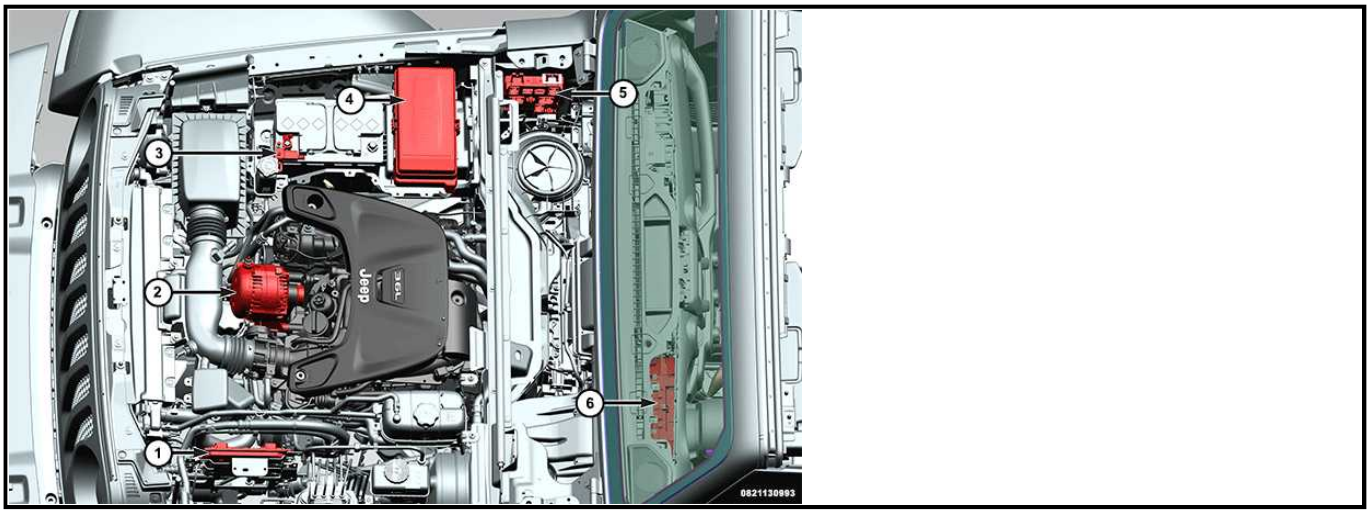
DESCRIPTION AND OPERATION

DESCRIPTION AND OPERATION

DESCRIPTION

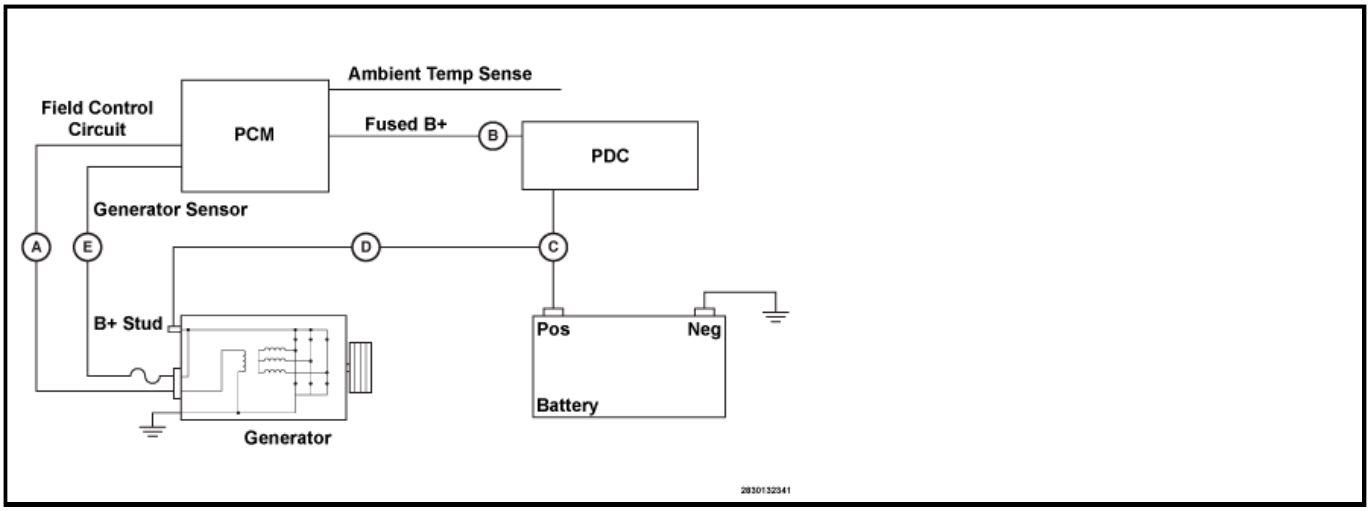


The charging system consists of the following components:

COMPONENT INDEX

1.	Refer to **POWERTRAIN CONTROL MODULE (PCM)** with an integrated Electronic Voltage Regulator (EVR).
2.	Refer to **GENERATOR**.
3.	Refer to **INTELLIGENT BATTERY SENSOR (IBS)**.
4.	Refer to **POWER DISTRIBUTION CENTER (PDC)**.
5.	Refer to **BODY CONTROL MODULE (BCM)**.
6.	Refer to **INSTRUMENT PANEL CLUSTER (IPC)**.

STANDARD GENERATOR SYSTEM OPERATION



The Electronic Voltage Regulation (EVR) system maintains the system voltage at a desired level by turning the Pulse Width Modulated (PWM) generator field control circuit (A) on and off. When the generator field is turned on, the system voltage increases. When the generator field is turned off, the system voltage slowly drops. The rate at which this happens is dependent upon the existing electrical loads, ambient under hood temperature,

and the engine speed. A constant system voltage (B, C, D) can be maintained only when the generator field is switched on and off at a duty cycle that very accurately emulates the existing electrical loads given the existing ambient under hood temperature and engine speed.

During normal operation, the voltage reading at the generator output stud will be very close to the target charging voltage viewed on the scan tool. This is the system voltage and is sensed by the PCM through the fused B+ circuit (B). With the generator connector plugged in, the voltage reading on the generator sense circuit will be approximately 3.5 volts less than the voltage at the generator output stud due the resistor inside the generator. This is the generator sense (E) input to the PCM. These two voltage sense inputs are used and compared during the different diagnostics performed on the EVR System by the PCM.

In diagnostic mode, when the PCM detects that the output voltage is too high or too low, the PCM runs a series of diagnostics to determine the cause. When the diagnostic is initiated, the PCM will change the field control circuit and look for a change in the output voltage. If no reaction is detected, the PCM rationalizes that it has lost control of the generator field control (A) due to an open or shorted condition. If the generator field control is active, and the engine speed is above a calibrated threshold, the PCM will run a series of tests that turn the generator field control off and on for a brief period of time and monitors the system voltage (B) for a calibrated amount of change in the voltage, to determine a failure of the generator. This diagnostic test requires repeated failures to insure that an erroneous fault is not set.

BODY CONTROL MODULE (BCM)

Refer to **COMPONENT INDEX**.

NOTE: **The following information applies to vehicles equipped with a smart generator.**

The BCM has two functions:

- it is the gateway for the battery status signals coming from the Intelligent Battery Sensor (IBS) to the Controller Area Network-Chassis (CAN-C) network
- it receives information from some vehicle loads and manages voltage limits by increasing or decreasing the generator voltage output. The battery voltage limits are monitored while these requested voltage changes are occurring. The BCM calculates the limits of the maximum charging voltage by utilizing a LIN bus message from the IBS indicating the battery temperature.

Depending on the state of some electrical loads and the maximum charging limit already calculated by the BCM, the BCM will set the minimum and maximum voltage limits for the generators target voltage. These limits are then broadcast on the CAN-C network.

The following signals are transmitted by BCM to the PCM using the CAN-C network:

- The battery current
- The battery temperature (B°C)
- The battery voltage (V)
- The battery state of charge (%)
- The maximum voltage allowed by BCM (V)
- The minimum voltage allowed by BCM (V)
- The IBS status signals
- The SAM failure status

The value of the voltage high strategy calculated by the BCM is performed by reading the following signals:

- High beams activated
- Front fog lamps activated
- Rear fog lamps activated
- The front wiper motor low or high state

- Rear wiper motor activated
- Low beams activated
- Positive Temperature Coefficient (PTC) heaters are present
- Programmable auxiliary switches are on. An equipped Power Take-Off (PTO) unit is an example of when you would find an auxiliary switch bank.
- Battery maximum charging voltage. This condition is always active.

The value of the voltage low strategy calculated by the BCM is performed by reading the following signals:

- High beams activated
- Front fog lamps activated
- Rear fog lamps activated
- The front wiper motor low or high state
- Rear wiper motor activated
- Low beams activated
- PTC heaters are present
- Programmable auxiliary switches are on. An equipped PTO unit is an example of when you would find an auxiliary switch bank.
- Requests from the Heating Ventilation and Air Conditioning (HVAC) system.

GENERATOR

Refer to **COMPONENT INDEX**.

Standard Generator

As the energized rotor begins to rotate within the generator, the spinning magnetic field induces a current into the windings of the stator coil.

The Y type stator winding connections deliver the induced Alternating Current (AC) to positive and negative diodes for rectification. From the diodes, rectified Direct Current (DC) is delivered to the vehicles electrical system through the generator, battery, and ground terminals.

Noise emitting from the generator may be caused by:

- Worn, loose or defective bearings
- Loose or defective drive pulley
- Incorrect, worn, damaged or misadjusted drive belt
- Loose mounting bolts
- Misaligned drive pulley
- Defective stator or diode
- Damaged internal fins

INSTRUMENT PANEL CLUSTER (IPC)

Refer to **COMPONENT INDEX**.

The IPC will switch on the charge system indicator (battery indicator, battery telltale) and the charging system audible chime when the IPC receives indication of a charging system failure from the PCM over the CAN-C network.

INTELLIGENT BATTERY SENSOR (IBS)

Refer to **COMPONENT INDEX**.

The IBS serves two primary purposes. The first is to provide the PCM with both immediate and historical calculated battery information, so the PCM can precisely control the charging system. The second purpose is to provide calculated data to the BCM for operation of the load-shedding feature. A fused power circuit and the bus are connected to the IBS though a two-terminal connector.

The IBS contains a low value resistor, or shunt. The shunt creates voltage drop, which is read by an internal controller to determine the current flow in and out of the battery. In addition to the shunt, the IBS contains a sensor to monitor the battery's temperature. Data gathered by the IBS, including temperature, voltage, and current measurements, are transmitted over a communication bus to the BCM, which is the LIN master node of the IBS. In addition to real-time measurements, the IBS transmits some calculated battery data over the bus, including SOC, State of Health (SOH), and State of Function (SOF). These values are calculated by storing measurements over time.

- SOC = Battery SOC is expressed as a percentage. The IBS calculates the SOC based on measured voltage, and charge and discharge rates. Therefore, SOC is not a direct percentage of battery voltage.
- SOF = Battery SOF is a calculated prediction of the lowest voltage the battery will drop to during engine cranking.

The battery sensor is readable and diagnosable by using the diagnostic scan tool which can display all of the available parameters needed for vehicle servicing or trouble shooting.

When the IBS is powered up for the first time or is powered after a battery disconnect, it enters a "recalibration" phase, where the IBS must recognize the type of battery and its characteristics and state. This information is sent to the IBS by the BCM. In this phase the tolerances on the state functions (SOC, SOF) are greater than in normal working condition. When the IBS is disconnected from the battery, the device loses its stored memory. When power is restored, the IBS starts a relearn process. Until the relearn process is complete, accurate battery state information is unavailable to other vehicle systems. The IBS relearn process requires one start and at least four hours of quiescent time (vehicle off, electrical system asleep). The relearn process is restarted every time power is reconnected to the IBS. This has a major effect on the Engine Start Stop (ESS) feature.

POWERTRAIN CONTROL MODULE (PCM)

Refer to **COMPONENT INDEX**.

The IBS and BCM communicate with the PCM to provide the proper charging strategy for the vehicle based on ambient temperature, vehicle electrical load and voltage.

POWER DISTRIBUTION CENTER (PDC)

Refer to **COMPONENT INDEX**.

The PDC for this vehicle is designed to provide safe, reliable, centralized and convenient access to distribution of the electrical current required to operate all of the many standard and optional factory-installed electrical and electronic powertrain, chassis, safety, comfort and convenience systems. At the same time, these systems were designed to provide centralized locations for conducting diagnosis of faulty circuits and for sourcing the additional current requirements of many aftermarket vehicle accessory and convenience items. The PDC connects directly to the B+ cable.

This power distribution system also incorporate various types of circuit control and protection features, including:

- Automatic resetting circuit breakers
- Cartridge fuses
- Blade fuses
- Printed Circuit Board (PCB) and non-PCB Relays

Most current vehicles utilize the Smart Charging control strategy. This strategy helps to improve vehicle performance, reduce CO2 emissions and increase fuel efficiency. The control strategy takes into account battery state of charge and electrical loads on the battery, as well as engine load. Vehicles that utilize the Smart Charging control strategy are equipped with an Intelligent Battery Sensor (IBS). The IBS is an important component of the Smart Charging control strategy.

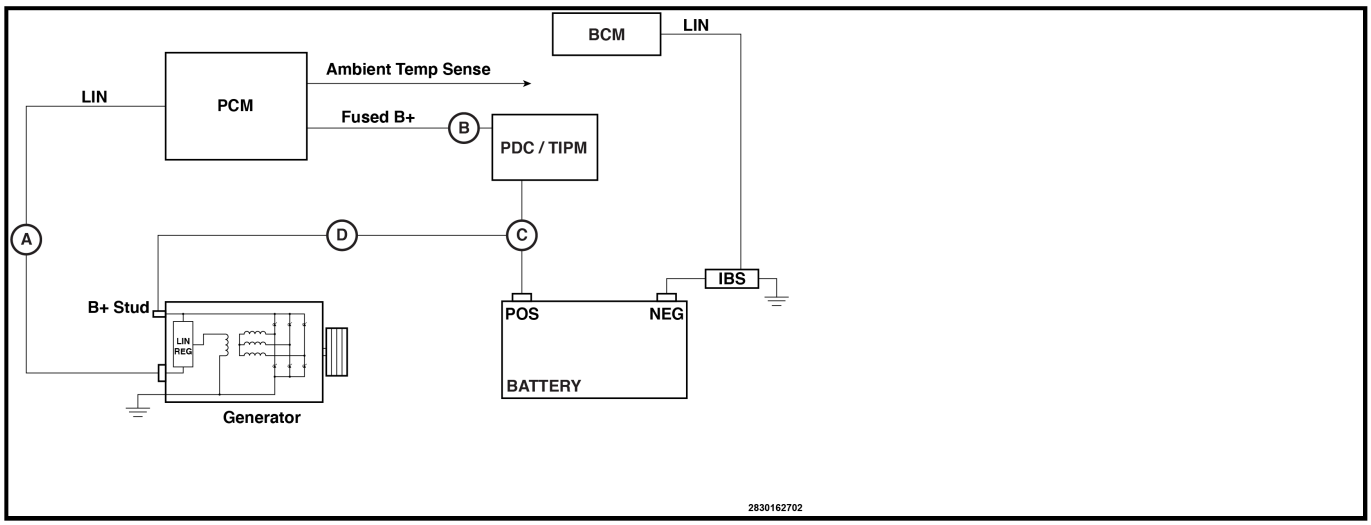
- **Idle and acceleration:** Charging is typically suspended during idle and acceleration conditions. Due to this strategy it can be common for the alternator output to be equal to, or close to typical battery voltage at idle and during engine acceleration.
- **Steady state speeds:** During steady state speeds the charge rate is typically low, just enough to maintain battery voltage.
- **Deceleration (regenerative braking):** The charge rate is typically very high during deceleration.

The Smart Charging strategy can be used with any combination of the following vehicle configurations:

- Single Battery System
- Dual Battery System
- Electronic Voltage Regulation (EVR) Charging systems which use a standard alternator directly controlled by the PCM
- Charging systems using a smart alternator communicating with the PCM via LIN Bus

On vehicles equipped with a smart alternator, the PCM sends voltage set point and ramp time commands to the alternator via a LIN bus communication circuit. The alternator controls the charging rate based on these commands.

FUNCTIONAL DESCRIPTION - SMART ALTERNATOR



The Smart Alternator communicates with the Powertrain Control Module (PCM) over a Pulse Width Modulated (PWM) LIN BUS communication circuit. The Smart Alternator contains an internal Intelligent Voltage Regulator that controls the Alternator overall operation. The Smart Alternator requires Battery supply on the Fused B+ circuit and a good case ground to power up the internal regulator and operate correctly. **The PCM sends the Smart Alternator the following messages/commands over the LIN BUS circuit:**

- Wake-up signal
- Voltage set point
- Ramp time
- Maximum current output based on operating and environmental conditions

The Smart Alternator controls the charging rate based on the PCM input commands. The Smart Alternator also performs diagnostics for electrical and mechanical faults with the Alternator. **The Smart Alternator sends the**

following information/faults regarding diagnostics and Alternator load conditions back to the PCM over the LIN BUS circuit:

- Regulator duty cycle
- Internal Battery voltage
- Measured energizing current
- Integrated circuit temperature
- Pulley rotational speed
- Error messages for internal mechanical error, electrical error, or over temperature error

FUNCTIONAL DESCRIPTION - INTELLIGENT BATTERY SENSOR (IBS)

The Intelligent Battery Sensor (IBS) is an electrical shunt with a microprocessor that is mounted in-line with the negative Battery Cable. The IBS monitors the Battery voltage as well as current flow into and out of the battery. The IBS also has a built-in thermistor that calculates the battery temperature. The microprocessor uses this data to calculate Battery State of Charge (SOC), battery internal resistance, charge received, electrical demand, and time in service. This information is reported through the LIN Bus circuit to the Body Control Module (BCM). The BCM broadcasts the information to the Powertrain Control Module (PCM) over the CAN Bus.

The IBS SOC data is also used by the BCM and other modules to determine when to begin disabling certain vehicle features that draw excessive electrical loads due to a low battery SOC. The SOC threshold for starting to disable features can vary based on vehicle and engine but is typically in the 50% to 60% range. The following items can contribute to, and should be considered when diagnosing a low SOC condition before replacing an IBS or battery:

- If the vehicle is jump started at the battery posts bypassing the IBS.
- If the battery is blind charged at the battery posts bypassing the IBS.
- Repeated short trip driving events not allowing enough charge time.
- The IBS accuracy is off and needs to relearn the battery SOC.

Depending on the vehicle, there could be a non-MIL DTC (P057F) set, or an EVIC message indicating a low battery state of charge limiting some features, such as ESS. In some cases, properly charging the batteries through the IBS can raise the IBS SOC enough to regain functionality and repair the issue. However, it can sometimes take two or three, 4-hour BUS off sleep cycles for an IBS to learn and update the Battery SOC. The IBS can be initiated into a learning curve by completely disconnecting the IBS from the battery, and disconnecting harness connector for 20 seconds. The IBS battery feed, LIN Bus and ground circuits should be checked before reconnecting the IBS. The IBS should default to approximately 80% SOC when reconnected. However, the IBS accuracy is determined to be low until the IBS can relearn battery SOC. This occurs after an engine run cycle and a subsequent ignition off sleep cycle of between one to four hours. Some features will be disabled until the IBS SOC is updated.

FUNCTIONAL DESCRIPTION - POWER DISTRIBUTION CENTER (PDC)

The PDC is designed to provide safe, reliable, centralized and convenient access to distribution of the electrical current required to operate all of the many standard and optional factory-installed electrical and electronic powertrain, chassis, safety, comfort and convenience systems. At the same time, these systems were designed to provide centralized locations for conducting diagnosis of faulty circuits and for sourcing the additional current requirements of many aftermarket vehicle accessory and convenience items. The PDC connects directly to the Battery Positive (B+) cable.

The power distribution systems also incorporate various types of circuit control and protection features, including:

- Automatic resetting circuit breakers
- Cartridge fuses

- Blade fuses
- Removable Relays
- Non serviceable Printed Circuit Board (PCB) Relays

The charging system is protected by a larger amperage fuse that is typically in the fuse array attached to the PDC.

FUNCTIONAL DESCRIPTION - INSTRUMENT PANEL CLUSTER (IPC)

The IPC will turn on the charge system indicator (battery indicator, battery telltale) and the charging system audible chime when the IPC receives indication of a charging system failure from the PCM over the Controller Area Network-Chassis (CAN-C) network.

FUNCTIONAL DESCRIPTION - BODY CONTROL MODULE (BCM)

The BCM is the gateway for all bus communications needing to be gated from one bus network to a different bus network. This grants the modules on different busses the ability to interact with each other. If the Local Interface Network (LIN) or CAN bus communications go down, the BCM will set the appropriate DTCs and display Signal Not Available (SNA) values.

The Intelligent Battery Sensor (IBS) communicates with the BCM through a LIN bus circuit. The BCM collects information relating to battery state of charge, temperature and electrical loads on the battery from the IBS. This information is broadcast over the bus networks to other modules, including the Powertrain Control Module (PCM) which uses this information to control and monitor the charging system.

FUNCTIONAL DESCRIPTION - POWERTRAIN CONTROL MODULE (PCM)

The PCM communicates and commands the charging rate to the Smart Alternator via the LIN bus circuit. The PCM does not directly perform diagnostics of the Smart Alternator. However, the PCM does store and report the faults communicated from the Smart Alternator via the LIN bus circuit.

The PCM diagnostic monitor compares the reported battery voltage from the Intelligent Battery Sensor (IBS) to the currently requested set voltage from the Smart Alternator. A fault will be detected if the absolute difference (VOLTAGE_DELTA) between commanded Smart Alternator and actual IBS voltage values vary from one another above a calibrated threshold for an accumulated period of time. When the PCM determines there is a charging system failure the PCM will send a message to the Instrument Cluster to illuminate the check gauges lamp (if equipped) with the engine running.

DIAGNOSIS AND TESTING

CHARGING SYSTEM - SMART ALTERNATOR

The PCM does not directly perform diagnostics for the Smart Alternator. However, the PCM does store and report the faults communicated from the Smart Alternator via the LIN bus circuit. The PCM diagnostic monitor compares the reported battery voltage from the Intelligent Battery Sensor (IBS) to the currently requested set voltage from the Smart Alternator. A fault will be detected if the absolute difference (VOLTAGE_DELTA) between commanded Smart Alternator and actual IBS voltage values vary from one another above a calibrated threshold over an accumulated period.

CHARGING SYSTEM TESTING

PRELIMINARY INSPECTION

Perform the following inspections before diagnosing the Smart Alternator system:

1. Verify proper battery condition and charge level.
2. Inspect condition and connections at the battery cable terminals, battery posts, ground locations and Smart Alternator. They should be clean and tight. Repair as required.

3. Inspect all fuses in both the BCM and Power Distribution Center (PDC) for tightness in receptacles. They should be properly installed and tight. Repair or replace as required.
4. Inspect Alternator drive belt and tensioner condition. Verify proper belt tension.

DIAGNOSTIC OVERVIEW - SMART ALTERNATOR

PCM DIAGNOSTICS: When an electrical, mechanical or over-temp fault is detected and reported by the Smart Alternator to the PCM, the PCM sets a fault (P-code) and sends a default voltage set point of 14.0 volts to the Smart Alternator. Most vehicles will combine the failure modes into one fault code (P065A). However, some vehicles will separate each failure mode and set individual DTCs. **It is important to note that on vehicles that use the combined P065A fault** that this DTC can also set if the **difference** between the commanded set point and IBS voltage feedback are greater than a calibrated threshold. This means that the charging output should be checked before condemning an Alternator as faulty when a DTC is present.

When communication is lost between the PCM and Smart Alternator, the Smart Alternator will default to a voltage set point between 13.5 and 14.0 volts. The PCM will set a loss of communication fault (U-code) against the Smart Alternator. Besides an open or shorted LIN Bus circuit, the PCM can also lose communication with the Smart Alternator if the battery supply (open in the cable) or case ground to the Smart Alternator is lost. An open charging system fuse can cause a loss of battery supply to the Smart Alternator.

DIAGNOSTIC STRATEGY: Since the Smart Charging system does not always charge at idle, it is not unusual to see typical battery voltage present at the Smart Alternator stud during idling. Monitoring the voltage at the Smart Alternator stud at idle is not an effective way of checking the Smart Alternator output capability. This could lead to misdiagnosis and unnecessary replacement of the Smart Alternator. If it is suspected that the Smart Alternator is not charging to the level commanded by the PCM, a more effective way to determine this is to disconnect the LIN Bus circuit at the Smart Alternator and monitoring the voltage alternator stud. Disconnecting the communication line should cause the Smart Alternator to default to charging between approximately 13.5 and 14 volts. If the voltage does not increase to 13.5 to 14.0 volts at idle with the LIN Bus circuit open, the Smart Alternator is most likely faulty.

NOTE: **This method only applies to the Smart Alternators, not to the Electronic Voltage Regulation (EVR) charging systems with a standard Alternator. Standard Alternators are controlled directly by the PCM using a PWM voltage supply to energize the field.**

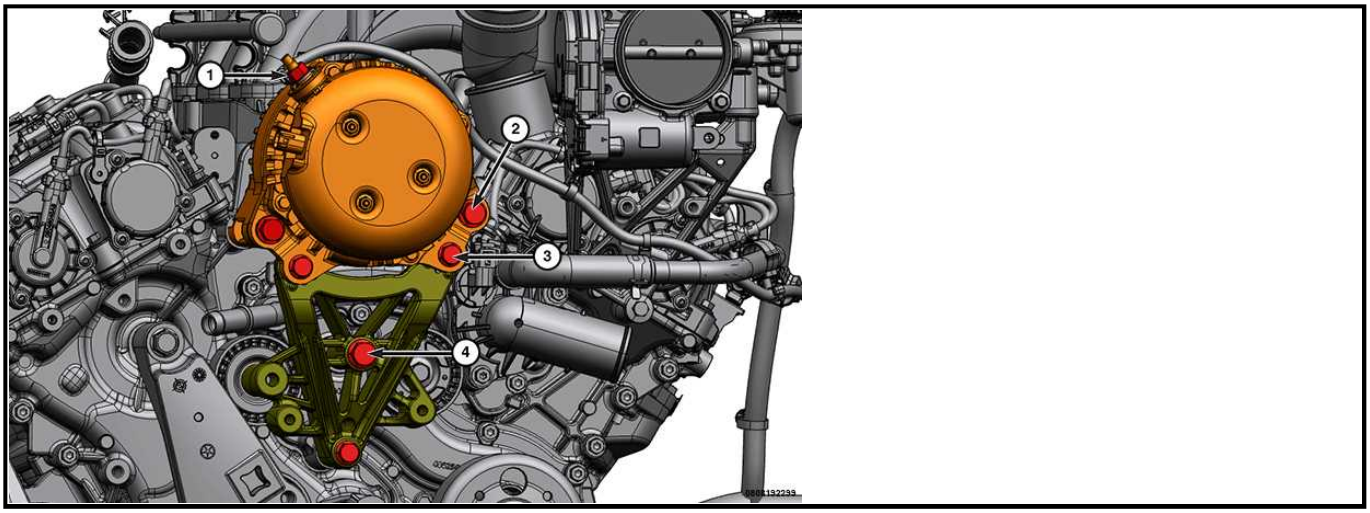
TECHNICAL SPECIFICATIONS

GENERATOR

3.6L W/ESS	180/220/240 AMP
3.0L Diesel	180/220/240 AMP

TORQUE SPECIFICATIONS

BATTERY/CHARGING SYSTEMS - 3.6L



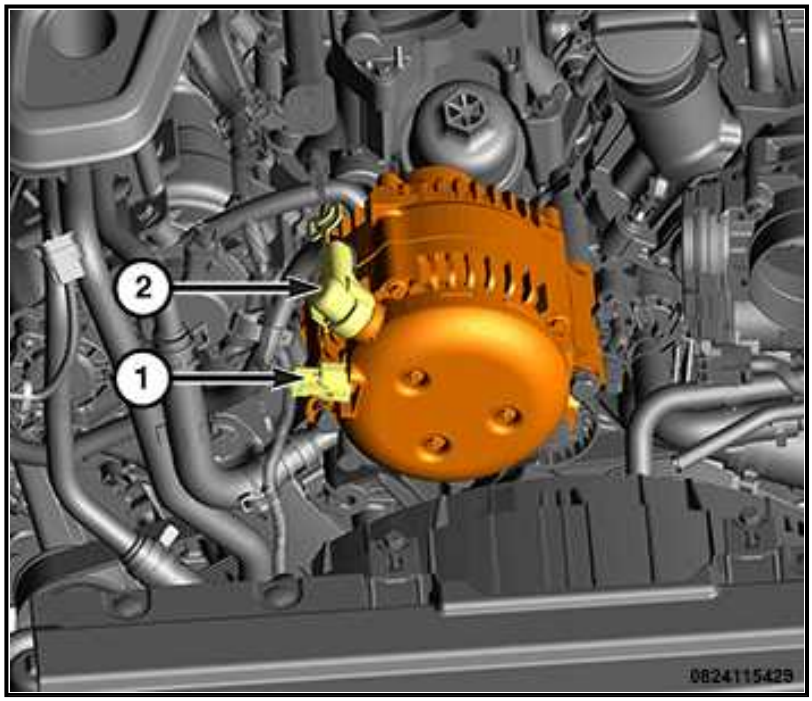
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENT
1	Generator B+ Nut	**20 N.m (15 Ft. Lbs.)**	-
2	Generator to Upper Engine Block 3.6L	**50 N.m (37 Ft. Lbs.)**	-
3	Generator to Bracket	**24 N.m (28 Ft. Lbs.)**	-
4	Generator Bracket to Cylinder Block	**55 N.m (41 Ft. Lbs.)**	-
-	Generator Bracket to Cylinder Block	**24 N.m (28 Ft. Lbs.)**	-

GENERATOR

REMOVAL AND INSTALLATION

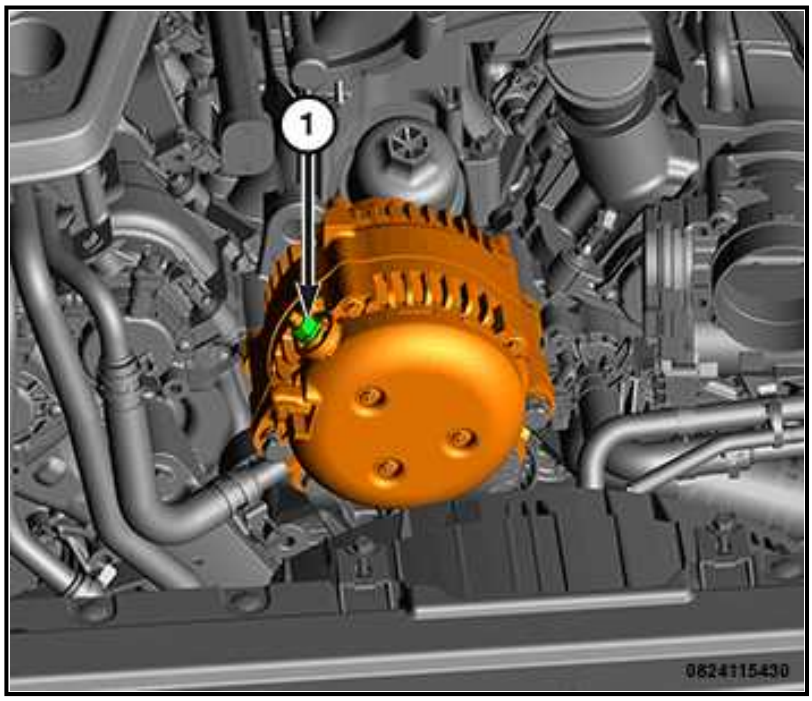
GENERATOR - 3.6L

1. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
2. Remove the air cleaner resonator tube. Refer to **RESONATOR, AIR CLEANER, REMOVAL AND INSTALLATION** .
3. Remove the serpentine belt. Refer to **TENSIONER, BELT, REMOVAL AND INSTALLATION** .



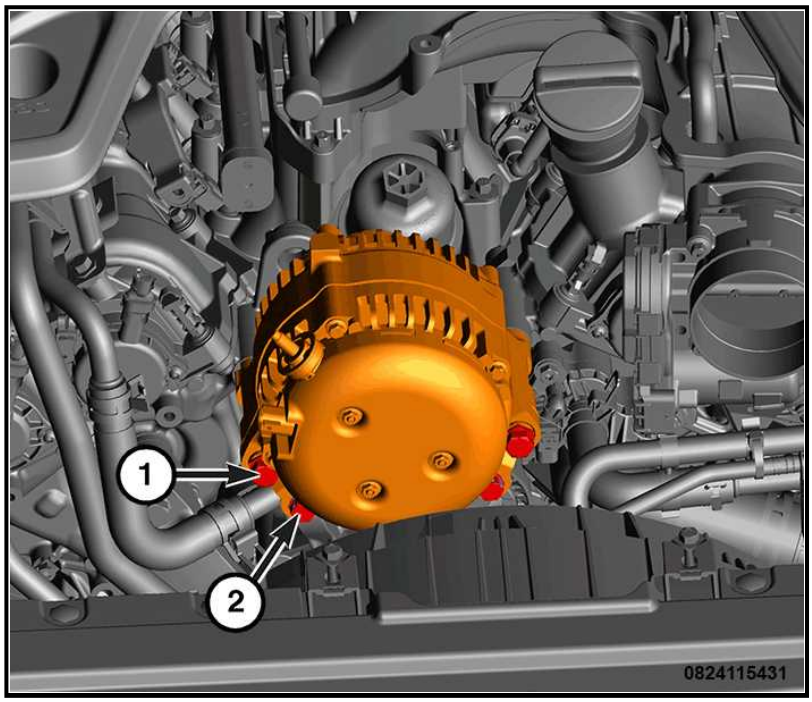
1 - Wire Harness Connector
2 - B+ Stud Cover

4. Remove the generator wire harness connector and the B+ battery stud cover.



1 - B+ Cable Nut

5. Remove the B+ stud nut and position aside the B+ cable.



1 - Generator to Front Engine Cover Bolts
2 - Generator to Generator Bracket Bolts

6. Remove the four generator mounting bolts and generator from vehicle.

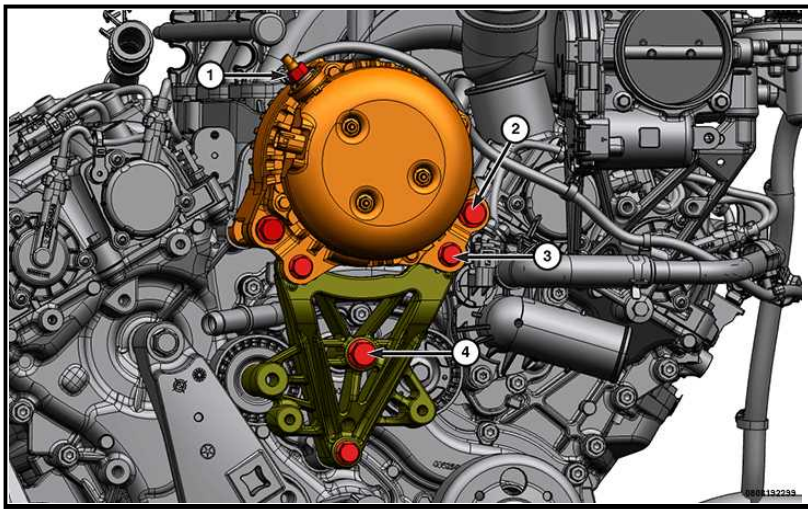
INSTALLATION

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.

TORQUE SPECIFICATIONS

BATTERY/CHARGING SYSTEMS - 3.6L



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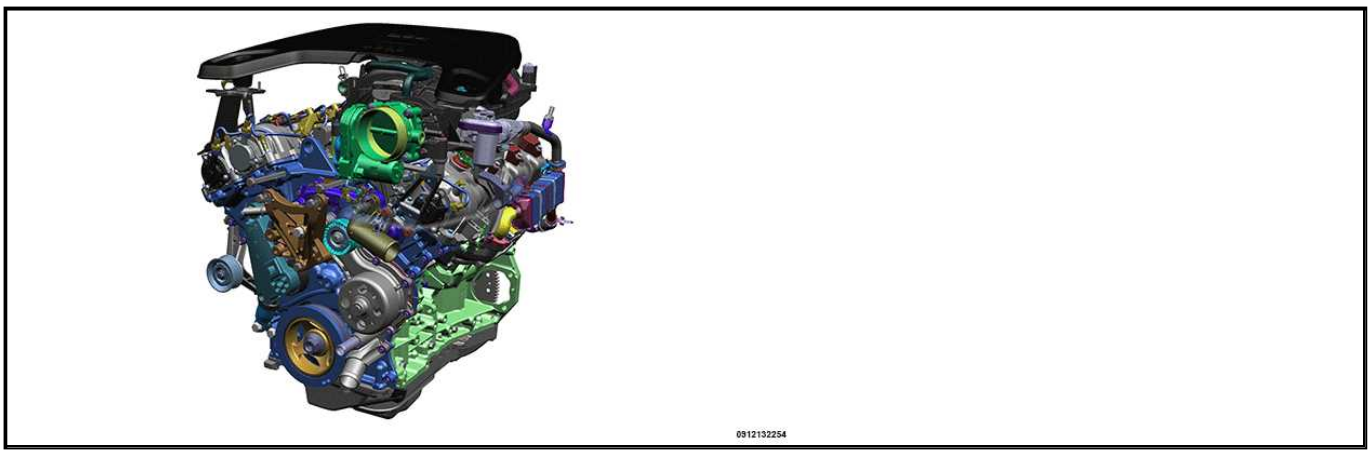
3	Generator to Bracket	**24 N.m (28 Ft. Lbs.)**	-
4	Generator Bracket to Cylinder Block	**55 N.m (41 Ft. Lbs.)**	-
-	Generator Bracket to Cylinder Block	**24 N.m (28 Ft. Lbs.)**	-

3.6L Engine (Service Information) (1 Of 3) - Gladiator [ERC, ERF]

DESCRIPTION AND OPERATION

DESCRIPTION AND OPERATION

CAUTION: **If the engine has experienced a catastrophic failure, THE INTAKE MANIFOLD MUST BE REPLACED!**



The 3.6 liter (219.7 CID) V-6 engine features Variable Valve Timing (VVT), Dual Overhead Camshafts (DOHC) and a high-pressure die-cast aluminum cylinder block with steel liners in a 60B° configuration. The 3.6 liter engine has a chain driven variable discharge oil pump with a two-stage pressure regulator for improved fuel economy. The exhaust manifolds are integrated into the cylinder heads for reduced weight. The cylinders are numbered from front to rear. The right bank is numbered 1, 3, 5 and the left bank is numbered 2, 4, 6. The firing order is 1-2-3-4-5-6. The engine serial number is located on the left side of the cylinder block at the transmission flange.

DIAGNOSIS AND TESTING

ENGINE MECHANICAL DIAGNOSTIC TABLE

CONDITION	POSSIBLE CAUSES	CORRECTIONS
NOISY VALVES	1. High or low oil level in crankcase	1. Refer to the appropriate information .
	2. Thin or diluted oil	2. Change oil and filter.
	3. Low oil pressure	3. Check oil pump, if Ok, check rod and main bearings for excessive wear.
	4. Spongy and/or stuck collapsed lash adjusters	4. Refer to **CYLINDER HEAD, DIAGNOSIS AND TESTING** .
	5. Dirt in lash adjusters	4. Replace as necessary.
	6. Worn rocker arms	5. Replace as necessary.
	7. Worn lash adjusters	6. Replace as necessary.
	8. Worn valve guides	7. Inspect the valve guides for wear, cracks or looseness. If either condition exists, replace the cylinder head. Refer to **CYLINDER HEAD ASSEMBLY, REMOVAL AND INSTALLATION** .
	9. Excessive runout of valve seats on valve faces	8. Refer to the appropriate information .

CONDITION	POSSIBLE CAUSES	CORRECTIONS
CONNECTING ROD NOISE	1. Insufficient oil supply	1. Refer to the appropriate information .
	2. Low oil pressure	2. Check oil pump, if OK, check rod and main bearings for excessive wear.
	3. Thin or diluted oil	3. Change oil and filter.
	4. Excessive bearing clearance	4. Replace as necessary.
	5. Connecting rod journal out-of-round	5. Service or replace crankshaft.
	6. Misaligned connecting rods	6. Replace bent connecting rods.
MAIN BEARING NOISE	1. Insufficient oil supply	1. Refer to the appropriate information .
	2. Low oil pressure	2. Check oil pump, if OK, check rod and main bearings for excessive wear.
	3. Thin or diluted oil	3. Change oil and filter.
	4. Excessive bearing clearance	4. Replace as necessary.
	5. Excessive end play	5. Check thrust washers for wear.
	6. Crankshaft journal out of round	6. Service or replace crankshaft.
	7. Loose flywheel or torque converter	7. Tighten to correct torque.

RELATIVE COMPRESSION TEST - MOPAR SCOPE

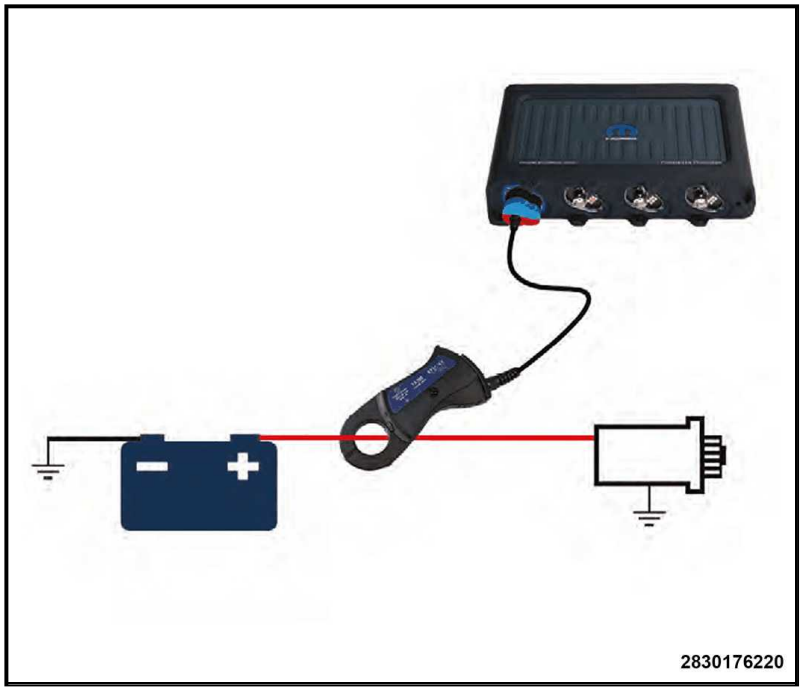
NOTE: **This procedure does not apply to a Hybrid vehicle that does not have a starter motor.**

A relative compression test can be performed to quickly determine if a cylinder has a mechanical issue causing a lack of compression and misfire condition. This can be done by checking the amperage draw of the starter motor with an oscilloscope during engine cranking. The amount of peak amperage for each cylinder during a compression stroke will increase or decrease in relation to cylinder compression. If a cylinder has low compression due to a mechanical issue, the amperage draw by the starter motor will also be lower when that cylinder is on the compression stroke. Follow the steps below to perform a relative compression test with the oscilloscope.

NOTE: **It is important to note when performing this check that the peak amperage can vary from vehicle to vehicle, even with the same size engines. There are many variables that can affect this such as the starter motor capacity and age, battery type and capacity, etc. For this reason it is best to compare the cylinders across the engine on the vehicle being tested. Saved readings from another vehicle with the same engine should only be used as a guideline for what is considered normal.**

To perform this correctly, the engine must be cranked without trying to start. If the engine is firing cylinders and trying to start it will skew the readings. On some vehicles, the PCM will allow the engine to crank without trying to start if the throttle is held at wide open throttle. Try cranking the engine with the accelerator pedal at wide open throttle to see if the vehicle being tested functions this way. This will allow performing the procedure without having to disable fuel.

1. Disable the fuel system so that the engine can crank without starting. Use the appropriate wiring information to determine how to best disable the fuel pump or fuel injectors. The best method is removing the fuse or relay.
2. Start the engine to allow the fuel in the rail and lines to be used up until the engine stalls. It may be necessary to do this a couple of times.



3. With the 2000A clamp connected to channel A on the scope, connect the 2000A clamp to the main battery cable that connects between the positive battery post and the starter motor. The clamp can be connected near the battery, the starter or anywhere in between that is accessible.
4. Set up the channels and scaling according to the table below:

NOTE: **The ignition coil sync is not necessary on initial testing. If the peaks are equal indicating that all of the cylinders are good during initial test, no further action is needed. If there is an issue with one or more of the cylinders, then the ignition coil can be used as a reference to help determine which cylinder is low.**

OSCILLOSCOPE CHANNEL SET-UP AND SCALING		
B	**CHANNEL A**	**CHANNEL B (IF NEEDED)**
Scope Lead	2000A clamp	Coil on Plug Probe
Voltage/Amperage scaling	1kA	Auto-scales to 10mA
Scope Connection	Connect to the battery cable from the battery to the starter motor	Place on an ignition coil for reference sync (preferably #1)
Graph Timing	Recommend 500 ms/div	

5. Setting up a trigger will allow auto capturing the data during cranking. If the trigger is not used the scope will need to be manually stopped to capture the data for analyzing. If a trigger is being used, set up the trigger for channel A according to the trigger set-up table below:

TRIGGER SET-UP				
Mode	**Trigger Type**	**Direction**	**Threshold**	**Pre-trigger percentage**
Single	Simple Edge	Rising	100A	10%

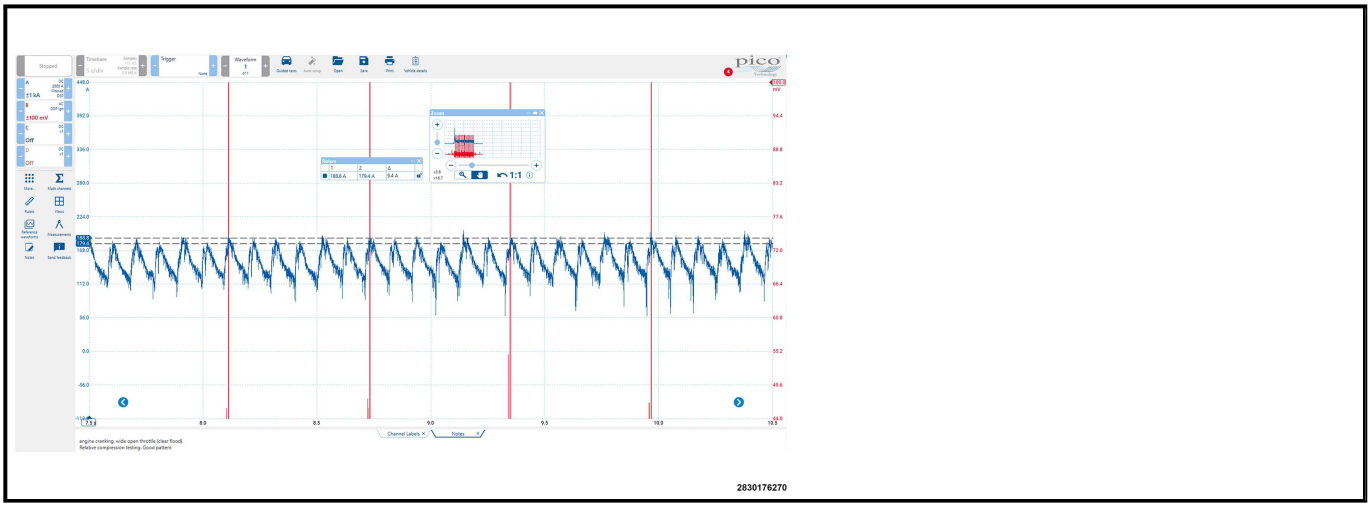
6. Hold the accelerator pedal open to help prevent the engine from trying to start.

NOTE: **Opening the throttle to wide open throttle can cause the PCM to turn off the coils on some engines. Therefore the throttle should not be opened to wide open throttle if the coil signal is not reading during cranking. If the coil sync is not being used, wide open throttle is best to keep the engine from trying to start.**

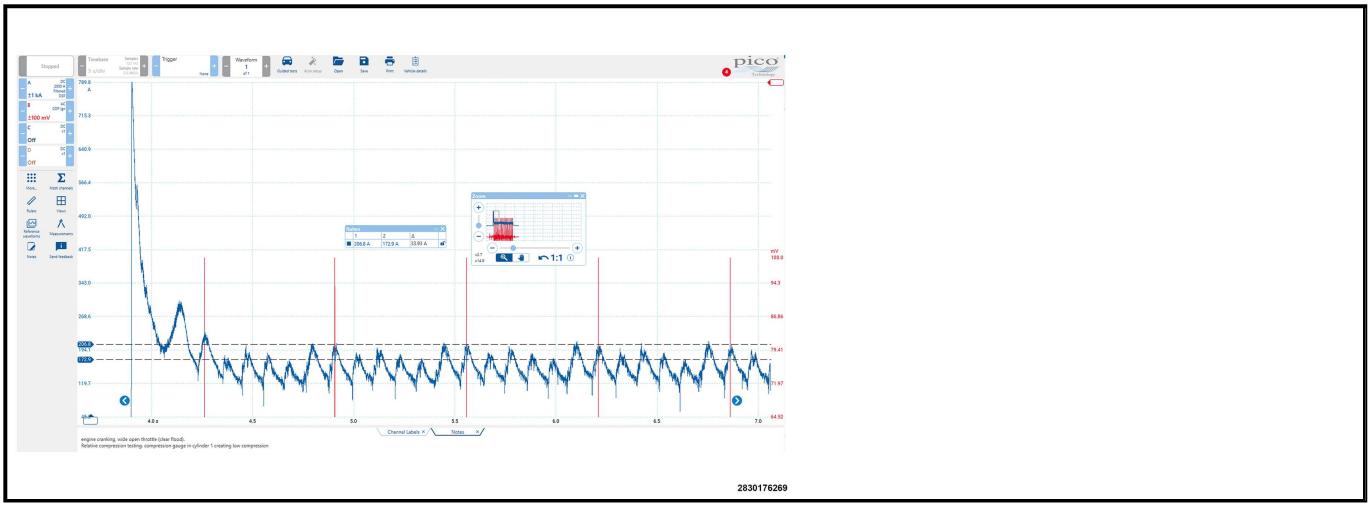
7. Crank the engine until the screen fills. If a trigger is not being used, stop the scope when the screen fills or the engine stops cranking.
8. Analyze the pulses in the cranking amperage for across all cylinders.

NOTE: **When analyzing the amperage draw, do not analyze the initial cranking cycle of the engine. There is always an initial in-rush at starter engagement for the first few cylinders. Analyze the 2nd or 3rd cycle of the engine when the amperage has stabilized. The red channel is showing ignition coil 1 sync as an example if the sync is needed.**

Below is an example of a vehicle with good compression in each cylinder. The amperage peaks will appear to be relatively equal. A physical compression and leak down test are likely not necessary on this vehicle since the peaks are relatively equal.



Below is an example of the same vehicle with low compression in cylinder 1. The spark plug was removed and a compression hose was inserted in the cylinder to simulate compression loss. In this example the red channel is showing ignition coil 3 firing as a sync. Using the firing order of 1-2-3-4-5-6 you can see that cylinder 1 is much lower than the cylinders with maximum current draw. In this example cylinder one is lower than all other cylinders. The cylinders before cylinder 1 are closer to the normal readings in the graph above but the cylinders directly after cylinder 1 are slightly higher than the graph above when all cylinders were good. This is normal with a low cylinder. With low compression in a cylinder the starter draw will decrease due to less resistance for the starter to fight on the compression stroke. The lack of compressed air aiding the piston as it travels back down on the combustion stroke will cause an in-rush on the following cylinder(s). If a cylinder has low compression, the difference for the faulty cylinder should be obvious. An actual compression test and cylinder leakage test should be performed to determine the issue.



CYLINDER COMPRESSION TEST

NOTE: **This procedure does not apply to a Hybrid vehicle that does not have a starter motor.**

NOTE: **Do not attempt to use a remote starter switch when testing a MULTI-AIR equipped engine, the ignition MUST remain in the "key on" position. If the ignition is in the "off" position, the intake valves will not actuate and the result will be no compression.**

NOTE: **The results of a cylinder compression pressure test can be utilized to diagnose several engine malfunctions.**

NOTE: **Be certain the battery is completely charged and the engine starter motor is in good operating condition. Otherwise the indicated compression pressures may not be valid for diagnosis purposes.**

1. If possible, for best results, the compression test should be performed on a warm engine.
2. Disable the fuel system and perform the fuel system pressure release procedure. Refer to **FUEL SYSTEM PRESSURE RELEASE** .
3. Remove the spark plugs and record the cylinder number of each spark plug for future reference.
4. Inspect the spark plug electrodes for abnormal firing indicators such as fouled, hot, oily, and others.
5. Install a compression pressure gauge following the manufacturer's instruction.
6. Crank the engine using the ignition key or by pressing the start button.
7. The pressure should build quickly for the first three revolutions and reach a maximum after about 5 to 7 revolutions, record the maximum compression gauge pressure. Continue the test for the remaining cylinders.

   NOTE: **The recommended compression pressures are to be used only as a guide to diagnosing engine problems. An engine should not be disassembled to determine the cause of low compression unless some malfunction is present.**

8. Compression should not be less than 689 kPa (100 psi) and not vary more than 25 percent from cylinder to cylinder.
9. If one or more cylinders have abnormally low compression pressures, repeat the compression test.

   NOTE: **If the same cylinder or cylinders repeat an abnormally low reading on the second compression test, it could indicate the existence of a problem in the cylinder in question.**

10. If one or more cylinders continue to have abnormally low compression pressures, perform the cylinder combustion pressure leakage test. Refer to **CYLINDER LEAKAGE TEST** .

CYLINDER LEAKAGE TEST

The combustion pressure leakage test provides an accurate means for determining engine condition.

Cylinder leakage testing will detect:

- Exhaust and intake valve leaks (improper seating).
- Leaks between adjacent cylinders or into water jacket.
- Any causes for combustion pressure loss.

Perform the following cylinder leakage test steps:

1. Check the coolant level and fill as required. DO NOT install the radiator cap.

2. Start and operate the engine until it attains normal operating temperature, then turn the engine OFF.
3. Remove the spark plugs.
4. Remove the oil filler cap.
5. Remove the air cleaner hose.
6. **Calibrate the tester according to the manufacturer's instructions.** The shop air source for testing should maintain a regulated air pressure at 552 kPa (80 psi).
7. Perform the test procedures on each cylinder according to the tester's manufacturer instructions. Set the piston of the cylinder to be tested at Top Dead Center (TDC) on the compression stroke.
8. As each cylinder is pressurized, listen for the air escaping through the throttle body, tailpipe and oil filler cap opening. Check for bubbles in the radiator coolant.

All gauge pressure indications should be equal, with **no more** than 25% leakage.

If leakage is greater then 25%, Refer to CYLINDER LEAKAGE DIAGNOSIS CHART below.

CYLINDER LEAKAGE DIAGNOSIS CHART

CONDITION	POSSIBLE CAUSE	CORRECTION
AIR ESCAPES THROUGH THROTTLE BODY	Intake valve bent, burnt, or not seated properly	Inspect valve and valve seat. Reface or replace, as necessary. Inspect valve springs. Replace as necessary.
AIR ESCAPES THROUGH TAILPIPE	Exhaust valve bent, burnt, or not seated properly	Inspect valve and valve seat. Reface or replace, as necessary. Inspect valve springs. Replace as necessary.
AIR ESCAPES THROUGH RADIATOR	Head gasket leaking or cracked cylinder head or block	Remove cylinder head and inspect. Replace inoperative part.
MORE THAN 50% LEAKAGE FROM ADJACENT CYLINDERS	Head gasket leaking or crack in cylinder head or block between adjacent cylinders	Remove cylinder head and inspect. Replace gasket, head, or block as necessary.
MORE THAN 25% LEAKAGE AND AIR ESCAPES THROUGH OIL FILLER CAP OPENING ONLY	Stuck or broken piston rings; cracked piston; worn rings and/or cylinder wall	Inspect for broken rings or piston. Measure ring gap and cylinder diameter, taper and out-of-round. Replace inoperative part as necessary.

OIL CONSUMPTION TEST AND DIAGNOSIS

The following diagnostic procedures are used to determine the source of excessive internal oil consumption, these procedures and tests apply to vehicles with 50, 000 miles or less.

NOTE: **Engine oil consumption may be greater than normal during engine break-in. Repairs should be delayed until vehicle has been driven at least 7, 500 miles.**

- **Severe service (high ambient temperature, short trips, heavy loading, trailer towing, taxi, off-road, or law enforcement use) may result in greater oil consumption than normal.**
- **Sustained high speed driving and high engine RPM operation may result in increased oil consumption.**
- **Failure to comply with the recommended oil type and viscosity rating, as outlined in the owner's manual, may impact oil economy as well as fuel economy.**
- **Oil consumption may increase with vehicle age and mileage due to normal engine wear.**

NOTE: **Because a few drops of external oil leakage per mile can quickly account for the loss of one quart of oil in a few hundred miles, ensure no external engine oil leaks are present.**

- **Oil leakage is not the same as oil consumption and all external leakage must be eliminated before any action can be taken to verify and/or correct oil consumption complaints.**
- **Verify that the engine has the correct oil level dipstick and dipstick tube installed.**
- **Verify that the engine is not being run in an overfilled condition. Check the oil level 5 minutes after a hot shutdown with the vehicle parked on a level surface. In no case should the level be above MAX or the FULL mark on the dipstick.**

OIL CONSUMPTION TEST

1. Check the oil level at least 5 minutes after a hot shutdown with the vehicle on a level surface.
2. If the oil level is low, top off with the proper viscosity and API service level engine oil. Add one bottle of MoparB® 4-In-1 Leak Detection Dye into the engine oil.
3. Tamper proof the oil pan drain plug, oil filter, dipstick (if equipped) and oil fill cap with a black light marking device (pen) or air conditioning dye applied with a small brush.

   NOTE: **The use of a black light marking device is recommended so the marks can only be seen with a ultraviolet light.**

4. Record the vehicle mileage. Note that the oil level at 'full' mark 5 minutes after hot shut-down and date.
5. Instruct the customer to drive the vehicle as usual.
6. Ask the customer to return to the servicing dealer after accumulating 500 miles, Check the oil level at least 5 minutes after a hot shutdown on a level surface. If the oil level is half way between the "FULL" and "ADD" mark or below, continue with the next step.
7. Using a black light, check for any external engine oil leaks, repair as necessary, if no external engine oil leaks are present, continue with oil consumption diagnosis.

OIL CONSUMPTION DIAGNOSIS

1. Check the Closed Crankcase Ventilation (CCV) system. Make sure the system is not restricted (one way by blowing air through it) and the CCV valve is the correct part based on the part number. Check the hoses and connectors for damage or leaks. It must have correct vacuum source at intake manifold through the hose-vent assembly. Normal vacuum is considered to be 18-20 in. Hg at idle, below 3000 ft. above sea level.
2. Perform a cylinder compression test and cylinder leakage test using the standard cylinder leakage tester and following manufacturers suggested best practices.

   NOTE: **Blow the spark plug sockets/bores out with compressed air to remove fluid or debris before removing the spark plugs.**

3. Verify the spark plugs are not oil saturated.
4. If one or more cylinders have more than 15% leak down further engine tear down and inspection will be required.

TOP 18 REASONS THAT MAY LEAD TO ENGINE OIL CONSUMPTION

1. **Tapered and Out-of-Round Cylinders -**

   The increased piston clearances permit the pistons to rock in the worn cylinders. While tilted momentarily, an abnormally large volume of oil is permitted to enter on one side of the piston. The rings, also tilted in the cylinder, permit oil to enter on one side. Upon reversal of the piston on each stroke, some of this oil is passed into the combustion chamber.

2. **Distorted Cylinders -**

   This may be caused by unequal heat distribution or unequal tightening of cylinder head bolts. This condition presents a surface which the rings may not be able to follow completely. In this case, there may

be areas where the rings will not remove all of the excess oil. When combustion takes place, this oil will be burned and cause high oil consumption.

3. **Improper operation of "Positive Crankcase Ventilation (PCV)" system** -

   The main purpose of the PCV valve is to recirculate blow-by gases back from the crankcase area through the engine to consume unburned hydrocarbons. The PCV system usually has a one way check valve and a make up air source. The system uses external tubing to route crankcase blow by gases to the intake manifold. Vacuum within the engine intake manifold pulls the blow by gases out of the crankcase into the combustion chamber along with the regular intake air and fuel mixture.

   The PCV system can become clogged with sludge and varnish deposits and trap blow by gases in the crankcase. This degrades the oil, promoting additional formation of deposit material. If left uncorrected, the result is plugged oil rings, oil consumption, rapid ring wear due to sludge buildup, ruptured gaskets and seals due to crankcase pressurization.

   If equipped with an engine driven vacuum pump, high oil consumption can be caused by unchecked airflow into the pump. This can be caused by anything that opens the vacuum pump intake port up to the atmosphere such as a faulty vacuum pump, hose fitting, hose and brake booster. If there is not a restriction (normally caused by the pump pulling vacuum on the brake booster), then the vacuum pump will pump a high volume of air. This high volume of air will pressurize the crankcase and cause excessive oil burning and oil flow through the PCV system.

4. **Worn Piston Ring Grooves** -

   For piston rings to form a good seal, the sides of the ring grooves must be true and flat - not flared or shouldered. Piston rings in tapered or irregular grooves will not seal properly and, consequently, oil will pass around behind the rings into the combustion chamber.

5. **Worn, Broken or Stuck Piston Rings** -

   When piston rings are broken, worn or stuck to such an extent that the correct tension and clearances are not maintained, this will allow oil to be drawn into the combustion chamber on the intake stroke and hot gases of combustion to be blown down the cylinder past the piston on the power stroke. All of these conditions will result in burning and carbon build up of the oil on the cylinders, pistons and rings.

6. **Cracked or Broken Ring Lands** -

   Cracked or broken ring lands prevent the rings from seating completely on their sides and cause oil pumping. This condition will lead to serious damage to the cylinders as well as complete destruction of the pistons and rings. Cracked or broken ring lands cannot be corrected by any means other than piston replacement.

7. **Worn Valve Stems, Guides and Seals** -

   When wear has taken place on valve stems, valve guides and valve seals, the vacuum in the intake manifold will draw oil and oil vapor passed the valve seals between the intake valve stems and guides. The oil will enter the intake manifold and then into the cylinder where it will be burned.

8. **Bent or Misaligned Connecting Rods** -

   Bent or misaligned connecting rods will not allow the pistons to ride straight in the cylinders. This will prevent the pistons and rings from forming a proper seal with the cylinder walls and promote oil consumption. In addition, it is possible that a bearing in a bent connect rod will not have uniform clearance on the connecting rod wrist pin. Under these conditions, the bearing will wear rapidly and throw off an excessive amount of oil into the cylinder.

9. **Fuel Dilution** -

   If raw fuel is allowed to enter the lubrication system, the oil will become thinner and more volatile and will result in higher oil consumption. The following conditions will lead to higher oil consumption:

- Excess fuel can enter and mix with the oil via a leaking fuel injector
- Gasoline contaminated with diesel fuel
- Restricted air intake
- Excessive idling

10. **Contaminated Cooling Systems** -

    Corrosion, rust, scale, sediment or other formations in the water jacket and radiator will prevent a cooling system from extracting heat efficiently. This is likely to cause cylinder distortion thus leading to higher oil consumption.

11. **Oil Viscosity** -

    The use of oil with a viscosity that is too light may result in high oil consumption. Refer to the vehicle owner's manual for the proper oil viscosity to be used under specific driving conditions and/or ambient temperatures.

12. **Dirty Engine Oil** -

    Failure to change the oil and filter at proper intervals may cause the oil to be so dirty that it will promote accumulation of sludge and varnish and restrict oil passages in the piston rings and pistons. This will increase oil consumption; dirty oil by nature is also consumed at a higher rate than clean oil.

13. **Crankcase Overfull** -

    Due to an error in inserting the oil dip stick so that it does not come to a seat on its shoulder, a low reading may be obtained. Additional oil may be added to make the reading appear normal with the stick in this incorrect position which will actually make the oil level too high. If the oil level is so high that the lower ends of the connecting rods touch the oil in the oil pan excessive quantities of oil will be thrown on the cylinder walls and some of it will work its way up into the combustion chamber.

14. **Excessively High Oil Pressure** -

    A faulty oil pressure relief valve may cause the oil pressure to be too high. The result will be that the engine will be flooded with an abnormally large amount of oil in a manner similar to that which occurs with worn bearings. This condition may also cause the oil filter to burst.

15. **Aftermarket Performance Chips and Modification** -

    Increasing performance through the use of performance/power enhancement products to a stock or factory engine will increase the chance of excessive oil consumption.

16. **Lugging Engine** -

    Lugging is running the engine at a lower RPM in a condition where a higher RPM (more power/torque) should be implemented. Especially susceptible on vehicles equipped with a manual transmission. This driving habit causes more stress loading on the piston and can lead to increases in engine oil consumption.

17. **Turbocharged Engines** -

    There is a possibility for PCV "push-over" due to higher crankcase pressure (as compared to naturally aspirated engines) which is normal for turbocharged engines. This condition causes varying amounts of engine oil to enter the intake manifold, charge air cooler and associated plumbing to and from the charge air cooler, also a leaking turbocharger seal will draw oil into the combustion chamber where it will burn (blue smoke from tail pipe may be present) and form carbon deposits which contribute to further oil consumption as they interfere with proper engine function.

18. **Restricted Air Intake** -

Excessive restriction in the air intake system will increase engine vacuum and can increase oil consumption, an extremely dirty air filter would be one example of this situation.

INTAKE MANIFOLD LEAKS

An intake manifold air leak is characterized by lower than normal manifold vacuum. Also, one or more cylinders may not be functioning.

WARNING: **Use extreme caution when the engine is operating. Do not stand in a direct line with the fan. Do not put your hands near the pulleys, belts or the fan. Do not wear loose clothing.**

1. Start the engine.
2. Spray a small stream of water (using a spray bottle) at the suspected leak area.
3. If the engine RPMs change, the area of the suspected leak has been found.
4. Repair as required.

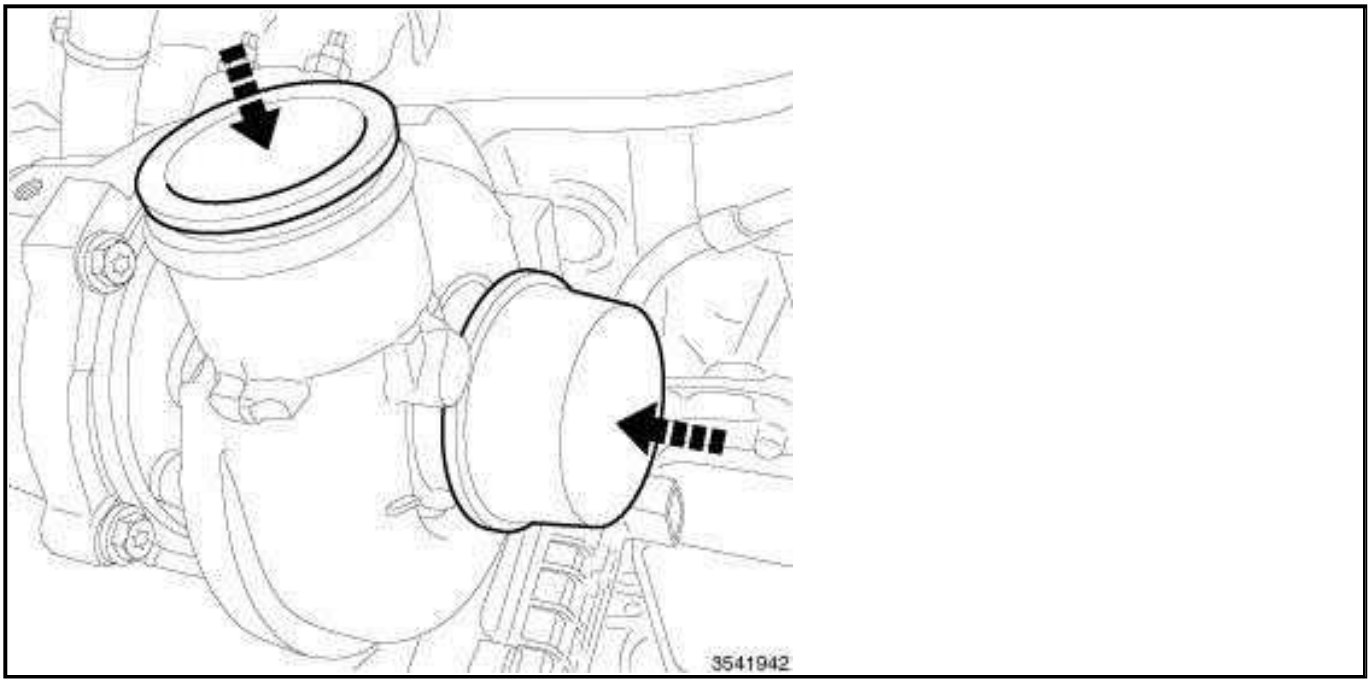
ENGINE LUBRICATION DIAGNOSTIC TABLE

CONDITION	POSSIBLE CAUSES	CORRECTION
OIL LEAKS	1. Misaligned or damaged gaskets and O-rings.	1. Replace as necessary.
	(a) Loose fasteners, broken or porous metal parts.	(a) Tighten fasteners, Repair or replace metal parts.
	2. Crankshaft rear oil seal.	2. Replace rear crankshaft oil seal. Refer to **SEAL, CRANKSHAFT OIL, REAR, REMOVAL AND INSTALLATION** .
	3. Crankshaft rear oil seal surface. Scratched, nicked or grooved.	3. Polish or replace crankshaft.
	4. Oil pan flange cracked.	4. Replace oil pan. Refer to **PAN, OIL, REMOVAL AND INSTALLATION** .
	5. Damaged or misaligned crankshaft front oil seal.	5. Replace front crankshaft oil seal. Refer to **SEAL, CRANKSHAFT OIL, FRONT, REMOVAL AND INSTALLATION** .
	6. Scratched or damaged vibration damper hub.	6. Polish or replace vibration damper.
OIL PRESSURE DROP	1. Low oil level.	1. Check and correct oil level.
	2. Faulty oil pressure sensor.	2. Replace oil pressure sensor. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION**.
	3. Low oil pressure.	3. Check main bearing clearance. Refer to **BEARING(S), CRANKSHAFT, MAIN, STANDARD PROCEDURE** . 3. Check rod bearing clearance. Refer to **BEARING(S), CONNECTING ROD, STANDARD PROCEDURE** .
	4. Clogged oil filter.	4. Replace oil filter. Refer to **FILTER, ENGINE OIL, REMOVAL AND INSTALLATION** .

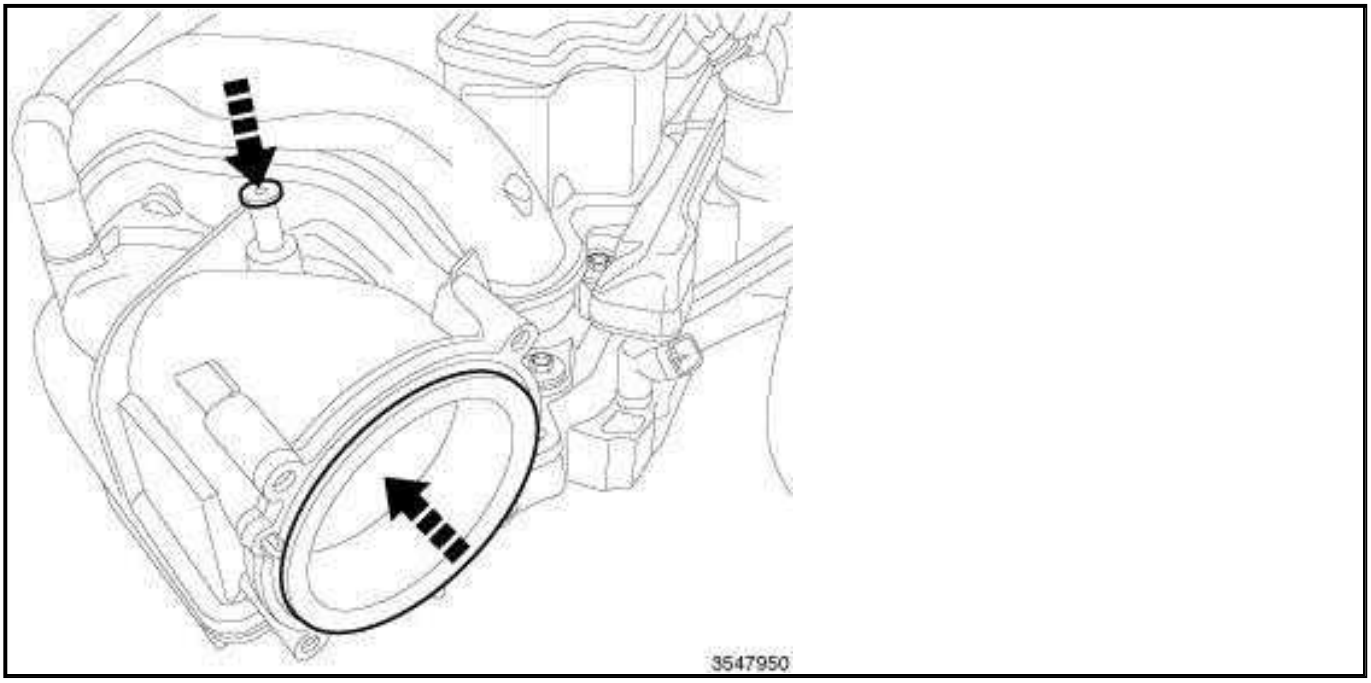
CONDITION	POSSIBLE CAUSES	CORRECTION
	5. Worn oil pump.	5. Replace oil pump. Refer to **PUMP, ENGINE OIL, REMOVAL AND INSTALLATION** .
	6. Thin or diluted oil.	6. Change oil and filter. Refer to **FILTER, ENGINE OIL** .
	7. Excessive bearing clearance.	7. Replace crankshaft bearings. Refer to **BEARING(S), CRANKSHAFT, MAIN, STANDARD PROCEDURE** . 7. Replace rod bearings. Refer to **BEARING(S), CONNECTING ROD, STANDARD PROCEDURE** .
	8. Oil pump relief valve stuck.	8. Replace oil pump. Refer to **PUMP, ENGINE OIL, REMOVAL AND INSTALLATION** .
	9. Oil pump pickup tube loose, damaged or clogged. 10. Damaged piston cooling jet.	9. Replace oil pump pick-up. Refer to **PICK-UP, OIL PUMP, REMOVAL AND INSTALLATION** . 10. Replace piston cooling jet. Refer to **JET, PISTON OIL COOLER, REMOVAL AND INSTALLATION** .
OIL PUMPING AT RINGS	1. Worn or damaged rings.	1. Hone cylinder bores and replace rings. Refer to **RING(S), PISTON, STANDARD PROCEDURE** .
	2. Carbon in oil ring slots.	2. Replace rings. Refer to **ROD, PISTON AND CONNECTING, REMOVAL AND INSTALLATION** .
	3. Worn valve guides.	3. Replace cylinder heads. Refer to **CYLINDER HEAD ASSEMBLY, REMOVAL AND INSTALLATION** .
	4. Leaking valve guide seals.	4. Replace valve guide seals. Refer to **SEAL(S), VALVE GUIDE, REMOVAL AND INSTALLATION** .

STANDARD PROCEDURE

DUST COVERS AND PROTECTIVE CAPS

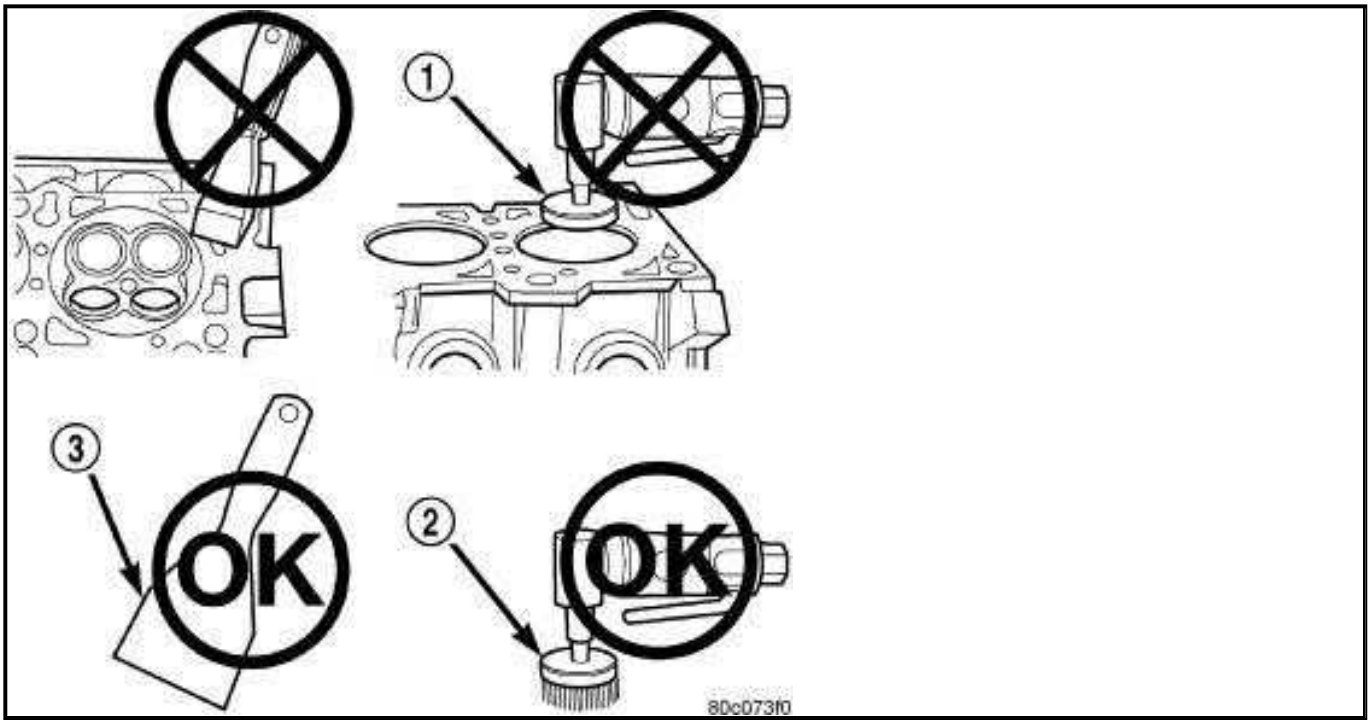


To avoid the possibility of dust, dirt, moisture and other foreign debris being introduced to the engine during service, cover or cap all openings when hoses and tubes are removed.



Covers installed over openings will reduce the possibility of foreign materials entering the engine systems. Using the (special tool #10368, Set, Universal Protective Cap), select the appropriate cover needed for the procedure.

ENGINE GASKET SURFACE PREPARATION



1 - Abrasive Pad
2 - 3M Roloc™ Bristle Disc
3 - Plastic/Wood Scraper

To ensure engine gasket sealing, proper surface preparation must be performed, especially with the use of aluminum engine components and multi-layer steel cylinder head gaskets.

DO NOT USE THE FOLLOWING TO CLEAN GASKET SURFACES:

- Metal scraper.
- Abrasive pad or paper to clean cylinder block and head.
- High speed power tool with an abrasive pad or a wire brush.

NOTE: **Multi-Layer Steel (MLS) head gaskets require a scratch free sealing surface.**

Only use the following for cleaning gasket surfaces:

- Solvent or a commercially available gasket remover.
- Plastic or wood scraper.
- Drill motor with 3M Roloc™ Bristle Disc (white or yellow).

CAUTION: **Excessive pressure or high RPM (beyond the recommended speed), can damage the sealing surfaces. The mild (white, 120 grit) bristle disc is recommended. If necessary, the medium (yellow, 80 grit) bristle disc may be used on cast iron surfaces with care.**

FORM-IN-PLACE GASKETS AND SEALERS

NOTE: **All of the sealants mentioned below are not used on every engine, they are listed as a general reference guide. See service information for specific sealer usage.**

There are numerous places where form-in-place gaskets are used on the engine. Care must be taken when applying form-in-place gaskets to assure obtaining the desired results. **Do not use form-in-place gasket material unless specified.** Bead size, continuity, and location are of great importance. Too thin a bead can result in leakage while too much can result in spill-over which can break off and obstruct fluid feed lines. A continuous bead of the proper width is essential to obtain a leak-free gasket. All sealing surfaces that use form-in-place

gaskets and sealers **must** be free of grease or oil. Surfaces should be cleaned with MoparB® brake parts cleaner prior to sealer application. After the sealer is applied, the parts should be assembled within 10 minutes.

There are numerous types of form-in-place gasket materials that are used in the engine area. Each has different properties and can not be used in place of the other.

SEALANT TYPES

- **MoparB® Engine Sealant RTV Silicone Rubber Adhesive** is used to seal components exposed to engine oil. This material is a specially designed black silicone rubber RTV that retains adhesion and sealing properties when exposed to engine oil. Moisture in the air causes the material to cure. This material is available in three ounce tubes and has a shelf life of one year. After one year this material will not properly cure. Always inspect the package for the expiration date before use.
- **MoparB® ATF-RTV** is a specifically designed black silicone rubber RTV that retains adhesion and sealing properties to seal components exposed to automatic transmission fluid, engine coolants, and moisture. This material is available in three ounce tubes and has a shelf life of one year. After one year this material will not properly cure. Always inspect the package for the expiration date before use.
- **MoparB® Gasket Maker** is an anaerobic type gasket material. The material cures in the absence of air when squeezed between two metallic surfaces. It will not cure if left in the uncovered tube. The anaerobic material is for use between two machined surfaces. Do not use on flexible metal flanges.
- **MoparB® Bed Plate Sealant** is a unique (green-in-color) anaerobic type gasket material that is specially made to seal the area between the bed plate and cylinder block without disturbing the bearing clearance or alignment of these components. The material cures slowly in the absence of air when torqued between two metallic surfaces and will rapidly cure when heat is applied.
- **MoparB® Threebond™ Engine RTV** is formulated as a high performance temperature vulcanized silicone with good elasticity, temperature and chemical resistance when cured. It is resistant to engine oil, transmission fluid and gear lube but not recommended for sealing engine coolant.

SEALANT APPLICATION

- MoparB® Gasket Maker material should be applied sparingly 1 mm (0.040 in.) diameter or less of sealant to one gasket surface. Be certain the material surrounds each mounting hole. Excess material can easily be wiped off. Components should be torqued in place within 15 minutes. The use of a locating dowel is recommended during assembly to prevent smearing material off the location.
- MoparB® Engine Sealant RTV or ATF-RTV gasket material should be applied in a continuous bead approximately 3 mm (0.120 in.) in diameter. All mounting holes must be circled. For corner sealing and "T" joint locations, a 3.17 or 6.35 mm (1/8 or 1/4 in.) drop is placed in the center of the gasket contact area. Uncured sealant may be removed with a shop towel. Components should be torqued in place while the sealant is still wet to the touch (within 10 minutes). The usage of a locating dowel is recommended during assembly to prevent smearing material off the location.
- MoparB® Threebond™ Engine RTV Sealant gasket material should be applied in a continuous bead approximately 3 mm (0.120 in.) in diameter. The gasket surfaces should be cleaned with isopropyl alcohol wipes in preparation for sealant application. All mounting holes must be circled. For corner sealing and "T" joint locations, a 3.17 or 6.35 mm (1/8 or 1/4 in.) drop is placed in the center of the gasket contact area. Uncured sealant may be removed with a shop towel. Components should be assembled within 10 minutes and torqued in place within 45 minutes. The usage of a locating dowel is recommended during assembly to prevent smearing material off the location.

HEAD BOLT THREAD REPAIR

NOTE: **The following procedure is performed using the TFC8313 3.6L Cylinder Head Bolt Thread Repair Kit**

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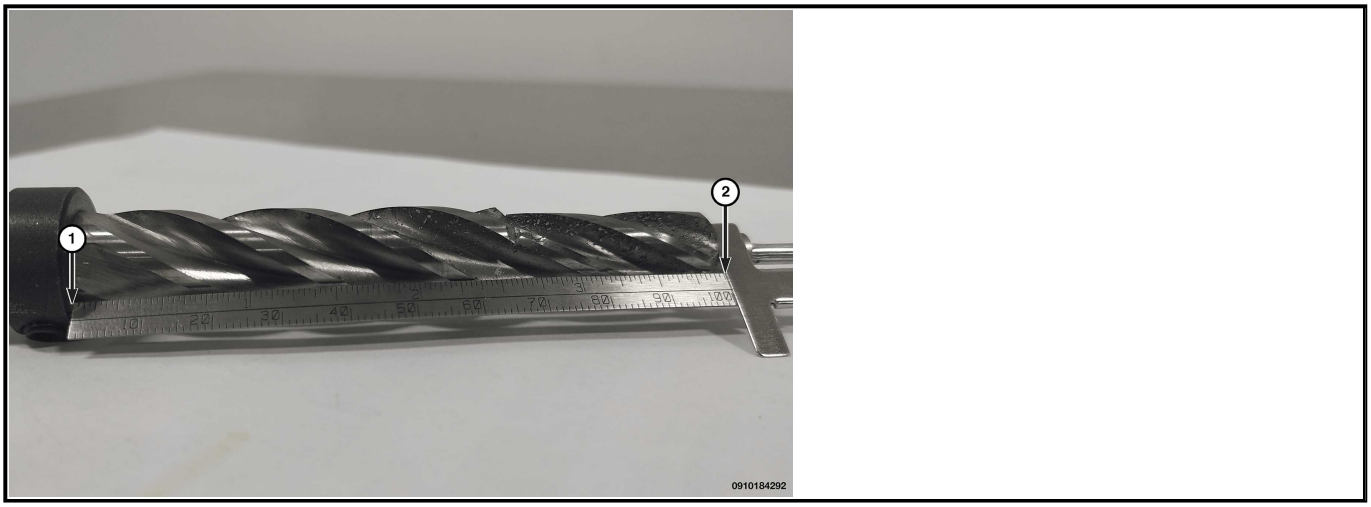
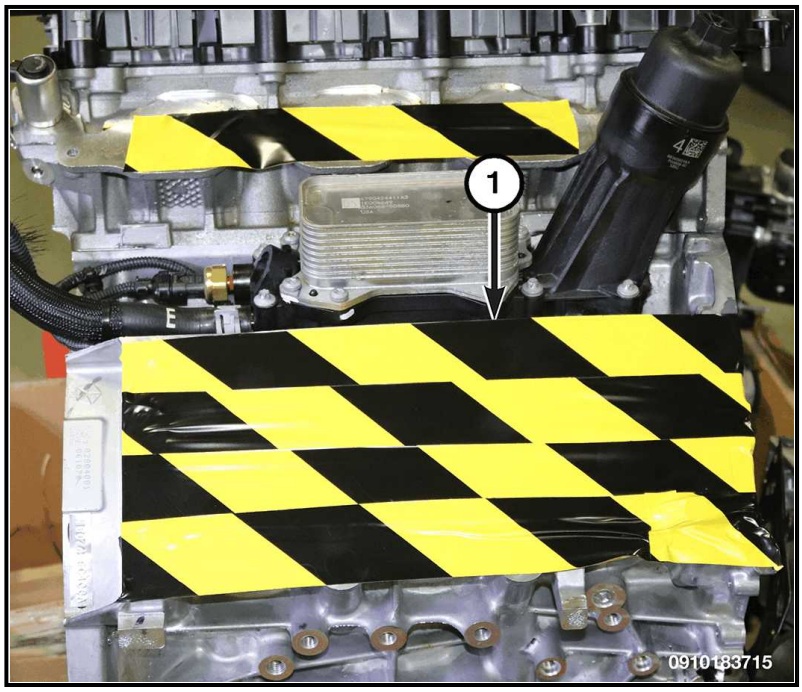
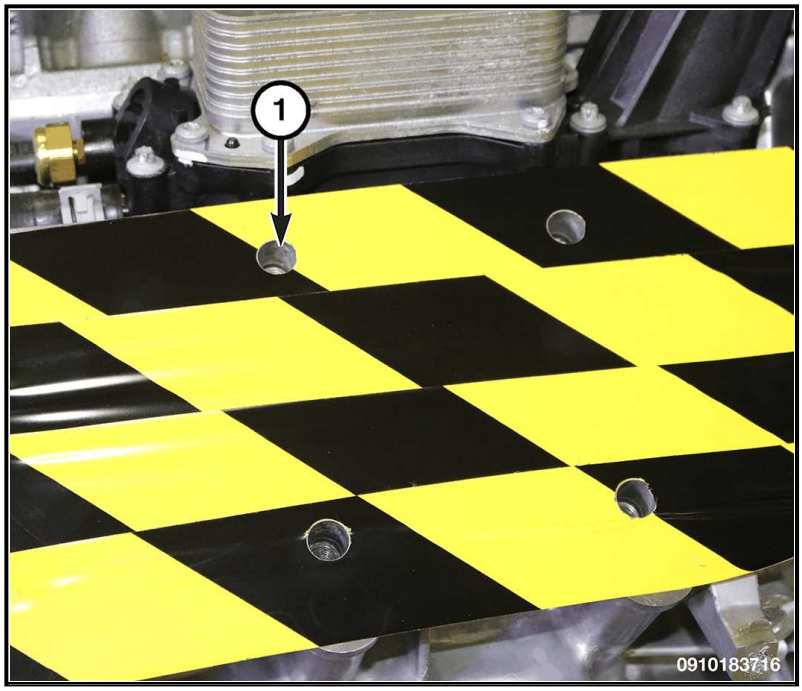


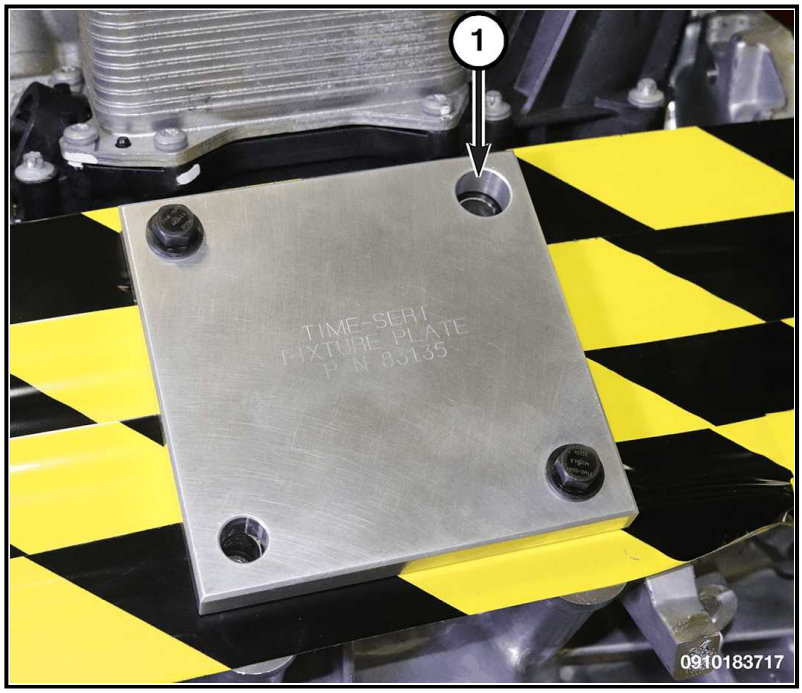
1. Mark the core drill starting from the bottom cutting edge (2) up to the bottom of the drill stop collar (1) for a total drill depth of 100 mm.



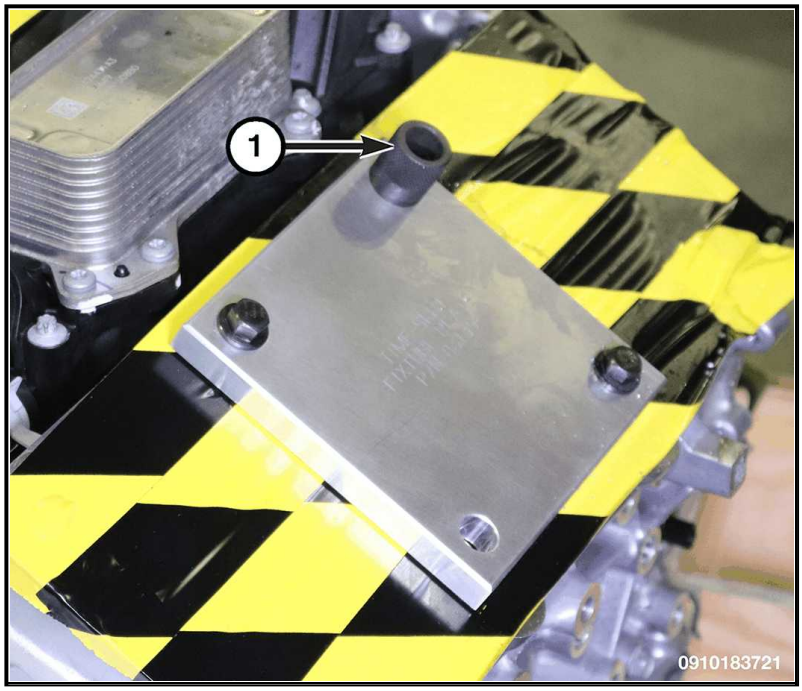
2. All open ports must be covered with tape (1) to prevent any debris from entering the engine.



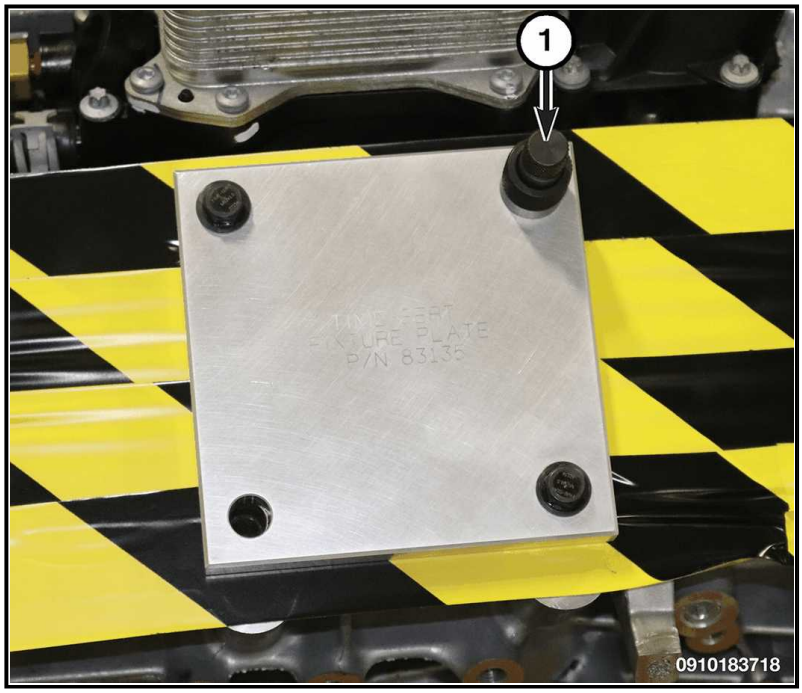
3. Remove the tape from only the holes (1) in which the drill fixture will be mounted.



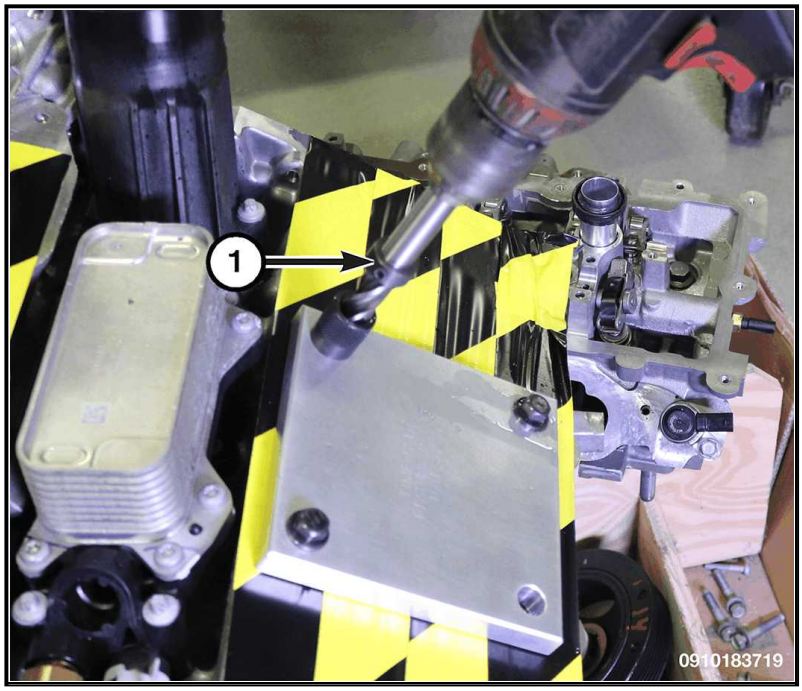
4. If necessary, remove the cylinder head alignment dowel pins from the engine block.
5. Place the drill fixture bushing hole (1) over the hole to be repaired and loosely install the bolts.



6. Install the drill bushing (1) into the fixture.

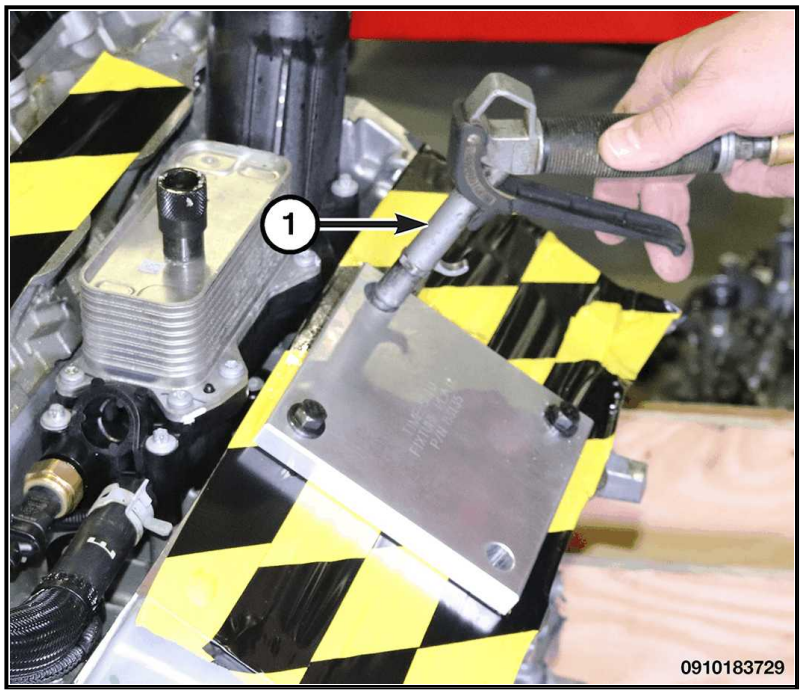


7. Place the line pin (1) into the drill bushing pick-up hole using minimal down pressure on the line pin. Tighten the drill fixture mounting bolts to 12 N.m, then remove the line pin.



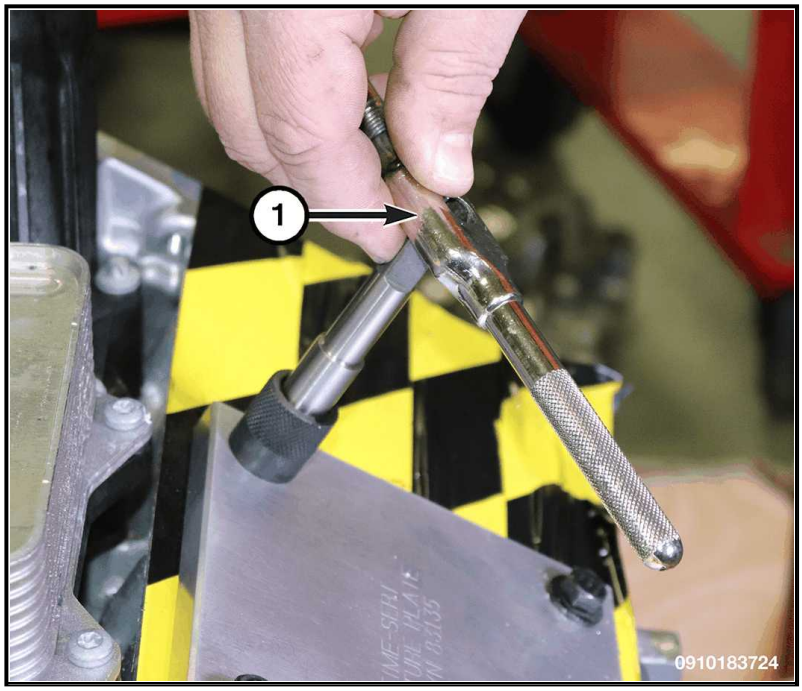
NOTE: **The use of drilling lubricant is required.**

8. Using a suitable drill motor and the supplied step drill bit with stop collar (1) properly adjusted to the correct depth, drill the hole until the stop collar touches the top of the drill bushing. Start the drill rotation after the drill is inside of the busing to prevent dulling of the cutting edges. This will require removing the drill and bushing several times to clear the metal chips.

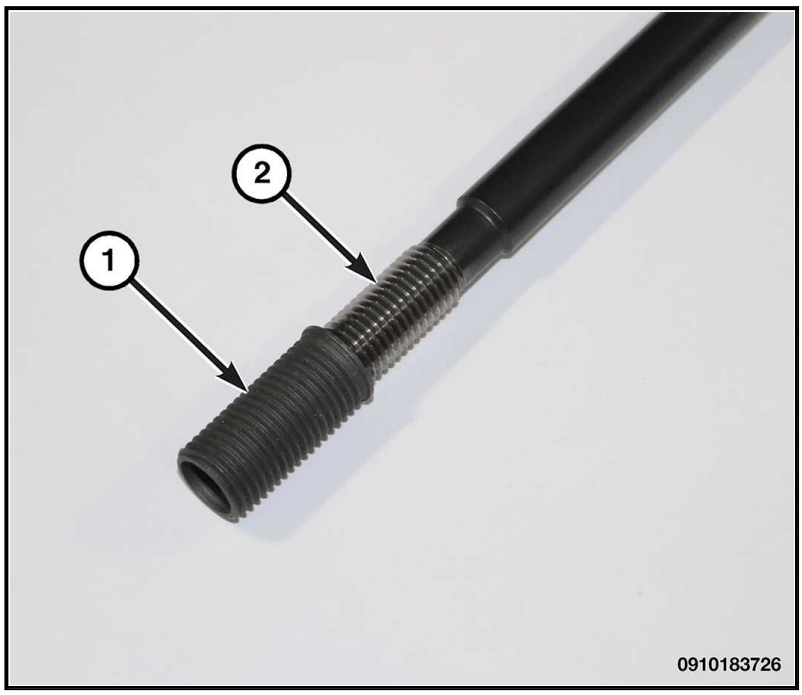


9. Thoroughly clean out all metal chips and debris using a long air nozzle (1) that must reach the bottom of the hole.

NOTE: **The use of drilling lubricant is required.**



10. Tap (1) through the drill bushing until the tap bottoms out. This will require removing the tap and bushing several times to clear metal chips. Clean all of the metal chips and debris using a brake or contact cleaner that will not leave an oily residue.
11. Use a flashlight to inspect the hole for chips and cleanliness. The hole must be clean and dry.



12. Lubricate the threads of the driver tool (2) with Time-Sert™ driver oil J-42385-110 or equivalent, using caution not to get oil onto the outer threads of the insert (1).
13. Screw an insert (1) onto the driver tool, rotating 2 turns.

14. Apply a drop of the supplied sealer (1) on the bottom threads of the insert and screw the insert into the prepared hole. When the head of the insert is seated, the driver will tighten up. Tighten the insert to 12 N.m to seat the insert, then remove the insert driver.
15. Remove the tape and thoroughly clean any residue.

NOTE: **When installing the cylinder head, the proper torque sequence and torque MUST be followed in accordance with the service procedures.**

REPAIR DAMAGED OR WORN THREADS

NOTE: **If stripped/pulled threads are found during removal of a main bearing cap bolt, the cylinder block must be replaced. DO NOT INSTALL A THREAD REPAIR KIT (Heli-Coil™).**

CAUTION: **Be sure that the tapped holes maintain the original center line.**

Damaged or worn threads

cannot

be repaired in the following locations:

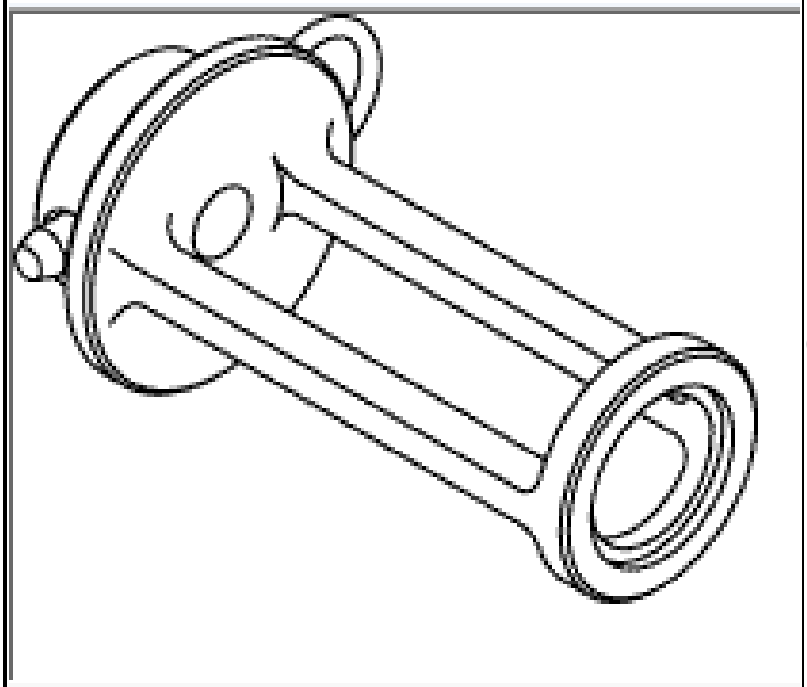
- Spark plug threads in the cylinder head.
- Camshaft bearing cap attaching threads.
- Crankshaft main bearing cap bolt threads in the engine block.

On many applications, damaged or worn threads can be repaired. Essentially, this repair consists of:

- Drilling out worn or damaged threads.
- Tapping the hole with a special Heli-Coil™ Tap, or equivalent.
- Installing an insert into the tapped hole to bring the hole back to its original thread size.

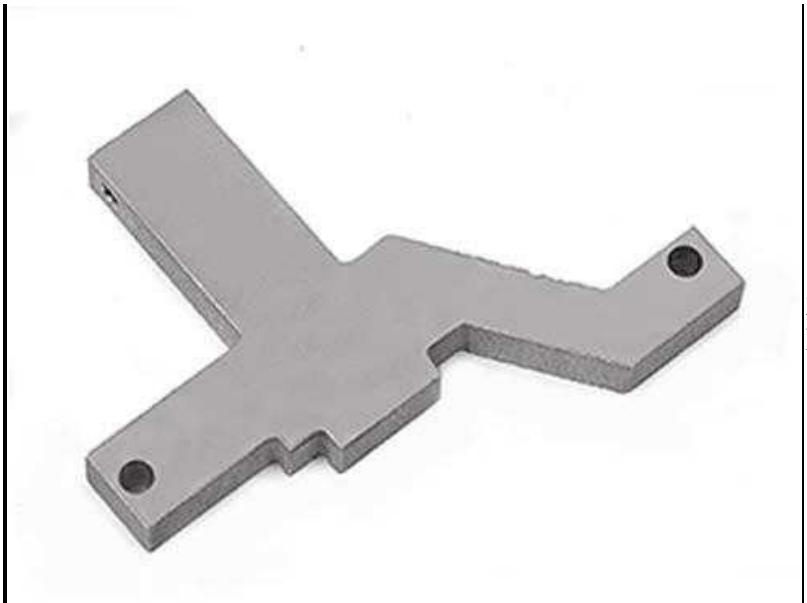
SPECIAL TOOLS

2021500090 - Adapter, Late Version 3.6L Oil Pressure Test

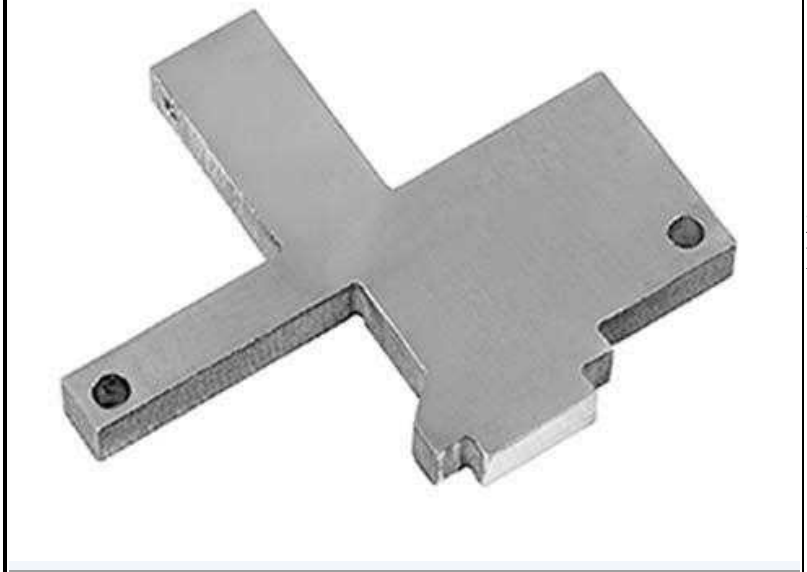


10224 - Adapter, Valve Spring (Originally Shipped In Kit Number(s) 10223.)

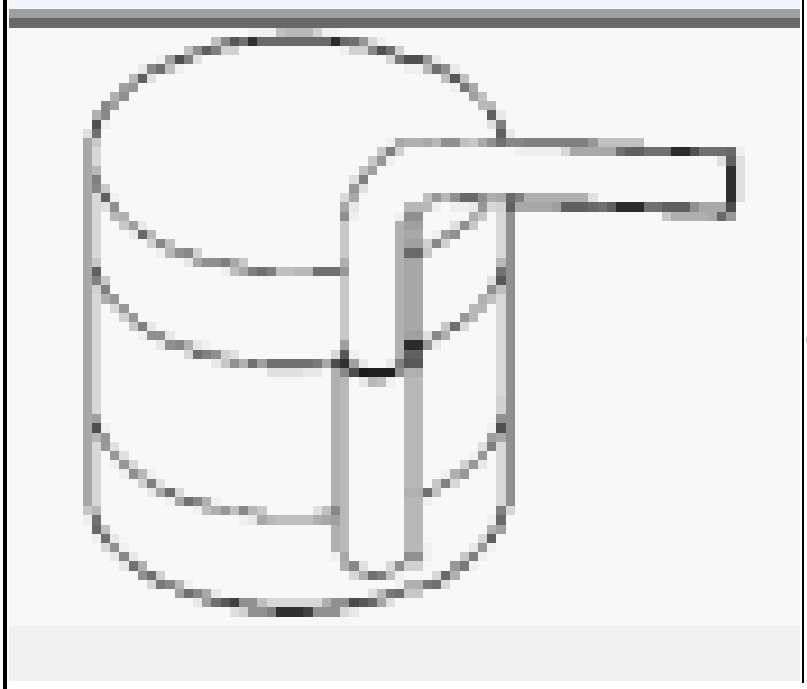
C-3685-A - Bloc-Chek Kit



2027902090 - Check Tool, Tone Wheel Right

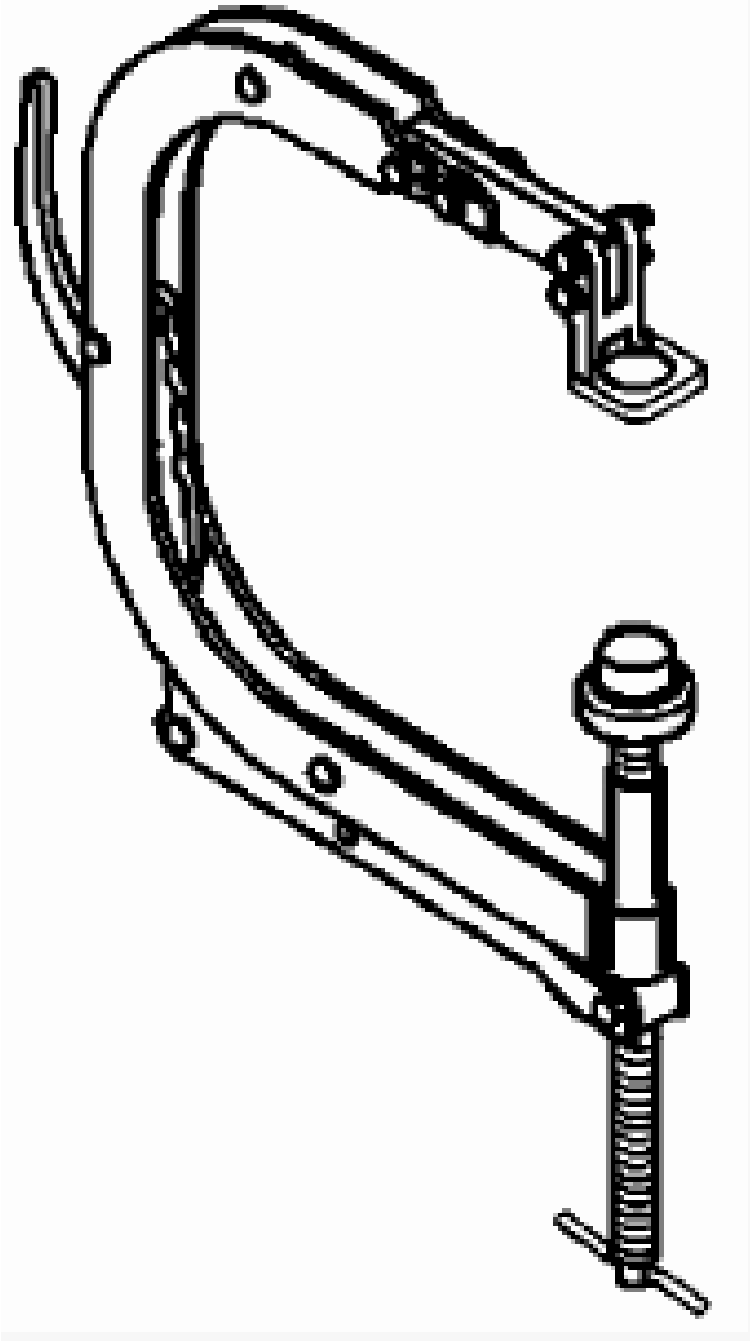


2027901090 - Check Tool, Tone Wheel Left

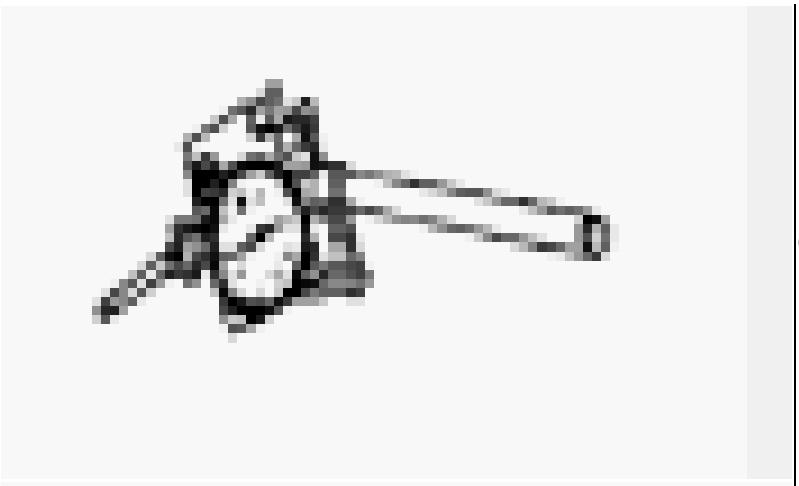


C-385 - Compressor, Piston

MD998772A - Compressor, Valve Spring (Originally Shipped In Kit Number(s) 8678, 8853, 8854.)

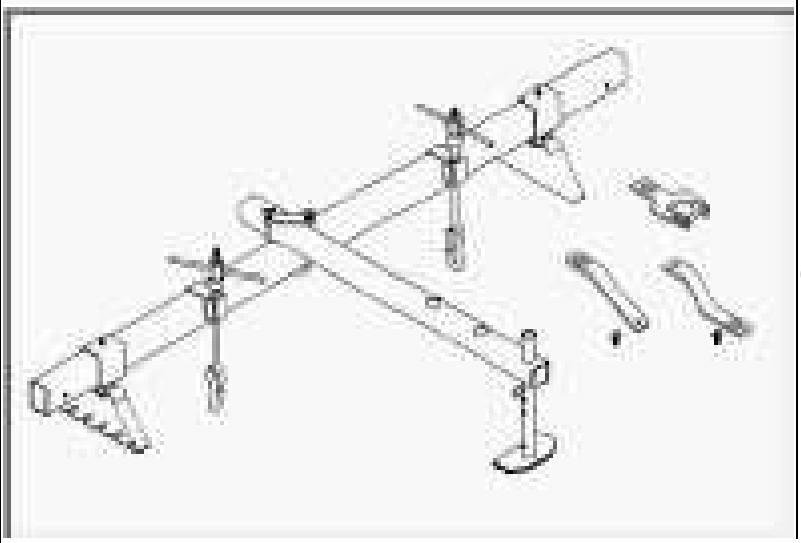


C-3422-D - Compressor, Valve Spring

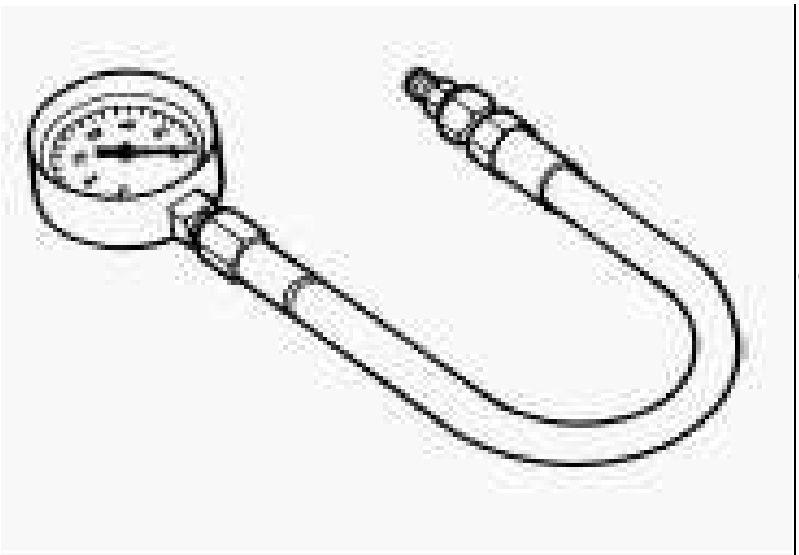


C-119 - Cylinder Indicator

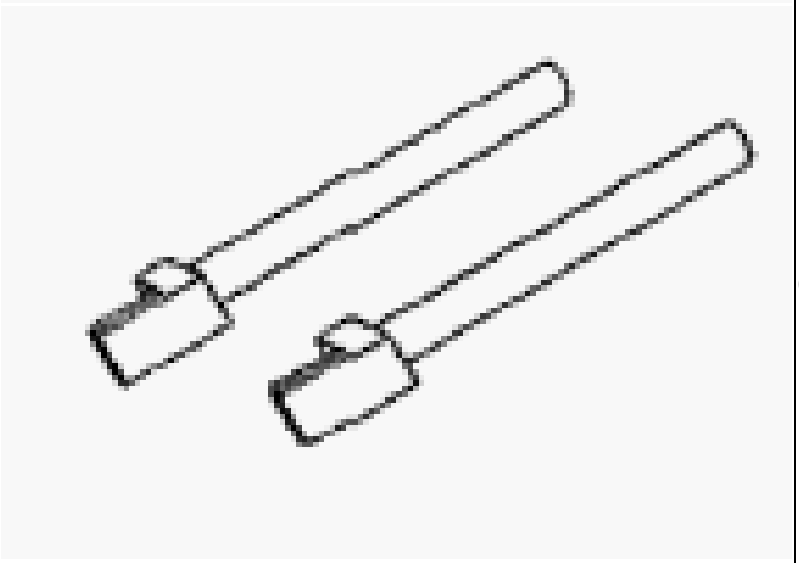
8875A - Disconnect, Transmission Cooler Line
(Originally Shipped In Kit Number(s) 9202, 9328, 9328-CAN, 9329, 9516, 9575.)



8534C - Fixture, Driveline Support
(Originally Shipped In Kit Number(s) 8534, 8534B, 8849, 9565.)



C-3292A - Gauge, Pressure



8189 - Guide Pins
(Originally Shipped In Kit Number(s) 8180, 8180CC, 8263, 8263CC.)

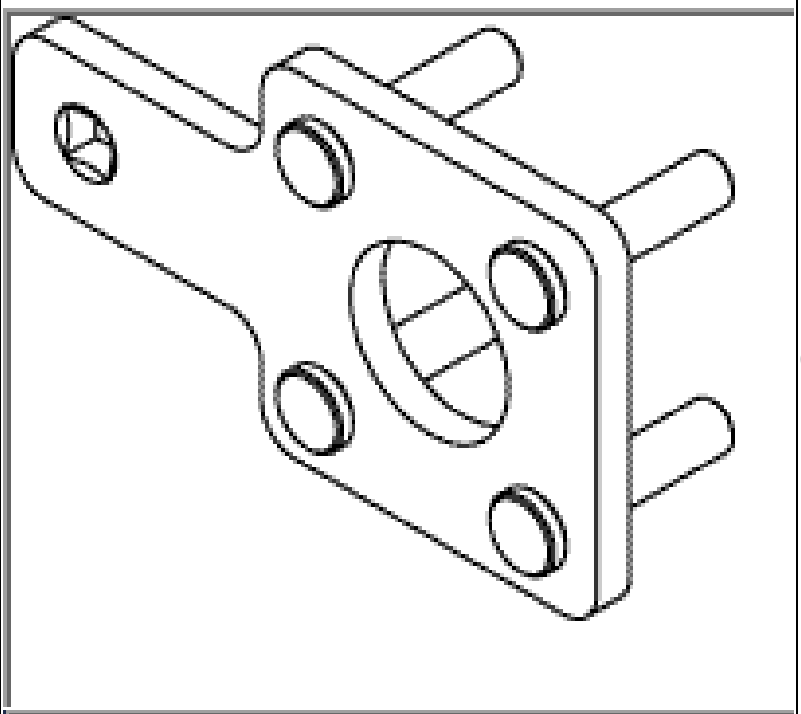
2025200090 - Holder, Camshaft

2025102090 - Holder, Camshaft Phaser - Right-Rear Cyl Head

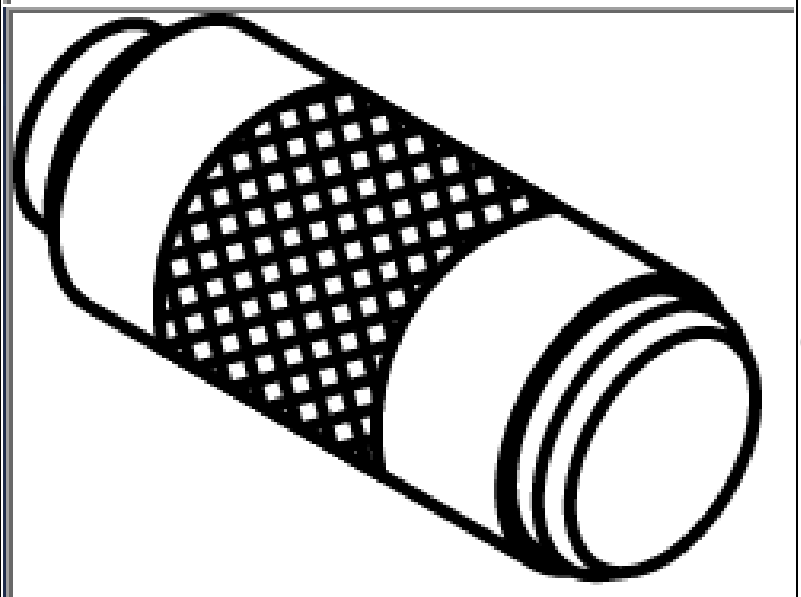
2025101090 - Holder, Camshaft Phaser - Left-Front Cyl Head

2025001090 - Holder, Timing Chain Tensioner, Left-Front

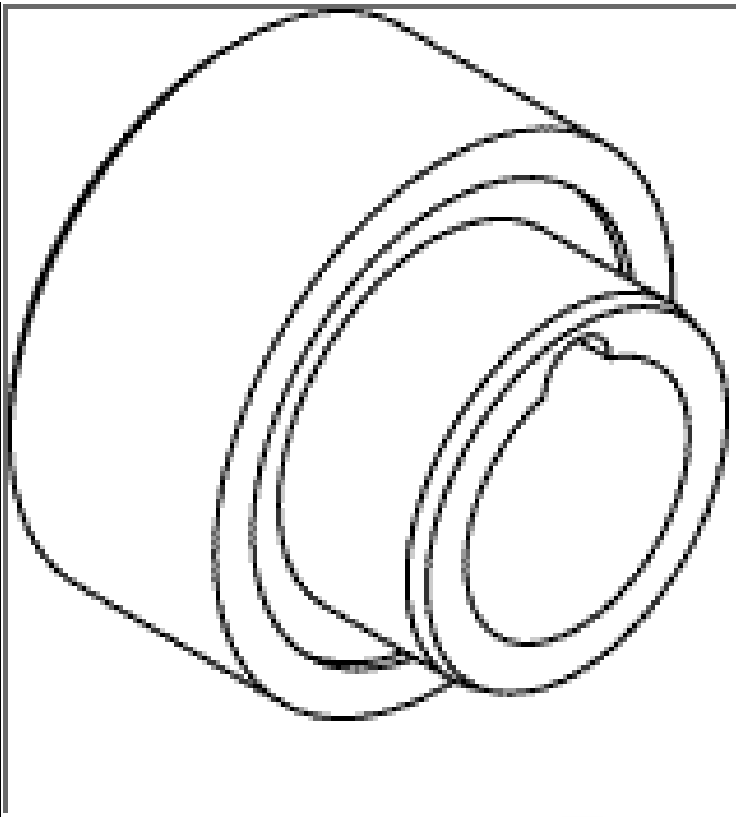
2025002090 - Holder, Timing Chain Tensioner, Right-Rear



10198 - Holder, Vibration Damper (Originally Shipped In Kit Number(s) 10223.)



10256 - Installer, Cam Installer, Cam Sensor/ Spark Plug Tube Seal (Originally Shipped In Kit Number(s) 10256.)



10199 - Installer, Crankshaft Front Oil Seal (Originally Shipped In Kit Number(s) 10223.)

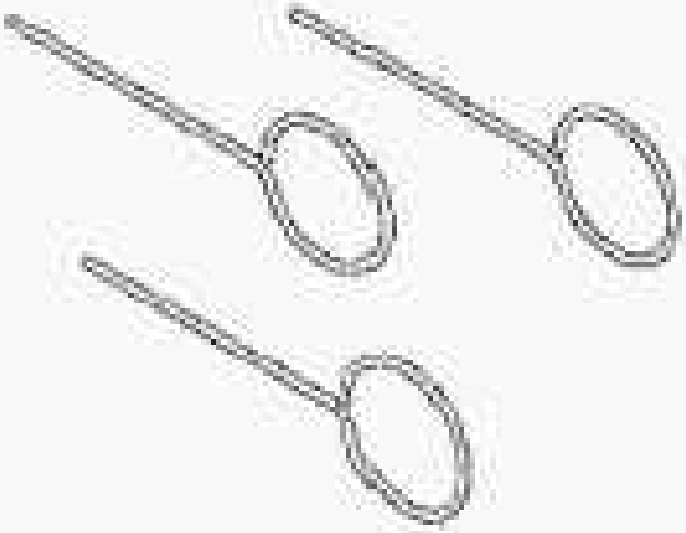
2024900090 - Installer, Spark Plug Tube

2027300090 - Kit, VVL Adapters

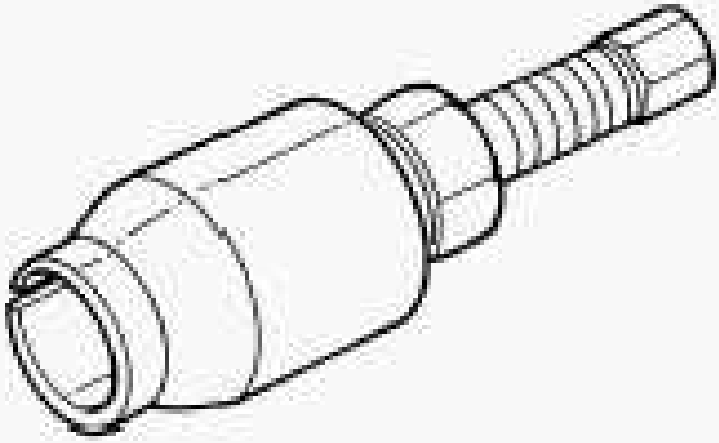
2028020090 - Lift Bracket, Engine-Left

2028010090 - Lift Bracket, Engine-Right

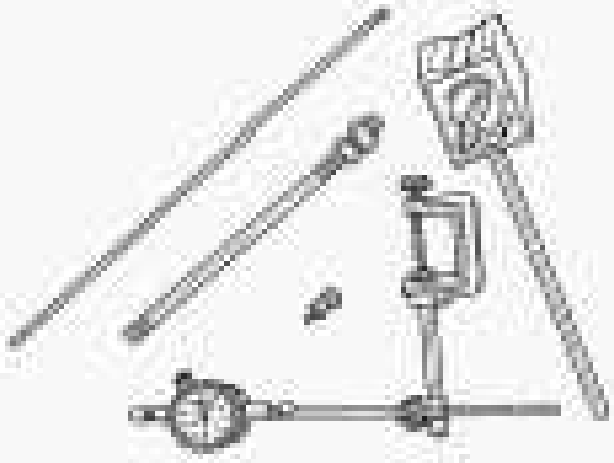
2025003090 - Pin, Chain Tensioner



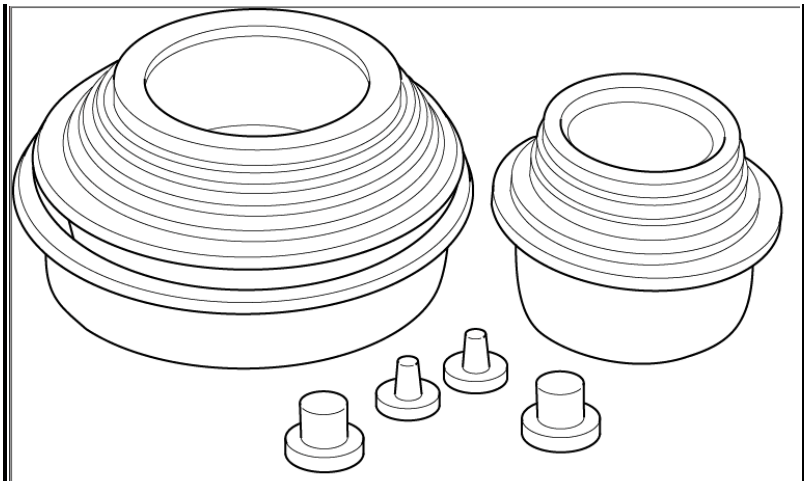
8514A - Pins, Tensioner
(Originally Shipped In Kit Number(s) 8283, 8283CC, 8527, 8527CC, 8575, 8575CC, 9975.)



8511 - Remover, Seal
(Originally Shipped In Kit Number(s) 8283, 8283CC, 8527, 8527CC, 8575, 8575CC, 9975.)



C-3339A - Set, Dial Indicator
(Originally Shipped In Kit Number(s) 9202.)

	10368 - Set, Universal Protective Cap

TECHNICAL SPECIFICATIONS

ENGINE SPECIFICATIONS

GENERAL SPECIFICATIONS

Description	Specification
Type	60B° DOHC V-6 24-Valve
Compression Ratio	11.3:1
Lead Cylinder	#1 Right Bank
Firing Order	1-2-3-4-5-6
Max horsepower (Peak Power)	283 - 305
Engine Speed of Peak Power	6400 RPM
Max Torque	260 (ft. lbs).
Fuel Shutoff	6700 RPM

OIL PRESSURE - UPGRADE ENGINE

Description	Specification	
	Metric	Standard
NOTE: Values in the table are valid for coolant temperature between 89 - 100B°C.		
Pressure @ Curb Idle Speed (650 RPM)*	103.4 - 234.4 kPa	15 - 34 psi
Pressure @ 1000 - 3000 RPM	193 - 241.3 kPa	28 - 35 psi
Pressure Above 3500 RPM	448.2 - 551.6 kPa	65 - 80 psi
*CAUTION: If oil pressure is zero at idle, DO NOT run the engine.		

Description	Metric	Standard
Displacement	3.6 Liters	220 Cubic Inches
Bore and Stroke	96.0 x 83.0 mm	3.779 in. x 3.268 in.

CYLINDER BLOCK

Description	Specification	
	Metric	Standard
Cylinder Bore Diameter - Grade 1	95.995 mm B± 0.005 mm	3.7793 in. B± 0.0002 in.
Cylinder Bore Diameter - Grade 2	96.005 mm B± 0.005 mm	3.7797 in. B± 0.0002 in.
Cylinder Bore Out-of-Round (Max.)	0.009 mm	0.00035 in.
Cylinder Bore Cylindricity	0.014 mm	0.0006 in.
Crankshaft Bore Taper* (Max.)	0.006 mm	0.0002 in.
Flatness (Head Gasket Surface)	0.09 mm	0.0035 in.

Description	Specification	
	Metric	Standard
*Measured over length of bulkhead		
Engine Oil Galley Plug**	0.0 mm - 2.0 mm	0.0 in - 0.0787 in
**Measured proud of machined surface		

PISTONS

Description	Specification	
	Metric	Standard
Material	Cast Aluminum Alloy	
Piston Diameter (Metal to Metal) - Grade 1	95.955 mm B± 0.005 mm	3.7778 in. B± 0.0002 in.
Piston Diameter (Metal to Metal) - Grade 2	95.965 mm B± 0.005 mm	3.7781 in. B± 0.0002 in.
Piston Diameter (Metal to Coating) - Grade 1	95.970 - 96.000 mm	3.7783 - 3.7795 in.
Piston Diameter (Metal to Coating) - Grade 2	95.980 - 96.010 mm	3.7787 - 3.7835 in.
Clearance at Size Location (Metal to Metal)	0.030 - 0.050 mm	0.0012 - 0.0020 in.
Clearance at Size Location (Metal to Coating)	0.010 - 0.030 mm	0.0004 - 0.0012 in.
Piston Weight	386 - 396 grams	13.61 - 13.97 oz.
Piston Pin Offset	0.6 mm	0.024 in.
Piston Ring Groove Diameter - No. 1	88.20 - 88.40 mm	3.472 - 3.480 in.
Piston Ring Groove Diameter - No. 2	87.80 - 88.0 mm	3.45 - 3.46 in.
Piston Ring Groove Diameter - No. 3	89.16 - 89.36 mm	3.510 - 3.518 in.

PISTON PINS

Description	Specification	
	Metric	Standard
Type	Full Floating	
Pin Diameter	22.000 - 21.995 mm	0.08661 - 0.8659 in.
Clearance in Piston	0.004 - 0.015 mm	0.00015 - 0.00059 in.
Clearance in Rod	0.011 - 0.026 mm	0.0004 - 0.001 in.

PISTON RINGS

Description	Specification	
	Metric	Standard
Ring Gap - Number 1 Ring (Top)	0.20 - 0.30 mm	0.0079 - 0.0118 in.
Ring Gap - Number 2 Ring (Center)	0.30 - 0.45 mm	0.012 - 0.018 in.
Ring Gap - Oil Control Ring (Steel Rails)	0.15 - 0.66 mm	0.006 - 0.026 in.

PISTON RING SIDE CLEARANCE

Description	Specification	
	Metric	Standard
Number 1 Ring (Top)	0.025 - 0.083 mm	0.0010 - 0.0033 in.
Number 2 Ring (Center)	0.030 - 0.078 mm	0.0012 - 0.0031 in.

Description	Specification	
	Metric	Standard
Oil Control Ring (Steel Rails)	0.027 - 0.21 mm	0.0011 - 0.0083 in.

PISTON RING WIDTH

Description	Specification	
	Metric	Standard
Number 1 Ring (Top)	2.97 - 3.23 mm	0.1169 - 0.1271 in.
Number 2 Ring (Center)	2.97 - 3.23 mm	0.1169 - 0.1271 in.
Oil Control Ring (Steel Rails)	1.930 - 2.083 mm	0.076 - 0.082 in.

CONNECTING RODS

Description	Specification	
	Metric	Standard
Bearing Clearance (With Crush)	0.023 - 0.064 mm	0.0009 - 0.0025 in.
Side Clearance	0.070 - 0.370 mm	0.0028 - 0.0146 in.
Side Clearance (Max.)	0.370 mm	0.0146 in.
Piston Pin Bore Diameter	22.016 B± 0.005 mm	0.8668 B± 0.0002 in.
Bearing Bore Out of Round (Max.)	0.008 mm	0.0003 in.
Total Weight (Less Bearing)	531.8 B± 8 grams	18.76 B± 0.28 oz.

CRANKSHAFT MAIN BEARING JOURNALS

Description	Specification	
	Metric	Standard
Diameter	67.996 B± 0.009 mm	2.677 B± 0.0035 in.
Bearing Clearance	0.024 - 0.050 mm	0.0009 - 0.0020 in.
Bearing Clearance (Max Wear Limit.)	0.055 mm	0.0022 in.
Out of Round (Max.)	0.005 mm	0.0002 in.
Taper (Max.)	0.005 mm	0.0002 in.
End Play	0.050 - 0.290 mm	0.0020 - 0.0114 in.
End Play (Max.)	0.290 mm	0.0114 in.

CONNECTING ROD JOURNALS

Description	Specification	
	Metric	Standard
Diameter	54.000 B± 0.009 mm	2.126 B± 0.0035 in.
Bearing Clearance	0.023 - 0.064 mm	0.0009 - 0.0025 in.
Out of Round (Max.)	0.005 mm	0.0002 in.
Taper (Max.)	0.005 mm	0.0002 in.

CAMSHAFT

Description	Specification	
	Metric	Standard
Bore Diameter - No. 1 Cam Towers	32.020 - 32.041 mm	1.260 - 1.261 in.
Bore Diameter - No. 2, 3, 4 Cam Towers	24.020 - 24.041 mm	0.945 - 0.946 in.
Bearing Journal Diameter - No. 1	31.976 - 31.995 mm	1.259 - 1.260 in.
Bearing Journal Diameter - No. 2, 3, 4	23.977 - 23.996 mm	0.944 - 0.945 in.
Bearing Clearance - No. 1	0.026 - 0.065 mm	0.001 - 0.003 in.
Bearing Clearance - No. 2, 3, 4	0.025 - 0.064 mm	0.000 - 0.002 in.

Description	Specification	
	Metric	Standard
High Lift Intake Duration Valve Timing @ 0.1524 mm Valve Lift (0.006")	261B°	
Low Lift Intake Duration Valve Timing @ 0.1524 mm Valve Lift (0.006")	147B°	
Duration - Exhaust Valve Timing @ 0.1524 mm Valve Lift (0.006")	260B°	
End Play	.214 mm	0.008 in.
Valve High Lift-Intake (Zero Lash)	10.3 mm	0.406 in.
Valve Low Lift-Intake (Zero Lash)	5.75 mm	0.226 in.
Valve Lift-Exhaust (Zero Lash)	10.0 mm	0.394 in.

VALVE TIMING-INTAKE VALVES

Description	Specification
High Lift - Opens	19B° (ATDC)
Low Lift - Opens	32B° (ATDC)
High Lift - Closes	280B° (ATDC)
Low Lift - Closes	179B° (ATDC)
High Lift - Centerline	146B°
Low Lift - Centerline	104B°
Note: Units are in crank degrees, using valve timing @ 0.1524 mm Valve Lift (0.006") as the threshold.	

VALVE TIMING-EXHAUST VALVES

Description	Specification
Opens	250B° (BTDC)
Closes	10B° (ATDC)
Centerline	123B°
Note: Units are in crank degrees, using valve timing @ 0.1524 mm Valve Lift (0.006") as the threshold.	

CYLINDER HEAD

Description	Specification	
	Metric	Standard
Gasket Thickness* (Compressed)	0.48 - 0.60 mm	0.019 - 0.024 in.
Flatness (Head Gasket Surface)	0.09 mm	0.0035 in.
Valve Seat Angle	44.75B° B± 0.25B° from the valve guide axis	
Valve Seat Runout (relative to the valve guide axis) - Intake and Exhaust	0.050 mm	0.002 in.
Intake Valve Seat Width	1.15 - 1.45 mm	0.045 - 0.057 in.
Exhaust Valve Seat Width	1.628 - 1.928 mm	0.064 - 0.076 in.
Guide Bore Diameter (Std.)	6.00 - 6.02 mm	0.236 - 0.237 in.
Valve Guide Height** - Intake and Exhaust	19.15 - 19.65 mm	0.753 - 0.774 in.
*Measured at the fire ring, not at the outer edge **Measured from cylinder head valve spring seat surface to top of guide		

VALVES

Description	Specification	
	Metric	Standard
Face Angle	45.25B° B± 0.25B°	
Head Diameter - Intake	39.0 B± 0.100 mm	1.535 B± 0.004 in.
Head Diameter - Exhaust	30.0 B± 0.100 mm	1.181 B± 0.004 in.
Length-Intake (Overall)	109.426 B± 0.23 mm	4.308 B± 0.009 in.
Length-Exhaust (Overall)	111.525 B± 0.23 mm	4.391 B± 0.009 in.
Stem Diameter - Intake	5.968 B± 0.009 mm	0.2350 B± 0.0004 in.
Stem Diameter - Exhaust	5.961B± 0.009 mm	0.2347 B± 0.0004 in.
Stem-to-Guide Clearance - Intake (New)	0.023 - 0.061 mm	0.0009 - 0.0024 in.
Stem-to-Guide Clearance - Exhaust (New)	0.030 - 0.068 mm	0.0012 - 0.0027 in.
Stem-to-Guide Clearance-Intake (Max., Rocking Method)	0.29 mm	0.011 in.
Stem-to-Guide Clearance - Exhaust (Max., Rocking Method)	0.37 mm	0.015 in.
Valve Stem Tip Height* - Intake	46.3 - 47.4 mm	1.822 - 1.866 in.
Valve Stem Tip Height* - Exhaust	48.73 - 49.83 mm	1.919 - 1.962 in.
*Valve tip to aluminum spring seat boss		

VALVE SPRING

Description	Specification	
	Metric	Standard
Free Length - Intake and Exhaust (Approx.)	52.5 mm	2.067 in.
Spring Force - Intake and Exhaust (Valve Closed)	266 B± 13 N @ 41.0 mm	60 B± 3 lbs. @ 1.61 in.
Spring Force - Intake (Valve Open)	688 B± 31 N @ 10.3 mm	155 B± 7 lbs. @ 0.4055 in.
Spring Force - Exhaust (Valve Open)	676 B± 30 N @ 10.0 mm	152 B± 6 lbs. @ 0.3937 in.
Number of Coils - Intake and Exhaust	9.35	
Wire Diameter - Intake and Exhaust	3.18 x 3.99 mm (ovate)	0.125 x 0.157 in. (ovate)
Installed Height - Intake and Exhaust (Spring seat top to bottom of retainer)	41.0 mm	1.61 in.

