

2021 ENGINE PERFORMANCE

3.6L Emissions Control - Gladiator [ERC, ERF]

CATALYST MONITOR

DESCRIPTION AND OPERATION

CATALYST MONITORING SYSTEM

DESCRIPTION

The Catalyst Monitoring system consists of the following components:

- Upstream and Downstream O₂ Sensors
- Catalytic Converter

OPERATION

The **State of Change (SOC)** catalyst monitor uses the signals from both the Upstream and Downstream Oxygen (O₂) Sensors to detect aging of the catalyst. The Upstream O₂ Sensor slow response monitor runs simultaneously to determine if the sensor signal is plausible. A pass/fail determination is made on the O₂ Sensor slow response diagnostic before a catalyst determination is made to prevent a false fail of the catalyst monitor. These monitors are intended to determine when the O₂ Sensor and catalyst systems have deteriorated to the point that tailpipe emissions exceed the appropriate malfunction limit.

CATALYTIC CONVERTER

Inside the Catalytic Converter, the exhaust gases flow through a dense ceramic honeycomb structure coated with the catalysts. The honeycomb structure allows the exhaust gases to touch a larger area of catalyst at once, so they are converted more quickly and efficiently. The three way catalysts work to reduce tailpipe emissions.

- The catalyst works by combining oxygen with Carbon Monoxide (CO) and unburned hydrocarbons (HC) to produce Carbon Dioxide (CO₂) and water (H₂O).
- The three way catalyst also reduces Oxides of Nitrogen (NO_x) using a chemical process to produce nitrogen and oxygen gases.

The Catalytic Converter operates most efficiently when the engine is operated within a narrow band of air/fuel ratios near the stoichiometric point, such that the exhaust gas composition oscillates between rich (excess fuel) and lean (excess oxygen). The Upstream O₂ Sensor feedback is used to maintain this optimal air/fuel ratio. The Downstream O₂ Sensor feedback is used to monitor the efficiency of the Catalytic Converter.

O₂ SENSORS (Switching 4-Wire O₂ Sensors and Wide-Band O₂ Sensors)

Switching 4-Wire O₂ Sensor Description:

The traditional Switching (4-wire) O₂ Sensors are mounted in the vehicle exhaust system. They are used to monitor how much unburned oxygen is in the exhaust as the exhaust exits the engine. Monitoring oxygen levels in the exhaust is a way of gauging the fuel mixture. The O₂ Sensors report to the Powertrain Control Module (PCM) if the fuel mixture is burning rich (less oxygen) or lean (more oxygen).

Switching 4-Wire O₂ Sensor Operation:

- **O₂ Sensor Heater Operation** - For a typical Switching (4-wire) Oxygen (O₂) Sensor output signal to function, the sense element must be heated to operating temperature. A resistive heater element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O₂ Sensor Heater resistance is directly proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a calculation to determine the heater resistance and

temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater temperature is determined using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (PWM) to prevent damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

- **O2 Sensor Output Operation** - Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is in normal operating temperature range. The output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected in a comparison chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/fuel mixture) it produces a higher voltage. In some instances a negative offset output of up to -1.0 volts may be introduced if the sensors reference chamber is contaminated. To allow for the negative voltage to be read, each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

Wide-Band O2 Sensor Description:

The wide-band O2 Sensor operates differently than traditional O2 Sensors. The wide-band O2 Sensor tip consists of two cells that provide different functions, a measurement chamber and a detection chamber with pumping capabilities. The oxygen pumping function is the ability to pump oxygen into or out of the measurement chamber depending on the level of oxygen in the measurement chamber. This function provides the wide-band sensing capabilities and is critical for proper oxygen measurement. The O2 Sensor Reference circuit provides a common bias supply to both the O2 Sensor Signal and the O2 Sensor Pump Cell Current circuits.

Wide-Band O2 Sensor Operation:

- **O2 Sensor Heater Operation** - For the wide-band O2 Sensor to deliver accurate readings the sensing elements must be heated. A Positive Temperature Coefficient (PTC) element inside the O2 Sensor heats up as current passes through it. This allows the system to enter Closed Loop quickly. The Powertrain Control Module (PCM) turns on this circuit based on Engine Coolant Temperature (ECT) and engine loads. The PCM monitors the O2 Sensors heater resistance for circuit fault detection.
- **O2 Sensor Output Operation** - During normal operation, the O2 Sensor Reference voltage and O2 Sensor Signal voltage will be a fixed voltage value. The O2 Sensor Current Pump voltage will switch from between 0.45 volts above and below the fixed O2 Sensor Return voltage, allowing current to flow in either direction through the pump. This correlates with the pumping of oxygen into and out of the measurement chamber. On a properly operating vehicle, this happens very quickly and the voltage reading should maintain a steady 0.45 volts when taking a voltage measurement between the O2 Sensor Signal circuit and the O2 Sensor Reference circuit of the O2 Sensor with the engine running and the O2 Sensor operating in closed loop.
- **O2 Sensor Pumping Element Operation** - When the exhaust stream has a lean air/fuel ratio (high oxygen content) the pumping element voltage will move toward +0.45 volts pumping oxygen out of the measurement chamber. When the exhaust stream has a rich air/fuel ratio (relatively low oxygen content) the pumping element voltage will move toward -0.45 volts pumping oxygen into the measurement chamber.

DIAGNOSIS AND TESTING

CATALYST MONITORING SYSTEM

Upstream O2 Sensor Monitoring

The Upstream O2 Sensor **State of Change (SOC)** monitor is used to detect a failed Upstream O2 Sensor. The Upstream O2 Sensor is very important for emission control and engine performance since it can provide immediate air/fuel ratio feedback. Therefore, proper operation of this Upstream O2 Sensor is critical. An aged Upstream O2 Sensor tends to be less active and has a slower response rate to changes in the air/fuel ratio of exhaust gas. As a result, the quality of the Upstream O2 Sensor can be determined by observing the voltage activity from the sensor. This monitor is triggered when the engine is running at certain MAP/RPM windows,

airflow is relatively stable and steady O₂ control is applied. The **SOC** for Upstream O₂ signal is captured in an internal calibrated time block (consisting of consecutive samples), such that even the slowest (but still considered as passing) O₂ Sensor should accumulate enough state changes to pass the monitor.

Catalyst Failure Rationality

The catalyst determination is based on the fact that when a catalyst ages it loses some of its Oxygen Storage Capacity (OSC). As a result, the exhaust gases can break through the catalyst causing the Downstream O₂ Sensor to deviate from its relatively neutral baseline position to a higher **SOC** value. In general, as more exhaust gases break through and lower the Oxygen Storage Capacity of the Catalytic Converter, the Downstream O₂ Sensor **SOC** will increase and get closer to the Upstream O₂ Sensor **SOC**. By observing and comparing the activity in the Downstream O₂ Sensor signal, located in the exhaust path downstream of the Catalytic Converter, with the Upstream O₂ Sensor located before the catalyst the degradation level of catalyst can be detected.

There are several different catalyst efficiency monitoring windows. Each specific window has several different enable conditions. The best opportunity for the catalyst efficiency monitor to run is:

- Engine temperature above 70B°C (158B°F)
- Engine speed approximately 1000-3000 rpm
- Vehicle speed 32-137 km/h (20-85 mph), under moderate engine load

Catalyst System Diagnostic Monitor

To make the determination, the Powertrain Control Module (PCM) monitors and compares the **SOC** ratio between the Downstream O₂ Sensor and the Upstream O₂ Sensor over a calibrated period of time. **Typically, if the catalyst is working properly, the ratio between the Downstream O₂ Sensor and the Upstream O₂ Sensor is approximately (0.2/1).** A simple way to understand this comparison is to understand that the shortest distance between two points is a straight line. Using this logic, if the sine wave signal of both sensors was recorded for a calibrated time period and straightened out for comparison, the length of the Downstream O₂ Sensor line would only measure approximately 20% of the length of the Upstream O₂ Sensor line. As the Catalytic Converter begins failing, the ratio will move towards 1/1. Typically, if the ratio becomes greater than a calibrated threshold, approximately 0.6/1, the PCM will consider the catalyst as failing and fault the system.

DIAGNOSIS AND TESTING - O₂ SENSOR

O₂ Sensor Diagnostics

The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. Because of how the switching (4-wire) O₂ Sensor operates, the circuit fault diagnostics for O₂ Sensors are algorithm based. This means an open or short in one of the O₂ Sensor circuits can cause a fault to set against another of the O₂ Sensor circuits. Understanding how to interpret the combination of DTCs and O₂ Sensor data provided can aid in narrowing down the fault in the system.

- **On vehicle/engine combinations that use only the traditional switching O₂ Sensors**, both of the Upstream and Downstream O₂ Sensor Return circuits originate from a single source within the PCM. Because of this, a short anywhere in the wiring in any of the O₂ Sensor Return circuits will affect all of the Upstream and Downstream O₂ Sensors.

With the diagnostic scan tool in data display, filter on O₂ in the search function and bring up the following information:

- O₂ Sensor signal voltage - the **raw signal voltage** should switch 2.5-3.5 volts on a normally functioning sensor.
- O₂ Sensor (0-1) signal voltage - the **differential signal voltage** which is calculated using the raw signal voltage minus the 2.5 volt bias on the return circuit of a normally functioning O₂ Sensor.
- Heater driver operation - displays the heater duty cycle.
- Heater temperature - this is determined by the total heater circuit resistance.

- Closed loop fuel control state - displays as open/closed.

Using the Diagnostic Scan Tool for Diagnostics

O2 Sensor Heater Diagnosis:

An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heater will remain disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that ignition cycle. Any of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output of sensor signal** , and the heater control is disabled, this will cause the affected O2 Sensor raw signal voltage to read high (usually stays above 4.0 volts) and can also eventually set a Signal Circuit High DTC. It is not unusual to have a Heater Control Circuit High or Low DTC and a Sensor Signal High DTC to be set together. **Important Note: A small amount of resistance (3-4 Ohms) may not set a Heater Control Circuit DTC but will affect heater operation and cause the SENSOR SIGNAL HIGH DTC to set** . Monitoring the heater duty cycle and temperature for a sensor that is reading high on the raw signal voltage can help in diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on the diagnostic scan tool for the affected sensor by as much as 371B°C (700B°F) when compared to the other Switching (4-wire) O2 Sensors. As little as 2.0 Ohms can increase the temperature reading approximately 121B°C (250B°F) on the diagnostic scan tool.

NOTE:

When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will be between approximately 30 and 50%. The typical heater temperature will range approximately 649-760B°C (1200-1400B°F) on the diagnostic scan tool. If there is an issue with the O2 Sensor heater or circuitry, the PCM will disable the

Using the Diagnostic Scan Tool for Diagnostics

	<p>heater driver and the duty cycle will be 0%. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably different.</p>
<p>O2 Sensor Signal Low Diagnosis:</p>	<p>Monitor the diagnostic scan tool and start the engine. With an O2 Sensor Signal shorted to ground and the O2 Sensor cold, the raw signal voltage will be at 0 volts, but the (0-1) differential voltage signal will read -2.5 volts and increase toward 0 volts as the sensor heats up. When the sensor is warm, the raw signal voltage reading and the (0-1) differential voltage reading will both read near 0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the raw voltage signals to switch between the 0-1 volt range on the other O2 Sensors. This may also cause the O2 Sensor Reference (Return) Voltage Circuit Low DTC to set.</p>
<p>O2 Sensor Signal High Diagnosis:</p>	<p>The O2 Sensor Signal High diagnostic can fail due to several conditions. As mentioned above, an open, short or any resistance in the heater circuitry can cause the signal voltage to remain high. Looking for abnormalities in the heater duty cycle or heater temperature of the affected sensor would indicate a heater control issue causing the signal circuit high fault. An open in a O2 sensor signal or return circuit will cause the raw signal voltage to read high, 4.0-5.0 volts, and the (0-1) differential voltage reading to be near 2.5 volts for the sensor. If both of the Downstream O2 Sensors are affected, it could indicate an open in the return circuit that is before the splice in the harness.</p>
<p>P1621-O2 Sensor Reference (Return) Circuit Low Diagnosis:</p>	<p>The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the return circuits are shorted to ground, the raw signal voltage readings for all O2 Sensors will read 0-1 volts instead of 2.5-3.5 volts. This happens because the bias voltage on the return circuit is pulled low for all sensors. As mentioned in the O2 Sensor Signal Low Diagnosis above, a short to ground in one of the sensor signal circuits will also pull the sensor return low for all sensors. However, this will cause the voltage reading on the sensor that has the shorted signal to read 0.0 volts on both the raw signal voltage and (0-1) differential voltage reading when the sensor is warm.</p>
<p>P1622-O2 Sensor Reference (Return) Circuit High Diagnosis:</p>	<p>A short to voltage in any of the sensor return circuits will cause the fault to set. The affected O2 Sensors will read 5.0 volts on the raw signal voltage. The (0-1) differential voltage reading will be 0.0 volts because the signal circuit voltage and return circuit voltage are both 5.0 volts. A short to voltage on one of the O2 Sensor signal circuits will cause the same fault condition and diagnostic scan tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, the (0-1) differential voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.</p>

CRANKCASE VENTILATION

DESCRIPTION AND OPERATION

POSITIVE CRANKCASE VENTILATION (PCV) SYSTEM - NON TURBO

DESCRIPTION

The Positive Crankcase Ventilation (PCV) System includes the following components:

COMPONENT INDEX

1.	INTAKE MANIFOLD
2.	PCV TUBE (DIRTY AIR TUBE)
3.	PCV VALVE
4.	MAKE-UP AIR (MUA) OIL SEPARATOR (PART OF VALVE COVER)
5.	MAKE-UP AIR (MUA) TUBE (FRESH AIR TUBE)

OPERATION

There are two sides to the Positive Crankcase Ventilation (PCV) system. The dirty side of the system consists of the PCV Valve, installed on the Valve Cover Oil Separator, and the PCV Tube that connects between the PCV Valve and Intake Manifold. The clean air side of the system consists of the Make-Up Air (MUA) Tube that connects between the MUA Oil Separator in the Valve Cover and the Fresh Air Hose, and Crankcase Pressure Sensor.

