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Cummins Diesel Diagnostics

This course is designed to help you to understand the principals of Diesel fuel injection and become efficient in diagnosing them. What's in it for you? Learning to become quicker and more accurate in diagnosing while having fewer comebacks.

The first subject covered in class is diesel combustion which is the stepping off point for automotive technicians that have little experience with the Cummins diesel engine and the Chrysler controls. Chrysler buys the engines from Cummins without and accessories. This makes the engine Cummins and everything else Chrysler.

The terminology is different in the diesel service bay and diesel technicians speak a little differently than their gas counterpart. For an example; the gas tech may state that the fuel pump requires replacing on a certain vehicle. Whereas the diesel tech will call the pump by its name, “the P7100 injection pump requires replacement. We replace a lot of fuel pumps at the research center, but we don’t refer to them by name. We are like so many other technicians, were gas guys who work on diesels. This class is written for guys like us.

Objectives

- Compression ignition characteristics
- Fuel System Overview (Common rail)
- Turbocharging Systems
- New Exhaust After-treatment Systems (DOC and DPF)
- Service Information and Scan tool use
- Diagnostic Strategies

The first diesel engines:

A little history about the diesel engine will offer n an insight. The diesel engine was patented in and refined in the late 1800s. American and European inventors worked on diesels, but it was Rudolf Diesel that is credited with the advance research and development. In 1897, Diesel built an engine that used heavy oil as a fuel. The single-cylinder engine developed 20 horsepower at 172 RPM and was more efficient that other engine at the time. Diesel most likely didn’t know how much his design would change the world of transportation.

For Dodge, in 1989, it was an outstanding decision to choose Cummins. First, it was an inline six, not a V-8, reducing maintenance costs. It had about 40% fewer working parts, leading to less expensive and quicker repairs. The engine had been well tested over 5 years before Dodge put a pickup around it, in tougher applications, and its record was outstanding. The long stroke of the 6 made serious amounts of torque, far more than the V-8 rivals from GM or Ford, at 246 ft lbs. for GM and 345 for Ford, with the Cummins at 400 ft. lbs. In diesels, torque is king; and 400 lb-ft at 1,700 rpm was hefty. Horsepower was also good at 160 hp at 2,500 rpm.

The engine is also direct injected whereby the fuel is injected right into the combustion chamber, unlike the two rival engines that put fuel into an indirect injection sequence, with a pre combustion chamber. The result is less heat produced from the Cummins, thereby allowing a smaller radiator, meaning less coolant. There are GM and Ford die-hard fans but it is widely accepted that the Cummins engine is stronger, more dependable, and has a longer life span.

Specifications

Model Year	Horsepower	Torque
1989	160 hp @ 2,500 RPM	400 lb-ft @ 1,600 RPM
1990	160 hp @ 2,500 RPM	400 lb-ft @ 1,600 RPM
1991	160 hp @ 2,500 RPM	400 lb-ft @ 1,600 RPM
1992	160 hp @ 2,500 RPM	400 lb-ft @ 1,600 RPM
1993	160 hp @ 2,500 RPM	400 lb-ft @ 1,600 RPM
1994	160 hp @ 2,500 RPM (auto trans) 175 hp @ 2,600 RPM (man trans)	400 lb-ft @ 1,500 RPM (auto trans) 420 lb-ft @ 1,500 RPM (man trans)
1995	160 hp @ 2,500 RPM (auto trans) 175 hp @ 2,600 RPM (man trans)	400 lb-ft @ 1,500 RPM (auto trans) 420 lb-ft @ 1,500 RPM (man trans)
1996	180 hp @ 2,500 RPM (auto trans) 215 hp @ 2,600 RPM (man trans)	420 lb-ft @ 1,500 RPM (auto trans) 440 lb-ft @ 1,500 RPM (man trans)
1997	180 hp @ 2,500 RPM (auto trans) 215 hp @ 2,600 RPM (man trans)	420 lb-ft @ 1,500 RPM (auto trans) 440 lb-ft @ 1,500 RPM (man trans)
1998	215 hp @ 2,700 RPM (auto trans) 235 hp @ 2,700 RPM (man trans)	420 lb-ft @ 1,600 RPM (auto trans) 460 lb-ft @ 1,600 RPM (man trans)
1999	215 hp @ 2,700 RPM (auto trans) 235 hp @ 2,700 RPM (man trans)	420 lb-ft @ 1,600 RPM (auto trans) 460 lb-ft @ 1,600 RPM (man trans)
2000	215 hp @ 2,700 RPM (auto trans) 235 hp @ 2,700 RPM (man trans)	420 lb-ft @ 1,600 RPM (auto trans) 460 lb-ft @ 1,600 RPM (man trans)
2001	235 hp @ 2,700 RPM 245 hp @ 2,700 RPM (high output)*	460 lb-ft @ 1,400 RPM 505 lb-ft @ 1,600 RPM (high output)
2002	235 hp @ 2,700 RPM 245 hp @ 2,900 RPM (high output)*	460 lb-ft @ 1,400 RPM 505 lb-ft @ 1,400 RPM (high output)
2003	235 hp @ 2,700 RPM 305 hp @ 2,900 RPM (high output)	460 lb-ft @ 1,400 RPM 555 lb-ft @ 1,400 RPM (high output)
2004	235 hp @ 2,700 RPM (CA) 305 hp @ 2,900 RPM 325 hp @ 2,900 RPM (high output)	460 lb-ft @ 1,400 RPM (CA) 555 lb-ft @ 1,400 RPM 600 lb-ft @ 1,600 RPM (HO)
2005	325 hp @ 2,900 RPM	610 lb-ft @ 1,600 RPM
2006	325 hp @ 2,900 RPM	610 lb-ft @ 1,600 RPM
2007	350 hp @ 3013 RPM	650 lb-ft @ 1,500 RPM 610 lb-ft @ 1,500 RPM (w/ manual trans)
2008	350 hp @ 3013 RPM	650 lb-ft @ 1,500 RPM 610 lb-ft @ 1,500 RPM (w/ manual trans)
2009	350 hp @ 3013 RPM	650 lb-ft @ 1,500 RPM 610 lb-ft @ 1,500 RPM (w/ manual trans)
2010	350 hp @ 3013 RPM	650 lb-ft @ 1,500 RPM 610 lb-ft @ 1,500 RPM (w/ manual trans)
2011	350 hp @ 3,000 RPM	650 lb-ft @ 1,500 RPM 800 lb-ft @ 1,600 RPM (Feb. 2011 upgrade)

The table below compares the 5.9L 12-valve, 5.9L 24-valve ISB, & 6.7L Cummins engines.			
	5.9L 12-valve	5.9L 24-valve ISB	6.7L ISB
Configuration:	Inline 6 cylinder	Inline 6 cylinder	inline 6 cylinder
Displacement:	359 ci, 5.9 liters	359 ci, 5.9 liters	409 ci, 6.7 liters
Compression Ratio:	17.0:1	16.3:1, 17.2:1*	17.3:1
Bore:	4.02 inches	4.02 inches	4.21 inches
Stroke:	4.72 inches	4.72 inches	4.88 inches
Turbocharger:	Holset Turbocharger	Holset Turbocharger	Variable geometry turbocharger
Valvetrain:	12 valve (2v per cyl), solid lifter camshaft	24 valve (4v per cyl), solid lifter camshaft	24 valve (4v per cyl), solid lifter camshaft
Injection System:	Bosch VE injection pump (89-93), Bosch P7100 injection pump (94-98).	Electronically controlled Bosch VP44 injection pump, Bosch high pressure common rail system for 2003.	Electronically controlled Bosch high pressure common rail.
Oil Capacity:	11 quarts	10 quarts	12 quarts
Peak Horsepower:	160 - 215 HP @ 2,500 RPM	235 - 325 HP @ 2,900 RPM	350 HP @ 3,013 RPM
Peak Torque:	400 - 440 lb-ft @ 1,600 RPM	460 - 610 lb-ft @ 1,600 RPM	800 lb-ft @ 1,600 RPM w/auto trans (current)

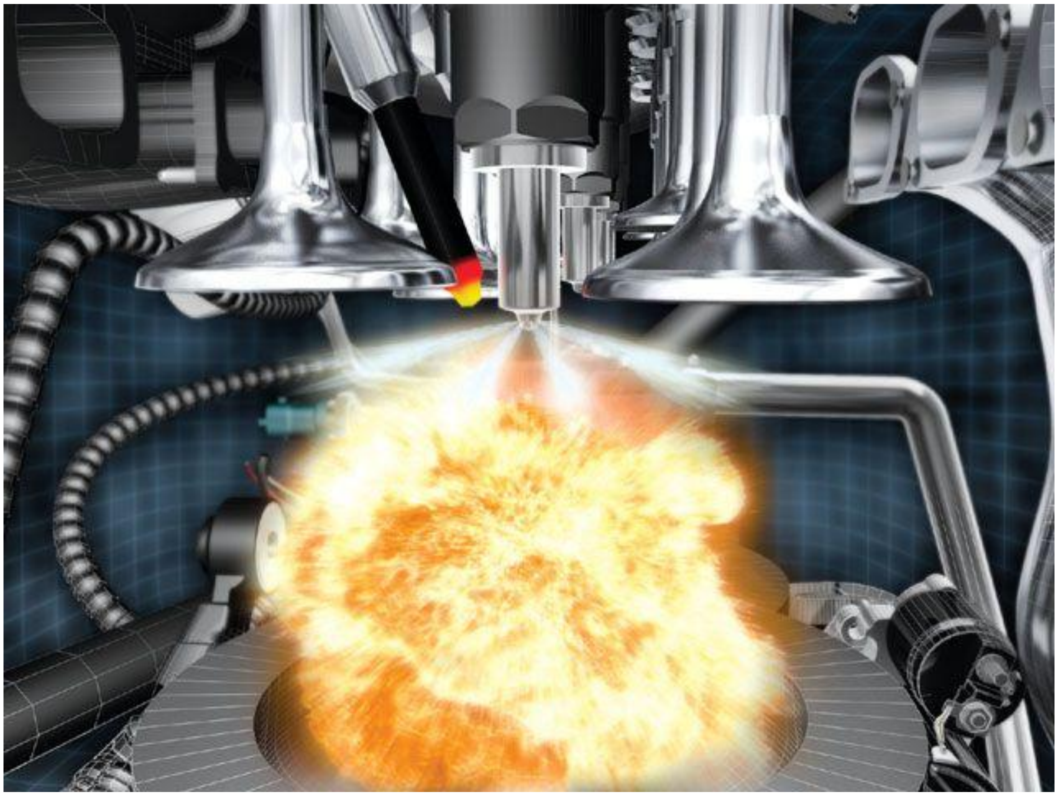
*High output version has a compression ratio of 17.2:1.

Diesel Fuel:

Diesel is a heavier fuel than gasoline. It contains more carbon atoms in longer chains than gasoline (technically, gasoline is typically C_9H_{20}, while diesel fuel is typically $C_{14}H_{30}$). Because it is heavier, it is more stable than gasoline and vaporizes at a higher temperature than gasoline. It also vaporizes much slower than gasoline which makes it burn slower. This requires diesel to be at a higher temperature to ignite. Gasoline can start to burn at temperatures of -40° F while diesel requires a temperature of at least 143° F!

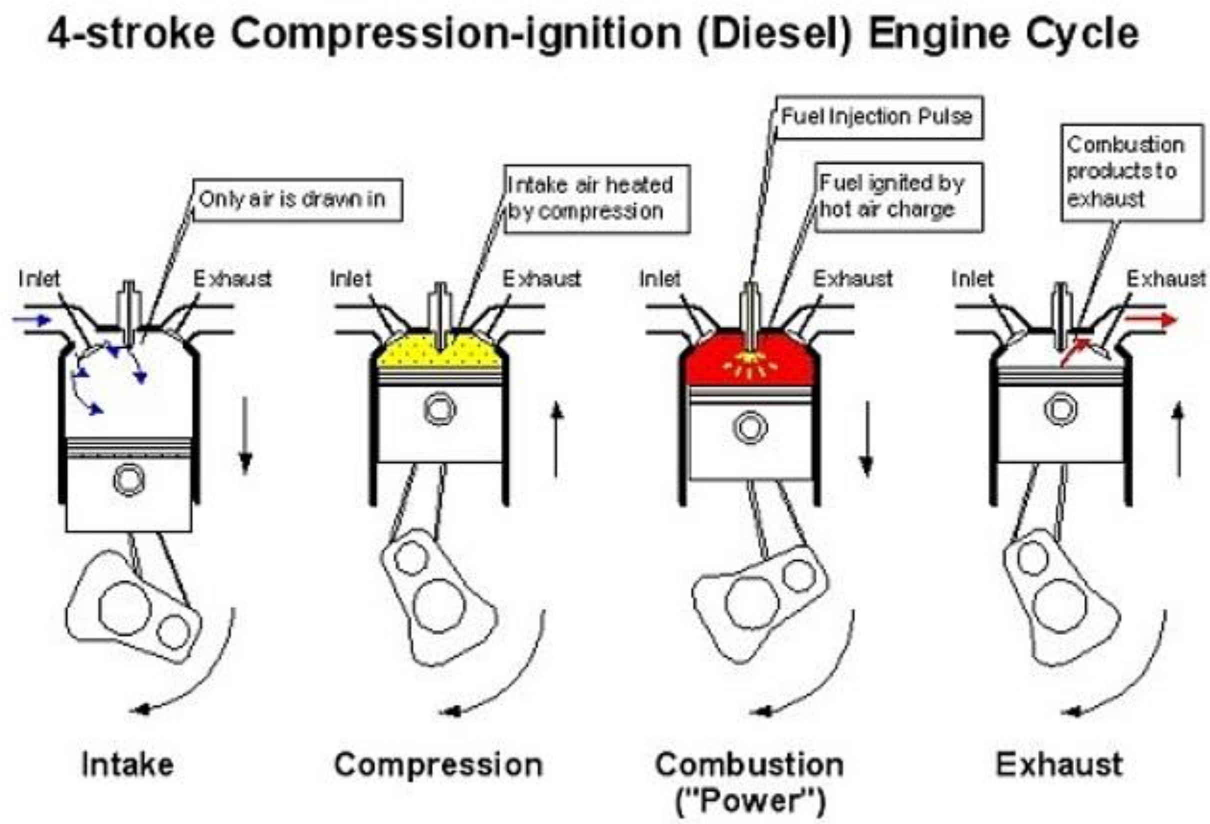
Diesel burns slower than gasoline, which allows it to produce a steady pressure on the piston for longer time. Consequently, diesel can be ignited spontaneously when it reaches the higher temperature. Diesel needs a temperature of 410° F to ignite spontaneously but will ignite or burn at a much lower temperature of 143° F. Consequently, diesel cannot be injected into the combustion chamber until the correct temperature is reached, or else it will ignite too soon. To reach the required temperature, air in the combustion chamber must be compressed more than in a gasoline engine, and because there is no fuel in the combustion chamber, the intake charge can be compressed without pre-ignition. A gasoline engine will have a higher compressions ratio than a diesel engine It is the; higher compression ratio, the higher vaporization point, the slower burning rate, the fact that diesel has about 17% more energy density than gasoline, that makes diesel much more efficient than gasoline.

Compression Ignition Engine:



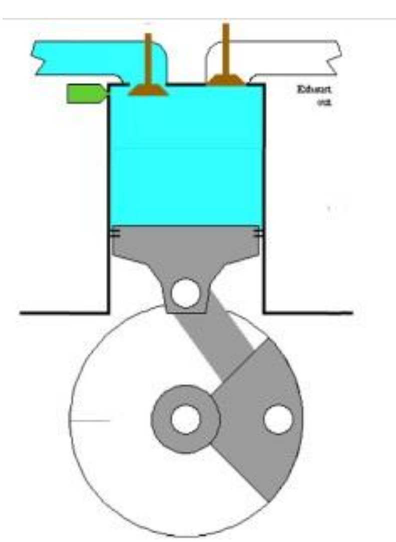
Diesel engines are classified as compression ignition engines because they don't require a spark to ignite the air/fuel mixture.

High compression, anywhere between 400-450 psi, in the cylinder superheats the air that is drawn into the cylinder. Through correct timing, fuel is injected into the cylinder and mixes with the air and ignites.

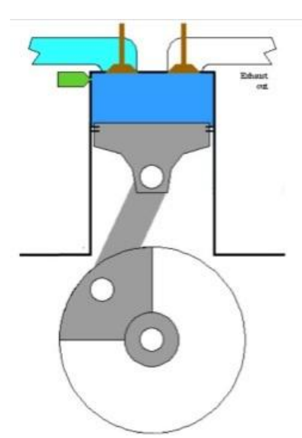


Four strokes of the diesel engine:

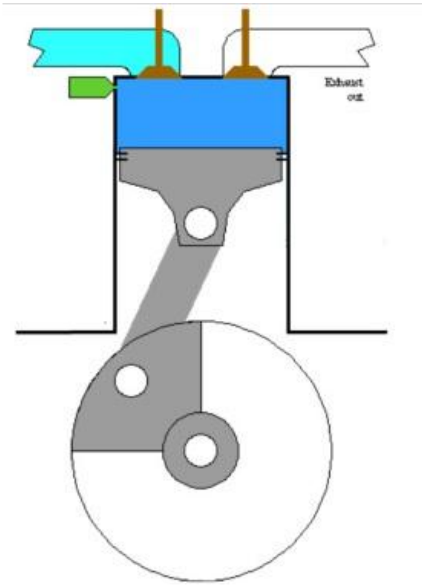
With gas engines it is the spark that is timed to ignite the air/fuel mixture. Injecting fuel into the cylinder is what is timed on the diesel engine. It is a four cycle engine. A cycle is a recurring sequence of events. The diesel cycle is described by the four strokes the pistons make as the engine is turned through two revolutions. The complete cycle of the diesel engine is 720 crankshaft rotations.



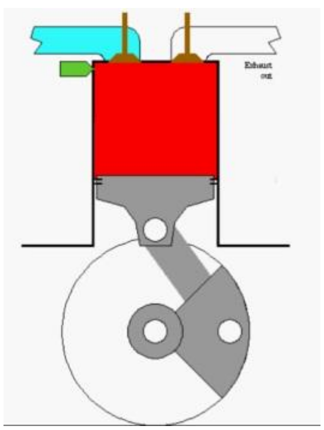
1. Intake: Only air is drawn into the cylinder on the intake stroke.



2. Compression: This description is of an ideal engine and not is what happens in a real world engine that isn't 100% efficient. As the piston starts upward, the intake valve closes and the air is at normal pressure. At this point the air charge is at

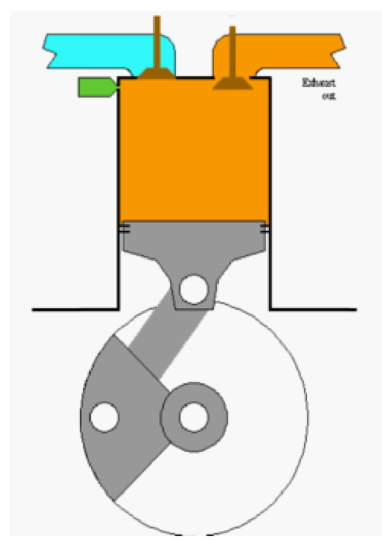


ambient air temperature (close to it). When the piston is half way up its stroke (cylinder volume halved) the temperature doubles and pressure increases. When the piston has moves up to halve the cylinder volume again, the temperature doubles again. At this point the pressure is increasing further. Every time the cylinder volume is halved, the temperature doubles.



Injection of the fuel is nominally before top dead center. The exact specification differs with engines and model years. The fuel must have time to completely atomize and mixed with the air to be ready to burn.

3. Power: The injection of the fuel is timed like spark in a gas engine, and mixes with the air. The heat ignites the air/fuel mixture.



4. Exhaust: The burnt gasses are exhausted.

Fuel fundamentals:

Diesel fuel has high energy content. It is available in two basic grade, number 1 and number 2.

Properties of diesel fuel:

The heat value determines how much power it will produce when it is burned. A calorimeter measures the heat value. The unit of measurement for the heat value is British thermal unit **(**BTU).1 BTU is approximately the amount of energy needed to heat 1 pound of water from 39 to 40°F. Diesel fuel (139,00BTUs) has a greater BTU rating than gasoline (124,500BTUs)

Cetane number:

Because diesels rely on compression ignition the fuel must be able to auto-ignite--and generally, the quicker the better. A higher Cetane number means a shorter ignition delay time and more complete combustion of the fuel charge in the combustion chamber. This, of course, translates into a smoother running, better performing engine with more power and fewer harmful emissions.

Fuel viscosity:

Viscosity is a measurement of resistance to flow. Viscosity increases with lower temperatures and decreases with higher temperatures. Low viscosity produces the fine mist which is required to atomize the fuel for combustion. A higher viscosity doesn't finely atomize the fuel causing the fuel not to ignite easily.

Sulfur content:

Sulfur in fuel cause accelerated engine wear. The wear is promoted by the corrosive effect of hydrogen sulfide in the fuel and sulfur dioxide or sulfur trioxide formed during the combustion process. Too little sulfur in the fuel is a problem because fuel leaks may occur because low sulfur fuel has lack lubrication characteristics. The fuel leaks will be where rubber seals are located.

Flash point:

It is the temperature to which the fuel must be heated before vapor is produced for ignition can occur.

Fuel Quality and Condition:

An important consideration is the quality of the fuel. Diesel accumulates water in fuel system because hot fuel is returned to the fuel tank and causes;

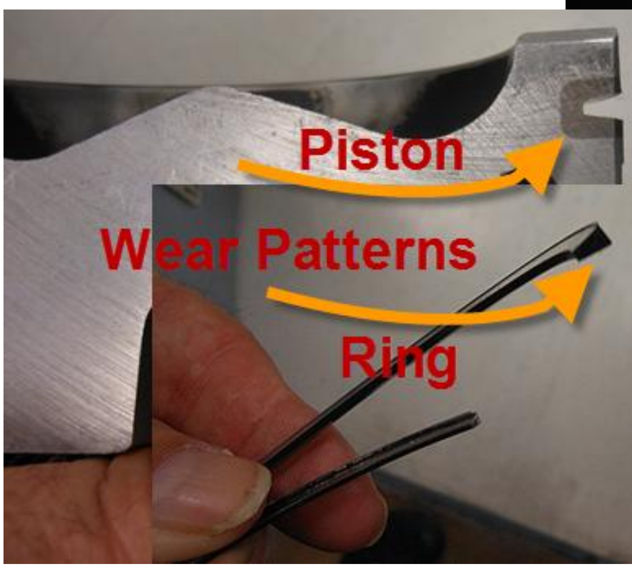
Condensation

Organic contamination (slime)

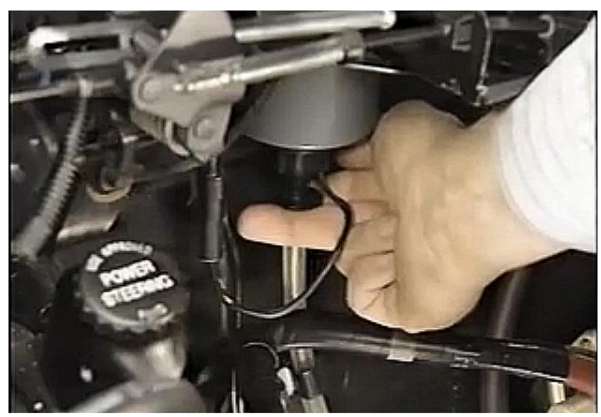
Gels at lower temperature (Fuel Waxing)

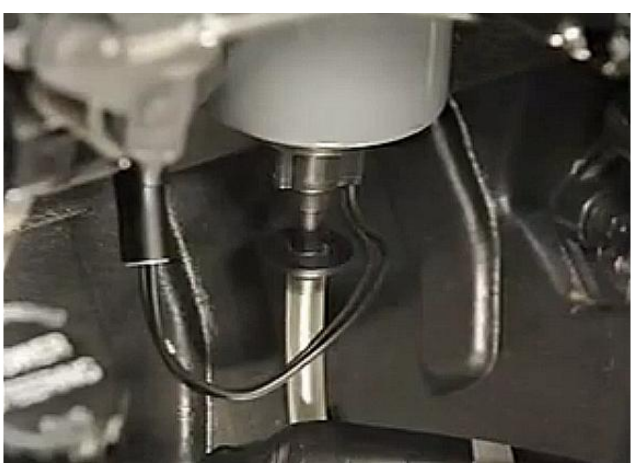
Because of the close tolerances in the fuel system fuel problems can and will cause many different problems up to a no start

This ring and piston shows the damage that contamination in the fuel can cause. The ring and it'd ring grove are worn in a strange shape. When the piston and ring could no longer create a seal the engine it had to be rebuilt. All because of the fuel quality was bad.



Chrysler recommends the use # 2 diesel fuel except in cold temperatures. When the average temperature is below 32°F use climatized # 2 diesel fuels which is a 50/50 blend of # 1 and # 2 diesel fuel. Follow the recommended maintenance for the fuel filter and the removable of water.





Fuel Quality and Condition:

Draining the water from the fuel filter is a necessary operation. Draining the water from the fuel/water separator at each refueling is suggested by the manufacturer using the valve at the bottom of the separator. Or drain the water when the water in fuel lamp appears on the dash.

Drain the water and sediment from the separator each time the fuel tank is filled.

Switch the ignition to get the 30 second prime to build up fuel pressure and drain.

Push up on the valve until clean fuel is evident. Newer vehicles don’t have a push valve, they have a threaded valve that has a, loosen and tighten operation.

Shut off the engine. Manually open the drain valve until clear fuel is visible.

Top Load Filter Type (1)

Pull up on the drain valve lever until fluid drains out of the drain tube. If nothing comes out of the drain tube, lift the lever several times to break the vacuum seal.

Spin-on Filter Type (2)

Lift up on the drain valve until fluid drains out of the drain tube. When finished, make sure that the valve closes.

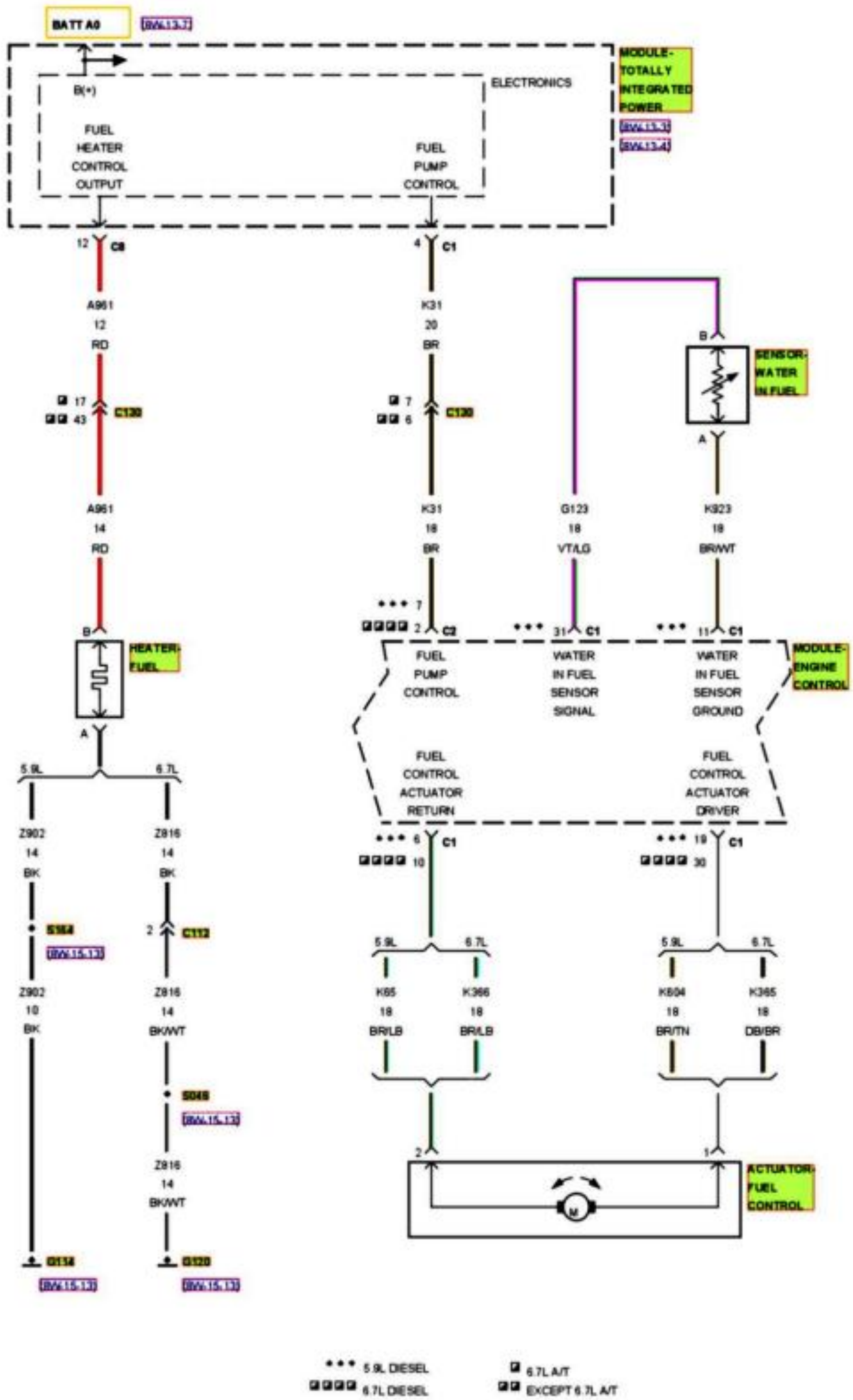
You may need to move the lever back and forth several times to get fluid to come out.

When you drain water from your fuel, a small amount of fuel will drain with it, meaning you must dispose of the water properly.

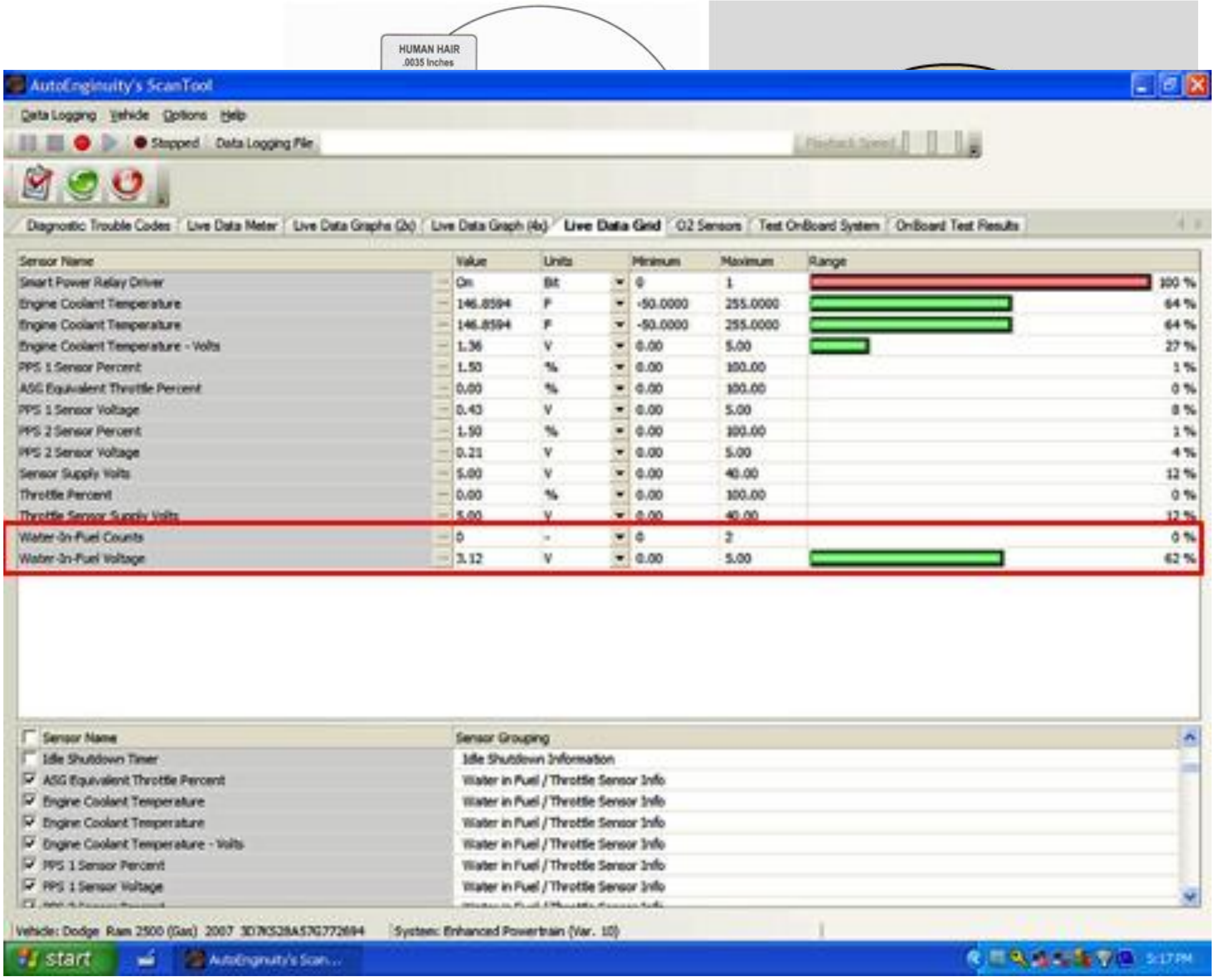
Note: Many owners choose not to drain the water on any regular schedule. They believe that if water accumulates the warning lamp will alert them and it can then be drained. You're more than welcome to explain it to them but think of it as more work for your shop if they don't.

Water in the fuel (WIF) sensor:

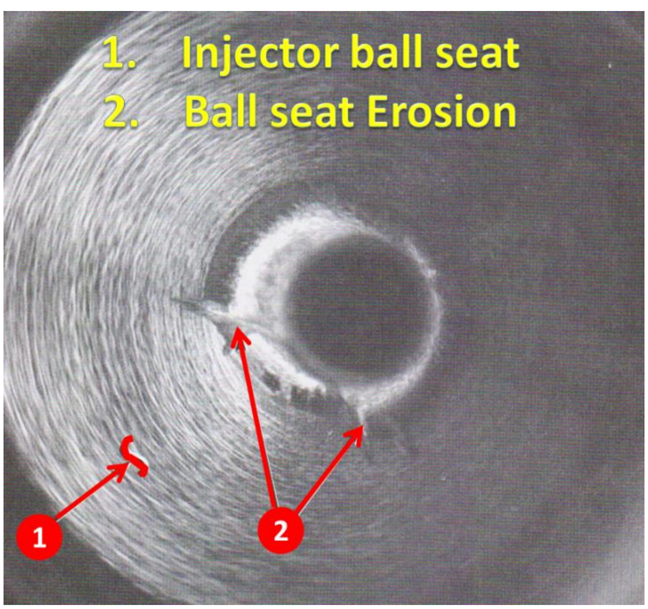
The lamp has a 3 second bulb check at ignition on. If it remains on longer than 3 seconds there is water in the fuel.


BATT A0
MODULE-TOTALLY INTEGRATED POWER
ELECTRONICS
B(+)
FUEL HEATER CONTROL OUTPUT
FUEL PUMP CONTROL
C8
C1
A961 12 RD
K31 20 BR
C130
A961 14 RD
K31 18 BR
G123 18 VT/LG
K923 18 BR/WT
SENSOR-WATER IN FUEL
HEATER-FUEL
C2
C1
MODULE-ENGINE CONTROL
FUEL PUMP CONTROL
WATER IN FUEL SENSOR SIGNAL
WATER IN FUEL SENSOR GROUND
FUEL CONTROL ACTUATOR RETURN
FUEL CONTROL ACTUATOR DRIVER
5.9L
6.7L
Z902 14 BK
Z816 14 BK
Z902 10 BK
Z816 14 BK/WT
K65 18 BR/LB
K366 18 BR/LB
K604 18 BR/TN
K365 18 DB/BR
ACTUATOR-FUEL CONTROL
M
5.9L DIESEL
6.7L DIESEL
6.7L A/T
EXCEPT 6.7L A/T

The sensor sends an input to the Engine Control Module (ECM) when it senses water in the fuel filter/water separator. As the water level in the filter/separator increases, the resistance across the WIF sensor decreases. This decrease in resistance is sent as a signal to the ECM and compared to a high water standard value. Once the value reaches 30 to 40 KΩ, the ECM will activate the water-in-fuel warning lamp through CCD bus circuits. The WIF sensor uses the difference of electrical conductivity through water and diesel fuel by 2 electrodes.



The fuel system components are manufactured to very close tolerances and operate under high pressure and high temperature. The components are susceptible to contamination with the injectors being the most susceptible to damage from small debris particles



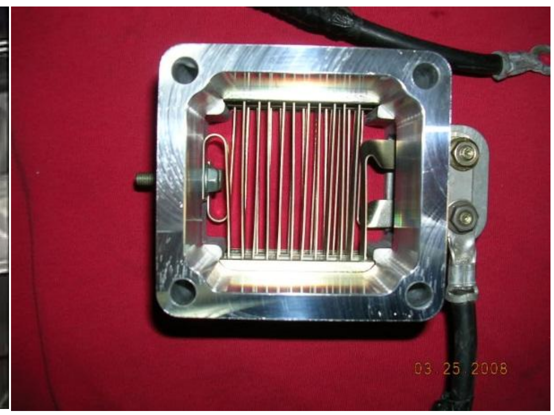
Fuel Contamination is Sediment / debris: dust, dirt, rust, or other metallic particles or any other non-organic solids. Water contamination emulsified or becomes a solid (most common). Organic fungus and bacteria that live in and feeds on diesel fuel is also a common contamination problem.

The fuel filter has two stages. The first stage is a 10 micron filter for water scavenging. The second is a 5 micron filter to capture any debris. Fuel enters the filter assembly and flow through both filtering elements from the outside to the inside where it enters the fuel outlet.

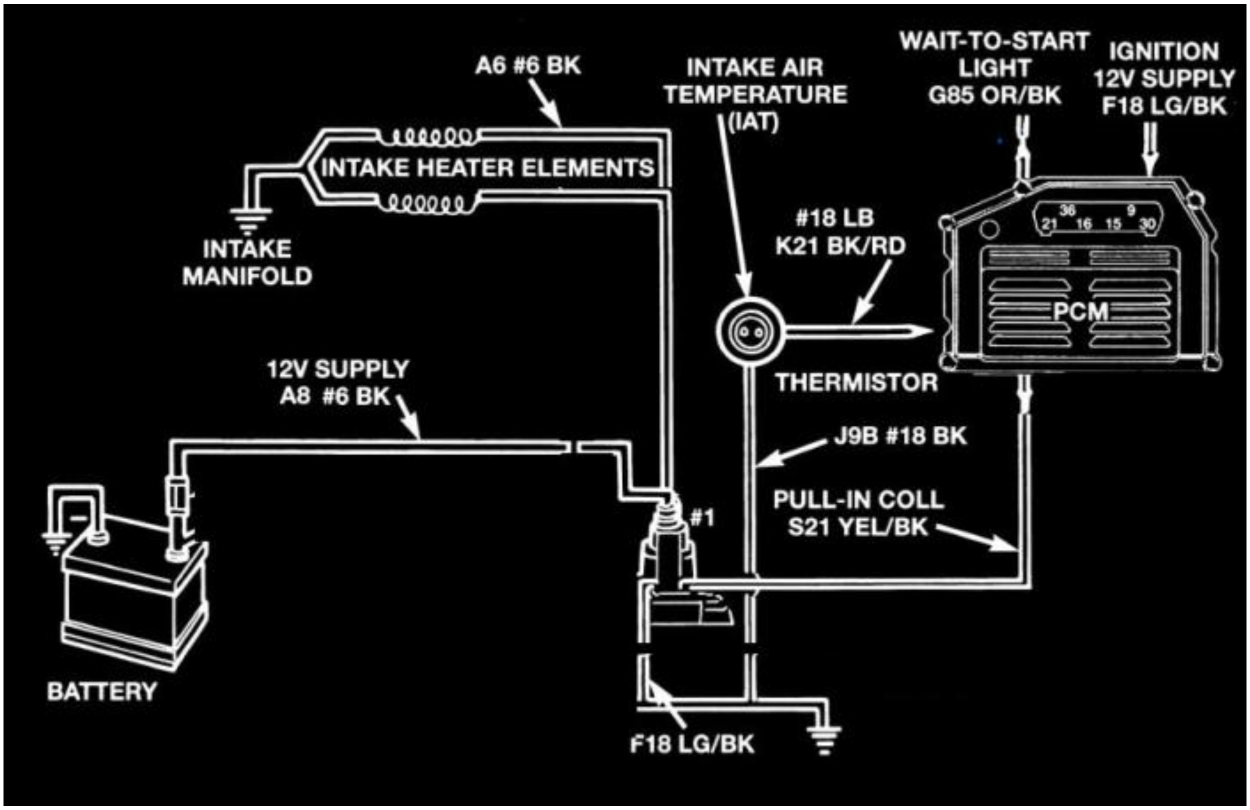
Air Intake Heater:

There is one or two air intake air heaters used to pre-heat the intake air for starting. The heaters are simple grid type heaters. The amount of time the heaters are on is based from the inlet air temperature sensor.

At temperatures below 60°F depress the accelerator pedal half way. And wait until the wait to start lamp to go out, before cranking the engine. This allows the intake air heaters to warm the incoming air. The heaters will continue to operate for an equal amount of time after the engine starts.



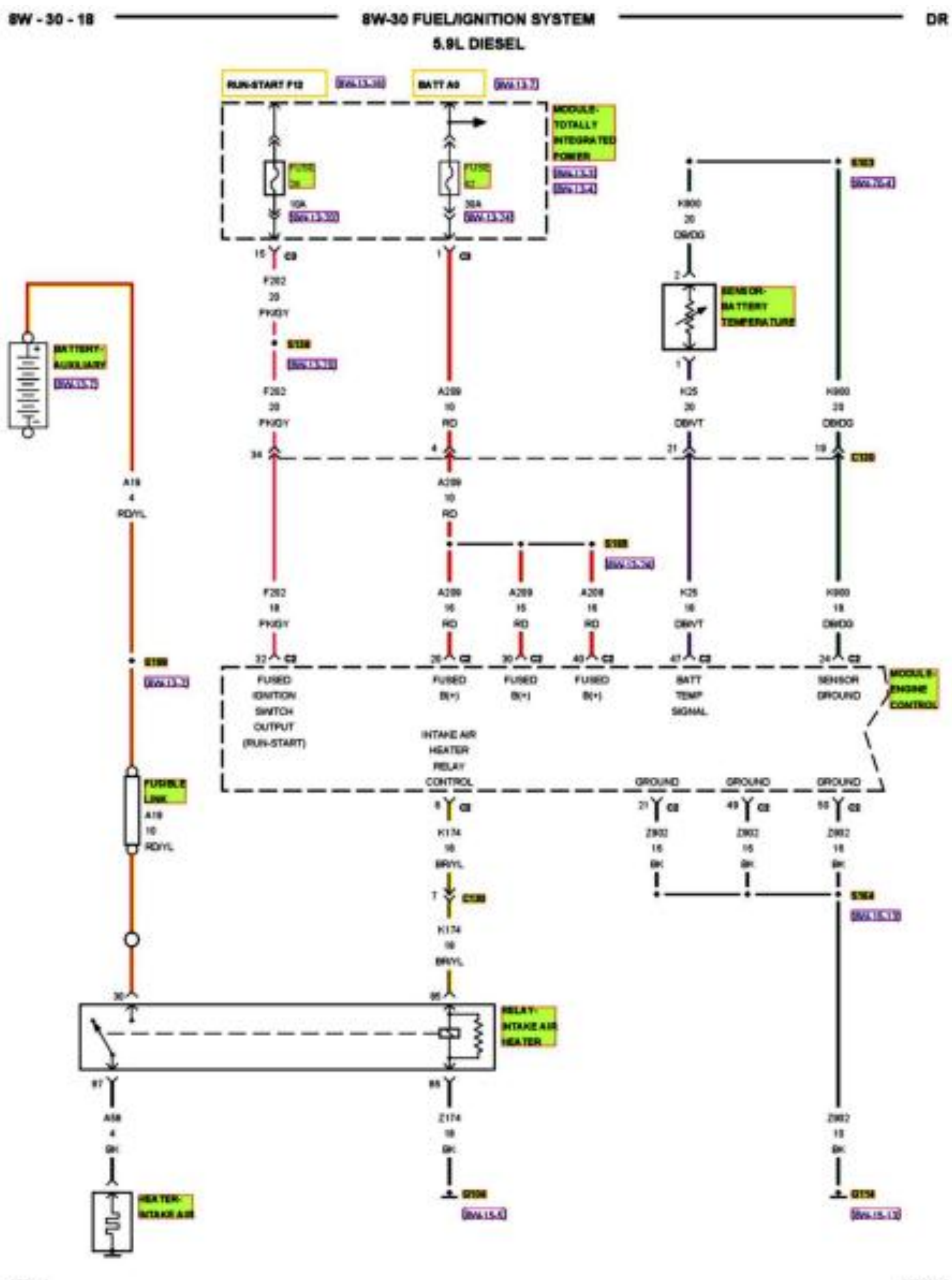
The intake manifold air heater element assembly is located in the top of the intake manifold. Electrical supply for the air heater element is controlled by the Engine Control Module (ECM) through the air heater relay.