TORQUE SPECIFICATIONS

AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-

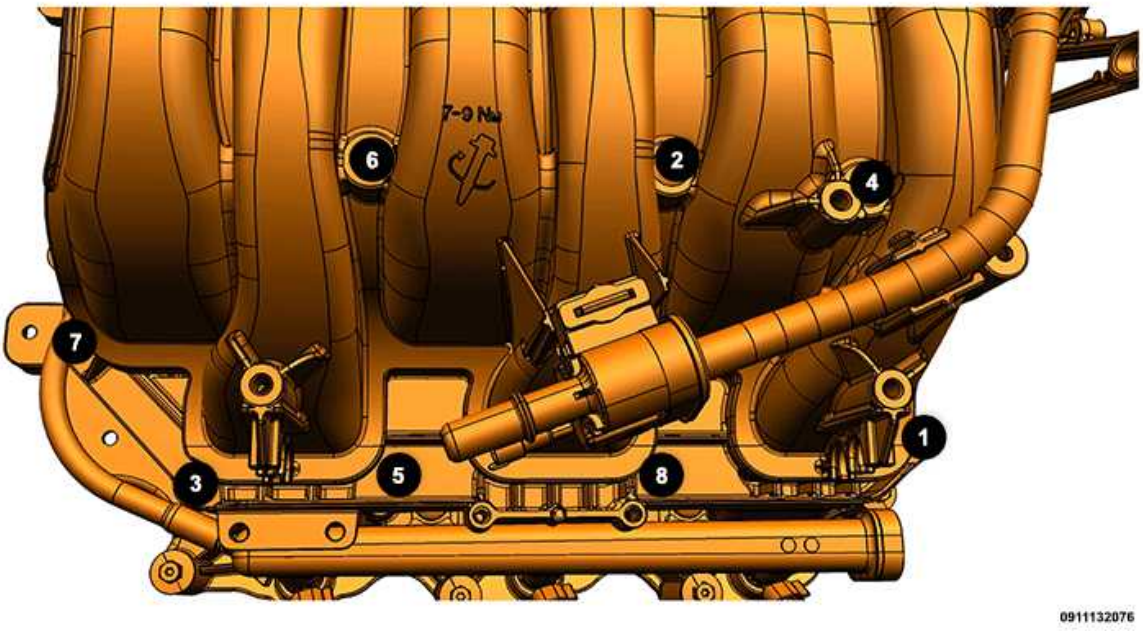


Fig. 1: Upper Intake Manifold Bolts Tightening/Loosening Sequence
Courtesy of CHRYSLER GROUP, LLC

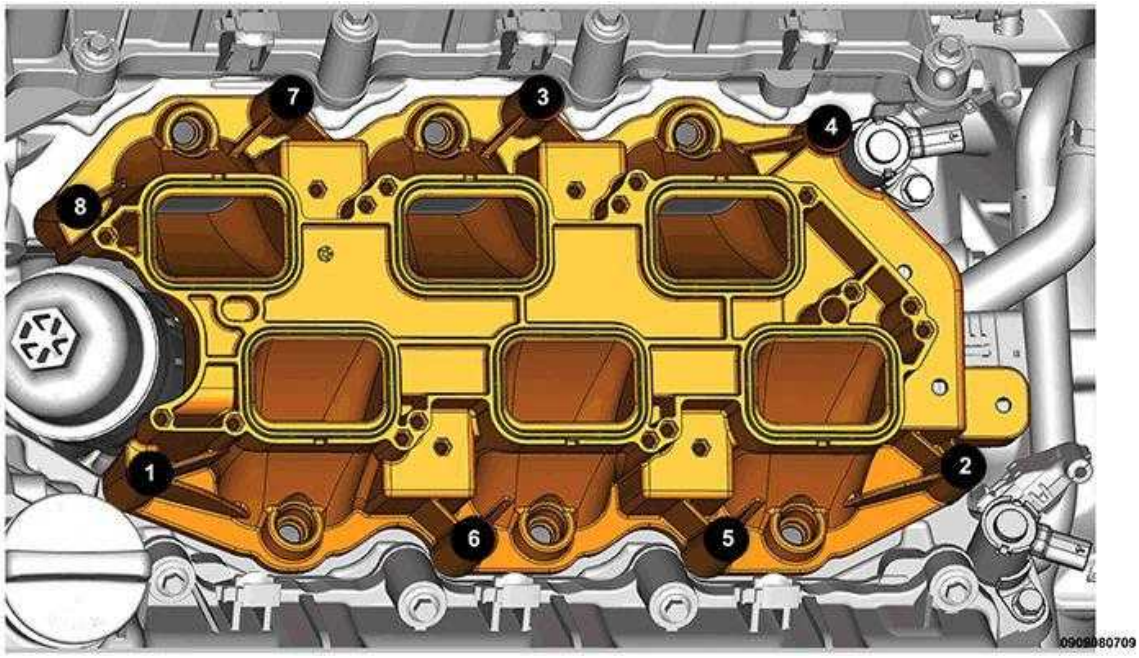


Fig. 2: Lower Intake Manifold Bolt Removal & Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

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	**Torque Procedure:** **NOTE:** **Bolts (1 - 8) are M6; Bolts (9, 10, 11) are M8; Bolt (12) is M10.** 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.)**	Tightening Sequence

DESCRIPTION	SPECIFICATION	COMMENTS
	4. **Step 3 - Tighten the M10 Bolts to 55 N.m (41 Ft. Lbs.)** 5. **Repeat the tightening sequence for all bolts**	

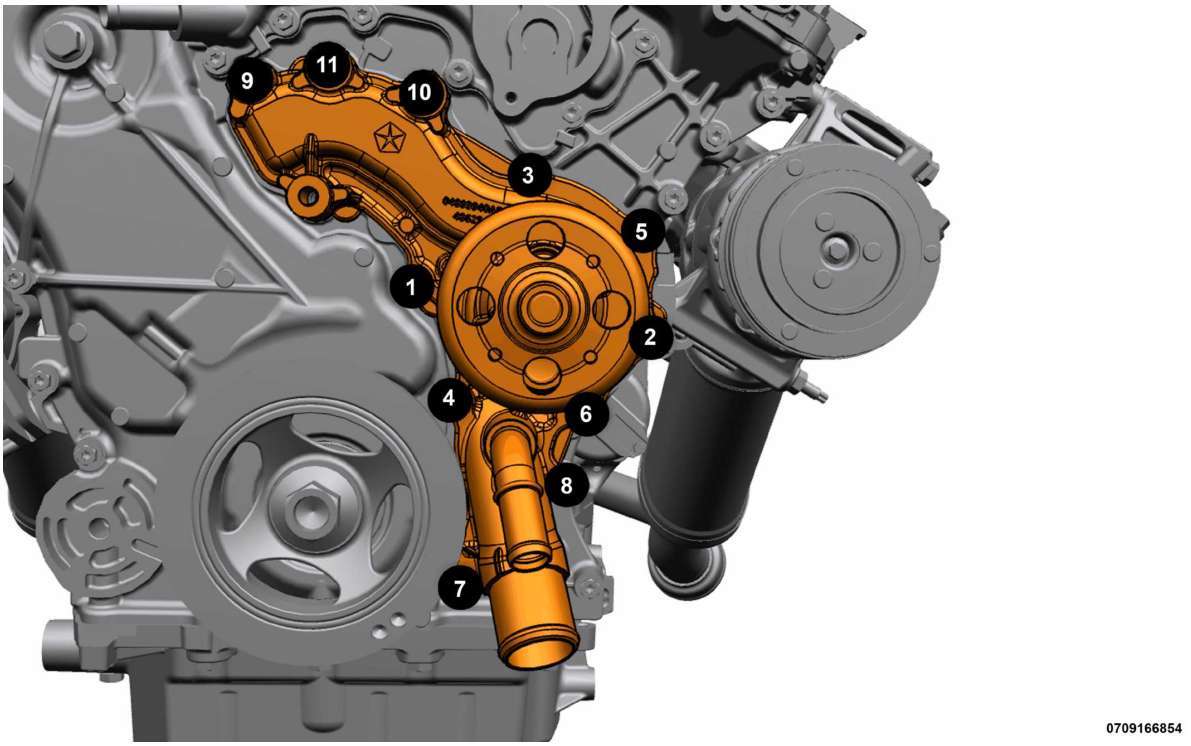
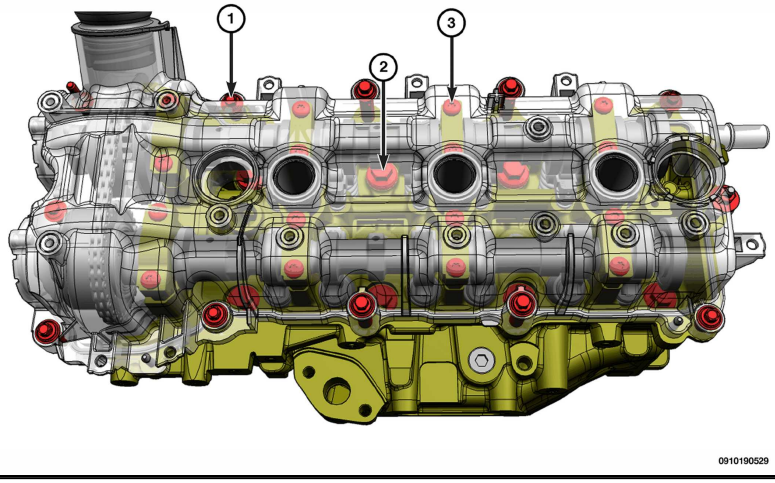


Fig. 3: Water Pump Bolts Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

CYLINDER HEAD



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Cylinder Head Cover M6 Bolts	**12 N.m (9 Ft. Lbs.)**	Tightening Sequence - Left
2	Cylinder Head Bolts	**Torque Procedure** For engine builds using a new block follow steps 1-9. For engine re-builds (reuse block) follow step 6-9.	Tightening Sequence - Left

CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
		1. 30 N. m (22 ft. lbs.) 2. 45 N. m (33 ft. lbs.) 3. Re-tighten all to 45 N. m (33 ft. lbs.) 4. All + 125B° Turn. Do not use a torque wrench for this step. 5. Loosen all fasteners in reverse of sequence shown 6. All to 30 N. m (22 ft. lbs.) 7. All to 45 N. m (33 ft. lbs.) 8. Re-tighten all to 45 N. m (33 ft. lbs.) 9. All + 130B° Turn. Do not use a torque wrench for this step.	
3	Camshaft Bearing Cap Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence - Left
-	Cylinder Head Coolant Pipe Plug	**35 N.m (26 Ft. Lbs.)**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
-	Cylinder Head Oil Galley Plug	**18 N.m (13 Ft. Lbs.)**	-
-	Cylinder Head Oil Restrictor M8 Plug	**15 N.m (11 Ft. Lbs.)**	-
-	Ground Strap Bolt to Right Cylinder Head	**23 N.m (17 Ft. Lbs.)**	-
-	Heater Core Supply Tube to Cylinder Head M8 Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Wire Harness Retainer Bracket to LH Cylinder Head Bolts	**10 N.m (89 In. Lbs.)**	-

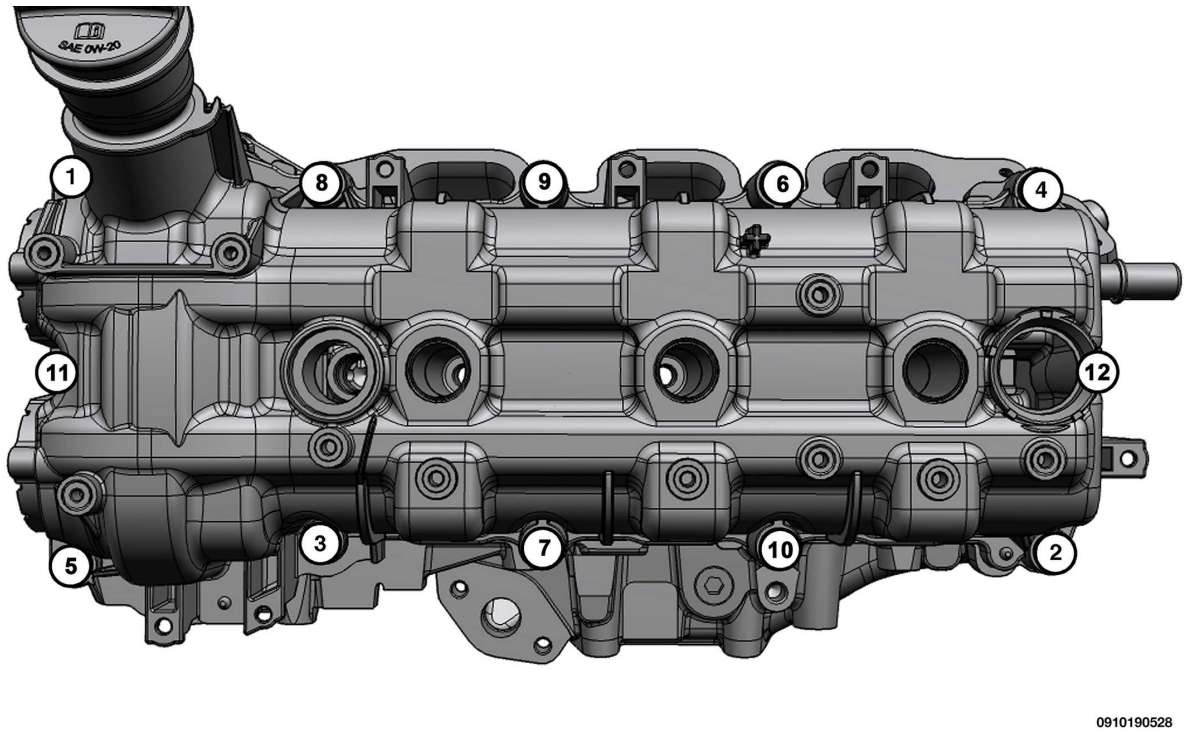


Fig. 4: Cylinder Head Cover Bolts Tightening Sequence (1 of 2)
Courtesy of CHRYSLER GROUP, LLC

Tightening Sequence - Right

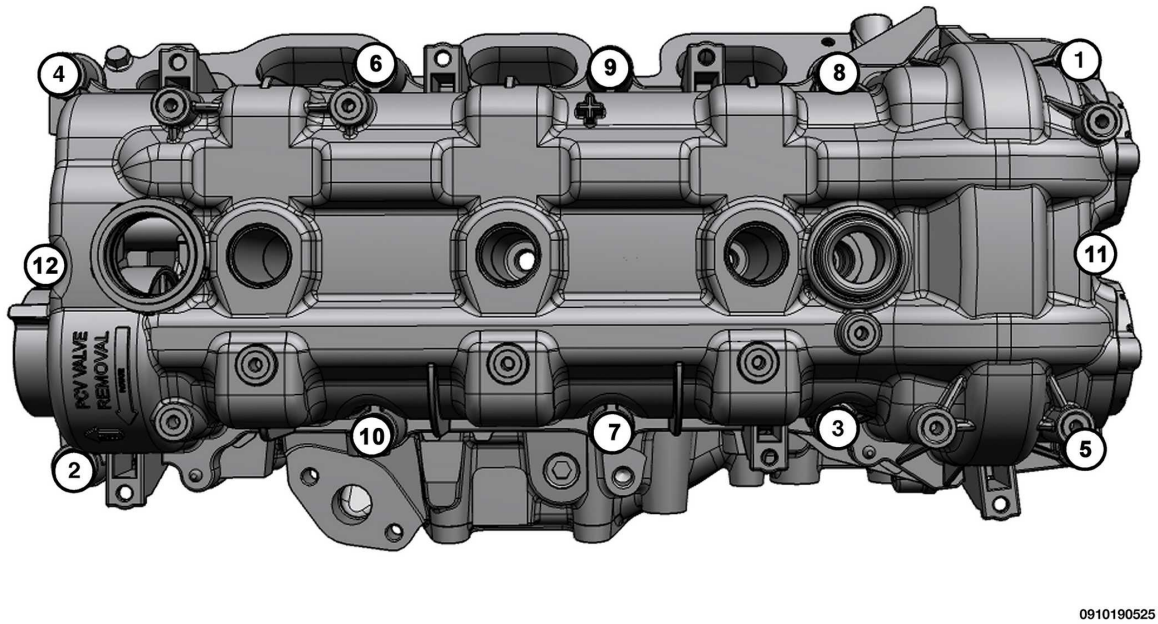


Fig. 5: Cylinder Head Cover Bolts Tightening Sequence (2 of 2)
Courtesy of CHRYSLER GROUP, LLC

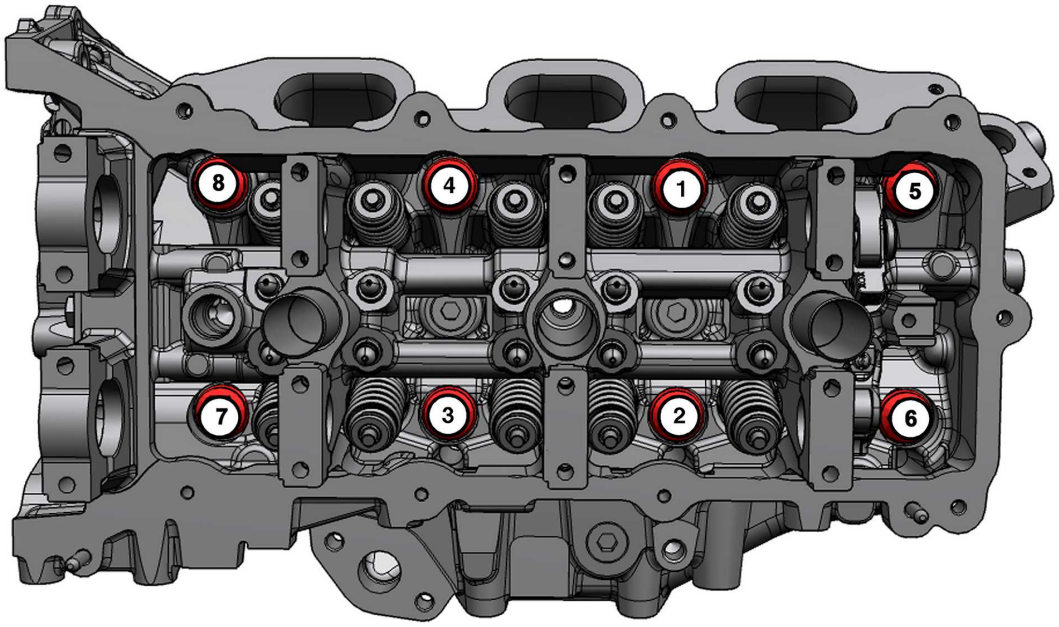


Fig. 6: Cylinder Head Bolts Tightening Sequence (1 of 2)
Courtesy of CHRYSLER GROUP, LLC

Tightening Sequence - Right

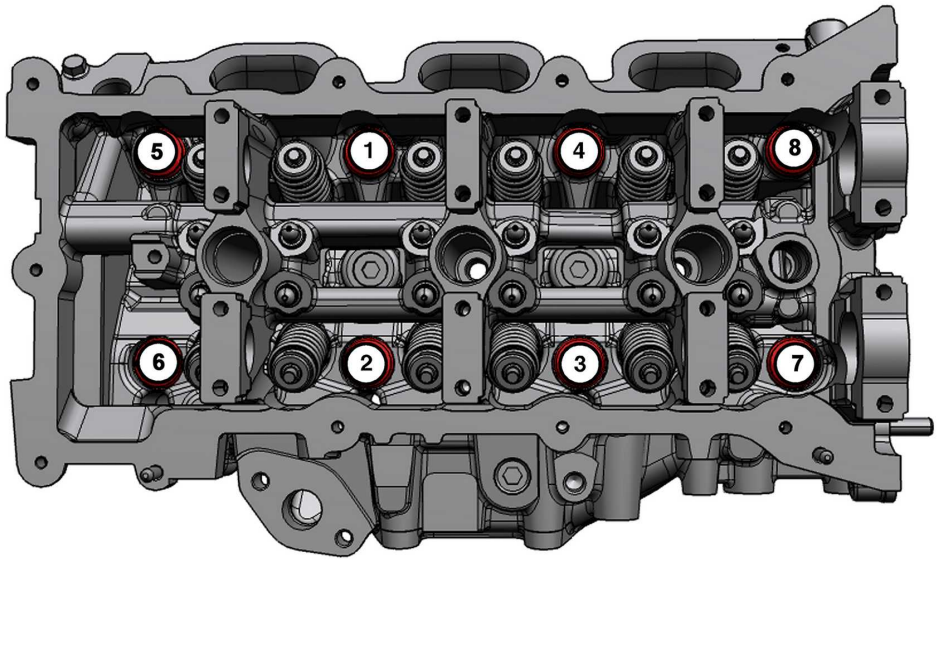


Fig. 7: Cylinder Head Bolts Tightening Sequence (2 of 2)
Courtesy of CHRYSLER GROUP, LLC

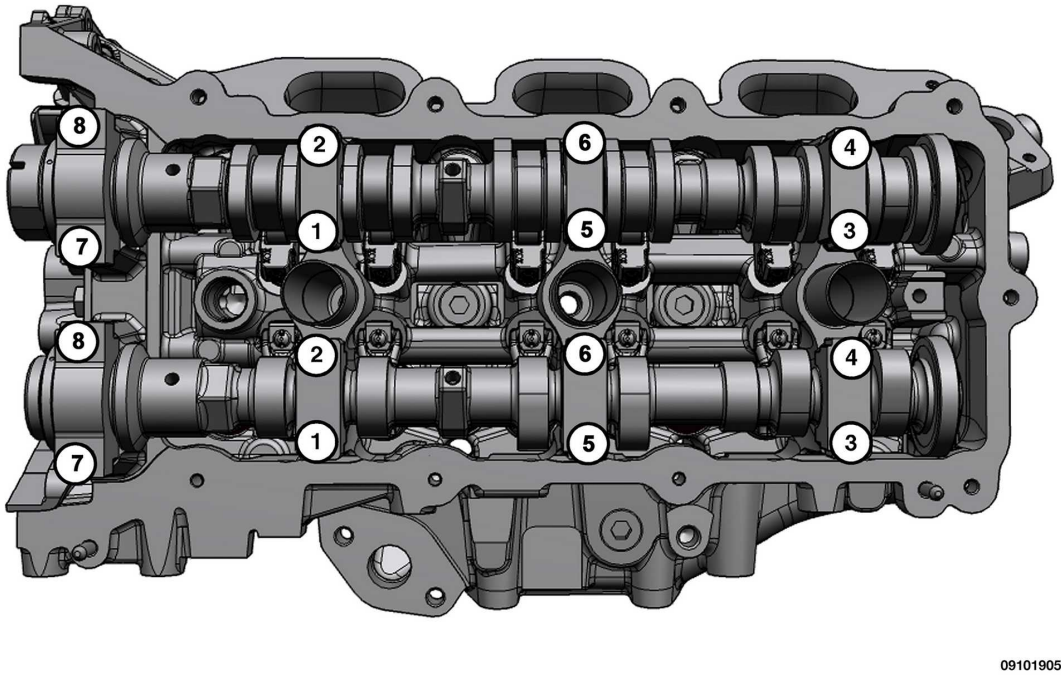


Fig. 8: Camshaft Bearing Cap Bolts Tightening Sequence (1 of 2)
Courtesy of CHRYSLER GROUP, LLC

Tightening Sequence - Right

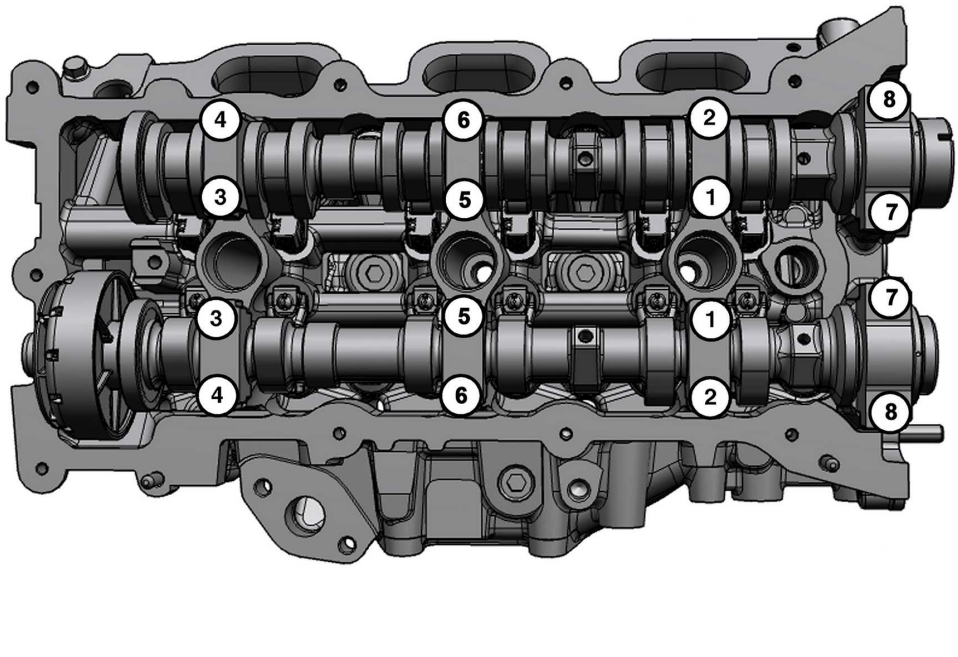


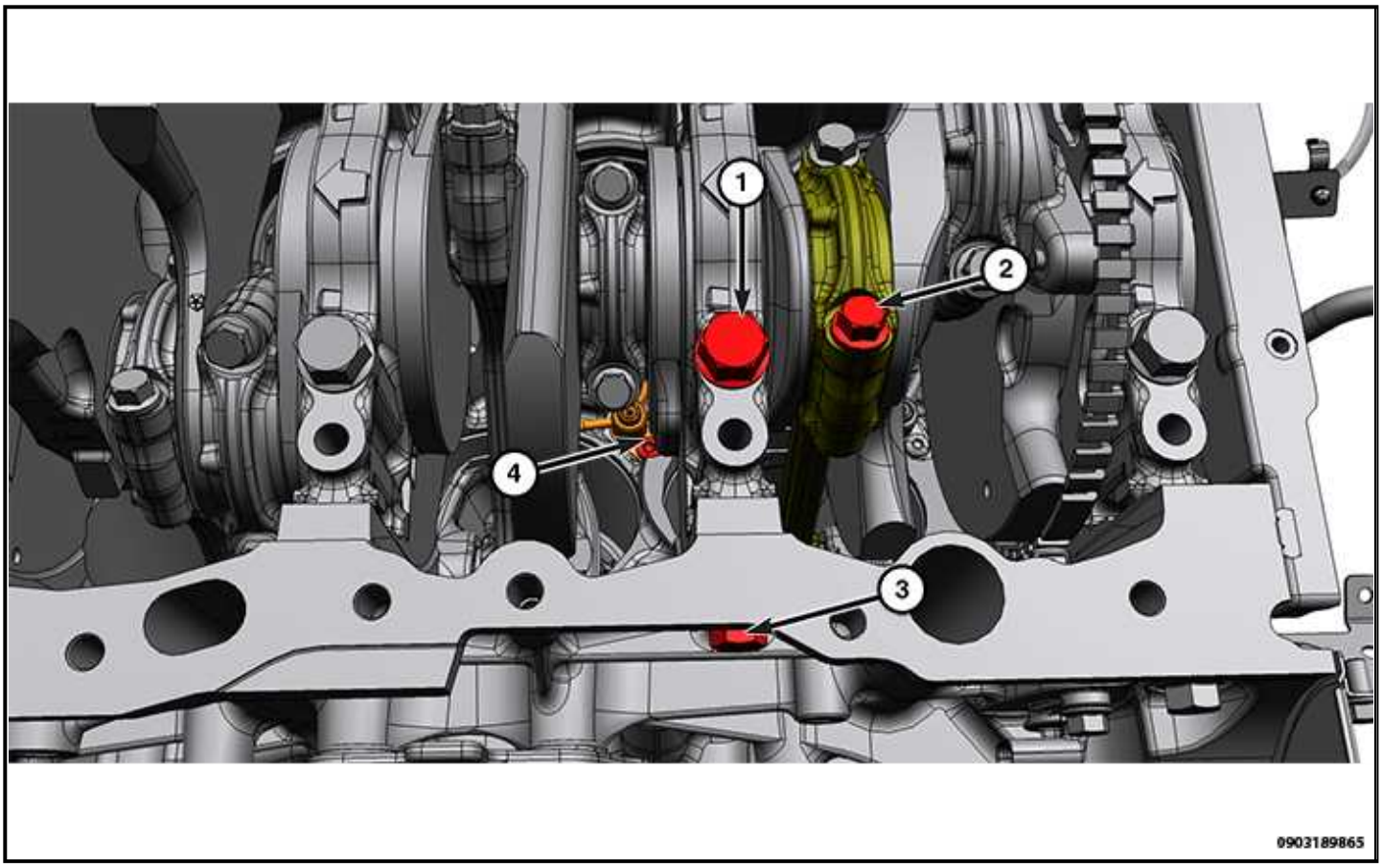
Fig. 9: Camshaft Bearing Cap Bolts Tightening Sequence (2 of 2)
Courtesy of CHRYSLER GROUP, LLC

ENGINE SENSORS

DESCRIPTION	SPECIFICATION	COMMENTS
Map Sensor	-	-
Coolant Temperature Sensor	**1/4 Turn to Engage**	-
EGR Temperature Sensor	**37 N. m (27 Ft. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Crankshaft Position (CKP) Sensor Bolt	**12 N.m (9 Ft. Lbs.)**	-
Engine Oil Pressure (EOP) Sensor	**20 N.m (15 Ft. Lbs.)**	-
Camshaft Position (CMP) Sensor to Cylinder Head	**9 N. m (80 In. Lbs.)**	-
Oxygen (O2) Sensor	**43 N.m (32 Ft. Lbs.)**	-
Oil Temperature Sensor to Cylinder Head	**11 N.m (8 Ft. Lbs.)**	-
Knock Sensor	**22 N.m (16 Ft. Lbs.)**	Do not reuse fastener. If removed, a new fastener must be installed and tightened to specifications

ENGINE BLOCK



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Crankshaft Inner Main Bearing Cap M11 Bolts	**Torque Procedure:** 1. **20 N.m (15 Ft. Lbs.)** 2. **Turn additional 90B°**	Tightening Sequence
2	Connecting Rod Cap Bolts	**Torque Procedure:** 1. **20 N.m (15 Ft. Lbs.)** 2. **Turn additional 90B°**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.

CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
3	Crankshaft Side Main Bearing Cap (Tie Bolt) M8 Bolts	**30 N.m (22 Ft. Lbs.)**	Tightening Sequence
4	Piston Oil Cooler Jet to Engine Block Bolt	**6 N.m (63 In. Lbs.)**	-
-	Crankshaft Outer Main Bearing Cap and Windage Tray M8 Bolts	**Torque Procedure:** 1. **21 N.m (15 Ft. Lbs.)** 2. **Turn additional 90B°**	Tightening Sequence
-	Crankshaft Target Wheel to Counterweight Bolts	**11 N.m (8 Ft. Lbs.)**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
-	Engine Block Ground Strap Bolt	**23 N.m (17 Ft. Lbs.)**	-
-	Engine Block Ground Strap to Frame Nut	**20 N.m (15 Ft. Lbs.)**	-
-	Engine Lift Bracket	**21 N.m (15 Ft. Lbs.)**	-
-	Rear Crankshaft Oil Seal Retainer Bolts	**12 N.m (9 Ft. Lbs.)**	Tightening Sequence

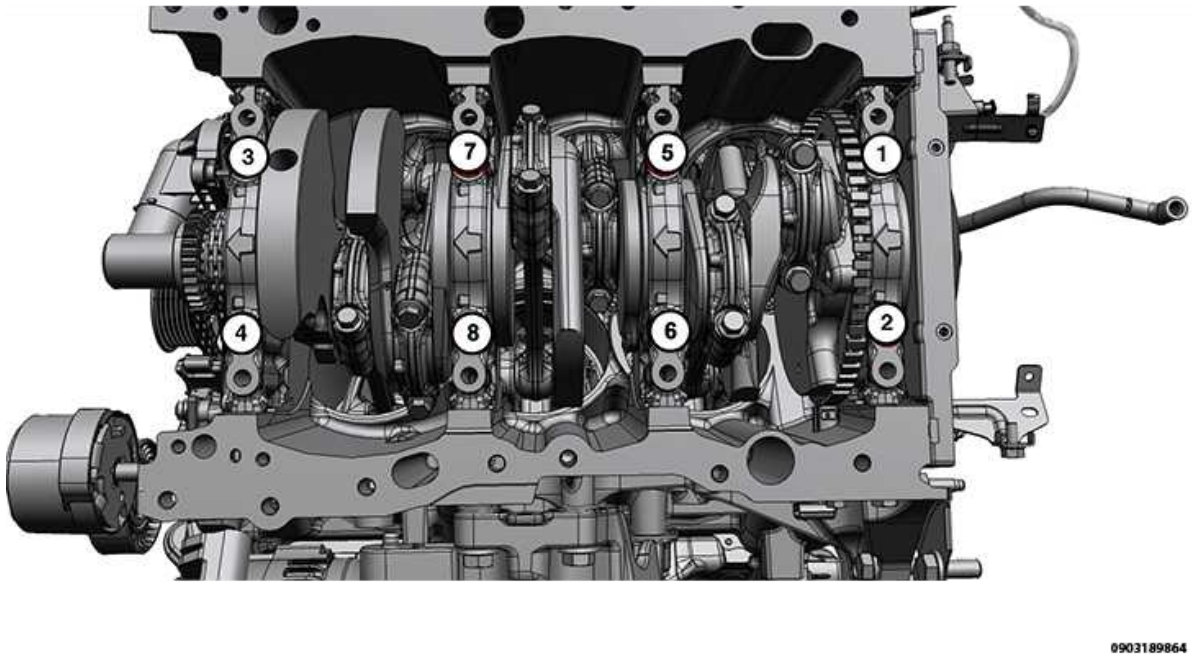


Fig. 10: Crankshaft Inner Main Bearing Cap Bolts Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

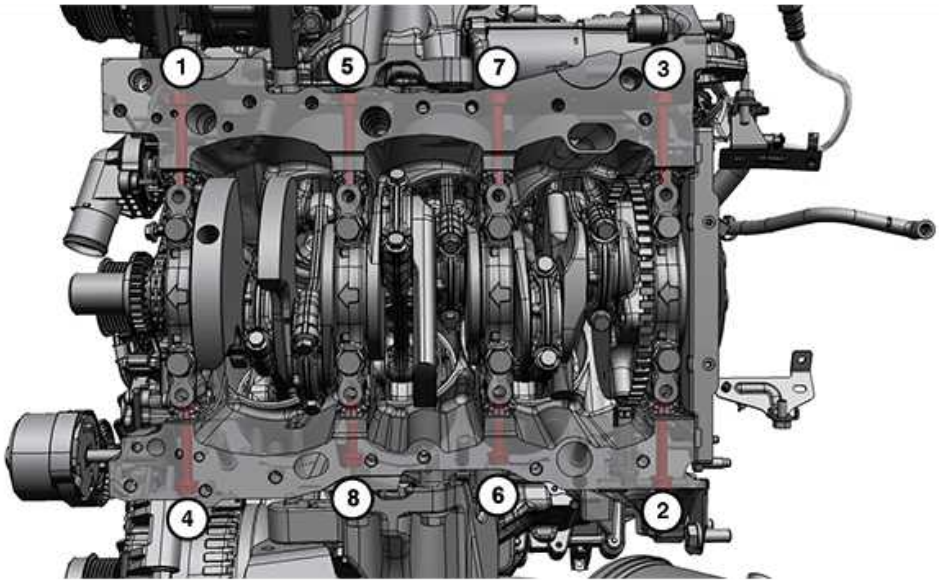


Fig. 11: Crankshaft Side Main Bearing Cap Bolts Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

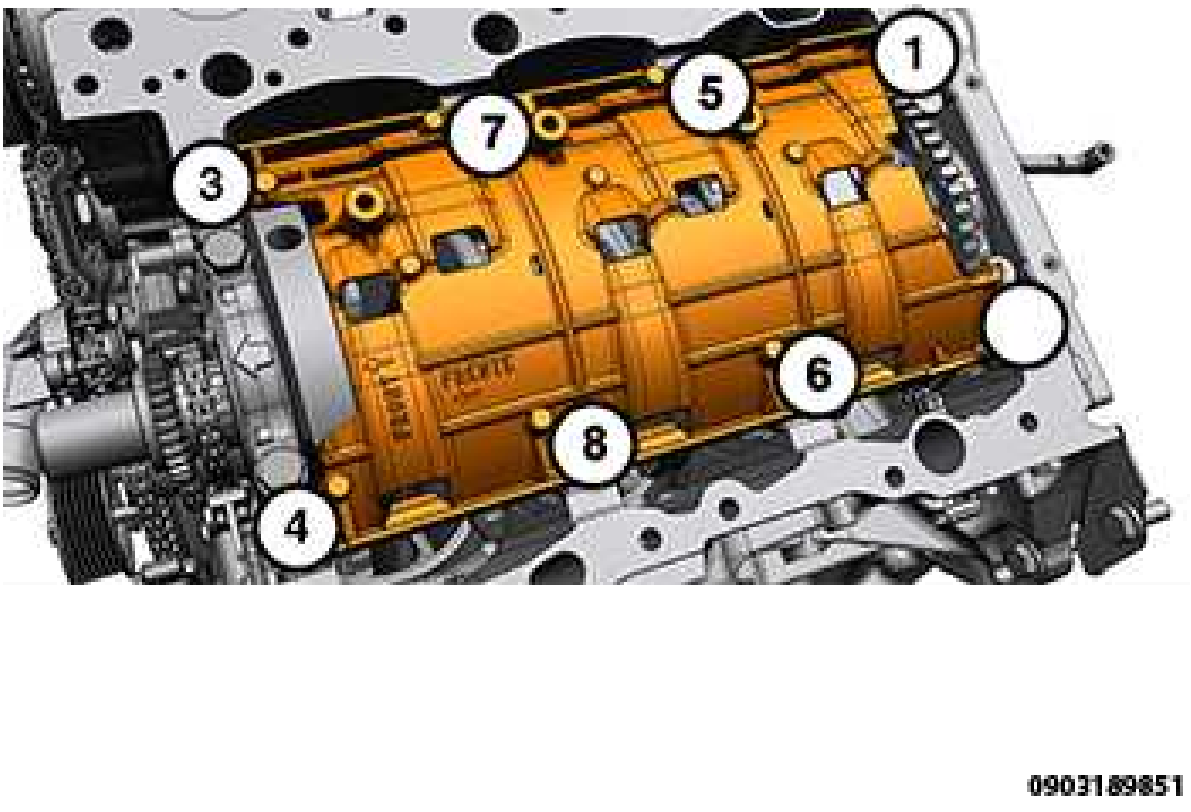
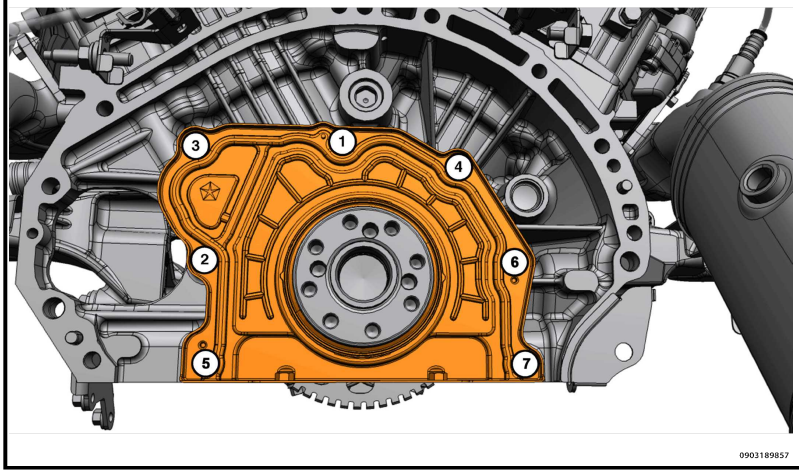


Fig. 12: Crankshaft Outer Main Bearing Cap and Windage Tray Bolts Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC



ENGINE MOUNTING

RIGHT ENGINE MOUNT

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Mount Isolator to Engine Mount Bracket	**122 N.m (90 Ft. Lbs.)**	-
Engine Mount Bracket to Engine Block	**65 N.m (48 Ft. Lbs.)**	-
Engine Mount Isolator to Frame	**55 N.m (41 Ft. Lbs.)**	-

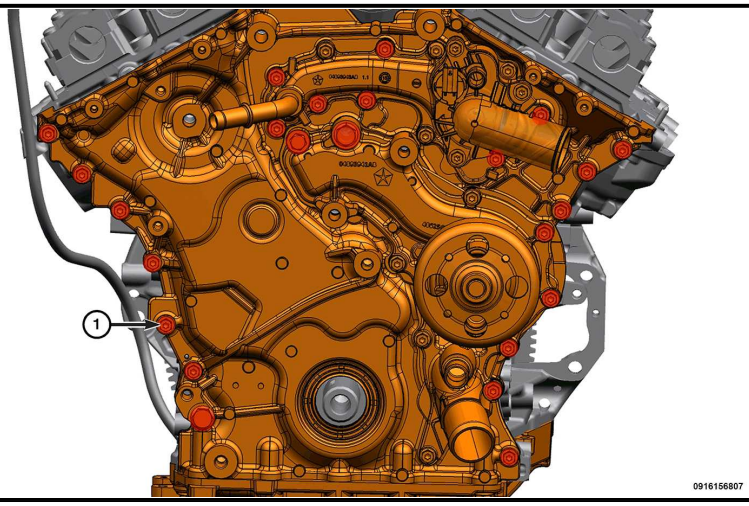
LEFT ENGINE MOUNT

DESCRIPTION	SPECIFICATION	COMMENTS
Left Engine Mount Bracket to Engine Block	**65 N.m (48 Ft. Lbs.)**	-
Left Engine Mount Isolator to Engine Mount Bracket	**122 N.m (90 Ft. Lbs.)**	-
Left Engine Mount Isolator to Frame	**55 N.m (41 Ft. Lbs.)**	-

FRONT ENGINE

DESCRIPTION	SPECIFICATION	COMMENTS
Center Idler Pulley Bracket Bolts	**M8 Bolts - 25 N.m (18 Ft. Lbs.)** **M10 Bolts - 55 N.m (41 Ft. Lbs.)**	-
Center Idler Pulley Bracket to Generator Bolts	**24 N.m (18 Ft. Lbs.)**	-
Center Idler Pulley Bolt	**50 N.m (37 Ft. Lbs.)**	-
Left Idler Pulley Bolt	**25 N.m (18 Ft. Lbs.)**	-
Right Idler Pulley Bracket Bolts	**24 N.m (18 Ft. Lbs.)**	-
Right Idler Pulley Bolt	**25 N.m (18 Ft. Lbs.)**	-
Vibration Damper M16 Bolt	**Torque Procedure:** 1. **40 N.m (30 Ft. Lbs.)** 2. **Rotate additional + 105B°**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Belt Tensioner Bolt	**50 N.m (37 Ft. Lbs.)**	-
Engine Timing Cover M6 Bolts Engine Timing Cover M8 Bolt Engine Timing Cover M10 Bolts	**12 N.m (9 Ft. Lbs.)** **25 N.m (18 Ft. Lbs.)** **55 N.m (41 Ft. Lbs.)**	**Tighten in a criss-cross pattern**



FUEL SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
Accelerator Pedal to Bulkhead Nuts	**12 N. m (9 Ft. Lbs.)**	-
Fuel Filler Tube to Body Bolts	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube to Body Nut(s)	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube Clamp	**4 N. m (35 In. Lbs.)**	-
Fuel Line Bundle to Transmission	**25 N.m (18 Ft. Lbs.)**	-
Fuel Pump Control Module	**6 N.m (53 In. Lbs.)**	-
Fuel Rail to Lower Intake	**7 N.m (62 In. Lbs.)**	-
Fuel Tank Deflector to Cross Member	**8 N.m (71 In. Lbs.)**	-
Fuel Tank Skid Plate Bolts	**95 N. m (70 Ft. Lbs.)**	-
Fuel Tank Strap to Skid Plate	**25 N. m (18 Ft. Lbs.)**	-

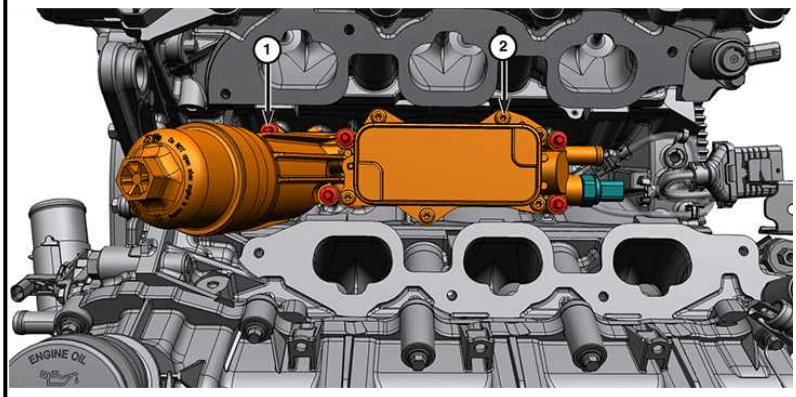
IGNITION CONTROL - 3.6L

DESCRIPTION	SPECIFICATION	COMMENTS
Ignition Capacitor Bolt	**10 N.m (89 In. Lbs.)**	-
Ignition Coil to Cylinder Head Cover	**8 N. m (71In. Lbs.)**	-
Spark Plugs	**20 N. m (15Ft. Lbs.)**	-

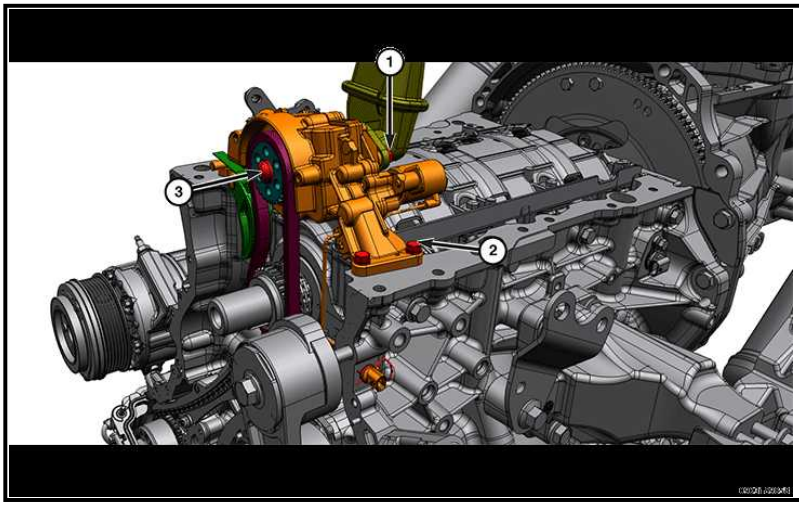
LUBRICATION

DESCRIPTION	SPECIFICATION	COMMENTS
Upper Oil Pan to Engine Block M8 Bolts	**23 N.m (17 Ft. Lbs.)**	-
Lower Oil Pan to Upper Oil Pan - M6 Bolts	**9 N.m (80 In. Lbs.)**	-
Lower Oil Pan to Upper Oil Nuts	**10 N.m (89 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Upper Oil Pan to Rear Seal Retainer M6 Bolts	**10 N.m (89 In. Lbs.)**	-
Oil Pan Drain Plug	**27 N.m (20 Ft. Lbs.)**	-
Oil Level Indicator to Cylinder Head Bolt	**18 N.m (13 Ft. Lbs.)**	-

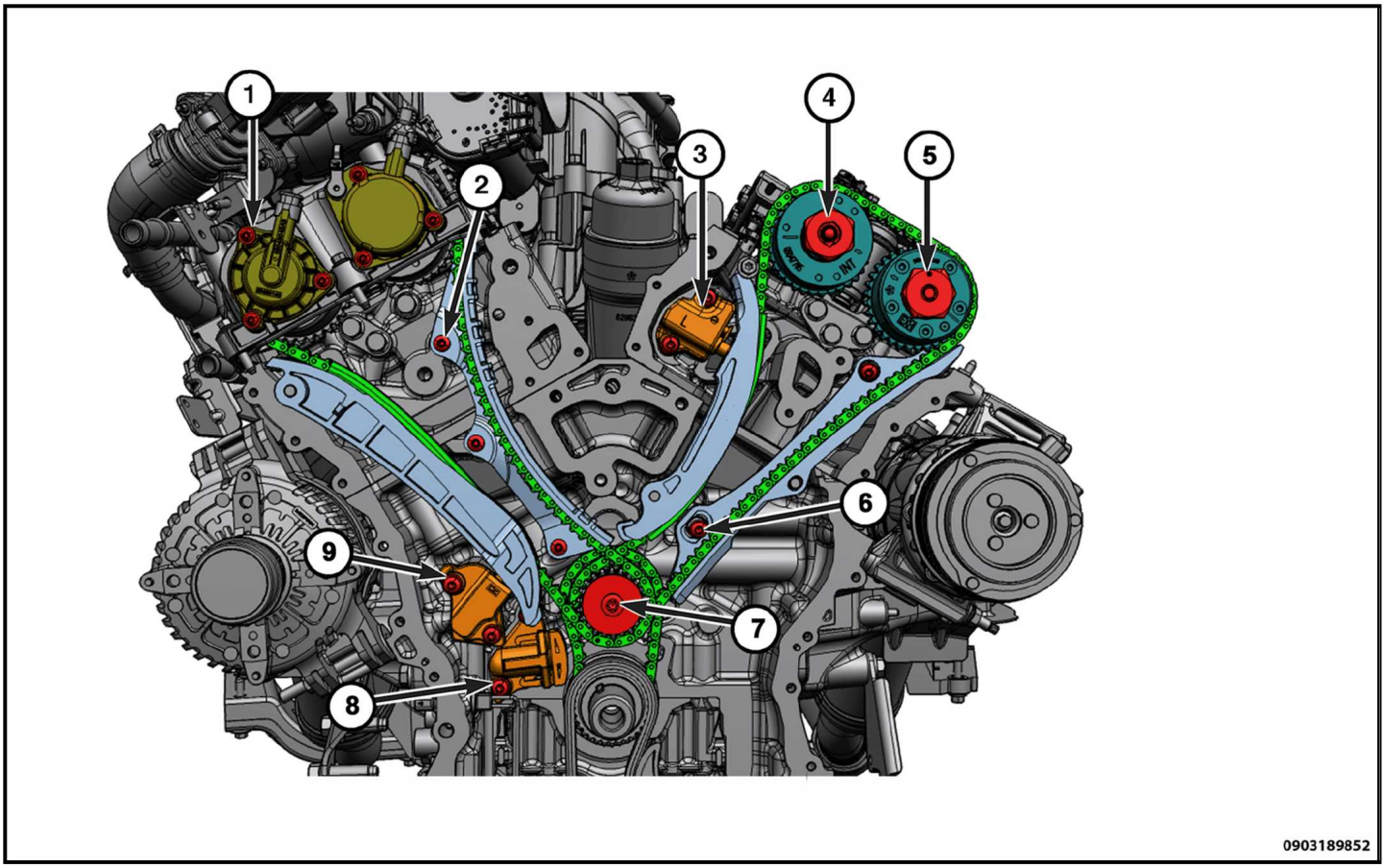


CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Oil Filter Housing/Oil Cooler to Engine Block M6 Bolts	**12 N.m (9 Ft. Lbs.)**	-
2	Oil Cooler to Oil Filter Housing Screws	**12 N.m (9 Ft. Lbs.)**	-
-	Oil Filter Housing Cap	**25 N.m (18 Ft. Lbs.)**	-



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Oil Pump Pick Up Tube to Oil Pump M6 Bolt	**8 N.m (71 In. Lbs.)**	-
-	Oil Pump Pick Up Tube Bracket to Windage Tray Bolt	**8 N.m (80 In. Lbs.)**	-
2	Oil Pump to Engine Block M6 Bolts	**12 N.m (9 Ft. Lbs.)**	-
3	Oil Pump Sprocket M8 Bolt	**26 N.m (18 Ft. Lbs.)**	-

VALVE TIMING



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

ENGINE ASSEMBLY

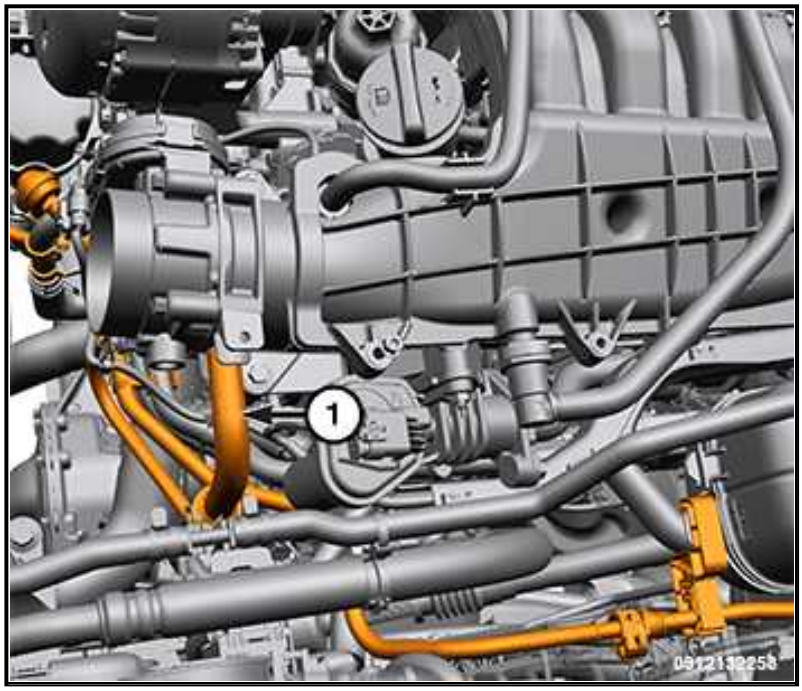
REMOVAL AND INSTALLATION

ENGINE ASSEMBLY

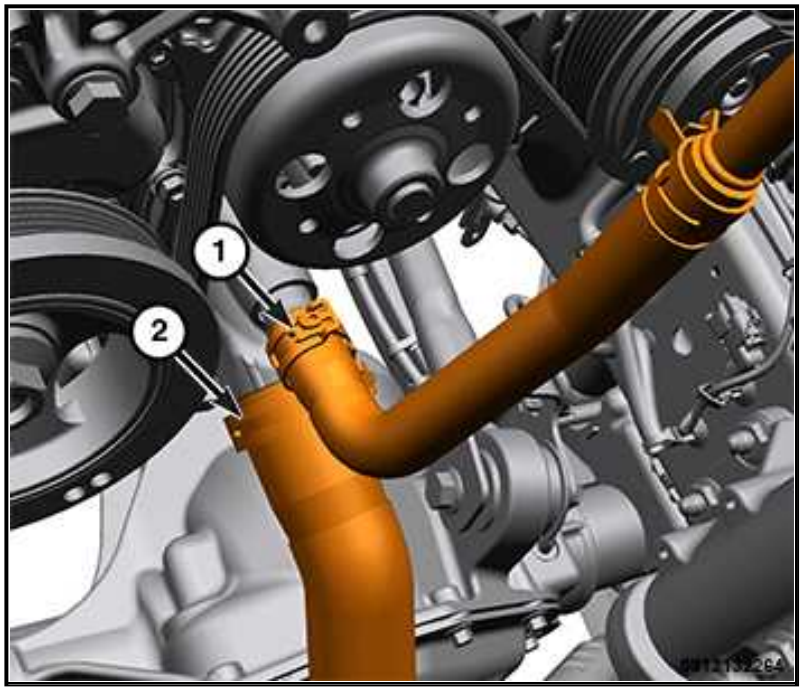
REMOVAL

CAUTION: **If the original engine has experienced a catastrophic failure or an individual failure with the piston, cylinder bore, engine block, valve or valve seat, the intake manifold MUST be replaced with a new manifold.**

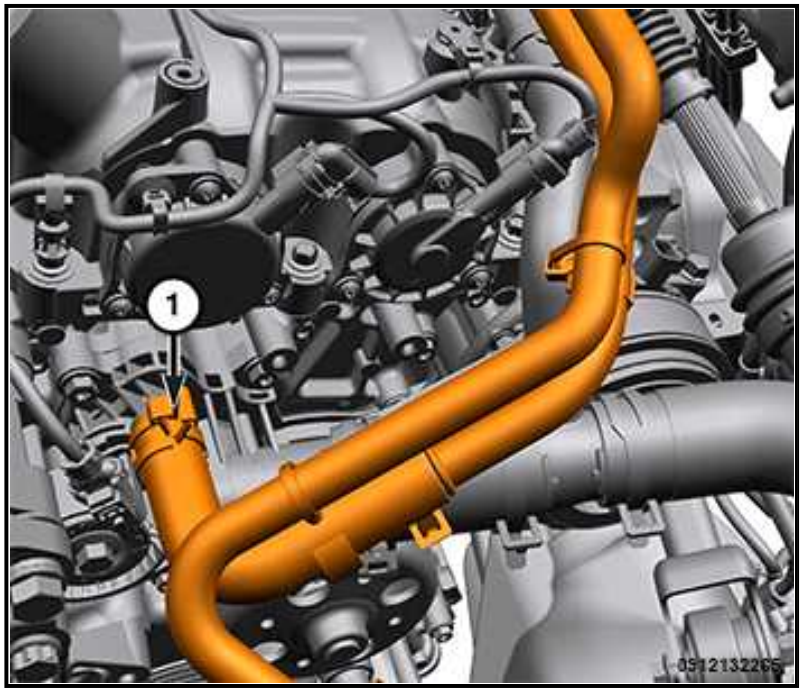
1. Perform the fuel pressure release procedure. Refer to **FUEL SYSTEM PRESSURE RELEASE** .
2. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
3. Remove the engine cover. Refer to **COVER, ENGINE, REMOVAL AND INSTALLATION**.
4. Remove the air cleaner body. Refer to **BODY, AIR CLEANER, REMOVAL AND INSTALLATION**.
5. Remove the battery tray. Refer to **TRAY, BATTERY, REMOVAL AND INSTALLATION** **TRAY, BATTERY, REMOVAL AND INSTALLATION** .
6. Drain the cooling system. Refer to **DRAINING** .
7. If required, drain the engine oil. Refer to the appropriate information .
8. Remove the front wheelhouse inner splash shields. Refer to **SHIELD, SPLASH, REAR WHEELHOUSE, REMOVAL AND INSTALLATION** .
9. Remove the cooling fan. Refer to **FAN, COOLING, REMOVAL AND INSTALLATION**.



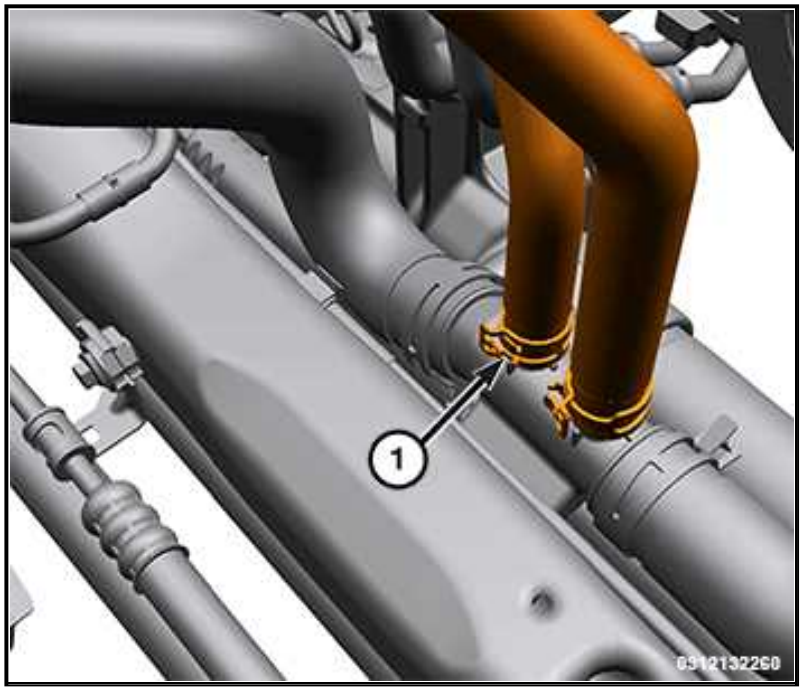
10. Remove the vacuum harness assembly (1).
11. Remove the electric vacuum pump. Refer to **PUMP, ELECTRIC VACUUM, REMOVAL AND INSTALLATION** .
12. Remove the pressurized coolant bottle. Refer to **BOTTLE, PRESSURIZED COOLANT, REMOVAL AND INSTALLATION**.
13. Remove the upper intake manifold and insulator. Refer to **MANIFOLD, EXHAUST, REMOVAL AND INSTALLATION** .
14. Remove the Exhaust Gas Recirculation (EGR) cooler. Refer to **COOLER, EXHAUST GAS RECIRCULATION (EGR), REMOVAL AND INSTALLATION** .
15. Remove the right and left catalytic converters. Refer to **CONVERTER, CATALYTIC, REMOVAL AND INSTALLATION** .



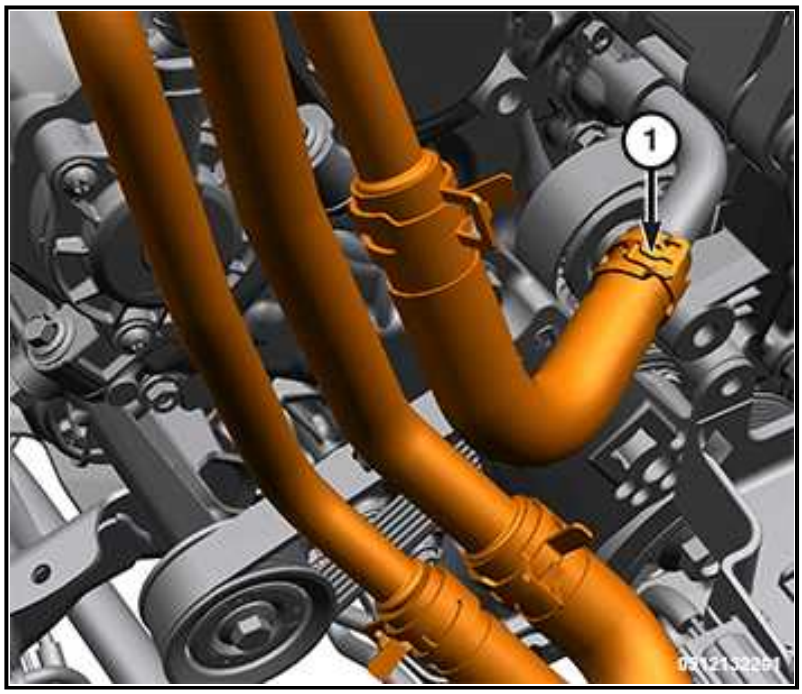
16. Remove the coolant bottle hose from the water pump (1).
17. Remove the lower radiator hose (2) from the engine water pump housing.



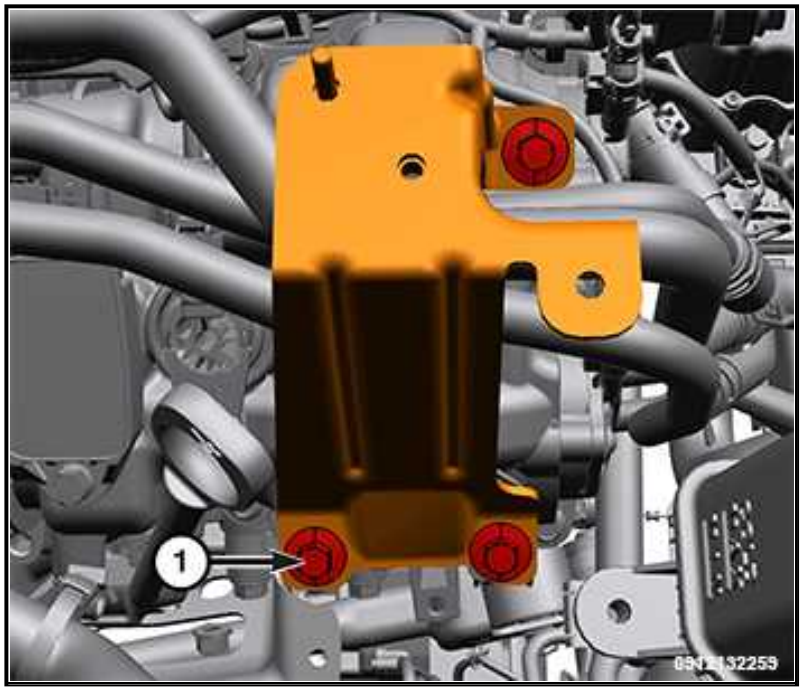
18. Remove the upper radiator hose from the engine thermostat housing.
19. Remove the Exhaust Gas Recirculation (EGR) cooler and coolant bottle hose assembly (1).



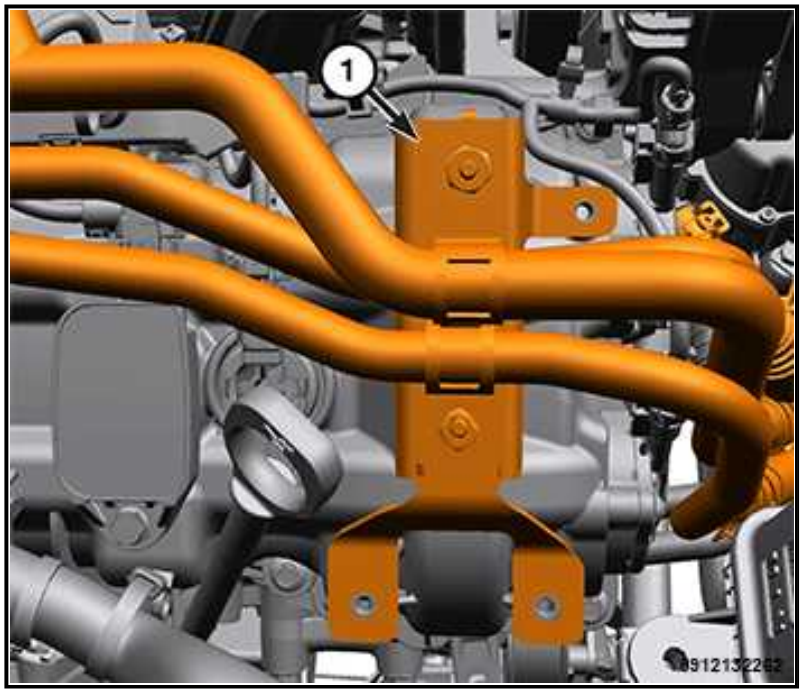
20. Remove the heater core supply hose (1), and oil cooler return hose from the lower radiator outlet hose.



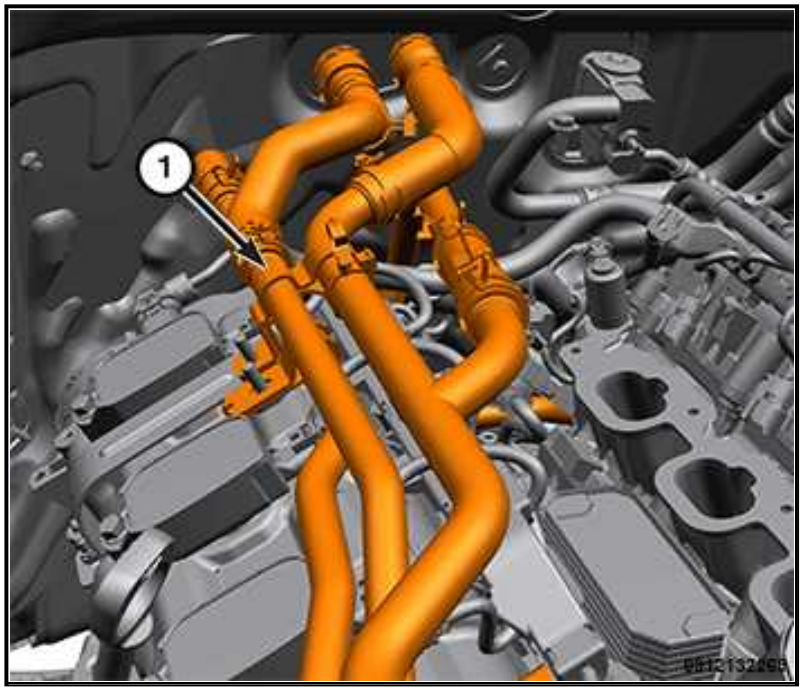
21. Disconnect the heater core return and supply (1) hoses.



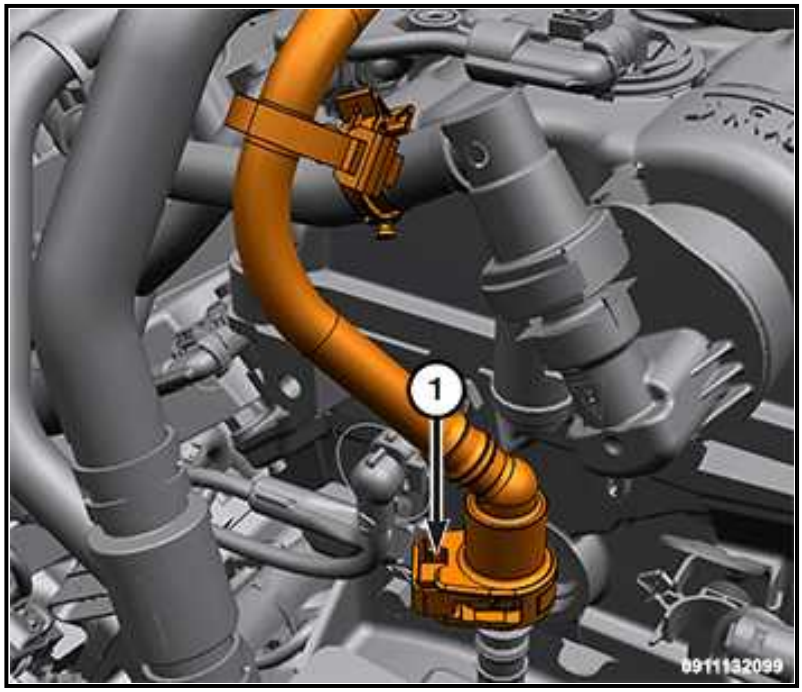
22. Remove the engine cover bracket bolts (1) and bracket.



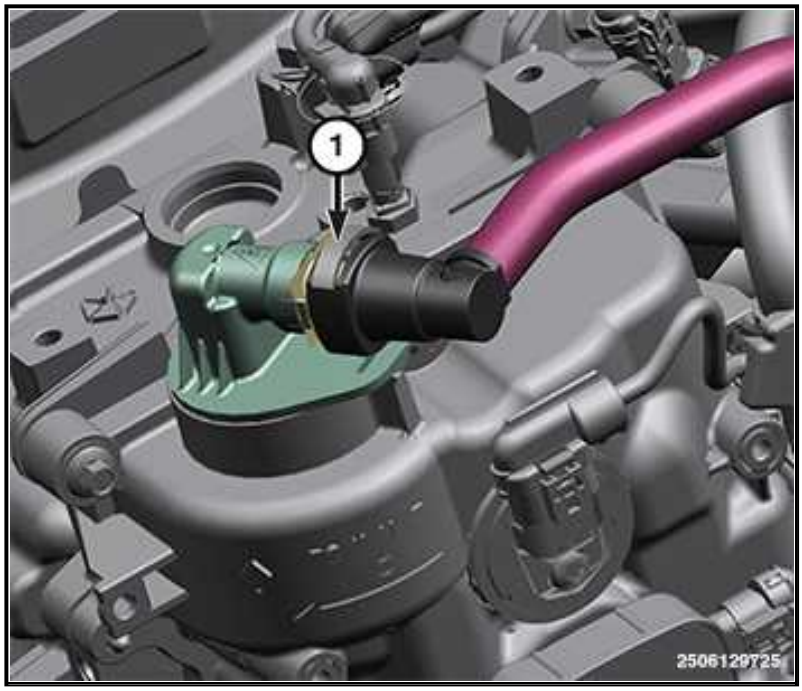
23. Remove two nuts and the heater core tube assembly from the right side support bracket (1).



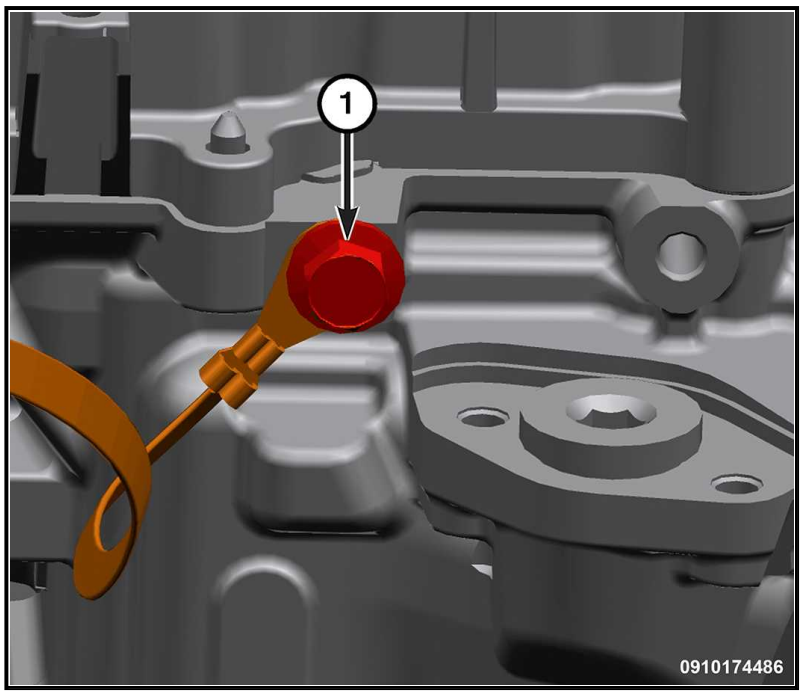
24. Remove the heater core tube assembly from the right side support bracket (1) and heater core.
25. Verify that all necessary coolant hoses have been removed from the engine.



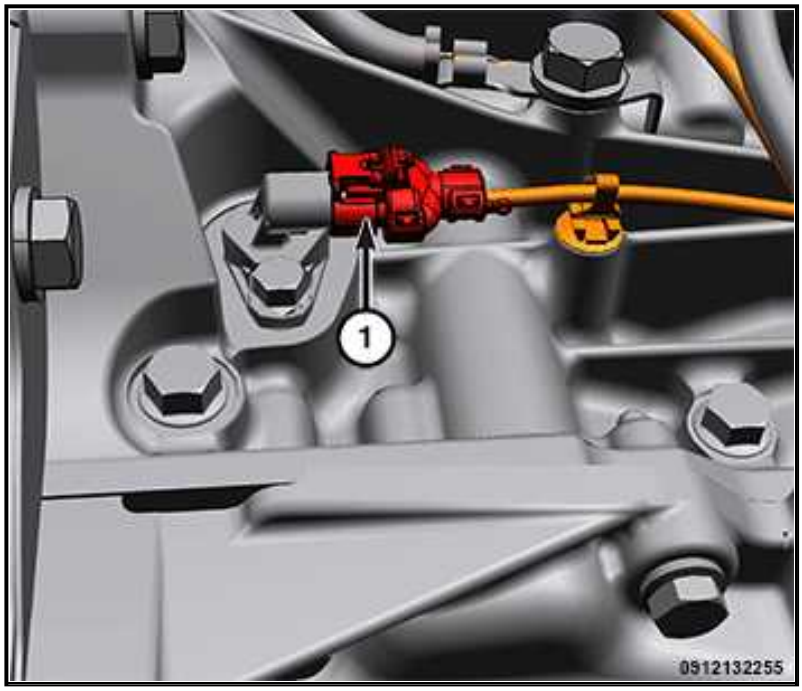
26. Disconnect and remove the vapor hose (1) at the rear of the engine.
27. Disconnect the fuel supply hose from the left side cylinder head cover and rear of the engine, then position aside.



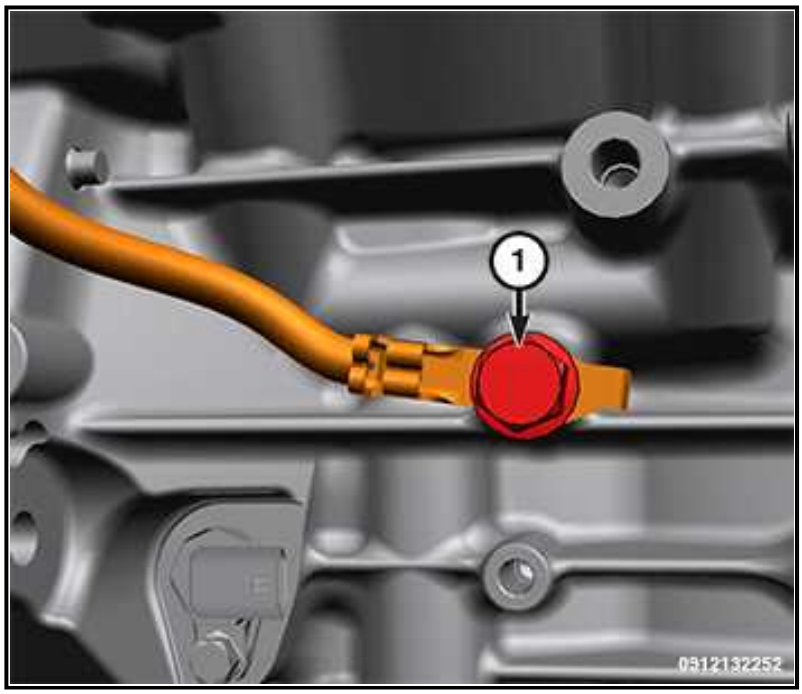
28. Push in on the tab (1) to release the quick disconnect and remove the hose from the Positive Crankcase Ventilation (PCV) valve.



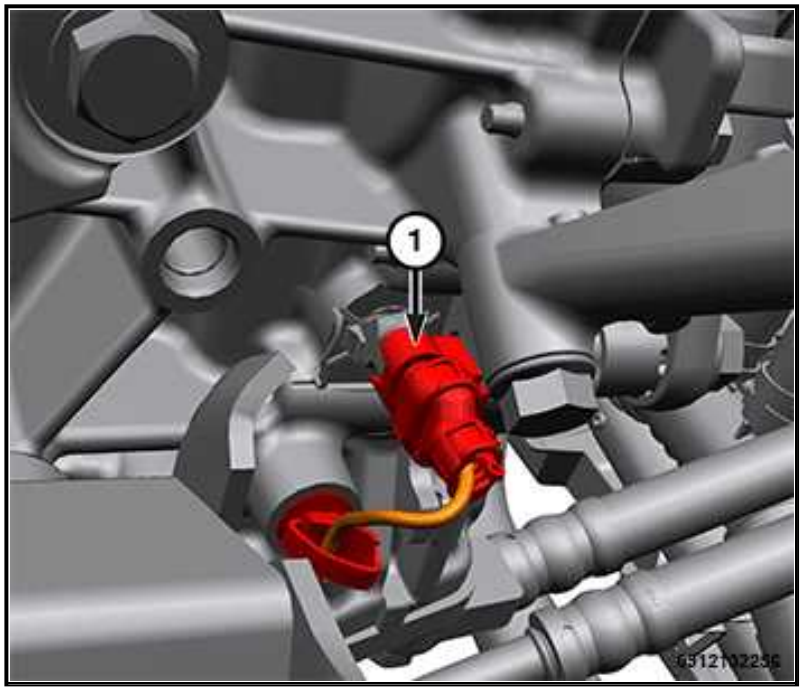
29. Remove the bolt (1) and the ground strap from the right cylinder head.



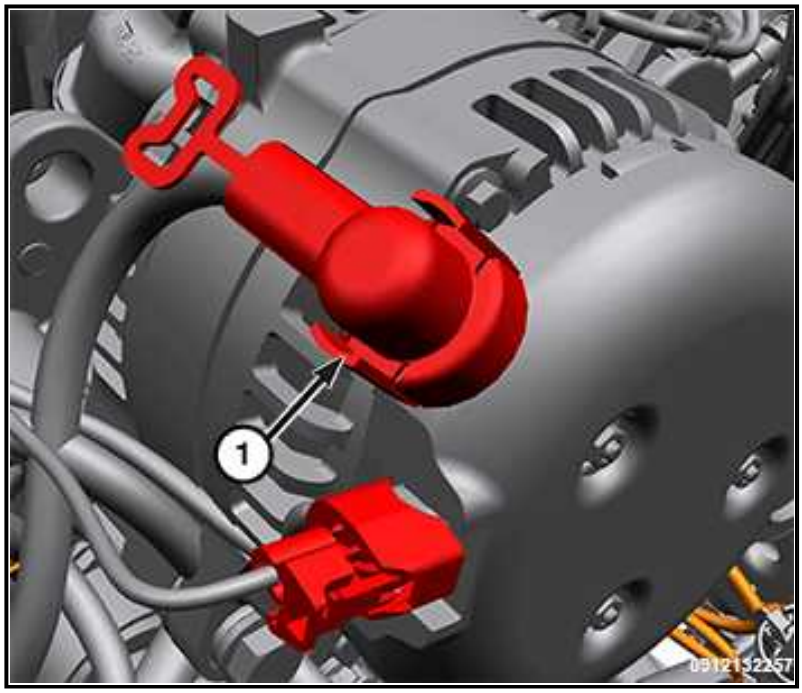
30. Disconnect the wire harness connector (1) from the Crankshaft Position (CKP) sensor.



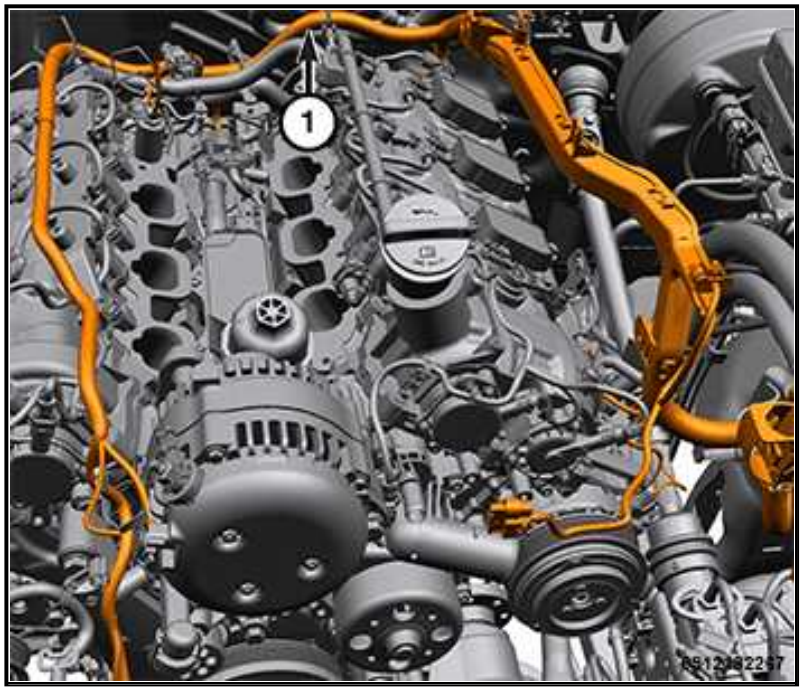
31. Remove the bolt (1) and ground strap from the engine block.



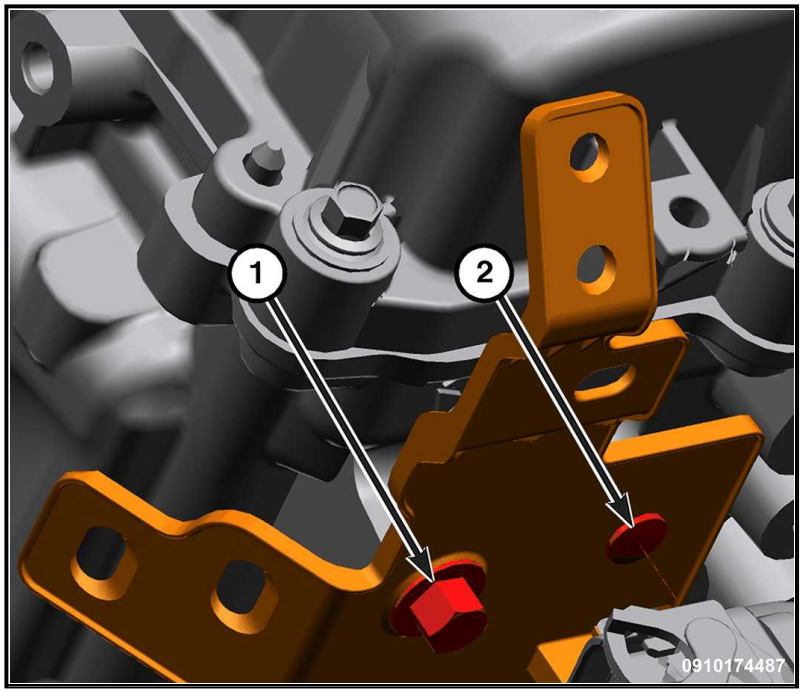
32. Disconnect the oil pump solenoid wire harness connector.



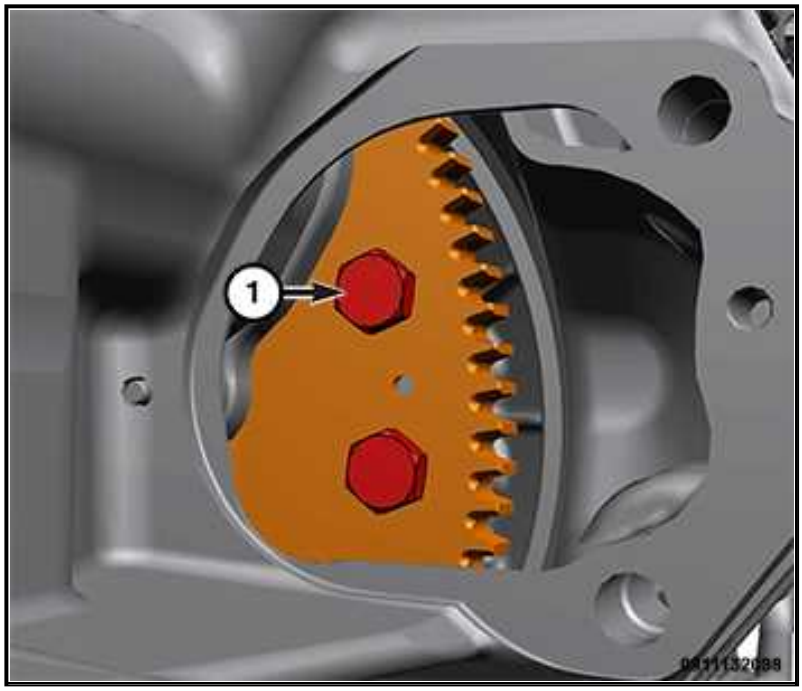
33. Disconnect the field circuit wire harness connector from the generator.
34. Remove the B+ terminal from the generator stud (1).
35. Remove the battery harness from the engine and position aside.
36. Remove the ignition capacitors. Refer to **CAPACITOR, IGNITION, REMOVAL AND INSTALLATION** .



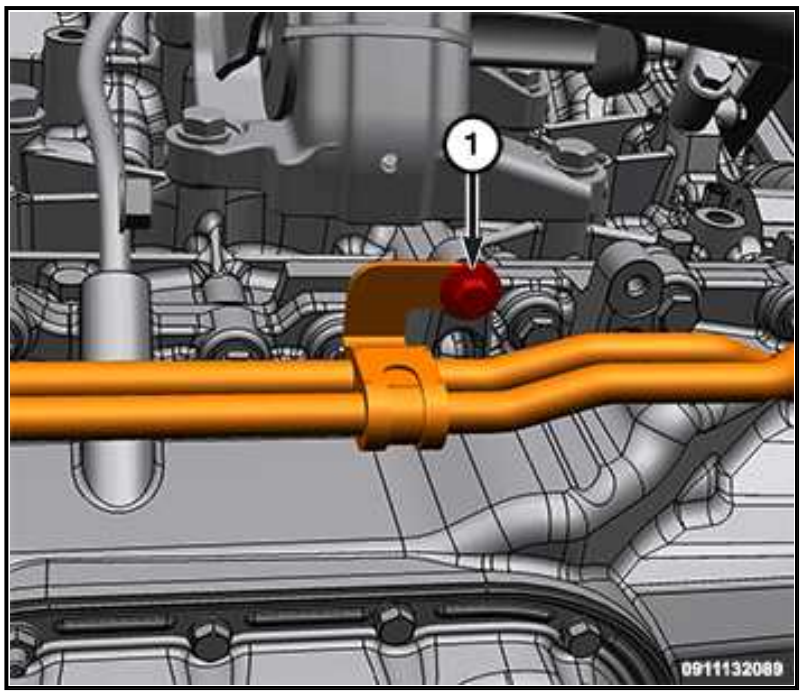
37. Disconnect the main harness from the engine injection/ignition harness at the rear of the engine (1).
38. Disengage the wire harness retainers from the right cylinder head cover.
39. Disconnect the wire harness from the Powertrain Control Module (PCM).



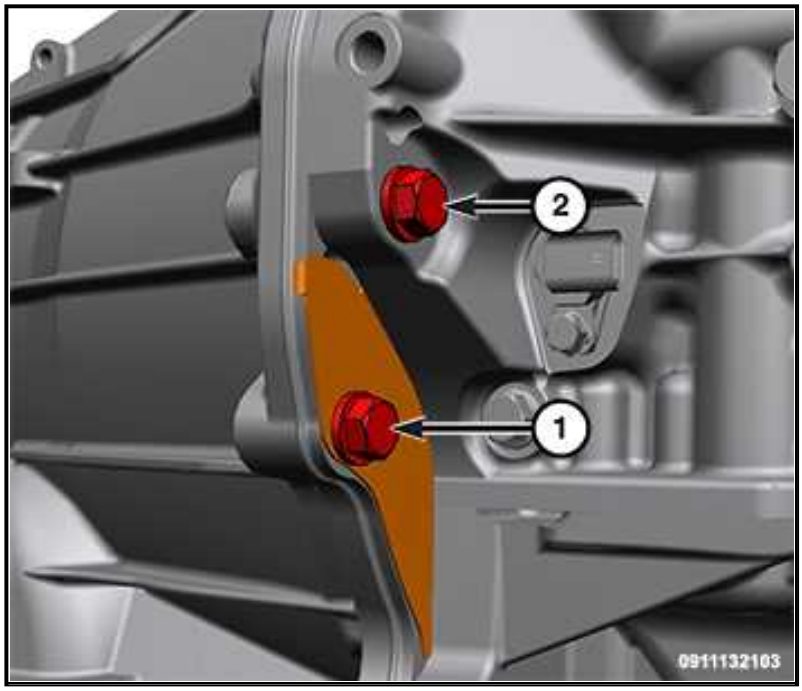
40. Remove the retainers (1, 2) from the rear of the left cylinder head.
41. Verify that all necessary wire harness connections have been disconnected from the engine, then position the harness aside.
42. Remove the A/C compressor and position aside. Refer to **COMPRESSOR, A/C, REMOVAL AND INSTALLATION** .
43. Remove the starter. Refer to **STARTER, REMOVAL AND INSTALLATION** .
44. Disconnect the power cord from the engine block heater (if equipped).
45. If equipped with a manual transmission, remove the manual transmission, then continue to step 52. Refer to **REMOVAL AND INSTALLATION** .
46. If equipped with an automatic transmission, continue to step 44.



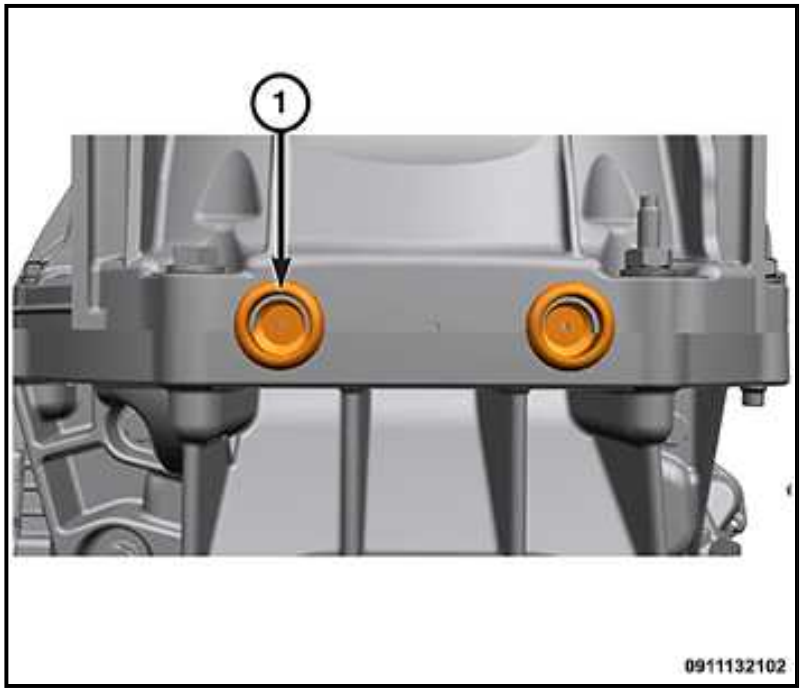
47. Rotate the crankshaft in a clockwise direction until the torque converter bolts (1) are accessible through the starter mounting. Remove the six torque converter bolts.



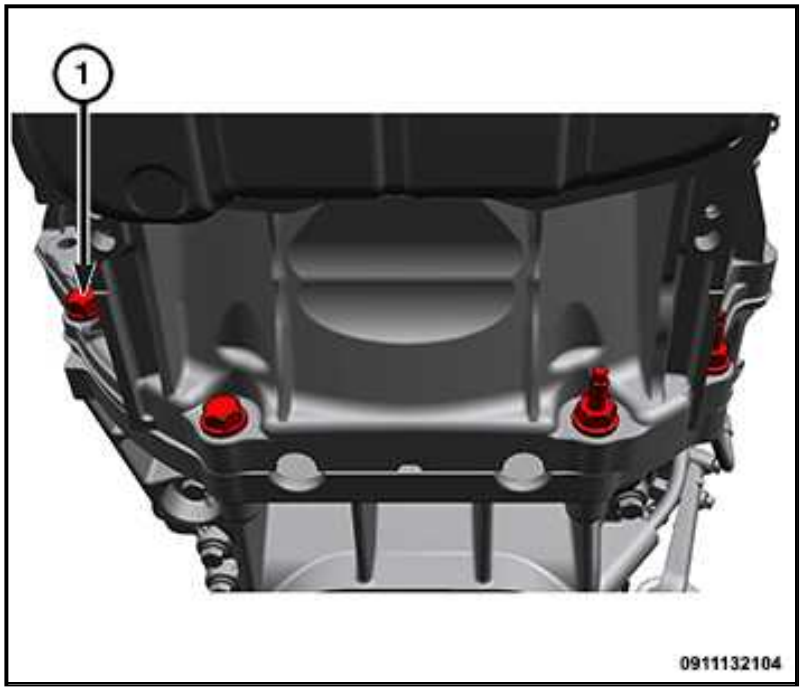
48. Remove the transmission cooler line retaining bolt (1) from the oil pan flange and position the transmission cooler lines aside.



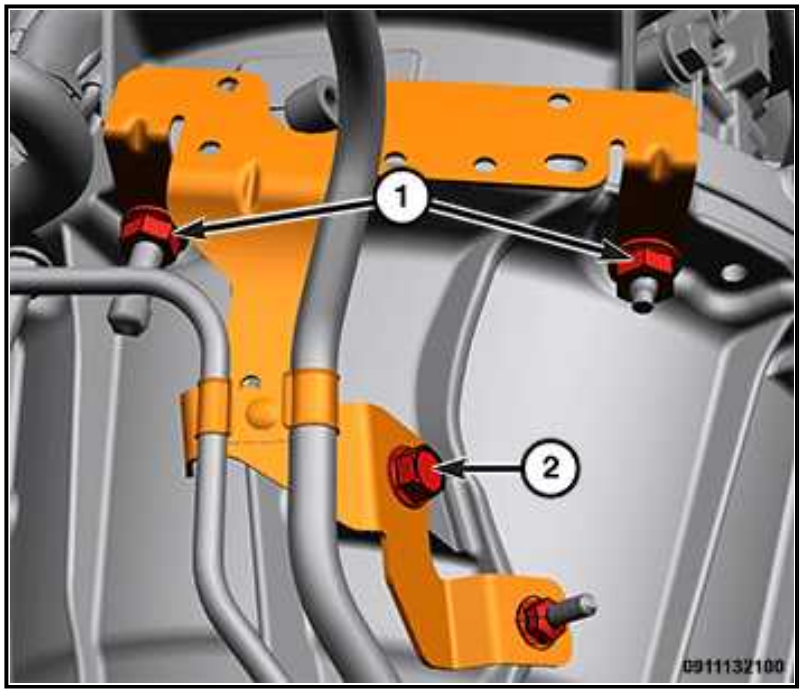
49. Remove the bolt (1) and the torque converter dust shield.
50. Remove the side engine to transmission bolt (2).



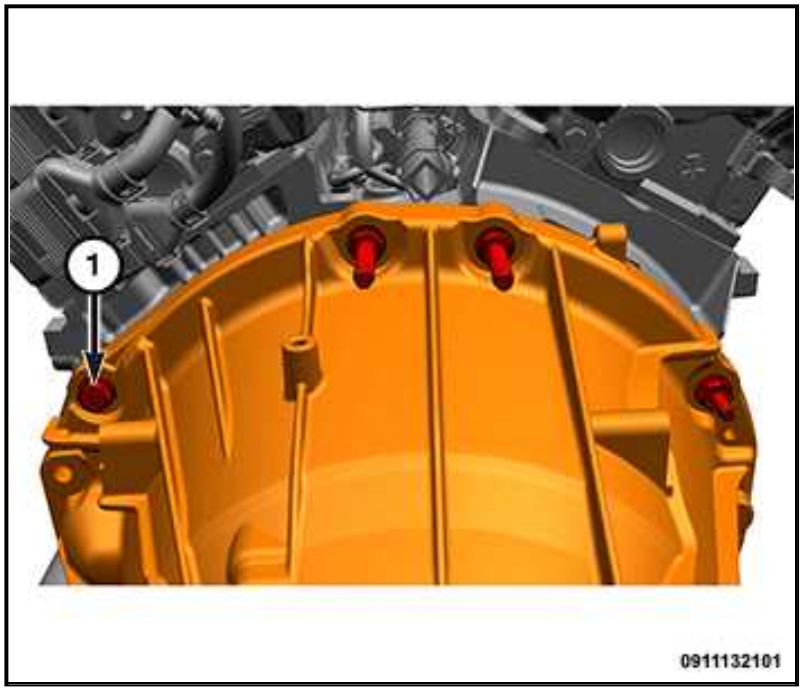
51. Remove two rubber plugs (1) covering the rear oil seal retainer flange bolts.



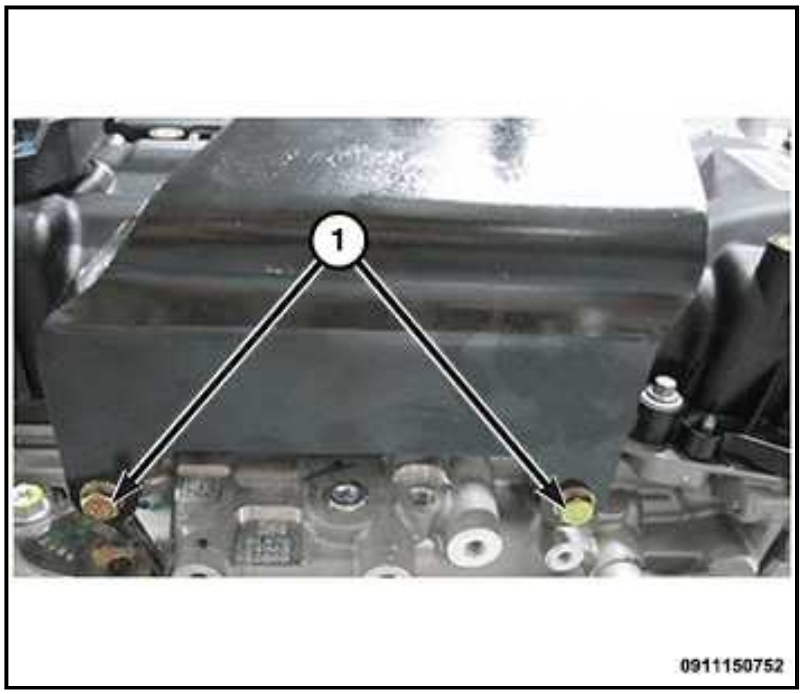
52. Remove four transmission to the engine oil pan bolts (1).



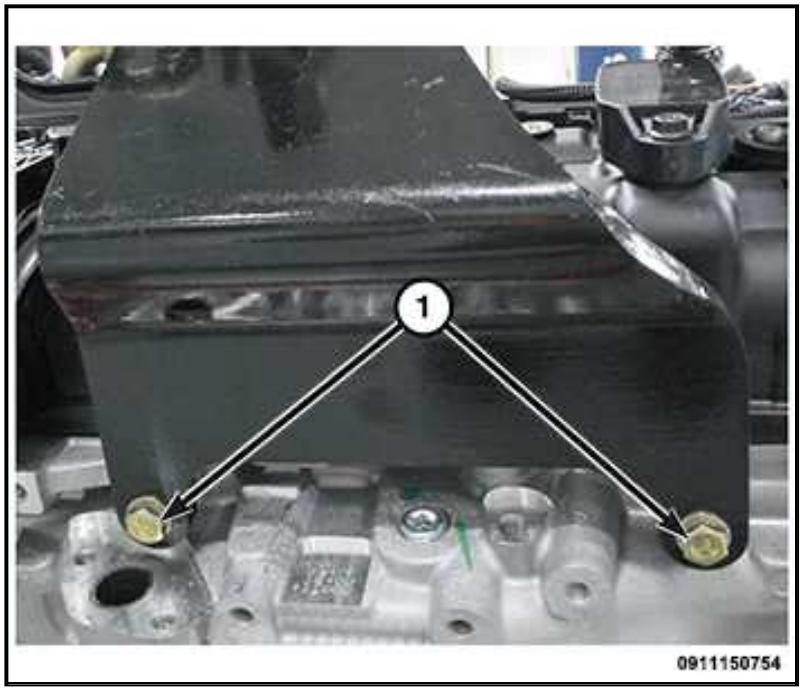
53. Remove the nuts (1) and bolt (2) securing the fuel line support bracket to the transmission and then position the bracket aside.



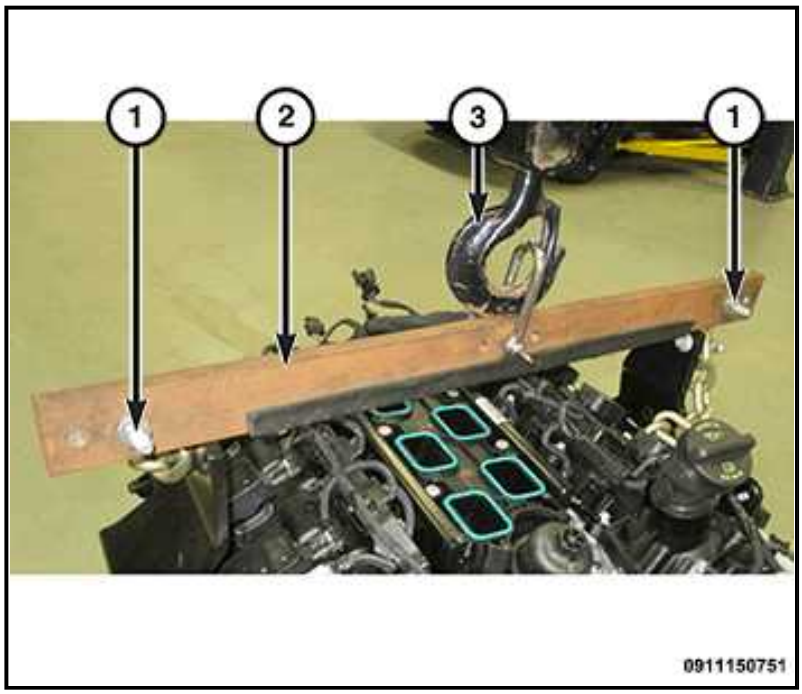
54. Remove four upper transmission to engine bolts (1).



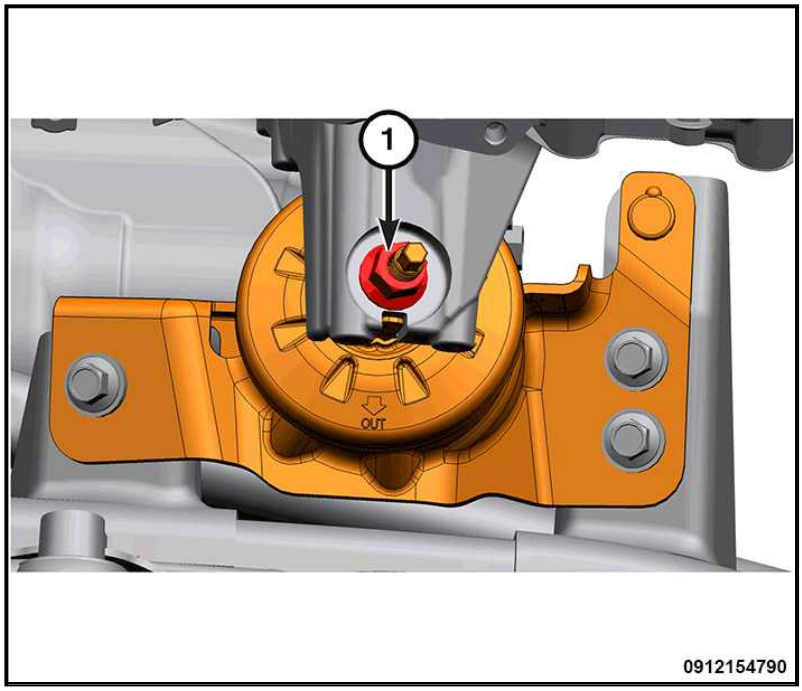
55. Install the Right Side Engine Lifting Bracket (special tool #2028010090, Lift Bracket, Engine-Right) on the RH cylinder head with bolts (1) provided with the Engine Lifting Bracket. Tighten the bolts to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .



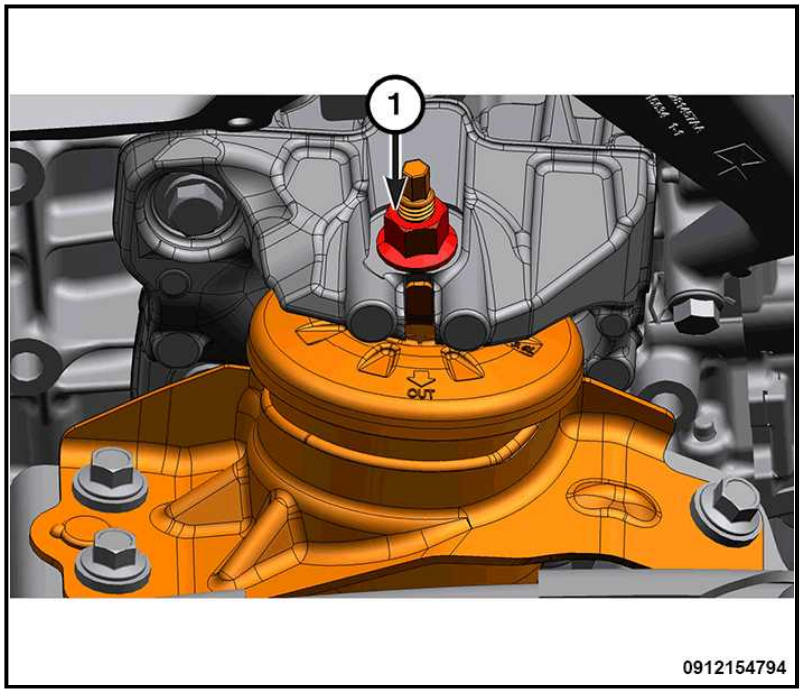
56. Install the Left Side Engine Lifting Bracket (special tool #2028020090, Lift Bracket, Engine-Left) on the LH cylinder head with bolts (1) from the Engine Lifting Bracket. Tighten the bolts to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .



57. Position a commercially available load-leveling lifting sling (2), between the engine lifting brackets (1) and an engine hoist (3).
58. If equipped with an automatic transmission, support the transmission with a suitable jack.



59. Remove the left side engine mount isolator nut (1).



60. Remove the right side engine mount isolator nut (1).

CAUTION: **While slowly separating the engine from the vehicle, constant checks must be made to assure proper positioning and that no damage to other components or wiring harnesses occur during separation.**

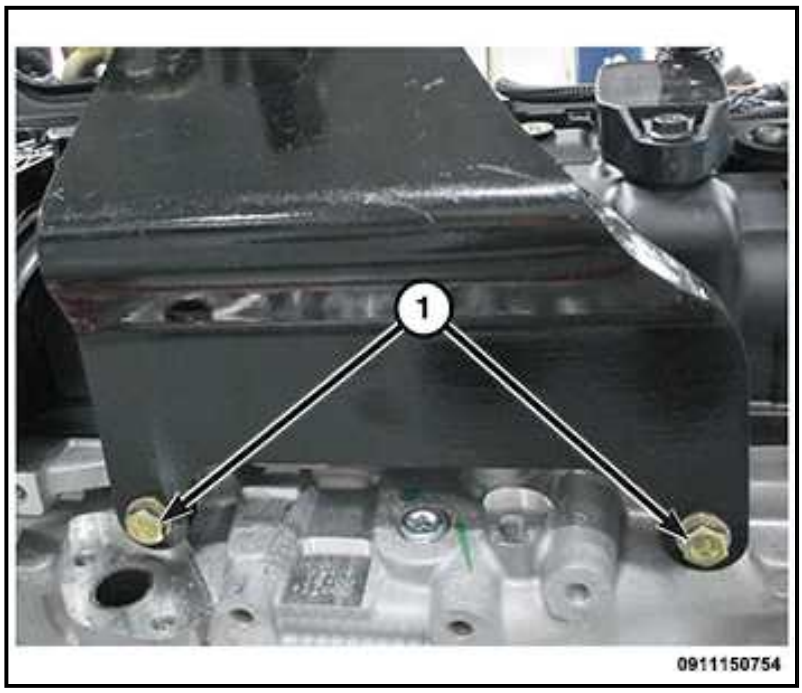
61. Carefully remove the engine from the engine bay area.
62. If required, remove the necessary components for installation onto the replacement engine.

INSTALLATION

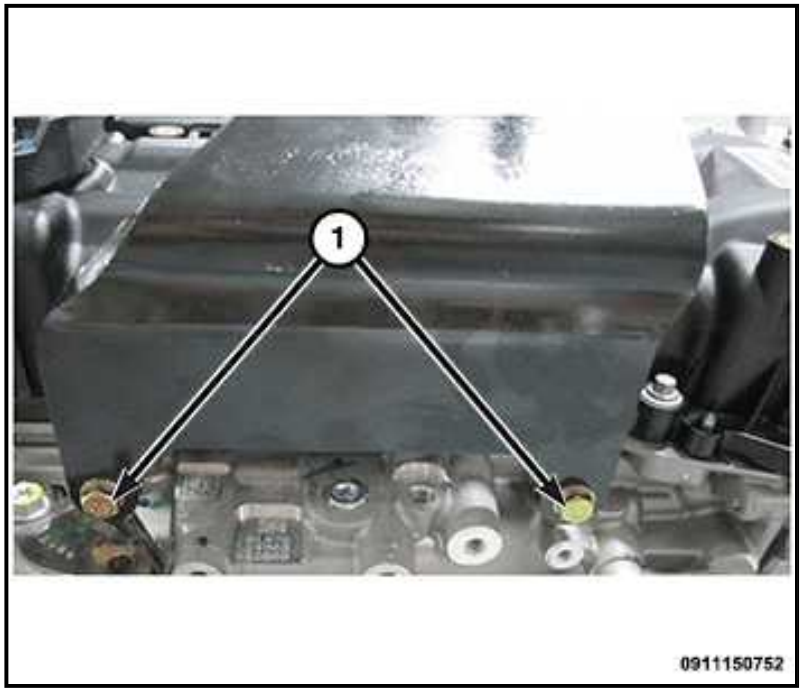
CAUTION: **If the original engine has experienced a catastrophic failure or an individual failure with the piston, cylinder bore, engine block, valve or valve seat, the intake manifold MUST be replaced with a new manifold.**

NOTE: **If installing a replacement engine, transfer the necessary components to the replacement engine.**

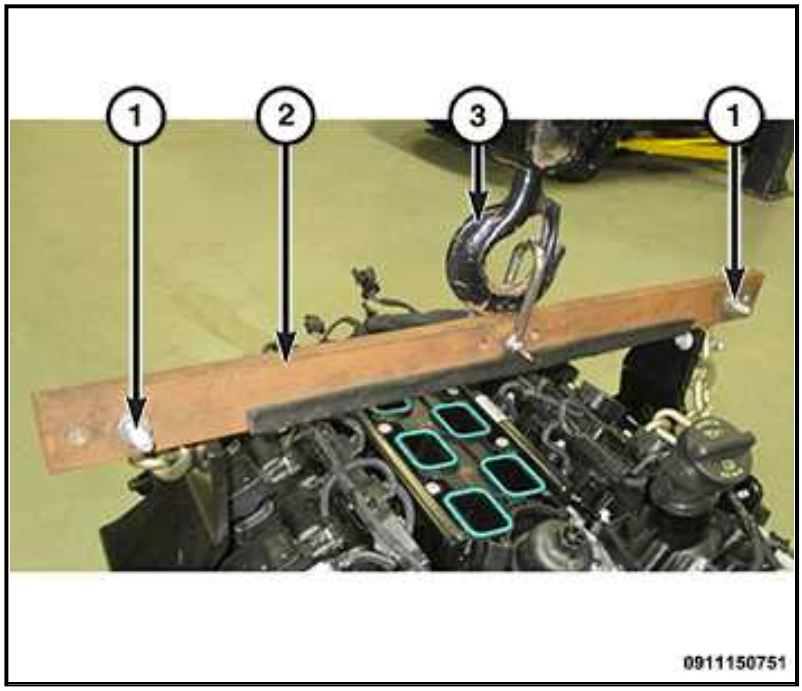
1. If required, remove the upper intake manifold. Refer to **MANIFOLD, INTAKE, REMOVAL AND INSTALLATION**.



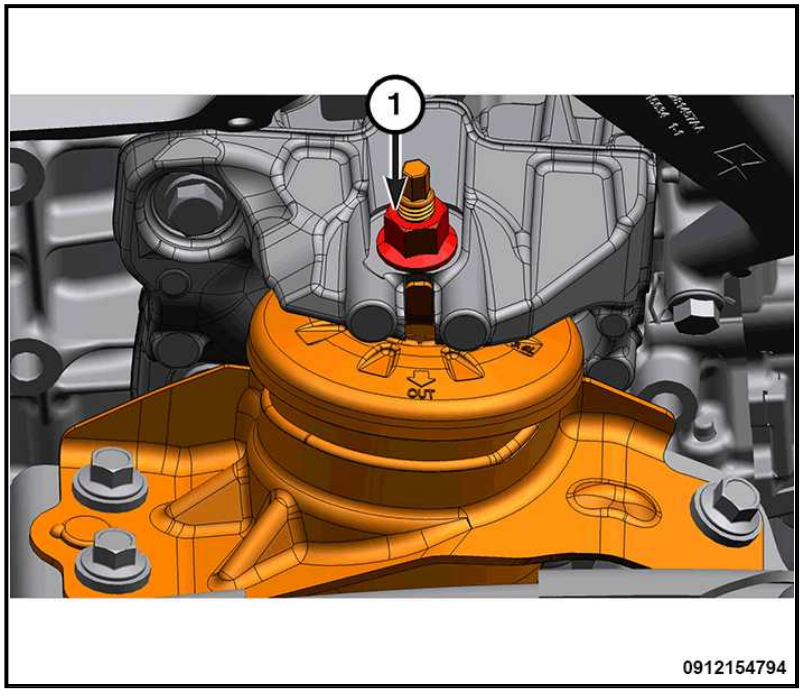
2. Install the Left Side Engine Lifting Bracket (special tool #2028020090, Lift Bracket, Engine-Left) on the LH cylinder head with the bolts (1) provided with the Engine Lifting Bracket. Tighten the bolts to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .



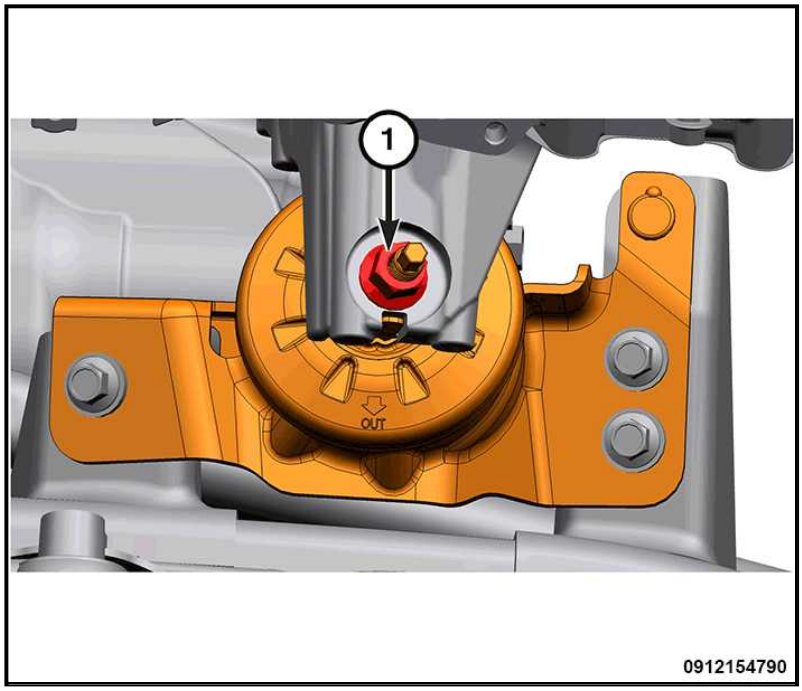
3. Install the Right Side Engine Lifting Bracket (special tool #2028010090, Lift Bracket, Engine-Right) on the RH cylinder head with the bolts (1) from the Engine Lifting Bracket. Tighten the bolts to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .



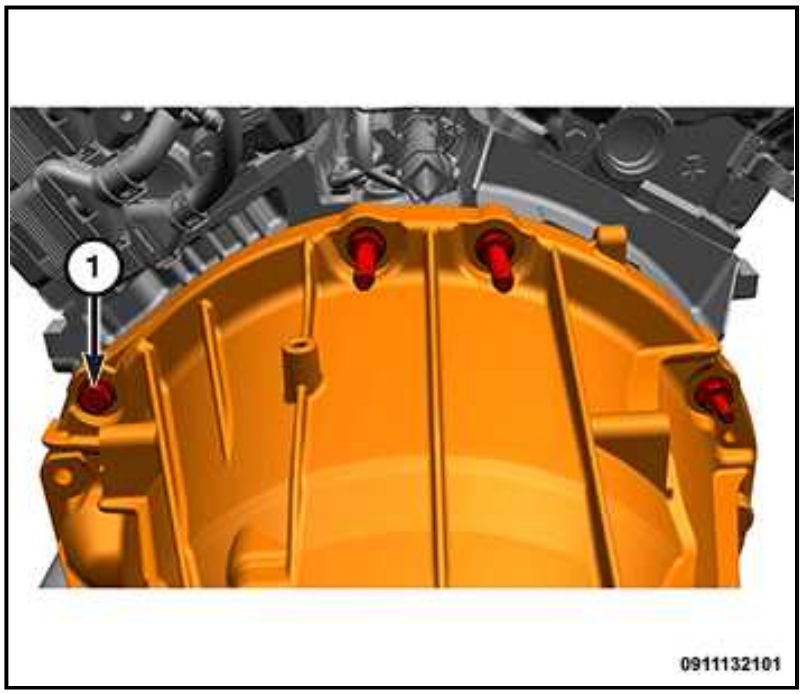
4. Position a commercially available load-leveling lifting sling (2), between the engine lifting brackets (1) and an engine hoist (3).
5. Position the engine in the vehicle. If equipped with an automatic transmission, align the two locator dowels into the transmission housing.
6. Align the left and right engine mount isolators within the frame mounting brackets and lower the engine so the weight is resting on the mounting bolts.



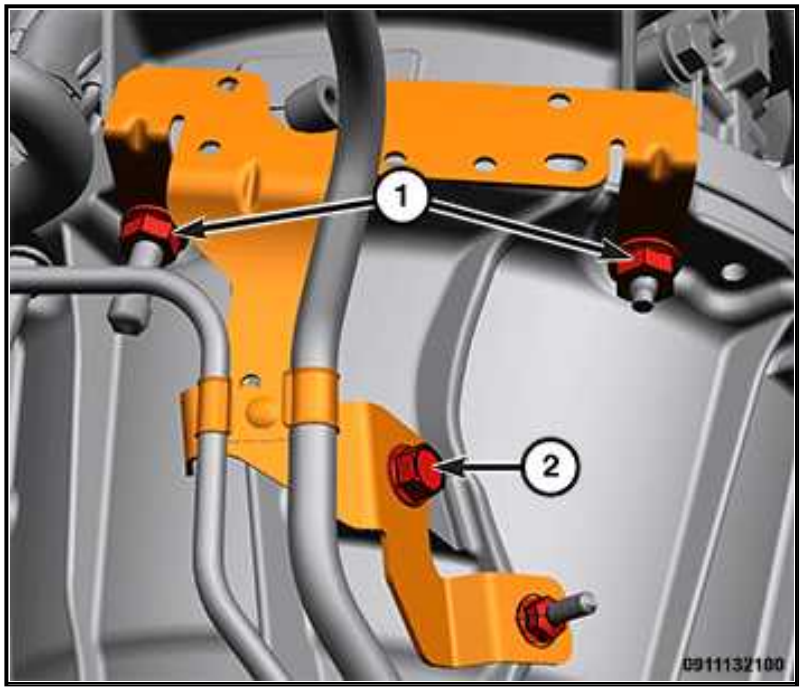
7. Tighten the right engine mount isolator to engine mount bracket nut (1) to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .



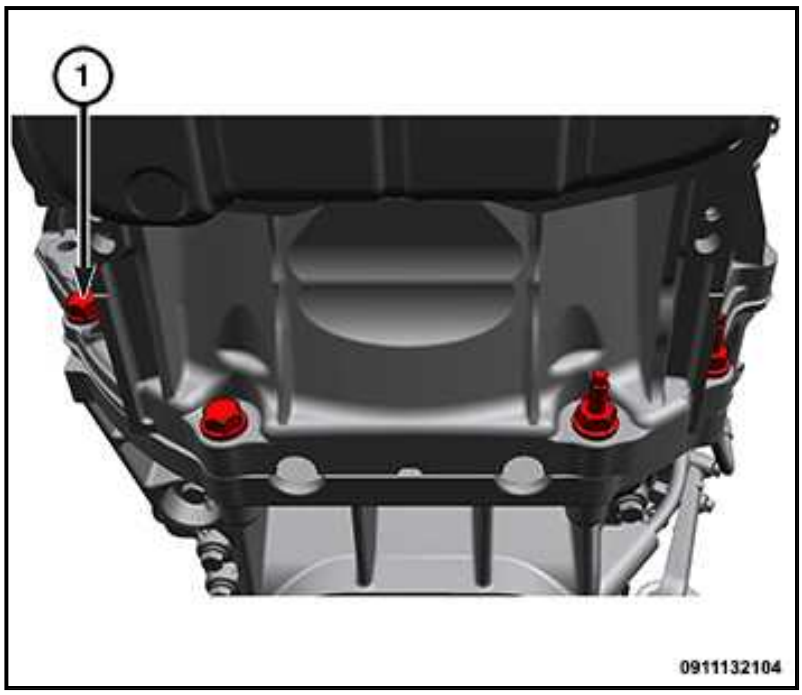
8. Tighten the left engine mount isolator to engine mount bracket nut (1) to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .
9. Remove the load-leveling lifting sling and lift brackets.
10. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .
11. Install the manual transmission, if equipped, then skip to step 21. Refer to **REMOVAL AND INSTALLATION** .
12. If equipped with an automatic transmission, continue to step 13.



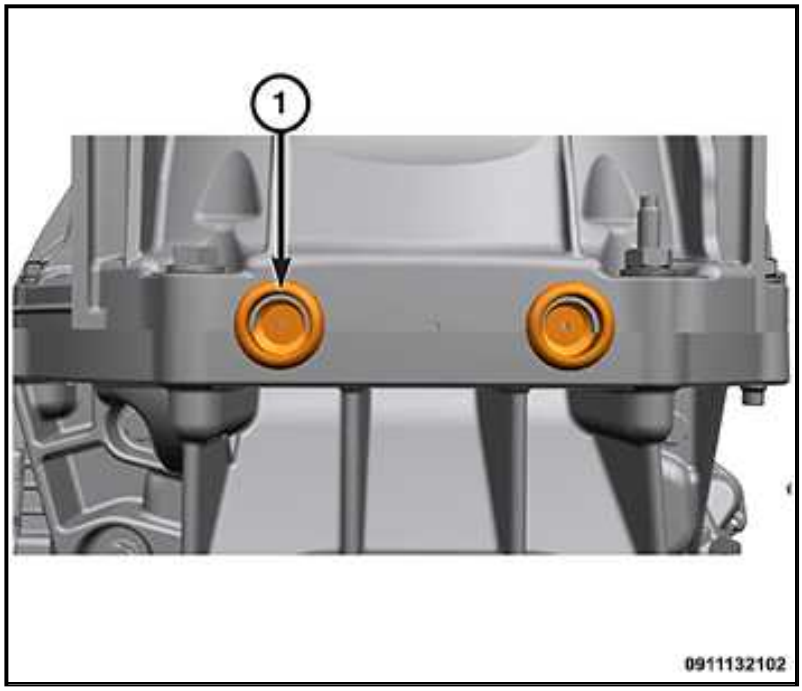
13. Install the four upper transmission to engine bolts and tighten to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .



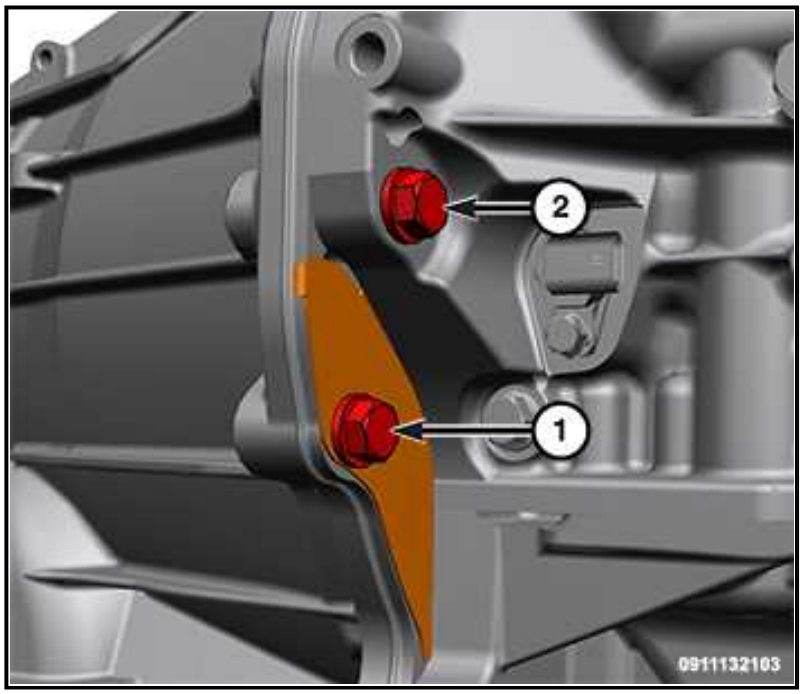
14. Install the fuel line support bracket nuts (1) and bolt (2) to the transmission and tighten to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .



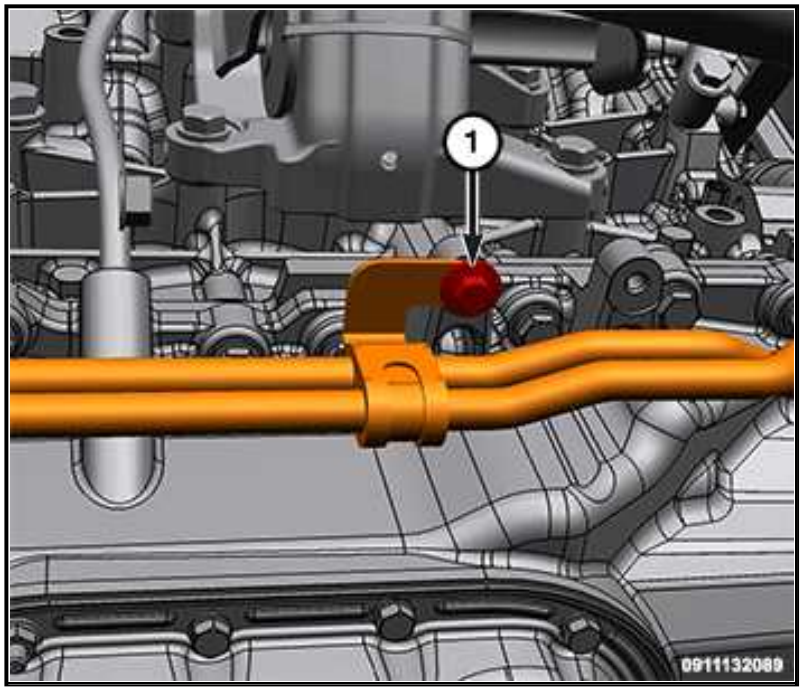
15. Install four transmission to the engine oil pan bolts (1) and tighten to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .



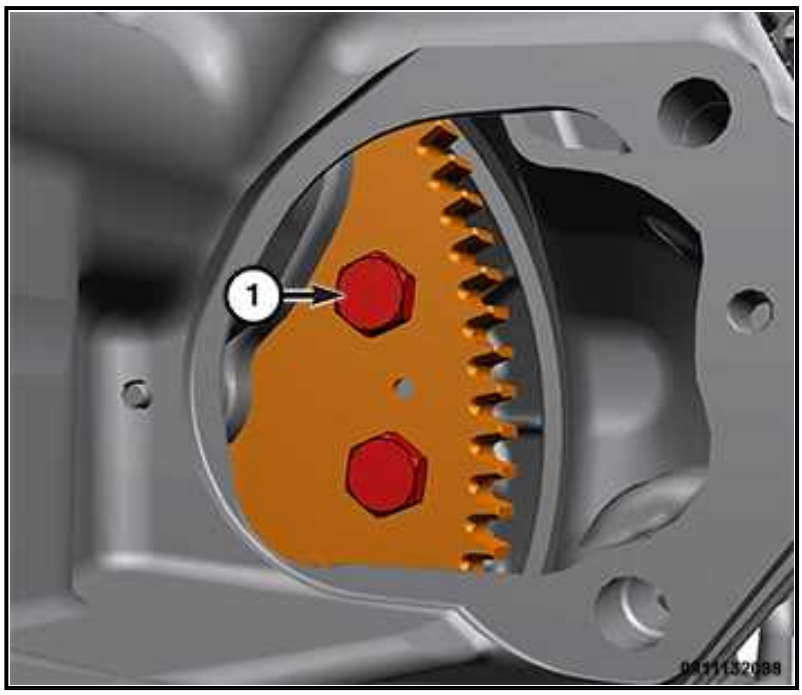
16. Install two rubber plugs (1) covering the rear oil seal retainer flange bolts.



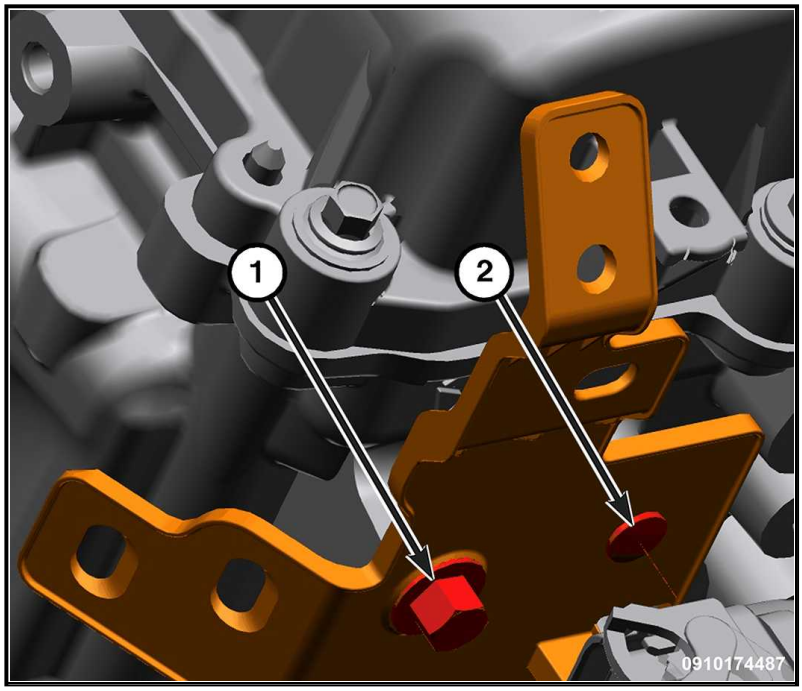
17. Install the torque converter dust shield with the bolt (1) and tighten to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .
18. Install the side engine to transmission bolt (2) and tighten to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .



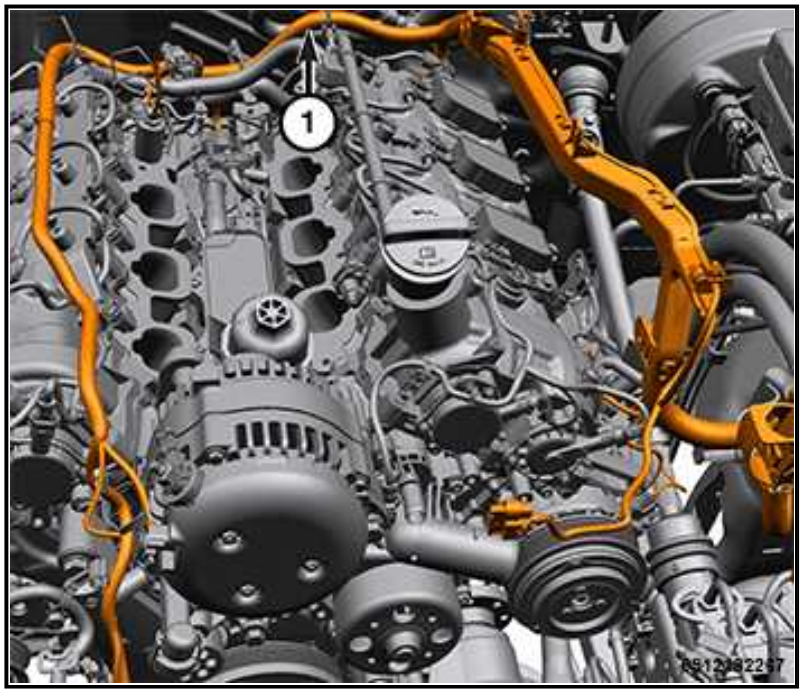
19. If equipped with an automatic transmission, engage the transmission cooler line retainer to the oil pan flange and tighten the bolt to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .



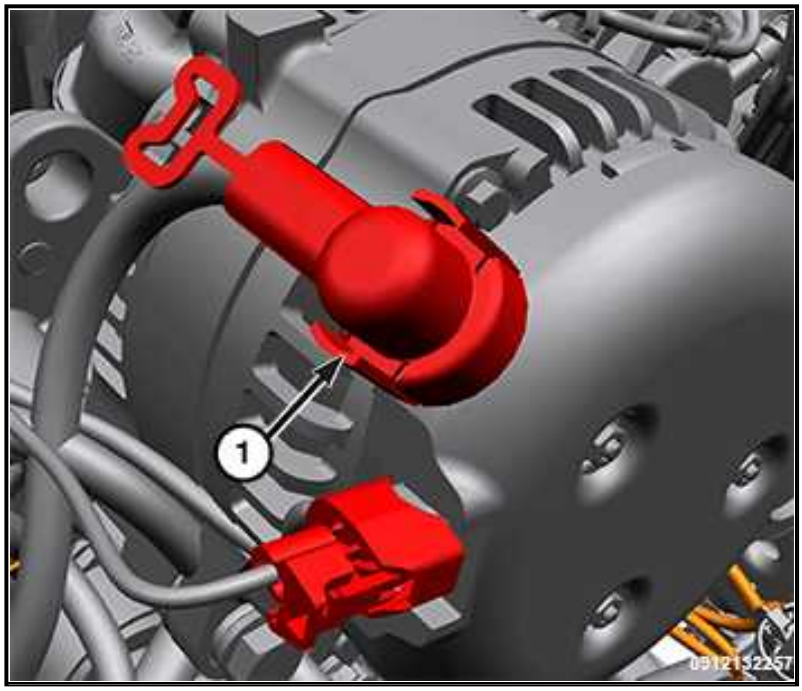
20. Rotate the crankshaft in a clockwise direction and install the six torque converter bolts (1) through the starter mounting and tighten to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .
21. Connect the power cord to the engine block heater (if equipped).
22. Install the starter. Refer to **STARTER, REMOVAL AND INSTALLATION** .
23. Install the A/C compressor Refer to **COMPRESSOR, A/C, REMOVAL AND INSTALLATION** .



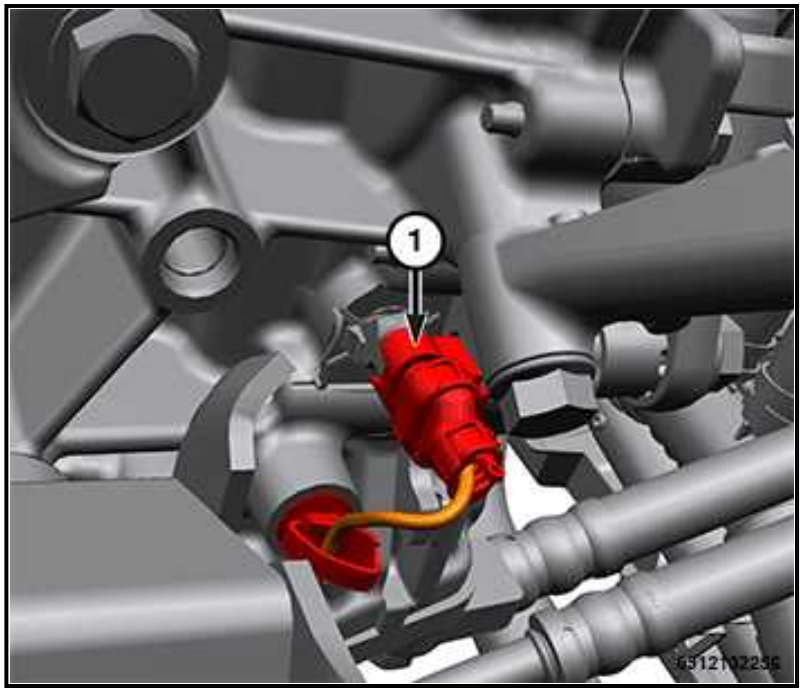
24. Position the wire harness and bracket to the left cylinder head.
25. Secure the fastener (2) to the cylinder head and tighten the bolt (1) to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .



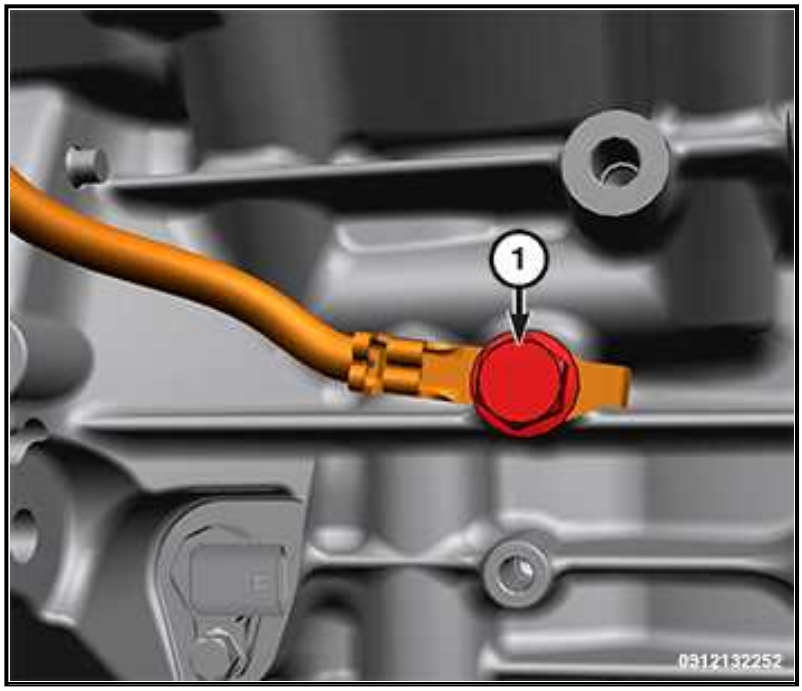
26. Install the main harness to the engine injection/ignition harness at the rear of the engine (1).
27. Install the wire harness retainers onto the right cylinder head cover.
28. Connect the wire harness connectors to the Powertrain Control Module (PCM).
29. Install the ignition capacitors. Refer to **CAPACITOR, IGNITION, REMOVAL AND INSTALLATION** .
30. Verify that all necessary wire harness connections have been connected to the engine.



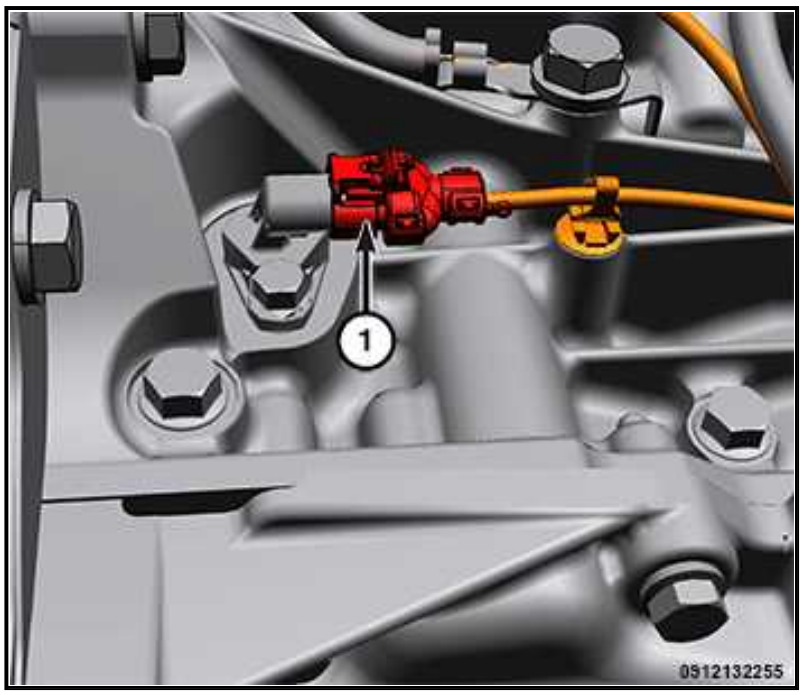
31. Install the battery harness onto the engine and secure the retaining clips.
32. Install the B+ terminal to the generator stud (1) and tighten to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .
33. Connect the field circuit wire harness connector to the generator.



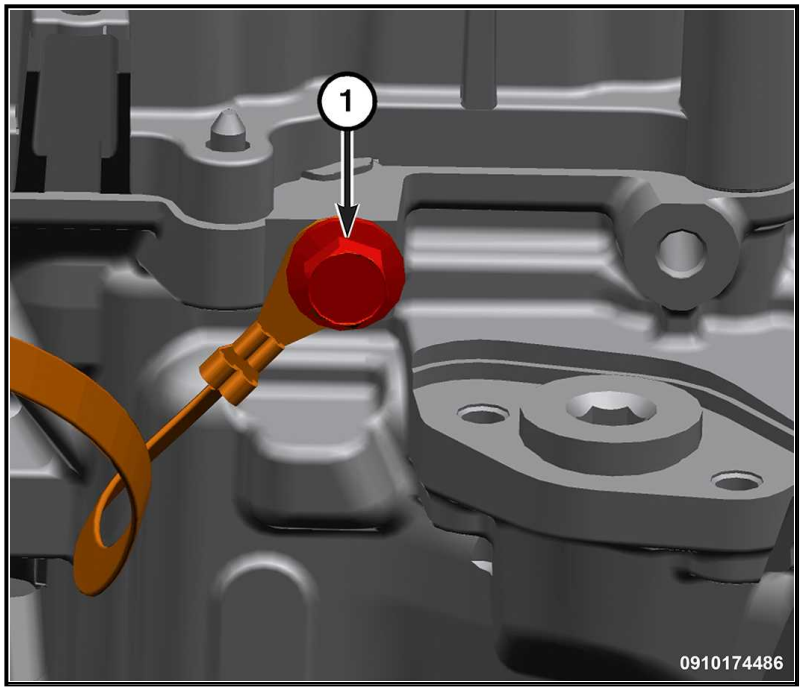
34. Connect the oil pump solenoid wire harness connector.



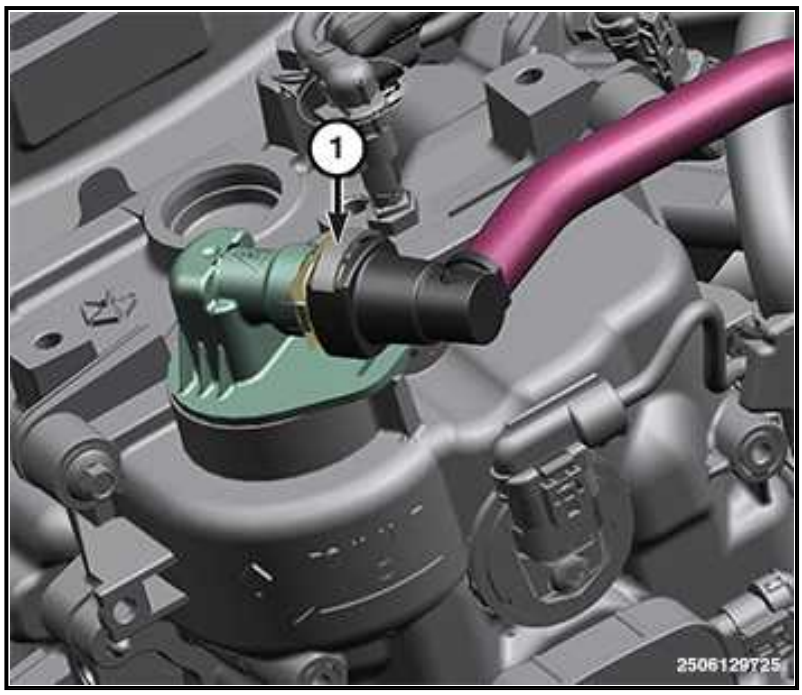
35. Install the ground strap and tighten the bolt (1) to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .



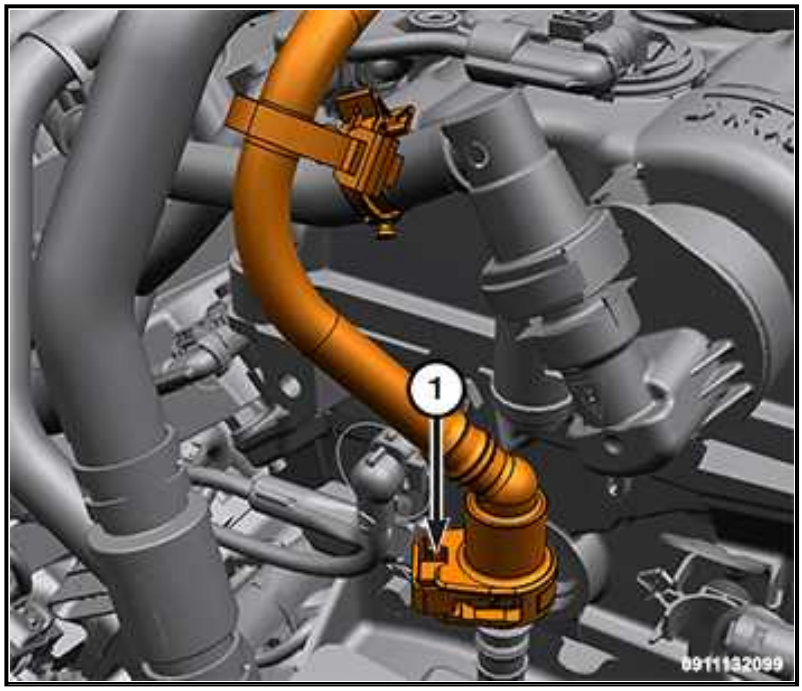
36. Connect the wire harness connector to the Crankshaft Position (CKP) sensor (1).



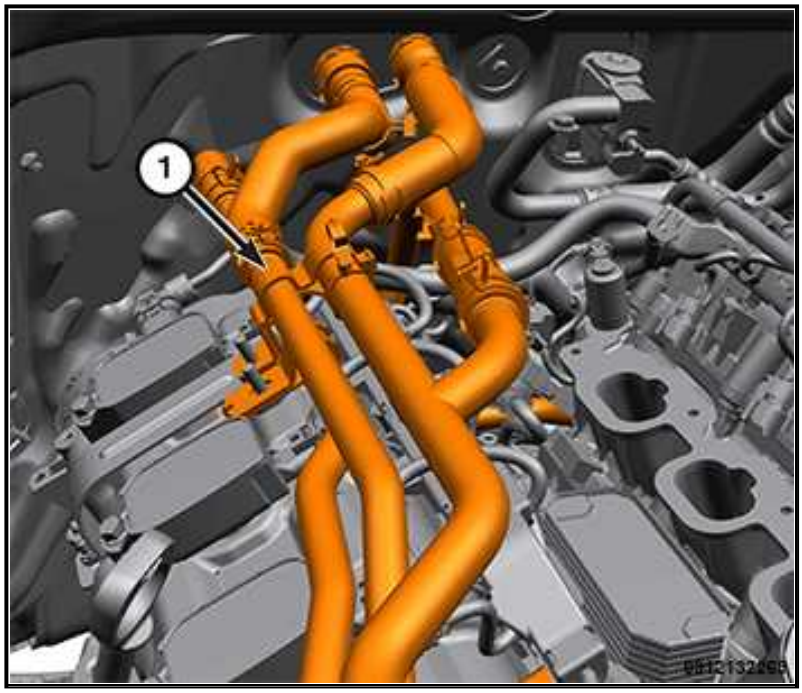
37. Install the ground strap to the right cylinder head and tighten the bolt (1) to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .



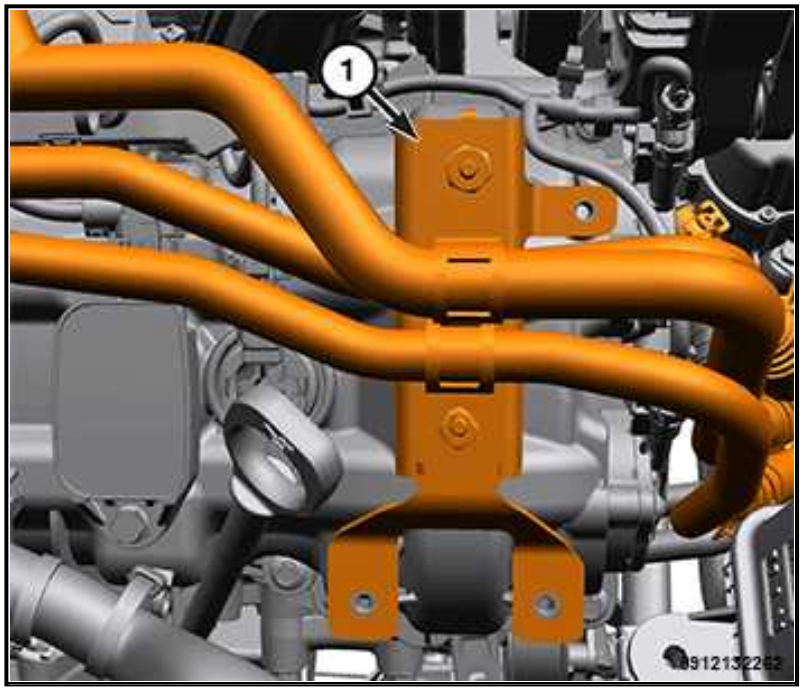
38. Install the PCV hose (1) to the PCV valve.



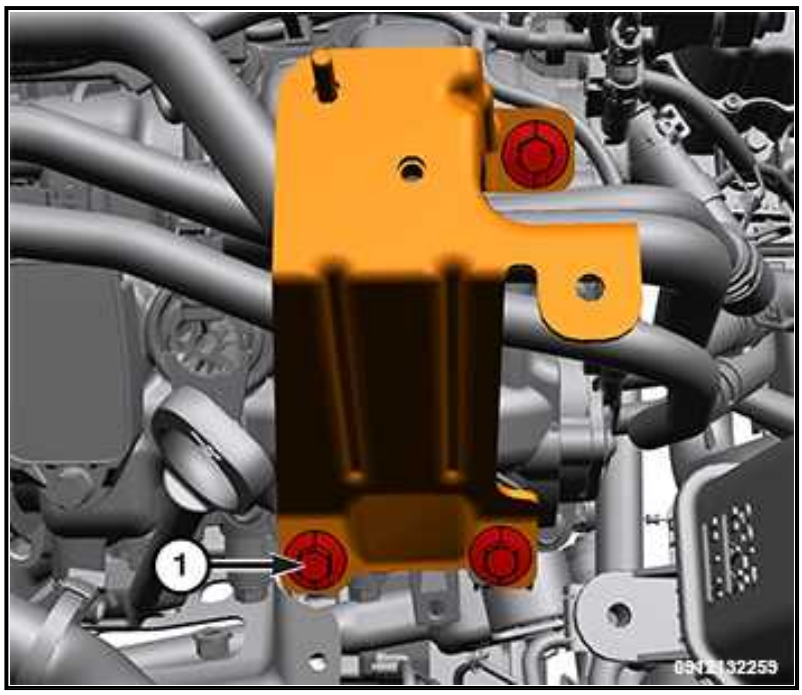
39. Connect the vapor hose (1) at the rear of the engine.
40. Connect the fuel supply hose to the left side cylinder head cover and at the rear of the engine.
41. Connect the fuel supply hose to the fuel rail. Refer to **RAIL(S), FUEL** .



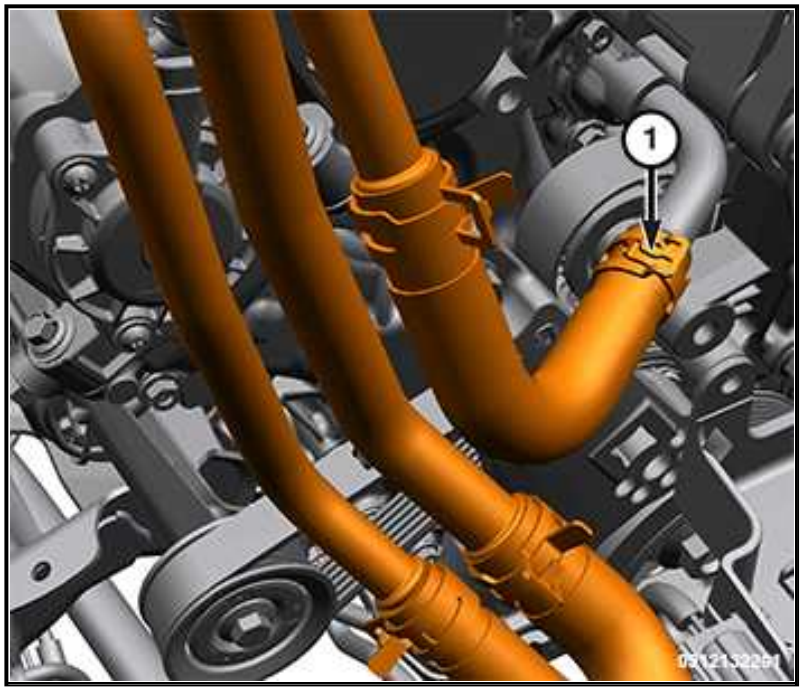
42. Install the heater core tube assembly to the right side support bracket (1) and heater core.



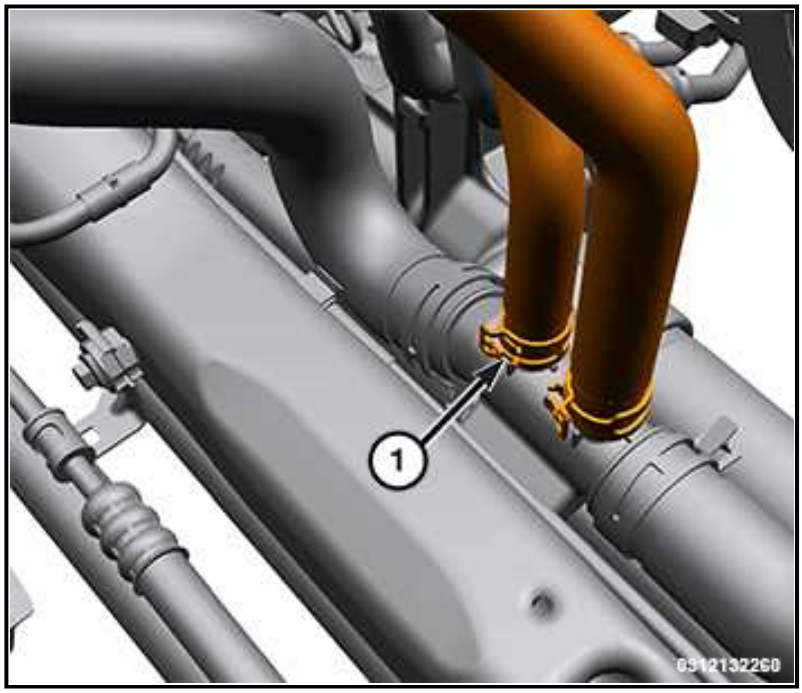
43. Install the heater core tube assembly with the right side support bracket (1) and tighten the nuts to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .



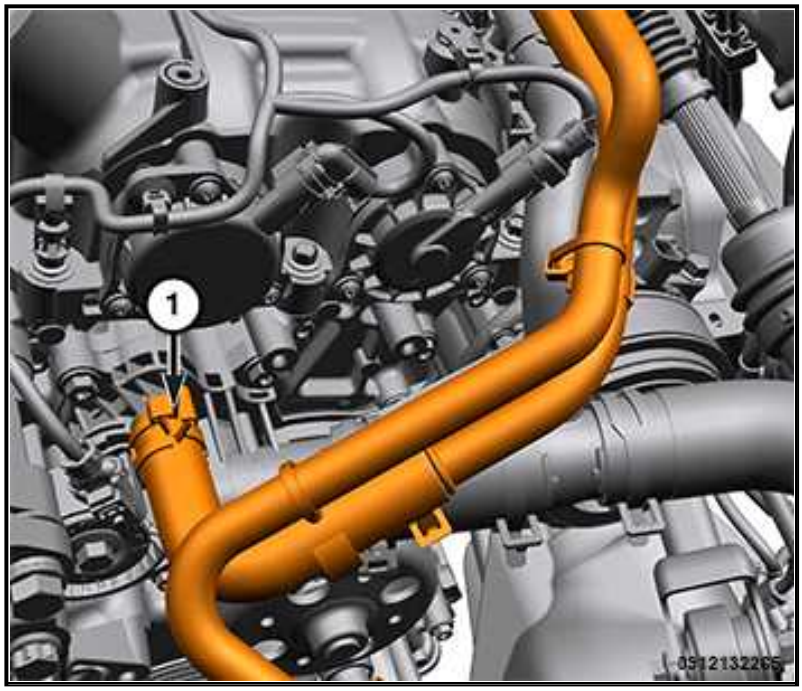
44. Instal the engine cover support bracket and tighten the bracket bolts (1) to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .



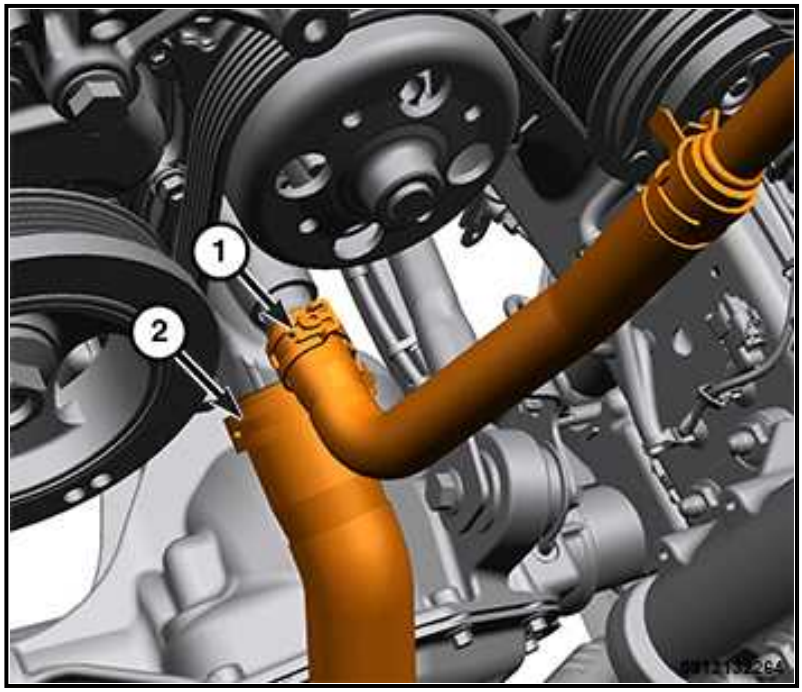
45. Connect the heater core return and supply (1) hoses.



46. Install the heater core supply hose (1), and oil cooler return hose to the lower radiator outlet hose.

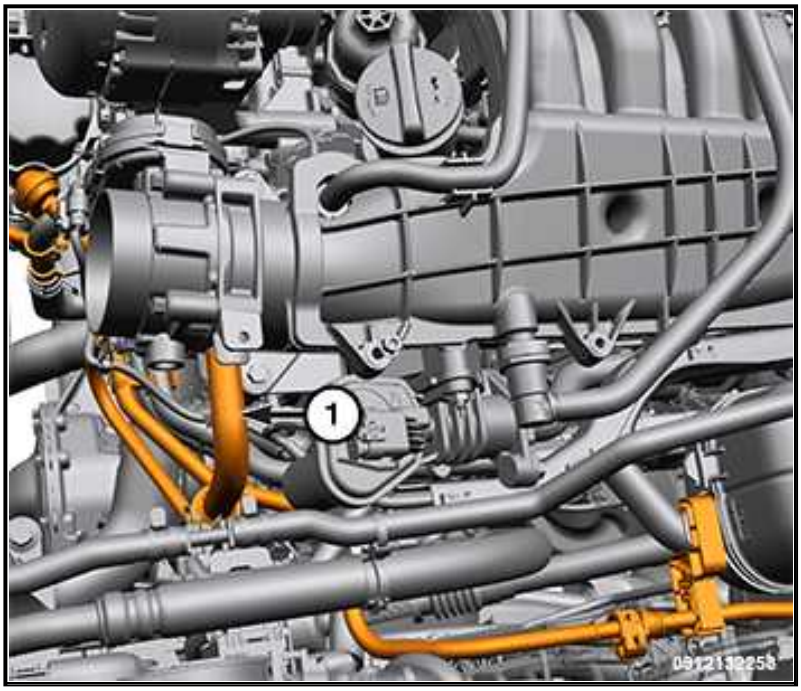


47. Install the Exhaust Gas Recirculation (EGR) cooler and coolant bottle hose assembly (1).
48. Install the upper radiator hose to the engine thermostat housing.



49. Install the lower radiator hose (2) to the engine water pump housing.
50. Install the coolant bottle hose to the water pump (1).
51. Install the right and left catalytic converters. Refer to **CONVERTER, CATALYTIC, REMOVAL AND INSTALLATION** .
52. Install the Exhaust Gas Recirculation (EGR) cooler. Refer to **COOLER, EXHAUST GAS RECIRCULATION (EGR), REMOVAL AND INSTALLATION** .
53. Install the upper intake manifold and insulator Refer to **MANIFOLD, INTAKE, REMOVAL AND INSTALLATION**.
54. Install the pressurized coolant bottle. Refer to **BOTTLE, PRESSURIZED COOLANT, REMOVAL AND INSTALLATION**.
55. Install the electric vacuum pump. Refer to **PUMP, ELECTRIC VACUUM, REMOVAL AND INSTALLATION** .

Remove the cooling fan. Refer to **FAN, COOLING, REMOVAL AND INSTALLATION**.



56. Install the vacuum harness assembly (1).
57. Install the cooling fan. Refer to **FAN, COOLING, REMOVAL AND INSTALLATION**.
58. Install the battery tray. Refer to **TRAY, BATTERY, REMOVAL AND INSTALLATION** .
59. Install the front wheelhouse inner splash shields. Refer to **SHIELD, SPLASH, REAR WHEELHOUSE, REMOVAL AND INSTALLATION** .
60. Install the air cleaner body. Refer to **BODY, AIR CLEANER, REMOVAL AND INSTALLATION**.
61. If removed, install the oil filter and fill the engine crankcase with the proper oil to the correct level Refer to **FILTER, ENGINE OIL** .
62. Fill the cooling system. Refer to **STANDARD PROCEDURE - FILLING** .
63. Install the engine cover. Refer to **COVER, ENGINE, REMOVAL AND INSTALLATION**.
64. Connect the negative battery cable(s). Refer to **CABLES, BATTERY** .
65. Run the engine until it reaches normal operating temperature. Check cooling system for correct fluid level Refer to the appropriate information .

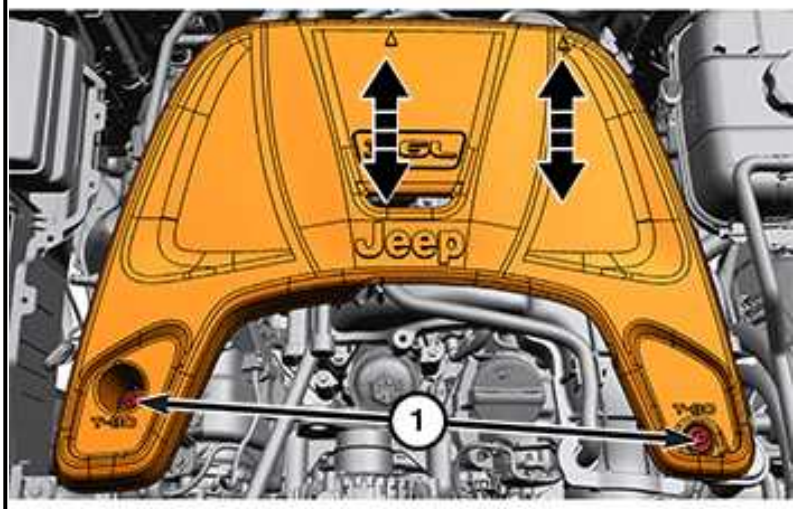
NOTE: **The Cam/Crank Variation Relearn procedure must be performed using the scan tool anytime there has been a repair/replacement made to a powertrain system, for example: flywheel, valvetrain, camshaft and/or crankshaft sensors or components.**

COVER, ENGINE

REMOVAL AND INSTALLATION

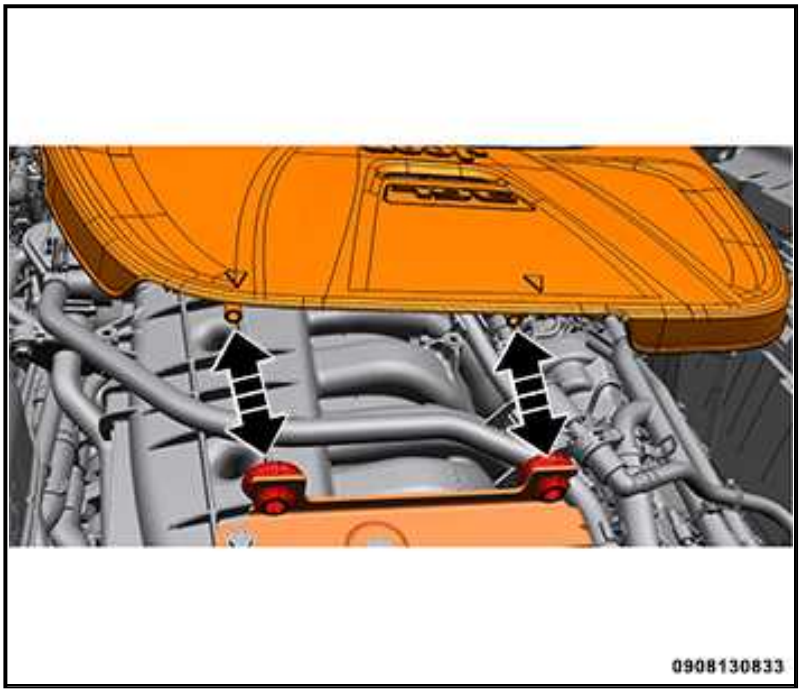
ENGINE COVER

REMOVAL



1 - Engine Cover Bolts

1. Remove the bolts from the engine cover.



2. Gently pull forward to disengage the rear grommets from the engine cover.

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

AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake	**8 N.m (71 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Manifold Bolts		
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-

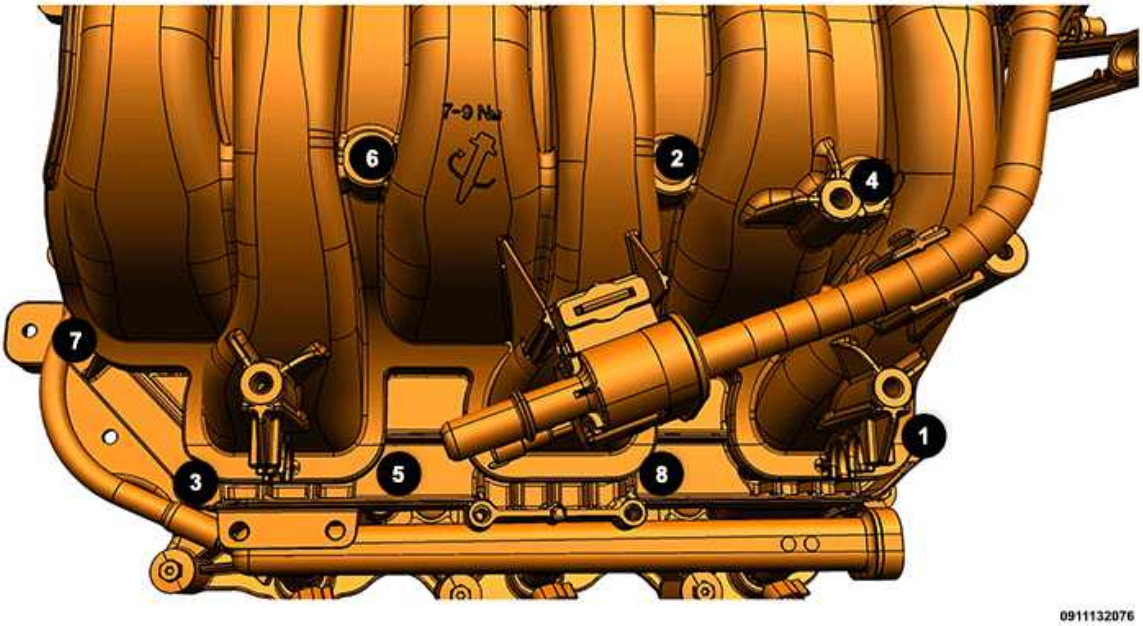


Fig. 13: Upper Intake Manifold Bolts Tightening/Loosening Sequence
Courtesy of CHRYSLER GROUP, LLC

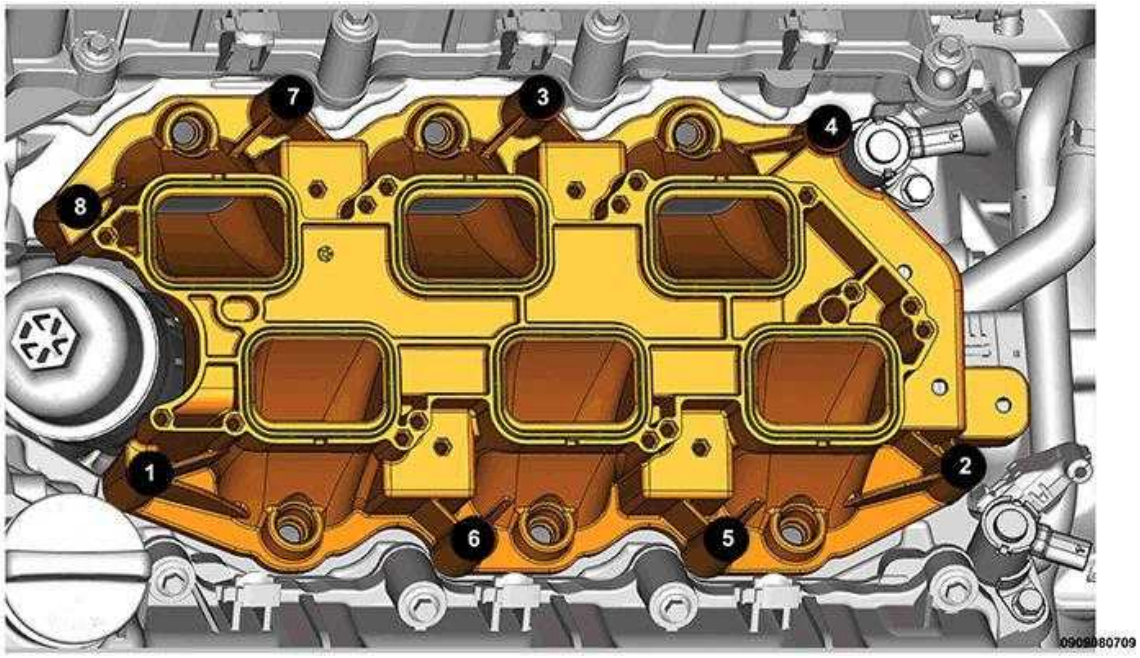


Fig. 14: Lower Intake Manifold Bolt Removal & Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

ENGINE SENSORS

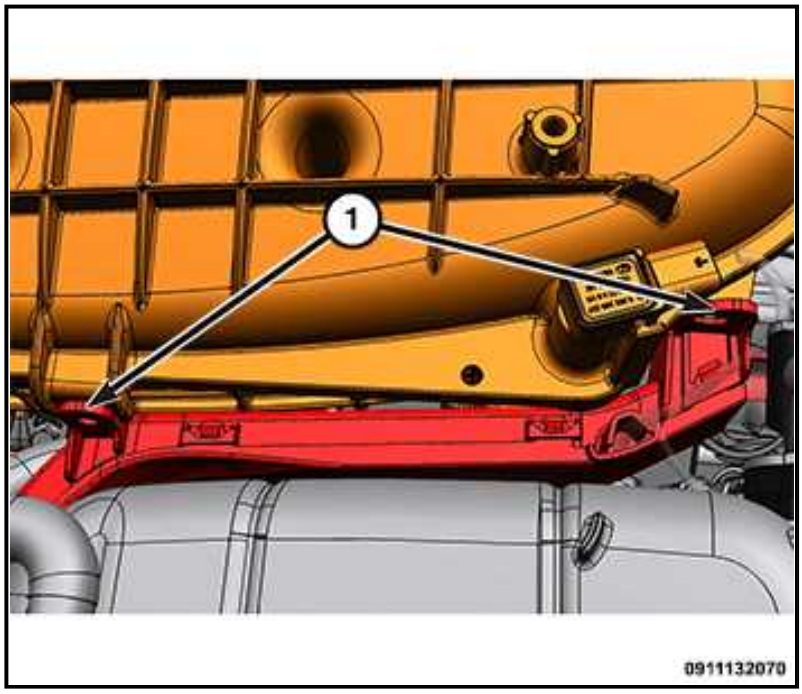
REMOVAL AND INSTALLATION

CAMSHAFT POSITION SENSOR - LEFT

REMOVAL

The Camshaft Position (CMP) sensors are located at the rear of the cylinder head covers and are bolted to the cylinder head.

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**.

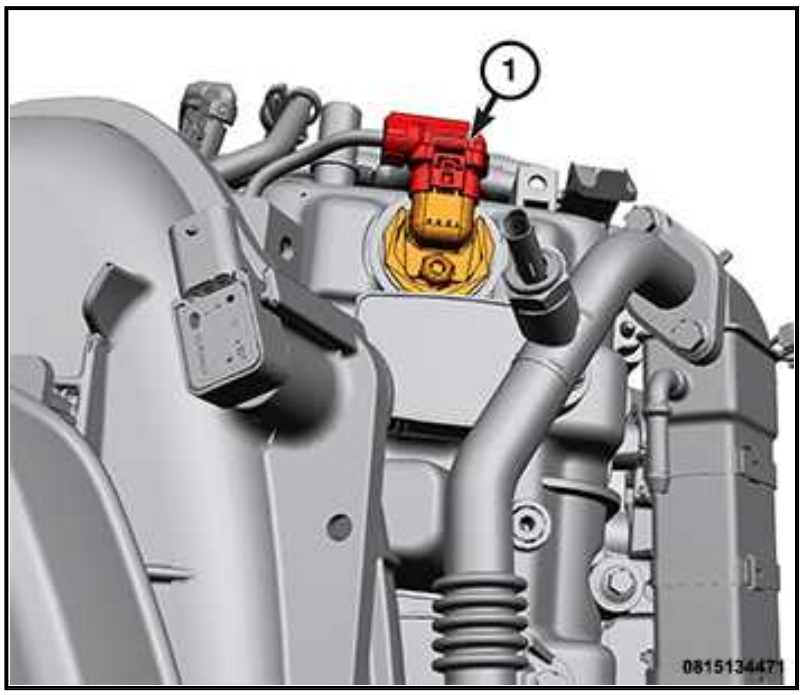


1 - Push Pins

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

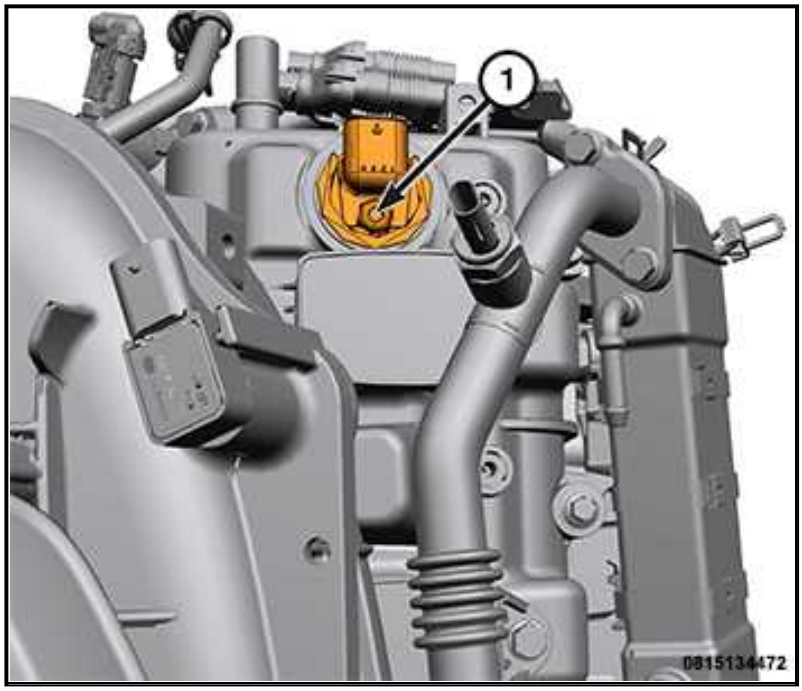
1 - Coolant Bottle

4. Position the coolant bottle aside, without removing the hoses or draining the cooling system. Refer to **BOTTLE, PRESSURIZED COOLANT, REMOVAL AND INSTALLATION**.



1 - CMP Sensor Wire Harness Connector

5. Disconnect the wire harness connector from the CMP sensor.



1 - CMP Sensor Bolt

6. Loosen the CMP sensor mounting bolt.
7. Pull the sensor and mounting bolt from the cylinder head cover.
8. The O-ring seal can be reused if not damaged.

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 out the camshaft position (CMP) sensor mounting bolt hole in cylinder head.
- The CMP sensor seal can be reused if not damaged.
- If required, install a new CMP sensor seal in the cylinder head cover:
  - Lubricate the CMP sensor seal inner and outer diameters with clean engine oil.
  - Place the CMP sensor seal on the Cam Sensor/Spark Plug Tube Seal Installer (special tool #10256, Installer, Cam Installer, Cam Sensor/ Spark Plug Tube Seal).
  - Push the seal into the cylinder head cover until the base of the seal is seated.
  - Remove the tool.

NOTE: **A properly installed CMP sensor seal will have a 1.5 - 2.0 mm (0.06 - 0.08 in.) gap between the cylinder head cover and the seal upper flange.**

- The sensor mounting bolt O-ring can be reused if not damaged.
- Apply a small amount of engine oil to the sensor mounting bolt O-ring.

NOTE: **If both left and right CMP sensors where removed, install them into their original locations.**

NOTE: **The Cam/Crank Variation Relearn procedure must be performed using the scan tool anytime there has been a repair/replacement made to a powertrain system, for example: flywheel, valvetrain, camshaft and/or crankshaft sensors or components.**

TORQUE SPECIFICATIONS

ENGINE SENSORS

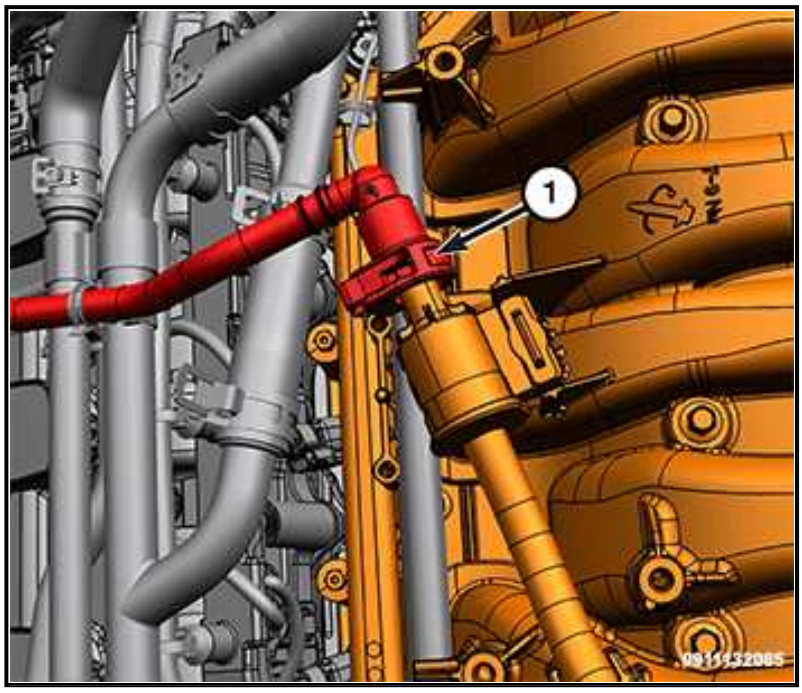
DESCRIPTION	SPECIFICATION	COMMENTS
Map Sensor	-	-
Coolant Temperature Sensor	**1/4 Turn to Engage**	-
EGR Temperature Sensor	**37 N. m (27 Ft. Lbs.)**	-
Crankshaft Position (CKP) Sensor Bolt	**12 N.m (9 Ft. Lbs.)**	-
Engine Oil Pressure (EOP) Sensor	**20 N.m (15 Ft. Lbs.)**	-
Camshaft Position (CMP) Sensor to Cylinder Head	**9 N. m (80 In. Lbs.)**	-
Oxygen (O2) Sensor	**43 N.m (32 Ft. Lbs.)**	-
Oil Temperature Sensor to Cylinder Head	**11 N.m (8 Ft. Lbs.)**	-
Knock Sensor	**22 N.m (16 Ft. Lbs.)**	Do not reuse fastener. If removed, a new fastener must be installed and tightened to specifications

CAMSHAFT POSITION SENSOR - RIGHT

REMOVAL

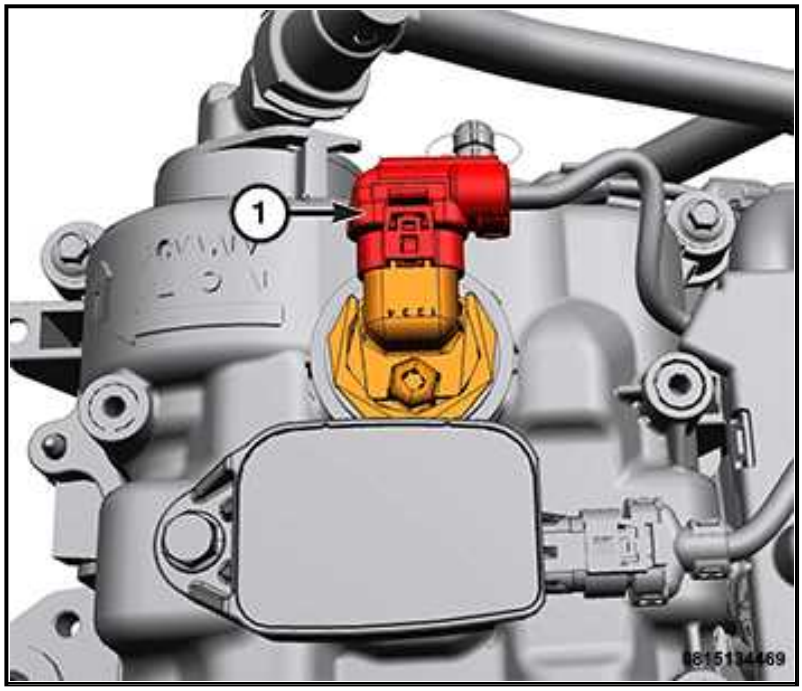
The Camshaft Position (CMP) sensors are located at the rear of the cylinder head covers and are bolted to the cylinder head.

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**.



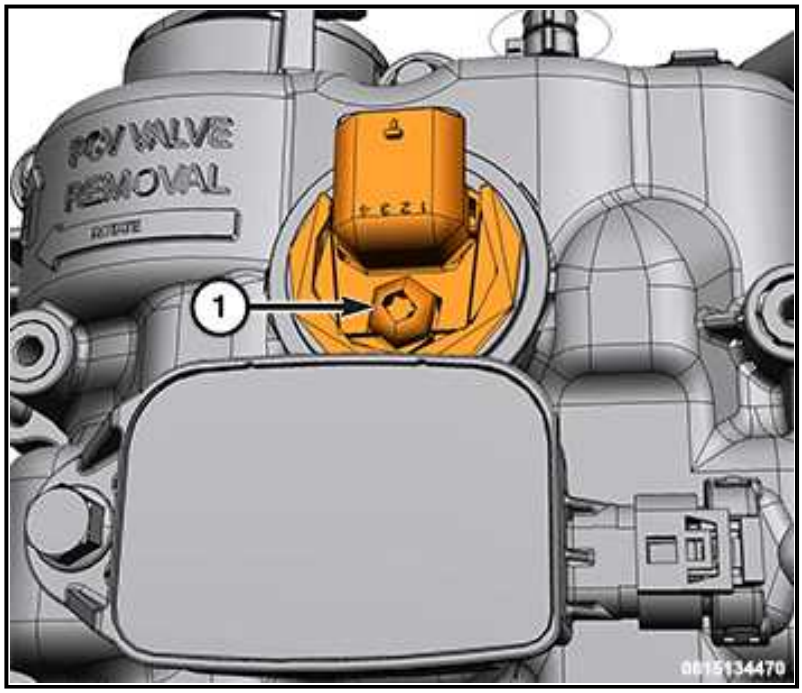
1 - Purge Line

3. Disconnect the purge line from the purge valve, remove from retaining clip and position aside.



1 - CMP Sensor Wire Harness Connector

4. Disconnect the wire harness connector from the CMP sensor.



1 - CMP Sensor Bolt

5. Loosen the CMP sensor mounting bolt.
6. Pull the sensor and mounting bolt from the cylinder head cover.
7. The O-ring seal can be reused if not damaged.

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 out the Camshaft Position (CMP) sensor mounting bolt hole in cylinder head.

- The CMP sensor seal can be reused if not damaged.
- If required, install a new CMP sensor seal in the cylinder head cover:
  - Lubricate the CMP sensor seal inner and outer diameters with clean engine oil.
  - Place the CMP sensor seal on the Cam Sensor/Spark Plug Tube Seal Installer (special tool #10256, Installer, Cam Installer, Cam Sensor/ Spark Plug Tube Seal).
  - Push the seal into the cylinder head cover until the base of the seal is seated.
  - Remove the tool.

NOTE: **A properly installed CMP sensor seal will have a 1.5 - 2.0 mm (0.06 - 0.08 in.) gap between the cylinder head cover and the seal upper flange.**

- The sensor mounting bolt O-ring can be reused if not damaged.
- Apply a small amount of engine oil to the sensor mounting bolt O-ring.

NOTE: **If both RH and LH CMP sensors where removed, install them into their original locations.**

NOTE: **The Cam/Crank Variation Relearn procedure must be performed using the scan tool anytime there has been a repair/replacement made to a powertrain system, for example: flywheel, valvetrain, camshaft and/or crankshaft sensors or components.**

TORQUE SPECIFICATIONS

ENGINE SENSORS

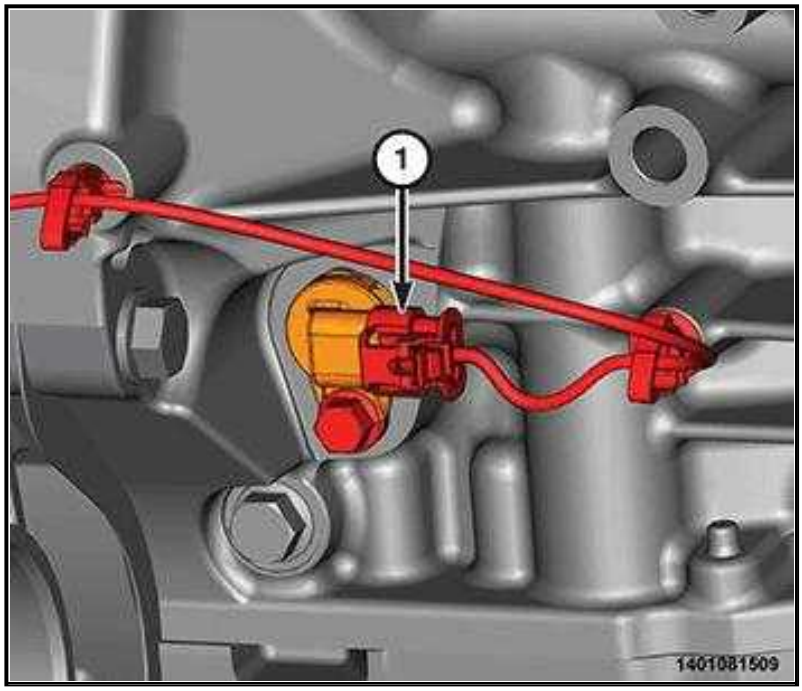
DESCRIPTION	SPECIFICATION	COMMENTS
Map Sensor	-	-
Coolant Temperature Sensor	**1/4 Turn to Engage**	-
EGR Temperature Sensor	**37 N. m (27 Ft. Lbs.)**	-
Crankshaft Position (CKP) Sensor Bolt	**12 N.m (9 Ft. Lbs.)**	-
Engine Oil Pressure (EOP) Sensor	**20 N.m (15 Ft. Lbs.)**	-
Camshaft Position (CMP) Sensor to Cylinder Head	**9 N. m (80 In. Lbs.)**	-
Oxygen (O2) Sensor	**43 N.m (32 Ft. Lbs.)**	-
Oil Temperature Sensor to Cylinder Head	**11 N.m (8 Ft. Lbs.)**	-
Knock Sensor	**22 N.m (16 Ft. Lbs.)**	Do not reuse fastener. If removed, a new fastener must be installed and tightened to specifications

CRANKSHAFT POSITION (CKP) SENSOR

REMOVAL

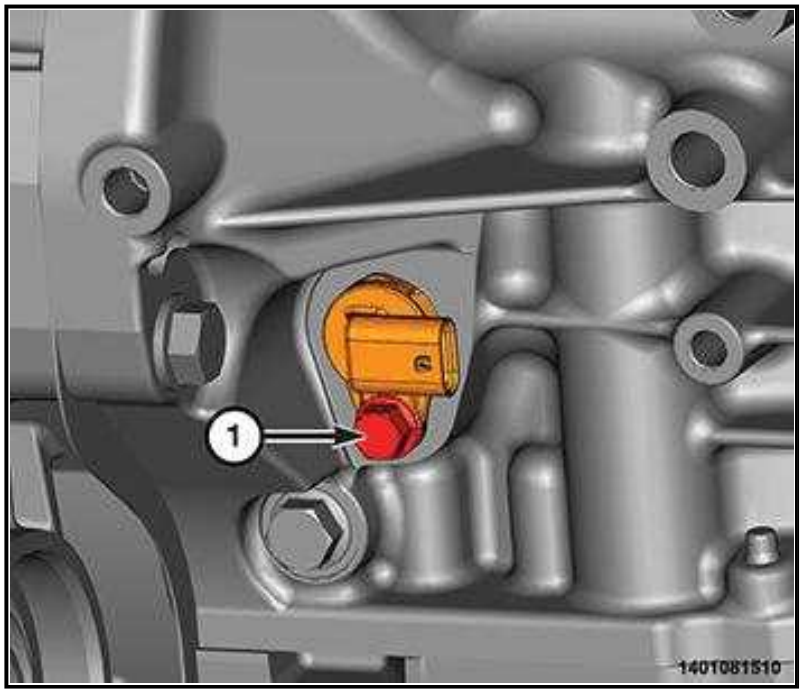
NOTE: **The Crankshaft Position (CKP) sensor is mounted into the right rear side (when looking from the inside the vehicle) of the cylinder block.**

1. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .



1 - CKP Sensor Wire Harness Connector

2. Disconnect the Crankshaft Position (CKP) Sensor wire harness connector (1).



1 - CKP Sensor Bolt

3. Remove the bolt and the CKP sensor.

INSTALLATION

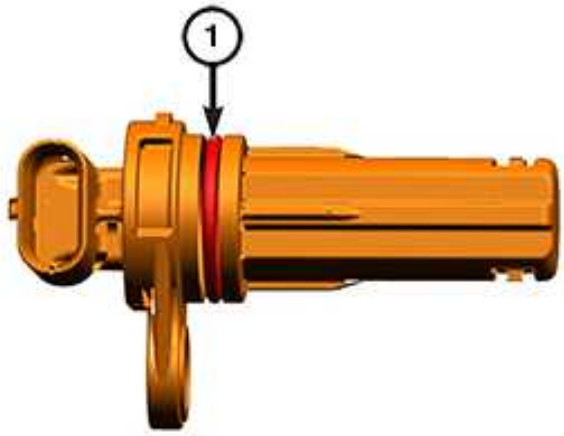
During installation, torque the fasteners to the specifications in the torque table(s) below.

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.

- Lubricate the CKP sensor O-ring with clean engine oil.
- Install the CKP sensor into the engine block with a slight rocking and twisting action.

CAUTION: **Before tightening the CKP sensor mounting bolt, be sure the sensor is completely flush to the cylinder block. If the CKP sensor is not flush, damage to the sensor mounting tang may result.**

- The Cam/Crank Variation Relearn procedure must be performed using the scan tool anytime there has been a repair/replacement made to the powertrain system, for example: flywheel, valvetrain, camshaft and or crankshaft sensors or components.



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1 - CKP Sensor O-ring

TORQUE SPECIFICATIONS

FUEL SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
Accelerator Pedal to Bulkhead Nuts	**12 N. m (9 Ft. Lbs.)**	-
Fuel Filler Tube to Body Bolts	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube to Body Nut(s)	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube Clamp	**4 N. m (35 In. Lbs.)**	-
Fuel Line Bundle to Transmission	**25 N.m (18 Ft. Lbs.)**	-
Fuel Pump Control Module	**6 N.m (53 In. Lbs.)**	-
Fuel Rail to Lower Intake	**7 N.m (62 In. Lbs.)**	-
Fuel Tank Deflector to Cross Member	**8 N.m (71 In. Lbs.)**	-
Fuel Tank Skid Plate Bolts	**95 N. m (70 Ft. Lbs.)**	-
Fuel Tank Strap to Skid Plate	**25 N. m (18 Ft. Lbs.)**	-

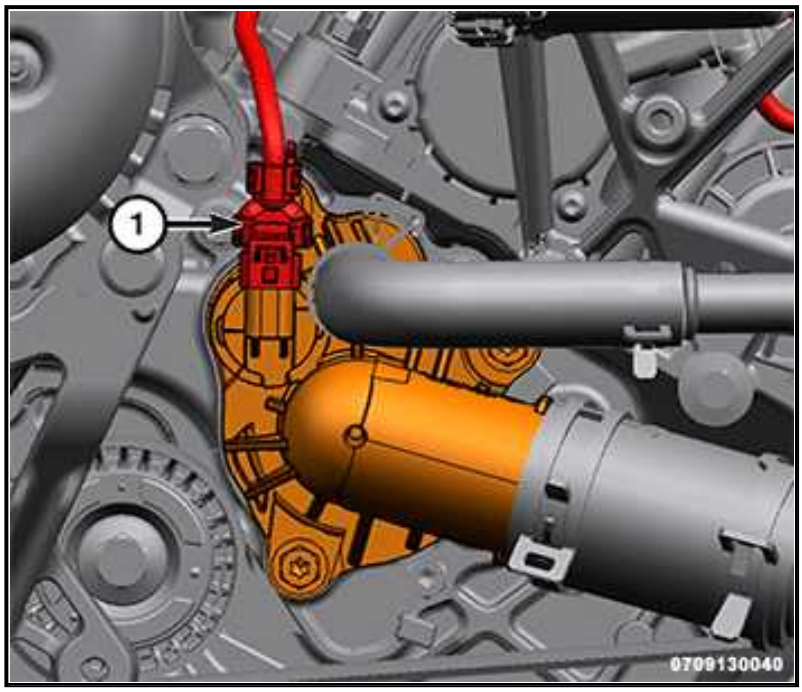
ECT SENSOR

REMOVAL

WARNING: **Hot, pressurized coolant can cause injury by scalding. Cooling system must be partially drained before removing the coolant temperature sensor.**

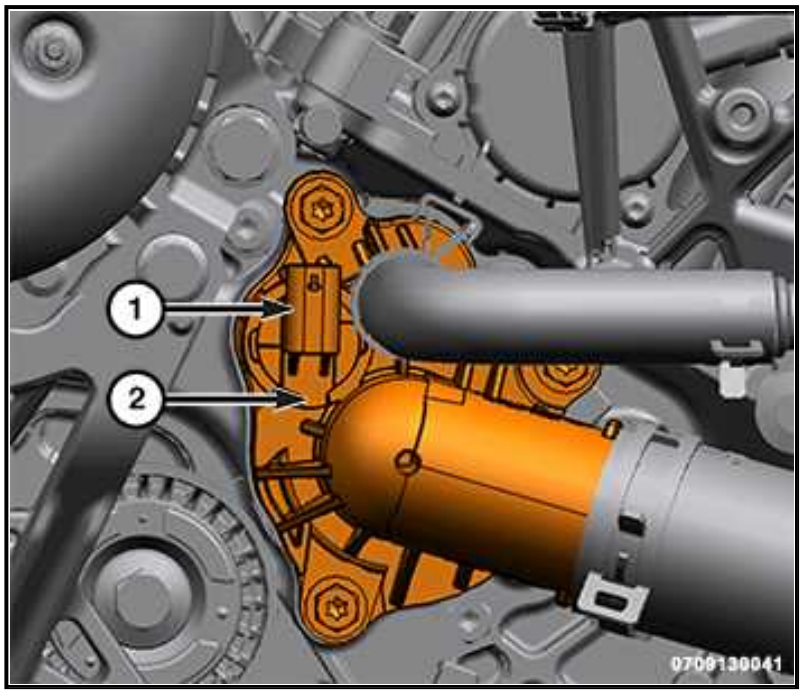
1. Drain the cooling system. Refer to **DRAINING** .

2. Remove the air cleaner resonator. Refer to **RESONATOR, AIR CLEANER, REMOVAL AND INSTALLATION**.



1 - Wire Harness Connector

3. Disconnect the Engine Coolant Temperature (ECT) sensor wire harness connector.



1 - ECT Sensor
2 - Lock Tab

4. Release the lock tab on the bottom of the ECT sensor and rotate the ECT sensor 1/4 turn counter clockwise to remove.

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.

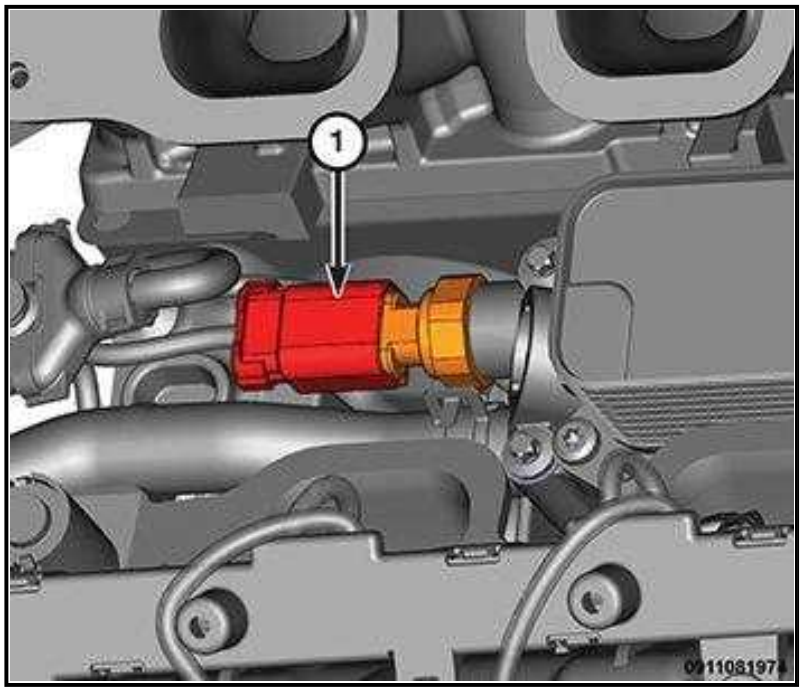
- Fill the cooling system. Refer to **STANDARD PROCEDURE - FILLING** .

TORQUE SPECIFICATIONS

ENGINE OIL PRESSURE (EOP) SENSOR

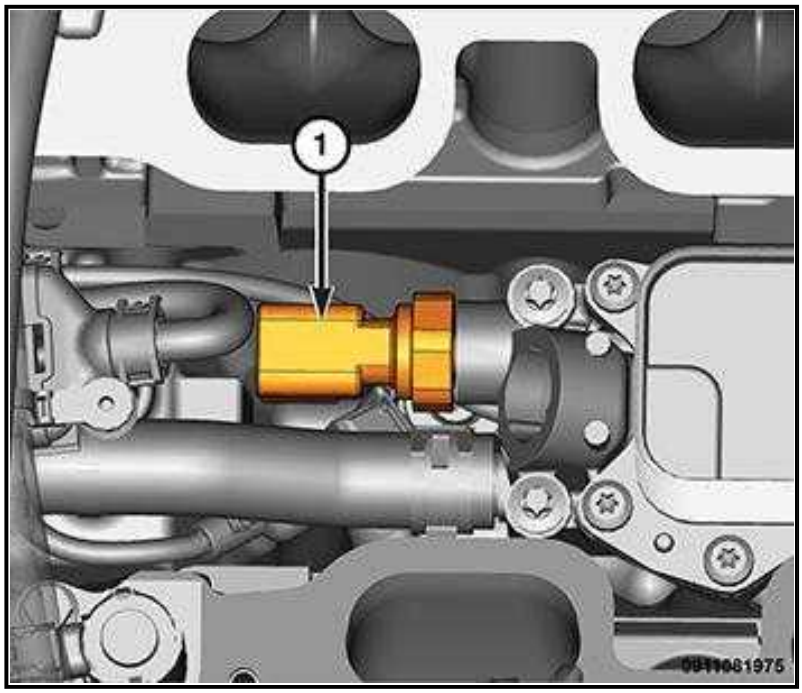
REMOVAL

1. Remove the upper intake manifold and lower intake manifold. Refer to **MANIFOLD, INTAKE, REMOVAL AND INSTALLATION**.



1 - Oil Pressure Sensor Harness Connector

2. Disconnect the oil pressure sensor wire harness connector.



1 - Oil Pressure Sensor

3. Remove the oil pressure sensor from the oil filter housing.

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

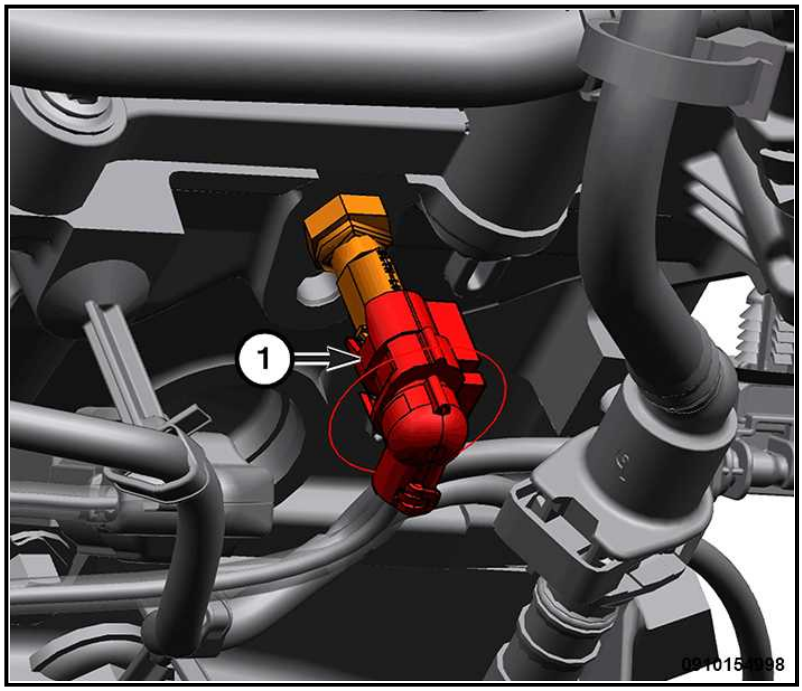
ENGINE SENSORS

DESCRIPTION	SPECIFICATION	COMMENTS
Map Sensor	-	-
Coolant Temperature Sensor	**1/4 Turn to Engage**	-
EGR Temperature Sensor	**37 N. m (27 Ft. Lbs.)**	-
Crankshaft Position (CKP) Sensor Bolt	**12 N.m (9 Ft. Lbs.)**	-
Engine Oil Pressure (EOP) Sensor	**20 N.m (15 Ft. Lbs.)**	-
Camshaft Position (CMP) Sensor to Cylinder Head	**9 N. m (80 In. Lbs.)**	-
Oxygen (O2) Sensor	**43 N.m (32 Ft. Lbs.)**	-
Oil Temperature Sensor to Cylinder Head	**11 N.m (8 Ft. Lbs.)**	-
Knock Sensor	**22 N.m (16 Ft. Lbs.)**	Do not reuse fastener. If removed, a new fastener must be installed and tightened to specifications

ENGINE OIL TEMPERATURE (EOT) SENSOR

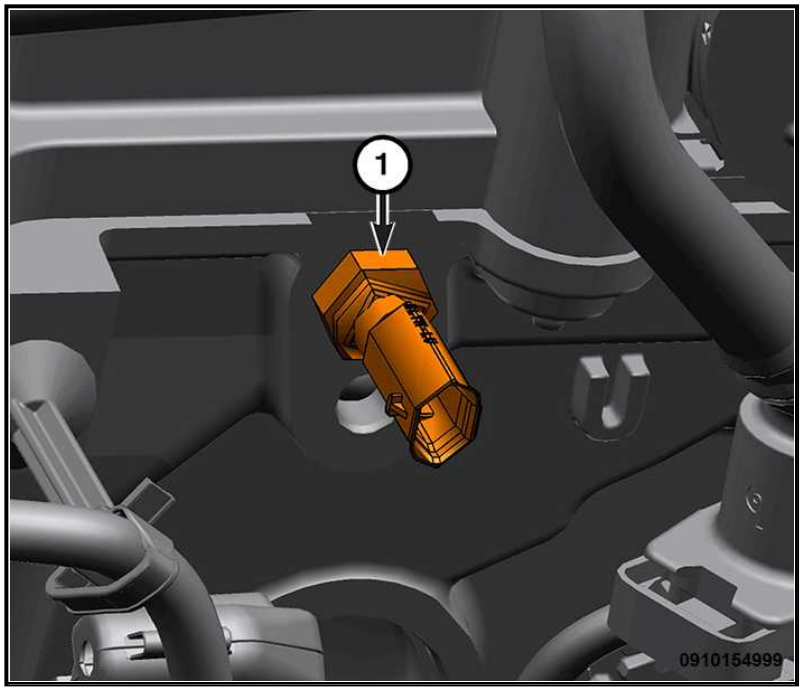
REMOVAL

1. Remove the engine cover. Refer to **COVER, ENGINE, REMOVAL AND INSTALLATION**.



1 - EOT Sensor Harness Connector

2. Disconnect the EOT sensor wire harness connector.



1 - EOT Sensor

3. Remove the EOT sensor from the right side cylinder head.

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

ENGINE SENSORS

DESCRIPTION	SPECIFICATION	COMMENTS
Map Sensor	-	-
Coolant Temperature Sensor	**1/4 Turn to Engage**	-
EGR Temperature Sensor	**37 N. m (27 Ft. Lbs.)**	-
Crankshaft Position (CKP) Sensor Bolt	**12 N.m (9 Ft. Lbs.)**	-
Engine Oil Pressure (EOP) Sensor	**20 N.m (15 Ft. Lbs.)**	-
Camshaft Position (CMP) Sensor to Cylinder Head	**9 N. m (80 In. Lbs.)**	-
Oxygen (O2) Sensor	**43 N.m (32 Ft. Lbs.)**	-
Oil Temperature Sensor to Cylinder Head	**11 N.m (8 Ft. Lbs.)**	-
Knock Sensor	**22 N.m (16 Ft. Lbs.)**	Do not reuse fastener. If removed, a new fastener must be installed and tightened to specifications

FUEL PRESSURE SENSOR

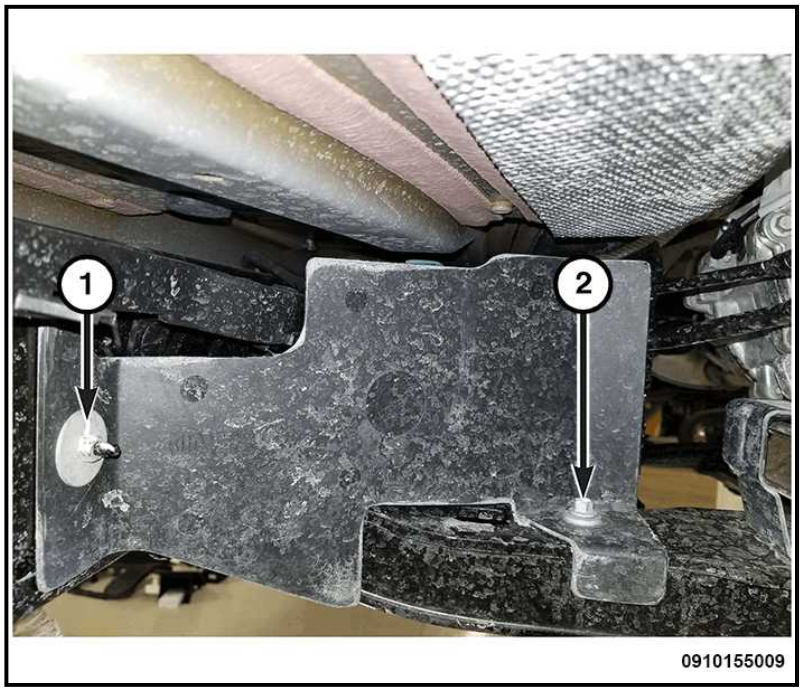
REMOVAL

CAUTION: **When removing the fuel supply line from the fuel inlet tube at the fuel rail, care must be taken that the fuel inlet tube is not being over-flexed. Damage to the fuel rail inlet tube may occur.**

WARNING: **The fuel system is under constant pressure even with engine off. Before servicing the fuel rail, fuel system pressure must be released.**

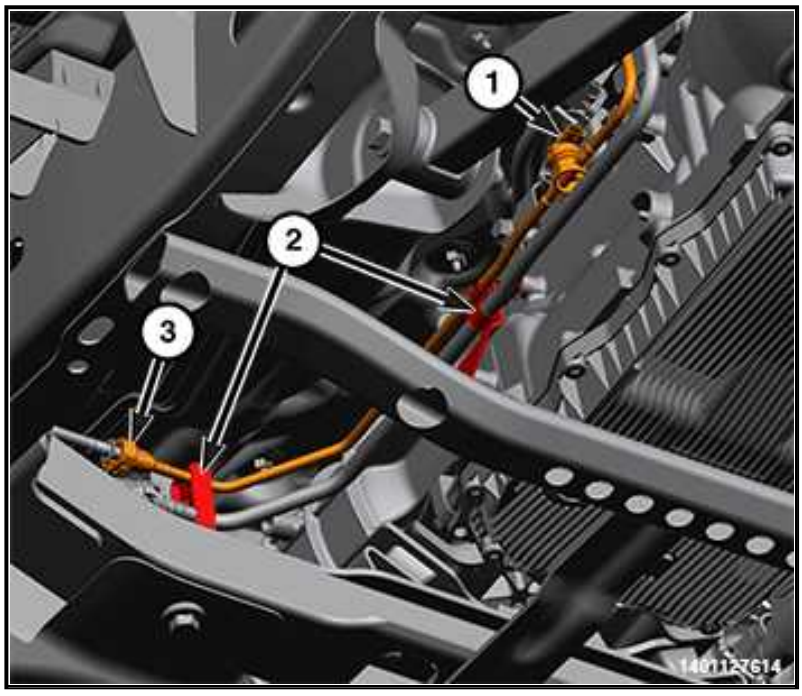
NOTE: **The fuel pressure sensor is incorporated into the fuel supply line.**

1. Perform the Fuel System Pressure Release procedure. Refer to **FUEL SYSTEM PRESSURE RELEASE** .
2. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
3. Remove the front propeller shaft. Refer to **REMOVAL AND INSTALLATION** .



1- Fuel Line Deflector Nut
2 - Fuel Line Deflector Bolt

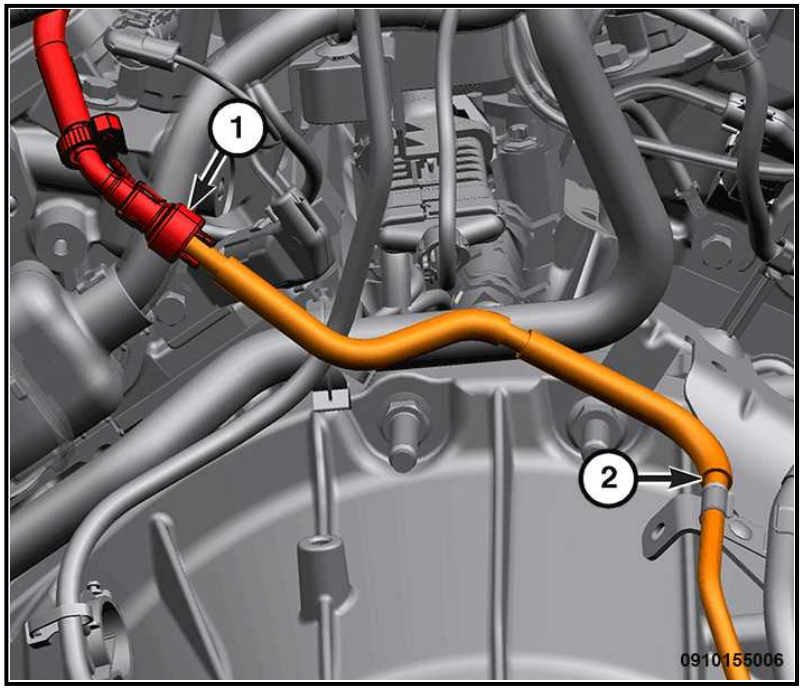
4. Remove the front fuel line deflector nut and bolt and remove the front fuel line deflector.



1- Fuel Pressure Sensor Harness Connector
2 - Fuel Line Retaining Clips

3 - Fuel Supply Line

5. Disconnect the Fuel Pressure Sensor wire harness connector.
6. Disconnect the fuel supply line at the front of fuel tank. Refer to **FUEL SYSTEM** .
7. Remove fuel line from all of the retaining clips.



1- Fuel Supply Line Quick Connect
2 - Bracket

8. Disconnect the fuel supply hose quick connect at the rear of the intake manifold and remove the hose assembly from the bracket. Refer to **FUEL SYSTEM** .

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.

- Secure the fuel line into all retaining clips.
- Check the fuel system for leaks.

TORQUE SPECIFICATIONS

FUEL SYSTEM

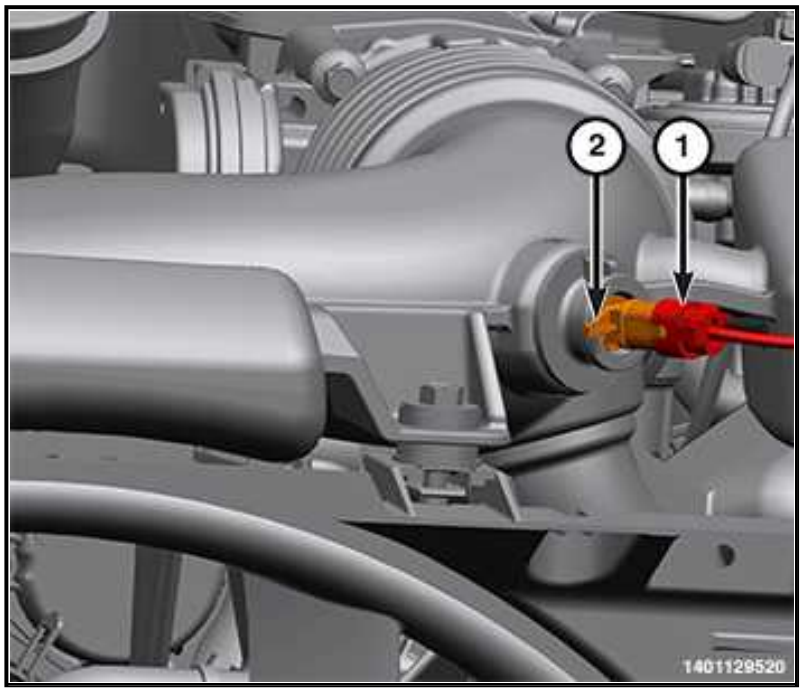
DESCRIPTION	SPECIFICATION	COMMENTS
Accelerator Pedal to Bulkhead Nuts	**12 N. m (9 Ft. Lbs.)**	-
Fuel Filler Tube to Body Bolts	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube to Body Nut(s)	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube Clamp	**4 N. m (35 In. Lbs.)**	-
Fuel Line Bundle to Transmission	**25 N.m (18 Ft. Lbs.)**	-
Fuel Pump Control Module	**6 N.m (53 In. Lbs.)**	-
Fuel Rail to Lower Intake	**7 N.m (62 In. Lbs.)**	-
Fuel Tank Deflector to Cross Member	**8 N.m (71 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Fuel Tank Skid Plate Bolts	**95 N. m (70 Ft. Lbs.)**	-
Fuel Tank Strap to Skid Plate	**25 N. m (18 Ft. Lbs.)**	-

INTAKE AIR TEMPERATURE (IAT) SENSOR

REMOVAL

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



1 - Wire Harness Connector
2 - IAT Sensor

2. Disconnect the Inlet Air Temperature (IAT) sensor wire harness connector.

NOTE: **Clean any dirt from around the sensor area prior to removing from the air cleaner resonator.**

3. Remove the IAT sensor from the air inlet tube by first lifting up the anti-rotation tab and turning the sensor 1/4 turn in the counter - clockwise direction. Ensure not to apply excessive force when lifting the tab to avoid damage.

INSTALLATION

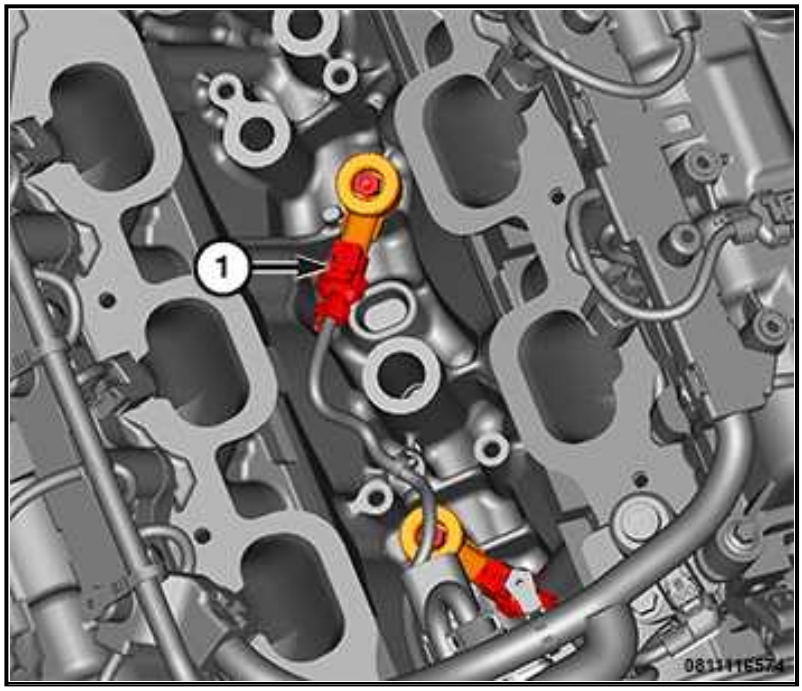
Follow the removal procedure in reverse for general reassembly of the components on the vehicle.

KNOCK SENSOR

REMOVAL

NOTE: **The forward sensor is known to the Powertrain Control Module (PCM) as knock sensor 1, the rear sensor is known to the PCM as knock sensor 2.**

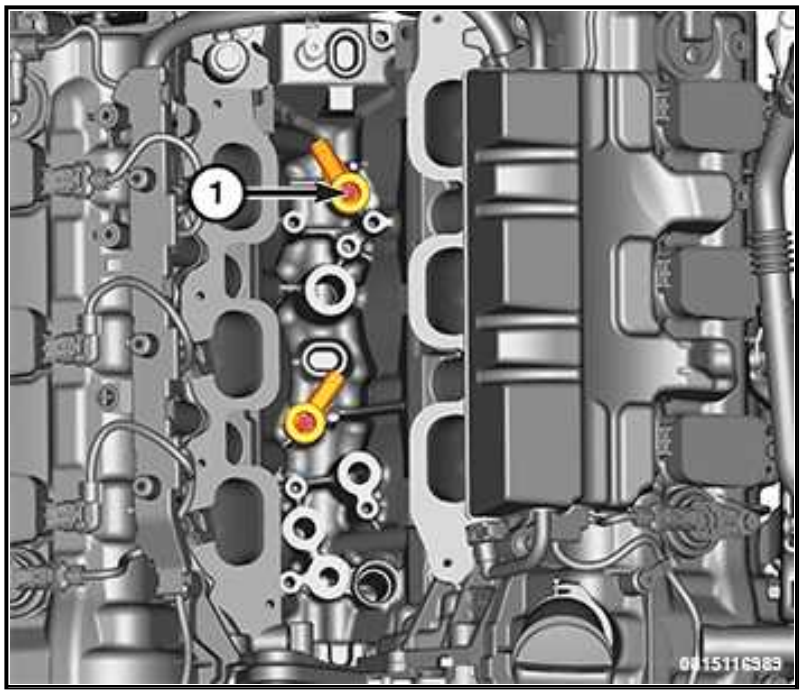
1. Perform the fuel pressure release procedure. Refer to **FUEL SYSTEM PRESSURE RELEASE** .
2. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
3. Drain the cooling system. Refer to **DRAINING** .
4. Remove the engine oil cooler. Refer to **COOLER, OIL, REMOVAL AND INSTALLATION** .



1 - Knock Sensor Wire Harness Connector

5. Disconnect the wire harness connector(s).

NOTE: **There may be a foam strip on the bolt threads. This foam is used only to retain the bolts to the sensors for plant assembly. It is not used as a sealant. Do not apply any adhesive, sealant or thread locking compound to these bolts.**



1 - Knock Sensor Bolts

6. Remove the mounting bolt(s) and discard, remove knock sensor 1 or knock sensor 2.

INSTALLATION

NOTE: **The forward sensor is known to the Powertrain Control Module (PCM) as knock sensor 1, the rear sensor is known to the PCM as knock sensor 2.**

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

- Thoroughly clean the knock sensor mounting holes.

NOTE: **Over or under tightening the sensor mounting bolts will affect knock sensor performance, possibly causing improper spark control. Always use the specified torque when installing the knock sensors.**

- There may be a foam strip on the bolt threads. This foam is used only to retain the bolts to the sensors for plant assembly. It is not used as a sealant. Do not apply any adhesive, sealant or thread locking compound to these bolts.
- Fill the cooling system. Refer to **STANDARD PROCEDURE - FILLING** .
- Operate the engine until it reaches normal operating temperature. Check cooling system for correct fluid levels. Refer to **COOLING SYSTEM** .

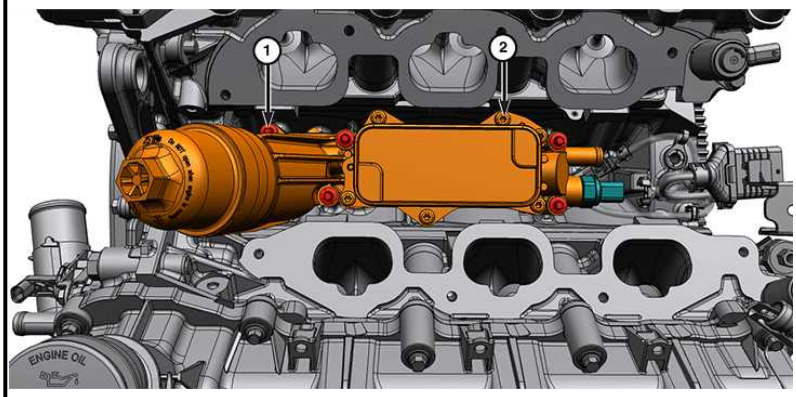
TORQUE SPECIFICATIONS

ENGINE SENSORS

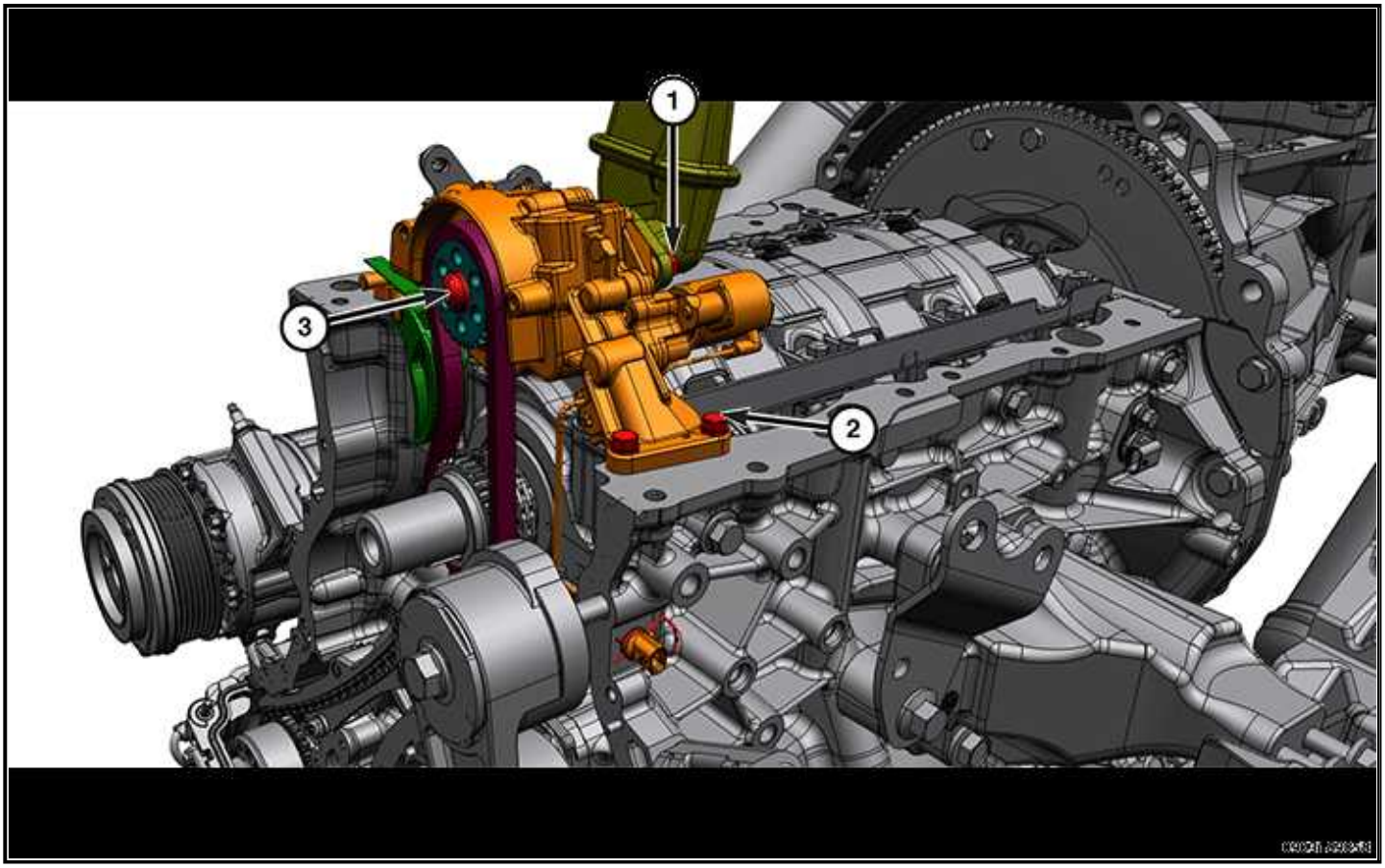
DESCRIPTION	SPECIFICATION	COMMENTS
Map Sensor	-	-
Coolant Temperature Sensor	**1/4 Turn to Engage**	-
EGR Temperature Sensor	**37 N. m (27 Ft. Lbs.)**	-
Crankshaft Position (CKP) Sensor Bolt	**12 N.m (9 Ft. Lbs.)**	-
Engine Oil Pressure (EOP) Sensor	**20 N.m (15 Ft. Lbs.)**	-
Camshaft Position (CMP) Sensor to Cylinder Head	**9 N. m (80 In. Lbs.)**	-
Oxygen (O2) Sensor	**43 N.m (32 Ft. Lbs.)**	-
Oil Temperature Sensor to Cylinder Head	**11 N.m (8 Ft. Lbs.)**	-
Knock Sensor	**22 N.m (16 Ft. Lbs.)**	Do not reuse fastener. If removed, a new fastener must be installed and tightened to specifications

LUBRICATION

DESCRIPTION	SPECIFICATION	COMMENTS
Upper Oil Pan to Engine Block M8 Bolts	**23 N.m (17 Ft. Lbs.)**	-
Lower Oil Pan to Upper Oil Pan - M6 Bolts	**9 N.m (80 In. Lbs.)**	-
Lower Oil Pan to Upper Oil Nuts	**10 N.m (89 In. Lbs.)**	-
Upper Oil Pan to Rear Seal Retainer M6 Bolts	**10 N.m (89 In. Lbs.)**	-
Oil Pan Drain Plug	**27 N.m (20 Ft. Lbs.)**	-
Oil Level Indicator to Cylinder Head Bolt	**18 N.m (13 Ft. Lbs.)**	-



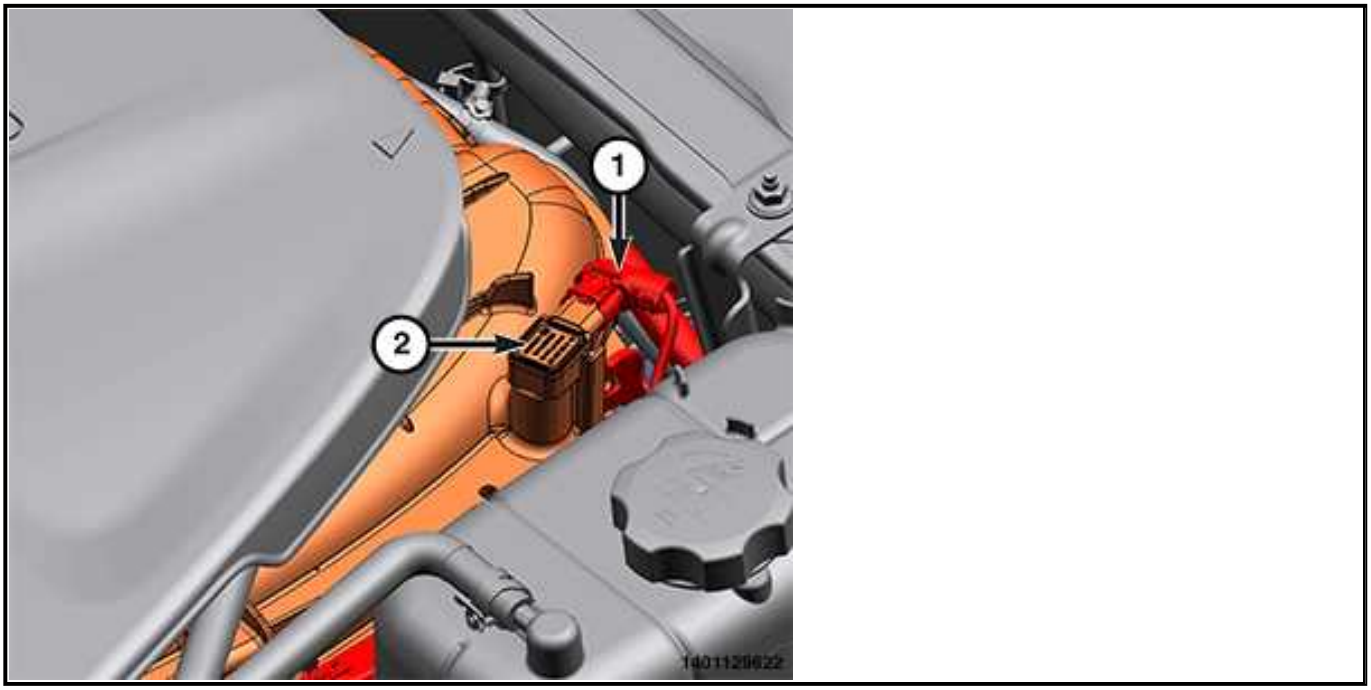
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Oil Filter Housing/Oil Cooler to Engine Block M6 Bolts	**12 N.m (9 Ft. Lbs.)**	-
2	Oil Cooler to Oil Filter Housing Screws	**12 N.m (9 Ft. Lbs.)**	-
-	Oil Filter Housing Cap	**25 N.m (18 Ft. Lbs.)**	-



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Oil Pump Pick Up Tube to Oil Pump M6 Bolt	**8 N.m (71 In. Lbs.)**	-
-	Oil Pump Pick Up Tube Bracket to Windage Tray Bolt	**8 N.m (80 In. Lbs.)**	-
2	Oil Pump to Engine Block M6 Bolts	**12 N.m (9 Ft. Lbs.)**	-
3	Oil Pump Sprocket M8 Bolt	**26 N.m (18 Ft. Lbs.)**	-

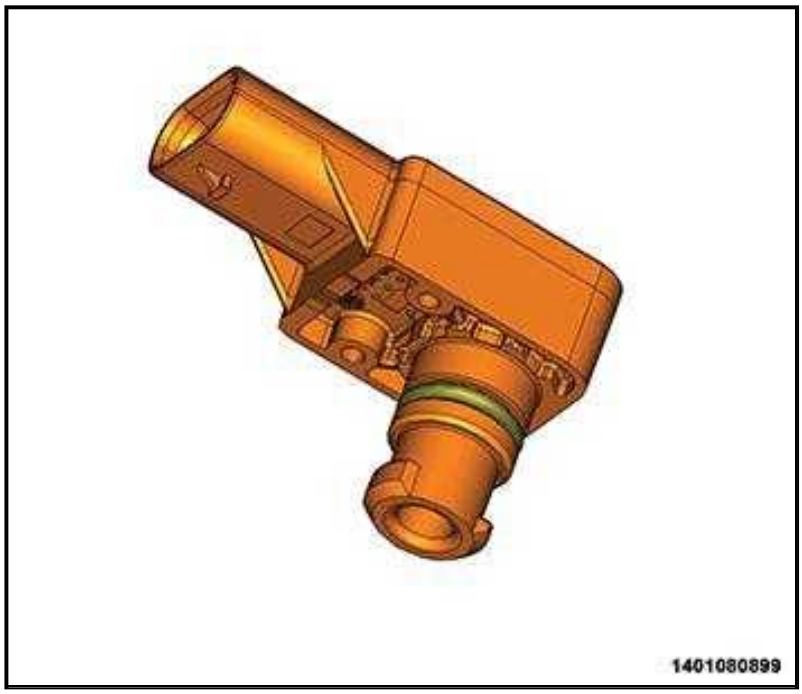
MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

REMOVAL



1 - MAP Sensor Wire Harness Connector
2 - MAP Sensor

1. Disconnect the Manifold Air Pressure (MAP) sensor wire harness connector.
2. Rotate the MAP sensor 1/4 turn counterclockwise and pull the sensor straight up and out of the upper intake manifold.

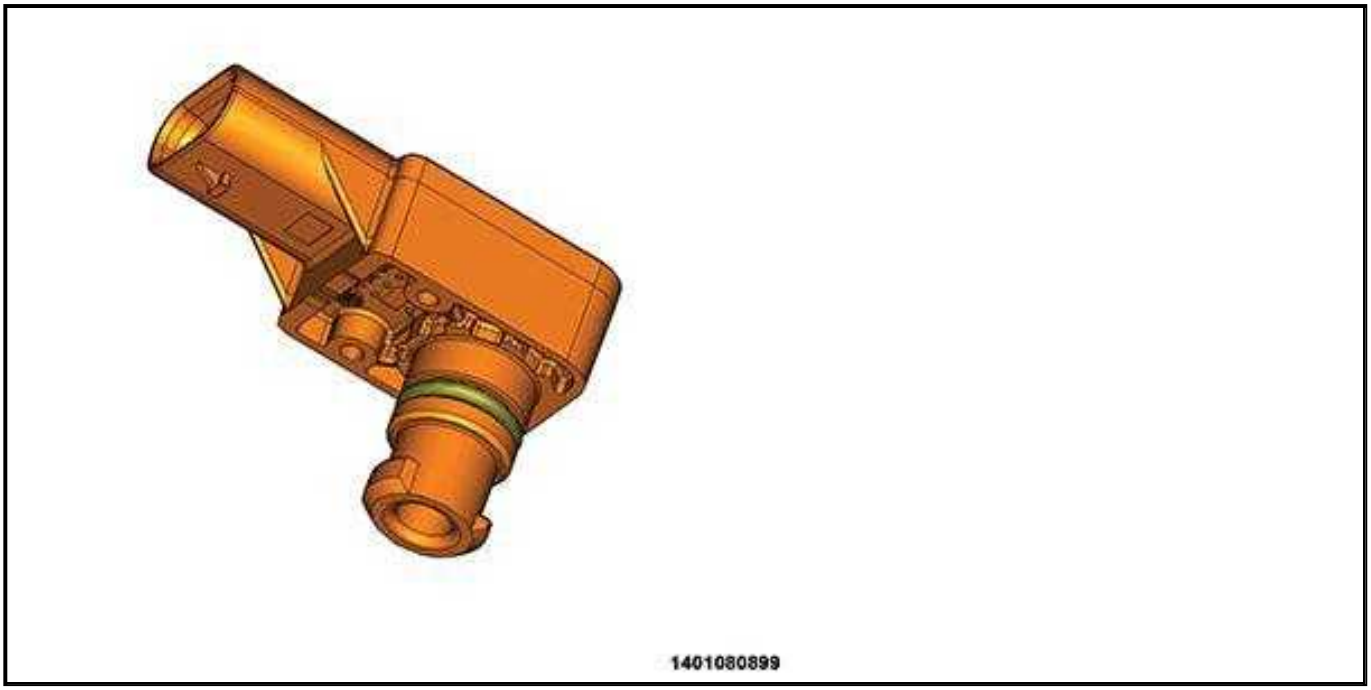


3. The MAP sensor O-ring can be reused if not damaged.

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.

- The MAP sensor O-ring can be reused if not damaged. Apply a small amount of engine oil to the sensor O-ring.



UPSTREAM O2 SENSORS

CAUTION: **Never apply any type of grease to the oxygen sensor electrical connector, or attempt any repair of the sensor wiring harness.**

WARNING: **The exhaust manifold, exhaust pipes and catalytic converter become very hot during engine operation. Allow engine to cool before removing oxygen sensor.**

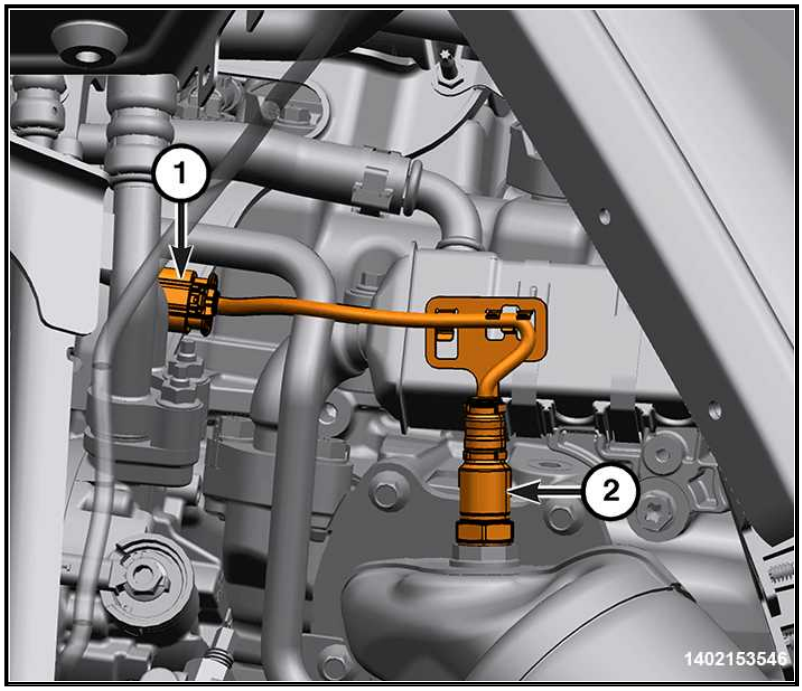
The engine is equipped with four heated oxygen sensors:

- The right upstream oxygen sensor is referred to as the 1/1 sensor.
- The right downstream oxygen sensor is referred to as the 1/2 sensor.
- The left upstream oxygen sensor is referred to as the 2/1 sensor.
- The left downstream oxygen sensor is referred to as the 2/2 sensor.

LEFT OXYGEN SENSOR

REMOVAL

1. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
2. Remove the left front wheelhouse splash shield. Refer to **SHIELD, SPLASH, REAR WHEELHOUSE, REMOVAL AND INSTALLATION** .



1 - O2 Sensor 2/1 Wire Harness Connector
2 - O2 Sensor 2/1

CAUTION: **When disconnecting the oxygen sensor electrical connector, do not pull directly on the wire going into the sensor. The sensor wiring can be damaged resulting in sensor failure.**

3. Disconnect the left upstream O2 sensor 2/1 wire harness connector.
4. Remove the upstream O2 sensor 2/1.
5. If necessary, clean the threads in the exhaust pipe using an appropriate tap.

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.

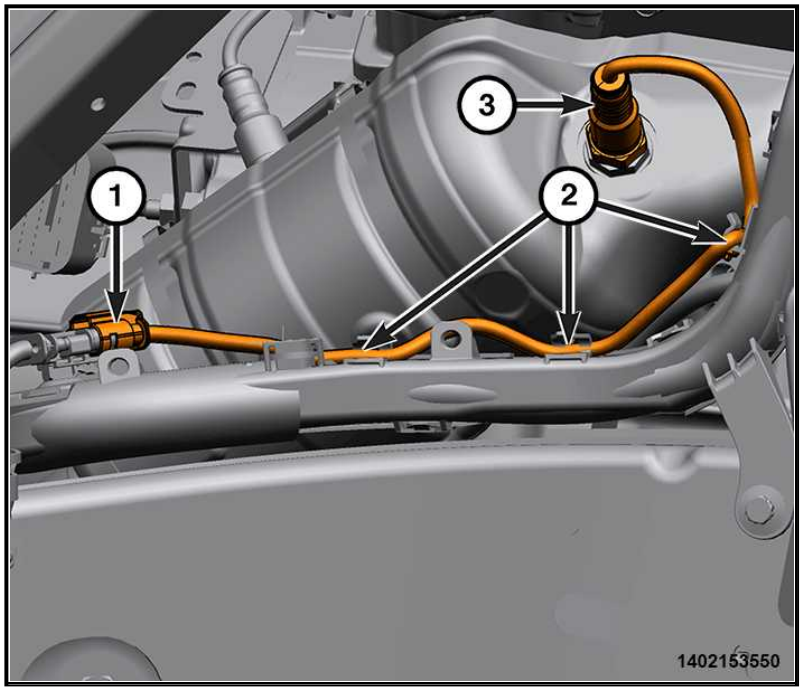
- If reinstalling the original O2 sensor, coat the sensor threads with MoparB® Anti-seize Lubricant. New sensors have compound on the threads and do not require additional coating. **Do Not add any additional anti-seize compound to the threads of a new O2 sensor.**

TORQUE SPECIFICATIONS

RIGHT UPSTREAM O2 SENSOR

REMOVAL

1. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
2. Remove the right front wheelhouse splash shield. Refer to **SHIELD, SPLASH, REAR WHEELHOUSE, REMOVAL AND INSTALLATION** .



1 - Upstream O2 Sensor Wiring Harness Connector
2 - Upstream O2 Sensor Wiring Harness Retainers
3 - Upstream O2 Sensor

CAUTION: **When disconnecting the oxygen sensor electrical connector, do not pull directly on the wire going into the sensor. The sensor wiring can be damaged resulting in sensor failure.**

3. Disconnect the right upstream O2 sensor 1/1 wire harness connector.
4. Detach the wire from the retainers and remove the O2 sensor.
5. If necessary, clean the threads in the exhaust pipe using an appropriate tap.

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 reinstalling the original O2 sensor, coat the sensor threads with MoparB® Anti-seize Lubricant. New sensors have compound on the threads and do not require additional coating. **Do Not add any additional anti-seize compound to the threads of a new O2 sensor.**

TORQUE SPECIFICATIONS

ENGINE SENSORS

DESCRIPTION	SPECIFICATION	COMMENTS
Map Sensor	-	-
Coolant Temperature Sensor	**1/4 Turn to Engage**	-
EGR Temperature Sensor	**37 N. m (27 Ft. Lbs.)**	-
Crankshaft Position (CKP) Sensor Bolt	**12 N.m (9 Ft. Lbs.)**	-
Engine Oil Pressure (EOP) Sensor	**20 N.m (15 Ft. Lbs.)**	-
Camshaft Position (CMP) Sensor to Cylinder Head	**9 N. m (80 In. Lbs.)**	-
Oxygen (O2) Sensor	**43 N.m (32 Ft. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Oil Temperature Sensor to Cylinder Head	**11 N.m (8 Ft. Lbs.)**	-
Knock Sensor	**22 N.m (16 Ft. Lbs.)**	Do not reuse fastener. If removed, a new fastener must be installed and tightened to specifications

DOWNSTREAM O2 SENSORS

CAUTION: **Never apply any type of grease to the oxygen sensor electrical connector, or attempt any repair of the sensor wiring harness.**

WARNING: **The exhaust manifold, exhaust pipes and catalytic converter become very hot during engine operation. Allow engine to cool before removing oxygen sensor.**

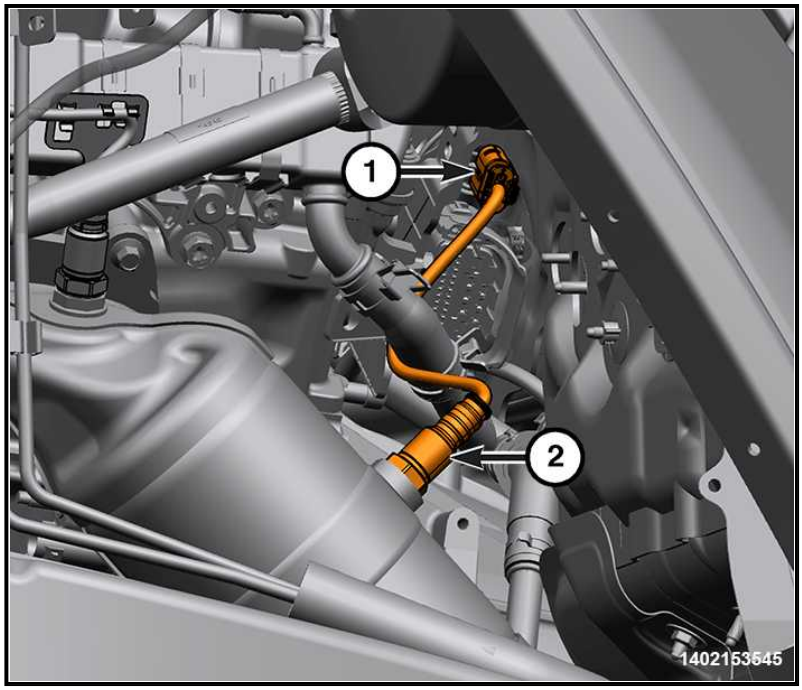
The engine is equipped with four heated oxygen sensors:

- The right upstream oxygen sensor is referred to as the 1/1 sensor.
- The right downstream oxygen sensor is referred to as the 1/2 sensor.
- The left upstream oxygen sensor is referred to as the 2/1 sensor.
- The left downstream oxygen sensor is referred to as the 2/2 sensor.

LEFT DOWNSTREAM O2 SENSOR

REMOVAL

1. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
2. Remove the left front wheelhouse splash shield. Refer to **SHIELD, SPLASH, REAR WHEELHOUSE, REMOVAL AND INSTALLATION** .



1 - O2 Sensor 2/2 Wire Harness Connector
2 - O2 Sensor 2/2

CAUTION: **When disconnecting the oxygen sensor electrical connector, do not pull directly on the wire going into the sensor. The sensor wiring can be damaged resulting in sensor failure.**

3. Disconnect the left downstream O2 sensor 2/2 wire harness connector.
4. Remove the left downstream O2 sensor 2/2 sensor.
5. If necessary, clean the threads in the exhaust pipe using an appropriate tap.

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.

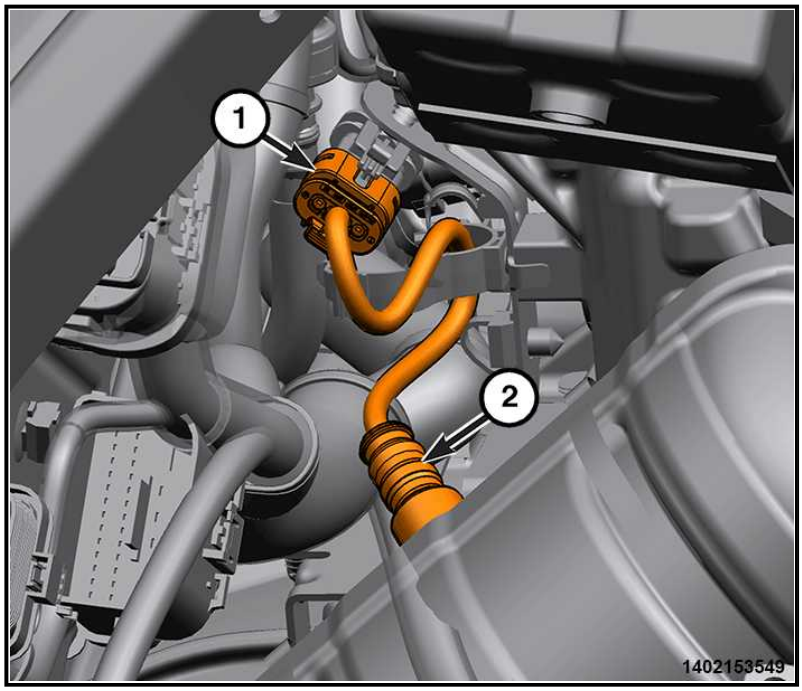
- If reinstalling the original O2 sensor, coat the sensor threads with MoparB® Anti-seize Lubricant. New sensors have compound on the threads and do not require additional coating. **Do Not add any additional anti-seize compound to the threads of a new O2 sensor.**

TORQUE SPECIFICATIONS

RIGHT DOWNSTREAM O2 SENSOR

REMOVAL

1. Remove the right front wheelhouse splash shield. Refer to **SHIELD, SPLASH, REAR WHEELHOUSE, REMOVAL AND INSTALLATION** .



1 - O2 Sensor 1/2 Wire Harness Connector

CAUTION: **When disconnecting the oxygen sensor electrical connector, do not pull directly on the wire going into the sensor. The sensor wiring can be damaged resulting in sensor failure.**

2. Disconnect the right downstream O2 sensor 1/2 wire harness connector then detach the wire harness from the retainer.
3. Remove the right downstream O2 sensor 1/2 sensor.
4. If necessary, clean the threads in the exhaust pipe using an appropriate tap.

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 reinstalling the original O2 sensor, coat the sensor threads with MoparB® Anti-seize Lubricant. New sensors have compound on the threads and do not require additional coating. **Do Not add any additional anti-seize compound to the threads of a new O2 sensor.**

ENGINE SENSORS

DESCRIPTION	SPECIFICATION	COMMENTS
Map Sensor	-	-
Coolant Temperature Sensor	**1/4 Turn to Engage**	-
EGR Temperature Sensor	**37 N. m (27 Ft. Lbs.)**	-
Crankshaft Position (CKP) Sensor Bolt	**12 N.m (9 Ft. Lbs.)**	-
Engine Oil Pressure (EOP) Sensor	**20 N.m (15 Ft. Lbs.)**	-
Camshaft Position (CMP) Sensor to Cylinder Head	**9 N. m (80 In. Lbs.)**	-
Oxygen (O2) Sensor	**43 N.m (32 Ft. Lbs.)**	-
Oil Temperature Sensor to Cylinder Head	**11 N.m (8 Ft. Lbs.)**	-
Knock Sensor	**22 N.m (16 Ft. Lbs.)**	Do not reuse fastener. If removed, a new fastener must be installed and tightened to specifications

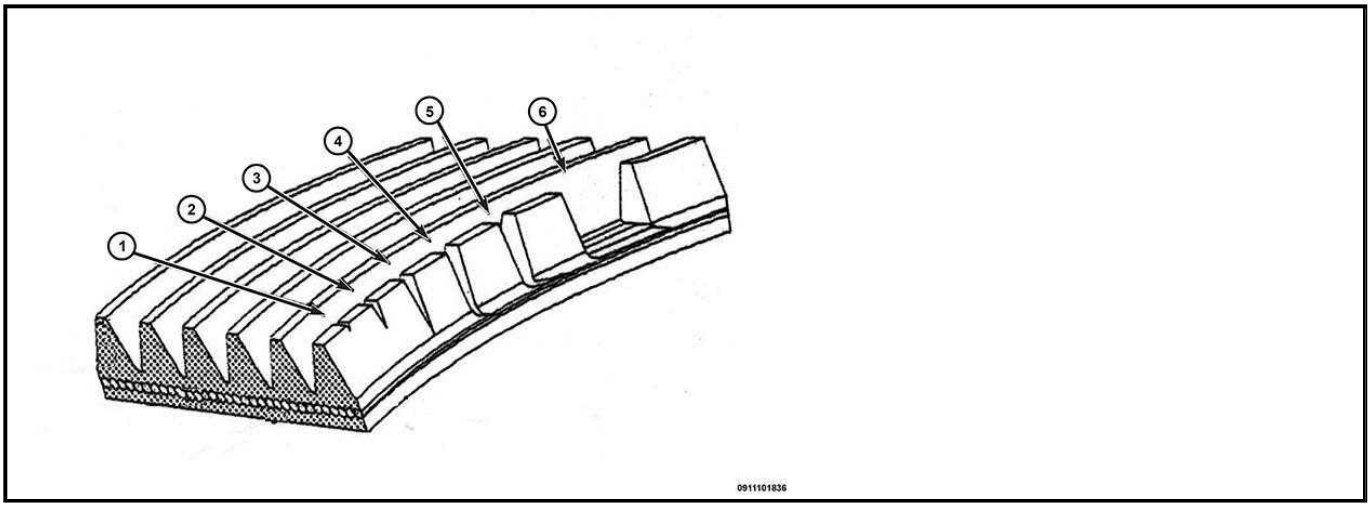
ACCESSORY DRIVE

BELT, SERPENTINE

DIAGNOSIS AND TESTING

DIAGNOSIS AND TESTING

VISUAL DIAGNOSIS



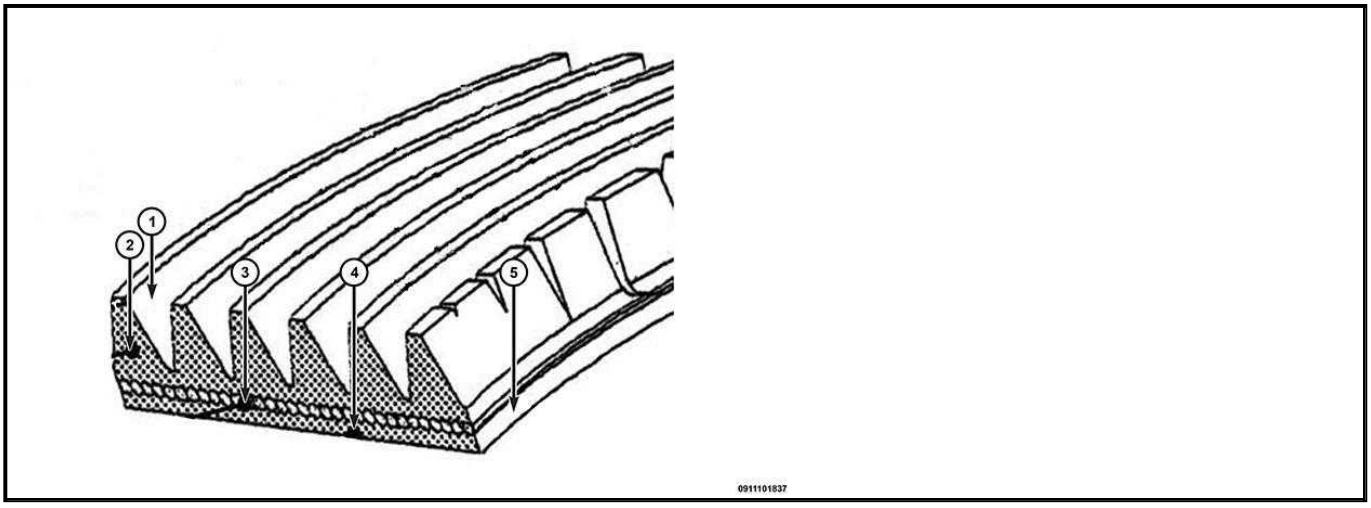
Class	Failure Mode	Occurrences
A	Micro Crack (1), Crack Down to 1/2 Rib Height (2)	No Limit
B	Crack Down to Rib Base (3)	3 or more
C	Crack Down to Cord (4) With Initial Rib Separation (5), Chunk (6)	0

REPLACEMENT GUIDELINES

1. Limit for occurrences reached for Class B and C damages.
2. Excessive wear to profile surface (See below for detailed information).
3. Damage to cutting edge including edge cord failure (See below for detailed information).
4. Contamination - engine oil, power steering fluid, coolant, brake fluid and others.
5. Belt noise (Please refer to the Noise Diagnosis information for detailed information).

NOTE: **Do not use belt dressing on a serpentine belt.**

NOISE DIAGNOSIS



The accessory drive belt is constructed as follows:

- Profile Surface (1)
- Rib Rubber (2)
- Cord/Tensile Member (3)
- Backing Rubber (4)
- Cutting Edge (5)

Noises generated by the accessory drive belt are most noticeable at idle. Before replacing a belt to resolve a noise condition, inspect all of the accessory drive pulleys for alignment, glazing, or excessive end play.

ACCESSORY DRIVE BELT DIAGNOSIS CHART

CONDITION	POSSIBLE CAUSES	CORRECTION
RIB CHUNKING - One or more ribs has separated from belt body (Class C)	1. Foreign objects imbedded in pulley grooves.	1. Remove foreign objects from pulley grooves. Replace belt.
	2. Installation damage	2. Replace belt
RIB OR BELT WEAR - Visual change in profile surface of belt, surface is glazed or shiny	1. Pulley misaligned	1. Align pulley(s)
	2. Abrasive environment	2. Clean pulley(s). Replace belt if necessary
	3. Rusted pulley(s)	3. Clean rust from pulley(s)
	4. Sharp or jagged pulley groove tips	4. Replace pulley. Inspect belt.
	5. Belt rubber deteriorated	5. Replace belt
BELT SLIPS	1. Belt slipping because of insufficient tension	1. Inspect tensioner and replace if necessary
	2. Belt or pulley exposed to substance that has reduced	2. Replace belt and clean pulleys

CONDITION	POSSIBLE CAUSES	CORRECTION
	friction (belt dressing, oil, ethylene glycol)	
	3. Driven component bearing failure (seizure)	3. Replace faulty component or bearing
	4. Belt glazed or hardened from heat and excessive slippage	4. Replace belt.
LONGITUDINAL BELT CRACKING (Between two ribs or on backside of belt)	1. Belt has mis-tracked from pulley groove	1. Replace belt
	2. Pulley groove tip has worn away rubber to tensile member	2. Replace belt
	3. Rock contamination (rock stuck between ribs)	3. Replace belt
"GROOVE JUMPING" (Belt does not maintain correct position on pulley)	1. Incorrect belt tension	1. Inspect tensioner and replace if necessary
	2. Pulley(s) not within design tolerance	2. Replace pulley(s)
	3. Foreign object(s) in grooves	3. Remove foreign objects from grooves
	4. Pulley misalignment	4. Align component
	5. Belt cord line is broken	5. Replace belt
BELT BROKEN (Note: Identify and correct problem before new belt is installed)	1. Incorrect belt tension	1. Inspect tensioner and replace if necessary
	2. Tensile member damaged during belt installation	2. Replace belt
	3. Severe misalignment	3. Align pulley(s)
	4. Bracket, pulley, or bearing failure	4. Replace defective component and belt
NOISE (Objectionable squeal, squeak, or rumble is heard or felt while drive belt is in operation)	1. Incorrect belt tension	1. Inspect tensioner and replace if necessary
	2. Bearing noise	2. Locate and repair
	3. Belt misalignment	3. Align belt and pulley(s)
	4. Belt to pulley mismatch	4. Install correct belt
	5. Driven component induced vibration	5. Locate defective driven component and repair
	6. Belt flat surface coming apart	6. Replace belt
	7. Contamination	7. Replace belt
TENSION SHEETING FABRIC FAILURE (Woven fabric on outside, circumference of belt has cracked or separated from body of belt)	1. Tension sheeting contacting stationary object	1. Correct rubbing condition
	2. Excessive heat causing woven fabric to age	2. Replace belt
	3. Tension sheeting splice has fractured	3. Replace belt
EDGE CORD FAILURE (Tensile member exposed at edges of belt or separated from belt body)	1. Incorrect belt tension	1. Inspect tensioner and replace if necessary
	2. Belt contacting stationary object	2. Replace belt
	3. Pulley(s) out of tolerance	3. Replace pulley and inspect belt
	4. Insufficient adhesion between tensile member and rubber matrix	4. Replace belt
CONTAMINATION (Belt is contaminated with foreign	1. Contamination on belt, such as oil, coolant, brake fluid, belt	1. Inspect for leaks and replace belt

CONDITION	POSSIBLE CAUSES	CORRECTION
substances)	dressing and others.	

REMOVAL AND INSTALLATION

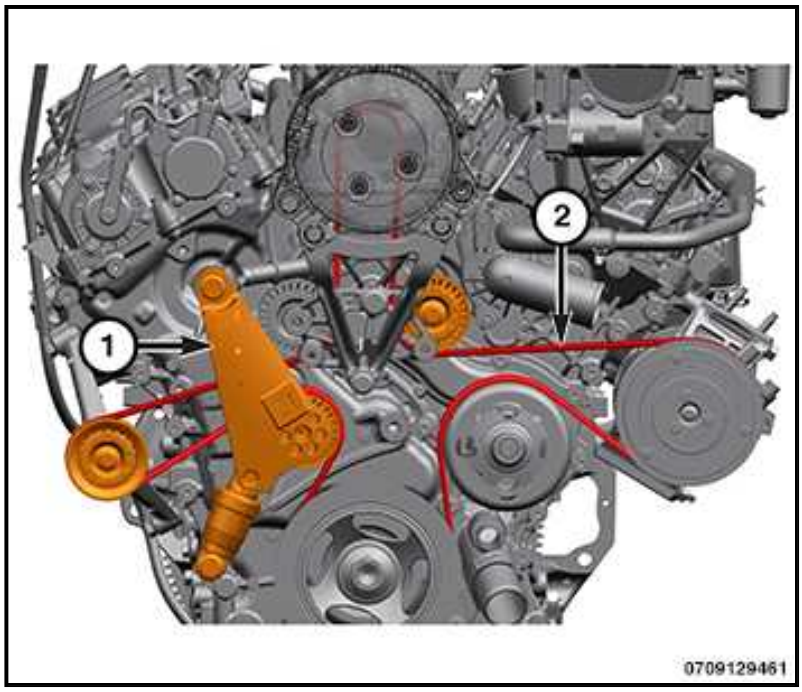
SERPENTINE BELT

REMOVAL

1. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
2. Remove the electric vacuum pump. Refer to **PUMP, ELECTRIC VACUUM, REMOVAL AND INSTALLATION** .

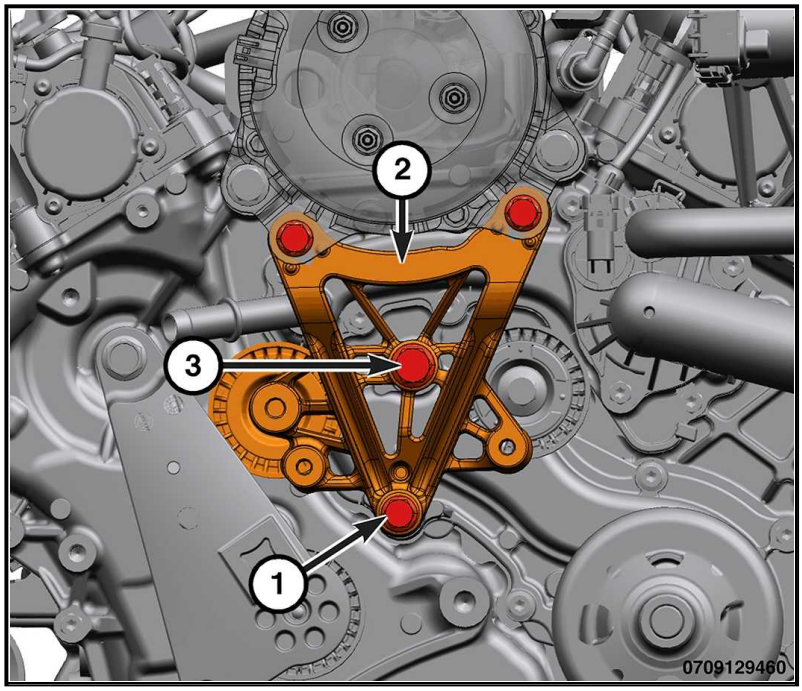
WARNING: **A slow and steady application of force and motion is required when compressing the belt tensioner strut. Any aggressive application of force will result in damage to the strut**

CAUTION: **Do not let the tensioner arm snapback to the fully extended position, severe damage may occur to the tensioner.**



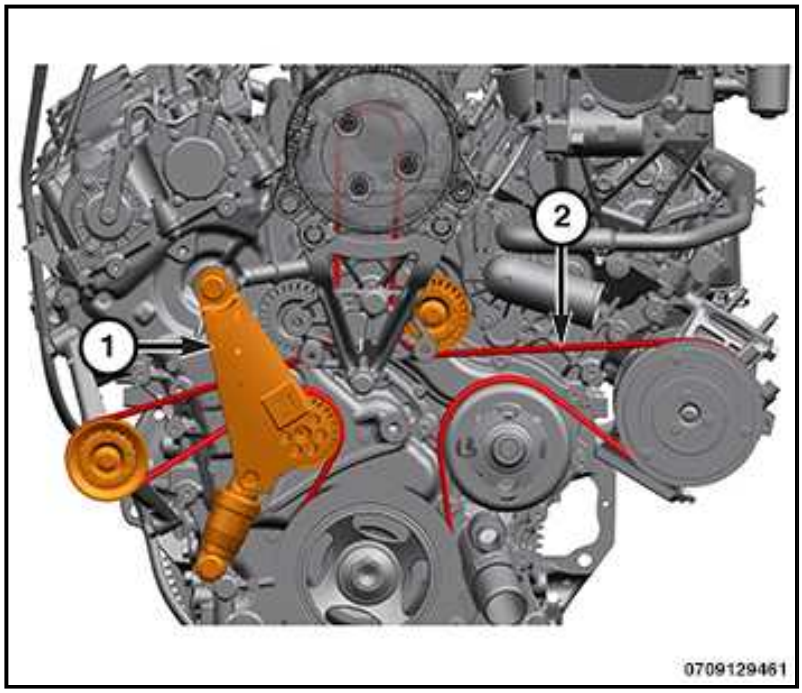
1 - Belt Tensioner
2 - Serpentine Belt

3. Rotate accessory belt tensioner **clockwise** until it contacts its stop. Remove serpentine belt from the right idler pulley, then slowly return the accessory drive belt tensioner into the free position.
4. Remove the generator. Refer to **GENERATOR, REMOVAL AND INSTALLATION** .



1 - Bracket Bolt
2 - Generator Support Bracket
3 - Bracket Bolt

5. Remove the remaining generator support bracket bolts and remove the generator support bracket.



1 - Belt Tensioner
2 - Serpentine Belt

6. Remove the serpentine belt.

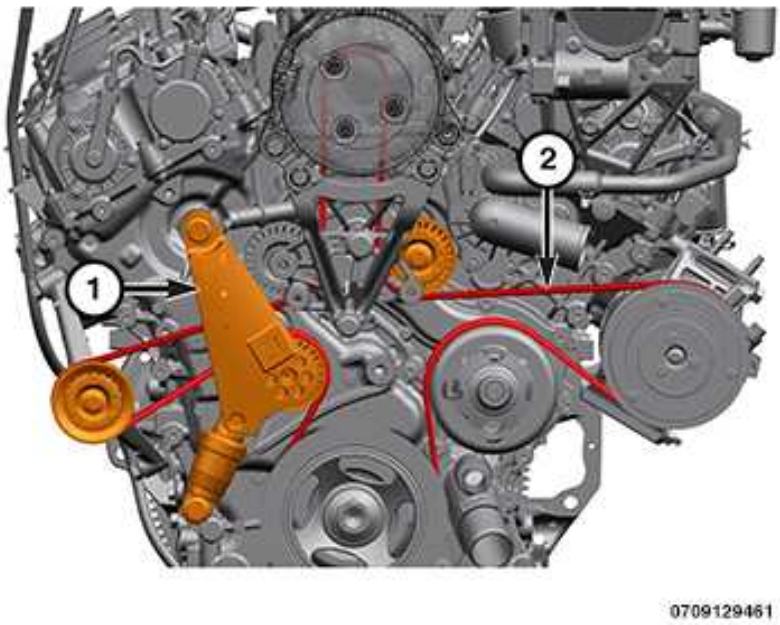
INSTALLATION

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.

WARNING: **A slow and steady application of force and motion is required when compressing the belt tensioner strut. Any aggressive application of force will result in damage to the strut**

- Check condition of all pulleys.
- Route serpentine belt around all pulleys except the right idler pulley. Install the generator support bracket and generator.
- Install the generator support bracket.
- Rotate the belt tensioner **clockwise** until it contacts its stop position. Route the serpentine belt (2) around the right idler pulley and slowly let the tensioner rotate into the belt. Make sure the serpentine belt is properly seated onto all pulleys.



1 - Belt Tensioner
2 - Serpentine Belt

TORQUE SPECIFICATIONS

TENSIONER, BELT

REMOVAL AND INSTALLATION

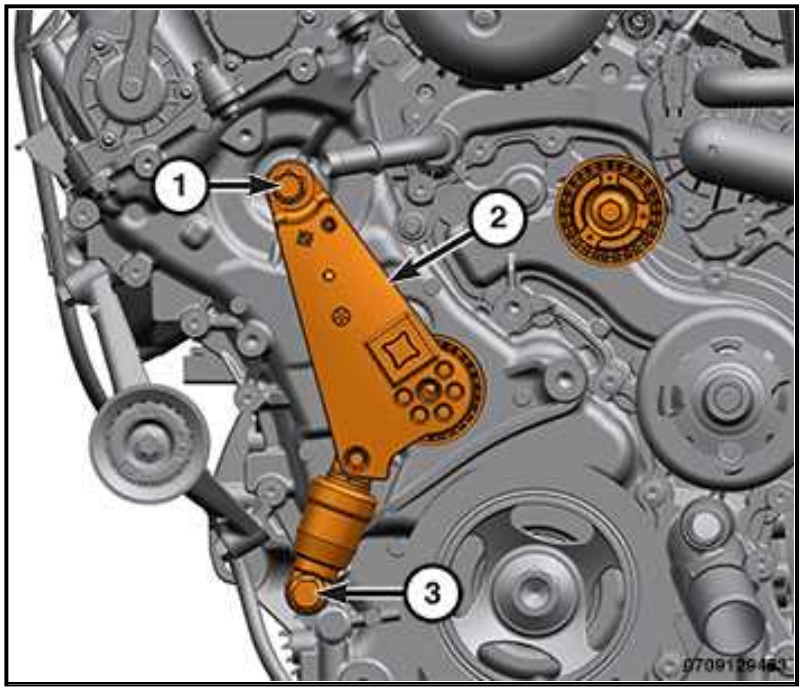
BELT TENSIONER

REMOVAL

WARNING: **Because of high spring tension, do not attempt to disassemble automatic tensioner. Unit is serviced as an assembly (except for pulley on tensioner).**

NOTE: **It is not necessary to completely remove the serpentine belt to remove the tensioner.**

1. Remove the serpentine belt from the right idler pulley. Refer to **BELT, SERPENTINE, REMOVAL AND INSTALLATION**.



1 - Belt Tensioner Bolt
2 - Belt Tensioner
3 - Belt Tensioner Bolt

2. Remove the bolts and the belt tensioner assembly.

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

PULLEY, IDLER

REMOVAL AND INSTALLATION

LEFT IDLER PULLEY

REMOVAL

1. Remove the serpentine belt. Refer to **BELT, SERPENTINE, REMOVAL AND INSTALLATION**.

1 - Left Idler Pulley Bolt
2 - Left Idler Pulley

2. Remove the bolt and the left idler pulley.

INSTALLATION

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

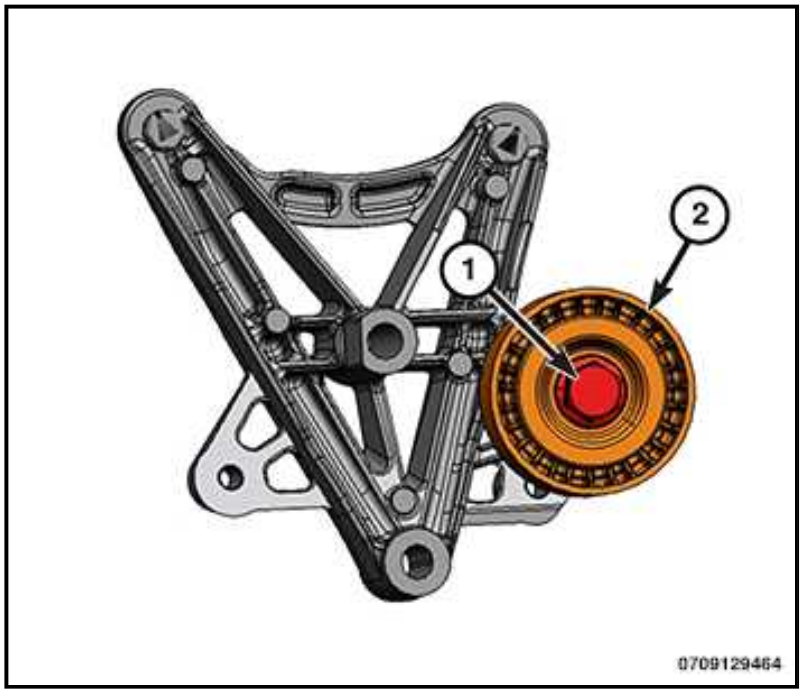
During installation, torque the fasteners to the specifications in the torque table(s) below.

TORQUE SPECIFICATIONS

CENTER IDLER PULLEY

REMOVAL

1. Remove the serpentine belt. Refer to **BELT, SERPENTINE, REMOVAL AND INSTALLATION**.



1 - Center Idler Pulley Bolt
2 - Center Idler Pulley

2. Remove the bolt and the center idler pulley from the generator support bracket.

INSTALLATION

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

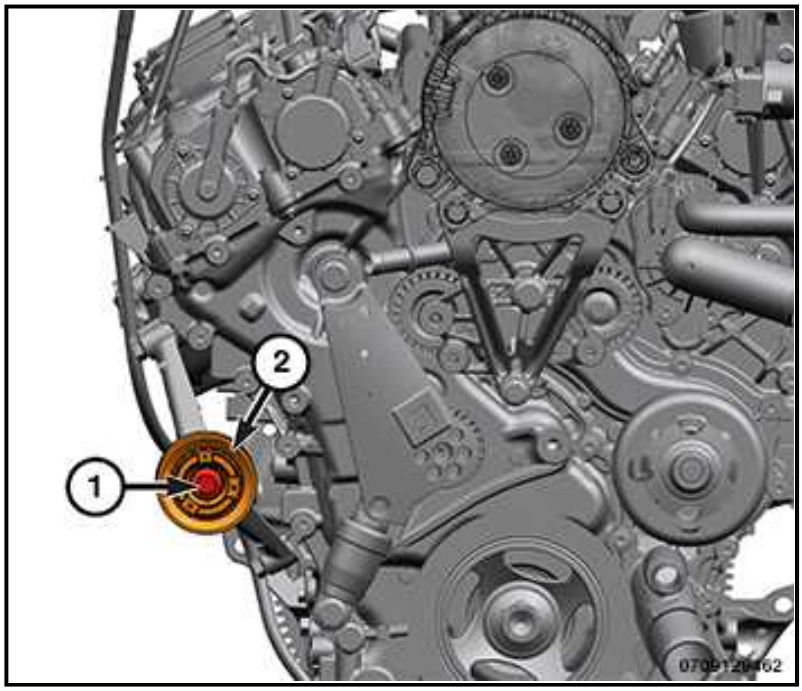
During installation, torque the fasteners to the specifications in the torque table(s) below.

TORQUE SPECIFICATIONS

RIGHT IDLER PULLEY

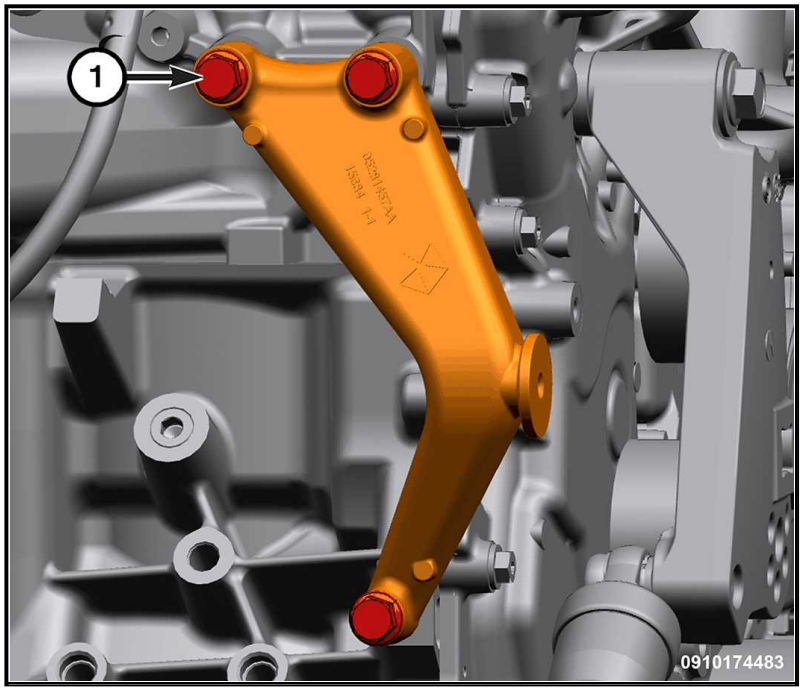
REMOVAL

1. Remove the serpentine belt from the right idler pulley. Refer to **BELT, SERPENTINE, REMOVAL AND INSTALLATION**.



1 - Right Idler Pulley Bolt
2 - Right Idler Pulley

2. Remove the bolt and the right idler pulley.



1 - Idler Pulley Bracket Bolt
2 - Idler Pulley Bracket

3. If necessary, remove the bolts and remove the idler pulley bracket.

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.

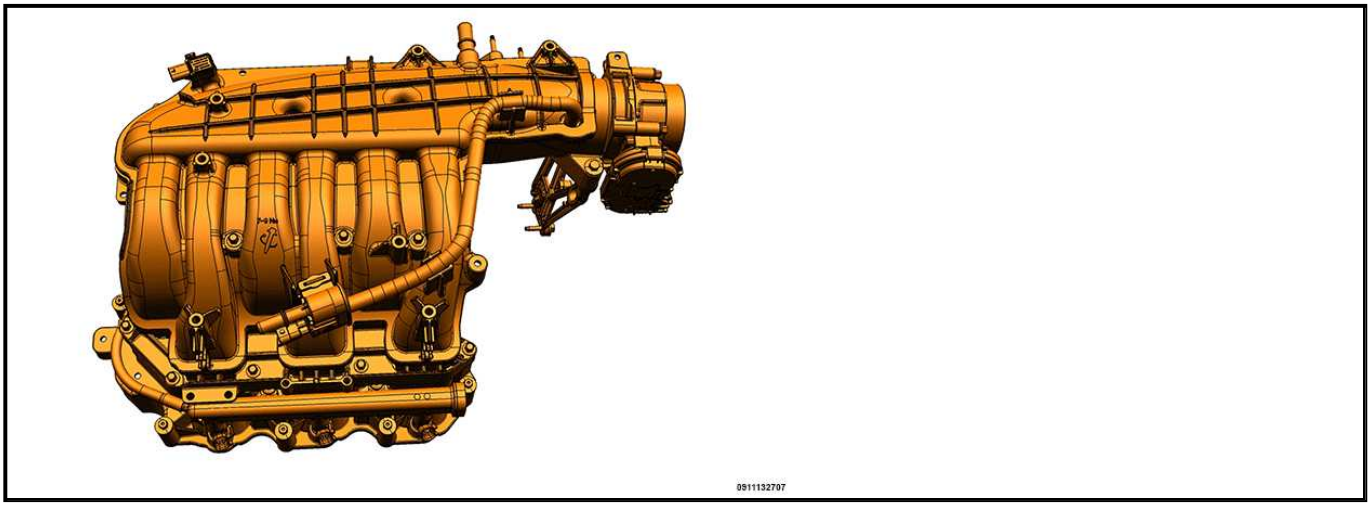
TORQUE SPECIFICATIONS

AIR INTAKE SYSTEM

DESCRIPTION AND OPERATION

DESCRIPTION AND OPERATION

UPPER INTAKE MANIFOLD

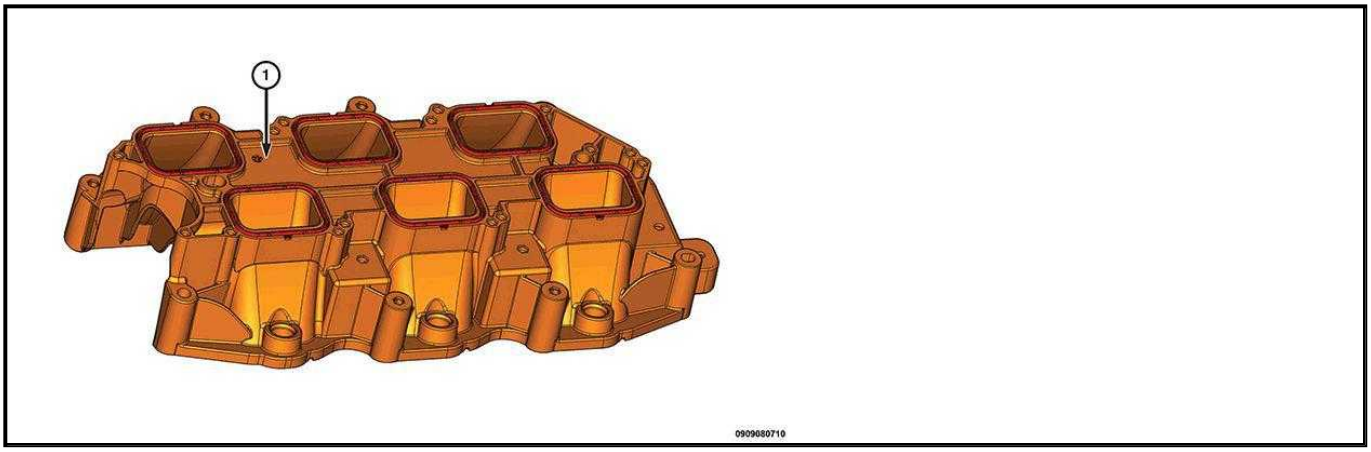


The upper intake manifold is an injection molded nylon composite design. The upper intake manifold is sealed to the lower intake manifold using six individual press-in-place Fluoroelastomer (FKM) gaskets. Inspect the gaskets whenever the upper intake manifold is removed from the engine. The gaskets may be reused if no issues are found. There is a silencer pad positioned between the upper and lower intake manifolds for improved Noise,

Vibration and Harshness (NVH). The left cylinder head cover has two alignment posts to aid proper installation of the silencer pad. The eight upper intake manifold fasteners thread directly into the composite lower intake manifold and are a self-taping design. If the upper intake manifold is damaged or cracked, it must be replaced.

The Electronic Throttle Control (ETC) and Manifold Air Pressure (MAP) sensor are attached directly to the upper intake manifold. The upper intake manifold also provides vacuum ports for brake booster, Positive Crankcase Ventilation (PCV) and emissions control.

LOWER INTAKE MANIFOLD



The lower intake manifold (1) is an injection molded nylon composite design. The lower intake manifold is sealed to the cylinder heads using six individual press-in-place Fluoroelastomer (FKM) gaskets. Inspect the gaskets whenever the lower intake manifold is removed from the engine. The gaskets may be reused if no issues are found. The eight upper intake manifold fasteners thread directly into the composite lower intake manifold and are a self-tapping design.

The four fuel rail fasteners also thread directly into the composite lower intake manifold and are a self-tapping design. The lower intake manifold can be serviced without removing the fuel injector rail. The fuel rail and fuel injectors must be installed into the lower intake manifold as an assembly. Do not attempt to install the fuel rail when the injectors are in the manifold. Always install new O-rings on the fuel injectors.

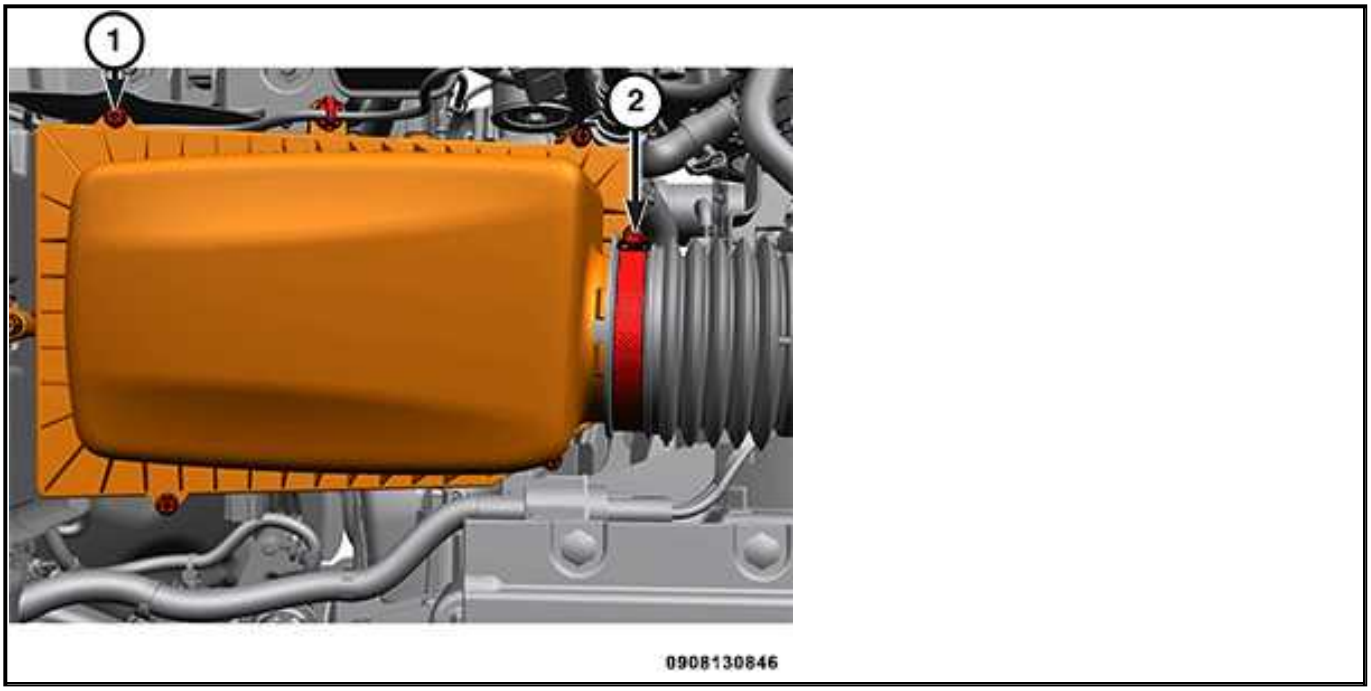
If the lower intake manifold is damaged or cracked, it must be replaced.

AIR CLEANER

REMOVAL AND INSTALLATION

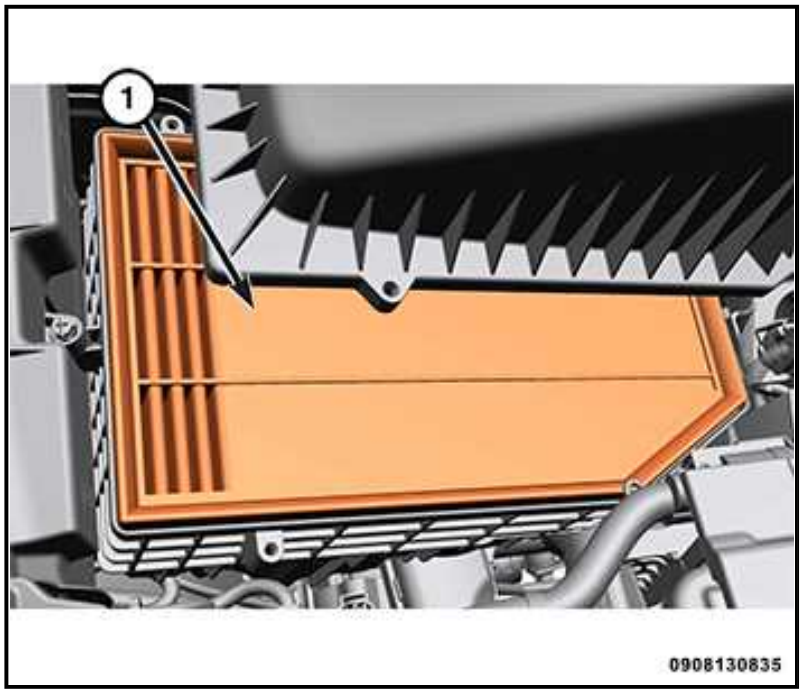
AIR CLEANER

REMOVAL



1 - Air Cleaner Housing Cover Bolts
2 - Clamp

1. Loosen the clamp at the air cleaner housing.
2. Remove the air cleaner housing cover bolts.
3. Lift the air cleaner housing cover off the housing and position aside.



1 - Air Cleaner Housing Element

4. Remove the air cleaner element.
5. Remove any dirt or debris from the bottom of the air cleaner housing.

CAUTION: **Do not use compressed air to clean out the air cleaner housing without first covering the air inlet to the throttle body. Dirt or foreign objects could enter the intake manifold causing engine damage.**

INSTALLATION

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

AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-

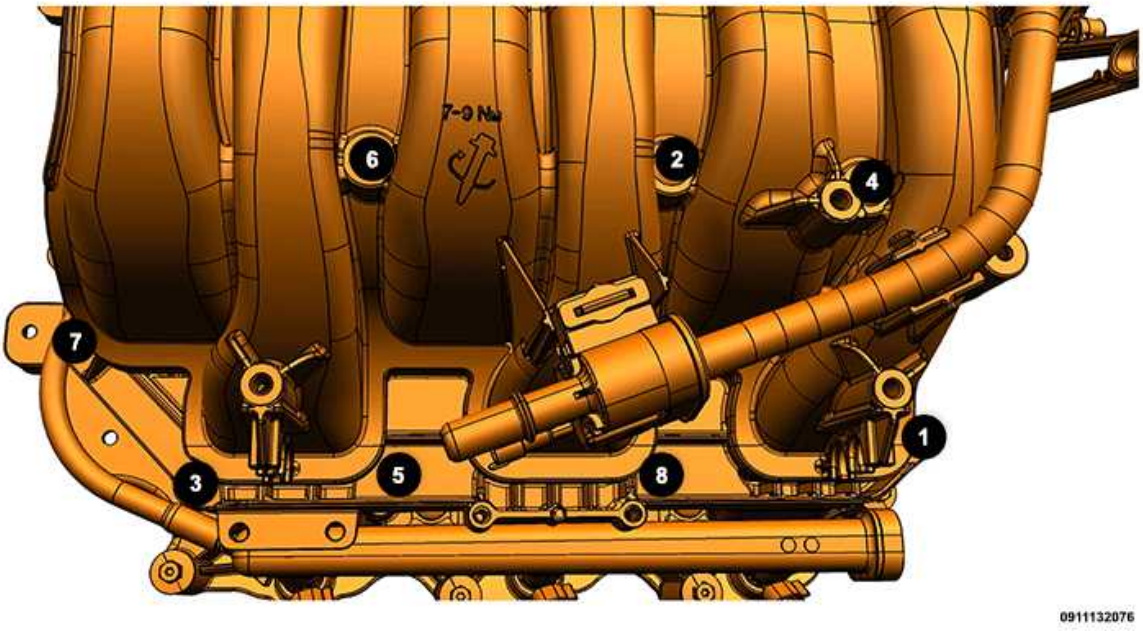


Fig. 15: Upper Intake Manifold Bolts Tightening/Loosening Sequence
Courtesy of CHRYSLER GROUP, LLC

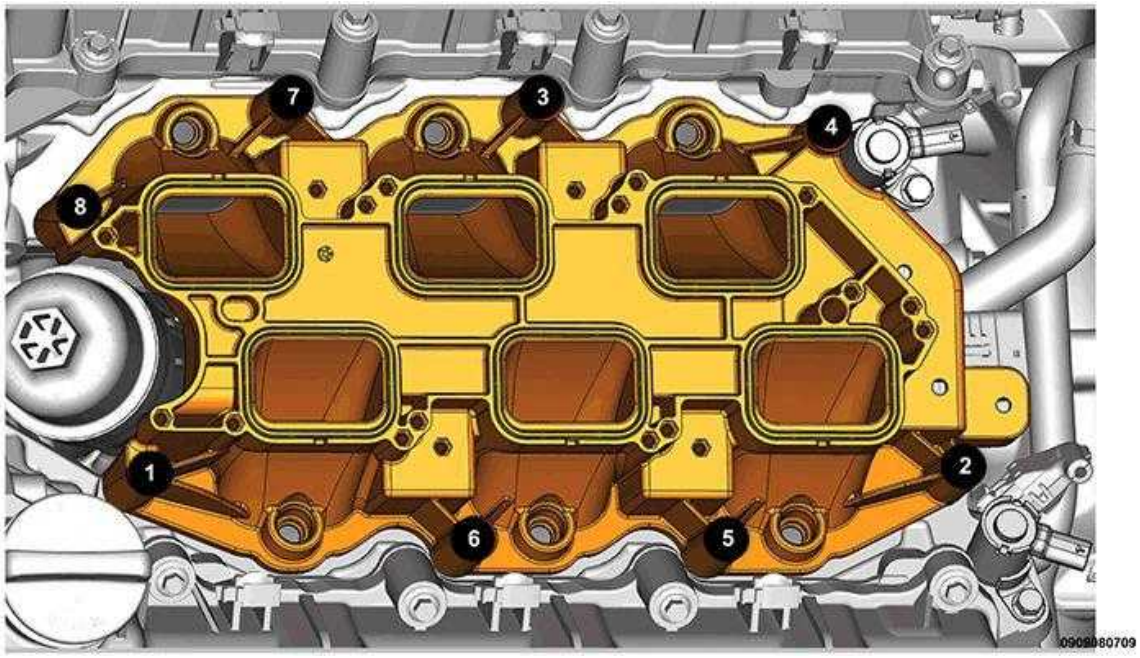


Fig. 16: Lower Intake Manifold Bolt Removal & Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

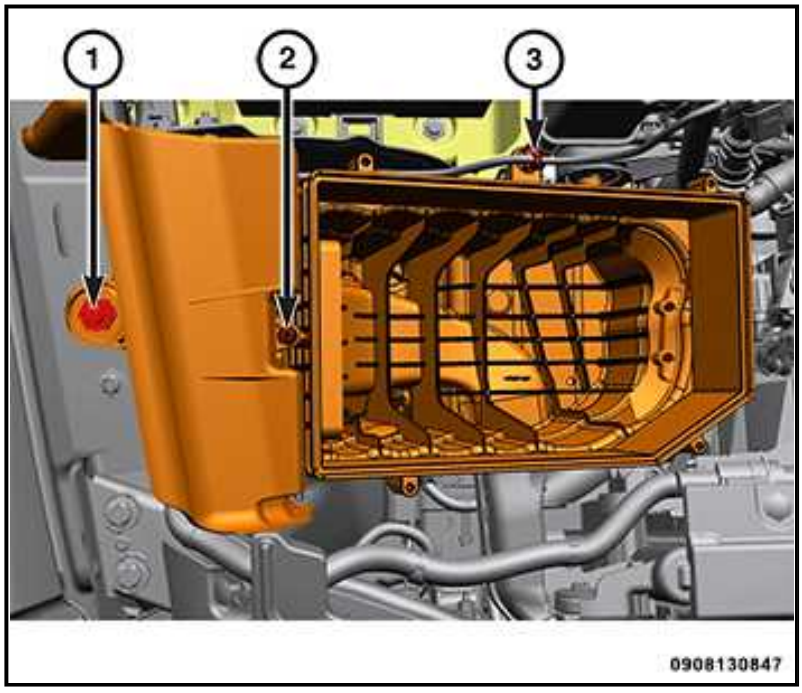
BODY, AIR CLEANER

REMOVAL AND INSTALLATION

AIR CLEANER BODY

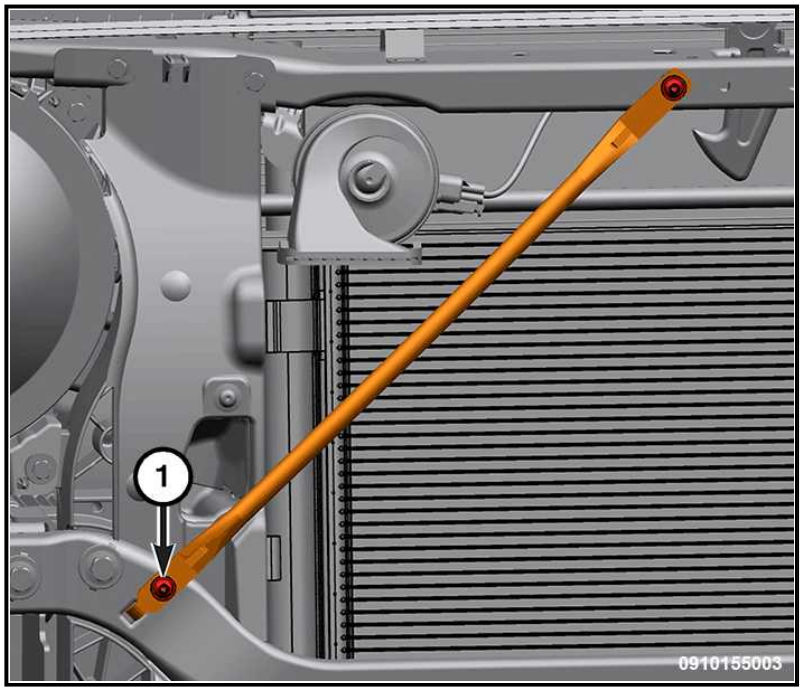
REMOVAL

1. Remove the air filter. Refer to **AIR CLEANER, REMOVAL AND INSTALLATION**.
2. Remove the air cleaner resonator. Refer to **RESONATOR, AIR CLEANER, REMOVAL AND INSTALLATION**.



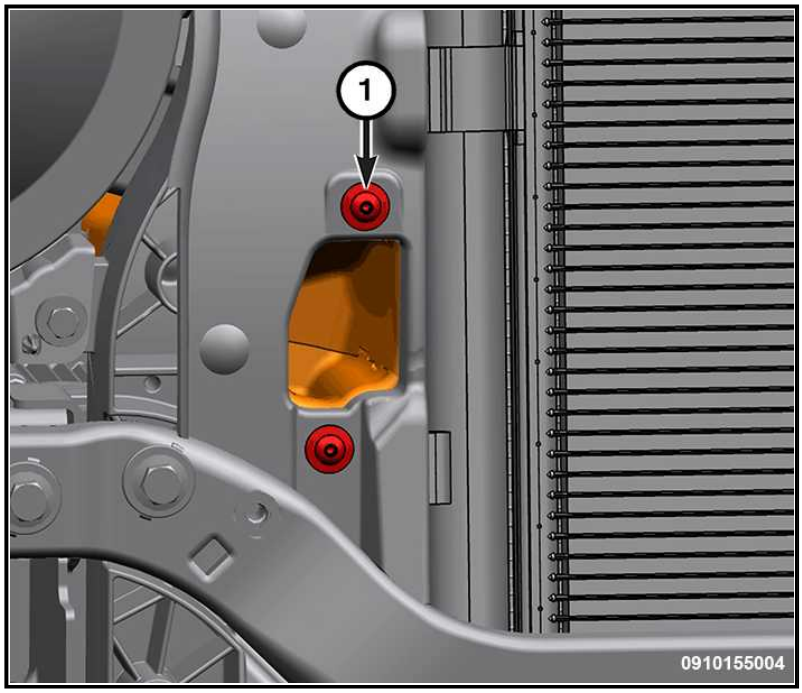
1 - Air Cleaner Housing Bolt
2 - Inlet Duct
3 - Air Cleaner Housing

3. Disconnect the wire harness retainer from the air cleaner housing.
4. Remove the bolt from the air cleaner housing and remove the housing from the vehicle.
5. Remove the retaining screw to disconnect the inlet duct from the air cleaner housing.
6. If removing the lower air inlet duct, remove the grille. Refer to **GRILLE, REMOVAL AND INSTALLATION** .



1 - Side Brace Screws

7. Loosen only the right side brace retaining screws to gain access to the inlet duct lower screw.



1 - Lower Inlet Duct Screws

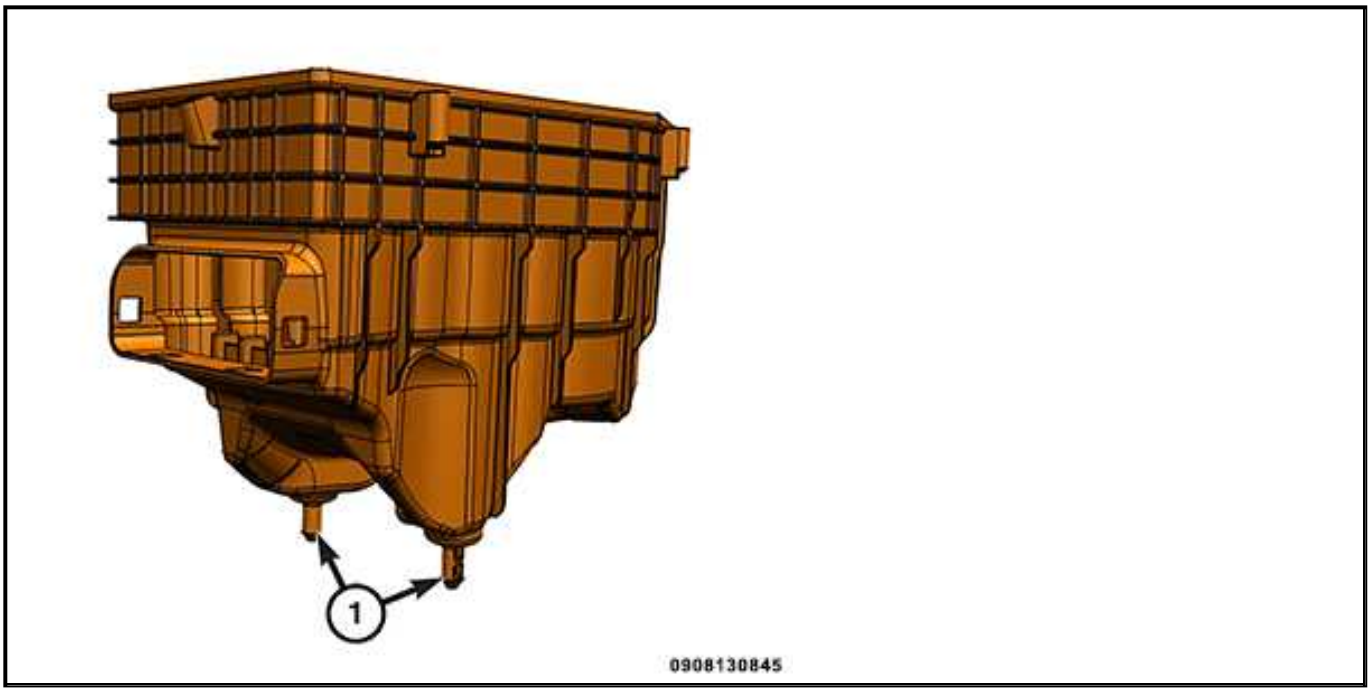
8. Remove the retaining screws and the lower inlet air duct.

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.

- Make sure to engage the locating pins into the grommets during installation.