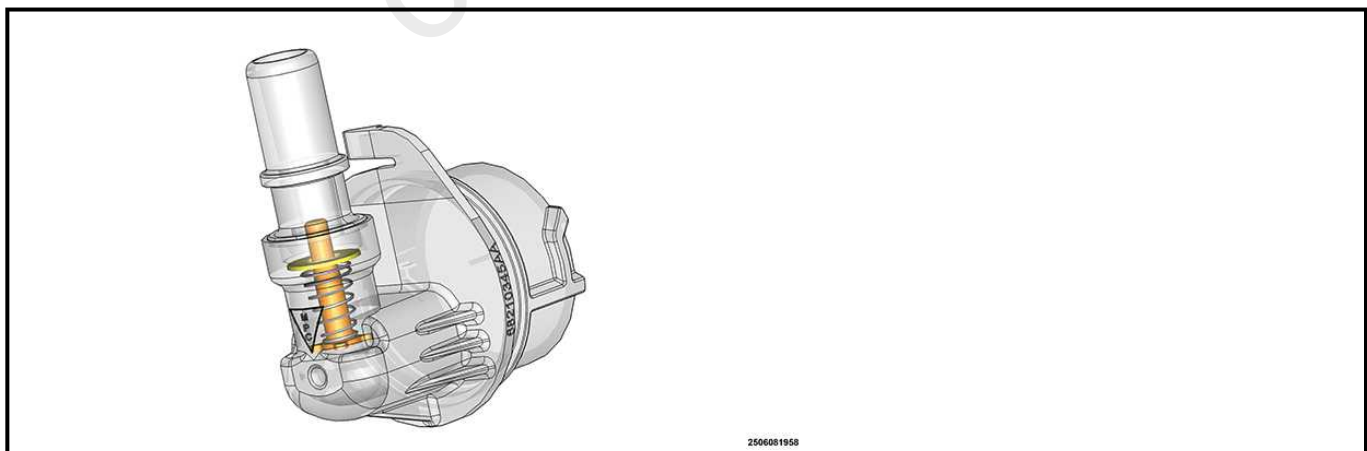
NATURALLY ASPIRATED OPERATION

When the engine is running Naturally Aspirated, clean air flows from the Fresh Air Hose, through the MUA Tube and MUA Oil Separator, to the crankcase. The crankcase vapors are pushed into the other Oil Separator in the Valve Cover. Engine vacuum draws the vapors into the Intake Manifold through the PCV Valve and PCV Tube where they are burned.

POSITIVE CRANKCASE VENTILATION (PCV) VALVE

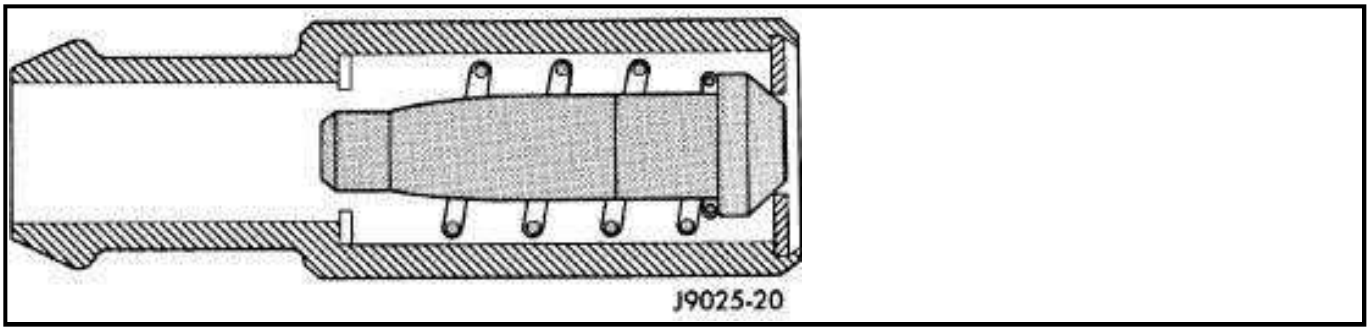
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The PCV Valve contains a spring loaded plunger. The plunger meters the amount of crankcase vapors routed into the combustion chamber based on intake manifold vacuum.

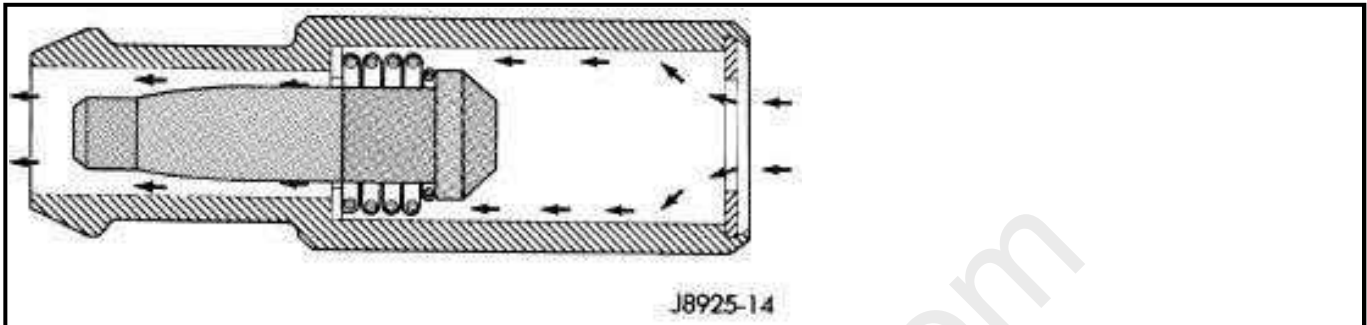


NOTE: Shown below are the typical views of the PCV Valve operation.

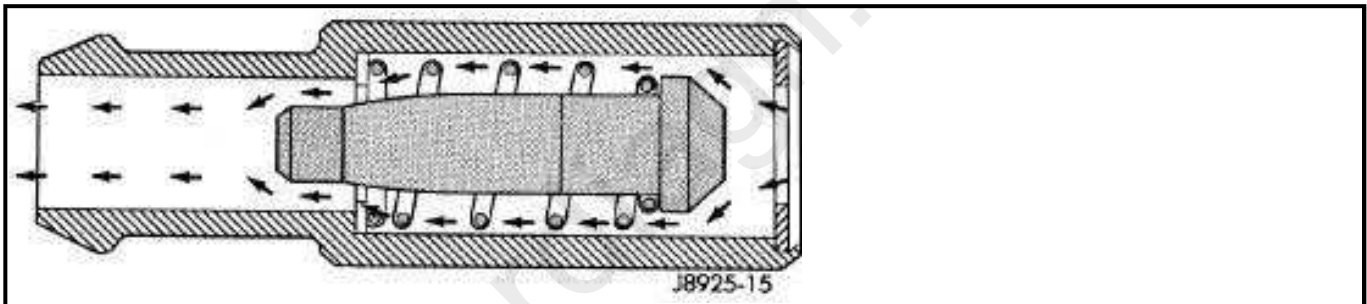
When the engine is not operating or during an engine backfire, the spring forces the plunger back against the seat. This prevents vapors from flowing through the valve.



When the engine is at idle or cruising, high manifold vacuum is present. At these times manifold vacuum is able to completely compress the spring and pull the plunger to the top of the valve. In this position there is minimal vapor flow through the valve.



During periods of moderate intake manifold vacuum the plunger is only pulled part way back from the inlet. This results in maximum vapor flow through the valve.



DIAGNOSIS AND TESTING

POSITIVE CRANKCASE VENTILATION (PCV) SYSTEM DIAGNOSTICS (TURBO OR NON-TURBO ENGINES)

WARNING: Apply parking brake or block wheels before performing any test or adjustment with the engine operating.

NON-TURBOCHARGED SYSTEM

The Powertrain Control Module (PCM) monitors the dirty air (PCV valve) and clean air (Make-Up Air/MUA) sides of the crankcase ventilation system. Perform the following steps to test the PCV and MUA crankcase ventilation system.

1. Remove the Make-Up Air (MUA) hose from the air cleaner body. Hold a piece of stiff paper (parts tag) loosely over the end of the MUA hose.
2. After allowing approximately 1 minute for crankcase pressure to reduce, the paper should draw up against the hose with noticeable force. If the engine does not draw the paper against the hose end, inspect the PCV valve and hose for blockage.
3. Turn the engine OFF. Remove the PCV valve. The valve should rattle when shaken.
4. Replace the PCV valve and retest the system if it does not operate as described in the preceding tests. **Do not attempt to clean the old PCV valve.**

TURBOCHARGED SYSTEM

The Powertrain Control Module (PCM) monitors the dirty air (PCV valve) and clean air (Make-Up Air/MUA) sides of the crankcase ventilation system for disconnects. The monitoring strategies are explained in the component information below.

DIAGNOSTICS - DIRTY AIR (PCV Valve) SIDE

- The dirty air side of the system does not have a sensor for detecting a hose disconnect. A disconnected PCV tube will cause a measurable vacuum leak and likely idle quality issues. However, the range of authority of torque management can keep engine rpm in control despite a disconnected PCV tube causing a vacuum leak. To diagnose this condition, an algorithm using the gas flow/air flow ratio is calculated and compared to a calibrated threshold. If the diagnostic is determined to be failing, a DTC (**P04FC**) is set.

NOTE: Since this diagnostic uses the calculated gas flow/air flow ratio to make a determination of a failure, any issue that effects the pressure in the intake manifold can cause this fault to set.

DIAGNOSTICS - CLEAN AIR (MUA) SIDE

- If the MUA tube is disconnected on the clean air tube, PCV vapors will leak into the atmosphere whenever the engine is in boost. The Crankcase Pressure Sensor is used to diagnose a disconnect in the MUA Tube. The Crankcase Pressure Sensor connects to a fitting on the Clean Air Tube that is also connected to the MUA tube. The PCM monitors the pressure pulsations in the Crankcase Pressure Sensor signal to determine whether or not the hose is connected. If the MUA tube is determined to be disconnected, a DTC (**P2C90**) is set. The PCM also monitors the sensor and circuits for electrical faults such as opens or shorts.

VALVE, POSITIVE CRANKCASE VENTILATION (PCV)

REMOVAL AND INSTALLATION

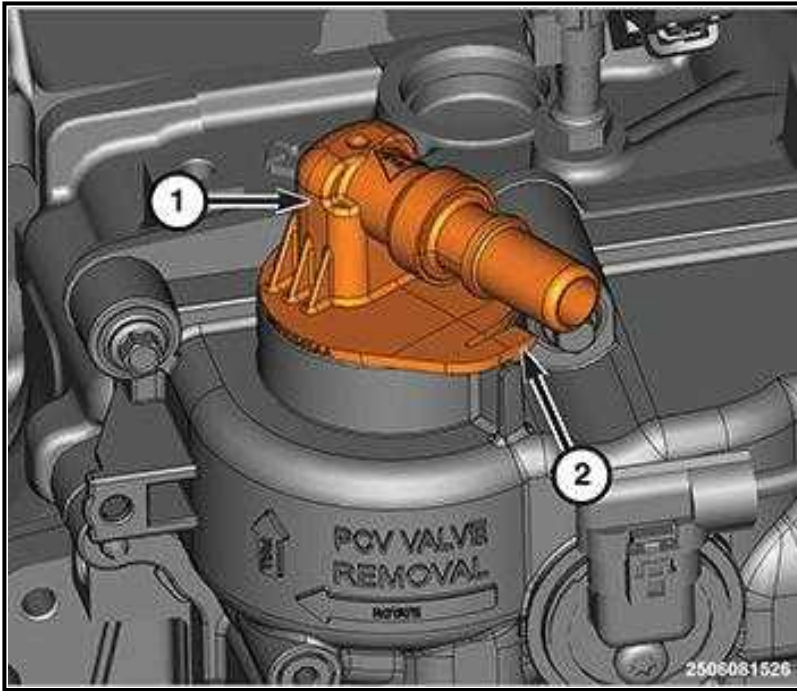
PCV VALVE

REMOVAL



1 - Lock Tab

1. Push in on the lock tab to release the quick disconnect and remove the hose from the Positive Crankcase Ventilation (PCV) valve.



- | |
|---------------|
| 1 - PCV Valve |
| 2 - Lock Tab |

2. Release the lock tab, turn the PCV valve clockwise and pull out to remove from the right cylinder head cover.

INSTALLATION

Follow the removal procedure in reverse for general reassembly of the components on the vehicle. The steps listed below are calling out specific procedures that should be followed during installation.

- Clean and inspect the sealing surfaces of the PCV valve and cylinder head cover. Lubricate the O-ring seal with clean engine oil.