WAIT-TO-START LAMP TURN-ON TIMES

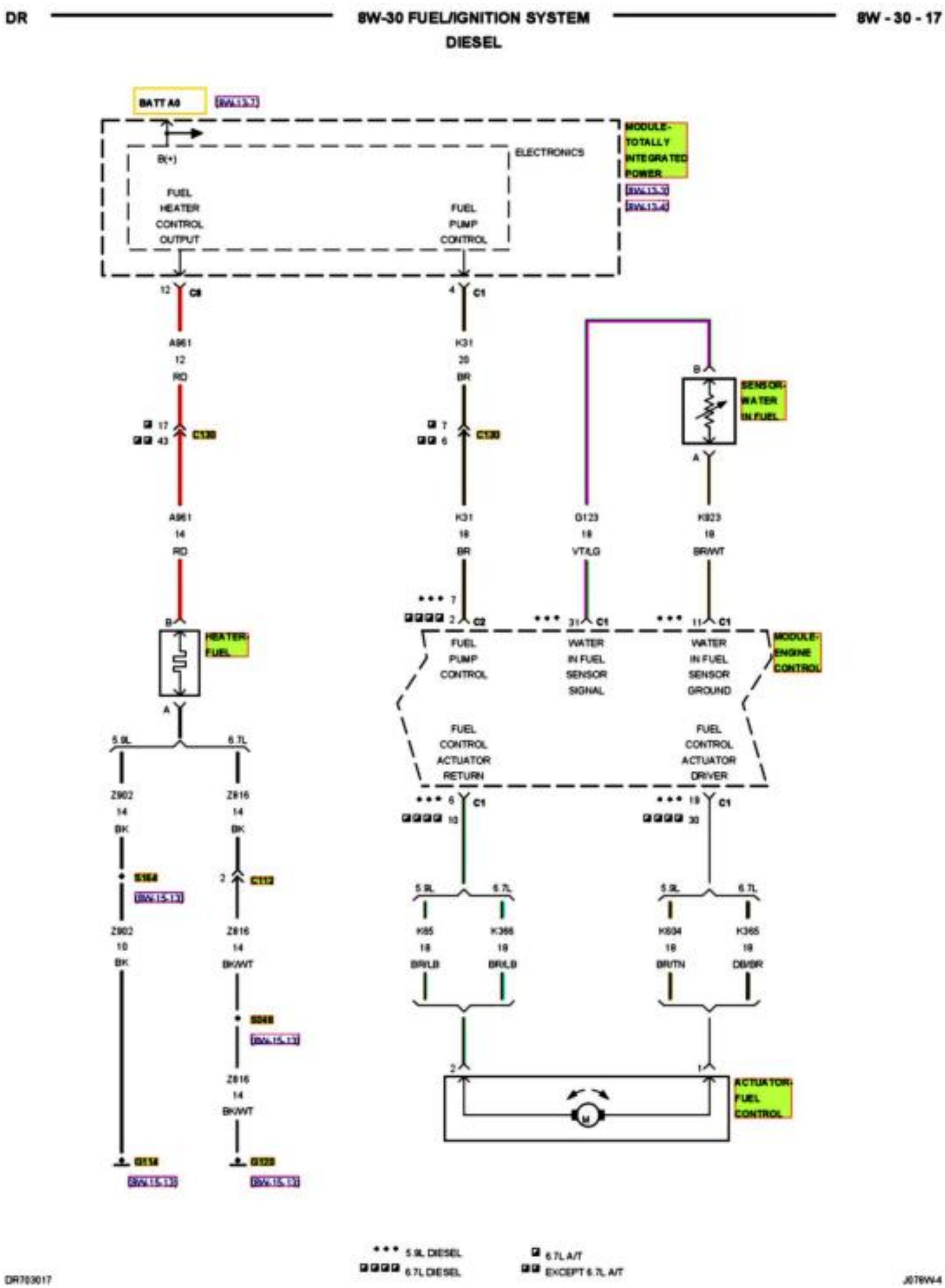
PRE-HEAT TIME WITH INTAKE MANIFOLD TEMPERATURE AT: (IN DEGREES° F)	PRE-HEAT TIME WITH BARO AT: (IN. HG.)				
	19.99 IN. HG	23.00 IN. HG.	25.00 IN. HG.	26.99 IN.HG.	29.00 IN. HG.
-40.09° F	30.0 seconds	30.0 seconds	30.0 seconds	30.0 seconds	30.0 seconds
-20.00° F	30.0 seconds	30.0 seconds	30.0 seconds	30.0 seconds	30.0 seconds
0.00° F	30.0 seconds	30.0 seconds	30.0 seconds	30.0 seconds	30.0 seconds
0.09° F	15.0 seconds	15.0 seconds	15.0 seconds	15.0 seconds	15.0 seconds
15.00° F	15.0 seconds	15.0 seconds	15.0 seconds	15.0 seconds	15.0 seconds
15.09° F	10.0 seconds	10.0 seconds	10.0 seconds	10.0 seconds	10.0 seconds
32.00° F	10.0 seconds	10.0 seconds	10.0 seconds	10.0 seconds	10.0 seconds
50.00° F	10.0 seconds	10.0 seconds	10.0 seconds	10.0 seconds	10.0 seconds
66.00° F	10.0 seconds	10.0 seconds	10.0 seconds	10.0 seconds	10.0 seconds
66.09° F	00.0 seconds	00.0 seconds	00.0 seconds	00.0 seconds	00.0 seconds

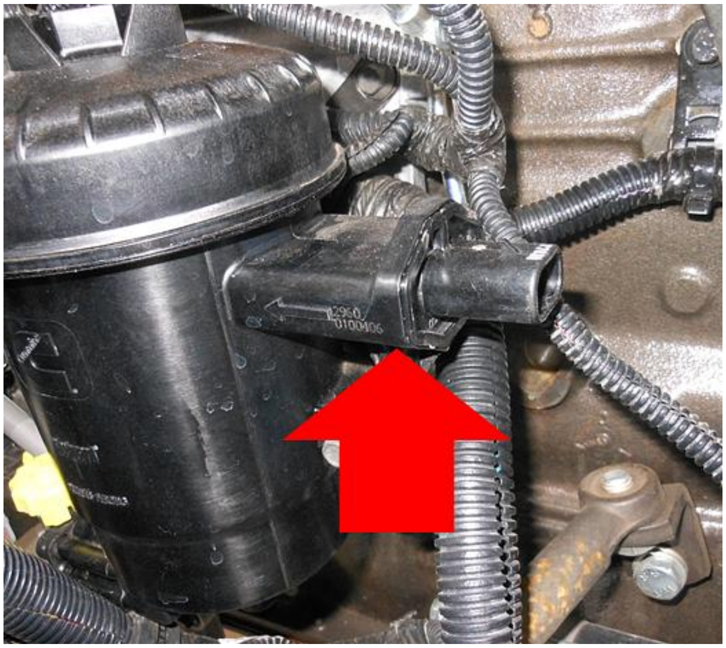
The chart show the time required to heat air at certain starting temperatures. The times are in a MAP which breaks down to 30, 15, 10, and 0 seconds. Somewhere above 60°F the wait drops to 0 seconds.



The PCM supplies a voltage to the air intake heater relay which closes it and battery power flows through the heater element. Remember that the current will continue to flow the same amount of time after the engine starts. Cycling the ignition on and off too frequency can damage the air intake heaters.

If you need to cycle the ignition on and off frequently pull the fuse. Chrysler doesn't recommend using starting fluid.





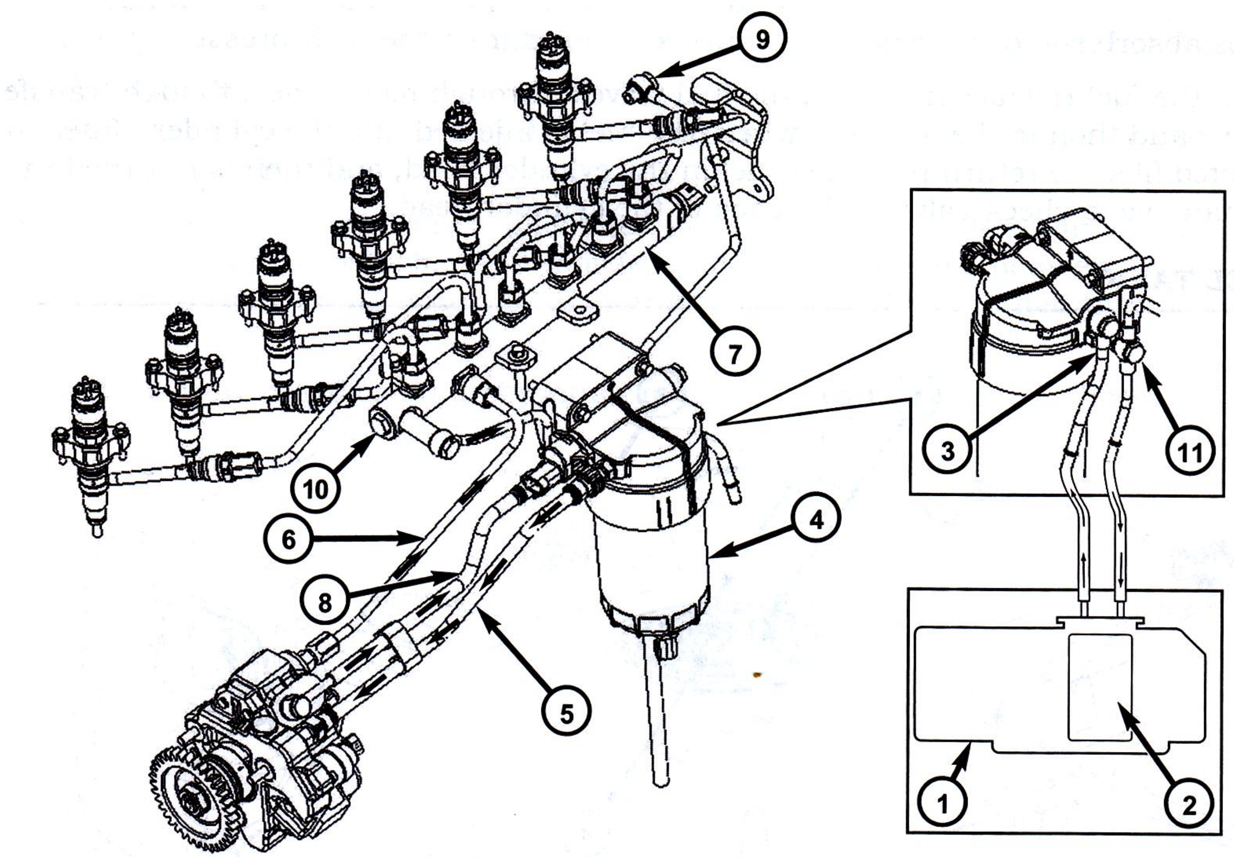
Fuel Heater:

The fuel heater is located in the top of the fuel/water separator filter adapter. It is used to prevent the diesel fuel from waxing inside the filter assembly. The heater has a built-in temperature sensor that monitors the fuel temperature. The heater is turned ON if the fuel temperature is less than or equal to 43°F, and is turned OFF if the fuel temperature is greater than or equal to 75°F. If the ambient air temperature is less than 32°F the PCM turns both heaters on.

The Fuel System:

Warning about fuel pressure:

High-pressure fuel lines deliver diesel fuel under extreme pressure from the injection pump to the fuel injectors. This may be as high as 180,000 kpa (26,107 psi). Use extreme caution when inspecting for high-pressure fuel leaks. High fuel injection pressure can cause personal injury if contact is made with the skin.



Different main components make up the fuel system:

- Fuel transfer (lift) pump mechanical or electric.
- Fuel pump (gear pump) that is attached to the fuel injection pump
- High pressure fuel injection pump
- Fuel injection rail
- Fuel injector
- Also to be considered as part of the overall fuel system are:
  - Accelerator Pedal
  - Air Cleaner Housing/Element
  - Check Valve Banjo Fitting at Rear of Cylinder Head
  - Fuel Connector Tubes
  - Fuel Drain Manifold (passage)
  - Fuel Drain Valve (at filter)
  - Fuel Filter/Water Separator
  - Fuel Heater
  - Fuel Heater Relay
  - Fuel Transfer Pump Relay
  - Fuel Level (gauge) Sending Unit
  - Fuel Pressure Limiting Valve

• Fuel Tank

• Fuel Tank Module (containing a fuel gauge sending unit, separate fuel filter located at bottom of tank module, and fuel transfer pump)

• High-Pressure Fuel Injector Lines

• In-Tank Fuel Filter (at bottom of fuel tank module)

• Low-Pressure Fuel Supply Lines

• Low-Pressure Fuel Return Lines

• Overflow Valve

• Accelerator Pedal Position Sensor (APPS) Located in Cab

• Water Draining (maintenance)

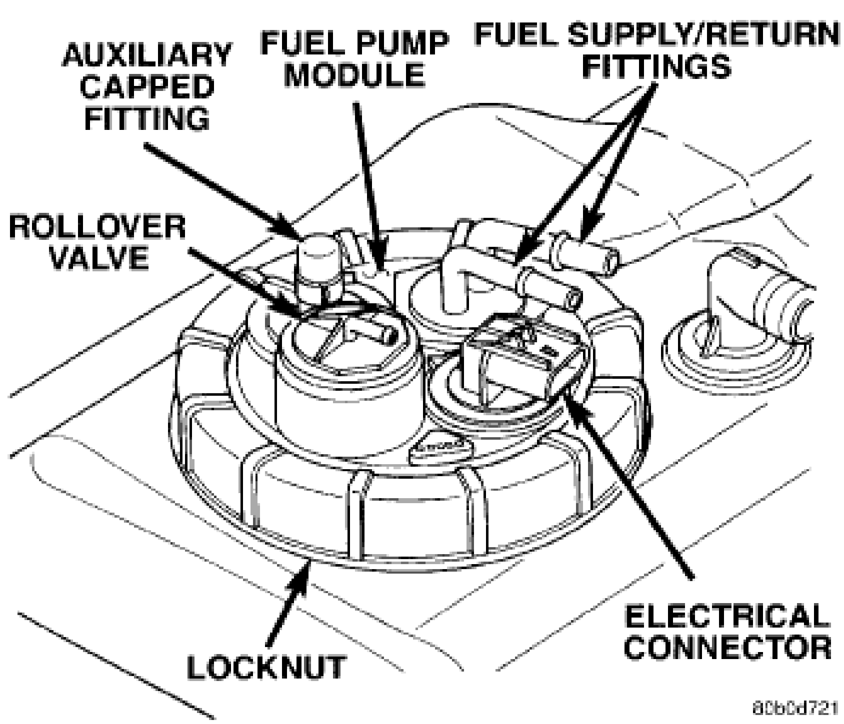
• Water-In-Fuel (WIF) Sensor

The fuel system used on the Cummins engine is an electronically controlled, HPCR (High-Pressure Common Rail) system. The HPCR system consists of five main components:

- Electric fuel transfer (lift) pump located in the fuel tank
  Fuel pump (gear pump) that is attached to the fuel injection pump
- High pressure fuel injection pump
- Fuel injection rail
- Fuel injector

Fuel Transfer (lift) Pump:

The pump is used to transfer fuel from the fuel tank to the injection. The injection pump isn't designed to draw fuel from the fuel tank and deliver high pressure to the fuel rail at the same time. It can do it for a



short time but in time fails. The injection pump is designed to be fed by the lift pump for proper pressure and lubrication.

If the lift pump fails the injection pump will continue to draw fuel through the lift pump under vacuum. At first you can't tell the difference in engine operation.

Symptoms of a bad lift pump:

The first thing most drivers notice is the engines becomes hard to start. Extended crank times are often ignored until it becomes several seconds of cranking. Another symptom is the idle rpm starts to get lower.

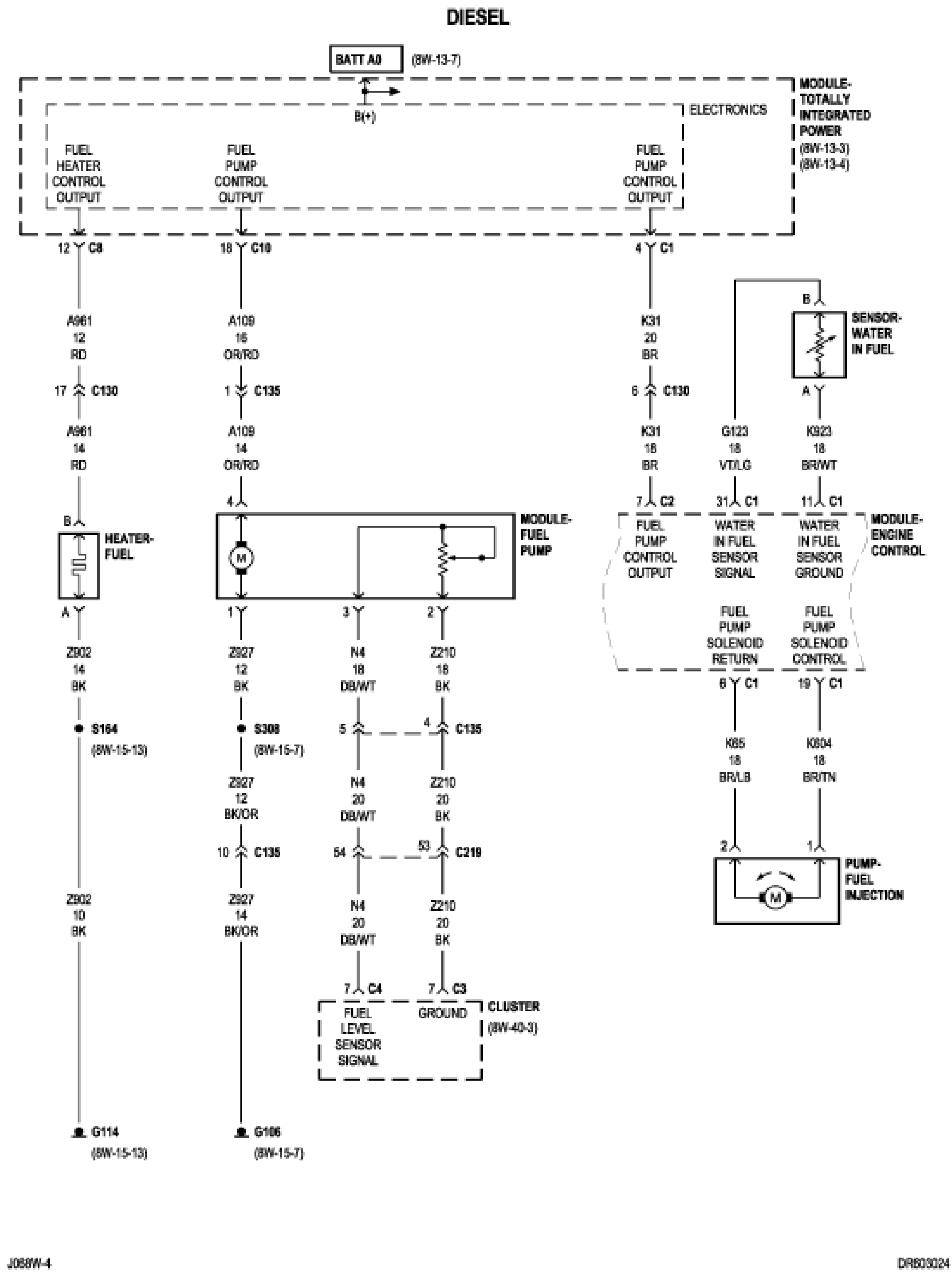
Drivers notice when the problem worsens to the point that the engine loses power. An underpowered engine is hard to ignore. Any vehicle that is used for towing gets noticed for lacking power right away.

If the problem isn't diagnosed and repaired the engine will crank but fail to start. Lift pumps on the Dodge Cummins engine have been problematic throughout the years and has changed design many times.

If you are in charge of keeping the vehicle on the road it is a good idea to install a pressure gauge or warning lamp that monitors the lift pump's pressure. Normal pressure is 10 to 15psi at idle and doesn't drop under 5 psi at wide open throttle.

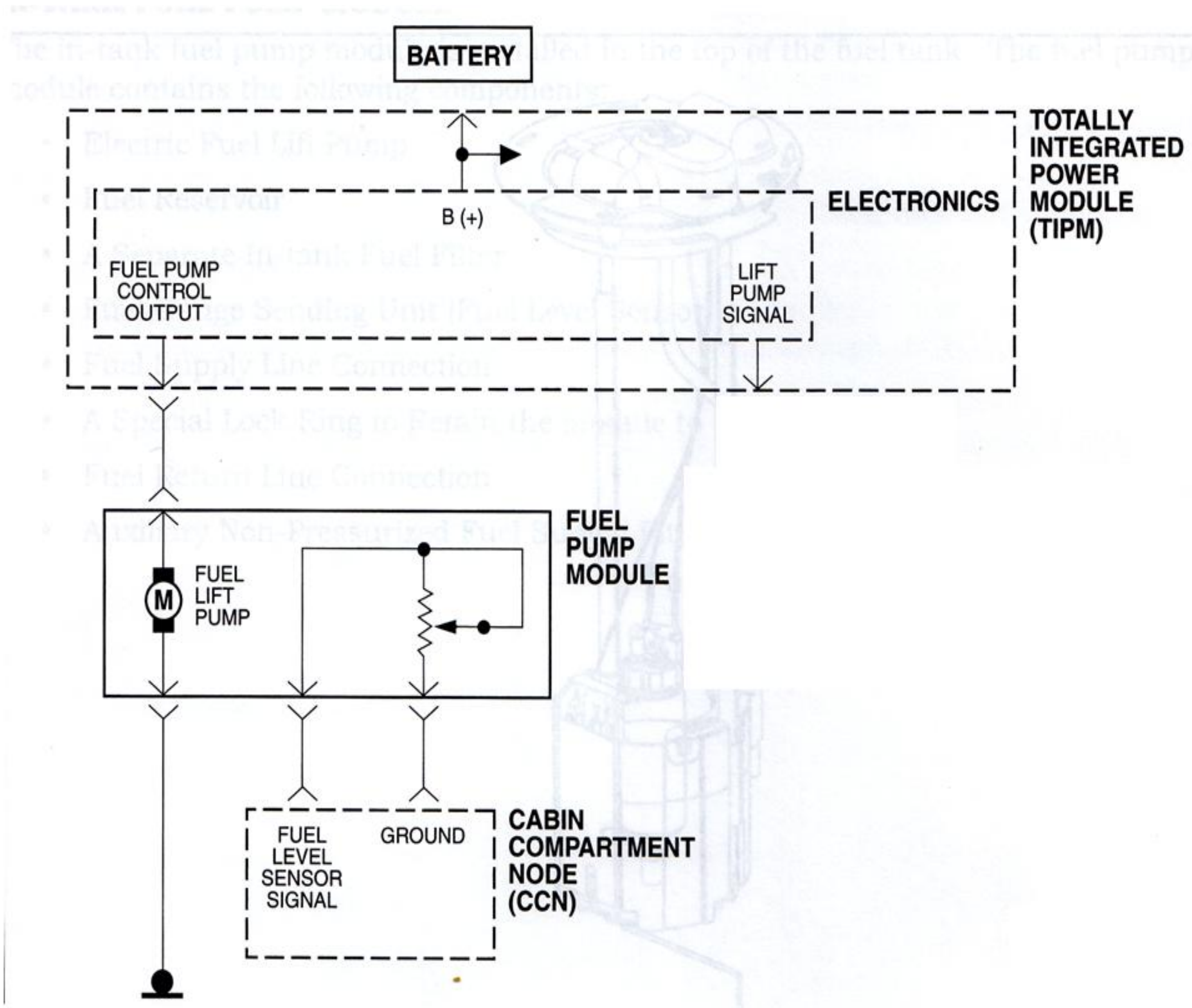
Mechanical and electrical fuel (lift) pumps:

The mechanical fuel (lift) pumps were used up to model year 1998 when they went to an electrical lift pump. In 1994 the design of the mechanical lift fuel pump was changed. They changed to an electrical lift pump in model year 1999.



The electrical lift pump is powered by ignition voltage and is controlled by the fuel control module. The pump’s maximum current draw is 5 amps.

The mechanical pump's normal output pressure is 3 to 6 psi. The electrical pump's normal pressure is 10 to 15psi at idle and doesn't drop under 5 psi at wide open throttle.



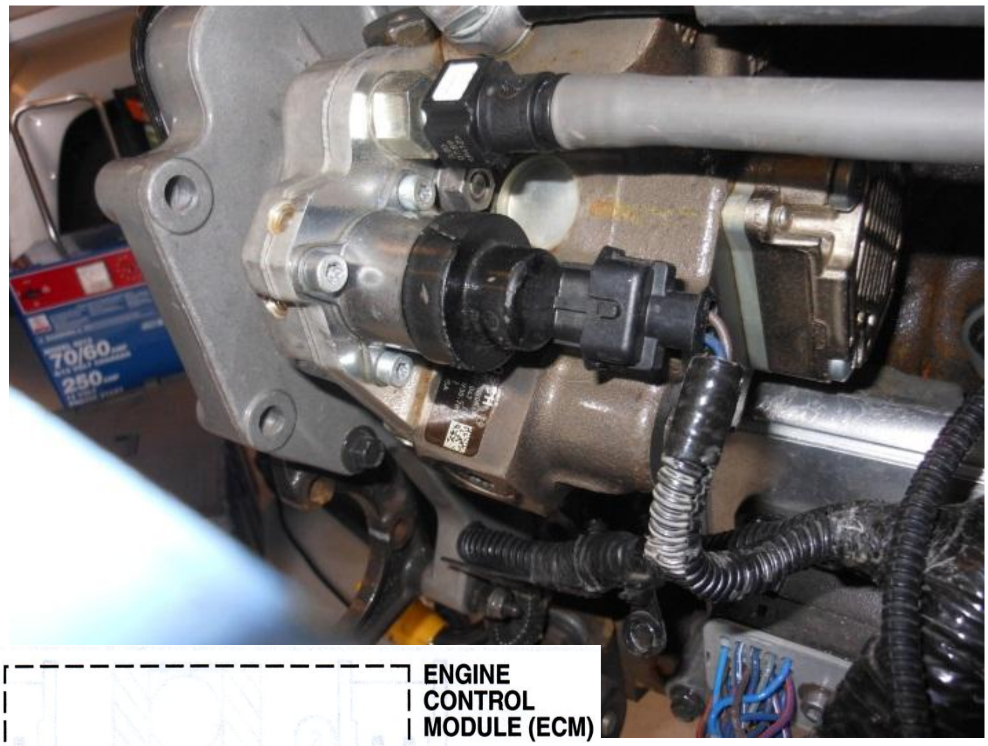
The lift pump is a part of the fuel pump module. The schematic shows that the electrical lift pump is powered by a high side driver in the Totally Integrated Power Module (TIPM).The TIPM determines when to turn the pump on from a dedicated signal from the PCM. The electric lift pump has only one mode of operation, 100% duty cycle.

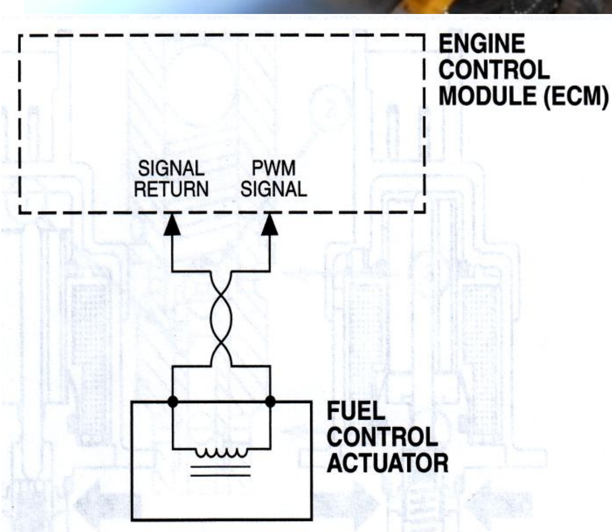
When the ignition is turned on the pump will operate at a 100% duty cycle for 25 seconds if the engine isn't started. If there is a crank but no start the pump will operate for 25 seconds. When the fuel heaters are on and the wait to start lamp is illuminated the pump will run. Whenever the engine is running the pump will run. If the engine stalls the pump stops immediately. The pump draws between 3.5 and 5.0 amps when running. The TIPM will set DTCs and store them for; fuel pump circuit too high or too low. A normal operating pump will pump more fuel than the engine needs to run under any load. Excess fuel is returned to the tank through the injector pump.

Fuel is forced through the fuel filter element then enters the high pressure fuel pump.

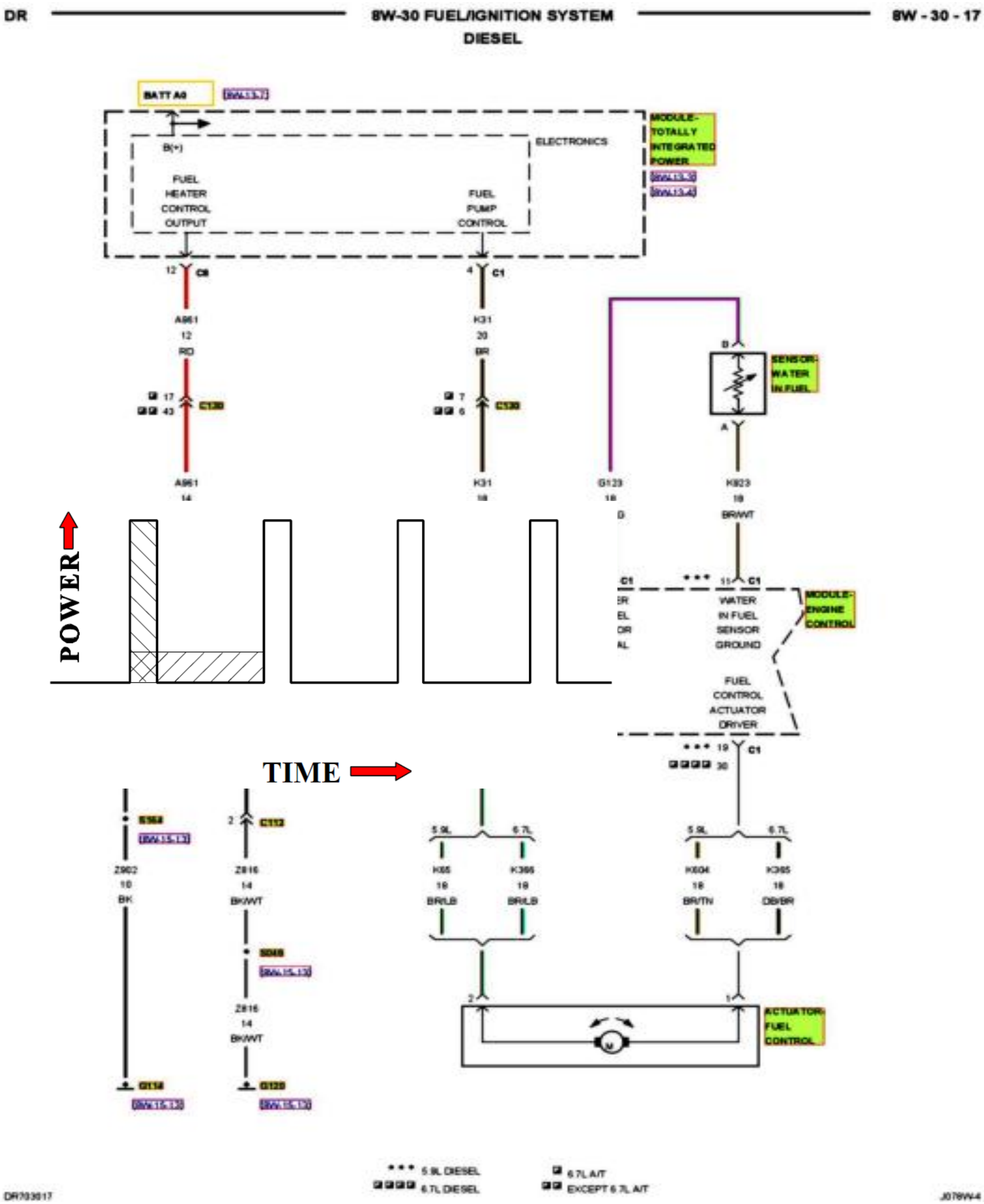
Fuel Control Actuator:

The FCA is an electronically controlled solenoid valve inside the injector pump. The PCM controls the amount of fuel that enters the high-pressure pumping chambers by opening and closing the FCA based on the fuel pressure requirement. The FPS (Fuel Pressure Sensor) on the fuel rail monitors the actual fuel pressure and provides it as an input to the PCM. When the actuator is opened, the maximum amount of fuel is being supplied to the fuel injection pump.

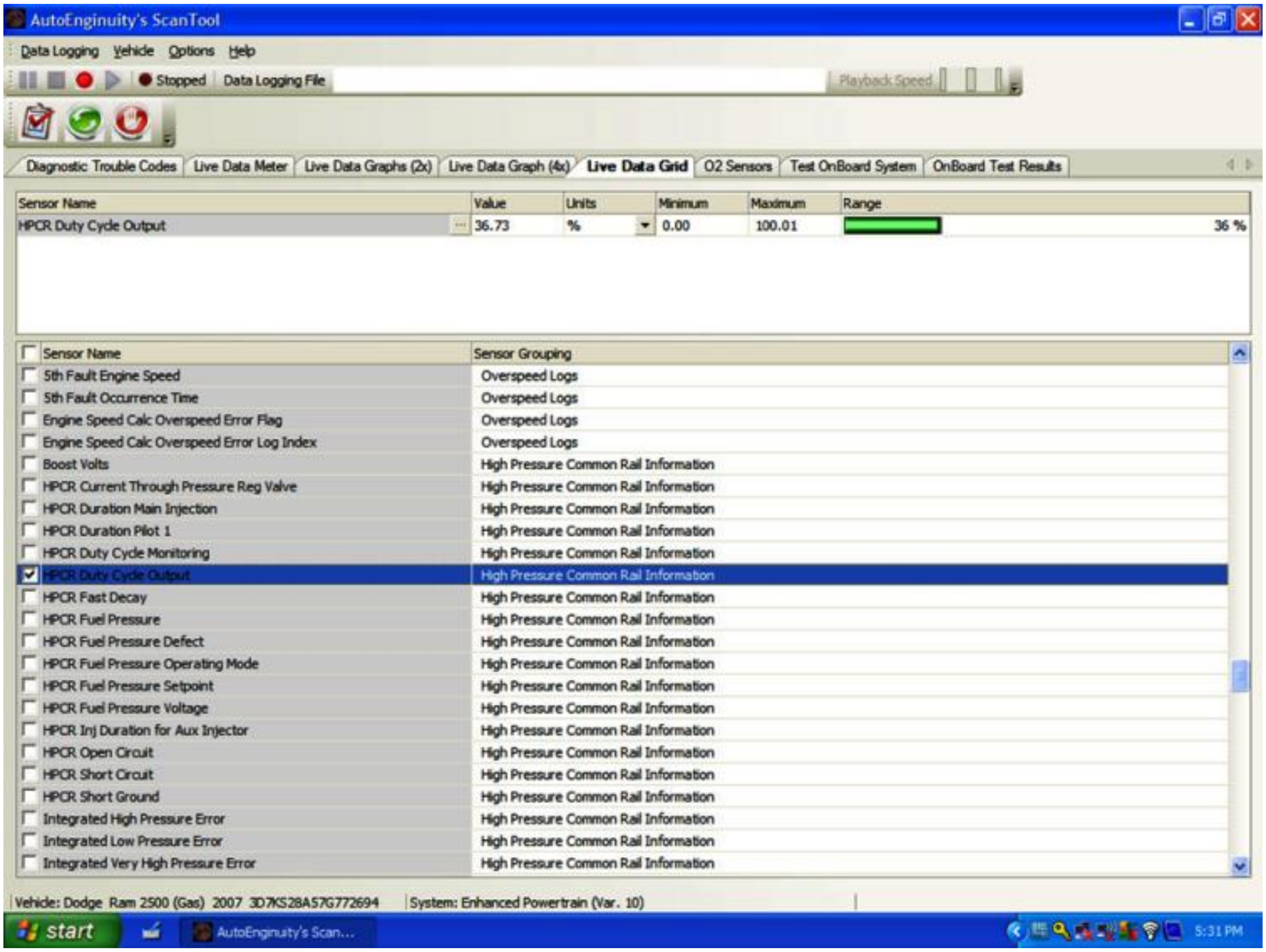




Pulse Width Modulated Signal (PWM) Duty Cycle:

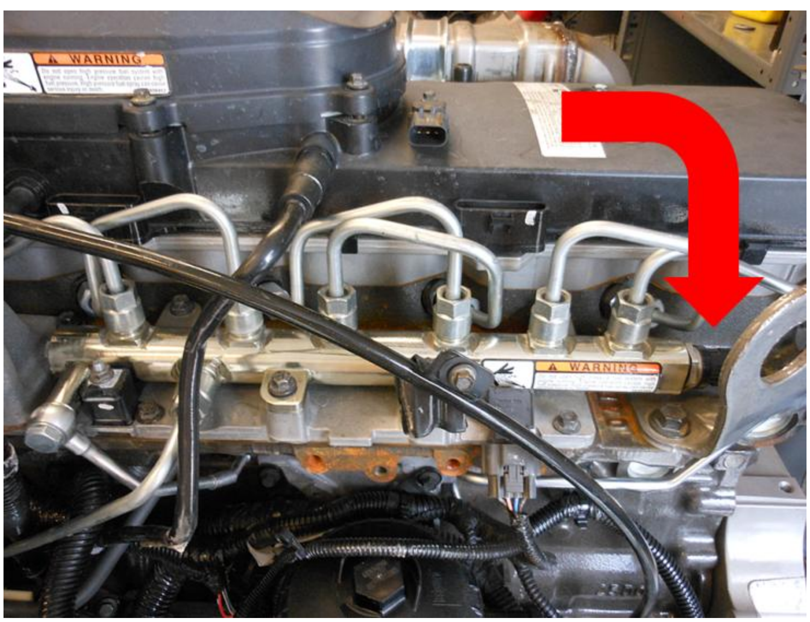


The fuel control module is controlled with a PWM duty cycle. The greater the PWM duty cycle is, the lower the fuel pressure. The lower the PWM duty cycle is, the higher the fuel pressure. If fuel pressure in

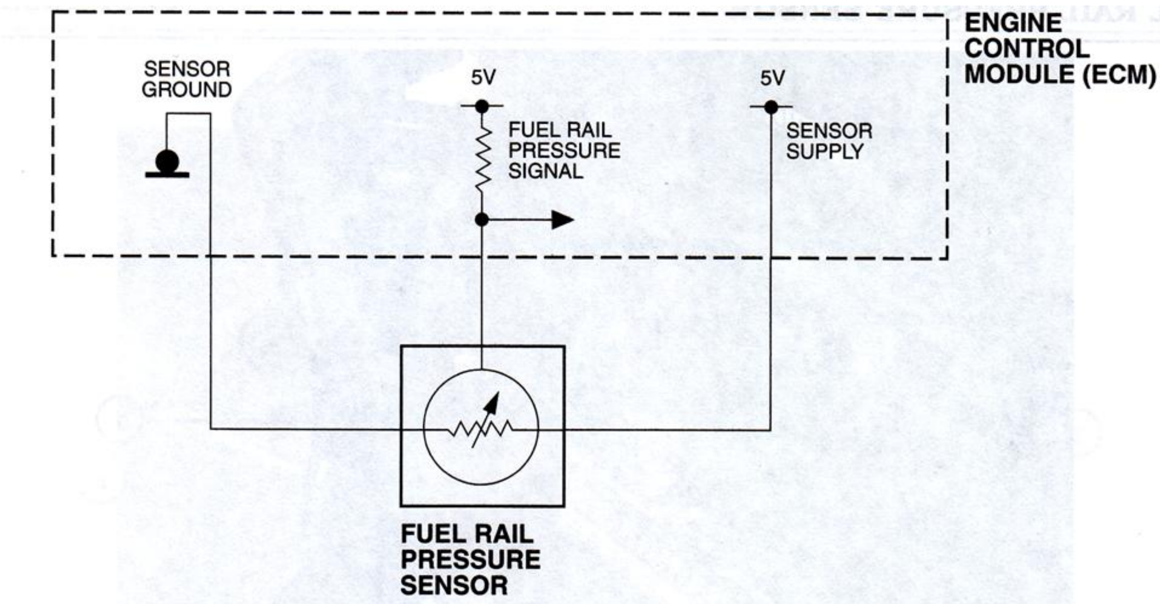


the fuel rail becomes too low the PCM commands a higher duty cycle to increase it. During engine start up the PCM commands a lower duty cycle to provide maximum fuel volume.

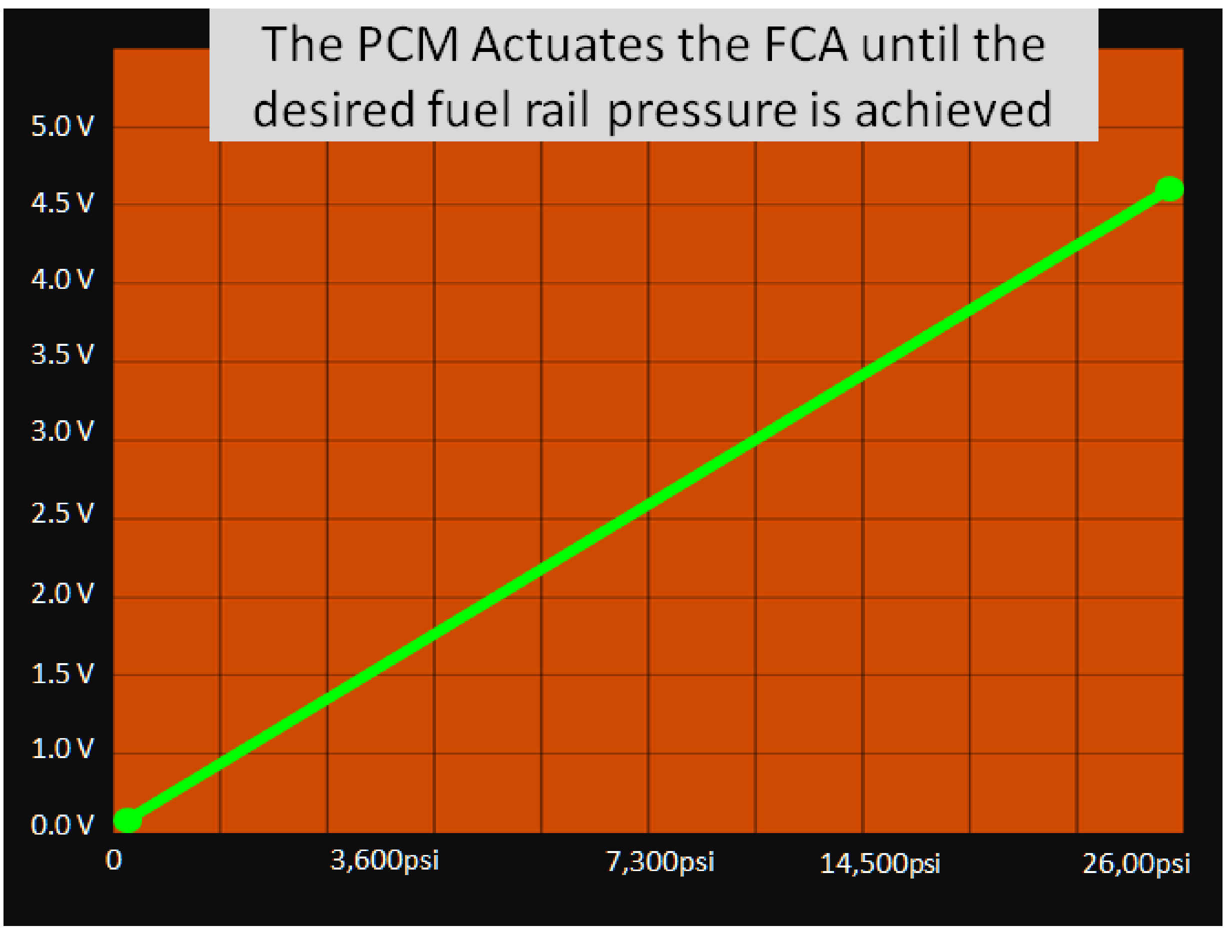
Fuel rail pressure sensor:



The fuel rail pressure sensor is mounted to the end of the fuel rail. The sensor provides an output voltage signal to the PCM that corresponds to fuel pressure.



ENGINE
CONTROL
MODULE (ECM)
SENSOR
GROUND
5V
FUEL RAIL
PRESSURE
SIGNAL
5V
SENSOR
SUPPLY
FUEL RAIL
PRESSURE
SENSOR

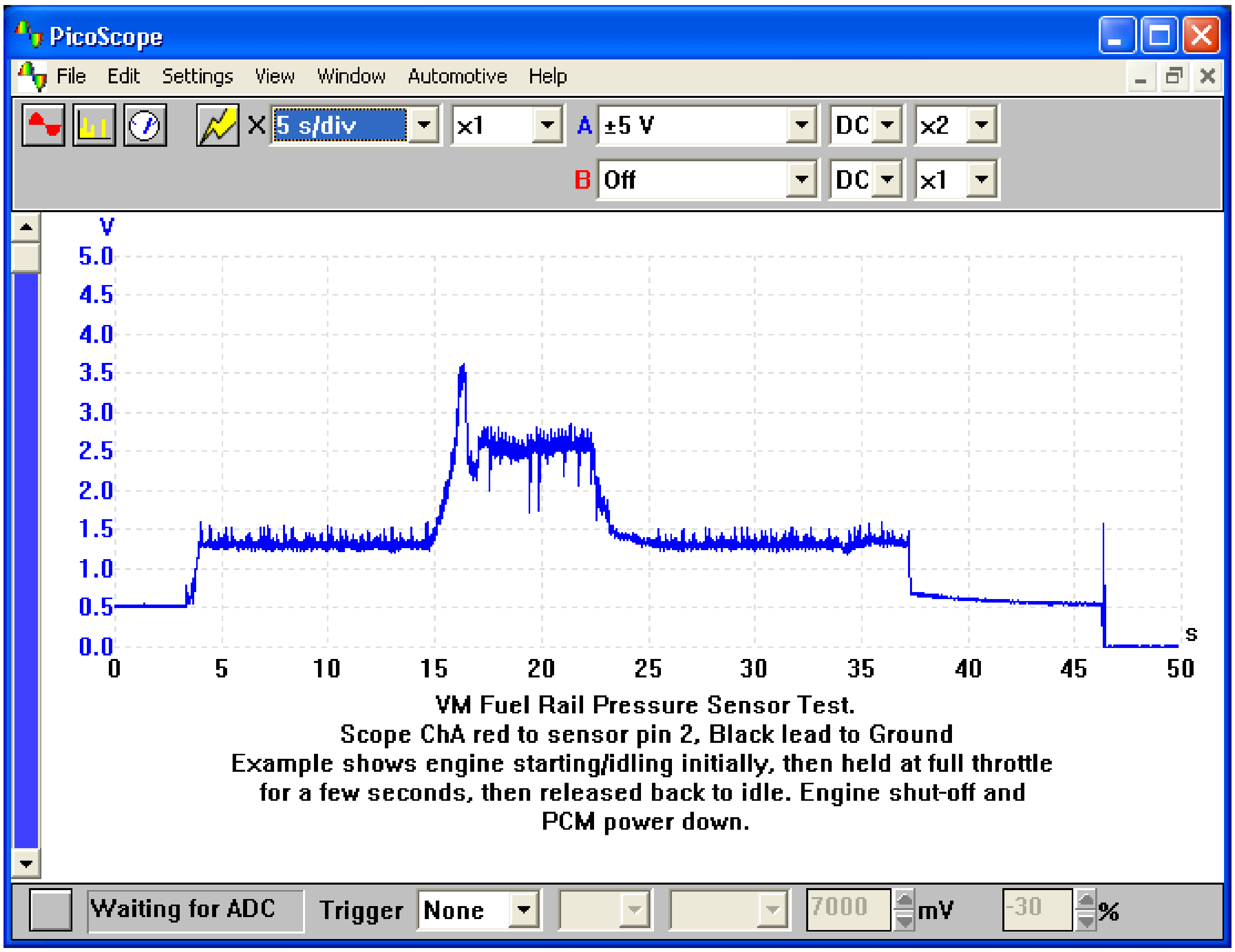


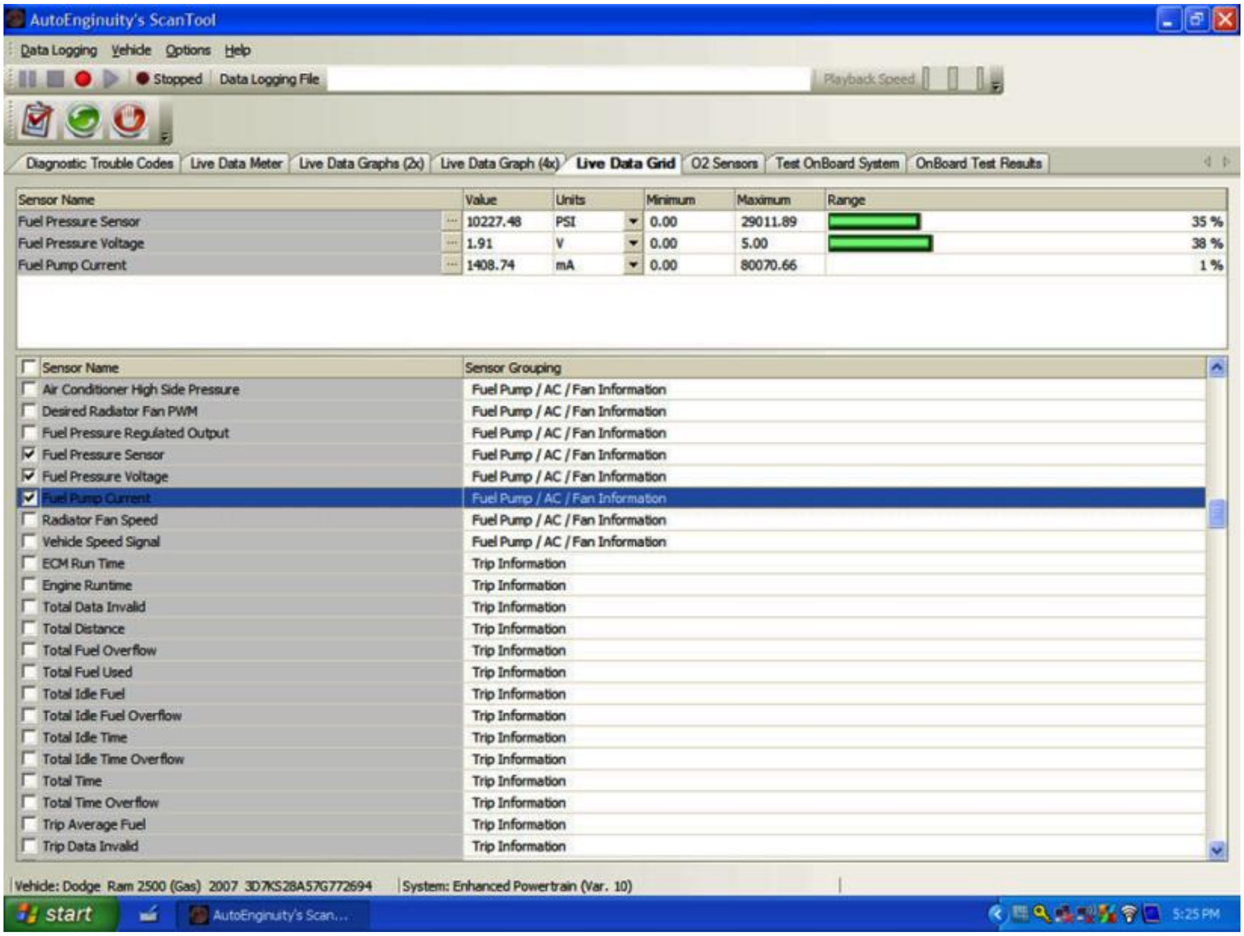
The PCM Actuates the FCA until the
desired fuel rail pressure is achieved
5.0 V
4.5 V
4.0 V
3.5 V
3.0 V
2.5 V
2.0 V
1.5 V
1.0 V
0.0 V
0
3,600psi
7,300psi
14,500psi
26,00psi

The sensor's output is linier from zero to maximum pressure. The ECM uses the signal from the fuel rail sensor to control the output of the fuel control actuator (FCA). The ECM supplies a 5.0 volt reference. Pressure in the fuel rail varies the signal from 0.5 to 4.5 volts.