1 - Locating Pins

TORQUE SPECIFICATIONS

AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-

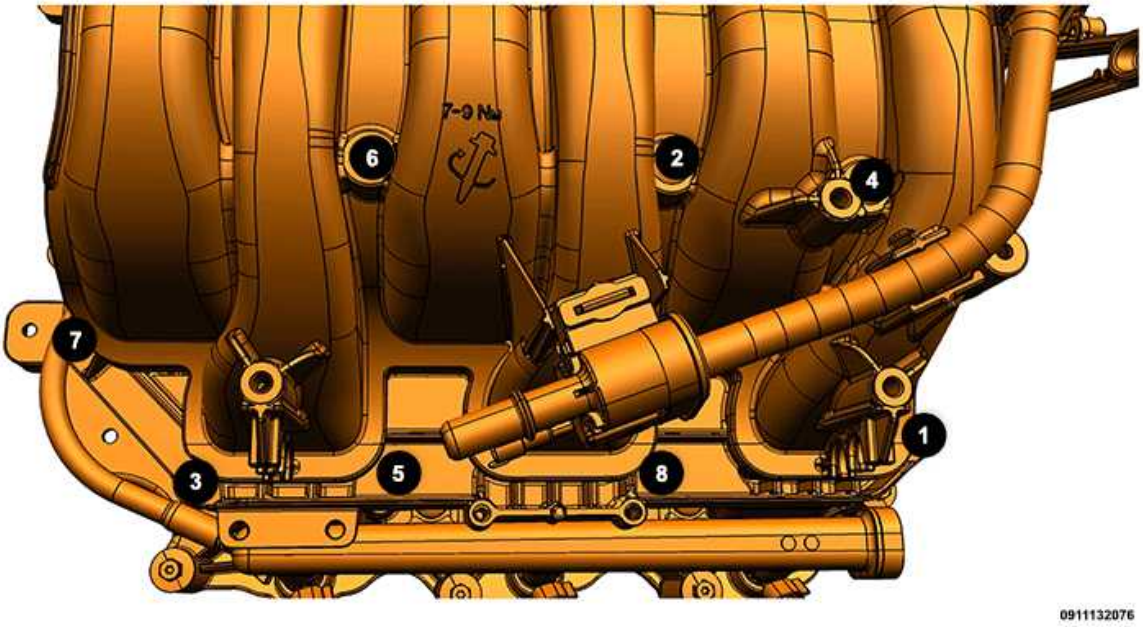


Fig. 17: Upper Intake Manifold Bolts Tightening/Loosening Sequence
Courtesy of CHRYSLER GROUP, LLC

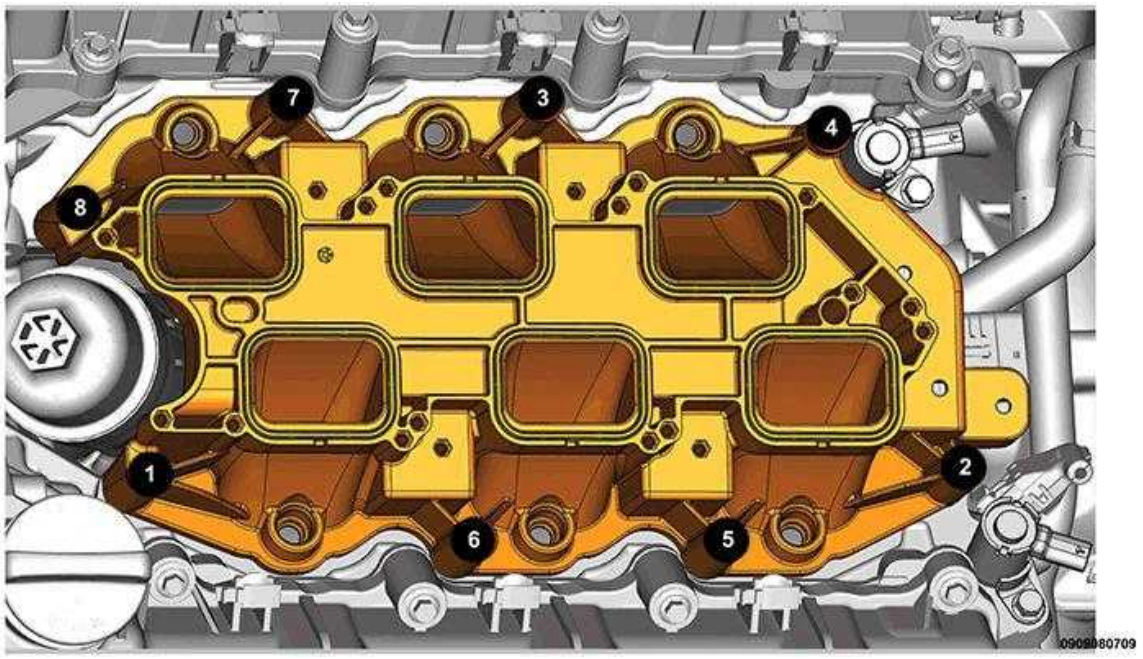


Fig. 18: Lower Intake Manifold Bolt Removal & Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

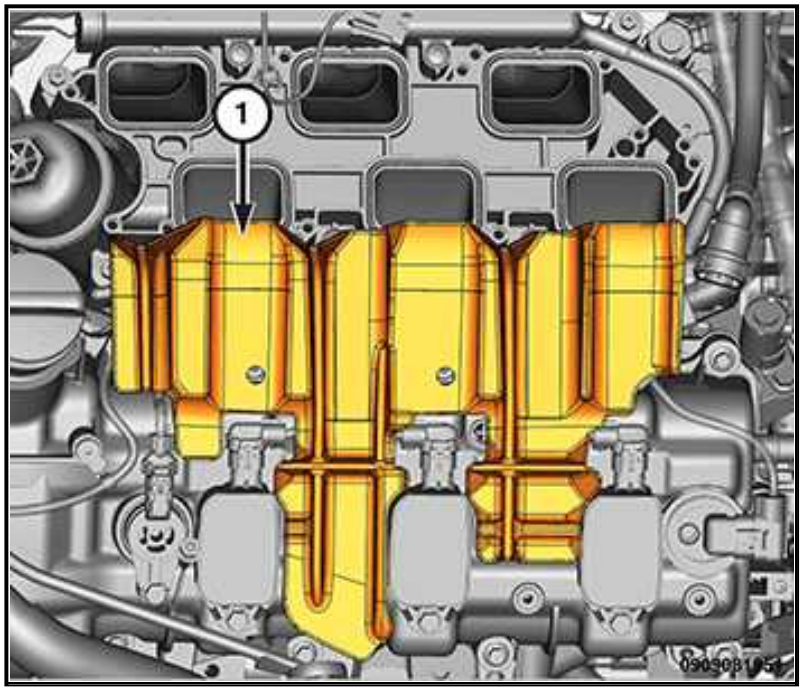
MANIFOLD, INTAKE

REMOVAL AND INSTALLATION

LOWER INTAKE MANIFOLD

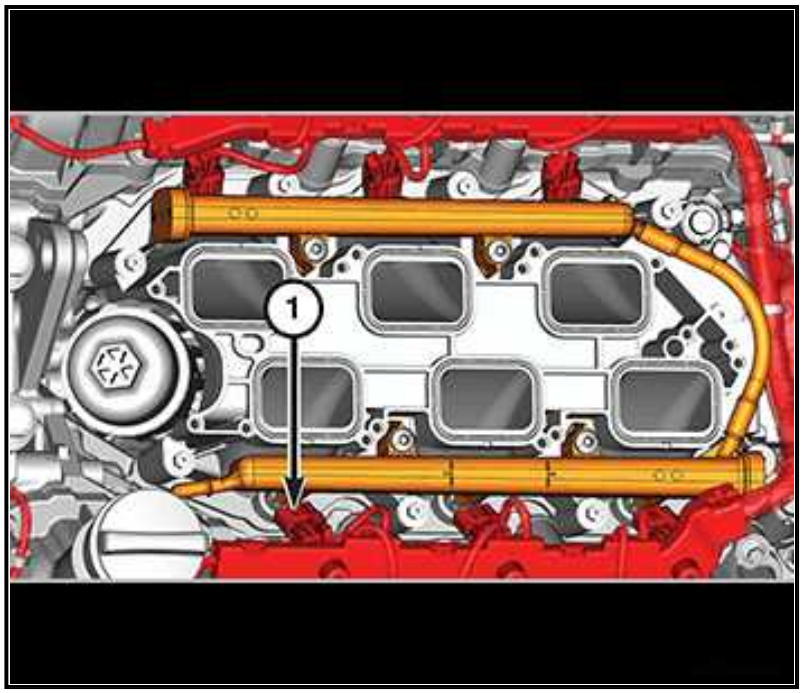
REMOVAL

1. Release the fuel system pressure. Refer to **FUEL SYSTEM PRESSURE RELEASE** .
2. Remove the upper intake manifold. Refer to **MANIFOLD, INTAKE, REMOVAL AND INSTALLATION**.



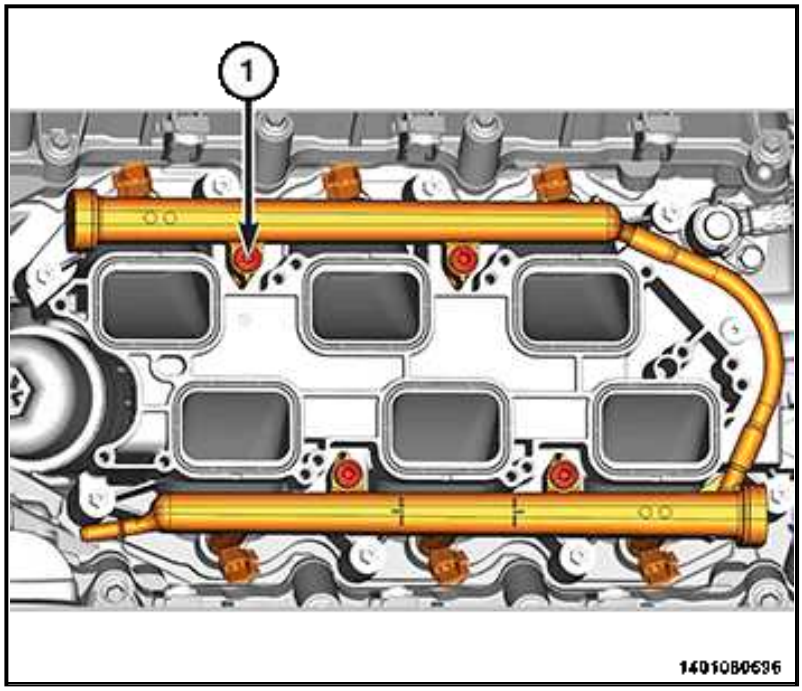
1 - Insulator

3. Remove the insulator from the top of the left cylinder head cover.
4. Disconnect the fuel supply hose from the fuel rail inlet. Refer to **FUEL SYSTEM** .



1 - Fuel Injector Harness Connector

5. Disconnect the fuel injector wire harness connectors and remove the wire harness assembly from the cylinder head covers on each side of the engine, then position the wire harness aside.



1 - Fuel Rail Bolts

6. Remove the bolts then lift the fuel rail and fuel injectors from the lower intake manifold.

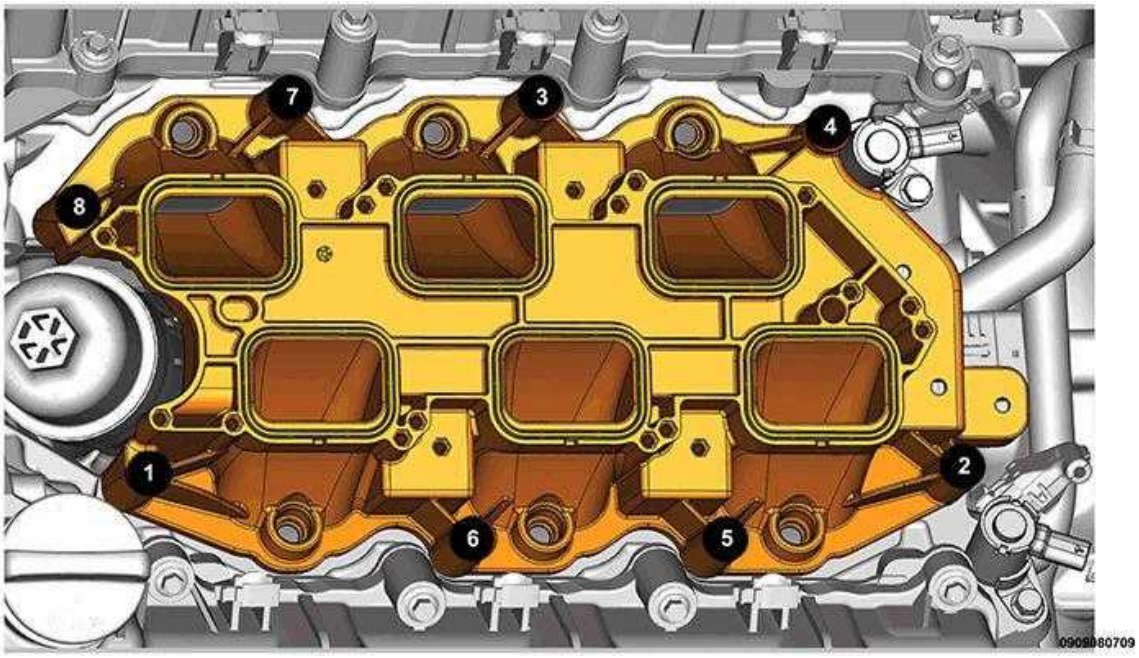


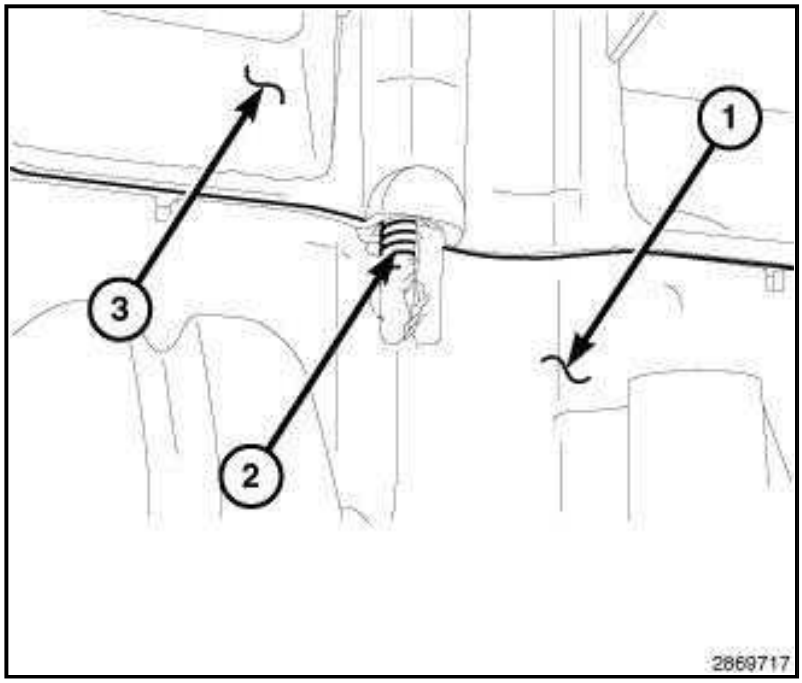
Fig. 19: Lower Intake Manifold Bolt Removal & Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

7. Using the sequence shown, remove the bolts and lower intake manifold.

INSPECTION:

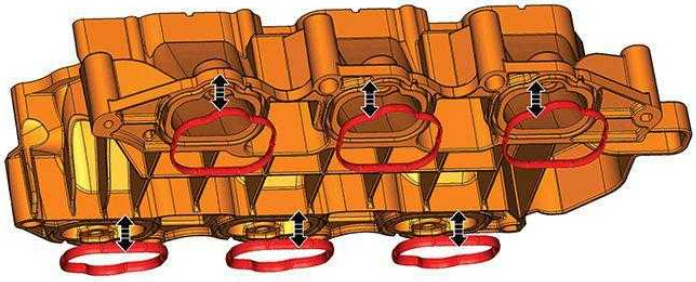
- Inspect the six lower intake manifold to cylinder head gaskets, and replace only if necessary.

NOTE: **FKM gaskets should not be cleaned with acetone, ketone (like MEK), organic acids (formic acid/acetic acid), toluene and benzene.**



1 - Lower Intake Manifold
2 - Upper Intake Manifold Bolt
3 - Upper Intake Manifold

- When the upper intake manifold and lower intake manifold are not aligned properly, cross threading of the upper intake manifold attaching bolts can occur. The graphic shows non-repairable damage to the lower intake manifold due to cross threading of an upper intake manifold attaching bolt.
- Check both the upper and lower intake manifolds for:
  - Damage and cracks.
  - Gasket surface damage or warping.
  - Check the fuel cross-over tube for damage or signs of abrasion. replace as necessary.
- Check the lower intake manifold for:
  - Damaged fuel injector ports.
- If either the upper or lower manifold exhibits any damaged or warped conditions, replace the manifold.



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.

- The lower intake manifold bolts must be tightened in the sequence shown in the torque table below.

- The upper intake manifold bolts must be tightened in the sequence shown in the torque table below.
- Start the engine and check for leaks.

TORQUE SPECIFICATIONS

AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-

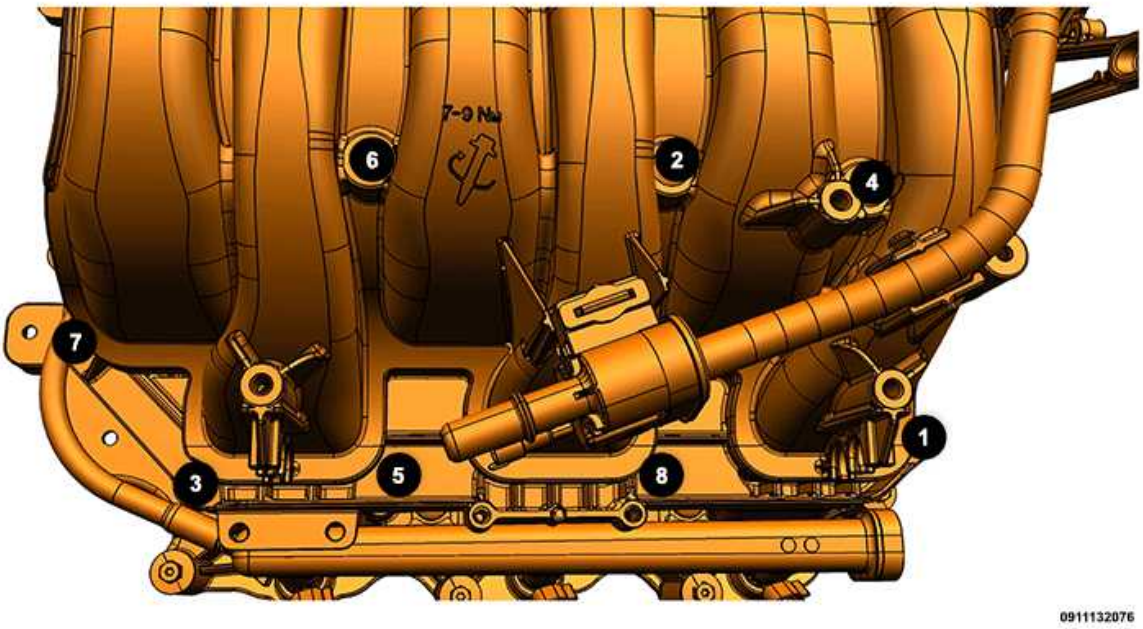


Fig. 20: Upper Intake Manifold Bolts Tightening/Loosening Sequence
Courtesy of CHRYSLER GROUP, LLC

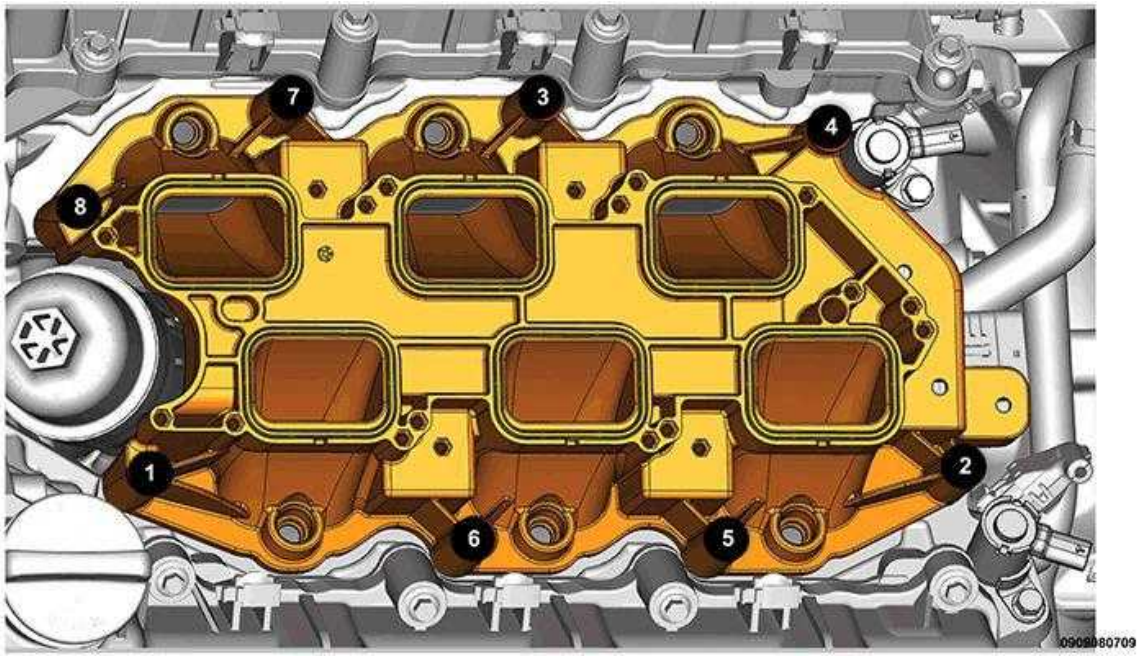
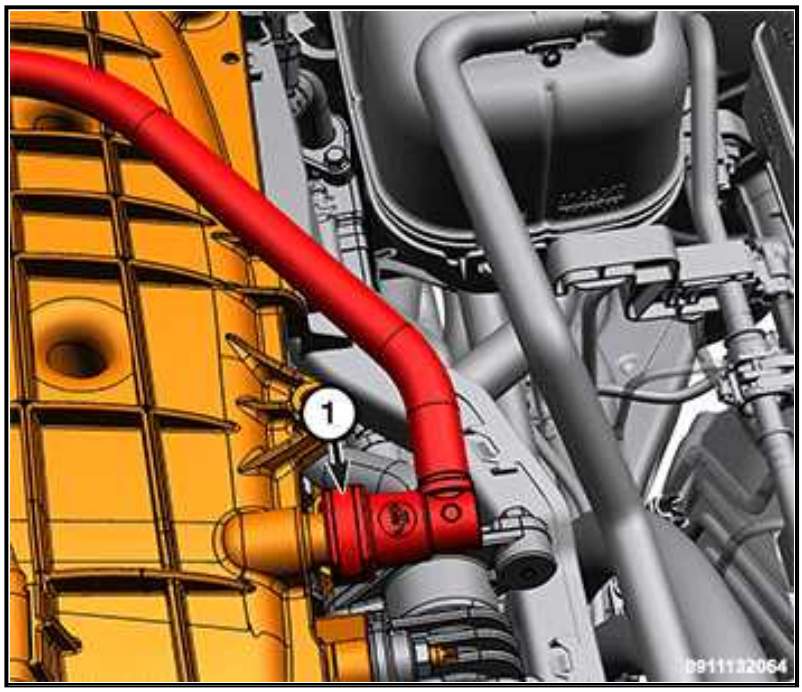


Fig. 21: Lower Intake Manifold Bolt Removal & Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

UPPER INTAKE MANIFOLD

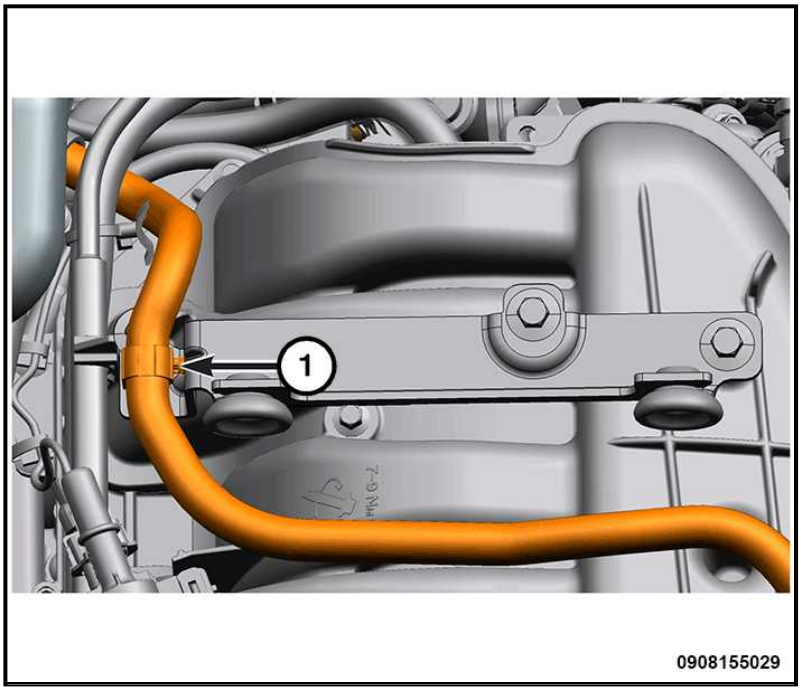
REMOVAL

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. Remove the air cleaner resonator. Refer to **RESONATOR, AIR CLEANER, REMOVAL AND INSTALLATION**.



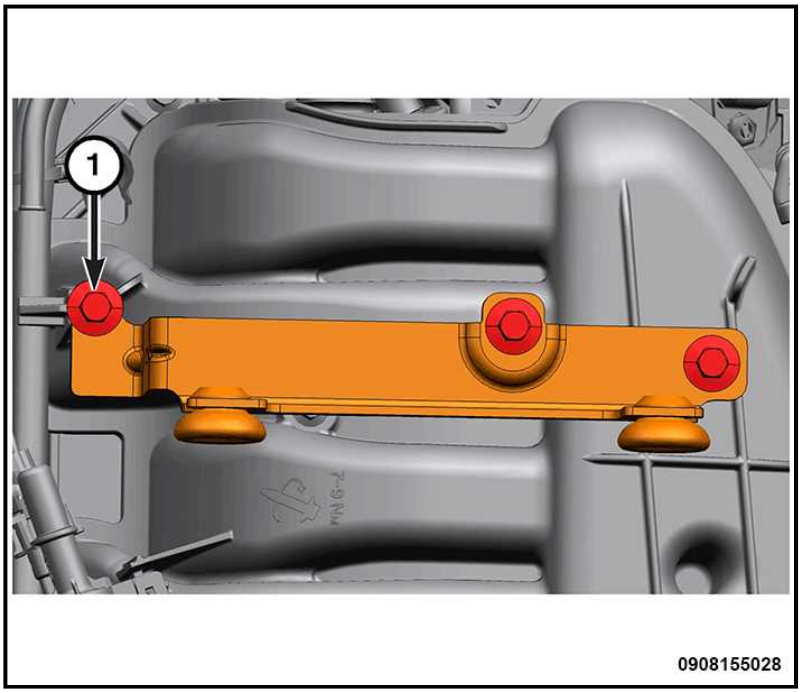
1 - PCV Hose

4. Disconnect the Positive Crankcase Ventilation (PCV) hose from the upper intake manifold.



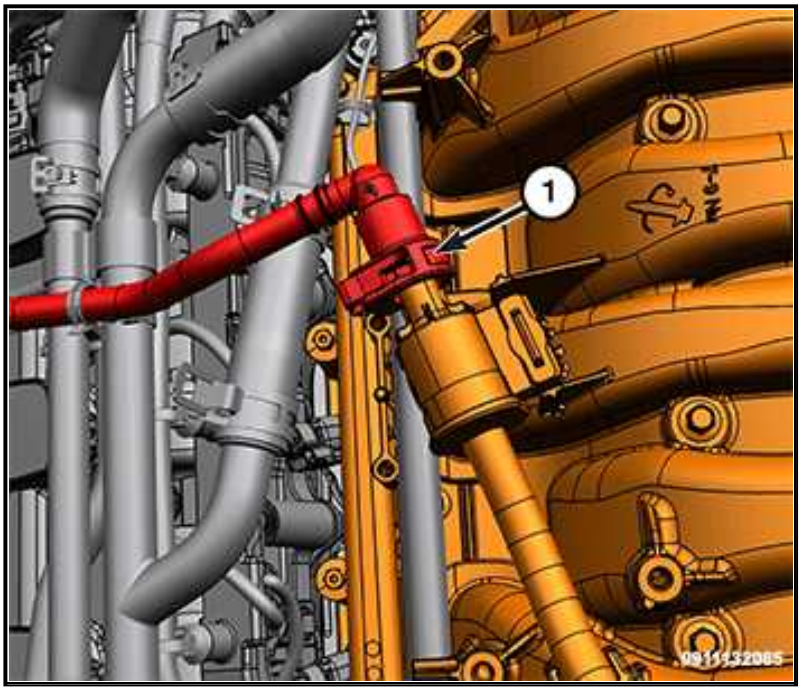
1 - PCV Hose

5. Disconnect the PCV hose from the engine cover bracket.



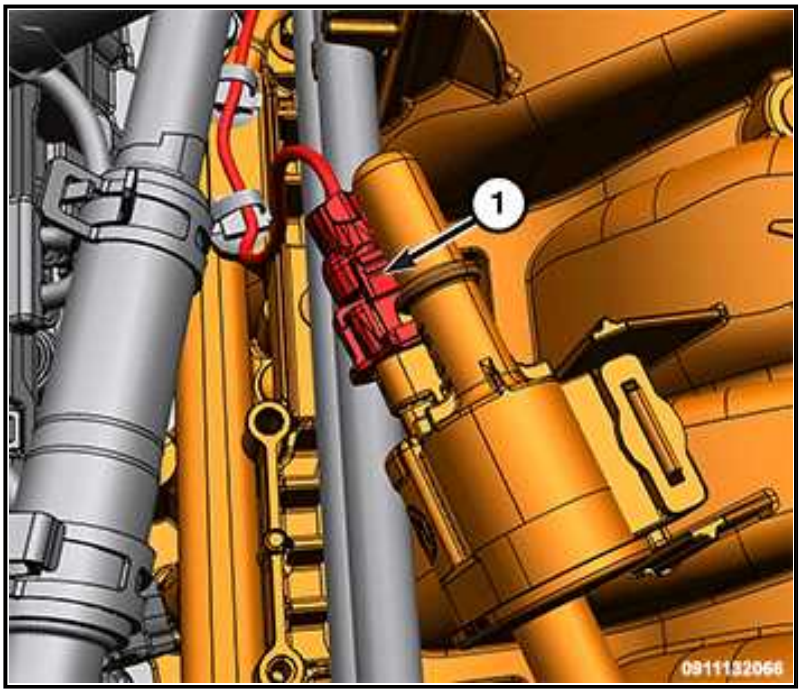
1 - Engine Cover Bracket Bolts

6. Remove the bolts and the engine cover bracket.



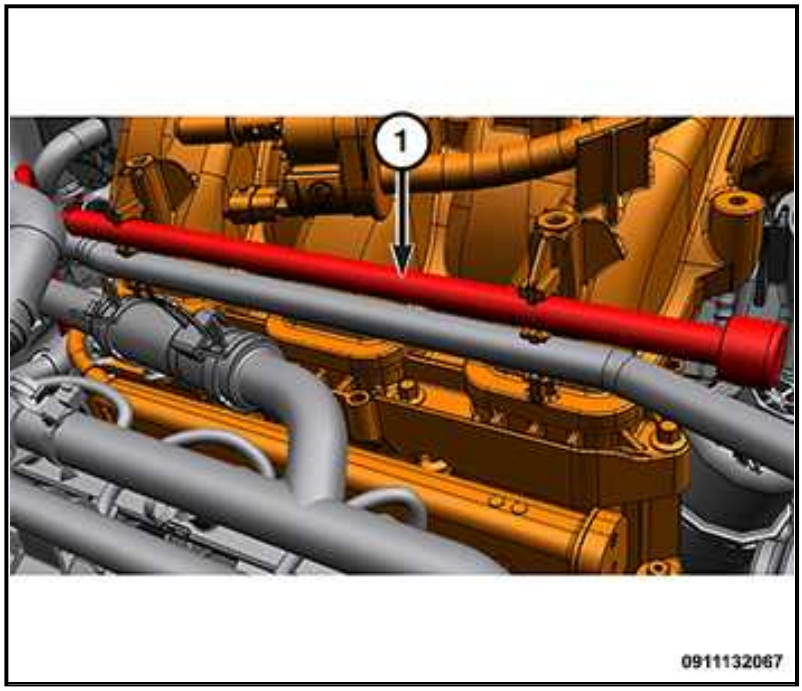
1 - Purge Vapor Line

7. Disconnect the purge vapor line.



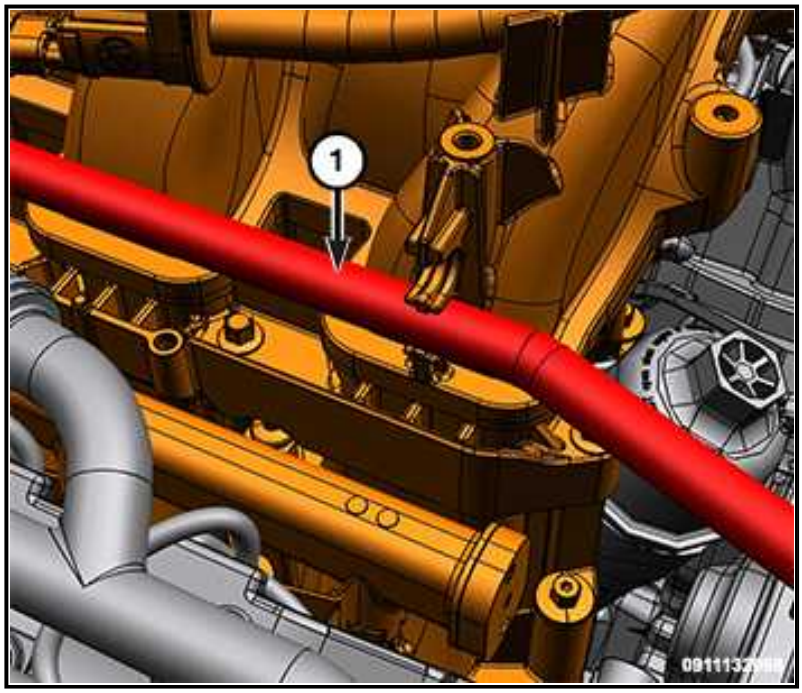
1 - Purge Solenoid Harness Connector

8. Disconnect the purge solenoid wire harness connector and detach the wire harness retainer from the manifold.



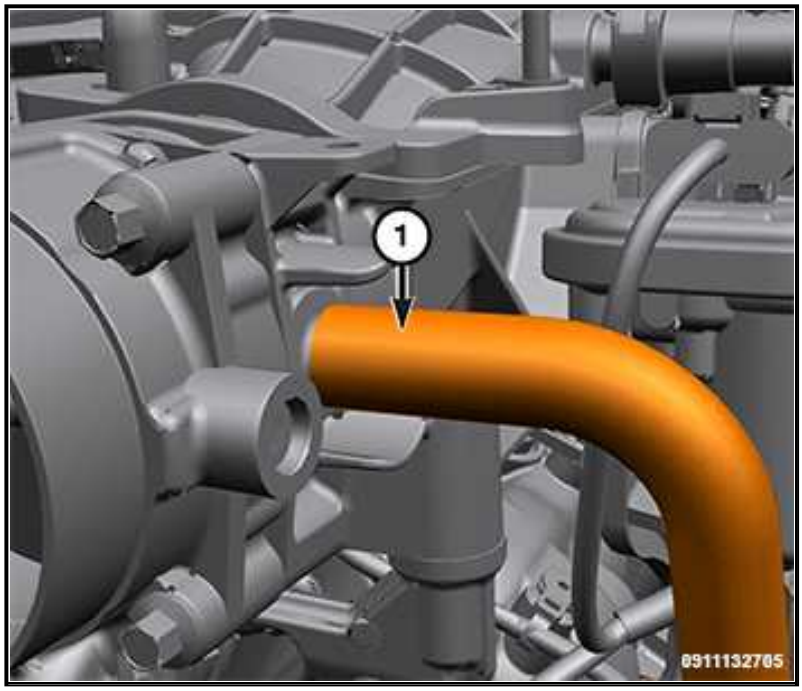
1 - Transmission Vent Hose

9. Remove the transmission vent hose from the upper intake manifold retaining brackets and move aside.



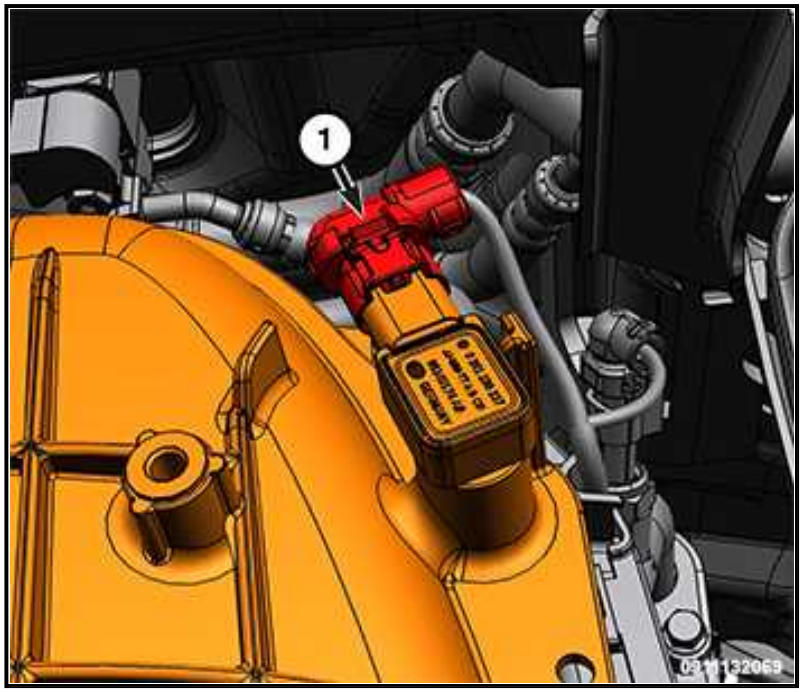
1 - Make-up Air Hose

10. Remove the make-up air hose from the lower intake manifold retaining brackets and move aside.



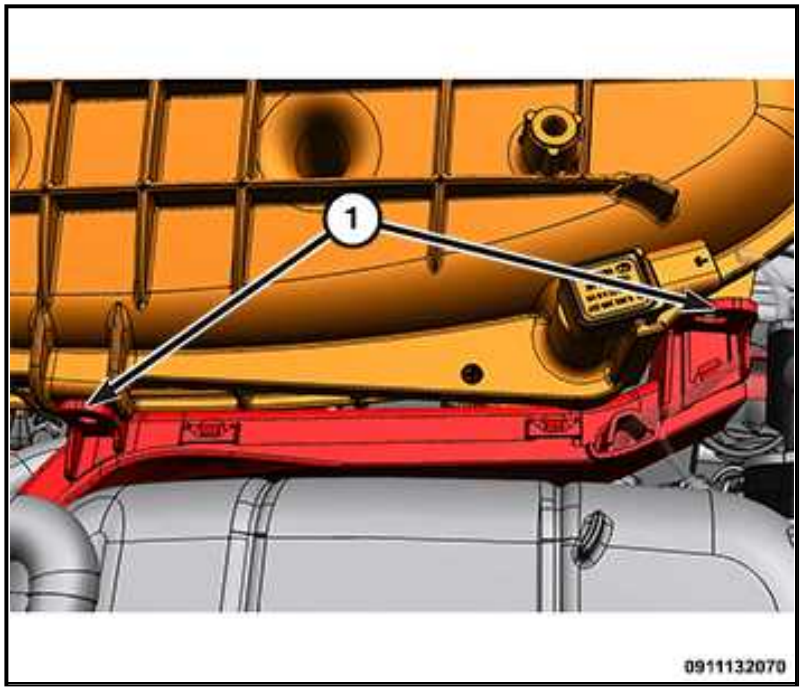
1 -
2 - Brake Booster Vacuum Hose

11. Disconnect the brake booster vacuum hose.



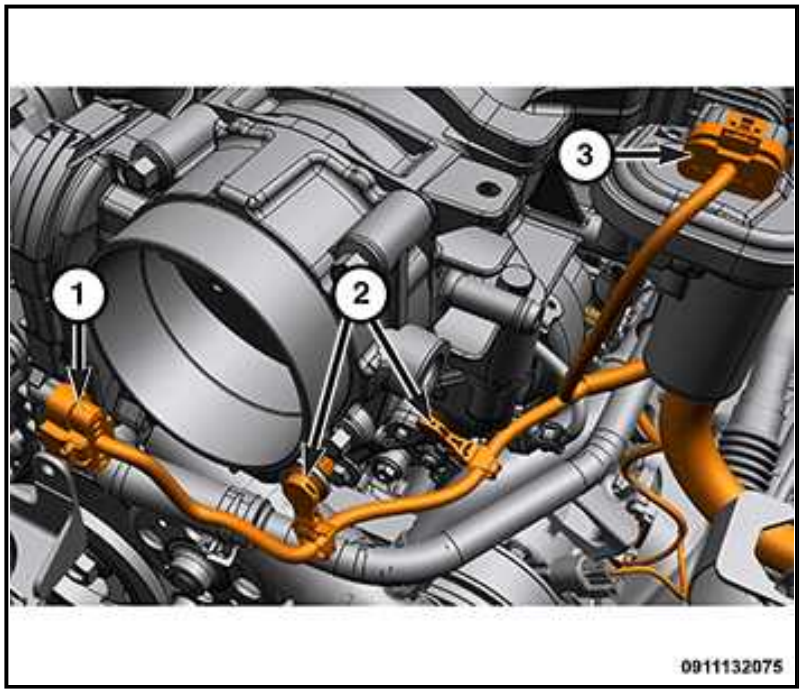
1 - MAP Sensor Harness Connector

12. Disconnect the Manifold Absolute Pressure (MAP) sensor wire harness connector and detach the wire harness retainer from the manifold.



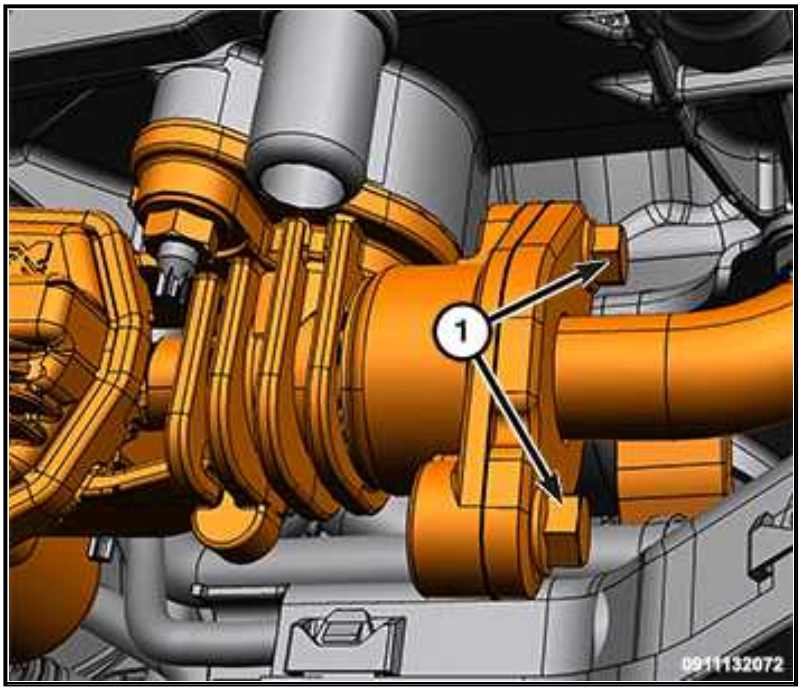
1 - Wire Harness Retainers

13. Remove the wire harness retainers from the upper intake manifold and position the harness aside.



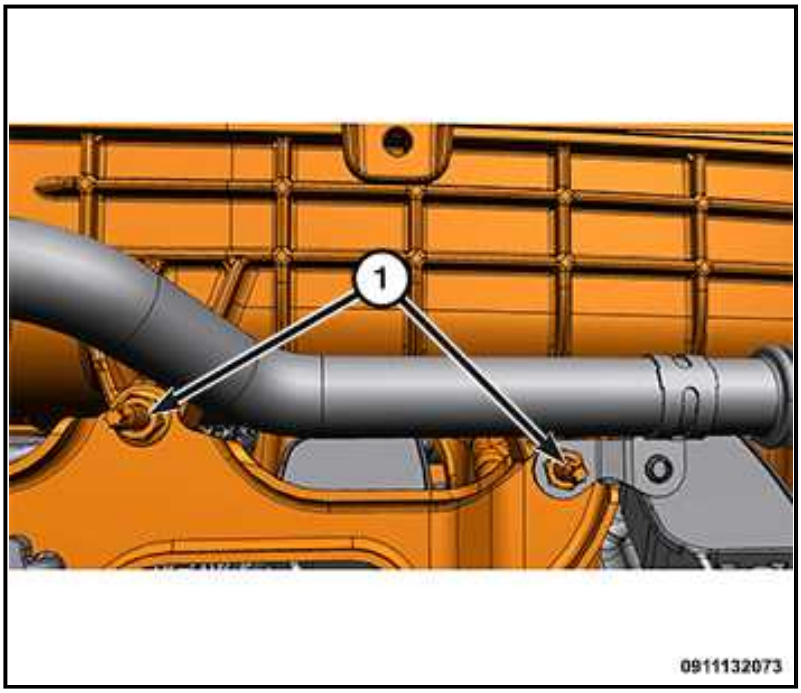
1 - Throttle Body Harness Connector
2 - Wire Harness Retainers
3 - EGR Valve Harness Connector

14. Disconnect the throttle body wire harness connector (1) and detach the wire harness retainers (2) from the throttle body.
15. Disconnect the Exhaust Gas Recirculation (EGR) valve wire harness connector (3).



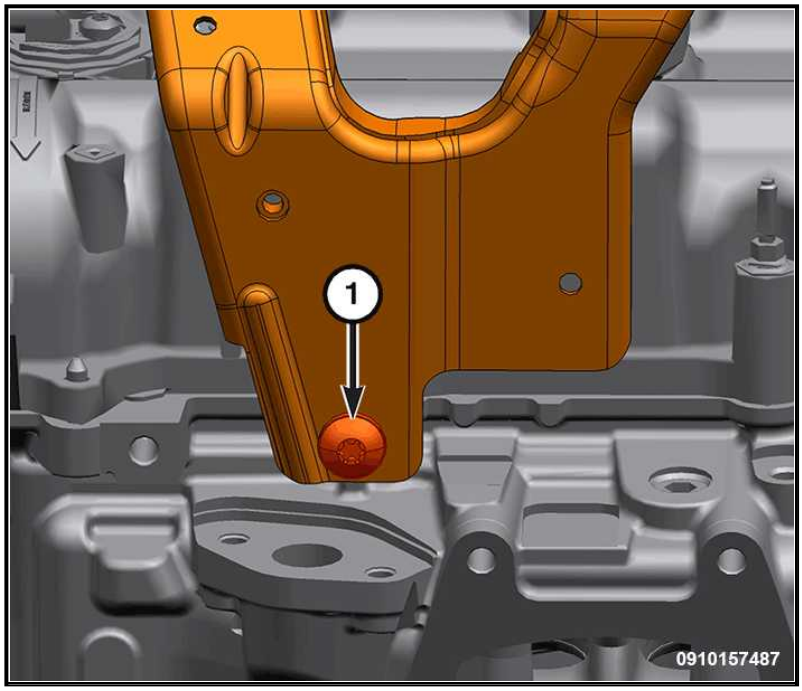
1 - EGR Valve Tube Bolts

16. Remove the EGR tube to EGR valve bolts.



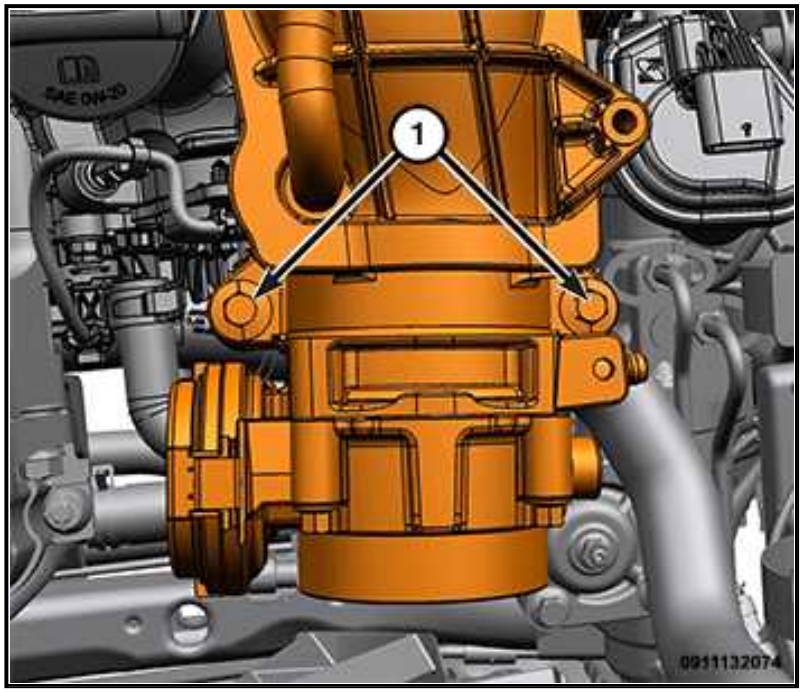
1 - Upper Intake Manifold Support Bracket Nuts

17. Remove the two upper intake manifold support bracket nuts.



1 - Upper Intake Manifold Support Bracket Bolt

18. If upper intake manifold support bracket removal or replacement is necessary, remove the lower intake support bracket bolt.



1 - Throttle Body Support Bracket Bolts

19. Remove the two upper intake manifold to throttle body support bracket bolts.

NOTE: **The upper intake manifold attaching bolts are captured in the upper intake manifold. Once loosened, the bolts will have to be lifted out of the lower intake manifold and held while removing the upper intake manifold.**

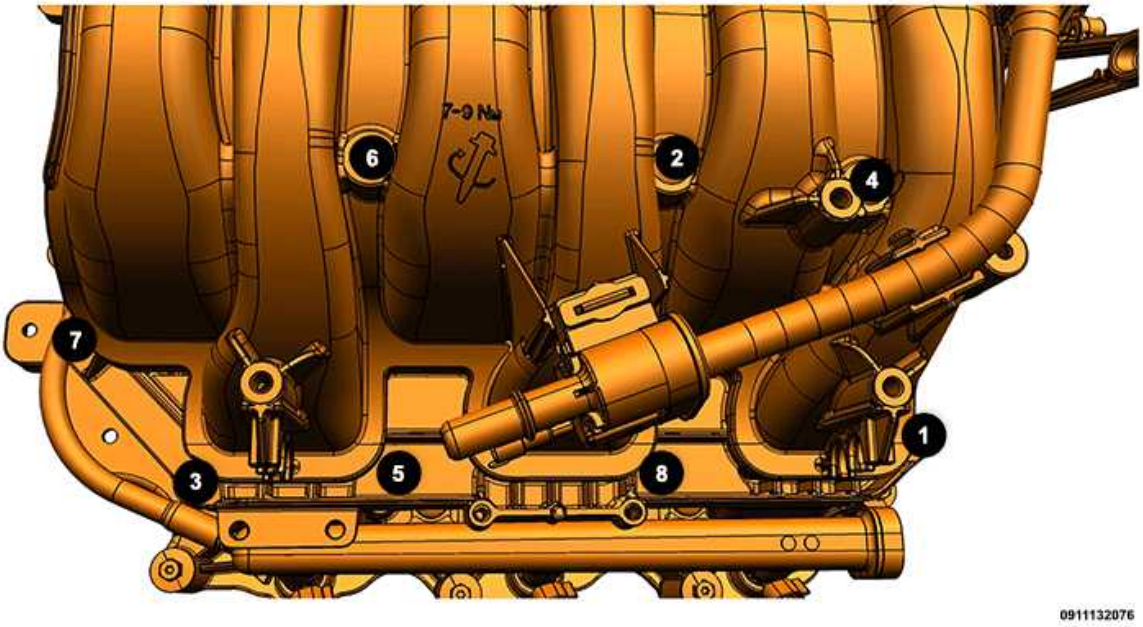


Fig. 22: Upper Intake Manifold Bolts Tightening/Loosening Sequence
Courtesy of CHRYSLER GROUP, LLC

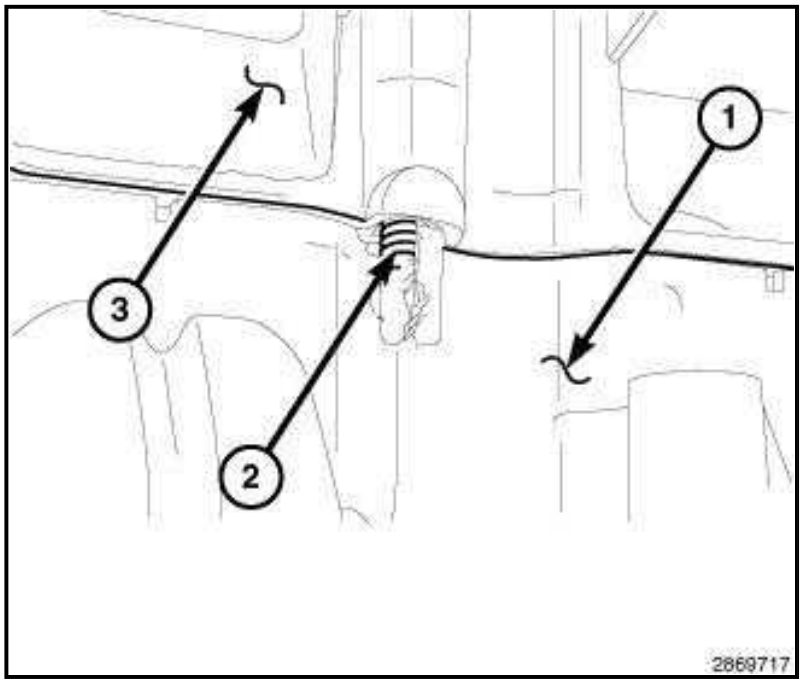
NOTE: Exercise care not to inadvertently loosen the two fuel rail attachment bolts that are in close proximity of the upper intake manifold attaching bolts.

20. Remove the eight bolts and the upper intake manifold.
21. Cover the open intake ports to prevent debris from entering the engine.

INSPECTION:

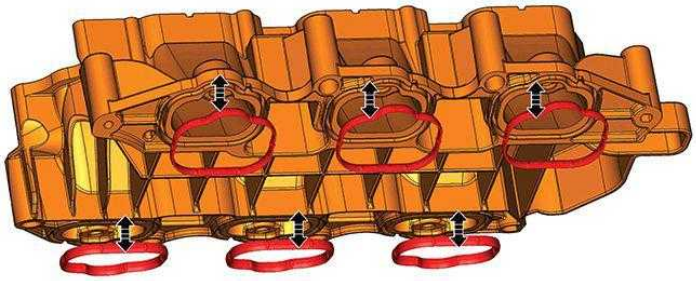
- Inspect the six lower intake manifold to cylinder head gaskets, and replace only if necessary.

NOTE: FKM gaskets should not be cleaned with acetone, ketone (like MEK), organic acids (formic acid/acetic acid), toluene and benzene.



1 - Lower Intake Manifold
2 - Upper Intake Manifold Bolt
3 - Upper Intake Manifold

- When the upper intake manifold and lower intake manifold are not aligned properly, cross threading of the upper intake manifold attaching bolts can occur. The graphic shows non-repairable damage to the lower intake manifold due to cross threading of an upper intake manifold attaching bolt.
- Check both the upper and lower intake manifolds for:
  - Damage and cracks.
  - Gasket surface damage or warping.
  - Check the fuel cross-over tube for damage or signs of abrasion. replace as necessary.
- Check the lower intake manifold for:
  - Damaged fuel injector ports.
- If either the upper or lower manifold exhibits any damaged or warped conditions, replace the manifold.



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.

- Lift and hold the eight upper intake attaching bolts clear of the mating surface. Back the bolts out slightly or if required, use an elastic band to hold the bolts clear of the mating surface.
- The upper intake manifold bolts must be tightened in the sequence shown in the torque table below.

TORQUE SPECIFICATIONS

AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-

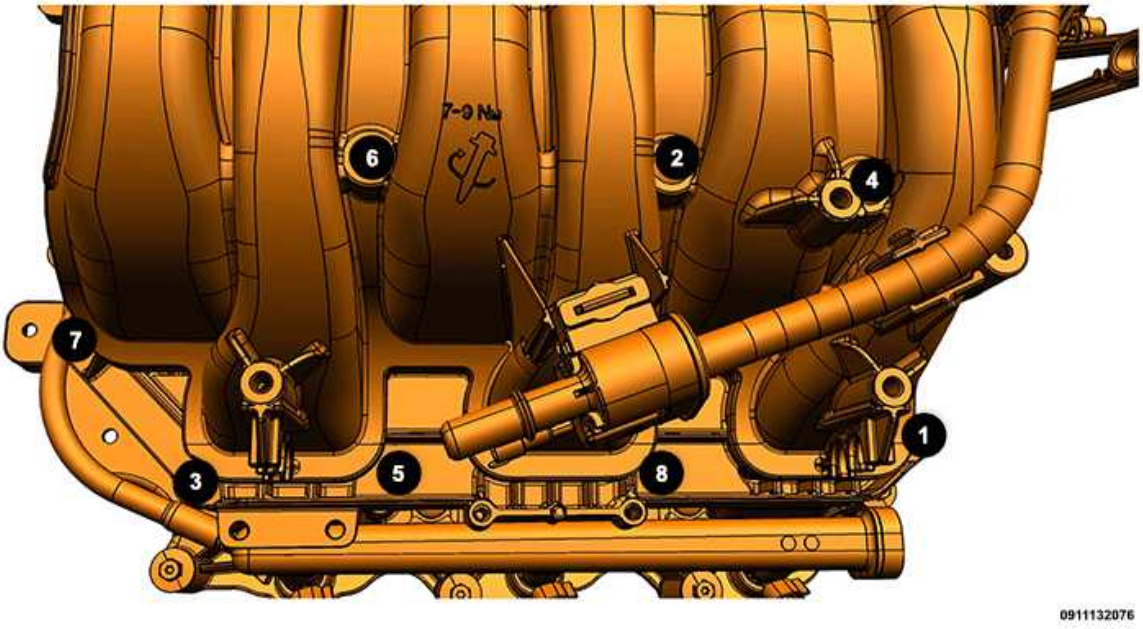


Fig. 23: Upper Intake Manifold Bolts Tightening/Loosening Sequence
Courtesy of CHRYSLER GROUP, LLC

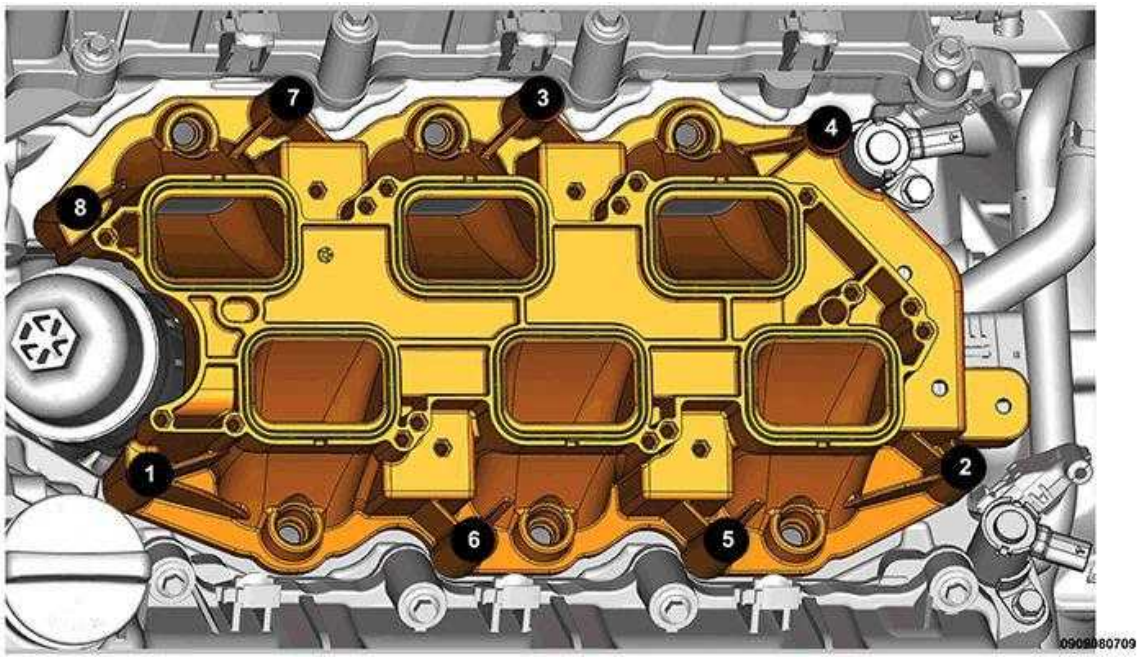


Fig. 24: Lower Intake Manifold Bolt Removal & Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

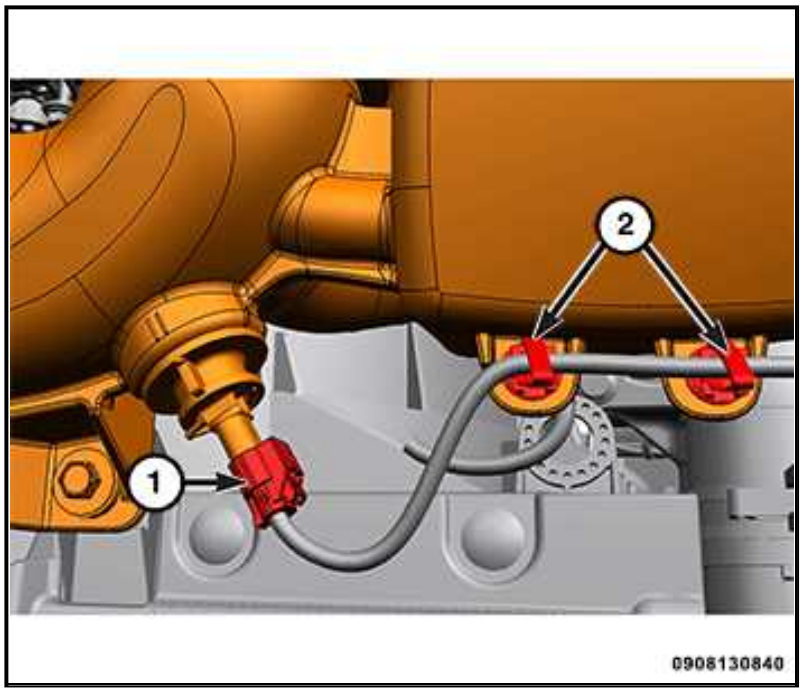
RESONATOR, AIR CLEANER

REMOVAL AND INSTALLATION

AIR CLEANER RESONATOR

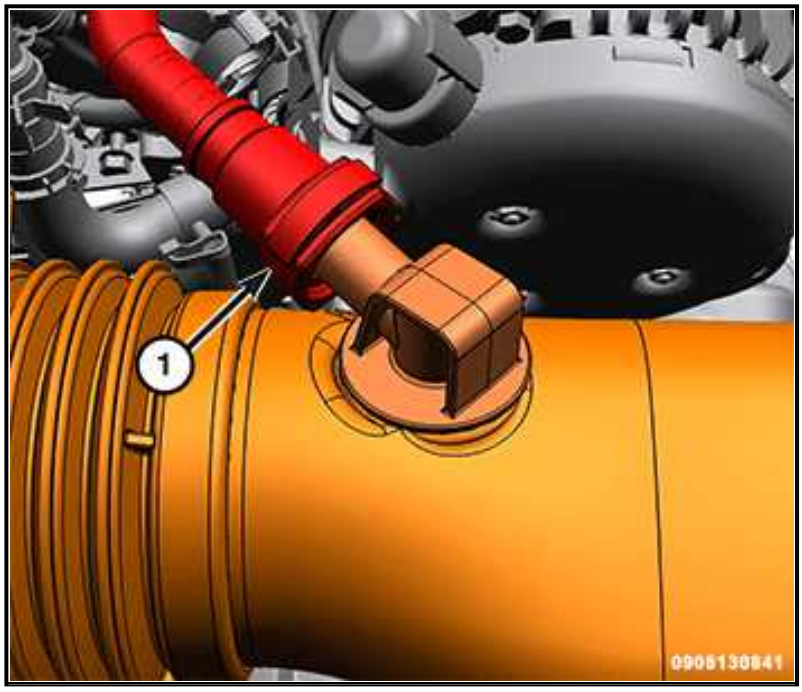
REMOVAL

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



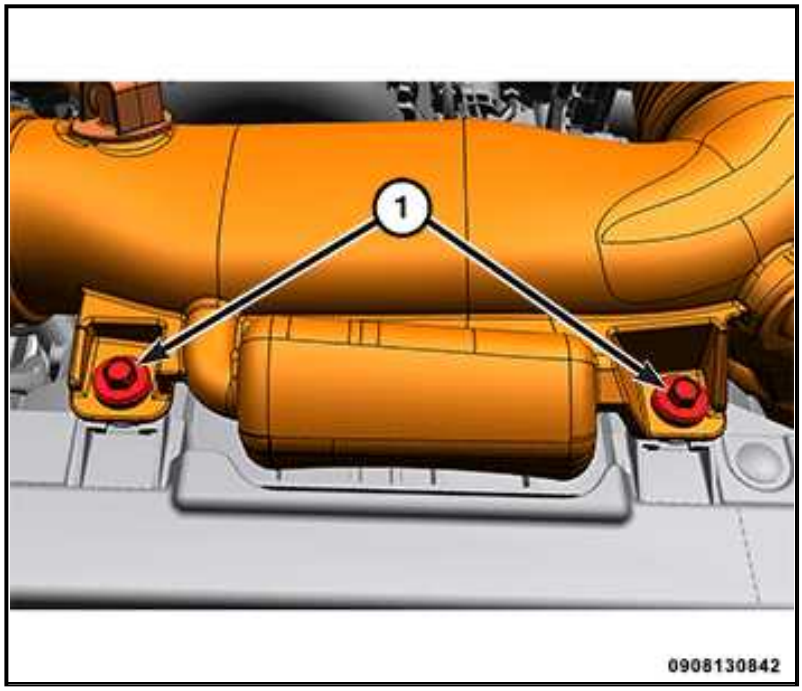
1 - Wire Harness Connector
2 - Wire Harness Retainers

2. Disconnect the wire harness connector from the Inlet Air Temperature (IAT) sensor.
3. Disengage the wire harness retainers from the resonator.



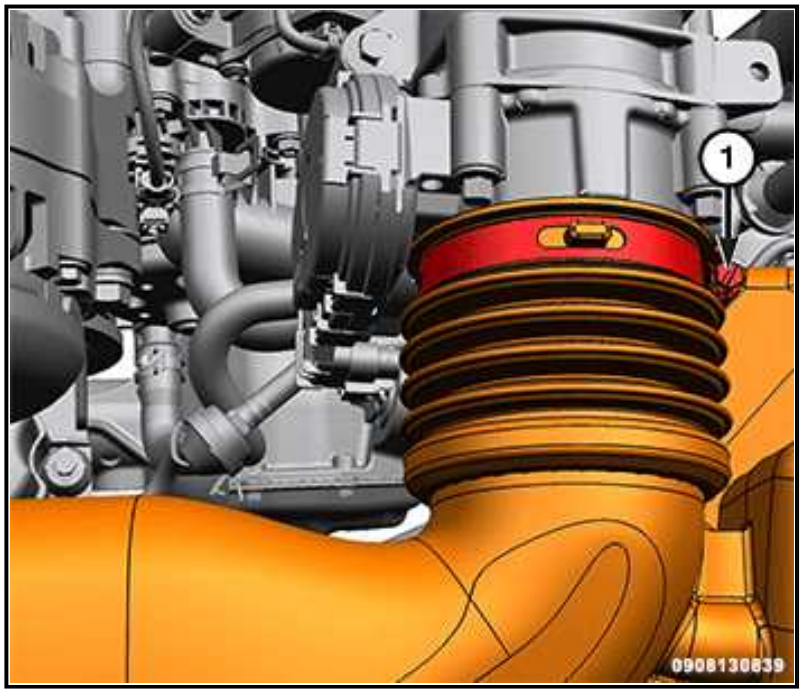
1 - Make-up Air Hose

4. Disconnect the make-up air hose.



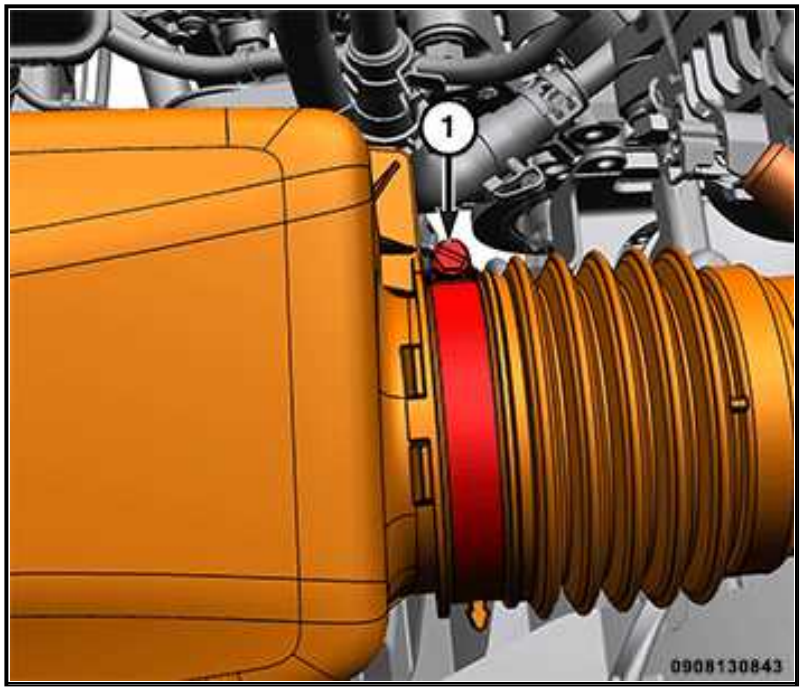
1 - Resonator Bolts

5. Remove the bolts from the resonator.



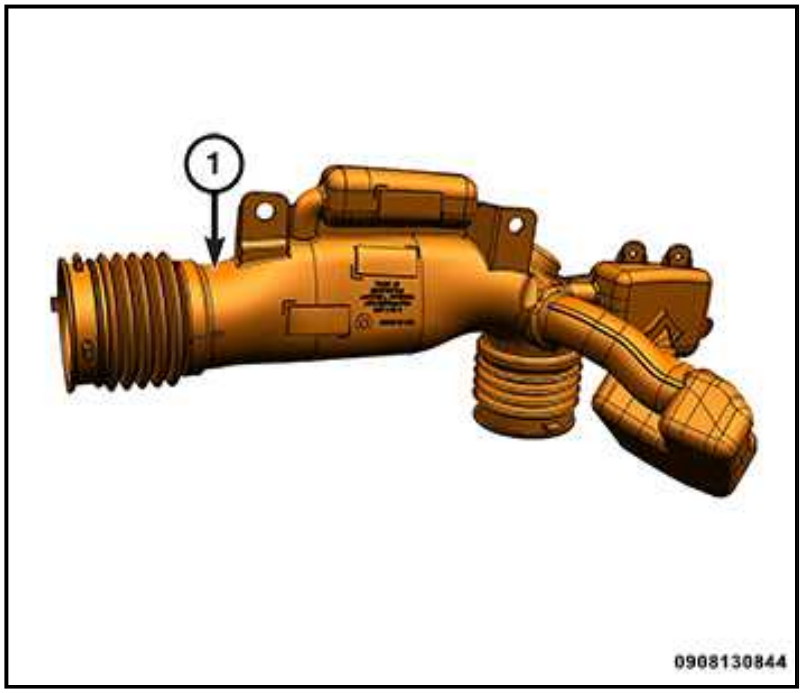
1 - Clamp

6. Loosen the clamp at the throttle body. Disengage and remove the resonator from the throttle body inlet.



1 - Clamp

7. Loosen the clamp at the housing.



1 - Resonator Bolts

8. Remove the resonator assembly.
9. If necessary, remove the Inlet Air Temperature (IAT) sensor from the resonator.

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

AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-

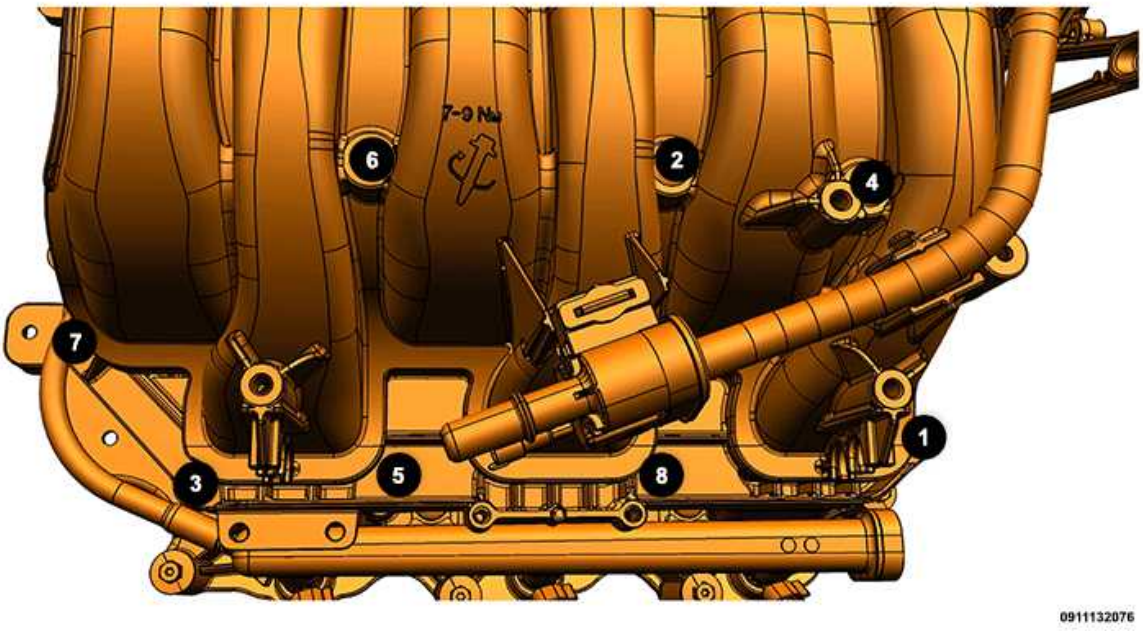


Fig. 25: Upper Intake Manifold Bolts Tightening/Loosening Sequence
Courtesy of CHRYSLER GROUP, LLC

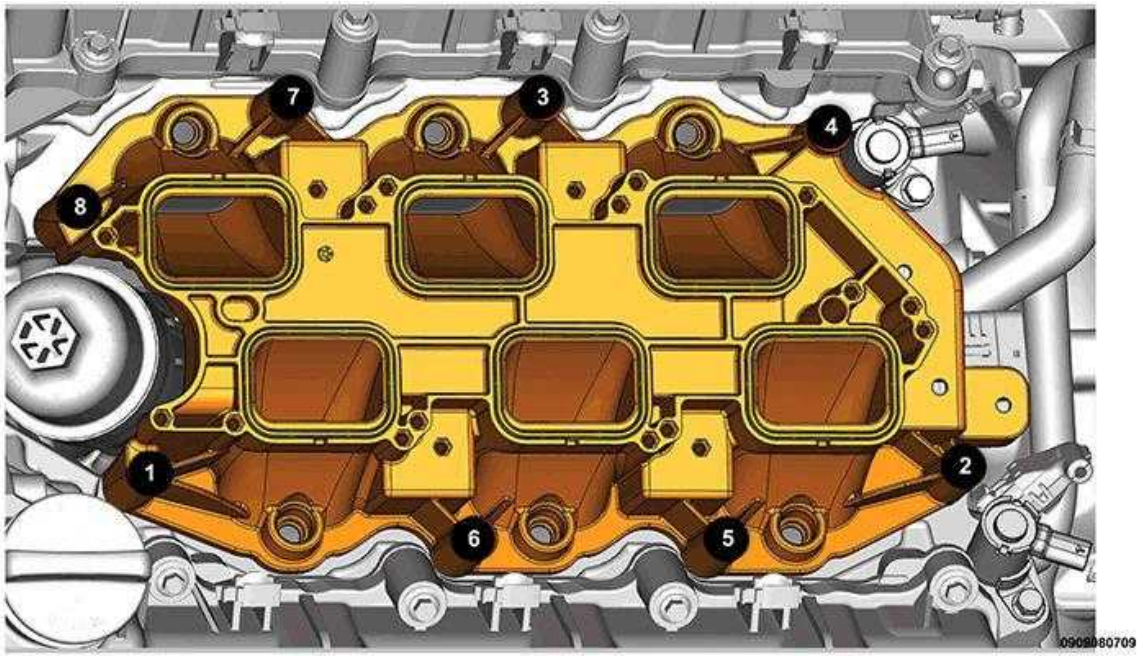


Fig. 26: Lower Intake Manifold Bolt Removal & Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

THROTTLE BODY

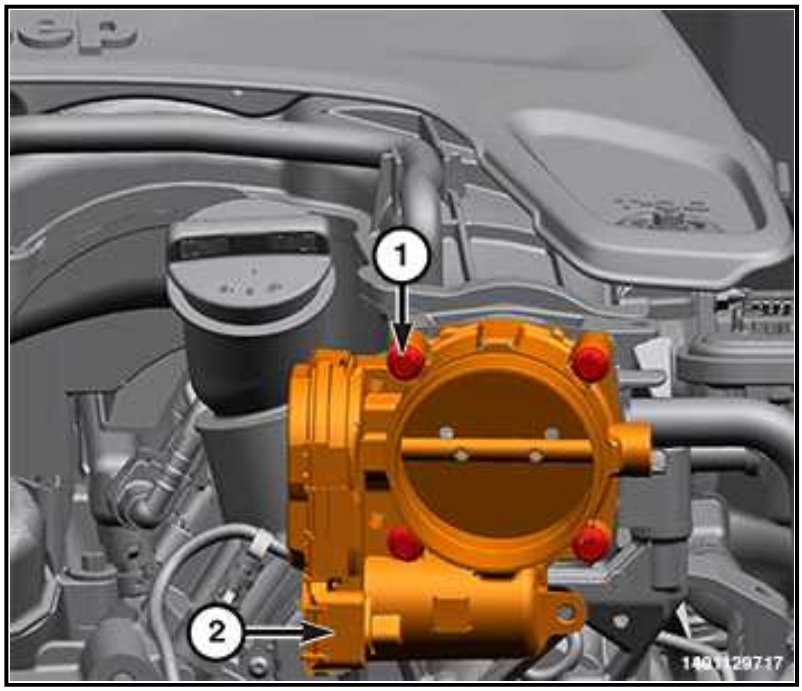
REMOVAL AND INSTALLATION

THROTTLE BODY

REMOVAL

CAUTION: **Never have the ignition key in the ON position when checking the throttle body shaft for a binding condition. This may set DTCs.**

1. Remove the air cleaner resonator. Refer to **RESONATOR, AIR CLEANER, REMOVAL AND INSTALLATION**.



1 - Throttle Body Bolts
2 - Wire Harness Connector

2. Disconnect the throttle body wire harness connector from the throttle body.
3. Remove the four bolts and the throttle body.
4. Remove and **DISCARD** the O-ring 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.

- Clean the mating surfaces of the throttle body and intake manifold.
- Use a **NEW** O-ring.
- Tighten the throttle body bolts in a criss-cross pattern.

TORQUE SPECIFICATIONS

AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-

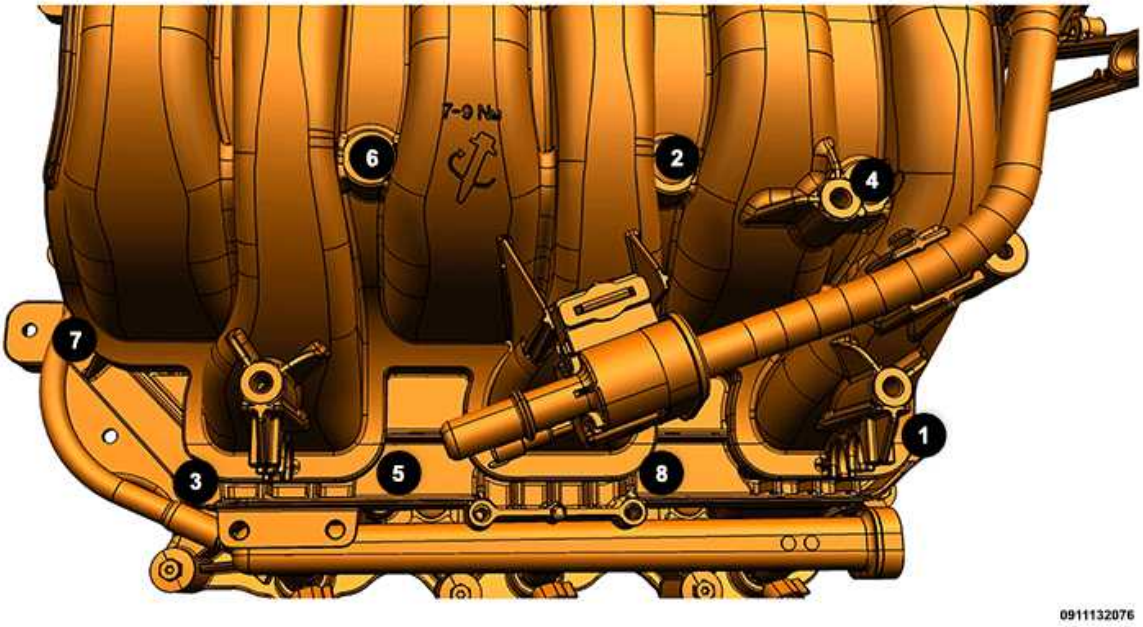


Fig. 27: Upper Intake Manifold Bolts Tightening/Loosening Sequence
Courtesy of CHRYSLER GROUP, LLC

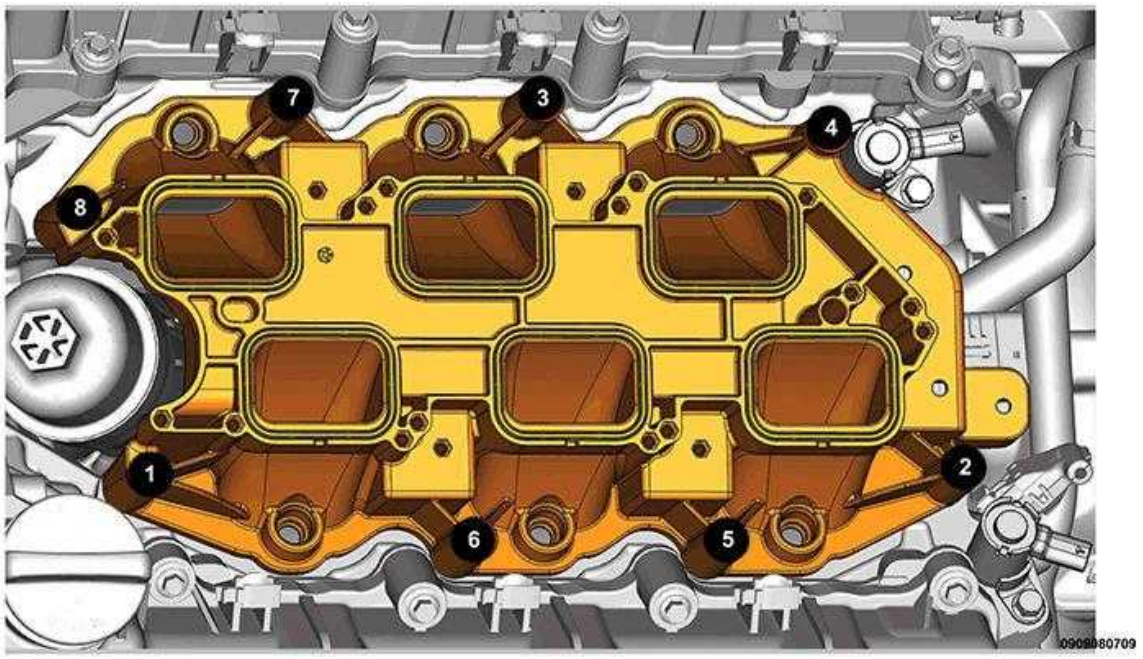


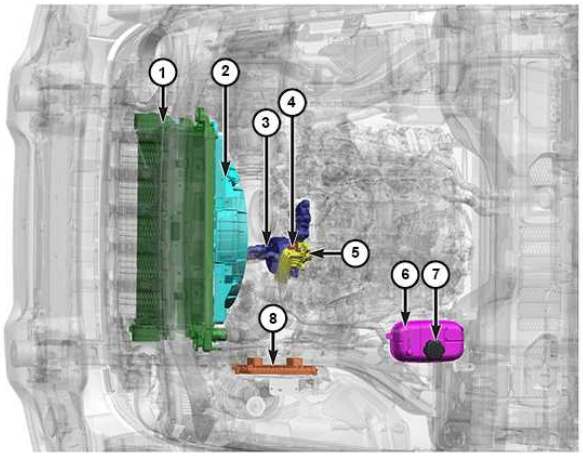
Fig. 28: Lower Intake Manifold Bolt Removal & Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

COOLING SYSTEM

DESCRIPTION AND OPERATION

COOLING SYSTEM

DESCRIPTION



The cooling system consists of the following components:

COMPONENT INDEX

1.	Refer to **RADIATOR**.
2.	Refer to **ELECTRIC COOLING FAN**.
3.	Refer to **WATER PUMP**.
4.	Refer to **ENGINE COOLANT TEMPERATURE (ECT) SENSOR**.
5.	Refer to **THERMOSTAT AND HOUSING ASSEMBLY**.
6.	Refer to **PRESSURIZED COOLANT BOTTLE**.
7.	Refer to **COOLING SYSTEM PRESSURE CAP**.
8.	Refer to **POWERTRAIN CONTROL MODULE (PCM)**.
-	Refer to **COOLANT**.

OPERATION

The cooling system regulates engine operating temperature. It allows the engine to reach normal operating temperature as quickly as possible, maintains normal operating temperature and prevents overheating.

The cooling system also provides a means of heating the passenger compartment, cooling the exhaust gases entering the Exhaust Gas Recirculation (EGR) Cooler, and cooling the engine oil. The cooling system also helps heat up the transmission oil by flowing through the transmission oil heater.

The cooling system is pressurized and uses a centrifugal water pump to circulate coolant throughout the system. A separate and remotely mounted, pressurized coolant bottle is used. When the engine is cold the thermostat is closed and the cooling system has no flow through the radiator or the transmission oil heater. The coolant flows through the engine, engine oil cooler, water pump, EGR Cooler, and passenger compartment heater core while the thermostat is closed. When the engine is warm the thermostat is full open and coolant will then flow through the radiator and transmission oil heater.

COOLANT

Refer to **COMPONENT INDEX**.

The cooling system is designed around the coolant. The coolant must accept heat from engine metal in the cylinder head area near the exhaust valves and engine block. Then coolant carries the heat to the radiator where the tube/fin radiator can transfer the heat to the air. The use of aluminum cylinder blocks, cylinder heads, and water pumps requires special corrosion protection. MoparB® Antifreeze/Coolant, or the equivalent ethylene-glycol base coolant with organic corrosion inhibitors (called OAT, for Organic Additive Technology) is recommended. This coolant offers the best engine cooling without corrosion when mixed with 50% ethylene-glycol and 50% distilled water to obtain a freeze point of -37B°C (-35B°F). If it becomes contaminated, drain, flush, and replace with fresh properly mixed coolant solution.

COOLING SYSTEM PRESSURE CAP

Refer to **COMPONENT INDEX**.

All radiators are equipped with a pressure cap. This cap releases pressure at some point within a range of 145 kPa (21 psi). The pressure relief point (in pounds) is printed in yellow on top of the cap. The cooling system will operate at pressures of 145 kPa (21 psi) above atmospheric pressure. This results in a higher coolant boiling point allowing increased radiator cooling capacity. The cap contains a spring-loaded pressure relief valve. This valve opens when system pressure reaches the release range of 145 kPa (21 psi). A rubber gasket seals the cap to maintain vacuum during coolant cool-down and to prevent leakage when system is under pressure.

ELECTRIC COOLING FAN

Refer to **COMPONENT INDEX**.

The electric cooling fan is integral to the fan shroud and is located between the radiator and the engine. The electric fan is controlled by the PCM. The electric cooling fan is not serviceable. Any failure of the fan blade, electric motor or fan shroud requires replacement of the fan module. The electric cooling fan is powered by a fuse located in the Power Distribution Center (PDC).

ENGINE COOLANT TEMPERATURE (ECT) SENSOR

Refer to **COMPONENT INDEX**.

The ECT sensor is used to sense engine coolant temperature. The sensor protrudes into the thermostat housing. The ECT sensor is a two-wire Negative Thermal Coefficient (NTC) sensor. Meaning, as engine coolant temperature increases, resistance (voltage) in the sensor decreases. As temperature decreases, resistance (voltage) in the sensor increases. With the ignition switch in the ON position, the PCM sends out a regulated 5 volt signal to the ECT sensor. The PCM then monitors the signal as it passes through the ECT sensor to the sensor ground (sensor return). When the engine is cold, the PCM will operate in open loop cycle. It will demand slightly richer air-fuel mixtures and higher idle speeds. This is done until normal operating temperatures are reached.

POWERTRAIN CONTROL MODULE (PCM)

Refer to **COMPONENT INDEX**.

The PCM is located next to the washer solvent reservoir. The PCM is a digital computer containing a microcontroller. The PCM receives input signals from various switches and sensors that are referred to as PCM Inputs. Based on these inputs, the PCM adjusts various engine and vehicle operations through devices that are referred to as PCM Outputs.

The PCM is powered by a fuse located in the PDC. The PCM uses the Controller Area Network-Chassis (CAN-C) bus to perform engine diagnostics and flash operations.

The PCM manages the cooling fan activation and speed selection by sending a desired Pulse Width Modulated (PWM) duty cycle (%) at a specified frequency (Hz) to the radiator fan. The PCM controls activation and deactivation of cooling fan to protect the engine from been over heated. During the fan activation, speed selection and deactivation of the radiator fan is based on the value of engine thermal variables that the PCM continuously monitors through direct equipped sensors, estimated algorithms, or it could be through request via Controller Area Network-Chassis (CAN-C) Controller Area Network-Electronic Powertrain (CAN-EPT).

The PCM is powered by a fuse located in the PDC.

CAN-C Inputs

- Electronic Climate Control (ECC)/Heating, Ventilation, & Air Conditioning (HVAC) request
- A/C refrigerant pressure sensor information
- Engine oil temperature
- Engine coolant temperature
- Engine RPM
- Engine run status

- Intake air temp
- Engine thermal management demand
- Vehicle speed
- Commanded ignition switch status
- Hood ajar status
- Ambient temp sensor voltage
- Maximum A/C demand to powertrain
- Transmission fluid temperature

CAN-C Outputs

- Radiator fan PWM duty cycle command [%]

CAN-EPT Inputs

- Air flow request

CAN-EPT Outputs

- Radiator fan request

Hardwire Outputs

- PWM command signal to the radiator cooling fan

PRESSURIZED COOLANT BOTTLE

Refer to **COMPONENT INDEX**.

A multi-chambered liquid coolant receiving bottle unitized from upper and lower plastic parts forming part of the closed coolant system of an internal combustion engine. When unitized the bottle comprises a pressurized coolant deaeration chamber separated by a convexly curved stationary pressure wall from overflow chamber. The chambers are arranged laterally side-by-side and are hydraulically connected to one another by a hose external of the bottle. The upper plastic part forming an upper portion of the coolant chamber supports a coolant filler neck that operatively mounts a pressure cap thereon. The pressure cap has a lower primary seal, an upper secondary seal and a vacuum breaker valve and cooperates with the filler neck so that coolant is transmitted to the overflow chamber from the deaeration chamber when the coolant of the system expands and from the overflow chamber to the de-aeration chamber when the system coolant contacts and creates a vacuum.

RADIATOR

Refer to **COMPONENT INDEX**.

A heavy duty cross-flow aluminum/plastic radiator is used. The radiator consists of an aluminum core and plastic end tanks, which are fastened to the core with clinch tabs and sealed with a high temperature rubber gasket. Vehicles equipped with automatic transmissions use a separate A/C condenser and transmission oil cooler located on the front of the radiator. If the plastic tank has been damaged, individual parts are not available, and the radiator must be replaced. As air passes through the radiator core, the heat within the coolant is dissipated into the ambient air.

THERMOSTAT AND HOUSING ASSEMBLY

Refer to **COMPONENT INDEX**.

A diaphragm-type thermostat controls the operating temperature of the engine by controlling the amount of coolant flow to the radiator. The thermostat is located inside of the thermostat housing and is serviced with the housing as one unit. On all engines the thermostat begins to open at 88B°C (190B°F) to allow flow to the radiator. The thermostat is fully open by 100B°C (212B°F). This provides quick engine warm up and overall temperature control. The same thermostat is used for winter and summer seasons. An engine should not be operated without a thermostat, except for servicing or testing. Operating without a thermostat causes other

problems such as longer engine warm-up time, unreliable warm-up performance, increased exhaust emissions and crankcase condensation. This condensation can result in sludge formation. The wax motor is located in a sealed container at the spring end of the thermostat. When heated, the internal wax expands, overcoming closing spring tension and water pump pressure to force the valve to open.

WATER PUMP

Refer to **COMPONENT INDEX**.

A centrifugal water pump circulates coolant through the water jackets, passages, intake manifold, radiator core, cooling system hoses and heater core. The pump is driven from the engine crankshaft by a single serpentine main drive belt. The water pump impeller is pressed onto the rear of a shaft that rotates in bearings pressed into the housing. The housing has two small holes to allow seepage to escape. The water pump seals are lubricated by the antifreeze in the coolant mixture. No additional lubrication is necessary. The water pump is mounted directly to the timing chain cover and is equipped with a non serviceable integral pulley. The water pump is used to circulate coolant through the cooling system. The coolant is pumped through the engine block, cylinder head, heater core, EGR cooler, oil cooler, transmission oil heater, and radiator.

DIAGNOSIS AND TESTING

COOLANT CONCENTRATION TESTING

CAUTION: Do not mix types of coolant - corrosion protection will be severely reduced.

CAUTION: Do not use coolant additives that are claimed to improve engine cooling.

Check coolant concentration when any additional coolant is added to the system, or after a coolant drain, flush and refill. Use of a hydrometer or the Refractometer (special tool #8286, Refractometer) can be used to test coolant concentration.

- A hydrometer tests the amount of glycol in a mixture by measuring the specific gravity of the mixture. The higher the concentration of ethylene glycol, the larger the number of balls that will float, and the higher the freeze protection (up to a maximum of 60% by volume glycol).
- The Refractometer (special tool #8286, Refractometer) tests the amount of glycol in a coolant mixture by measuring the amount a beam of light bends as it passes through the fluid.
- Some coolant manufacturers use other types of glycols in their coolant formulations. Propylene glycol is the most common new coolant. However, propylene glycol based coolants do not provide the same freezing protection and corrosion protection and are not recommended.

1. Visually inspect the coolant for contamination. Must be free of engine oil, transmission oil, dirt and/or other materials that can adversely affect the cooling system.
    - If the coolant is **found to be contaminated** after a visual inspection, discard the coolant.
    - If the coolant is **found to be clear of contamination** after a visual inspection the test the coolant concentration.

2. Using a Refractometer (special tool #8286, Refractometer) or equivalent, following the manufacturer's instructions, test the coolant freeze point:
   - If the coolant freeze point **is between** -31B°C and -45B°C (-25B°F and -50B°F), save the coolant for reuse.
   - If the coolant freeze point **is not between** -31B°C and -45B°C (-25B°F and -50B°F), discard the coolant.

COOLING SYSTEM DIAGNOSIS

CONDITION	POSSIBLE CAUSE	CORRECTION
TEMPERATURE GAUGE READS LOW.	1. Diagnostic Trouble Code (DTC) has been set indicating a stuck open engine thermostat.	1. Replace the thermostat, if directed by DTC diagnosis. Refer to **THERMOSTAT, REMOVAL AND INSTALLATION** **THERMOSTAT, REMOVAL AND INSTALLATION**. If a DTC has not been set, the problem may be with the temperature gauge.
B	2. Engine Coolant Temperature (ECT) sensor.	2. Check connector and wiring to and from the ECT sensor. Repair as necessary.
B	3. Inoperative temperature gauge.	3. Check gauge operation. Refer to **DESCRIPTION AND OPERATION** .
B	4. Coolant level low during cold ambient temperature, accompanied by poor heater performance.	4. Check coolant level in the pressurized coolant bottle. Inspect the system for leaks. Refer to **COOLING SYSTEM LEAKS** . Repair as necessary. Refer to WARNINGS in this information before removing the pressure cap.
TEMPERATURE GAUGE READS HIGH OR ENGINE COOLANT WARNING LAMP ILLUMINATES. COOLANT MAY OR MAY NOT BE LOST FROM SYSTEM.	1. Trailer being towed, a steep hill being climbed, vehicle being operated in slow moving traffic, or engine idling during high ambient (outside) temperatures with air conditioning on. High	1. This may be a temporary condition and repair is not necessary. Turn off the air conditioning and drive the vehicle without any of the previous conditions. Observe the temperature gauge. The gauge should return to

CONDITION	POSSIBLE CAUSE	CORRECTION
	altitudes could also cause these conditions.	the normal range. If the gauge does not return to the normal range, determine the cause of the overheating and repair.
B	2. Inoperative temperature gauge.	2. Check gauge operation. Refer to **DESCRIPTION AND OPERATION** .
B	3. Is temperature warning lamp (if equipped) illuminating unnecessarily?	3. Check warning lamp operation. Refer to **DESCRIPTION AND OPERATION** .
B	4. Coolant level low in pressurized coolant bottle?	4. Check for coolant leaks and repair as necessary. Refer to **COOLING SYSTEM LEAKS** .
B	5. Pressure cap not installed tightly. If cap is loose, boiling point of coolant will be lowered. Also refer to the following step 6.	5. Tighten cap.
B	6. Poor seals at pressure cap.	6. (a) Check condition of cap and cap seals. Refer to the appropriate information . Replace cap if necessary.
B	B	(b) Check condition of filler neck. If neck is warped or damaged, replace the pressurized coolant bottle. Refer to **BOTTLE, PRESSURIZED COOLANT, REMOVAL AND INSTALLATION**.
B	7. Freeze point of coolant not correct. Mixture ratio may be too rich.	7. Check coolant concentration. Refer to **COOLANT CONCENTRATION TESTING** . Adjust the glycol ratio as required.
B	8. Coolant not flowing through system.	8. Check for coolant flow in the pressurized coolant bottle with some coolant removed, engine warm, and thermostat open. Coolant should be observed flowing into the bottle. If flow is not observed, determine the reason for lack of flow and repair as necessary.
B	9. Radiator air seals missing or improperly installed.	9. Inspect air seals. Correct as necessary.
B	10. Radiator or A/C condenser fins are dirty or clogged.	10. Clean obstruction from fins.
B	11. Radiator core is plugged or corroded.	11. Clean or replace the radiator. Refer to **RADIATOR, REMOVAL AND INSTALLATION**.
B	12. Fuel or ignition system problems.	12. Refer to appropriate Powertrain Diagnostic Procedures. Repair as necessary.
B	13. Dragging Brakes.	13. Inspect the brake system and repair as necessary. Refer to **DIAGNOSIS AND TESTING** .

CONDITION	POSSIBLE CAUSE	CORRECTION
B	14. Bug screen or other aftermarket accessory is being used causing reduced air flow.	14. Remove bug screen or accessory.
B	15. Thermostat partially or completely closed.	15. Check thermostat operation and replace as necessary. Refer to **THERMOSTAT, REMOVAL AND INSTALLATION**.
B	16. Cooling fan not operating properly.	16. Check electric fan operation and repair as necessary.
B	17. Cylinder head gasket leaking.	17. Check cylinder head gasket for leaks. Refer to **CYLINDER HEAD** .
B	18. Heater core leaking.	18. Check heater core for leaks.
TEMPERATURE GAUGE READING IS INCONSISTENT (FLUCTUATES, CYCLES OR IS ERRATIC).	1. The gauge may cycle up and down. This is due to the cycling of the electric radiator fan.	1. A normal condition. No correction is necessary. If gauge cycling is the hot zone, check electric fan operation and repair as necessary.
B	2. During cold weather operation with the heater blower in the high position, the gauge reading may drop slightly.	2. A normal condition. No correction is necessary.
B	3. Temperature gauge or Engine Coolant Temperature (ECT) sensor is defective or shorted.	3. Check gauge operation. Refer to **DESCRIPTION AND OPERATION** .
B	4. Gauge reading rises when vehicle is brought to a stop after heavy use (engine still running).	4. A normal condition. No correction is necessary. The gauge should return to normal range after vehicle is driven.
B	5. Gauge reading high after restarting a warmed-up (hot) engine.	5. A normal condition. No correction is necessary. The gauge should return to normal range after a few minutes of engine operation.
B	6. Coolant level low in radiator (air will build up in the cooling system causing the thermostat to open late).	6. Check and correct coolant leaks. Refer to **COOLING SYSTEM LEAKS** .
B	7. Cylinder head gasket leaking allowing exhaust gas to enter cooling system. This will cause thermostat to open late.	7. (a) Check for cylinder head gasket leaks. Refer to **CYLINDER HEAD** . Repair as necessary.
B		(b) Check for coolant in the engine oil. Inspect for white steam emitting from exhaust system. Repair as necessary.
B	8. Water pump impeller loose on shaft.	8. Check water pump and replace as necessary. Refer to **PUMP, WATER, REMOVAL AND INSTALLATION**.
B	9. Air leak on the suction side of water pump allows air to build up in cooling system. This will cause the thermostat to open late.	9. Locate leak and repair as necessary.

CONDITION	POSSIBLE CAUSE	CORRECTION
PRESSURE CAP IS BLOWING OFF STEAM AND/OR COOLANT FLOWING INTO PRESSURIZED COOLANT BOTTLE. TEMPERATURE GAUGE READING MAY BE ABOVE NORMAL, BUT NOT HIGH. COOLANT LEVEL MAY BE HIGH IN THE BOTTLE.	1. Pressure relief valve in pressure cap is defective.	1. Check condition of pressure cap and seals. Refer to the appropriate information . Replace as necessary.
COOLANT LOSS TO THE GROUND WITHOUT PRESSURE CAP BLOWOFF. GAUGE IS READING HIGH OR HOT.	1. Coolant leaks in radiator, cooling system hoses, water pump or engine.	1. Pressure test cooling system and repair as necessary. Refer to the appropriate information .
DETONATION OR PRE-IGNITION (NOT CAUSED BY IGNITION SYSTEM). GAUGE MAY OR MAY NOT BE READING HIGH.	1. Engine overheating.	1. Check reason for overheating and repair as necessary.
B	2. Freeze point of coolant not correct.	2. Check the freeze point of the coolant. Refer to the appropriate information . Adjust the glycol ratio as required.
HOSE OR HOSES COLLAPSE WHEN ENGINE IS COOLING.	1. Vacuum created in cooling system on engine cool-down is not being relieved through the pressure cap relief valve.	1. (a) Pressure cap relief valve stuck. Refer to the appropriate information . Replace as necessary.
B	B	(b) Vent in pressure cap is plugged. Clean vent and repair as necessary.
B	B	(c) Pressurized coolant bottle is internally blocked or plugged. Check for blockage and repair as necessary.
RADIATOR FAN OPERATES ALL THE TIME.	1. Malfunctioning electrical component or circuit.	1. Refer to appropriate Powertrain Diagnostic Procedures. Repair as necessary.
	2. Check for low coolant level.	2. Repair as necessary.
RADIATOR FAN WILL NOT OPERATE, GAUGE READING HIGH OR HOT.	1. Fan motor defective.	1. Refer to appropriate Powertrain Diagnostic Procedures manual for operation of the scan tool. Repair as necessary.
B	2. Fan control circuit, Powertrain Control Module (PCM) or engine coolant temperature sensor defective.	2. Refer to appropriate Powertrain Diagnostic Procedures manual for operation of the scan tool. Repair as necessary.
B	3. Blown fuse in Power Distribution Center (PDC).	3. Determine cause for blown fuse and repair as necessary.
NOISY FAN.	1. Fan blade loose.	1. Replace the engine cooling fan assembly. Refer to **FAN, COOLING, REMOVAL AND INSTALLATION** **FAN, COOLING, REMOVAL AND INSTALLATION**.
B	2. Fan blade striking a surrounding object.	2. Locate point of fan blade contact and repair as necessary.
B	3. Air obstructions at radiator or A/C condenser.	3. Remove obstructions and/or clean debris from radiator and/or

CONDITION	POSSIBLE CAUSE	CORRECTION
		A/C condenser.
B	4. Electric fan motor defective.	4. Replace the engine cooling fan assembly. Refer to **FAN, COOLING, REMOVAL AND INSTALLATION**.
INADEQUATE AIR CONDITIONER PERFORMANCE (COOLING SYSTEM SUSPECTED).	1. Electric radiator fan not operating when A/C is on.	1. Refer to appropriate Powertrain Diagnostic Procedures manual for operation of the scan tool. Repair as necessary.
B	2. Radiator and/or air conditioning condenser is restricted, obstructed or dirty.	2. Remove restriction and/or clean as necessary.
B	3. Radiator air seals missing or improperly installed.	3. Inspect air seals. Repair as necessary.
B	4. Engine is overheating (heat may be transferred from radiator to A/C condenser). High under hood temperature due to engine overheating may also transfer heat to A/C components.	4. Correct overheating condition. Refer to this information.
INADEQUATE HEATER PERFORMANCE.	1. Has a Diagnostic Trouble Code (DTC) been set?	1. Refer to Powertrain Diagnostic Procedures.
B	2. Coolant level low.	2. Check cooling system for leaks. Refer to **COOLING SYSTEM LEAKS** . Repair as necessary.
B	3. Obstructions in heater hose fittings at engine.	3. Remove heater hoses at both ends and check for obstructions. Repair as necessary.
B	4. Heater hose kinked.	4. Locate kinked area and repair as necessary.
B	5. Water pump is not pumping coolant through the heater core. When the engine is fully warmed up, both heater hoses should be hot to the touch.	5. Check accessory drive belt operation. Repair as necessary.
HEAT ODOR.	1. Various heat shields are used at certain components. One or more of these shields may be missing.	1. Locate missing shields and replace or repair as necessary.
B	2. Is temperature gauge reading above the normal range?	2. Check gauge operation. Refer to **DESCRIPTION AND OPERATION** .
B	3. Is cooling fan operating correctly?	3. Repair as necessary.
B	4. Has undercoating been applied to any unnecessary component.	4. Clean undercoating as necessary.
B	5. Engine may be running rich causing the catalytic converter to overheat.	5. Refer to appropriate Powertrain Diagnostic Procedures manual for operation of the scan tool. Repair as necessary.
POOR DRIVEABILITY (THERMOSTAT POSSIBLY STUCK	1. Has a DTC been set?	1. Refer to the Powertrain Diagnostic Procedure manual for

CONDITION	POSSIBLE CAUSE	CORRECTION
OPEN). GAUGE MAY BE READING LOW.		checking a DTC related to the thermostat.
STEAM IS COMING FROM FRONT OF VEHICLE NEAR GRILLE AREA WHEN WEATHER IS WET, ENGINE IS WARMED UP, RUNNING, AND VEHICLE IS STATIONARY. TEMPERATURE GAUGE IS IN NORMAL RANGE.	1. During wet weather, moisture (snow, ice or rain condensation) on the radiator will evaporate when the thermostat opens. This opening allows heated water into the radiator. When the moisture contacts the hot radiator, steam may be emitted. This usually occurs in cold weather with no fan or airflow to blow it away.	1. Occasional steam emitting from this area is normal. No repair is necessary.
COOLANT COLOR.	1. Coolant color is not necessarily an indication of adequate corrosion or temperature protection. Do not rely on coolant color for determining condition of coolant.	1. Check the freeze point of the coolant. Refer to the appropriate information . Adjust the glycol ratio as required.
COOLANT LEVEL CHANGES IN COOLANT RECOVERY/RESERVE BOTTLE.	1. Level changes are to be expected as coolant volume fluctuates with engine temperature. If the level in the bottle was between the FULL HOT and ADD marks at normal engine operating temperature, the level should return to within that range after operation at elevated temperatures.	1. A normal condition. No repair is necessary.

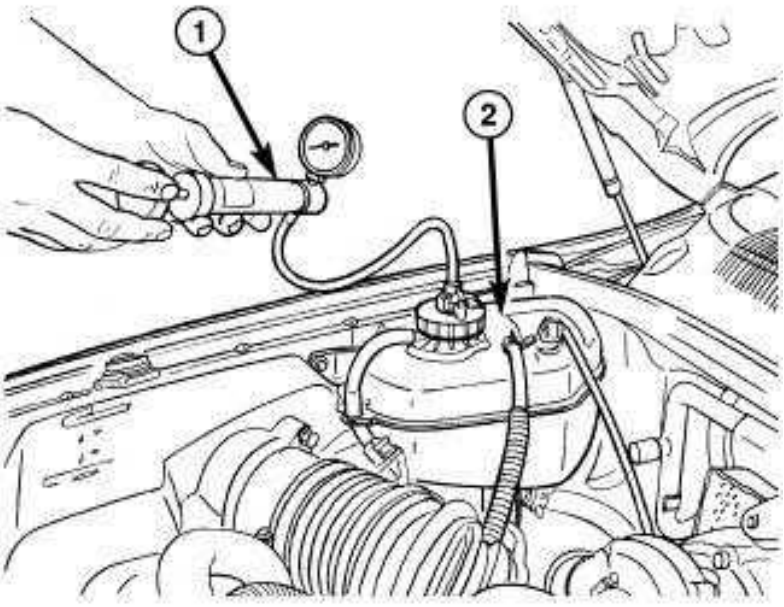
COOLING SYSTEM LEAKS

ULTRAVIOLET LIGHT METHOD

A leak detection additive is available through the parts department that can be added to the engine cooling system. The additive is highly visible under ultraviolet light (black light). Pour one ounce of additive into the engine cooling system. Place the heater control unit in HEAT position. Start and operate the engine until the radiator upper hose is warm to the touch. Aim the commercially available black light at the components to be checked. If leaks are present, the black light will cause the additive to glow a bright green color.

The black light can be used in conjunction with a pressure tester to determine if any external leaks exist.

PRESSURE TESTER METHOD



WARNING: **Hot, pressurized coolant can cause injury by scalding.**

The cooling system being tested should be at normal operating temperature. Recheck the cooling system cold if coolant loss is not located during the warm system examination.

Make sure the system is not under pressure and carefully examine the pressure cap and the cap sealing surface for nicks, crack, paint, dirt and residue.

Inspect the outside of the filler neck. If damaged, seating of the pressure cap valve and tester seal could be affected.

Attach the SVT275 Cooling Pressure Tester (1) available from MoparB® Service Equipment, or an equivalent to the pressurized coolant bottle (2).

Note the maximum pressure specification on the pressure cap.

Operate tester pump to apply pressure to system. Do not exceed the maximum pressure specification on the pressure cap. If hoses enlarge excessively or bulges while testing, replace as necessary.

Observe gauge pointer and determine condition of cooling system according to following criteria:

Holds Steady: If pointer remains steady for two minutes, serious coolant leaks are not present in system. However, there could be an internal engine leak that does not appear with normal system test pressure. If it is certain that engine coolant is being lost and leaks cannot be detected, inspect for internal engine leakage or perform the Internal Engine Leakage Test. Refer to the appropriate information .

Drops Slowly: Indicates a small leak or seepage is occurring. Examine all connections for seepage or slight leakage with a black light or a flashlight. Inspect radiator, hoses, gasket edges and components.

Drops Quickly: Indicates that serious leakage is occurring. Examine system for external leakage. If leaks are not visible, inspect for internal engine leakage and internal transmission heater leaks are possible.

INTERNAL ENGINE LEAKAGE INSPECTION

One method is to operate the engine for a short period to churn the oil and the remove the engine dipstick, and inspect for water globules on the stick. Depending on the results, it may be necessary to remove the engine oil pan drain plug and drain a small amount of engine oil. If coolant is present in the pan, it will drain first because it is heavier than oil.

WARNING: **With radiator pressure tester tool installed on radiator, do not allow pressure to exceed 145 kpa (21 psi). Pressure will build up quickly if a combustion leak is present. To release pressure, rock tester from side to side. When removing tester, do not turn tester more than 1/2 turn if system is under pressure.**

Operate the engine without the pressure cap on the engine pressurized coolant bottle until the thermostat opens. Attach a Pressure Tester to the filler neck. If pressure builds up quickly, it may indicate a combustion leak exists. This is usually the result of a cylinder head gasket leak or a crack in the engine, or a leaking engine oil cooler. Repair as necessary.

If there is not an immediate pressure increase, pump the Pressure Tester until indicated pressure is within the system range of 110 kPa (16 psi). Fluctuation of the gauge pointer indicates compression or combustion leakage into the engine cooling system.

Because the vehicle is equipped with a catalytic converter, **do not** short out cylinders to isolate the compression leak.

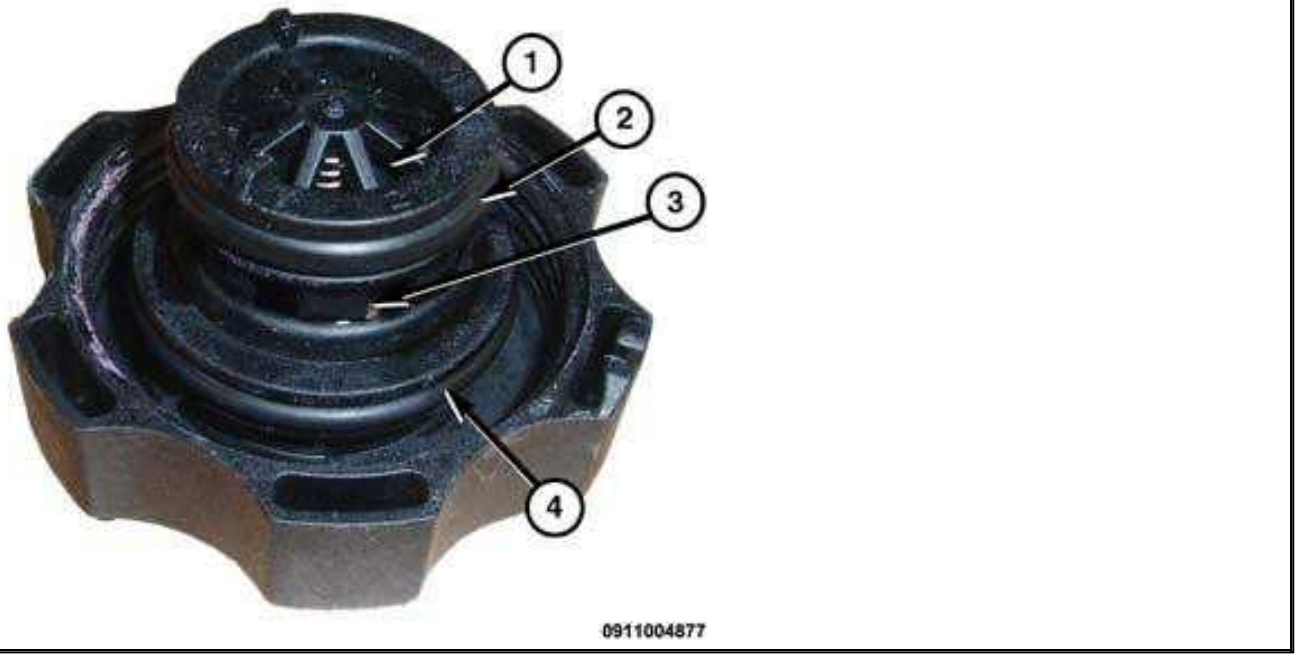
If the needle on the dial of the pressure tester does not fluctuate, increase the engine RPM's a few times to check for an abnormal amount of coolant or steam. This would be emitted from the exhaust pipe. Coolant or steam from the exhaust pipe may indicate a faulty cylinder head gasket, cracked engine cylinder head or cylinder block.

TRANSMISSION HEATER LEAKAGE INSPECTION

1. If the engine is overheating and the transmission is shifting harshly from reverse to forward.
    1. Inspect the coolant in the pressurized coolant bottle and try to determine the type contamination, is the contamination transmission oil or engine oil?
    2. If transmission oil contamination is suspected then remove the transmission fill plug from the right rear of the transmission case and obtain a sample of the transmission fluid.
    3. Is the transmission fluid normal in color or is it milky in color?
    4. If the transmission fluid is milky in color then their is a very good chance the transmission heater has an internal leak.

RADIATOR CAP INSPECTION AND TESTING

- The vent valve in the cap should normally be closed by the main spring.
- If the O-ring seal is damaged, replace the cap.
- A replacement cap must be the type designed for use on a pressurized coolant bottle.



1 - Vent Valve
2 - O-Ring
3 - Main Spring
4 - O-Ring

CAUTION: **Radiator pressure testing tools are very sensitive to small air leaks which will not cause cooling system problems. A pressure cap that does not have a history of coolant loss should not be replaced just because it leaks slowly when tested with this tool. Add water to tool. Turn tool upside down and recheck pressure cap to confirm that cap needs replacement.**

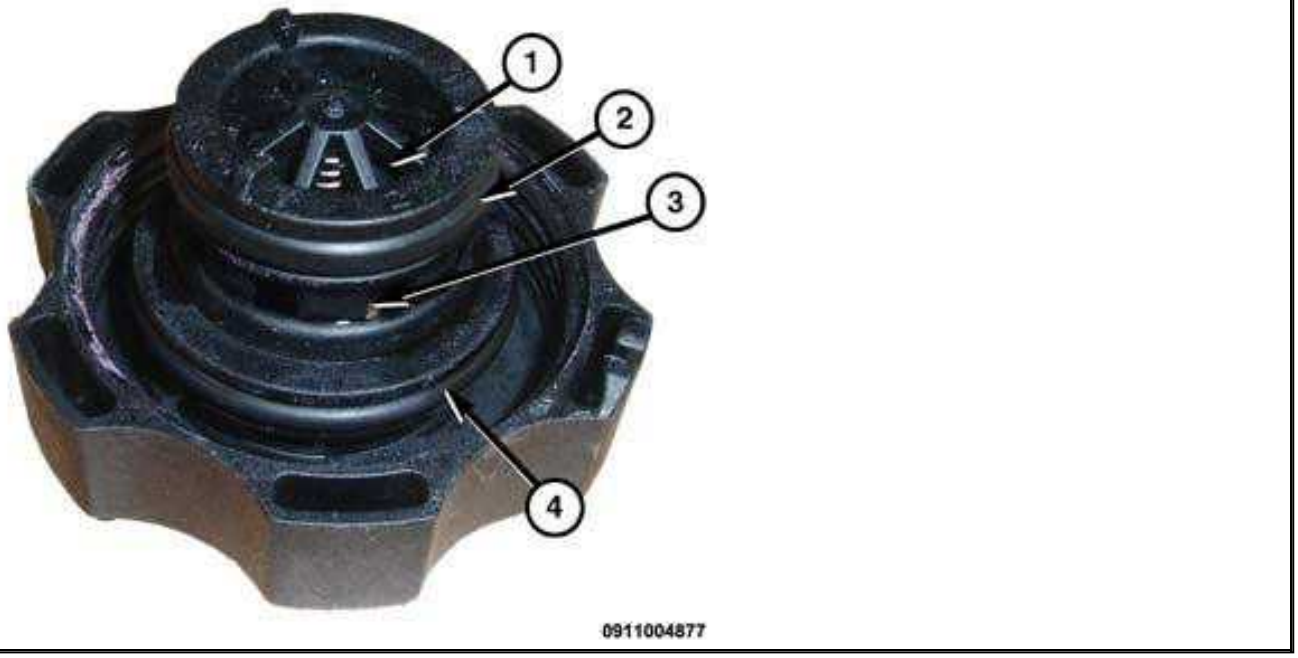
Remove the cap. Be sure that the sealing surfaces are clean. Moisten the rubber gasket with water and install the cap on a commercially available pressure tester.

Using the cooling system tester, bring the pressure up to the pressure inscribed on cap. For example if the radiator cap shows 21 psi and the applied pressure to the radiator cap fails to hold up to 21 psi, replace the cap.

NOTE: **If the cap is designed to hold up to 21 psi (inscribed on the cap) and during the test, the pressure rapidly bleeds off prior to 21 psi, the radiator cap has failed.**

The pressure cap may test properly while positioned on the pressure test tool. It may not hold pressure or vacuum when installed on the pressurized coolant bottle. If the test passes on the tool but there is sufficient evidence that the cap fails on the bottle, inspect the coolant bottle neck for damage or debris that may prevent the cap from sealing properly.

RADIATOR CAP INSPECTION



1 - Vent Valve
2 - Lower O-Ring Seal
3 - Main Spring
4 - Upper O-Ring Seal

The vent valve in the cap is normally closed.

If the O-ring seal is damaged, replace the cap.

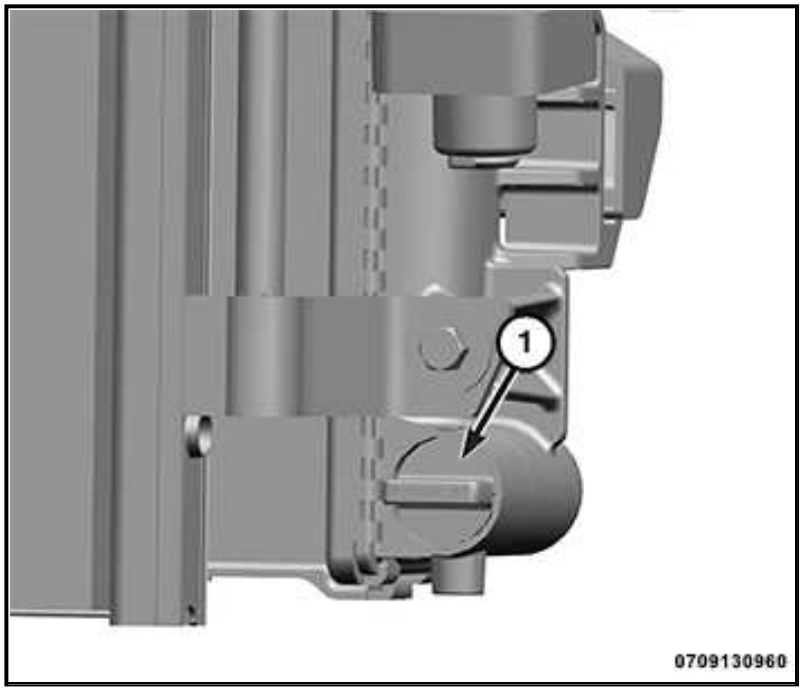
A replacement cap must be the type designed for use on a pressurized coolant bottle.

STANDARD PROCEDURE

DRAINING

WARNING: **Do not remove or loosen the coolant pressure cap, cylinder block drain plugs, or the draincock when the system is hot and under pressure because serious burns from the coolant can occur.**

1. Remove the front air dam. Refer to **AIR DAM, FRONT, REMOVAL AND INSTALLATION** .



1 - Draincock

NOTE: **The draincock is located on the front of the radiator, on the lower left side.**

2. **Verify the system is not pressurized** and open the draincock.
3. If equipped and necessary, remove the cylinder block drain plug(s).

STANDARD PROCEDURE - FILLING

WARNING: **ANTIFREEZE COOLANT IS HARMFUL IF SWALLOWED OR INHALED. IF SWALLOWED, DRINK TWO GLASSES OF WATER AND INDUCE VOMITING. IF INHALED, MOVE TO FRESH AIR AREA. SEEK MEDICAL ATTENTION IMMEDIATELY. DO NOT STORE IN OPEN OR UNMARKED CONTAINERS. WASH SKIN AND CLOTHING THOROUGHLY AFTER COMING IN CONTACT WITH ETHYLENE GLYCOL. KEEP OUT OF REACH OF CHILDREN. DISPOSE OF GLYCOL BASED COOLANT PROPERLY. CONTACT YOUR DEALER OR GOVERNMENT AGENCY FOR LOCATION OF COLLECTION CENTER IN YOUR AREA. DO NOT OPEN A COOLING SYSTEM WHEN THE ENGINE IS AT OPERATING TEMPERATURE OR HOT UNDER PRESSURE; PERSONAL INJURY CAN RESULT. AVOID RADIATOR COOLING FAN AND OTHER MOVING COMPONENTS WHEN ENGINE COMPARTMENT RELATED SERVICE IS PERFORMED; PERSONAL INJURY CAN RESULT.**

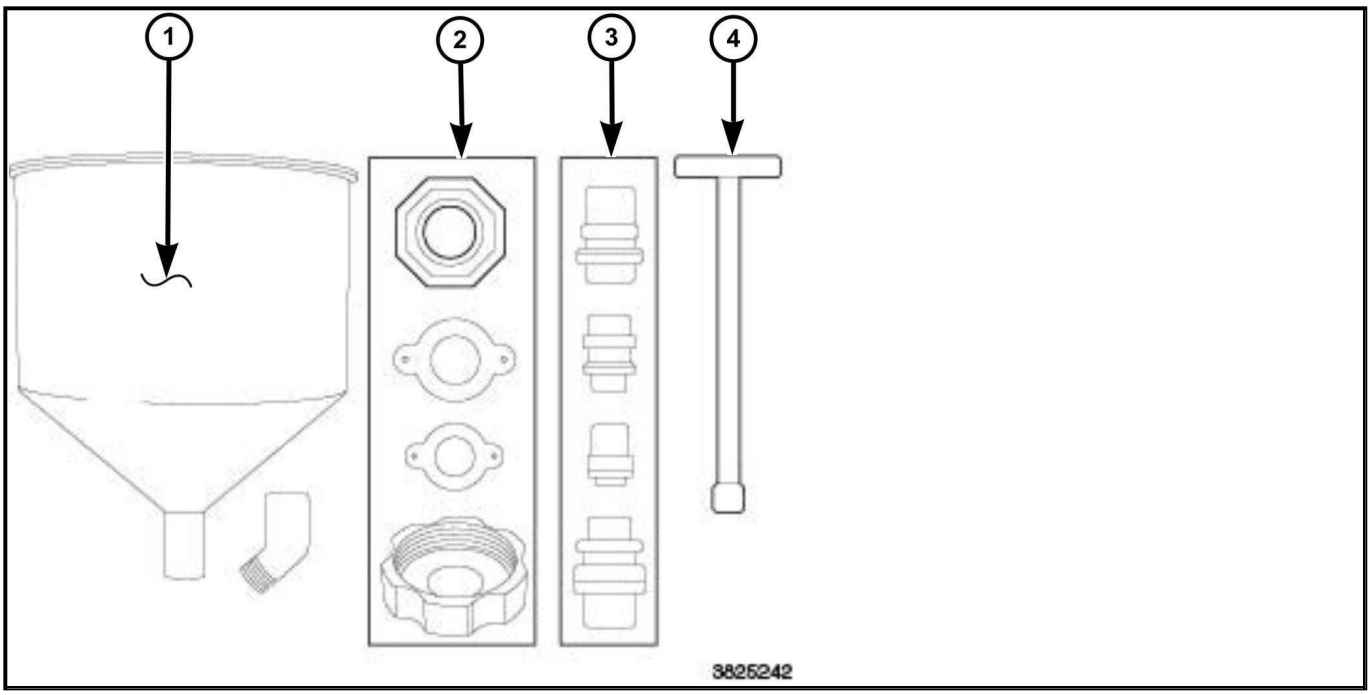
WARNING: **WEAR APPROPRIATE EYE AND HAND PROTECTION WHEN PERFORMING THIS PROCEDURE.**

CAUTION: **Do not use well water or suspect water supply in cooling system. A 50/50 mixture of the recommended antifreeze coolant and distilled water is recommended.**

NOTE: **Cooling system fill procedure is critical to overall cooling system performance.**

NOTE: **Make sure all hoses are connected and radiator draincock is closed. Draincock should be hand tightened only.**

COOLANT FILL



1. Install coolant fill funnel (1) (special tool #8195A, Funnel).
2. Fill the pressurized coolant bottle to the recommended level.
3. Start the engine and allow the engine to warm up at idle for roughly 10 minutes.
4. Top the coolant off if required.
5. Increase the engine speed slightly until the thermostat opens and verify the fan is operating.
6. Top the coolant level if required.
7. Allow the engine to idle for several minutes.
8. Shut the engine off.

NOTE: **The use of a external fan can be used to help aid in the cooling of the engine.**

9. Allow the engine to cool down enough for the thermostat to close.
10. Top the coolant off if required.
11. Restart the engine and increase the engine speed slightly until the thermostat opens.
12. Allow the engine to idle after the thermostat opens.
13. Verify the cooling fan is operational.
14. Check the level of the coolant.
15. Top the coolant off if required.
16. Remove the funnel from the pressurized coolant bottle.
17. Install the radiator cap.
18. Take the vehicle for a test drive.
19. Top the coolant off if required.

COOLANT AIR EVACUATION

WARNING: **ANTIFREEZE IS AN ETHYLENE GLYCOL BASE COOLANT AND IS HARMFUL IF SWALLOWED OR INHALED. IF SWALLOWED, DRINK TWO GLASSES OF WATER AND INDUCE VOMITING. IF INHALED, MOVE TO FRESH AIR AREA. SEEK MEDICAL ATTENTION IMMEDIATELY. DO NOT STORE IN OPEN OR UNMARKED CONTAINERS. WASH SKIN AND CLOTHING THOROUGHLY AFTER COMING IN CONTACT WITH ETHYLENE GLYCOL. KEEP OUT OF REACH OF CHILDREN. DISPOSE OF GLYCOL BASED COOLANT PROPERLY. CONTACT YOUR DEALER OR GOVERNMENT AGENCY FOR LOCATION OF COLLECTION CENTER IN**

YOUR AREA. DO NOT OPEN A COOLING SYSTEM WHEN THE ENGINE IS AT OPERATING TEMPERATURE OR HOT UNDER PRESSURE; PERSONAL INJURY CAN RESULT. AVOID RADIATOR COOLING FAN WHEN ENGINE COMPARTMENT RELATED SERVICE IS PERFORMED; PERSONAL INJURY CAN RESULT.

WARNING: **WEAR APPROPRIATE EYE AND HAND PROTECTION WHEN PERFORMING THIS PROCEDURE.**

CAUTION: **Failure to purge air from the cooling system can result in an overheating condition and severe engine damage.**

NOTE: **The preferred way to remove air from the cooling system is to use the Mopar Essential Tools and Service Equipment (special tool #399-550000, Tool, UView Airlift™ Cooling System Refill) or equivalent.**

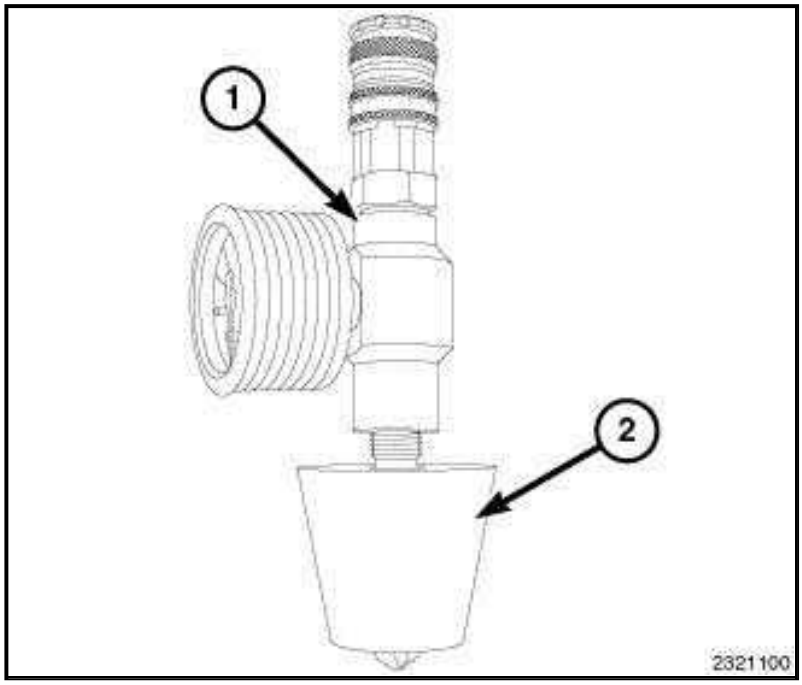
Evacuating or purging air from the cooling system involves the use of a pressurized air operated vacuum generator. The vacuum created allows for a quick and complete coolant refilling while minimizing the possibility of creating airlocks in the system components.

NOTE: **To avoid damage to the cooling system, ensure that no component would be susceptible to damage when a vacuum is drawn on the system.**

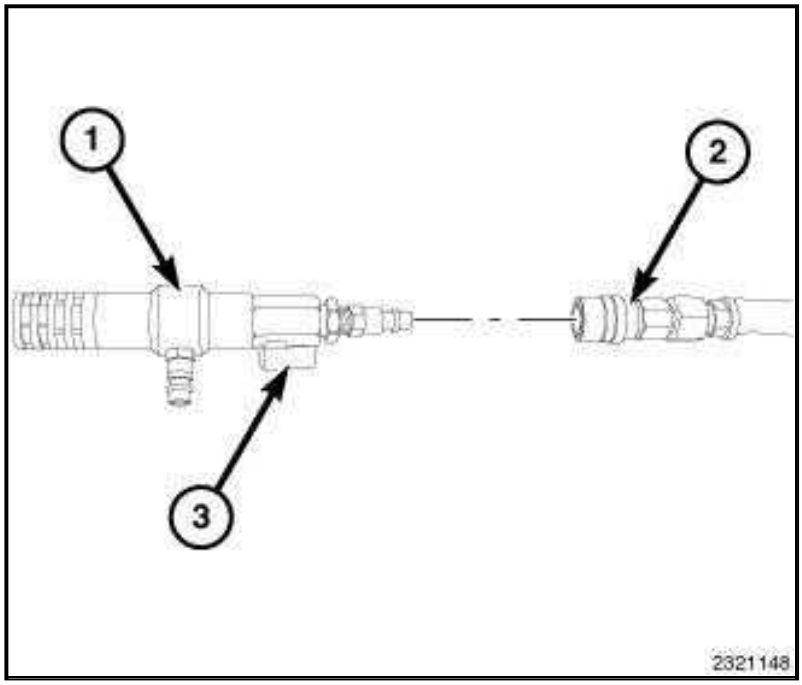
NOTE: **The service area where this procedure is performed should have a minimum shop air availability of 80 PSI (5.5 bar) and should be equipped with an air dryer system.**

NOTE: **For best results, the radiator should be empty. The vehicle's heater control should be set to the heat position (ignition may need to be turned to the on position but do not start the engine).**

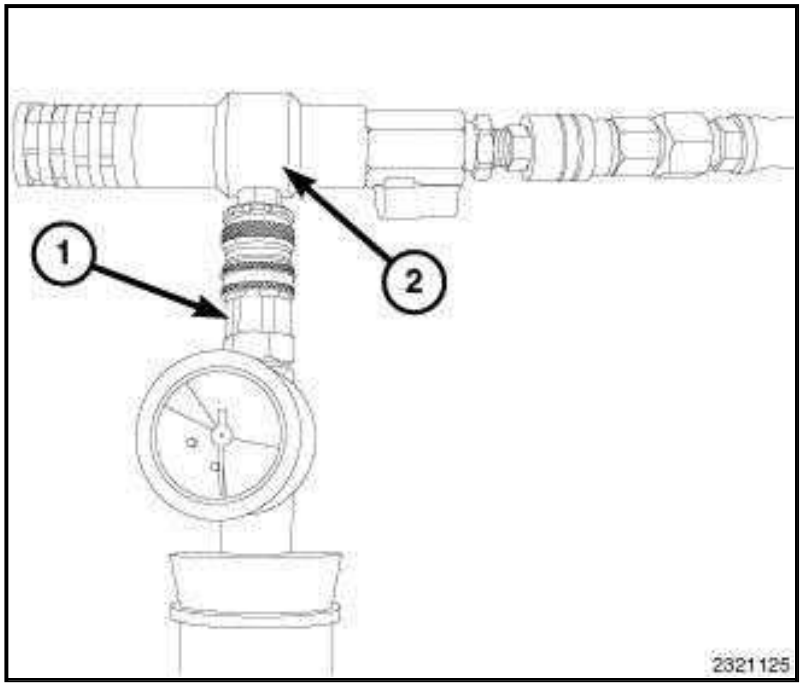
1. Refer to the Mopar Essential Tools and Service Equipment (special tool #399-550000, Tool, UView Airlift™ Cooling System Refill) or equivalent tool's operating manual for specific assembly steps.



2. Choose an appropriate adapter cone (2) that will fit the vehicle's cooling system filler neck.
3. Attach the adapter cone (2) to the vacuum gauge (1).



4. Make sure the vacuum generator/venturi ball valve (3) is closed and attach an airline hose (2) (minimum shop air requirement of 80 PSI/5.5 bar) to the vacuum generator/venturi (1).



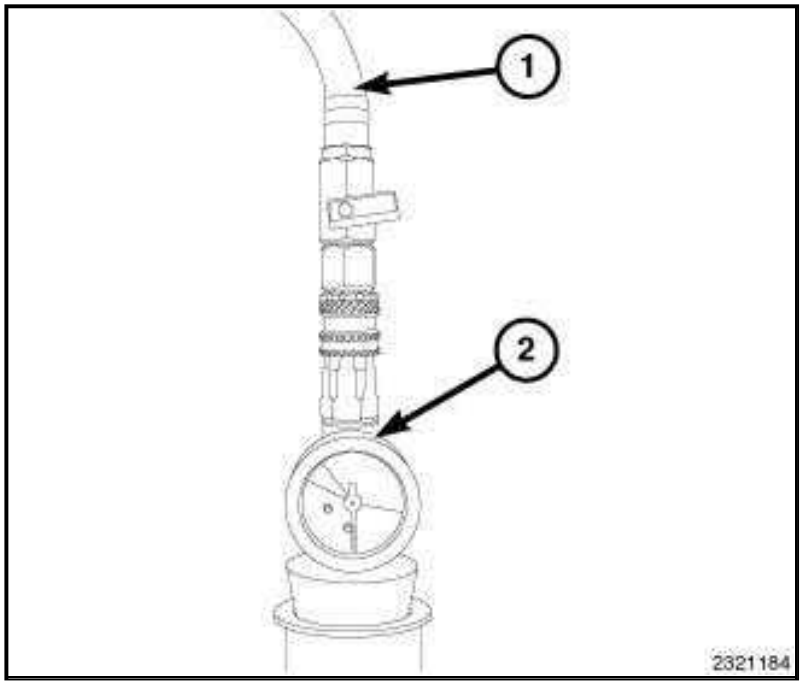
5. Position the adaptor cone/vacuum gauge assembly (1) into the filler neck. Confirm that the adapter cone is sealed properly.
6. Connect the vacuum generator/venturi (2) to the positioned adaptor cone/vacuum gauge assembly (1).
7. Open the vacuum generator/venturi ball valve.

NOTE: **Do not bump or move the assembly as it may result in loss of vacuum.**

8. Let the system run until the vacuum gauge shows a good vacuum through the cooling system. Refer to the tool's operating manual for appropriate pressure readings.

NOTE: **If a strong vacuum is being created in the system, it is normal to see the radiator hoses collapse.**

9. Close the vacuum generator/venturi ball valve.



10. Disconnect the vacuum generator/venturi and airline (1) from the adaptor cone/vacuum gauge assembly (2).
11. Wait approximately 20 seconds, if the pressure readings do not move, the system has no leaks. If the pressure readings move, a leak could be present in the system. Check for leaks and repeat the procedure.
12. Place the tool's suction hose into the coolant's container.

NOTE: **Confirm that there is a sufficient amount of coolant mixed to the required strength/protection level available for use. For best results and to assist the refilling procedure, place the coolant container at the same height as the filler neck. Always draw more coolant than required. If the coolant level is too low, it will pull air into the cooling system which could result in airlocks within the system.**

13. Pre-fill the tool suction hose (2) with coolant.
14. Connect the tool's suction hose (2) to the adaptor cone/vacuum gauge assembly (3).
15. Open the suction hose's ball valve to begin filling the cooling system.
16. When the vacuum gauge reads zero, the system is filled.

NOTE: **If filling through a pressurized coolant bottle, stop filling when the proper level is reached.**

17. Close the suction hose's ball valve and remove the suction hose from the adaptor cone/vacuum gauge assembly.
18. Remove the adaptor cone/vacuum gauge assembly from the filler neck.
19. Install the cap on the filler neck.
20. Start and run the engine with the heater control unit in the HEAT position.
21. Look for flow at the coolant bottle return hose inlet.

CAUTION: **If there is no flow present at the coolant bottle return hose inlet, you must repeat the procedure beginning at step 1 or engine damage may occur.**

22. After the engine has reached normal operating temperature, shut the engine off and allow it to cool. When the engine is cooling down, coolant will be drawn into the radiator.
23. Add coolant to the pressurized coolant bottle or reservoir tank as necessary. **Only add coolant to the container when the engine is cold. Coolant level in a warm engine will be higher due to thermal**

expansion. Add necessary coolant to raise container level to the COLD MINIMUM mark after each cool down period.

24. Once the appropriate coolant level is achieved, install the cap on the filler neck.

CLEANING/REVERSE FLUSHING

CLEANING

Drain the cooling system and refill with water. Run the engine with the radiator cap installed until the upper radiator hose is hot. Stop the engine and drain the water from system. If the water is dirty, fill the system with water, run the engine and drain the system. Repeat this procedure until the water drains clean.

REVERSE FLUSHING

Reverse flushing of the cooling system is the forcing of water through the cooling system. This is done using air pressure in the opposite direction of normal coolant flow. It is usually only necessary with very dirty systems with evidence of partial plugging.

REVERSE FLUSHING RADIATOR

Disconnect the radiator hoses from the radiator inlet and outlet. Attach a information of the radiator hose to the radiator bottom outlet fitting and insert the flushing gun. Connect a water supply hose and air supply hose to the flushing gun.

CAUTION: Internal radiator pressure must not exceed 138 kPa (20 psi) as damage to radiator may result.

Allow the radiator to fill with water. When the radiator is filled, apply air in short blasts. Allow the radiator to refill between blasts. Continue this reverse flushing until clean water flows out through the rear of the radiator cooling tube passages.

REVERSE FLUSHING ENGINE

- Drain the cooling system. Remove the thermostat housing and thermostat. Install the thermostat housing. Disconnect the radiator upper hose from the radiator and attach the flushing gun to the hose. Disconnect the radiator lower hose from the water pump and attach a lead-away hose to the water pump inlet fitting.

  CAUTION: On vehicles equipped with a heater water control valve, be sure the heater control valve is closed (heat off). This will prevent coolant flow with scale and other deposits from entering the heater core.

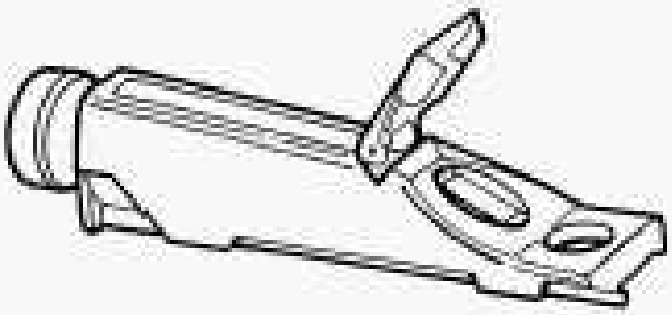
- Connect the water supply hose and air supply hose to flushing gun. Allow the engine to fill with water. When the engine is filled, apply air in short blasts, allowing the system to fill between air blasts. Continue until clean water flows through the lead away hose.
- Remove the lead away hose, flushing gun, water supply hose and air supply hose. Remove the thermostat housing and install the thermostat. Install the thermostat housing with a replacement gasket. Refer to Thermostat Replacement. Connect the radiator hoses. Refill the cooling system with the correct antifreeze/water mixture. Refer to Refilling the Cooling System.

CHEMICAL CLEANING

In some instances, use a radiator cleaner (MoparB® Radiator Kleen or equivalent) before flushing. This will soften scale and other deposits and aid flushing operation.

CAUTION: Follow manufacturers instructions when using these products.

SPECIAL TOOLS

	8286 - Refractometer
	8875A - Disconnect, Transmission Cooler Line (Originally Shipped In Kit Number(s) 9202, 9328, 9328-CAN, 9329, 9516, 9575.)

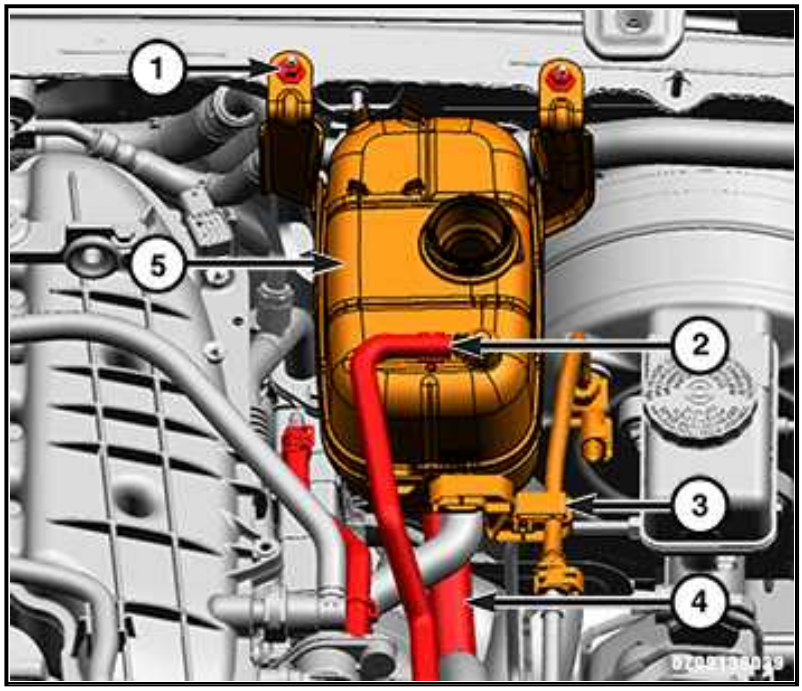
BOTTLE, PRESSURIZED COOLANT

REMOVAL AND INSTALLATION

COOLANT BOTTLE

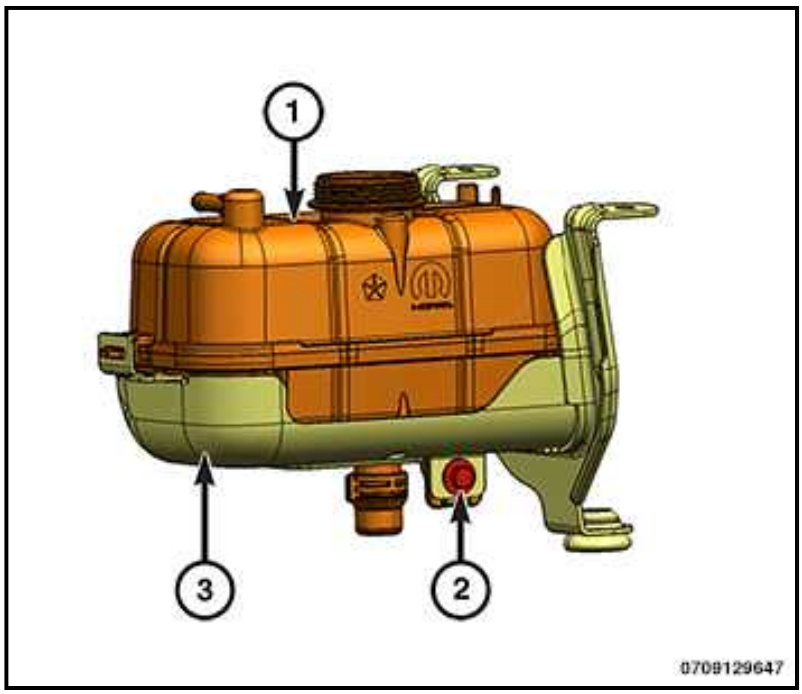
REMOVAL

1. Drain the Engine Cooling System. Refer to **DRAINING** .



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

2. Disconnect the coolant vent hose from the pressurized coolant bottle.
3. Remove the vacuum hose retainer from the pressurized coolant bottle.
4. Remove the nuts and lift the pressurized coolant bottle up to gain access to the lower coolant hose.
5. Disconnect the lower coolant hose and remove the pressurized coolant bottle.



1 - Pressurized Coolant Bottle
2 - Bolt
3 - Bracket

6. If necessary, remove the bolt and the pressurized coolant bottle from the bracket.

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.

- Connect the lower coolant hose to the bottle first and then install the pressurized coolant bottle.
- Fill and leak check the engine coolant system. Refer to **STANDARD PROCEDURE - FILLING** .

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	**Torque Procedure:** **NOTE:** **Bolts (1 - 8) are M6; Bolts (9, 10, 11) are M8; Bolt (12) is M10.** 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

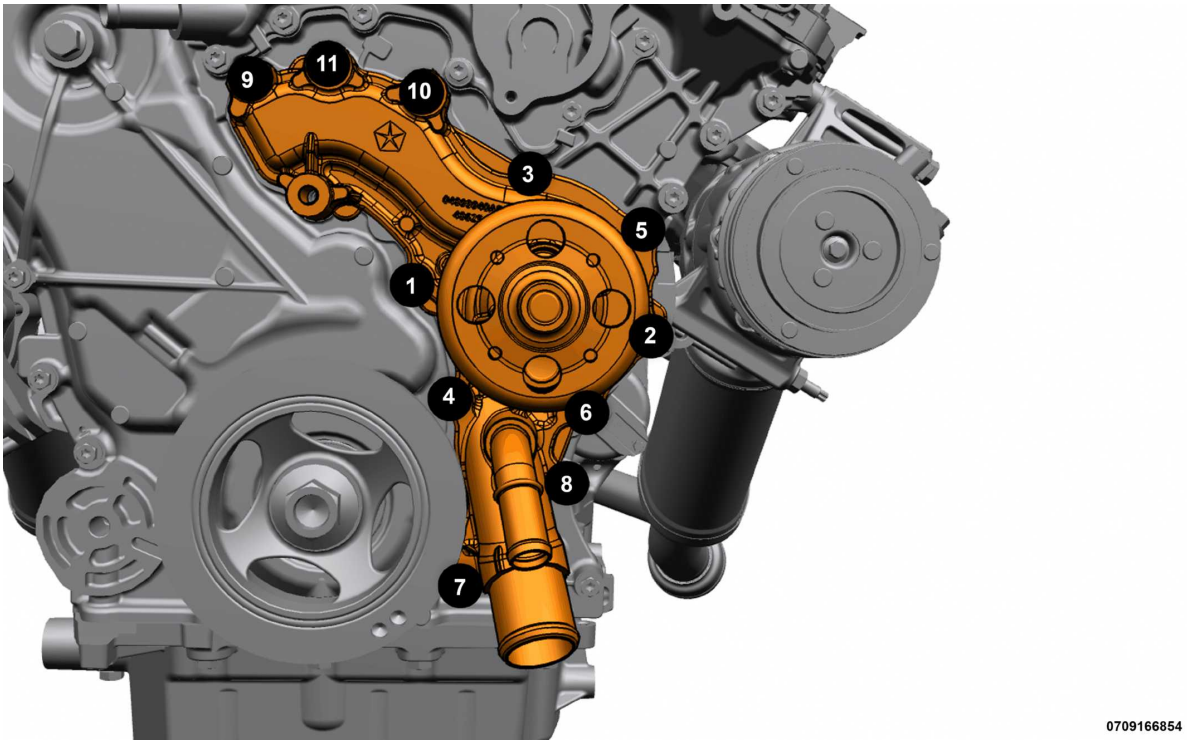


Fig. 29: Water Pump Bolts Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

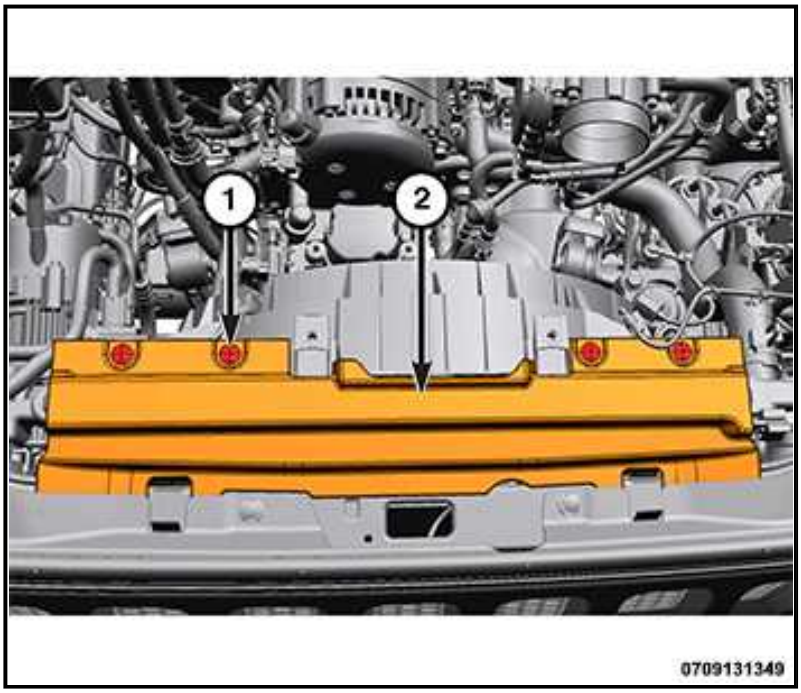
FAN, COOLING

REMOVAL AND INSTALLATION

REMOVAL AND INSTALLATION

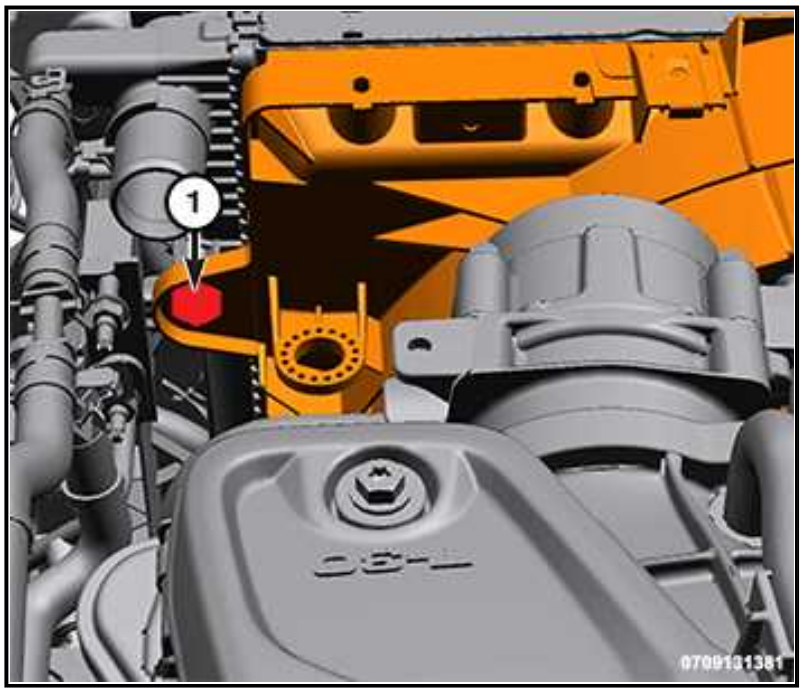
REMOVAL

1. Remove the air cleaner resonator. Refer to **RESONATOR, AIR CLEANER, REMOVAL AND INSTALLATION**.
2. Remove the air cleaner body. Refer to **BODY, AIR CLEANER, REMOVAL AND INSTALLATION**.



