Pressure (LP) fuel return connection
2	Low Pressure (LP) fuel supply connection
3	Fuel temperature sensor
4	Driveshaft
5	Fuel outlet to bank 2 fuel rail
6	Fuel metering valve
7	Fuel outlet to bank 1 fuel rail

The High Pressure (HP) fuel pump is a two piston radial plunger pump. The pump has the ability to produce a maximum pressure of 2000 bar (29007 lbf/in²).

The HP fuel pump is driven from the bank 2 cylinder head exhaust camshaft via a toothed belt. The drive from the belt rotates a camshaft within the pump which operates a plunger within each pumping element. A procedure and special tools are required for pump or belt replacement to time the pump.
For additional information, refer to: Engine (303-01A, Description and Operation) / Fuel Charging and Controls (303-04A, Description and Operation).

The HP fuel pump comprises:

- Two HP pumping elements
- A fuel metering valve
- An internal transfer pump
- A fuel temperature sensor.

The fuel is delivered to the internal transfer pump via the external fuel filter and a Low Pressure (LP) fuel pump which is located in the fuel tank.
For additional information, refer to: Fuel Tank and Lines (310-01A, Description and Operation).

The fuel metering valve is located in the feed port between the HP pumping elements and the internal transfer pump. The fuel metering valve is a variable position solenoid-operated valve that is controlled by the Powertrain Control Module (PCM). The fuel metering valve determines the amount of fuel that is delivered from the internal transfer pump to the HP pumping elements. When there is no signal to the fuel metering valve, the valve is closed and there is no fuel delivery.

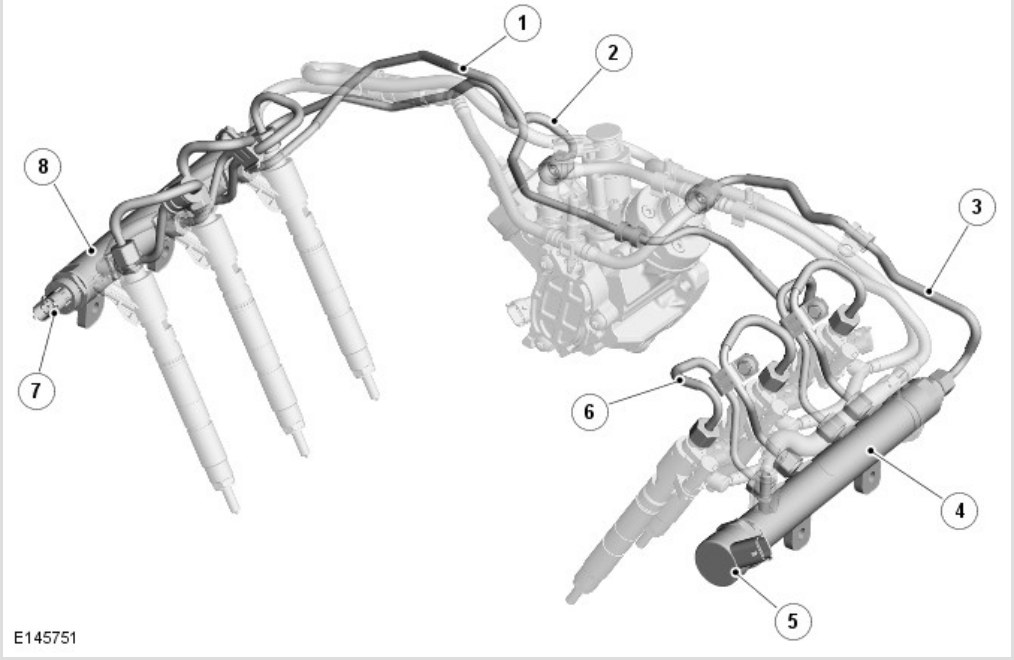
The fuel from the internal transfer pump is passed to the HP pumping elements at a constant pressure known as transfer pressure. The transfer pressure is controlled by an internal Pressure Relief Valve (PRV). Once the fuel enters each of the HP pumping elements the pressure rises rapidly. Each HP pumping element provides a HP supply to one of the fuel rails. The pressure is controlled by the fuel rail Pressure Control Valve (PCV) and the Fuel Rail Pressure (FRP) sensor.