Fuel Rail Sensor's voltage VS Ohms:

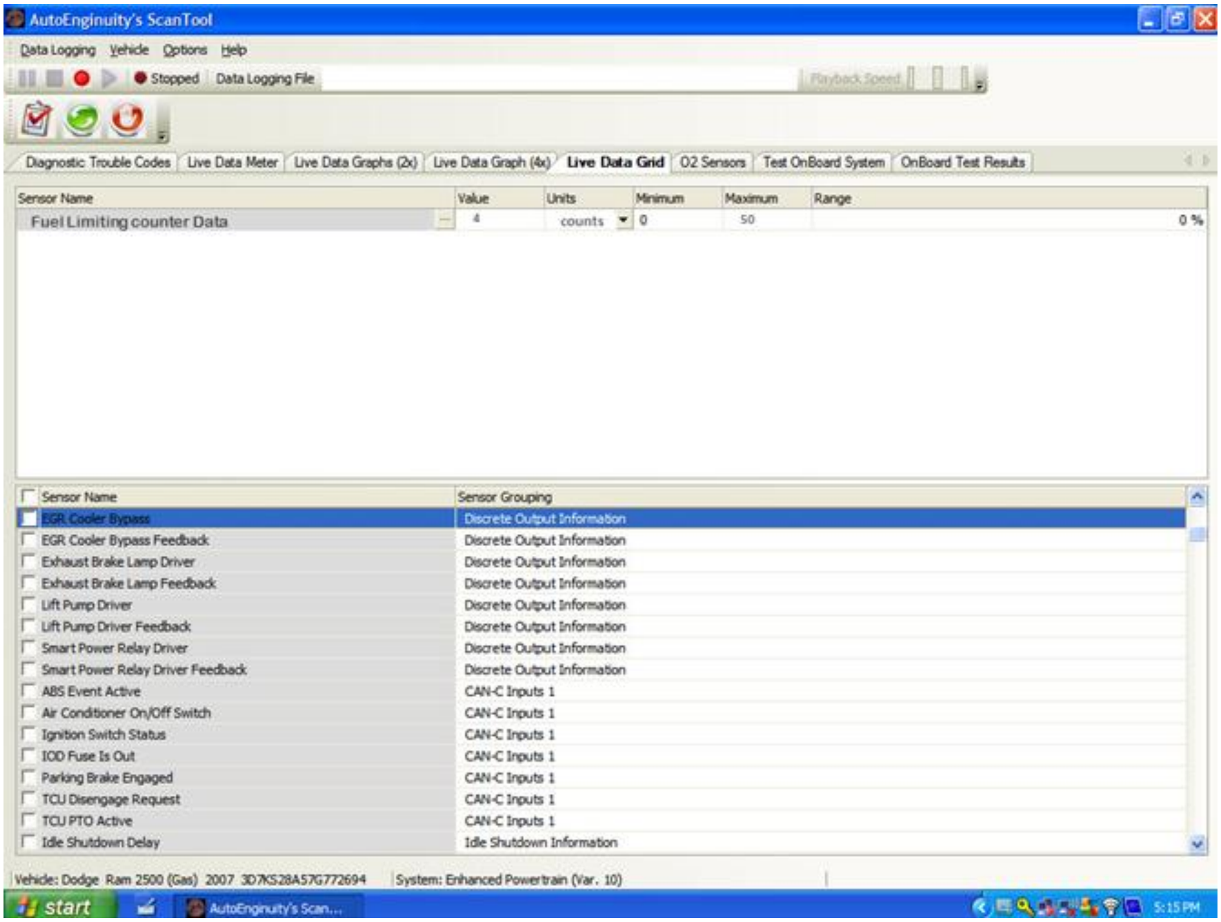
Idle	1.5v	7kΩ
1500 RPM	2.1v	10kΩ
2000 RPM	2.8v	15.5k Ω
2500 RPM	3.25v	18.5k Ω
WOT	3.69v	21k Ω





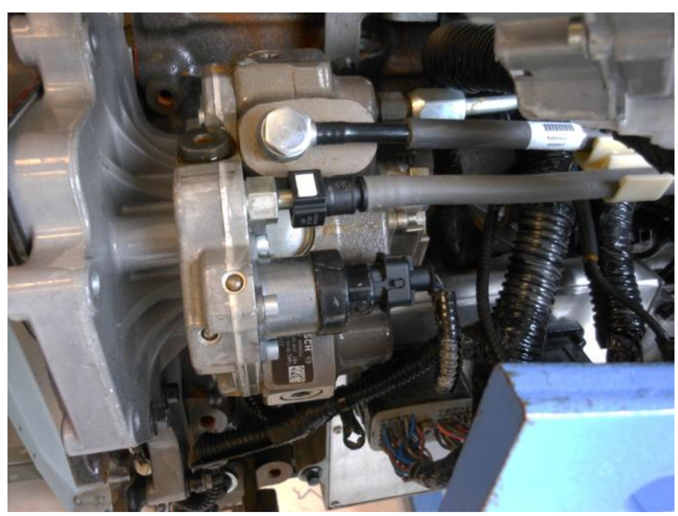
Fuel Rail Pressure Limiting Valve:

It is threaded into the front end of the fuel rail. It is a mechanical relief valve for controlling pressure. It relieves fuel rail pressure if it exceeds 28,282 psi in the fuel rail. The PCM counts the fuel limiting events based on the fuel rail pressure sensor. A DTC is set if there are too many (50) relief events.



Over flow valve:

There are two channels in the injection pump, One to the FCA, and the other to the Cascade over flow valve. The valve regulates how much fuel is used for lubrication and how much is returned to the fuel tank through a return passage in the filter housing. The overflow valve is internal to the injection pump and returns fuel to the fuel tank through a passage in the filter housing.



Electronically controlled High Pressure Common Rail Pump:

It is a gear driven pump which receives fuel from the lift pump and pressurizes the fuel to 4,351 to 26,107 psi. The fuel is supplied to the common fuel rail.

Common Fuel Rail:

Stores fuel and acts as an accumulator and distributes high pressure fuel to the injectors through steel lines. It is called a common rail because it is common to all cylinders. The pressure in the rail remains at an almost constant pressure to ensure the same pressure at each injector.

Injectors:

The injectors for the 6.7 L and late model 5.9 L engines are electrically operated by the PCM. They are solenoid actuated injectors. The injectors are controlled (actuated) by the PCM by controlling the solenoid portion.

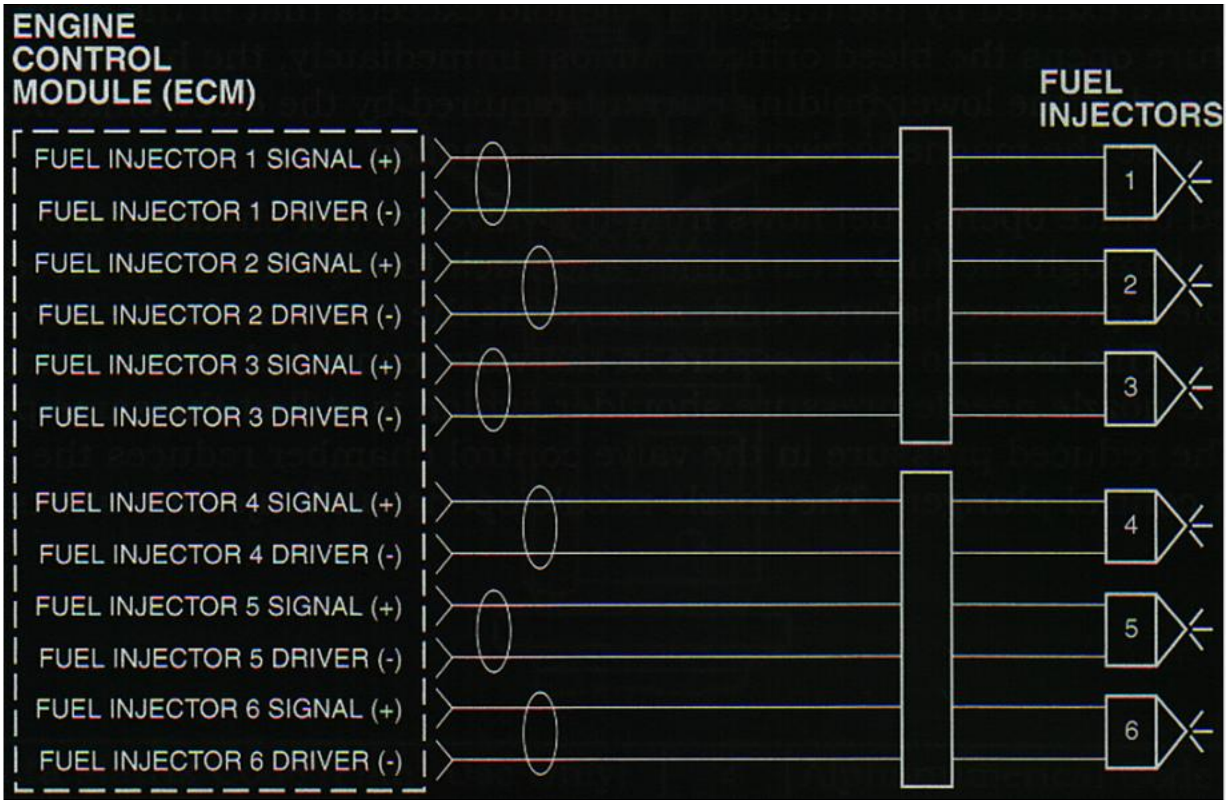
The PCM controls the injection and timing of the fuel through the control of the injector/solenoids. An electronic pulse is sent to the solenoid to create a magnetic field that will lift the injector’s needle from its seat. The pilot, main, and post injection pulses are all electronically controlled.

The pilot injection event contributes to a quitter engine and a smooth idle

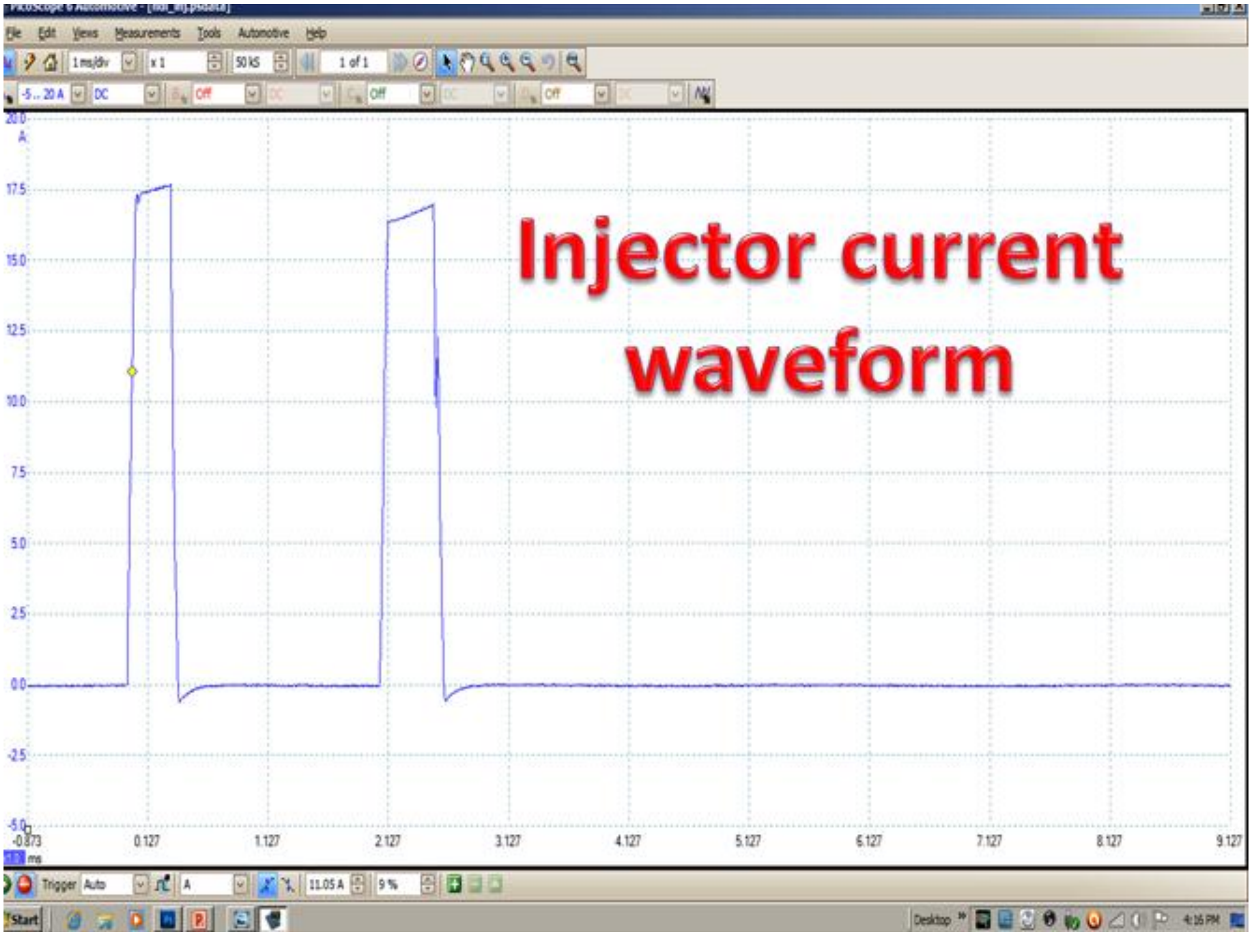
The main injection event develops power

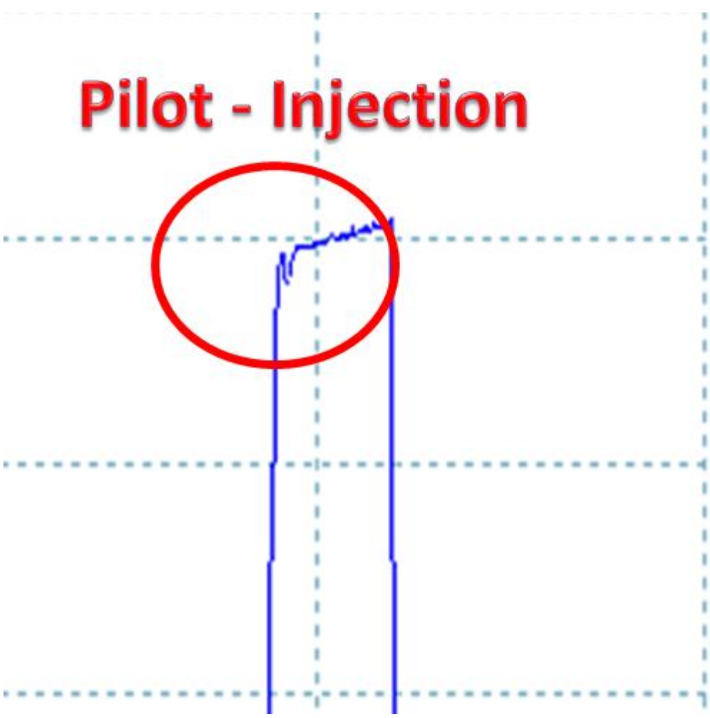
Pilot, Main, and Post Injection:

The two post injection event, only occur during the regeneration process and heats the catalyst to burn off soot/ash in the particulate filter.

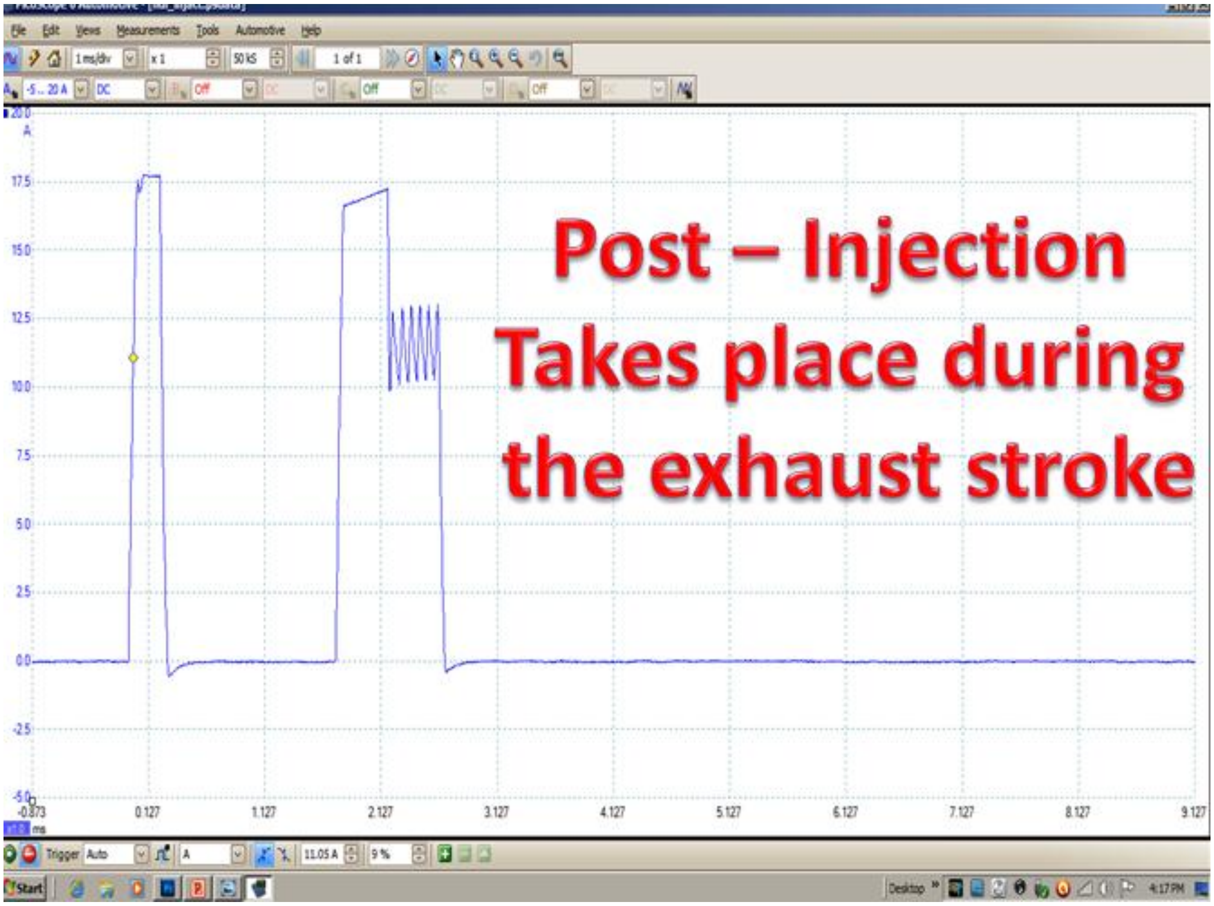


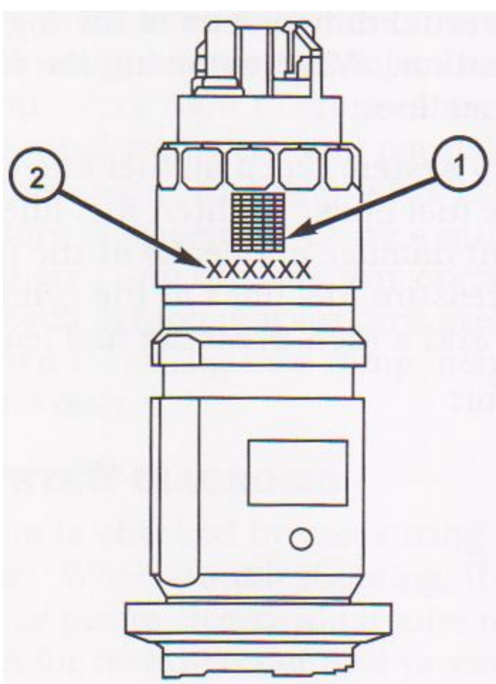
The injectors work off a 48 volt circuit. The PCM has a step up transformer inside and it uses capacitors to store and release energy. It also has two drivers for each injector. One to control the power side and the other controls the ground side.





Injector Correction Code:





Each of the injectors has a six digit alphanumeric correction code. The code identifies the injector's calibration. If replacing any or all of the injectors the new code must be programed into the PCM. If the PCM is replaced the correction codes for each injector must be programed into the new PCM.

INJECTOR DATA INCOMPATIBLE

If the code isn't programed into the PCM or is programed incorrectly, the PCM will set a DTC. As an example; a P268D CYLINDER 2 INJECTOR DATA INCOMPATIBLE may be set.

These are the codes for each cylinder:

P268C Cylinder 1 injector data incompatible

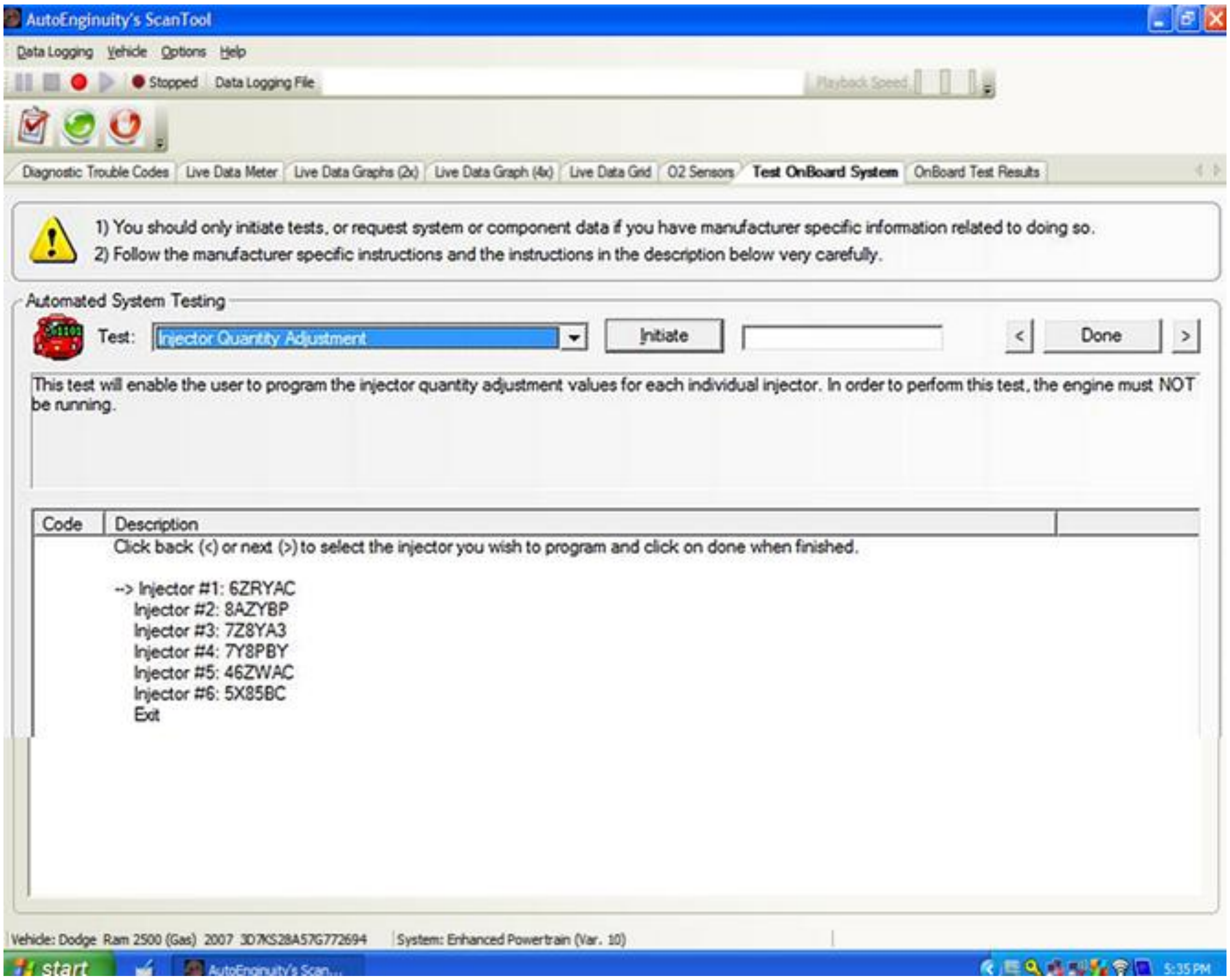
P268D Cylinder 2 injector data incompatible

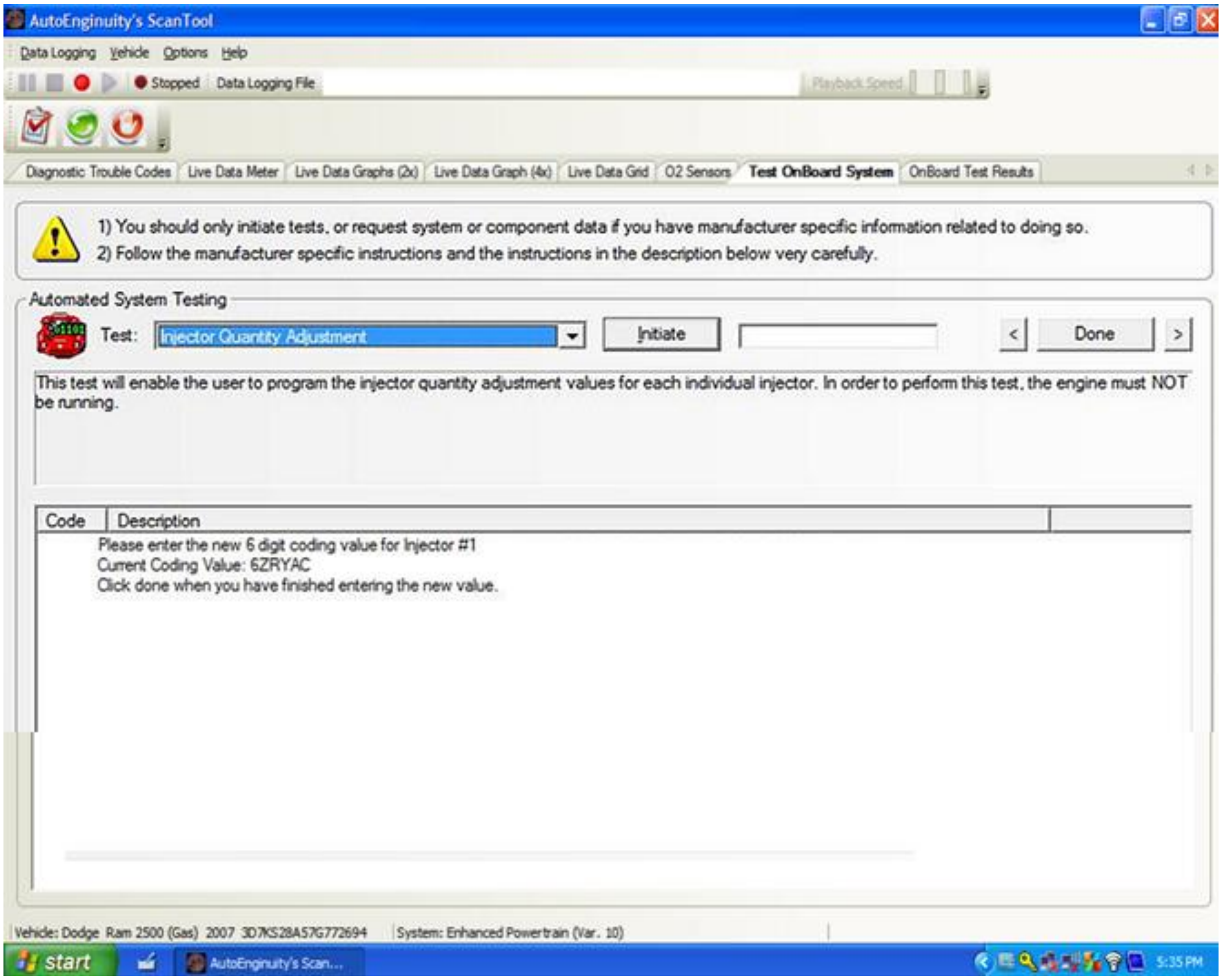
P268E Cylinder 3 injector data incompatible

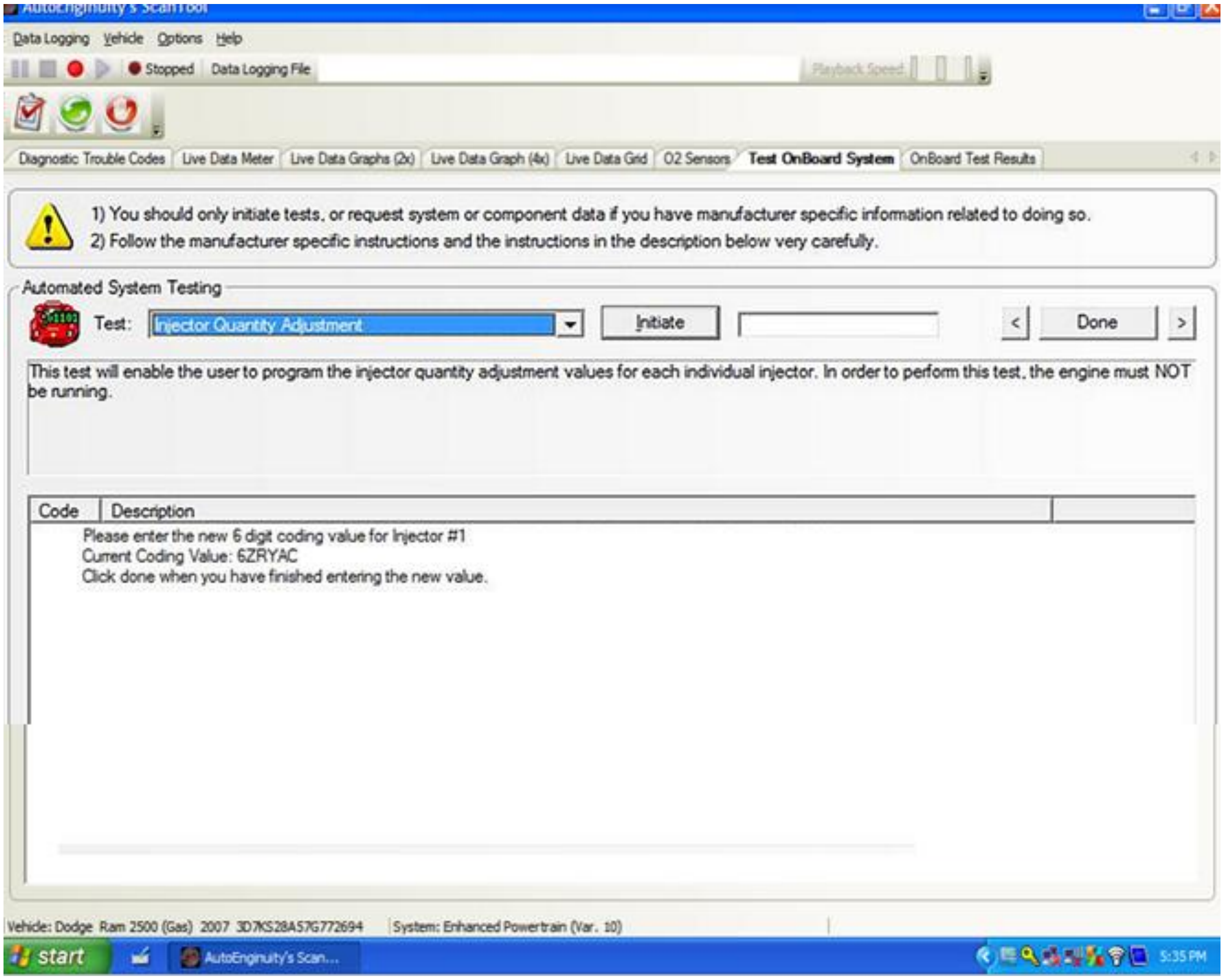
P268F Cylinder 4 injector data incompatible

P2690 Cylinder 5 injector data incompatible

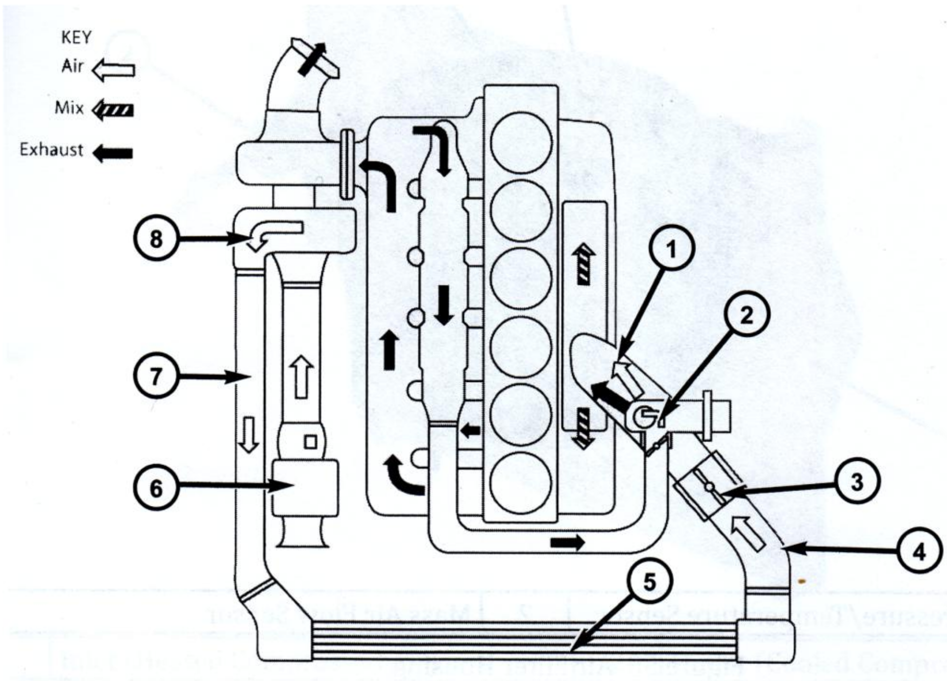
P2691 Cylinder 6 injector data incompatible




AutoEnginuity's ScanTool
Data Logging Vehicle Options Help
Stopped Data Logging File
Playback Speed
Diagnostic Trouble Codes Live Data Meter Live Data Graphs (2x) Live Data Graph (4x) Live Data Grid O2 Sensors Test OnBoard System OnBoard Test Results
1) You should only initiate tests, or request system or component data if you have manufacturer specific information related to doing so.
2) Follow the manufacturer specific instructions and the instructions in the description below very carefully.
Automated System Testing
Test: Injector Quantity Adjustment
Initiate
Done
This test will enable the user to program the injector quantity adjustment values for each individual injector. In order to perform this test, the engine must NOT be running.
Code
Description
Please enter the new 6 digit coding value for Injector #1
Current Coding Value: 6ZRYAC
Click done when you have finished entering the new value.
Vehicle: Dodge Ram 2500 (Gas) 2007 3D7KS28A57G772694
System: Enhanced Powertrain (Var. 10)
start
AutoEnginuity's Scan...
5:35 PM


AutoEnginuity's ScanTool
Data Logging Vehicle Options Help
Stopped Data Logging File
Playback Speed
Diagnostic Trouble Codes
Live Data Meter
Live Data Graphs (2x)
Live Data Graph (4x)
Live Data Grid
O2 Sensors
Test OnBoard System
OnBoard Test Results
1) You should only initiate tests, or request system or component data if you have manufacturer specific information related to doing so.
2) Follow the manufacturer specific instructions and the instructions in the description below very carefully.
Automated System Testing
Test: Injector Quantity Adjustment
Initiate
Done
This test will enable the user to program the injector quantity adjustment values for each individual injector. In order to perform this test, the engine must NOT be running.
Code
Description
Please enter the new 6 digit coding value for Injector #1
Current Coding Value: 6ZRYAC
Click done when you have finished entering the new value.
Vehicle: Dodge Ram 2500 (Gas) 2007 3D7KS28A57G772694
System: Enhanced Powertrain (Var. 10)
start
AutoEnginuity's Scan...
5:35 PM

Air Management:



Air Filter Housing and Element:

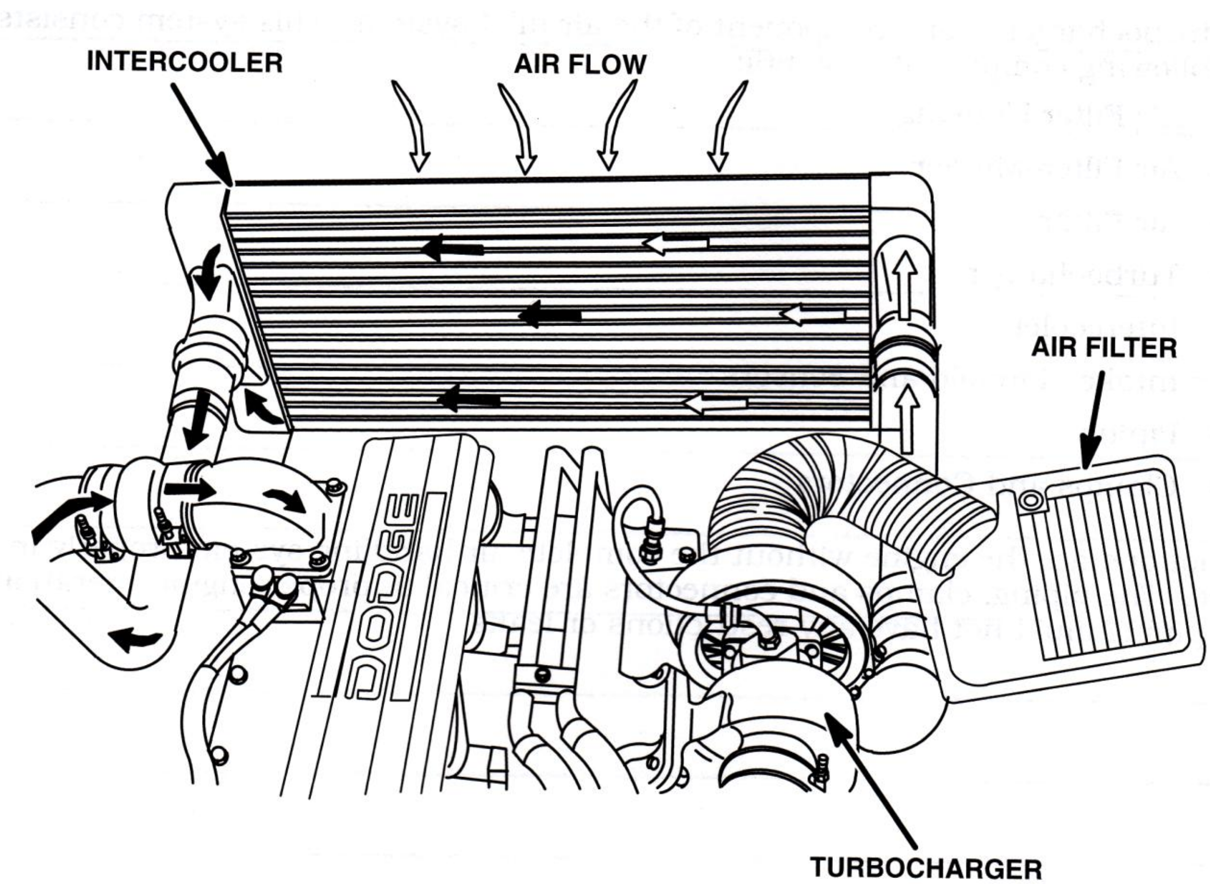
Early models had a mechanical service minder.

Later models have an electronic service minder.

Air filter supplies clean air to the intake turbocharger. The inlet air temperature and manifold pressure sensor are mounted in the housing. The Mass Air Flow (MAF) sensor is also mounted in the housing.

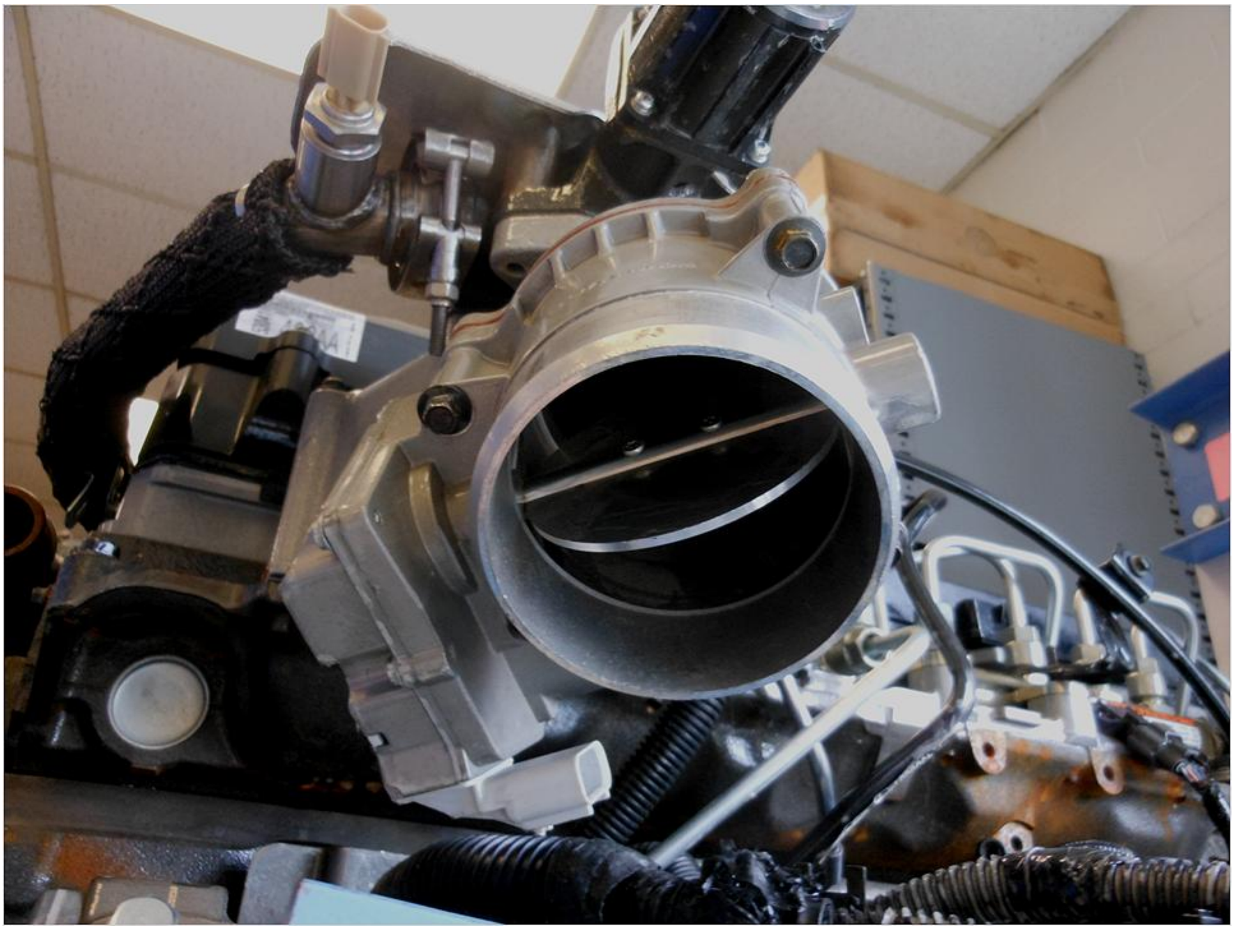
Charge Air Cooler (CAC):

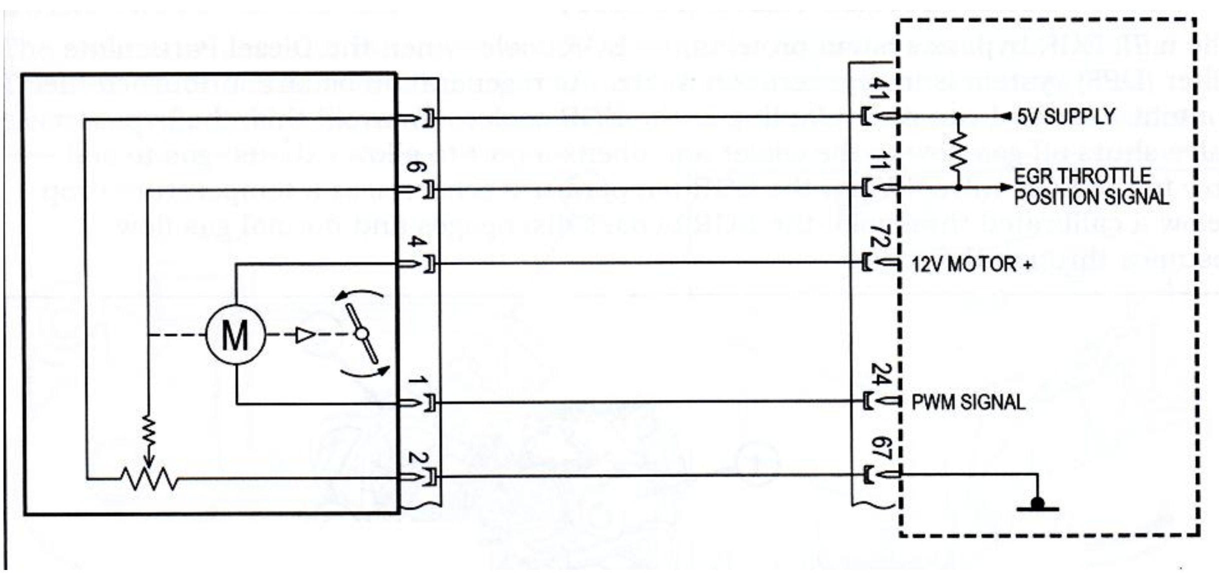
When a gas is compressed into a smaller volume, both the pressure and the temperature of the gas will increase. To reduce NOx pollution and improve engine efficiency, an after cooler is used to remove some of the heat from the intake air. To meet emission standards the turbocharger's air must be cooled before entering the intake.