EVAPORATIVE EMISSIONS

DESCRIPTION AND OPERATION

EVAPORATIVE EMISSIONS SYSTEM

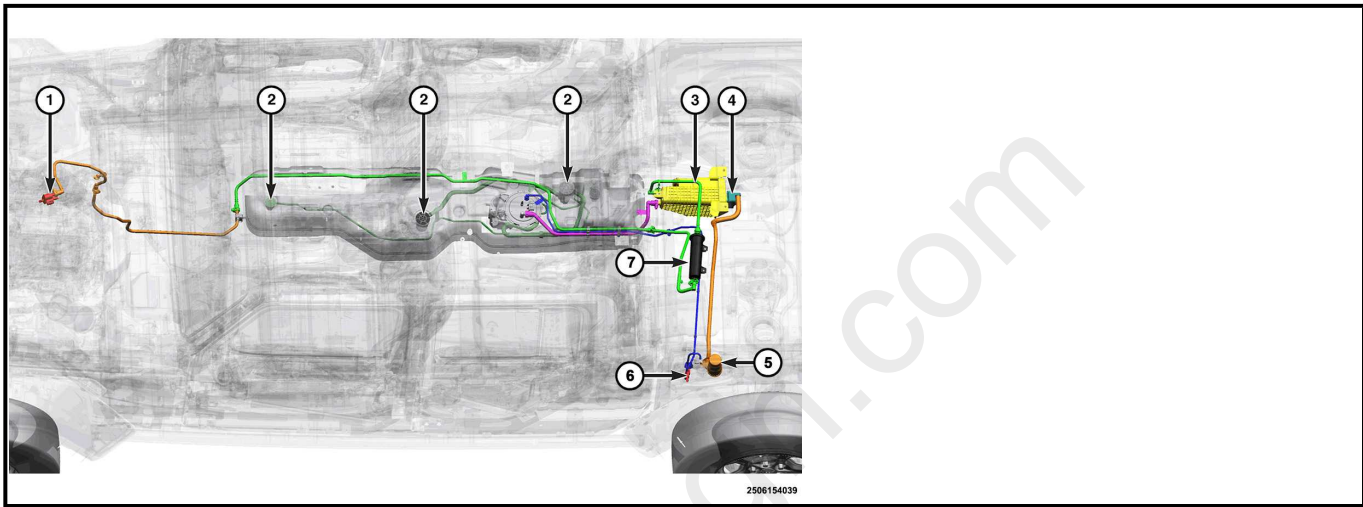
DESCRIPTION

COMPONENT LOCATION VIEW:

The Evaporative Emissions system consists of the following components:

COMPONENT INDEX

1.	Evaporative Emissions Purge Solenoid
2.	Internal Tank Vents
3.	Charcoal Canister
4.	Emission System Integrity Monitor (ESIM)
5.	Canister Fresh Air Filter
6.	Fuel Tank Pressure (FTP) Sensor
7.	Expansion Chamber



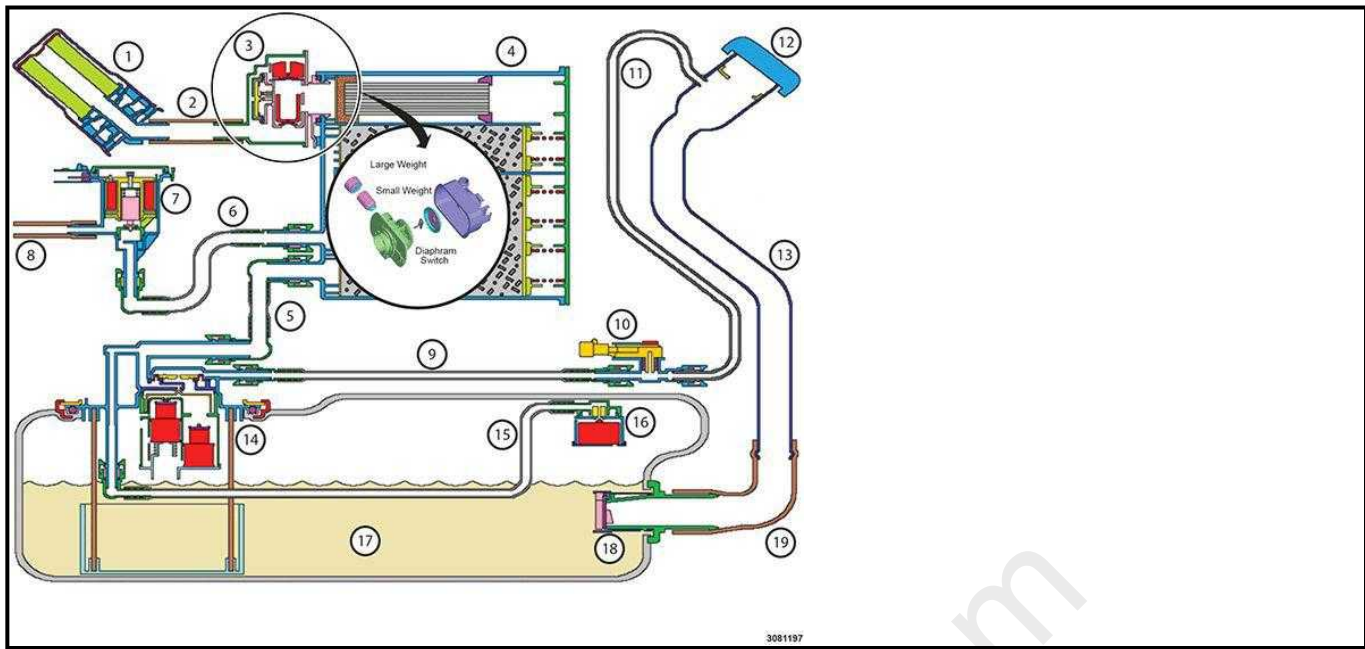
COMPONENT CONFIGURATION VIEW:

The generic graphic below is intended to show the complete Evaporative Emissions turbo system consisting of the following components:

EVAP SYSTEM COMPONENTS			
CALLOUT	DESCRIPTION	CALLOUT	DESCRIPTION
1	Canister Fresh Air Filter	11	Recirculation Tube (metal portion) (FTP Sensor to Fuel Filler Tube)
2	Filter Hose (Filter to ESIM)	12	Gas Cap or Cap-less Refueling Unit (if equipped)
3	Emission System Integrity Monitor (ESIM)	13	Fuel Filler Tube
4	Charcoal Canister	14	Multi-Function Control Valve (MFCV) in the Fuel Delivery Flange - Internal Tank Vents
5	Canister Tube (Fuel Tank to Canister)	15	Grade Vent Valve (GVV) Tube (GVV to MFCV)
6	Purge Tube - Noise Muffler (Purge Solenoid to Canister)	16	Grade Vent Valve (GVV) - Internal Tank Vents
7	Purge Solenoid	17	Fuel Tank
8	Manifold Hose (Purge Solenoid to Engine Manifold)	18	Inlet Check Valve (ICV)
9	Recirculation Tube (Fuel Tank to FTP Sensor)	19	Hose - Fuel Filler Tube to ICV

EVAP SYSTEM COMPONENTS

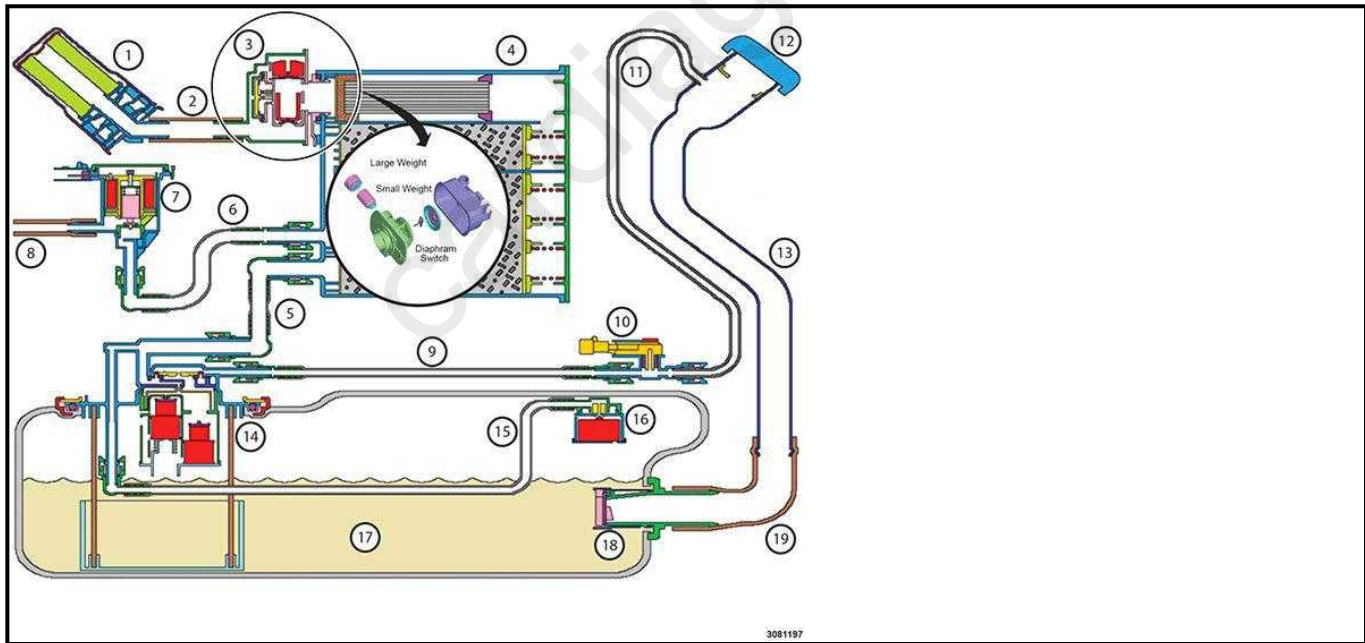
CALLOUT	DESCRIPTION	CALLOUT	DESCRIPTION
10	Fuel Tank Pressure (FTP) Sensor		B



DIAGNOSIS AND TESTING

EVAP EMISSIONS PCM DIAGNOSTICS - NON TURBO

The complete Evaporative Emissions System consists of the following configuration and operational components:



NOTE: This generic graphic is designed to show the system components and configuration.

EVAP SYSTEM COMPONENTS

CALLOUT	DESCRIPTION	CALLOUT	DESCRIPTION
1	Filter - Fresh Air Inlet	11	Recirculation Tube (metal portion) (FTPS to Fuel Filler Tube)

EVAP SYSTEM COMPONENTS

CALLOUT	DESCRIPTION	CALLOUT	DESCRIPTION
2	Filter Hose (Filter to ESIM)	12	Gas Cap or Cap-less Refueling Unit (if equipped)
3	Evaporative System Integrity Monitor (ESIM)	13	Fuel Filler Tube
4	Evaporative Charcoal Canister	14	Multi-Function Control Valve (MFCV) in the Fuel Delivery Flange
5	Canister Tube (Fuel Tank to Canister)	15	Grade Vent Valve (GVV) Tube (GVV to MFCV)
6	Purge Tube (Purge Solenoid to Canister)	16	GVV
7	Purge Solenoid	17	Fuel Tank
8	Manifold Hose (Purge Solenoid to Engine Manifold)	18	Inlet Check Valve (ICV)
9	Recirculation Tube (Fuel Tank to FTPS)	19	Hose - Fuel Filler Tube to ICV
10	Fuel Tank Pressure Sensor (FTPS)		B

NOTE: The Emission System Integrity Monitor (ESIM) Switch alone is used for all leak check diagnostics. The Fuel Tank Pressure (FTP) Sensor is not used for diagnosing the system for a leak.

ESIM SWITCH MONITOR - STUCK CLOSED At ignition OFF, the state of the ESIM switch is evaluated. If the switch is open, a pass flag is set and the PCM will complete power down. If the switch is closed, the PCM will wait a calibrated delay time and open the purge solenoid. In a normally functioning system, this will relieve the vacuum trapped in the charcoal canister allowing the switch to open. If the switch opens, a pass flag is set and the PCM will power down. If the PCM detects that the ESIM switch is still closed after a calibrated time, an error is detected and a switch stuck closed failure is set at the next engine RUN cycle. Two consecutive failed events will mature a fault (P0452) .

SMALL LEAK MONITOR

This is an accumulative monitor and the data from each valid event is recorded and added to the previously recorded events. The PCM timer records the engine ON/drive cycle and engine OFF time for each small leak monitor event. For an event to be valid the PCM must see the following:

1. An engine ON/drive cycle for a minimum of 2-5 minutes.

NOTE: The engine ON timer will stop counting after a maximum of 26 minutes.

2. And, when the engine is shut down, an engine OFF timer starts. There is a 12 minute delay time in which the PCM will ignore ESIM switch input. The engine OFF timer period will continue to count until one of these three conditions exist:

- The engine is started without a switch closure during the event.

NOTE: At the next key ON cycle, a determination is made as to whether the event was valid and the information is kept.

- An ESIM switch closed input is received after the 12 minute delay during the event.

NOTE: If the switch closed input is received, the PCM records that the switch has closed and stores the engine shut down time.

- After a maximum of 17.5 hours without an ESIM switch closure during the event.

This monitor will **increment the accumulation fail timers** until **both** have reached a calibrated threshold (engine ON - 100 minutes and engine OFF - 70 hours). When the monitor records a valid **switch closure (small leak passing event)** , the fail timers are reset.

LEAK SIZE DETERMINATION: If the PCM did not see an ESIM switch closed signal during the previous ignition OFF cycle and there is a cold start (the event was valid), an intrusive leak test is run to determine if a large leak is present. Immediately after start-up, while the engine is cold, the purge solenoid is opened to create vacuum in the evaporative system to a calibrated vacuum point that is beyond the ESIM switch closing threshold. **The pass/fail time will vary based on the total fuel volume at the time of the test.**

- If the switch does not close at all during purging because of a switch that is stuck open or vacuum cannot be created below -250 Pa within a calibrated time, it is determined to be a general evaporative system failure (**P0440 Diagnostic Trouble Code (DTC)**).
- If vacuum is created and the switch has closed, the PCM stops purging and monitors the switch closure time. If the switch opens before a calibrated time, a large leak is present. Two consecutive failure events will mature a fault (**P0455 DTC**).
- If vacuum is created and the switch has closed, the PCM stops purging and monitors the switch closure time. If the switch stays closed longer than a calibrated period of time, it is determined that a large leak is not present and the Small Leak Monitor will continue to run until the accumulative monitor reaches its threshold. If no ESIM switch closures were recorded during the entire **accumulated timer** , it is determined that a small leak is present (**P0456 DTC**).

NOTE: It is important to understand how extreme temperature changes can effect your results when diagnosing the system. It can either mask a leak by creating vacuum too rapidly, temporarily overcoming the leak, or make a sealed system appear to be leaking due to excessive vapor build-up decaying vacuum too rapidly. This could be from the vehicle heat soaking after a long drive cycle or being brought into a shop environment that is vastly different from the outside environment. Be aware of these factors when performing the checks on the system .

PURGE FLOW MONITOR

NOTE: The Fuel Tank Pressure (FTP) Sensor alone is used for Purge Performance diagnostics. The ESIM switch is not used for diagnosing the purge system.