A controlled amount of fuel is allowed to leak-off from the internal transfer pump. This fuel cools and lubricates the internal components of the HP fuel pump. the fuel is returned to the fuel tank through the LP fuel return line.

The fuel temperature sensor is located on the rear of the HP fuel pump. It measures the fuel temperature in the LP side of the HP fuel pump. The PCM continually monitors this signal to determine the fuel temperature to prevent overheating of the fuel system. The PCM will also make fine adjustments to the fuel injection quantity to adjust for fuel temperature.

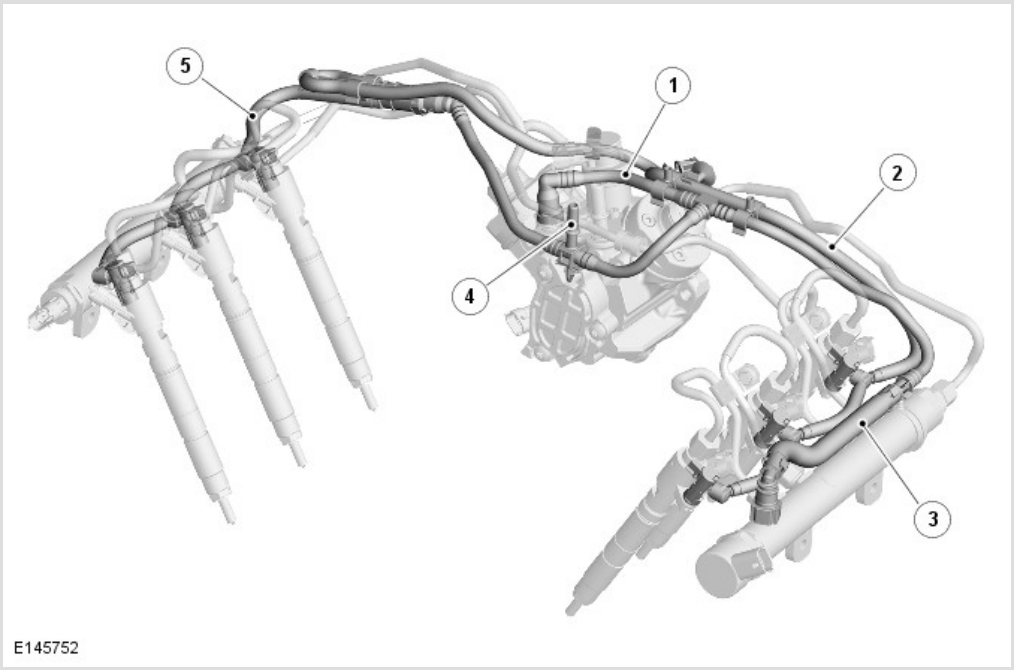
FUEL RAILS

Fuel Rails and High Pressure Fuel Lines



ITEM	DESCRIPTION
1	Fuel rail balance pipe
2	Supply pipe to bank 1 fuel rail
3	Supply pipe to bank 2 fuel rail
4	Fuel rail - Bank 2
5	Fuel Pressure Control Valve (PCV)
6	Supply pipe to fuel injector (6 off)
7	Fuel Rail Pressure (FRP) sensor
8	Fuel rail - Bank 1

Low Pressure Fuel Lines



ITEM	DESCRIPTION
1	High Pressure (HP) fuel pump fuel return tube
2	Bank 2 fuel injector leak-back tube
3	Fuel rail Pressure Control Valve (PCV) fuel return tube
4	Fuel return connection to fuel cooler
5	Bank 1 fuel injector leak-back tube

Two fuel rails are used with each rail supplying High Pressure (HP) fuel to three fuel injectors.