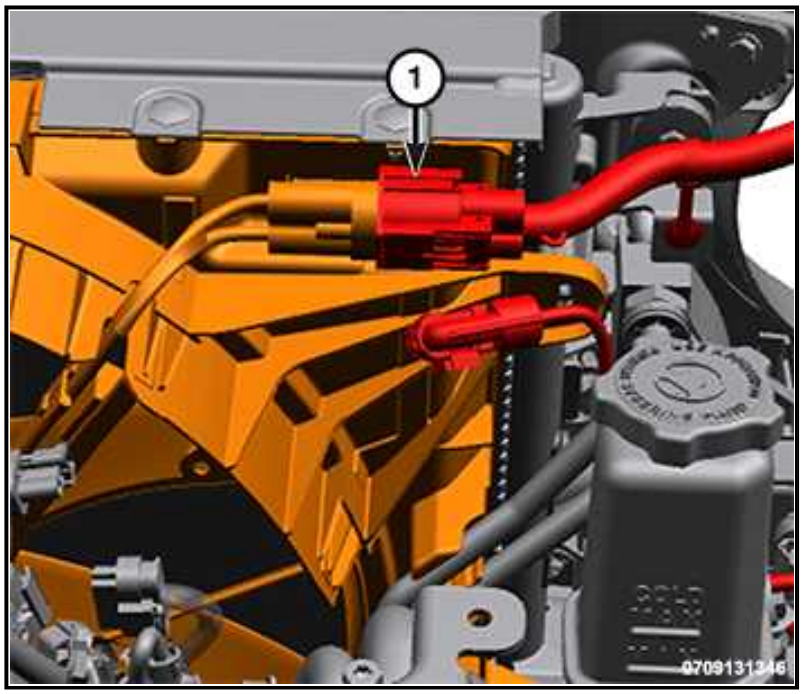
1 - Push Pins
2 - Upper Air Deflector

3. Remove the push pin retainers and the upper air deflector.



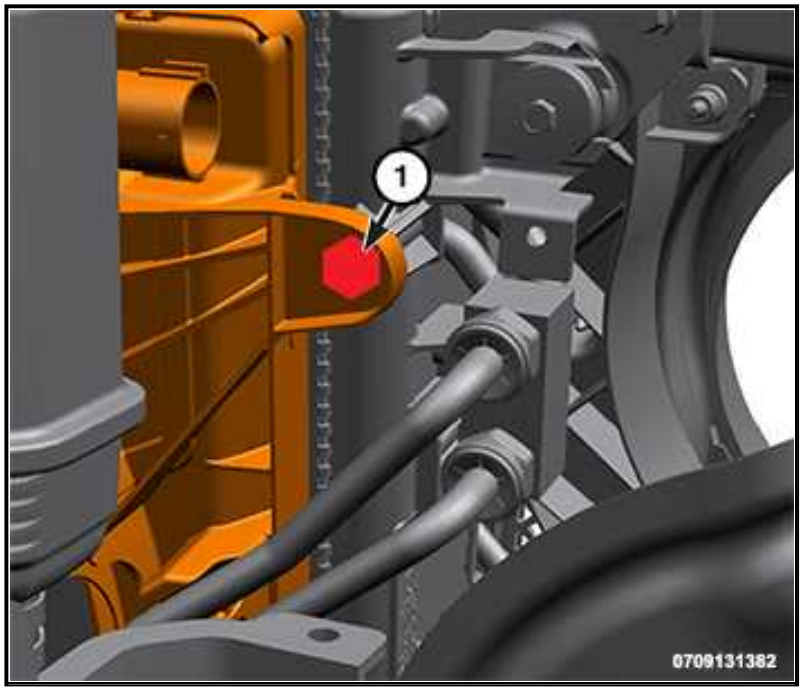
1 - Left Upper Cooling Fan Mounting Bolt

4. Remove the left upper cooling fan mounting bolt.



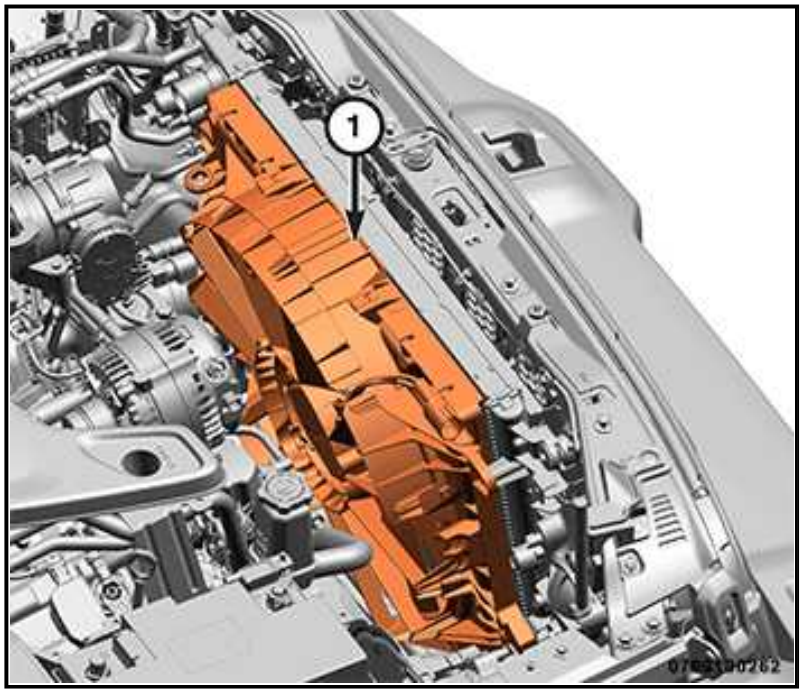
1 - Wire Harness Connector

5. Disconnect the cooling fan wire harness connector.



1 - Right Upper Cooling Fan Mounting Bolt

6. Remove the right upper cooling fan mounting bolt.



1 - Cooling Fan Assembly

7. Remove the cooling fan assembly by pulling upwards and away from the radiator.

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 necessary, transfer any grommets or fasteners to the **NEW** cooling fan assembly.

TORQUE SPECIFICATIONS

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.)**	-
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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	**Torque Procedure:** **NOTE:** **Bolts (1 - 8) are M6; Bolts (9, 10, 11) are M8; Bolt (12) is M10.** 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

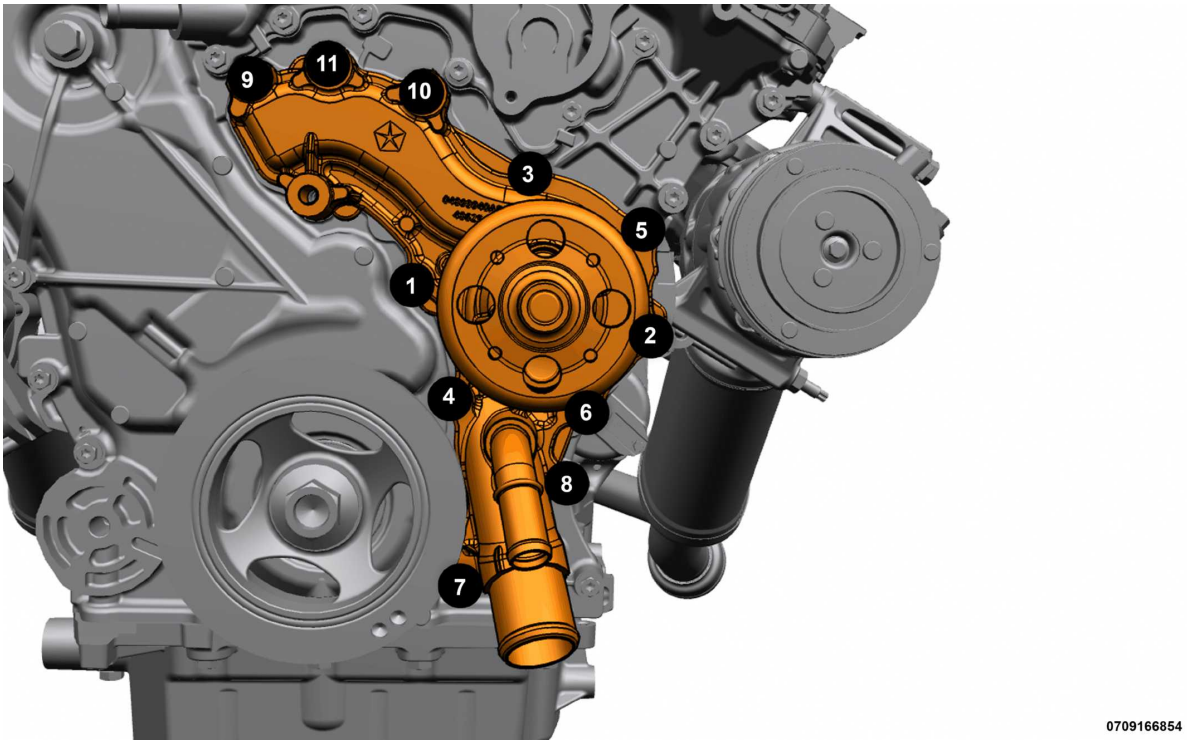


Fig. 30: Water Pump Bolts Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

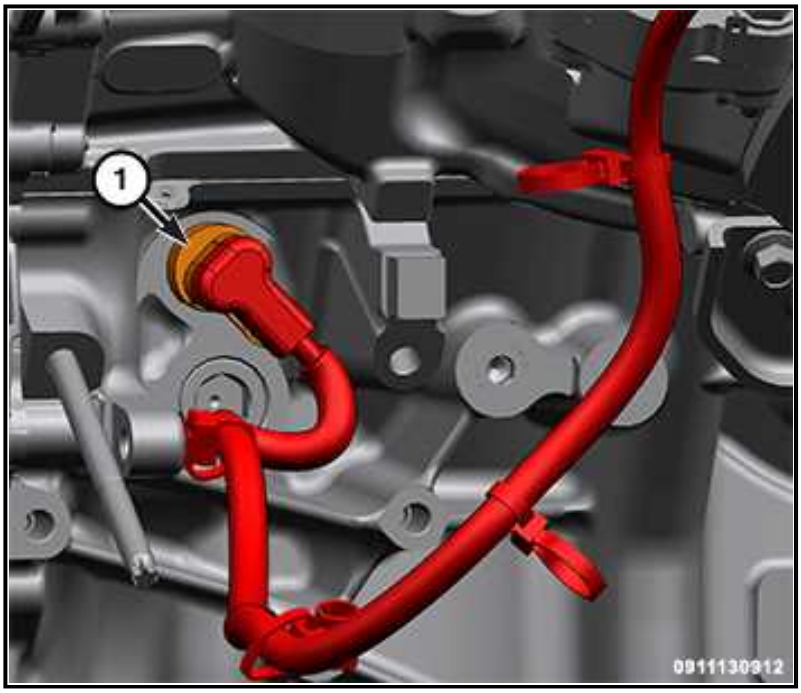
HEATER, COOLANT

REMOVAL AND INSTALLATION

ENGINE BLOCK HEATER

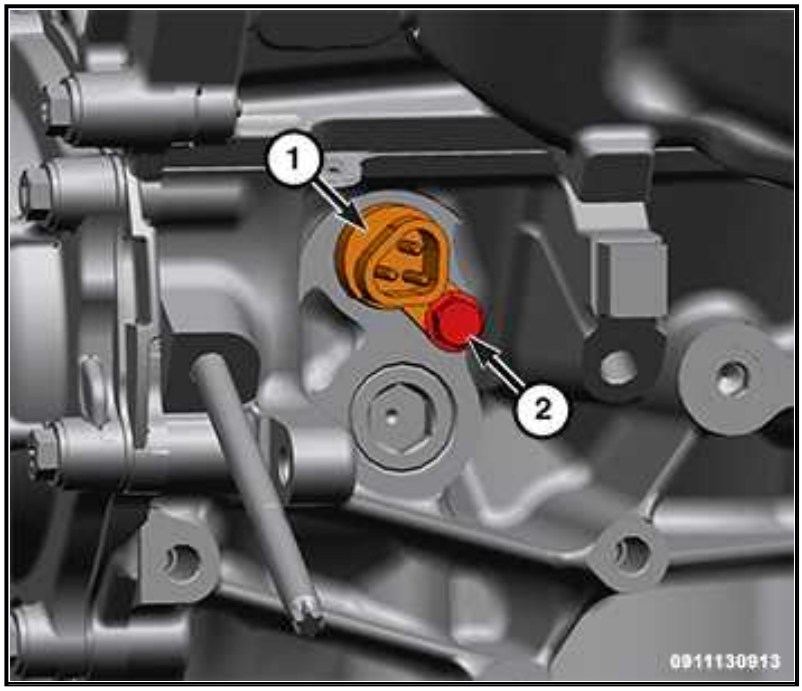
REMOVAL

1. Remove the A/C compressor. Refer to **COMPRESSOR, A/C, REMOVAL AND INSTALLATION** .



1 - Power Cord Plug

2. Disconnect the power cord plug from the engine block heater.



1 - Block Heater
2 - Bolt

3. Remove the bolt and the engine block heater.

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 block heater sealing surface.

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	**Torque Procedure:** **NOTE:** **Bolts (1 - 8) are M6;**	Tightening Sequence

DESCRIPTION	SPECIFICATION	COMMENTS
	Bolts (9, 10, 11) are M8; Bolt (12) is M10. 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**	

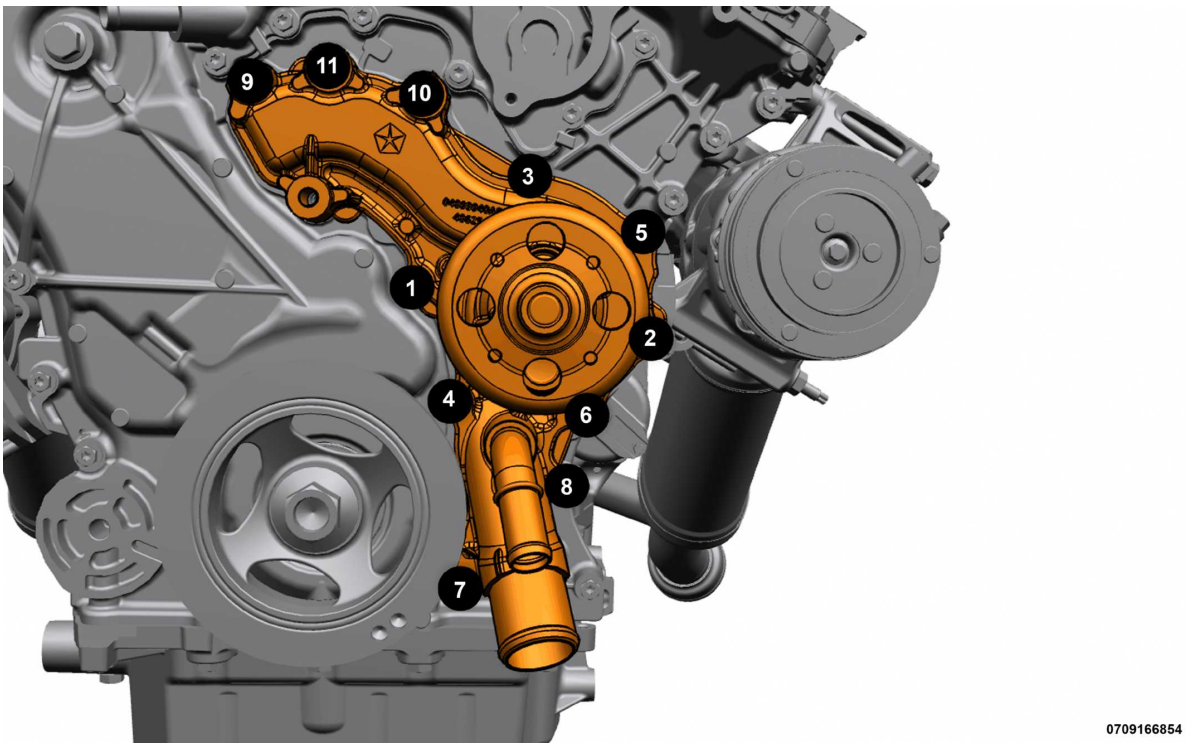


Fig. 31: Water Pump Bolts Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

PUMP, WATER

REMOVAL AND INSTALLATION

WATER PUMP

REMOVAL

The water pump on 3.6L engines is bolted directly to the engine timing chain case cover.

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

WARNING: **Constant tension hose clamps are used on most cooling system hoses. When removing or installing, use only tools designed for servicing this**

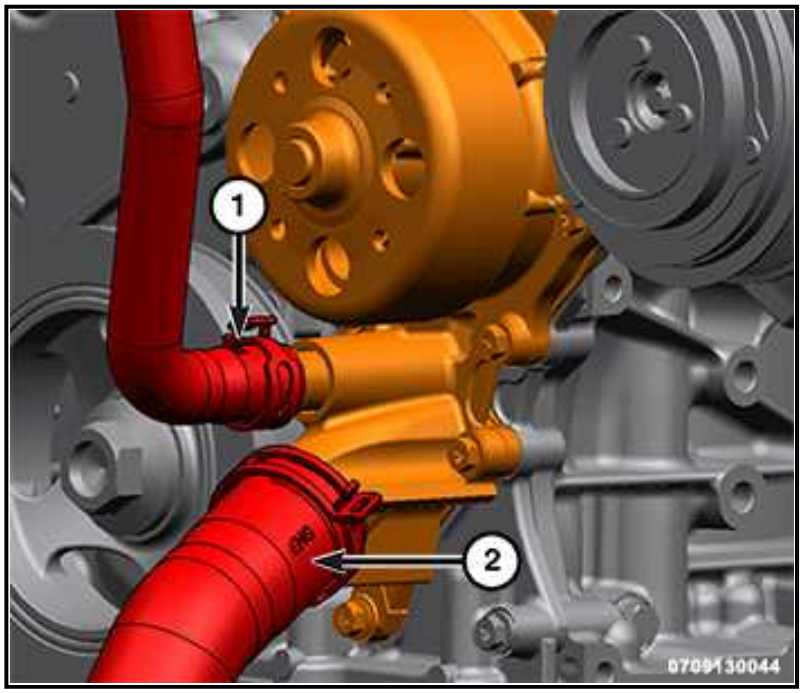
type of clamp. Always wear safety glasses when servicing constant tension clamps.

CAUTION: **A number or letter is stamped into the tongue of constant tension clamps. If replacement is necessary, use only an original equipment clamp with matching number or letter.**

2. Drain the cooling system. Refer to **DRAINING** .
3. Remove the generator and bracket. Refer to **GENERATOR, REMOVAL AND INSTALLATION** .

1 - Left Idler Pulley Bolt
2 - Left Idler Pulley

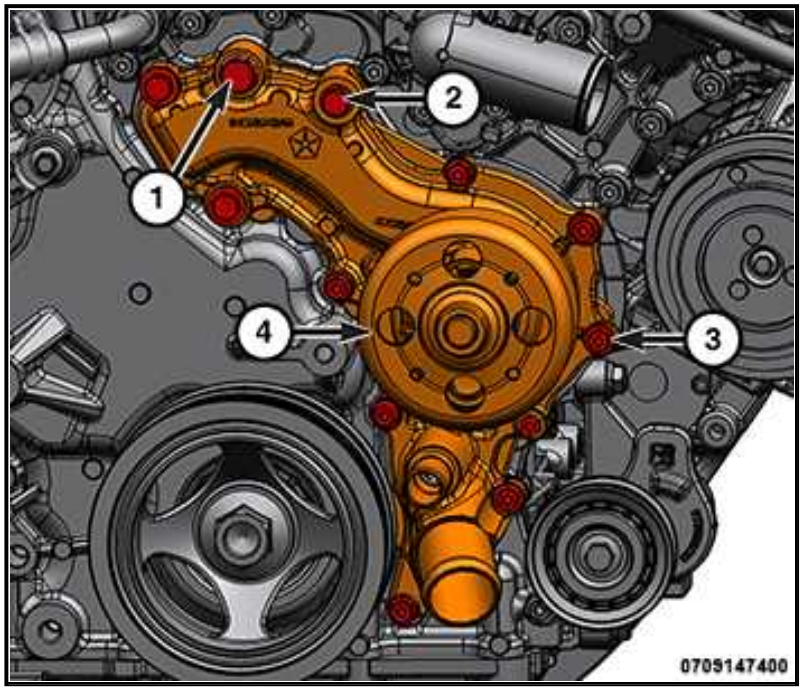
4. Remove the bolt and the left idler pulley.



1 - Heater Hose
2 - Lower Radiator Hose

5. Remove the Heater hose and the lower radiator hose.

CAUTION: **Do not pry on the water pump at the timing chain case/cover. The machined surfaces may be damaged resulting in leaks.**



1 - M10 Bolt
2 - M8 Bolts
3 - M6 Bolts
4 - Water Pump

NOTE: **Take notice to the three different water pump bolt sizes.**

6. Remove the bolts and the water pump.
7. Remove and discard the water pump 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.
- The water pump bolts must be tightened in the sequence shown in the torque table below.
- Spin water pump to be sure that pump impeller does not rub against timing chain case/cover.
- Fill the cooling system. Refer to **STANDARD PROCEDURE - FILLING** .

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.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
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	**Torque Procedure:** **NOTE:** **Bolts (1 - 8) are M6; Bolts (9, 10, 11) are M8; Bolt (12) is M10.** 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

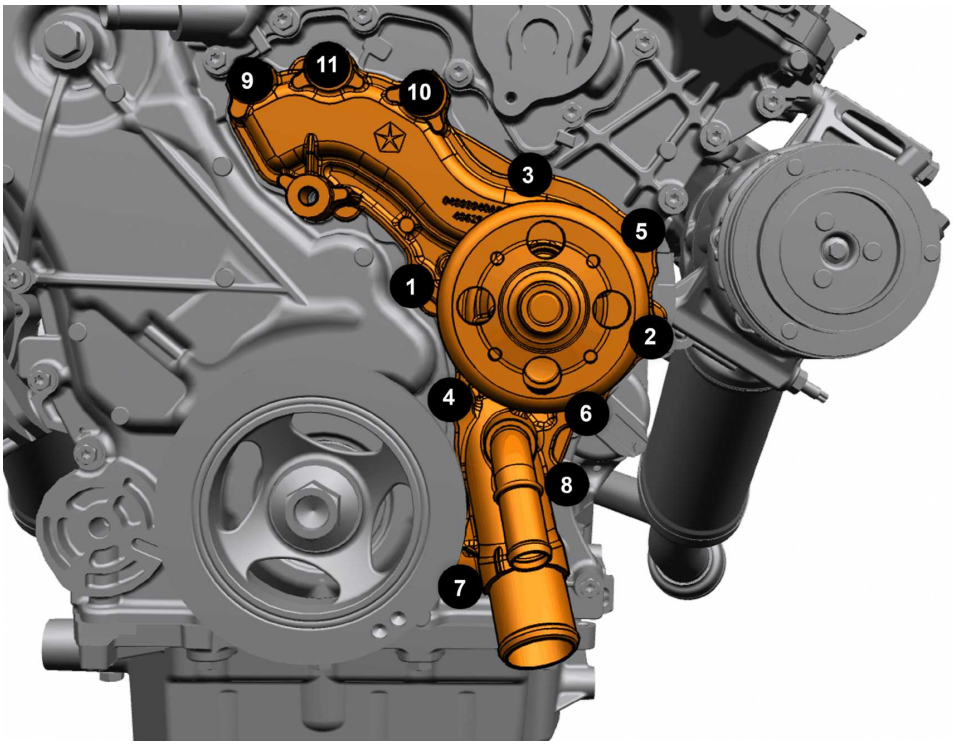


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Fig. 32: Water Pump Bolts Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

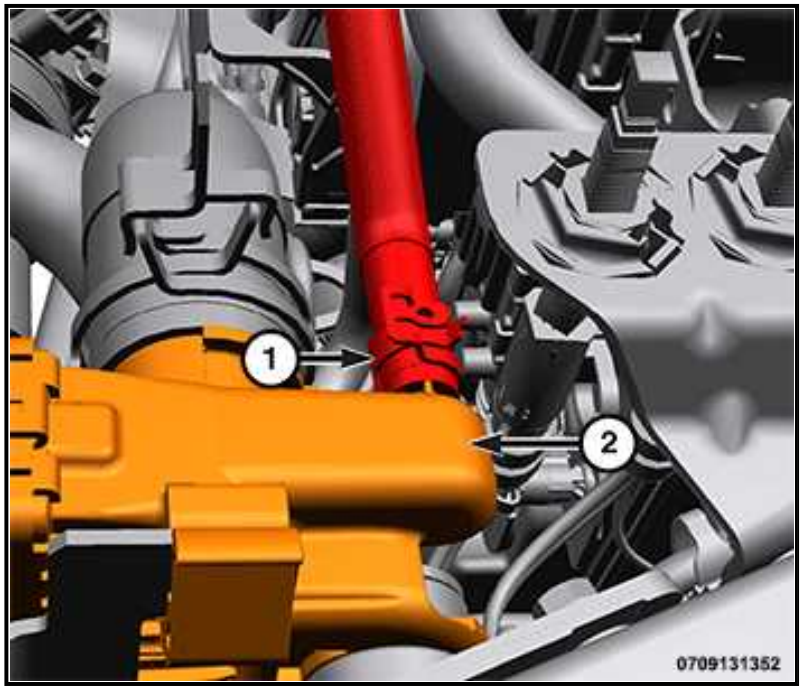
RADIATOR

REMOVAL AND INSTALLATION

RADIATOR

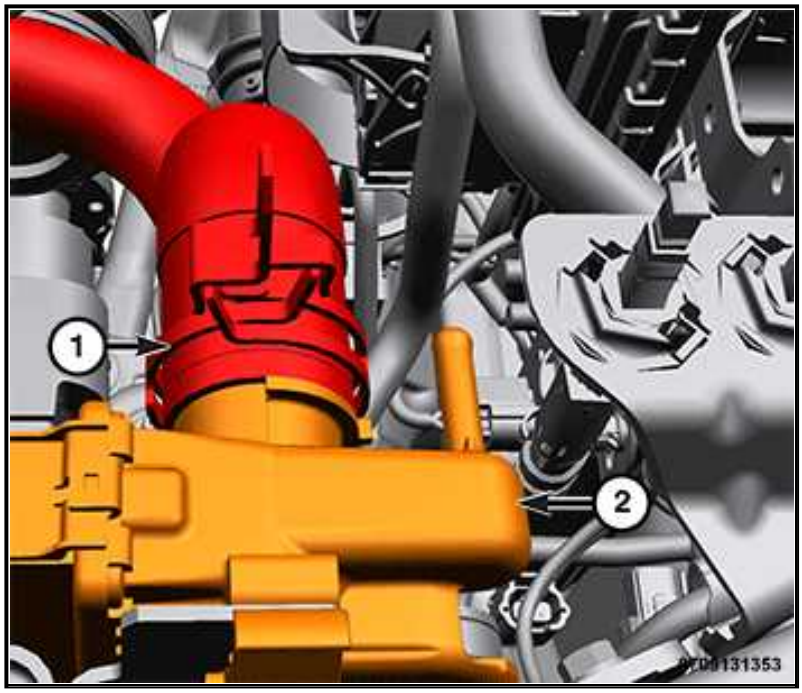
REMOVAL

1. Drain the cooling system. Refer to **DRAINING** .
2. Remove the cooling fan. Refer to **FAN, COOLING, REMOVAL AND INSTALLATION**.



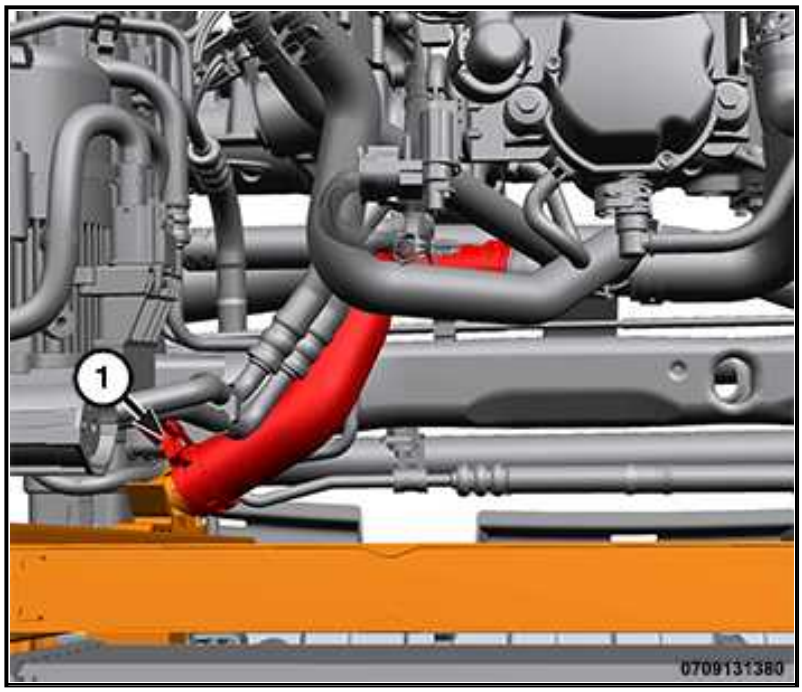
1 - Coolant Hose
2 - Radiator

3. Remove the coolant hose from the upper left side of radiator.



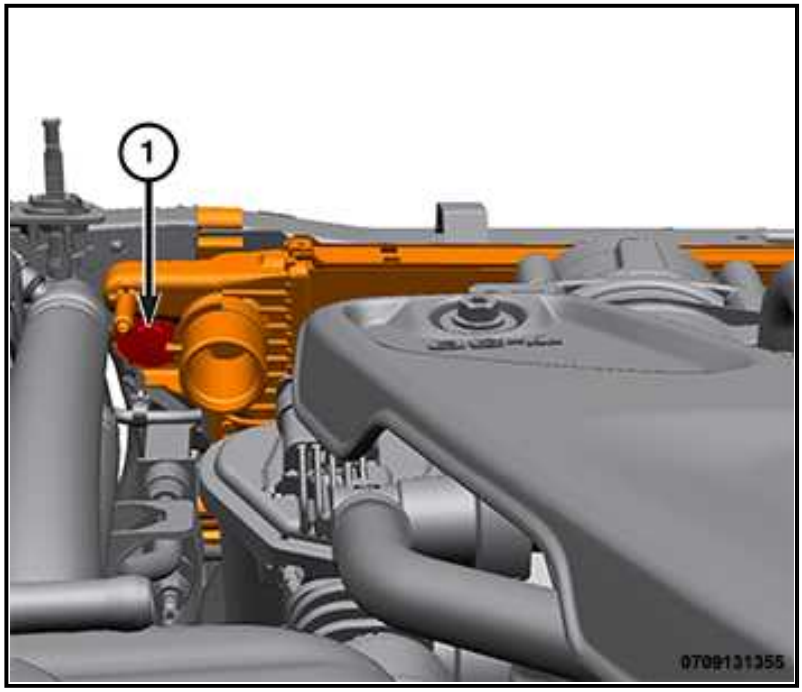
1 - Upper Radiator Hose
2 - Radiator

4. Remove the upper radiator hose from the radiator.



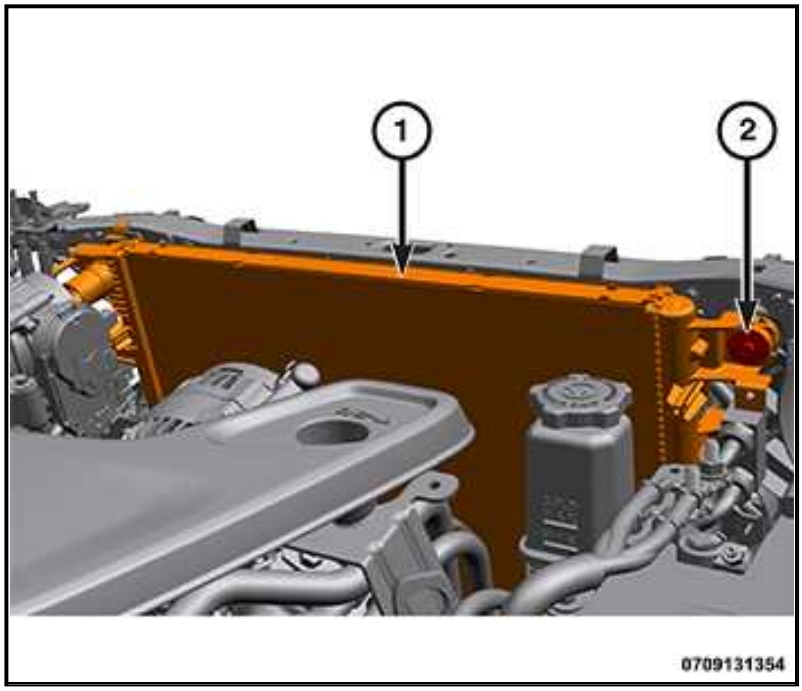
1 - Lower Radiator Hose

5. Remove the lower radiator hose clamp and hose from the radiator. Position the hose aside.
6. Remove the grille. Refer to **GRILLE, REMOVAL AND INSTALLATION** .



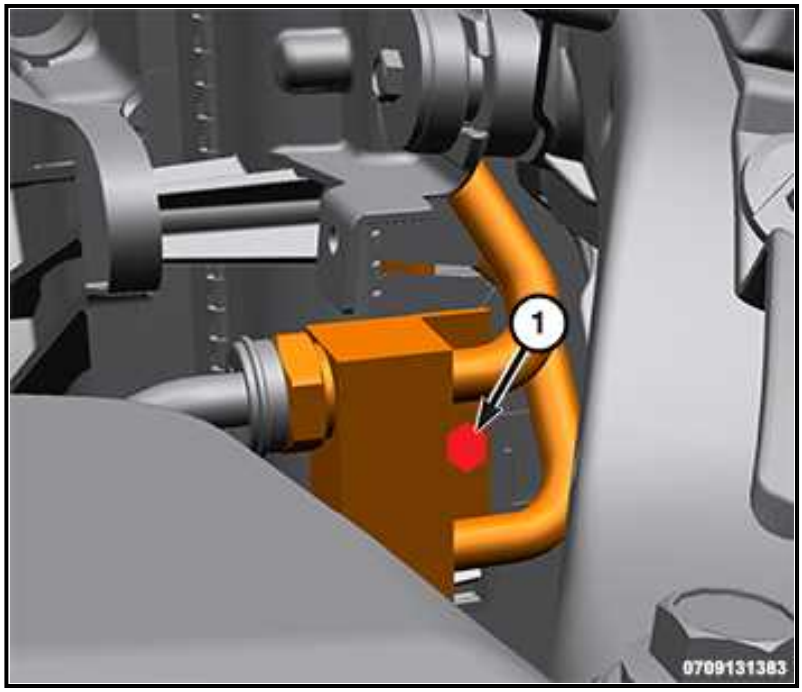
1 - Radiator Bolt

7. Remove the left upper radiator bolt.



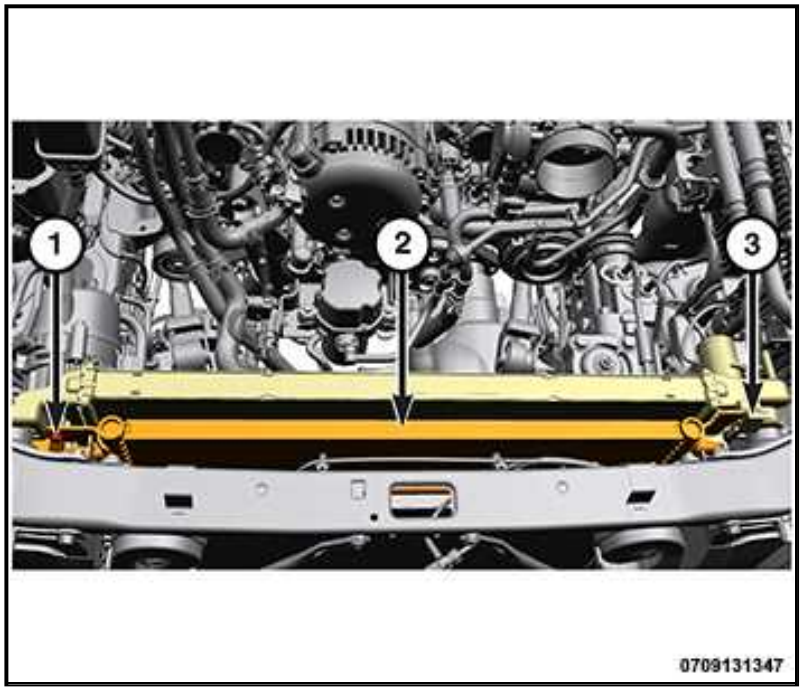
1 - Radiator
2 - Radiator Bolt

8. Remove the right upper radiator bolt.
9. Tilt the radiator inward to gain access to the transmission cooler.
10. Remove the right headlight unit. Refer to **UNIT, HEADLAMP, REMOVAL AND INSTALLATION** .



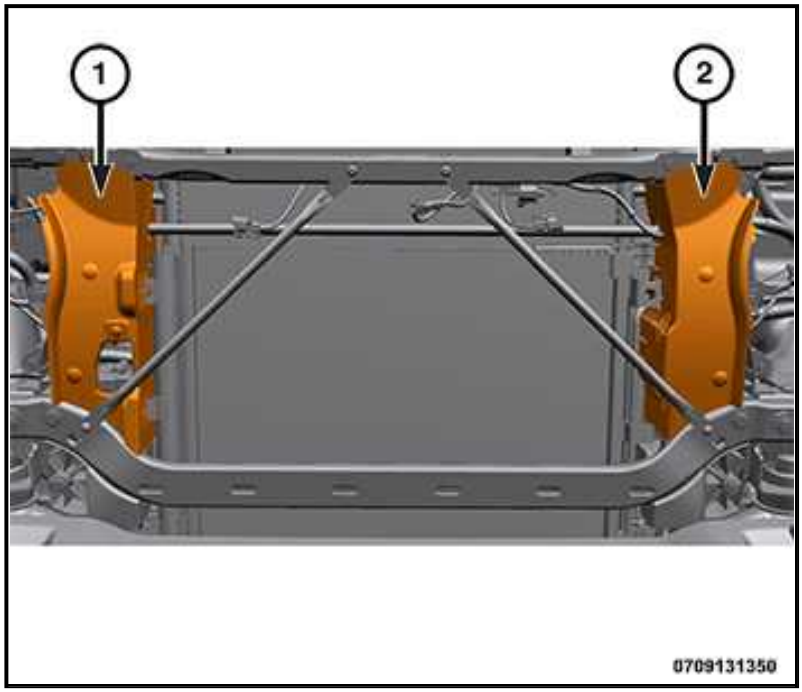
1 - Trans Cooler Manifold Bolt

11. Working from the right front, remove the bolt securing the transmission cooler manifold to the radiator.



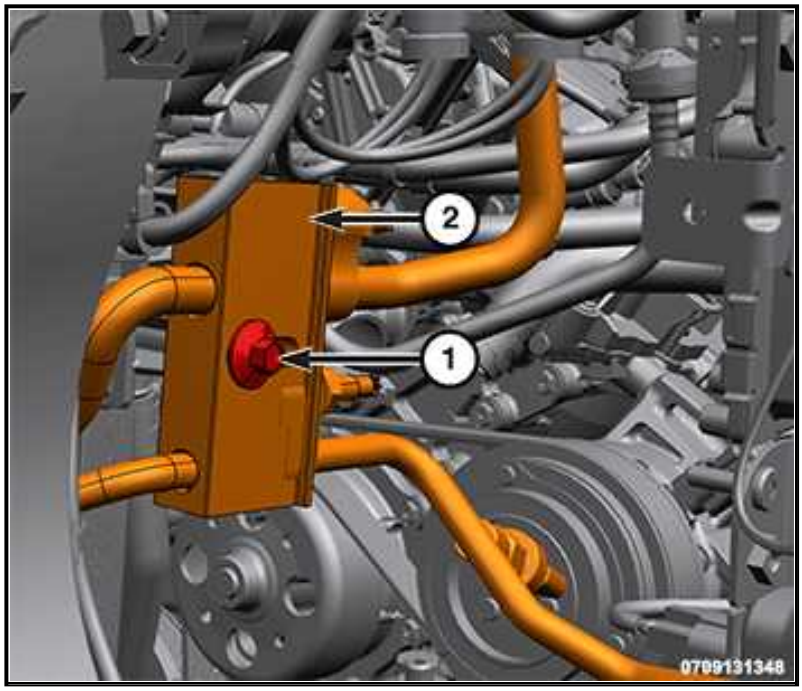
1 - Left Trans Cooler Bolt
2 - Transmission Cooler
3 - Transmission Cooler Retaining Tab

12. Working from the front, remove the left transmission cooler bolt, release the retaining tab and lift up cooler to separate it from the radiator.



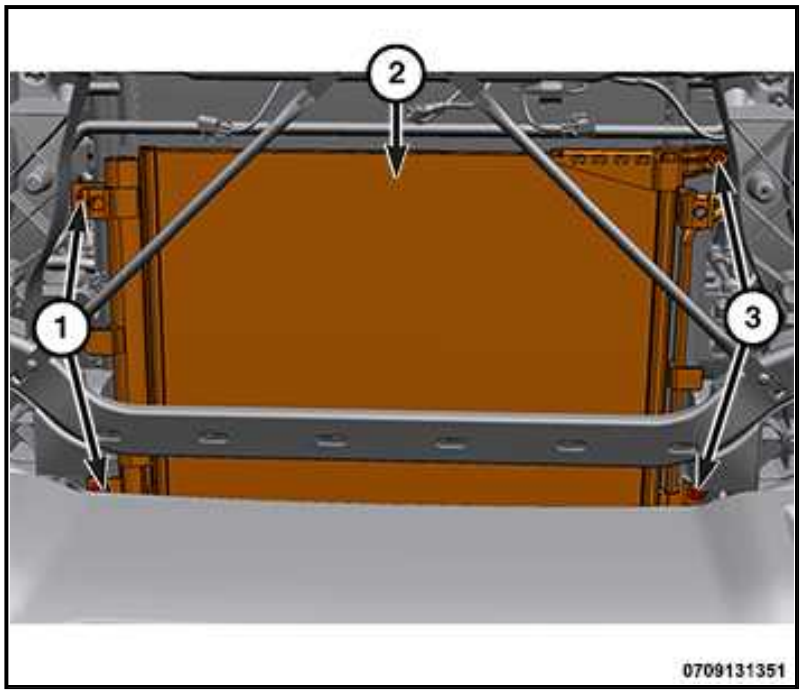
1 - Right Air Deflector
2 - Left Air Deflector

13. Working from the front remove the left side and right side radiator air deflectors.
14. Remove the left headlight unit. Refer to **UNIT, HEADLAMP, REMOVAL AND INSTALLATION** .



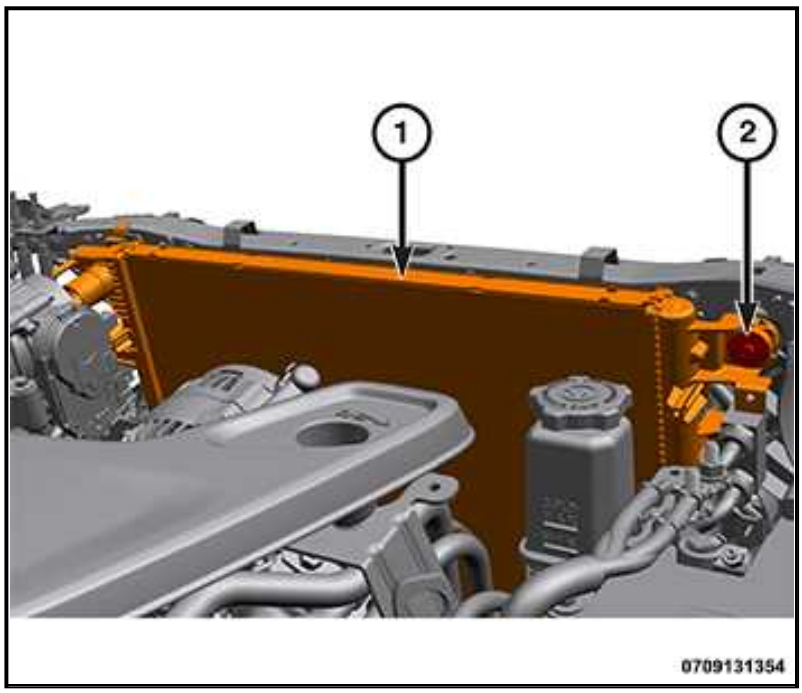
1 - A/C Condenser Manifold
2 - A/C Condenser Manifold Bolt

15. Remove the left side A/C condenser manifold bolt from the front side of the radiator.



1 - Right A/C Condenser Bolt
2 - A/C Condenser
3 - Left A/C Condenser Bolt

16. Working from the front, remove the right side A/C condenser bolts.
17. Working from the front, remove the left side A/C condenser bolts and separate the A/C condenser from the radiator.



1 - Radiator
2 - Radiator Bolt

18. Carefully lift the radiator and remove it from the vehicle.

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.

- Verify that the A/C Condenser and Transmission Cooler are properly installed and aligned before securing radiator in place.
- Fill the cooling system. Refer to **STANDARD PROCEDURE - FILLING** .

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	**Torque Procedure:** **NOTE:**	Tightening Sequence

DESCRIPTION	SPECIFICATION	COMMENTS
	Bolts (1 - 8) are M6; Bolts (9, 10, 11) are M8; Bolt (12) is M10. 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**	

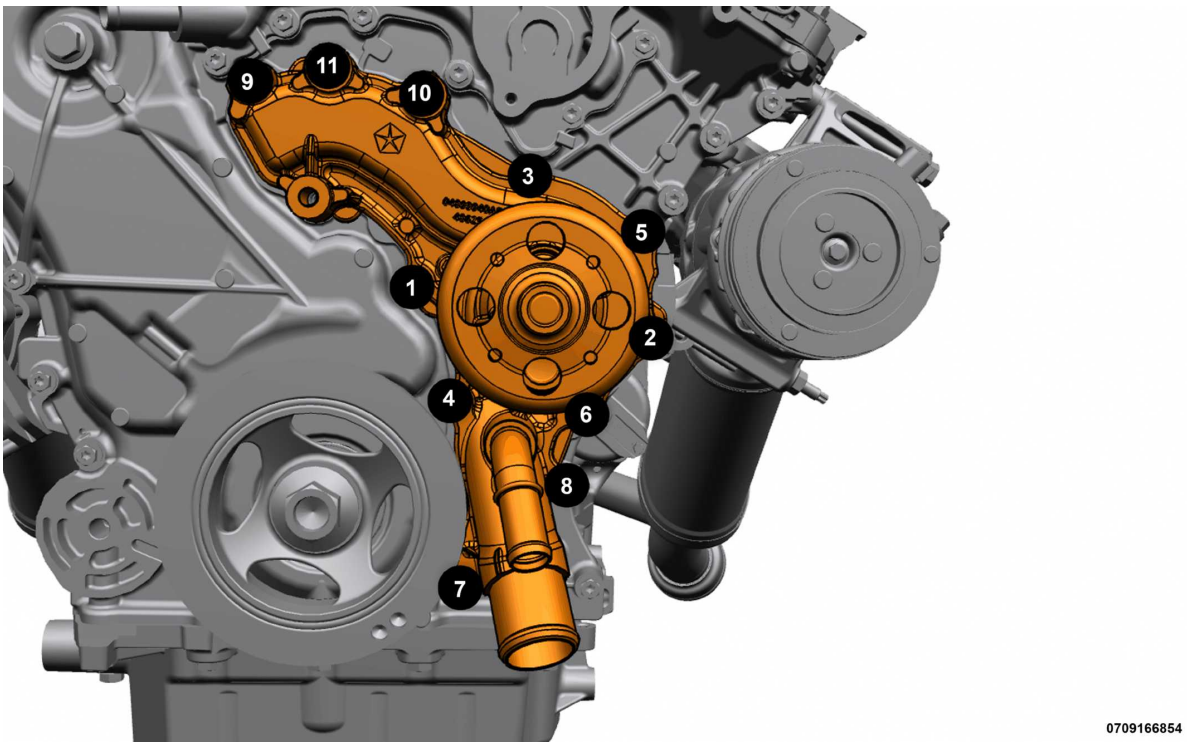


Fig. 33: Water Pump Bolts Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

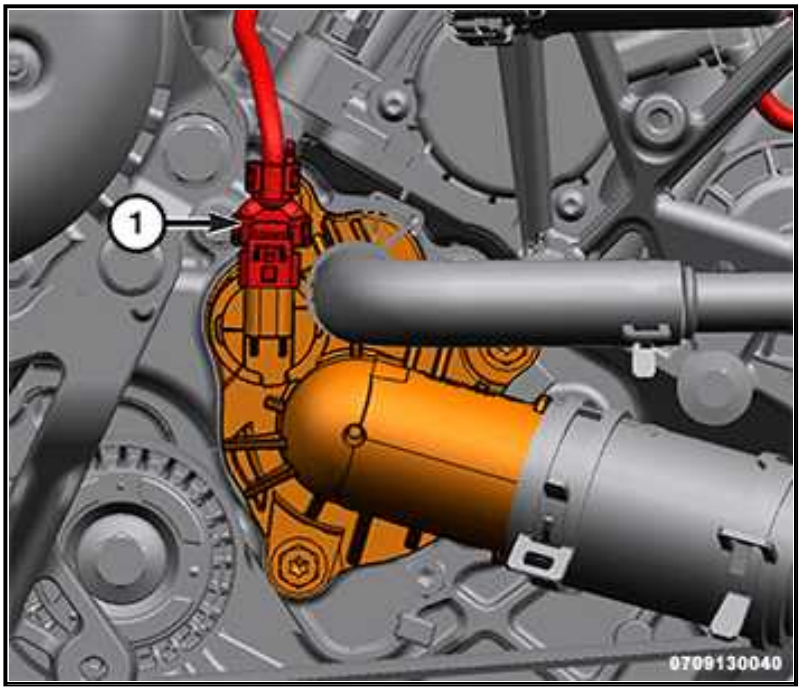
THERMOSTAT

REMOVAL AND INSTALLATION

THERMOSTAT

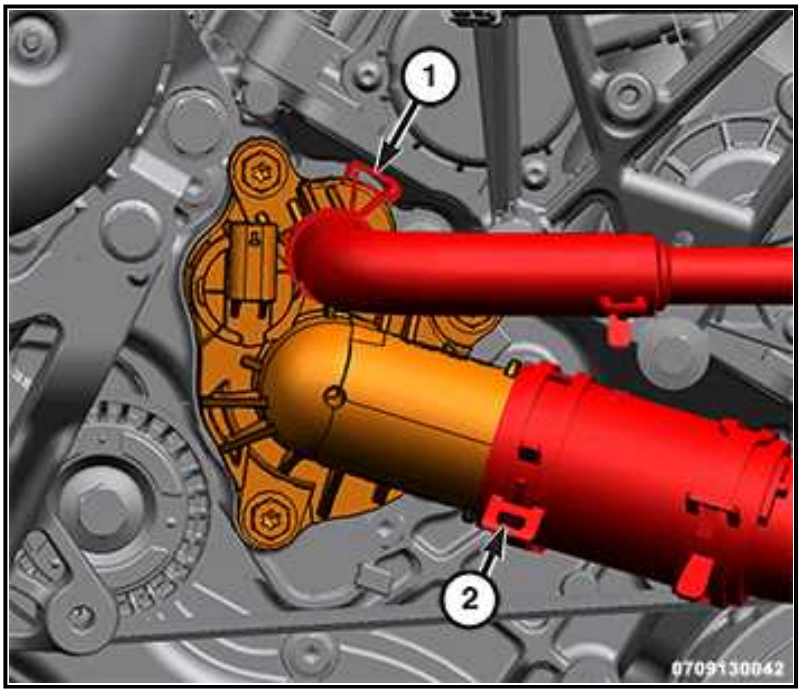
REMOVAL

1. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
2. Drain the cooling system. Refer to **DRAINING** .
3. Remove the air cleaner resonator. Refer to **RESONATOR, AIR CLEANER, REMOVAL AND INSTALLATION**.



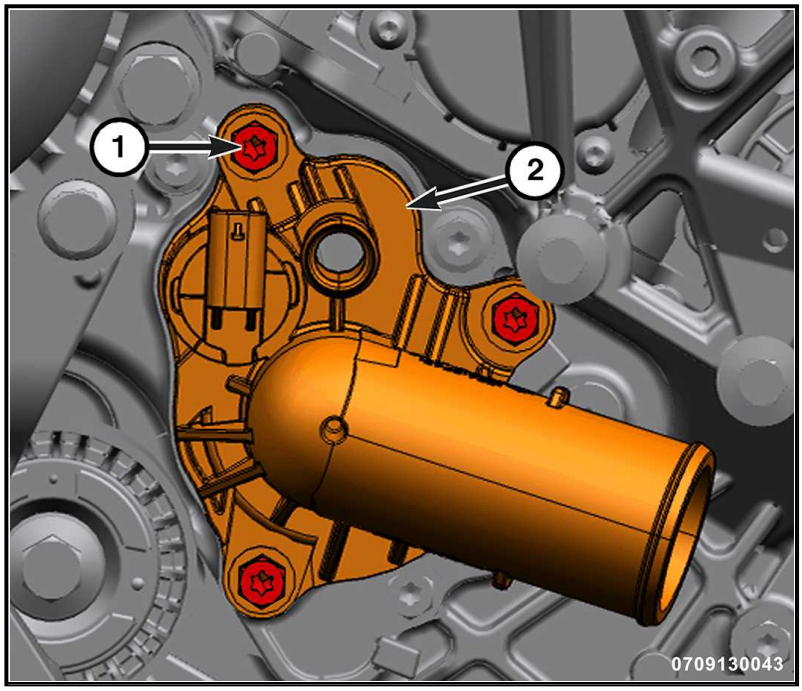
1 - ECT Sensor Wire Harness Connector

4. Disconnect the Engine Coolant Temperature (ECT) sensor harness connector.



1 - EGR Cooler Coolant Hose
2 - Upper Radiator Hose

5. Remove the Exhaust Gas Recirculation (EGR) cooler coolant hose from the thermostat housing.
6. Remove the upper radiator hose from the thermostat housing.



1 - Thermostat Housing Bolts
2 - Thermostat Housing

7. Remove the bolts and the thermostat housing.
8. Remove and discard the thermostat 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.
- Fill the cooling system. Refer to **STANDARD PROCEDURE - FILLING** .
- Run the engine until it reaches normal operating temperature. Check the cooling system for leaks and correct fluid level

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.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Water Pump Bolts	**Torque Procedure:** **NOTE:** **Bolts (1 - 8) are M6; Bolts (9, 10, 11) are M8; Bolt (12) is M10.** 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

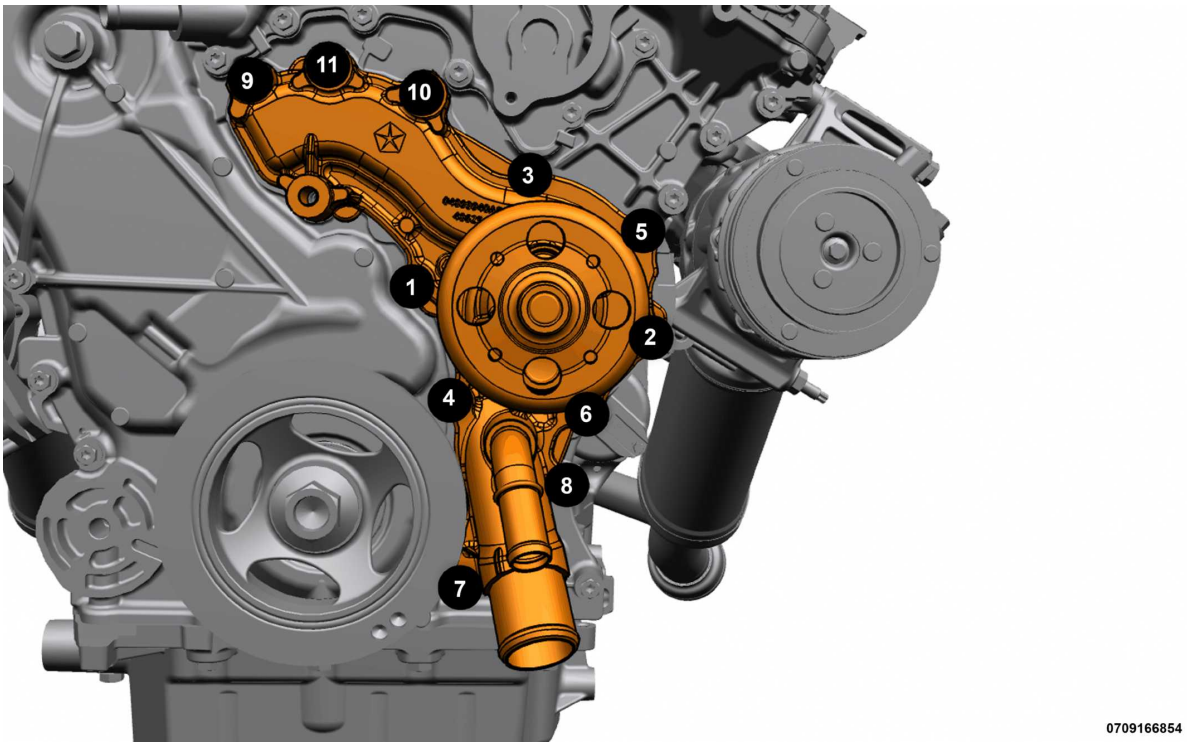
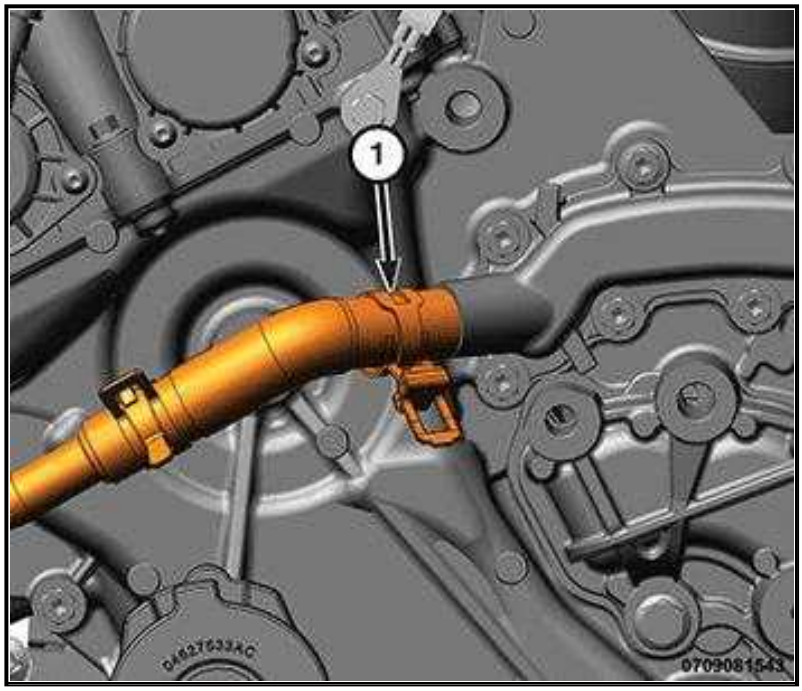


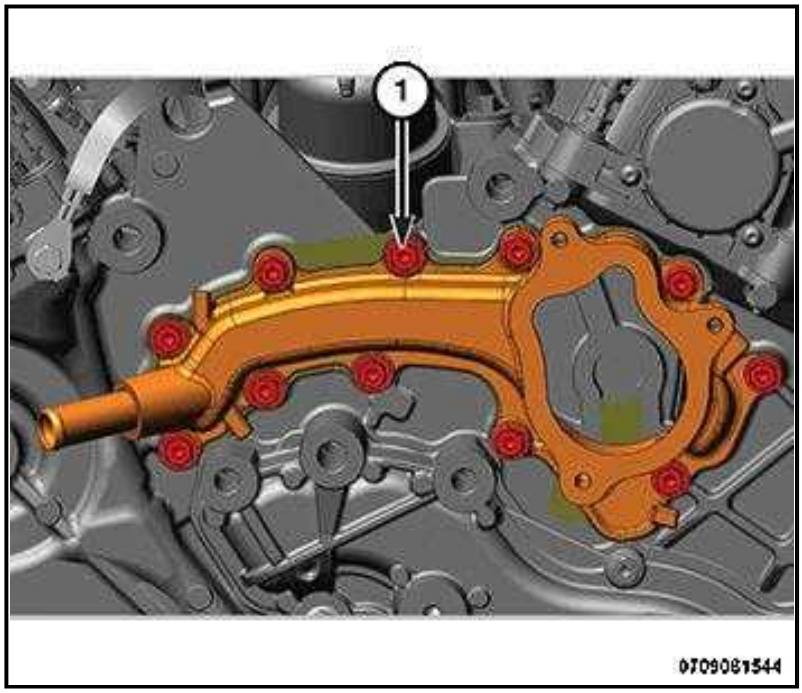
Fig. 34: Water Pump Bolts Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

COOLANT CROSSOVER - 3.6L

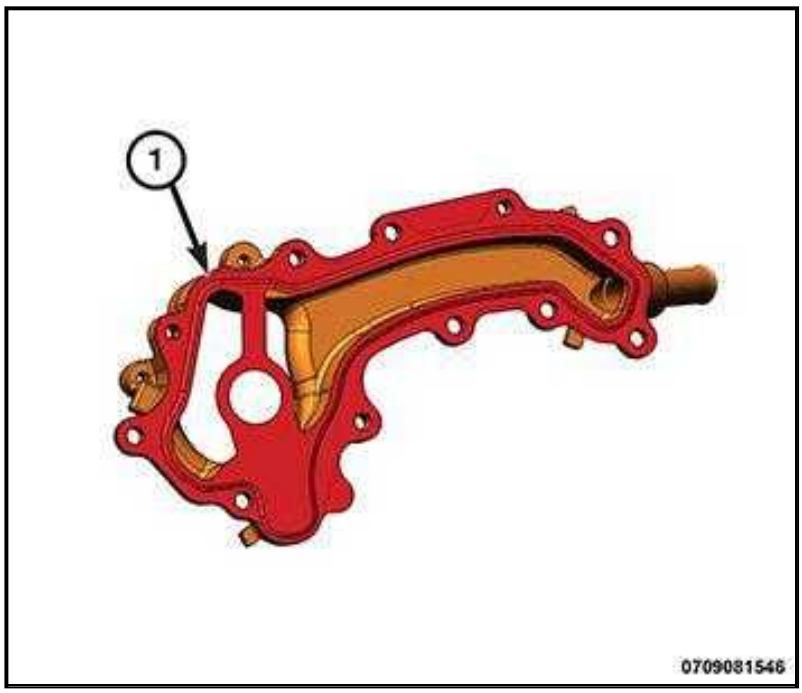
1. Remove the thermostat housing assembly. Refer to **THERMOSTAT, REMOVAL AND INSTALLATION**.
2. Remove the serpentine belt. Refer to **TENSIONER, BELT, REMOVAL AND INSTALLATION**.



3. Remove the heater supply hose from the coolant crossover (1).



4. Remove the coolant crossover mounting bolts (1). Take notice to the four bolts that bolt directly to the timing cover.



5. Remove the coolant crossover and discard gasket (1).

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.
- Fill the cooling system. Refer to **STANDARD PROCEDURE - FILLING** .
- Run the engine until it reaches normal operating temperature. Check the cooling system for leaks and correct fluid level.

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	**Torque Procedure:** **NOTE:** **Bolts (1 - 8) are M6;**	Tightening Sequence

DESCRIPTION	SPECIFICATION	COMMENTS
	Bolts (9, 10, 11) are M8; Bolt (12) is M10. 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**	

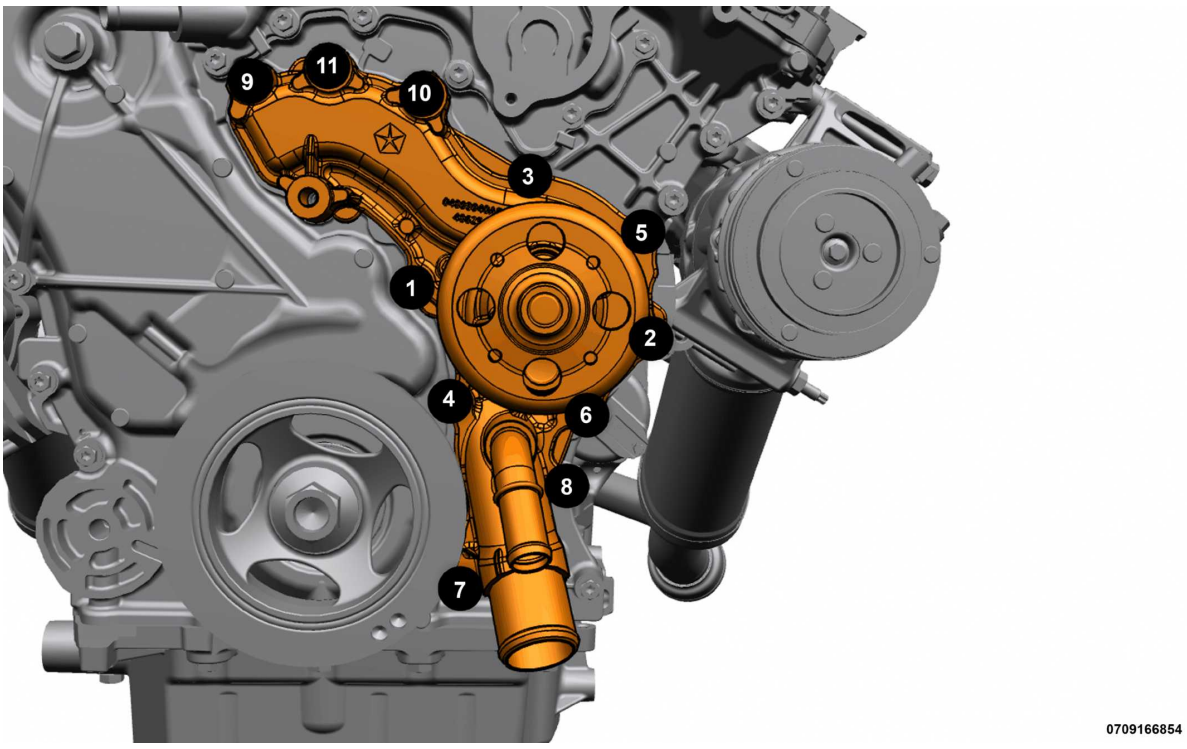
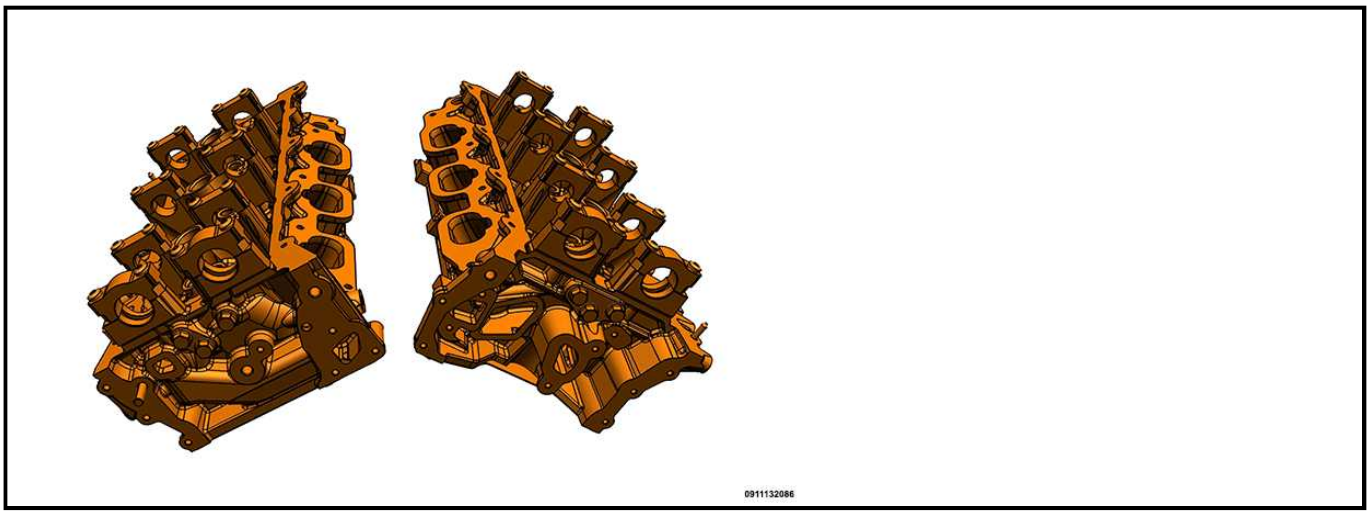


Fig. 35: Water Pump Bolts Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

CYLINDER HEAD

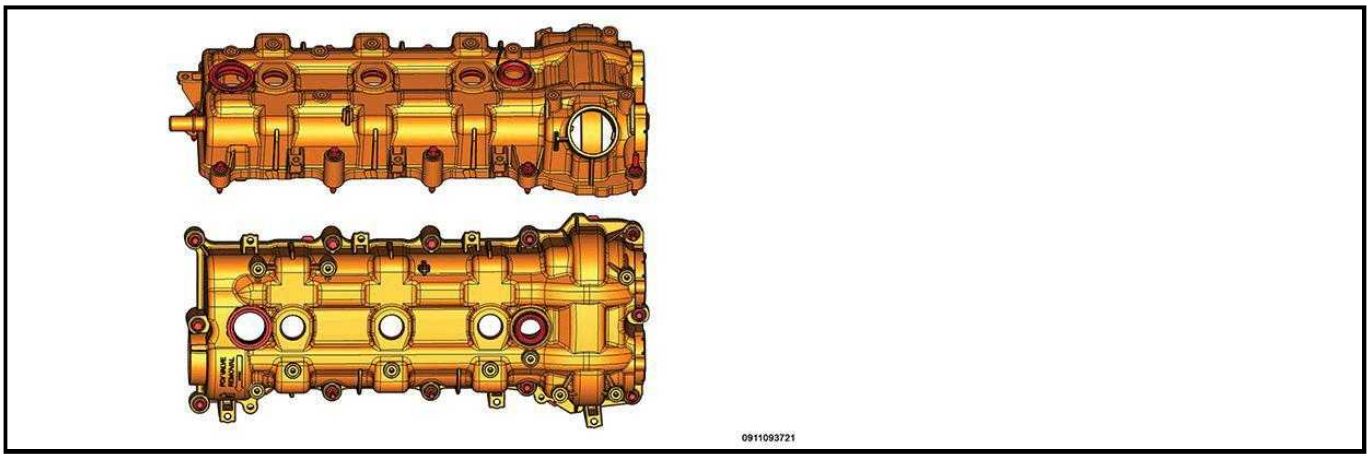
DESCRIPTION AND OPERATION

CYLINDER HEAD



The aluminum cylinder heads are a unique design with left and right castings. The exhaust manifolds are integrated into the cylinder heads. The cylinder head features four valves per cylinder with pressed in powdered metal valve guides. The valve guides are not serviceable. The Dual Over Head Camshaft (DOHC) valvetrain uses roller rocker arms with hydraulic lifters. The cylinder head's camshaft bearing caps are made of powdered metal and the location and direction of each cap is marked on the side of the caps. The spark plug tubes are pressed into the cylinder heads and sealed in place. The tubes are a thin wall design and caution must be taken when working in the spark plug tube area.

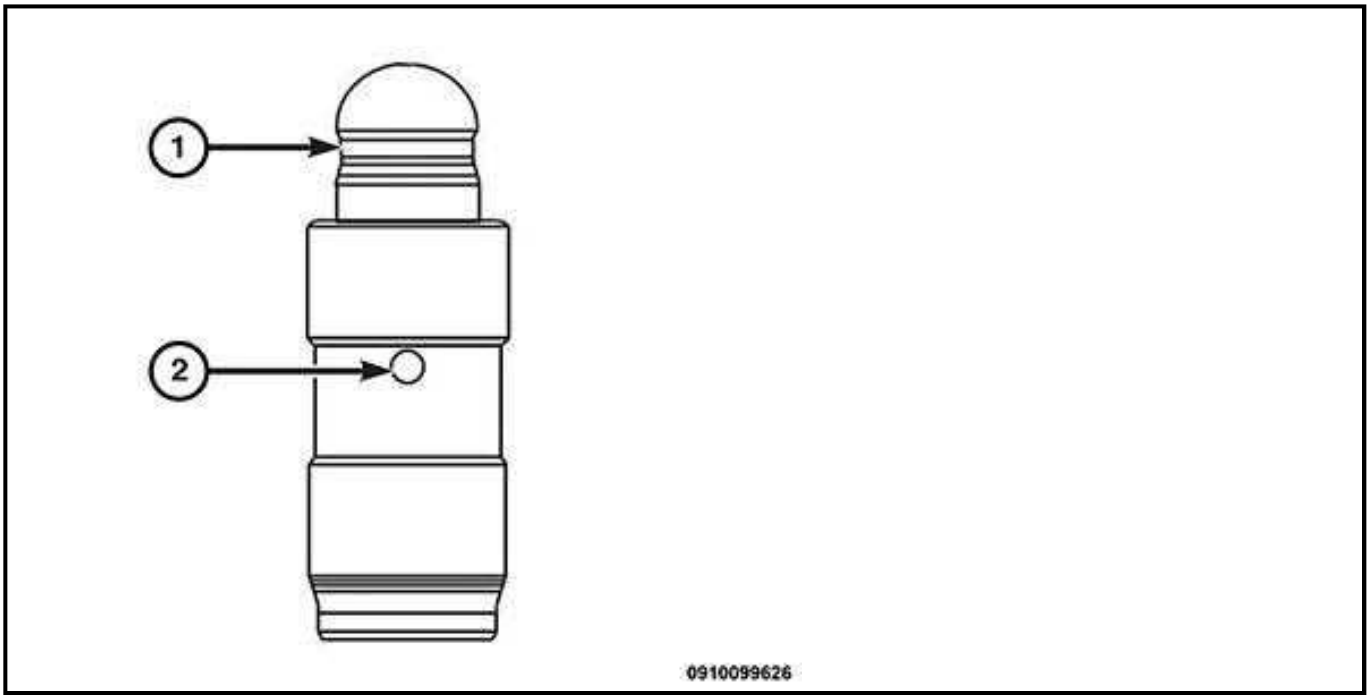
CYLINDER HEAD COVER



The cylinder head covers are made of a carbon and fiberglass composite.

- The cylinder head covers are not interchangeable from side-to-side.
- The cylinder head covers are sealed with a press-in-place gasket that is designed to isolate the cover from the cylinder head for improved Noise Vibration and Harshness (NVH).
- There are two dowel pins on the outboard side of the cover flange to locate the cover to holes in the cylinder head.
- Room Temperature Vulcanizing silicone (RTV) is used to seal the T-joint at the timing cover, cylinder head and cylinder head cover.

HYDRAULIC LIFTER

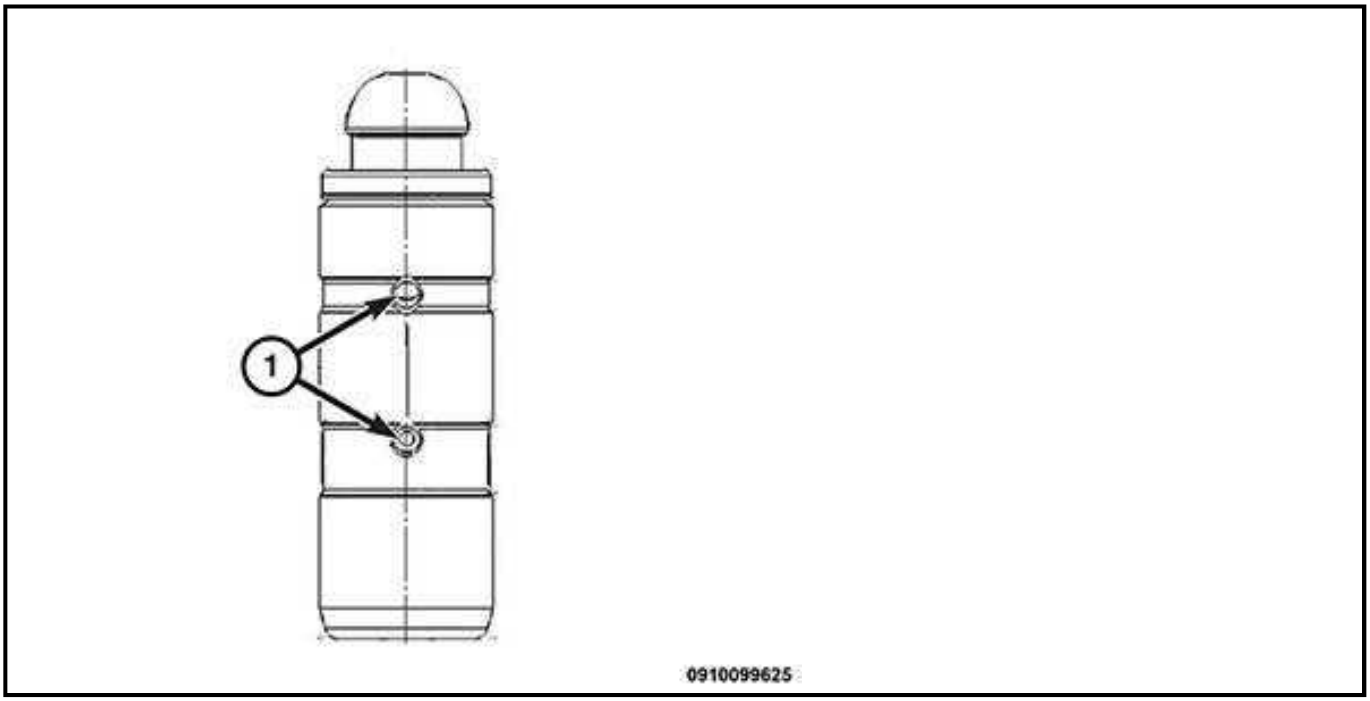


1 - Retaining Clip Location
2 - Oil Feed

The exhaust hydraulic lifter is attached to the exhaust roller rocker arm with a retaining clip. The internal check ball is reversed, compared to previous model years.

NOTE: **The exhaust hydraulic lifter and exhaust rocker arm should not be unclipped during diagnosis and handling.**

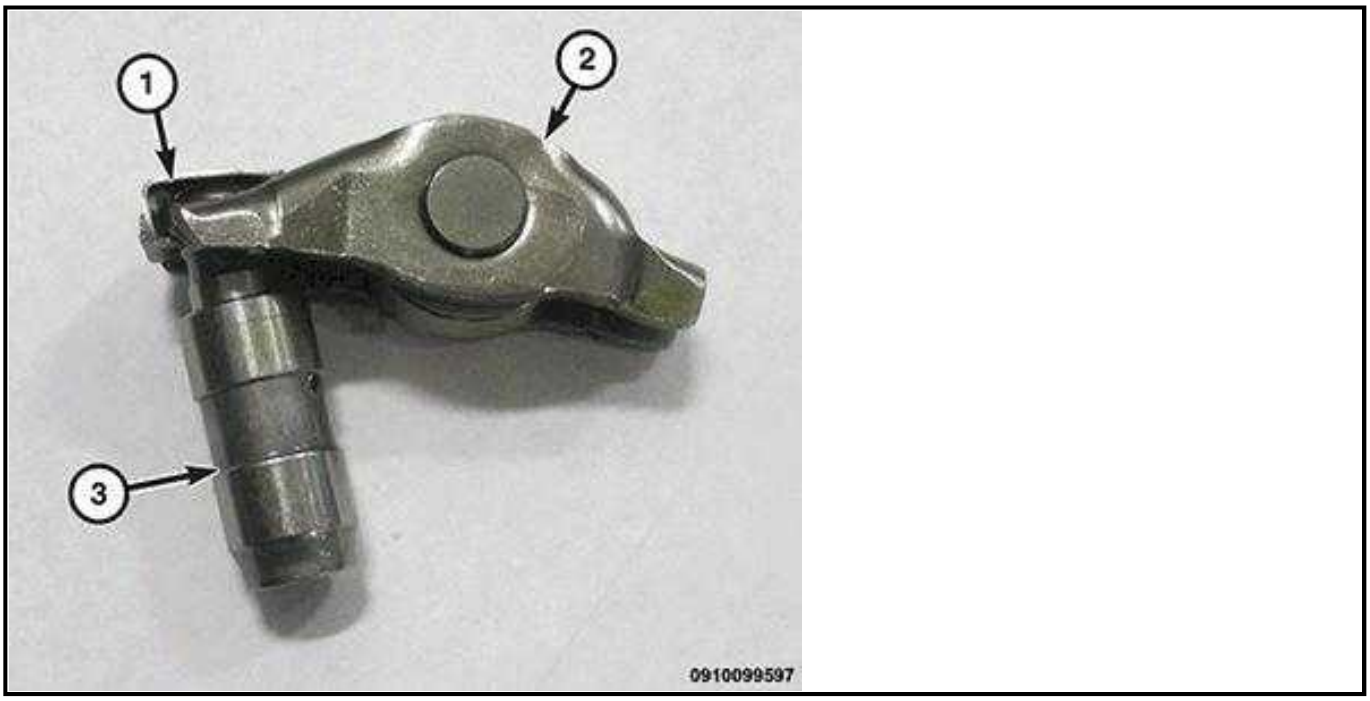
NOTE: **The exhaust hydraulic lifter must never be interchanged with any other hydraulic lifter than what is specifically designated for this vehicle. The internal check ball is reversed and could cause engine damage if an incorrect part is installed.**



1 - Dual Oil Feed

The intake hydraulic lifter has a dual oil feed feature to accommodate the two-step Variable Valve Lift (VVL) system.

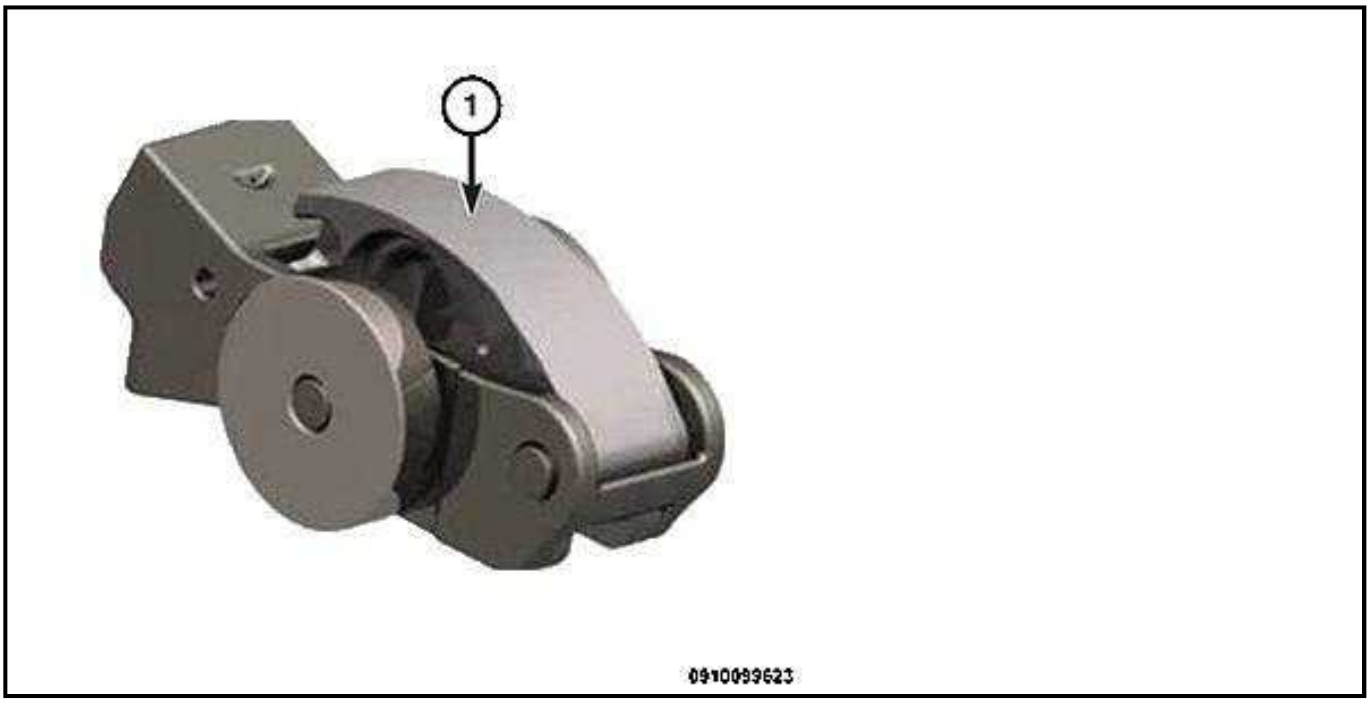
ROCKER ARM



1 - Retaining Clip
2 - Rocker Arm
3 - Hydraulic Lifter

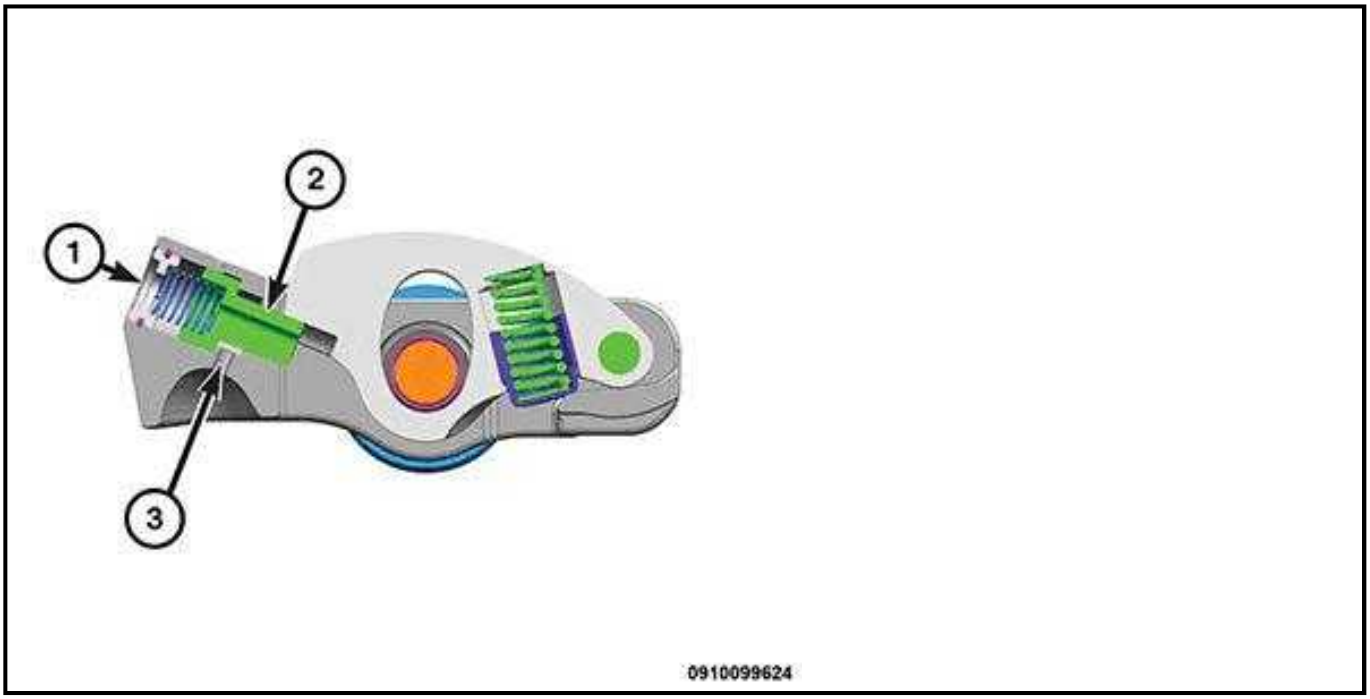
The exhaust roller rocker arms are stamped steel with an integral roller bearing. The exhaust rocker arms are attached to the hydraulic lifters with a retaining clip.

NOTE: **The exhaust rocker arm and exhaust hydraulic lifter should not be unclipped during diagnosis and handling.**



1 - Rocker Arm

The intake two-step roller rocker arms use oil pressure to control high or low intake valve lift depending on configuration.

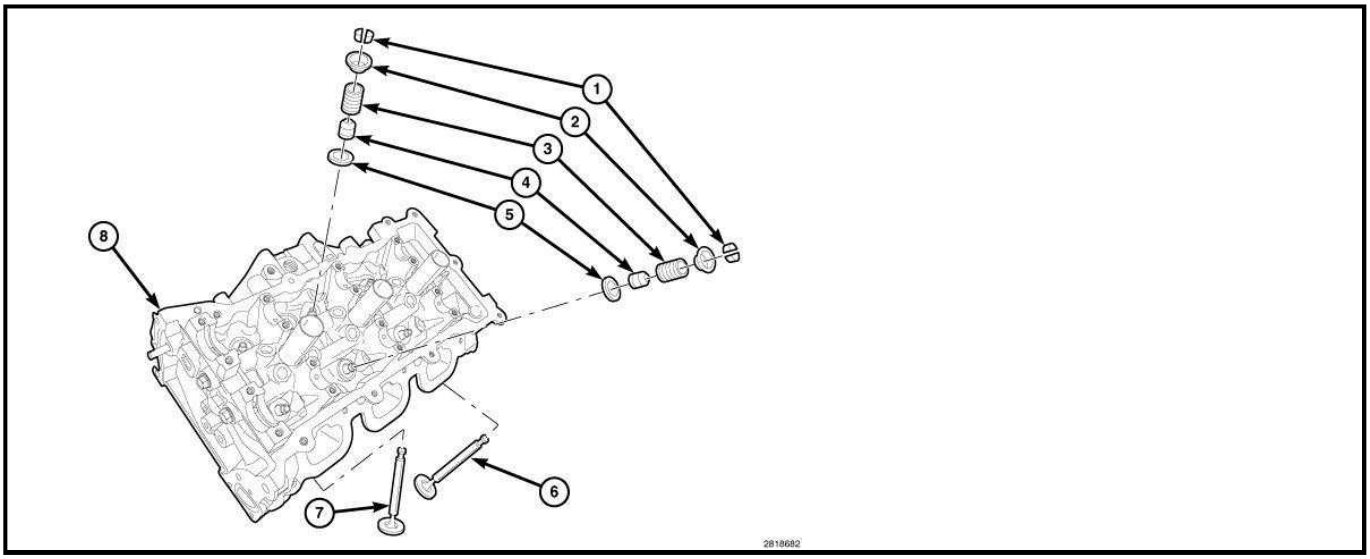


1 - Low Lift Position
2 - High Lift Position
3 - Oil Pressure From Two-stop Solenoid

Configuration is controlled by the Powertrain Control Module (PCM).

- Low lift position - Pin Retracted
- High lift position - Pin Extended
- Oil Pressure from the two-stop solenoid

VALVE



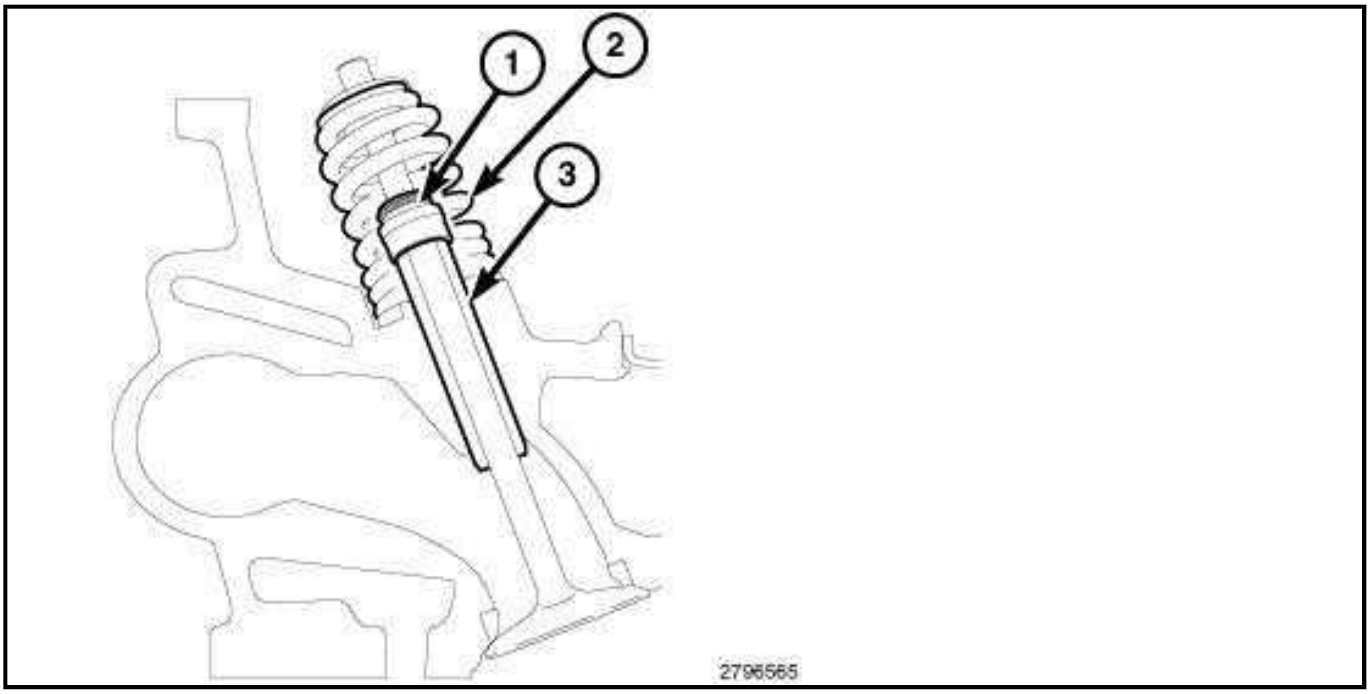
The intake valve (6) is made from a one piece forged heat resistant (martensitic) steel. The exhaust valve (7) is a two piece construction with a forged (austenitic) head welded to the (martensitic) stem. Both valves have a nitrided surface treatment to prevent scuffing except at the tip and lock grooves. The four valves per cylinder are actuated by roller rocker arms, which pivot on stationary lash adjusters. All valves use three bead lock keepers (1) to retain springs (3) and to promote valve rotation.

For cylinder head (8) description and operation. Refer to **CYLINDER HEAD, DESCRIPTION AND OPERATION**.

For valve seal (4) description and operation. Refer to **SEAL(S), VALVE GUIDE, REMOVAL AND INSTALLATION**.

For valve spring and seat (5) description and operation. Refer to **SPRING(S), VALVE, REMOVAL AND INSTALLATION**.

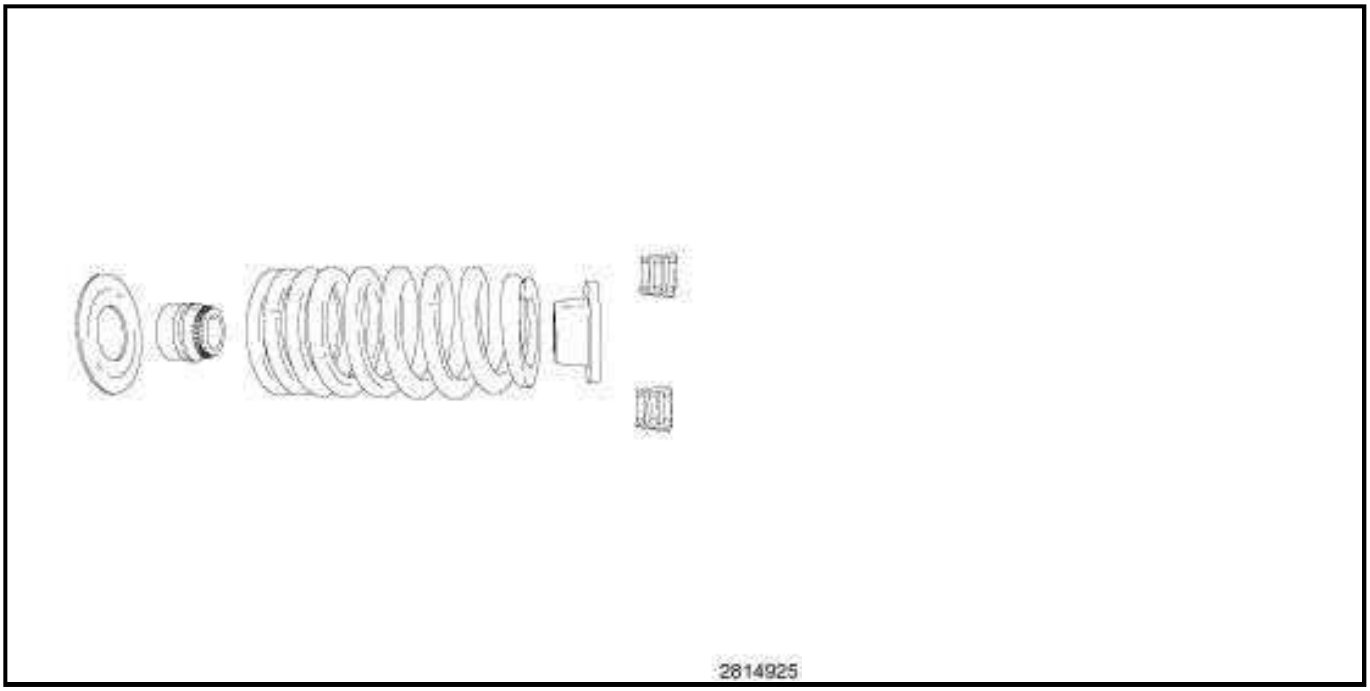
VALVE GUIDE SEAL



1 - Valve Guide Seal
2 - Valve Spring
3 - Valve Guide

The valve guide seals are made of elastomer over-molded steel in a non-integrated type guide mounted configuration. The seal is not held in place by the valve spring. The valve guide seals are not reusable if removed from the valve guides, they must be replaced. Always coat the seals with clean engine oil before installing the valves.

VALVE SPRING



The valve springs are a beehive design and made from high strength chrome silicon steel. The springs are common for intake and exhaust applications. Valve guide seals are rubber overmolded on a steel support cylinder with a garter spring at the seal lip. The seals are not integrated with the valve spring seat. The valve spring seat is a flat steel washer. The steel valve spring retainers are designed for use with beehive springs and the valve spring retainer locks are a three bead Butt type design.

DIAGNOSIS AND TESTING

CYLINDER HEAD GASKET

A cylinder head gasket leak can be located between adjacent cylinders or between a cylinder and the adjacent water jacket.

Possible indications of the cylinder head gasket leaking between adjacent cylinders are:

- Loss of engine power
- Engine misfiring
- Poor fuel economy

Possible indications of the cylinder head gasket leaking between a cylinder and an adjacent water jacket are:

- Engine overheating
- Loss of coolant
- Excessive steam (white smoke) emitting from exhaust
- Coolant foaming

CYLINDER-TO-CYLINDER LEAKAGE TEST

To determine if an engine cylinder head gasket is leaking between the cylinders located next to each other, follow the procedures in Cylinder Compression Pressure Test. Refer to **CYLINDER COMPRESSION TEST** . An engine cylinder head gasket leaking between the cylinders will result in approximately a 50 - 70% reduction in compression pressure.

CYLINDER-TO-WATER JACKET LEAKAGE TEST

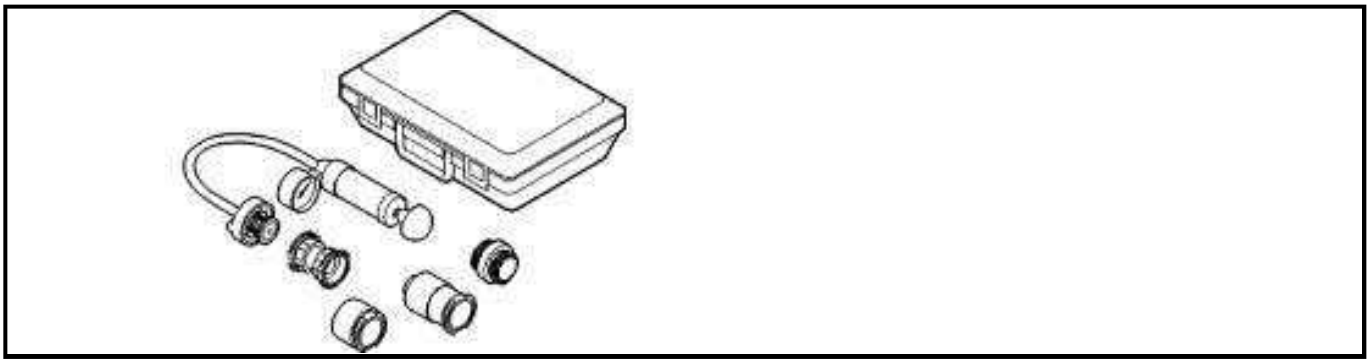
WARNING: USE EXTREME CAUTION WHEN THE ENGINE IS OPERATING WITH COOLANT PRESSURE CAP REMOVED.

VISUAL TEST METHOD

With the engine cool, remove the coolant pressure cap. Start the engine and allow it to warm up until thermostat opens.

If a large combustion/compression pressure leak exists, bubbles will be visible in the coolant.

PRESSURE TEST METHOD



WARNING: WITH THE COOLING SYSTEM TESTER IN PLACE, PRESSURE WILL BUILD UP FAST. EXCESSIVE PRESSURE BUILT UP BY CONTINUOUS ENGINE OPERATION MUST BE RELEASED TO A SAFE PRESSURE POINT. NEVER PERMIT THE PRESSURE TO EXCEED 138 kPa (20 psi).

Install SVT275 Cooling Pressure Tester available from MoparB® Service Equipment, or an equivalent to the pressurized coolant bottle. Start the engine and observe the tester's pressure gauge. If gauge pulsates with every power stroke of a cylinder a combustion pressure leak is evident.

CHEMICAL TEST METHOD

Combustion leaks into the cooling system can also be checked by using a (special tool #C-3685-A, Bloc-Chek Kit) or equivalent. Perform the test following the procedures supplied with the tool kit.

HYDRAULIC LIFTER(S) NOISE DIAGNOSIS

Proper noise diagnosis is essential in locating the source of an Noise, Vibration, and Harshness (NVH) complaint. Locating a lash adjuster (tappet) type noise can sometimes be difficult. As a result, an initial misdiagnosis may occur.

Refer to the following chart for possible causes and correction of a lash adjuster (tappet) type noise.

LASH ADJUSTER (TAPPET) NOISE CHART

POSSIBLE CAUSES	CORRECTION
1. Engine oil level-too high or too low. This may allow aerated oil to enter the adjusters and cause them to be spongy.	1. Check and correct the engine oil level.
2. Insufficient running time after rebuilding a cylinder head. De-aeration of the lash adjusters may be required	2. See Below: (a) Run the engine between 2000 and 3000 RPM for three to five minutes. Return the engine to standard idle speed for 30 to 60 seconds. Evaluate noise. If

POSSIBLE CAUSES	CORRECTION	
	noise is present, repeat the process an additional 4 cycles. If noise is present after additional cycles, take the vehicle on a typical drive cycle. **NOTE:** **The typical drive cycle will be about 10-15 miles of combined highway and city driving. Avoid marshaling maneuvers (quick start/stop operation) during evaluation.** (b) Low speed running of up to 1 hour may be required to fully evacuate trapped air from the valvetrain system. During this time, turn engine off and let set for a few minutes before restarting. Repeat this several times after engine has reached normal operating temperature.	
3. Debris/air trapped in the intake/exhaust lash adjuster(s).	3. **Intake adjuster only:** Check the intake lash adjuster(s) for a collapsed condition while installed in the cylinder head. Press down on the intake rocker arm in a manner that would compress the intake lash adjuster(s). Normal intake adjuster(s) should feel very firm and difficult to compress. If the intake lash adjuster(s) can be compressed or there is lash between the rocker arm and cam lobe, remove the suspect intake lash adjuster(s) from the cylinder head for further evaluation. Refer to **LIFTER(S), HYDRAULIC, REMOVAL AND INSTALLATION**. (a) A collapsed lash adjuster(s) will remain in a compressed state with no external force and no return force from the spring. This is caused when debris jams the piston causing the top plunger of the lash adjuster to stay collapsed in the bottom housing. If the lash adjuster(s) are confirmed to be collapsed, replace the lash adjuster(s).	B
	(b) A spongy lash adjuster(s) will return to its original state after being compressed. This is caused by air trapped in the lash adjuster(s) or debris blocking the check ball. The lash adjuster(s) will compress under a force and be returned to the original position under a spring force. If the lash adjuster(s) are confirmed to be spongy, repeat Step 2 as further run time may be required to de-aerate the lash adjuster(s). After repeating Step 2, see	B

POSSIBLE CAUSES	CORRECTION	
	Steps 1, 4, 5, and 8. **Exhaust lash adjuster(s) only:** Check the exhaust lash adjuster(s) for a collapsed condition while installed in the cylinder head. Press down on the exhaust rocker arm in a manner that would compress the exhaust lash adjuster(s). Normal exhaust adjuster(s) are designed to be compressible, but they will exert a reactionary spring force during compression and return to full expansion without a compression force. If the exhaust lash adjuster(s) can be compressed without returning to full expansion, remove the suspect lash adjuster(s) from the cylinder head for further evaluation. Refer to **LIFTER(S), HYDRAULIC, REMOVAL AND INSTALLATION**. (c) A collapsed lash adjuster(s) will remain in a compressed state with no external force and no return force from the spring. This is caused when debris jams the piston causing the top plunger of the lash adjuster to stay collapsed in the bottom housing. If the lash adjuster(s) are confirmed to be collapsed, replace the lash adjuster(s).	
4. Low oil pressure.	4. See below: (a) Check and correct the engine oil level. (b) Check the engine oil pressure. Refer to **LUBRICATION, DIAGNOSIS AND TESTING**. (c) Check for excessive main bearing clearance and correct. Refer to **BEARING(S), CRANKSHAFT, MAIN, STANDARD PROCEDURE**. (d) Check for a worn oil pump. Check the camshaft journals and the bearing bores for abnormal wear patterns, scoring, grooving, fatigue, pitting or a foreign material. Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION**.	B B B B B
5. A plugged oil restrictor in the oil passages to the cylinder head(s).	5. Check the cylinder head oil passages for blockage. Clean or replace as necessary.	
6. Worn valve guide(s).	6. Measure the valve stem-to-guide clearance. Refer to **VALVE TIMING** .	
7. Rocker arm loose, adjuster stuck or at maximum extension and still leaves lash in the system.	7. See below: (a) Check the camshaft journal and lobe for abnormal wear patterns, scoring, grooving, fatigue, pitting or a foreign material. Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION**. (b) Check the rocker arm(s) for proper alignment to the camshaft lobe(s) and valve stem(s). Refer to **ROCKER ARM, VALVE, REMOVAL AND INSTALLATION**. (c) Check the lash adjuster(s) for proper operation and replace as necessary. Refer to **LIFTER(S), HYDRAULIC, REMOVAL AND INSTALLATION**.	B B B
8. Air ingested into the engine oil due to a broken or cracked oil pump pickup tube.	8. Check the pickup tube and replace as necessary. Refer to **PICK-UP, OIL PUMP, REMOVAL AND INSTALLATION**.	

HYDRAULIC LASH ADJUSTER

A tappet-like noise may be produced from several items. Check the following items.

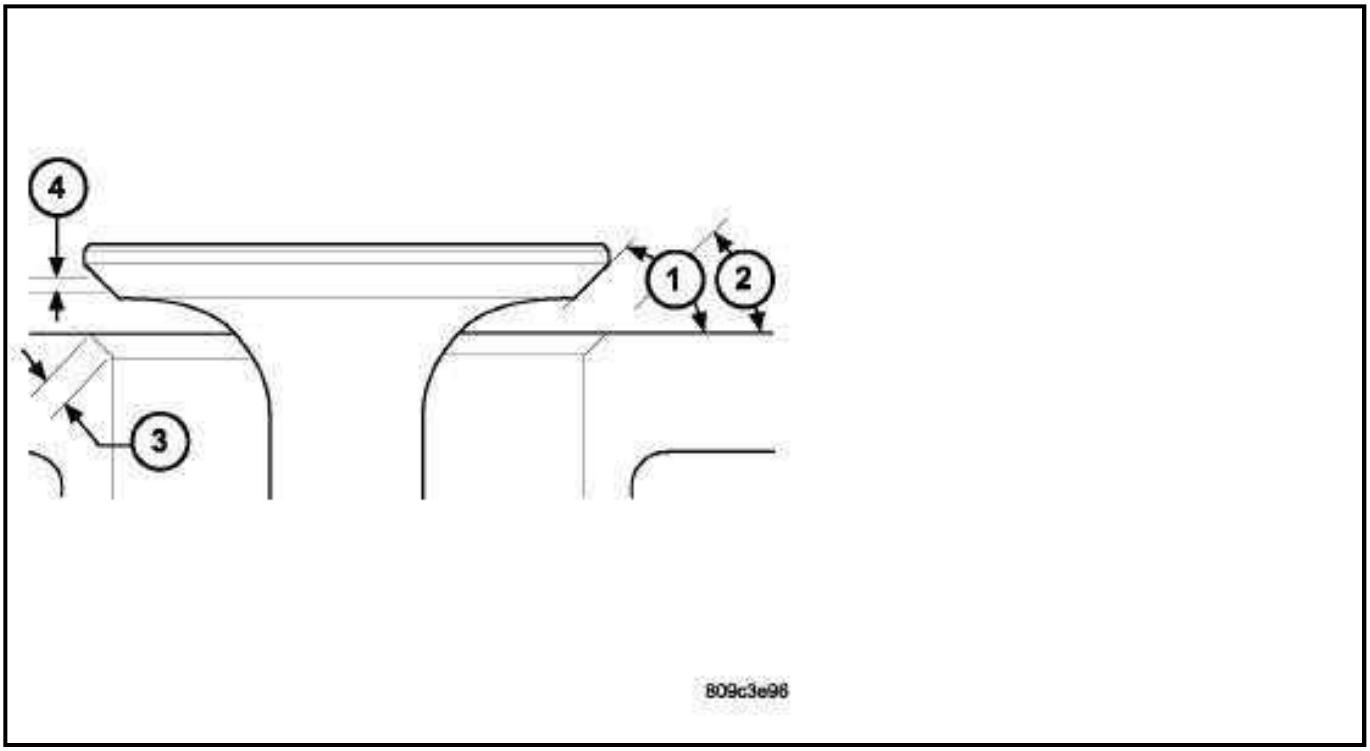
1. Engine oil level too high or too low. This may cause aerated oil to enter the adjusters and cause them to be spongy.
2. Insufficient running time after rebuilding the cylinder head. Low speed running up to 1 hour may be required.
3. Turn the engine off and let set for a few minutes before restarting. Repeat this several times after the engine has reached normal operating temperature.
4. Low oil pressure.
5. The oil restrictor in cylinder head gasket or the oil passage to the cylinder head is plugged with debris.
6. Air ingested into oil due to broken or cracked oil pump pick up.
7. Worn valve guides.
8. Rocker arm ears contacting valve spring retainer.
9. Rocker arm loose, adjuster stuck or at maximum extension and still leaves lash in the system.
10. Oil leak or excessive cam bore wear in cylinder head.
11. Faulty lash adjuster.

The internal check balls on the exhaust hydraulic lash adjusters are reversed, for more information. Refer to **CYLINDER HEAD, DESCRIPTION AND OPERATION**.

NOTE: **The exhaust hydraulic lifter must never be interchanged with any other hydraulic lifter than what is specifically designated for this vehicle. The internal check ball is reversed and could cause engine damage if an incorrect part is installed.**

STANDARD PROCEDURE

REFACING INTAKE AND EXHAUST VALVES



1 - Seat Width
2 - Face Angle
3 - Seat Angle

4 - Seat Contact Area

The intake and exhaust valves have a 45.25 B± 0.25 degree face angle. The valve seats have a 44.75 B± 0.25 degree face angle.

CLEANING

CAUTION: **When cleaning cylinder head and cylinder block surfaces, DO NOT use a metal scraper because the surfaces could be cut or ground. Use ONLY a wooden or plastic scraper.**

To ensure engine gasket sealing, proper surface preparation must be performed, especially with aluminum engine components and multi-layer steel cylinder head gaskets.

NOTE: **Multi-Layer Steel (MLS) head gaskets require a scratch free sealing surface.**

1. Remove all gasket material from cylinder head and block. Refer to this information . Be careful not to gouge or scratch the aluminum head sealing surface.
2. Clean all engine oil passages.

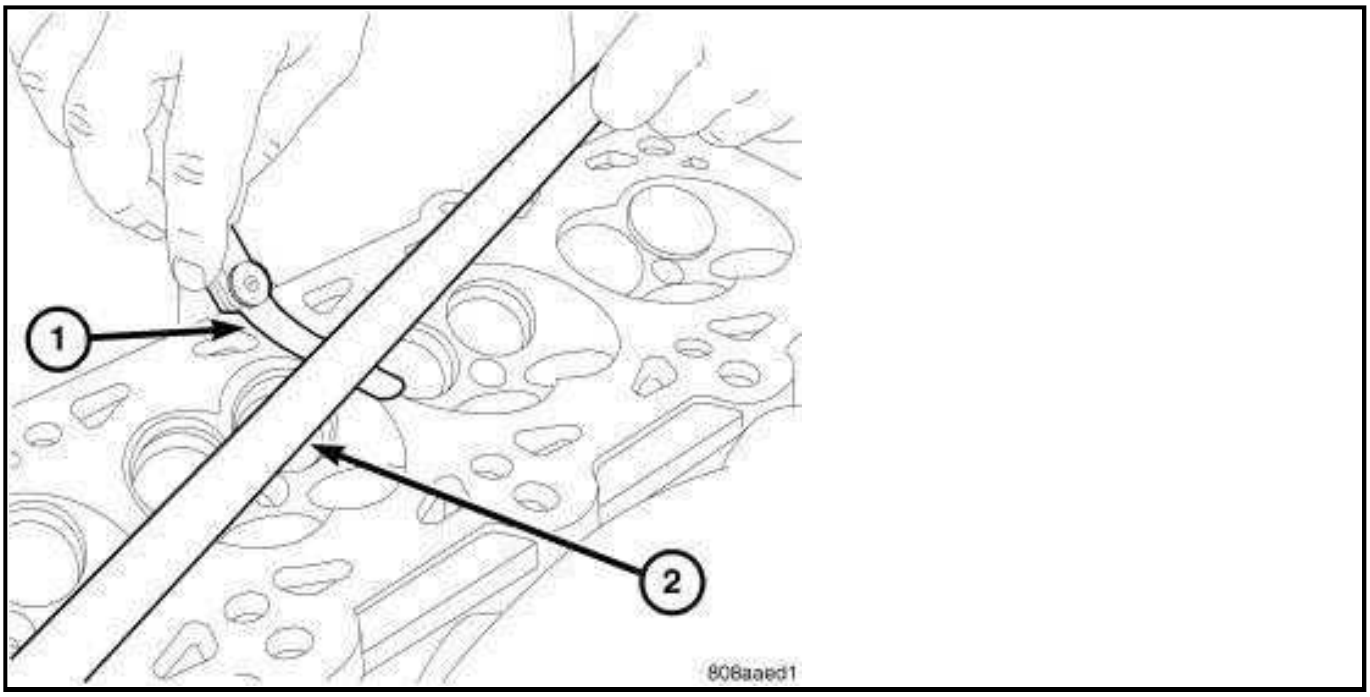
CAUTION: **Non-compressible debris such as oil, coolant or RTV sealants that are not removed from bolt holes can cause the aluminum casting to crack when tightening the bolts.**

3. Clean out the cylinder head bolt holes in the engine block.

DO NOT USE any adhesives when installing the MLS head gaskets. The use of adhesives may cause the gasket not to seal properly and may leak. MLS gaskets are to be installed on a surface free of debris and oils.

INSPECTION

INSPECTION



1. Check the cylinder head for warping with a straight edge (2) and feeler gauge (1).
2. Cylinder head must be flat within specifications. Refer to **ENGINE SPECIFICATIONS** .
3. Verify that the valve tappets move freely in their bores and that they have been rotating.

4. Inspect camshaft bearing journals for scoring.
5. Remove carbon and varnish deposits from inside of valve guides with a reliable guide cleaner.
6. Inspect the following components and verify that they are within specifications. Refer to **ENGINE SPECIFICATIONS** .
    - Camshafts
    - Valve Tappets
    - Springs
    - Valve Seats
    - Valve Guides
    - Valves

ROCKER ARM

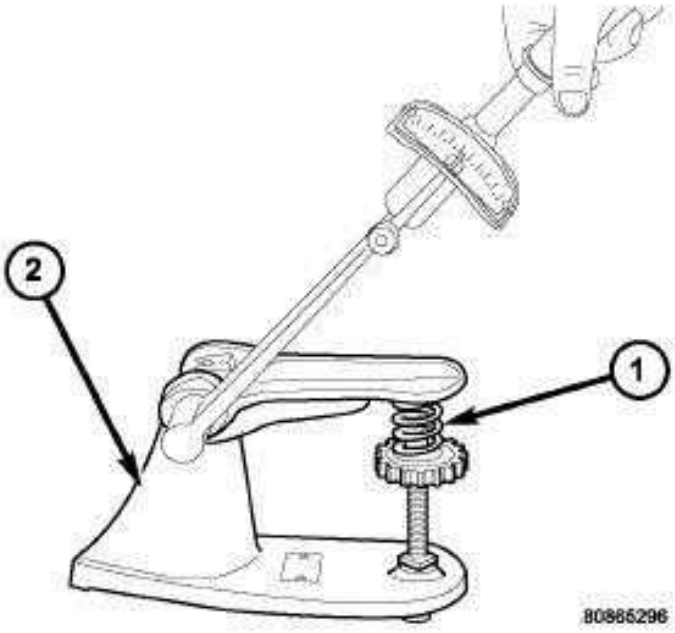
1 - Rocker Arm Assembly

Inspect the intake rocker arm assembly for wear or damage. Replace as necessary.

1 - Rocker Arm Assembly
2 - Retaining Clip

Inspect the exhaust rocker arm assembly for wear or damage. Replace as necessary.

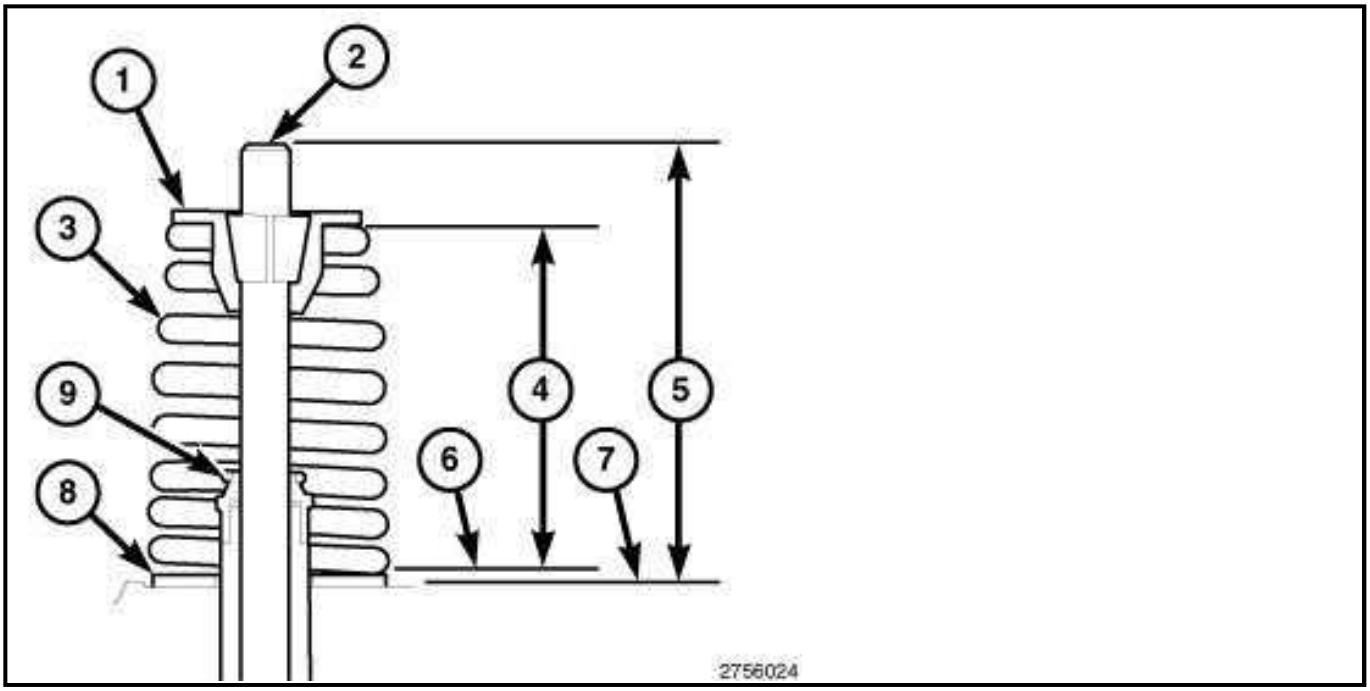
VALVE SPRING



1 - Valve Spring
2 - Test Fixture

When valves have been removed for inspection, reconditioning or replacement, valve springs should be checked against specifications for free-length, spring force and spring installed height. Refer to **ENGINE SPECIFICATIONS** .

Spring force can be measured with a test fixture. Follow the tool manufactures instructions. Replace any springs that do not meet specifications.



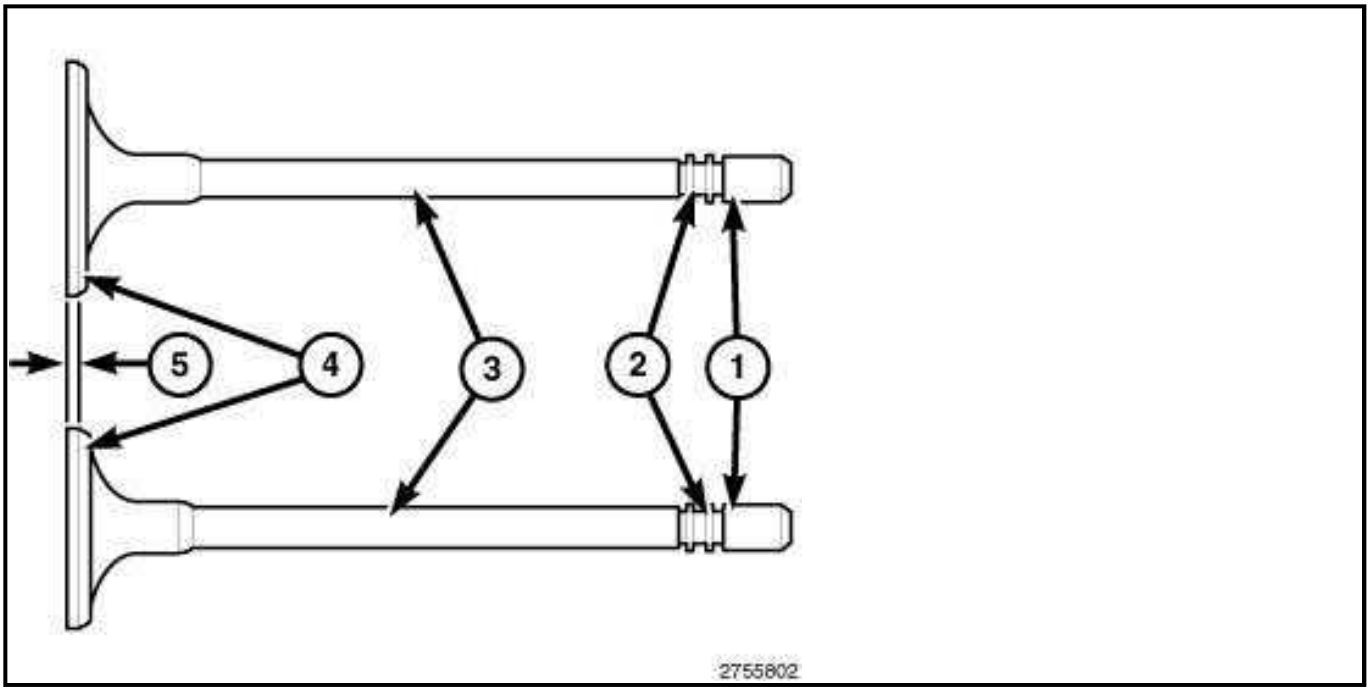
1 - Spring Retainer
2 - Valve Stem
3 - Valve Spring
4 - Valve Spring Height
5 - Valve Stem Tip Height
6 - Spring Seat
7 - Cylinder Head
8 - Second Spring Seat

Installed height of the valve spring must be checked with the valve assembled into the cylinder head.

If the valves or valve seats have been refinished and the installed valve spring height is greater than 41.0 mm (1.61 in.), install a second spring seat in the head counter bore under the original valve spring seat to bring the spring height within specification. Make sure the measurement is taken from the top of spring seat to the bottom surface of spring retainer.

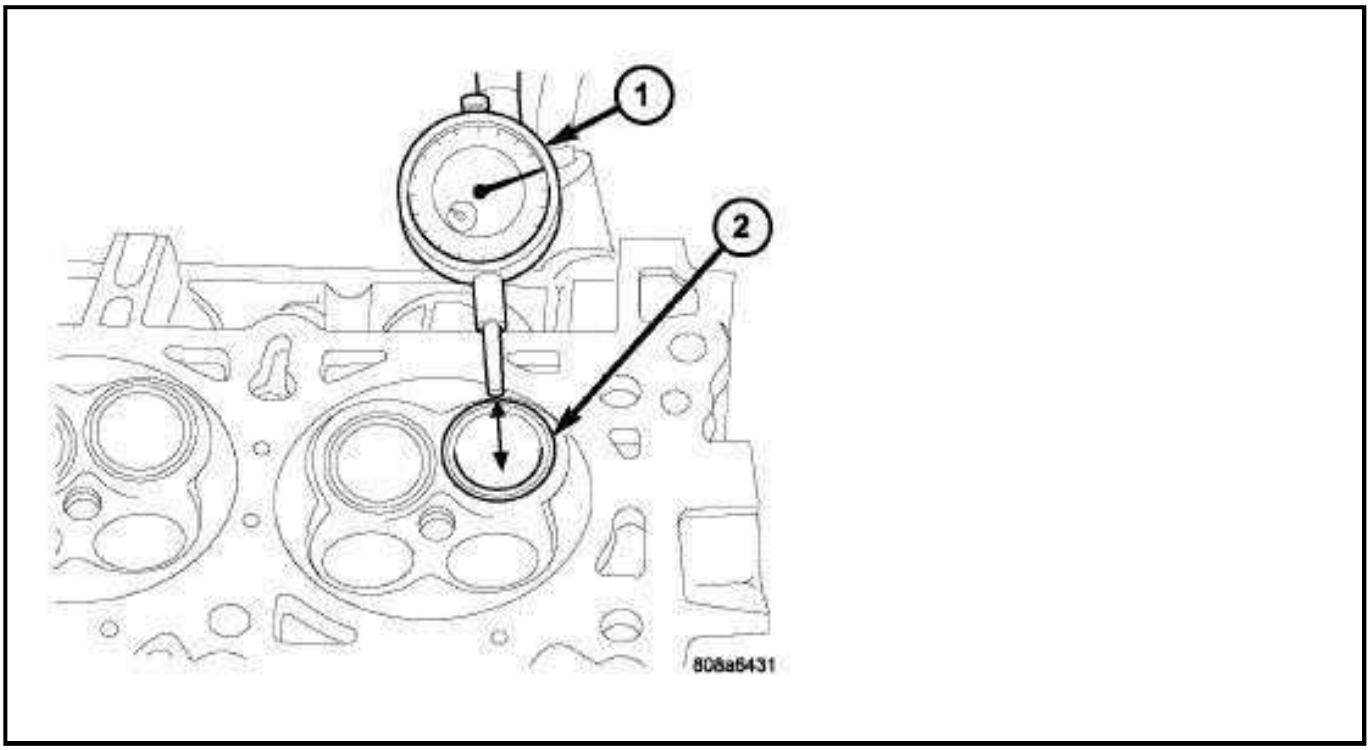
VALVES AND GUIDES

VALVES



1. Clean and inspect the valves thoroughly. Replace burned, warped and cracked valves.
2. Inspect the retainer lock grooves for wear or damage (2).
3. Inspect the valve face (4) for wear and pitting.
4. Measure the valve stems (3) and margins (5) for wear.

VALVE GUIDES



1. Remove carbon and varnish deposits from inside of the valve guides with a reliable guide cleaner.
2. Measure valve stem-to-guide clearance as follows:
3. Install the valve (2) into the cylinder head so that it is 15 mm (0.590 in.) from the valve seat. A small piece of hose may be used to hold the valve in place.
4. Attach the Dial Indicator Set (special tool #C-3339A, Set, Dial Indicator) (1) to the cylinder head and set it at a right angle to the valve stem being measured.

NOTE: **If stem-to-guide clearance exceeds specifications, you must measure the valve stem. If the valve stem is within specification or if the valve guide is loose in the cylinder head, replace the cylinder head.**

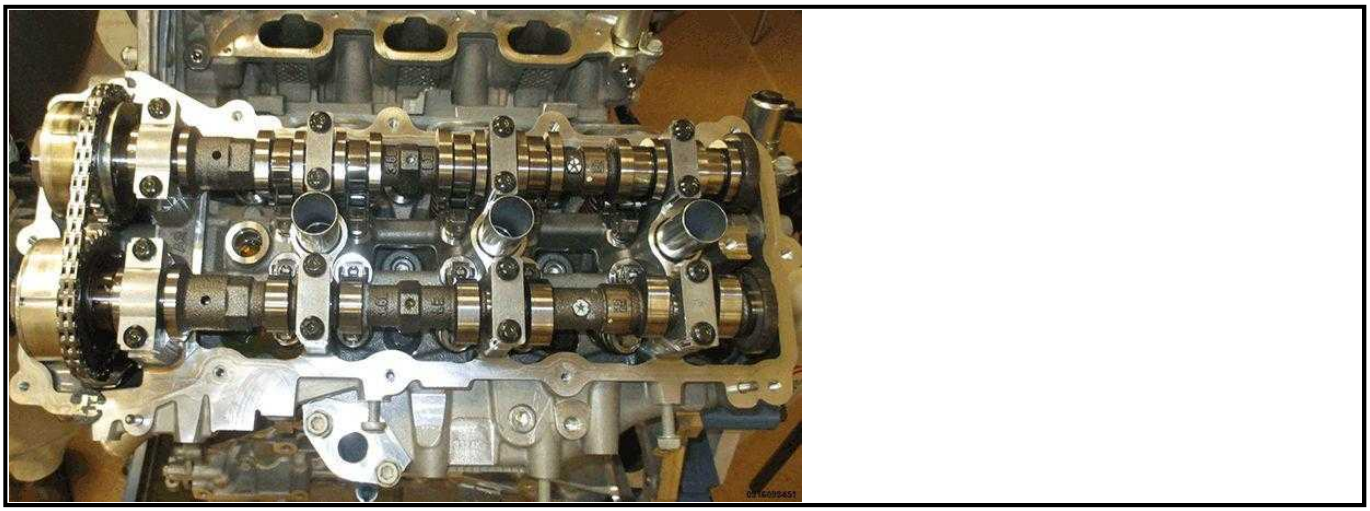
5. Move the valve to and from the indicator. Compare this reading to the specification. Refer to **ENGINE SPECIFICATIONS** .

CAMSHAFT, ENGINE

DESCRIPTION AND OPERATION

DESCRIPTION AND OPERATION

CAMSHAFT



The Pentastar engine uses a Dual Over Head Camshaft (DOHC) configuration designed to work with the two-step Variable Valve Lift (VVL) system.

- The camshafts are a nodular cast iron design.
- Each camshaft has a pressed on magnetic timing wheel that is magnetically encoded.
- The two Camshaft Position (CMP) sensors are located between the timing wheels.
- Attached to the rear of the right exhaust camshaft is a centrifuge which is part of the crankcase ventilation system.

Intake Camshafts

- Intake valve lift centerlines: 146B° (high lift), 104B° (low lift).
- Tri-lobe design for two-step switchable roller finger follower.
- Gun drilled for weight reduction.

Exhaust Camshafts

- Valve lift centerline: 123B°.
- Refined double-polish surface finish on journals
- Gun drilled for weight reduction.

The centrifuge is used to separate oil droplets from the crankcase gases before they enter the PCV valve. Four bearing journals are machined into the camshaft. Camshaft end play is controlled by two thrust walls that border the nose piece journal.

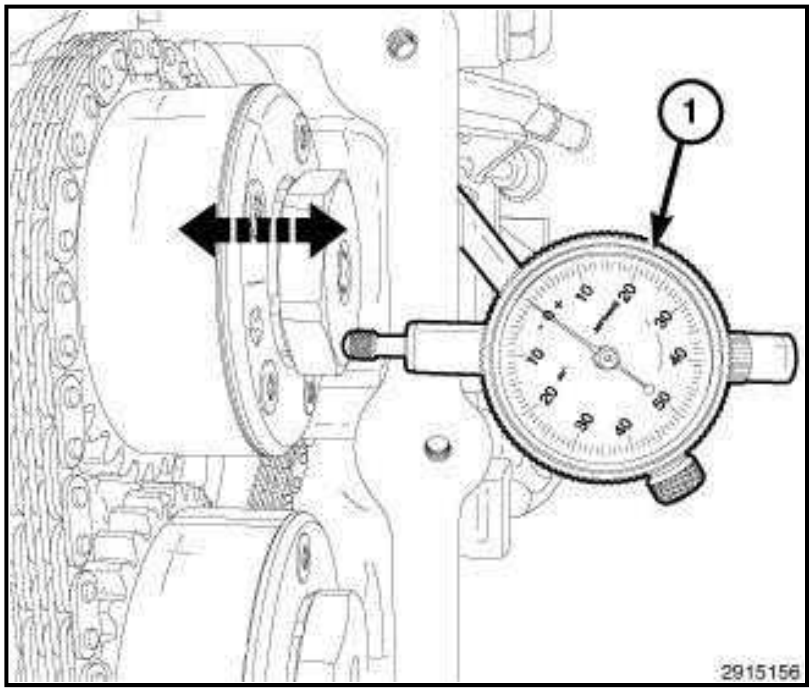
STANDARD PROCEDURE

CAMSHAFT END PLAY

1. Remove the cylinder head cover. Refer to **COVER(S), CYLINDER HEAD, REMOVAL AND INSTALLATION**.

NOTE: **Cylinder #1 or #4 must be used when checking for Top Dead Center (TDC).**

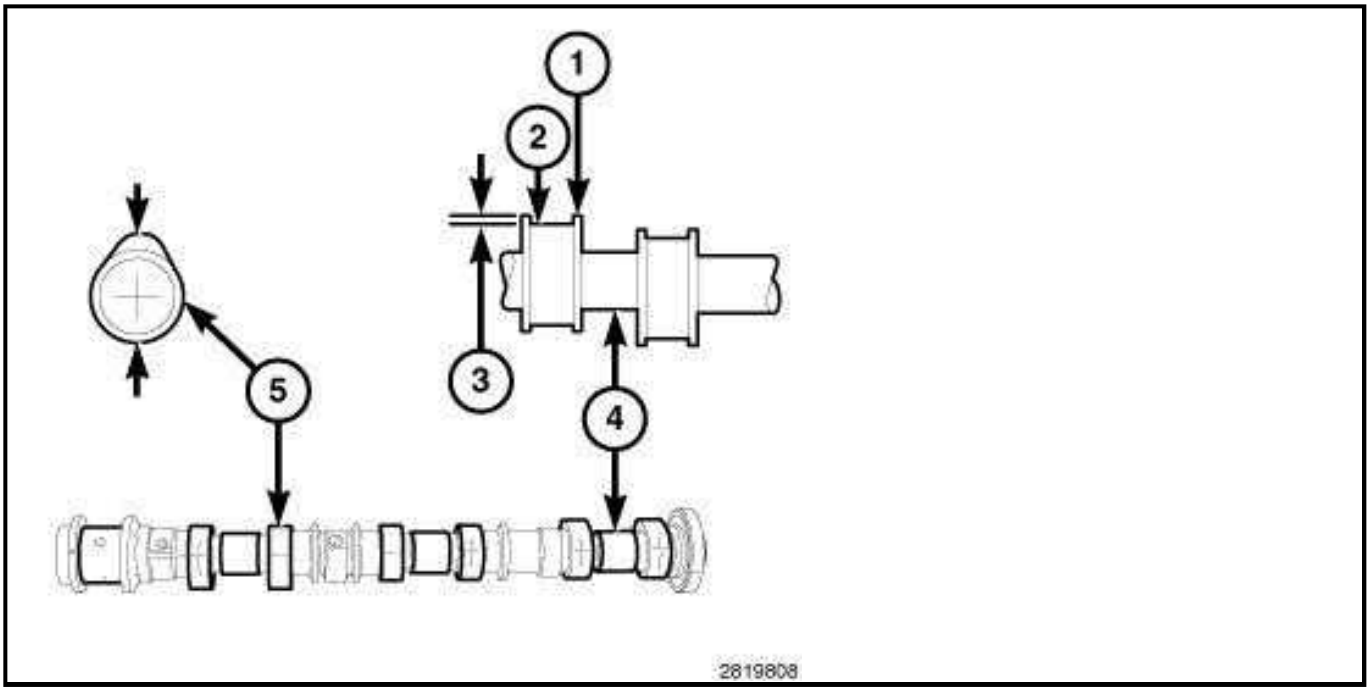
NOTE: **Right intake camshaft shown, other camshafts similar.**



1 - Dial Indicator

2. Mount the Dial Indicator Set (special tool #C-3339A, Set, Dial Indicator) to a stationary point at the front of the engine. Place the probe perpendicular against the Oil Control Valve (OCV) of the camshaft.
3. Move the camshaft all the way to the rear of its travel.
4. Zero the dial indicator.
5. Move the camshaft forward to the limit of travel and read the dial indicator. Compare the measured end play to the specification. Refer to **ENGINE SPECIFICATIONS** .

INSPECTION



NOTE: **RH intake camshaft shown, other camshafts similar.**

1. Inspect camshaft bearing journals (4) for damage and binding. If journals are binding, check the cylinder head for damage. Also check cylinder head oil holes for clogging.
2. Check the surface of the cam lobes (5) for abnormal wear (3). Measure and compare the unworn area (1) to the worn area (2). Replace camshafts that are not within specification. Refer to **ENGINE SPECIFICATIONS** .

REMOVAL AND INSTALLATION

LEFT CAMSHAFT

REMOVAL

CAUTION: **When the timing chain is removed and the cylinder heads are still installed, do not forcefully rotate the camshafts or crankshaft independently of each other. Severe valve or piston damage can occur.**

CAUTION: **DO NOT STAMP OR STRIKE THE CAMSHAFT BEARING CAPS. SEVERE DAMAGE WILL OCCUR TO THE BEARING CAPS.**

1. Remove the camshaft phasers. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** .

NOTE: **Camshaft bearing caps should have been marked during engine manufacturing. For example, the number one exhaust camshaft bearing cap is marked "1E->". The caps should be installed with the notch forward.**

1 - Alignment Holes

2. Rotate the camshafts counterclockwise to position the alignment holes **approximately 30B° before top-dead-center** . This places the camshafts in the neutral position (no valve load).

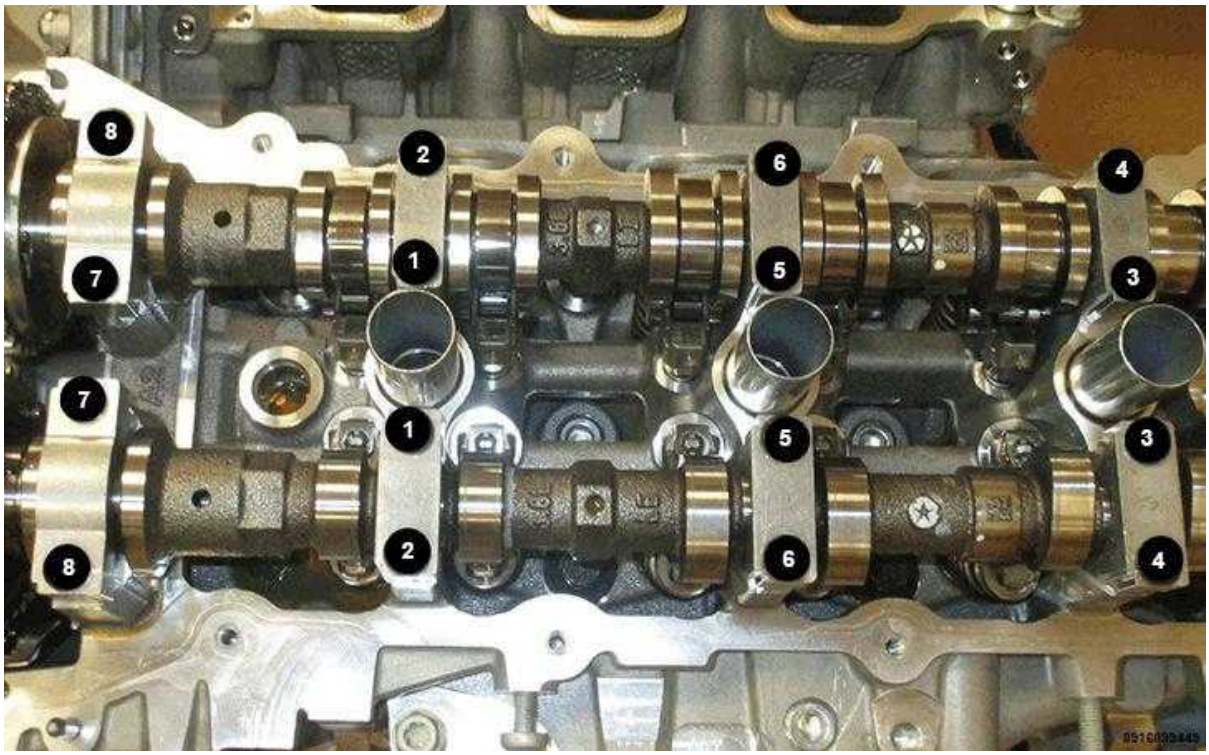


Fig. 1: Camshaft Bearing Cap Bolts Removal & Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

3. Loosen the camshaft bearing cap bolts reversing the sequence shown, starting at 8 and ending with 1.

NOTE: **When the camshaft is removed the rocker arms may slide downward, mark the rocker arms before removing the camshaft.**

4. Remove the camshaft bearing caps and the camshafts.

INSTALLATION

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

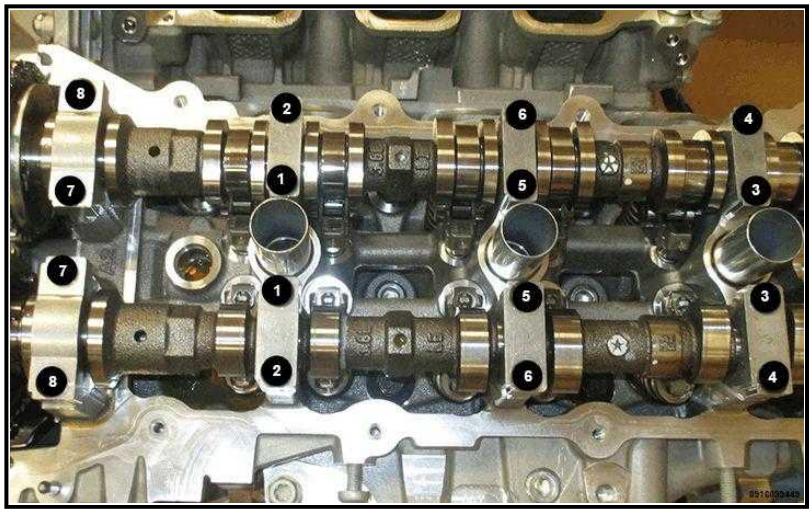
1. Lubricate the camshaft journals with clean engine oil.

CAUTION: **Do not rotate the camshafts more than a few degrees independently of the crankshaft. Valve to piston contact could occur resulting in possible valve damage. If the camshafts need to be rotated more than a few degrees, first move the pistons away from the cylinder heads by rotating the crankshaft counterclockwise to a position 30B° before-top-dead-center. Once the camshafts are returned to their top-dead-center position, rotate the crankshaft clockwise to return the crankshaft to top-dead-center.**

1 - Alignment Holes

2. Install the left side camshaft(s) with the alignment holes positioned approximately 30B° before top-dead-center. This will place the camshafts at the neutral position (no valve load) easing the installation of the camshaft bearing caps.

   Caps are identified numerically (1 through 4), intake or exhaust (I or E) and should be installed from the front to the rear of the engine. All caps should be installed with the notch forward so that the stamped arrows (<) on the caps point toward the front of the engine.

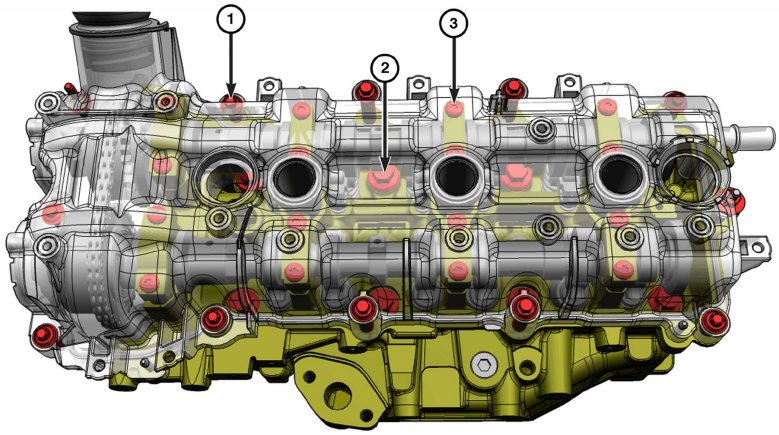


3. Install the camshaft bearing caps and tighten the bolts finger tight.
4. Verify the rocker arms are aligned to the cam lobe. Refer to **ROCKER ARM, VALVE, REMOVAL AND INSTALLATION**.
5. Using the tightening sequence shown, tighten the bearing cap bolts to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .
6. Rotate the camshafts clockwise to top-dead-center by positioning the alignment holes vertically.
7. Install the camshaft phasers. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** .