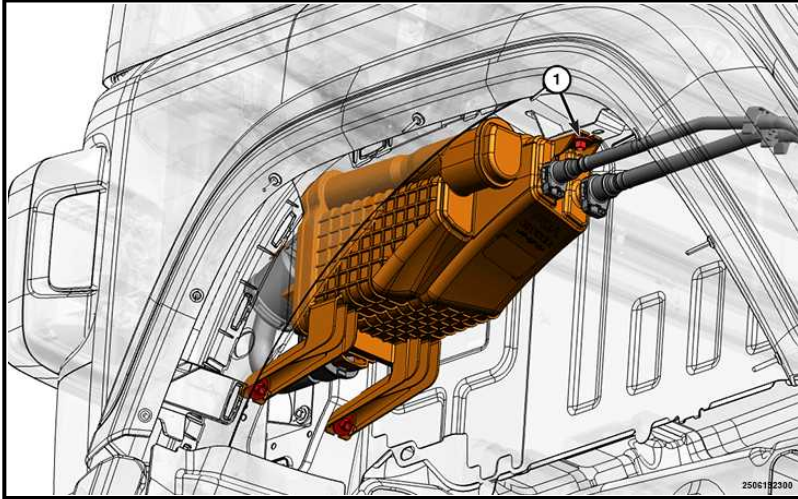
The Purge Flow Monitor Diagnostic will only run if the Small Leak Monitor recorded a pass on the previous ignition OFF event and the test data was valid. Because the leak detection diagnostics can only verify that the fuel tank system is sealed while the purge valve is closed, it cannot determine if the purge line between the solenoid and intake manifold is pinched or leaking. The Purge Flow Monitor is needed to verify these failure modes. The Purge Flow Monitor works on the premise that as flow through the system increases, so does the pressure drop in the system. The PCM monitors the FTP Sensor and looks for increasing vacuum in the fuel tank with increasing purge flow. Conversely, it looks for decreasing vacuum in the fuel tank with decreasing flow.

- **The non-intrusive purge monitor** runs during normal operation once the enable conditions are met and looks for a calibrated increase in vacuum in the fuel tank with increased purge flow, referred to as side 1. If side 1 passes, the purge monitor looks for a calibrated decrease in vacuum in the fuel tank with decreasing purge flow, referred to as side 2. If side 2 passes, the purge monitor is complete. If the purge flow monitor fails either side 1 or side 2, or does not complete both side 1 and side 2 within a specified time, an intrusive test is initiated to verify the results from the non-intrusive test.
- **The intrusive diagnostic** increases and decreases the purge flow in a more controlled manner to allow a more accurate test result. If the PCM detects a failure during the intrusive test, a purge system performance fault is set (**P0441**).

TECHNICAL SPECIFICATIONS

TORQUE SPECIFICATIONS

EVAP EMISSIONS



DESCRIPTION	SPECIFICATIONS	COMMENT
Vapor Canister to Vehicle Nuts	5 N.m (44 In. Lbs.)	-

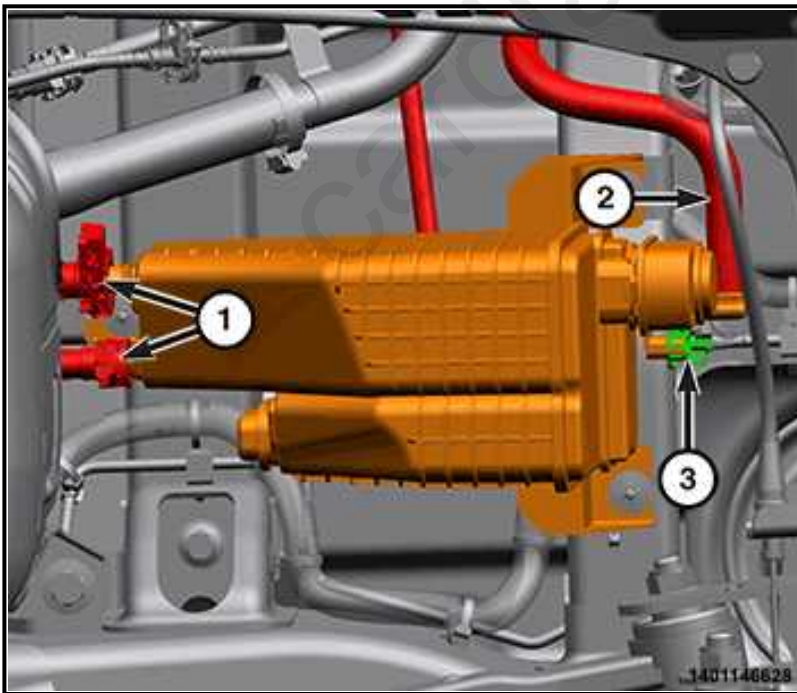
CANISTER, VAPOR

REMOVAL AND INSTALLATION

VAPOR CANISTER

REMOVAL

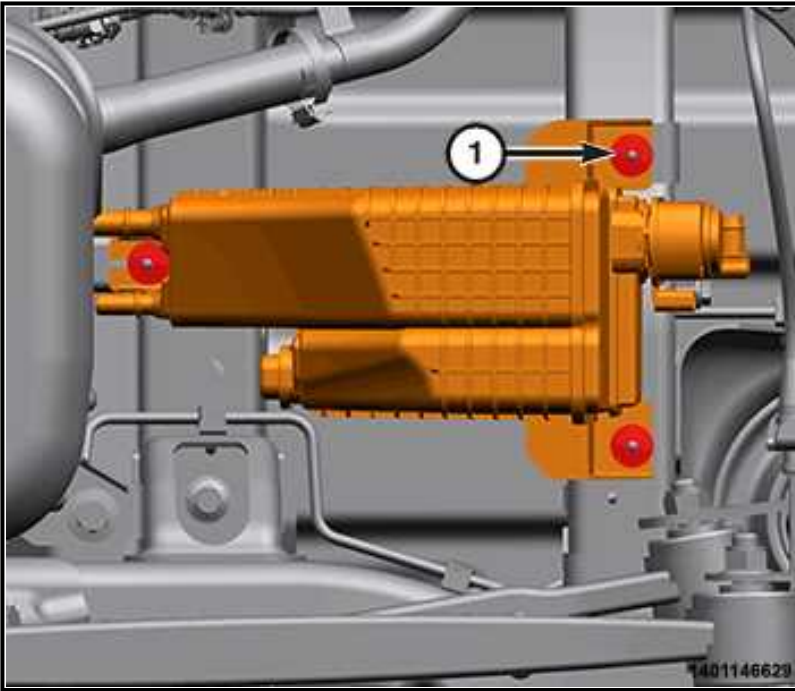
1. Disconnect and isolate the negative battery cable(s). Refer to [CABLES, BATTERY](#).
2. Raise and support the vehicle. Refer to [HOISTING, STANDARD PROCEDURE](#).



- | |
|---------------------------------|
| 1 - Vapor Line Quick Connectors |
| 2 - Fresh Air Hose |
| 3 - ESIM Wire Harness Connector |

3. Disconnect the vapor line quick-connectors from the canister.

4. Disconnect the hose from the Evaporative System Integrity Monitor (ESIM).
5. Disconnect the wire harness connector from the ESIM.



1 - Vapor Canister Nuts

6. Remove the mounting nuts and remove canister from vehicle.
7. If required remove the ESIM from the EVAP canister. Refer to [SWITCH, EVAPORATIVE EMISSIONS SYSTEM MONITOR, REMOVAL AND INSTALLATION.](#)

INSTALLATION

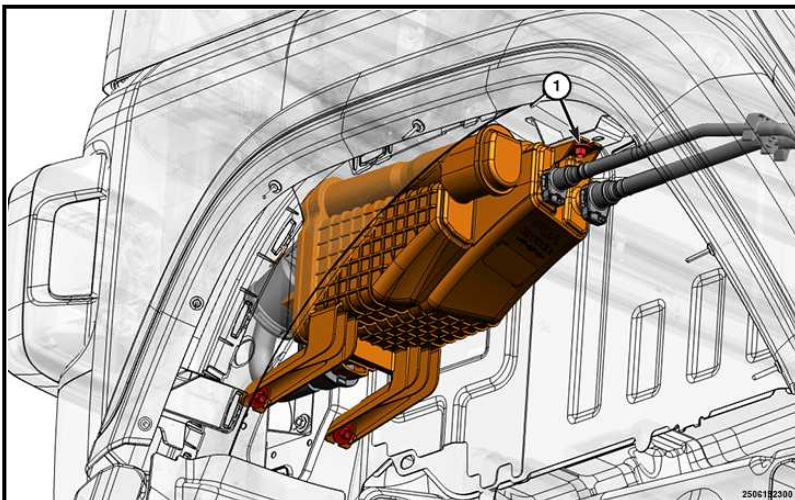
During installation, torque the fasteners to the specifications in the torque table(s) below.

Follow the removal procedure in reverse for general reassembly of the components on the vehicle. The steps listed below are calling out specific procedures that should be followed during installation.

- If removed, install the ESIM to the EVAP canister Refer to [SWITCH, EVAPORATIVE EMISSIONS SYSTEM MONITOR, REMOVAL AND INSTALLATION.](#)

TORQUE SPECIFICATIONS

EVAP EMISSIONS



DESCRIPTION	SPECIFICATIONS	COMMENT
Vapor Canister to Vehicle Nuts	5 N.m (44 In. Lbs.)	-

FILTER, VAPOR CANISTER

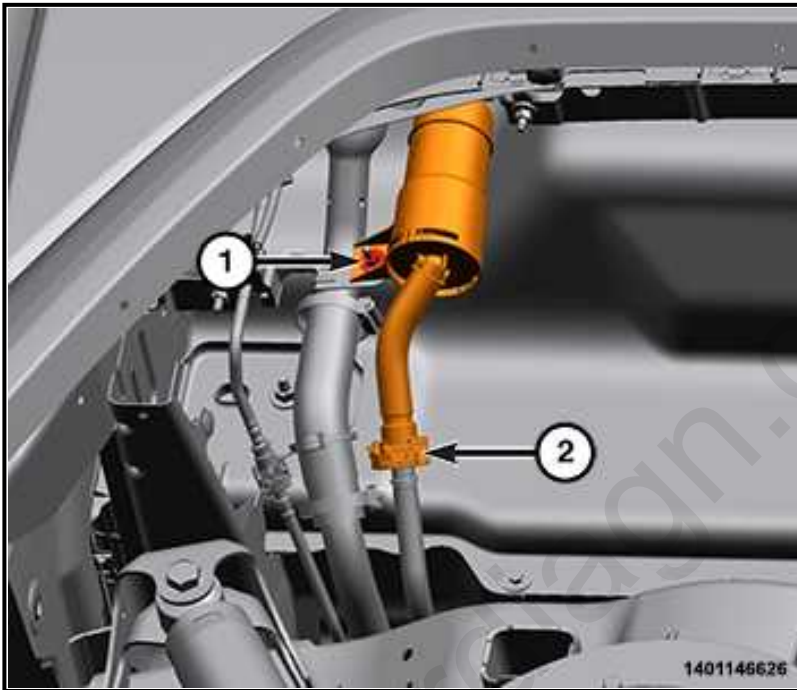
REMOVAL AND INSTALLATION

VAPOR CANISTER FILTER

REMOVAL

The fresh air filter is located on the side of the vapor canister.

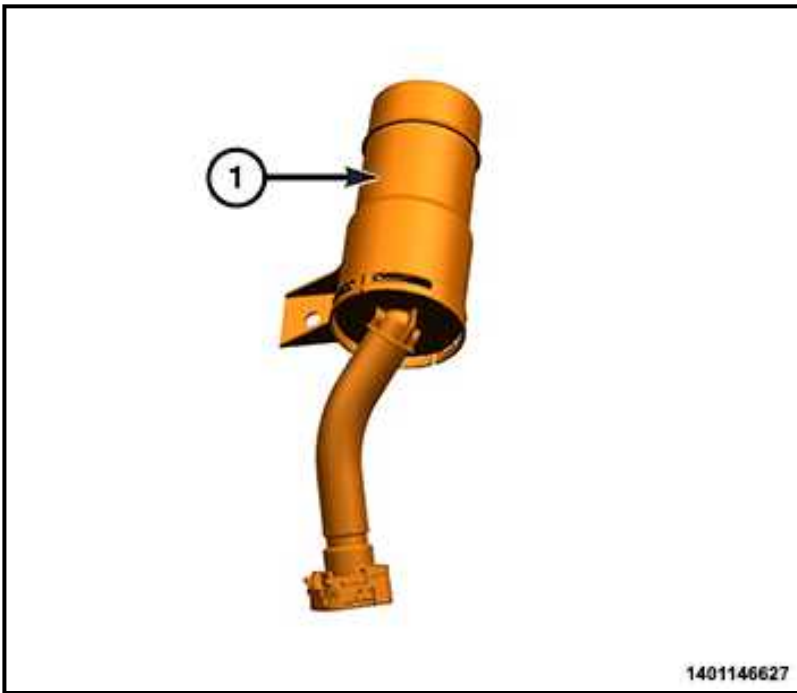
1. Remove the left rear wheel splash shield. Refer to [SHIELD, SPLASH, REAR WHEELHOUSE, REMOVAL AND INSTALLATION](#) .



1 - Fresh Air Filter Nut

2 - Fresh Air Filter Hose Quick Connector

2. Remove the nut securing the fresh air filter to the fuel filler tube.
3. Disconnect the quick connector.



1 - Fresh Air Filter Nut

4. Remove the fresh air filter with hose from the vehicle.

INSTALLATION

Follow the removal procedure in reverse for general reassembly of the components on the vehicle. The steps listed below are calling out specific procedures that should be followed during installation.

- Tighten the fresh air filter securely.

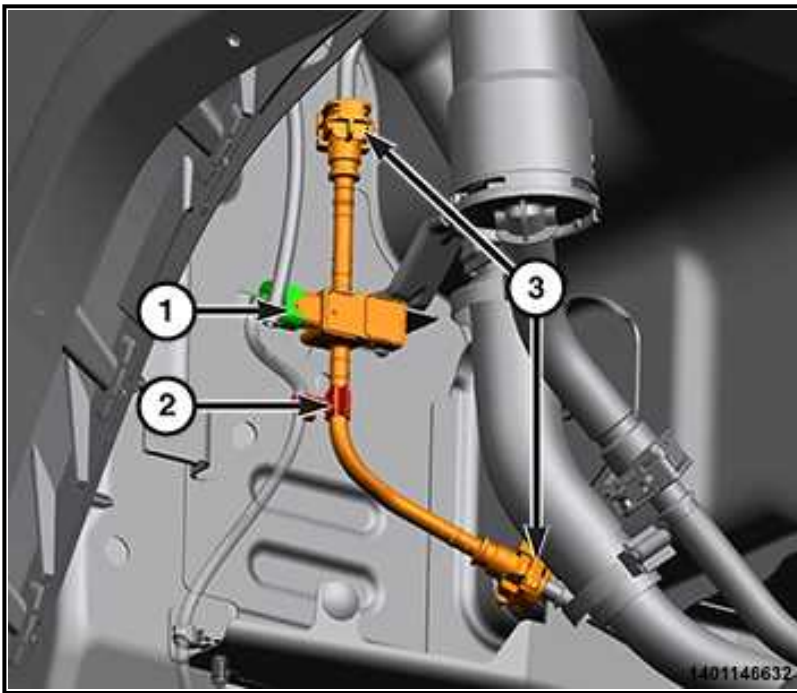
SENSOR, FUEL TANK PRESSURE

REMOVAL AND INSTALLATION

FUEL TANK PRESSURE SENSOR

REMOVAL

1. Remove the left rear wheelhouse splash shield. Refer to [SHIELD, SPLASH, REAR WHEELHOUSE, REMOVAL AND INSTALLATION](#).