EGR Airflow Throttle Control Valve:

It is located between the CAC and the intake manifold. It is PCM controlled to increase EGR flow by creating a higher pressure differential between the exhaust system and the boost pressure in the intake. This allows exhaust gas to enter into the intake manifold. It is a normally open valve when not activated, not restricting the air flow.

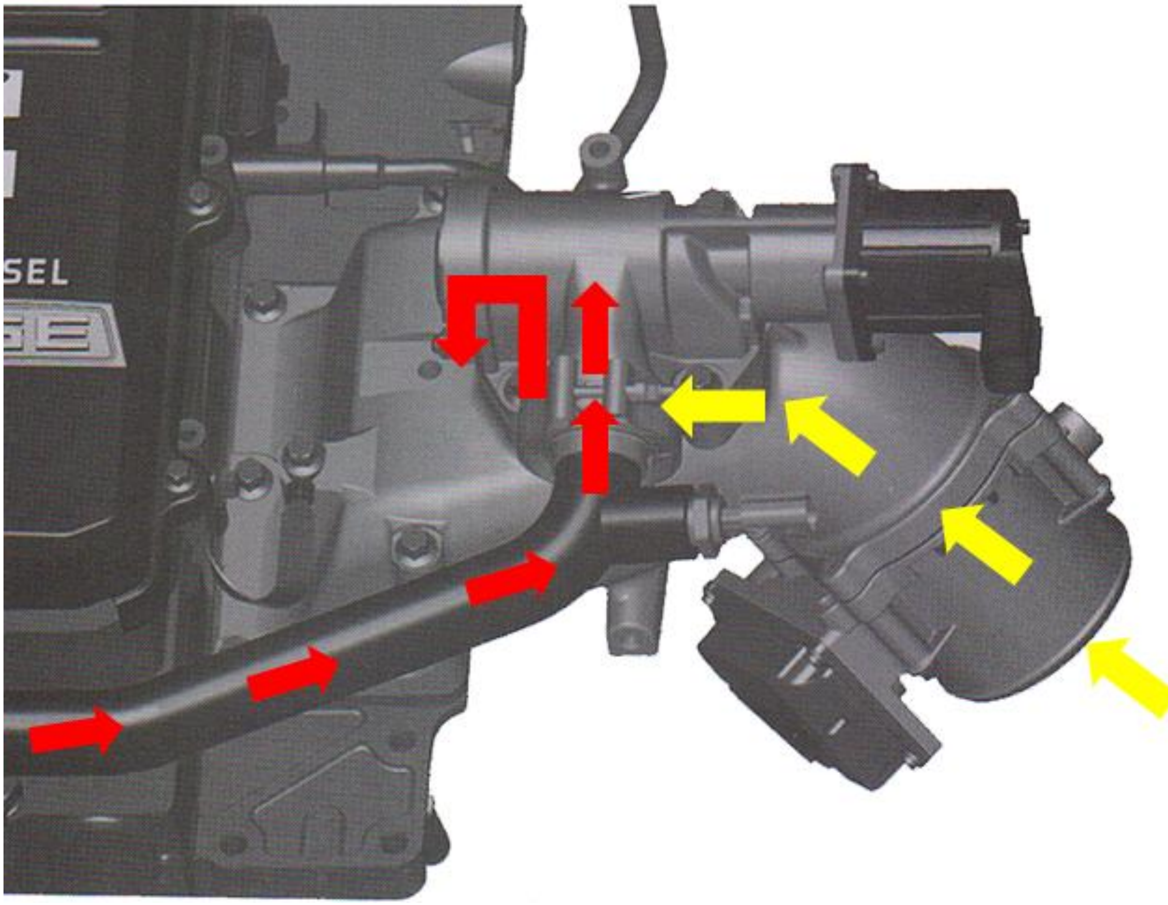




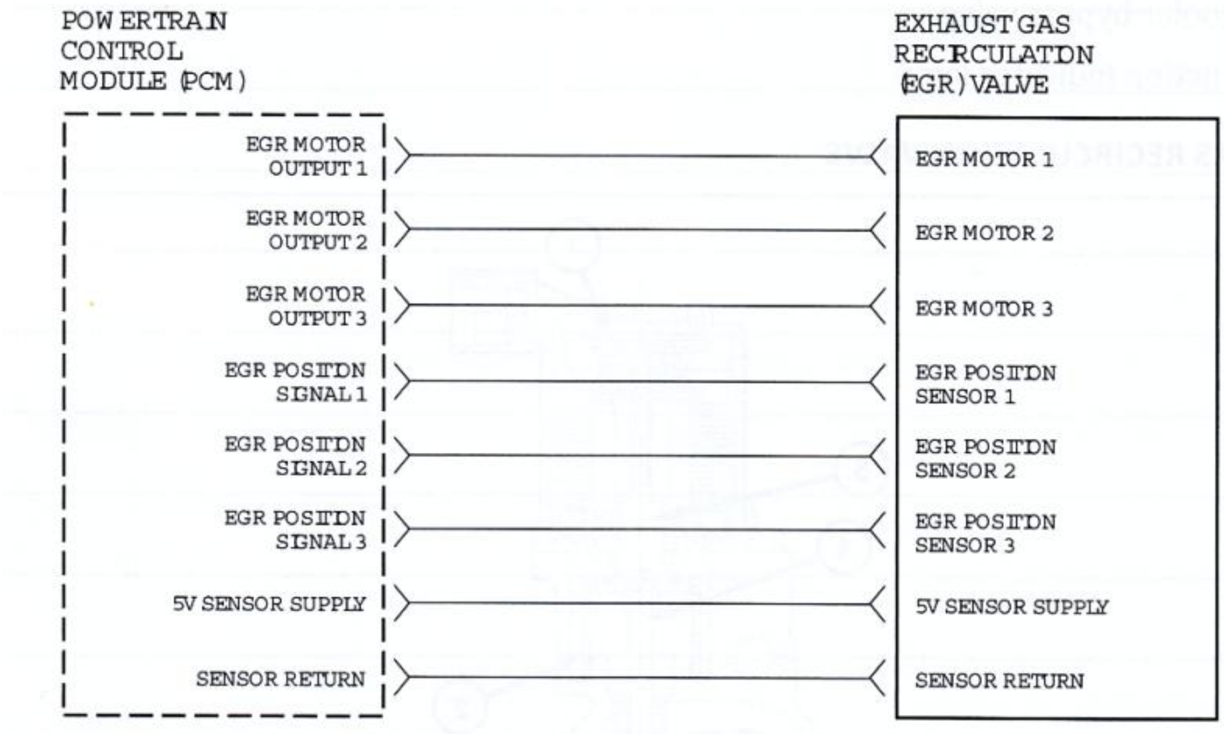
The PCM supplies 5.0 volts to the throttle valve's signal circuit. The sweeper contact moves in proportion to the valve's plate as it moves. The signal is used as feedback information.

Exhaust Gas Recirculation Valve (EGR):

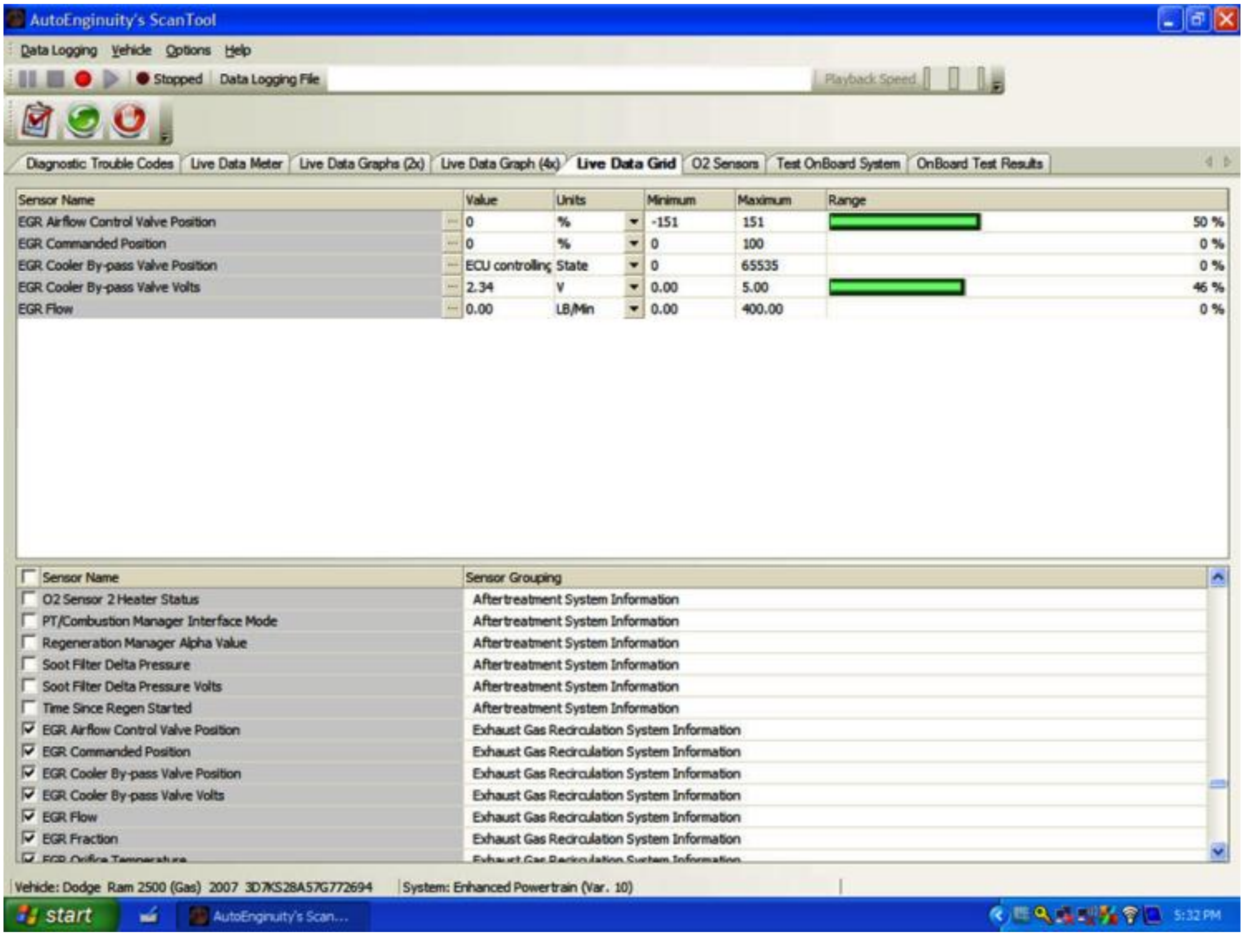
Allows exhaust gas to enter the intake manifold to reduce NOx. The hot exhaust gas exits the exhaust manifold passes through the EGR cooler before being mixed with cooler inlet air by the EGR valve. The mixture then enters the intake manifold. The exhaust gas and air mixture is designed to reduce NOx by reducing the temperature.



The EGR mixture is inert (non-combustible) and dilutes the intake charge. EGR is active at low, medium, and high engine loads. Control is based from engine load and speed. The PCM evaluates the inputs and uses a stored map to control EGR flow and throttle air valve.



The EGR is driven by a 3-phase motor. There are three Hall Effect sensors that detect EGR position inside the valve assembly. At ignition on the PCM commands the EGR off as a self-test to check and see if it is leaking?

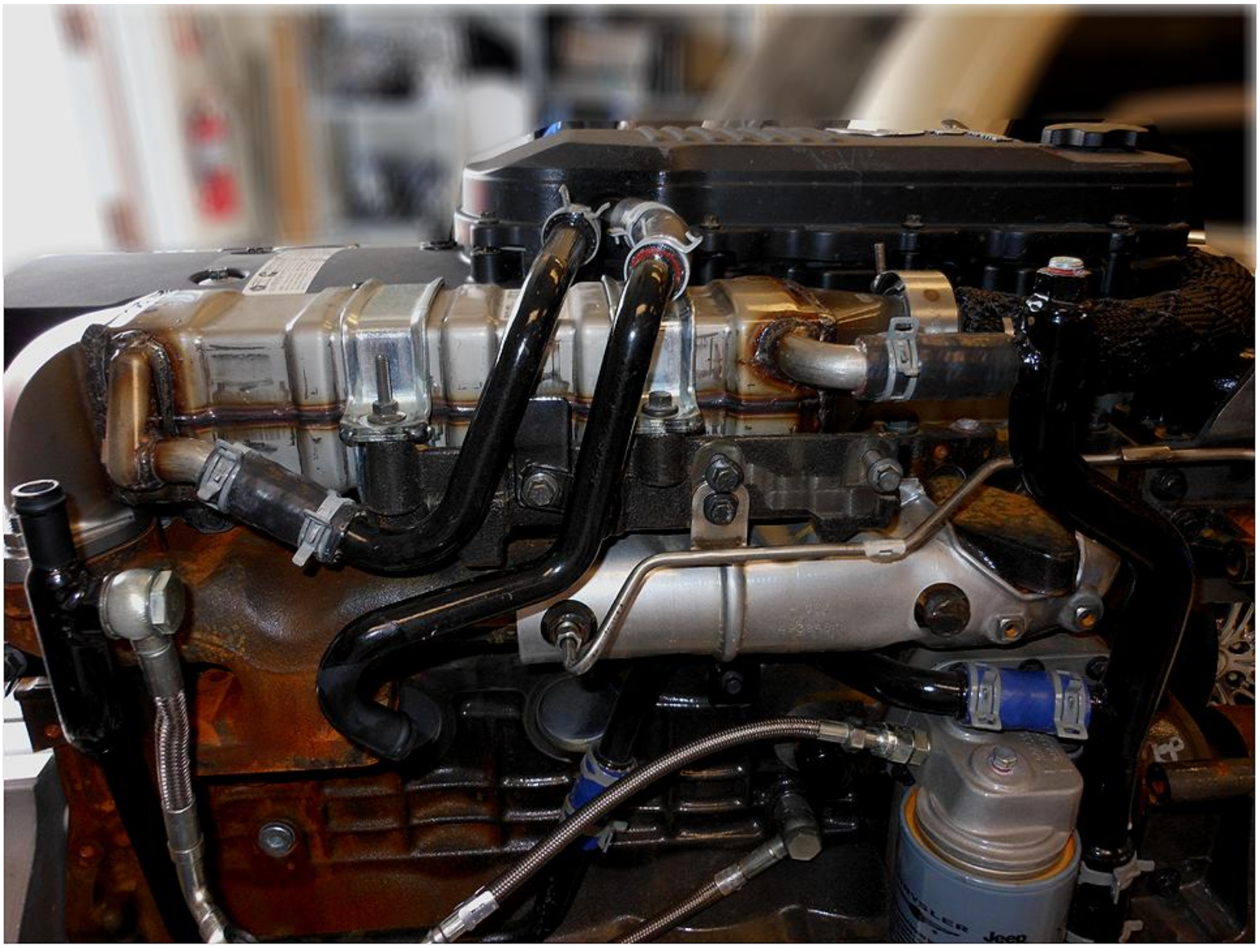


The PCM calculates the EGR rate based from:

- MAF Sensor
- Boost Pressure sensor
- Intake air sensor
- Inlet air pressure sensor
- Accelerator pedal position sensors
- Crankshaft position sensor
- O_2 sensor

EGR Cooler:

Because diesel exhaust is hotter than a gas engine's exhaust the EGR gas must be cooled before it can be sent to the intake manifold. The cooler is connected to the exhaust manifold so some exhaust flows into the cooler from the exhaust manifold. The EGR cooler is cooled by engine coolant. The exhaust gas is cooled and enters the crossover tube which routes the gas into the EGR valve.

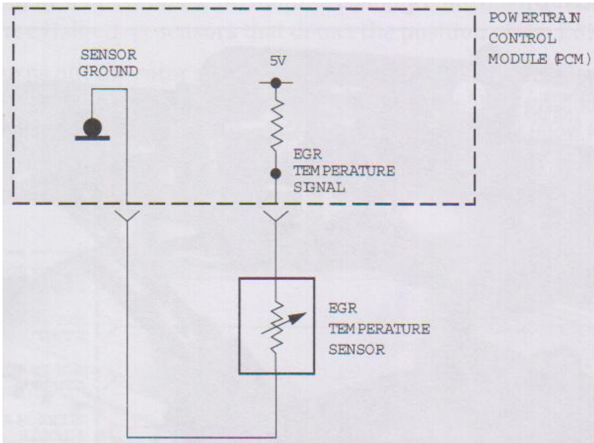


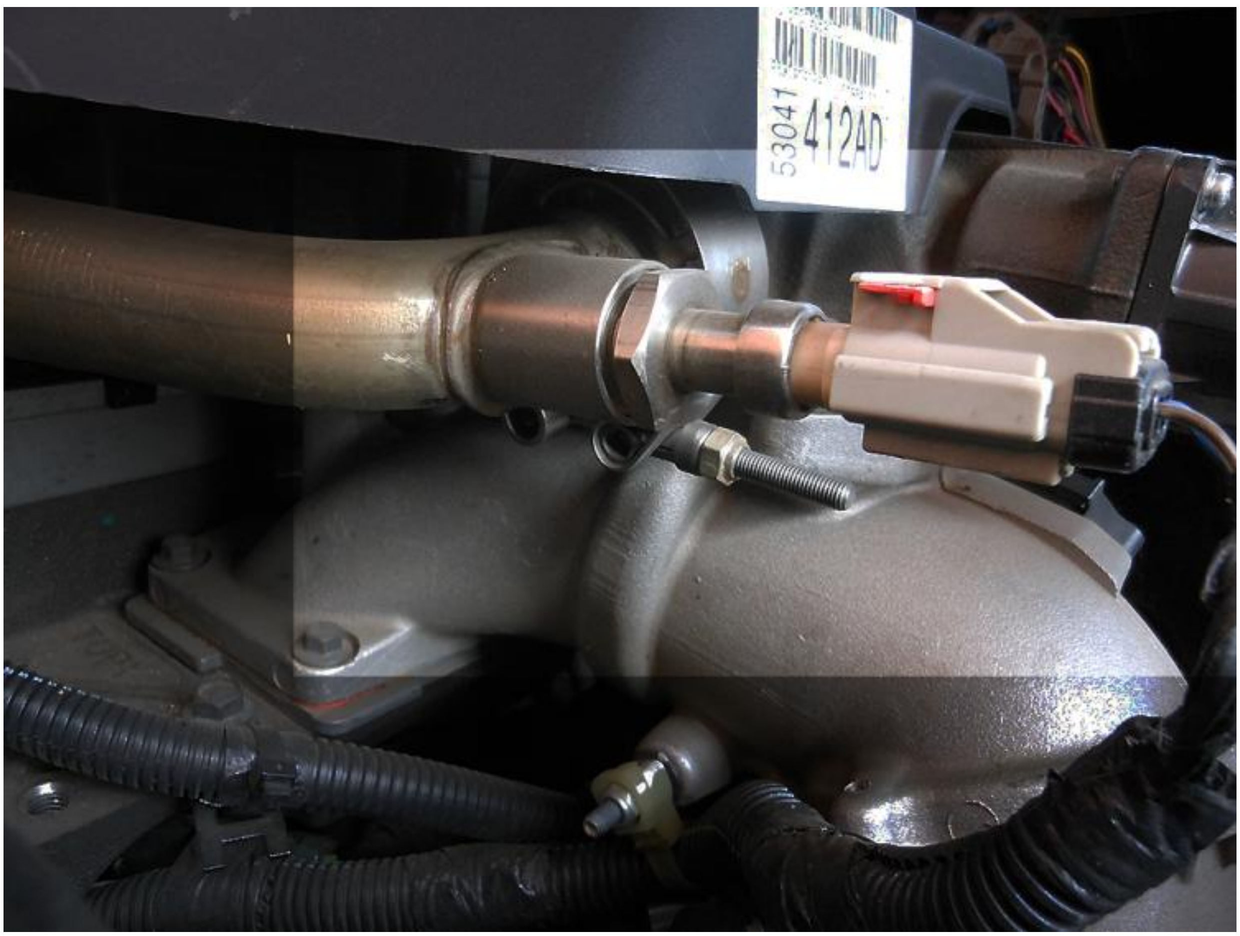
EGR Cooler By-Pass:

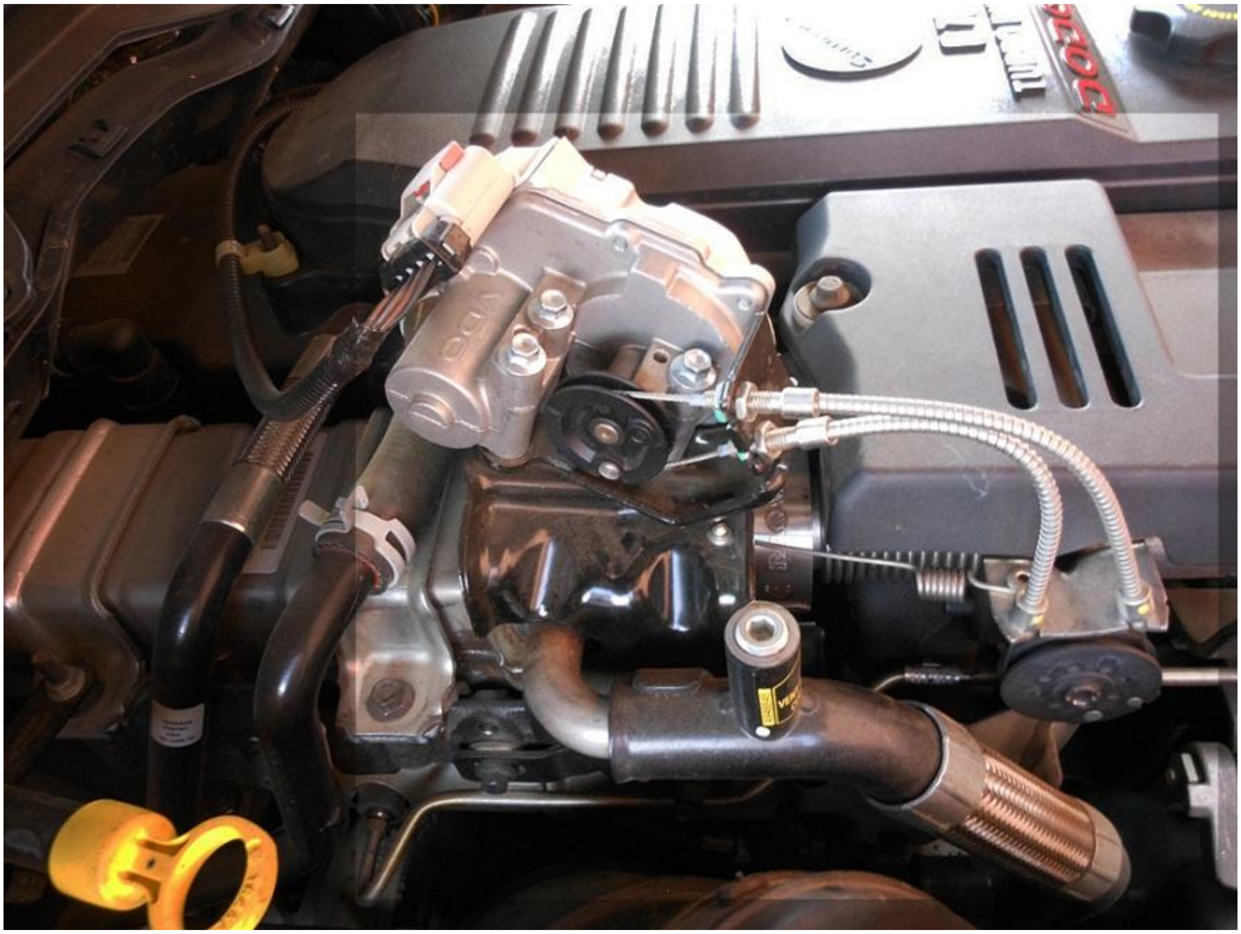
The EGR cooler by-pass, blocks exhaust gas flowing to the cooler and opens the valve allowing gas to continue flowing to the EGR valve. It activates during Aftertreatment regeneration only. Unburned fuel can cause fouling of the cooler so during the post injection the EGR is in by-pass mode. All vehicles do not use the EGR cooler By-Pass system. The larger Cab Chassis series are under different emission standards.

EGR Temperature Sensor:

When the temperature sensor indicates that the temperature has returned to normal after regeneration the EGR by-pass de-activates. The PCM uses the EGR temperature sensor's input signal to determine the temperature of the EGR gas.


POWERTRAIN
CONTROL
MODULE (PCM)
SENSOR
GROUND
5V
EGR
TEMPERATURE
SIGNAL
EGR
TEMPERATURE
SENSOR

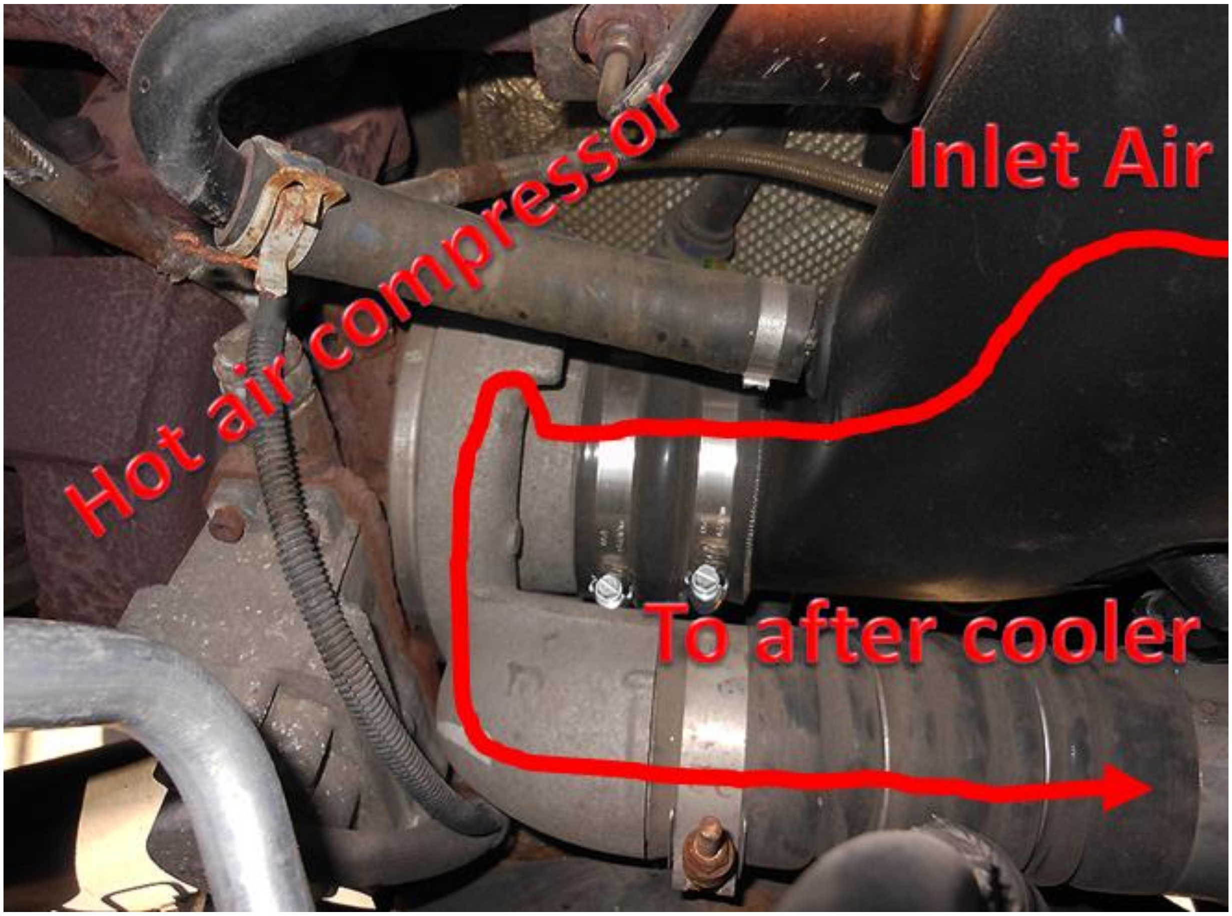

53041
412AD

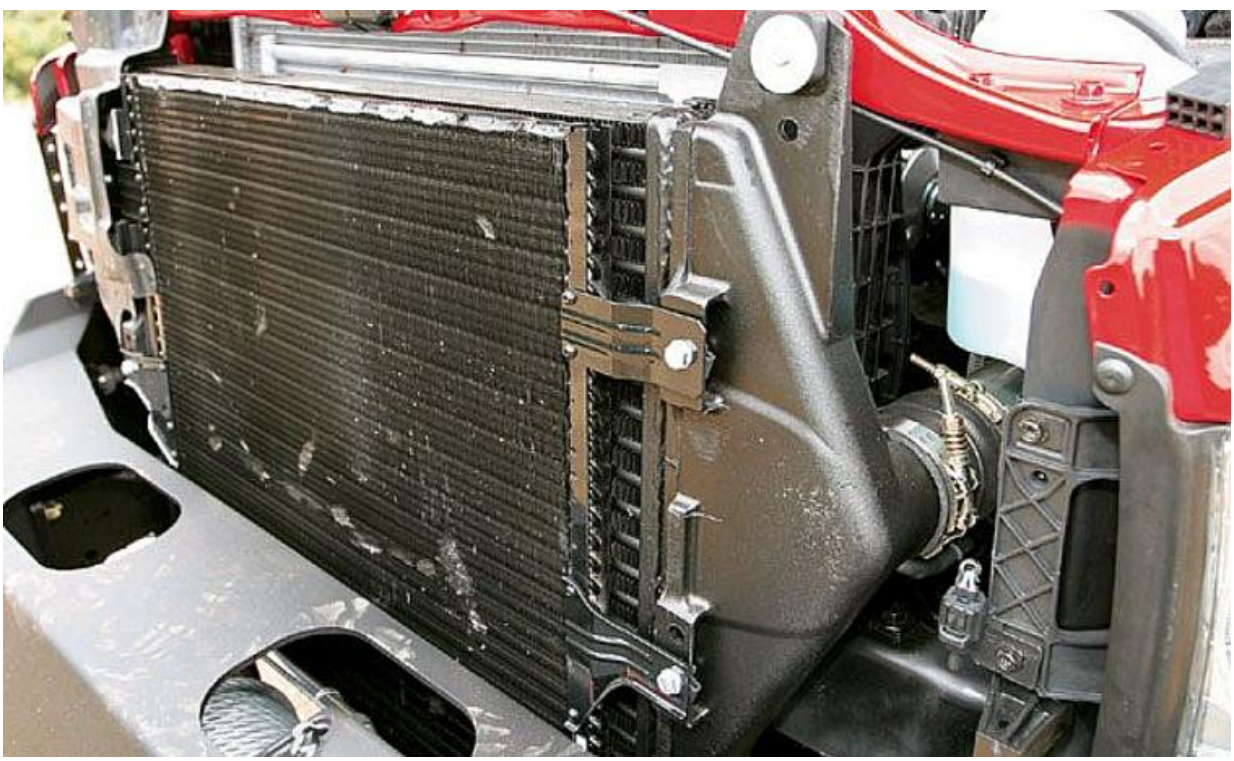


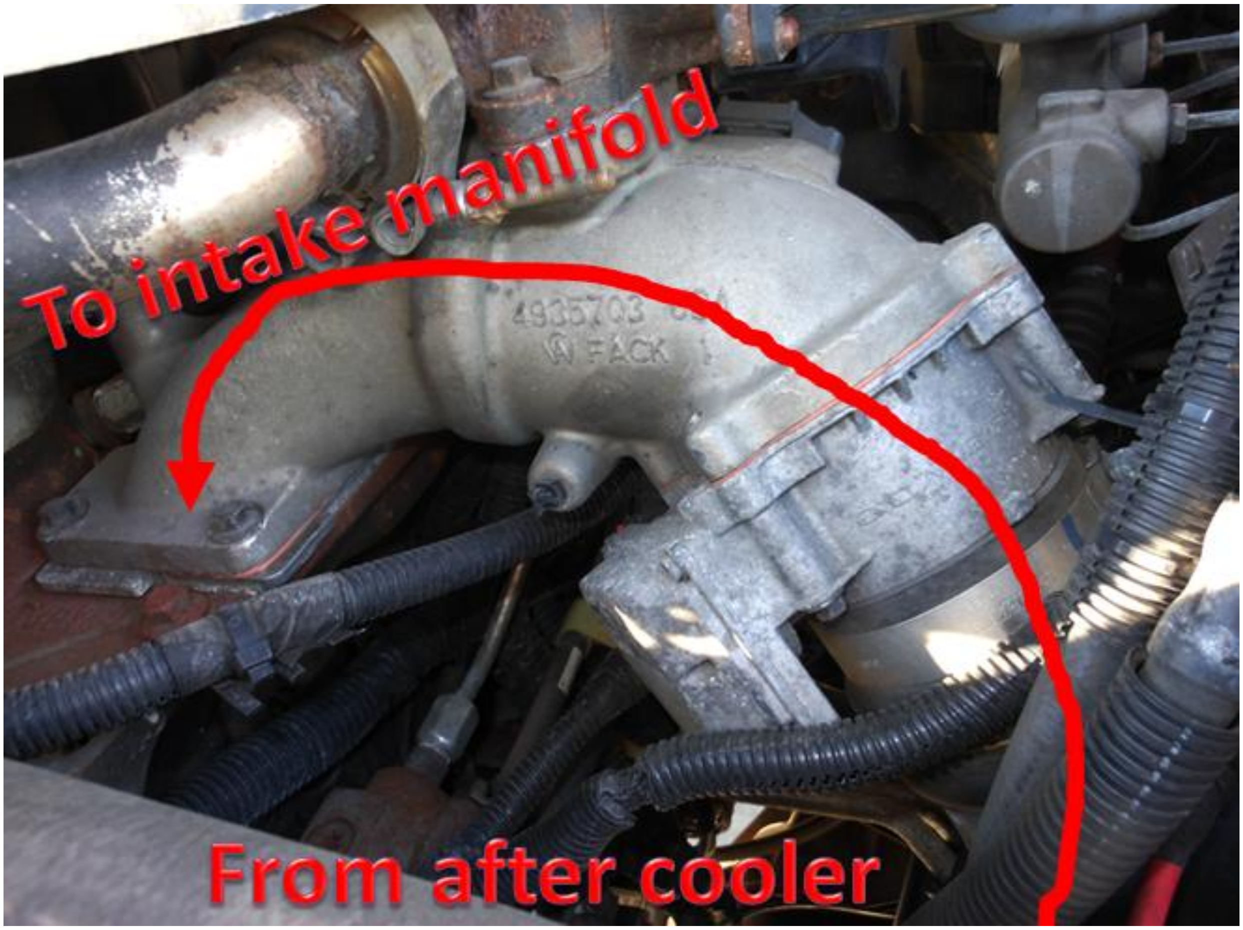
The EGR by-pass control system is a mechanical pulley and cable arrangement.

Turbochargers:

The turbocharger is a component of the air inlet system. The Cummins engine uses a turbocharger to reduce emissions and improve efficiency. Turbochargers also improve the performance of the engine. The main disadvantage of a turbocharger is heat. It uses exhaust gas to operate.


Hot air compressor
Inlet Air
To after cooler



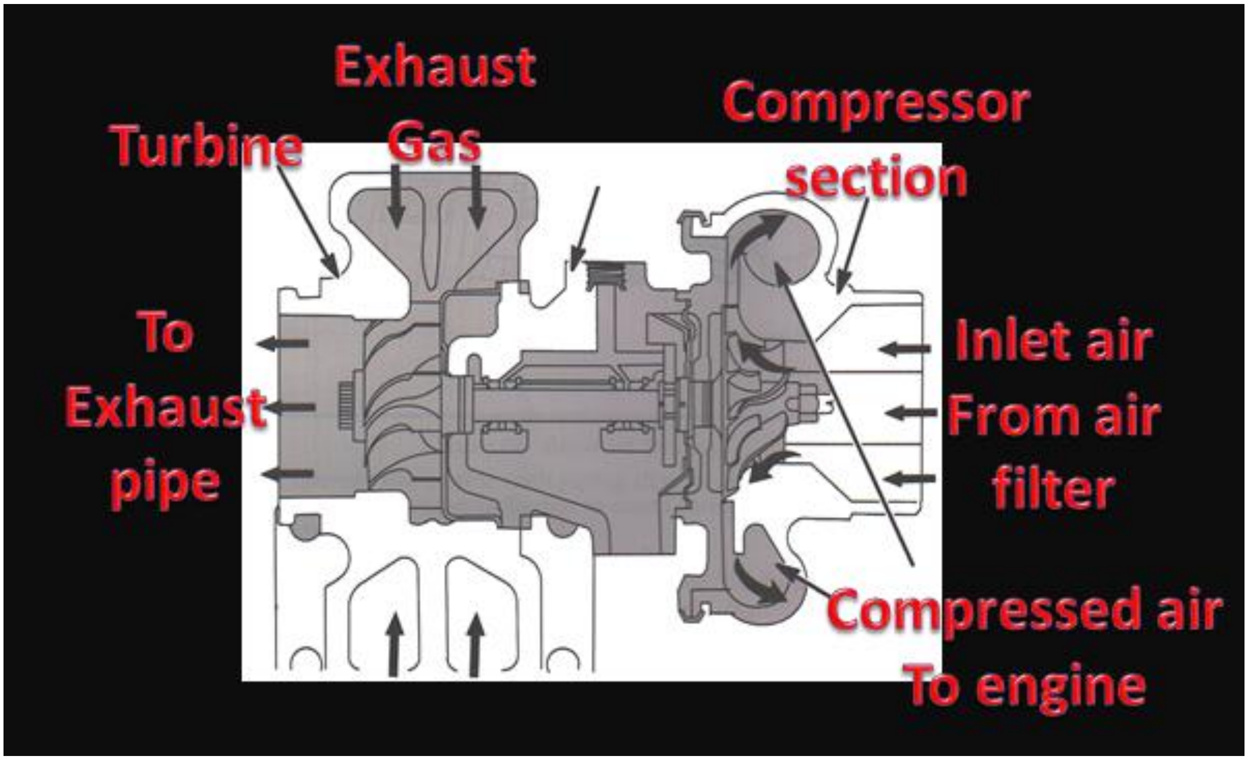


Turbocharger operation:

Generally, 1/3 of the heat energy obtained from burning the fuel in the cylinder is transferred to the crankshaft in a diesel engine. Another 1/3 of heat energy is dumped into the cooling system, and the last 1/3 escapes through the engine exhaust. This means that an engine producing 100 hp at the flywheel also dumps the equivalent of 100 hp into the cooling system, and another 100 hp into the exhaust system. A turbocharger converts 1/3 of the heat and pressure in the exhaust stream into compressor power. An engine producing 100 hp to the drivetrain is using 33hp from the exhaust to power the turbocharger. At 200hp, the turbocharger in a Cummins B can extract 66 hp from the exhaust to power the turbocharger.

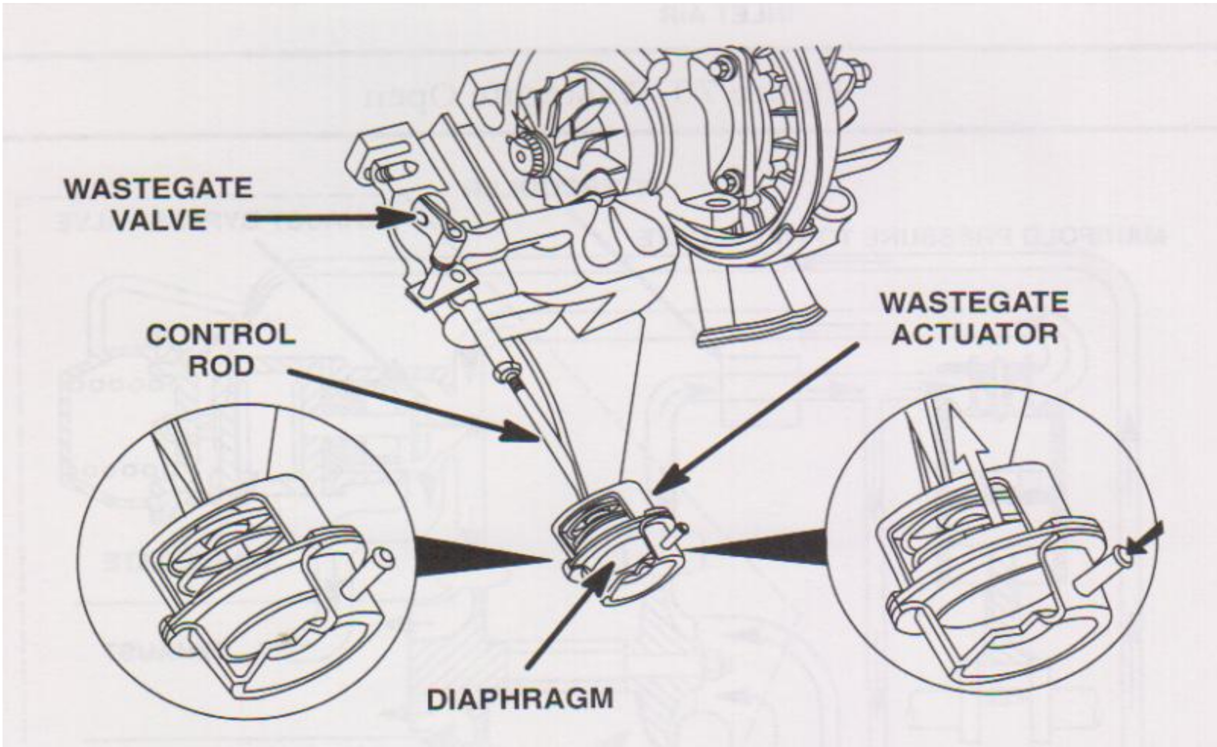
Boost:

Boost is the pressure above atmospheric pressure (in psi) that the turbocharger generates. Boost pressures are slightly less at the manifold than they are at the turbocharger outlet due to cooling and expansion of the air charge as it passes through the intercooler. Boost is a product of the turbocharger compressing the inlet air.



Wastegate 5.9L ISB:

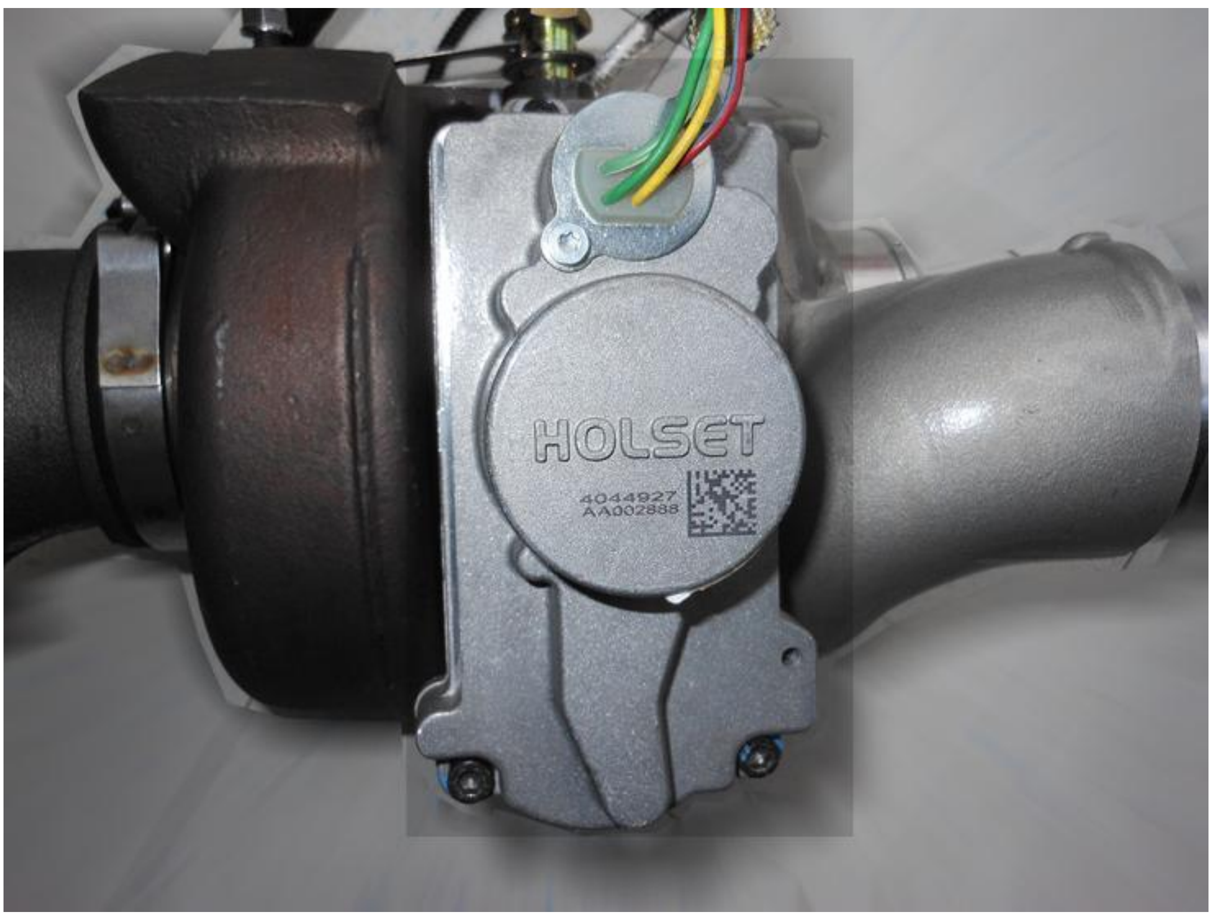
The waste gate limits the maximum boost generated by the turbocharger. It uses a pressure activated diaphragm to drive a rod to operate an exhaust bypass and limits the maximum boost.