Each rail has five threaded connections which provide for the attachment of:

- The HP fuel supply from the HP fuel pump
- The balance pipe and connections for the three injectors supplied with fuel from that rail.

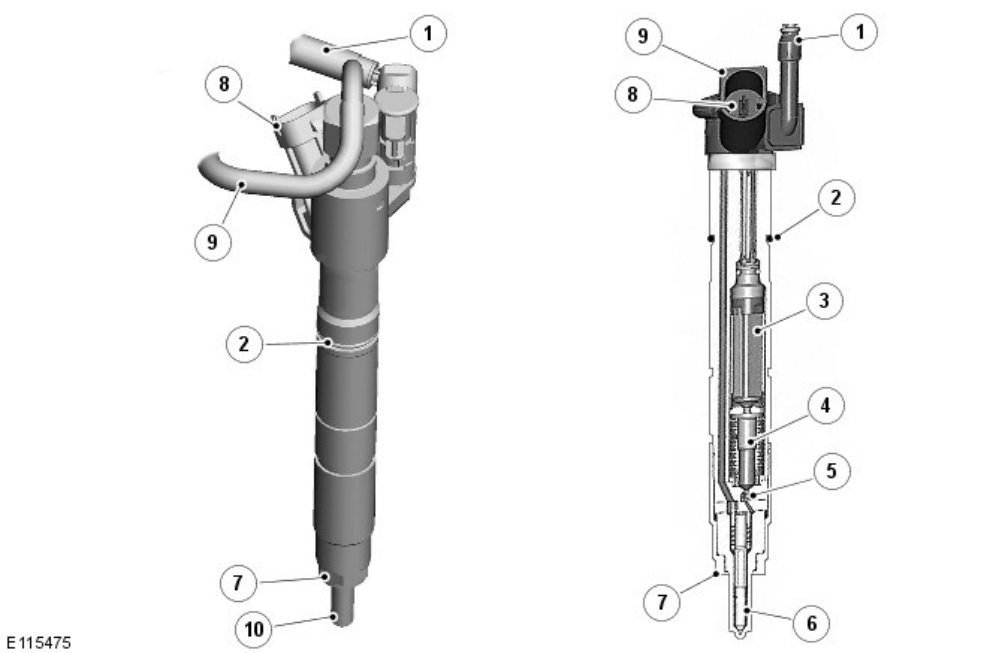
A Fuel Rail Pressure (FRP) sensor is located in the front of the bank 1 fuel rail. The FRP sensor detects fuel pressure in the fuel rails. The bank 2 fuel rail houses a fuel rail Pressure Control Valve (PCV). The Powertrain Control Module (PCM) controls the fuel

rail PCV using signals from the FRP sensor. Fuel released by the fuel rail PCV flows into the Low Pressure (LP) fuel return line.

The FRP sensor is a piezo-resistive type sensor containing an actuating diaphragm. Deflection of the diaphragm provides a proportional signal (output) voltage to the PCM, dependant on the fuel pressure within the fuel rail.

Both rails are connected together with a balance pipe. The balance pipe makes sure that the pressure in both rails is equal. The pressure is equal even though each rail is supplied from a different pumping element in the HP fuel pump.

FUEL INJECTORS



ITEM	DESCRIPTION
1	Fuel return
2	O-ring seal
3	Piezo stack actuator
4	Hydraulic coupler
5	Control valve
6	Nozzle body
7	Copper sealing washer
8	Electrical connector
9	High Pressure (HP) feed
10	Nozzle

CAUTION:

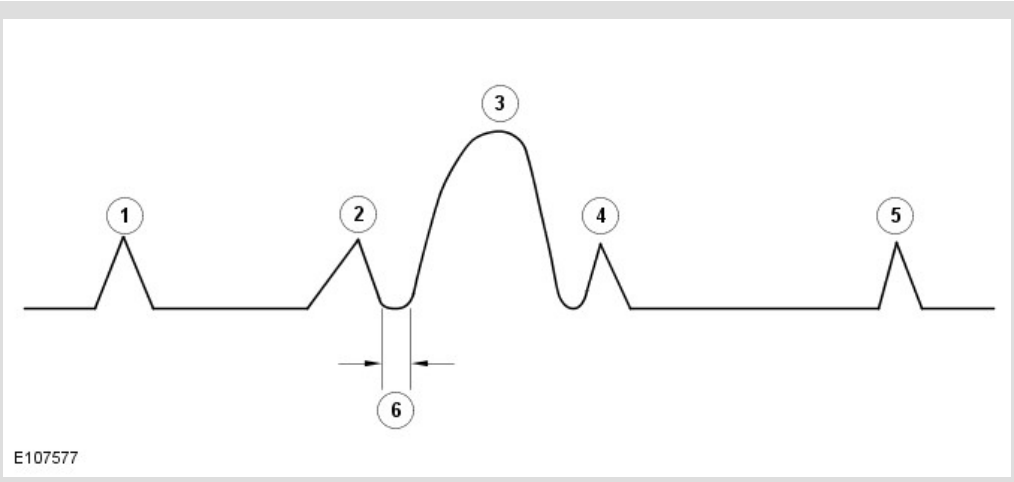
Each injection event is controlled by a charge and discharge cycle allowing energy to dissipate in, and recover from, the injector. Never disconnect the wiring connector when the vehicle is running. The injector may remain open thus causing engine damage.

Six fuel injectors are used in the fuel system. A piezo actuator in each injector is electronically controlled by the Powertrain Control Module (PCM). The PCM operates the injector in response to engine speed and load conditions.

Each injector has an electrical connector which connects the injector to the engine harness. A fuel connection on the top of the injector provides for the High Pressure (HP) fuel inlet from the related fuel rail. A second fuel connection allows fuel leakage within the injector to drain into the Low Pressure (LP) fuel return line.

Each injector is located in a machined hole in the cylinder head. The fuel injector is sealed in the cylinder head with a copper sealing washer and an O-ring seal. The injector is retained in the cylinder head with a clamp plate and two bolts. If an injector is removed or replaced, a new copper sealing washer and a clamp plate must be used when refitting the injector.

The injector can operate up to five times during one combustion cycle depending on engine speed and load. The injection sequence can occur as follows:



1. Pilot injection - Occurs before the main injection and improves fuel and air mixing.
2. Pre-injection - Shortens the main injection's ignition delay and therefore reduces the generation of nitrous oxides.

3. Main injection - Delivers the required engine torque.
4. After injection - Occurs after the main injection and assists the re-burn of any remaining particulate matter.
5. Post injection - Helps manage the temperature of the exhaust gas for more effective exhaust-gas after-treatment.
6. Injection delay 0.4 ms.

Each injector is calibrated to the PCM and the applicable cylinder to which it is fitted. Therefore, if an injector is removed it must be refitted to the cylinder from which it was removed. If a new injector is fitted, a calibration routine using approved diagnostic equipment must be performed to calibrate the injector unique code to the PCM.

The operating voltage of the injector is between 110 and 163 Volts depending on engine speed and load. Care must be taken when working in the vicinity of the injectors. The pressure increases linearly from 200 to 1200 bar (2900 to 17404 lbf/in²).

Each injector has an electrical resistance value of between 150 - 250 kOhms.

OPERATION

ENGINE STARTING

During starting, the fuel rail pressure must be at least 120 bar (1740 lbf/in²). Should the pressure be below this figure, the injectors will not operate, resulting in the vehicle not starting.

ENGINE STOPPING

To stop the engine the Powertrain Control Module (PCM) stops energizing the actuators in the fuel injectors. Therefore, no fuel is injected and the engine speed drops to zero. For additional information, refer to: Electronic Engine Controls (303-14A, Description and Operation).