NOTE: **The Cam/Crank Variation Relearn procedure must be performed using the scan tool anytime there has been a repair/replacement made to a powertrain system, for example: flywheel, valvetrain, camshaft and/or crankshaft sensors or components.**

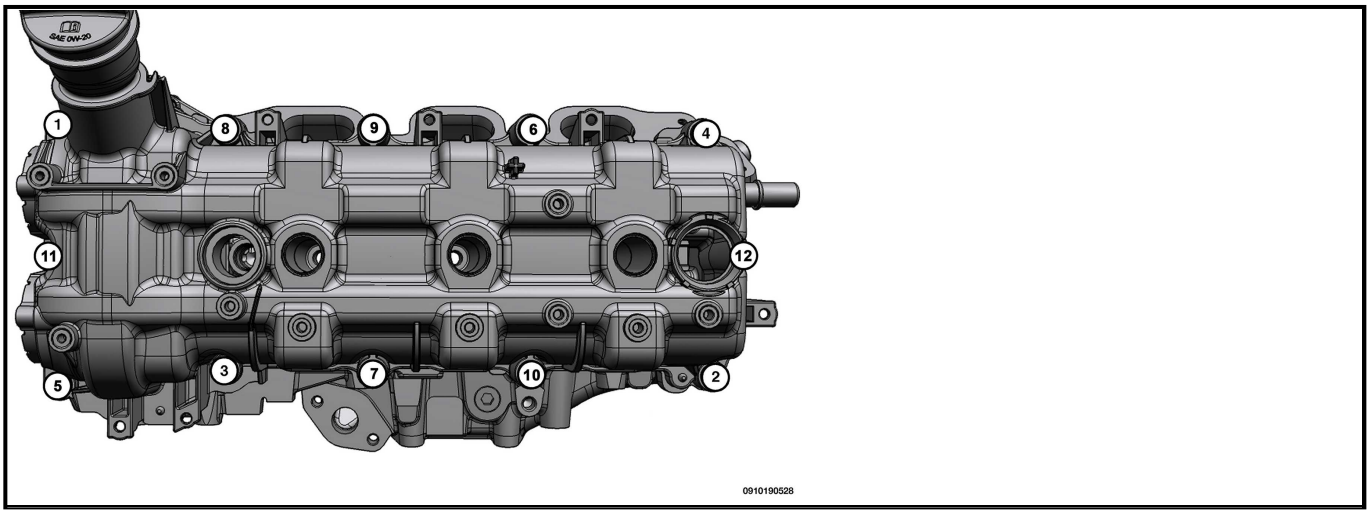
TORQUE SPECIFICATIONS

CYLINDER HEAD

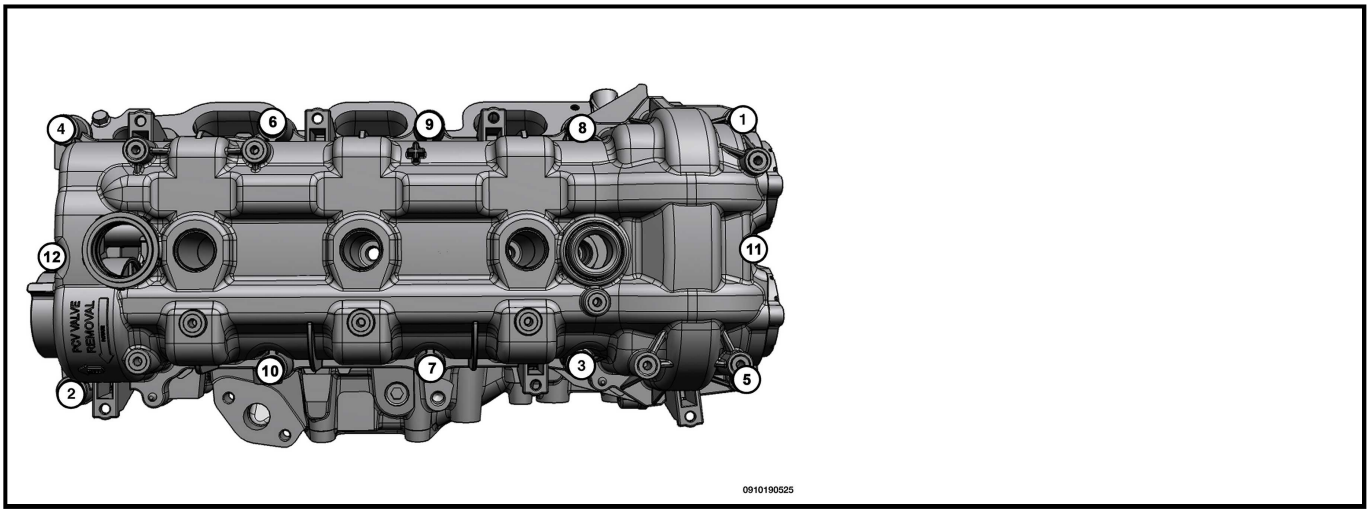


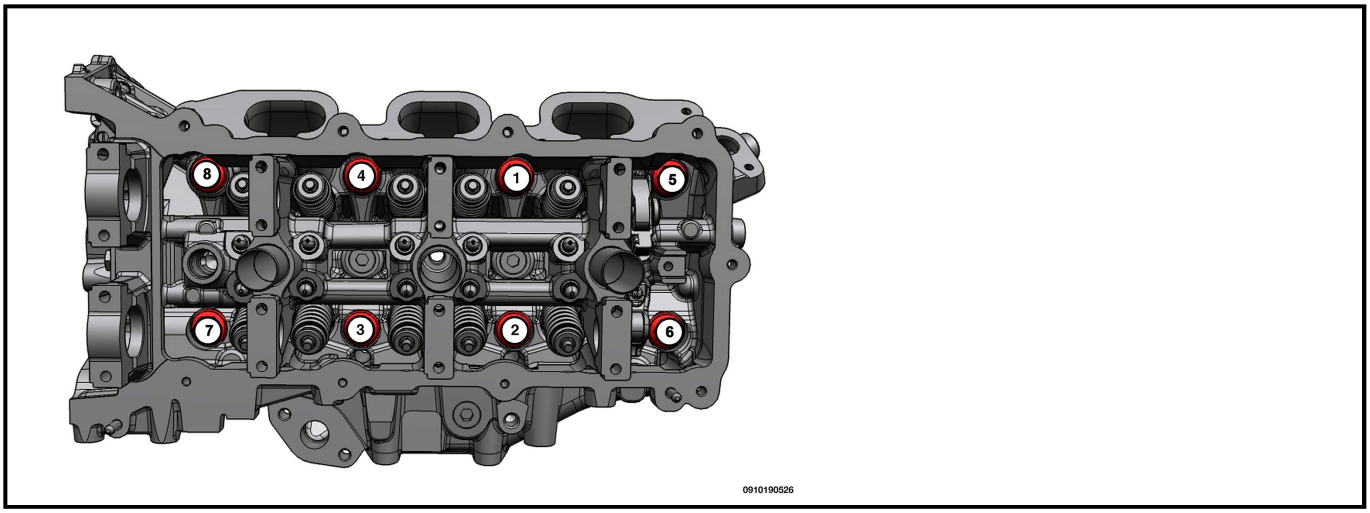
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Cylinder Head Cover M6 Bolts	**12 N.m (9 Ft. Lbs.)**	Tightening Sequence - Left
2	Cylinder Head Bolts	**Torque Procedure** For engine builds using a new block follow steps 1-9. For engine re-builds (reuse block) follow step 6-9. 1. 30 N. m (22 ft. lbs.) 2. 45 N. m (33 ft. lbs.) 3. Re-tighten all to 45 N. m (33 ft. lbs.) 4. All + 125B° Turn. Do not use a torque wrench for this step. 5. Loosen all fasteners in reverse of sequence shown 6. All to 30 N. m (22 ft. lbs.) 7. All to 45 N. m (33 ft. lbs.) 8. Re-tighten all to 45 N. m (33 ft. lbs.) 9. All + 130B° Turn. Do not use a torque wrench for this step.	Tightening Sequence - Left
3	Camshaft Bearing Cap Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence - Left

CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
-	Cylinder Head Coolant Pipe Plug	**35 N.m (26 Ft. Lbs.)**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
-	Cylinder Head Oil Galley Plug	**18 N.m (13 Ft. Lbs.)**	-
-	Cylinder Head Oil Restrictor M8 Plug	**15 N.m (11 Ft. Lbs.)**	-
-	Ground Strap Bolt to Right Cylinder Head	**23 N.m (17 Ft. Lbs.)**	-
-	Heater Core Supply Tube to Cylinder Head M8 Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Wire Harness Retainer Bracket to LH Cylinder Head Bolts	**10 N.m (89 In. Lbs.)**	-

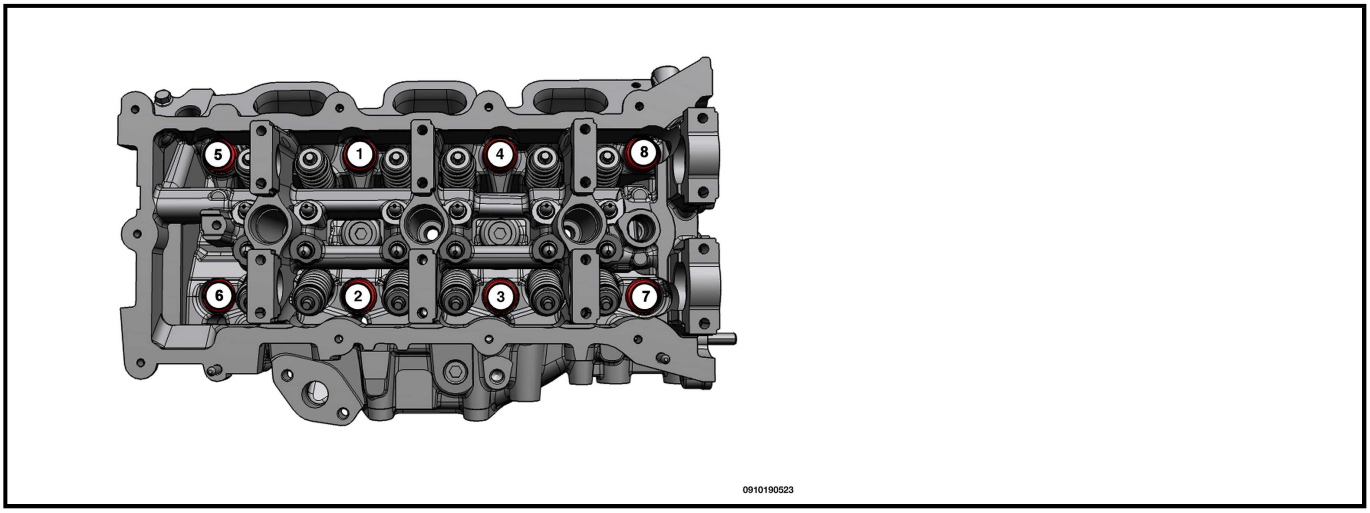


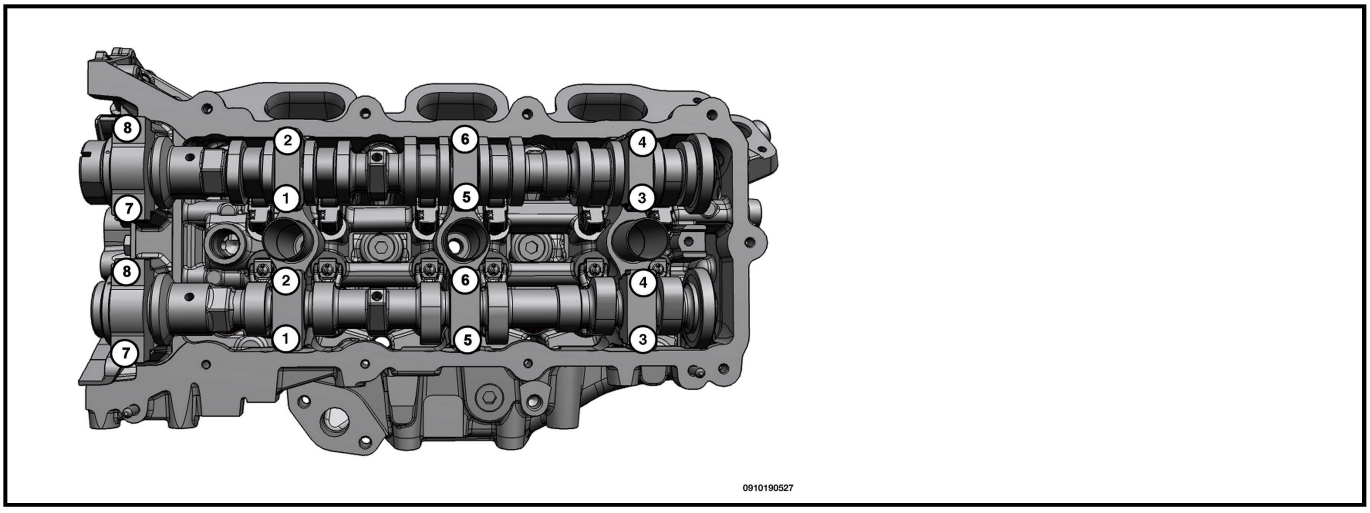
Tightening Sequence - Right





Tightening Sequence - Right





Tightening Sequence - Right

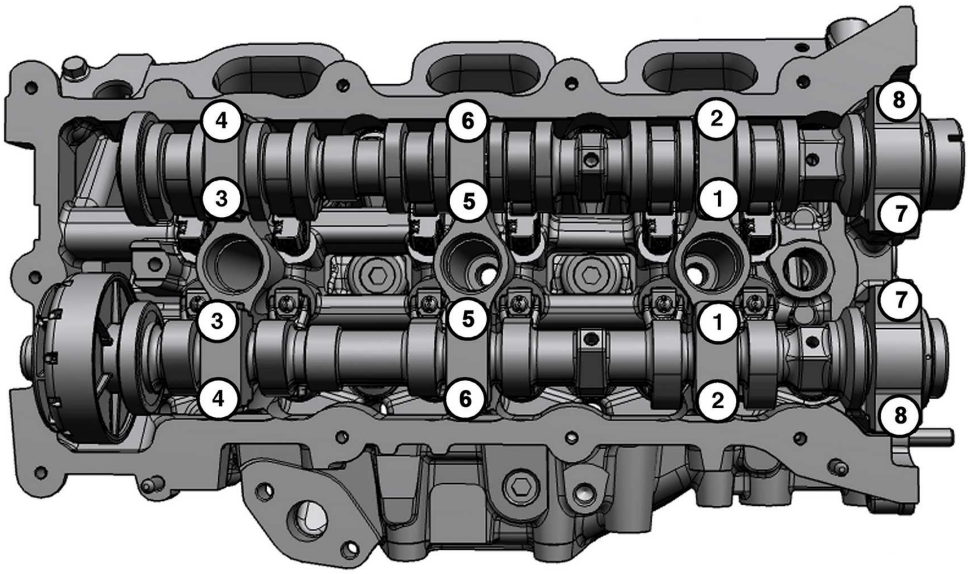
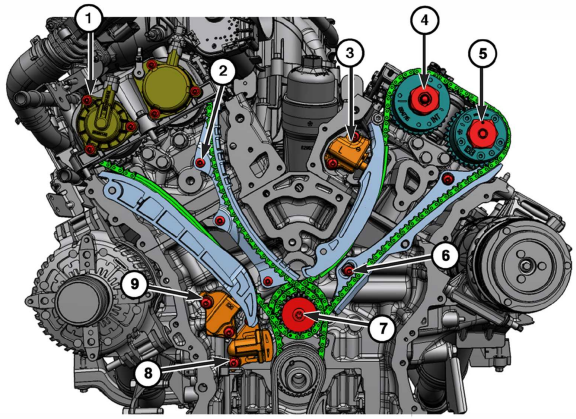


Fig. 2: Camshaft Bearing Cap Bolts Tightening Sequence (2 of 2)
Courtesy of CHRYSLER GROUP, LLC

VALVE TIMING

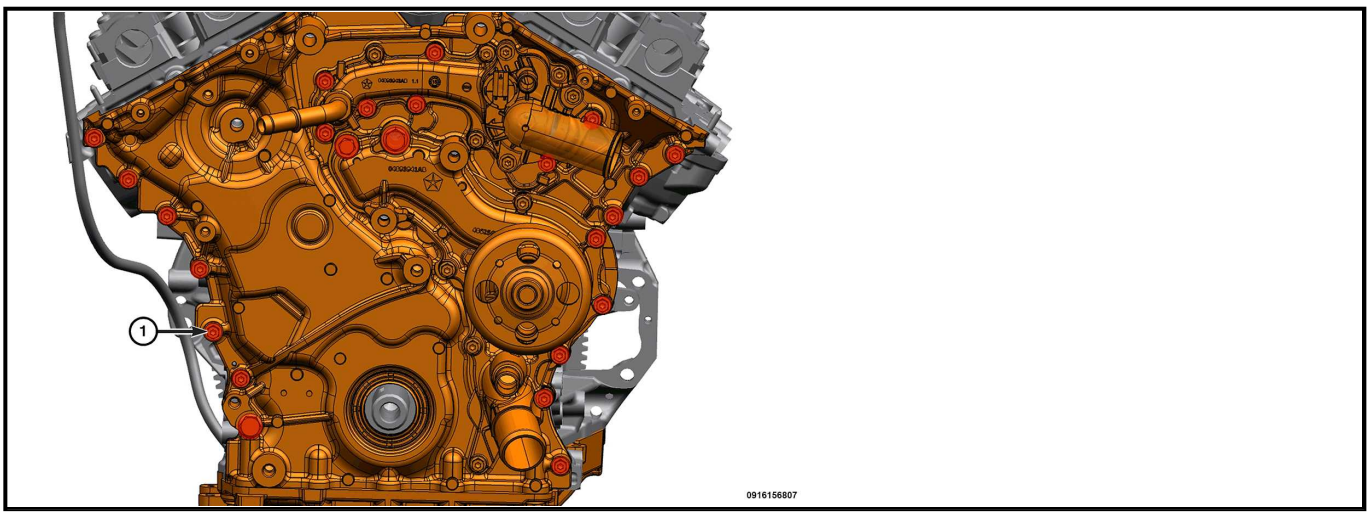


CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-

CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

FRONT ENGINE

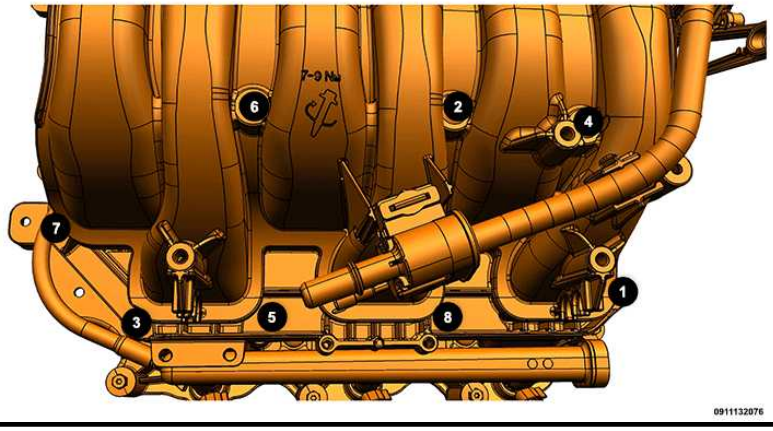
DESCRIPTION	SPECIFICATION	COMMENTS
Center Idler Pulley Bracket Bolts	**M8 Bolts - 25 N.m (18 Ft. Lbs.)** **M10 Bolts - 55 N.m (41 Ft. Lbs.)**	-
Center Idler Pulley Bracket to Generator Bolts	**24 N.m (18 Ft. Lbs.)**	-
Center Idler Pulley Bolt	**50 N.m (37 Ft. Lbs.)**	-
Left Idler Pulley Bolt	**25 N.m (18 Ft. Lbs.)**	-
Right Idler Pulley Bracket Bolts	**24 N.m (18 Ft. Lbs.)**	-
Right Idler Pulley Bolt	**25 N.m (18 Ft. Lbs.)**	-
Vibration Damper M16 Bolt	**Torque Procedure:** 1. **40 N.m (30 Ft. Lbs.)** 2. **Rotate additional + 105B°**	-
Belt Tensioner Bolt	**50 N.m (37 Ft. Lbs.)**	-
Engine Timing Cover M6 Bolts Engine Timing Cover M8 Bolt Engine Timing Cover M10 Bolts	**12 N.m (9 Ft. Lbs.)** **25 N.m (18 Ft. Lbs.)** **55 N.m (41 Ft. Lbs.)**	**Tighten in a criss-cross pattern**

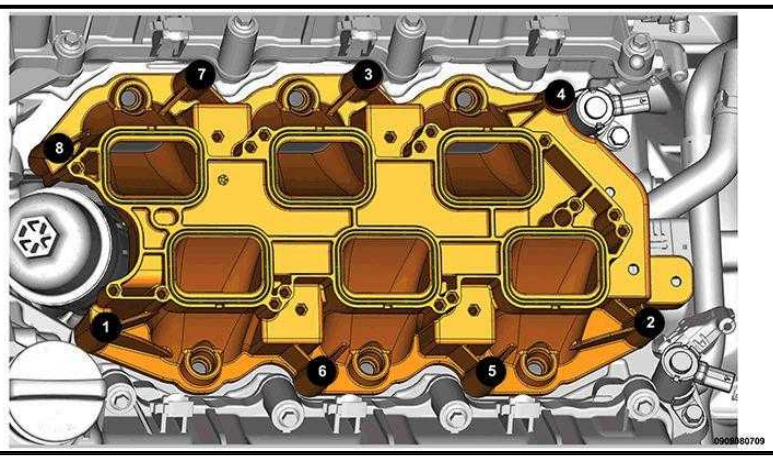


AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-





RIGHT CAMSHAFT

REMOVAL

CAUTION: **When the timing chain is removed and the cylinder heads are still installed, do not forcefully rotate the camshafts or crankshaft independently of each other. Severe valve or piston damage can occur.**

CAUTION: **DO NOT STAMP OR STRIKE THE CAMSHAFT BEARING CAPS. SEVERE DAMAGE WILL OCCUR TO THE BEARING CAPS.**

1. Remove the variable valve timing assembly. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** .

NOTE: **Camshaft bearing caps should have been marked during engine manufacturing. For example, the number one exhaust camshaft bearing cap is marked "1E->". The caps should be installed with the notch forward.**

1 - Alignment Holes

2. Rotate the camshafts counterclockwise to position the alignment holes at top-dead-center.

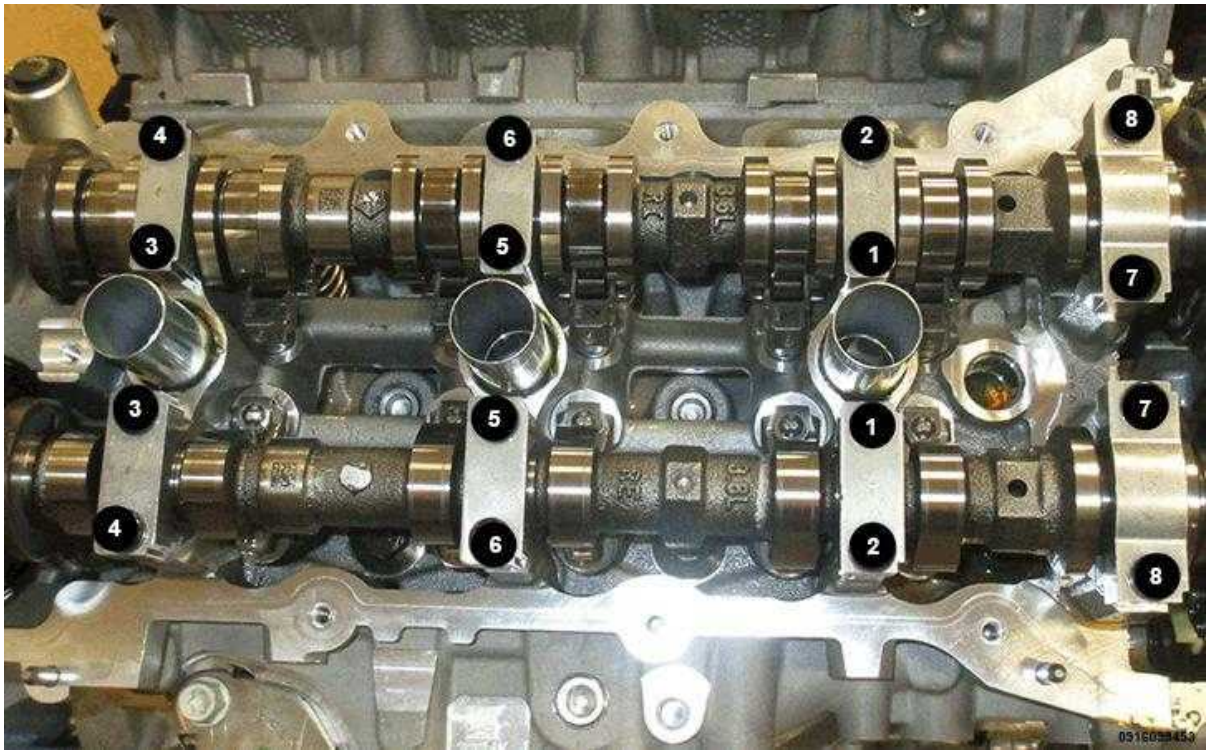


Fig. 3: Camshaft Bearing Cap Bolts Tightening Sequence - Right
Courtesy of CHRYSLER GROUP, LLC

3. Loosen the camshaft bearing cap bolts reversing the sequence shown, starting at 8 and ending with 1.

NOTE: **When the camshaft is removed the rocker arms may slide downward, mark the rocker arms before removing the camshaft.**

4. Remove the camshaft bearing caps and the camshafts.

INSTALLATION

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

1. Lubricate camshaft journals with clean engine oil.

CAUTION: **Do not rotate the camshafts more than a few degrees independently of the crankshaft. Valve to piston contact could occur resulting in possible valve damage. If the camshafts need to be rotated more than a few degrees, first move the pistons away from the cylinder heads by rotating the crankshaft counterclockwise to a position 30B° before-top-dead-center. Once the camshafts are returned to their top-dead-center position, rotate the crankshaft clockwise to return the crankshaft to top-dead-center.**

1 - Alignment Holes

2. Install the right side camshaft(s) at top-dead-center by positioning the alignment holes vertically. This will place the camshafts at the neutral position (no valve load) easing the installation of the camshaft bearing caps.

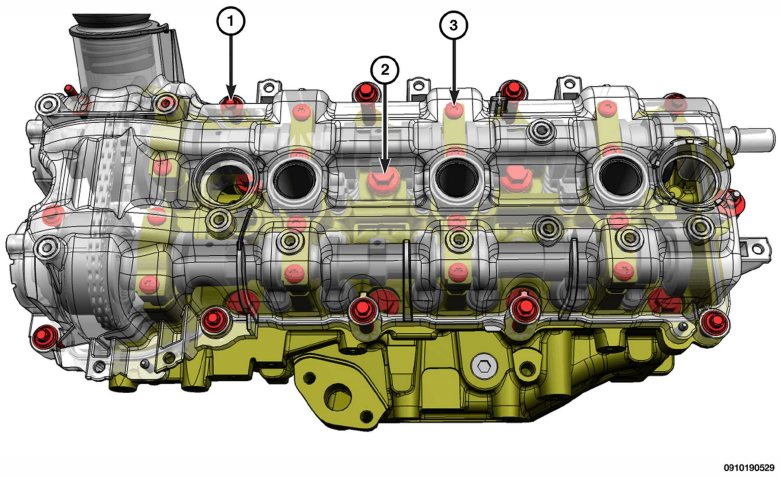
NOTE: **Caps are identified numerically (1 through 4), intake or exhaust (I or E) and should be installed from the front to the rear of the engine. All caps should be installed with the notch forward so that the stamped arrows (<) on the caps point toward the front of the engine.**

3. Install the camshaft bearing caps and tighten the bolts finger tight.
4. Verify the rocker arms are aligned to the cam lobe. Refer to **ROCKER ARM, VALVE, REMOVAL AND INSTALLATION**.
5. Using the sequence shown, tighten the bearing cap bolts to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .
6. Rotate the camshaft clockwise to the top-dead-center by positioning the alignment holes vertically.
7. Install the variable valve timing assembly. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** .

NOTE: **The Cam/Crank Variation Relearn procedure must be performed using the scan tool anytime there has been a repair/replacement made to a powertrain system, for example: flywheel, valvetrain, camshaft and/or crankshaft sensors or components.**

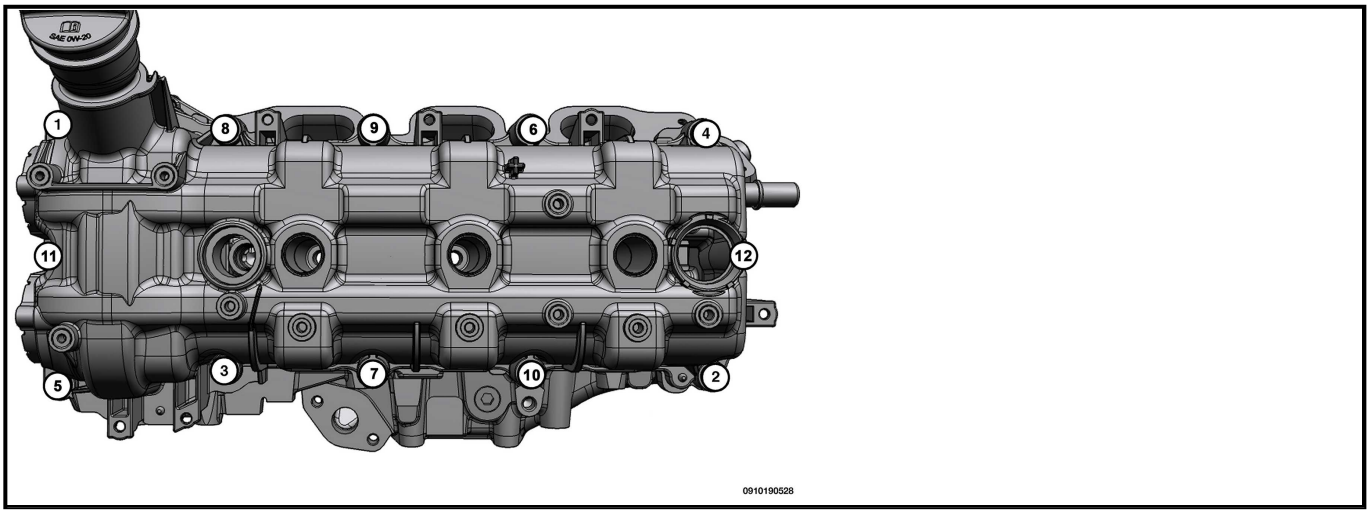
TORQUE SPECIFICATIONS

CYLINDER HEAD

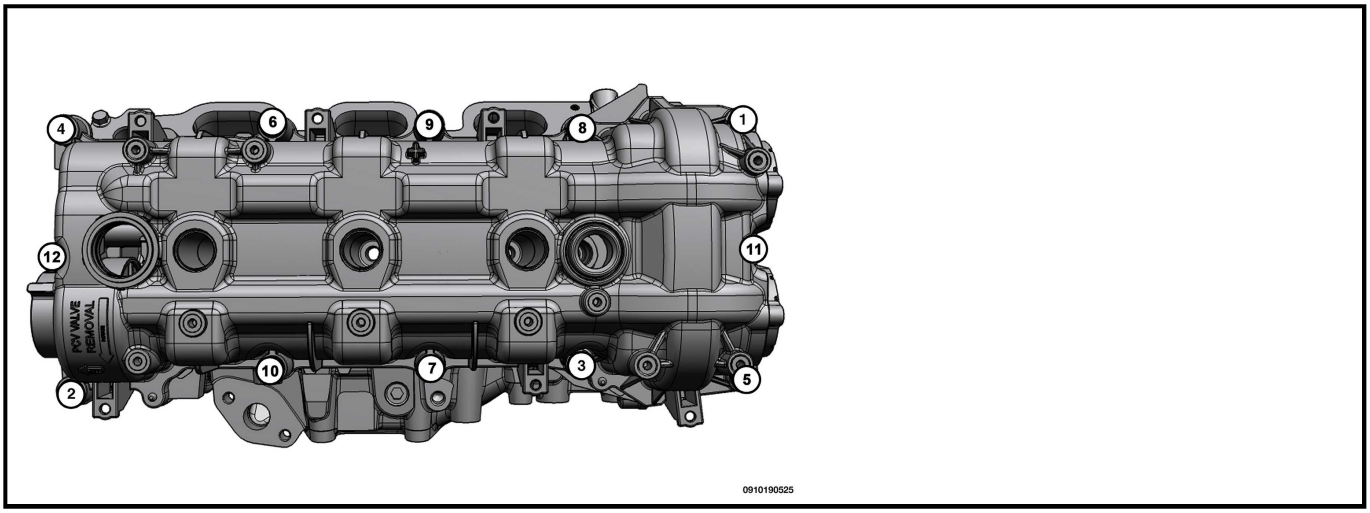


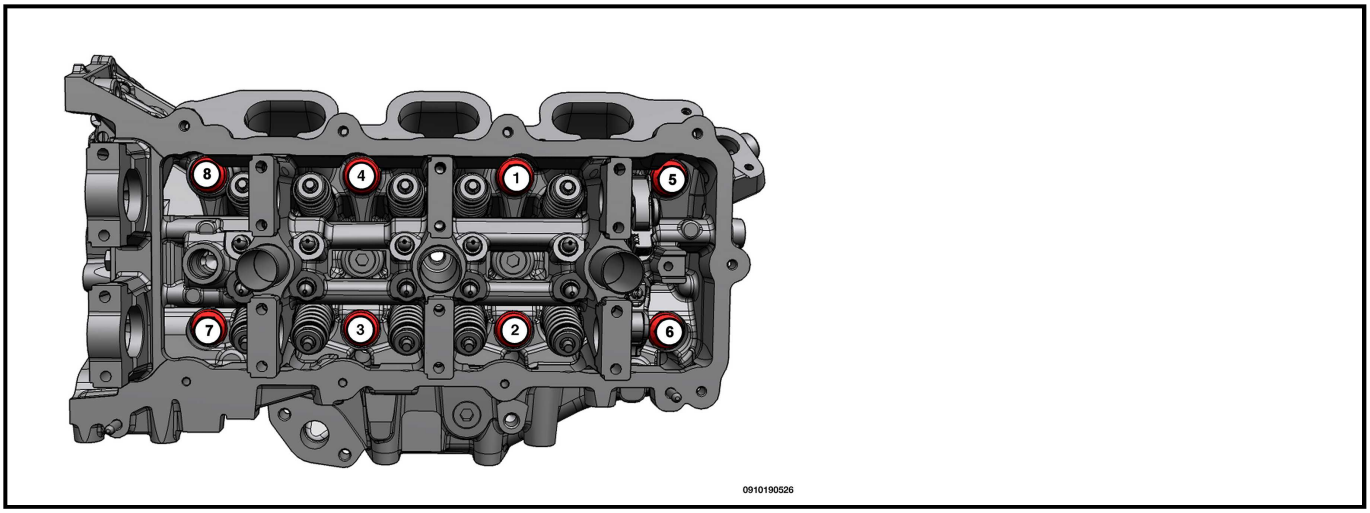
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Cylinder Head Cover M6 Bolts	**12 N.m (9 Ft. Lbs.)**	Tightening Sequence - Left
2	Cylinder Head Bolts	**Torque Procedure** For engine builds using a new block follow steps 1-9. For engine re-builds (reuse block) follow step 6-9. 1. 30 N. m (22 ft. lbs.) 2. 45 N. m (33 ft. lbs.) 3. Re-tighten all to 45 N. m (33 ft. lbs.) 4. All + 125B° Turn. Do not use a torque wrench for this step. 5. Loosen all fasteners in reverse of sequence shown 6. All to 30 N. m (22 ft. lbs.) 7. All to 45 N. m (33 ft. lbs.) 8. Re-tighten all to 45 N. m (33 ft. lbs.) 9. All + 130B° Turn. Do not use a torque wrench for this step.	Tightening Sequence - Left
3	Camshaft Bearing Cap Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence - Left
-	Cylinder Head Coolant Pipe Plug	**35 N.m (26 Ft. Lbs.)**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
-	Cylinder Head Oil Galley Plug	**18 N.m (13 Ft. Lbs.)**	-

CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
-	Cylinder Head Oil Restrictor M8 Plug	**15 N.m (11 Ft. Lbs.)**	-
-	Ground Strap Bolt to Right Cylinder Head	**23 N.m (17 Ft. Lbs.)**	-
-	Heater Core Supply Tube to Cylinder Head M8 Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Wire Harness Retainer Bracket to LH Cylinder Head Bolts	**10 N.m (89 In. Lbs.)**	-

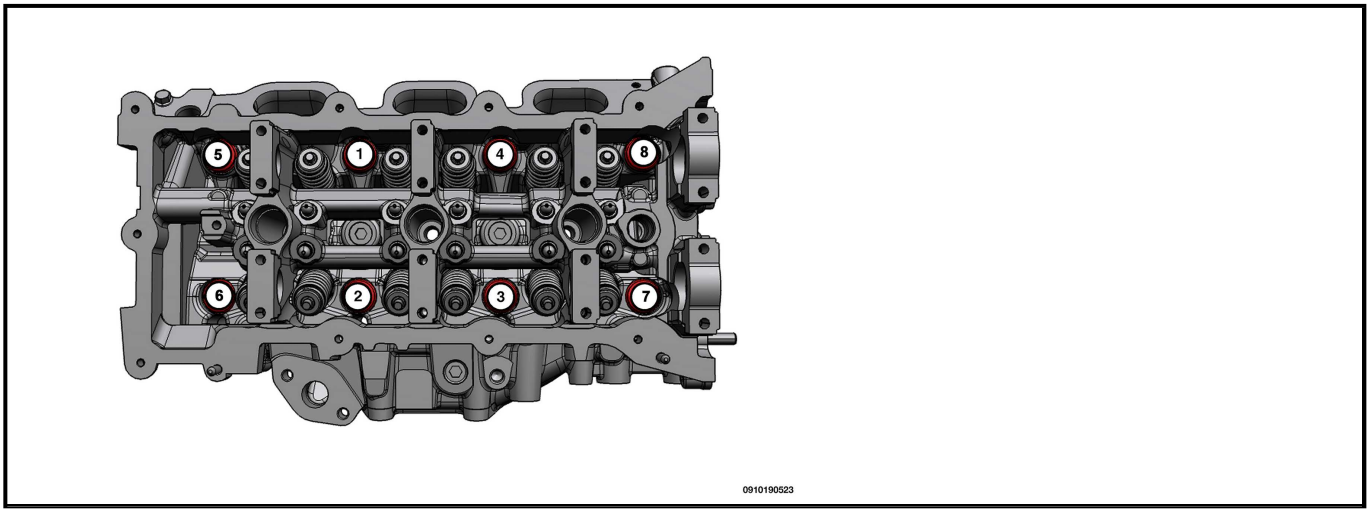


Tightening Sequence - Right





Tightening Sequence - Right



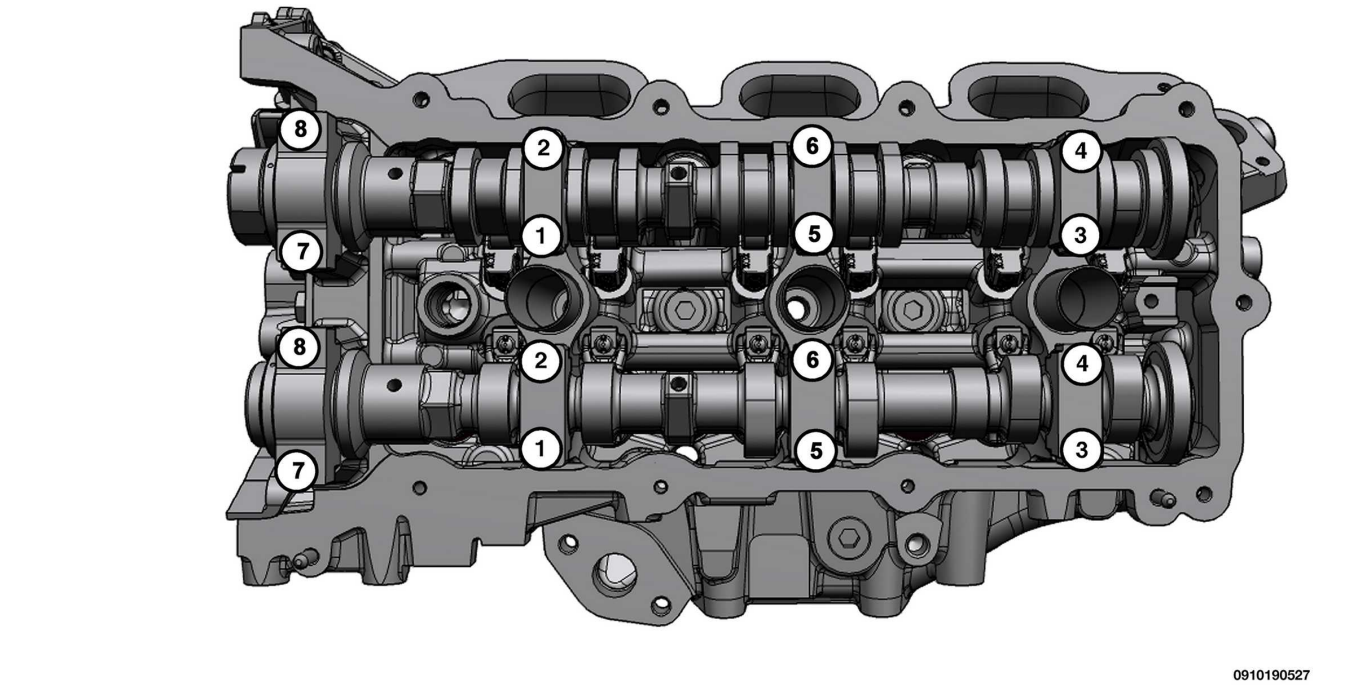
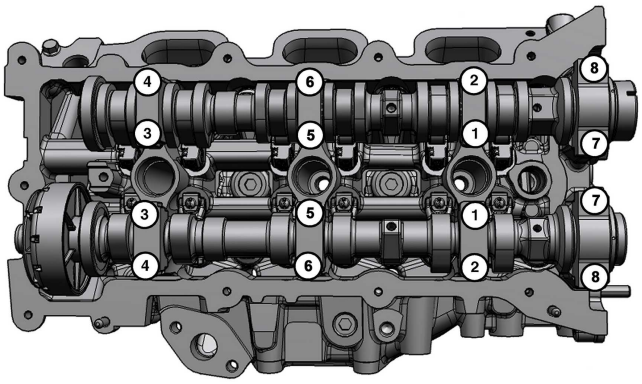


Fig. 4: Camshaft Bearing Cap Bolts Tightening Sequence (1 of 2)
Courtesy of CHRYSLER GROUP, LLC

Tightening Sequence - Right



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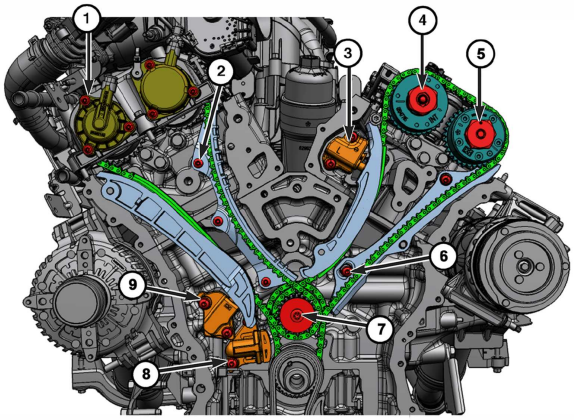
VALVE TIMING



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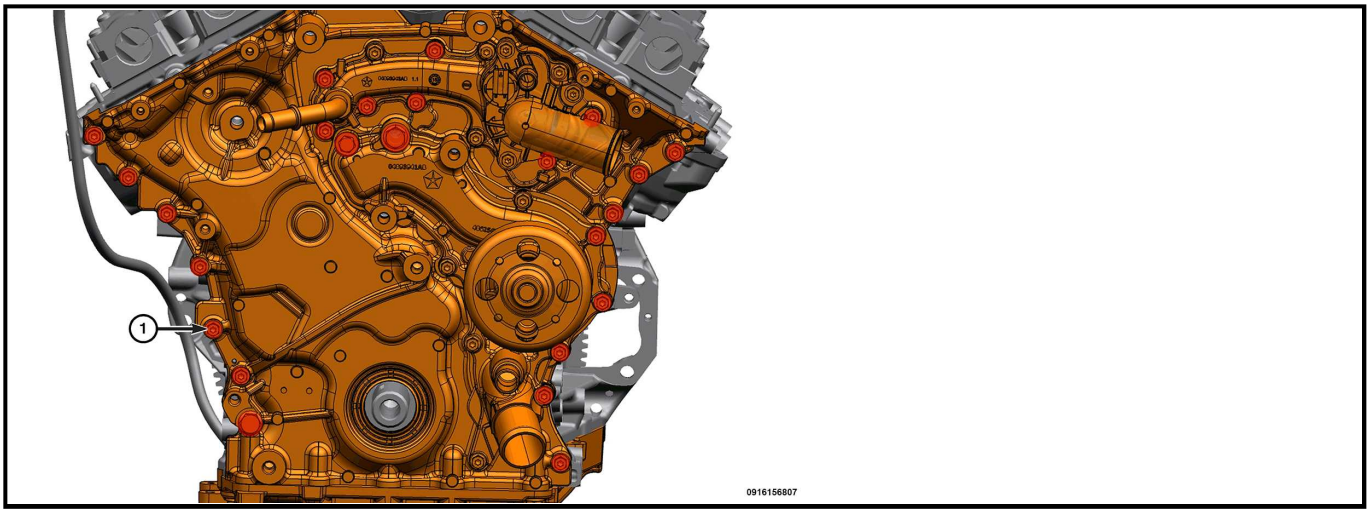
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-

CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

FRONT ENGINE

DESCRIPTION	SPECIFICATION	COMMENTS
Center Idler Pulley Bracket Bolts	**M8 Bolts - 25 N.m (18 Ft. Lbs.)** **M10 Bolts - 55 N.m (41 Ft. Lbs.)**	-
Center Idler Pulley Bracket to Generator Bolts	**24 N.m (18 Ft. Lbs.)**	-
Center Idler Pulley Bolt	**50 N.m (37 Ft. Lbs.)**	-
Left Idler Pulley Bolt	**25 N.m (18 Ft. Lbs.)**	-
Right Idler Pulley Bracket Bolts	**24 N.m (18 Ft. Lbs.)**	-
Right Idler Pulley Bolt	**25 N.m (18 Ft. Lbs.)**	-
Vibration Damper M16 Bolt	**Torque Procedure:** 1. **40 N.m (30 Ft. Lbs.)** 2. **Rotate additional + 105B°**	-
Belt Tensioner Bolt	**50 N.m (37 Ft. Lbs.)**	-
Engine Timing Cover M6 Bolts Engine Timing Cover M8 Bolt Engine Timing Cover M10 Bolts	**12 N.m (9 Ft. Lbs.)** **25 N.m (18 Ft. Lbs.)** **55 N.m (41 Ft. Lbs.)**	**Tighten in a criss-cross pattern**

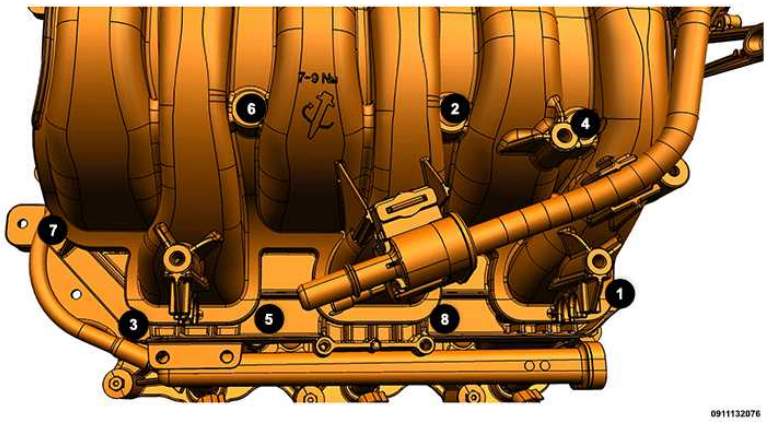


AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-



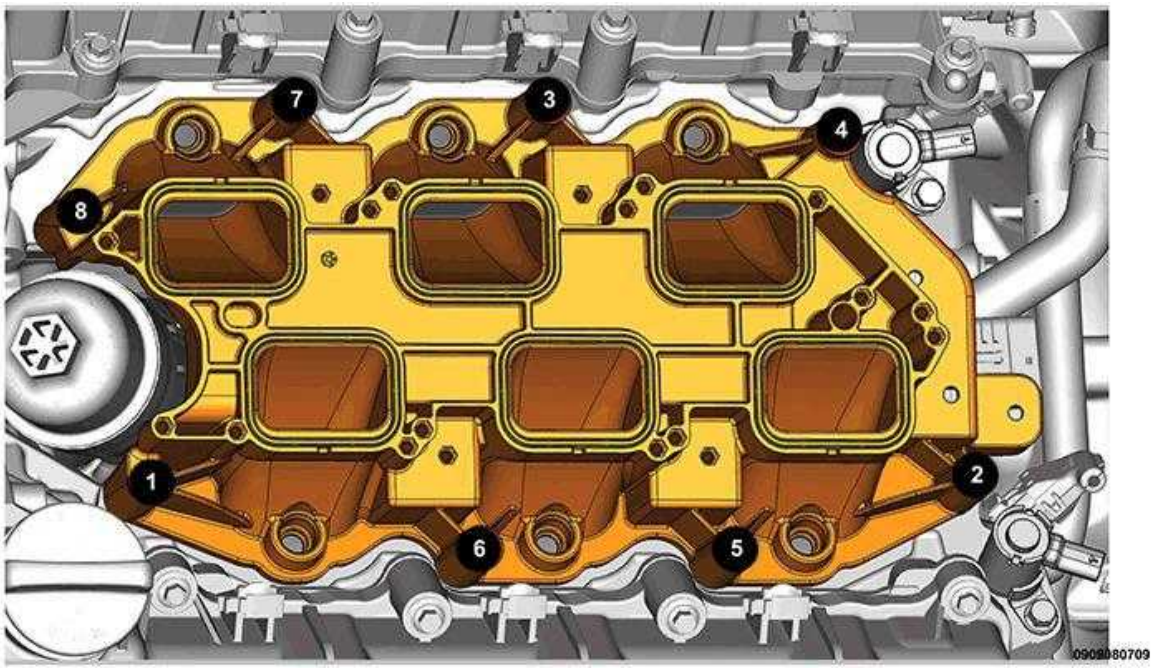


Fig. 5: Lower Intake Manifold Bolt Removal & Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

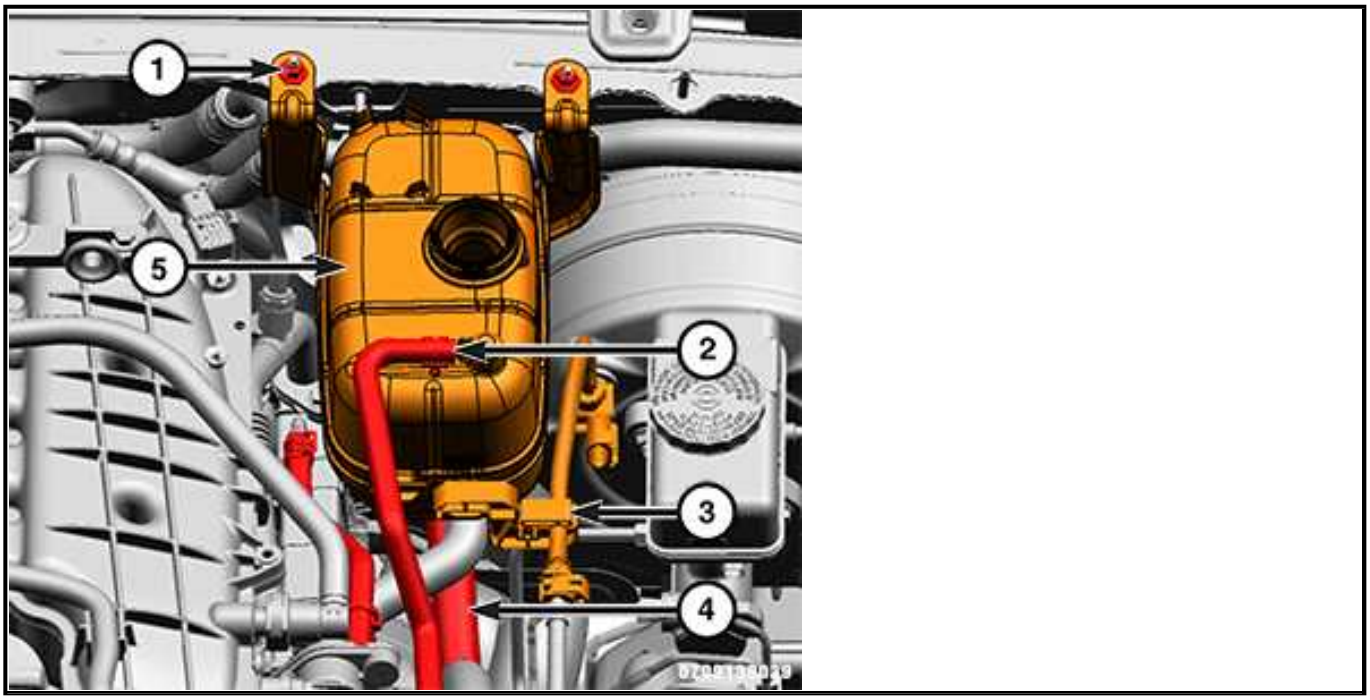
COVER(S), CYLINDER HEAD

REMOVAL AND INSTALLATION

LEFT CYLINDER HEAD COVER

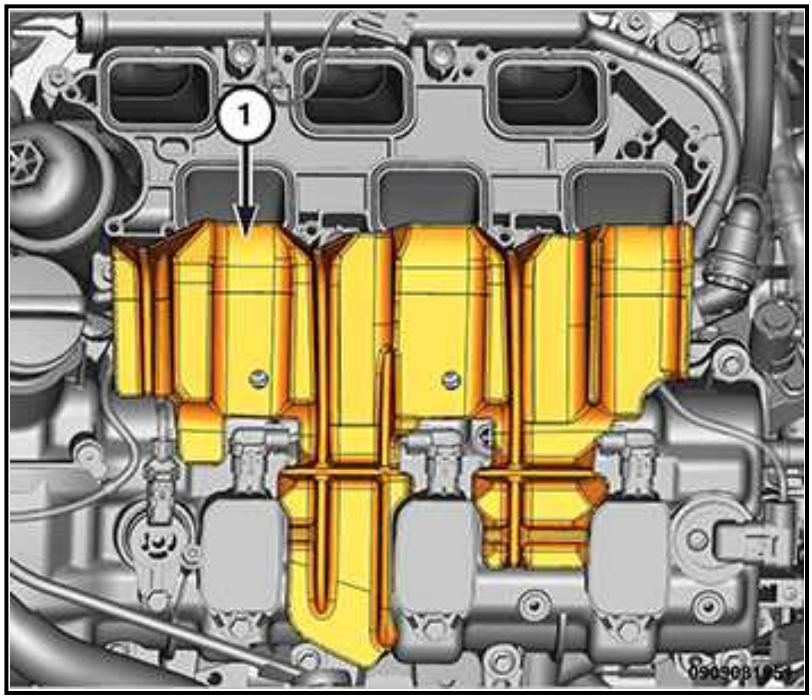
REMOVAL

NOTE: **The magnetic timing wheels must not come in contact with magnets (pickup tools, trays, etc.) or any other strong magnetic field. This will destroy the timing wheels ability to correctly relay camshaft position to the camshaft position sensor.**



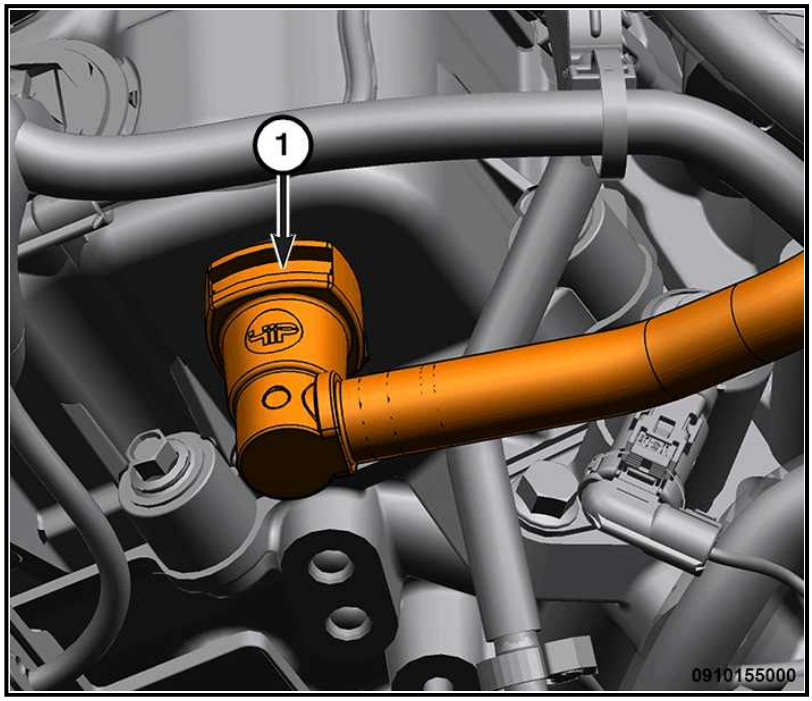
1 - Coolant Bottle Nuts
2 - Degas Hose
3 - Master Cylinder Hose Retainer
4 - Coolant Hose
5 - Coolant Bottle

1. Remove the nuts and lift the pressurized coolant bottle up and position aside.
2. The coolant hoses do not need to be removed.
3. Remove the upper intake manifold and support brackets. Refer to **MANIFOLD, INTAKE, REMOVAL AND INSTALLATION** .



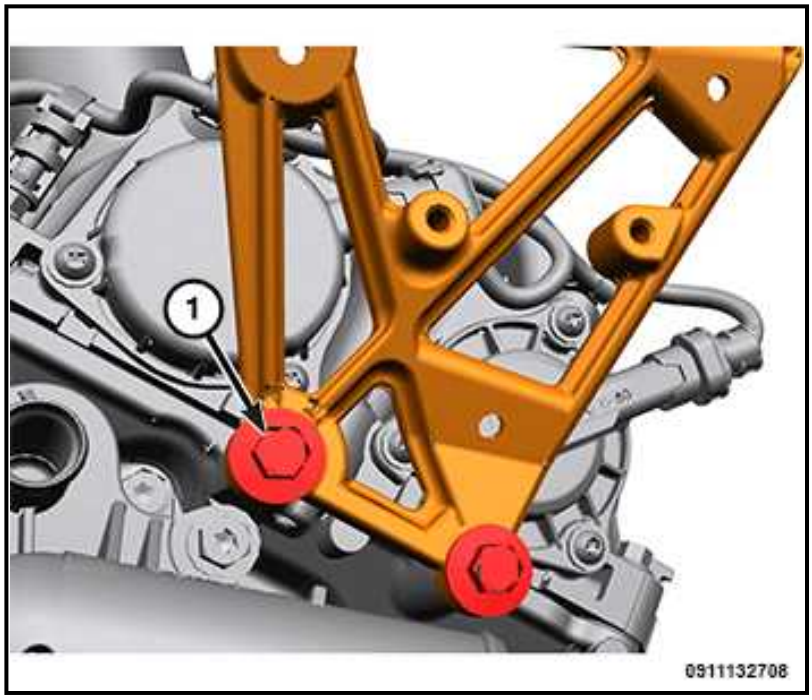
1 - Insulator

4. Remove the insulator from the LH cylinder head cover.
5. Cover the open intake ports to prevent debris from entering the engine.



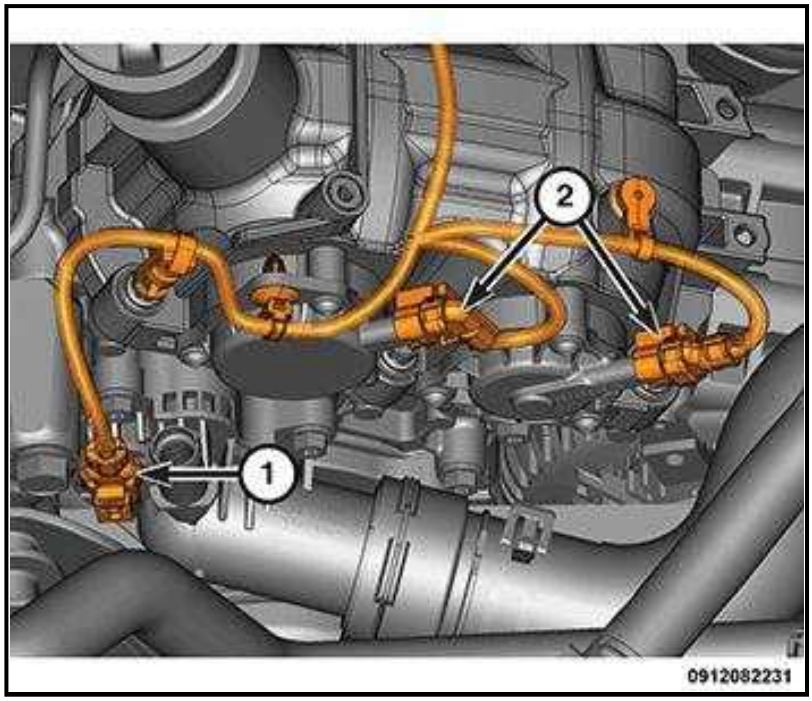
1 - Make-up Air Hose

6. Disconnect the make-up air hose.



1 - Throttle Body Support Bracket Bolts

7. Remove the throttle body support bracket bolts and the bracket.

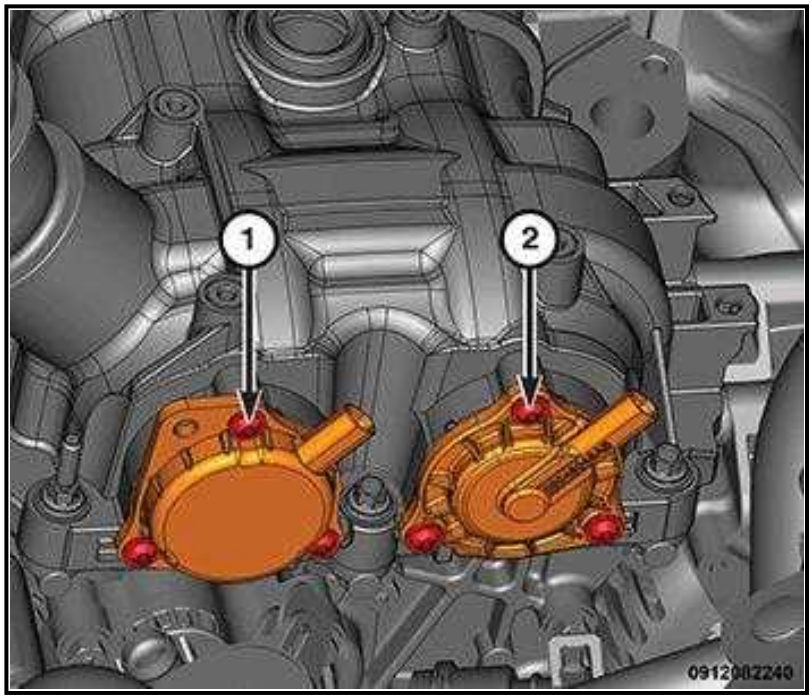


1 - ECT Sensor Wire Harness Connectors
2 - VVT Solenoid Wire Harness Connectors

8. Disconnect the wire harness connectors from the variable valve timing solenoids on the left cylinder head cover.

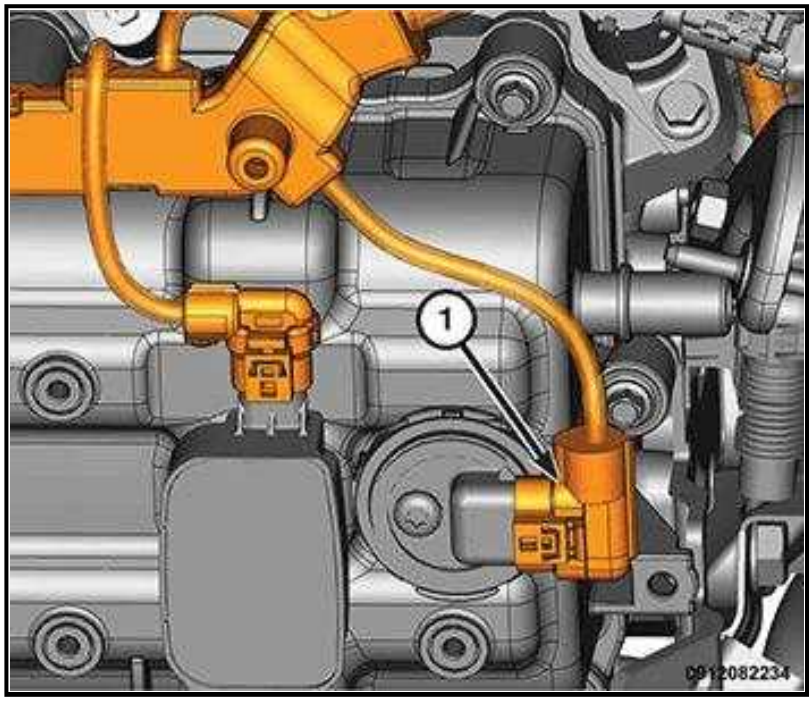
NOTE: **Mark the variable valve timing solenoid connectors with a paint pen or equivalent so that they may be reinstalled in their original locations.**

9. Disconnect the engine coolant temperature sensor wire harness connector.
10. Disengage the wire harness retainers from the left cylinder head cover.



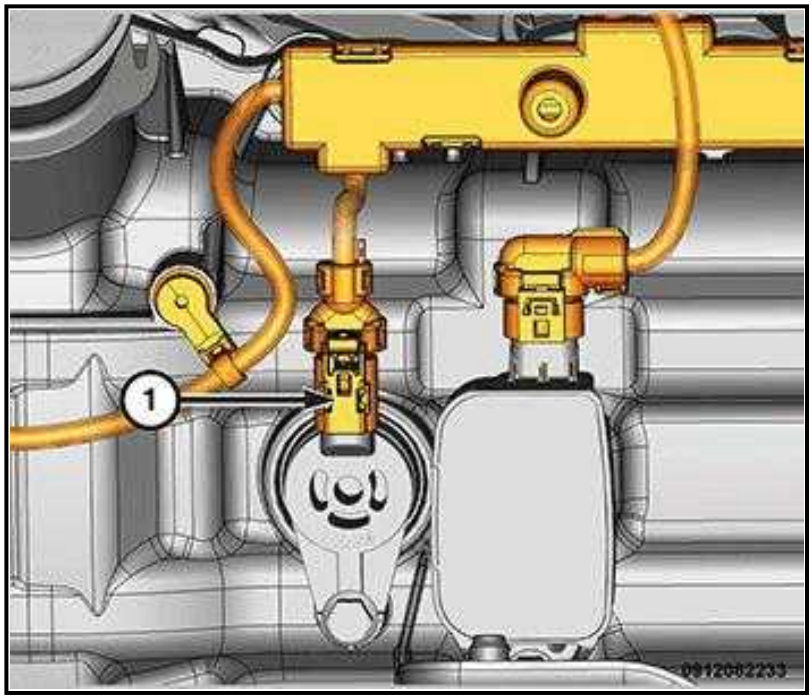
1 - Intake VVT Solenoid
2 - Exhaust VVT Solenoid

11. Mark the variable valve timing solenoids with a paint pen or equivalent so that they may be reinstalled in their original locations.
12. Remove the variable valve timing solenoids. Refer to **SOLENOID, REMOVAL AND INSTALLATION** .



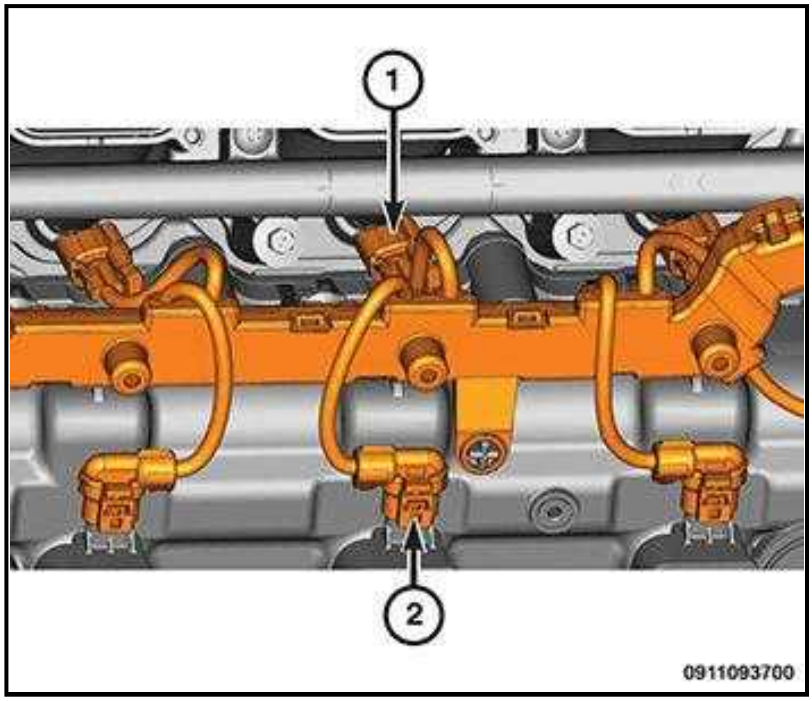
1 - CMP Sensor Wire Harness Connector

13. Disconnect the left Camshaft Position (CMP) sensor wire harness connector.



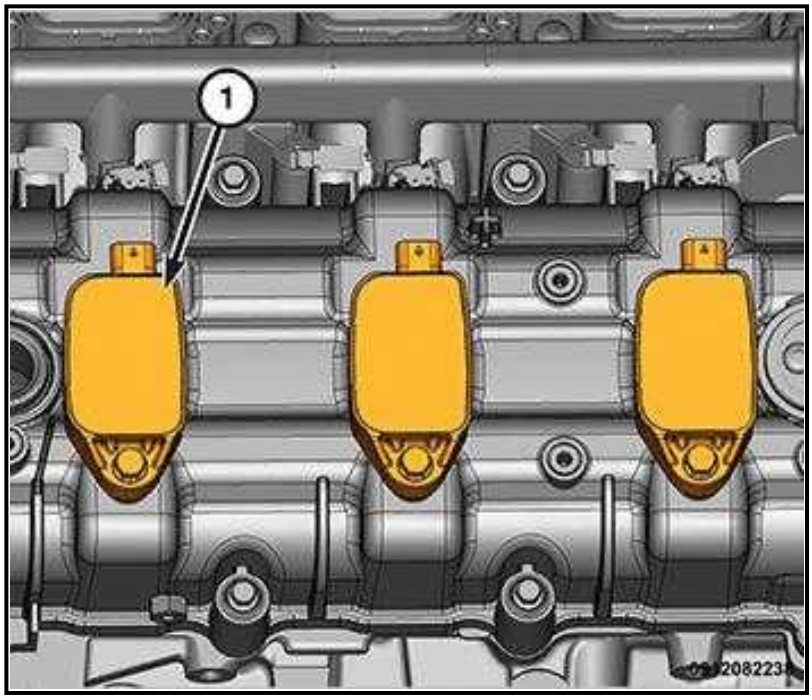
1 - VVL Solenoid Wire Harness Connector

14. Disconnect the Variable Valve Lift (VVL) solenoid wire harness connector.



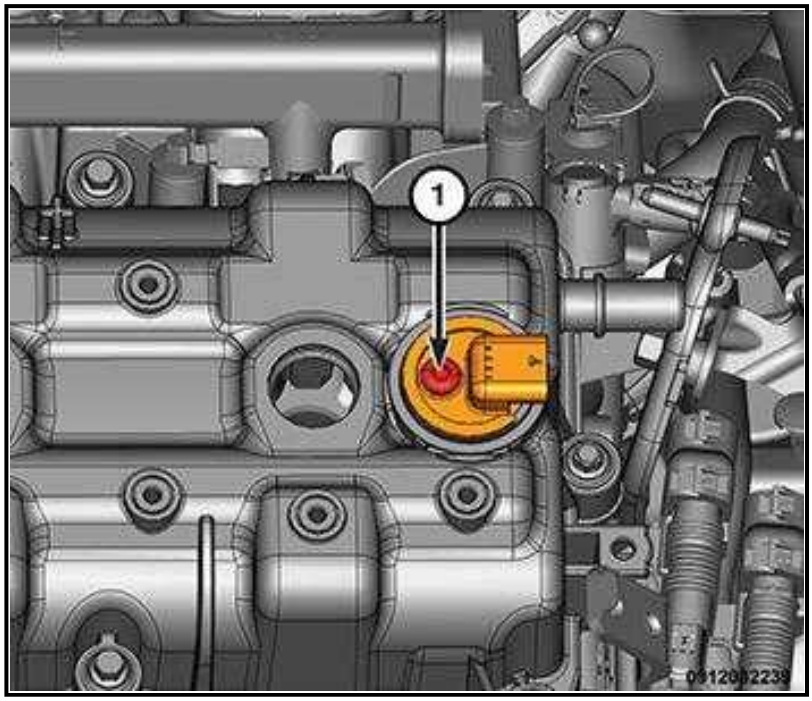
1 - Fuel Injector Wire Harness Connectors
2 - Ignition Coil Wire Harness Connectors

15. Disconnect the wire harness connectors from fuel injectors and ignition coils.
16. Remove the wire harness assembly from the left side cylinder head cover and position aside.



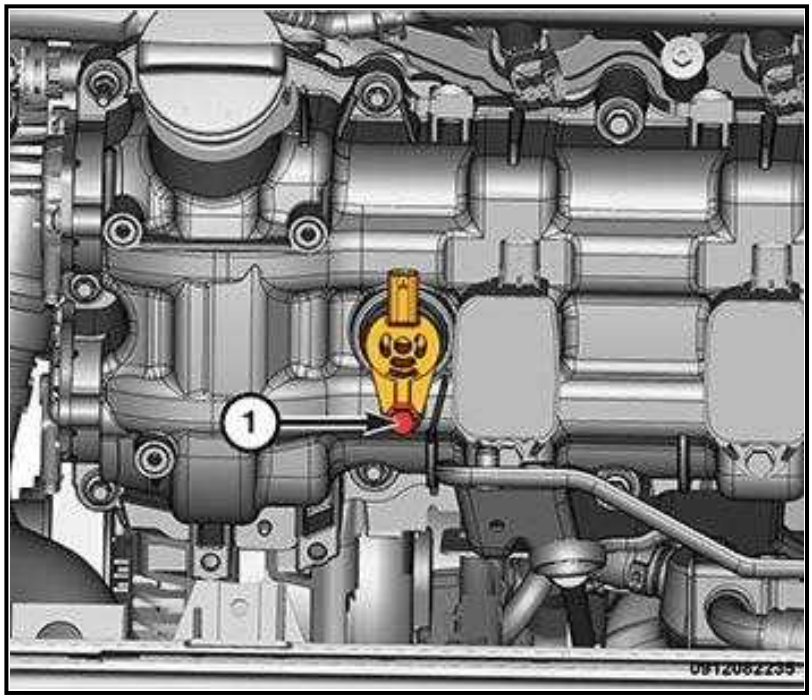
1 - Ignition Coils

17. Remove the left side ignition coils (1). Refer to **COIL, IGNITION, REMOVAL AND INSTALLATION**.



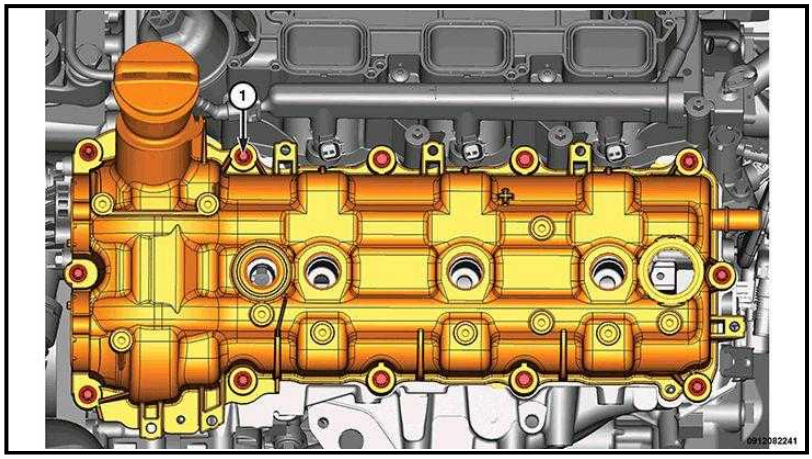
1 - CMP Sensor

18. Remove the camshaft position sensor from the left cylinder head cover. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .



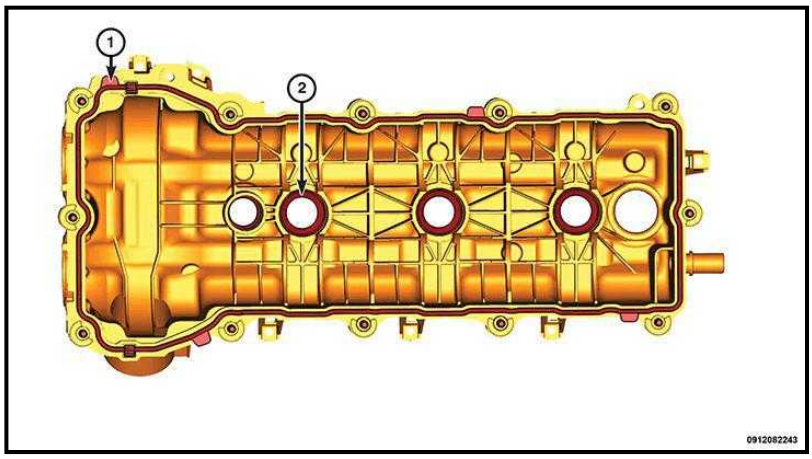
1 - VVL Solenoid

19. Remove the VVL solenoid (1) from the left cylinder head cover. Refer to **COVER(S), CYLINDER HEAD, REMOVAL AND INSTALLATION**.



1 - Cylinder Head Cover Bolts

20. Loosen ten cylinder head cover mounting fasteners and remove the cylinder head cover.



1 - Cylinder Head Cover Gasket
2 - Spark Plug Tube Seals

21. Remove and discard the cylinder head cover gasket.
22. The spark plug tube seals can be reused if not damaged.

CAUTION: **Do not use oil based liquids, wire brushes, abrasive wheels or metal scrapers to clean the engine gasket surfaces. Use only isopropyl (rubbing) alcohol, along with plastic or wooden scrapers. Improper gasket surface preparation may result in engine fluid leakage.**

23. Remove all residual sealant from the cylinder head, timing chain cover and cylinder head cover mating surfaces. Refer to **CLEANING** .

INSTALLATION

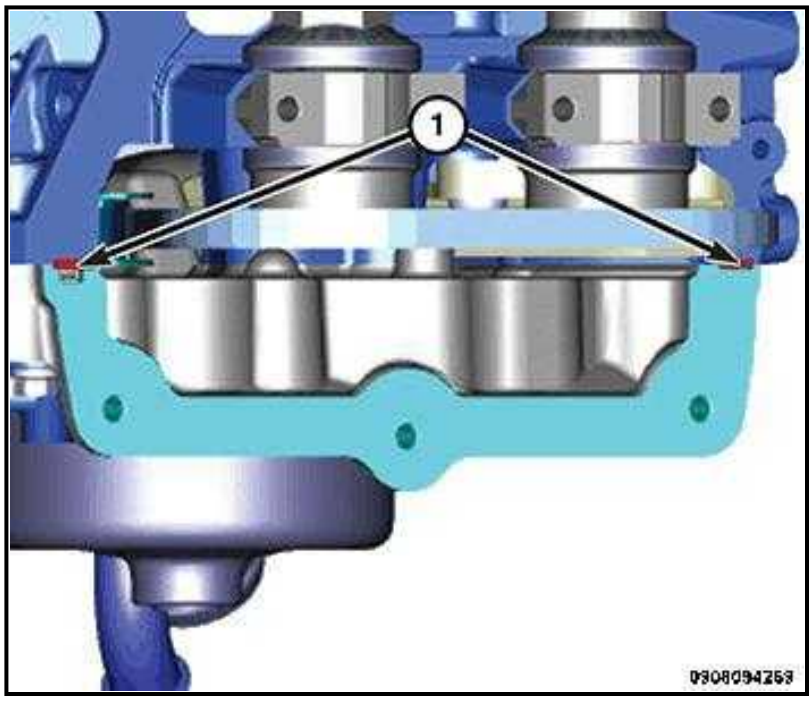
During installation, torque the fasteners to the specifications in the torque table(s) below.

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.

- The magnetic timing wheels must not come in contact with magnets (pickup tools, trays, etc.) or any other strong magnetic field. This will destroy the timing wheels ability to correctly relay camshaft position to the camshaft position sensor.
- Clean the engine timing cover, cylinder head and cylinder head cover mating surfaces with isopropyl alcohol in preparation for sealant application.

CAUTION: **Engine assembly requires the use of a unique sealant that is compatible with engine oil. Using a sealant other than MoparB® Threebond Engine RTV Sealant may result in engine fluid leakage.**

CAUTION: **Following the application of MoparB® Threebond Engine RTV Sealant to the gasket surfaces, the components must be assembled within 10 minutes and the attaching fasteners must be tightened to specification within 45 minutes. Prolonged exposure to the air prior to assembly may result in engine fluid leakage.**

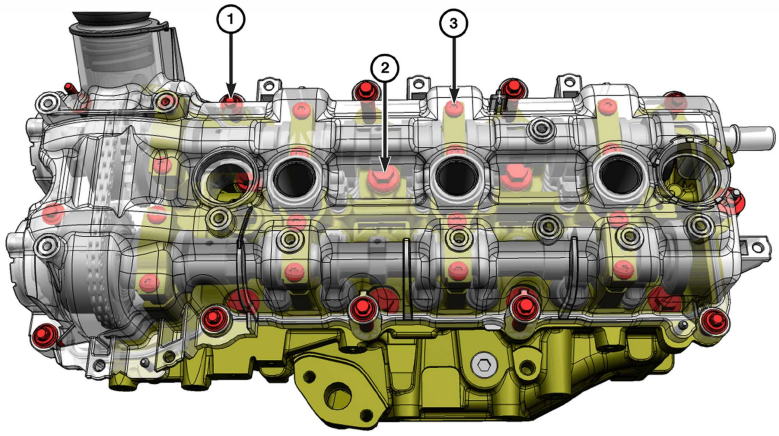


1 - T-joints

- Apply an 11 mm dollop of MoparB® Threebond Engine RTV Sealant to the two engine timing cover to cylinder head T-joints.
- The cylinder head cover bolts must be tightened in the sequence shown in the torque table below.
- Refer to the markings made at disassembly and install the variable valve timing solenoids in their original locations.
- The Cam/Crank Variation Relearn procedure must be performed using the scan tool anytime there has been a repair/replacement made to a powertrain system, for example: flywheel, valvetrain, camshaft and/or crankshaft sensors or components.

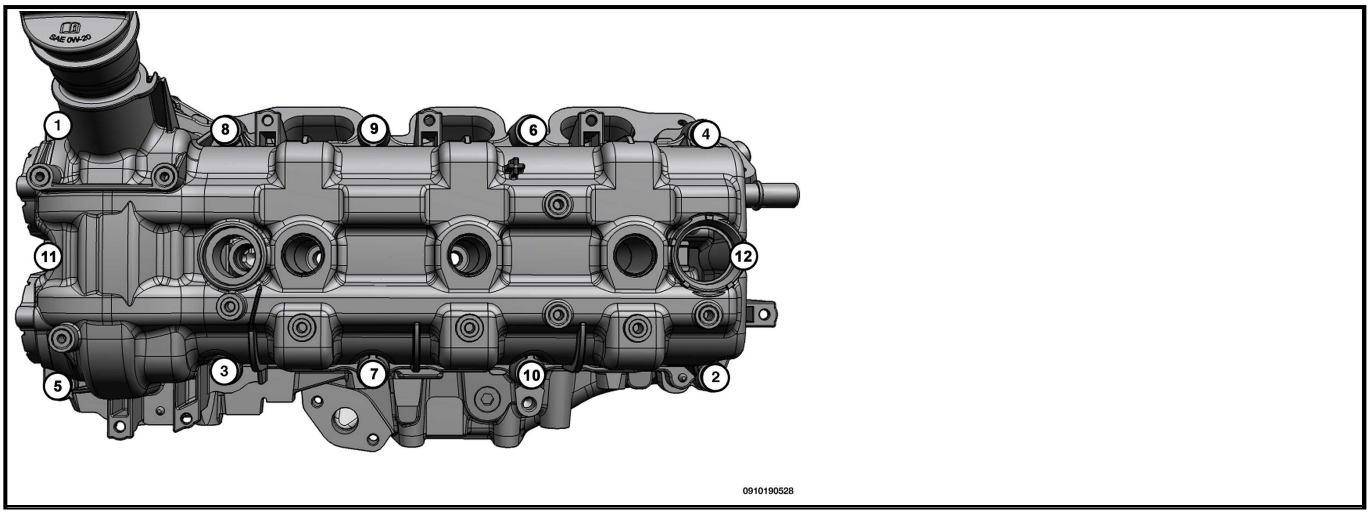
TORQUE SPECIFICATIONS

CYLINDER HEAD

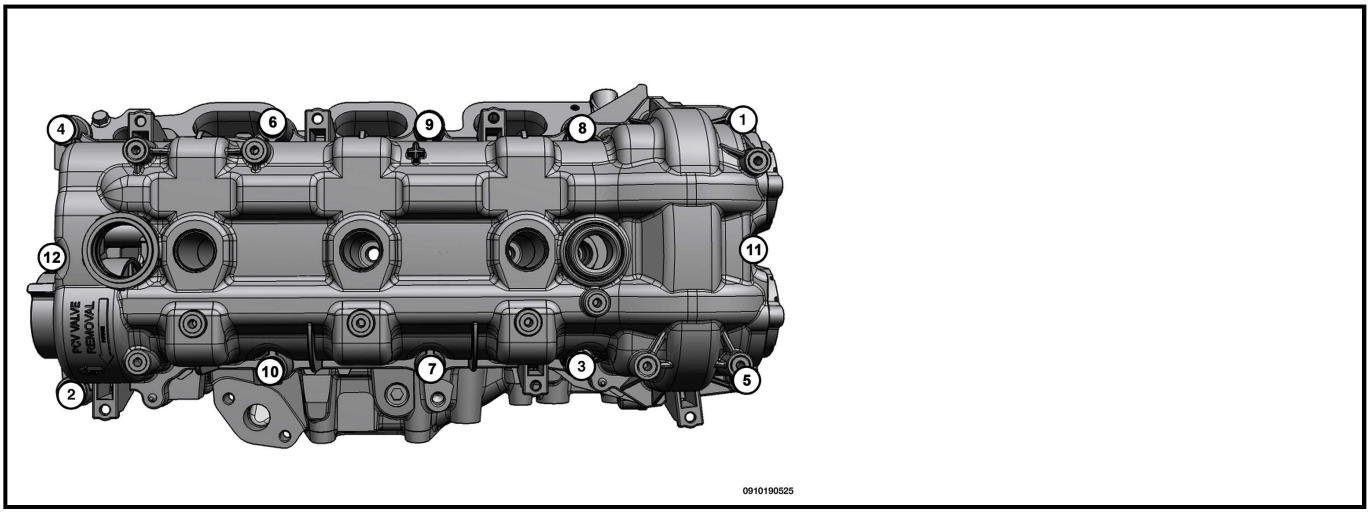


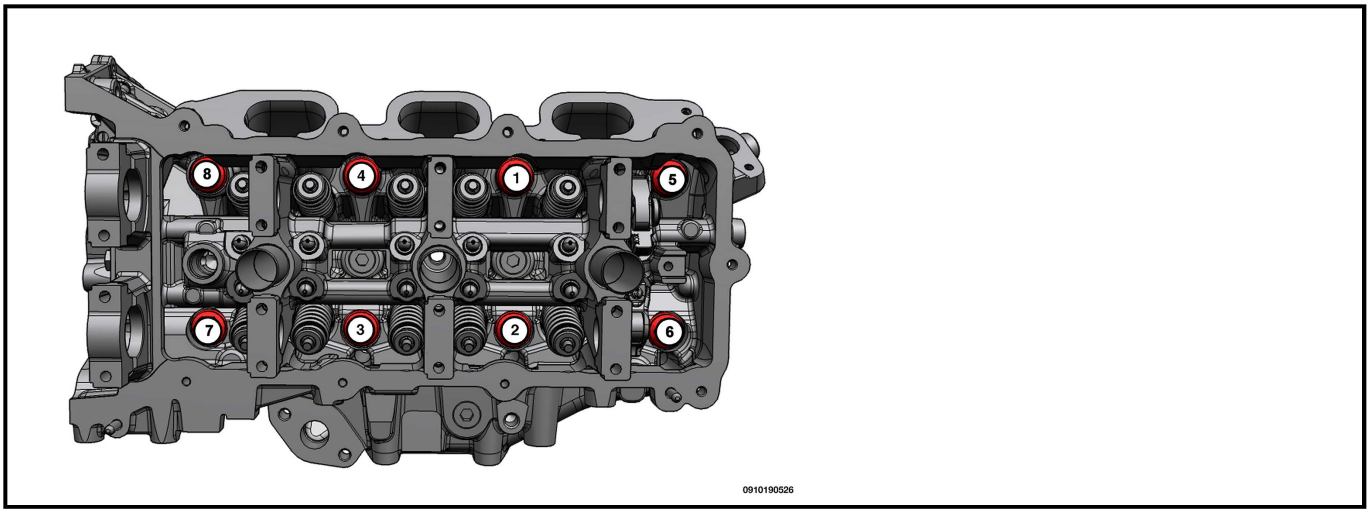
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Cylinder Head Cover M6 Bolts	**12 N.m (9 Ft. Lbs.)**	Tightening Sequence - Left
2	Cylinder Head Bolts	**Torque Procedure** For engine builds using a new block follow steps 1-9. For engine re-builds (reuse block) follow step 6-9. 1. 30 N. m (22 ft. lbs.) 2. 45 N. m (33 ft. lbs.) 3. Re-tighten all to 45 N. m (33 ft. lbs.) 4. All + 125B° Turn. Do not use a torque wrench for this step. 5. Loosen all fasteners in reverse of sequence shown 6. All to 30 N. m (22 ft. lbs.) 7. All to 45 N. m (33 ft. lbs.) 8. Re-tighten all to 45 N. m (33 ft. lbs.) 9. All + 130B° Turn. Do not use a torque	Tightening Sequence - Left

CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
		wrench for this step.	
3	Camshaft Bearing Cap Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence - Left
-	Cylinder Head Coolant Pipe Plug	**35 N.m (26 Ft. Lbs.)**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
-	Cylinder Head Oil Galley Plug	**18 N.m (13 Ft. Lbs.)**	-
-	Cylinder Head Oil Restrictor M8 Plug	**15 N.m (11 Ft. Lbs.)**	-
-	Ground Strap Bolt to Right Cylinder Head	**23 N.m (17 Ft. Lbs.)**	-
-	Heater Core Supply Tube to Cylinder Head M8 Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Wire Harness Retainer Bracket to LH Cylinder Head Bolts	**10 N.m (89 In. Lbs.)**	-



Tightening Sequence - Right





Tightening Sequence - Right

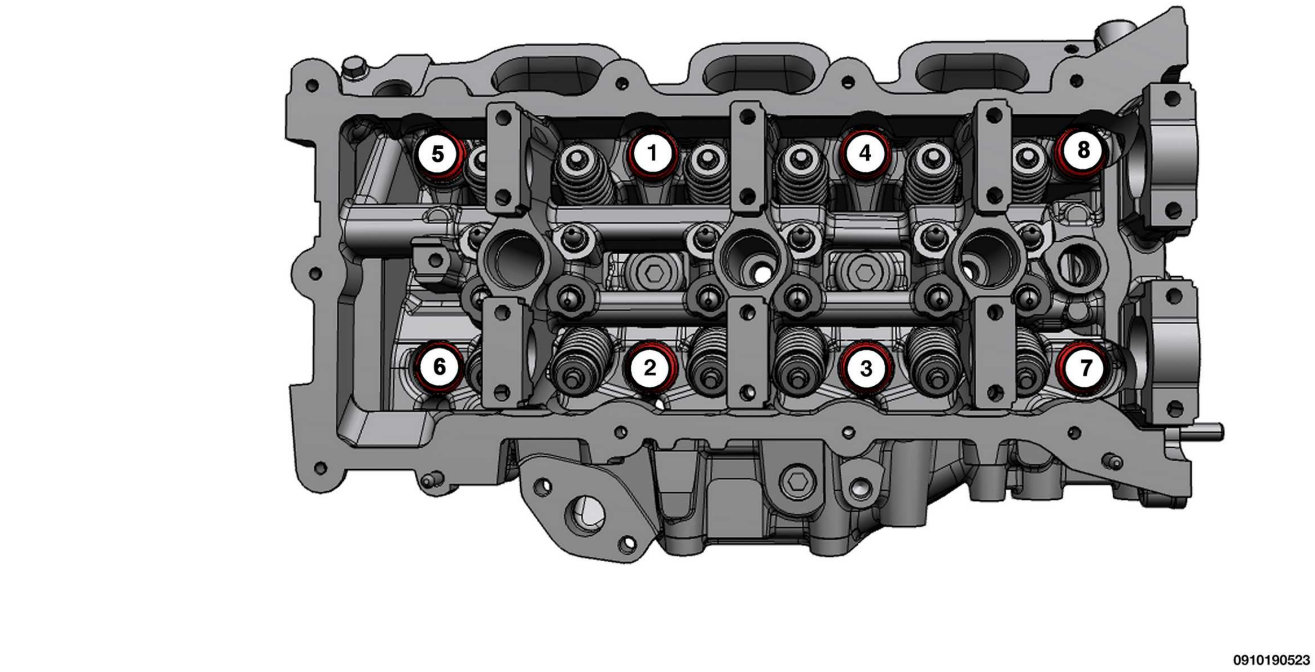
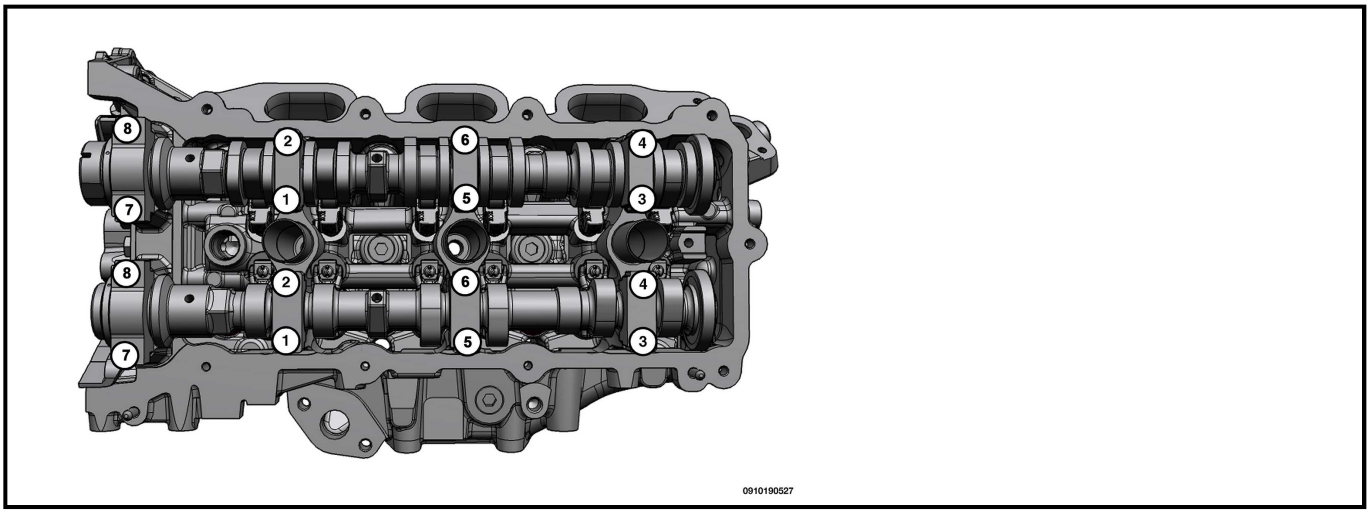
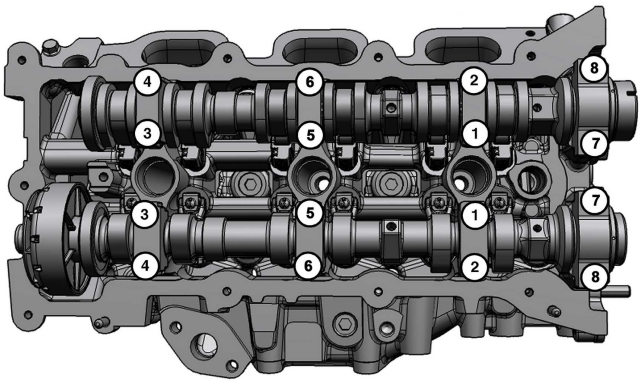


Fig. 6: Cylinder Head Bolts Tightening Sequence (2 of 2)
Courtesy of CHRYSLER GROUP, LLC



Tightening Sequence - Right



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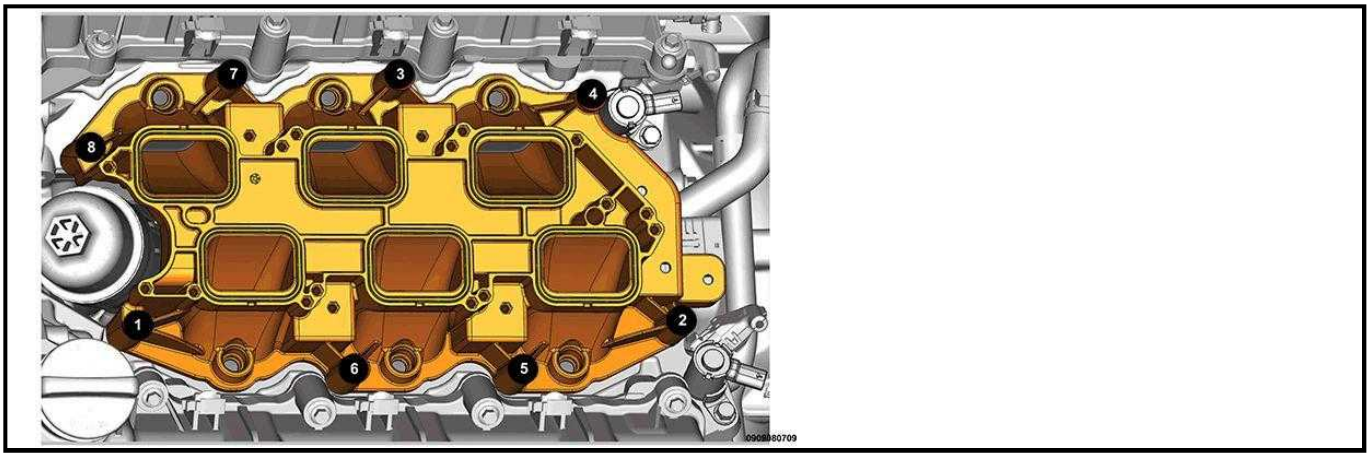
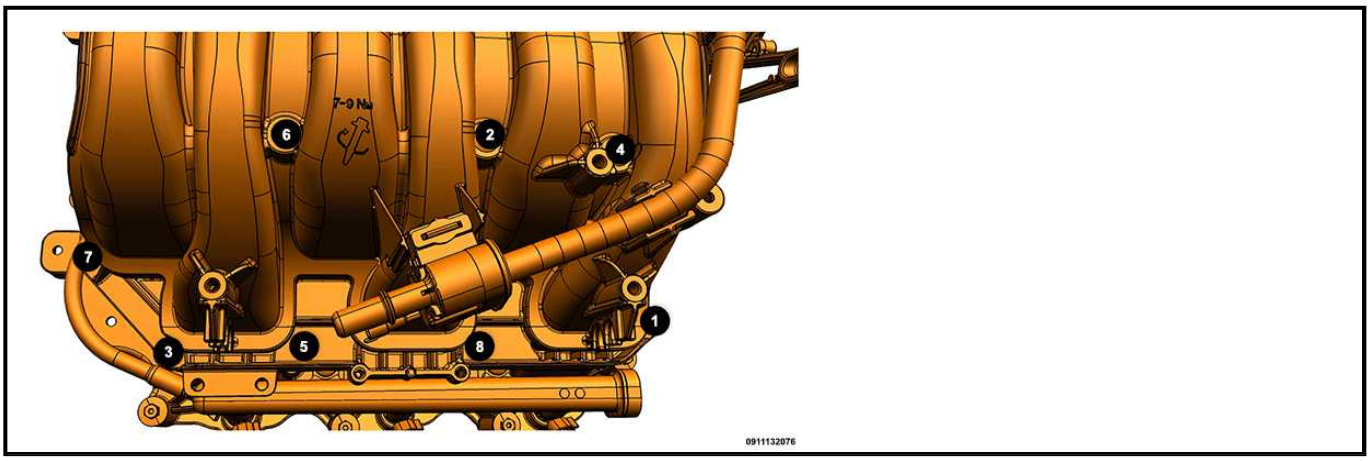
AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-





RIGHT CYLINDER HEAD COVER

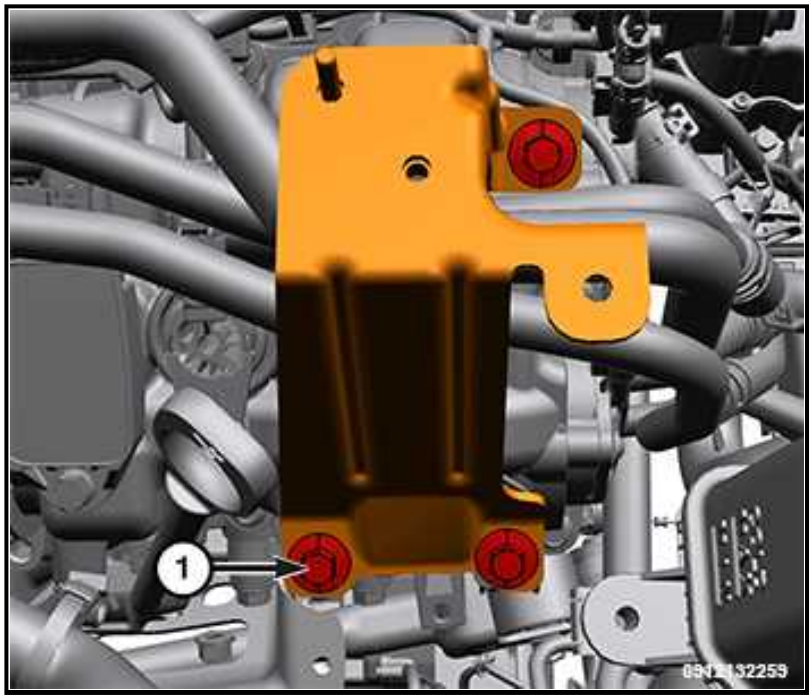
REMOVAL

NOTE: **The magnetic timing wheels must not come in contact with magnets (pickup tools, trays, ect.) or any other strong magnetic field. This will destroy the timing wheels ability to correctly relay camshaft position to the camshaft position sensor.**

1. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
2. Remove the air cleaner resonator Refer to **RESONATOR, AIR CLEANER, REMOVAL AND INSTALLATION** .

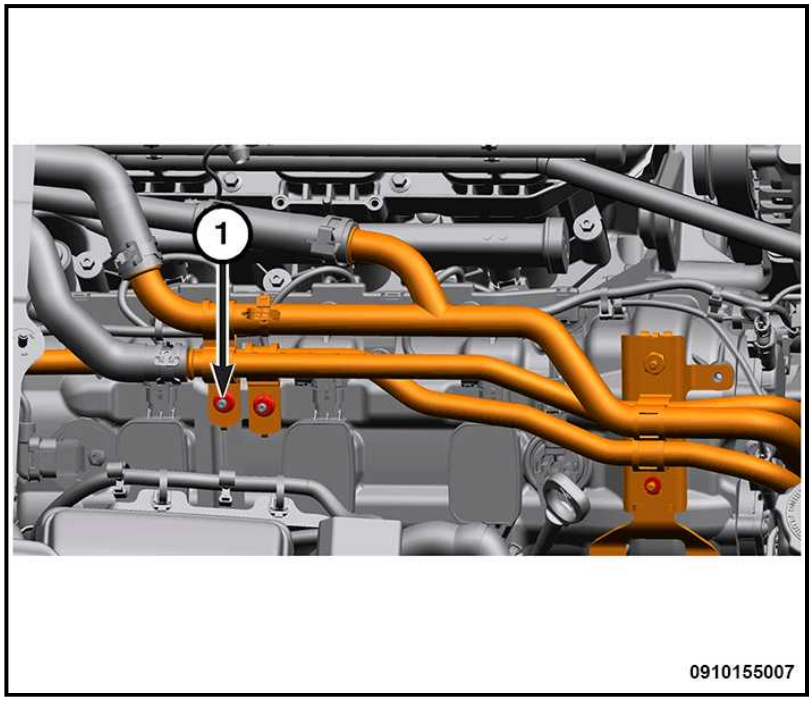
   .

3. Remove the engine cover.
4. Drain the cooling system. Refer to **DRAINING** .



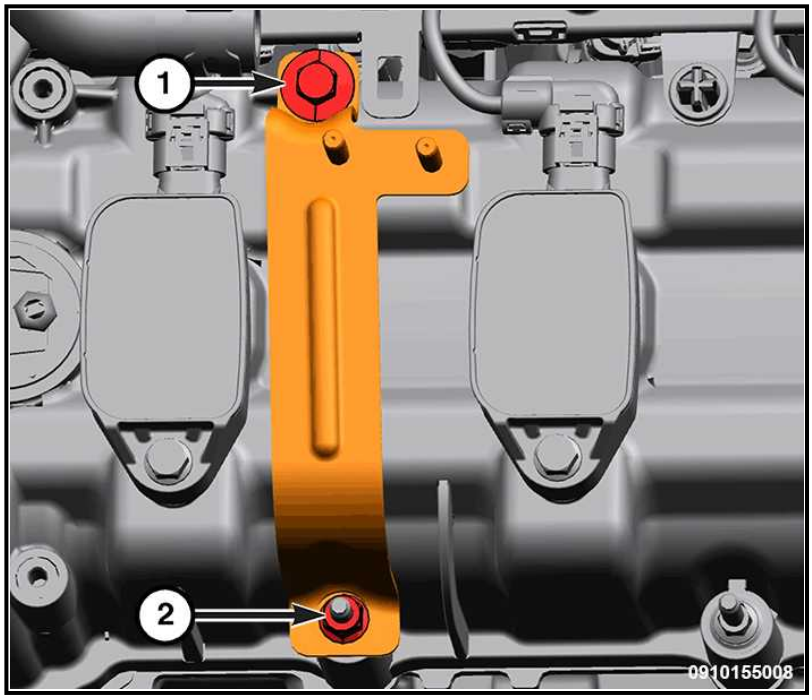
1 - Engine Cover Bracket Bolts

5. Remove the engine cover bracket bolts and bracket.



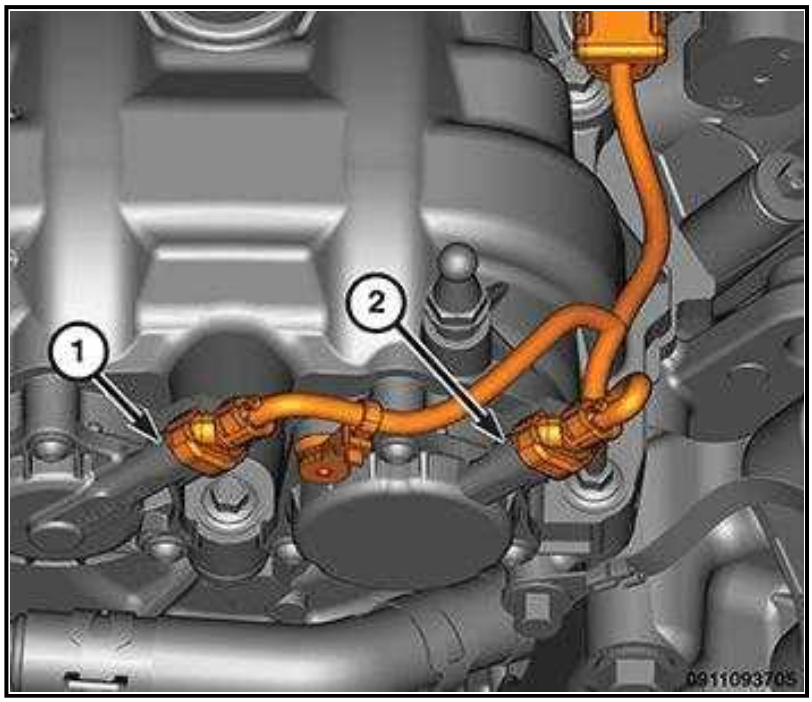
1 - Heater Tube Assembly Nuts

6. Remove the nuts securing the heater tube assembly to the right side cylinder head cover, disconnect the hoses from the tube assembly and position aside.



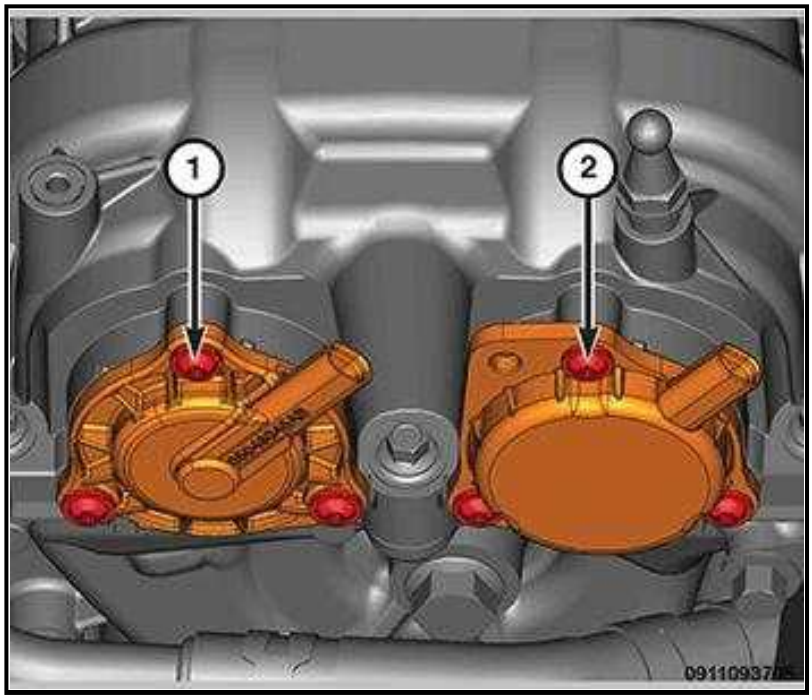
1 - Heater Hose Support Bracket Bolt
2 - Heater Hose Support Bracket Nut

7. Remove the nut and bolt securing the heater hose support bracket to the right side cylinder head cover.



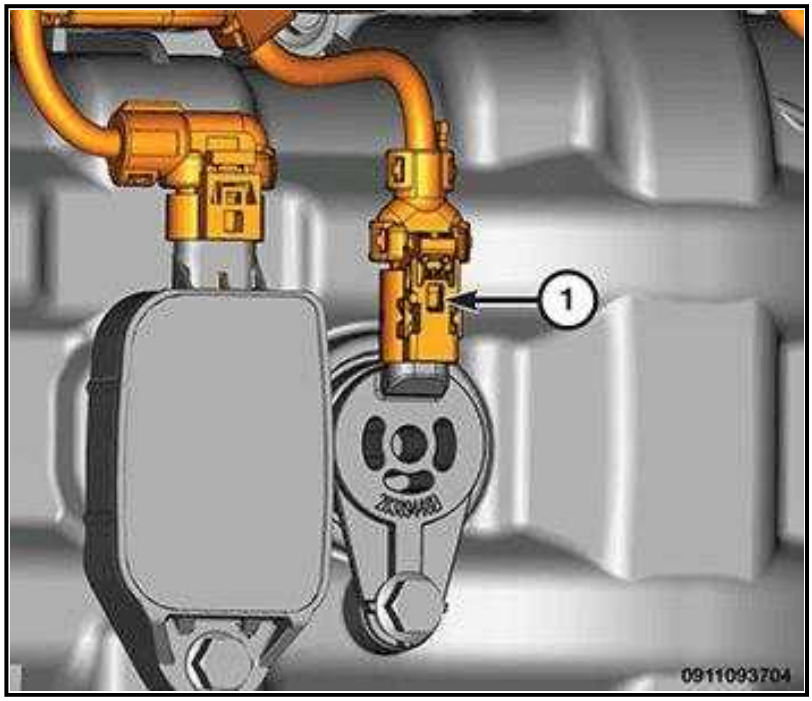
1 - Exhaust VVT Solenoid Wire Harness Connectors
2 - Intake VVT Solenoid Wire Harness Connectors

8. Disconnect the variable valve timing solenoid wire harness connectors.
9. Disengage the wire harness retainers from the right cylinder head cover.



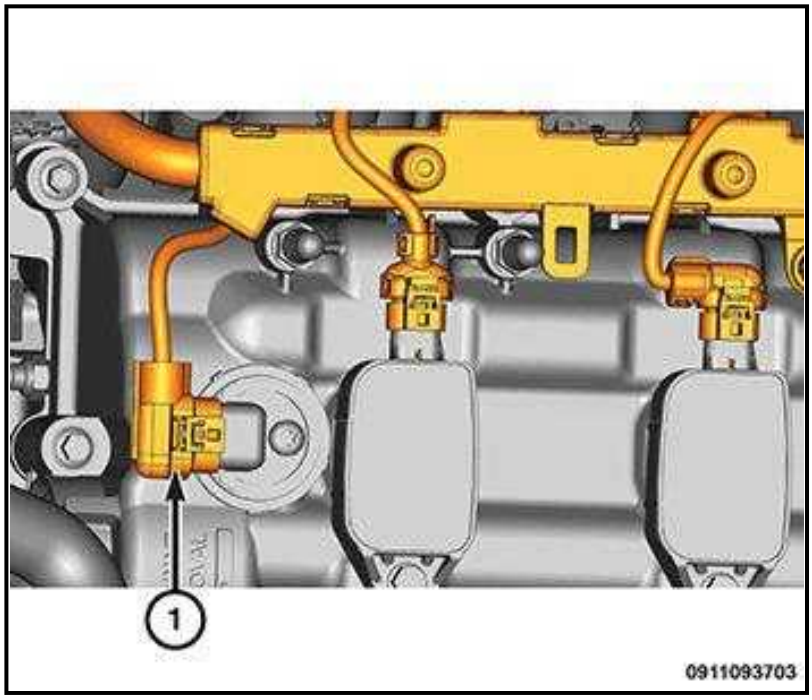
1 - Exhaust VVT Solenoid Wire Harness Connectors
2 - Intake VVT Solenoid Wire Harness Connectors

10. Mark the variable valve timing solenoids with a paint pen or equivalent so that they may be reinstalled in their original locations.
11. Remove the variable valve timing solenoids.



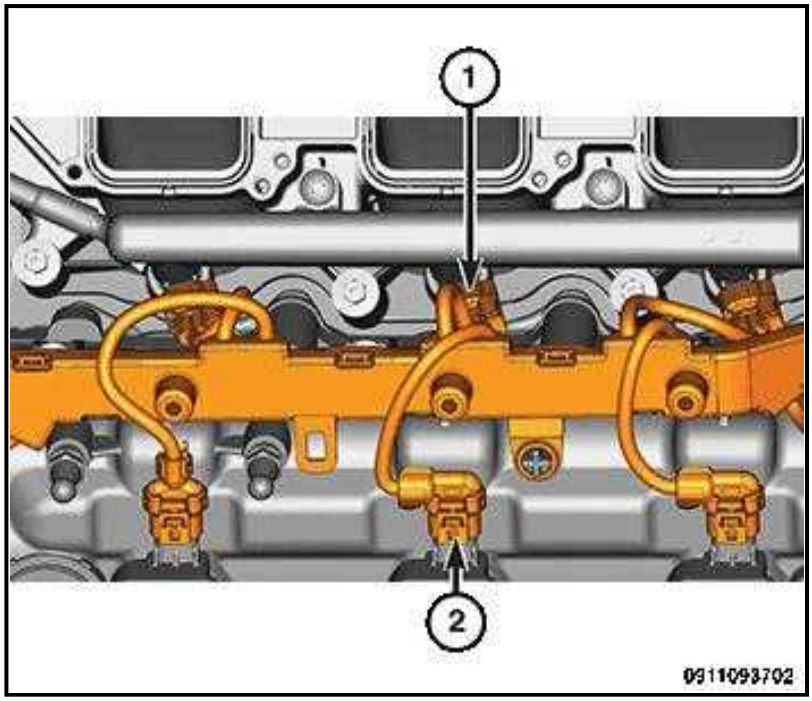
1 - VVL Solenoid Wire Harness Connector

12. Disconnect the Variable Valve Lift (VVL) solenoid wire harness connector.



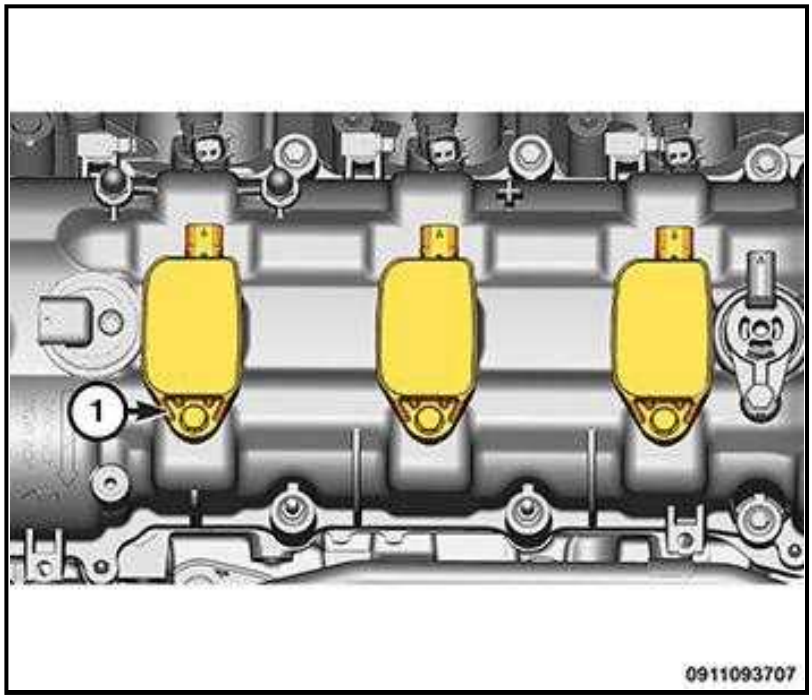
1 - CMP Sensor Wire Harness Connector

13. Disconnect the wire harness connector from the right side Camshaft Position (CMP) sensor.



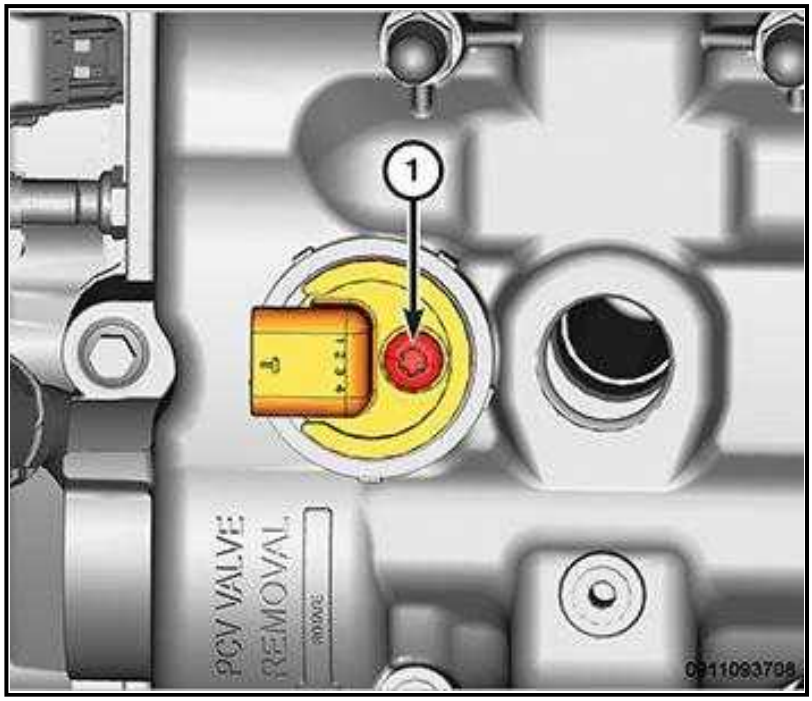
1 - Fuel Injector Wire Harness Connector
2 - Ignition Coil Wire Harness Connector

14. Disconnect the fuel injector and ignition coil wire harness retainers and position the wire harness aside.



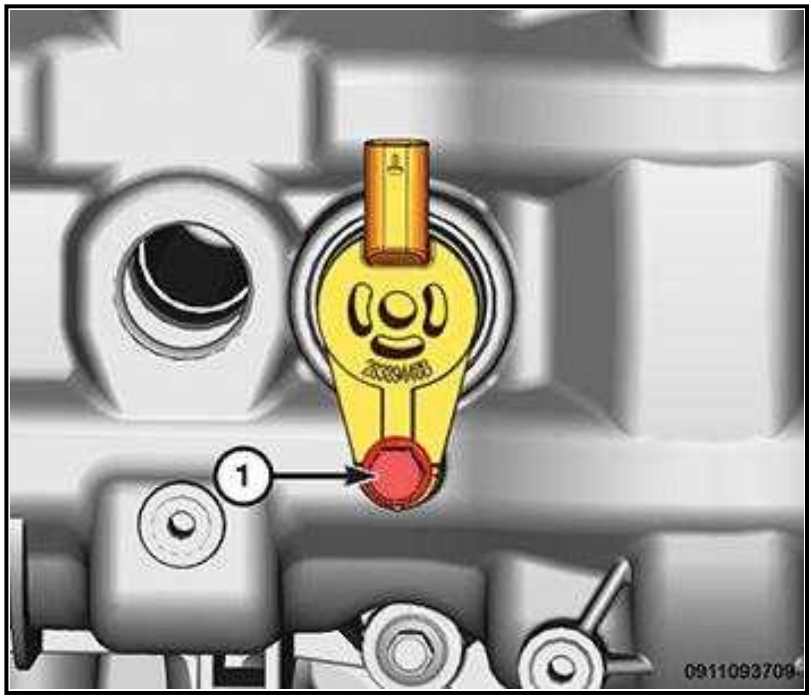
1 - Ignition Coils

15. Remove the right side ignition coils.



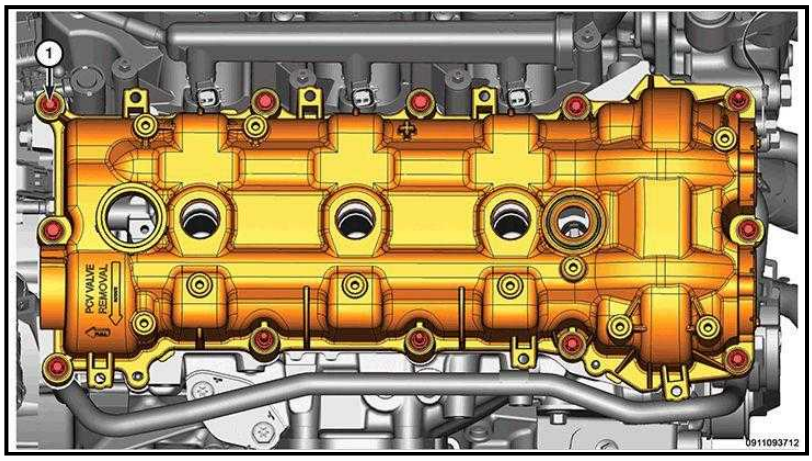
1 - CMP Sensor

16. Remove the camshaft position sensor.



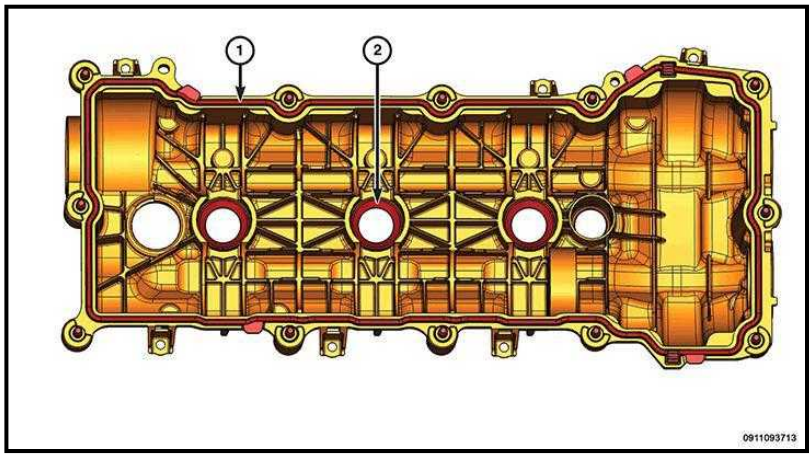
1 - VVL Solenoid

17. Remove the VVL solenoid from the right cylinder head cover.
18. Remove the PCV valve. Refer to **VALVE, POSITIVE CRANKCASE VENTILATION (PCV), REMOVAL AND INSTALLATION** .



1 - Cylinder Head Cover Bolts

19. Loosen the cylinder head cover mounting bolts and remove the cylinder head cover.



1 - Cylinder Head Cover Gasket

2 - Spark Plug Tube Seals

20. Remove and discard the cylinder head cover gasket.
21. The spark plug tube seals can be reused if not damaged.

CAUTION: **Do not use oil based liquids, wire brushes, abrasive wheels or metal scrapers to clean the engine gasket surfaces. Use only isopropyl (rubbing) alcohol, along with plastic or wooden scrapers. Improper gasket surface preparation may result in engine fluid leakage.**

22. Remove all residual sealant from the cylinder head, timing chain cover and cylinder head cover mating surfaces. Refer to **CLEANING** .

INSTALLATION

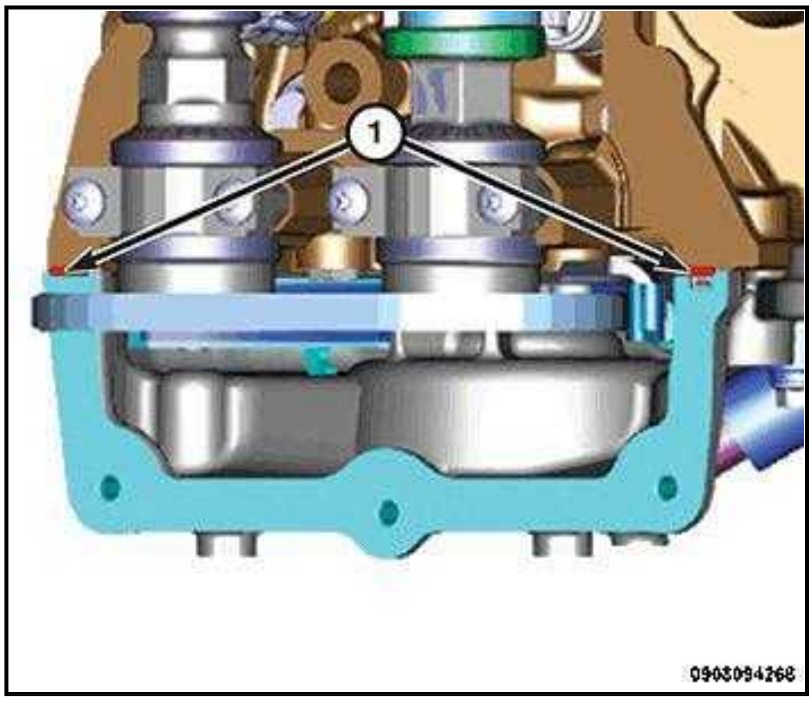
During installation, torque the fasteners to the specifications in the torque table(s) below.

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.

- The magnetic timing wheels must not come in contact with magnets (pickup tools, trays, etc.) or any other strong magnetic field. This will destroy the timing wheels ability to correctly relay camshaft position to the camshaft position sensor.
- Clean the engine timing cover, cylinder head and cylinder head cover mating surfaces with isopropyl alcohol in preparation for sealant application.

CAUTION: **Engine assembly requires the use of a unique sealant that is compatible with engine oil. Using a sealant other than MoparB® Threebond Engine RTV Sealant may result in engine fluid leakage.**

CAUTION: **Following the application of MoparB® Threebond Engine RTV Sealant to the gasket surfaces, the components must be assembled within 10 minutes and the attaching fasteners must be tightened to specification within 45 minutes. Prolonged exposure to the air prior to assembly may result in engine fluid leakage.**

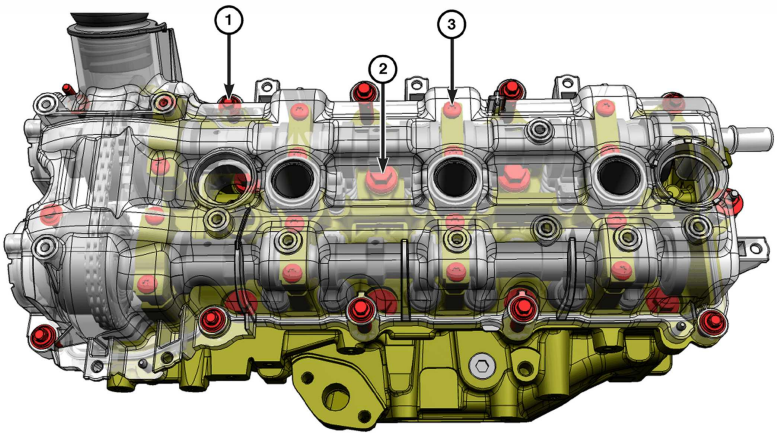


1 - T-joints

- Apply an 11 mm dollop of MoparB® Threebond Engine RTV Sealant to the two engine timing cover to cylinder head T-joints.
- The cylinder head cover bolts must be tightened in the sequence shown in the torque table below.
- Refer to the markings made at disassembly and install the variable valve timing solenoids in their original locations.
- Fill the cooling system. Refer to **STANDARD PROCEDURE - FILLING** .
- The Cam/Crank Variation Relearn procedure must be performed using the scan tool anytime there has been a repair/replacement made to a powertrain system, for example: flywheel, valvetrain, camshaft and/or crankshaft sensors or components.

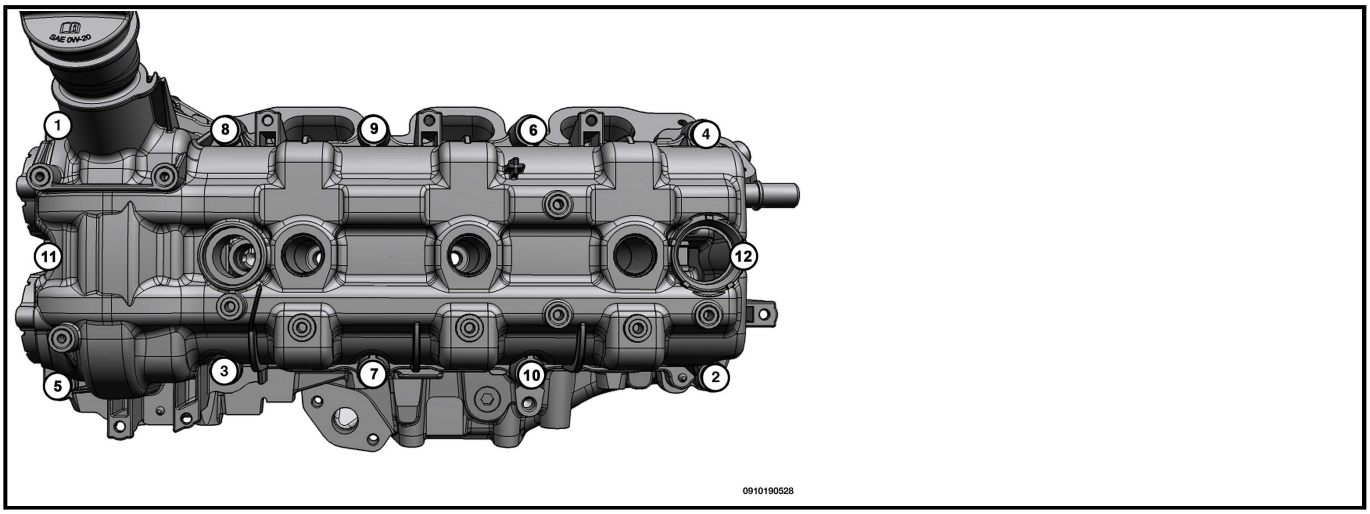
TORQUE SPECIFICATIONS

CYLINDER HEAD



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Cylinder Head Cover M6 Bolts	**12 N.m (9 Ft. Lbs.)**	Tightening Sequence - Left
2	Cylinder Head Bolts	**Torque Procedure** For engine builds using a new block follow steps 1-9. For engine re-builds (reuse block) follow step 6-9. 1. 30 N. m (22 ft. lbs.) 2. 45 N. m (33 ft. lbs.) 3. Re-tighten all to 45 N. m (33 ft. lbs.) 4. All + 125B° Turn. Do not use a torque wrench for this step. 5. Loosen all fasteners in reverse of sequence shown 6. All to 30 N. m (22 ft. lbs.) 7. All to 45 N. m (33 ft. lbs.) 8. Re-tighten all to 45 N. m (33 ft. lbs.)	Tightening Sequence - Left

CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
		9. All + 130B° Turn. Do not use a torque wrench for this step.	
3	Camshaft Bearing Cap Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence - Left
-	Cylinder Head Coolant Pipe Plug	**35 N.m (26 Ft. Lbs.)**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
-	Cylinder Head Oil Galley Plug	**18 N.m (13 Ft. Lbs.)**	-
-	Cylinder Head Oil Restrictor M8 Plug	**15 N.m (11 Ft. Lbs.)**	-
-	Ground Strap Bolt to Right Cylinder Head	**23 N.m (17 Ft. Lbs.)**	-
-	Heater Core Supply Tube to Cylinder Head M8 Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Wire Harness Retainer Bracket to LH Cylinder Head Bolts	**10 N.m (89 In. Lbs.)**	-



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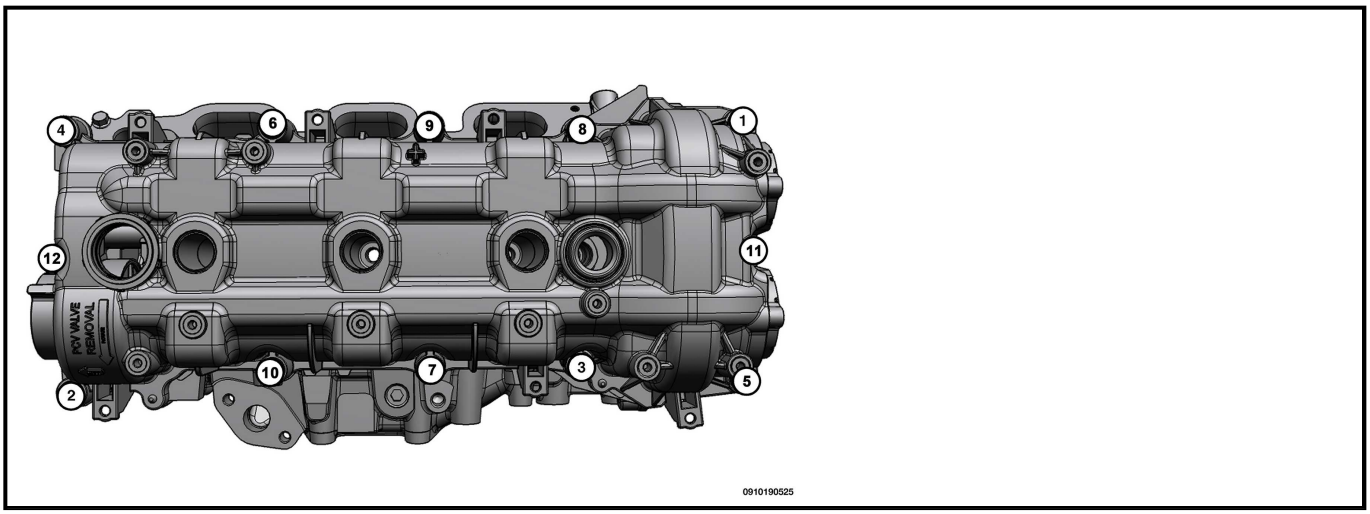
Tightening Sequence - Right



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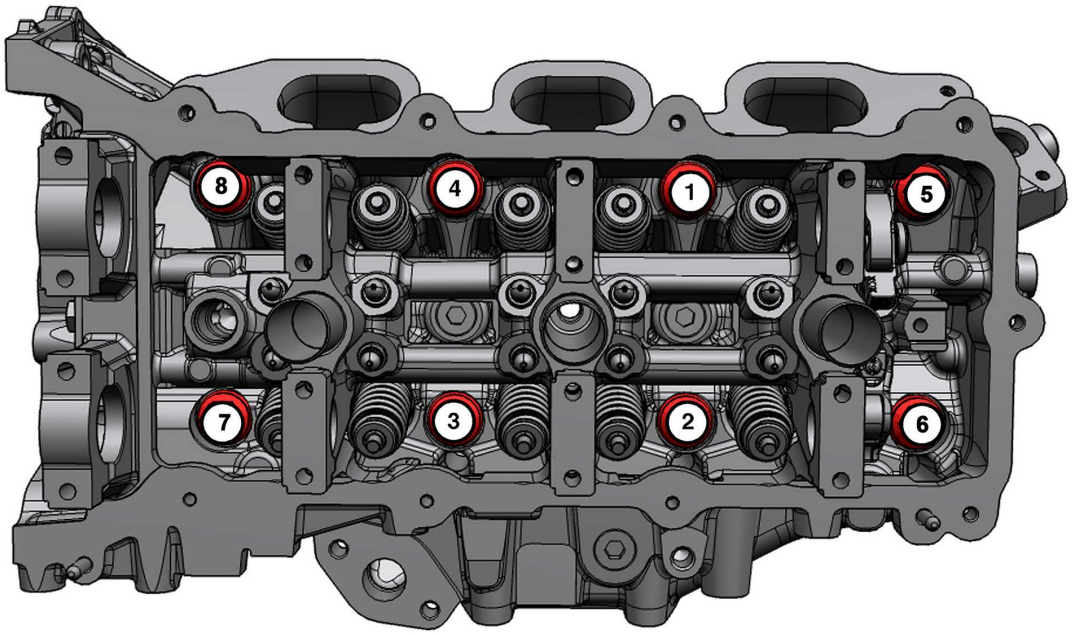
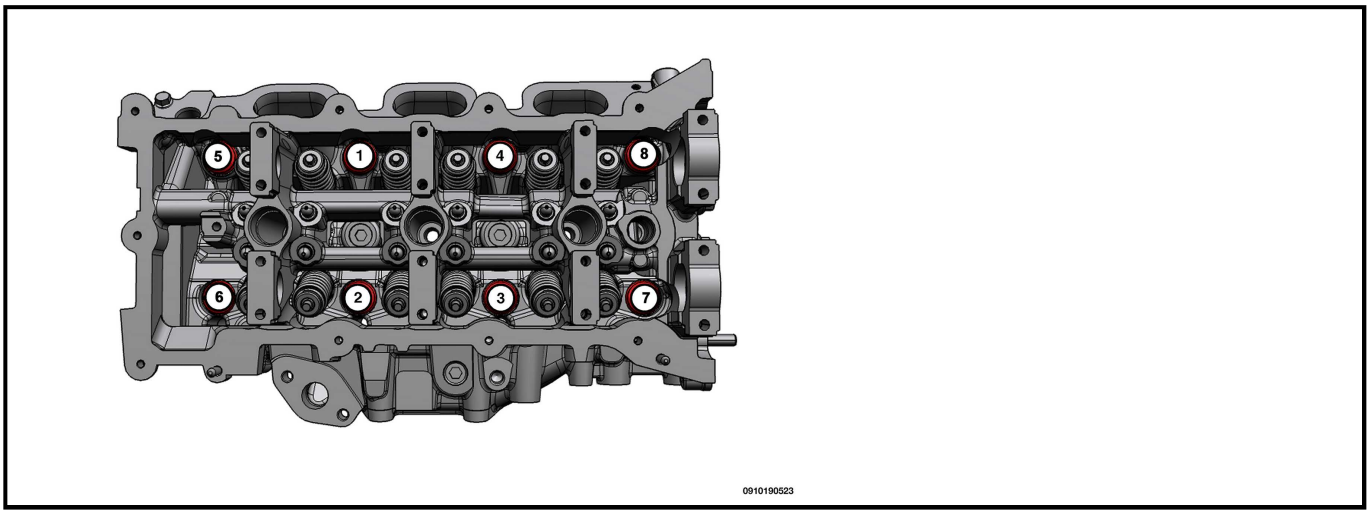
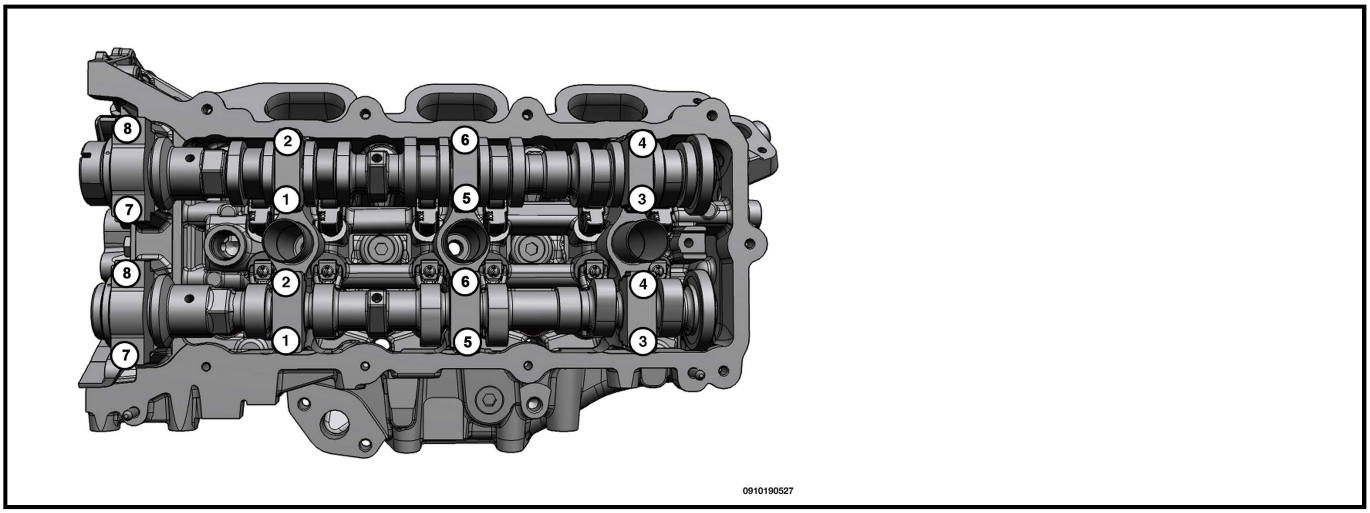


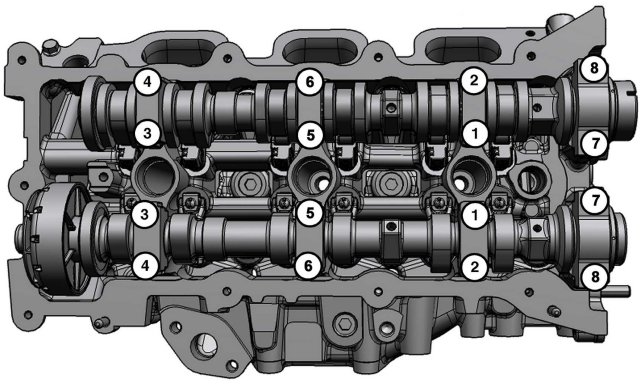
Fig. 7: Cylinder Head Bolts Tightening Sequence (1 of 2)
Courtesy of CHRYSLER GROUP, LLC

Tightening Sequence - Right





Tightening Sequence - Right



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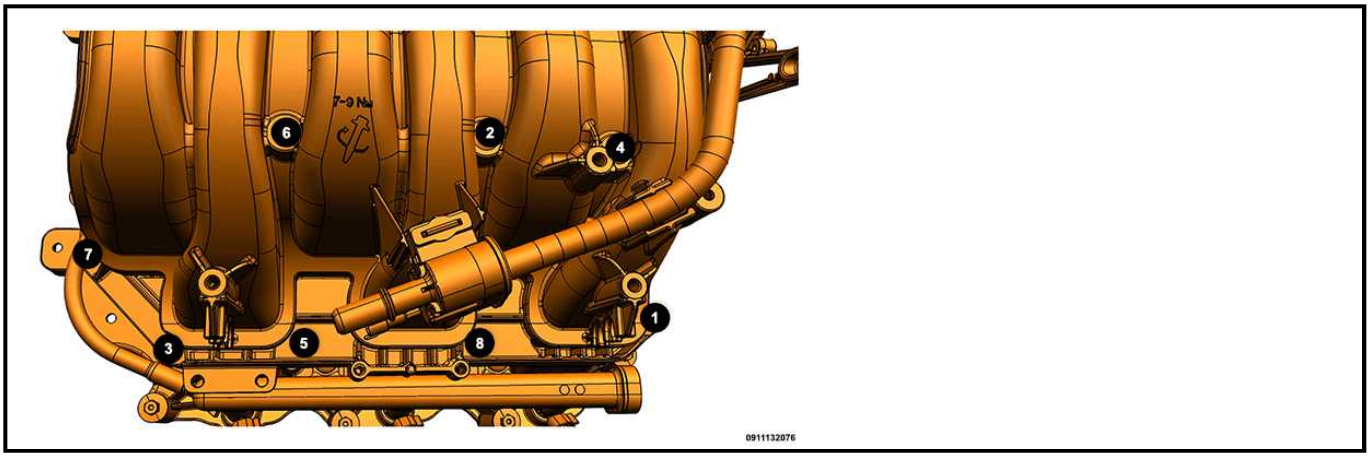
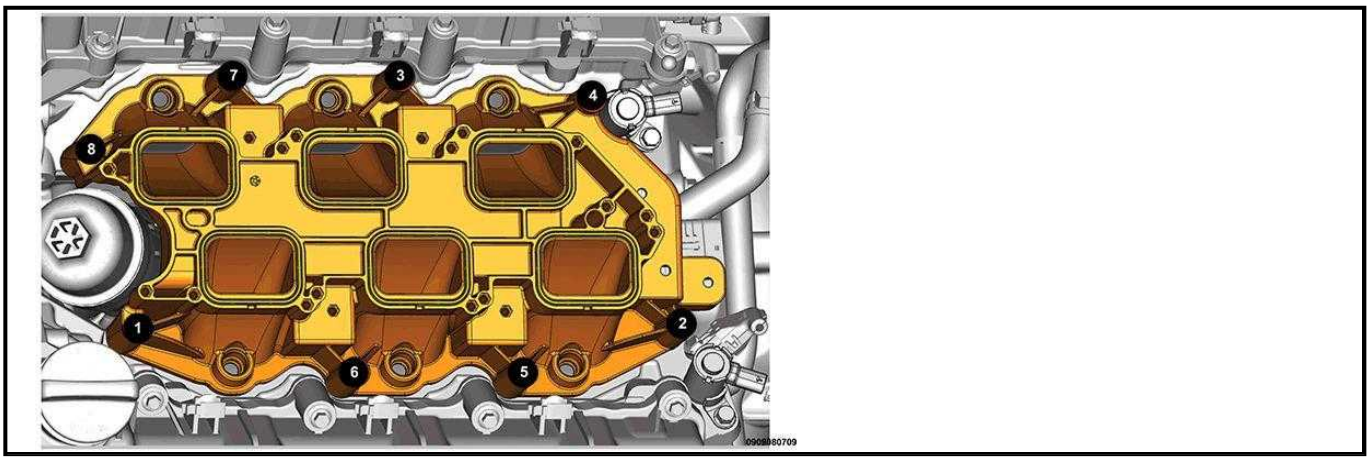
AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-





CYLINDER HEAD ASSEMBLY

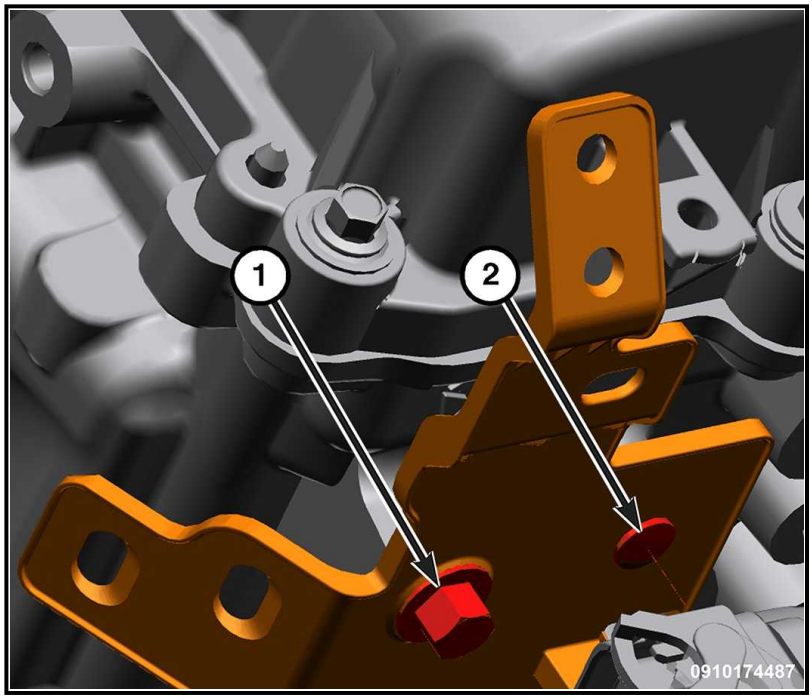
REMOVAL AND INSTALLATION

LEFT CYLINDER HEAD

REMOVAL

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

1. Perform the fuel pressure release procedure. Refer to **FUEL SYSTEM PRESSURE RELEASE** .
2. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
3. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .
4. Drain the cooling system. Refer to **DRAINING** .
5. Drain the engine oil. Refer to the appropriate information .
6. Remove the upper and lower intake manifolds and insulator. Refer to **MANIFOLD, INTAKE, REMOVAL AND INSTALLATION** .
7. Remove the Exhaust Gas Recirculation (EGR) cooler and upper intake manifold support bracket. Refer to **COOLER, EXHAUST GAS RECIRCULATION (EGR), REMOVAL AND INSTALLATION** .
8. Remove the heater core return hose from the water pump bypass.
9. Remove the A/C compressor and position aside. Refer to **COMPRESSOR, A/C, REMOVAL AND INSTALLATION** .
10. Remove the left catalytic converter from the cylinder head and position aside. Refer to **CONVERTER, CATALYTIC, REMOVAL AND INSTALLATION** .
11. Remove the left side ignition capacitor. Refer to **CAPACITOR, IGNITION, REMOVAL AND INSTALLATION**.

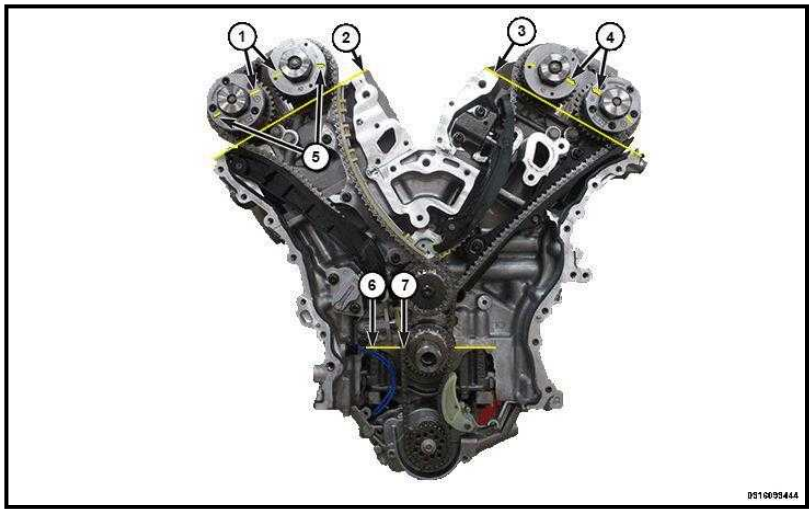


1 - Wire Harness Bracket Bolt	
2 - Wire Harness Bracket Fastener	

12. Remove the fasteners and disengage engine wire harness from the left cylinder head.
13. Reposition wire harness for cylinder head removal.
14. Remove the spark plugs. Refer to **SPARK PLUG, REMOVAL AND INSTALLATION**.
15. Remove the cylinder head covers and engine timing cover. Refer to **COVER(S), ENGINE TIMING, REMOVAL AND INSTALLATION** .