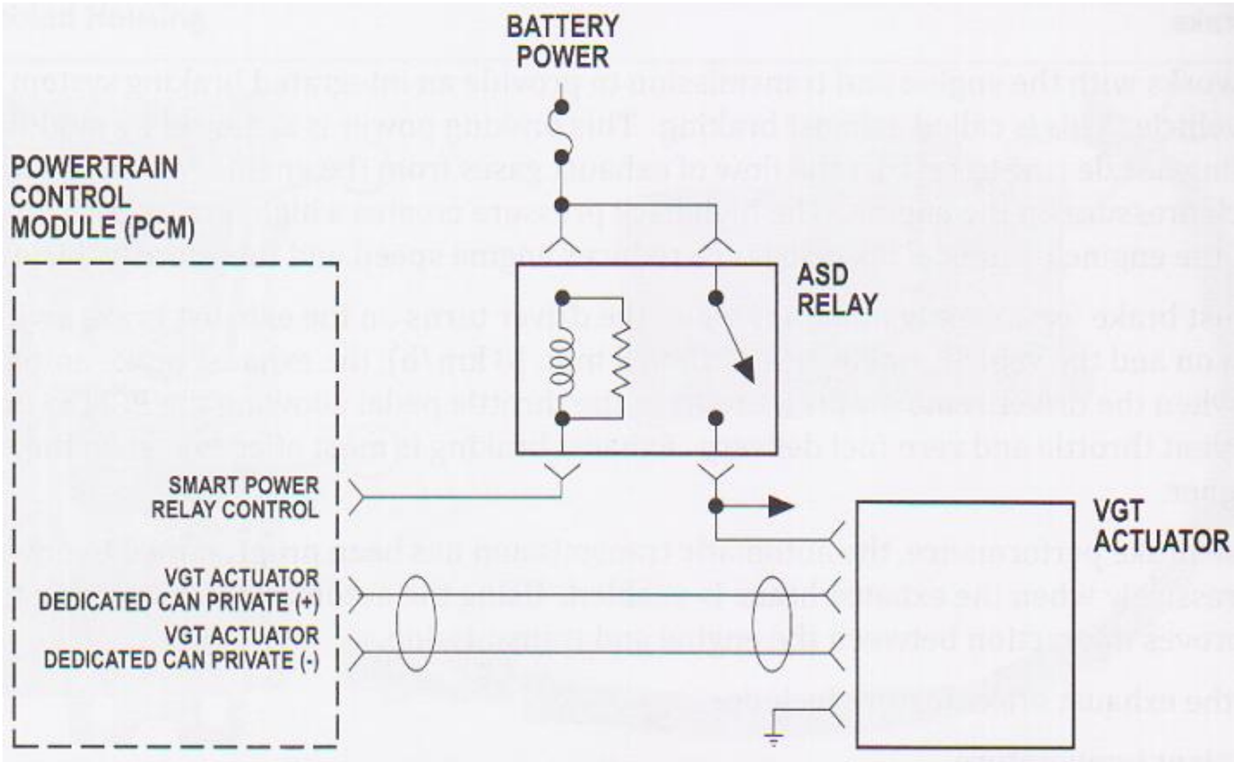

WASTEGATE
VALVE
CONTROL
ROD
WASTEGATE
ACTUATOR
DIAPHRAGM

Ram Diesel Turbocharger Specifications (stock engine)					
Year	Engine Rating	Max Boost Range	Wastegate	Holset Turbocharger	Turbine Housing (sq cm)
89-90	160 HP	22-25 psi	22 psi	H1C	18
91-92.5	160 HP	15-19 psi	17 psi	H1C	21
92.5-93	160 HP (CPL 1579)	18-21 psi	19 psi	H1C	18
94	160, 175 HP	15-18 psi	17 psi	WH1C	12
94	160, 175 HP	15-18 psi	17 psi	HX35W	12
95-98	160, 175, 180 HP	15-18 psi	17 psi	HX35W	12
96-98	215 HP	21-23 psi	23 psi	HX35W	12
98-00 ETC	215, 235 HP	18-20 psi	20.8 psi	HX35W	12
01 ETC	235 HP Auto and Manual	20.5 psi	23 psi	HY35W	9 single port
01 ETC	235 HP Manual	20.5 psi	23 psi	HX35W	12
01 ETH	245 HP	20.5 psi	26 psi	HX35W	12

The 6.7L Variable Geometry Turbocharge (VGT) Turbocharger:

The 6.7L engine doesn't use a wastegate. It has the Variable Geometry Turbocharge (VGT) which is controlled by the PCM. A variable electronic solenoid moves a mechanical arm that changes the turbocharger output.

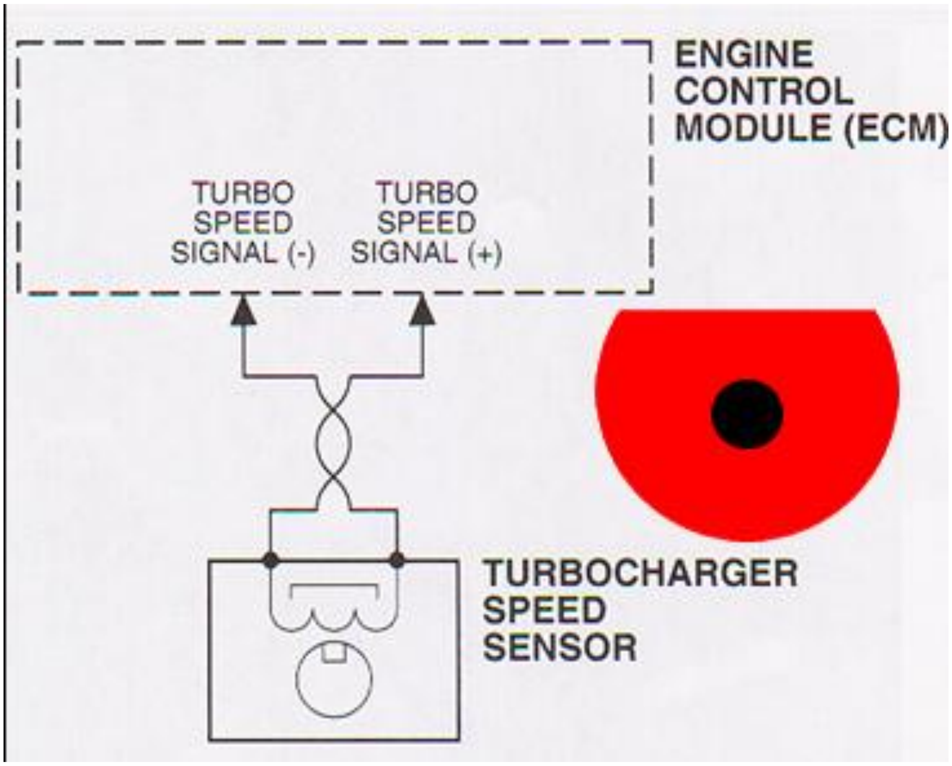




The actuator controls a sliding nozzle ring inside the turbocharger. Moving the nozzle forward reduces turbo boost (the vane spins faster). Moving the nozzle rearward increases turbo boost (the vane spins slower). The VGT is liquid cooled.

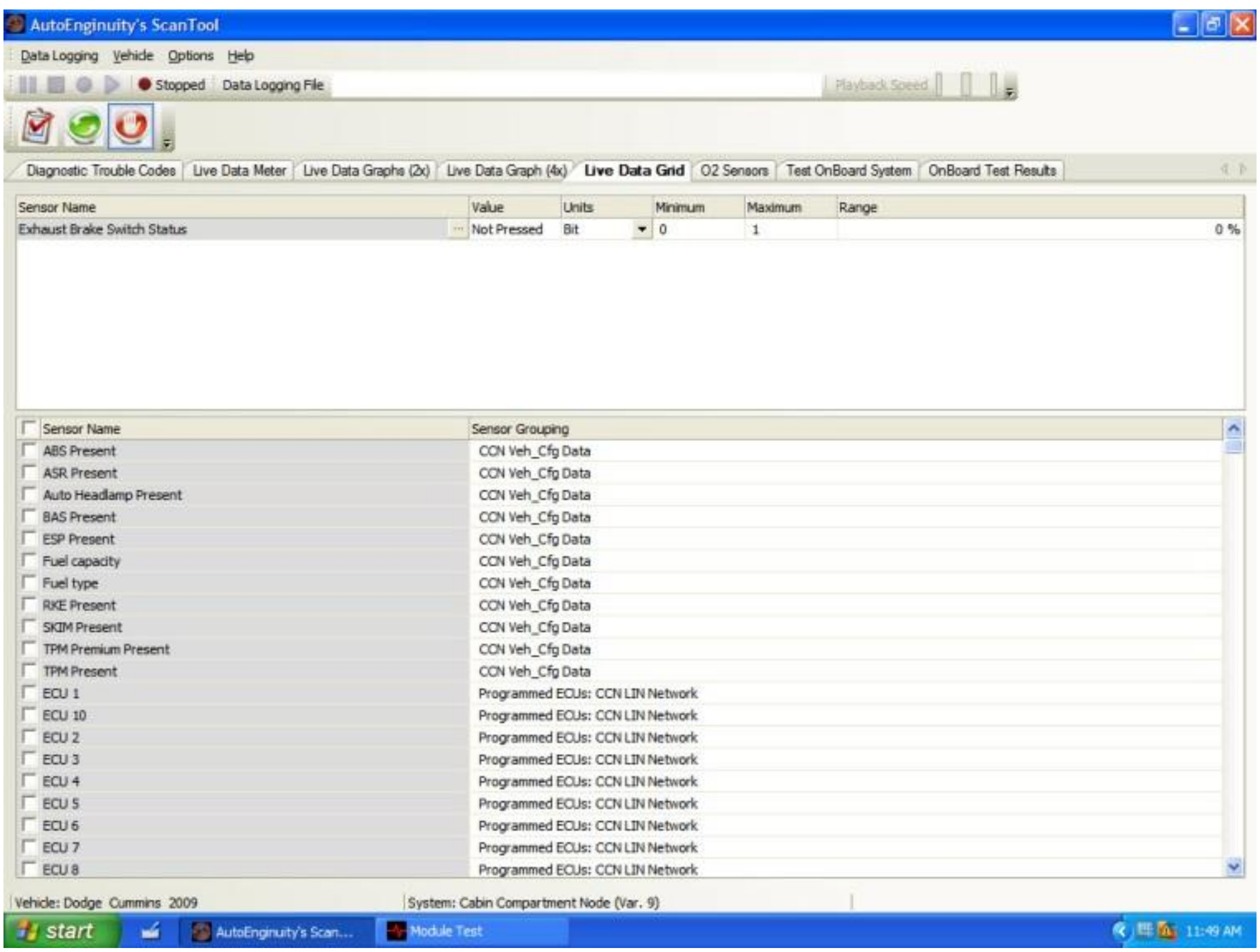
VGT Turbocharger Speed Sensor:

The PCM uses the sensor to estimate boost pressure. This sensor is used in the OBD-II Intake Manifold Diagnostic Rationality Monitor. The sensor is a variable reluctance speed sensor (PM). As the flat spot on the shaft spins past the sensor it creates a signal which the PCM interprets into turbocharger speed.


ENGINE
CONTROL
MODULE (ECM)
TURBO
SPEED
SIGNAL (-)
TURBO
SPEED
SIGNAL (+)
TURBOCHARGER
SPEED
SENSOR

Exhaust Brake:

The VGT works with the engine and transmission to provide an integrated braking system to help slow the vehicle (called exhaust braking). The driver must turn on the exhaust brake switch for the system to activate exhaust braking.



The exhaust brake automatically operates when the driver releases the accelerator pedal. Braking power is achieved by modulating the sliding nozzle in the turbo to create a back pressure on the engine. The pressure creates a high level of resistance on the movement of the pistons reducing engine speed.

It may be used to reduce engine warm up time if:

- The vehicle is less than 5mph
- The exhaust brake switch must be on
- Engine coolant temperature must be below 180°F
- Ambient temperature must be below 60°F

Exhaust Gas Aftertreatment System:

The aftertreatment system was designed to meet emission standards (2010). It reduces NOx and Particulate Matter (PM) emissions. The NOx absorber system doesn't use any exhaust fluid.

A pipe from the turbo to the system transfers exhaust heat to the diesel particulate filter (DPF). The aftertreatment system uses an Oxidation Catalyst to reduce Hydrocarbons (DOC), and the Diesel Particulate Filter (DPF). Particulate filters are designed to trap particulates of soot/ash and burn them at the appropriate time. The soot/ash is burned during regeneration.

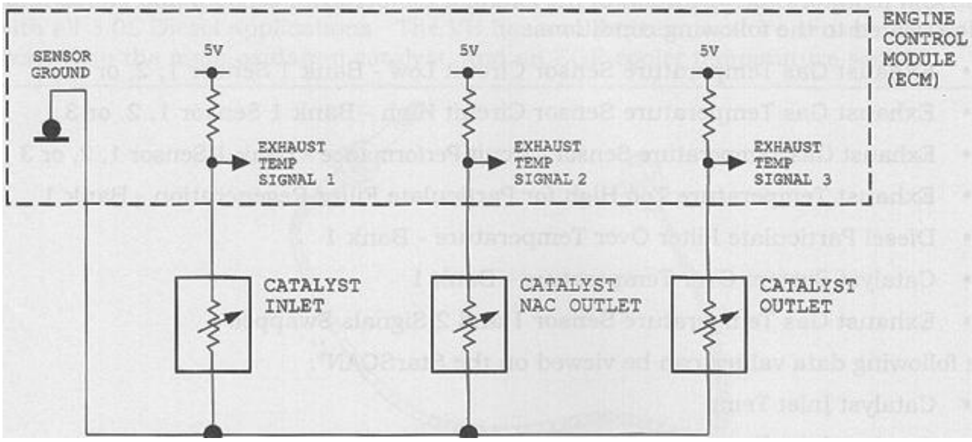
Diesel Particulate Filter (DPF):

Exhaust gases reach the DPF prior to flowing into the muffler so that the soot/ash doesn't enter. Diesel particulate filters decrease the amount of diesel particulates (soot/ash) and unburned hydrocarbons released from the combustion of diesel fuel. The honeycomb structure of the DPF captures soot/ash. The problem associated with DPF's is that over time, soot collecting in the DPF can clog it, resulting in decreased performance and fuel efficiency. To reduce DPF clogging an exhaust aftertreatment known as active regeneration is used. Sensors tell the PCM when excessive particulate matter has built up in the DPF, and active regeneration mode is triggered. During regeneration, the engine idle is increased to help build up heat the DPF, and diesel fuel is injected during the exhaust stroke, allowing fuel to enter the exhaust system and burn in the DPF. The combustion of diesel fuel in the DPF generates the heat necessary to burn off soot cleaning it.

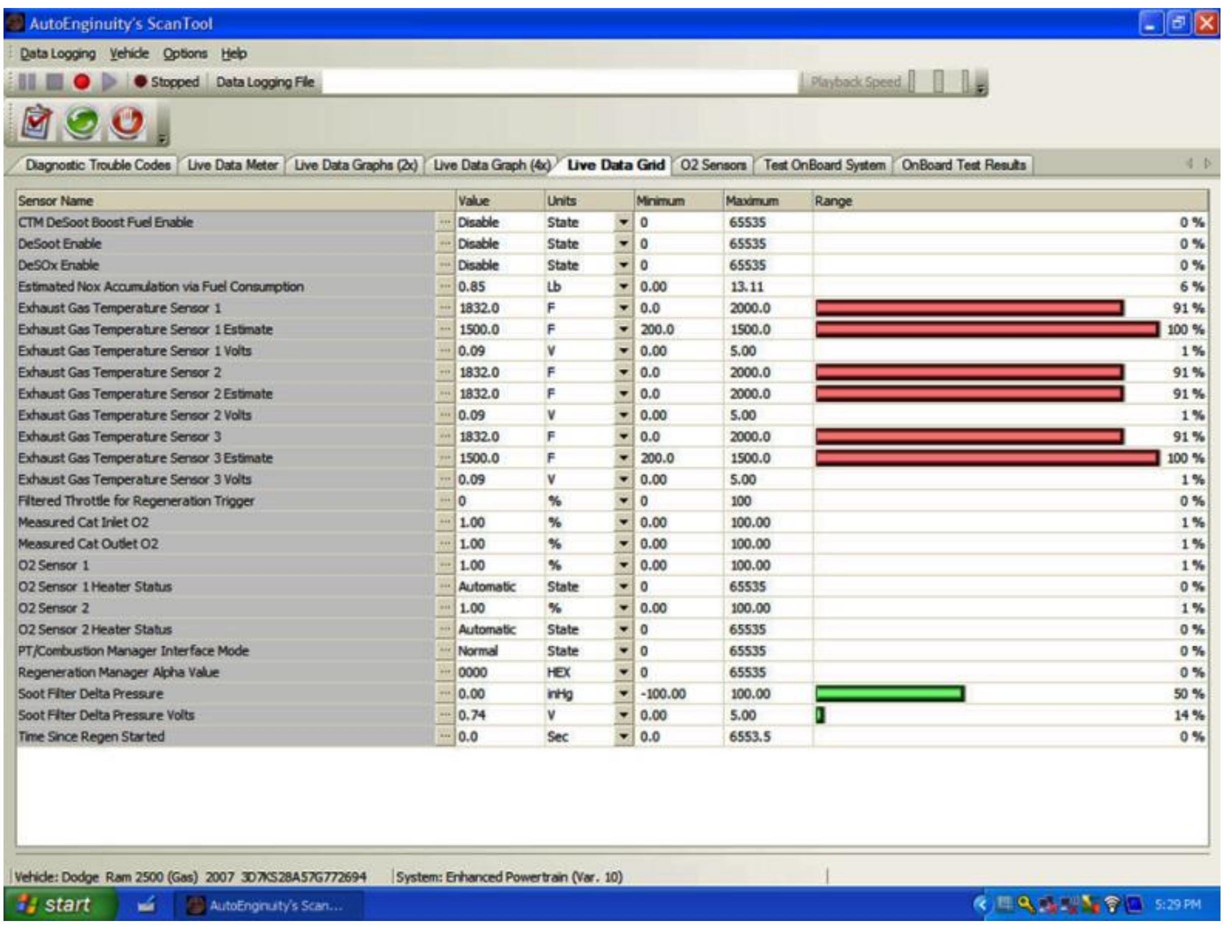
Regeneration:

Regeneration begins when the exhaust gas temperature reaches somewhere near 1000°F), which can be achieved under medium to heavy load conditions. There must be sufficient heat in the exhaust system to burn off the soot/ash. The system will regenerate on its own if enough heat has been generated normally. If there isn't enough heat, the system enters active regeneration. The PCM cycles the fuel injectors post combustion to add diesel fuel to help the burn off process.

Exhaust gas catalysts temperature sensors:



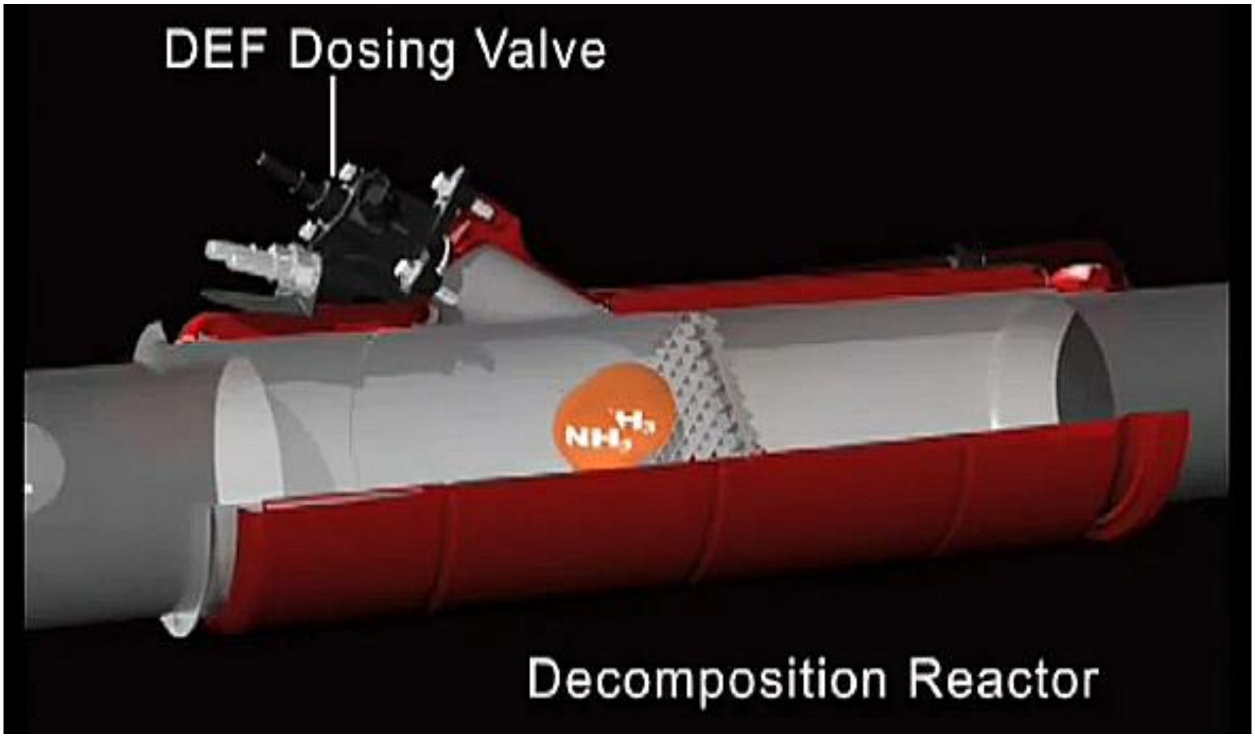
The PCM uses 3 temperature sensors to determine exhaust temperature. These can be viewed in scan data.

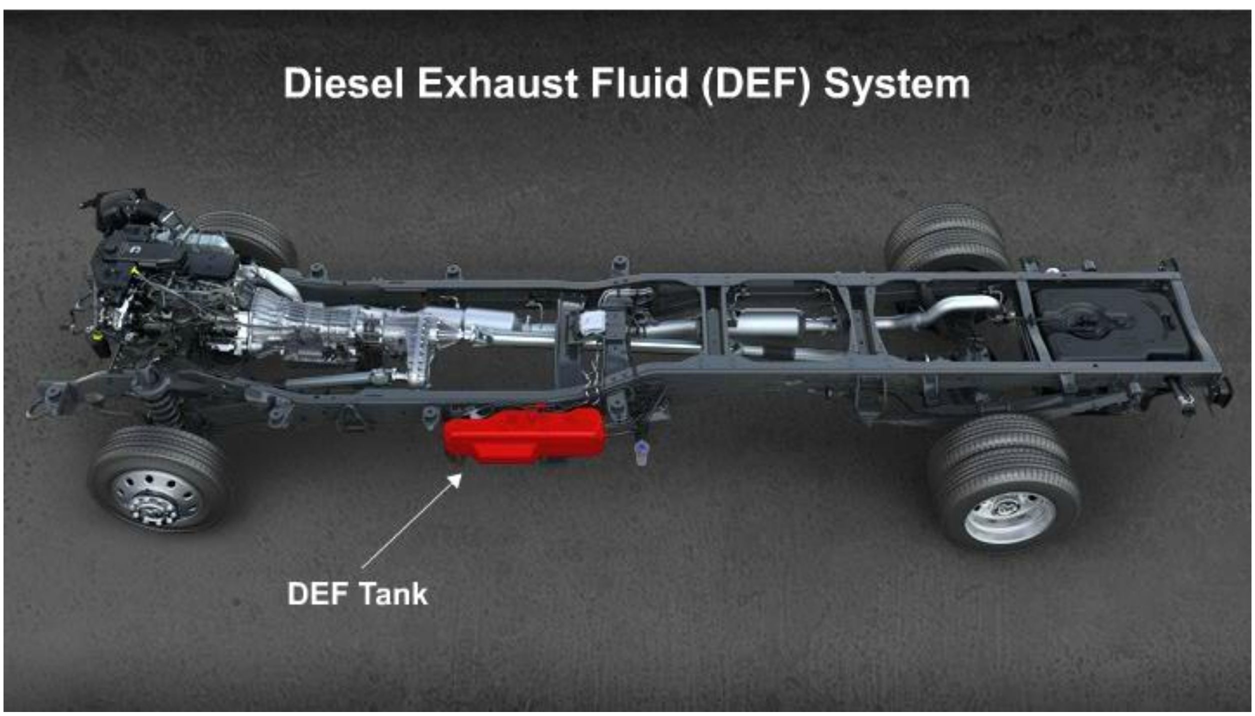


Sensor Name	Value	Units	Minimum	Maximum	Range
CTM DeSoot Boost Fuel Enable	Disable	State	0	65535	0 %
DeSoot Enable	Disable	State	0	65535	0 %
DeSOx Enable	Disable	State	0	65535	0 %
Estimated Nox Accumulation via Fuel Consumption	0.85	Lb	0.00	13.11	6 %
Exhaust Gas Temperature Sensor 1	1832.0	F	0.0	2000.0	91 %
Exhaust Gas Temperature Sensor 1 Estimate	1500.0	F	200.0	1500.0	100 %
Exhaust Gas Temperature Sensor 1 Volts	0.09	V	0.00	5.00	1 %
Exhaust Gas Temperature Sensor 2	1832.0	F	0.0	2000.0	91 %
Exhaust Gas Temperature Sensor 2 Estimate	1832.0	F	0.0	2000.0	91 %
Exhaust Gas Temperature Sensor 2 Volts	0.09	V	0.00	5.00	1 %
Exhaust Gas Temperature Sensor 3	1832.0	F	0.0	2000.0	91 %
Exhaust Gas Temperature Sensor 3 Estimate	1500.0	F	200.0	1500.0	100 %
Exhaust Gas Temperature Sensor 3 Volts	0.09	V	0.00	5.00	1 %
Filtered Throttle for Regeneration Trigger	0	%	0	100	0 %
Measured Cat Inlet O2	1.00	%	0.00	100.00	1 %
Measured Cat Outlet O2	1.00	%	0.00	100.00	1 %
O2 Sensor 1	1.00	%	0.00	100.00	1 %
O2 Sensor 1 Heater Status	Automatic	State	0	65535	0 %
O2 Sensor 2	1.00	%	0.00	100.00	1 %
O2 Sensor 2 Heater Status	Automatic	State	0	65535	0 %
PT/Combustion Manager Interface Mode	Normal	State	0	65535	0 %
Regeneration Manager Alpha Value	0000	HEX	0	65535	0 %
Soot Filter Delta Pressure	0.00	inHg	-100.00	100.00	50 %
Soot Filter Delta Pressure Volts	0.74	V	0.00	5.00	14 %
Time Since Regen Started	0.0	Sec	0.0	6553.5	0 %

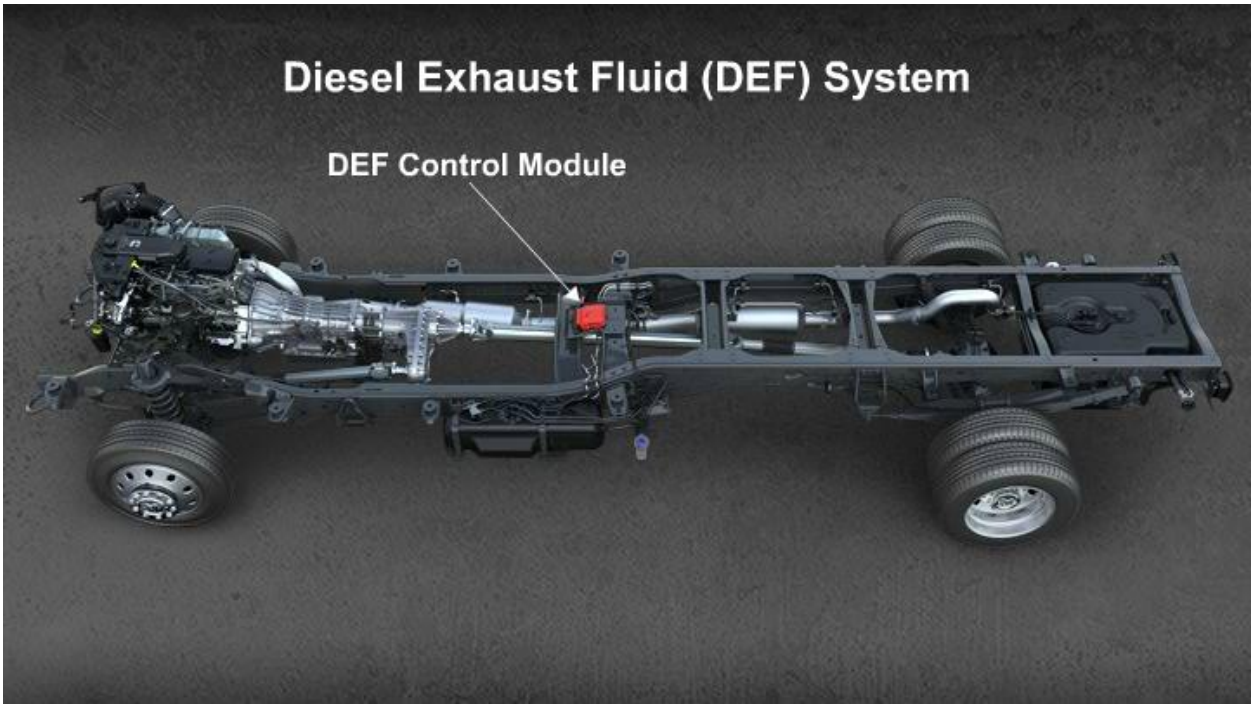
Diesel Exhaust Fluid and Selective Catalytic Reduction System (DEFSCR):

The diesel exhaust fluid (DEF) is designed to reduce NOx. The DEF is used with a selective catalytic reduction system (SCR Cat). The Diesel Exhaust Fluid is injected through a PCM controlled Dosing Valve mounted in the SCR Cat. The system helps converting the NOx into nitrogen and water by-product. This system is on Dodge's Cab Chassis vehicles (Larger Trucks) (Not Pick-ups).





The tank holds 8 gallons of DEF and is heated so that DEF won't freeze. Engine coolant runs through a tube inside the tank.



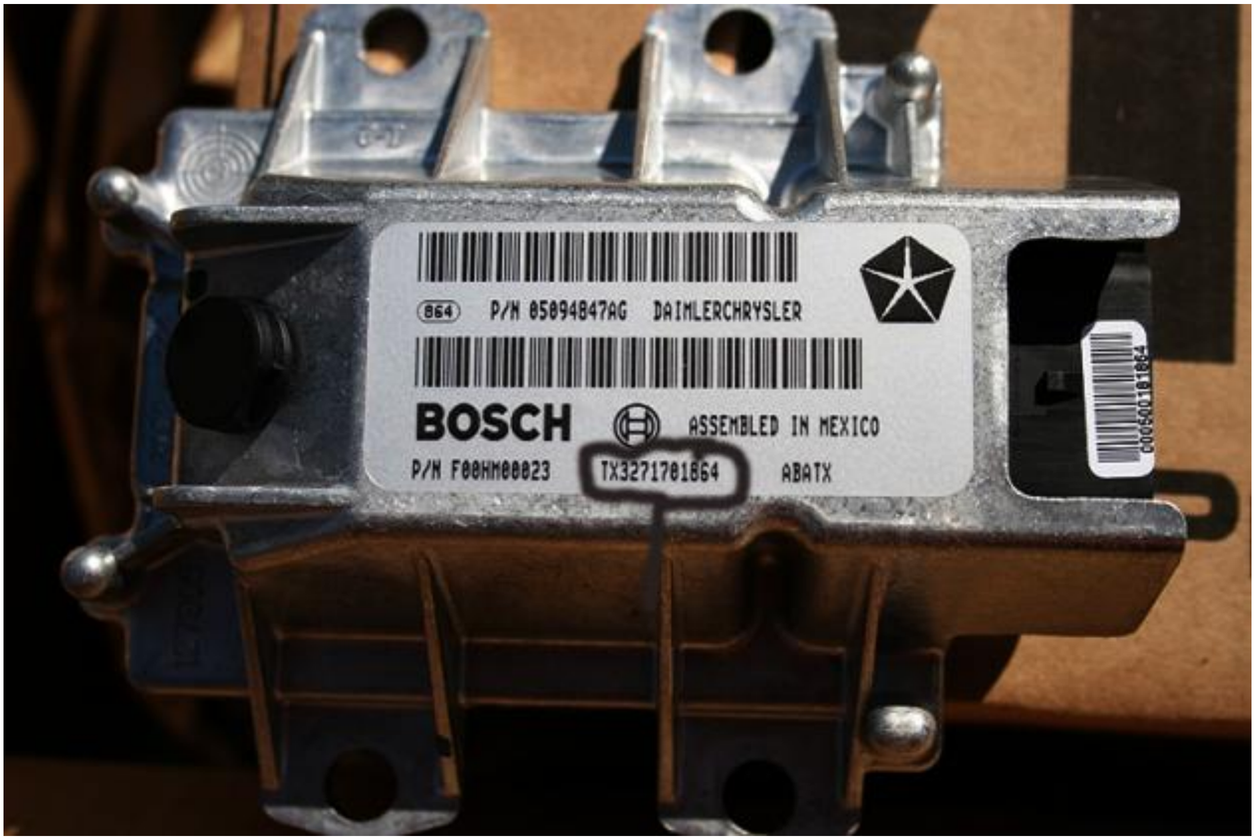
The Dosing control unit controls the supply Pump, the Injector, and the heater. The control unit communicates over the CAN BUS.

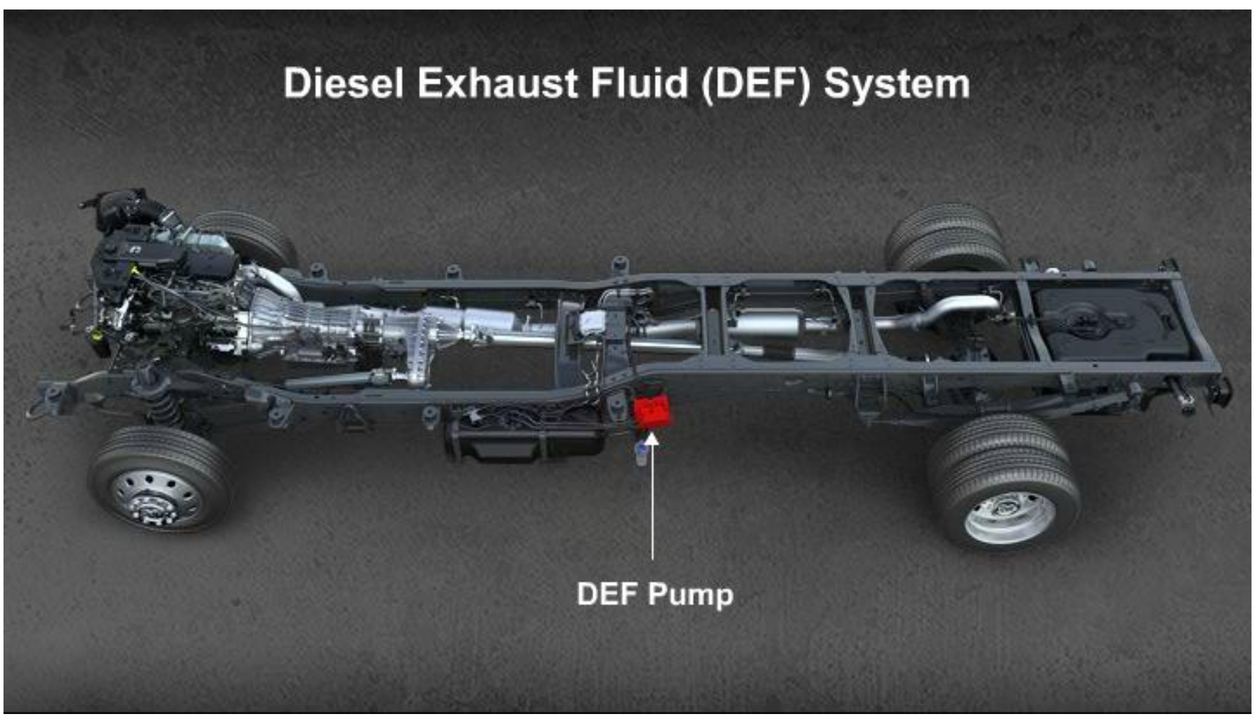
Communication Note:

The PCM, DCU, NOx modules and turbocharger actuator are on a dedicated CAN BUS. A dedicated BUS means that it is PRIVATE (Stand Alone BUS), where only certain control units communicate. The BUS is a High Speed CAN. Twisted pair of wires when not communicating is at 2.5 volts. CAN high is pulled up and CAN low is pulled down when communicating.

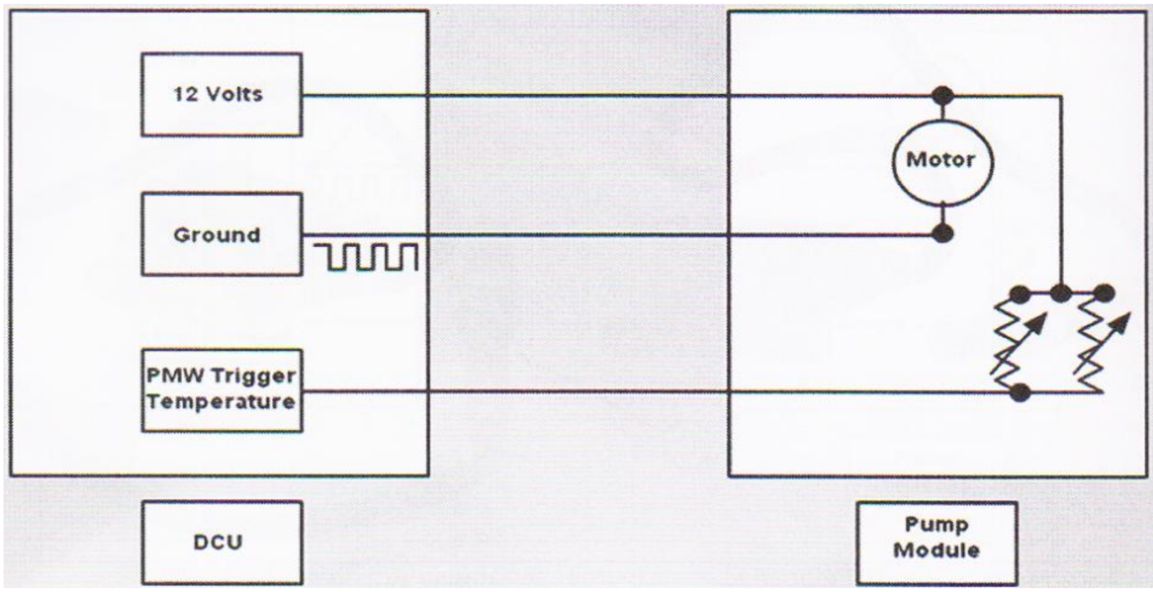
NOx 1 and NOx 2 Modules and Sensors:

There are two NOx modules and sensors, one upstream and one downstream of the Catalytic Converters. They report to the PCM the actual NOx entering and exiting the Catalytic converter.

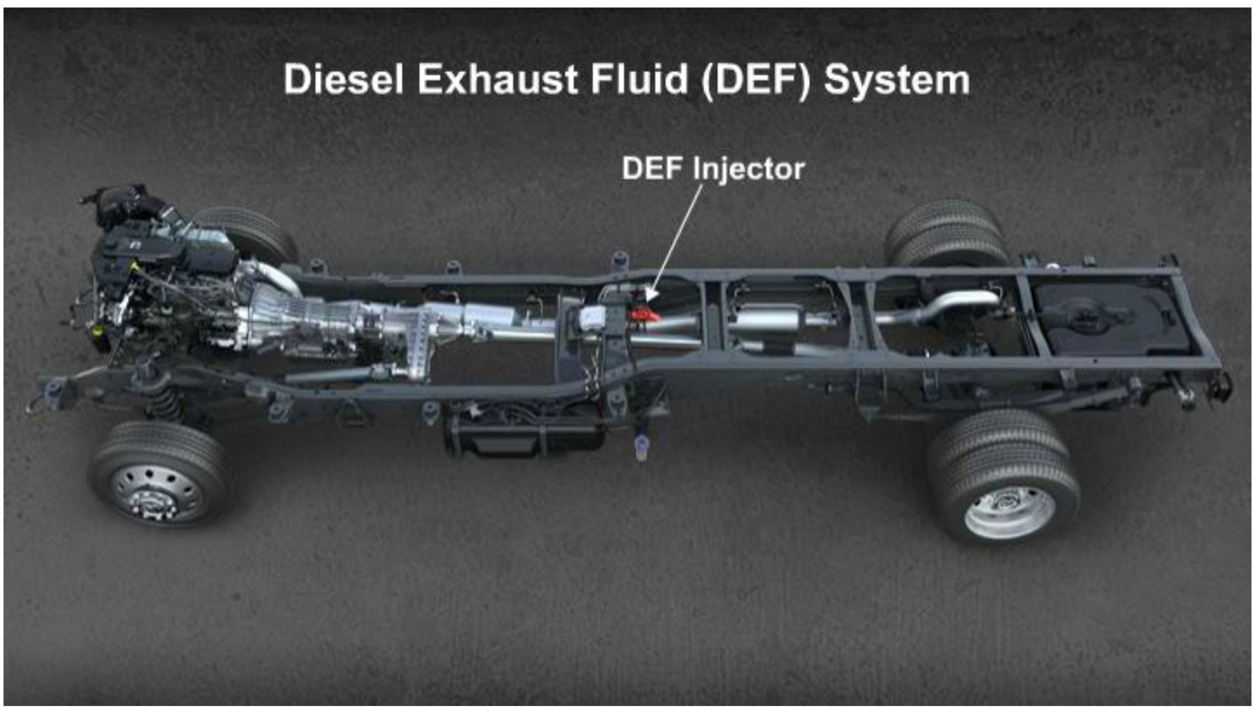


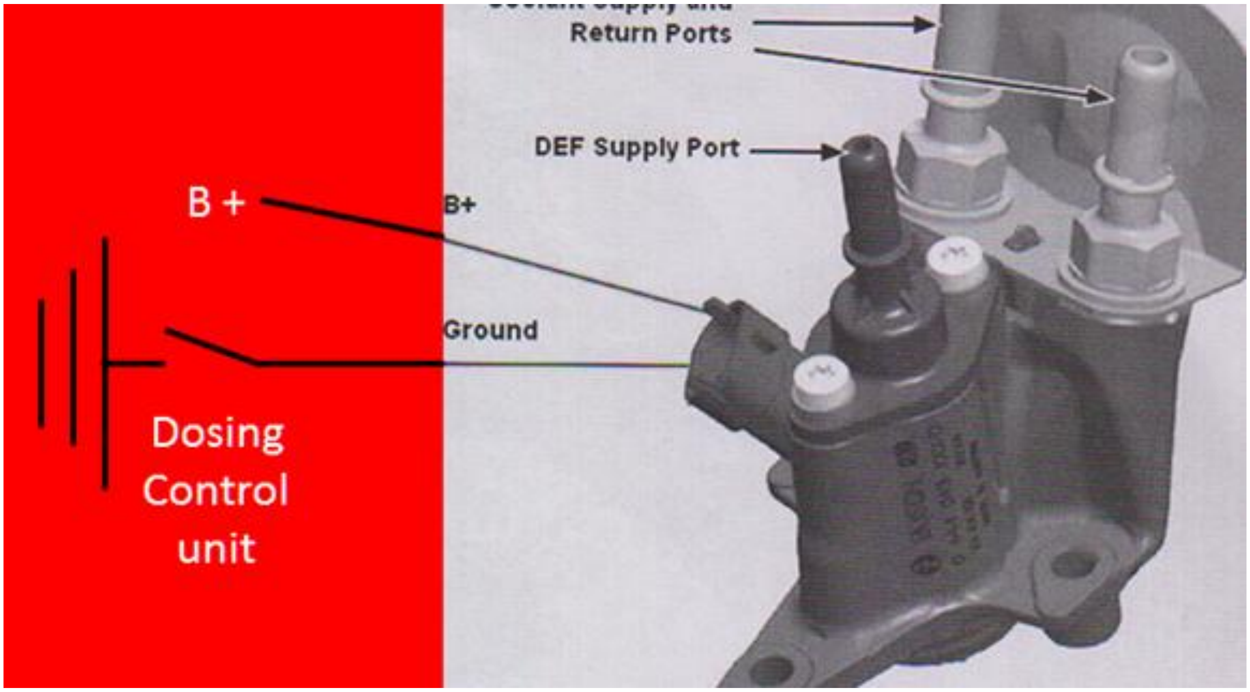


The DEF pump supplies pressure to transfer the fluid from the holding tank to the injector.



The pump is controlled by a PWM signal from the control unit.





The driver's information display will send warning messages about the system.