HIGH PRESSURE FUEL PUMP

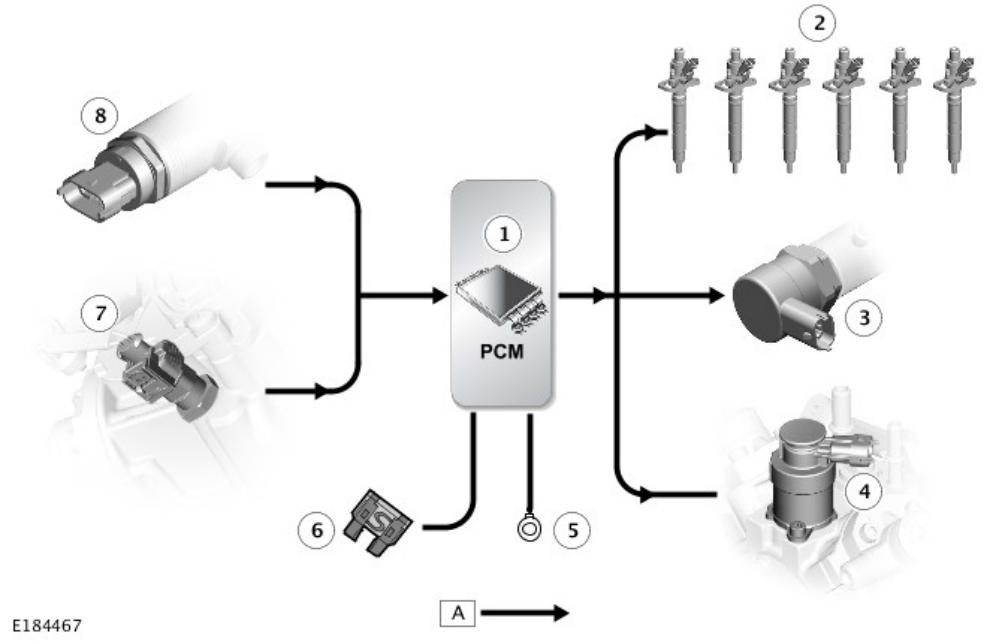
When the High Pressure (HP) fuel pump is rotated, pressure is created when:

- The fuel metering valve is open
- The fuel rail Pressure Control Valve (PCV) is closed.

Both valves are electronically controlled by the Powertrain Control Module (PCM) to allow variable fuel delivery and pressure control. When the fuel injectors operate, the fuel rail pressure drop is off-set by additional fuel being delivered to the fuel rails. This is controlled by the fuel rail Pressure Control Valve (PCV). The fuel pressure in the system is reduced within a few seconds after the engine has stopped. This is due to the

fuel rail PCV no longer having the holding current it requires, and therefore the PCV opens. No residual pressure remains in the system and the fuel is released into the Low Pressure (LP) fuel return line through the open fuel rail PCV.

CONTROL DIAGRAM



A = HARDWIRED

ITEM	DESCRIPTION
1	Powertrain Control Module (PCM)
2	Fuel injector (6 off)
3	Fuel rail Pressure Control Valve (PCV)
4	Fuel metering valve
5	Ground
6	Power supply from Powertrain Control Module (PCM) relay in Engine Junction Box (EJB)
7	Fuel temperature sensor
8	Fuel Rail Pressure (FRP) sensor

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FUEL CHARGING AND CONTROLS - TDV6 3.0L DIESEL

DIAGNOSIS AND TESTING

PRINCIPLES OF OPERATION

For a detailed description of the fuel charging and controls system and operation, refer to the relevant Description and Operation section of the workshop manual.
REFER to: Fuel Charging and Controls (303-04A, Description and Operation).

INSPECTION AND VERIFICATION

WARNING:

Make sure that all suitable safety precautions are observed when carrying out any work on the fuel system. Failure to observe this warning may result in personal injury.