1 - FTP Sensor Wire Harness Connector
2 - Wire Harness Retainer
3 - FTP Sensor Vapor Line to Vapor Tube Quick Connectors

2. Disconnect the Fuel Tank Pressure Sensor wire harness connector.
3. Release the wire harness retaining clip from sensor line.
4. Disconnect the Fuel Tank Pressure Sensor line quick connect fittings and remove the fuel tank pressure sensor assembly.

INSTALLATION

Follow the removal procedure in reverse for general reassembly of the components on the vehicle.

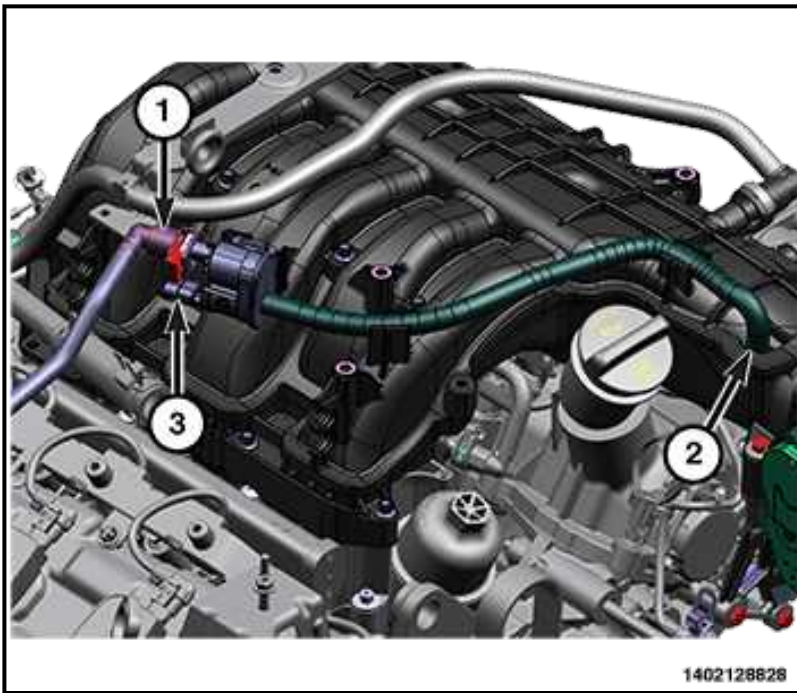
SOLENOID, EVAPORATIVE EMISSIONS PURGE

REMOVAL AND INSTALLATION

PURGE SOLENOID

REMOVAL

1. Disconnect and isolate the negative battery cable(s). Refer to [CABLES, BATTERY](#) .
2. Remove the engine cover. Refer to [COVER, ENGINE, REMOVAL AND INSTALLATION](#) .



1 - Purge Vapor Line
2 - Purge Hose
3 - Wire Harness Connector

3. Remove the purge vapor line quick connect from the purge solenoid.
4. Remove the purge hose from the intake manifold.
5. Disconnect the Purge Solenoid wire harness connector.
6. Remove the Evaporator Purge Solenoid from the bracket.

INSTALLATION

Follow the removal procedure in reverse for general reassembly of the components on the vehicle.

SWITCH, EVAPORATIVE EMISSIONS SYSTEM MONITOR

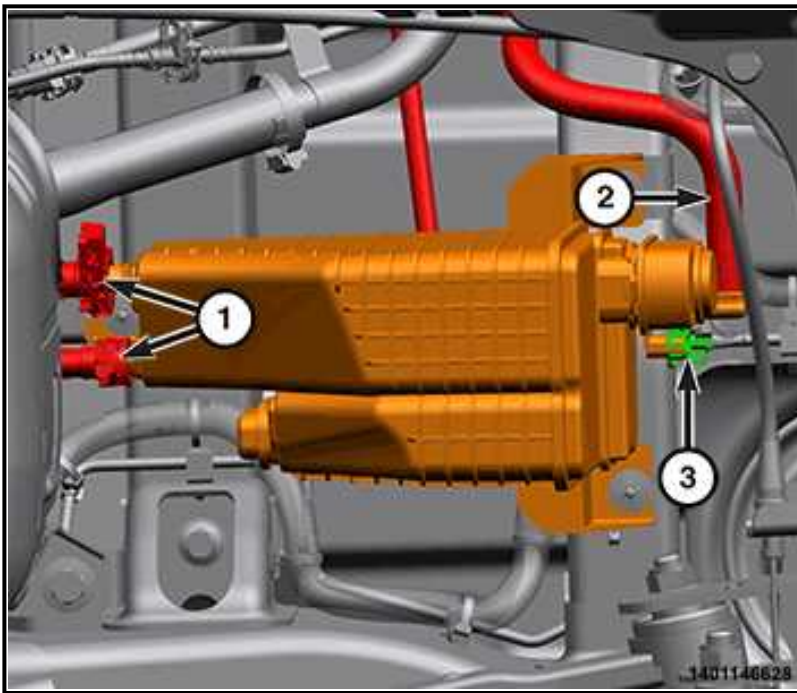
REMOVAL AND INSTALLATION

REMOVAL AND INSTALLATION

REMOVAL

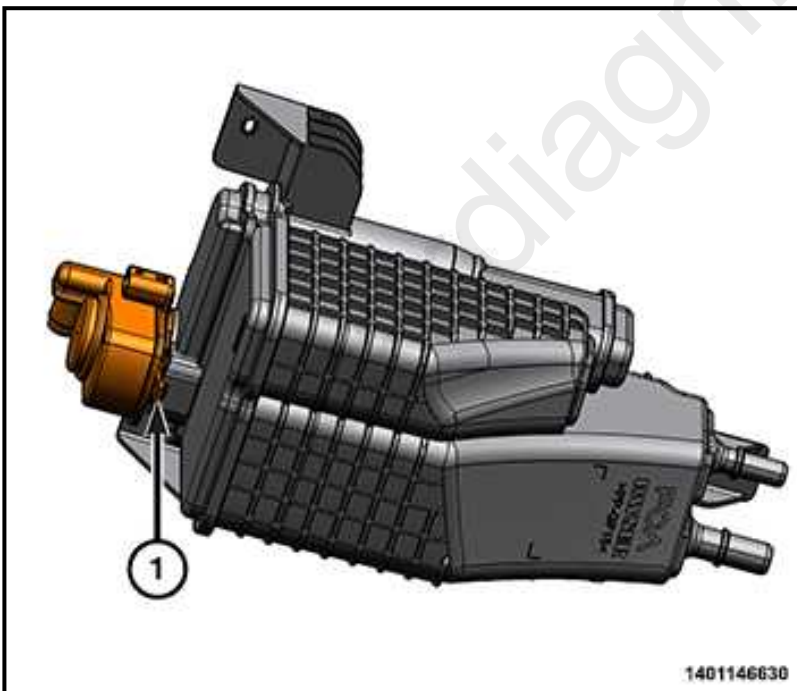
The Evaporative System Integrity Monitor (ESIM) switch is located on the vapor canister.

1. Raise and support the vehicle. Refer to [HOISTING, STANDARD PROCEDURE](#) .



1 - Vapor Line to Canister Quick Connectors
2 - Fresh Air Filter Hose
3 - ESIM Wire Harness Connector

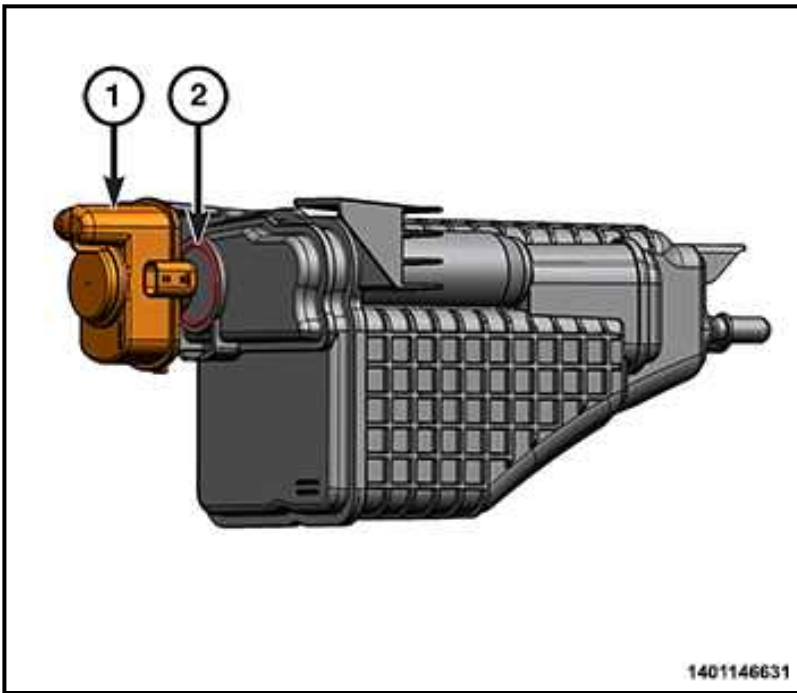
2. Disconnect the hose from the Evaporative System Integrity Monitor (ESIM).
3. Disconnect the wire harness connector from the ESIM.



1 - ESIM Lock Tab

NOTE: Clean the area around the Evaporative System Integrity Monitor (ESIM) switch prior to removal.

4. Push lock tab towards the ESIM and rotate the ESIM 45B° to unlock the ESIM from the carbon canister.



1 - ESIM
2 - Seal

5. Remove the ESIM and seal.

INSTALLATION

During installation, torque the fasteners to the specifications in the torque table(s) below.

Follow the removal procedure in reverse for general reassembly of the components on the vehicle. The steps listed below are calling out specific procedures that should be followed during installation.

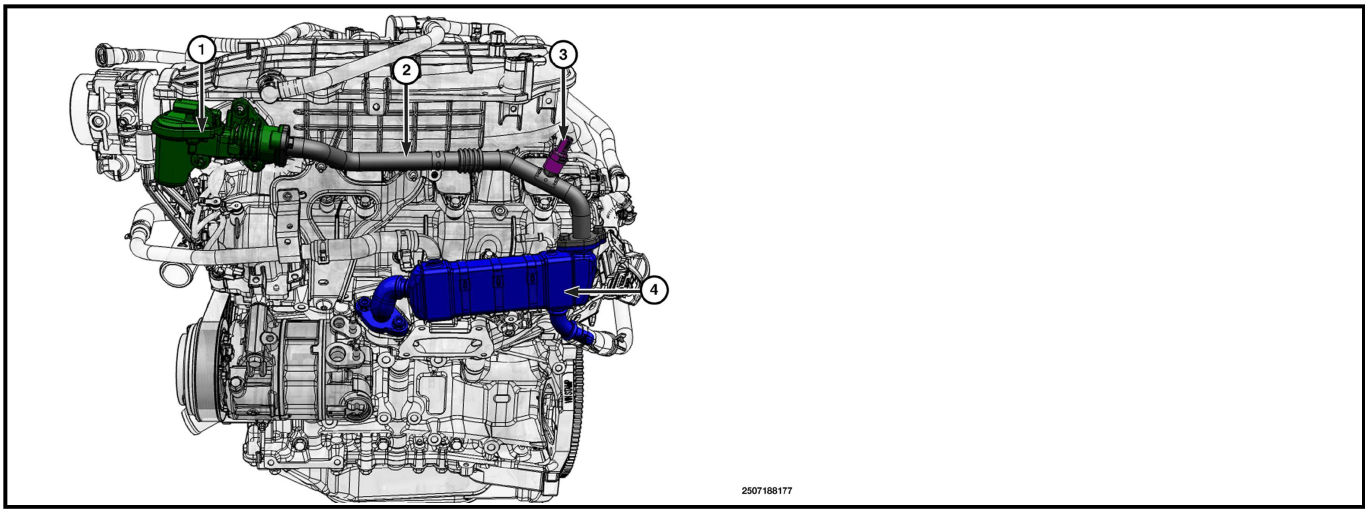
- Install a clean seal into the groove of the vapor canister. The ESIM seal can be lubricated with talcum powder to prevent the seal from binding and turning during installation of the ESIM causing a leak in the system.
- Verify the ESIM is fully engaged and locked. The connector on the ESIM must be at the 3 O'clock position for the vent weights to operated properly in the ESIM.
- Use the scan tool to run the Small Leak Test to very system function.

EXHAUST GAS RECIRCULATION

DESCRIPTION AND OPERATION

DESCRIPTION AND OPERATION

DESCRIPTION



The Exhaust Gas Recirculation (EGR) system includes the following components (location picture is 3.6L typical):

COMPONENT INDEX

1.	Refer to EGR VALVE .
2.	Refer to EGR PIPE .
3.	Refer to EGR TEMPERATURE SENSOR .
4.	Refer to EGR COOLER .

The Exhaust Gas Recirculation (EGR) System recirculates exhaust gases back into the Intake Manifold to be mixed with the incoming fuel/air mixture. This helps reduce combustion chamber temperatures improving emissions and fuel economy. The hot exhaust gases are cooled by the EGR Cooler before reaching the EGR Valve. The Exhaust Gas Recirculation (EGR) Temperature Sensor is positioned between the EGR Cooler and EGR Valve. The feedback signal from the sensor is used to monitor the cooling efficiency of the recirculated exhaust gases passing through the EGR Cooler Assembly. The EGR System does not operate at idle. It typically operates during steady state speeds. A Stuck or leaking EGR Valve can cause engine stumble, sags, hesitation, rough idle, engine stalling and drivability concerns.