NOTE: **Take this opportunity to measure timing chain wear. Refer to MEASURING TIMING CHAIN WEAR .**

16. Lower the vehicle.



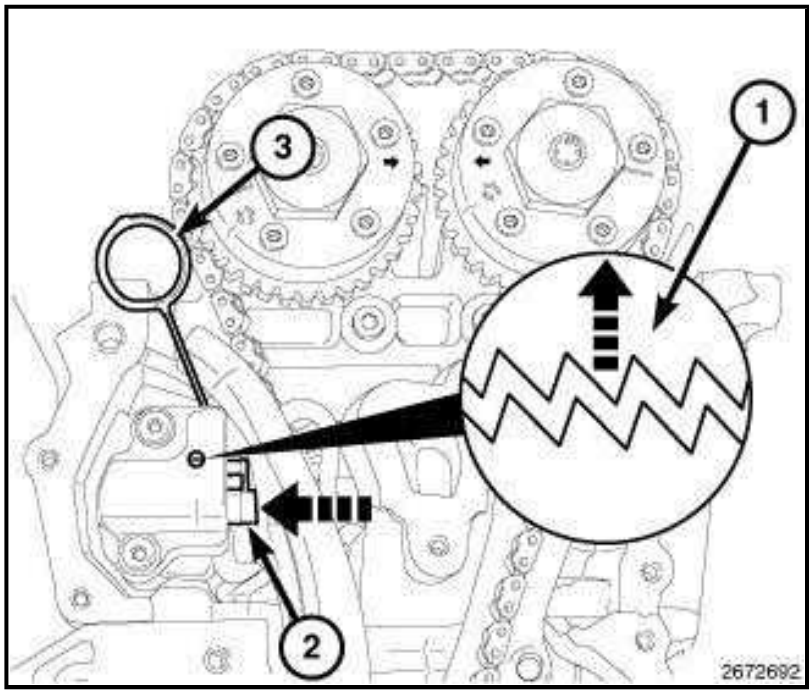
1 - Scribe Line	5 - Right Cam Phaser Arrows
2 - Left Valve Cover Sealing Surface	6 - Block/Bearing Cap Junction
3 - Left Valve Cover Sealing Surface	7 - Crankshaft Dimple
4 - Left Cam Phaser Arrows	B

CAUTION: **When aligning timing marks, always rotate engine by turning the crankshaft. Failure to do so will result in valve or piston damage.**

17. Rotate the crankshaft clockwise to place the number one piston at TDC on the exhaust stroke by aligning the dimple on the crankshaft with the block/bearing cap junction. The left side cam phaser arrows should point toward each other and be parallel to the valve cover sealing surface. The right side cam phaser arrows should point away from each other and the scribe lines should be parallel to the valve cover sealing surface.

CAUTION: **Always reinstall timing chains so that they maintain the same direction of rotation. Inverting a previously run chain on a previously run sprocket will result in excessive wear to both the chain and sprocket.**

18. Mark the direction of rotation on the timing chain using a paint pen or equivalent to aid in reassembly.



1 - Pawl
2 - Piston

CAUTION: **When the timing chains are removed and the cylinder heads are still installed, DO NOT rotate the camshafts or crankshaft without first locating the proper crankshaft position. Failure to do so will result in valve or piston damage.**

19. Reset the LH cam chain tensioner by lifting the pawl, pushing back the piston and installing Tensioner Pin (special tool #8514A, Pins, Tensioner) (3)

    Refer to **VALVE TIMING** .

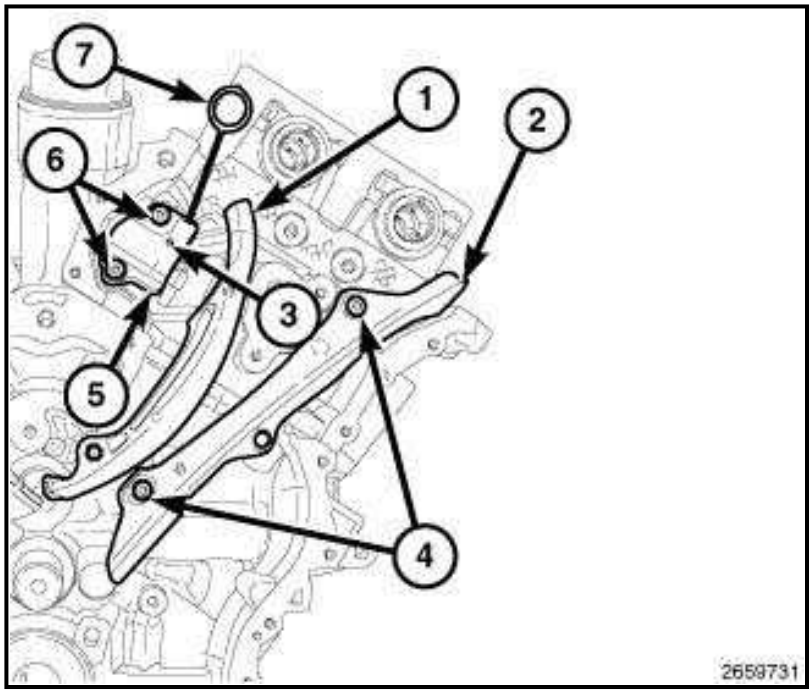
20. Remove the left side camshafts. Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION**.

NOTE: **If the rocker arms are to be reused, identify their positions so that they can be reassembled into their original locations.**

21. Remove the rocker arms. Refer to **ROCKER ARM, VALVE, REMOVAL AND INSTALLATION**.

NOTE: **If the hydraulic lifters are to be reused, identify their positions so that they can be reassembled into their original locations.**

22. If required, remove the hydraulic lifters. Refer to **LIFTER(S), HYDRAULIC, REMOVAL AND INSTALLATION**.



1 - LH Cam Chain Tensioner Arm	5 - LH Cam Chain Tensioner
2 - LH Cam Chain Guide	6 - Tensioner Bolts
3 - Tensioner	7 - Tensioner Pin
4 - Guide Bolts	B

23. Remove the LH cam chain tensioner arm.
24. Remove the two bolts and the LH cam chain tensioner.
25. Remove the two bolts and the LH cam chain guide.

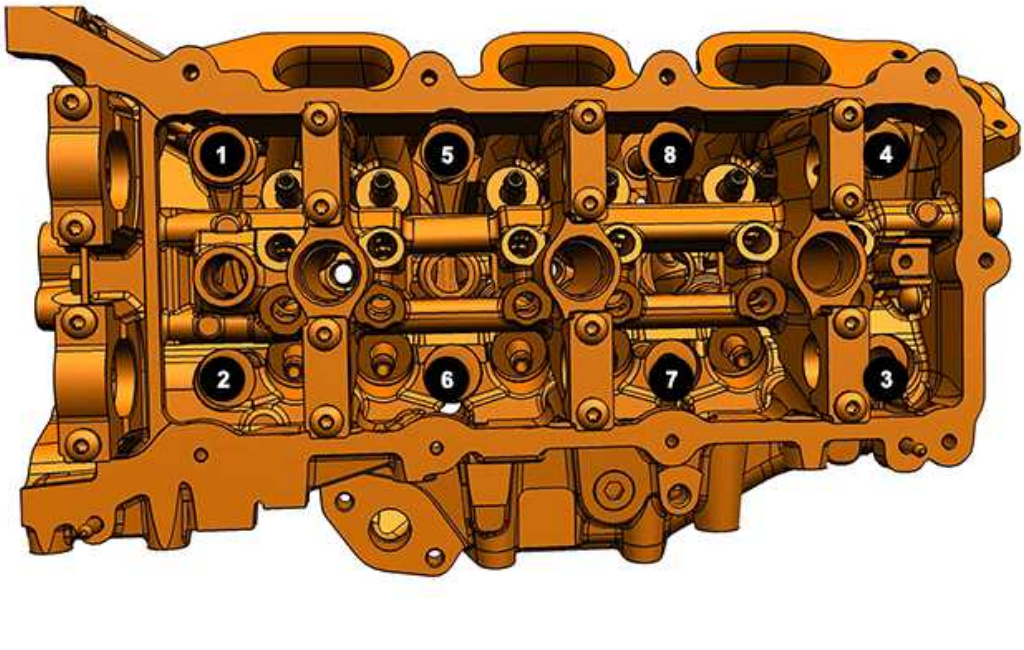


Fig. 8: Cylinder Head Bolts Loosening Sequence - Left
Courtesy of CHRYSLER GROUP, LLC

CAUTION: **DO NOT use an impact gun or any type of power tools to break loose or remove the head bolts. This can cause the threads to pull out of the block**

with the bolts.

26. Using the sequence shown, remove the cylinder head retaining bolts.

1 - Head Gasket
2 - Dowels

WARNING: **The multi-layered steel head gaskets have very sharp edges that could cause personal injury if not handled carefully.**

NOTE: **The head gasket crimps the locating dowels and the dowels may pull out of the engine block when the head gasket is removed.**

27. Remove the cylinder head and gasket. Discard the gasket.

CAUTION: **Do not lay the cylinder head on its gasket sealing surface, due to the design of the cylinder head gasket, any distortion to the cylinder head sealing surface may prevent the gasket from properly sealing resulting in leaks.**

INSTALLATION

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

1. If removed, install the ignition coil capacitor and the engine wire harness, then tighten to the proper torque specifications in the torque table below.

1 - Head Gasket
2 - Dowels

2. Clean and prepare the gasket sealing surfaces of the cylinder head and block. Refer to **CLEANING** .

CAUTION: **Non-compressible debris such as oil, coolant or RTV sealants that are not removed from bolt holes can cause the aluminum casting to crack when tightening the bolts.**

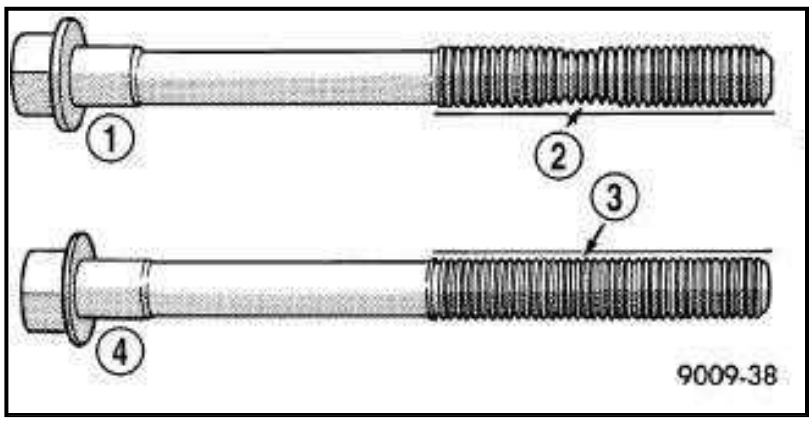
CAUTION: **When cleaning cylinder head and cylinder block surfaces, DO NOT use a metal scraper because the surfaces could be cut or ground. Use ONLY a wooden or plastic scraper.**

3. Clean out the cylinder head bolt holes in the engine block.

WARNING: **The multi-layered steel head gaskets have very sharp edges that could cause personal injury if not handled carefully.**

CAUTION: **The installation of the cylinder head gaskets are not interchangeable between the left and right cylinder heads. They are clearly marked (3) with "R" for right and "L" for left. They must be applied on a dry surface, without the use of any adhesives.**

4. Position the **NEW** cylinder head gasket on the locating dowels.



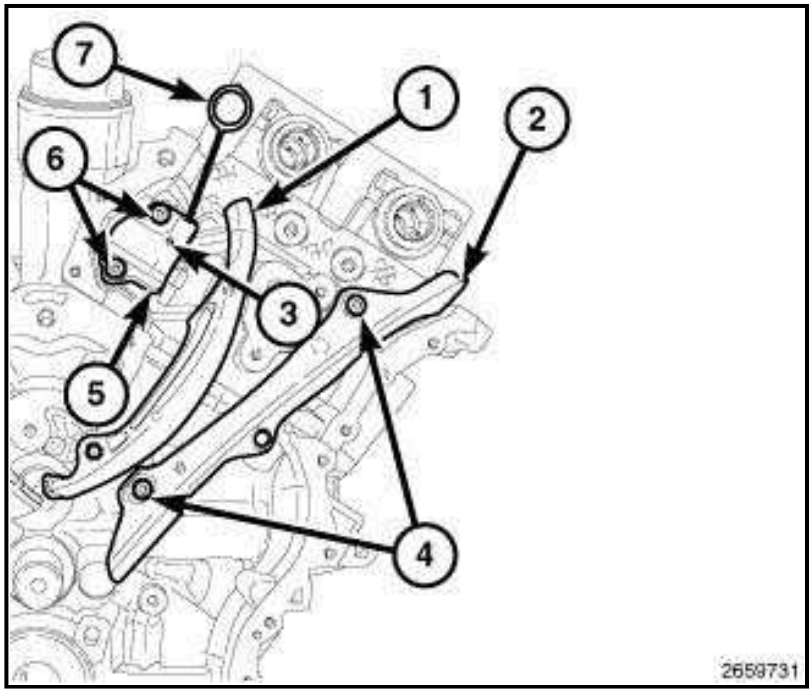
1 - Cylinder Head Bolt
2 - Unacceptable Thread Contact
3 - Acceptable Thread Contact
4 - Cylinder Head Bolt

CAUTION: **The cylinder head bolts are tightened using a torque plus angle procedure. The bolts must be examined BEFORE reuse. If the threads are necked down the bolts must be replaced.**

5. Check cylinder head bolts for necking by holding a scale or straight edge against the threads. If all the threads do not contact the scale the bolt must be replaced.
6. Position the cylinder head onto the cylinder block. Make sure the cylinder head seats fully over the locating dowels.

NOTE: **Do not apply any additional oil to the bolt threads.**

7. Install the cylinder head bolts finger tight.
8. The cylinder head bolts must be tightened in the sequence shown in the torque table below.

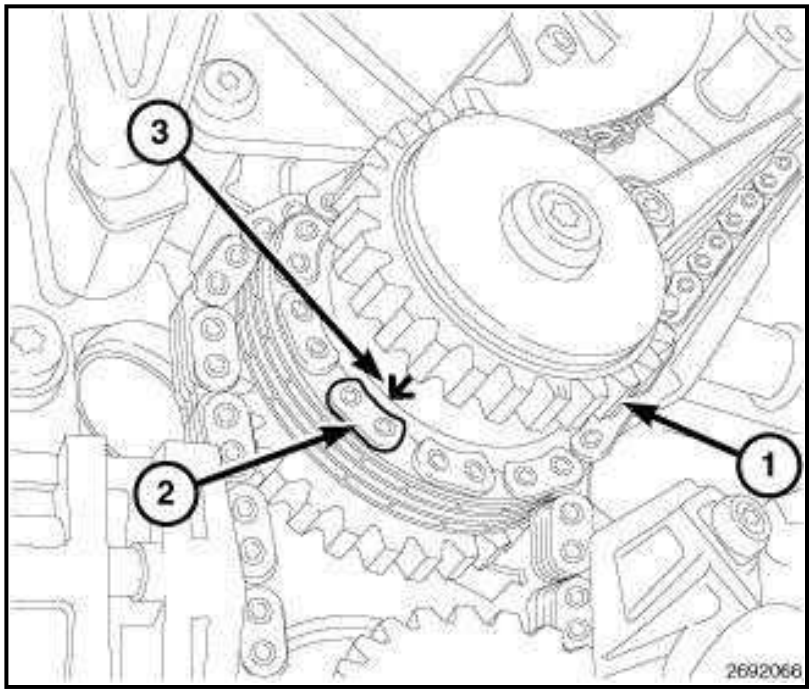


1 - LH Cam Chain Tensioner Arm	5 - LH Cam Chain Tensioner
2 - LH Cam Chain Guide	6 - Tensioner Bolts
3 - Tensioner	7 - Tensioner Pin
4 - Guide Bolts	B

9. Install the LH cam chain guide with two bolts and tighten the bolts.
10. Install the LH cam chain tensioner to the cylinder head with two bolts and tighten the bolts.
11. Reset the LH cam chain tensioner by lifting the pawl, pushing back the piston and installing Tensioner Pin (special tool #8514A, Pins, Tensioner)

    Refer to **VALVE TIMING** .

12. Install the LH tensioner arm.



1 - Idler Sprocket
2 - Plated Link
3 - Alignment Arrow

13. Drape the left side cam chain onto the idler sprocket so that the arrow is aligned with the plated link on the cam chain.

CAUTION: **Always reinstall timing chains so that they maintain the same direction of rotation. Inverting a previously run chain on a previously run sprocket will result in excessive wear to both the chain and sprocket.**

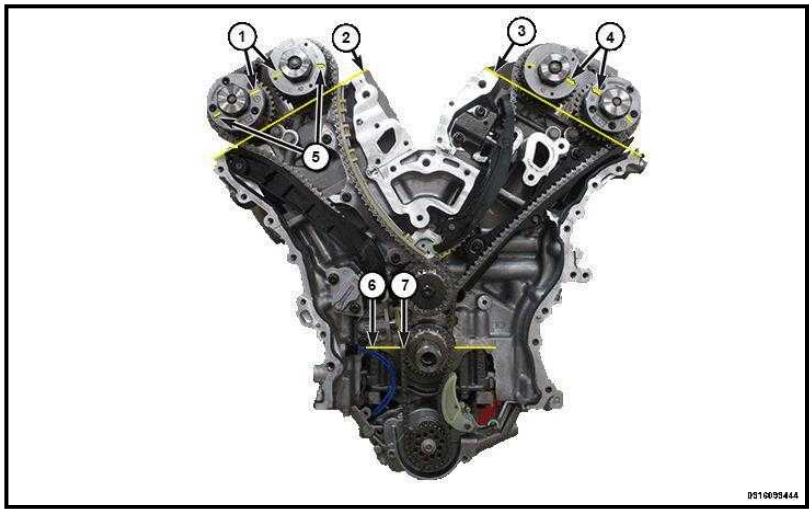
14. If removed, install the hydraulic lifters. Refer to **ROCKER ARM, VALVE, REMOVAL AND INSTALLATION**.

NOTE: **If the rocker arms and hydraulic are being reused, reassemble them into their original locations.**

15. Install the rocker arms and camshafts. Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION**.

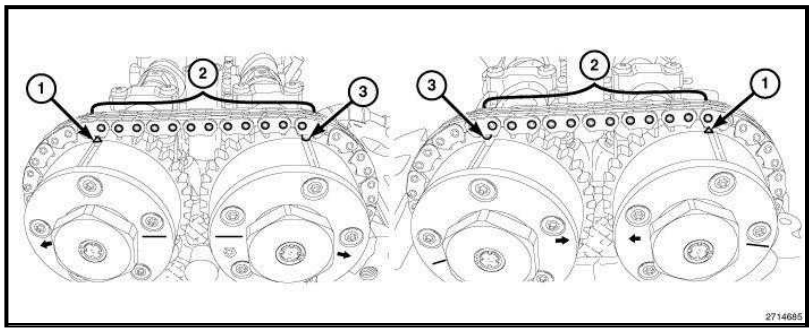
CAUTION: **Do not rotate the camshafts more than a few degrees independently of the crankshaft. Valve to piston contact could occur resulting in possible valve damage. If the camshafts need to be rotated more than a few degrees, first move the pistons away from the cylinder heads by rotating the crankshaft counterclockwise to a position 30B° before-top-dead-center. Once the camshafts are returned to their top-dead-center position, rotate the crankshaft clockwise to return the crankshaft to top-dead-center.**

16. Remove the Tensioner Pin (special tool #8514A, Pins, Tensioner) from the LH camshaft chain tensioner.



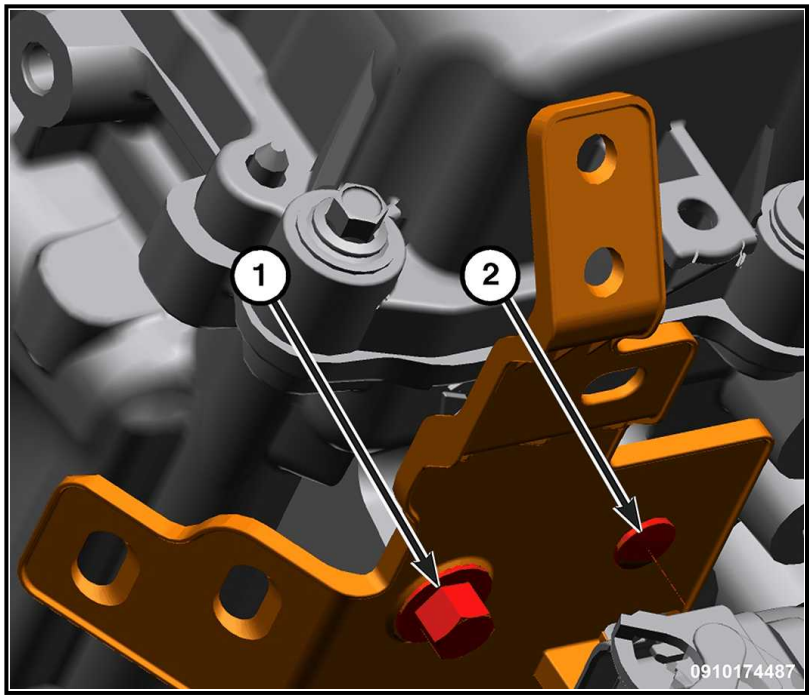
1 - Scribe Line	5 - Right Cam Phaser Arrows
2 - Left Valve Cover Sealing Surface	6 - Block/Bearing Cap Junction
3 - Left Valve Cover Sealing Surface	7 - Crankshaft Dimple
4 - Left Cam Phaser Arrows	B

17. Rotate the crankshaft clockwise two complete revolutions stopping when the dimple on the crankshaft is aligned the with the block/bearing cap junction.
18. While maintaining this alignment, verify that the arrows on the left side camshaft phasers point toward each other and are parallel to the valve cover sealing surface and that the right side cam phaser arrows point away from each other and the scribe lines are parallel to the valve cover sealing surface.



1 - Exhaust Camshaft Phaser Triangle Marking
2 - 12 Link Pins
3 - Intake Camshaft Phaser Triangle Marking

19. There should be 12 chain link pins between the exhaust camshaft phaser triangle marking and the intake camshaft phaser circle marking.
20. If the engine timing is not correct. Refer to **CHAIN AND SPROCKETS, TIMING, REMOVAL AND INSTALLATION** .
21. Install the engine timing cover and cylinder head covers. Refer to **COVER(S), ENGINE TIMING, REMOVAL AND INSTALLATION** .
22. Install the spark plugs. Refer to **SPARK PLUG, REMOVAL AND INSTALLATION**.



1 - Wire Harness Bracket Bolt
2 - Wire Harness Bracket Fastener

23. Position the wire harness and bracket to the left cylinder head.
24. Secure the fastener to the cylinder head and tighten the bolt

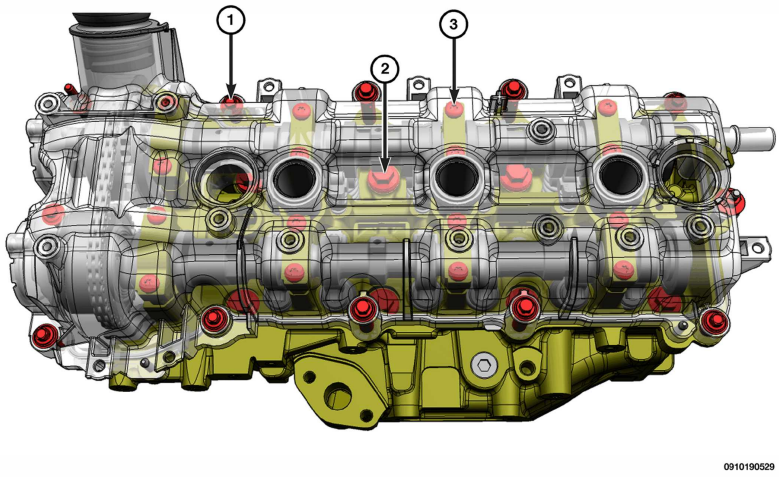
    .

25. Install the left side ignition capacitor. Refer to **CAPACITOR, IGNITION, REMOVAL AND INSTALLATION**.
26. Install the left side catalytic converter. Refer to **CONVERTER, CATALYTIC, REMOVAL AND INSTALLATION** .
27. Install the A/C compressor. Refer to **COMPRESSOR, A/C, REMOVAL AND INSTALLATION** .
28. Install the heater core return hose onto the water pump bypass.
29. Install the Exhaust Gas Recirculation (EGR) cooler and upper intake manifold support bracket with lower bolt. Refer to **COOLER, EXHAUST GAS RECIRCULATION (EGR), REMOVAL AND INSTALLATION** .
30. Install the upper and lower intake manifolds. Refer to **MANIFOLD, INTAKE, REMOVAL AND INSTALLATION** .
31. Install a new oil filter and fill the engine crankcase with the proper oil to the correct level. Refer to **LUBRICATION** .
32. Fill the cooling system. Refer to **STANDARD PROCEDURE - FILLING** .
33. Connect the negative battery cable(s). Refer to **CABLES, BATTERY** .
34. Run the engine until it reaches normal operating temperature. Check cooling system for correct fluid level. Refer to **COOLING SYSTEM** .

NOTE: **The Cam/Crank Variation Relearn procedure must be performed using the scan tool anytime there has been a repair/replacement made to a powertrain system, for example: flywheel, valvetrain, camshaft and/or crankshaft sensors or components.**

TORQUE SPECIFICATIONS

CYLINDER HEAD



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Cylinder Head Cover M6 Bolts	**12 N.m (9 Ft. Lbs.)**	Tightening Sequence - Left
2	Cylinder Head Bolts	**Torque Procedure** For engine builds using a new block follow steps 1-9. For engine re-builds (reuse block) follow step 6-9. 1. 30 N. m (22 ft. lbs.) 2. 45 N. m (33 ft. lbs.) 3. Re-tighten all to 45 N. m (33 ft. lbs.) 4. All + 125B° Turn. Do not use a torque wrench for this step. 5. Loosen all fasteners in reverse of sequence shown 6. All to 30 N. m (22 ft. lbs.) 7. All to 45 N. m (33 ft. lbs.) 8. Re-tighten all to 45 N. m (33 ft. lbs.) 9. All + 130B° Turn. Do not use a torque wrench for this step.	Tightening Sequence - Left
3	Camshaft Bearing Cap Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence - Left
-	Cylinder Head Coolant Pipe Plug	**35 N.m (26 Ft. Lbs.)**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
-	Cylinder Head Oil Galley Plug	**18 N.m (13 Ft. Lbs.)**	-
-	Cylinder Head Oil Restrictor M8 Plug	**15 N.m (11 Ft. Lbs.)**	-

CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
-	Ground Strap Bolt to Right Cylinder Head	**23 N.m (17 Ft. Lbs.)**	-
-	Heater Core Supply Tube to Cylinder Head M8 Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Wire Harness Retainer Bracket to LH Cylinder Head Bolts	**10 N.m (89 In. Lbs.)**	-

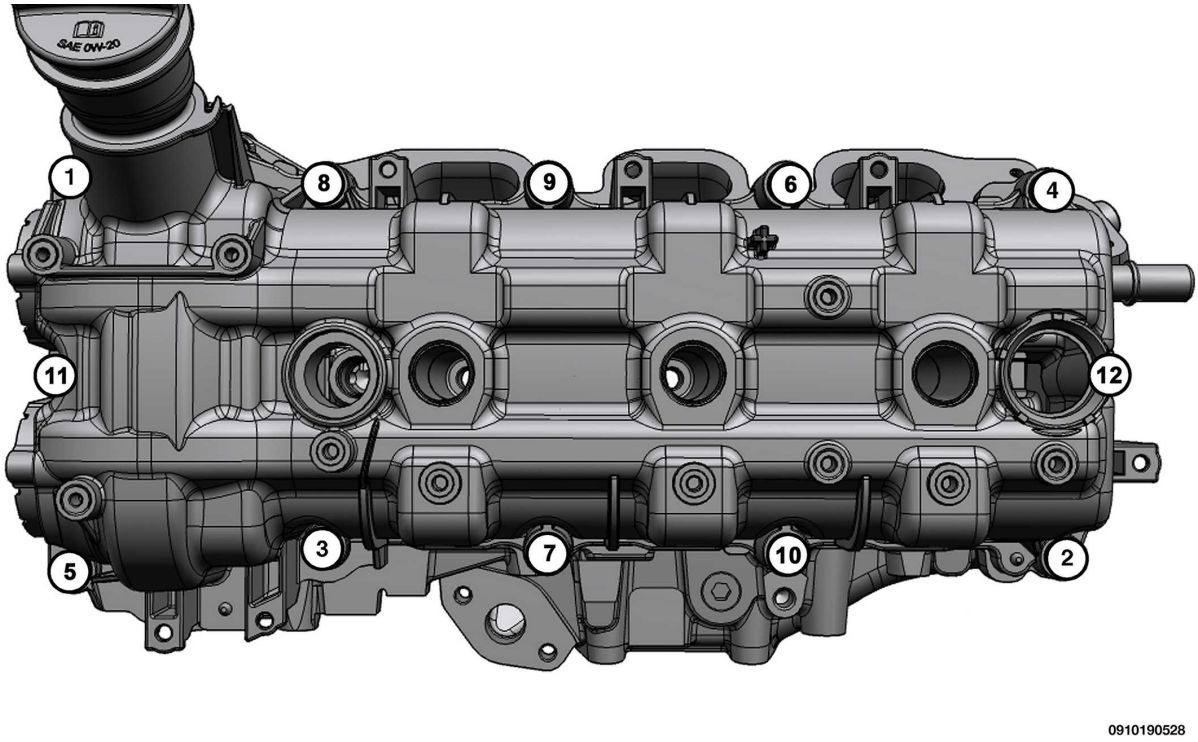


Fig. 9: Cylinder Head Cover Bolts Tightening Sequence (1 of 2)
Courtesy of CHRYSLER GROUP, LLC

Tightening Sequence - Right

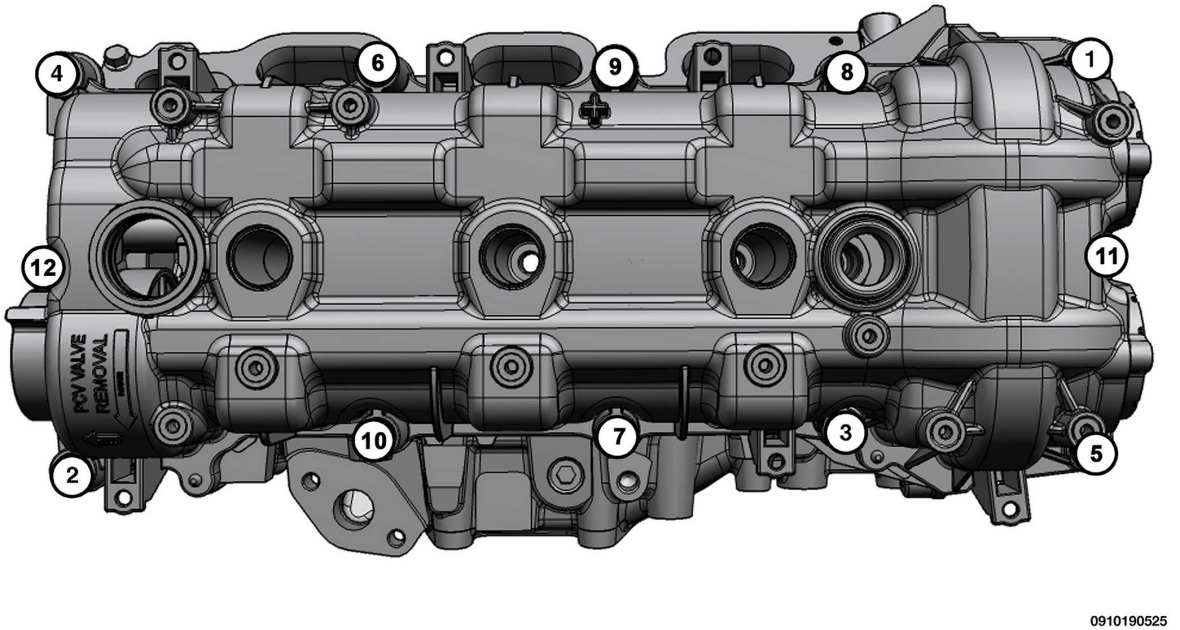
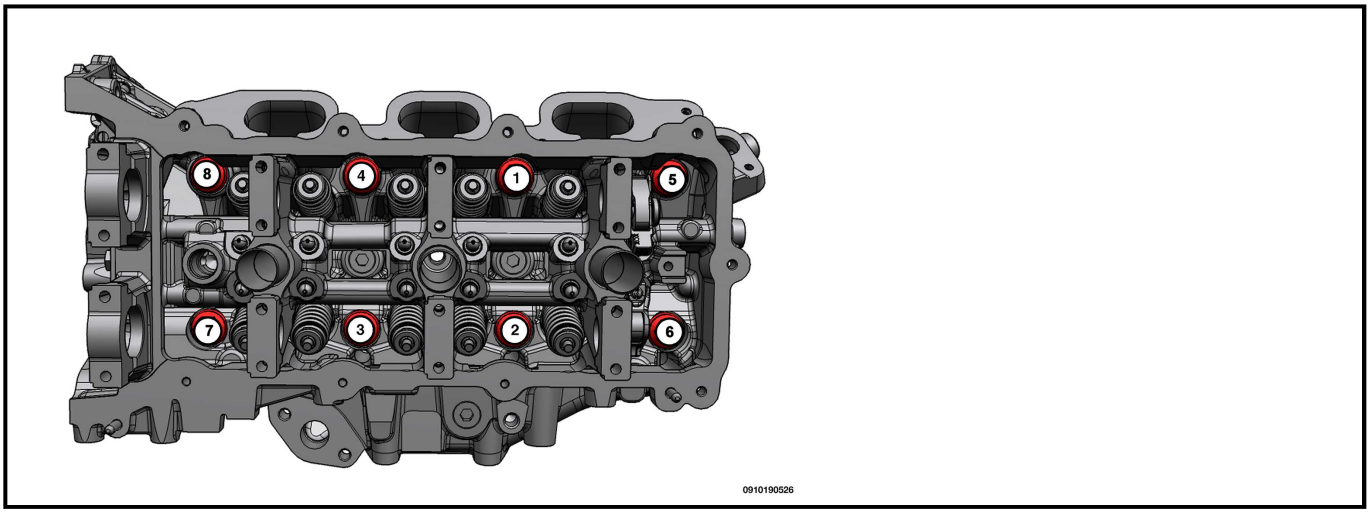
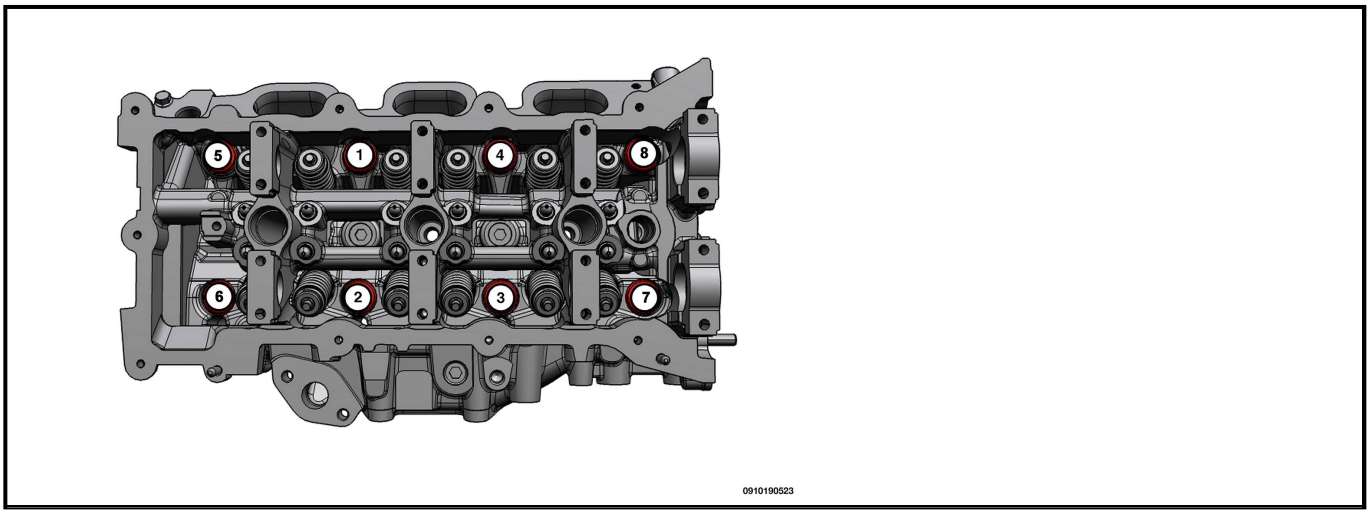
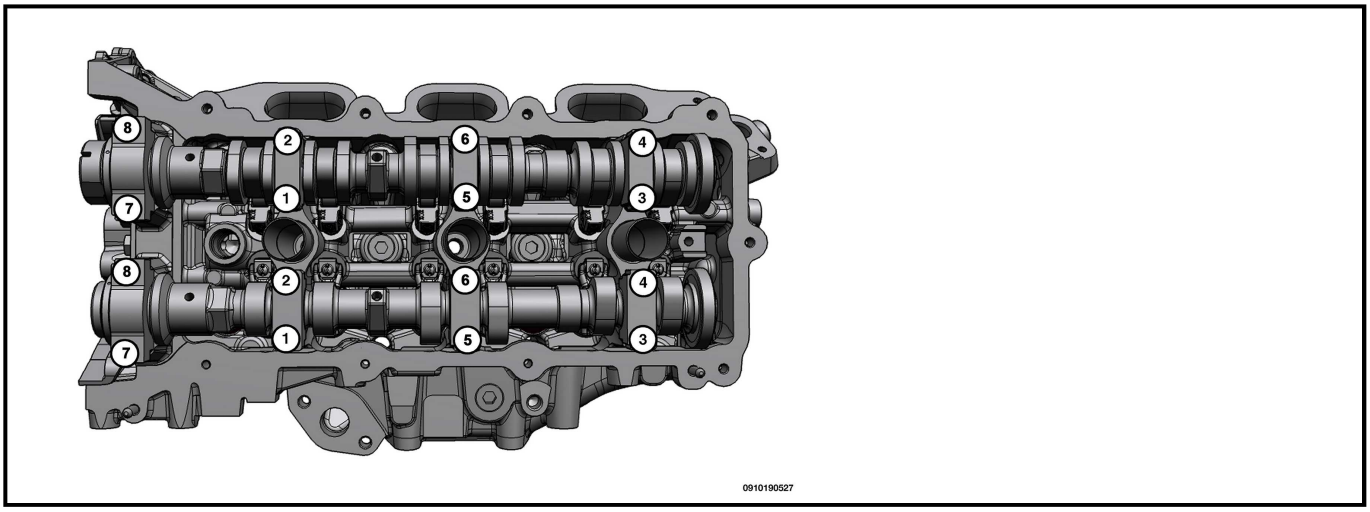


Fig. 10: Cylinder Head Cover Bolts Tightening Sequence (2 of 2)
Courtesy of CHRYSLER GROUP, LLC

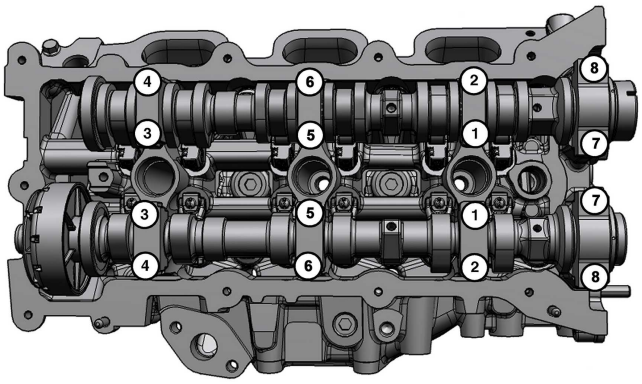


Tightening Sequence - Right





Tightening Sequence - Right



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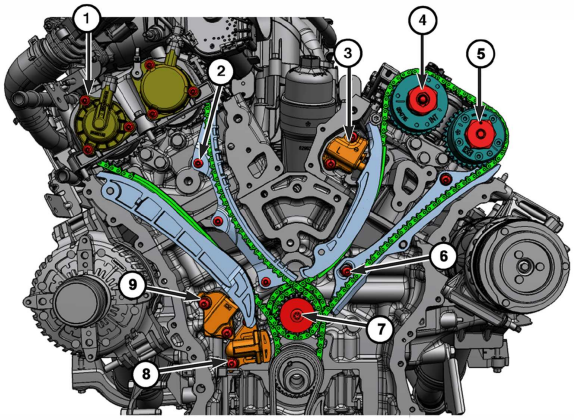
VALVE TIMING



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CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-

CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

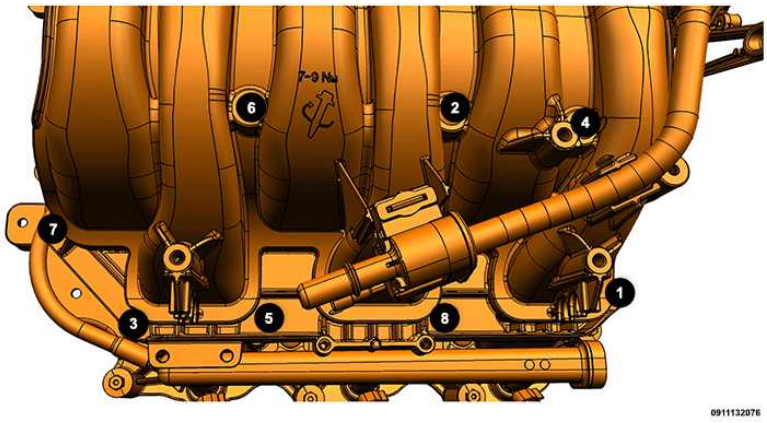
TORQUE SPECIFICATIONS - 3.6L EXHAUST SYSTEM

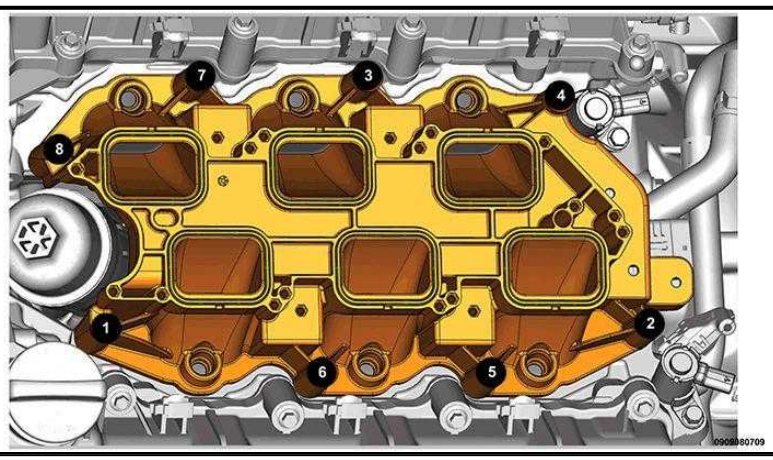
DESCRIPTION	SPECIFICATION	COMMENTS
Catalytic Converter to Cylinder Head Bolts	**24 N. m (18 Ft. Lbs.)**	-
Exhaust Y-Pipe-to-Catalytic Converter Flange Bolts	**18 N. m (13 Ft. Lbs.)**	-
Exhaust Resonator Clamp Bolt	**26 N. m (19 Ft. Lbs.)**	-
Front Exhaust Isolator Bolts	**30 N. m (22 Ft. Lbs.)**	-
Muffler Clamp Nuts	**55 N. m (41 Ft. Lbs.)**	-
Muffler Exhaust Isolator Bolts	**25 N. m (18 Ft. Lbs.)**	-
Heat Shield Nuts	**3 N.m (27 In. Lbs.)**	-

AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-





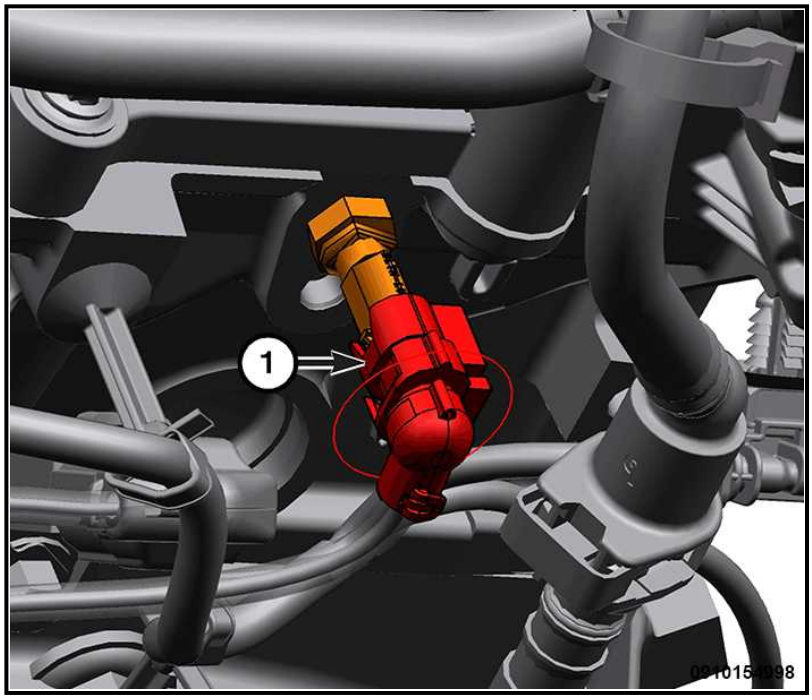
EGR SYSTEM

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.)**	-

RIGHT CYLINDER HEAD

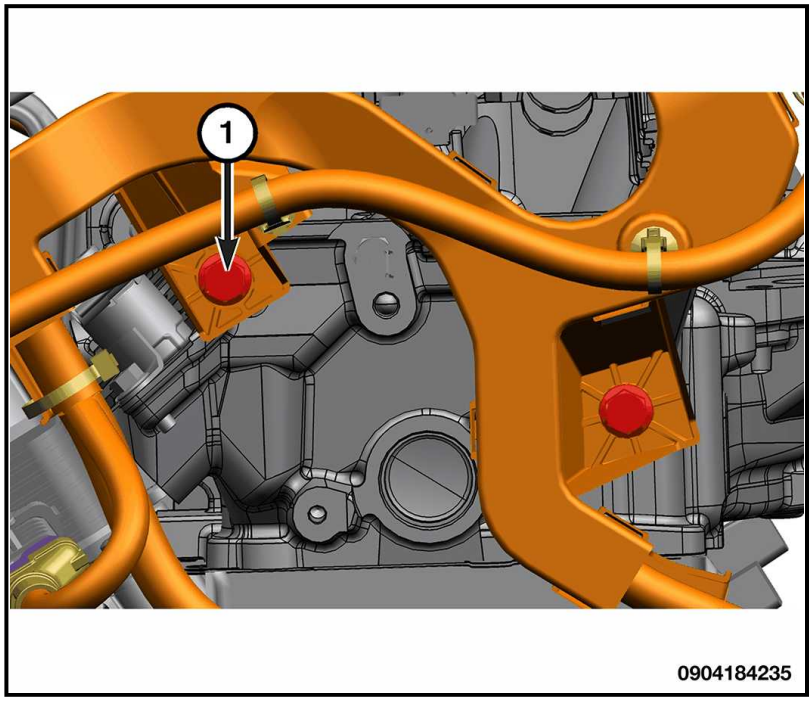
REMOVAL

1. Perform the fuel pressure release procedure. Refer to **FUEL SYSTEM PRESSURE RELEASE** .
2. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
3. Remove the upper and lower intake manifolds and insulator. Refer to **MANIFOLD, INTAKE, REMOVAL AND INSTALLATION** .
4. Remove the generator fasteners and position the generator aside. Refer to **GENERATOR, REMOVAL AND INSTALLATION** .
5. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .
6. Drain the engine oil. Refer to the appropriate information .
7. Remove the right side catalytic converter and position aside. Refer to **CONVERTER, CATALYTIC, REMOVAL AND INSTALLATION** .



1 - Wire Harness Connector

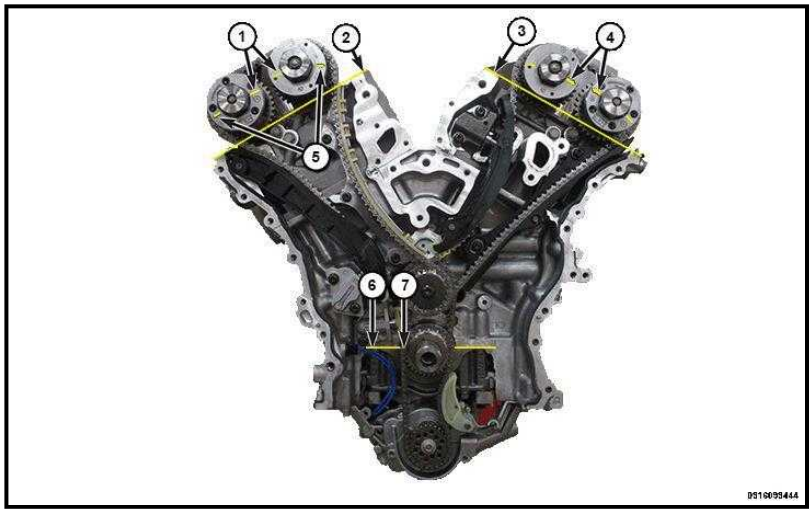
8. Disconnect the oil temperature sensor wire harness connector.
9. Remove the right side ignition coil capacitor and ground wire. Refer to **CAPACITOR, IGNITION, REMOVAL AND INSTALLATION**.
10. Remove the spark plugs. Refer to **SPARK PLUG, REMOVAL AND INSTALLATION**.



1 - Wire Harness Fasteners

11. Remove the wire harness fasteners from the right cylinder head and position the harness aside.
12. Remove the bank 1 rear Variable Valve Lift (VVL) solenoid. Refer to **SOLENOID, REMOVAL AND INSTALLATION** .
13. Remove the cylinder head covers and engine timing cover. Refer to **COVER(S), ENGINE TIMING, REMOVAL AND INSTALLATION** .

NOTE: **Take this opportunity to measure timing chain wear. Refer to MEASURING TIMING CHAIN WEAR .**



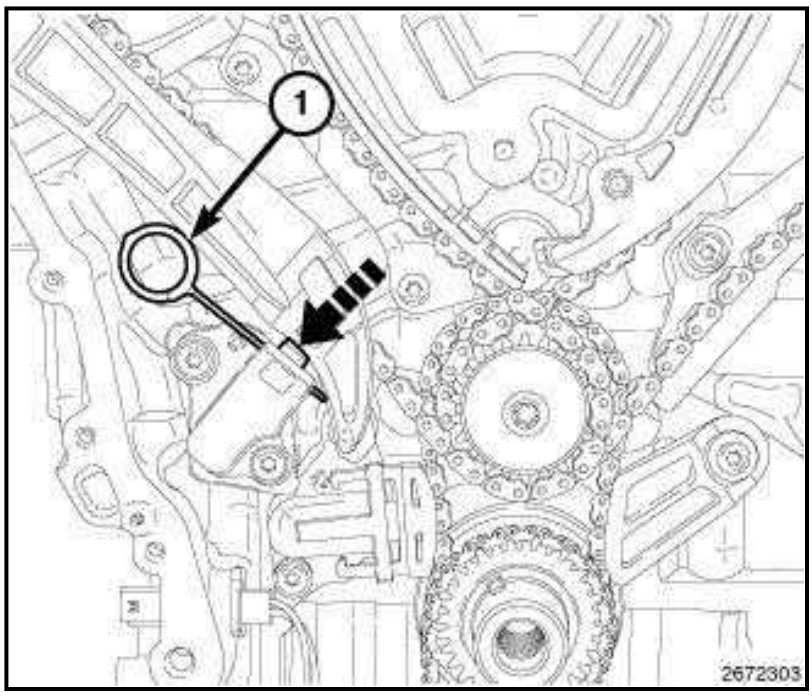
1 - Scribe Line	5 - Right Cam Phaser Arrows
2 - Right Valve Cover Sealing Surface	6 - Block/Bearing Cap Junction
3 - Left Valve Cover Sealing Surface	7 - Crankshaft Dimple
4 - Left Cam Phaser Arrows	B

CAUTION: **When aligning timing marks, always rotate engine by turning the crankshaft. Failure to do so will result in valve or piston damage.**

14. Rotate the crankshaft clockwise to place the number one piston at Top Dead Center (TDC) on the exhaust stroke by aligning the dimple on the crankshaft with the block/bearing cap junction. The left side cam phaser arrows should point toward each other and be parallel to the valve cover sealing surface. The right side cam phaser arrows should point away from each other and the scribe lines should be parallel to the valve cover sealing surface.

CAUTION: **Always reinstall timing chains so that they maintain the same direction of rotation. Inverting a previously run chain on a previously run sprocket will result in excessive wear to both the chain and sprocket.**

15. Mark the direction of rotation on the timing chain using a paint pen or equivalent to aid in reassembly.



1 - Tensioner Pin Tool

CAUTION: **When the timing chains are removed and the cylinder heads are still installed, DO NOT rotate the camshafts or crankshaft without first locating the proper crankshaft position. Failure to do so will result in valve or piston damage.**

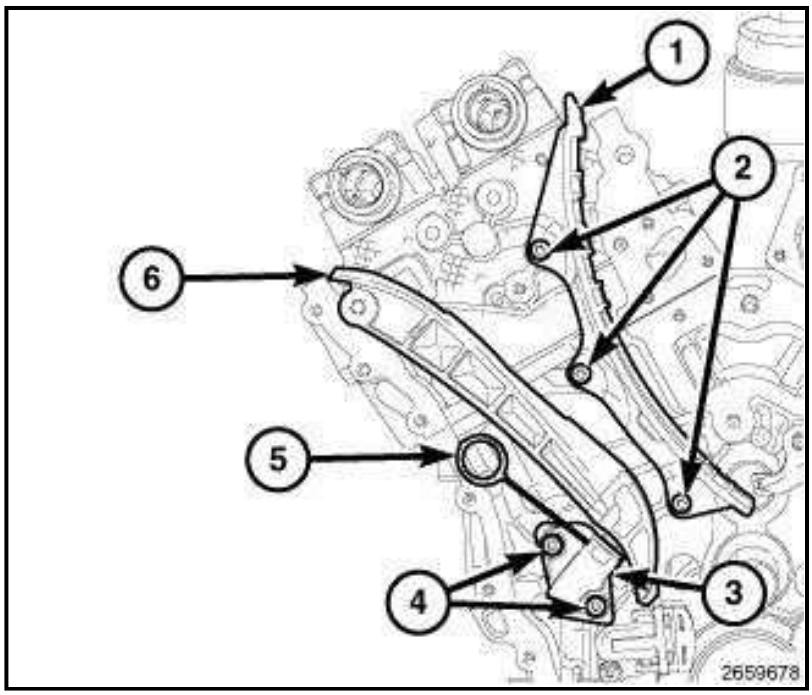
16. Reset the RH cam chain tensioner by pushing back the tensioner piston and installing Tensioner Pin (special tool #8514A, Pins, Tensioner).
17. Remove the right camshafts. Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION**.

NOTE: **If the rocker arms are to be reused, identify their positions so that they can be reassembled into their original locations.**

18. Remove the rocker arms. Refer to **ROCKER ARM, VALVE, REMOVAL AND INSTALLATION**.

NOTE: **If the hydraulic lifters are to be reused, identify their positions so that they can be reassembled into their original locations.**

19. If required, remove the hydraulic lifters. Refer to **LIFTER(S), HYDRAULIC, REMOVAL AND INSTALLATION**.



1 - RH Timing Chain Guide	4 - Chain Tensioner Bolts
2 - Chain Guide Bolts	5 - Tensioner Pin Tool
3 - Timing Chain Tensioner	6 - Tensioner Arm

20. Remove the RH timing chain tensioner arm.
21. Remove the two bolts and the RH timing chain tensioner.
22. Remove the three chain guide bolts and the RH timing chain guide.

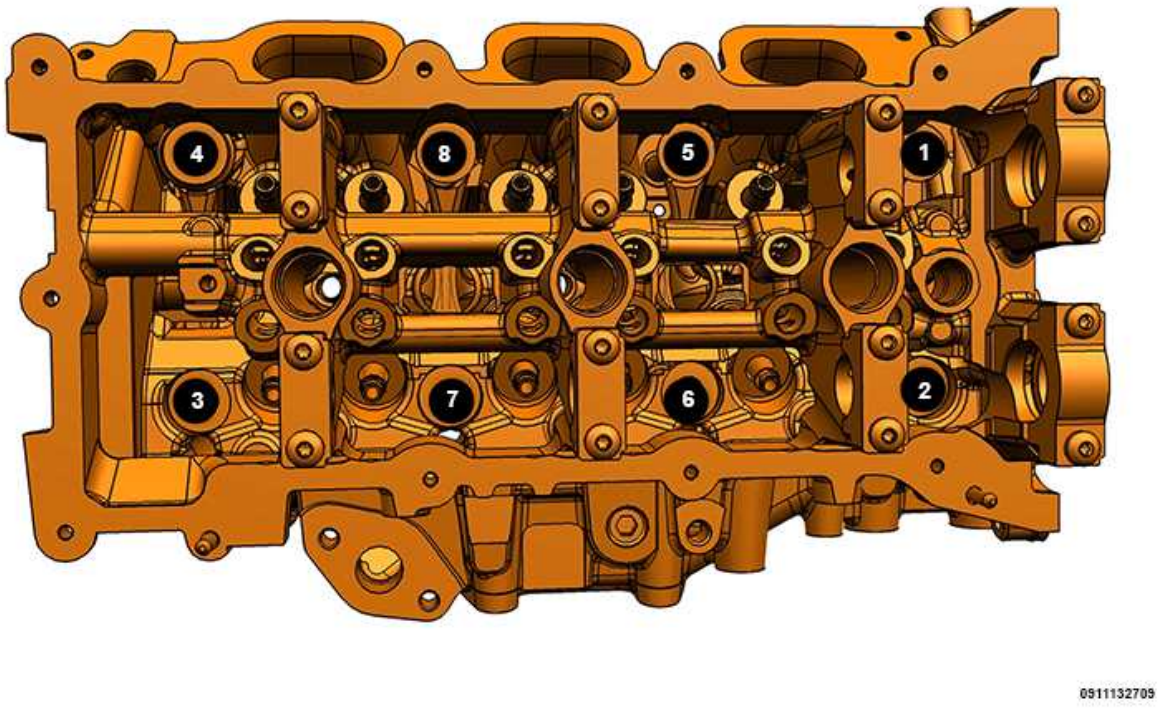


Fig. 11: Cylinder Head Bolt Loosening Sequence - Right
Courtesy of CHRYSLER GROUP, LLC

CAUTION: **DO NOT use an impact gun or any type of power tools to break loose or remove the head bolts. This can cause the threads to pull out of the block with the bolts.**

23. Using the sequence shown, remove the cylinder head retaining bolts.

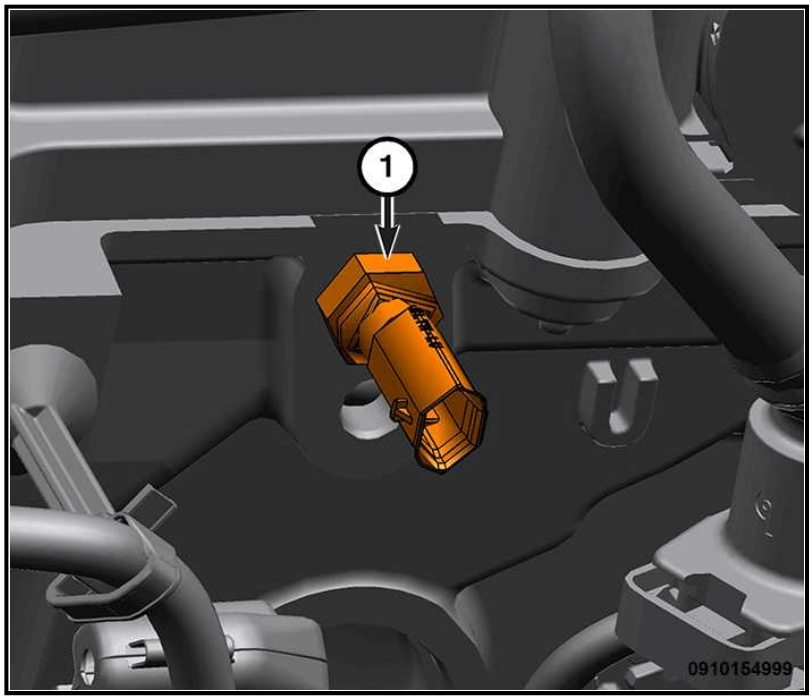
1 - Head Gasket
2 - Locating Dowels
3 - Identifier

WARNING: **The multi-layered steel head gaskets have very sharp edges that could cause personal injury if not handled carefully.**

NOTE: **The head gasket crimps the locating dowels and the dowels may pull out of the engine block when the head gasket is removed.**

24. Remove the cylinder head and gasket. Discard the gasket.

CAUTION: **Do not lay the cylinder head on its gasket sealing surface, due to the design of the cylinder head gasket, any distortion to the cylinder head sealing surface may prevent the gasket from properly sealing resulting in leaks.**



1 - Oil Temperature Sensor

25. If required, remove the oil temperature sensor.

INSTALLATION

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

1. If removed, install the oil temperature sensor and tighten.

1 - Head Gasket
2 - Locating Dowls
3 - Identifier

2. Clean and prepare the gasket sealing surfaces of the cylinder head and block. Refer to **CLEANING** .

CAUTION: **Non-compressible debris such as oil, coolant or RTV sealants that are not removed from bolt holes can cause the aluminum casting to crack when tightening the bolts.**

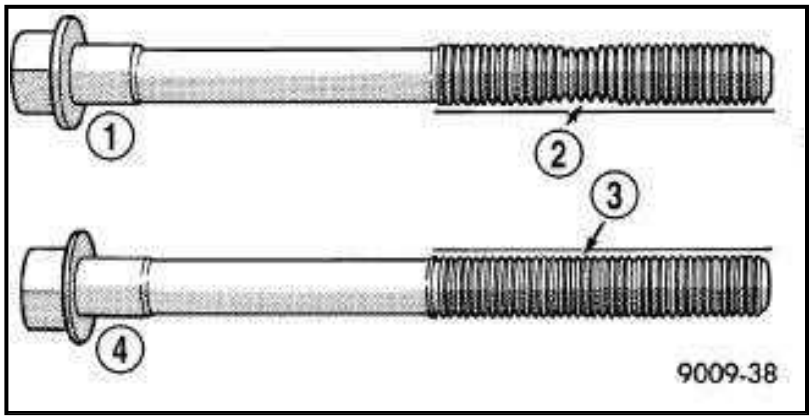
CAUTION: **When cleaning cylinder head and cylinder block surfaces, DO NOT use a metal scraper because the surfaces could be cut or ground. Use ONLY a wooden or plastic scraper.**

3. Clean out the cylinder head bolt holes in the engine block.

WARNING: **The multi-layered steel head gaskets have very sharp edges that could cause personal injury if not handled carefully.**

NOTE: **The installation of the cylinder head gasket are not interchangeable between left and right cylinder heads. The are identified with a "R" for right or "L" for left. They must be applied on a dry surface, without the use of any adhesives.**

4. Position the new cylinder head gasket on the locating dowels.



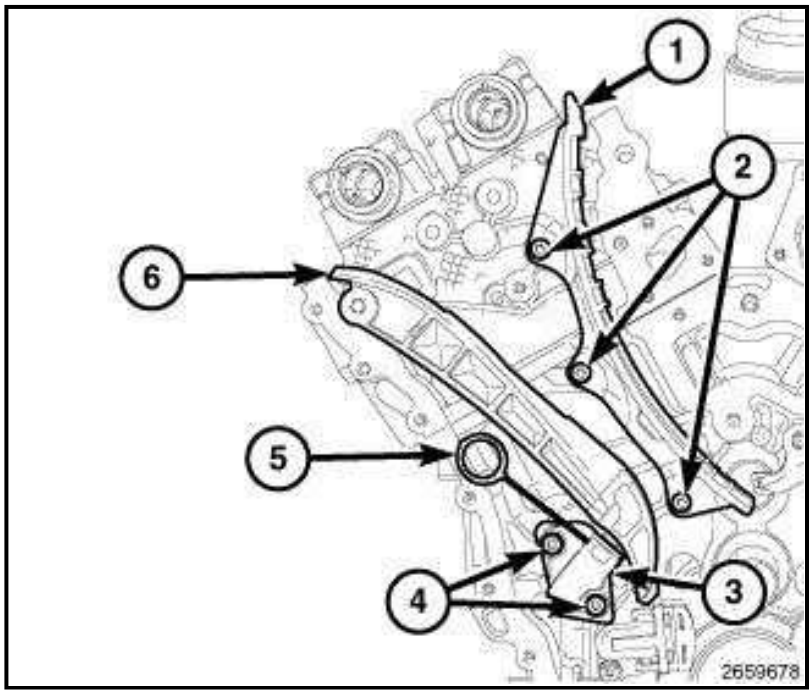
1 - Cylinder Head Bolt
2 - Unacceptable Thread Contact
3 - Acceptable Thread Contact
4 - Cylinder Head Bolt

CAUTION: **The cylinder head bolts are tightened using a torque plus angle procedure. The bolts must be examined BEFORE reuse. If the threads are necked down the bolts must be replaced.**

5. Check cylinder head bolts for necking by holding a scale or straight edge against the threads. If all the threads do not contact the scale the bolt must be replaced.
6. Position the cylinder head onto the cylinder block. Make sure the cylinder head seats fully over the locating dowels.

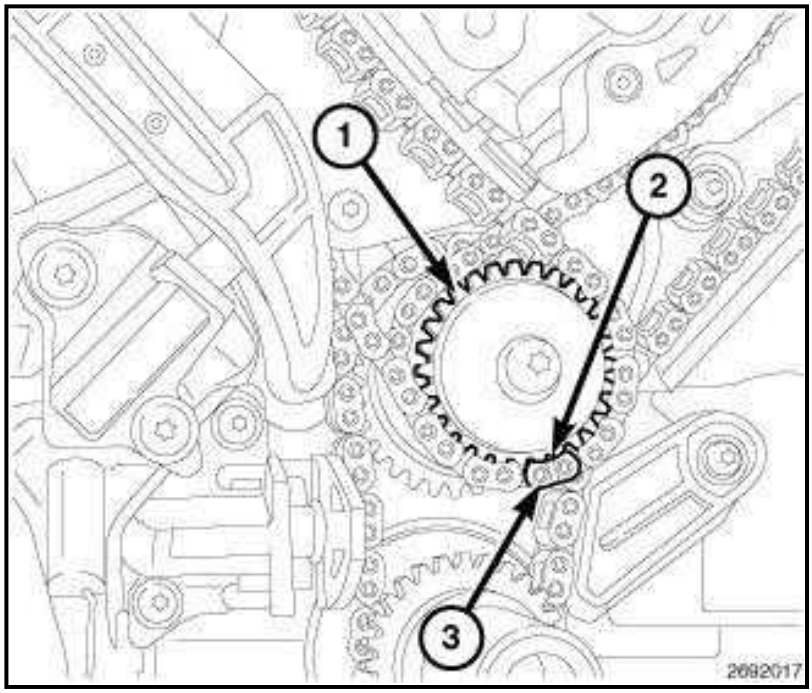
NOTE: **Do not apply any additional oil to the bolt threads.**

7. The cylinder head bolts must be tightened in the sequence shown in the torque table below.



1 - RH Timing Chain Guide
2 - Chain Guide Bolts
3 - Timing Chain Tensioner
4 - Chain Tensioner Bolts
5 - Tensioner Pin Tool
6 - Tensioner Arm

8. Install the RH timing chain guide with three bolts and tighten the chain guide bolts.
9. Install the RH timing chain tensioner to the engine block with two bolts and tighten the chain tensioner bolts.
10. Reset the RH timing chain tensioner by pushing back the tensioner piston and installing Tensioner Pin (special tool #8514A, Pins, Tensioner).
11. Install the RH tensioner arm.



1 - Idler Sprocket
2 - Dimple
3 - Plated Link

12. Drape the right side cam chain onto the idler sprocket so that the dimple is aligned with the plated link on the cam chain.

CAUTION: **Always reinstall timing chains so that they maintain the same direction of rotation. Inverting a previously run chain on a previously run sprocket will result in excessive wear to both the chain and sprocket.**

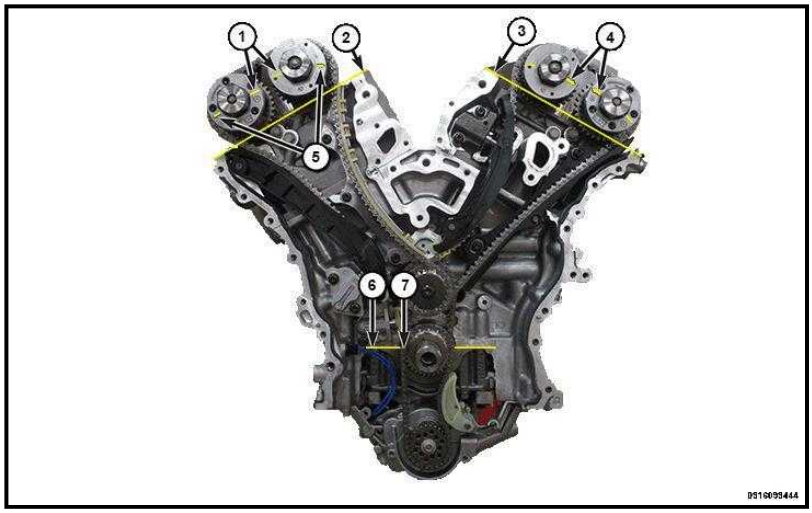
13. If removed, install the hydraulic lifters. Refer to **LIFTER(S), HYDRAULIC, REMOVAL AND INSTALLATION**.

NOTE: **If the rocker arms and hydraulic lifters are being reused, reassemble them into their original locations.**

14. Install the rocker arms and camshafts. Refer to **ROCKER ARM, VALVE, REMOVAL AND INSTALLATION**.

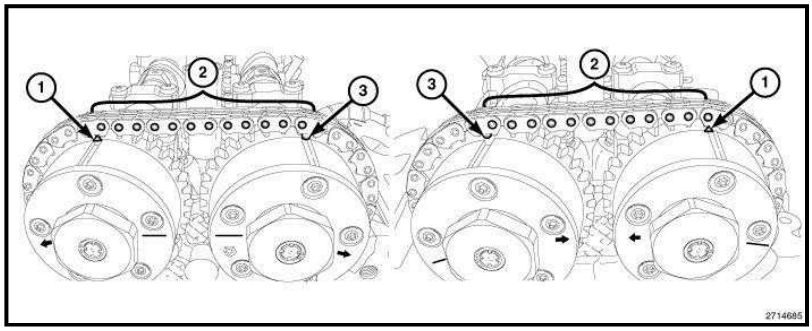
CAUTION: **Do not rotate the camshafts more than a few degrees independently of the crankshaft. Valve to piston contact could occur resulting in possible valve damage. If the camshafts need to be rotated more than a few degrees, first move the pistons away from the cylinder heads by rotating the crankshaft counterclockwise to a position 30B° before-top-dead-center. Once the camshafts are returned to their top-dead-center position, rotate the crankshaft clockwise to return the crankshaft to top-dead-center.**

15. Remove the Tensioner Pin (special tool #8514A, Pins, Tensioner) from the RH cam chain tensioner.



1 - Scribe Line	5 - Right Cam Phaser Arrows
2 - Right Valve Cover Sealing Surface	6 - Block/Bearing Cap Junction
3 - Left Valve Cover Sealing Surface	7 - Crankshaft Dimple
4 - Left Cam Phaser Arrows	B

16. Rotate the crankshaft clockwise two complete revolutions stopping when the dimple on the crankshaft is aligned the with the block/bearing cap junction.
17. Rotate the crankshaft clockwise to place the number one piston at Top Dead Center (TDC) on the exhaust stroke by aligning the dimple on the crankshaft with the block/bearing cap junction. The left side cam phaser arrows should point toward each other and be parallel to the valve cover sealing surface. The right side cam phaser arrows should point away from each other and the scribe lines should be parallel to the valve cover sealing surface.



1 - Triangle Marking
2 - 12 Chain Link Pins
3 - Circle Marking

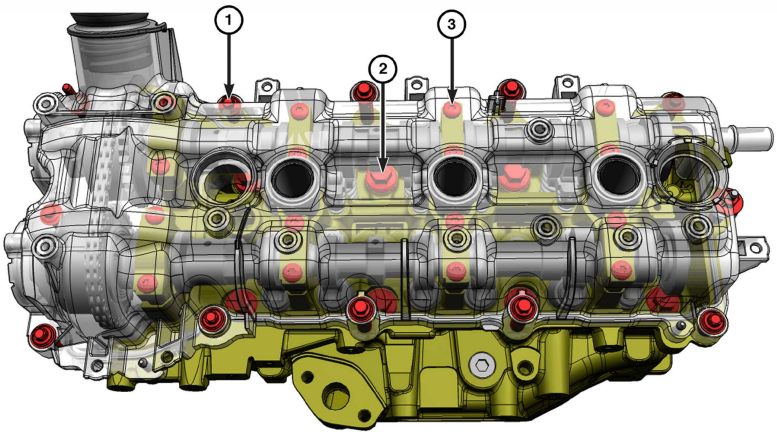
18. There should be 12 chain pins between the exhaust cam phaser triangle marking and the intake cam phaser circle marking.
19. If the engine timing is not correct. Refer to **CHAIN AND SPROCKETS, TIMING, REMOVAL AND INSTALLATION** .
20. Install the engine timing cover and cylinder head covers. Refer to **COVER(S), ENGINE TIMING, REMOVAL AND INSTALLATION** .
21. Install the bank 1 rear Variable Valve Lift (VVL) solenoid. Refer to **SOLENOID, REMOVAL AND INSTALLATION** .
22. Install the wire harness to the right cylinder head and securely tighten the fasteners.
23. Install the ignition coil capacitor and ground. Refer to **CAPACITOR, IGNITION, REMOVAL AND INSTALLATION**.
24. Install the spark plugs. Refer to **SPARK PLUG, REMOVAL AND INSTALLATION**.
25. Connect the oil temperature sensor wire harness connector.

26. Install the right side catalytic converter. Refer to **CONVERTER, CATALYTIC, REMOVAL AND INSTALLATION** .
27. Connect the right upstream oxygen sensor connectors to the main wire harness.
28. Install the upper and lower intake manifolds. Refer to **MANIFOLD, INTAKE, REMOVAL AND INSTALLATION** .
29. Install a new oil filter and fill the engine crankcase with the proper oil to the correct level. Refer to **FILTER, ENGINE OIL** .
30. Fill the cooling system. Refer to **STANDARD PROCEDURE - FILLING** .
31. Connect the negative battery cable(s). Refer to **CABLES, BATTERY** .
32. Run the engine until it reaches normal operating temperature. Check cooling system for correct fluid level. Refer to **COOLING SYSTEM** .

NOTE: **The Cam/Crank Variation Relearn procedure must be performed using the scan tool anytime there has been a repair/replacement made to a powertrain system, for example: flywheel, valvetrain, camshaft and/or crankshaft sensors or components.**

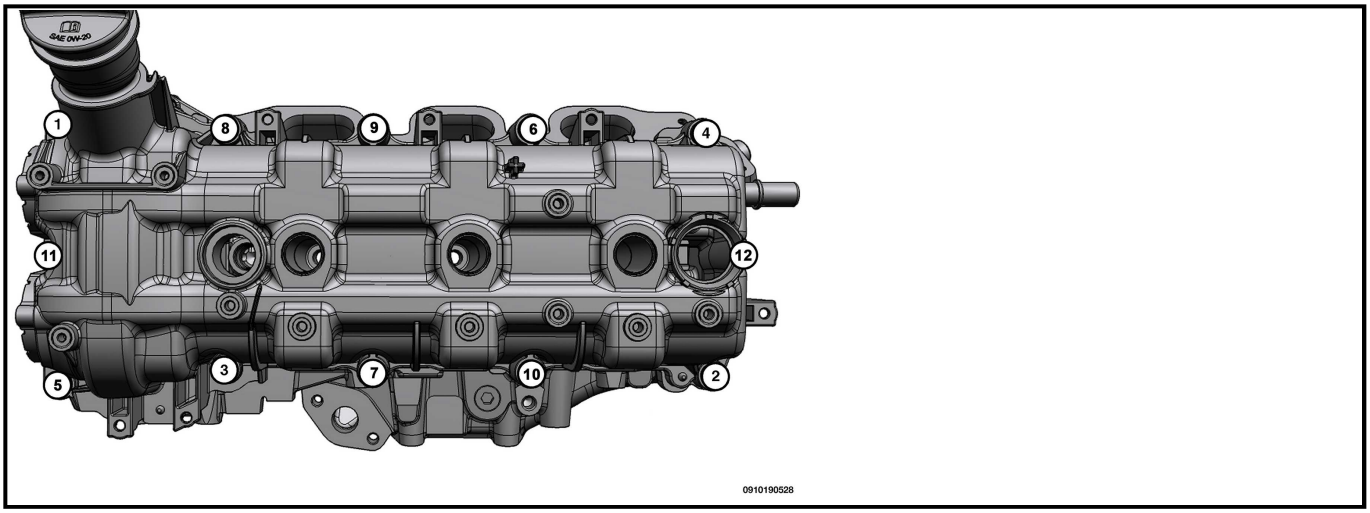
TORQUE SPECIFICATIONS

CYLINDER HEAD

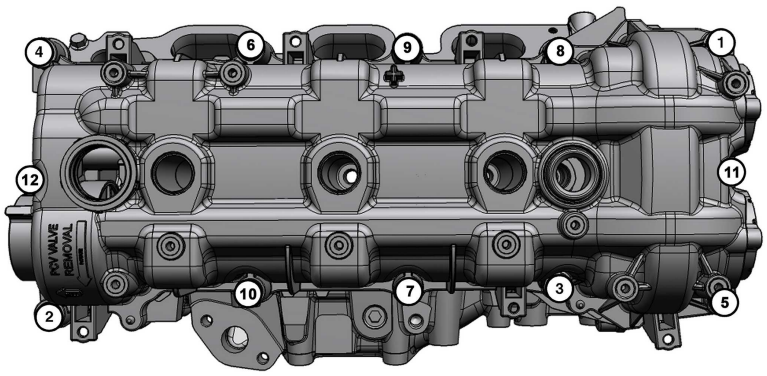


CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Cylinder Head Cover M6 Bolts	**12 N.m (9 Ft. Lbs.)**	Tightening Sequence - Left
2	Cylinder Head Bolts	**Torque Procedure** For engine builds using a new block follow steps 1-9. For engine re-builds (reuse block) follow step 6-9. 1. 30 N. m (22 ft. lbs.) 2. 45 N. m (33 ft. lbs.) 3. Re-tighten all to 45 N. m (33 ft. lbs.) 4. All + 125B° Turn. Do not use a torque wrench for this step. 5. Loosen all fasteners in reverse of sequence shown	Tightening Sequence - Left

CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
		6. All to 30 N. m (22 ft. lbs.) 7. All to 45 N. m (33 ft. lbs.) 8. Re-tighten all to 45 N. m (33 ft. lbs.) 9. All + 130B° Turn. Do not use a torque wrench for this step.	
3	Camshaft Bearing Cap Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence - Left
-	Cylinder Head Coolant Pipe Plug	**35 N.m (26 Ft. Lbs.)**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
-	Cylinder Head Oil Galley Plug	**18 N.m (13 Ft. Lbs.)**	-
-	Cylinder Head Oil Restrictor M8 Plug	**15 N.m (11 Ft. Lbs.)**	-
-	Ground Strap Bolt to Right Cylinder Head	**23 N.m (17 Ft. Lbs.)**	-
-	Heater Core Supply Tube to Cylinder Head M8 Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Wire Harness Retainer Bracket to LH Cylinder Head Bolts	**10 N.m (89 In. Lbs.)**	-



Tightening Sequence - Right



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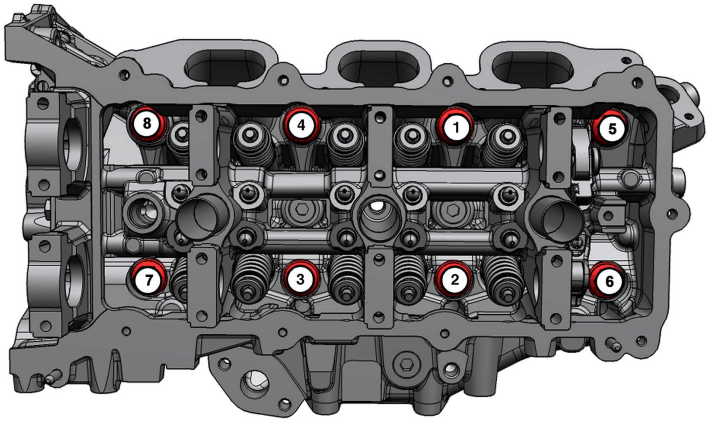

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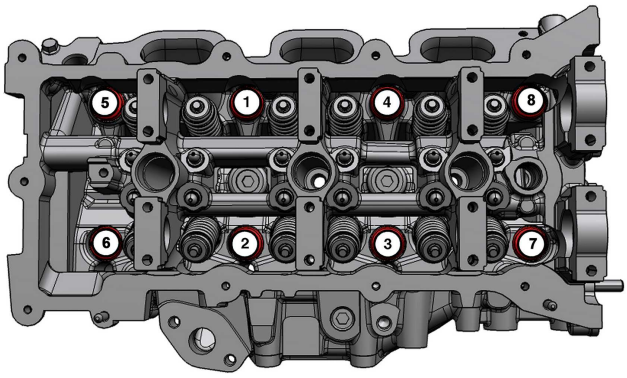
Tightening Sequence - Right



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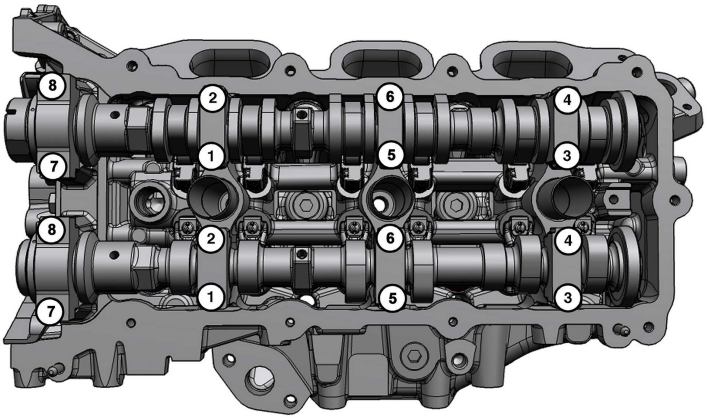
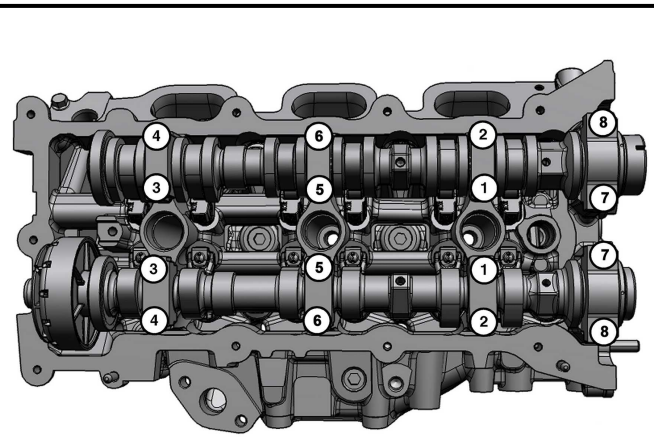
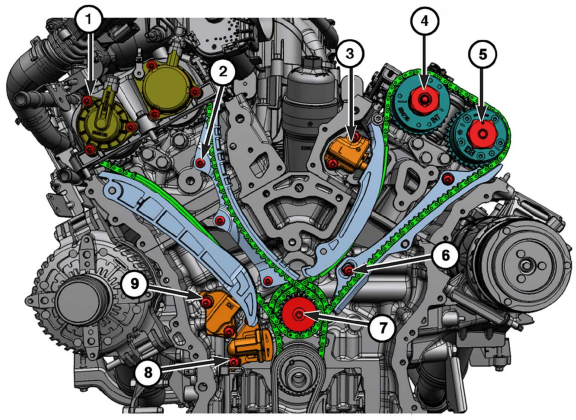


Tightening Sequence - Right



VALVE TIMING



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-

CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

TORQUE SPECIFICATIONS - 3.6L EXHAUST SYSTEM

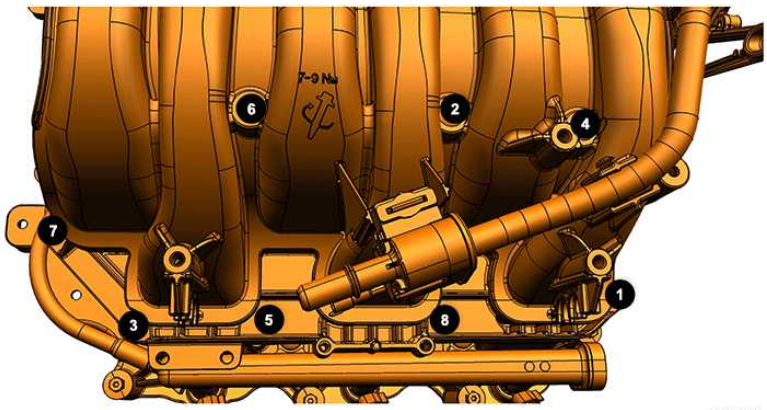
DESCRIPTION	SPECIFICATION	COMMENTS
Catalytic Converter to Cylinder Head Bolts	**24 N. m (18 Ft. Lbs.)**	-
Exhaust Y-Pipe-to-Catalytic Converter Flange Bolts	**18 N. m (13 Ft. Lbs.)**	-
Exhaust Resonator Clamp Bolt	**26 N. m (19 Ft. Lbs.)**	-
Front Exhaust Isolator Bolts	**30 N. m (22 Ft. Lbs.)**	-
Muffler Clamp Nuts	**55 N. m (41 Ft. Lbs.)**	-
Muffler Exhaust Isolator Bolts	**25 N. m (18 Ft. Lbs.)**	-
Heat Shield Nuts	**3 N.m (27 In. Lbs.)**	-

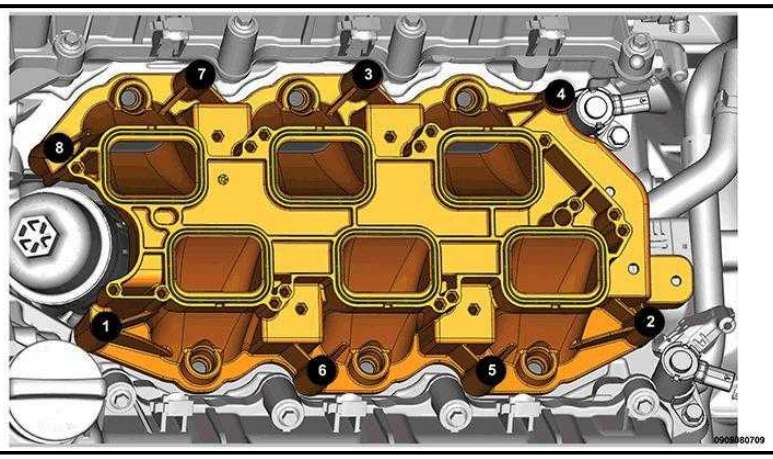
AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-





LIFTER(S), HYDRAULIC

REMOVAL AND INSTALLATION

HYDRAULIC LIFTERS

REMOVAL

NOTE: **The LH cylinder head hydraulic lifters are shown, the RH cylinder head hydraulic lifters are similar.**

1. Remove the camshaft(s). Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION**.

NOTE: **If the rocker arms are to be reused, identify their positions so that they can be reassembled into their original locations.**

2. Remove the rocker arm(s). Refer to **ROCKER ARM, VALVE, REMOVAL AND INSTALLATION**.

1 - Exhaust Hydraulic Lifters

NOTE: **If the hydraulic lifters are to be reused, identify their positions so that they can be reassembled into their original locations.**

3. The exhaust hydraulic lifters should have been removed with the rockers arms, as they are attached with a retaining clip.

NOTE: **The exhaust hydraulic lifter and exhaust rocker arm should not be unclipped during diagnosis and handling.**

1 - Intake Hydraulic Lifters

4. Remove the intake hydraulic lifter(s).

INSTALLATION

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

1 - Intake Hydraulic Lifters

NOTE: **The LH cylinder head hydraulic lifters are shown, the RH cylinder head hydraulic lifters are similar. If the hydraulic lifters are being reused, reassemble them into their original locations.**

NOTE: **The exhaust hydraulic lifter must never be interchanged with any other hydraulic lifter than what is specifically designated for this vehicle. The internal check ball is reversed and could cause engine damage if an incorrect part is installed.**

1. Verify that the hydraulic lifters are at least partially full of oil. There should be little or no plunger travel with the intake hydraulic lifter is depressed and there should be some plunger travel with the exhaust hydraulic lifter.
2. Install the intake hydraulic lifter(s).

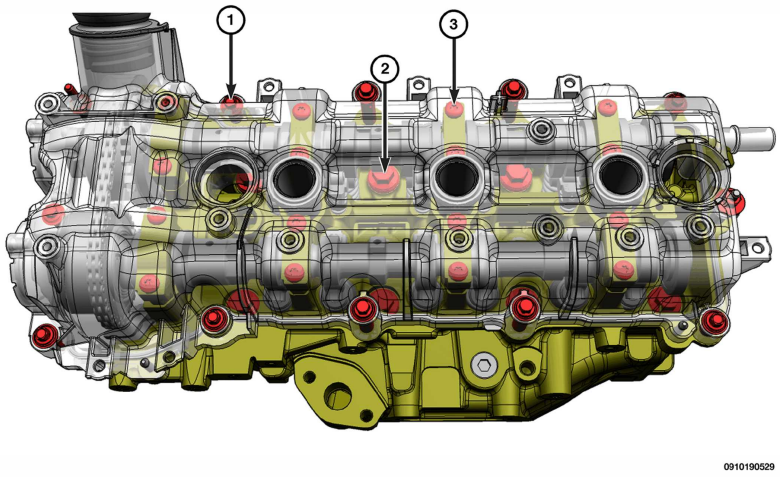
NOTE: **If the rocker arms are being reused, reassemble them into their original locations.**

1 - Exhaust Hydraulic Lifters

3. The exhaust hydraulic lifters are installed with the rocker arms, as they are attached to the rocker arm with a clip.
4. Install the rocker arm(s). Refer to **ROCKER ARM, VALVE, REMOVAL AND INSTALLATION**.
5. Install the camshaft(s), phasers, cylinder head cover(s) and upper intake manifold. Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION**.

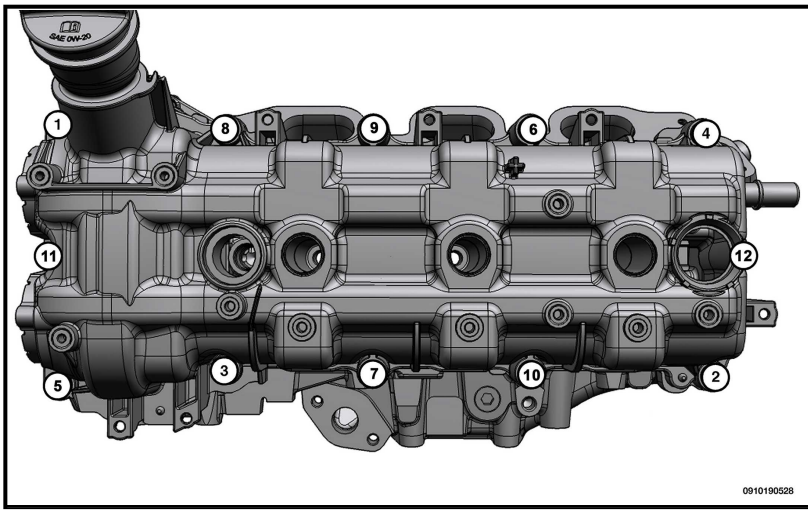
TORQUE SPECIFICATIONS

CYLINDER HEAD



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Cylinder Head Cover M6 Bolts	**12 N.m (9 Ft. Lbs.)**	Tightening Sequence - Left
2	Cylinder Head Bolts	**Torque Procedure** For engine builds using a new block follow steps 1-9. For engine re-builds (reuse block) follow step 6-9. 1. 30 N. m (22 ft. lbs.) 2. 45 N. m (33 ft. lbs.) 3. Re-tighten all to 45 N. m (33 ft. lbs.) 4. All + 125B° Turn. Do not use a torque wrench for this step. 5. Loosen all fasteners in reverse of sequence shown 6. All to 30 N. m (22 ft. lbs.) 7. All to 45 N. m (33 ft. lbs.) 8. Re-tighten all to 45 N. m (33 ft. lbs.) 9. All + 130B° Turn. Do not use a torque wrench for this step.	Tightening Sequence - Left
3	Camshaft Bearing Cap Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence - Left
-	Cylinder Head Coolant Pipe Plug	**35 N.m (26 Ft. Lbs.)**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
-	Cylinder Head Oil Galley Plug	**18 N.m (13 Ft. Lbs.)**	-
-	Cylinder Head Oil Restrictor M8 Plug	**15 N.m (11 Ft. Lbs.)**	-

CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
-	Ground Strap Bolt to Right Cylinder Head	**23 N.m (17 Ft. Lbs.)**	-
-	Heater Core Supply Tube to Cylinder Head M8 Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Wire Harness Retainer Bracket to LH Cylinder Head Bolts	**10 N.m (89 In. Lbs.)**	-



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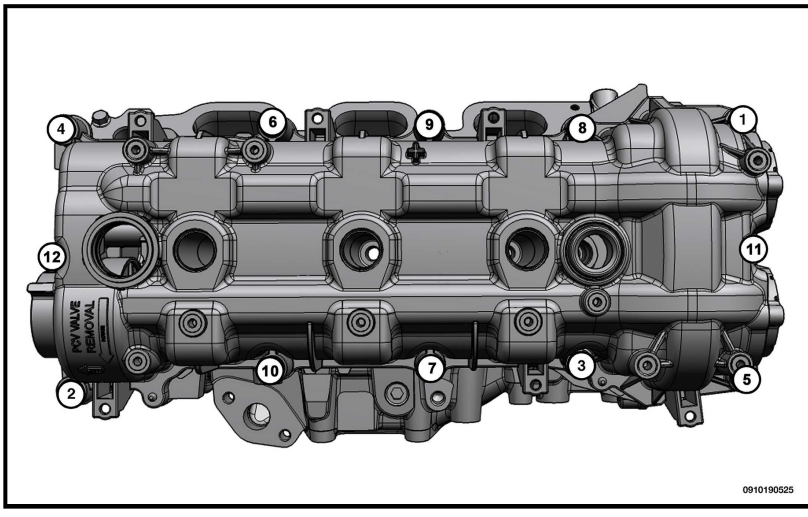
Tightening Sequence - Right



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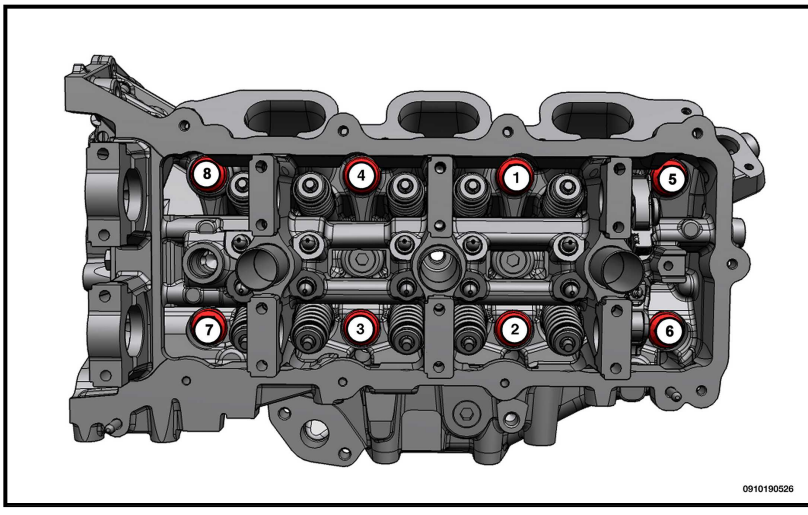

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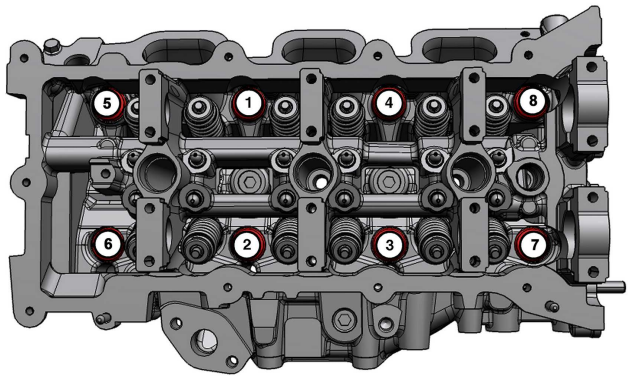
Tightening Sequence - Right



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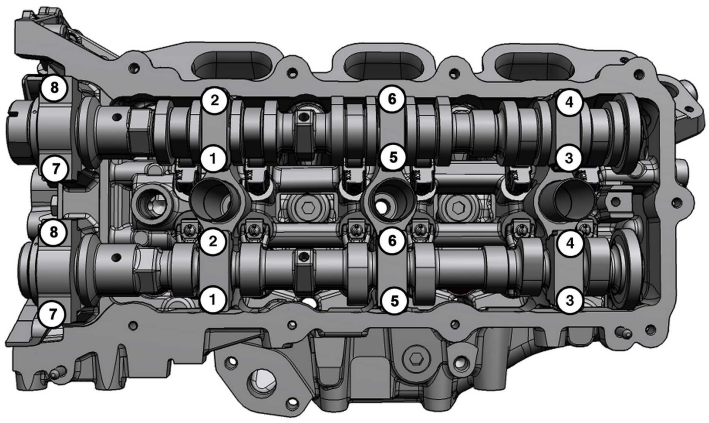

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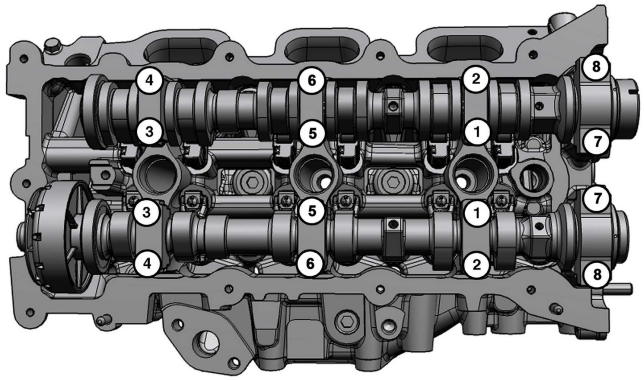
Tightening Sequence - Right



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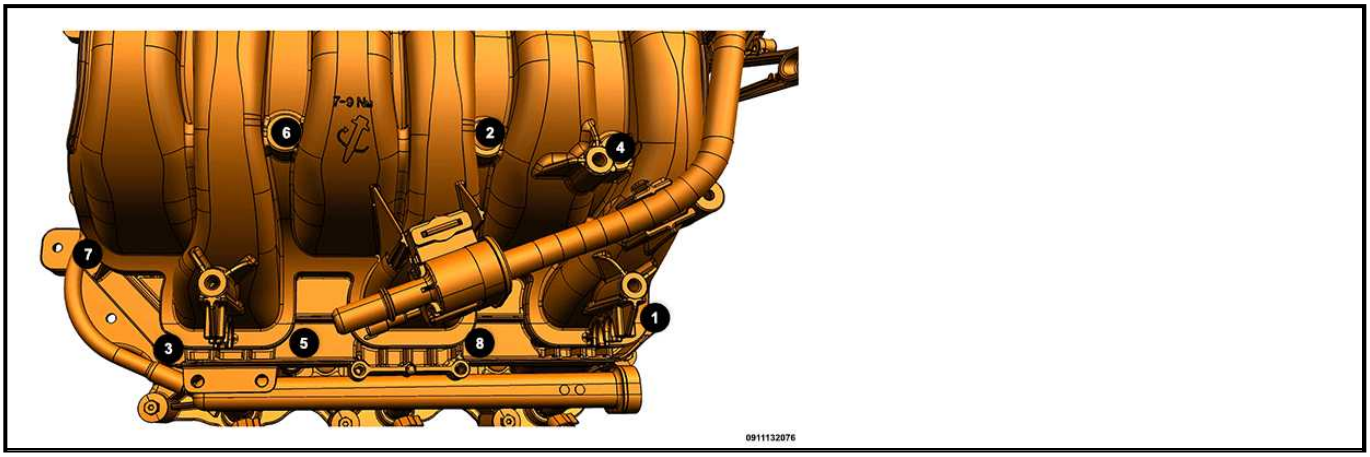
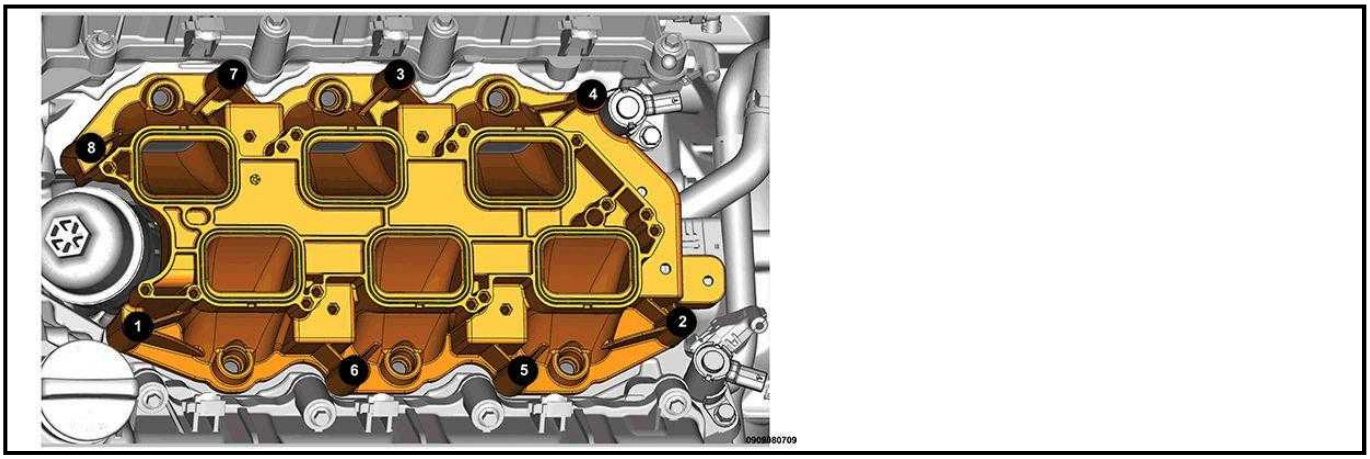
AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-

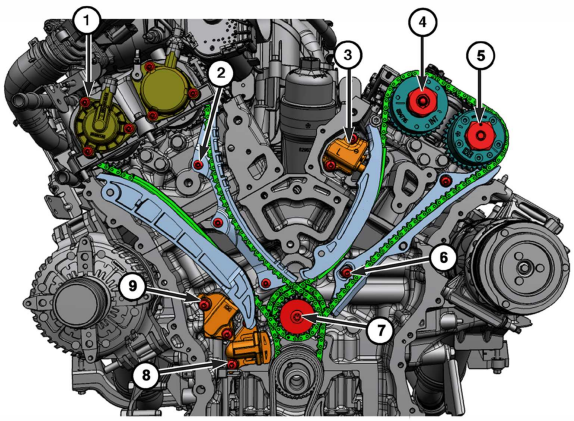
DESCRIPTION	SPECIFICATION	COMMENTS
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-





VALVE TIMING



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CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

ROCKER ARM, VALVE

REMOVAL AND INSTALLATION

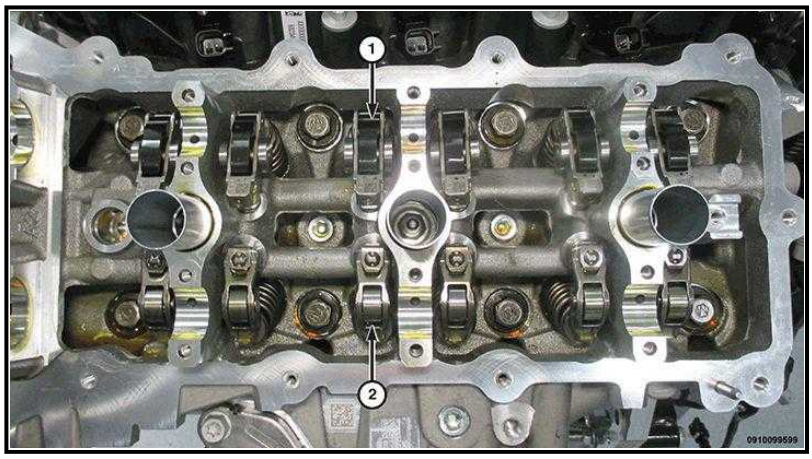
ROCKER ARMS

REMOVAL

NOTE: **The LH cylinder head rocker arms are shown, the RH cylinder head rocker arms are similar.**

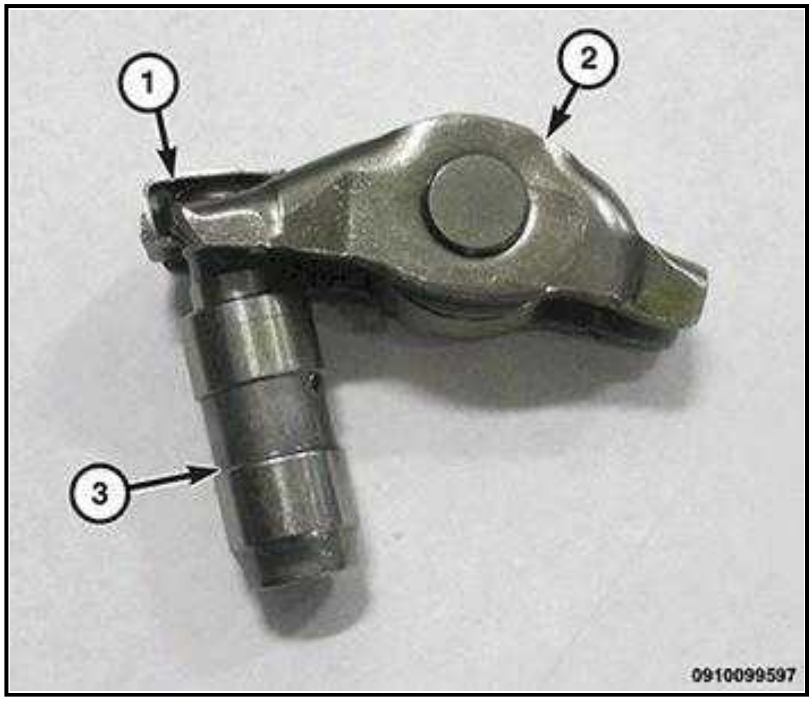
1. Remove the camshaft(s). Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION**.

NOTE: **If the rocker arms are to be reused, identify their positions so that they can be reassembled into their original locations.**



1 - Intake Rocker Arms
2 - Exhaust Rocker Arm and Hydraulic Lifter Assemblies

2. Remove the intake rocker arm(s).
3. Remove the exhaust rocker arm and hydraulic lifter assembly.



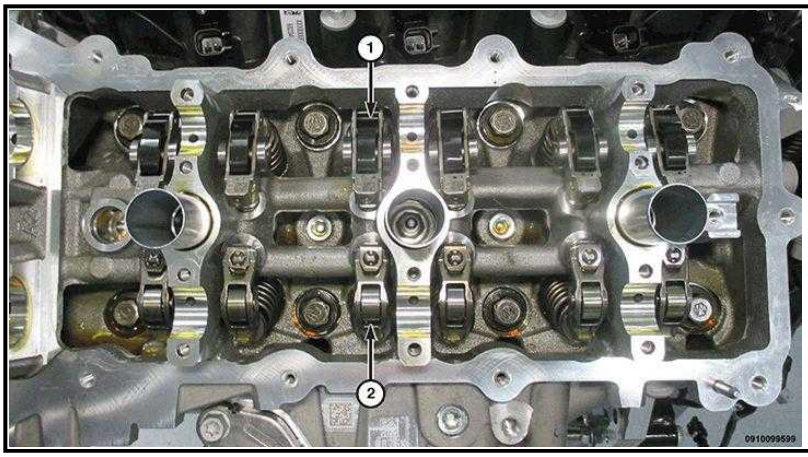
1 - Retaining Clip
2 - Exhaust Rocker Arm
3 - Hydraulic Lifter

4. The exhaust rocker arm will come out as an assembly with the hydraulic lifter, as it is attached with a retaining clip.

INSTALLATION

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

CAUTION: **Proper inspection of the rocker arms is required to ensure proper installation. Inspection from the top and also side view is critical to verify the proper seated position of each and every rocker arm. Failure to install the rocker arms correctly may cause severe engine damage.**



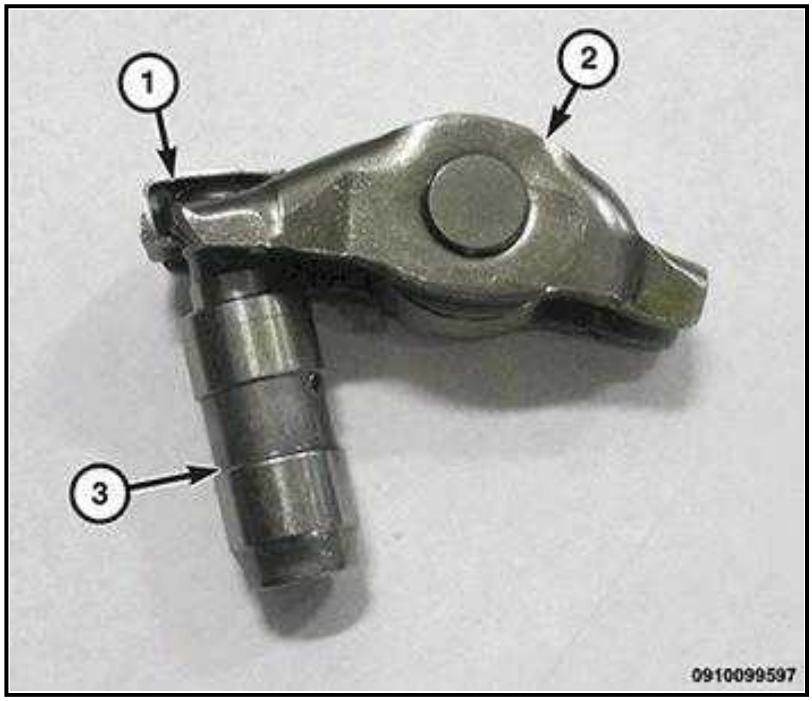
1 - Intake Rocker Arms
2 - Exhaust Rocker Arm and Hydraulic Lifter Assemblies

NOTE: **The LH cylinder head rocker arms are shown, the RH cylinder head rocker arms are similar. If the rocker arms are being reused, reassemble them into their original locations.**

1. Lubricate the rocker arms with clean engine oil before installation.

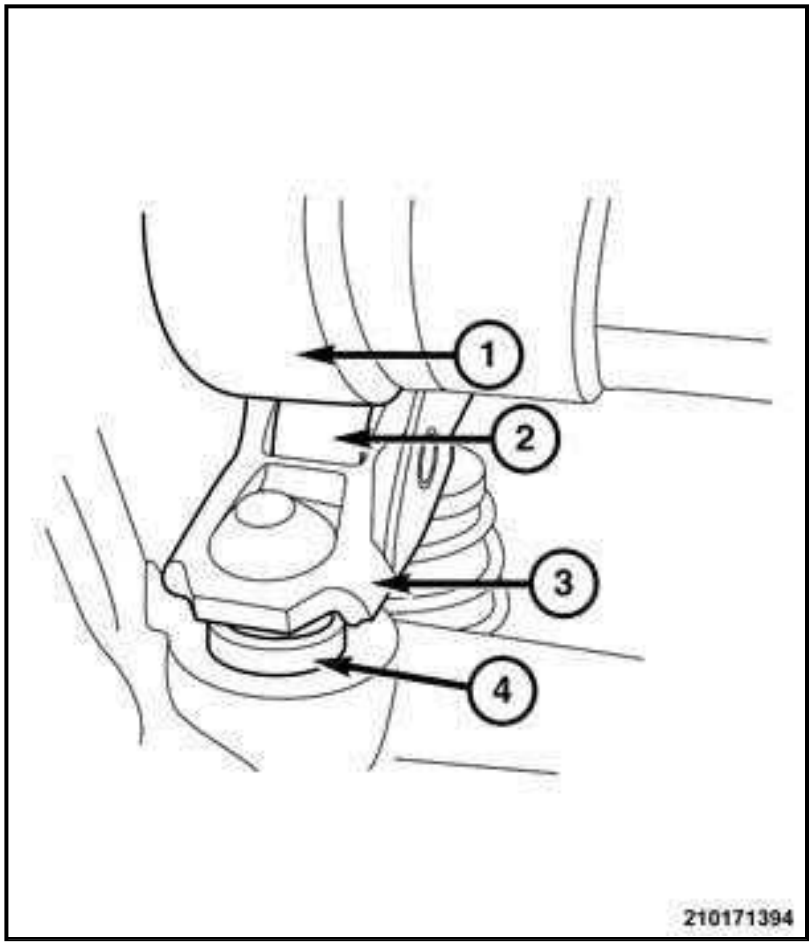
NOTE: **When placing the rocker arms. The valve stem should fit securely into the rocker arm guides.**

2. Position the intake rocker arm(s) onto the lifter(s) and valve stem(s).
3. Install the exhaust rocker arm(s) and hydraulic lifter(s).



1 - Retaining Clip
2 - Exhaust Rocker Arm
3 - Hydraulic Lifter

4. The exhaust rocker arm(s) are attached to the hydraulic lifter with a retaining clip.

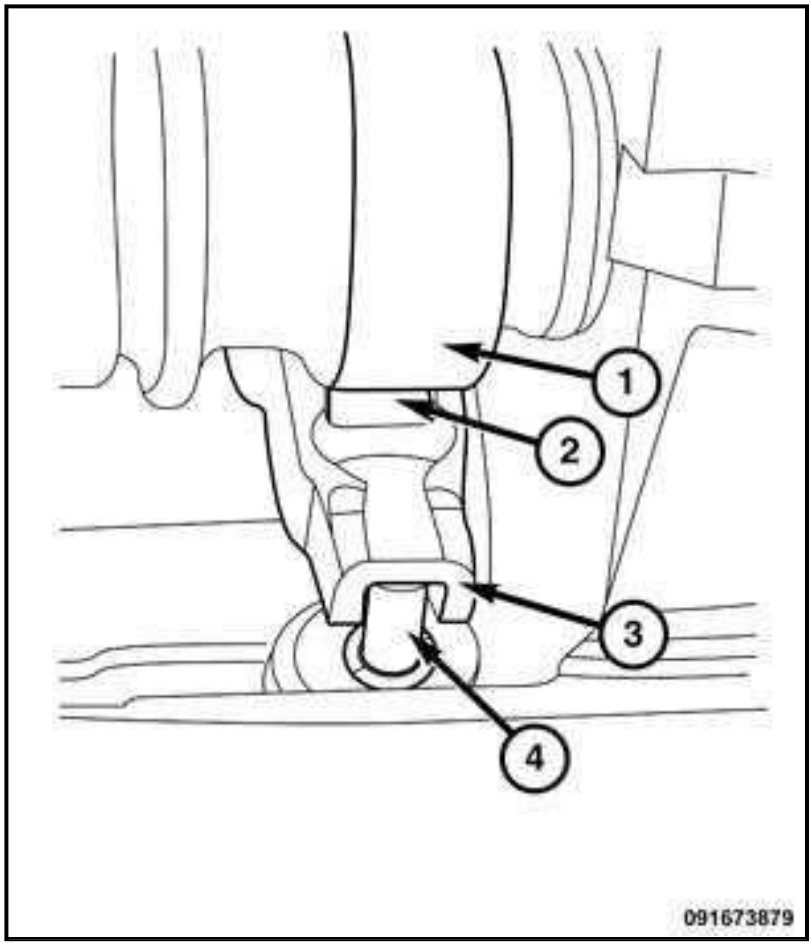


1 - Camshaft Lobe
2 - Rocker Arm Roller
3 - Rocker Arm
4 - Hydraulic Lifter

5. Install the camshaft(s). Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION**.

NOTE: **If any of the rocker arms are not installed properly. Loosen the bearing caps and reposition the rocker arms.**

6. Verify that the rocker arm is positioned over the lifter.
7. Verify that the rocker arm roller is seated to the camshaft lobe.

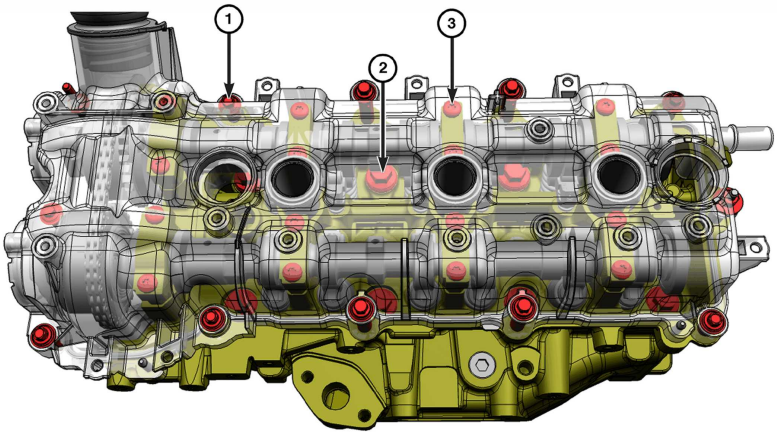


1 - Camshaft Lobe
2 - Rocker Arm Roller
3 - Rocker Arm Guides
4 - Valve Stem

8. Use a mirror to verify the valve stem is centered between the rocker arm guides.
9. Verify the camshaft lobe is centered over the rocker arm roller.

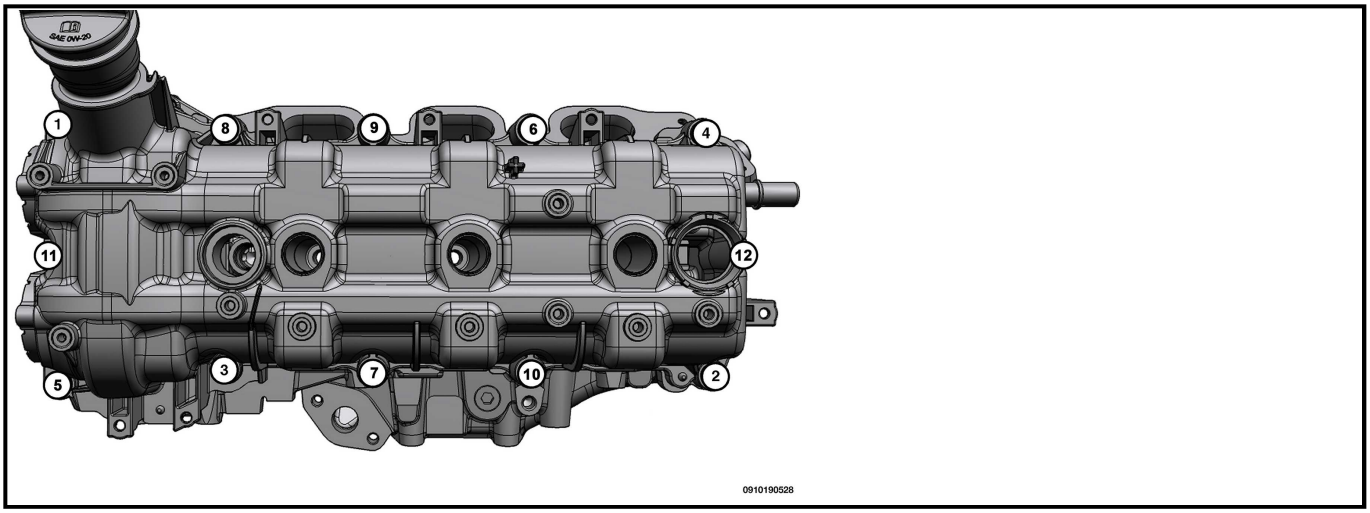
TORQUE SPECIFICATIONS

CYLINDER HEAD

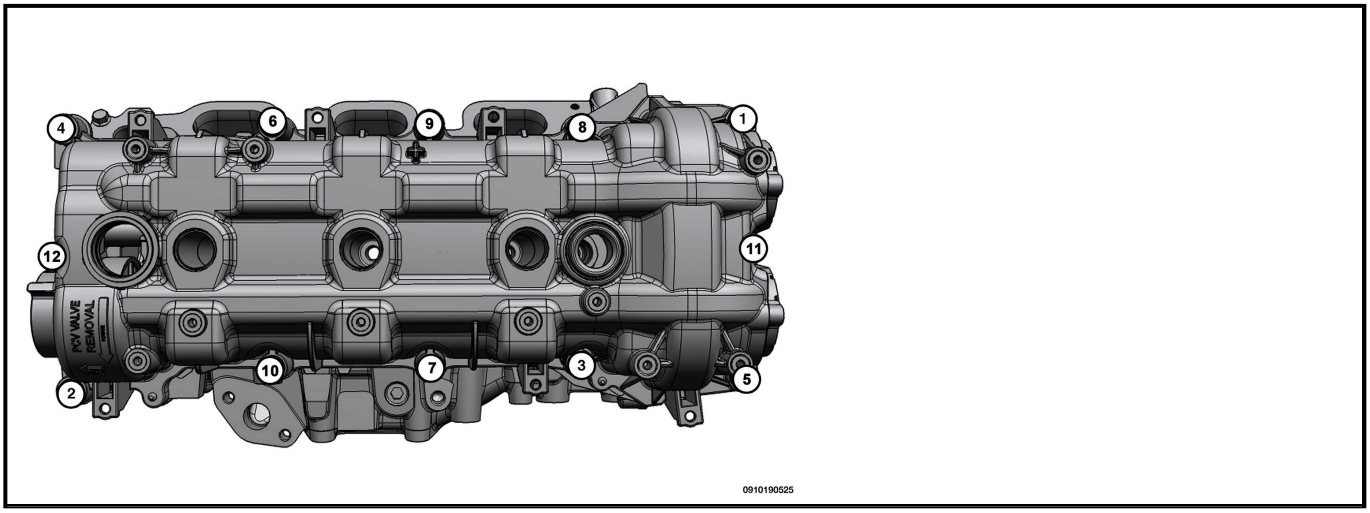


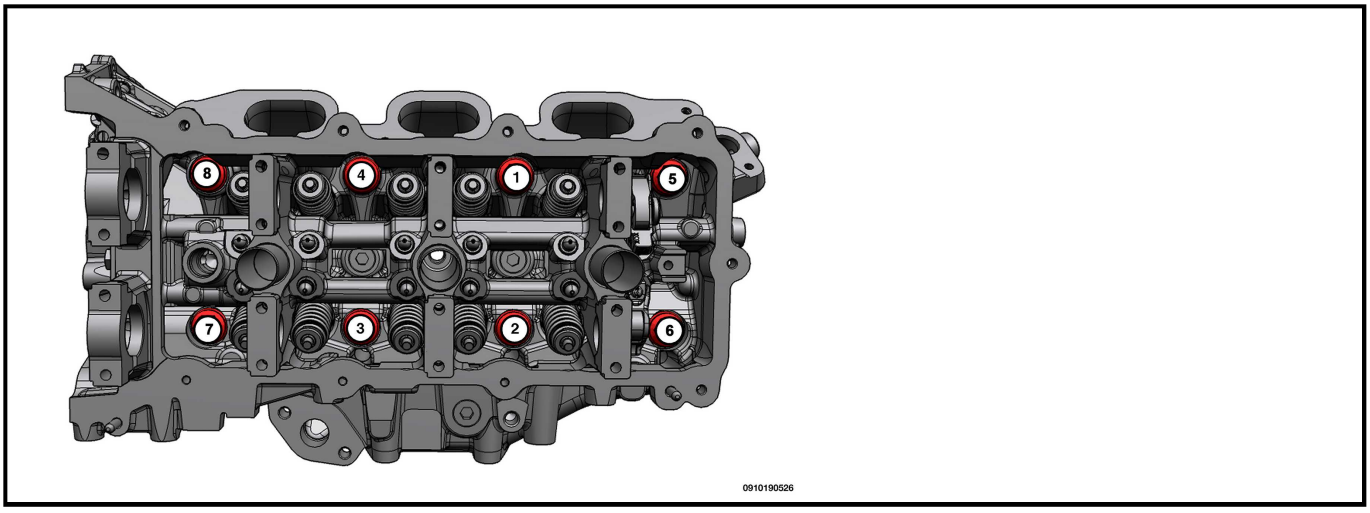
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Cylinder Head Cover M6 Bolts	**12 N.m (9 Ft. Lbs.)**	Tightening Sequence - Left

CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
2	Cylinder Head Bolts	**Torque Procedure** For engine builds using a new block follow steps 1-9. For engine re-builds (reuse block) follow step 6-9. 1. 30 N. m (22 ft. lbs.) 2. 45 N. m (33 ft. lbs.) 3. Re-tighten all to 45 N. m (33 ft. lbs.) 4. All + 125B° Turn. Do not use a torque wrench for this step. 5. Loosen all fasteners in reverse of sequence shown 6. All to 30 N. m (22 ft. lbs.) 7. All to 45 N. m (33 ft. lbs.) 8. Re-tighten all to 45 N. m (33 ft. lbs.) 9. All + 130B° Turn. Do not use a torque wrench for this step.	Tightening Sequence - Left
3	Camshaft Bearing Cap Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence - Left
-	Cylinder Head Coolant Pipe Plug	**35 N.m (26 Ft. Lbs.)**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
-	Cylinder Head Oil Galley Plug	**18 N.m (13 Ft. Lbs.)**	-
-	Cylinder Head Oil Restrictor M8 Plug	**15 N.m (11 Ft. Lbs.)**	-
-	Ground Strap Bolt to Right Cylinder Head	**23 N.m (17 Ft. Lbs.)**	-
-	Heater Core Supply Tube to Cylinder Head M8 Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Wire Harness Retainer Bracket to LH Cylinder Head Bolts	**10 N.m (89 In. Lbs.)**	-

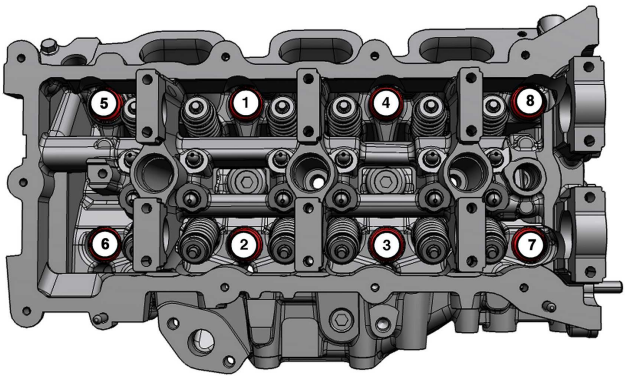


Tightening Sequence - Right





Tightening Sequence - Right



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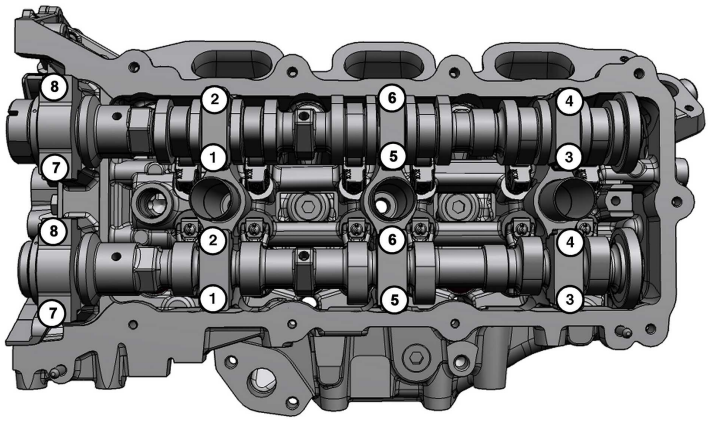

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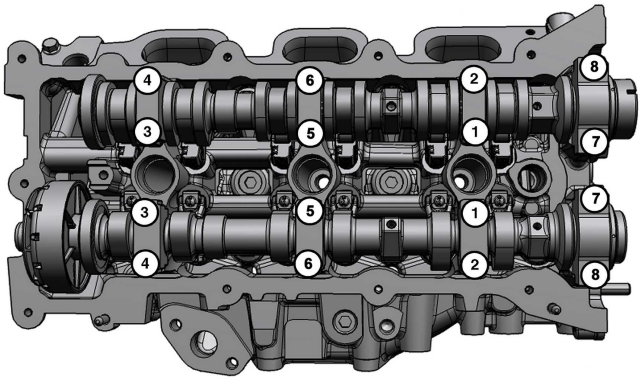
Tightening Sequence - Right



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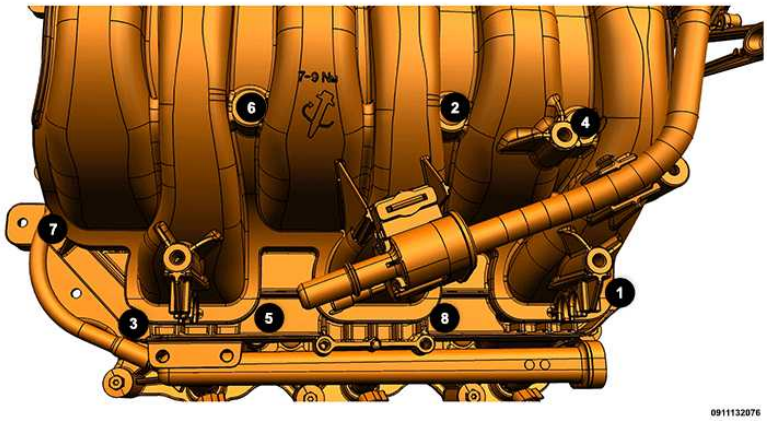
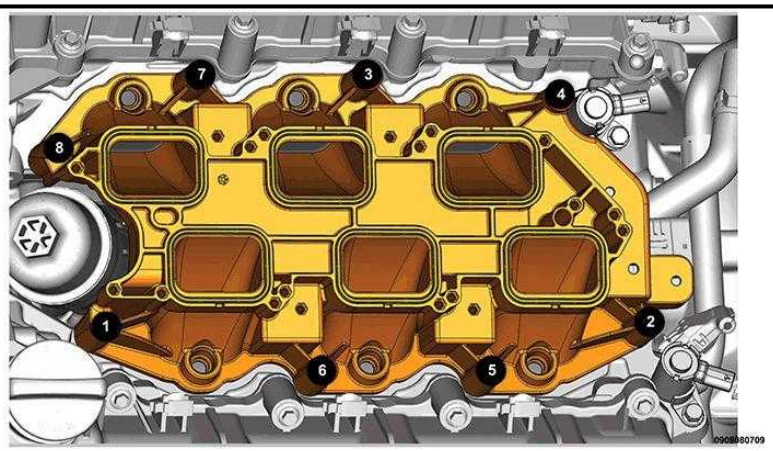
AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-

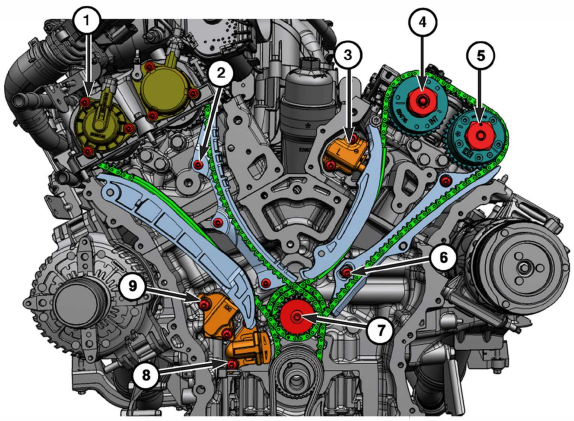
DESCRIPTION	SPECIFICATION	COMMENTS
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-





VALVE TIMING



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CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

SEAL(S), VALVE GUIDE

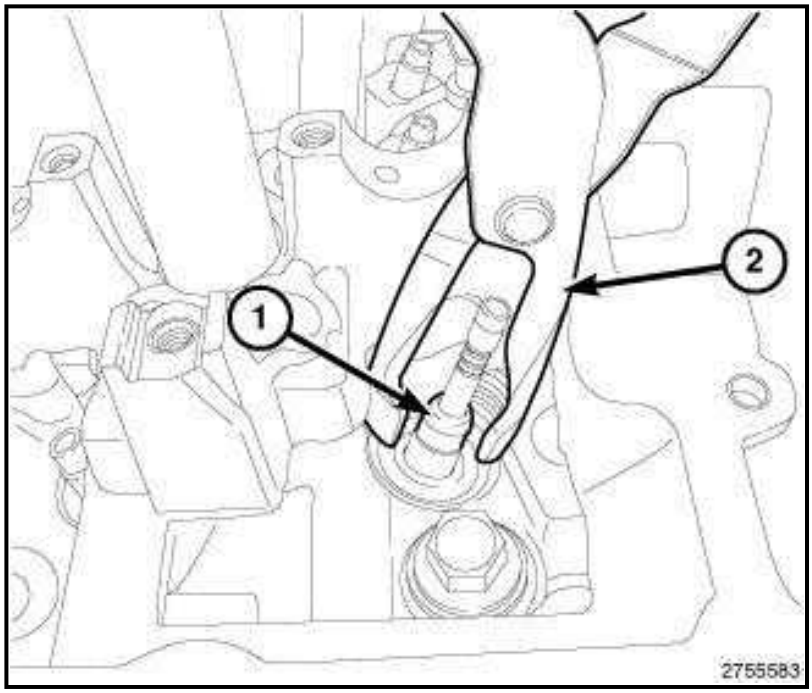
REMOVAL AND INSTALLATION

VALVE GUIDE SEALS

REMOVAL

NOTE: **If the springs are to be reused, identify their positions so that they can be reassembled into their original locations.**

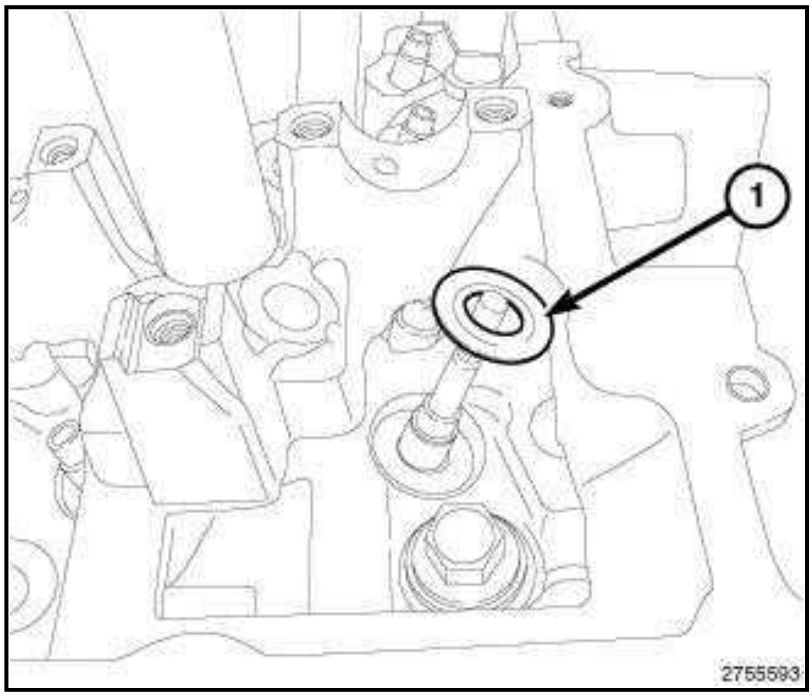
1. Remove the valve spring(s). Refer to **SPRING(S), VALVE, REMOVAL AND INSTALLATION**.



1 - Valve Guide Seal
2 - Valve Seal Tool

NOTE: **Number 5 cylinder exhaust valve guide seal shown, all other valve guide seals similar.**

2. Remove the valve guide seal using a valve seal tool. Discard the removed seal.



1 - Valve Spring Seat

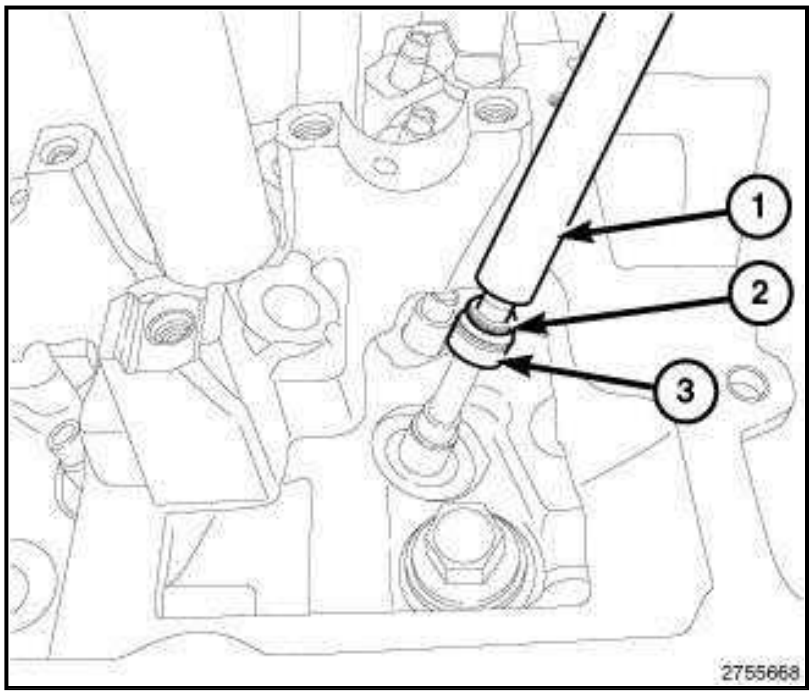
3. If required, remove the valve spring seat.
4. If required, remove the valve(s). Refer to **VALVES, INTAKE AND EXHAUST, REMOVAL AND INSTALLATION**.

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.

- Reassemble the valves into their original locations. If the valves or valve seats have been refinished, verify that the valve stem tip height is within specification.

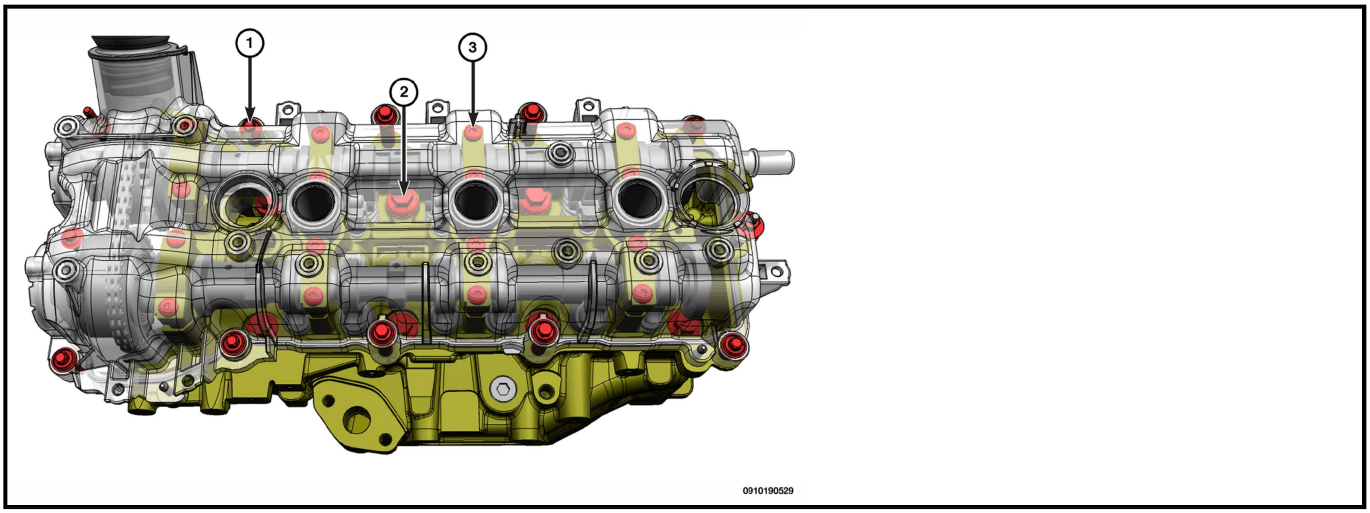


1 - Driver Tool
2 - Garter Spring
3 - Valve Guide Seal

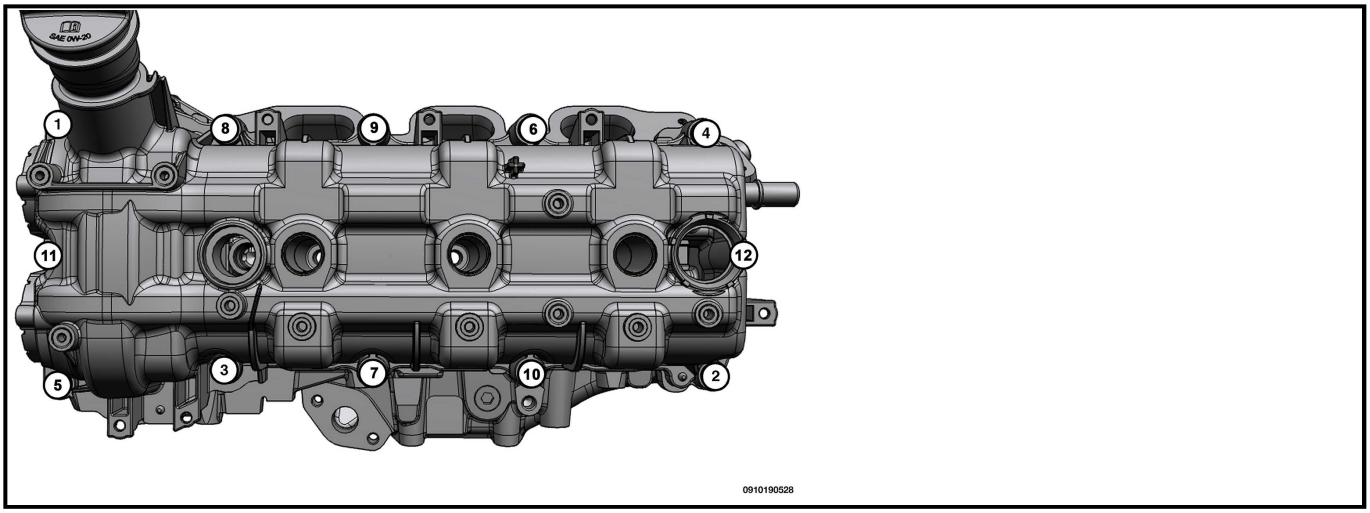
- Ensure that the garter spring is intact around the top of the valve guide seal. Number 5 cylinder exhaust valve guide seal shown, all other valves similar.
- Apply engine oil to the lip of the valve guide seal. Install the valve guide seal over the valve stem. Using an appropriate driver, push the seal firmly and squarely over the valve guide. **Do Not Force** the seal against the top of guide.
- If the valve springs are being reused, reassemble them into their original locations.