CAUTION:

Make sure that absolute cleanliness is observed when working with these components. Always install blanking plugs to any open orifices or lines. Failure to follow this instruction may result in damage to the vehicle.

NOTE:

Check and rectify basic faults before beginning diagnostic routines involving pinpoint tests.

1. Verify the customer concern.

1. Visually inspect for obvious signs of mechanical or electrical damage.

Visual Inspection

MECHANICAL	ELECTRICAL
■ Low/Contaminated fuel ■ Fuel supply/return line(s) ■ High-pressure fuel supply line(s) ■ Fuel tank and filler pipe ■ Fuel leak(s) ■ Fuel filler cap ■ Fuel filter ■ Push connect fittings ■ Fuel rail ■ Fuel pump ■ Exhaust gas recirculation system	■ Fuses ■ Glow plug indicator ■ Inertia fuel shut off switch ■ Fuel pump module ■ Sensor(s) ■ Engine control module ■ Fuel volume control valve ■ Fuel pressure control valve ■ Fuel rail pressure sensor ■ Fuel temperature sensor ■ Fuel injector(s) ■ Exhaust gas recirculation system

1. If an obvious cause for an observed or reported concern is found, correct the cause (if possible) before proceeding to the next step.

1. If the cause is not visually evident, verify the symptom and refer to the Symptom Chart, alternatively check for Diagnostic Trouble Codes (DTCs) and refer to the DTC Index.

SYMPTOM CHART

SYMPTOM	POSSIBLE CAUSES	ACTION
Engine cranks, but does not start	■ Inertia fuel shut off switch ■ Low /Contaminated fuel ■ Air leakage ■ Low-pressure fuel system fault ■ Fuel pump module (lift pump) fault	Check that the inertia switch has not tripped. Check the fuel level and condition. Draw off approximately 1 ltr (2.11 pints) of fuel and allow to stand for 1 minute. Check to make sure there is no separation of the fuel indicating water or other liquid in the fuel. Check the intake air system for leaks. Check the lift pump operation, check the low-pressure fuel system for leaks /damage. Check the fuel filter, check for DTCs indicating a fuel volume or pressure control valve fault. Check the fuel pump. Check the CKP sensor circuits. Refer to the electrical guides.

	■ Blocked fuel filter ■ Fuel volume regulator blocked /contaminated ■ Fuel pressure control valve blocked /contaminated ■ Fuel pump fault ■ Crankshaft position sensor	
Difficult to start	■ Glow plug system fault (very cold conditions) ■ Low /Contaminated fuel ■ Air leakage ■ Fuel pump module (lift pump) fault ■ Low-pressure fuel system fault ■ Blocked fuel filter ■ Fuel volume control valve blocked /contaminated ■ Fuel pressure control valve blocked /contaminated ■ Exhaust gas recirculation valve fault	Check the glow plug circuits. Refer to the electrical guides. Check the fuel level/condition. Draw off approximately 1 ltr (2.11 pints) of fuel and allow to stand for 1 minute. Check to make sure there is no separation of the fuel indicating water or other liquid in the fuel. Check the intake air system for leaks. Check the lift pump operation, check the low-pressure fuel system for leaks/damage. Check the fuel filter, check for DTCs indicating a fuel volume or pressure control valve fault. Check the exhaust gas recirculation system.
Rough idle	■ Intake air system fault ■ Low /Contaminated fuel ■ Low-pressure fuel system fault ■ Blocked fuel filter	Check the intake air system for leaks. Check the fuel level /condition. Draw off approximately 1 ltr (2.11 pints) of fuel and allow to stand for 1 minute. Check to make sure there is no separation of the fuel indicating water or other liquid in the fuel. Check the low-pressure fuel system for leaks/damage. Check the fuel filter, check for DTCs indicating a fuel volume or pressure control valve fault. Check the exhaust gas recirculation system.