EGR VALVE

Refer to [COMPONENT INDEX](#).

OPERATION:

The cooled Exhaust Gas Recirculation (EGR) Valve Assembly contains an electric Direct Current (DC) Motor and a gear box. An eccentric drive translates the gearbox output from a rotating motion (DC Motor) to a linear stroke (output shaft). The full range of travel of the shaft is approximately 5.0 mm from a fully closed to fully open position. An internal return spring ensures that the valve returns back to its closed position as a fail safe. The EGR Valve is controlled by the Powertrain Control Module (PCM) using an internal **H-Bridge driver**. The H-Bridge operates the EGR Valve using a Pulse Width Modulation (PWM) control to help reduce current draw. This helps protect the DC Motor from overheating and reduces electrical load on the system voltage.

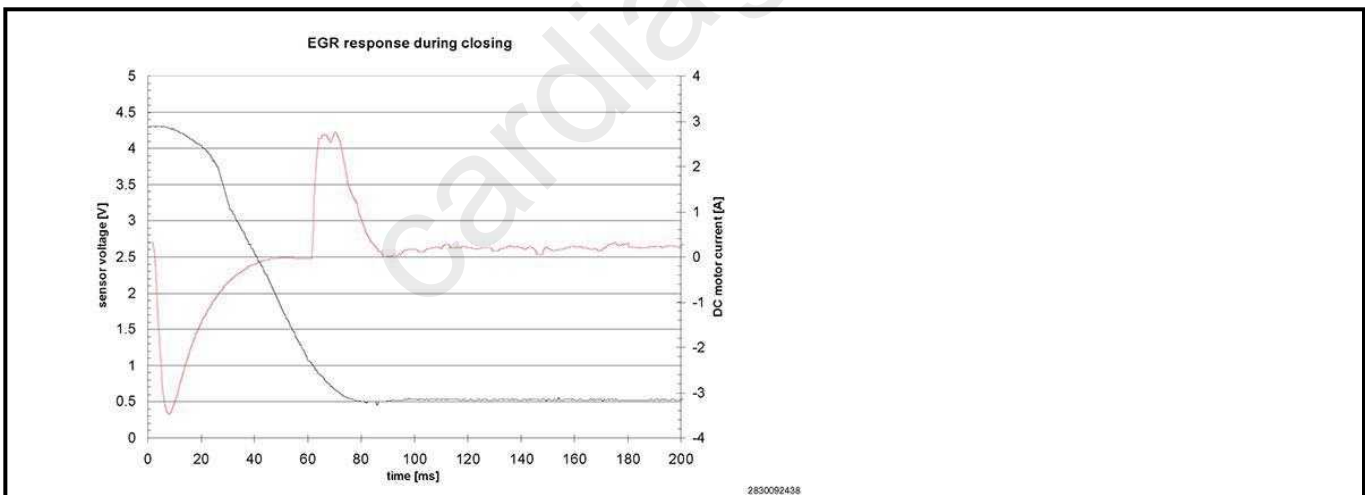
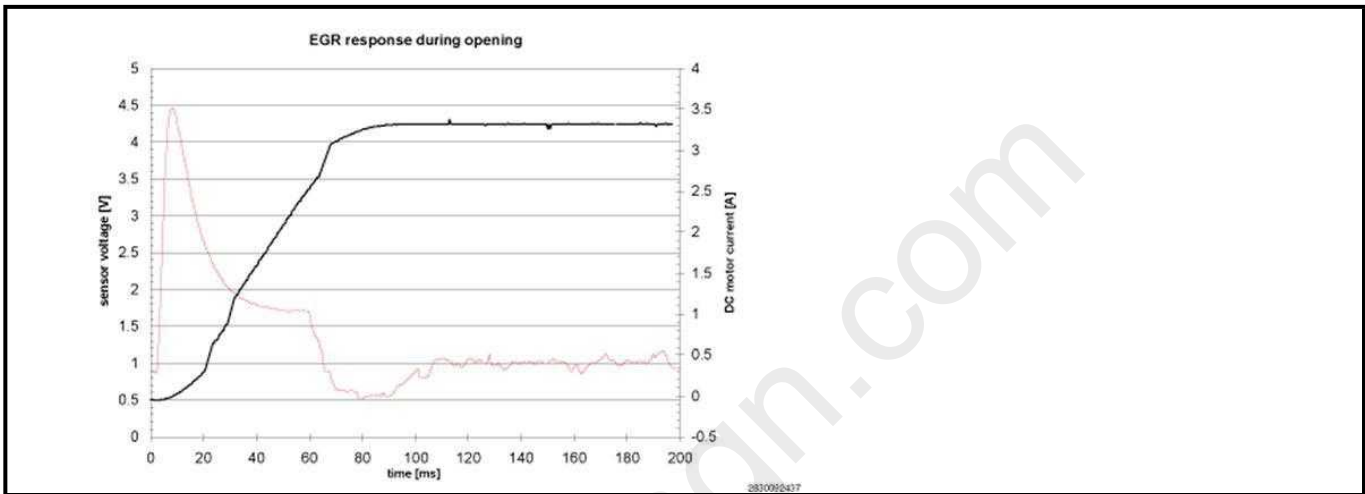
The EGR Valve is operated and monitored in the following manner:

- During the initial opening of the EGR Valve the PCM drives the PWM duty cycle high resulting in a higher current draw. After the valve is fully opened the PCM duty cycle is reduced to maintain the EGR Valve position. This reduces the current draw and protects from overheating the EGR Valve DC Motor.
- The PCM monitors the temperature and current draw of the DC Motor inside the EGR Valve and will adjust the duty cycle to prevent the EGR Valve windings from overheating. Typically the peak current draw, by the EGR Valve, occurs during opening the valve and the maximum current load for a typical application is approximately 6.0 amps. The duty cycle is adjusted after opening the valve so that the typical average current draw is approximately 0.5 amps while holding the valve open.

- The PCM also applies a current in the closing direction to fulfill the required dynamic performance. This is done to control the closing speed of the shaft near the stop. This ensures that the valve does not close too fast causing the valve disk to be forced into the stop harshly which may damage the internal gearbox.
- When the EGR Valve is in the closed position the PCM will press the poppet into the seat with a -10% duty cycle to clean soot from the disc and seat.

There is a position sensor located on the output shaft. The sensor operates as a typical three wire sensor, with a 5-Volt Supply, Sensor Signal, and Sensor Ground circuit. Full range of travel of the output shaft will result in a change of approximately 3.9 volts in the position sensor reading. During normal operation the sensor signal will range between approximately 0.5 volts and 4.3 volts.

NOTE: See the figures below for a typical current draw on the DC Motor and voltage reading of the sensor during the EGR Valve opening and closing. The red line represents current draw of the DC Motor and the black line represents the position sensor voltage.



EGR PIPE

Refer to [COMPONENT INDEX](#).

The EGR pipe transfers the cooled exhaust gases from the EGR Cooler back to the Intake Manifold.

EGR TEMPERATURE SENSOR

Refer to [COMPONENT INDEX](#).

The EGR Temperature Sensor is positioned between the EGR Cooler and EGR Valve. The feedback signal from the sensor is used to monitor the cooling efficiency of the recirculated exhaust gases passing through the EGR Cooler assembly. At lower temperatures the signal feedback voltage will read closer to the upper

operating parameter. As the recirculated exhaust gas temperature increases, the signal feedback voltage will decrease toward the lower operating parameter.

EGR COOLER

Refer to **COMPONENT INDEX**.

The EGR Cooler is located on the left side of the engine. The EGR Cooler uses engine coolant to reduce the temperature of the exhaust gas that is recirculated to the Intake Manifold, which in turn helps reduce NOx emissions.

DIAGNOSIS AND TESTING

EXHAUST GAS RECIRCULATION (EGR) SYSTEM

The Powertrain Control Module (PCM) monitors the Exhaust Gas Recirculation (EGR) valve and system for several failure modes.

EGR Valve (DC Motor)

The PCM performs electrical diagnostics on the EGR valve and circuits. If the PCM detects that the current draw or Pulse Width Modulation (PWM) to the EGR valve is too high or low for a calibrated period, the PCM determines that the EGR valve motor or circuitry is faulted and not operating properly.

- The PCM can detect a circuit high or circuit low fault during operation of the component, whereas open circuit detection can only occur when the component is not being commanded ON. If an open occurs in the component or circuits during the operation, the PCM will normally detect the failure during the performance diagnostic for the system that the component is being used to control.
- The EGR valve control circuits can be driven high or low depending on whether the EGR valve is being opened or closed.
- The PCM monitors the EGR control circuits for excessive current draw in both directions. The following are the possible failure modes of the EGR control circuits:
 - A short to ground fault in the EGR valve (+) control circuit will set the P1E27 or P01E28 DTC, depending on which direction the EGR valve is being driven when the fault occurs.
 - A short to ground fault in the EGR valve (-) control circuit will set the P0489 or P0490 DTC, depending on which direction the EGR valve is being driven when the fault occurs.
 - An open circuit or short to voltage fault in either EGR valve control circuit will set the P0403 DTC.

EGR Position Sensor

The PCM performs the circuit low and high fault diagnostics on the EGR position sensor signal. The sensor is determined to be irrational if the difference between the actual valve position and commanded valve position is more than a calibrated threshold when the EGR valve is commanded open.

- The PCM learns the EGR valve open and closed positions once per drive cycle. In the case of an EGR valve replacement, the "**EGR VALVE REPLACED**" routine should be performed using the diagnostic scan tool.
- The PCM monitors the EGR position sensor during the operation to determine if the EGR valve is in the correct commanded position. The EGR valve is monitored for over-shoot conditions and offset from the learned open and closed positions.

EGR Temperature Sensor

The PCM performs the circuit low and high fault diagnostics on the EGR temperature sensor signal. The sensor is checked for rationality after a cold soak. At the next key ON after a cold soak, the EGR temperature sensor signal is compared to the Engine Coolant Temperature (ECT) sensor signal and Ambient Air Temperature (AAT) sensor signal. If the difference between the EGR temperature sensor signal and the other signals is more

than a calibrated threshold, the EGR temperature sensor rationality diagnostic fails. If there are no EGR temperature sensor faults present, the PCM uses the feedback from the sensor to monitor the efficiency of the EGR cooler during operation.

TECHNICAL SPECIFICATIONS

TORQUE SPECIFICATIONS

EGR SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
EGR Blocker Plug to Cylinder Head	50 N. m (37 Ft. Lbs.)	-
EGR Cooler to Cylinder Head Mounting	23 N. m (17 Ft. Lbs.)	-
EGR Tube to EGR Cooler	10 N. m (7 Ft. Lbs.)	-
EGR Tube to EGR Valve	10 N. m (7 Ft. Lbs.)	-
EGR Valve Nuts	10 N. m (7 Ft. Lbs.)	-

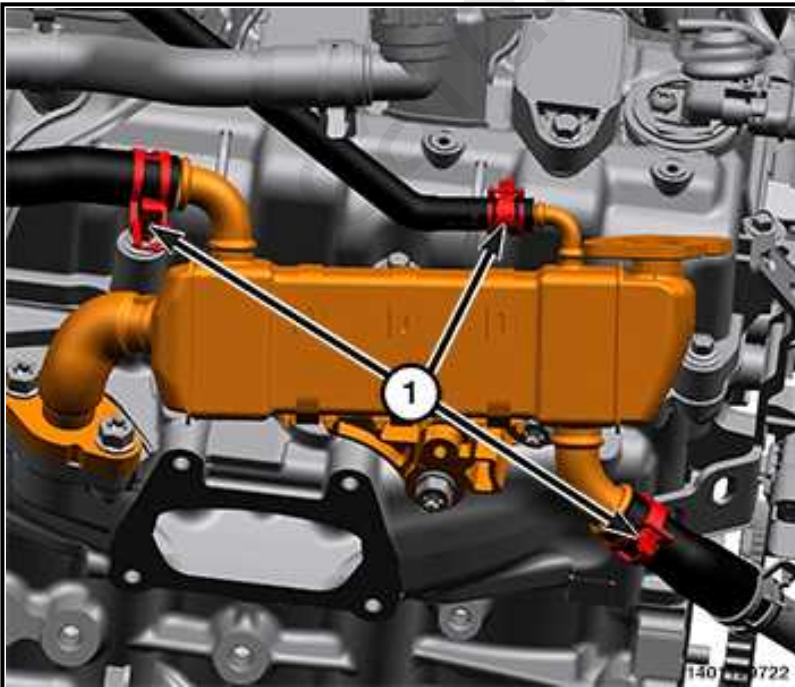
COOLER, EXHAUST GAS RECIRCULATION (EGR)

REMOVAL AND INSTALLATION

REMOVAL AND INSTALLATION

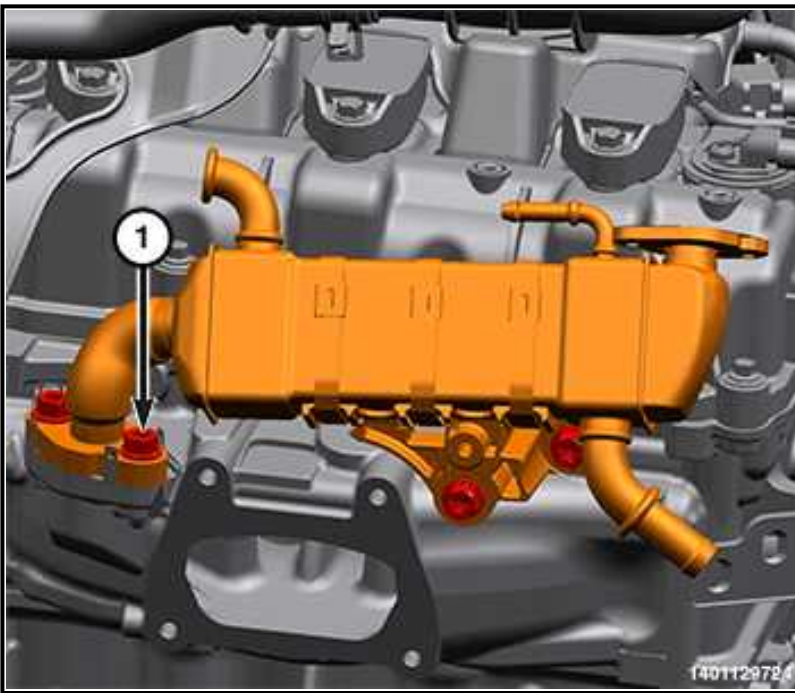
REMOVAL

1. Disconnect and isolate the negative battery cable(s). Refer to [CABLES, BATTERY](#) .
2. Remove the engine cover. Refer to [COVER, ENGINE, REMOVAL AND INSTALLATION](#) .
3. Drain the cooling system. Refer to [DRAINING](#) .
4. Remove the Exhaust Gas Recirculation (EGR) tube. Refer to [TUBE, EXHAUST GAS RECIRCULATION \(EGR\), CROSSOVER, REMOVAL AND INSTALLATION](#) .