- Low DEF Refill Soon (1,000-600 miles left)
- Refill DEF Engine Will Not Restart in Miles (600-100 miles left)
- Refill DEF Engine Will Not Start (100-0 miles left)

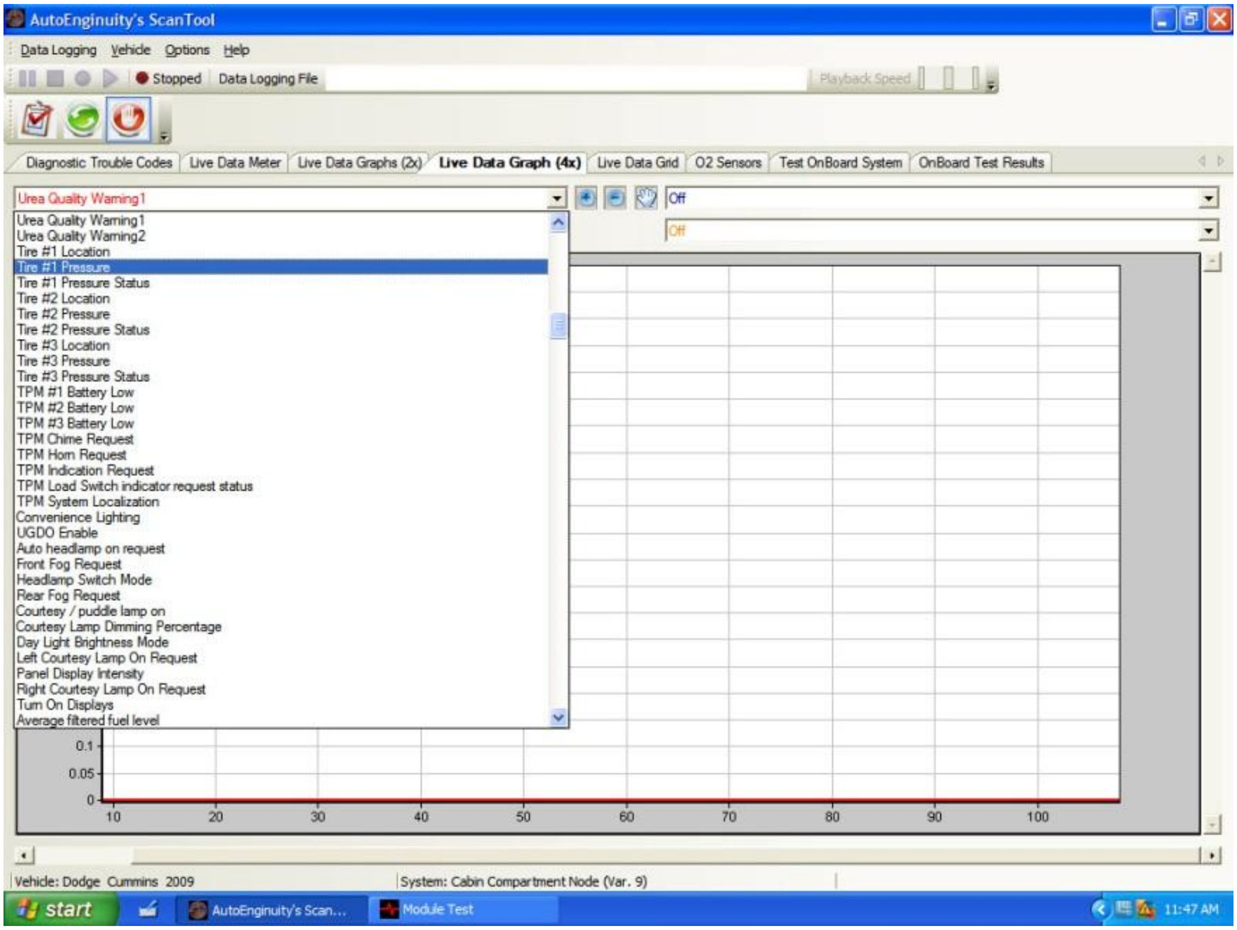
When the message the vehicle will not start appears, the PCM cuts fuel at start up. If the engine is running it will continue to run until it is shut down or stalls then will not start.

There are 4 modes of DEF operation.

- Standby; when the engine isn't running
- No Pressure Control; if ambient temperature is below 16°F until the system heats up the DEF to thaw
- Pressure Control; The pump runs to refill the system
- After run; when the engine is shut off, the DCU opens the injector and cycles the pump to evacuate the fluid from the lines and pump (20-30 seconds)

DEF has a shelf life.

Temperature °F	Estimated Shelf Life
32	Infinity
50	75 Years
68	11 Years
95	10 Months
104	4 Months
122	1 Month
140	1 Week



Urea quality has a PID in Scan Data. The reason there isn't a value in this example; this is a pick up and not a Cab Chasses truck. Pick up trucks don't not have the DEF system installed on them.

Engine Oil:

Chrysler recommends API CJ4 -15W- 40 - Low Ash Oil is required for the 6.7L engine. It has less sulfur and phosphorus than other oils. It is refined to work with and prolong the life of the aftertreatment components.

OBDII Diagnostics:

The Dodge Cummins truck is an OBD-II complaint vehicle. The 5.9 L meets the 2007 standard and the 6.7 L meets the 2010 standard. As with a gas vehicle that is OBD-II, it can be diagnosed with different type of equipment. OBD-II is addressed with a Scan Tool. The scan tool you have in your shop may or may not have the same data as the one we use in the examples.

There is OBD-II diagnostic test mode available from the PCM. You may have never heard of them because you call them by different name. For example OBD-II diagnostic test mode 1 is what we call data or PIDs.

Low Sulfur Fuel:

One of the first subjects discussed in this course was fuel quality.

Chrysler designed the 6.7L and 5.9L to run on low sulfur diesel fuel only. It produces less Particulate Matter from combustion and enables the NOX absorber to be highly effective. Clean diesel exhaust-gas systems use catalysts to reduce hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NOx), and soot/ash. The active catalyst surface can be damaged if Low or Ultra Low sulfur fuel isn't used. Starting June 1, 2006, refiners were required to begin phasing in the Ultra-Low Sulfur Diesel Fuel.

Bio-Diesel Fuel:

B5 fuel is bio-diesel fuel that contains 5% bio-diesel and 95% standard diesel fuel. B5 is the maximum acceptable level of Bio-Diesel Fuel recommended by Chrysler for consumer vehicles.

Biodiesel is a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats, meeting ASTM D 6751, designated B100.

Biodiesel Blend, n. -- a blend of biodiesel fuel with petroleum-based diesel fuel designated BXX, where XX is the volume percent of biodiesel.

This tight definition was needed in order to secure vehicle, engine and fuel injection equipment company support for biodiesel, as well as to secure American Society for Testing and Materials (ASTM) specs.

B20 approved on Dodge Ram for approved Government, Military and Commercial Fleets –

B5 approved for all other diesel applications

B5 Factory Fill in place for Dodge Ram. Biodiesel fuel must meet ASTM D6751 or ASTM D7467 and fuel should be used within 6 months of production.

B20 Approval is for 2002 and later emissions-compliant On-Highway ISX, ISM, ISL, ISC and ISB engines. B20 is also approved for Off-Highway engines including: QSX, QSM, QSL, QSC, QSB6.7, QSB4.5, QSM Marine, and QSM G-Drive. All 2010 Cummins engines will be B20 compliant.

Biodiesel Raw Materials:

Oil or Fat	Alcohol
Soybean	Methanol
Corn	Ethanol
Canola	
Cottonseed	Catalyst
Sunflower	Sodium hydroxide
Beef tallow	Potassium hydroxide
Pork lard	
Used cooking oils	

Advantages

High Cetane (avg. over 50)

- Ultra Low Sulfur (avg. ~ 2 PPM)
- High Lubricity, even in blends as low as 1-2%
- High Energy Balance (3.5 to 1)
- Renewable, Sustainable, Domestically Produced
- Increases overall fuel production capacity in USA
- Reduces HC, PM, CO in existing diesel engines
- Enhanced Lubricity

Equipment benefits

- Superior lubricity
- B2 has up to 66% more lubricity than #2 Diesel
- EPA required sulfur reduction in 2006
- No overdosing concerns vs. other lubricity additives

Disadvantages

- Lower Energy Content
- 8% fewer BTU's per gallon, but also higher Cetane #, lubricity, etc.
- Poor cold weather performance

This can be mitigated by blending with diesel fuel or with additives, or using low gel point feed stocks such as rapeseed/canola.

Stability Concerns

Biodiesel is less oxidative stable than petroleum diesel fuel. Old fuel can become acidic and form sediments and varnish. Additives can prevent this.

Scalability (lining)

Solvency (de-lining)

Injectors & Bio-Diesel Fuel

Higher than specified amounts of Bio-diesel fuel has been found to cause multiple injector failures

This can direct a technician's diagnostics in the wrong direction

The problem is the fuel not the vehicle

Operational Issues

1. Cold flow – fuel filter plugging
2. Microbial growth – fuel filter plugging
3. Incomplete reaction – fuel filter plugging
4. Fuel oxidation – fuel filter plugging

Fuel filter plugging is the most common operational issue

Oxygen Sensor Module and Sensors:

They are mounted to the frame to their exposer to vibration and heat. There are two sensors one in front and one behind the NOX absorber. Their information won't display data in all scan tools because they are a standalone module on a separate BUS. The PCM uses the sensors along with the MAF sensor to control EGR.

Connect the Scan Tool:

Lambda:

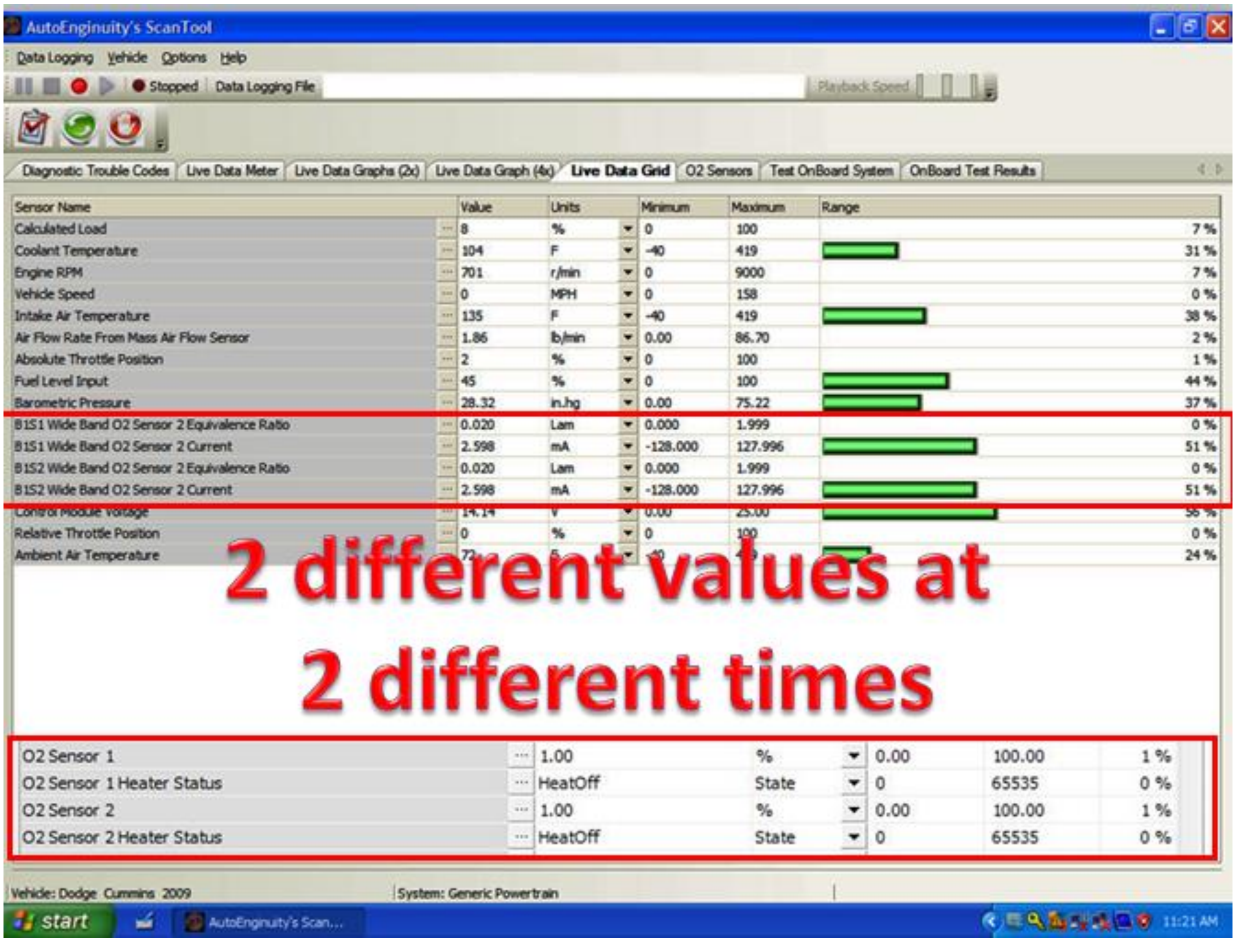
A Lambda value of 1.0 is equal to:

Stoichiometric

14.7:1

450 mv

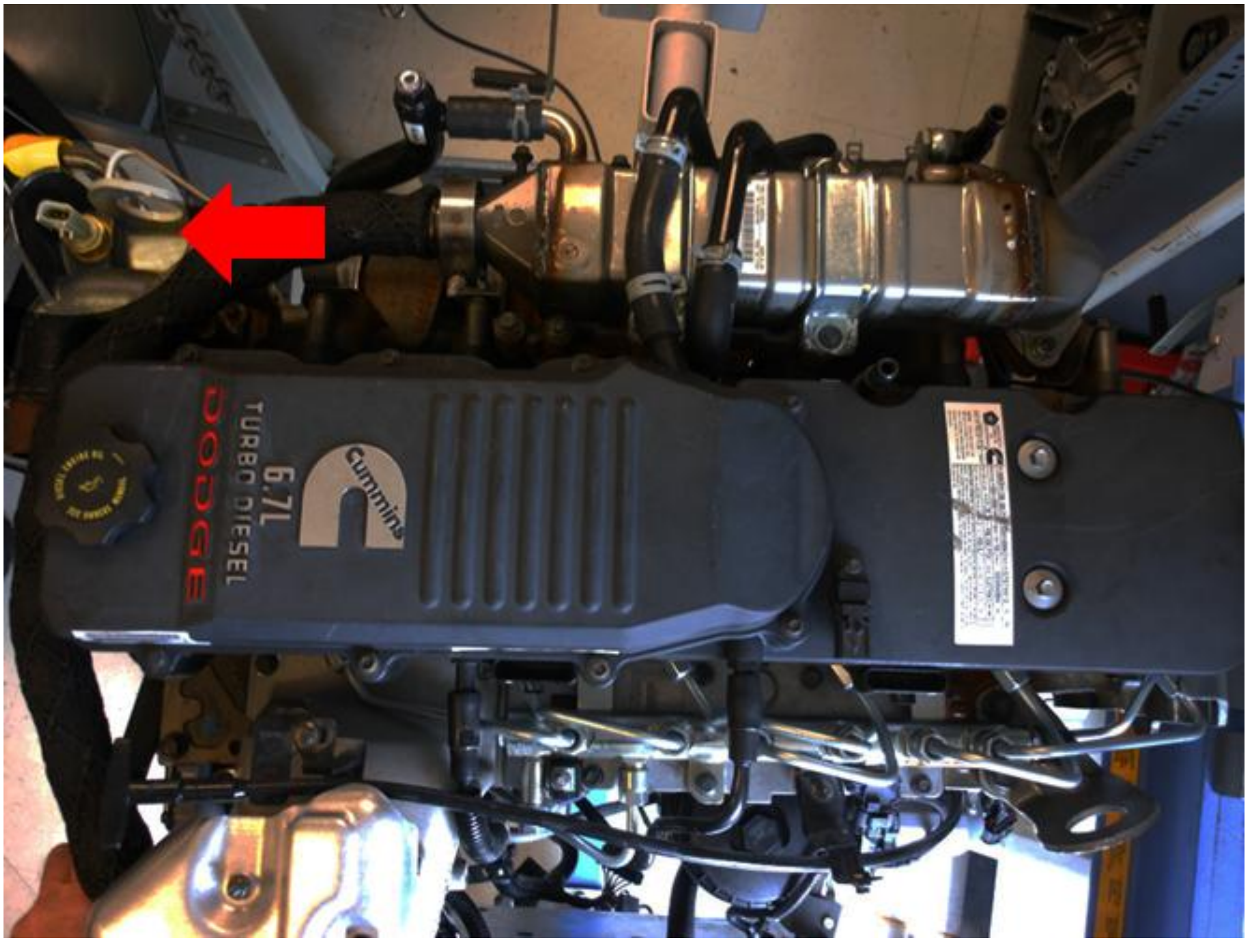
- A Lambda value of 0.8 is full rich
- A Lambda value of 1.2 is full lean

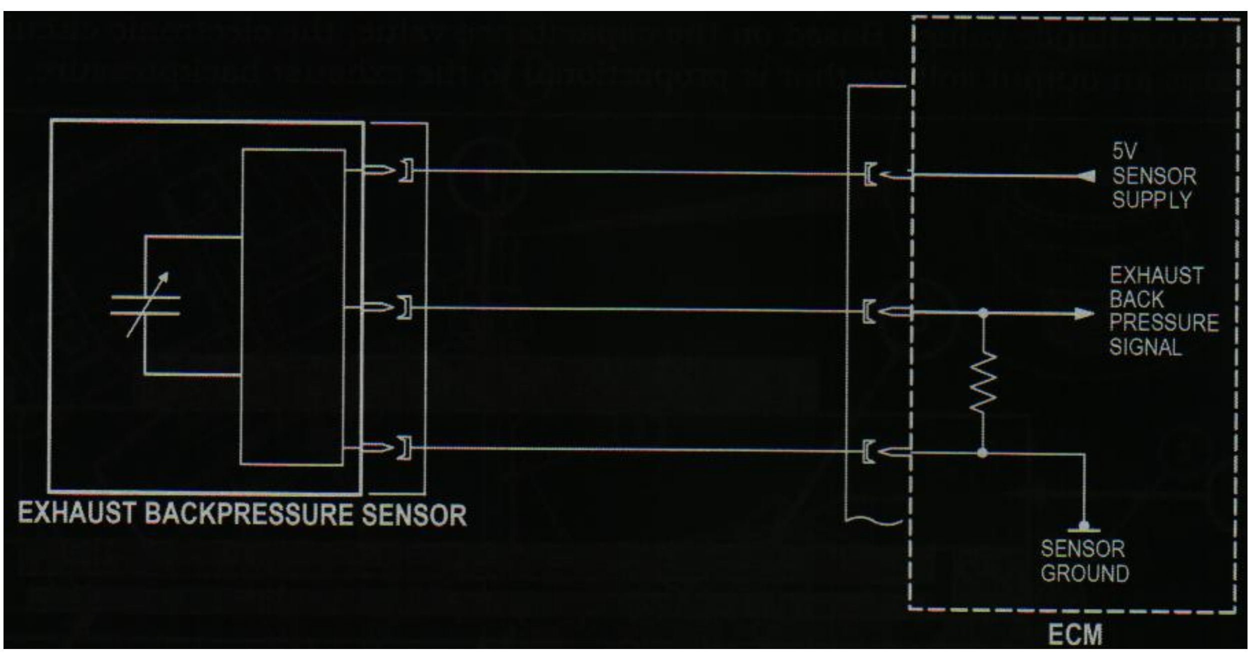


The Lambda value should remain at 1.0 indicating the correct fuel mixture for EGR control. If the value is greater 1.0 or less than 1.0, the PCM changes the EGR flow.

Exhaust Back Pressure Sensor:

The signal from the exhaust back pressure sensor is used by the PCM to control emissions and EGR valve operation. The signal ranges from 0.5 to 4.5 volts. The lower the voltage the low the pressure.

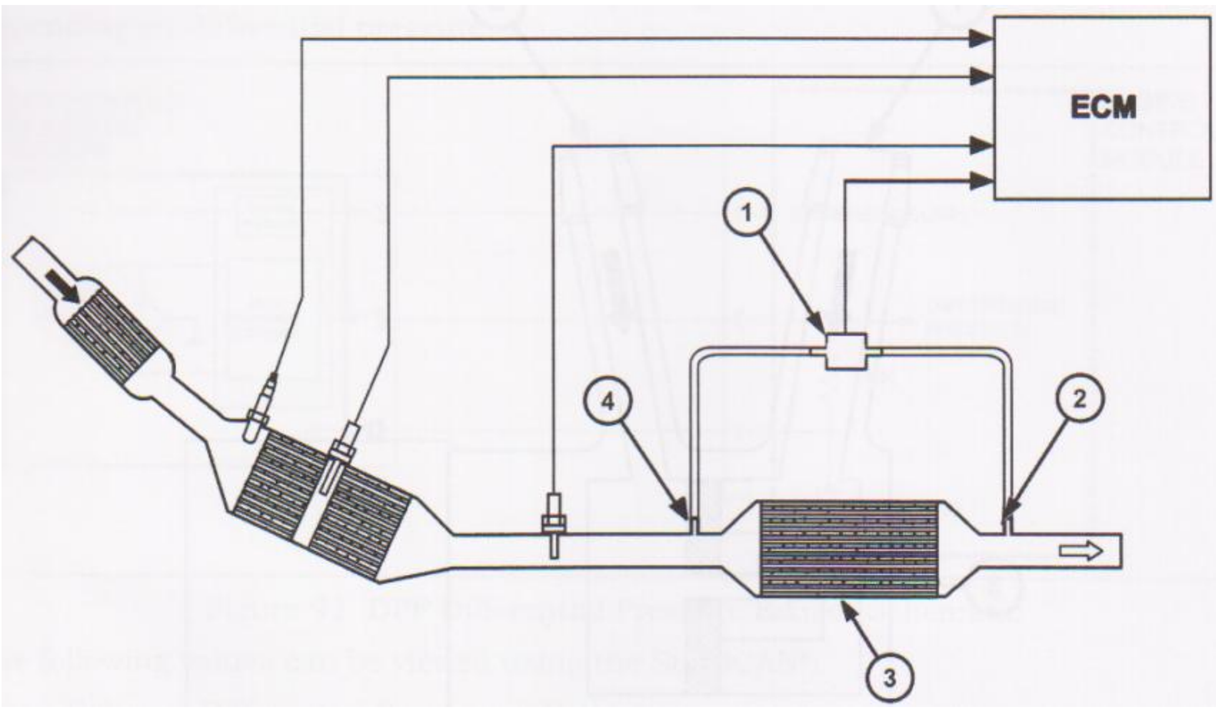

6.7L
TURBO DIESEL
DODGE
Cummins

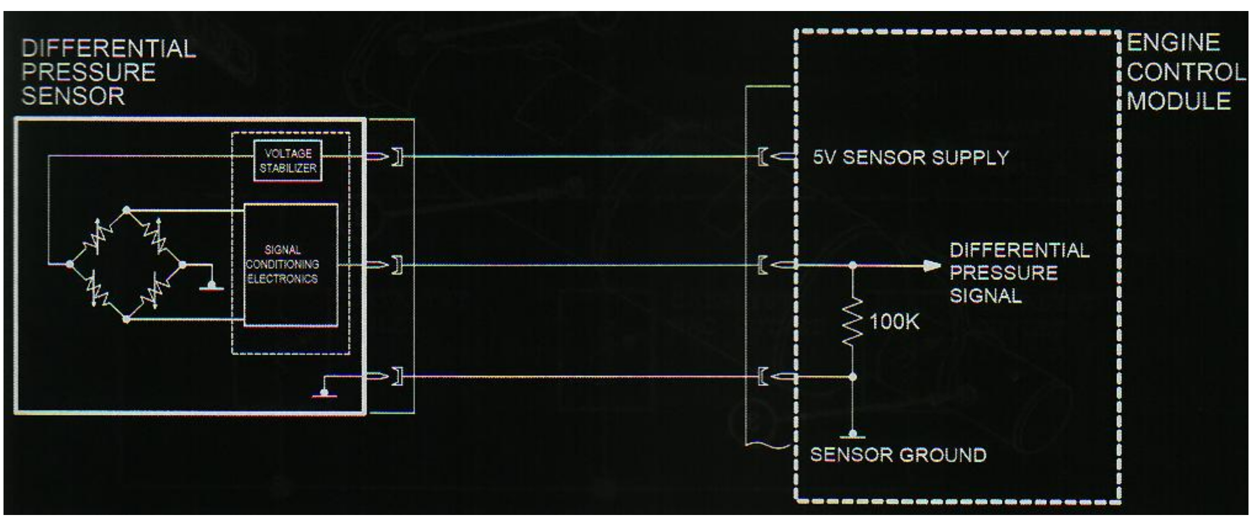

5V
SENSOR
SUPPLY
EXHAUST
BACK
PRESSURE
SIGNAL
EXHAUST BACKPRESSURE SENSOR
SENSOR
GROUND
ECM

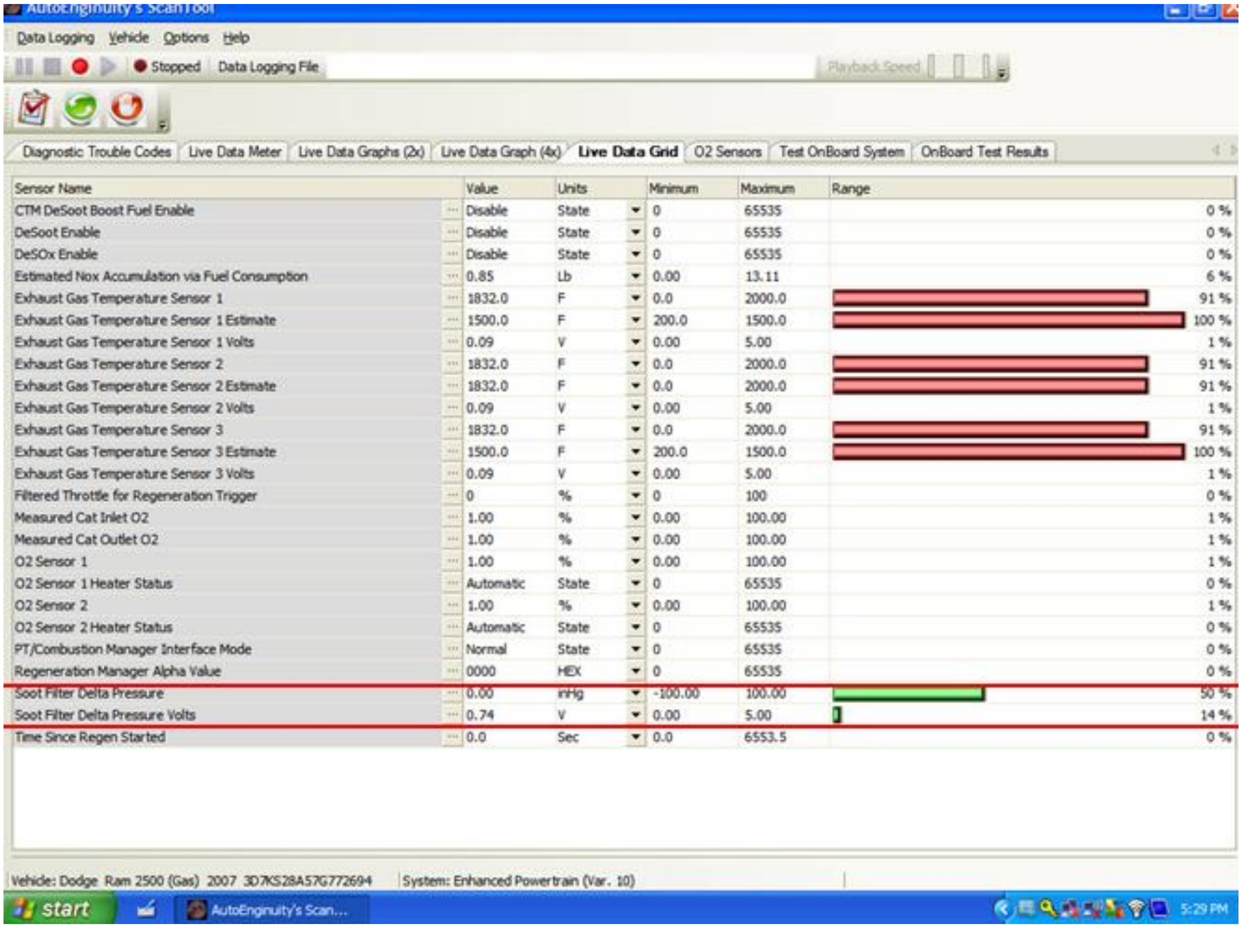
Pressure Differential Sensor:

The differential-pressure sensor (DPS) is used to determine when the DPF is restricted. As particulate matter builds up in the DPF, the pressure in front of the filter increases. The DPS compares the pressure before and after the DPF, and when the pressure ahead of the DPF reaches a predetermined level, regeneration occurs. When there is no soot/ash; pressure is almost identical on both sides. The higher the soot/ash load, the higher the differential voltage. The higher the differential voltage form the sensor, the higher the voltage signal output. The PCM uses the signal to determine when and how long regeneration should be.

It mounts to frame rail or transmission to keep it away from heat. Two pressure tubes connect before and after the DPF and interprets pressure drop as possible high soot/ash loads.



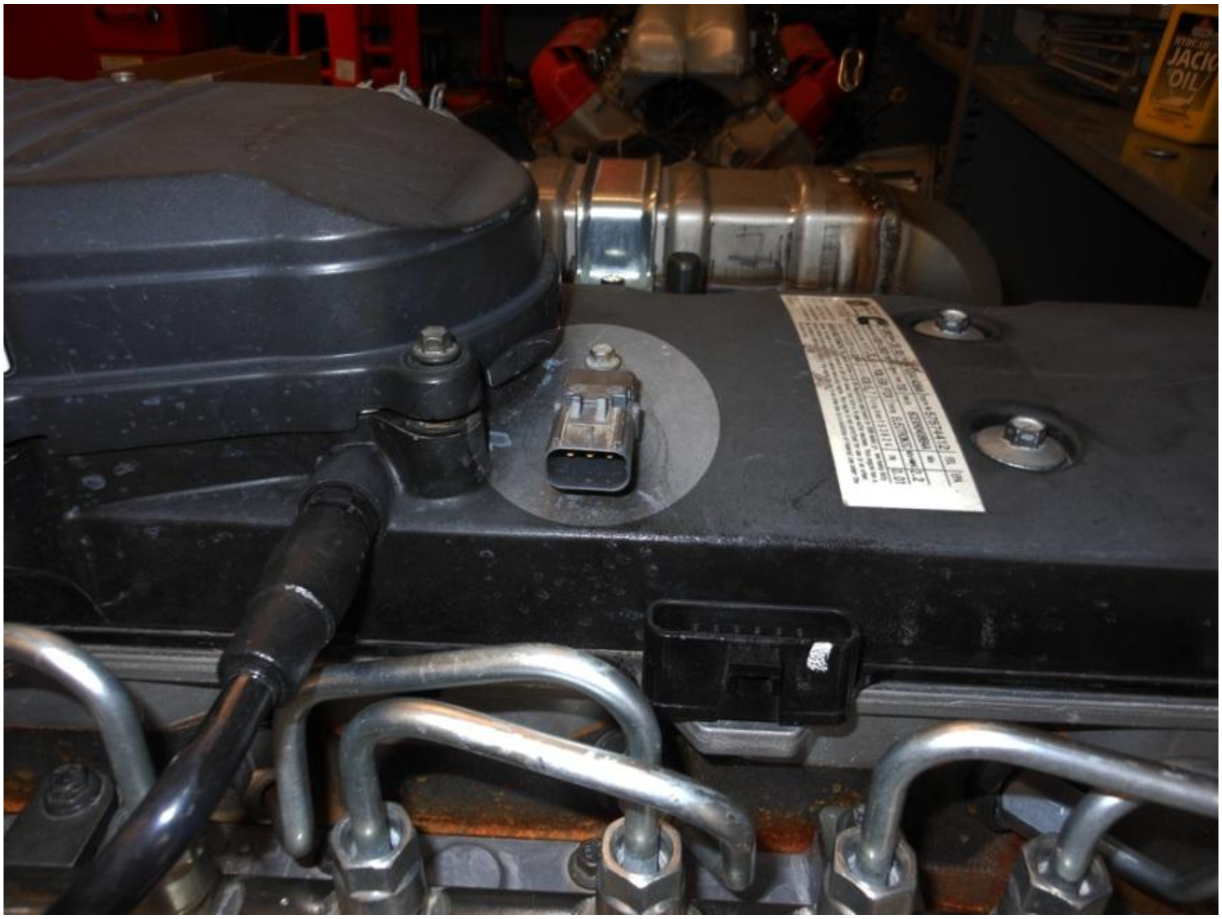


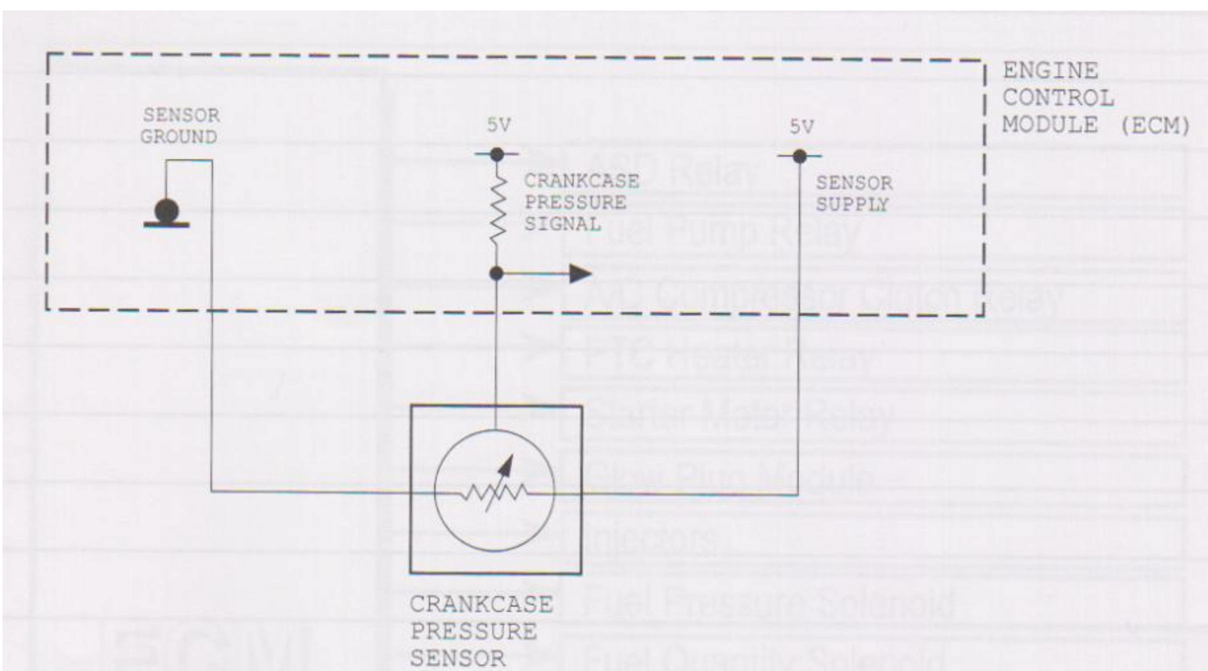


Sensor Name	Value	Units	Minimum	Maximum	Range
CTM DeSoot Boost Fuel Enable	Disable	State	0	65535	0 %
DeSoot Enable	Disable	State	0	65535	0 %
DeSOx Enable	Disable	State	0	65535	0 %
Estimated Nox Accumulation via Fuel Consumption	0.85	Lb	0.00	13.11	6 %
Exhaust Gas Temperature Sensor 1	1832.0	F	0.0	2000.0	91 %
Exhaust Gas Temperature Sensor 1 Estimate	1500.0	F	200.0	1500.0	100 %
Exhaust Gas Temperature Sensor 1 Volts	0.09	V	0.00	5.00	1 %
Exhaust Gas Temperature Sensor 2	1832.0	F	0.0	2000.0	91 %
Exhaust Gas Temperature Sensor 2 Estimate	1832.0	F	0.0	2000.0	91 %
Exhaust Gas Temperature Sensor 2 Volts	0.09	V	0.00	5.00	1 %
Exhaust Gas Temperature Sensor 3	1832.0	F	0.0	2000.0	91 %
Exhaust Gas Temperature Sensor 3 Estimate	1500.0	F	200.0	1500.0	100 %
Exhaust Gas Temperature Sensor 3 Volts	0.09	V	0.00	5.00	1 %
Filtered Throttle for Regeneration Trigger	0	%	0	100	0 %
Measured Cat Inlet O2	1.00	%	0.00	100.00	1 %
Measured Cat Outlet O2	1.00	%	0.00	100.00	1 %
O2 Sensor 1	1.00	%	0.00	100.00	1 %
O2 Sensor 1 Heater Status	Automatic	State	0	65535	0 %
O2 Sensor 2	1.00	%	0.00	100.00	1 %
O2 Sensor 2 Heater Status	Automatic	State	0	65535	0 %
PT/Combustion Manager Interface Mode	Normal	State	0	65535	0 %
Regeneration Manager Alpha Value	0000	HEX	0	65535	0 %
Soot Filter Delta Pressure	0.00	inHg	-100.00	100.00	50 %
Soot Filter Delta Pressure Volts	0.74	V	0.00	5.00	14 %
Time Since Regen Started	0.0	Sec	0.0	6553.5	0 %

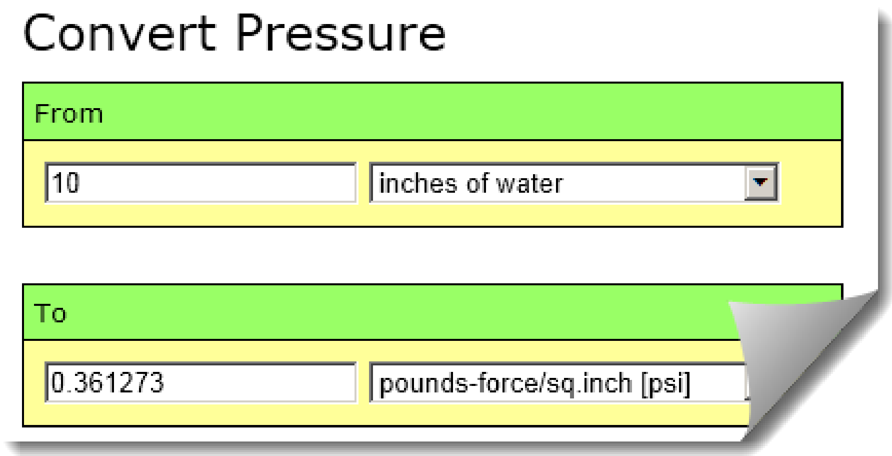
Crankcase Pressure Sensor:

It mounted just to the rear of the breather cover. The PCM uses the sensor to determine the condition of the crankcase ventilation filter and in determining if the filter is present.





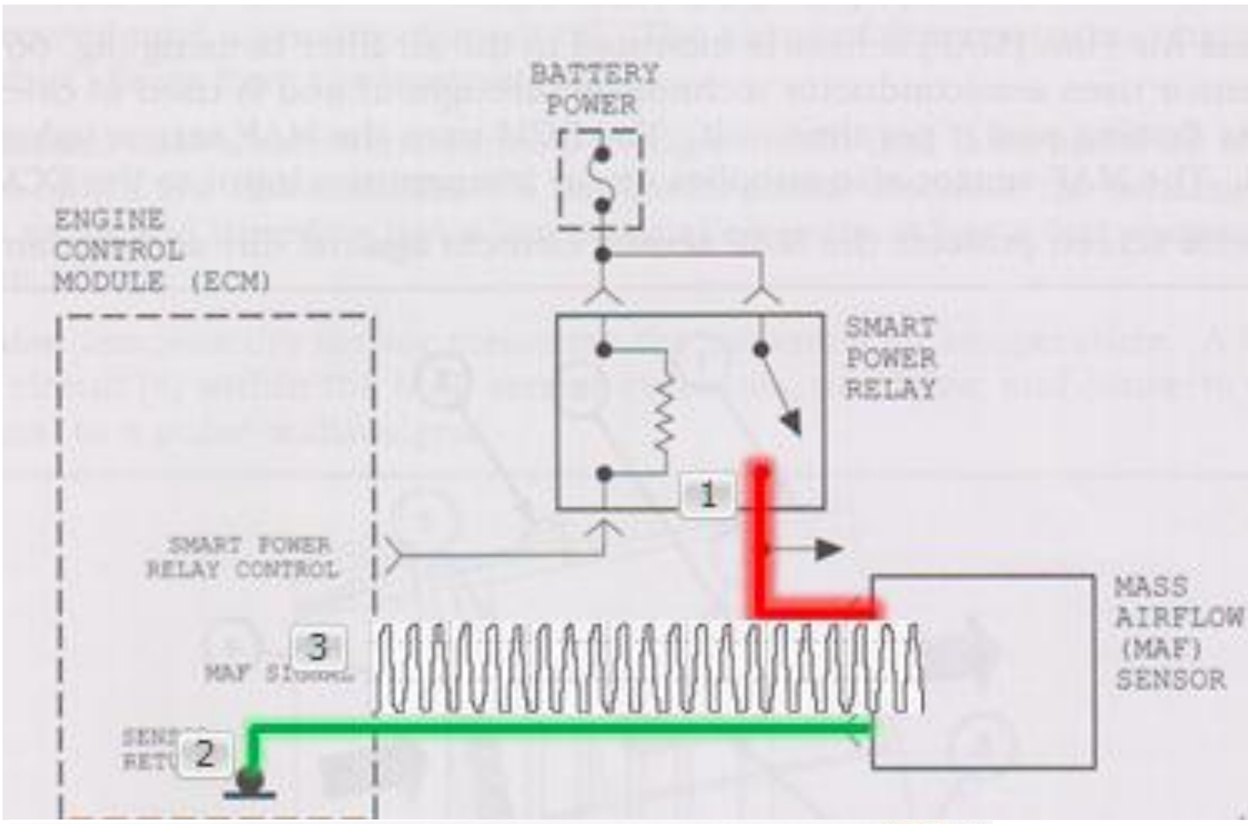
The crankcase pressure sensor is capable measuring from – 10 to +10 inches of water.

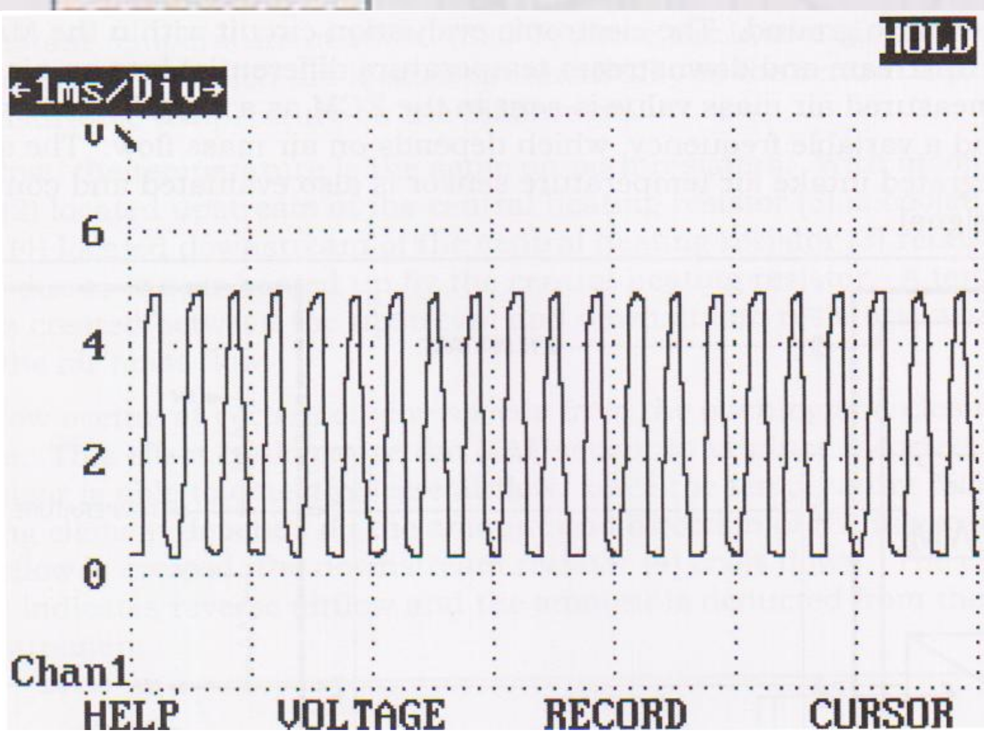


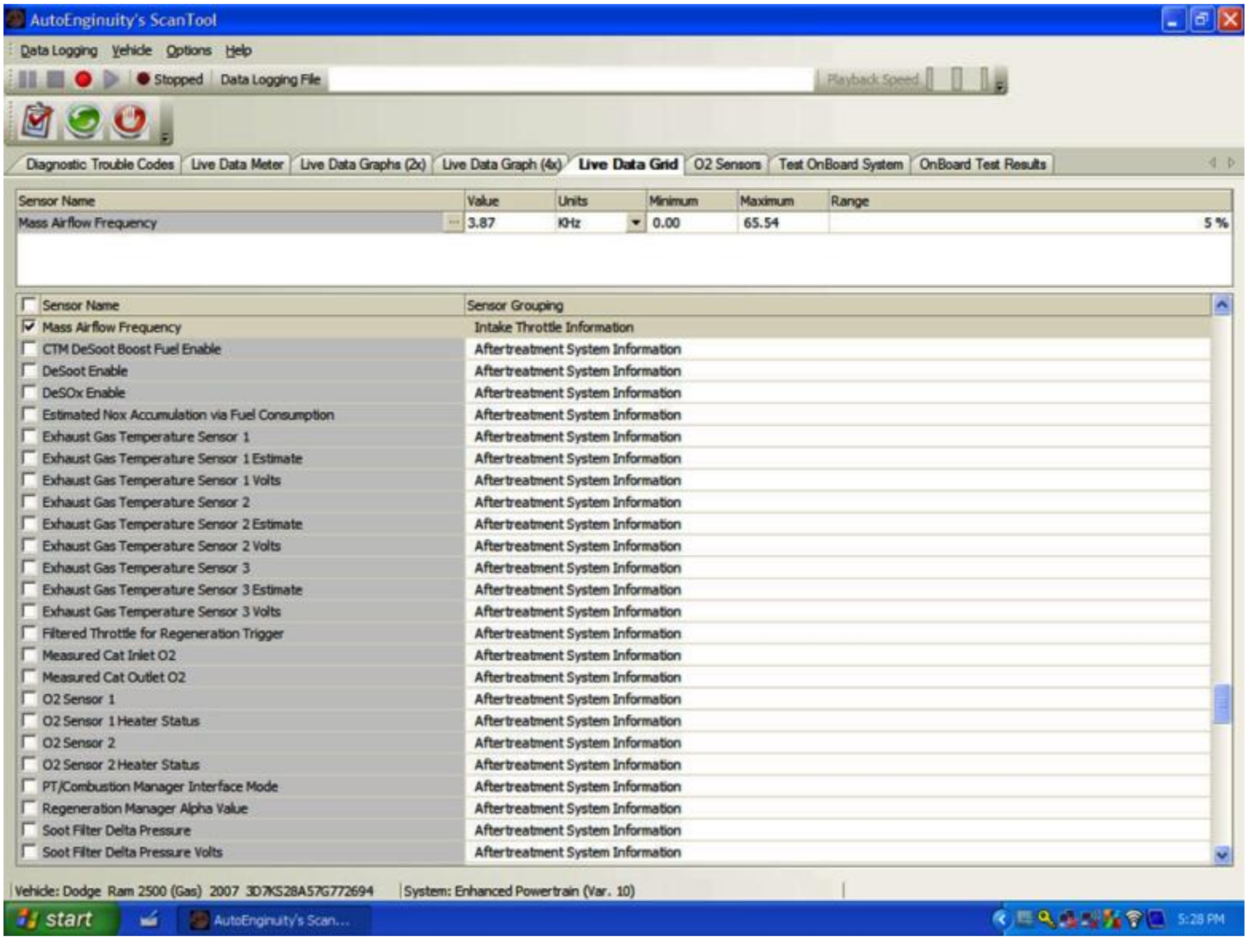
Mass Air Flow Sensor (MAF):

It is mounted on the air filter housing. The PCM uses the MAF sensor to manage the EGR system operation. It isn’t use for fuel control.

The MAF is a voltage based sensor. When voltage is applied to a wire it gets hot. As air flows across it, it cools. As it cools, the resistance of the circuit drops and allows additional current to flow through it. The PCM determines how much current is flowing. The sensor changes the current into a frequency and the PCM interprets the frequency into air flow.