	■ Fuel volume control valve blocked /contaminated ■ Fuel pressure control valve blocked /contaminated ■ Exhaust gas recirculation valve fault	
Lack of power when accelerating	■ Intake air system fault ■ Restricted exhaust system ■ Low fuel pressure ■ Exhaust gas recirculation valve fault ■ Turbocharger actuator fault	Check the intake air system for leakage or restriction. Check for a blockage/restriction in the exhaust system, install new components as necessary. Check for DTCs indicating a fuel pressure fault. Check the exhaust gas recirculation system. Check turbocharger actuator.
Engine stops /stalls	■ Air leakage ■ Low /Contaminated fuel ■ Low-pressure fuel system fault ■ High pressure fuel leak ■ Fuel volume control valve blocked /contaminated ■ Fuel pressure control valve blocked /contaminated ■ Exhaust gas recirculation valve fault	Check the intake air system for leaks. Check the fuel level /condition. Draw off approximately 1 ltr (2.11 pints) of fuel and allow to stand for 1 minute. Check to make sure there is no separation of the fuel indicating water or other liquid in the fuel. Check the fuel system for leaks/damage: Check for DTCs indicating a fuel volume or pressure control valve fault. Check the exhaust gas recirculation system.
Engine judders	■ Low /Contaminated fuel ■ Air ingress ■ Low-pressure fuel system fault	Check the fuel level/condition. Draw off approximately 1 ltr (2.11 pints) of fuel and allow to stand for 1 minute. Check to make sure there is no separation of the fuel indicating water or other liquid in the fuel. Check the intake air system for leaks. Check the low-pressure fuel system for leaks/damage. Check the high pressure fuel system for leaks, check for DTCs indicating a fuel volume or pressure control valve fault. Check the fuel pump.

	■ Fuel metering valve blocked /contaminated ■ Fuel volume control valve blocked /contaminated ■ Fuel pressure control valve blocked /contaminated ■ High pressure fuel leak ■ Fuel pump fault	
Excessive fuel consumption	■ Low-pressure fuel system fault ■ Fuel volume control valve blocked /contaminated ■ Fuel pressure control valve blocked /contaminated ■ Fuel temperature sensor leak ■ High pressure fuel leak ■ Injector(s) fault ■ Exhaust gas recirculation valve fault	Check the low-pressure fuel system for leaks/damage. Check for DTCs indicating a fuel volume or pressure control valve fault. Check the fuel temperature sensor, fuel pump, etc for leaks. Check for injector DTCs. Check the exhaust gas recirculation system.

DTC INDEX

For a list of Diagnostic Trouble Codes (DTCs) that could be logged on this vehicle, please refer to Section 100-00.
REFER to: Diagnostic Trouble Code (DTC) Index - TDV6 3.0L Diesel, DTC: Engine Control Module (100-00 General Information, Description and Operation).

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FUEL CHARGING AND CONTROLS - TDV6 3.0L DIESEL

SPECIFICATIONS

Torque Specification

NOTE:

A = refer to procedure for the correct torque sequence.

DESCRIPTION	NM	LB-FT	LB-IN
Fuel injection pump cradle bolts	3	2	26
Fuel injection pump retaining bolts	23	16	-
Fuel injection pump bracket	10	-	88
Fuel injection pump sprocket bolt	50	37	-
Fuel injection pump belt rear cover retaining bolts	10	-	88
Camshaft rear end accessory drive (READ) pulley hub retaining bolt	A	-	-
Fuel injection pump belt tensioner retaining bolt	23	16	-
Camshaft READ pulley retaining bolt	A	-	-
Fuel injector retaining bolts	9	-	80
Fuel rail retaining bolts	24	18	
High-pressure fuel line bracket retaining bolts	10	-	88
High-pressure fuel line union nuts	A	-	-
Fuel rail supply tube union nuts	A	-	-
Fuel crossover line union nuts	A	-	-
Crankcase ventilation pipe retain bolts	10	-	88
Intake air shutoff valve retaining nut	10	-	88