1 - EGR Cooler Coolant Hoses

5. Remove the coolant hoses from the of the EGR cooler.



1 - EGR Cooler Bolts

6. Remove the bolts securing the EGR cooler.
7. Remove and discard the gasket.

INSTALLATION

During installation, torque the fasteners to the specifications in the torque table(s) below.

Follow the removal procedure in reverse for general reassembly of the components on the vehicle. The steps listed below are calling out specific procedures that should be followed during installation.

- Clean the gasket mating surfaces.
- Using a **NEW** gasket, install the EGR cooler and hand tighten the inlet tube bolts.
- Install the lower bolts securing the EGR cooler and torque all bolts.
- Connect the lower coolant hose to the pressurized coolant bottle first and then install the pressurized coolant bottle.
- Fill the cooling system. Refer to [STANDARD PROCEDURE - FILLING](#) .

TORQUE SPECIFICATIONS

EGR SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
EGR Blocker Plug to Cylinder Head	50 N. m (37 Ft. Lbs.)	-
EGR Cooler to Cylinder Head Mounting	23 N. m (17 Ft. Lbs.)	-
EGR Tube to EGR Cooler	10 N. m (7 Ft. Lbs.)	-
EGR Tube to EGR Valve	10 N. m (7 Ft. Lbs.)	-
EGR Valve Nuts	10 N. m (7 Ft. Lbs.)	-

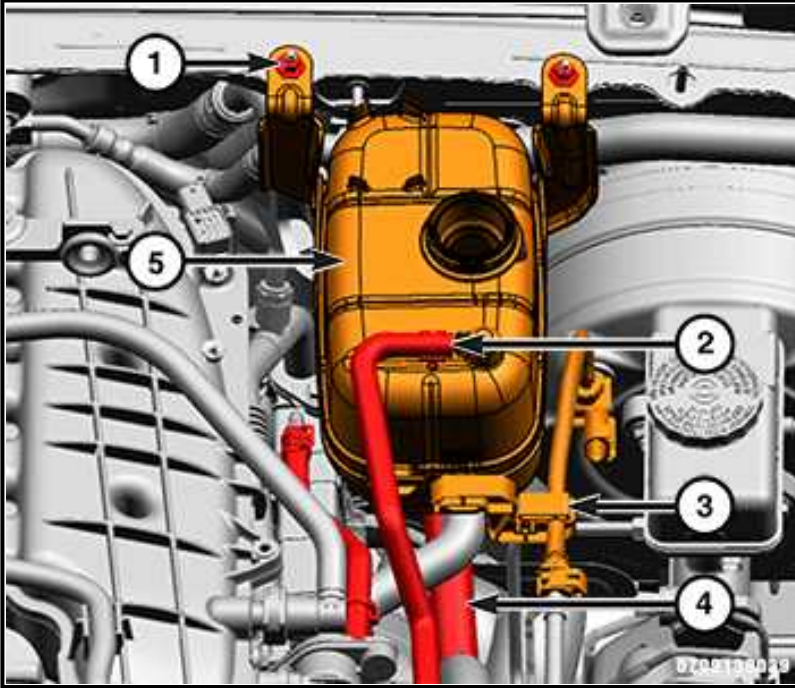
SENSOR, EGR TEMPERATURE

REMOVAL AND INSTALLATION

EGR TEMPERATURE SENSOR

REMOVAL

1. Disconnect and isolate the negative battery cable(s). Refer to [CABLES, BATTERY](#) .

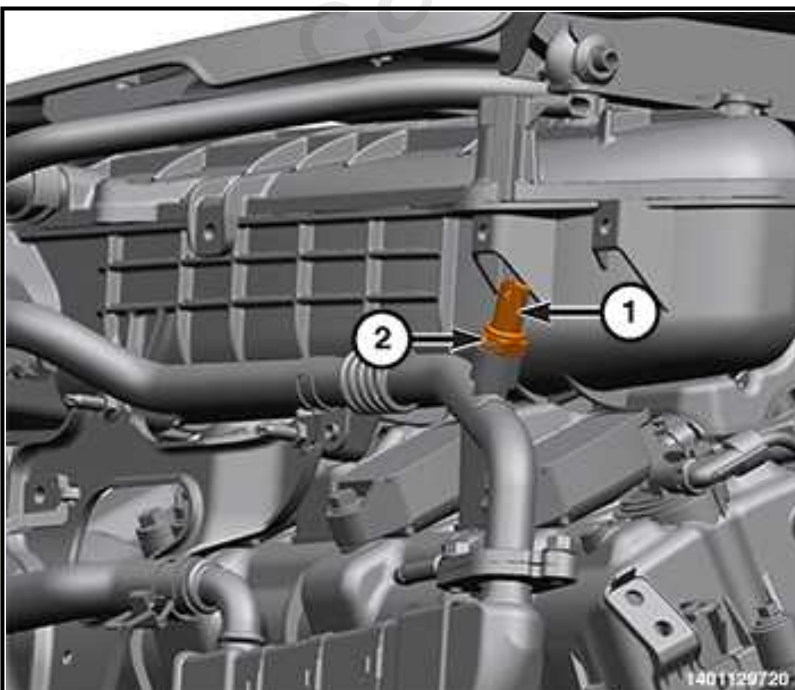


1 - Coolant Bottle Nuts
2 - Coolant Vent Hose
3 - Vacuum Hose Retainer
4 - Coolant Hose
5 - Pressurized Coolant Bottle

2. Remove the vacuum hose retainer from the pressurized coolant bottle.

NOTE: It is not necessary to drain the cooling system.

3. Remove the nuts and position aside the pressurized coolant bottle.



1 - Wire Harness Connector

2 - EGR Temperature Sensor

4. Disconnect the Exhaust Gas Recirculation (EGR) temperature sensor wire harness connector.
5. Remove the EGR temperature sensor from EGR tube.

INSTALLATION

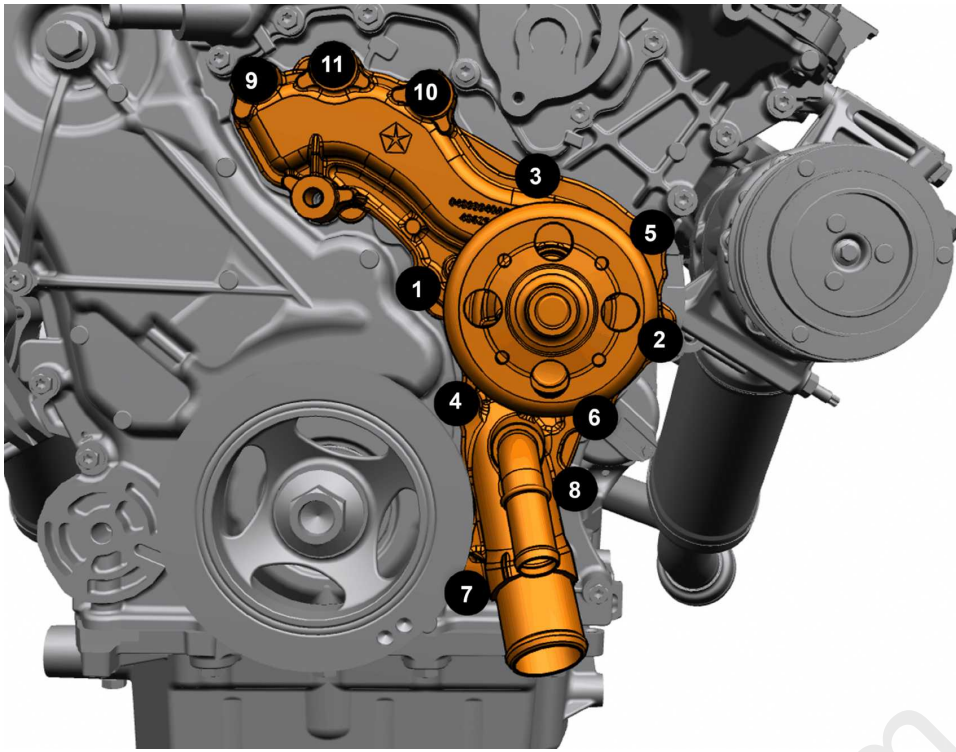
Follow the removal procedure in reverse for general reassembly of the components on the vehicle.

During installation, torque the fasteners to the specifications in the torque table(s) below.

TORQUE SPECIFICATIONS

COOLING SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
Block Heater Bolt	12 N.m (9 Ft. Lbs.)	-
Coolant Crossover Bolts	12 N.m (9 Ft. Lbs.)	-
Coolant Tube Bolt	9 N.m (80 In. Lbs.)	-
Cooling Fan Bolts	8 N.m (71 In. Lbs.)	-
Pressurized Coolant Bottle Bolt	5 N.m (44 In. Lbs.)	-
Pressurized Coolant Bottle Nuts	10 N.m (89 In. Lbs.)	-
Radiator Brace Bolts	10 N.m (89 In. Lbs.)	-
Radiator to Body Bolts	11 N.m (8 Ft. Lbs.)	-
Heater Hose Assembly Bracket Nuts	8 N.m (71 In. Lbs.)	-
Heater Hose Assembly Support Bracket Bolts	8 N.m (71 In. Lbs.)	-
Thermostat Housing Bolts	10 N.m (89 In. Lbs.)	-
Water Pump Bolts	<p>Torque Procedure:</p> <p>NOTE: Bolts (1 - 8) are M6; Bolts (9, 10, 11) are M8; Bolt (12) is M10.</p> <ol style="list-style-type: none">1. Hand tighten all bolts2. Step 1 - Tighten the M6 Bolts to 11 N.m (8 Ft. Lbs.)3. Step 2 - Tighten the M8 Bolts to 23 N.m (17 Ft. Lbs.)4. Step 3 - Tighten the M10 Bolts to 55 N.m (41 Ft. Lbs.)5. Repeat the tightening sequence for all bolts	Tightening Sequence



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Fig. 1: Water Pump Bolts Tightening Sequence

Courtesy of CHRYSLER GROUP, LLC

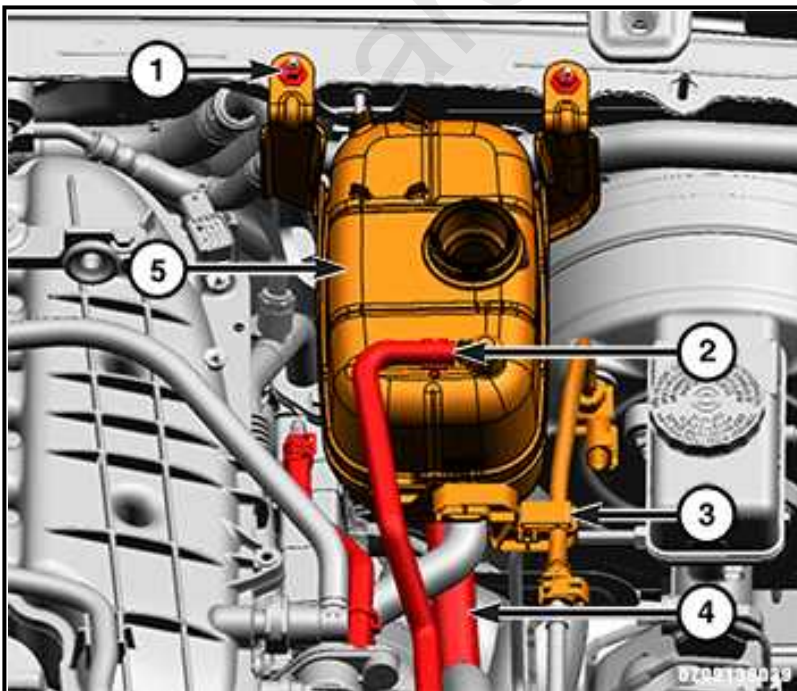
TUBE, EXHAUST GAS RECIRCULATION (EGR), CROSSOVER

REMOVAL AND INSTALLATION

EGR TUBE

REMOVAL

1. Disconnect and isolate the negative battery cable(s). Refer to [CABLES, BATTERY](#) .
2. Remove the engine cover. Refer to [COVER, ENGINE, REMOVAL AND INSTALLATION](#) .