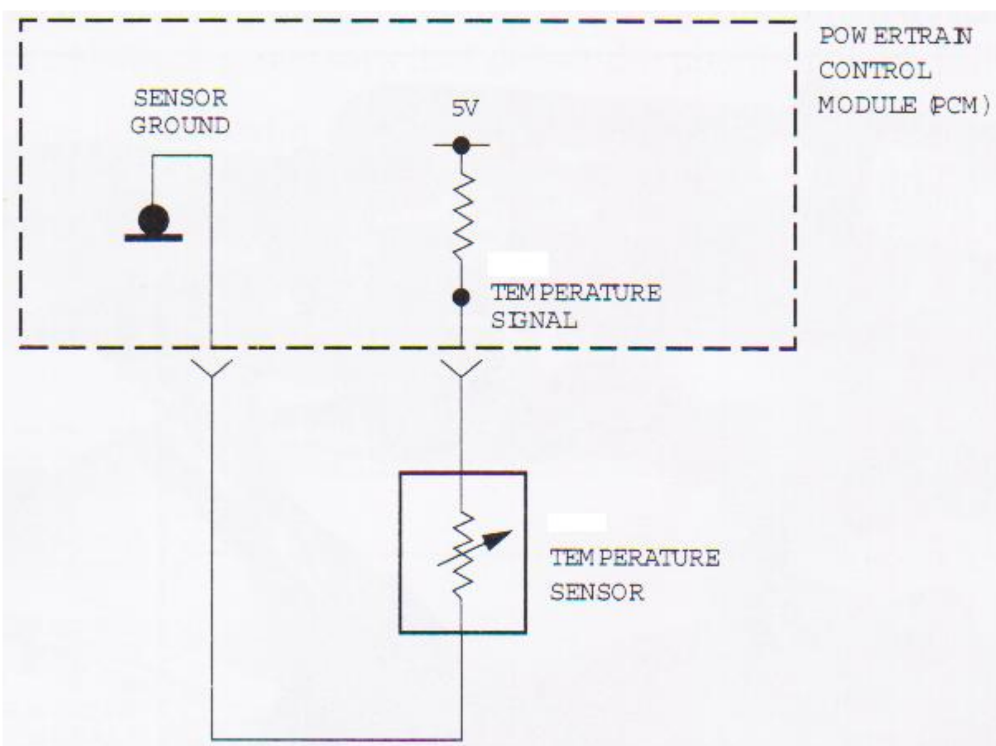






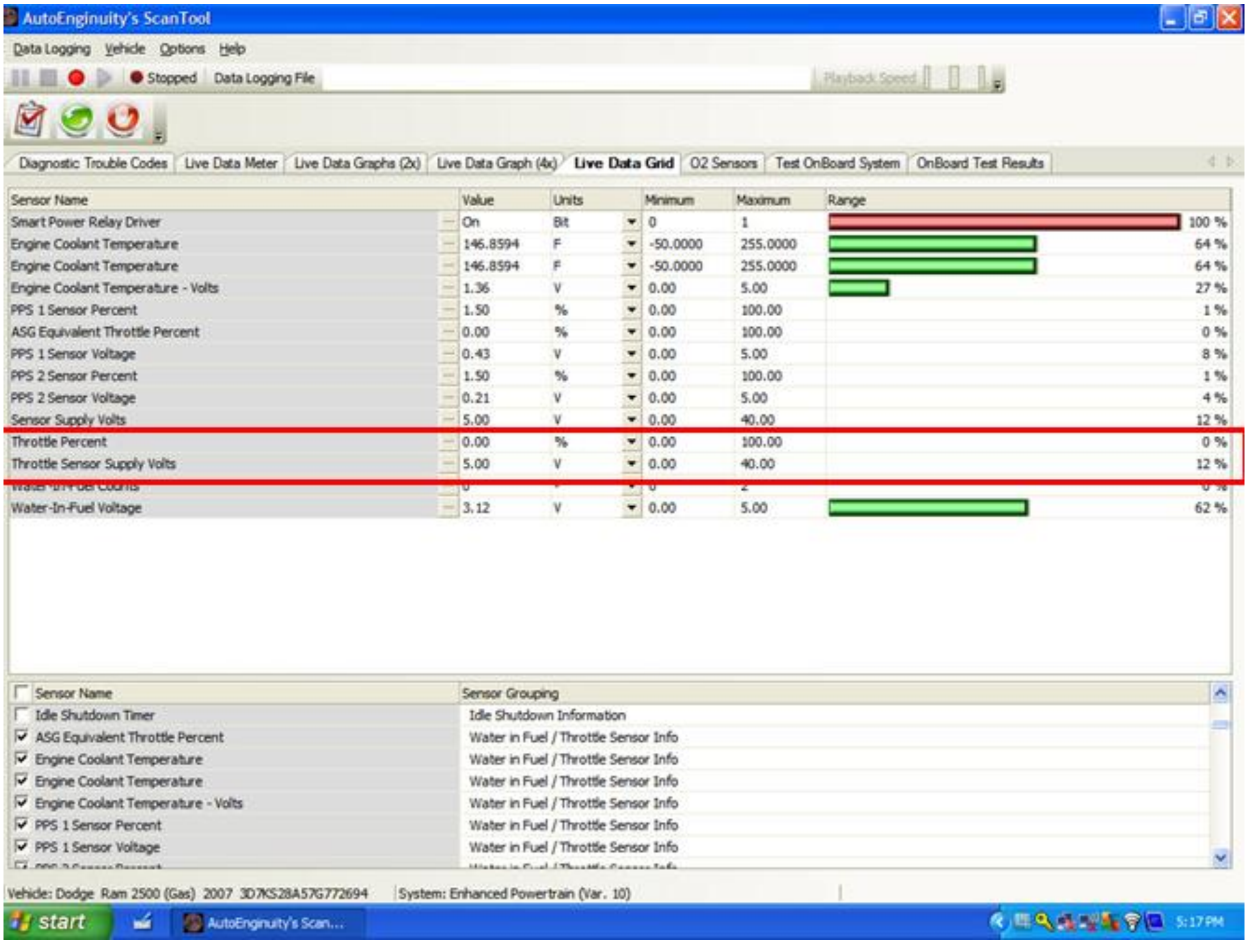
Inlet Air Temperature Sensor:

The sensor is mounted in the air cleaner. It is a combination Manifold Pressure and air Temperature sensor. The temperature sensor is used by the PCM to determine air density. The MAP senor has no fuel or air control function, the PCM uses it for diagnostics.


POWERTRAIN
CONTROL
MODULE (PCM)
SENSOR
GROUND
5V
TEMPERATURE
SIGNAL
TEMPERATURE
SENSOR

Accelerator Pedal Position Sensors (APP):

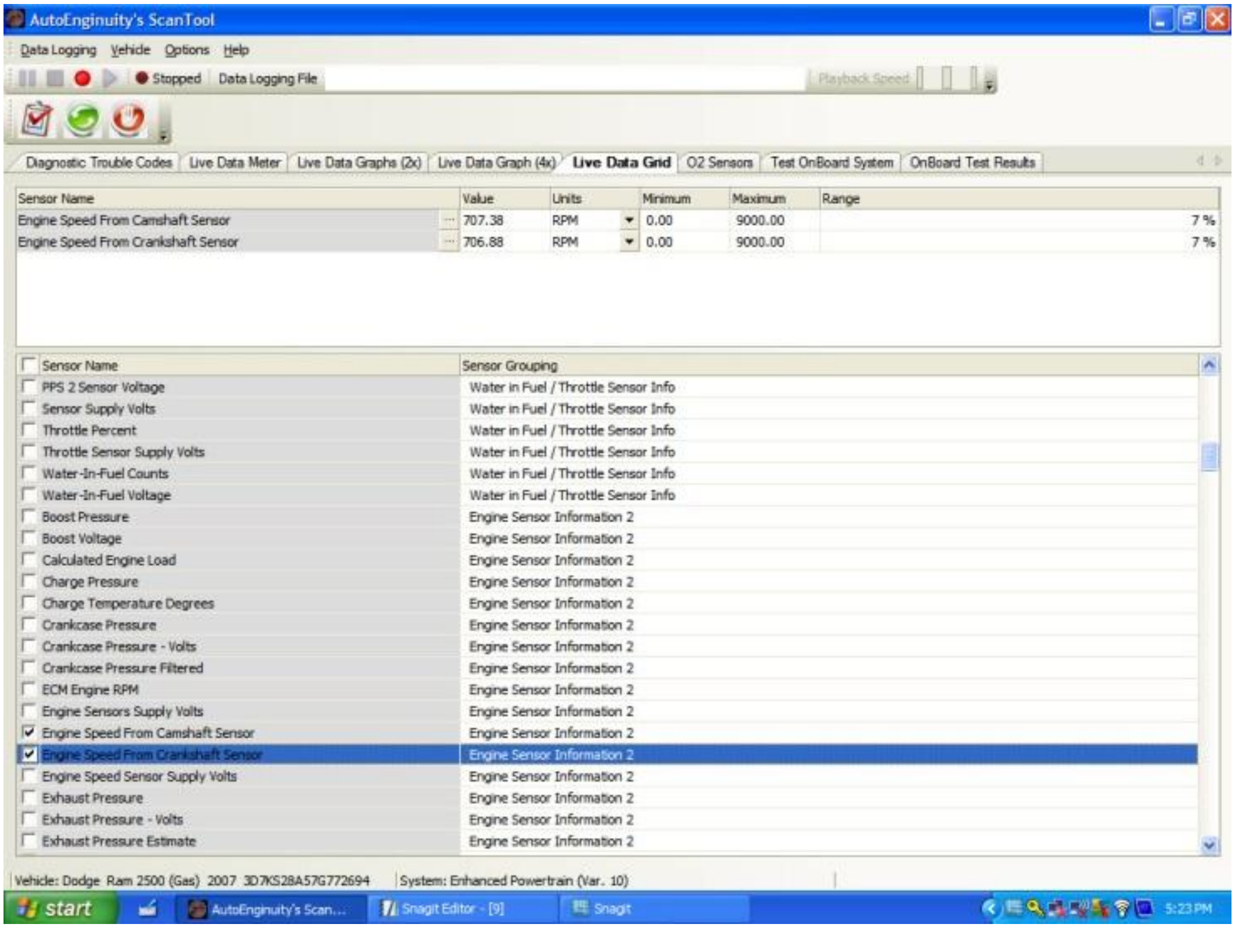
There are two APPs mounted in the pedal assembly. They both report to the PCM. One signal is half the voltage of the other. The PCM uses the signal to interpret the driver's request for torque.



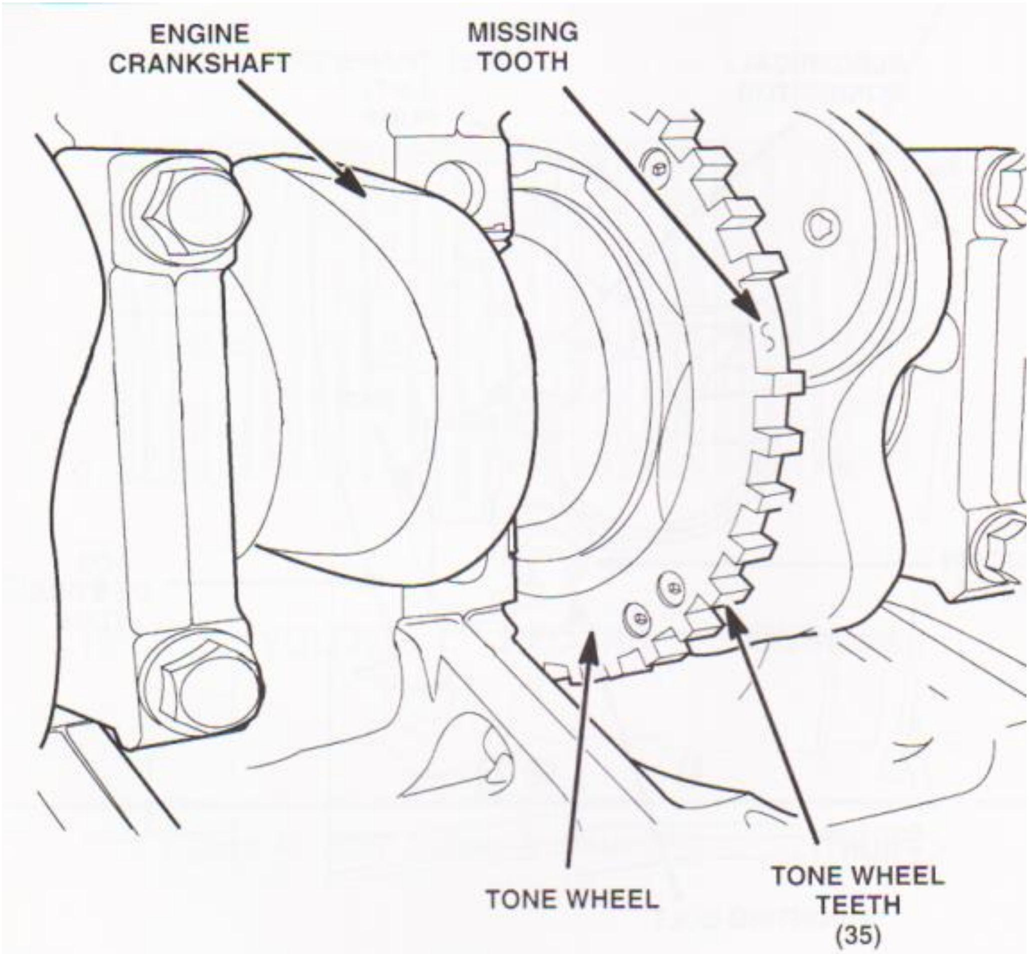
Crankshaft Position Sensor (CKP):

Tit is the primary engine speed indicator. The CKP contains a Hall Effect device. It uses a rotating, notched target wheel (tone wheel) (target) to create a signal. As the tone wheel rotates, the notches pass the tip of the CKP.

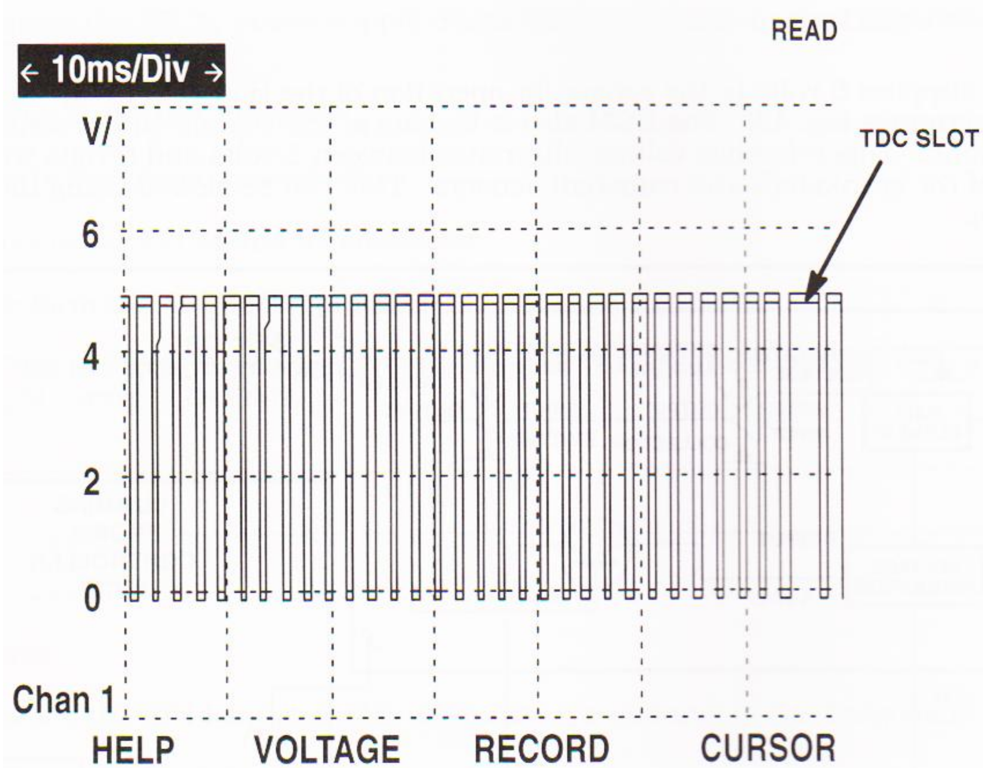
When the leading edge of the tone wheel notch passes the tip of the interruption of magnetic field causes the voltage to switch high resulting in a signal of approximately 5 volts. When the trailing edge of the tone wheel notch passes the tip the change of the magnetic field causes the signal voltage to switch low to 0 volts. The PCM uses the crankshaft position sensor for fuel injection timing, and Transmission control.


AutoEnginuity's ScanTool
Data Logging Vehicle Options Help
Stopped Data Logging File
Playback Speed
Diagnostic Trouble Codes | Live Data Meter | Live Data Graphs (2x) | Live Data Graph (4x) | Live Data Grid | O2 Sensors | Test OnBoard System | OnBoard Test Results
Sensor Name | Value | Units | Minimum | Maximum | Range
Engine Speed From Camshaft Sensor | 707.38 | RPM | 0.00 | 9000.00 | 7 %
Engine Speed From Crankshaft Sensor | 706.88 | RPM | 0.00 | 9000.00 | 7 %
Sensor Name | Sensor Grouping
PPS 2 Sensor Voltage | Water in Fuel / Throttle Sensor Info
Sensor Supply Volts | Water in Fuel / Throttle Sensor Info
Throttle Percent | Water in Fuel / Throttle Sensor Info
Throttle Sensor Supply Volts | Water in Fuel / Throttle Sensor Info
Water-In-Fuel Counts | Water in Fuel / Throttle Sensor Info
Water-In-Fuel Voltage | Water in Fuel / Throttle Sensor Info
Boost Pressure | Engine Sensor Information 2
Boost Voltage | Engine Sensor Information 2
Calculated Engine Load | Engine Sensor Information 2
Charge Pressure | Engine Sensor Information 2
Charge Temperature Degrees | Engine Sensor Information 2
Crankcase Pressure | Engine Sensor Information 2
Crankcase Pressure - Volts | Engine Sensor Information 2
Crankcase Pressure Filtered | Engine Sensor Information 2
ECM Engine RPM | Engine Sensor Information 2
Engine Sensors Supply Volts | Engine Sensor Information 2
Engine Speed From Camshaft Sensor | Engine Sensor Information 2
Engine Speed From Crankshaft Sensor | Engine Sensor Information 2
Engine Speed Sensor Supply Volts | Engine Sensor Information 2
Exhaust Pressure | Engine Sensor Information 2
Exhaust Pressure - Volts | Engine Sensor Information 2
Exhaust Pressure Estimate | Engine Sensor Information 2
Vehicle: Dodge Ram 2500 (Gas) 2007 3D7KS28A57G772694
System: Enhanced Powertrain (Var. 10)
start
AutoEnginuity's Scan...
Snagit Editor - [9]
Snagit
5:23 PM


35 Teeth and 1 missing tooth

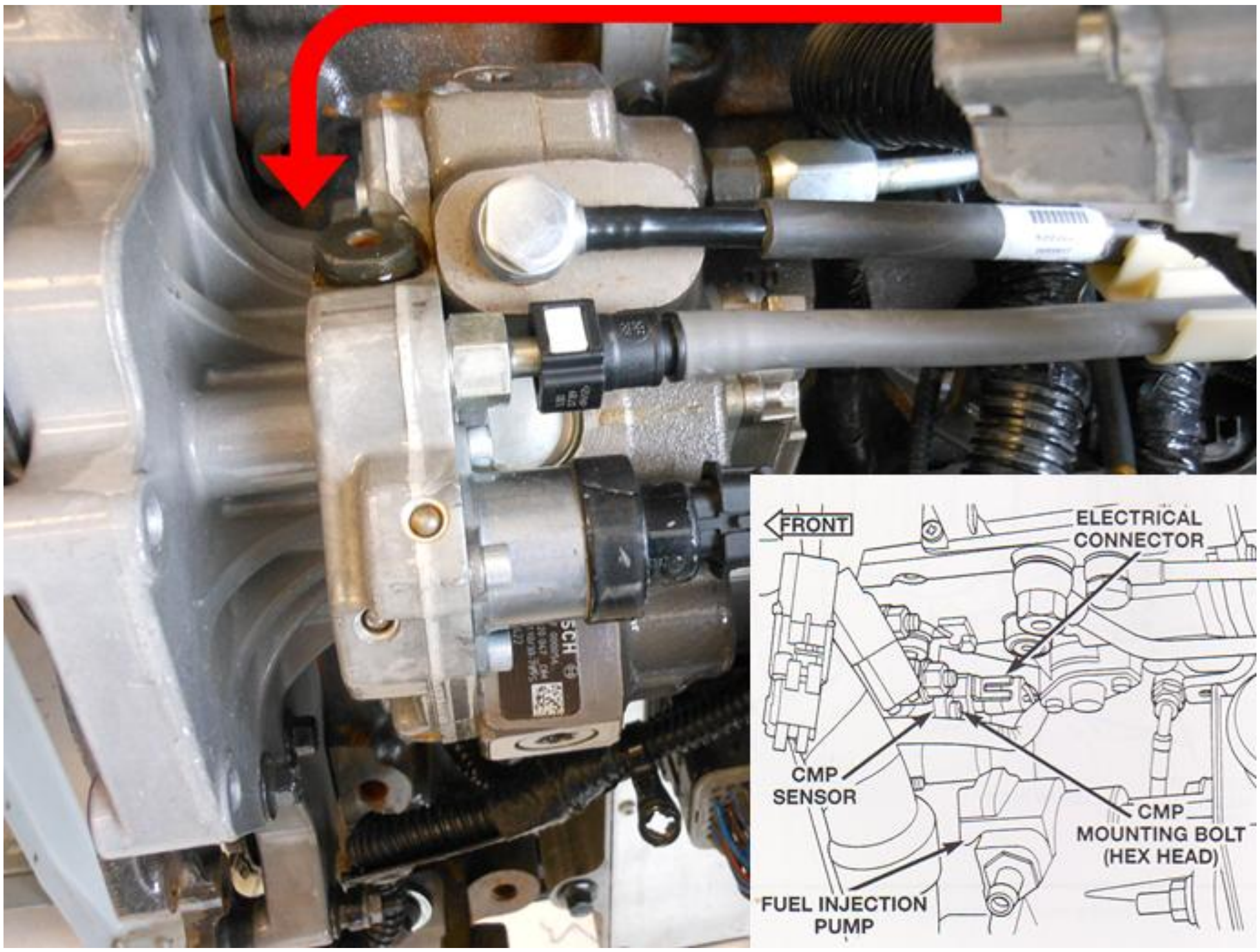


The missing tooth indicates the cylinders I and 6 is at top dead center.



Camshaft Position Sensor (CMP):

It is a Hall Effect sensor. It is referred to it as Engine Position Sensor in some Chrysler and Cummins information. The CMP detects a hole in the rear of the camshaft gear as its target. The PCM uses this CMP information primarily on engine start-up, once the engine is running; the PCM uses the CMP as a backup sensor for engine speed. The CMP is also used for engine diagnostics not as an input for the PCM.



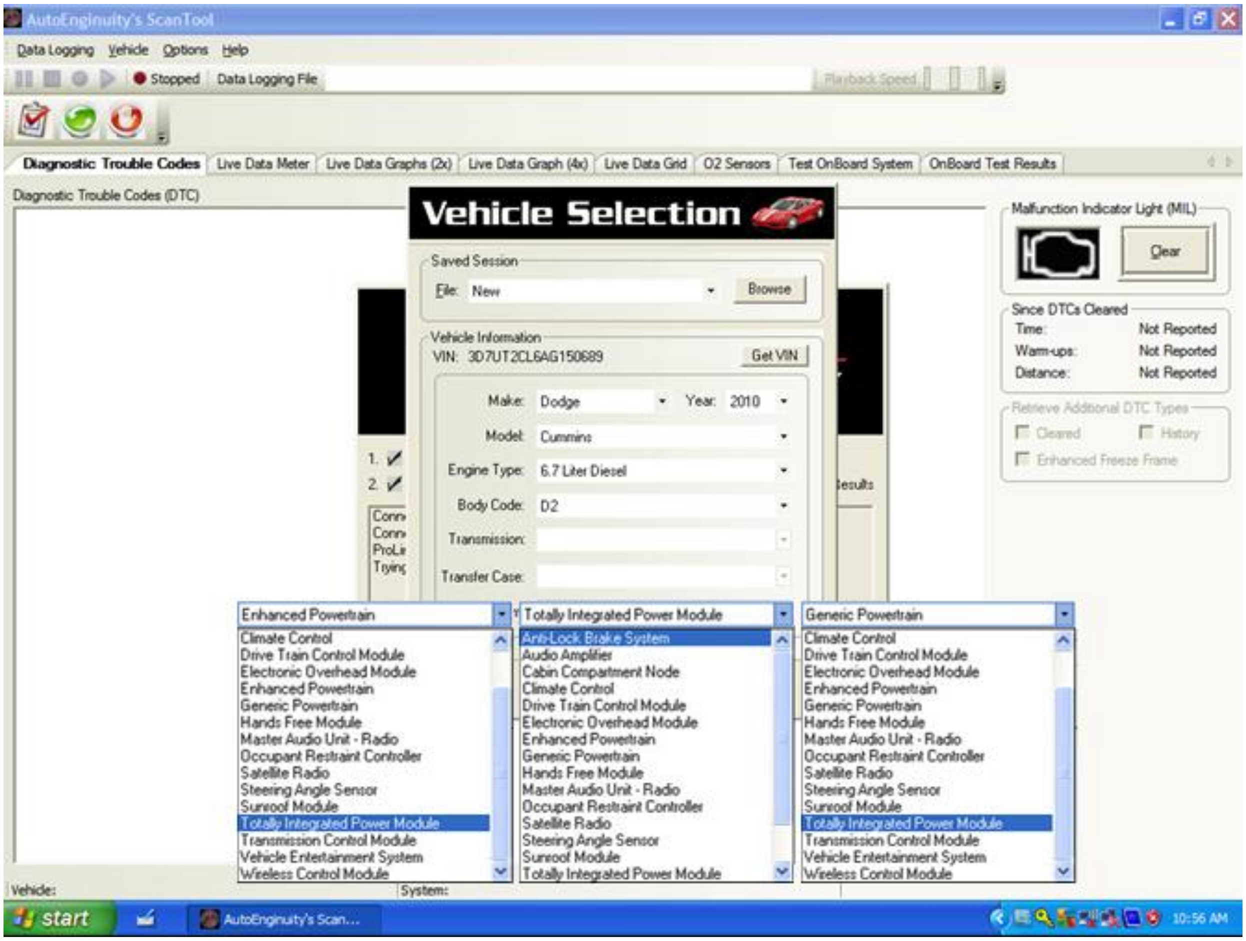
The PCM also uses the crankshaft and camshaft position sensors to determine if the Cam and Crank shafts are misaligned.

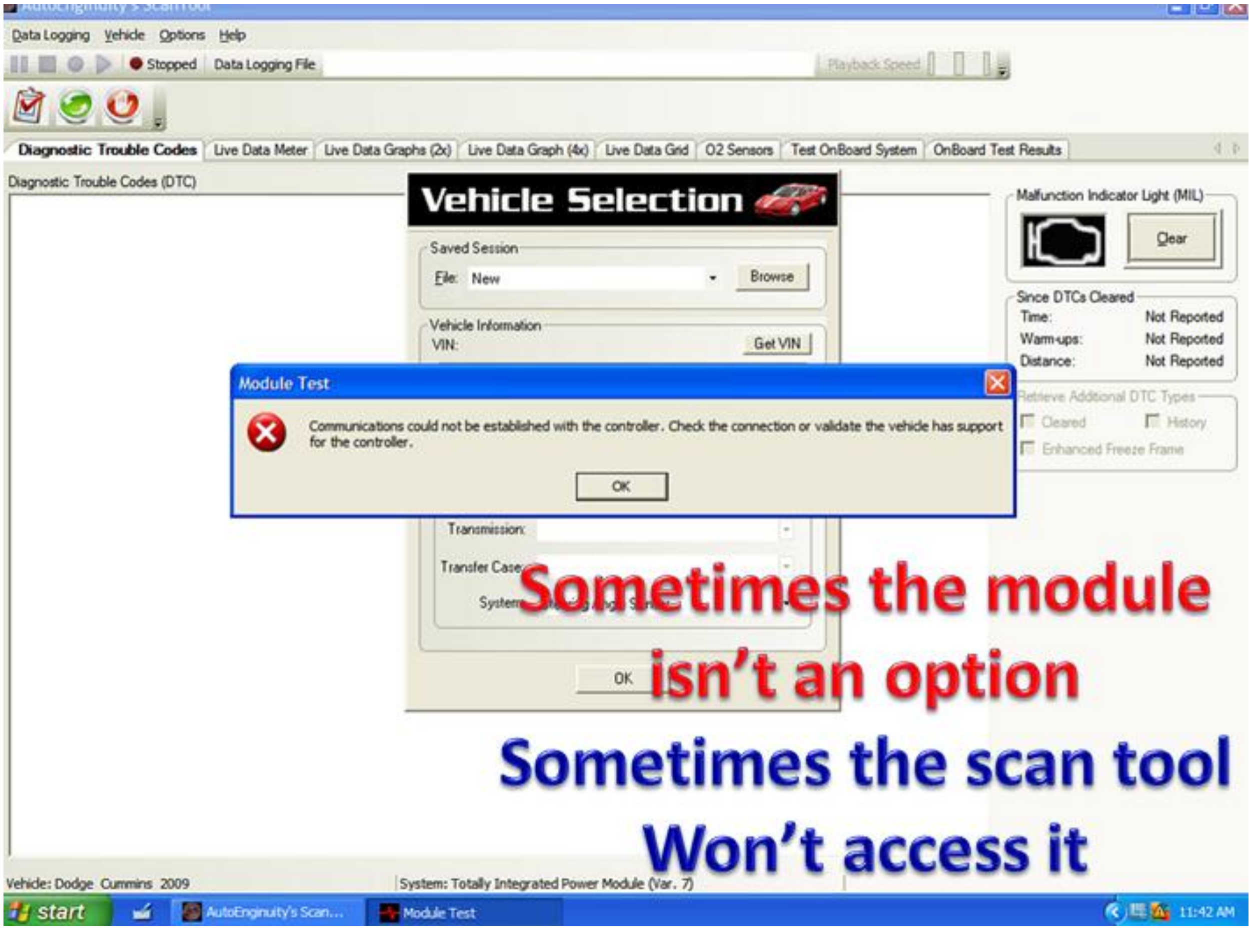
P0016 - CKP/CMP Timing Misalignment – Bank 1 Sensor 1

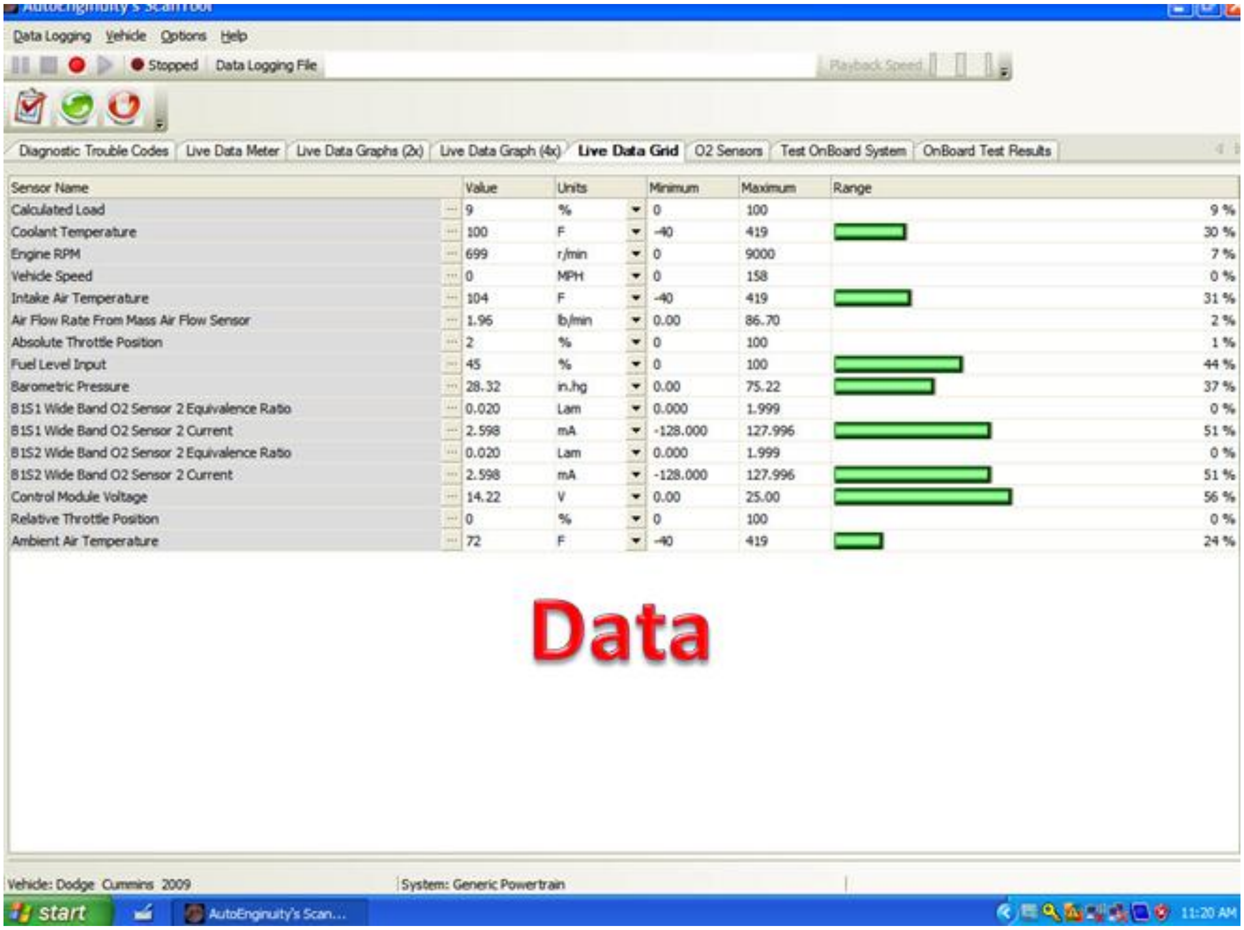
The PCM monitors position of the missing tooth on the crankshaft position sensor and the camshaft position sensor.

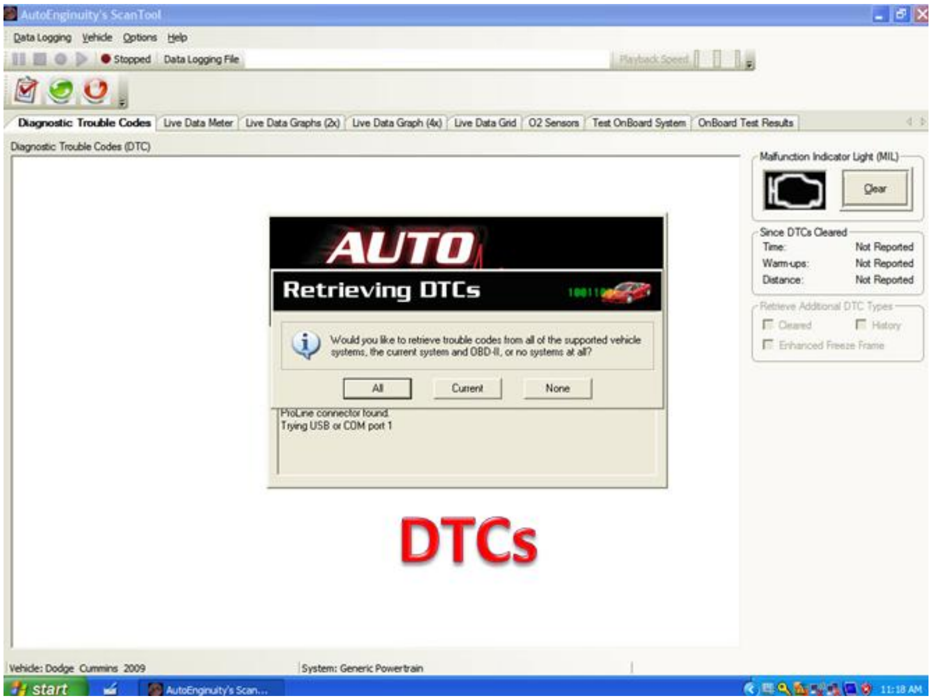
If the two positions don’t match, the ECM then determines there is a mechanical misalignment between the two sensors.

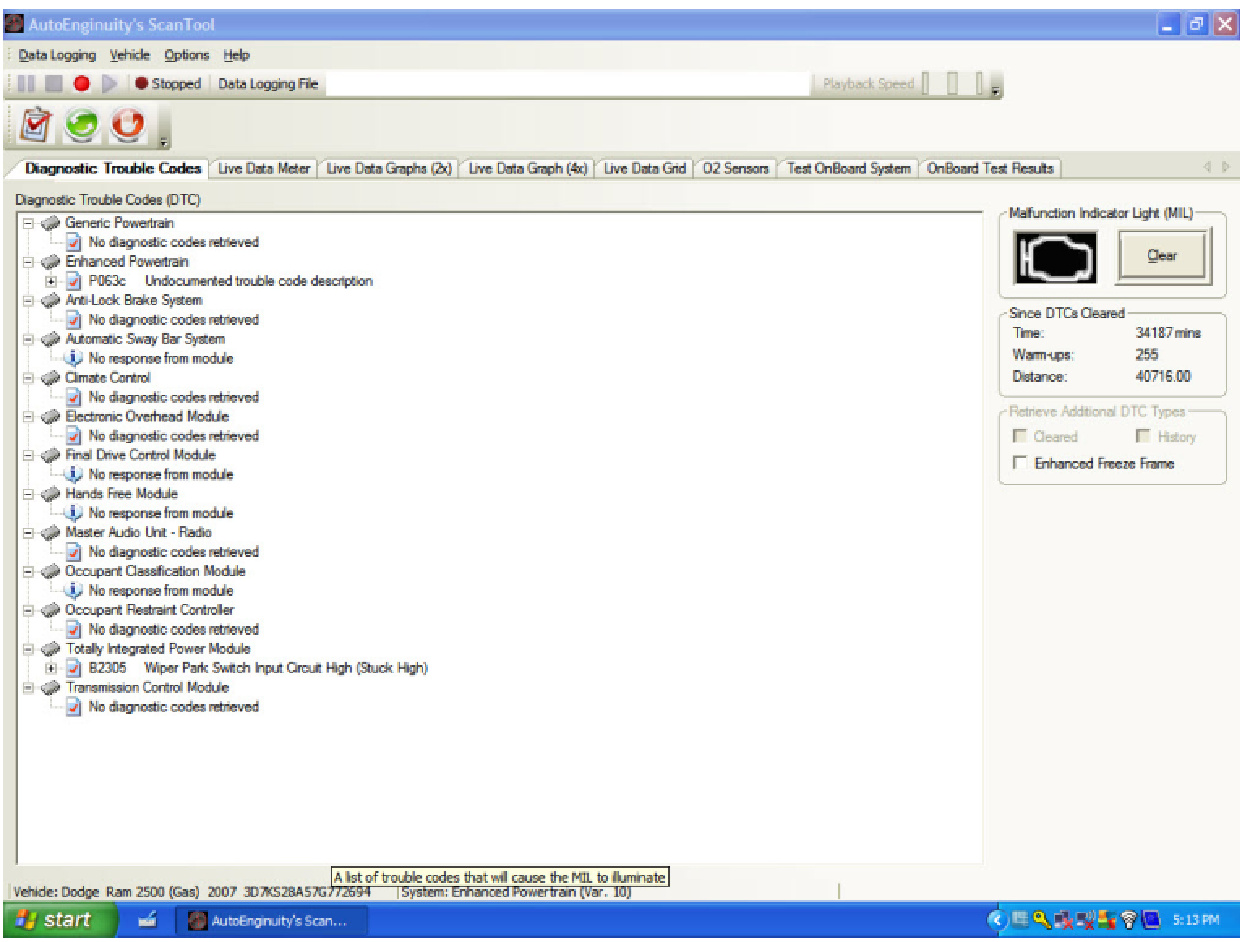
OBD-II stores different data in different modules. Certain data can only be viewed when the correct module is accessed. Make sure you are in the right module when looking for data.




Data Logging Vehicle Options Help
Stopped
Data Logging File
Playback Speed
Diagnostic Trouble Codes
Live Data Meter
Live Data Graphs (2x)
Live Data Graph (4x)
Live Data Grid
O2 Sensors
Test OnBoard System
OnBoard Test Results
Diagnostic Trouble Codes (DTC)
Vehicle Selection
Saved Session
File: New
Browse
Vehicle Information
VIN:
Get VIN
Malfunction Indicator Light (MIL)
Clear
Since DTCs Cleared
Time: Not Reported
Warm-ups: Not Reported
Distance: Not Reported
Retrieve Additional DTC Types
Cleared
History
Enhanced Freeze Frame
Module Test
Communications could not be established with the controller. Check the connection or validate the vehicle has support for the controller.
OK
Transmission:
Transfer Case:
OK
Sometimes the module isn’t an option
Sometimes the scan tool Won’t access it
Vehicle: Dodge Cummins 2009
System: Totally Integrated Power Module (Var. 7)
start
AutoEnginuity's Scan...
Module Test
11:42 AM

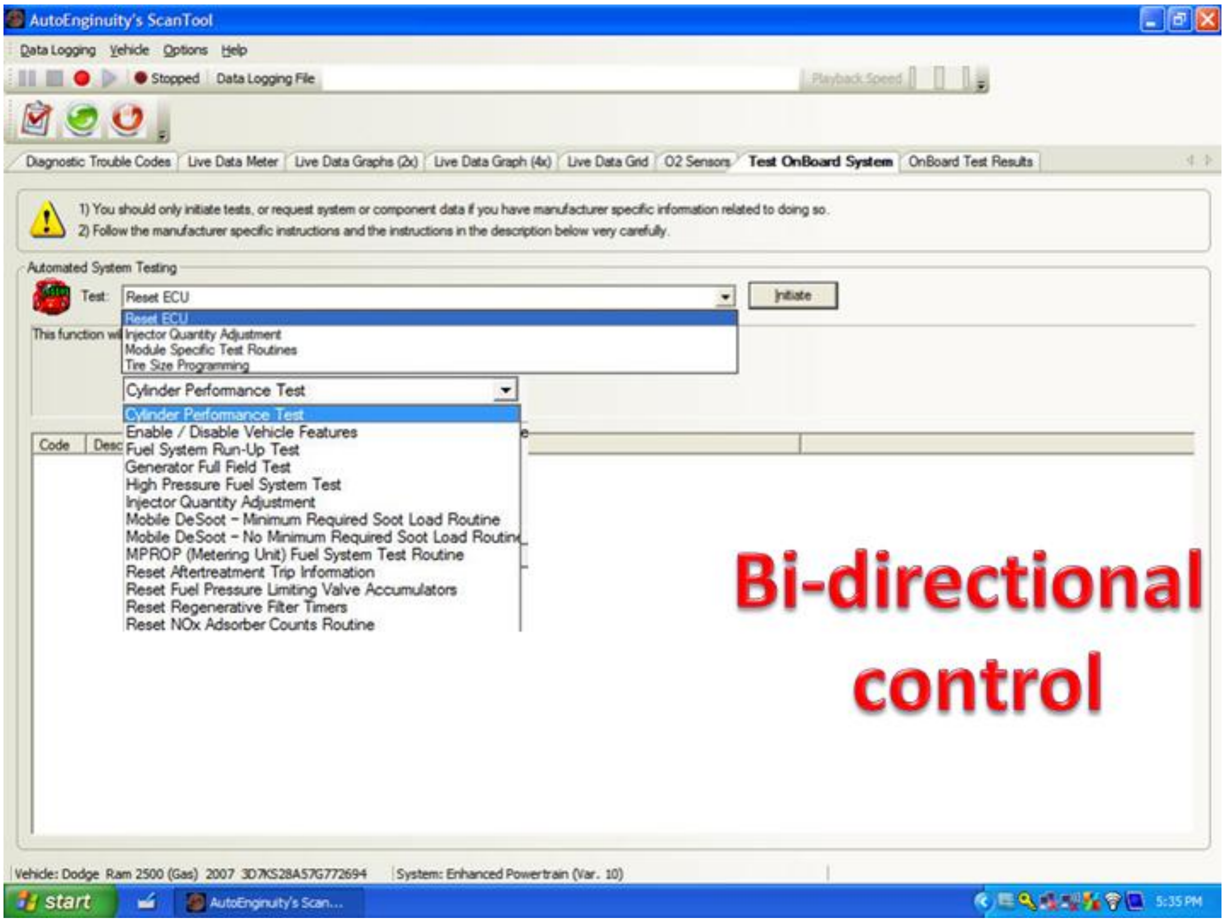

Data Logging Vehicle Options Help
Stopped Data Logging File
Playback Speed
Diagnostic Trouble Codes
Live Data Meter
Live Data Graphs (2x)
Live Data Graph (4x)
Live Data Grid
O2 Sensors
Test OnBoard System
OnBoard Test Results
Sensor Name Value Units Minimum Maximum Range
Calculated Load 9 % 0 100 9 %
Coolant Temperature 100 F -40 419 30 %
Engine RPM 699 r/min 0 9000 7 %
Vehicle Speed 0 MPH 0 158 0 %
Intake Air Temperature 104 F -40 419 31 %
Air Flow Rate From Mass Air Flow Sensor 1.96 lb/min 0.00 86.70 2 %
Absolute Throttle Position 2 % 0 100 1 %
Fuel Level Input 45 % 0 100 44 %
Barometric Pressure 28.32 in.hg 0.00 75.22 37 %
B1S1 Wide Band O2 Sensor 2 Equivalence Ratio 0.020 Lam 0.000 1.999 0 %
B1S1 Wide Band O2 Sensor 2 Current 2.598 mA -128.000 127.996 51 %
B1S2 Wide Band O2 Sensor 2 Equivalence Ratio 0.020 Lam 0.000 1.999 0 %
B1S2 Wide Band O2 Sensor 2 Current 2.598 mA -128.000 127.996 51 %
Control Module Voltage 14.22 V 0.00 25.00 56 %
Relative Throttle Position 0 % 0 100 0 %
Ambient Air Temperature 72 F -40 419 24 %
Data
Vehicle: Dodge Cummins 2009
System: Generic Powertrain
start
AutoEnginuity's Scan...
11:20 AM

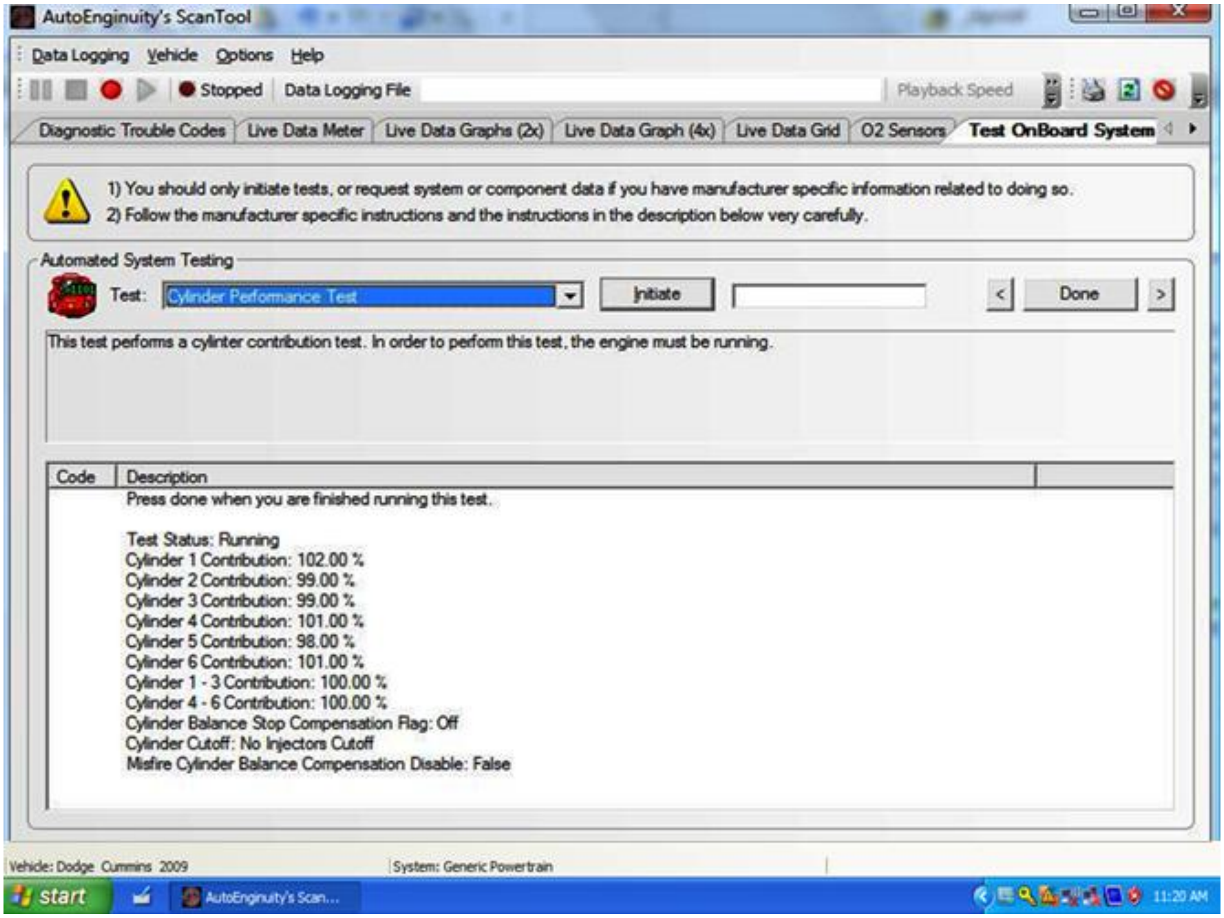

AutoEnginuity's ScanTool
Data Logging Vehicle Options Help
Stopped Data Logging File
Diagnostic Trouble Codes | Live Data Meter | Live Data Graphs (2x) | Live Data Graph (4x) | Live Data Grid | O2 Sensors | Test OnBoard System | OnBoard Test Results
Diagnostic Trouble Codes (DTC)
Malfunction Indicator Light (MIL)
Clear
Since DTCs Cleared
Time: Not Reported
Warm-ups: Not Reported
Distance: Not Reported
Retrieve Additional DTC Types
Cleared
History
Enhanced Freeze Frame
AUTO
Retrieving DTCs
Would you like to retrieve trouble codes from all of the supported vehicle systems, the current system and OBD-II, or no systems at all?
All
Current
None
ProLine connector found.
Trying USB or COM port 1
DTCs
Vehicle: Dodge Cummins 2009
System: Generic Powertrain
start
11:18 AM


AutoEnginuity's ScanTool
Data Logging Vehicle Options Help
Stopped Data Logging File
Playback Speed
Diagnostic Trouble Codes | Live Data Meter | Live Data Graphs (2x) | Live Data Graph (4x) | Live Data Grid | O2 Sensors | Test OnBoard System | OnBoard Test Results
Diagnostic Trouble Codes (DTC)
Generic Powertrain
No diagnostic codes retrieved
Enhanced Powertrain
P063c Undocumented trouble code description
Anti-Lock Brake System
No diagnostic codes retrieved
Automatic Sway Bar System
No response from module
Climate Control
No diagnostic codes retrieved
Electronic Overhead Module
No diagnostic codes retrieved
Final Drive Control Module
No response from module
Hands Free Module
No response from module
Master Audio Unit - Radio
No diagnostic codes retrieved
Occupant Classification Module
No response from module
Occupant Restraint Controller
No diagnostic codes retrieved
Totally Integrated Power Module
B2305 Wiper Park Switch Input Circuit High (Stuck High)
Transmission Control Module
No diagnostic codes retrieved
Malfunction Indicator Light (MIL)
Clear
Since DTCs Cleared
Time: 34187 mins
Warm-ups: 255
Distance: 40716.00
Retrieve Additional DTC Types
Cleared
History
Enhanced Freeze Frame
A list of trouble codes that will cause the MIL to illuminate
Vehicle: Dodge Ram 2500 (Gas) 2007 3D7KS28A57G772694
System: Enhanced Powertrain (Var. 10)
start
AutoEnginuity's Scan...
5:13 PM

Be careful when clearing diagnostic trouble code.