1 - Coolant Bottle Nuts
2 - Coolant Vent Hose

3 - Vacuum Hose Retainer

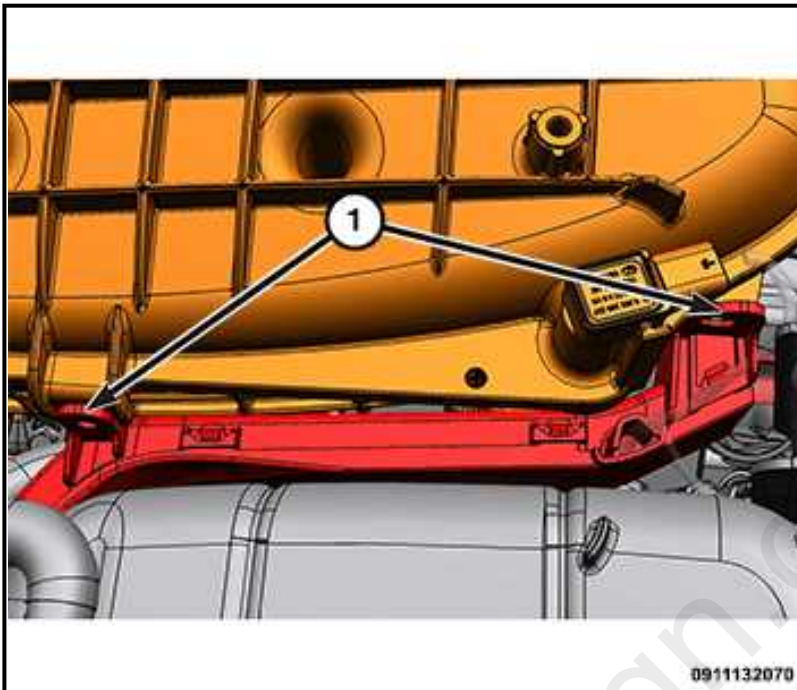
4 - Coolant Hose

5 - Pressurized Coolant Bottle

3. Remove the vacuum hose retainer from the pressurized coolant bottle.

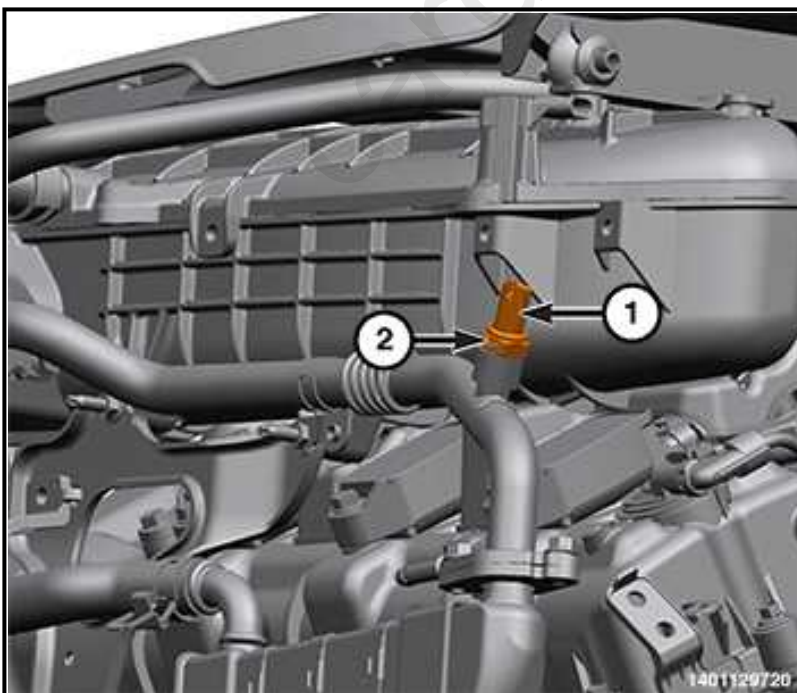
NOTE: It is not necessary to drain the cooling system.

4. Remove the nuts and position aside the pressurized coolant bottle.



1 - Engine Wire Harness Push Pins

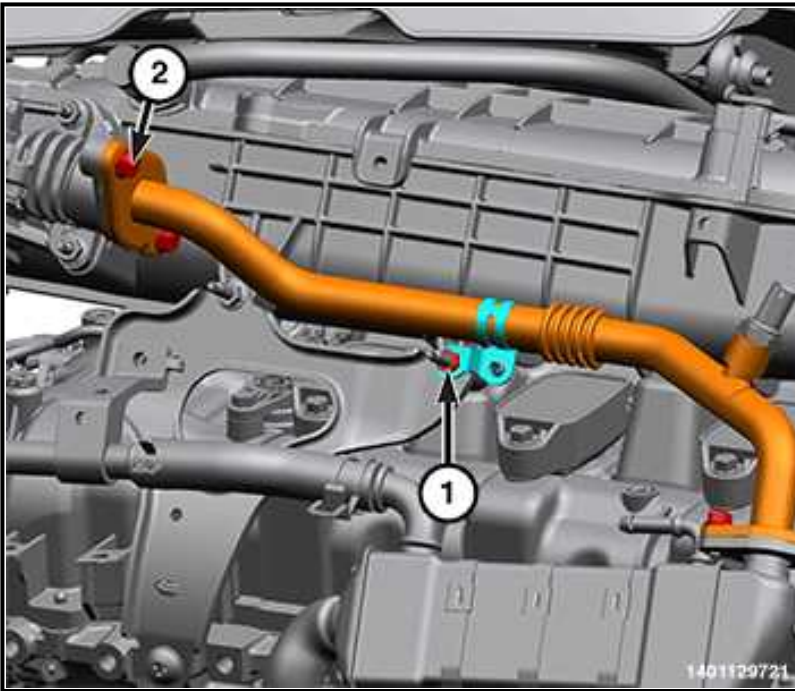
5. Remove the push pins and position aside the engine wire harness.



1 - Wire Harness Connector

2 - EGR Temperature Sensor

6. Disconnect the Exhaust Gas Recirculation (EGR) temperature sensor wire harness connector (1).



1 - EGR Tube Support Bracket Nut
2 - EGR Tube Bolts

7. Remove the nut for the EGR tube support bracket.

8. Remove the EGR valve to Exhaust Gas Recirculation (EGR) tube.

INSTALLATION

During installation, torque the fasteners to the specifications in the torque table(s) below.

Follow the removal procedure in reverse for general reassembly of the components on the vehicle. The steps listed below are calling out specific procedures that should be followed during installation.

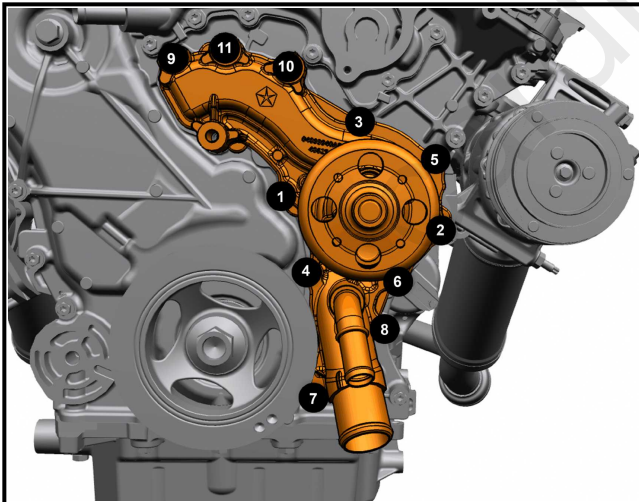
- Clean the gasket mating surfaces.
- Using a **NEW** gasket, install the EGR cooler and hand tighten the inlet tube bolts.
- Install the lower bolts securing the EGR cooler and torque all bolts.
- Connect the lower coolant hose to the pressurized coolant bottle first and then install the pressurized coolant bottle.

TORQUE SPECIFICATIONS

COOLING SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
Block Heater Bolt	12 N.m (9 Ft. Lbs.)	-
Coolant Crossover Bolts	12 N.m (9 Ft. Lbs.)	-
Coolant Tube Bolt	9 N.m (80 In. Lbs.)	-
Cooling Fan Bolts	8 N.m (71 In. Lbs.)	-
Pressurized Coolant Bottle Bolt	5 N.m (44 In. Lbs.)	-
Pressurized Coolant Bottle Nuts	10 N.m (89 In. Lbs.)	-
Radiator Brace Bolts	10 N.m (89 In. Lbs.)	-
Radiator to Body Bolts	11 N.m (8 Ft. Lbs.)	-

DESCRIPTION	SPECIFICATION	COMMENTS
Heater Hose Assembly Bracket Nuts	8 N.m (71 In. Lbs.)	-
Heater Hose Assembly Support Bracket Bolts	8 N.m (71 In. Lbs.)	-
Thermostat Housing Bolts	10 N.m (89 In. Lbs.)	-
Water Pump Bolts	<p>Torque Procedure:</p> <p>NOTE: Bolts (1 - 8) are M6; Bolts (9, 10, 11) are M8; Bolt (12) is M10.</p> <ol style="list-style-type: none"> 1. Hand tighten all bolts 2. Step 1 - Tighten the M6 Bolts to 11 N.m (8 Ft. Lbs.) 3. Step 2 - Tighten the M8 Bolts to 23 N.m (17 Ft. Lbs.) 4. Step 3 - Tighten the M10 Bolts to 55 N.m (41 Ft. Lbs.) 5. Repeat the tightening sequence for all bolts 	Tightening Sequence



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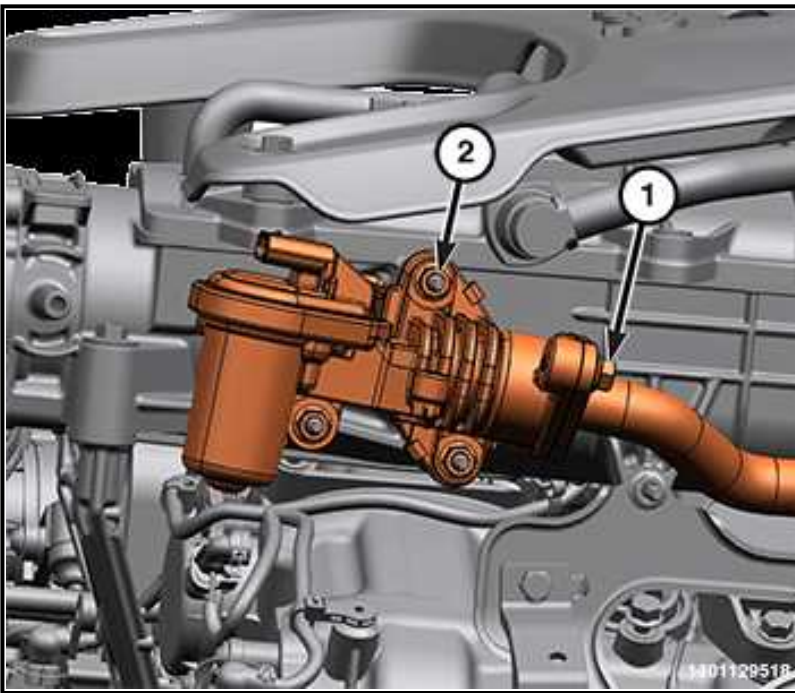
VALVE, EXHAUST GAS RECIRCULATION (EGR)

REMOVAL AND INSTALLATION

EGR VALVE

REMOVAL

1. Disconnect and isolate the negative battery cable(s). Refer to [CABLES, BATTERY](#) .
2. Disconnect the Exhaust Gas Recirculation (EGR) Valve wire harness connector.



1 - EGR Tube Bolts

2 - EGR Valve Bolts

3. Remove the bolts securing the EGR tube to EGR valve.
4. Remove the three nuts and the EGR valve.

INSTALLATION

During installation, torque the fasteners to the specifications in the torque table(s) below.

Follow the removal procedure in reverse for general reassembly of the components on the vehicle. The steps listed below are calling out specific procedures that should be followed during installation.

- Use a **NEW** gasket for the EGR valve.
- Perform EGR valve re-learn procedure if replacing with new valve.

TORQUE SPECIFICATIONS

EGR SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
EGR Blocker Plug to Cylinder Head	50 N. m (37 Ft. Lbs.)	-
EGR Cooler to Cylinder Head Mounting	23 N. m (17 Ft. Lbs.)	-
EGR Tube to EGR Cooler	10 N. m (7 Ft. Lbs.)	-
EGR Tube to EGR Valve	10 N. m (7 Ft. Lbs.)	-
EGR Valve Nuts	10 N. m (7 Ft. Lbs.)	-

PERMANENT FAULT CODES

DIAGNOSIS AND TESTING

PERMANENT FAULT CODES

Permanent Fault Codes (PFCs)

PFCs are very similar to a regular Diagnostic Trouble Code (DTC), except that they cannot be reset by disconnecting the vehicle battery or cleared using a diagnostic scan tool. PFCs are DTCs that are stored in the EEPROM memory of some Electronic Control Units (ECUs) starting in 2010. **Only DTCs that illuminate the Malfunction Indicator Lamp (MIL) will be stored as Permanent Fault Codes.**

NOTE: Starting July 1, 2019, the presence of Permanent Fault Codes will be considered in determining the vehicle's smog emission test result in states which require emission testing.

Vehicles that have a PFC stored in the OBD system will fail the smog emission test regardless of whether the MIL is illuminated because a stored PFC indicates the OBD system has not yet successfully verified that a previously detected emissions related malfunction no longer exists.

All PFCs must be cleared in order to pass state emission testing. The diagnostic scan tool can be used to check for PFCs in the **"GUIDED DIAGNOSTICS"** tab. The DTC number and ECU storing the DTC will be displayed for each PFC. Not all vehicles built after 2010 store Permanent Fault Codes in the ECUs, therefore if it is not applicable for the vehicle, then no PFC will be displayed in the **"GUIDED DIAGNOSTICS"** tab. If there are no PFCs stored in any ECU, then no additional action is required and PFCs will not be the reason for state emission testing failure. However, if there are PFCs stored, they must first be cleared to pass state emission testing.

There are only two ways that PFCs can be cleared:

1. **Three successful trips** (no recurring faults) with the diagnostic monitor running and passing will naturally clear the MIL and PFCs.
2. After the vehicle has been repaired and the DTC erased with a diagnostic scan tool or a battery disconnect, complete **one successful trip** with the diagnostic monitor running and passing.

NOTE: It is important to note that this does not need to be done during every normal repair action. Repairing an issue and erasing the DTCs with the diagnostic scan tool will turn off the MIL after performing normal repairs and erasing the DTCs with the diagnostic scan tool. It is only necessary to check for PFCs when a repair for a DTC is done to a vehicle and that vehicle needs to pass smog emission testing.

There is one other scenario where a vehicle can pass state emission testing with a PFC present. If the vehicle completes 15 or more warm-up cycles (as defined below) and has been driven 322 kilometers (200 miles) or more since the OBD information was last cleared, the emission test will pass because the time to complete 15 warm-up cycles and drive 322 kilometers (200 miles) is reasonable for vehicles to complete the self-diagnostic tests. When the DTC fault is repaired, the diagnostic monitors and PFC diagnostics should naturally run and clear long before these limits are reached.

- **One warm-up cycle is defined as:** The engine coolant temperature increases a minimum of 4.4B°C (40B°F), a change of 22.2B°C (71.9B°F), and reaches at least 71.1B°C (160B°F) during a drive cycle.
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