When you clear DTCs you clear the Hard DTC, History DTC, Freeze Frame, MIL, Mode-6 test results, Mode-5 test results, and Long Term Fuel Trim. Do you really want to do that?





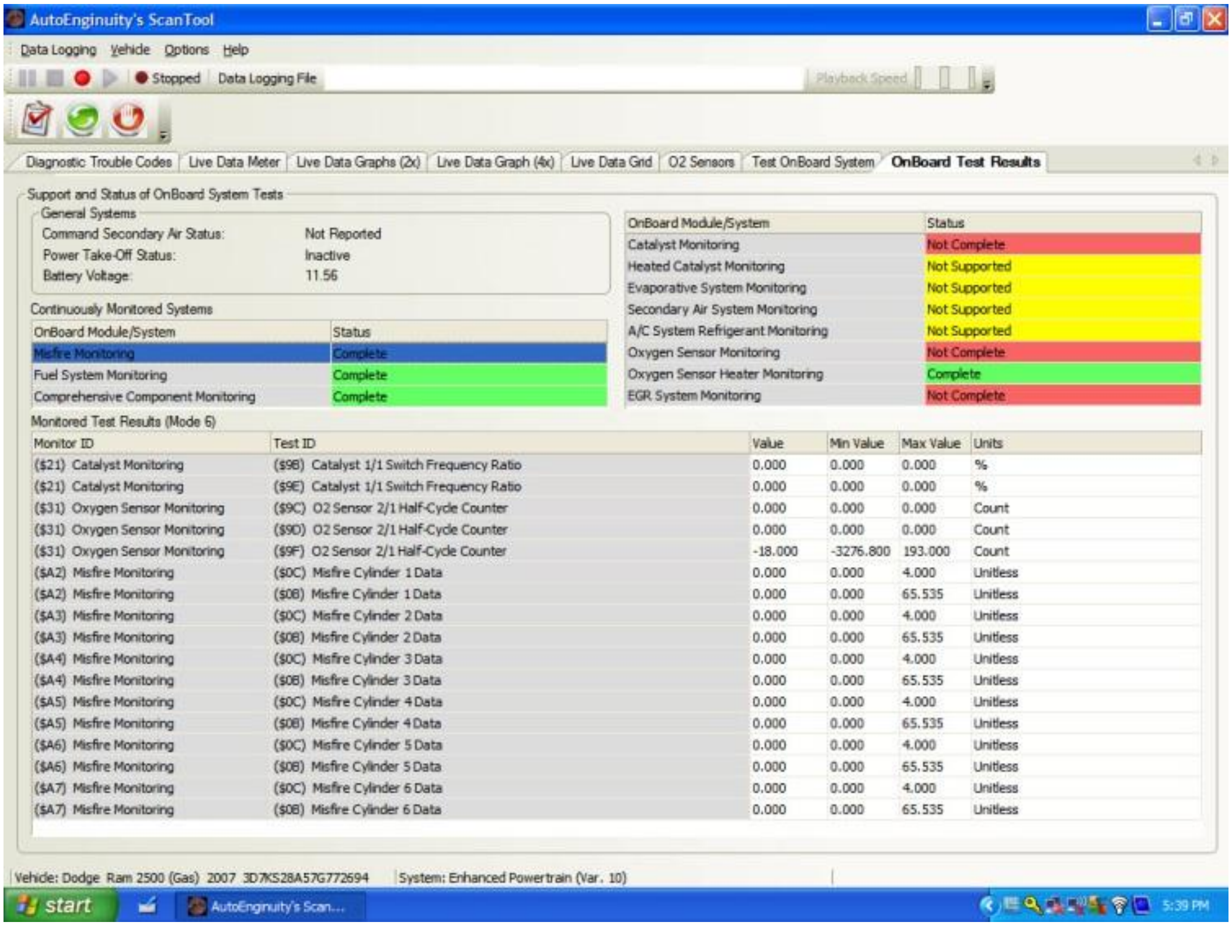
OBD –II Diagnostic Mode 6:

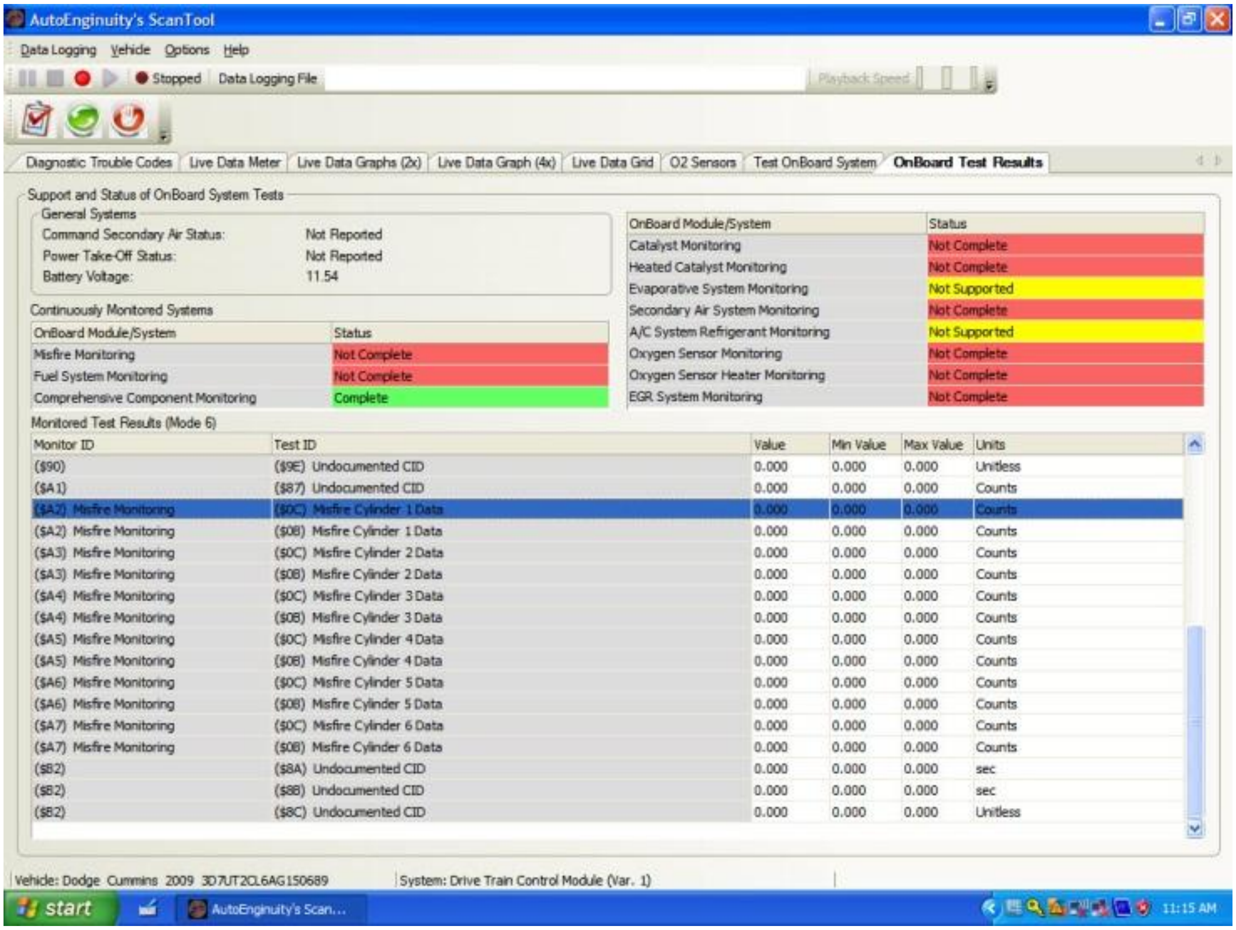
The test results of the last time the non-continuous monitors ran and completed

Completed doesn't mean PASS/or FAIL it means completed

Pass means that the monitor ran and the monitor passes the tests

Fail means that the monitor ran and failed the tests


AutoEnginuity's ScanTool
Data Logging Vehicle Options Help
Stopped Data Logging File
Playback Speed
Diagnostic Trouble Codes Live Data Meter Live Data Graphs (2x) Live Data Graph (4x) Live Data Grid O2 Sensors Test OnBoard System OnBoard Test Results
Support and Status of OnBoard System Tests
General Systems
Command Secondary Air Status: Not Reported
Power Take-Off Status: Inactive
Battery Voltage: 11.56
Continuously Monitored Systems
OnBoard Module/System Status
Misfire Monitoring Complete
Fuel System Monitoring Complete
Comprehensive Component Monitoring Complete
OnBoard Module/System Status
Catalyst Monitoring Not Complete
Heated Catalyst Monitoring Not Supported
Evaporative System Monitoring Not Supported
Secondary Air System Monitoring Not Supported
A/C System Refrigerant Monitoring Not Supported
Oxygen Sensor Monitoring Not Complete
Oxygen Sensor Heater Monitoring Complete
EGR System Monitoring Not Complete
Monitored Test Results (Mode 6)
Monitor ID Test ID Value Min Value Max Value Units
($21) Catalyst Monitoring ($98) Catalyst 1/1 Switch Frequency Ratio 0.000 0.000 0.000 %
($21) Catalyst Monitoring ($9E) Catalyst 1/1 Switch Frequency Ratio 0.000 0.000 0.000 %
($31) Oxygen Sensor Monitoring ($9C) O2 Sensor 2/1 Half-Cycle Counter 0.000 0.000 0.000 Count
($31) Oxygen Sensor Monitoring ($9D) O2 Sensor 2/1 Half-Cycle Counter 0.000 0.000 0.000 Count
($31) Oxygen Sensor Monitoring ($9F) O2 Sensor 2/1 Half-Cycle Counter -18.000 -3276.800 193.000 Count
($A2) Misfire Monitoring ($0C) Misfire Cylinder 1 Data 0.000 0.000 4.000 Unitless
($A2) Misfire Monitoring ($0B) Misfire Cylinder 1 Data 0.000 0.000 65.535 Unitless
($A3) Misfire Monitoring ($0C) Misfire Cylinder 2 Data 0.000 0.000 4.000 Unitless
($A3) Misfire Monitoring ($0B) Misfire Cylinder 2 Data 0.000 0.000 65.535 Unitless
($A4) Misfire Monitoring ($0C) Misfire Cylinder 3 Data 0.000 0.000 4.000 Unitless
($A4) Misfire Monitoring ($0B) Misfire Cylinder 3 Data 0.000 0.000 65.535 Unitless
($A5) Misfire Monitoring ($0C) Misfire Cylinder 4 Data 0.000 0.000 4.000 Unitless
($A5) Misfire Monitoring ($0B) Misfire Cylinder 4 Data 0.000 0.000 65.535 Unitless
($A6) Misfire Monitoring ($0C) Misfire Cylinder 5 Data 0.000 0.000 4.000 Unitless
($A6) Misfire Monitoring ($0B) Misfire Cylinder 5 Data 0.000 0.000 65.535 Unitless
($A7) Misfire Monitoring ($0C) Misfire Cylinder 6 Data 0.000 0.000 4.000 Unitless
($A7) Misfire Monitoring ($0B) Misfire Cylinder 6 Data 0.000 0.000 65.535 Unitless
Vehicle: Dodge Ram 2500 (Gas) 2007 3D7KS28A57G772694
System: Enhanced Powertrain (Var. 10)
start
AutoEnginuity's Scan...
5:39 PM



No Start Diagnostics:

Always check the available fuel to the injection pump (Lift Pump operation)

Injection pump is cooled and lubricated by fuel and is quickly damaged when starved of fuel flow

Fuel starved Injection pump can damage/contaminate the entire system, including injectors, with metal filings

Lift Pump Operation:

The injection pump requires reduced pressure for starting

Or a hard start condition will result

The ECU provides a 25% Duty Cycle to the transfer pump while the key is in the crank position

This creates 5-8 PSI at the injection pump

When the engine starts the duty cycle is switched to 100% and 10-16 PSI should result

If the engine does not start and the key is left on the ECU will run the pump at a 100% DC for 25 seconds

At 100% DC the transfer pump should supply a minimum of 45 oz. of fuel during the 25 second

Engine startup mode:

When the starter motor is engaged;

The PCM receives inputs from:

- Battery voltage
- Engine Coolant Temperature (ECT) Sensor
- Crankshaft Position (CKP) Sensor
- Intake Manifold Air Temperature (IAT) Sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor (TPS)
- Camshaft Position Sensor (CMP) signal

No start:

The PCM monitors the crankshaft position sensor

If the PCM does not receive a CKP signal within 3 seconds of the engine cranking, it will shut down the fuel injection system

Diagnostics Poor operation and No start:

High Pressure Fuel Pump Performance Test (Engine Cranking/Running)

Monitor rail pressure with scan tool while the engine is at idle

Compare the fuel pressure set point with the actual fuel pressure reading

If actual fuel pressure reading fluctuates more than +/- 500 psi from the set point, then replace the Fuel Control Actuator (FCA)

As an example:

- Fuel Pressure sensor 9827.56 psi
- Fuel Pressure set point 9784.63 psi

No Start:

Disconnect high pressure fuel line from fuel rail and route the high pressure fuel line into a graduated cylinder

Crank the engine for three (3) 10 second intervals (30 total seconds of flow time)

3 separate intervals to prevent damage to the starter)

Fuel flow based on engine cranking speed Minimum fuel pump flow at 150 RPM cranking speed is 70mL

Minimum fuel pump flow at 200 RPM cranking speed is 90mL

No Start:

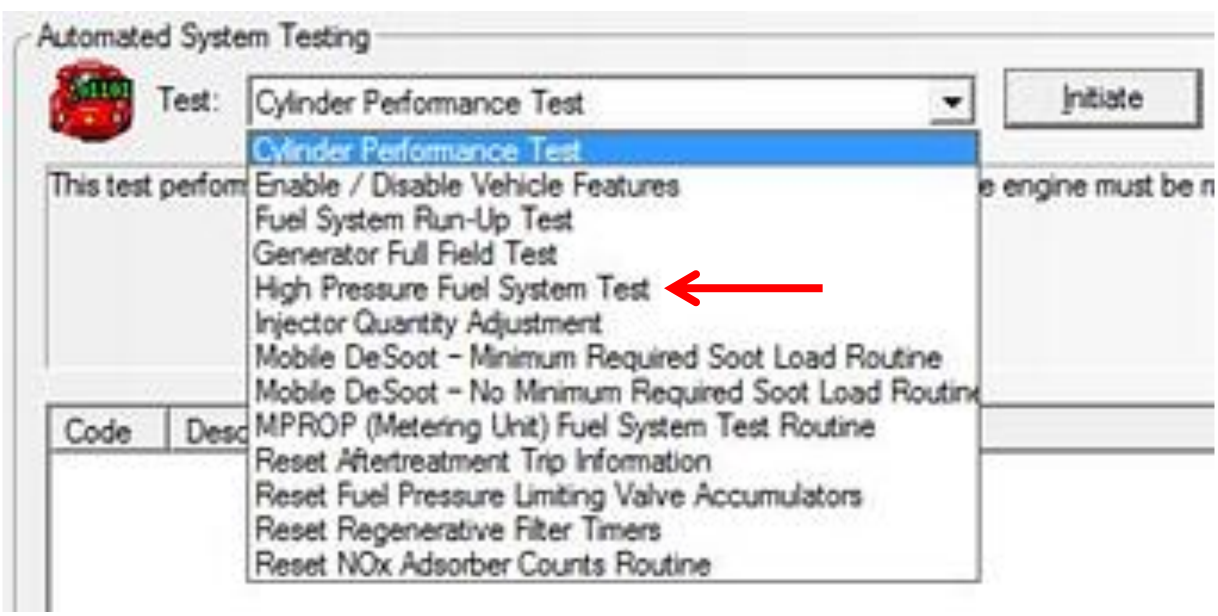
Use the PID Fuel pressure and see if pressure is excessive (above 26,831 psi)

Remove the fuel line at the pressure limiting valve

Install test fitting and connect hose and place in a container

Run the fuel pressure limiting valve test

If valve allows excessive pressure replace it



EGR Valve Functionality Monitor

EGR SYSTEM MONITORS

EGR Valve Functionality Monitor

Description

The EGR valve contains three Hall effect sensors to detect position. The three position sensors correspond to six valid sectors in which the valve can be. If the valve position skips a sector(s), a fault counter is either increased or decreased. When the counter equals a calibrated threshold, the rationality fault becomes active. The position sensors are integral to the valve assembly and are not serviced separately.

This monitors runs continuously.

Enable Conditions

None

Abort Conditions

EGR driver Out-of-Range (OOR) errors.

Monitor Operation

The ECM performs the following checks on the EGR Valve:

- Drive Open Circuit
- Drive Short Circuit
- Auto Zero Check
- Over Current/Stuck Check

Every time the EGR valve is commanded closed, the ECM checks its position against a learned auto zero position.

The ECM lights the MIL immediately when the an error is detected. The ECM turns off the MIL when the diagnostic runs and passes in four consecutive drive cycles.

EGR Valve Position Rationality

EGR Valve Position Sensor Rationality

Description

The EGR valve contains three Hall effect sensors to detect position. The three position sensors correspond to six valid sectors in which the valve can be. If the valve position skips a sector(s), a fault counter is either increased or decreased. When the counter equals a calibrated threshold, the rationality fault becomes active. The position sensors are integral to the valve assembly and are not serviced separately.

Enable Conditions

None

Abort Conditions

EGR Position Sensor OOR errors.

Monitor Operation

The three position sensors correspond to six valid sectors in which the valve can be. If the valve position skips a sector(s), a fault counter is either increased or else decreased. When the counter equals a calibrated threshold, the rationality fault becomes active.

The ECM lights the MIL immediately when the an error is detected.

EGR Valve Position Sensor Circuit Errors

EGR Valve Position Sensor Circuit Errors

Description

The EGR valve contains three Hall effect sensors to detect position. The three position sensors correspond to six valid sectors in which the valve can be. If the valve position skips a sector(s), a fault counter is either increased or decreased. When the counter equals a calibrated threshold, the rationality fault becomes active. The position sensors are integral to the valve assembly and are not serviced separately.

The monitors runs continuously.

Enable Conditions

None.

Abort Conditions

None.

Monitor Operation

If the three position sensors all read high or low, which indicates a failed position sensor, a counter is increased or decreased. When this counter equals a calibrated threshold, the circuit fault becomes active.

The ECM lights the MIL immediately when the an error is detected.

EGR Cooler Bypass Function

EGR Cooler Bypass Function

Description

The monitor detects when the EGR Cooler Bypass Valve does not function correctly.

The monitor runs continuously.

Enable Conditions

None

Abort Conditions

None

Monitor Operation

The EGR Bypass Valve is an intelligent device with built in diagnostics. When it detects an error, it grounds a status line and after a calibrated time, a fault is set.

The following diagnostics tests run in the EGR Bypass controller:

- Supply Voltage Low (< 7V)
- Over Temperature (PCB Temp > 140C)
- Time to long to reach stops (> 2sec)
- Travel past stops (Span too Large)

Shorted High/Low diagnostics are also conducted on the discrete output command to the bypass valve.

The MIL is illuminated after an error has been detected for a second consecutive drive cycle.

EGR low and high flow Monitor

EGR Low/High Flow Monitors

Description

The monitor detects when the EGR error (high or low) causes the engine to exceed emissions by 1.5 times. This is anticipated to be an NOx based threshold for Low flow. It is NOT anticipated that a High Flow problem will cause the engine to exceed the 1.5 limit.

The monitor runs whenever enable conditions are met.

Enable Conditions

Warm Running Engine (Coolant, Intake Manifold Temperature > than a calibrated threshold).

Abort Conditions

EGR valve electrical errors.

VGT Errors (electrical and functional).

IAT Error (electrical and functional).

Exhaust manifold pressure, intake manifold pressure, MAF, coolant or intake manifold temperature sensor errors (OOR and rationality).

Monitor Operation

Algorithm integrates the positive and negative EGR fraction error over a calibrated period. After that period, the algorithm makes a decision.

- If the positive error is greater than the high error threshold, the EGR high flow error becomes active.
- If the negative error is greater than the low error threshold, the EGR low flow error becomes active.

The ECM lights the MIL immediately when the an error is detected.

EGR Temperature Sensor Rationality

EGR Temperature Sensor Rationality

Description

The EGR temperature sensor rationality has two parts: key-on and change.

Enable Conditions

Engine state is stop.

Ignition key-off time must be greater than a calibrated threshold.

Engine state is RUN (change only).

Key on temperature estimate must be greater than 50°F.

Abort Conditions

EGR temperature sensor OOR errors.

Key on temperature estimate status is not good.

Intake manifold pressure, MAF, OOR and rationality errors.

Ignition key-off timer errors.

Monitor Operation

Key-on – If the difference between the EGR temperature and the Key On Temperature Estimate is greater than a calibrated threshold, the rationality fault becomes active.

Change – If the EGR Flow and engine load are greater than a calibrated threshold, a counter is increased or decreased. When the counter equals a calibrated threshold, the EGR temperature is compared against the initial key-on EGR temperature. If the difference is NOT greater than a calibrated threshold, the rationality fault becomes active.

The MIL is illuminated after the error has been detected for a second consecutive drive cycle.

Intake Air and Boost System Monitors

Air Intake Throttle Functionality Monitor

INTAKE AIR AND BOOST AIR SYSTEM MONITORS

Air Intake Throttle Functionality

Description

The Air Intake Throttle monitor detects when the air intake throttle does not function correctly. At key-on, if it doesn't see a transition in the error status line within a calibrated period, the PCM assumes the controller is not functioning. If the circuit opens, the line goes high indicating an error.

Enable Conditions

This monitor runs continuously.

Enable Conditions

None

Abort Conditions

None

Monitor Operation

The intake throttle is an intelligent device with built-in diagnostics. When it detects an error, it grounds a status line and after a calibrated time, a fault is set.

The following diagnostic tests run in the Air Intake Throttle controller:

- Invalid commanded set point (PWM command frequency 250Hz +-8Hz, DC from 3% - 97%)
- Position Failure (Deviation between set point and actual > 2.5^{O} for two seconds)
- Sensor Failure Out of Range (Sensor exceeds 90^{O})
- Sensor Failure Gradient (Gradient of value is > 2000^{O}/sec)
- Return Spring Failure (> 750 msec for 10^{O} open to close position)
- Time to long to reach stops (> 2 seconds)
- Travel past stops (span too large)

Shorted high/low diagnostics are also conducted on the PWM output command to the intake throttle.

The MIL is illuminated if an error has been detected for a second consecutive drive cycle.

Intake Manifold Pressure Rationality

Intake Manifold Pressure Rationality

Description

The intake manifold pressure sensor rationality checks the sensor value against an estimated intake manifold pressure.

The monitors run continuously.

Enable Conditions

None.

Abort Conditions

Intake manifold pressure sensor OOR errors.

Sensor supply errors

Ambient air pressure, ambient air temperature, intake manifold temp, or turbo speed sensor errors OOR and rationality errors.

Monitor Operation

If the difference between the estimated intake manifold pressure and intake manifold pressure sensor is greater than a calibrated threshold a counter is increased or decreased. When the counter equals a calibrated threshold the fault becomes active.

The ECM lights the MIL immediately when the an error is detected.

Exhaust Manifold Pressure Rationality

Exhaust Manifold Pressure Rationality

Description

The exhaust manifold pressure sensor rationality checks the sensor value against an estimated exhaust manifold pressure.

The monitors run continuously.

Enable Conditions

None.

Abort Conditions

Exhaust manifold pressure sensor OOR errors.

Sensor Supply Errors.

EGR position, or intake manifold pressure sensor errors OOR and rationality errors.

Monitor Operation

An average error is calculated between the estimated exhaust manifold pressure and the exhaust manifold pressure sensor for a calibrated period of time. If the average error is greater than a calibrated threshold, a counter is increased. When the counter becomes equal to a calibrated threshold, the fault becomes active.

The MIL is illuminated after the error has been detected for a second consecutive drive cycle.

Mass Air Flow Rationality

Mass Air Flow Rationality

Description

The MAF sensor rationality has two parts: key-on and running.

The monitors run continuously.

Enable Conditions

Engine state is stop (key-on).

Engine state is run (running).

EGR position is closed (running).

Air Throttle position is greater than a calibrated threshold.

Abort Conditions

VGT errors - electrical and functional.

MAF sensor OOR errors.

Smart Relay Errors (power to the MAF sensor)

Exhaust manifold pressure, intake manifold pressure, or intake manifold temperature sensor errors OOR and rationality errors.

Air throttle errors.

Monitor Operation

Key-on – the algorithm checks the MAF sensor reading is "zero" (lower than a calibrated threshold).

Running – an average error is calculated between the estimated charge air flow and MAF sensor while the EGR is closed for a calibrated period. If the average error is greater than a calibrated threshold, the fault becomes active.

The MIL is illuminated after the error has been detected for a second consecutive drive cycle.

Turbo Speed Sensor Rationality

Turbo Speed Sensor Rationality

Description

The VGT speed sensor rationality checks the sensor value against an estimated turbo speed.

The monitor runs whenever enable conditions are met.

Enable Conditions

VGT speed estimate greater than a calibrated threshold.

Abort Conditions

Turbo speed sensor OOR errors.

Sensor supply errors.

Ambient air pressure, ambient air temperature, intake manifold temperature, or intake manifold pressure sensor errors OOR and rationality errors.

Monitor Operation

An average error is calculated between the estimated turbo speed and the turbo speed sensor for a calibrated period. If the average error is greater than a calibrated threshold, a counter is increased. When the counter becomes equal to a calibrated threshold, the fault becomes active.

The MIL is illuminated after the error has been detected for a second consecutive drive cycle.

Intelligent Turbo Variable Geometry

Variable Geometry Turbo – Intelligent Device

Description

The VGT has an integrated controller. The Cummins interface with the VGT is a J1939 datalink circuit.

The monitors run continuously.

Abort Conditions

Loss of communication with VGT Controller.

Monitor Operation

The VGT Controller detects the following errors:

- VGT Controller – bad intelligent device
- VGT – out of calibration (auto zero and span)
- Mechanically Stuck
- Low VGT controller supply voltage

The MIL is illuminated when the error first becomes active.

EXHAUST AFTER TREATMENT SYSTEM MONITORS

DOC Efficiency Monitor

Description

The monitor detects when the DOC efficiency causes the engine to exceed emissions by 1.75 times.

The monitor runs whenever enable conditions are met.

Enable Conditions

Engine State is run.

Hydrocarbon flow must be between the minimum and maximum calibrated thresholds and be steady for a calibrated period.

Exhaust mass flow must be between the minimum and maximum calibrated thresholds and be steady for a calibrated period.

DOC inlet or outlet temperatures must be greater than a calibrated threshold.

Abort Conditions

DOC inlet or outlet temperatures sensor OOR and rationality errors

Fuel system error

Misfire monitor error

Intake manifold pressure sensor OOR and rationality errors

Monitor Operation

If the difference between DOC inlet or outlet temperatures is less than the result of the mathematical formula for a calibrated period of time, the fault becomes active.

The MIL is illuminated after the error has been detected for a second consecutive drive cycle.

The algorithm calculates a in-use performance ratio for the DOC efficiency monitor.

Regenerations are disabled when this fault is active.

DOC Presence Monitor

DOC Presence Monitor

Description

The DOC presence monitor looks for a change in temperature from EGT #1 to EGT #2 to determine if the DOC is present and functioning.

The monitor runs whenever enable conditions are met.

Enable Conditions

Engine state is run.

Hydrocarbon flow must be between the minimum and maximum calibrated thresholds and be steady for a calibrated period.

Exhaust mass flow must be between the minimum and maximum calibrated thresholds and be steady for a calibrated period.

DOC inlet or outlet temperatures must be greater than a calibrated threshold.

Abort Conditions

DOC inlet or outlet temperatures sensor OOR and rationality errors

Fuel system error

Misfire monitor error

Intake manifold pressure sensor OOR and rationality errors

Monitor Operation

If the difference between DOC inlet or outlet temperatures is less than a calibrated threshold for a calibrated period, then the fault becomes active.

The MIL will be illuminated after the error has been detected for a second consecutive drive cycle.

The algorithm calculates a in-use performance ratio for the DOC presence monitor.

Regenerations is disabled when this fault is active.

DOC over Temperature Monitor

DOC Over Temperature Monitor

Description

The DOC over temperature monitor looks at exhaust temperatures that indicate if the catalyst has physically been damaged.

The monitor runs continuously.

Enable Conditions

None.

Abort Conditions

DOC inlet or outlet temperatures sensors OOR and rationality errors

Monitor Operation

There are three separate monitors:

- Persistence – If DOC outlet temperature becomes higher than a calibrated threshold for a calibrated number of times, the fault becomes active.
- Severe High – If either DOC outlet temperatures is higher than a calibrated threshold, for a calibrated period of time, the fault becomes active.
- Severe Exotherm – If the difference between DOC inlet or outlet temperatures is higher than a calibrated threshold for a calibrated period.

The MIL is illuminated when the error first becomes active, and may only be cleared by a scan tool after replacement of the DOC.

Regenerations are disabled when this fault becomes active.

Particulate Filter Missing Monitor

Particulate Filter – Missing Filter Monitor

Description

The DPF missing filter monitor uses DPF delta pressure to determine if the filter is missing.

The monitor runs whenever enable conditions are met.

Enable Conditions

Exhaust mass flow must be between the minimum and maximum calibrated thresholds.

Abort Conditions

DPF delta pressure sensor OOR and rationality errors

DPF over temperature error

DPF excessive back pressure error

DPF efficiency error

Monitor Operation

If the DPF flow resistance is less than a calibrated threshold for a calibrated period, the fault becomes active. The DPF flow resistance is calculated using the DPF delta pressure and dividing it by the flow rate.

The MIL is illuminated after the error has been detected for a second consecutive drive cycle.

Regenerations are disabled when this fault becomes active.

EGR Temperature Rationality, Key-on

EGT Sensor Key-on Rationality

Description

The exhaust gas temperature sensor key-on rationality has two parts. EGT #3 is compared to engine coolant temperature and intake manifold temperature at key-on. As the Aftertreatment system warms up, EGT #1, EGT #2 and EGT #3 are compared to one another.

Enable Conditions

Engine state is stop (key-on only).

Ignition key-off time must be more than a calibrated threshold.

Initial engine coolant temperature is greater than a calibrated threshold (approximately 10°C [50°F]).

Abort Conditions

EGT #1, #2, #3 Sensor OOR errors.

Sensor supply errors.

Engine coolant temperature OOR and rationality errors.

Intake manifold temperature OOR and rationality errors.

Ignition key-off timer errors.

Monitor Operation

EGT #3 is compared to engine coolant temperature and intake manifold temperature. If intake manifold temperature and engine coolant temperature are within 5°C (10°F), and the difference between EGT #3 and engine coolant temperature and intake manifold temperature is greater than a calibrated threshold, the fault becomes active.

As the Aftertreatment system warms up, EGT #1, EGT #2, and EGT #3 are compared. If the difference between EGT #1 and EGT #3 (to account for the thermal masses in the Aftertreatment system) is greater than a calibrated threshold, the fault becomes active. The same logic with a different thermal mass calibration is used to verify EGT #2.

The MIL is illuminated after the error has been detected for a second consecutive drive cycle.

EGR Temperature Rationality, Key-off

EGT Sensor Change Rationality

Description

The exhaust gas temperature sensor rationality change ensures that the sensors are not stuck at ambient.

Enable Conditions

Ignition key-off time must be greater than a calibrated threshold.

Abort Conditions

EGT #1, #2, #3 sensor OOR errors.

Sensor supply errors.

Ignition key-off timer errors.

Monitor Operation

Change: The algorithm compares the current EGT Sensor value to the initial key-on EGT sensor value. If the difference is less than a calibrated threshold for a calibrated distance traveled, the fault becomes active.

For EGT #1 and #2, if the initial temperature is below 10°C (75°F), the initial temperature is set to 10°C (75°F).

For EGT #3, if the initial temperature is below 10°C (50°F), the initial temperature is set to 10°C (50°F).

The MIL is illuminated after the error has been detected for a second consecutive drive cycle.

EGR Temperature Sensors Reversed

EGT Sensor #1 & #2 Reversed

Description

The Exhaust Gas Temperature (EGT) sensor reversed rationality compares the two sensors during a dosing event, to determine that sensor #2 is after the DOC.

Enable Conditions

Engine state is run.

Hydrocarbon flow must be between the minimum and maximum calibrated thresholds for a calibrated period of time.

Exhaust mass flow must be between the minimum and maximum calibrated thresholds for a calibrated period of time.

EGT #1 and EGT #2 must be greater than a calibrated threshold.

Abort Conditions

EGT #1, #2 sensor OOR and rationality errors.

Fuel system error.

Misfire monitor error.

Intake manifold pressure sensor OOR and rationality errors.

DOC efficiency / presence error.

Monitor Operation

If EGT #1 is greater than EGT #2 by a calibrated threshold for a calibrated period, the fault becomes active.

The MIL is illuminated after the error has been detected for a second consecutive drive cycle.

An algorithm calculates an In-Use Performance Ratio for the EGT Sensor Rationality.

DPF Delta Pressure Rationality, High

DPF Delta Pressure Rationality - High

Description

The DPF delta pressure sensor rationality high error checks the sensor value at a known zero flow condition.

Enable Conditions

Engine state is stop.

Ignition key-off time must be greater than a calibrated threshold.

Abort Conditions

Particulate Filter Delta Pressure Sensor OOR errors.

Particulate Filter Delta Pressure Sensor Low rationality error.

Ignition Key-off timer errors.

Monitor Operation

If at key-on, the DPF Delta Pressure Sensor is greater than a calibrated threshold, the fault is active.

The MIL is illuminated after the error has been detected for a second consecutive drive cycle.

DPF Delta Pressure Rationality, Low

DPF Delta Pressure Rationality - Low

Description

The DPF delta pressure sensor rationality low error will check the sensor value at a known exhaust flow condition.

Enable Conditions

Engine state is run.

Abort Conditions

Particulate filter delta pressure sensor OOR errors.

Particulate filter delta pressure sensor high rationality error.

Monitor Operation

The algorithm compares the current DPF delta pressure sensor value to the initial key-on DPF delta pressure sensor value. If the difference is less than a calibrated threshold for a calibrated distance traveled, the fault becomes active.

The MIL is illuminated after the error has been detected for a second consecutive drive cycle.

Misfire Monitor

MISFIRE MONITOR

Description

The misfire monitor examines crank speed data to determine dead cylinders.

The monitor runs whenever enable conditions are met.

Enable Conditions

Engine Speed is at idle (fueling controlled by low speed governor)

Coolant Temperature > 140°C (284°F)

Engine load < 35%

Throttle = 0%

PTO is OFF

Road Speed = 0 MPH

Abort Conditions

Engine Speed Sensor OOR or rationality errors.

Fuel Rail Pressure Sensor, Coolant Temperature, Throttle OOR or rationality errors.

FCA, Fuel Lift Pump, or Sensor Supply errors.

Electrical Injector Faults.

PTO is on.

Monitor Operation

The monitor gathers and filters engine crank speed data for 10 seconds after the enable conditions are met.

If the crank speed deviation for a cylinder (120° crank rotation) is less than a calibrated threshold, a misfire fault is set for that cylinder.

If more than one cylinder has failed, a multiple cylinder misfire fault is set.

The MIL is illuminated after the error has been detected for a second consecutive drive cycle.

Fuel System Monitor

FUEL SYSTEM MONITORS

Fuel System Monitor – Low Pressure

Description

The Fuel System Monitor detects when the fuel system has an error that causes the engine to exceed emissions by 1.5 times.

The monitor runs whenever enable conditions are met.

Enable Conditions

Engine speed is greater than a calibrated threshold.

Fuel rail pressure is greater than a calibrated threshold.

Abort Conditions

Engine Speed sensor OOR or rationality errors.

Fuel Rail Pressure Sensor OOR or rationality errors.

FCA, Fuel Lift Pump, or Sensor Supply errors.

Monitor Operation

The algorithm calculates a fuel rail pressure error by taking the fuel rail pressure minus the fuel rail commanded pressure, plus a calibrated offset. If the fuel rail pressure error is less than a calibrated threshold for a calibrated period, the fault becomes active.

The MIL is illuminated when the error first becomes active.

Fuel Rail Pressure Sensor Rationality

Fuel Rail Pressure Sensor Rationality

Description

The Fuel Rail Pressure Sensor Rationality has three parts: Key-on (same as today's product), too high (same as today's product), and Idle Fuel Rail Pressure diagnostic.

The Idle Fuel Rail Pressure Diagnostic monitor runs whenever enable conditions are met.

Enable Conditions

Engine speed is at idle.

Engine coolant temperature is greater than a calibrated threshold.

Power Take-Off (PTO) and idle-up features are NOT ACTIVE.

Vehicle speed is less than a calibrated threshold (approximately 0 mph).

Throttle is less than a calibrated threshold (approximately 0%).

Fuel level must be greater than a calibrated threshold (15%).

Misfire monitor must have completed PASS at least once during this drive cycle.

Abort Conditions

Fuel Rail Pressure, Fuel Pump, Injector, or Fuel Lift Pump OOR errors.

Engine Coolant Temperature, Throttle, or Vehicle Speed Sensor OOR and rationality errors.

Fuel System Monitor errors.

Fuel Rail Pressure Rationality - Continued

Monitor Operation

This diagnostic monitors for "stop light conditions" when the vehicle is operating at no-load low speed idle. While under "stoplight conditions" the diagnostic actively assumes control of some combustion related parameters. While actively evaluating the sensor accuracy, the diagnostic overrides the commands for pilot quantity, pilot-to-main separation, and rail pressure. (The total fueling command is allowed to be controlled normally.) The average total fueling under reference conditions is established as a baseline. After a fueling baseline is established, the algorithm commands rail pressure to ramp down while holding the pilot quantity and separation constant. If the rail pressure sensor is working correctly, the total fueling command does not change significantly from the baseline level. However, if the fuel rail pressure is offset high, the fuel command increases dramatically as the fuel rail pressure is ramped down. A DTC is set when a significant rise in fuel command is observed during the diagnostics active check.

The MIL is illuminated after the error has been detected for a second consecutive drive cycle.

Pressure and Temperature Sensor Rationality, Key-on

PRESSURE AND TEMPERATURE SENSOR MONITORS

Pressure Sensor Key-on Rationalities

Description

A new algorithm was created to complete a key-on check of all the pressure sensors on the engine.

Enable Conditions

Engine State is STOP

Abort Conditions

Ambient Air, Crankcase, Intake Manifold, and Exhaust Manifold Pressure OOR and rationality errors.

Sensor Supply errors.

Monitor Operation:

The algorithm compares ambient air, intake manifold, and exhaust manifold pressures.

If intake and exhaust manifold pressures are within a calibrated threshold, and ambient air pressure differs from intake and exhaust manifold pressure by more than a calibrated threshold, the Ambient Air Pressure Sensor Rationality error will become active.

If ambient air and exhaust manifold pressures are within a calibrated threshold, and intake manifold pressure differs from ambient air and exhaust manifold pressure by more than a calibrated threshold, the intake manifold pressure sensor rationality error becomes active.

If ambient air and intake manifold pressures are within a calibrated threshold, and exhaust manifold pressure differs from ambient air and intake manifold pressure by more than a calibrated threshold, the exhaust manifold pressure sensor rationality error becomes active.

The MIL is illuminated after the error has been detected for a second consecutive drive cycle.

The algorithm calculates a in-use performance ratio for the Crankcase Pressure Sensor Rationality.

Temperature Sensor Estimate, Key-on

Key-on Temperature Estimate

Description

This algorithm calculates an estimated engine/engine bay temperature by computing a weighted average of the various sensors located on or around the engine. The weighting system is done because of the differences in sensor tolerances and reliability.

This estimate is used for the key-on temperature checks to improve robustness while decreasing the complexity of the current diagnostic.

Since multiple sensors are used, it increases the fault tolerance of the key on temperature diagnostics.

The estimate helps overcome problems inherit in some sensors:

- Block heaters affecting coolant temperature
- Ambient air temperature located close to hood (reads high in dark truck on cold, sunny day)
- Battery chargers affecting battery temperature

The estimate is used in the EGR Temperature and CAC Out Temperature Rationalities initially, with plans to integrate it into all key on temperature checks.

Temperature Sensor Rationality, Key-on

Key-on Temperature Sensor Rationality

Description

The temperature sensor key-on rationality covers the ambient air, battery, and intake manifold temperature sensors.

The algorithm compares the sensor values with each other and in some cases, engine coolant temperature. If the difference between the initial key-on sensor values is greater than a threshold, the fault for the specific sensor becomes active.

Monitor Improvements

Added disable for below -6°C (20°F).

Multiple thresholds are added to the monitor.

Large threshold – to be used with checks of the battery temperature sensor. This threshold is calibrated to a larger number to allow for sensor inaccuracy.

Small threshold – to be used with checks of the ambient air, intake manifold, and engine coolant temperatures. This threshold is calibrated to a smaller number allowing for the sensors with the better accuracy.

Charge Air Cooler Out Rationality

Charge Air Cooler Out Rationality

Description

The CAC Out Temperature Sensor Rationality has two parts: key-on and change.

Enable Conditions

Engine state is stop.

Ignition key-off time must be greater than a calibrated threshold.

Engine state is run (change only).

Key-on temperature estimate must be greater than a calibrated threshold.

Abort Conditions

CAC Out Temperature Sensor OOR errors.

Key-on temperature estimate status is not GOOD.

Ignition key-off timer errors.

Monitor Operation

Key-on – If the difference between the CAC Out temperature and the key-on temperature estimate is greater than a calibrated threshold, the rationality fault will become active.

Change – After the engine has run a calibrated period above a calibrated amount of intake manifold pressure, the CAC out temperature is compared to the initial key-on CAC out temperature. If the difference is NOT greater than a calibrated threshold, the rationality fault becomes active.

The MIL is illuminated after the error has been detected for a second consecutive drive cycle.