TORQUE SPECIFICATIONS

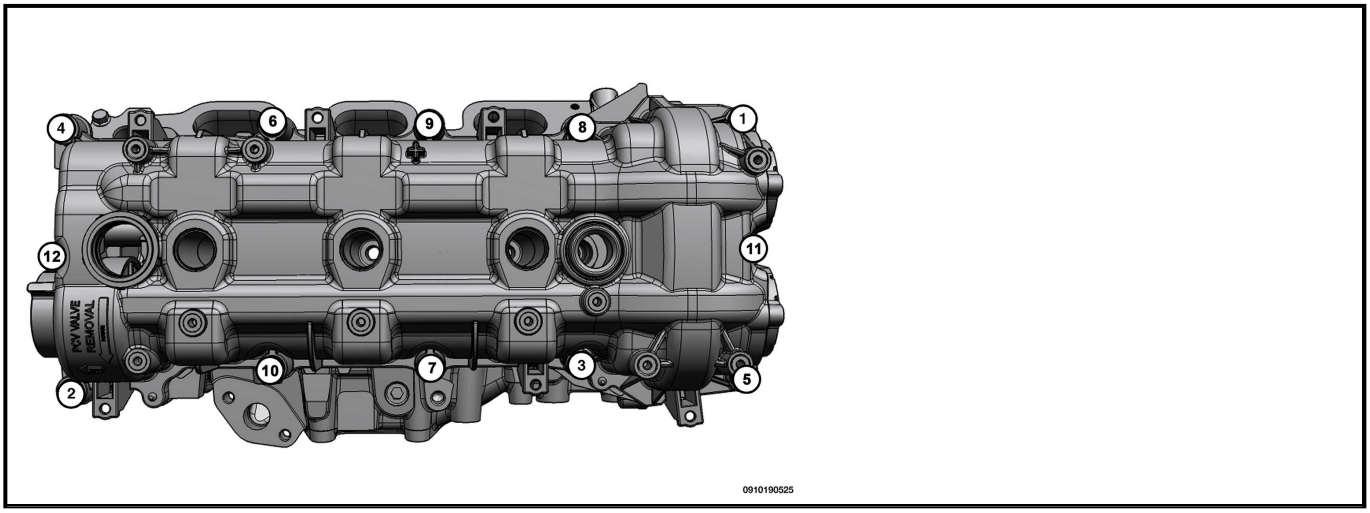
CYLINDER HEAD

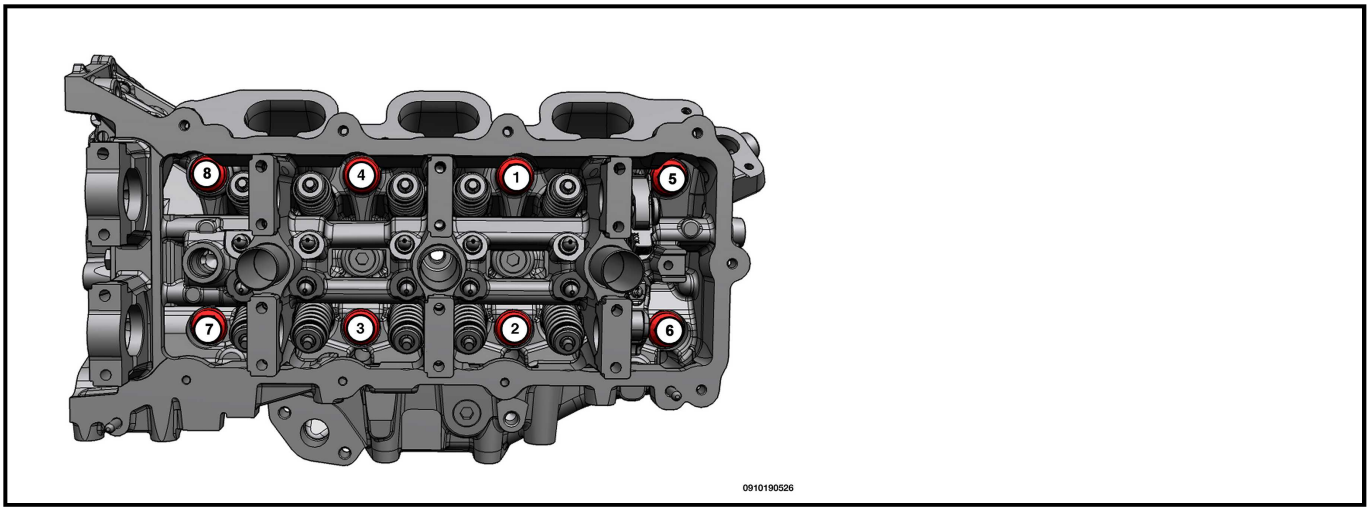


CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Cylinder Head Cover M6 Bolts	**12 N.m (9 Ft. Lbs.)**	Tightening Sequence - Left
2	Cylinder Head Bolts	**Torque Procedure** For engine builds using a new block follow steps 1-9. For engine re-builds (reuse block) follow step 6-9. 1. 30 N. m (22 ft. lbs.) 2. 45 N. m (33 ft. lbs.) 3. Re-tighten all to 45 N. m (33 ft. lbs.) 4. All + 125B° Turn. Do not use a torque wrench for this step. 5. Loosen all fasteners in reverse of sequence shown 6. All to 30 N. m (22 ft. lbs.) 7. All to 45 N. m (33 ft. lbs.) 8. Re-tighten all to 45 N. m (33 ft. lbs.) 9. All + 130B° Turn. Do not use a torque wrench for this step.	Tightening Sequence - Left
3	Camshaft Bearing Cap Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence - Left
-	Cylinder Head Coolant Pipe Plug	**35 N.m (26 Ft. Lbs.)**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
-	Cylinder Head Oil Galley Plug	**18 N.m (13 Ft. Lbs.)**	-
-	Cylinder Head Oil Restrictor M8 Plug	**15 N.m (11 Ft. Lbs.)**	-
-	Ground Strap Bolt to Right Cylinder Head	**23 N.m (17 Ft. Lbs.)**	-
-	Heater Core Supply Tube to Cylinder Head M8 Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Wire Harness Retainer Bracket to LH Cylinder Head Bolts	**10 N.m (89 In. Lbs.)**	-

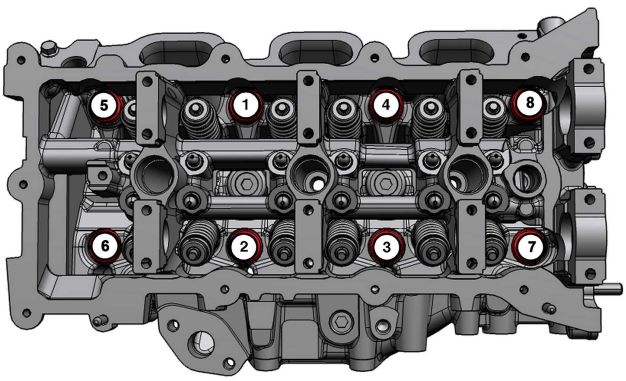


Tightening Sequence - Right





Tightening Sequence - Right



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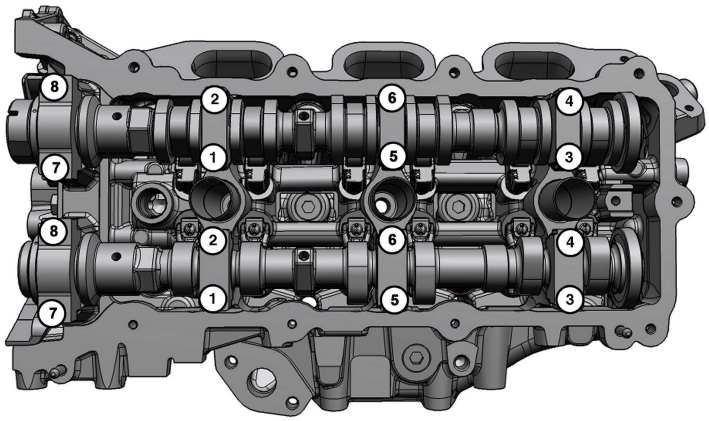

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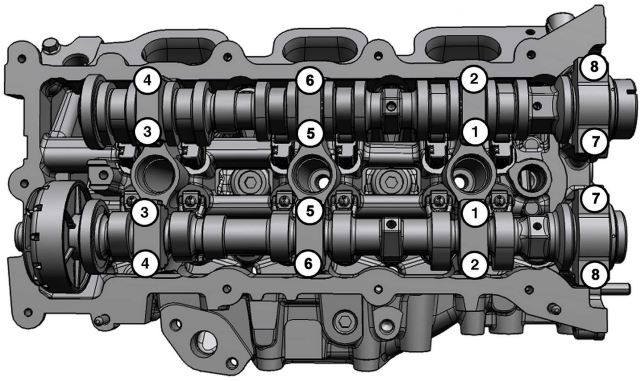
Tightening Sequence - Right



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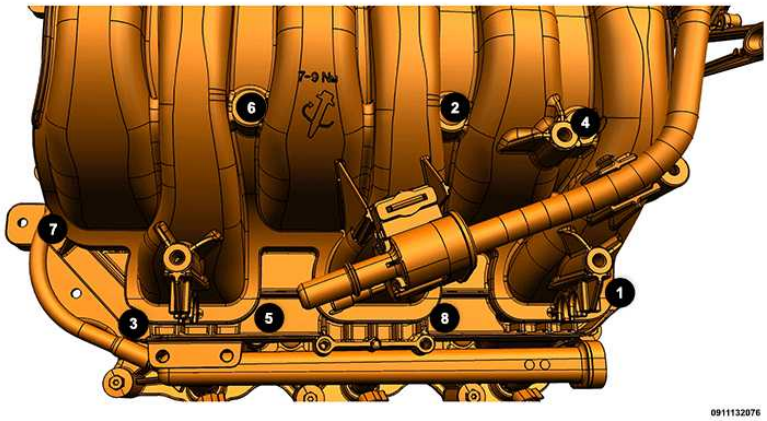
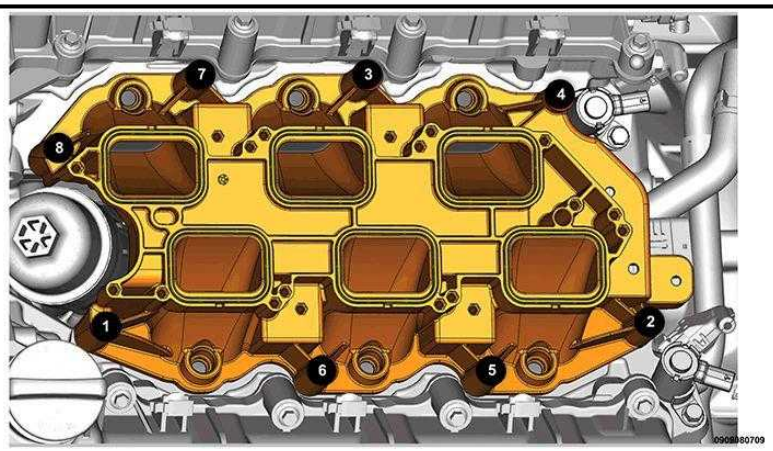
AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-

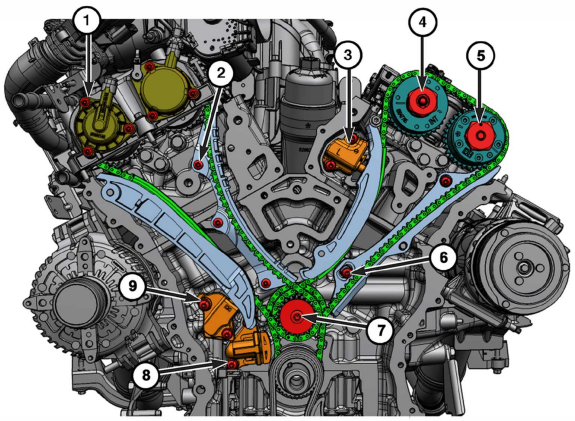
DESCRIPTION	SPECIFICATION	COMMENTS
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-





VALVE TIMING



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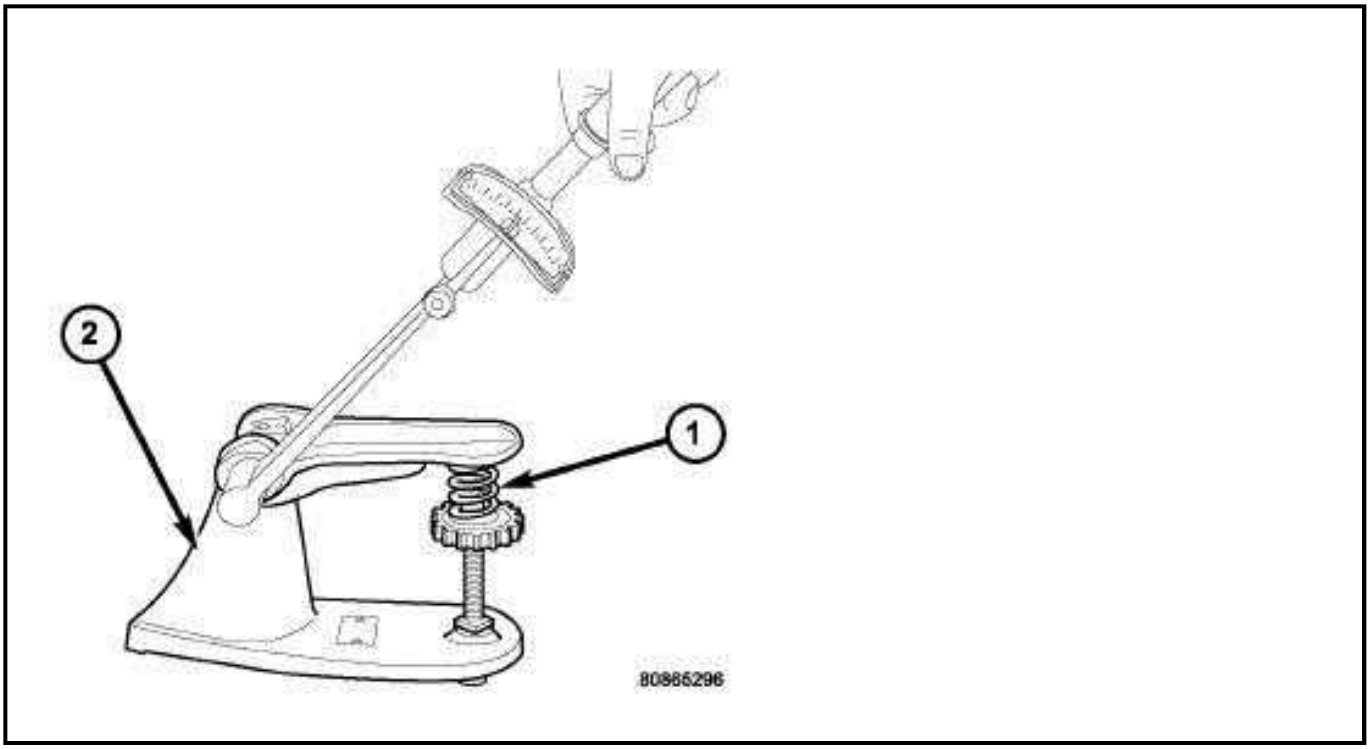
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

SPRING(S), VALVE

INSPECTION

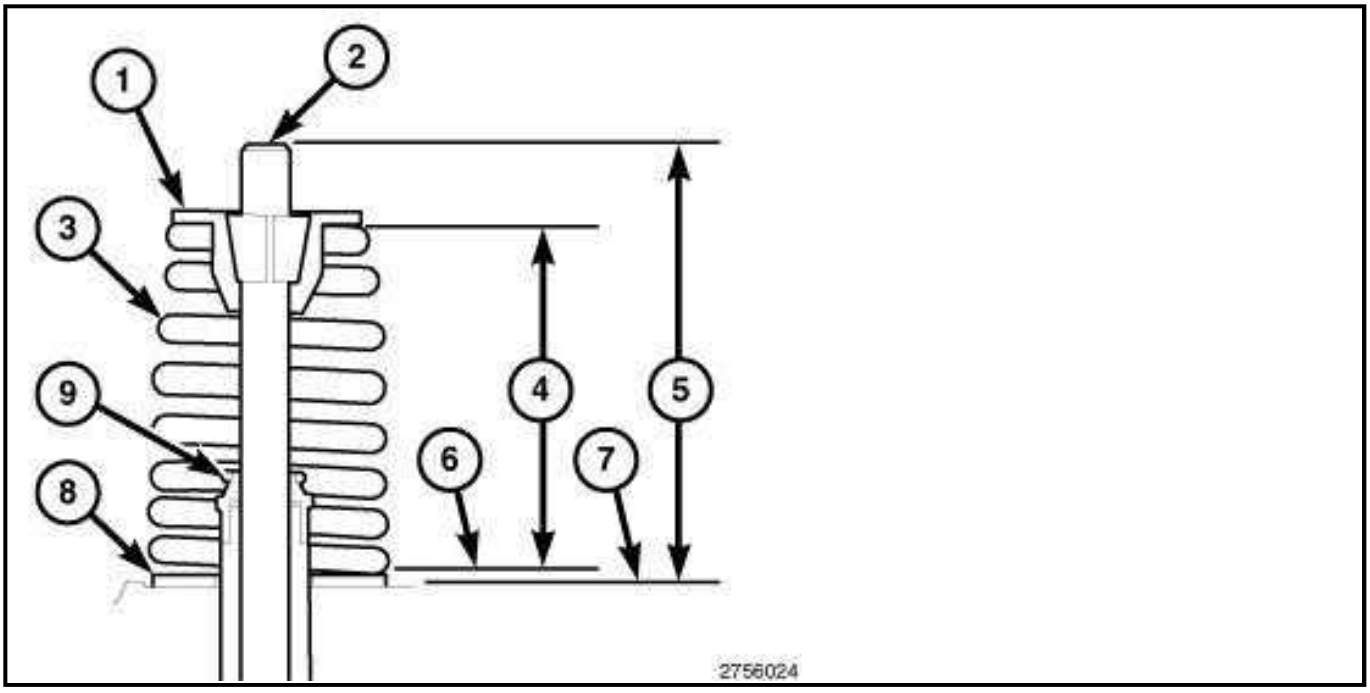
VALVE SPRING



1 - Valve Spring
2 - Test Fixture

When valves have been removed for inspection, reconditioning or replacement, valve springs should be checked against specifications for free-length, spring force and spring installed height. Refer to **ENGINE SPECIFICATIONS** .

Spring force can be measured with a test fixture. Follow the tool manufactures instructions. Replace any springs that do not meet specifications.



1 - Spring Retainer
2 - Valve Stem
3 - Valve Spring
4 - Valve Spring Height
5 - Valve Stem Tip Height

6 - Spring Seat
7 - Cylinder Head
8 - Second Spring Seat

Installed height of the valve spring must be checked with the valve assembled into the cylinder head.

If the valves or valve seats have been refinished and the installed valve spring height is greater than 41.0 mm (1.61 in.), install a second spring seat in the head counter bore under the original valve spring seat to bring the spring height within specification. Make sure the measurement is taken from the top of spring seat to the bottom surface of spring retainer.

REMOVAL AND INSTALLATION

ON VEHICLE

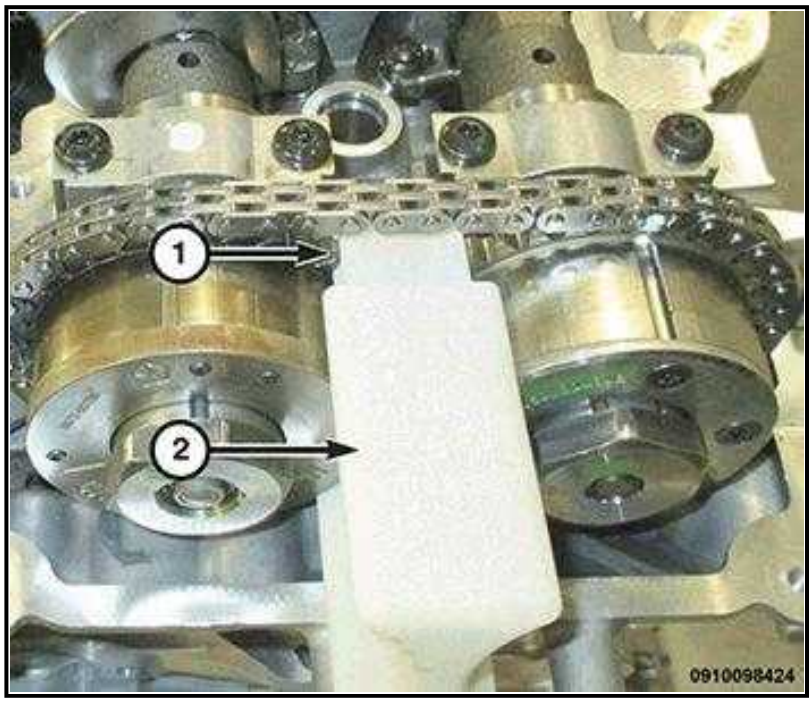
REMOVAL

1. Remove both cylinder head covers. Refer to **COVER(S), CYLINDER HEAD, REMOVAL AND INSTALLATION**.

   NOTE: **Only remove the camshafts from one head at a time. The opposite head must remain assembled in order to lock the crankshaft against rotation.**

   NOTE: **If the rocker arms are to be reused, identify their positions so that they can be reassembled into their original locations.**

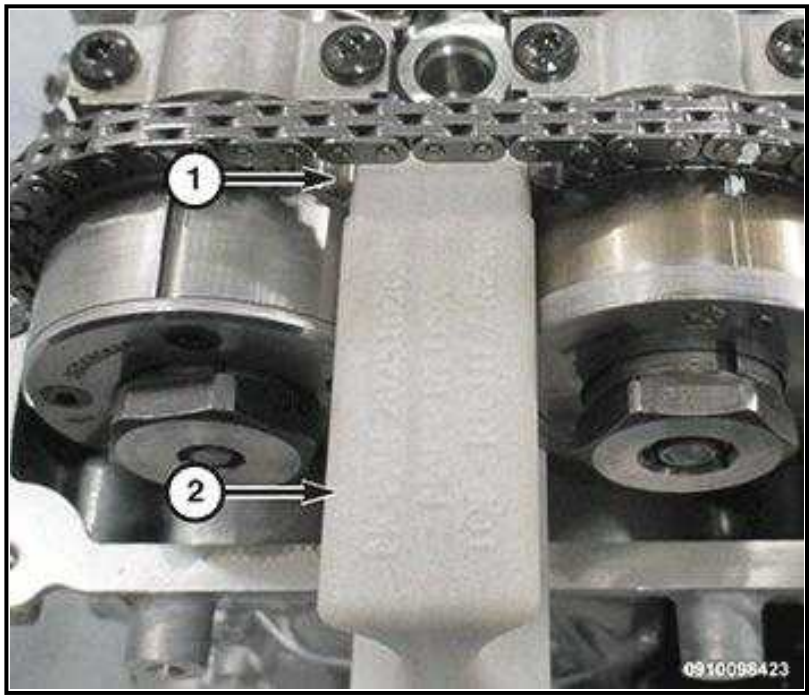
2. Remove the rocker arm(s). Refer to **ROCKER ARM, VALVE, REMOVAL AND INSTALLATION**.



1 - Timing Sprocket Teeth
2 - Camshaft Phaser Holder Tool

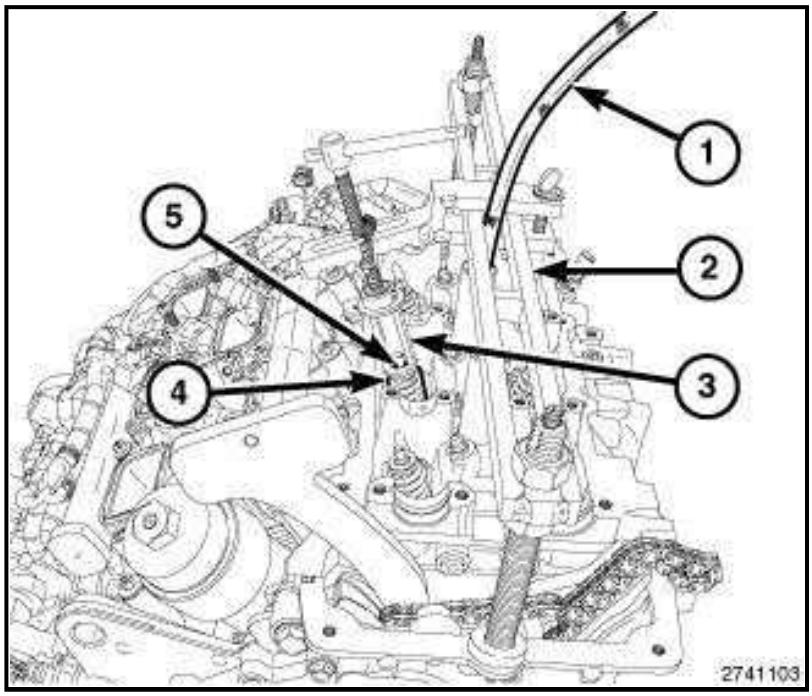
CAUTION: **Air pressure applied to the cylinder holds the valves in place. This air pressure also has a tendency to force the piston down and rotate the crankshaft. Do not allow the crankshaft to rotate. Crankshaft rotation may damage the timing chain or front timing cover and affect camshaft timing.**

3. If removing the RH camshafts, install the (special tool #2025101090, Holder, Camshaft Phaser - Left-Front Cyl Head) to lock the crankshaft against rotation.



1 - Timing Sprocket Teeth
2 - Camshaft Phaser Holder Tool

4. If removing the LH camshafts, install the (special tool #2025102090, Holder, Camshaft Phaser - Right-Rear Cyl Head) to lock the crankshaft against rotation.



1 - Regulated Shop Air
2 - Valve Spring Compressor Tool
3 - Valve Spring Adaptor Tool
4 - Valve Spring
5 - Valve Spring Retainer

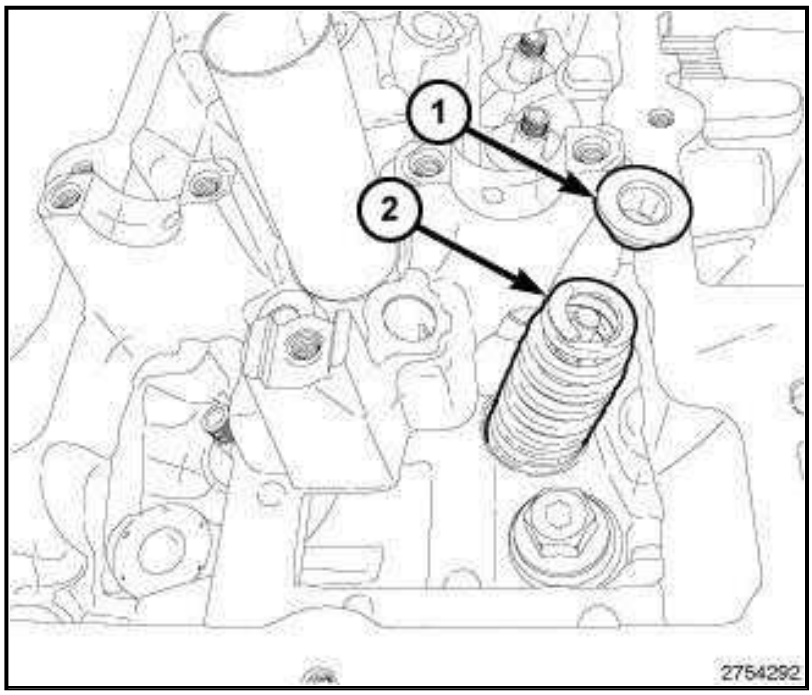
NOTE: **Number 4 cylinder intake valve spring compression shown, all other valves similar.**

5. Remove the spark plug. Refer to **SPARK PLUG, REMOVAL AND INSTALLATION**.

6. Install Valve Spring Compressor (special tool #MD998772A, Compressor, Valve Spring) onto the cylinder head.

CAUTION: **Air pressure must be maintained as long as the valve springs are removed to prevent the valves from dropping into the cylinders.**

7. Install a spark plug adapter attached to a regulated shop air supply. Pressurize the cylinder being serviced to 620.5 - 689 kPa (90 - 100 psi) to hold the valves in place.
8. Using Valve Spring Compressor Adapter (special tool #10224, Adapter, Valve Spring), compress valve spring and remove valve retaining locks.



1 - Valve Spring Retainer
2 - Valve Spring

NOTE: **If the springs are to be reused, identify their positions so that they can be reassembled into their original locations. Number 5 cylinder exhaust valve spring shown, all other valve springs similar.**

9. Release the valve spring compressor and remove the valve spring retainer and valve spring.
10. If required, remove the valve guide seal and spring seat. Refer to **SEAL(S), VALVE GUIDE, REMOVAL AND INSTALLATION**.

INSTALLATION

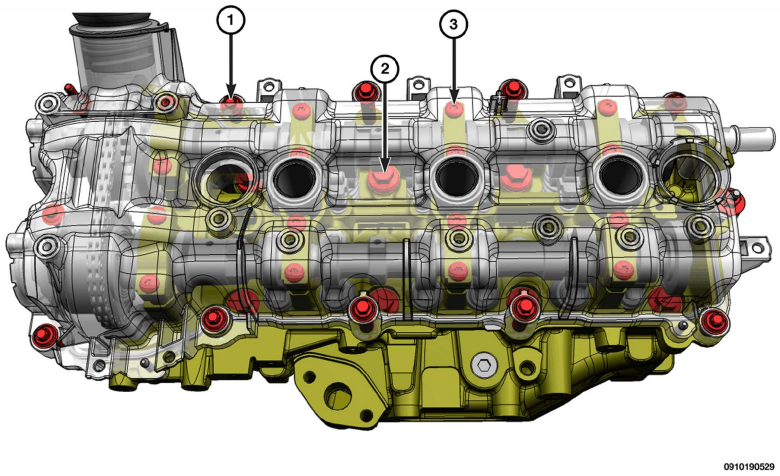
During installation, torque the fasteners to the specifications in the torque table(s) below.

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 the valve springs are being reused, reassemble them into their original locations.
- Compress the valve springs with the (special tool #10224, Adapter, Valve Spring) mounted in the (special tool #MD998772A, Compressor, Valve Spring)
- If the rocker arms are being reused, reassemble them into their original locations.

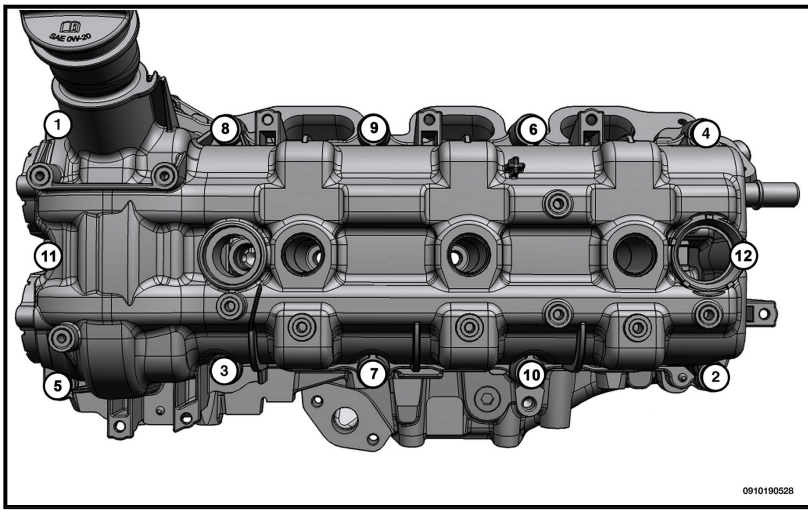
TORQUE SPECIFICATIONS

CYLINDER HEAD



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Cylinder Head Cover M6 Bolts	**12 N.m (9 Ft. Lbs.)**	Tightening Sequence - Left
2	Cylinder Head Bolts	**Torque Procedure** For engine builds using a new block follow steps 1-9. For engine re-builds (reuse block) follow step 6-9. 1. 30 N. m (22 ft. lbs.) 2. 45 N. m (33 ft. lbs.) 3. Re-tighten all to 45 N. m (33 ft. lbs.) 4. All + 125B° Turn. Do not use a torque wrench for this step. 5. Loosen all fasteners in reverse of sequence shown 6. All to 30 N. m (22 ft. lbs.) 7. All to 45 N. m (33 ft. lbs.) 8. Re-tighten all to 45 N. m (33 ft. lbs.) 9. All + 130B° Turn. Do not use a torque wrench for this step.	Tightening Sequence - Left
3	Camshaft Bearing Cap Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence - Left
-	Cylinder Head Coolant Pipe Plug	**35 N.m (26 Ft. Lbs.)**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
-	Cylinder Head Oil Galley Plug	**18 N.m (13 Ft. Lbs.)**	-
-	Cylinder Head Oil Restrictor M8 Plug	**15 N.m (11 Ft. Lbs.)**	-

CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
-	Ground Strap Bolt to Right Cylinder Head	**23 N.m (17 Ft. Lbs.)**	-
-	Heater Core Supply Tube to Cylinder Head M8 Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Wire Harness Retainer Bracket to LH Cylinder Head Bolts	**10 N.m (89 In. Lbs.)**	-



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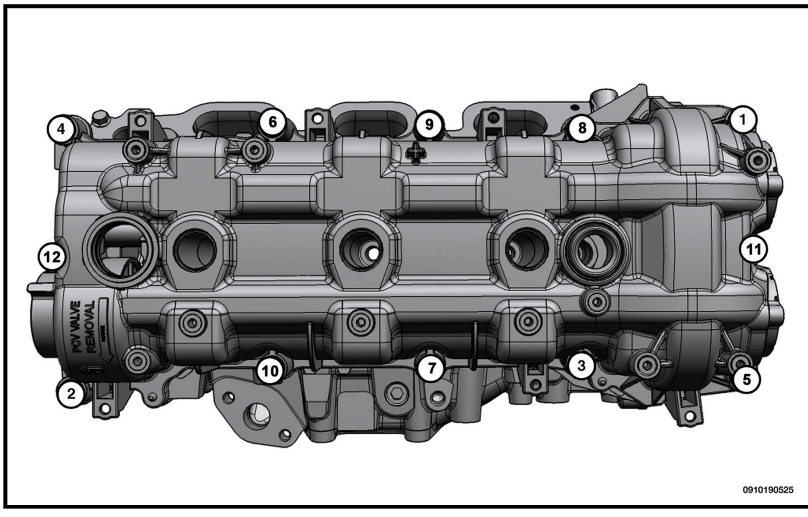
Tightening Sequence - Right



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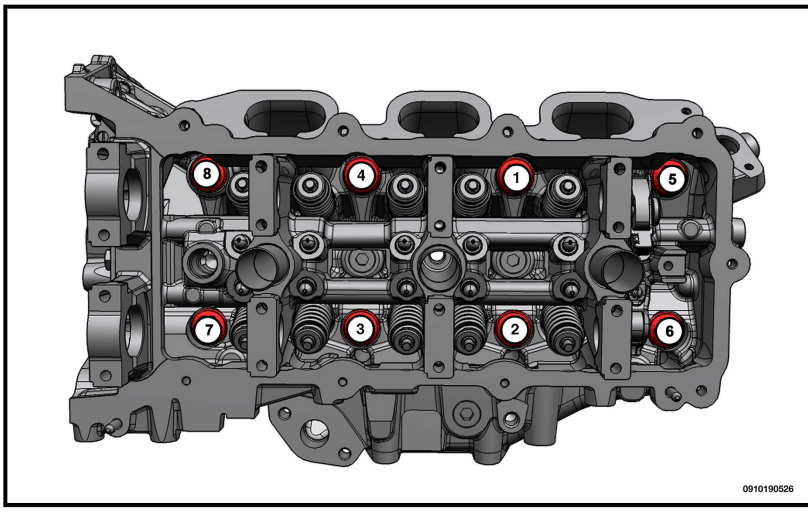

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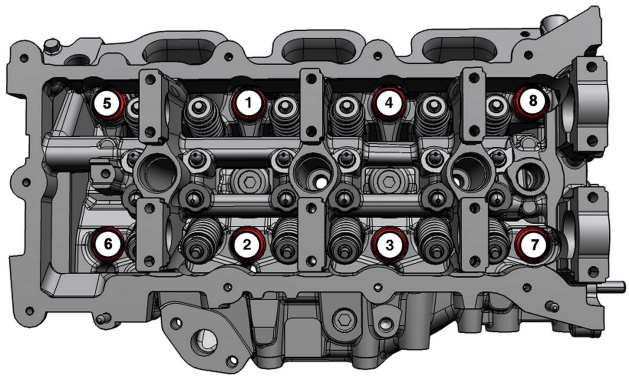
Tightening Sequence - Right



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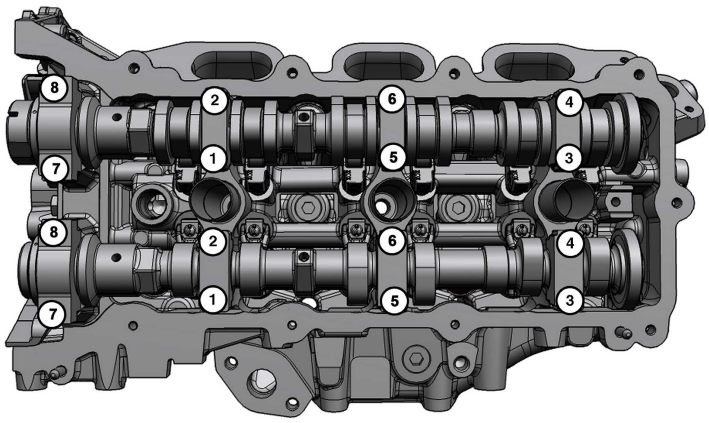

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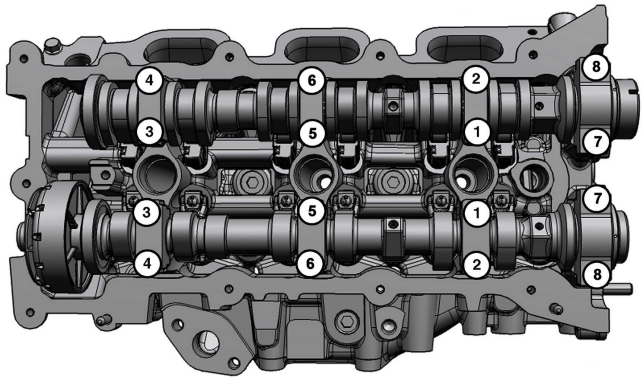
Tightening Sequence - Right



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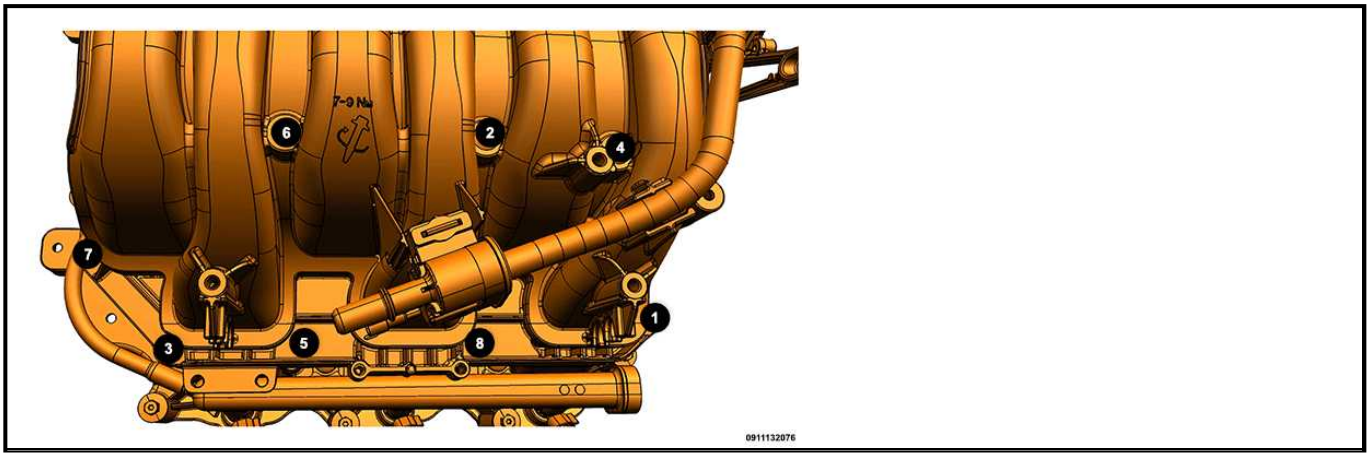
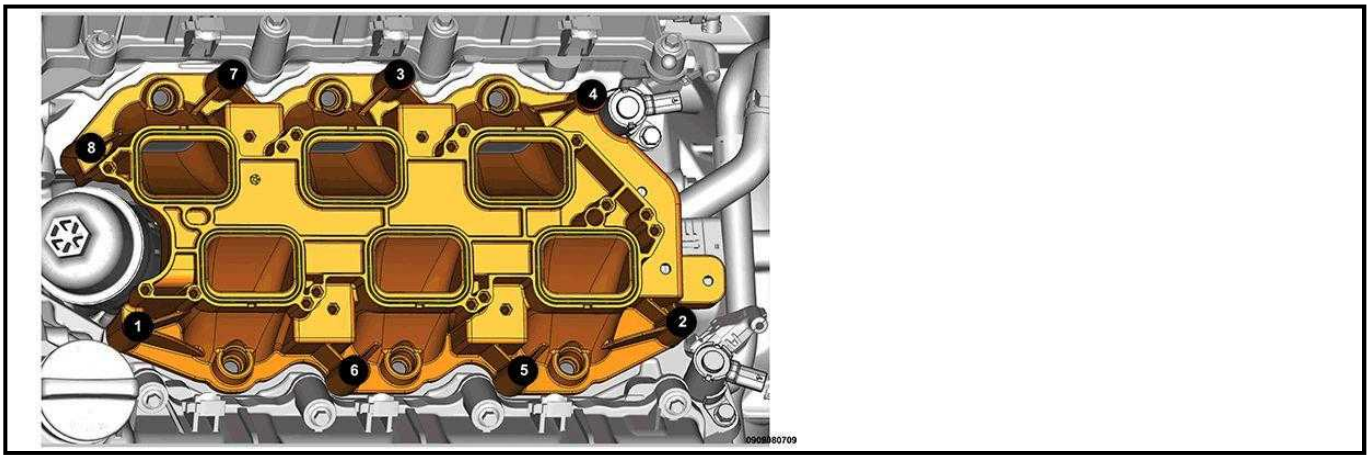
AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-

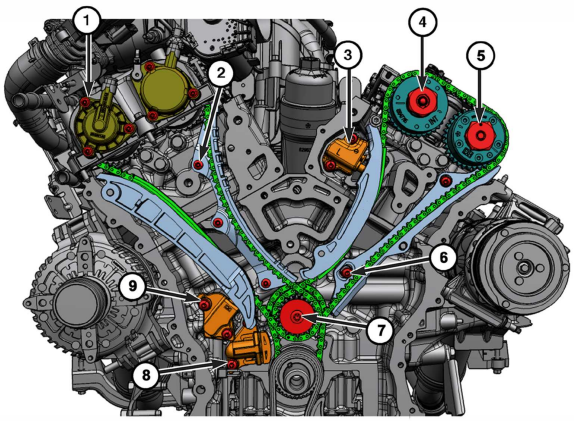
DESCRIPTION	SPECIFICATION	COMMENTS
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-





VALVE TIMING



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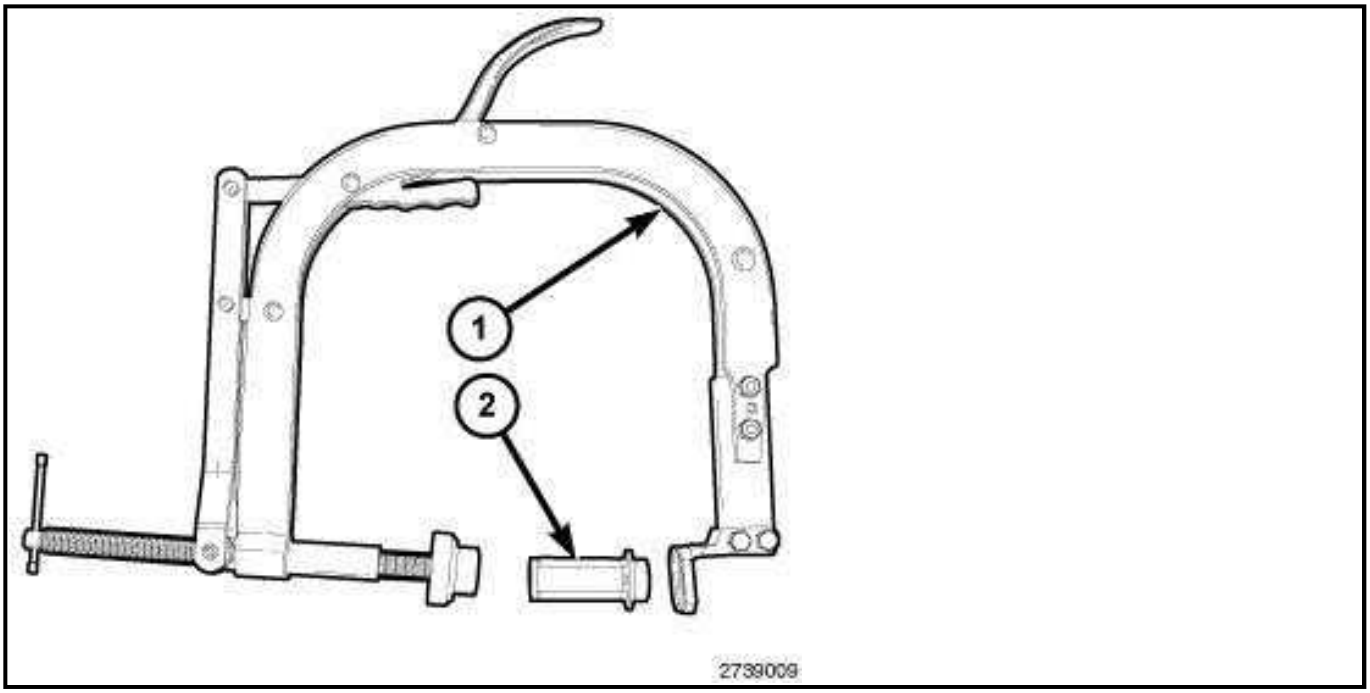
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

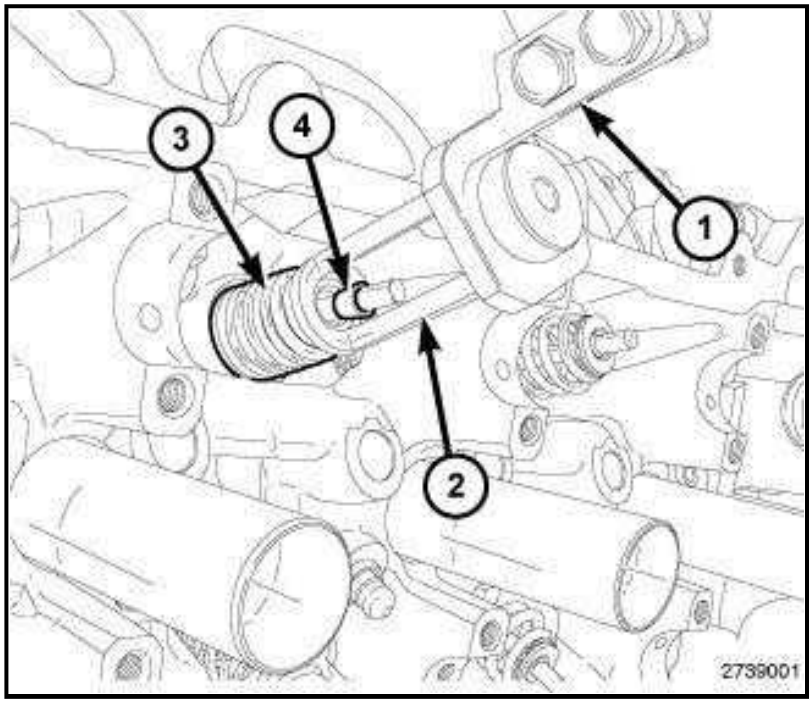
OFF VEHICLE

REMOVAL



1 - Valve Spring Compressor Tool
2 - Valve Spring Adaptor

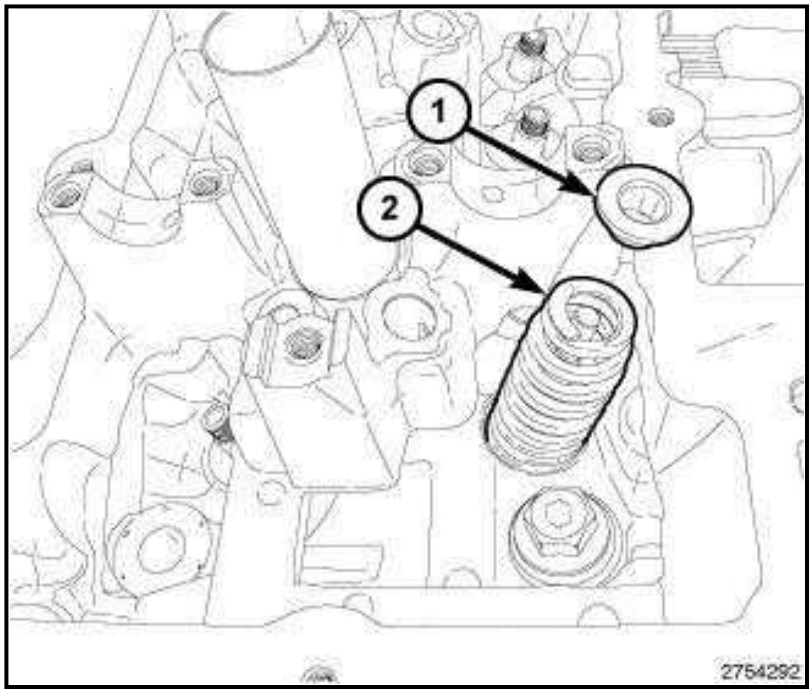
1. Remove the cylinder head(s). Refer to **CYLINDER HEAD ASSEMBLY, REMOVAL AND INSTALLATION**.
2. Position the Valve Spring Compressor Adapter (special tool #10224, Adapter, Valve Spring) in the Valve Spring Compressor (special tool #C-3422-D, Compressor, Valve Spring).



1 - Valve Spring Compressor Tool
2 - Valve Spring Adaptor
3 - Valve Spring
4 - Valve Spring Retainer Locks

NOTE: **Number 3 cylinder intake valve spring compression shown, all other valves similar.**

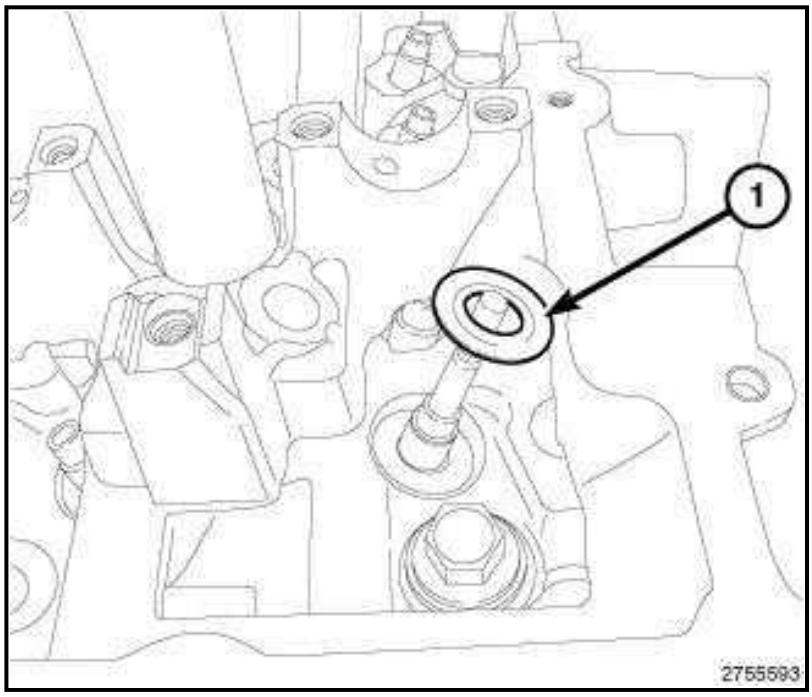
3. Compress the valve spring and remove the valve retaining locks.



1 - Valve Spring Retainer
2 - Valve Spring

NOTE: **If the springs are to be reused, identify their positions so that they can be reassembled into their original locations. Number 5 cylinder exhaust valve spring shown, all other valves similar.**

4. Release the valve spring compressor and remove the valve spring retainer and valve spring).



1 - Valve Spring Seat

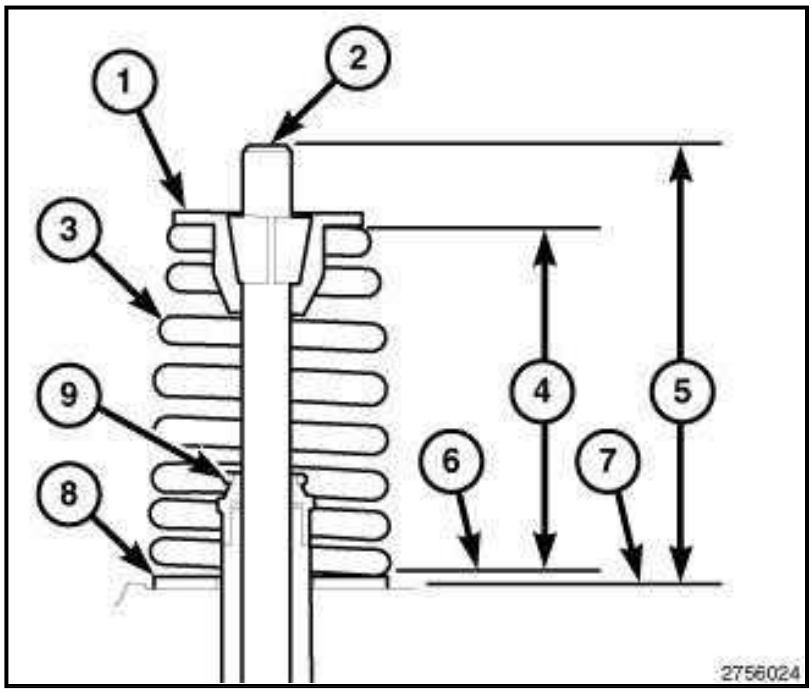
5. Remove the spring seat.

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 the valve springs are being reused, reassemble them into their original locations.

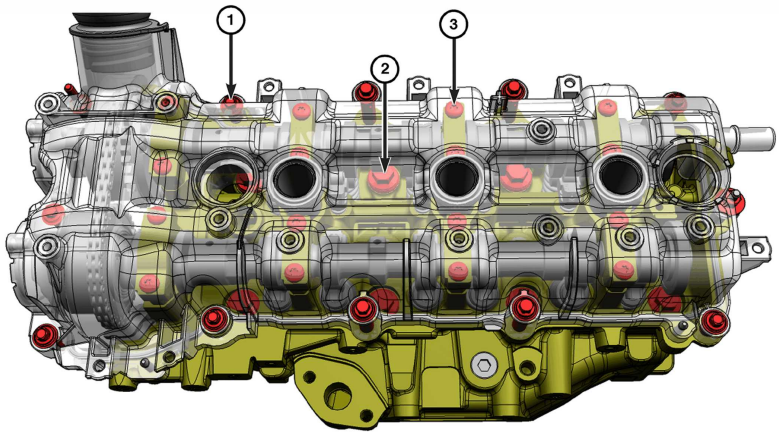


1 - Valve Spring Retainer	6 - Top of Valve Spring Seat
2 - Valve Stem	7 - Cylinder Head Counter Bore Surface
3 - Valve Spring	8 - Valve Spring Seat
4 - Valve Spring Height Measurement	9 - Valve Guide
5 - Valve Tip Height	B

- If the valves or valve seats have been refinished, check the installed height of the valve springs. If the installed valve spring height is greater than 40.0 mm (1.575 in.), install an additional spring seat in the head counter bore under the original valve spring seat to bring the spring height back within specification. Make sure the measurement is taken from the top of spring seat to the bottom surface of spring retainer.
- If the valves or valve seats have been refinished, check the valve tip height. If the valve tip height exceeds the specification, grind the valve tip until it is within specification. Refer to **ENGINE SPECIFICATIONS** . Make sure the measurement is taken from the cylinder head surface to the top of the valve stem.

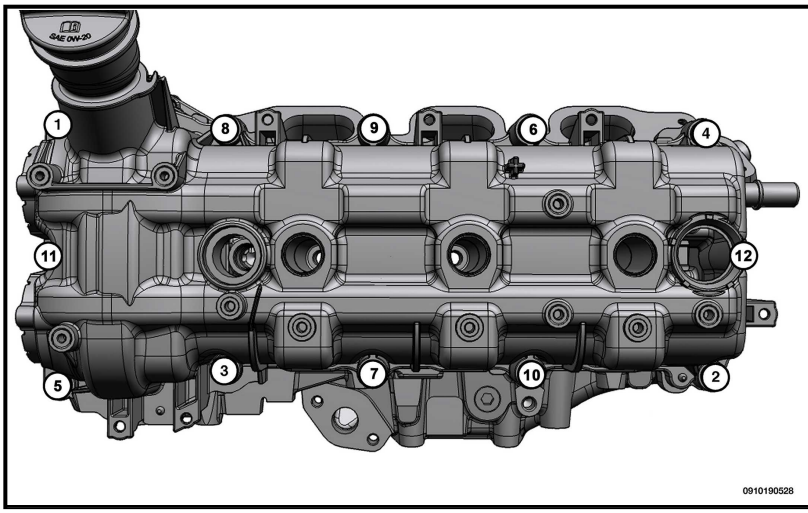
TORQUE SPECIFICATIONS

CYLINDER HEAD



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Cylinder Head Cover M6 Bolts	**12 N.m (9 Ft. Lbs.)**	Tightening Sequence - Left
2	Cylinder Head Bolts	**Torque Procedure** For engine builds using a new block follow steps 1-9. For engine re-builds (reuse block) follow step 6-9. 1. 30 N. m (22 ft. lbs.) 2. 45 N. m (33 ft. lbs.) 3. Re-tighten all to 45 N. m (33 ft. lbs.) 4. All + 125B° Turn. Do not use a torque wrench for this step. 5. Loosen all fasteners in reverse of sequence shown 6. All to 30 N. m (22 ft. lbs.) 7. All to 45 N. m (33 ft. lbs.) 8. Re-tighten all to 45 N. m (33 ft. lbs.) 9. All + 130B° Turn. Do not use a torque wrench for this step.	Tightening Sequence - Left
3	Camshaft Bearing Cap Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence - Left
-	Cylinder Head Coolant Pipe Plug	**35 N.m (26 Ft. Lbs.)**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
-	Cylinder Head Oil Galley Plug	**18 N.m (13 Ft. Lbs.)**	-
-	Cylinder Head Oil Restrictor M8 Plug	**15 N.m (11 Ft. Lbs.)**	-

CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
-	Ground Strap Bolt to Right Cylinder Head	**23 N.m (17 Ft. Lbs.)**	-
-	Heater Core Supply Tube to Cylinder Head M8 Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Wire Harness Retainer Bracket to LH Cylinder Head Bolts	**10 N.m (89 In. Lbs.)**	-



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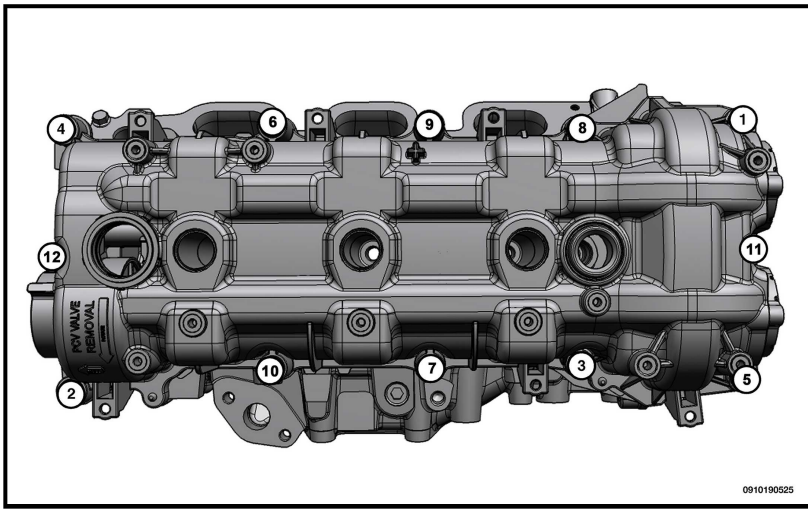
Tightening Sequence - Right



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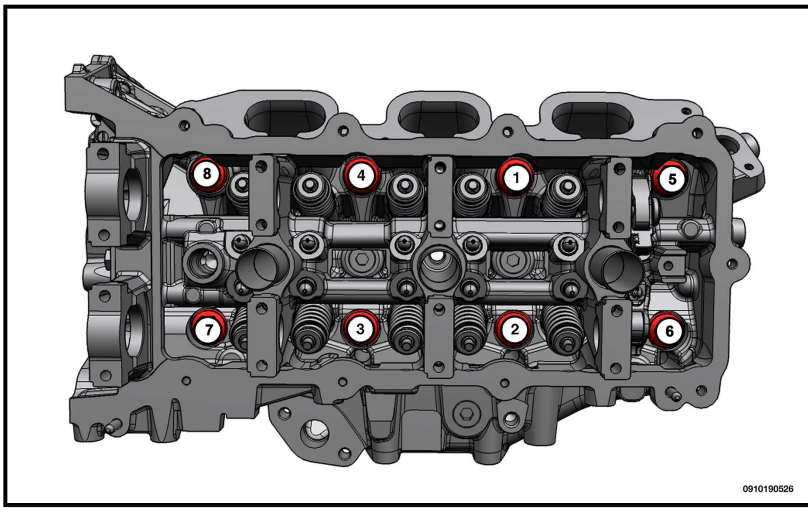

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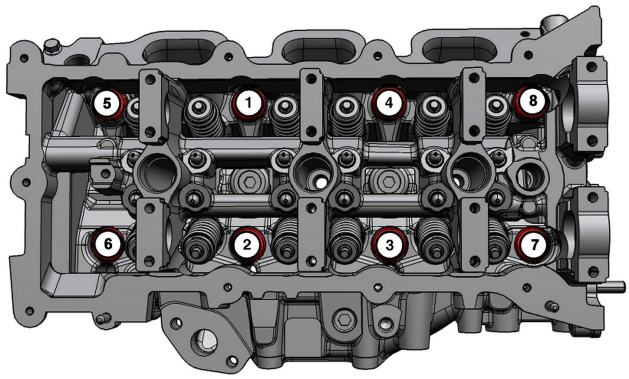
Tightening Sequence - Right



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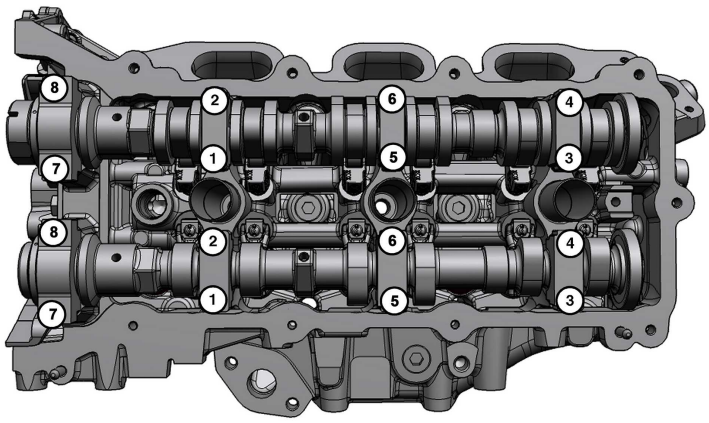

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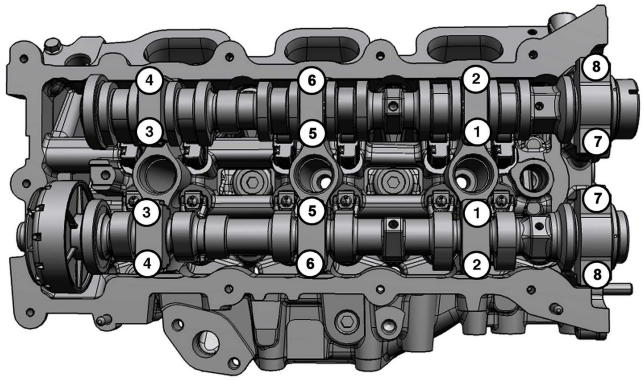
Tightening Sequence - Right



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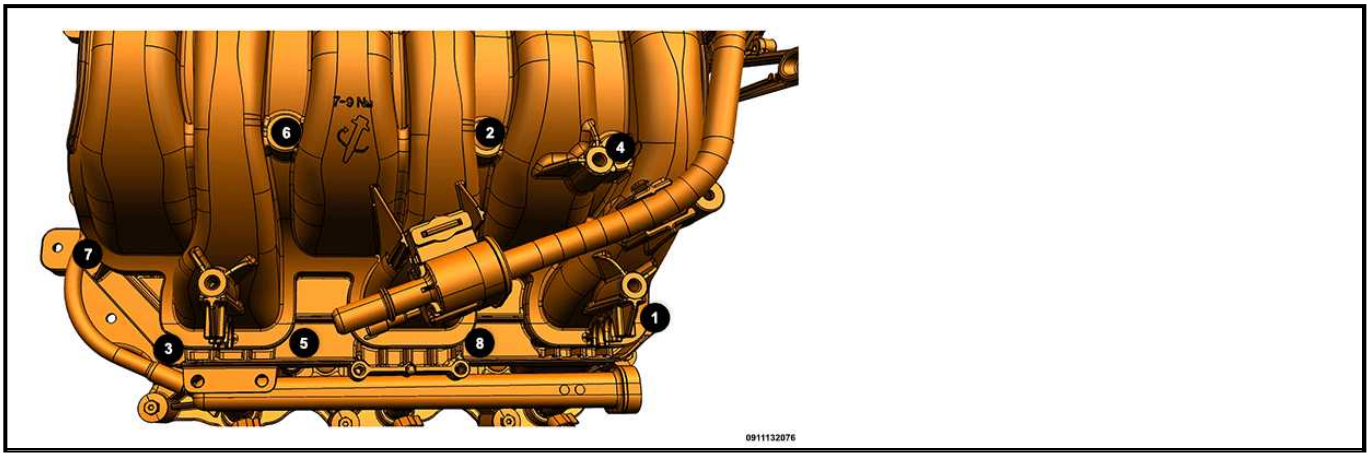
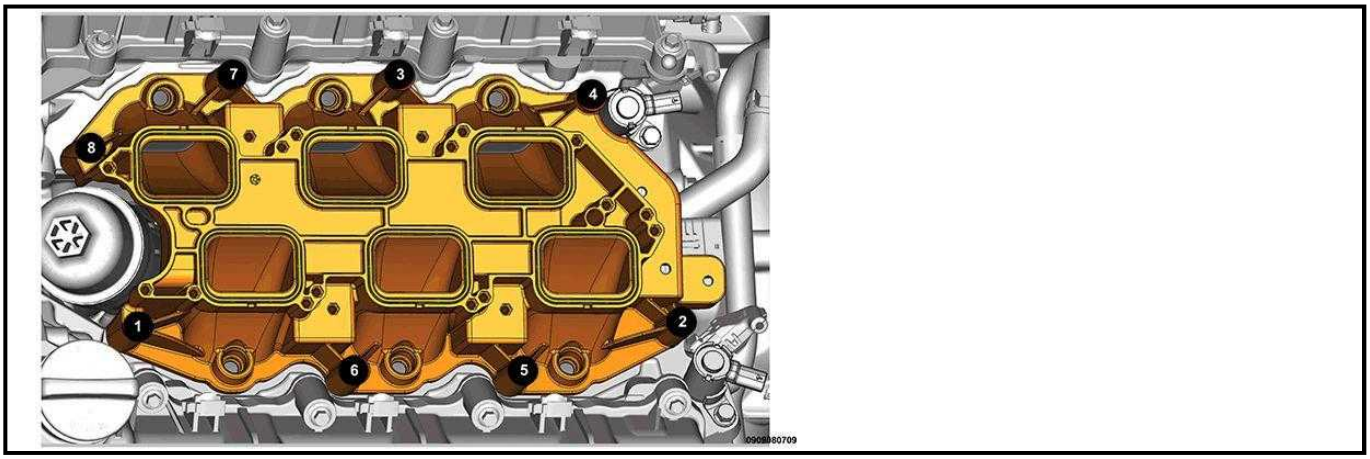
AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-

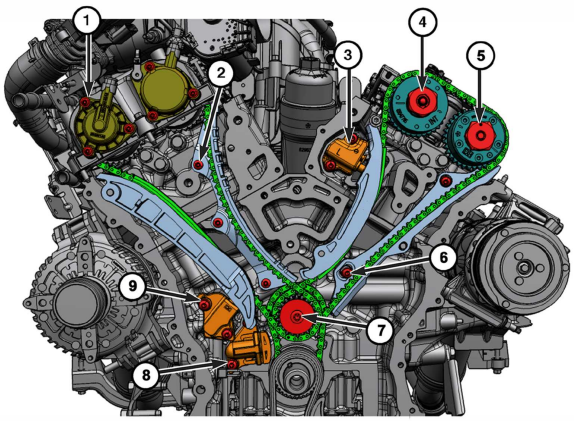
DESCRIPTION	SPECIFICATION	COMMENTS
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-





VALVE TIMING



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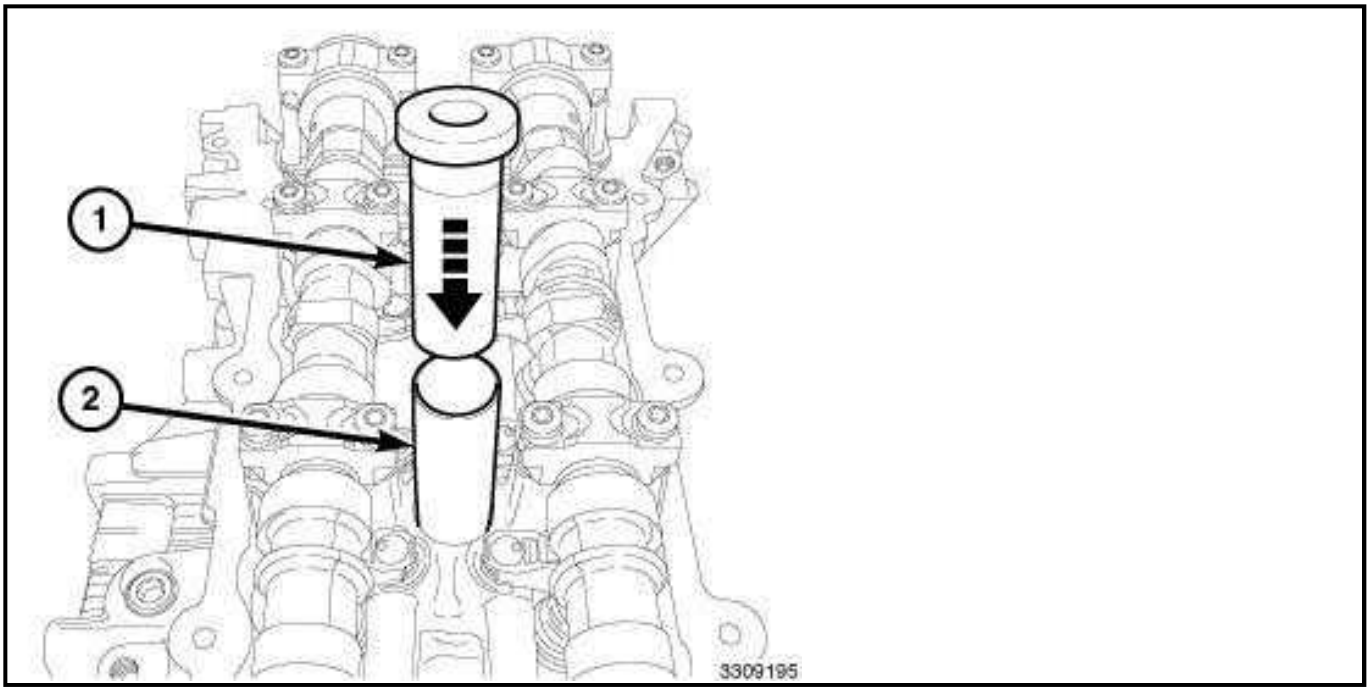
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

TUBE, SPARK PLUG

REMOVAL AND INSTALLATION

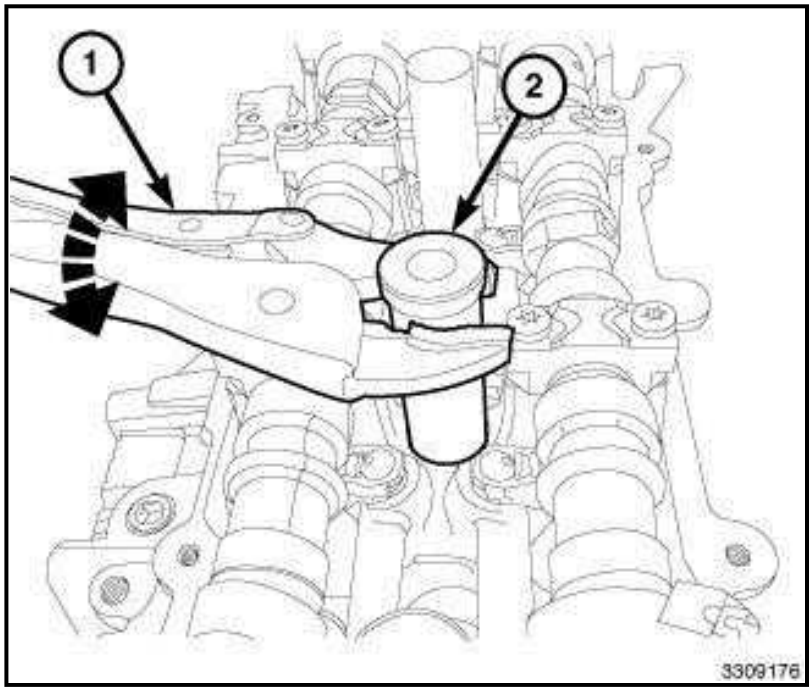
SPARK PLUG TUBE

REMOVAL



1 - Spark Plug Tube Installer
2 - Spark Plug Tube

1. Remove the ignition coils. Refer to **COIL, IGNITION, REMOVAL AND INSTALLATION**.
2. Using compressed air, blow out any dirt or contaminates from around the top of the spark plugs.
3. Remove the cylinder head cover(s). Refer to **COVER(S), CYLINDER HEAD, REMOVAL AND INSTALLATION**.
4. Install the top half of the (special tool #2024900090, Installer, Spark Plug Tube) into the spark plug tube to be removed.

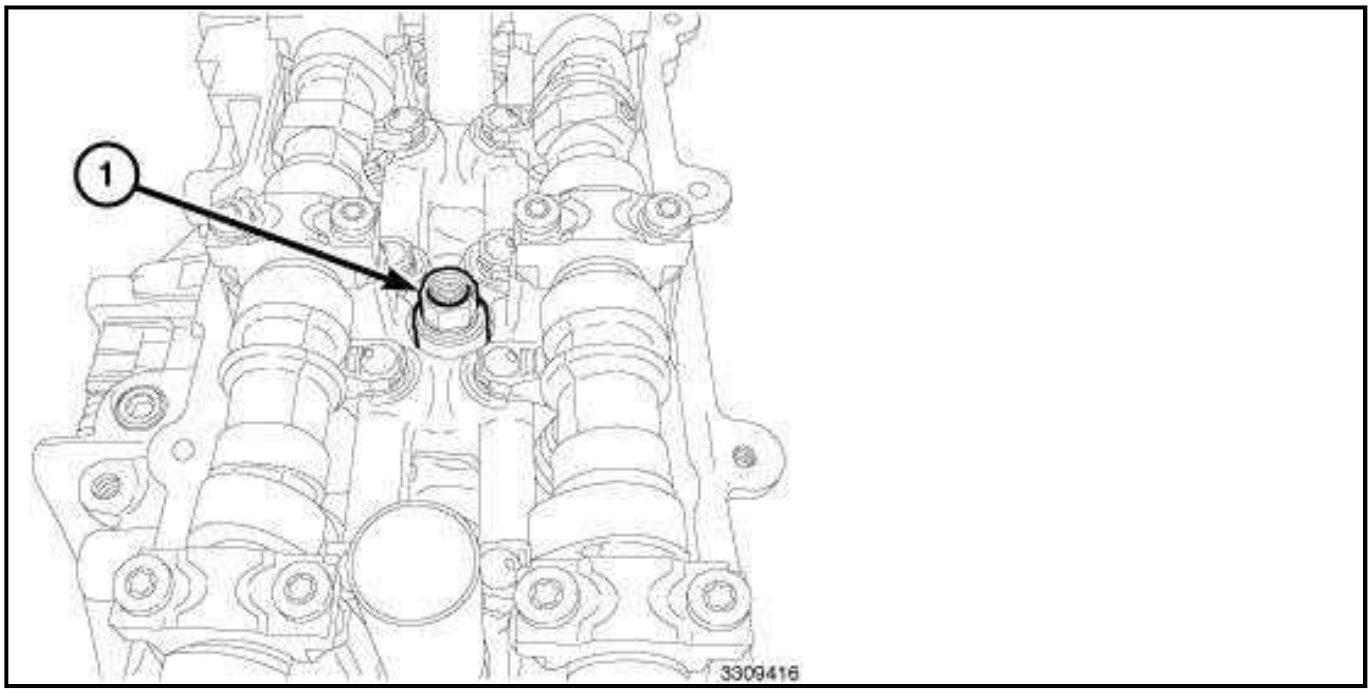


1 - Locking Pliers
2 - Spark Plug Tube

5. Using suitable locking pliers, remove the spark plug tube from the cylinder head and discard the tube.
6. Clean the area around the spark plug tube mounting with MoparB® Parts Cleaner or equivalent.

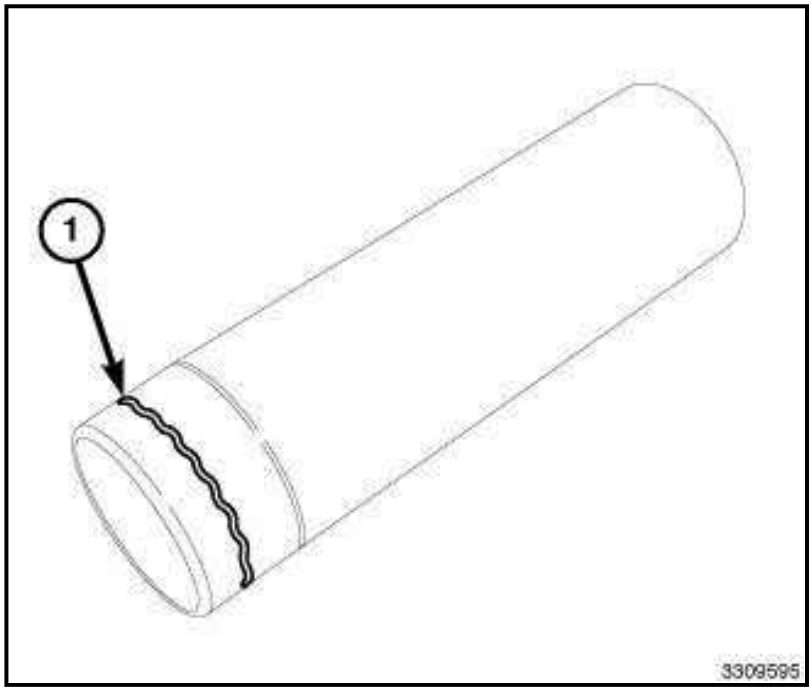
INSTALLATION

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



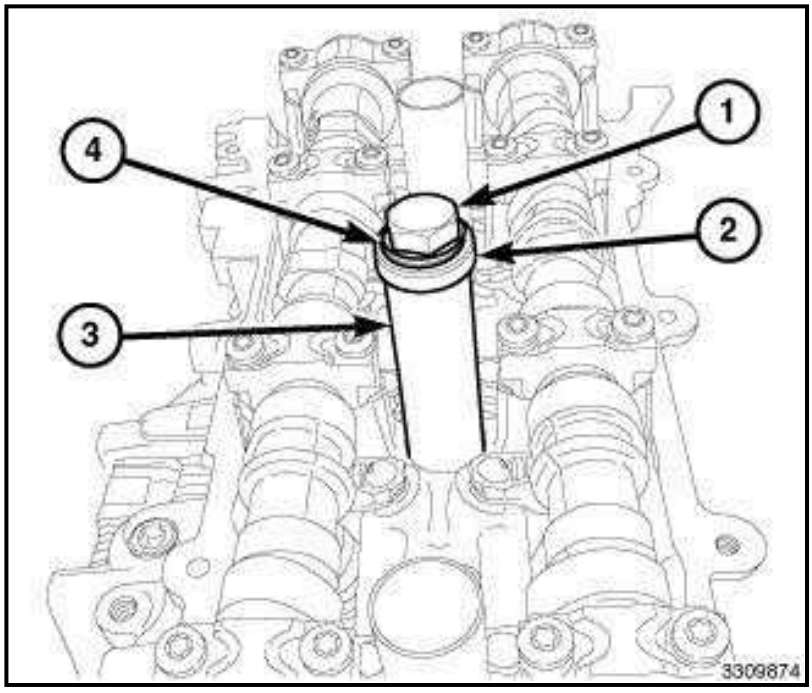
1 - Spark Plug Tube Installer

1. Remove the spark plug. Refer to **SPARK PLUG, REMOVAL AND INSTALLATION**.
2. Install the lower half of the (special tool #2024900090, Installer, Spark Plug Tube) into the cylinder head and tighten to the proper torque specification for the spark plug.



1 - Sealer Bead

3. Apply MoparB® Stud and Bearing Mount to the new spark plug tube approximately 3 mm (0.118 in.) from the end of the tube, in a 2 mm (0.078 in.) wide bead.



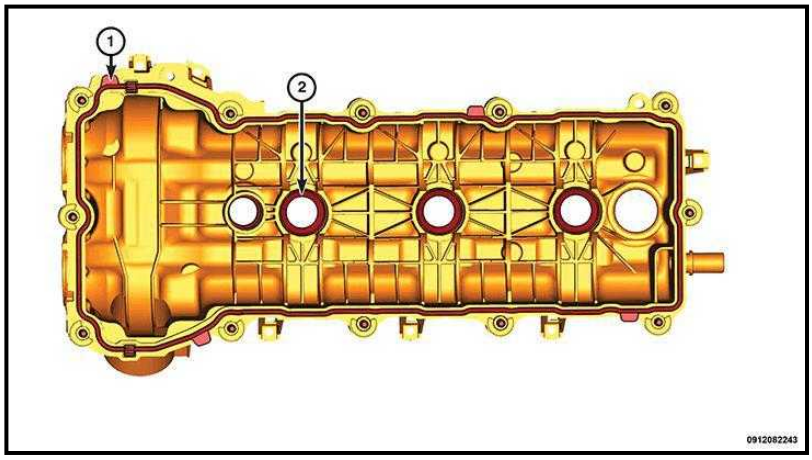
1 - Installer Bolt
2 - Spark Plug Tube Installer
3 - Spark Plug Tube
4 - Thrust Washers

4. Position the spark plug tube on the top half of the (special tool #2024900090, Installer, Spark Plug Tube) and assemble the tool on the cylinder head. Make sure there are two thrust washers installed.

CAUTION: **Do not overtighten the bolt (1). Overtightening can damage the cylinder head spark plug threads.**

5. Tighten the bolt to draw the spark plug tube into position. When the top half of the tool contacts the bottom half of the tool, the tube is installed.
6. Install the spark plug. Refer to **SPARK PLUG, REMOVAL AND INSTALLATION**.

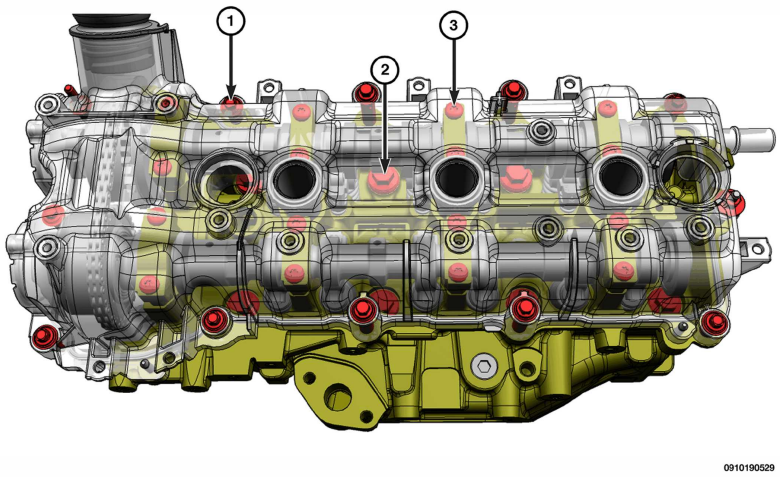
CAUTION: **Spark plug torque is critical and must not exceed the specified value. Overtightening stretches the spark plug shell reducing its heat transfer capability resulting in possible catastrophic engine failure.**



7. If required, install **NEW** spark plug tube seals.
8. Install the cylinder head cover(s). Refer to **COVER(S), CYLINDER HEAD, REMOVAL AND INSTALLATION**.

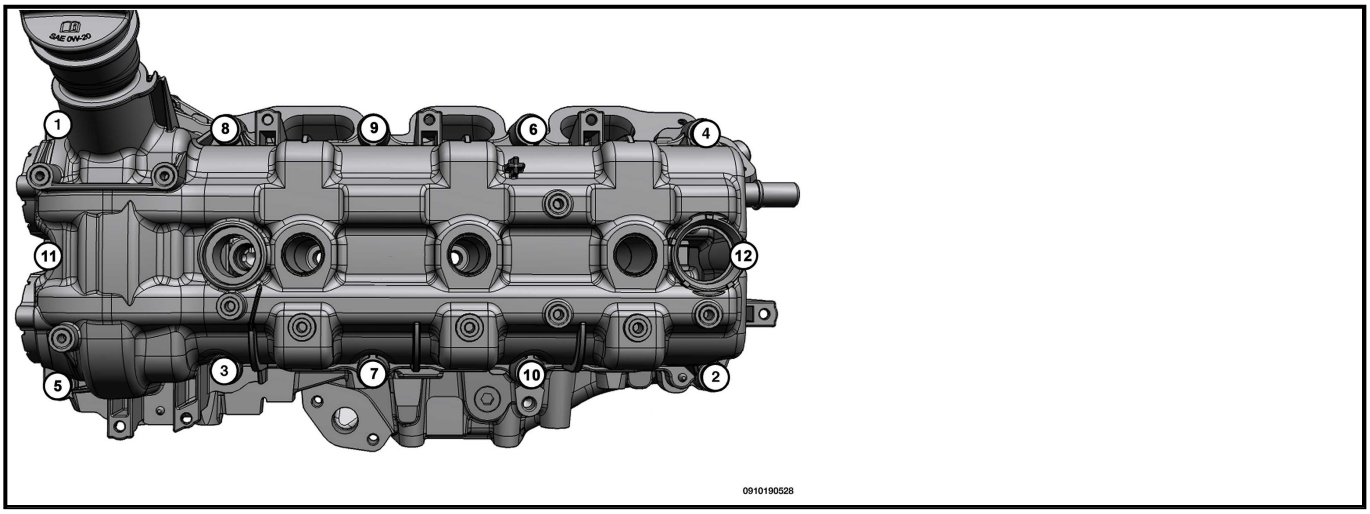
TORQUE SPECIFICATIONS

CYLINDER HEAD

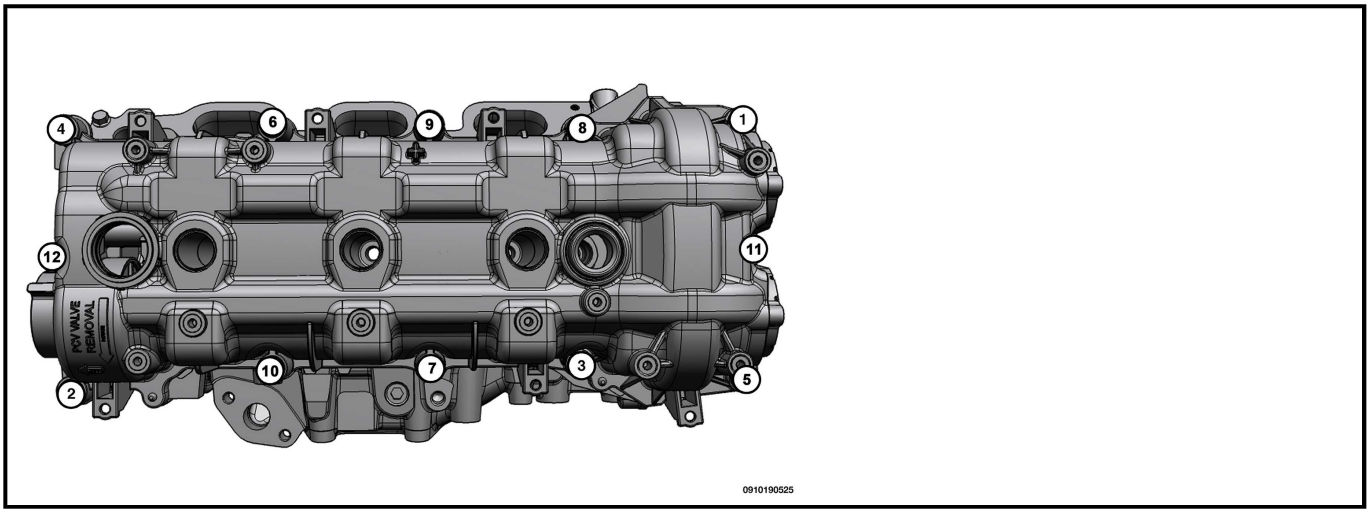


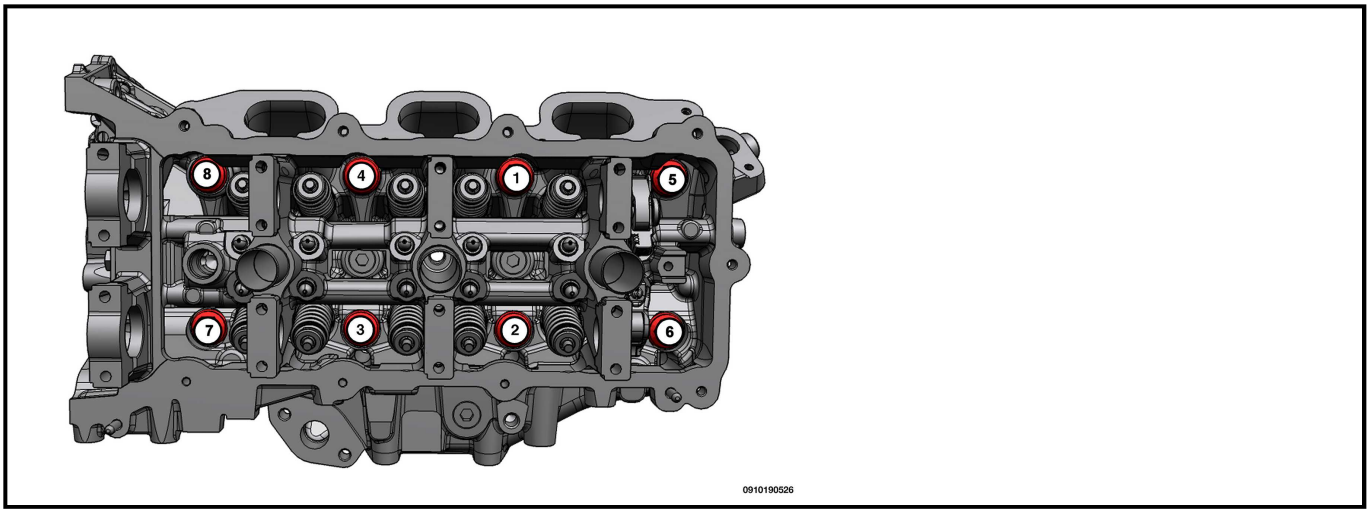
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Cylinder Head Cover M6 Bolts	**12 N.m (9 Ft. Lbs.)**	Tightening Sequence - Left
2	Cylinder Head Bolts	**Torque Procedure** For engine builds using a new block follow steps 1-9. For engine re-builds (reuse block) follow step 6-9. 1. 30 N. m (22 ft. lbs.) 2. 45 N. m (33 ft. lbs.) 3. Re-tighten all to 45 N. m (33 ft. lbs.) 4. All + 125B° Turn. Do not use a torque wrench for this step. 5. Loosen all fasteners in reverse of sequence shown 6. All to 30 N. m (22 ft. lbs.) 7. All to 45 N. m (33 ft. lbs.) 8. Re-tighten all to 45 N. m (33 ft. lbs.) 9. All + 130B° Turn. Do not use a torque wrench for this step.	Tightening Sequence - Left
3	Camshaft Bearing Cap Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence - Left
-	Cylinder Head Coolant Pipe Plug	**35 N.m (26 Ft. Lbs.)**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
-	Cylinder Head Oil Galley Plug	**18 N.m (13 Ft. Lbs.)**	-

CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
-	Cylinder Head Oil Restrictor M8 Plug	**15 N.m (11 Ft. Lbs.)**	-
-	Ground Strap Bolt to Right Cylinder Head	**23 N.m (17 Ft. Lbs.)**	-
-	Heater Core Supply Tube to Cylinder Head M8 Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Wire Harness Retainer Bracket to LH Cylinder Head Bolts	**10 N.m (89 In. Lbs.)**	-

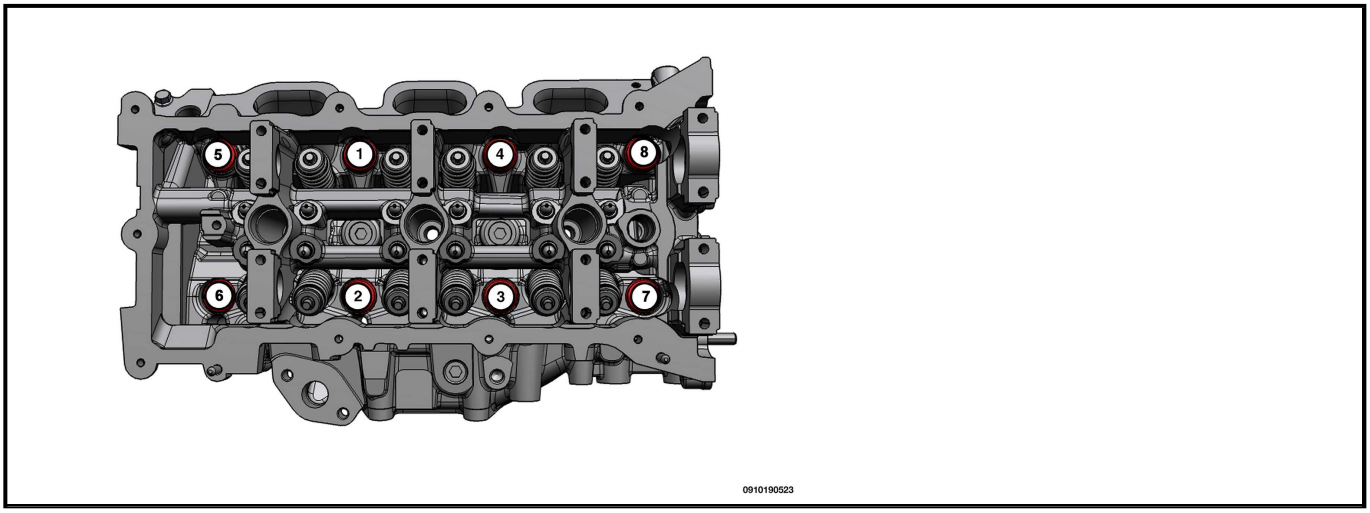


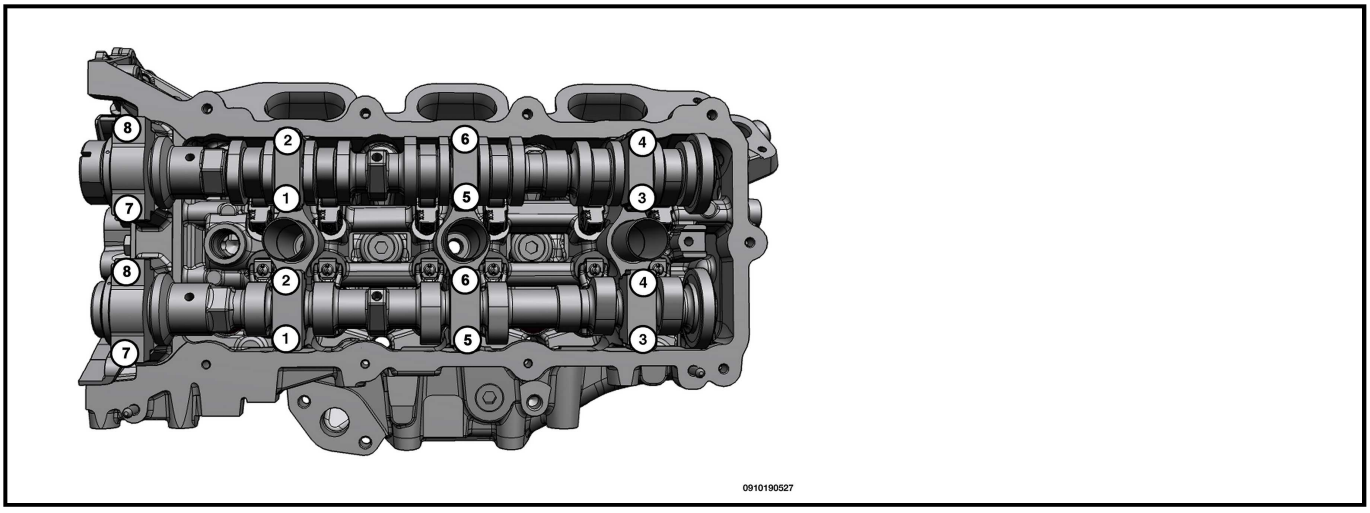
Tightening Sequence - Right



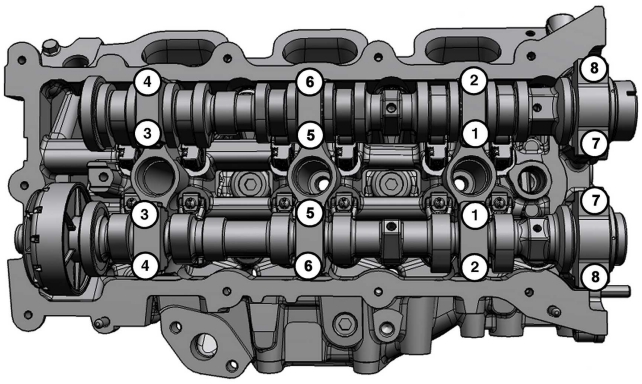


Tightening Sequence - Right





Tightening Sequence - Right



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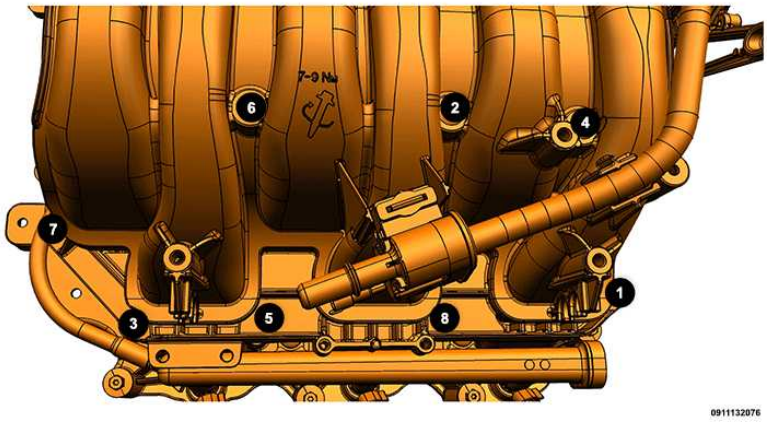
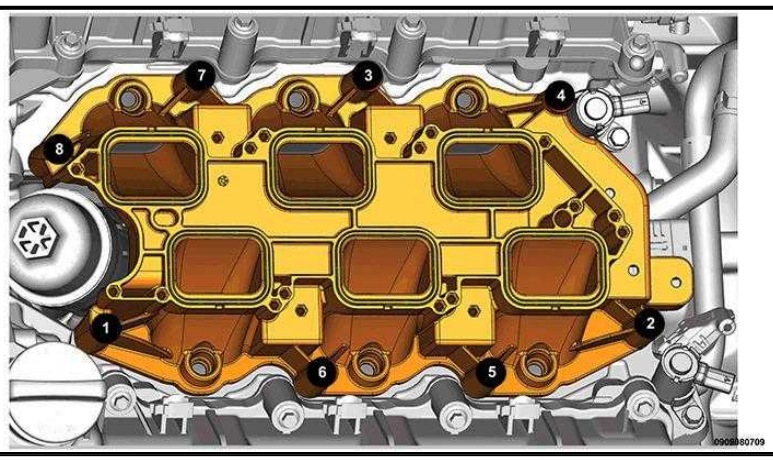
AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-





IGNITION CONTROL - 3.6L

DESCRIPTION	SPECIFICATION	COMMENTS
Ignition Capacitor Bolt	**10 N.m (89 In. Lbs.)**	-
Ignition Coil to Cylinder Head Cover	**8 N. m (71In. Lbs.)**	-
Spark Plugs	**20 N. m (15Ft. Lbs.)**	-

VALVES, INTAKE AND EXHAUST

REMOVAL AND INSTALLATION

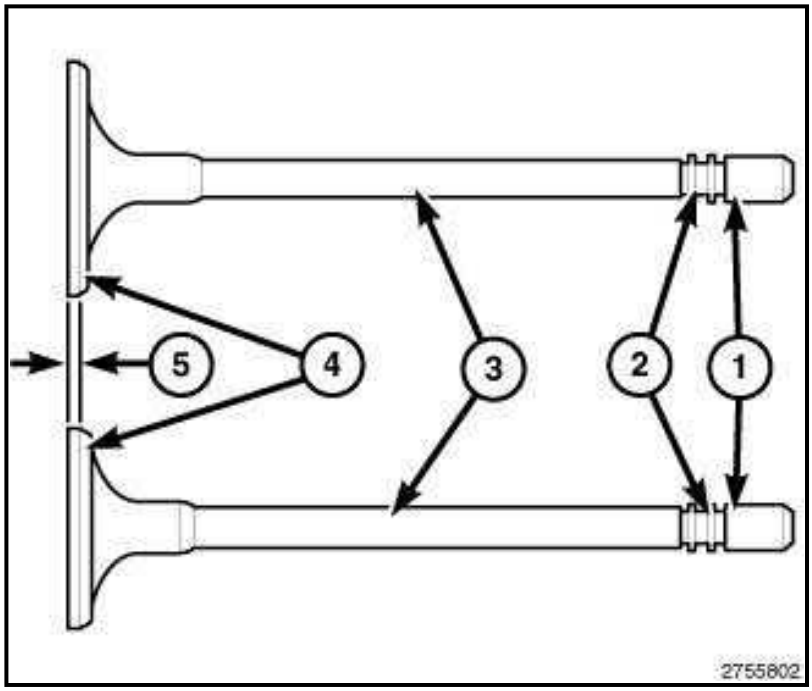
VALVES

REMOVAL

1. Remove the cylinder head(s). Refer to **CYLINDER HEAD ASSEMBLY, REMOVAL AND INSTALLATION**.

   NOTE: **If the springs are to be reused, identify their positions so that they can be reassembled into their original locations.**

2. Remove the valve spring(s). Refer to **SPRING(S), VALVE, REMOVAL AND INSTALLATION**.



1 - Valve Stem Tip
2 - Lock Grooves
3 - Valves
4 - Valve Face
5 - Valve Face Angle

CAUTION: **Before removing the valves, remove any burrs from the valve stem retainer lock grooves (2) and stem tip (1) to prevent damage to the valve guides.**

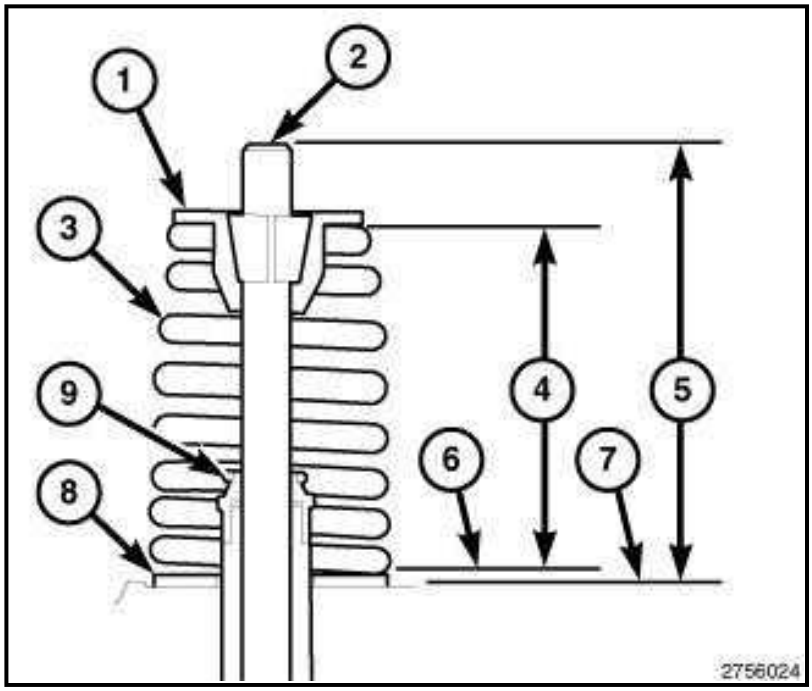
3. Remove the valve(s). Identify each valve to ensure installation in the original location.
4. If required, remove the valve guide seal and spring seat. Refer to **SEAL(S), VALVE GUIDE, REMOVAL AND INSTALLATION**.

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.

- Coat the valve stems with clean engine oil and install the valves into the cylinder head. If the valve springs are being reused, reassemble them into their original locations.

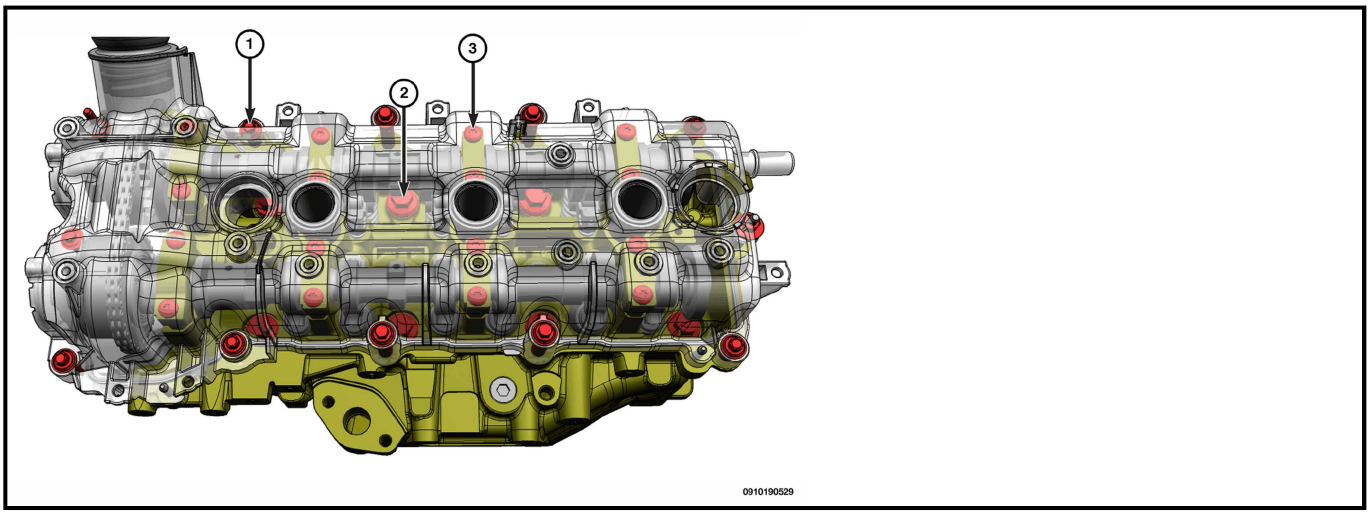


1 - Valve Spring Retainer	6 - Top of Valve Spring Seat
2 - Valve Stem	7 - Cylinder Head Counter Bore Surface
3 - Valve Spring	8 - Valve Spring Seat
4 - Valve Spring Height Measurement	9 - Valve Guide
5 - Valve Tip Height	B

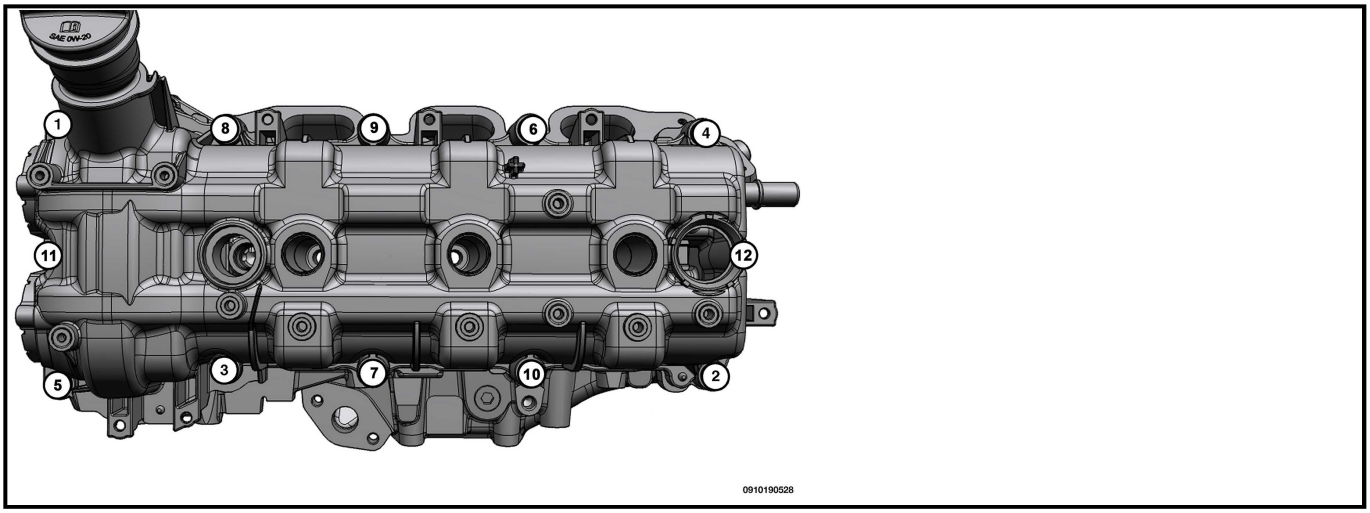
- If the valves or valve seats have been refinished, check the installed height of the valve springs. If the installed valve spring height is greater than 40.0 mm (1.575 in.), install an additional spring seat in the head counter bore under the original valve spring seat to bring the spring height back within specification. Make sure the measurement is taken from the top of spring seat to the bottom surface of spring retainer.
- If the valves or valve seats have been refinished, check the valve tip height. If the valve tip height exceeds the specification, grind the valve tip until it is within specification. Refer to **ENGINE SPECIFICATIONS** . Make sure the measurement is taken from the cylinder head surface to the top of the valve stem.

TORQUE SPECIFICATIONS

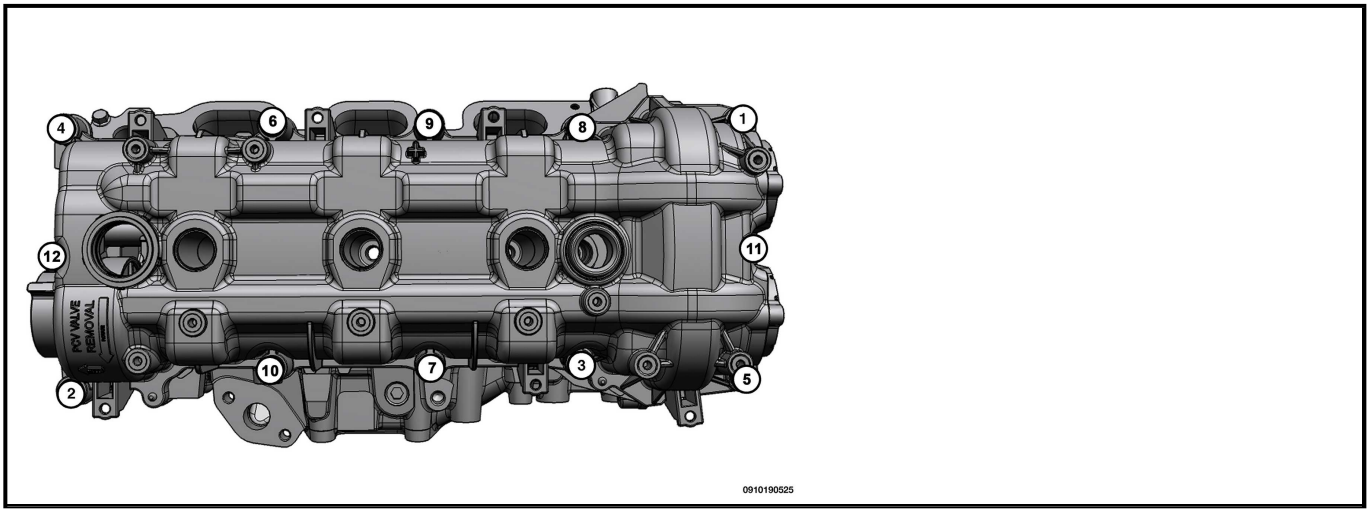
CYLINDER HEAD

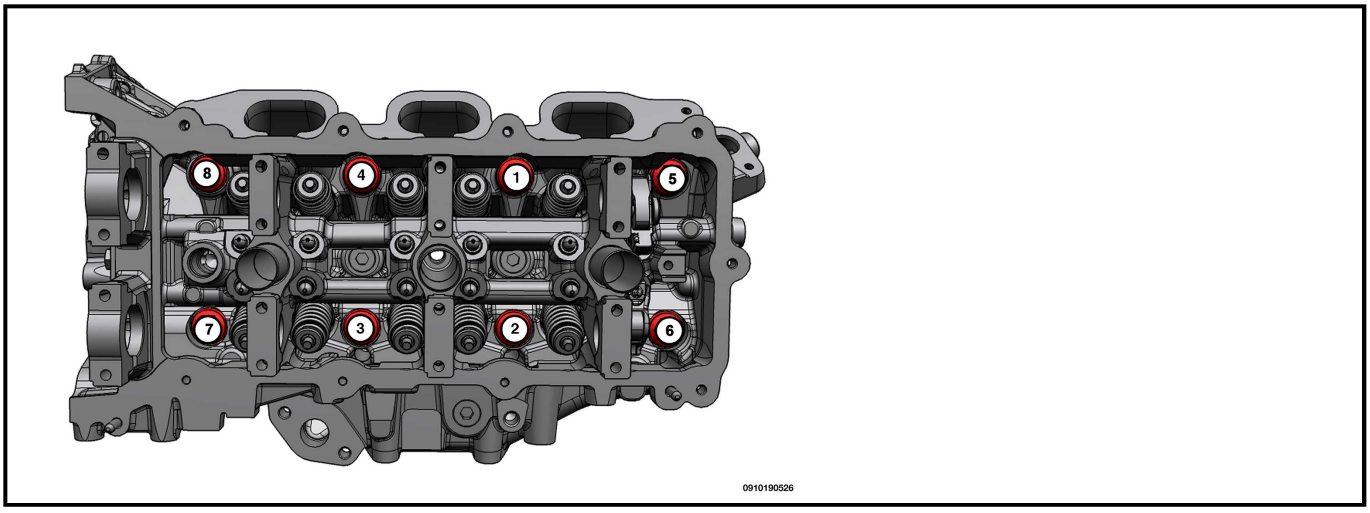


CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Cylinder Head Cover M6 Bolts	**12 N.m (9 Ft. Lbs.)**	Tightening Sequence - Left
2	Cylinder Head Bolts	**Torque Procedure** For engine builds using a new block follow steps 1-9. For engine re-builds (reuse block) follow step 6-9. 1. 30 N. m (22 ft. lbs.) 2. 45 N. m (33 ft. lbs.) 3. Re-tighten all to 45 N. m (33 ft. lbs.) 4. All + 125B° Turn. Do not use a torque wrench for this step. 5. Loosen all fasteners in reverse of sequence shown 6. All to 30 N. m (22 ft. lbs.) 7. All to 45 N. m (33 ft. lbs.) 8. Re-tighten all to 45 N. m (33 ft. lbs.) 9. All + 130B° Turn. Do not use a torque wrench for this step.	Tightening Sequence - Left
3	Camshaft Bearing Cap Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence - Left
-	Cylinder Head Coolant Pipe Plug	**35 N.m (26 Ft. Lbs.)**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
-	Cylinder Head Oil Galley Plug	**18 N.m (13 Ft. Lbs.)**	-
-	Cylinder Head Oil Restrictor M8 Plug	**15 N.m (11 Ft. Lbs.)**	-
-	Ground Strap Bolt to Right Cylinder Head	**23 N.m (17 Ft. Lbs.)**	-
-	Heater Core Supply Tube to Cylinder Head M8 Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Wire Harness Retainer Bracket to LH Cylinder Head Bolts	**10 N.m (89 In. Lbs.)**	-

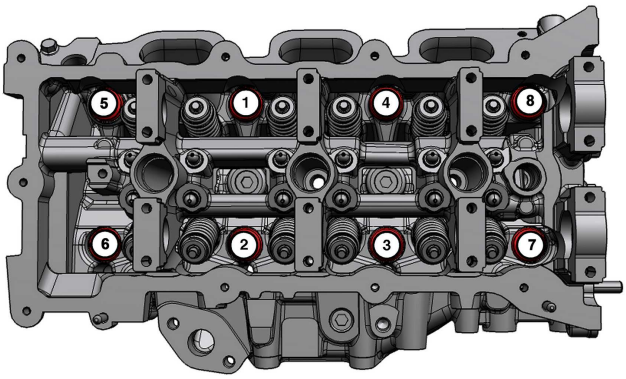


Tightening Sequence - Right





Tightening Sequence - Right



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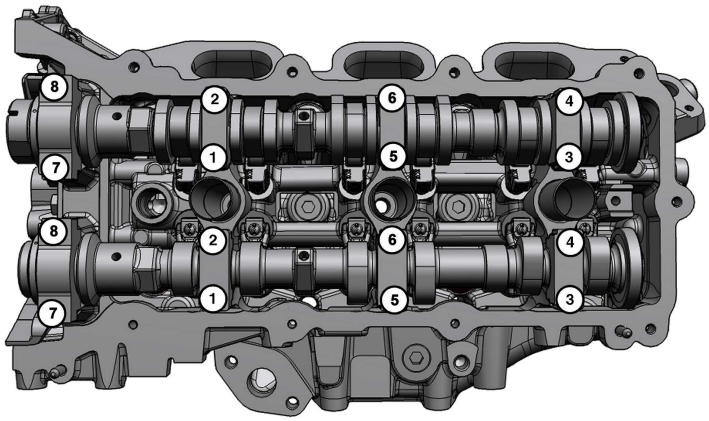

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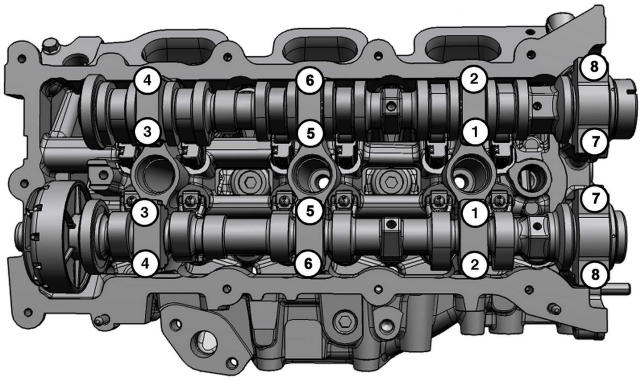
Tightening Sequence - Right



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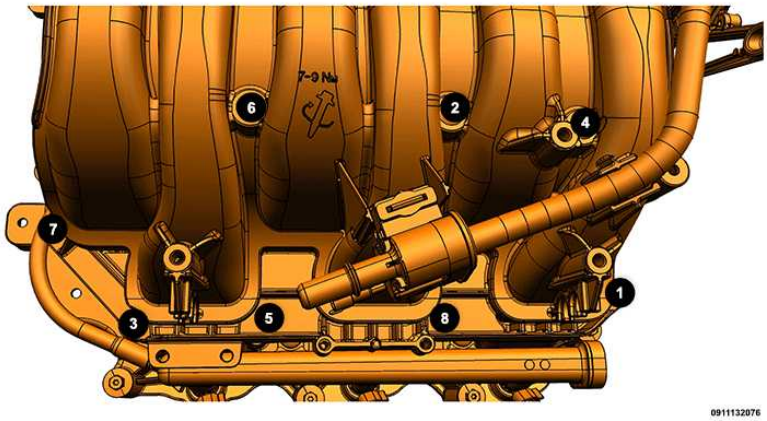
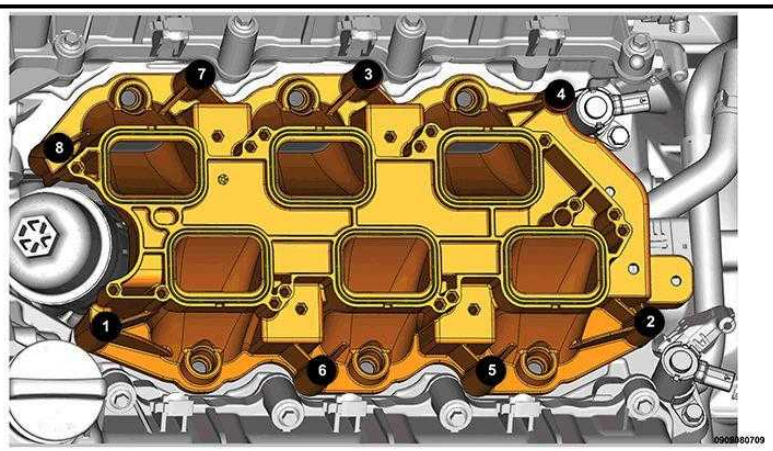
AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-

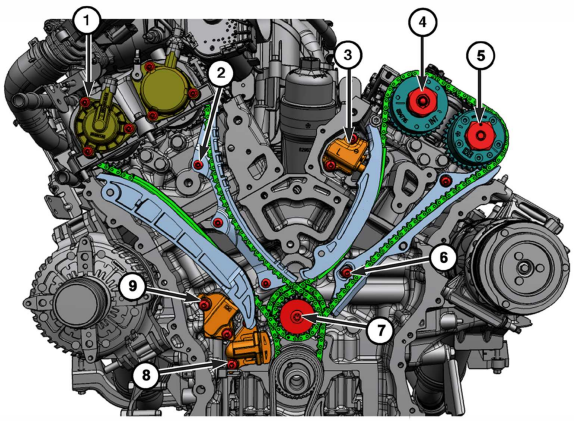
DESCRIPTION	SPECIFICATION	COMMENTS
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-





VALVE TIMING



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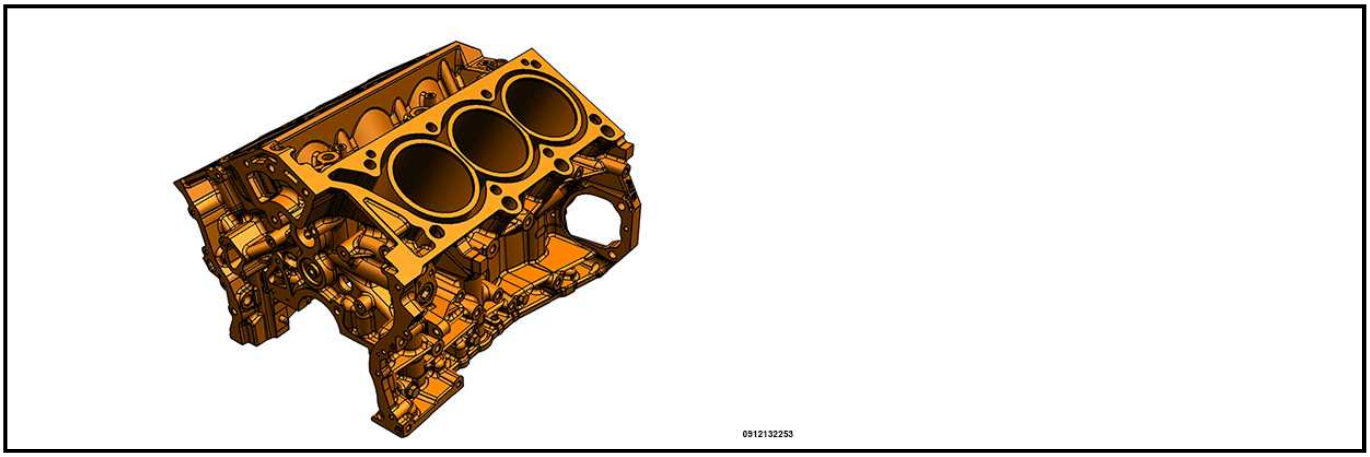
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

ENGINE BLOCK

DESCRIPTION AND OPERATION

ENGINE BLOCK



The cylinder block is a 60 degree high-pressure die cast aluminum design with cast iron cylinder liners.

- The leading side of the block is on the right side and houses cylinders 1, 3 and 5.
- The cylinder block is an open deck design with cut slots between each cylinder.
- Two knock sensors are located in the block valley.
- The cylinder block has three sets of piston cooling jets which are attached to the main oil gallery.
- The four powdered metal main bearing caps are a cross-bolted design and have directional arrows molded into the caps.
- The number 2 main bearing is the location for the two piece upper half thrust bearings.
- The thrust bearings are installed with the oil groves facing outward.
- The main bearing caps are a six bolt design and cross-bolted for improved lower end strength.
- There are three oil drain back drillings located on each of the cylinder banks.

STANDARD PROCEDURE

CYLINDER BORE DEGLAZING

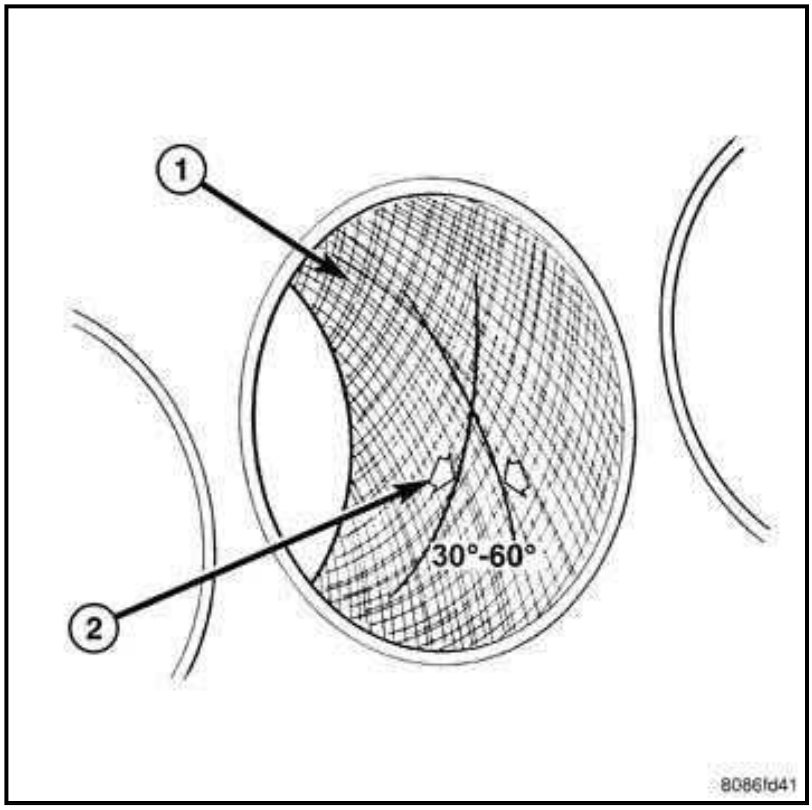
Before deglazing, mask the crankcase area to keep abrasive materials from entering the engine lower end. Tape off any openings to prevent abrasive material from entering the coolant and oil circuits.

CAUTION: DO NOT use rigid type hones to remove cylinder wall glaze.

1. Select an appropriate size flexible ball hone.

   CAUTION: DO NOT use engine or transmission oil, mineral spirits, or kerosene.

2. Deglazing of the cylinder walls may be done if the cylinder bore is straight and round. About 20-60 strokes, depending on the condition of the cylinder bore, will be sufficient to provide a satisfactory surface. Use a light **honing** oil, available from major oil distributors.



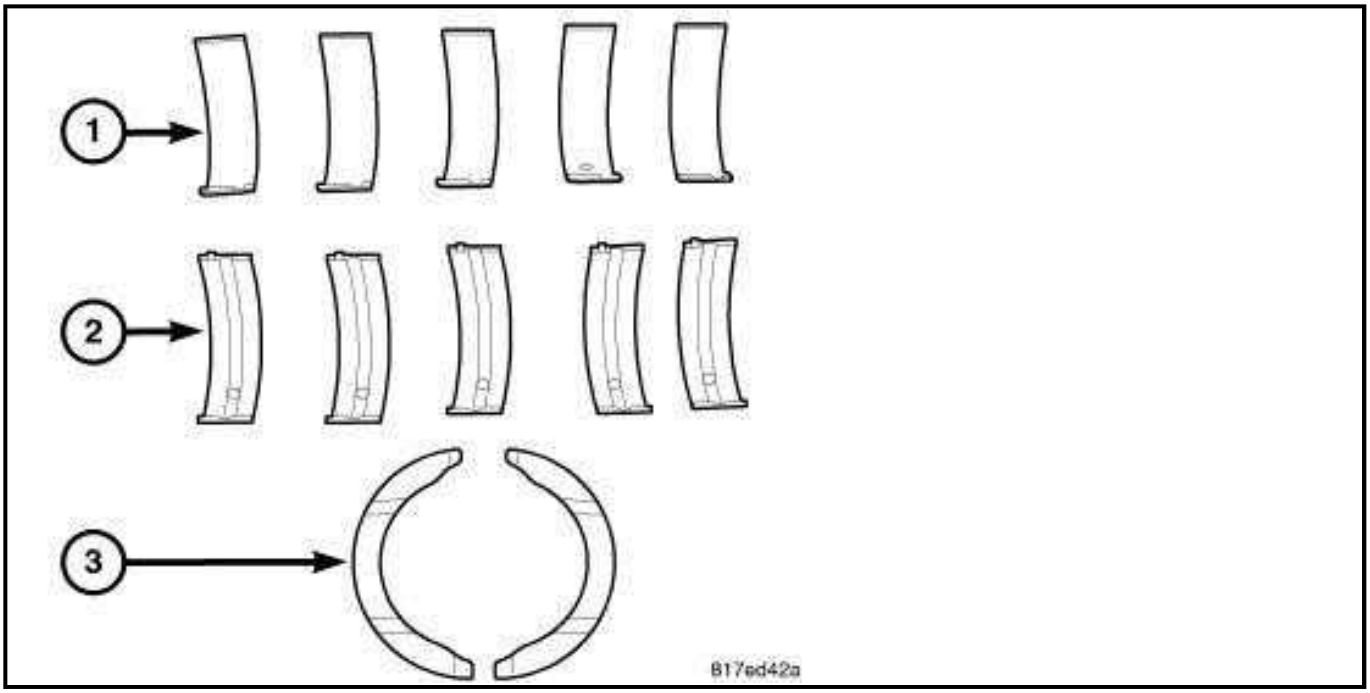
1 - Crosshatch Angle
2 - 30B° to 60B° Inclusive Angle

3. Deglazing should be done by moving the hone up and down fast enough to get a crosshatch pattern. The hone marks should intersect at 30B° to 60B° inclusive angle for proper seating of rings.
4. A controlled hone motor speed between 200 and 300 RPM is necessary to obtain the proper crosshatch angle. The number of up and down strokes per minute can be regulated to get the desired 30B° to 60B° inclusive angle. Faster up and down strokes increase the crosshatch angle.
5. After deglazing, it is necessary that the block be cleaned to remove all traces of abrasive. Use a brush to wash parts with a solution of hot water and detergent. Dry parts thoroughly. Use a clean, white, lint-free cloth to check that the bore is clean. Oil the bores after cleaning to prevent rusting. Upon completion, perform a visual inspection of the cylinder block passages to inspect for abrasive debris. If any debris is found, repeat the cleaning process.

NOTE: **Cylinder bore diameter should not increase more than 20 microns during deglazing process from original nominal bore diameter, if the maximum of 20 microns is exceeded, the cylinder block must be replaced. If deglazing the cylinder bore cannot remove the light scratches and scuffs the cylinder block should be replaced.**

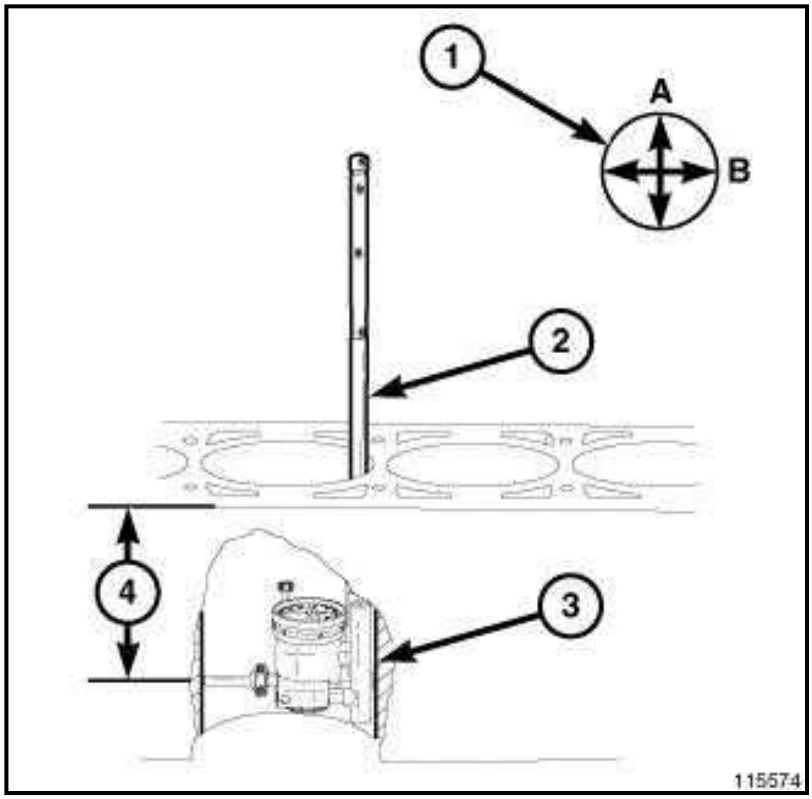
INSPECTION

ENGINE BLOCK



1 - Main Bearing
2 - Main Bearing
3 - Thrust Bearing

1. Wipe the bearing inserts clean and inspect for the following:
    - Inspect the inserts for abnormal wear patterns, scoring, grooving, fatigue, pitting and for metal or other foreign material imbedded in the lining.
    - Inspect the back of the inserts for fractures, scrapes, or irregular wear patterns.
    - Inspect the insert locking tabs for damage.
    - Inspect the crankshaft thrust bearings for scoring, scratches, wear or blueing.
2. Replace any bearing that shows abnormal wear. Refer to **BEARING(S), CRANKSHAFT, MAIN, STANDARD PROCEDURE**.
3. Inspect the main bearing bores for signs of scoring, nicks and burrs.
4. If the cylinder block main bearing bores show damage, the engine block must be replaced.



1 - Cylinder Indicator
2 - Bore Gauge
3 - Cylinder Bore
4 - Top Of Cylinder Bore

5. Use a cylinder bore gauge to correctly measure the inside diameter of the cylinder bore. A cylinder bore gauge capable of reading in 0.003 mm (0.0001 in.) INCREMENTS is required. If a bore gauge is not available, do not use an inside micrometer.
6. Measure the inside diameter of the cylinder bore at three levels below the top of the bore. Start at the top of the bore, perpendicular (across or at 90 degrees) to the axis of the crankshaft at point A.
7. Repeat the measurement near the middle of the bore, then repeat the measurement near the bottom of the bore.
8. Determine taper by subtracting the smaller diameter from the larger diameter.
9. Rotate the Cylinder Indicator 90B° to point B and repeat the three measurements. Verify that the maximum taper is within. Refer to **ENGINE SPECIFICATIONS** .
10. Determine out-of-roundness by comparing the difference between A and B at each of the three levels. Verify that the maximum out of round is within. Refer to **ENGINE SPECIFICATIONS** .

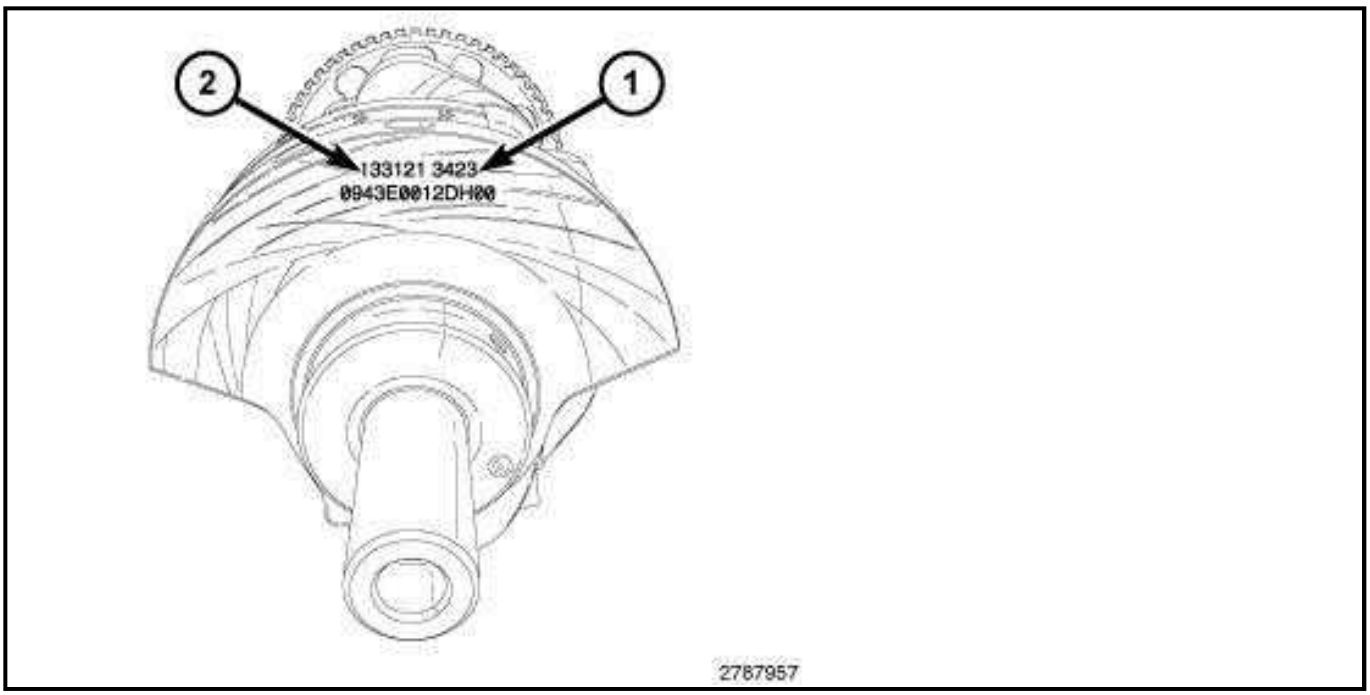
NOTE: **A slight amount of taper always exists in the cylinder bore after the engine has been in use for a period of time.**

11. If cylinder bore taper and out-of-roundness are within specification, the cylinder bore can be honed. Refer to **STANDARD PROCEDURE** . If the cylinder bore taper or out-of-round condition exceeds the maximum limits, the cylinder block must be replaced.

BEARING(S), CONNECTING ROD

STANDARD PROCEDURE

CONNECTING ROD BEARING FITTING



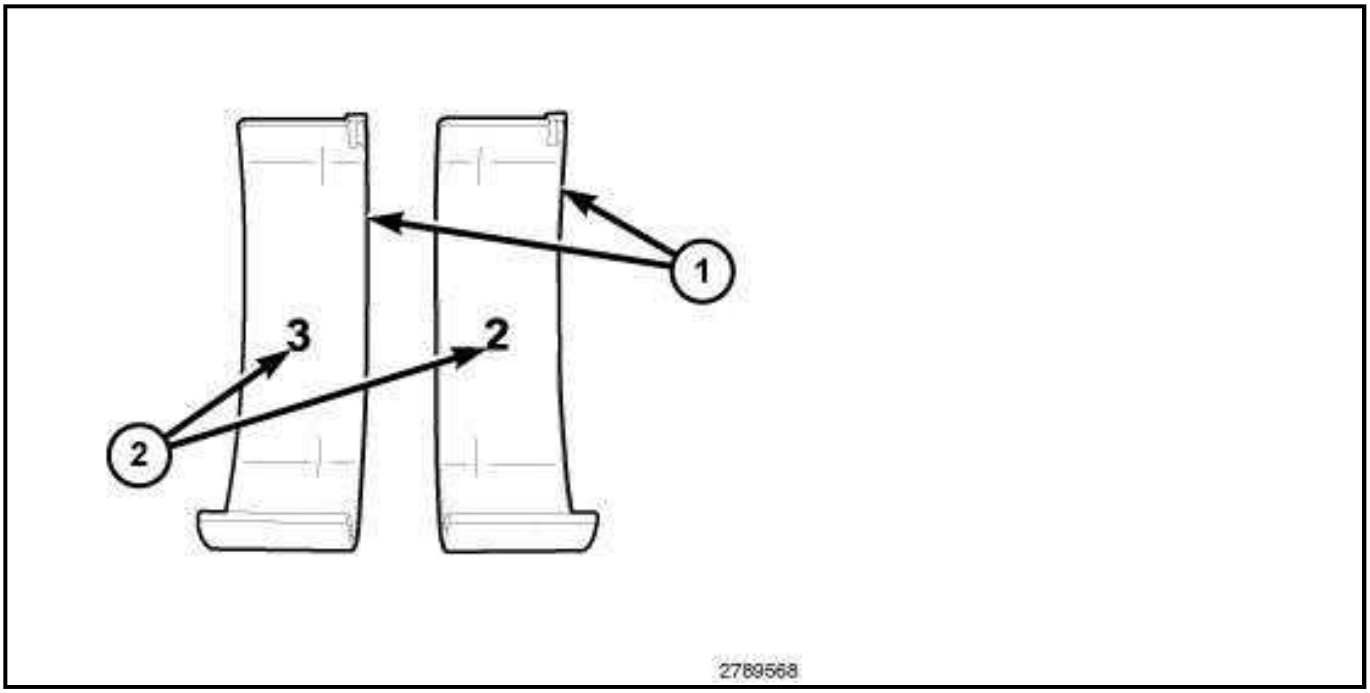
1 - Main Bearing Sizes
2 - Rod Bearing Sizes

The connecting rod bearings are "select fit" to achieve proper oil clearance. Connecting rod bearing journal diameter grade markings are stamped into the front crankshaft counterweight. These marks are read from left to right, corresponding with journal number 1, 2, 3, 4, 5, 6. Select the bearing size that corresponds to the crankshaft markings for each rod bearing journal.

NOTE: **There are a string of ten (10) digits on the front of the counterweight. The FIRST 6 correspond to the Rod Bearing Sizes. The LAST 4 correspond to the Main Bearing Sizes.**

Connecting rod bearing journal diameter grade markings correspond to specific journal diameters. The chart below identifies the three crankshaft grade markings and their associated journal diameters.

Crankshaft Marking	Journal Size mm (in.)
1	53.9910 - 53.9969 mm (2.1256 - 2.1258 in.)
2	53.9970 - 54.0029 mm (2.1259 - 2.1261 in.)
3	54.0030 - 54.0090 mm (2.1261 - 2.1263 in.)



1 - Connecting Rod Bearings
2 - Bearing Size

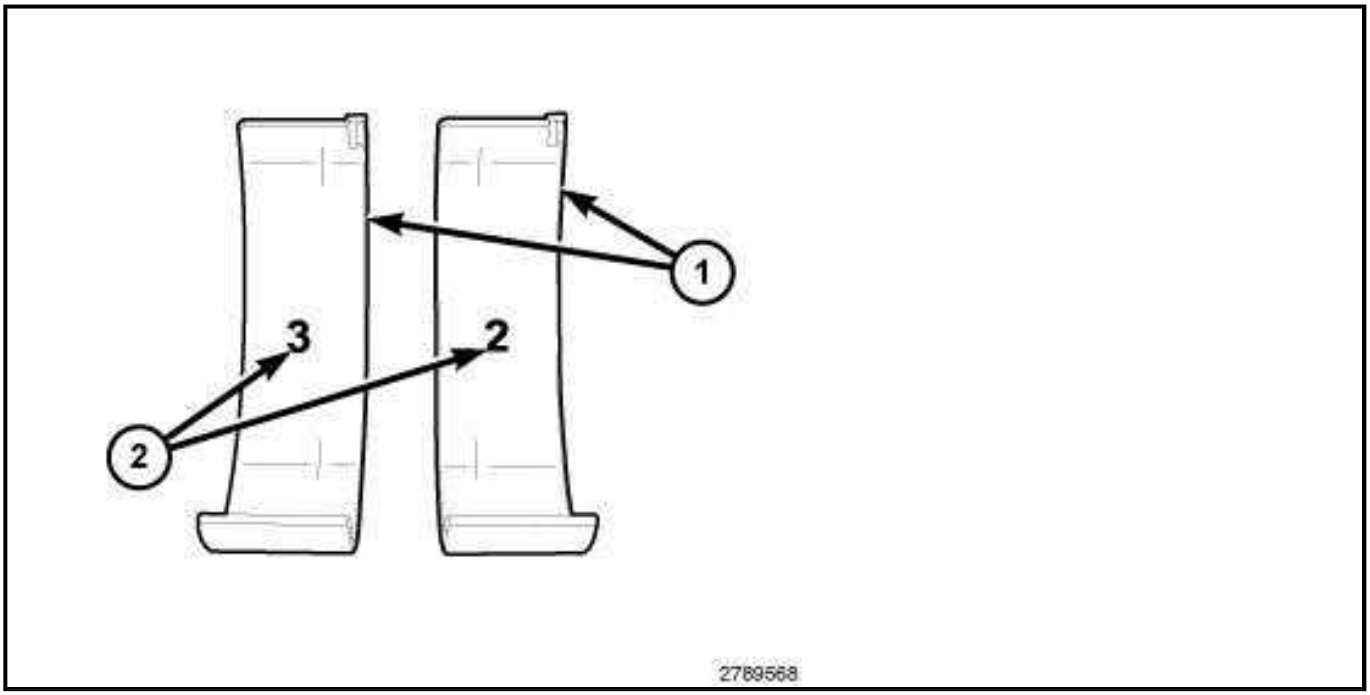
NOTE: **Install the rod bearings in pairs. Do not mix sizes or use a new bearing half with an old bearing half.**

The connecting rod bearing shells are marked with the bearing size on the bearing lining surface. The bearings are available in three different sizes in order to achieve the desired oil clearance.

Rod bearing shells are available in three sizes. The chart below identifies the three bearing sizes.

Bearing Marking	Size mm (in.)
1	1.583 - 1.580 mm (0.0623 - 0.0622 in.)
2	1.580 - 1.577 mm (0.0622 - 0.0620 in.)
3	1.577 - 1.574 mm (0.0621 - 0.0619 in.)

CONNECTING ROD BEARING



1 - Connecting Rod Bearings
2 - Bearing Size

The connecting rod bearings can be serviced in-vehicle. They must be replaced one-at-a-time in order to prevent the pistons from contacting the valves. The connecting rod bearings are "select fit" to achieve proper oil clearances. Refer to **BEARING(S), CONNECTING ROD, STANDARD PROCEDURE**.

1. Remove the spark plugs. Refer to **SPARK PLUG, REMOVAL AND INSTALLATION**.
2. Remove the oil pan, oil pump pick-up and engine oil pump. Refer to **PUMP, ENGINE OIL, REMOVAL AND INSTALLATION**.

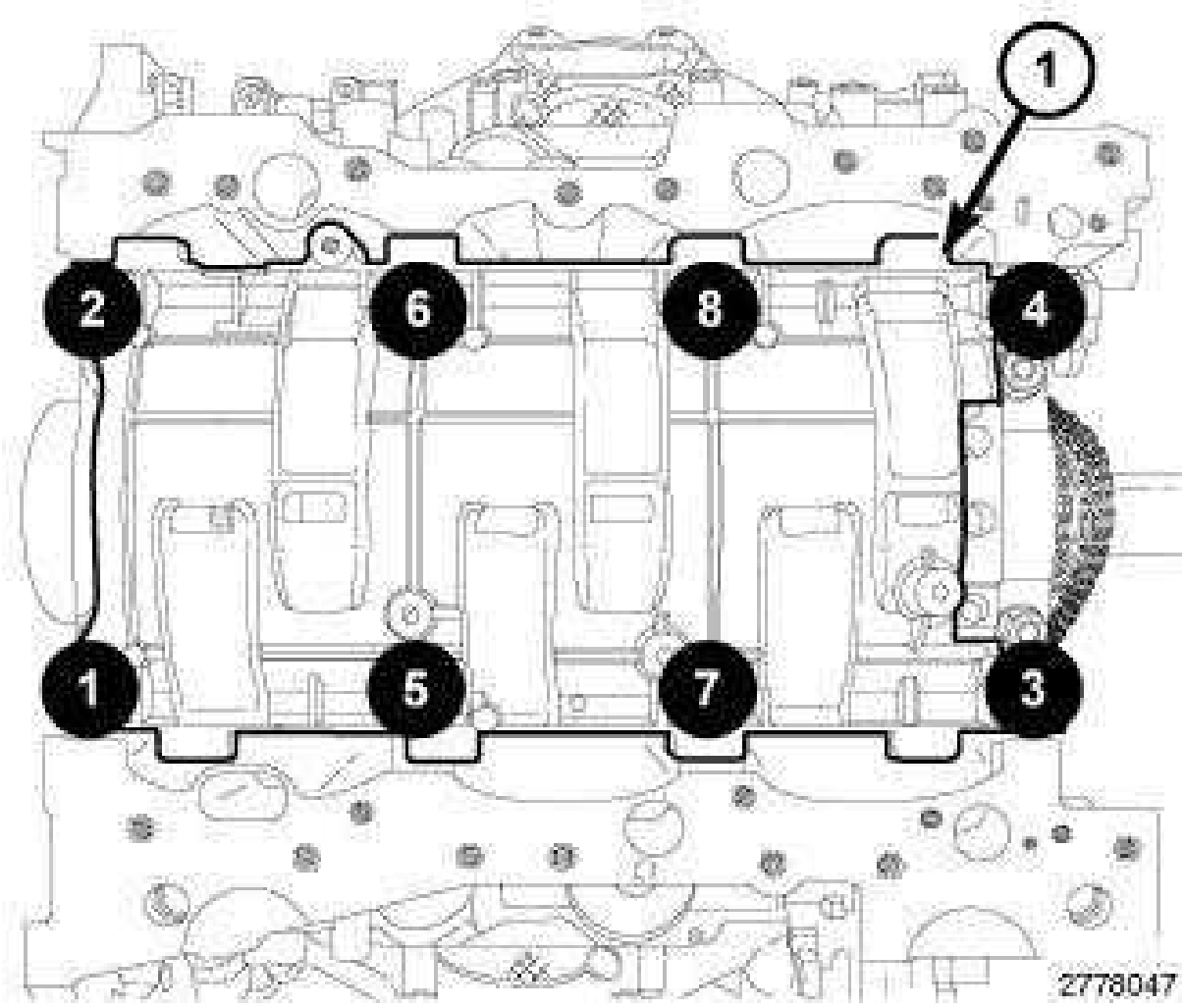
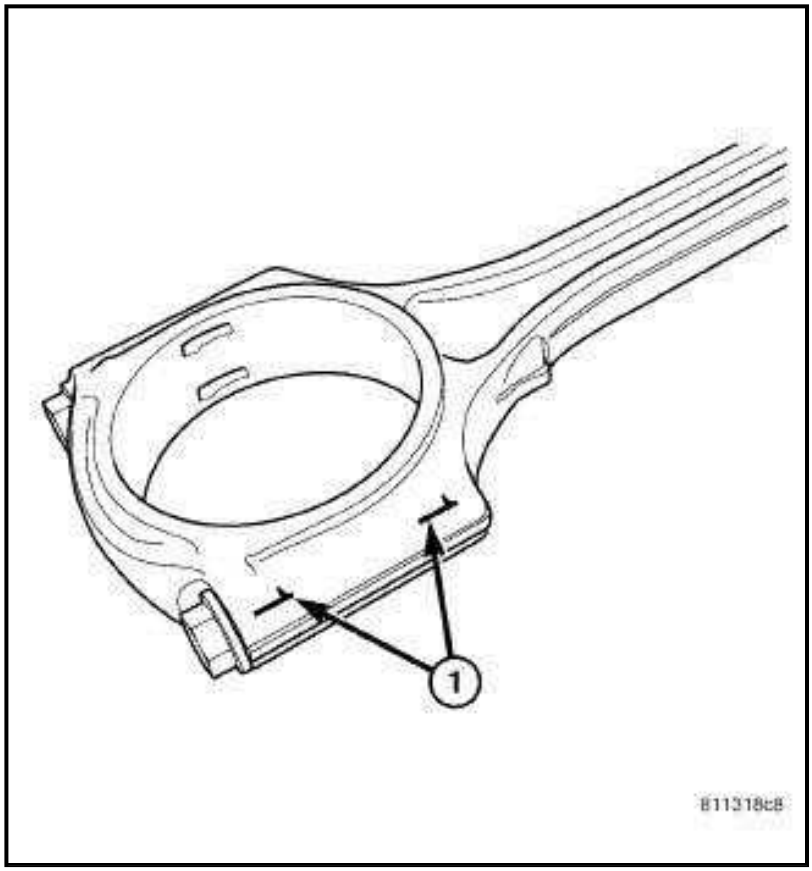


Fig. 12: Main Bearing Cap Bolts From Windage Tray Removal Sequence
Courtesy of CHRYSLER GROUP, LLC

1 - Windage Tray

3. Remove the eight main bearing cap bolts from the windage tray in the sequence shown and remove the windage tray.

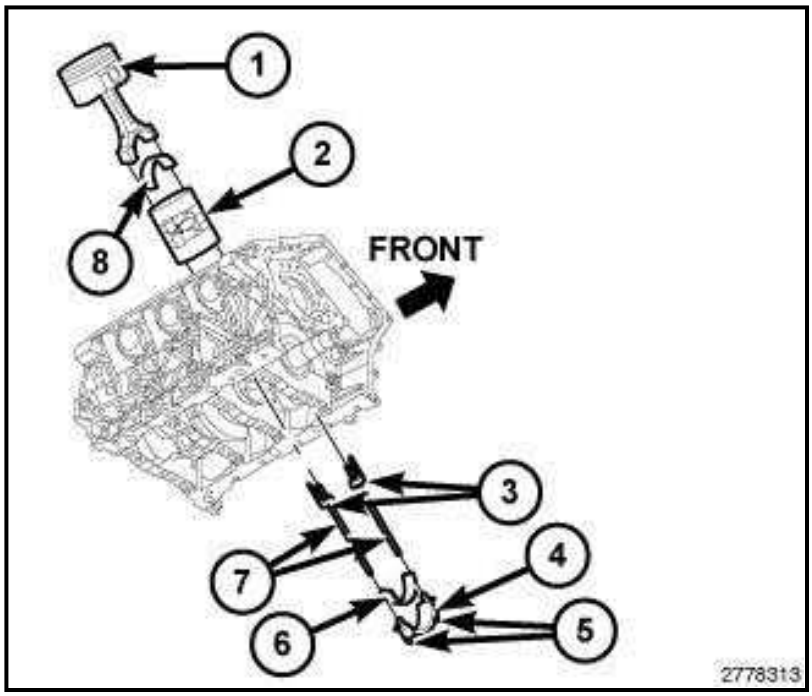


1 - Connecting Rod and Cap Marking Location

CAUTION: **DO NOT use a number stamp or a punch to mark connecting rods or caps, as damage to connecting rods could occur.**

NOTE: **Connecting rods and bearing caps are not interchangeable and should be marked before removing to ensure correct reassembly.**

4. Mark connecting rod and bearing cap positions using a permanent ink marker or scribe tool.



1 - Piston and Connecting Rod	5 - Connecting Rod Cap Bolts
2 - Piston Installer Tool	6 - Lower Connecting Rod Bearing

3 - Plastic Guide Plates	7 - Guide Pins
4 - Connecting Rod Cap	8 - Upper Connecting Rod Bearing

CAUTION: **Replace only one connecting rod bearing at a time while all other connecting rod bearing caps remain properly tightened. If all connecting rod bearing caps are removed, crankshaft rotation will result in valve or piston damage.**

CAUTION: **Care must be taken not to damage the fractured rod and cap joint face surfaces, as engine damage may occur.**

5. Remove the connecting rod cap bolts and the connecting rod cap. Discard the cap bolts.
6. Remove the plastic guide plates from the Guide Pins (special tool #8189, Guide Pins) and install the Guide Pins to the connecting rod being removed.

CAUTION: **Care must be taken not to nick crankshaft journals, as engine damage may occur.**

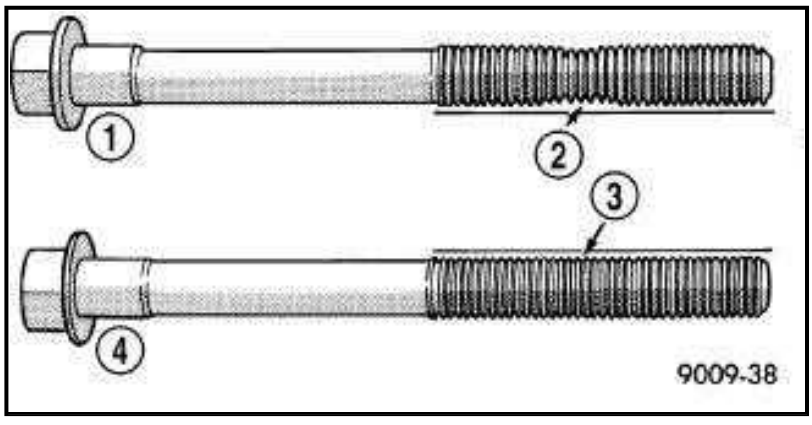
7. Rotate the crankshaft away from the connecting rod and remove the bearing shell.
8. Inspect the rods and bearings for abnormal wear patterns, scoring, grooving, fatigue, pitting and for metal or other foreign material imbedded in the lining. Refer to **ENGINE BLOCK, INSPECTION**.
9. If required, check the connecting rod bearing clearances by the use of Plastigage or equivalent. Refer to **STANDARD PROCEDURE** .
10. If required, select and fit new bearings to the connecting rod. Refer to **BEARING(S), CONNECTING ROD, STANDARD PROCEDURE**.
11. Install the bearing shell on the connecting rod with the tang inserted into the machined groove in the rod. Lubricate the bearing surface with clean engine oil.
12. Rotate the crankshaft while guiding the connecting rod into position over the rod journal.

CAUTION: **The connecting rod bolts must not be reused. Always replace the connecting rod bolts whenever they are loosened or removed.**

13. Install the bearing shell on the connecting rod cap with the tang inserted into the machined groove in the cap. Lubricate the bearing surface with clean engine oil.

NOTE: **Do not lubricate the threads of the connecting rod cap bolts.**

14. Install the connecting rod cap and bearing with the tang on the same side as the rod. Tighten the **NEW** connecting rod cap bolts to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .
15. If required, check the connecting rod side clearance. Refer to **ROD, PISTON AND CONNECTING, STANDARD PROCEDURE**.
16. Repeat the previous steps for each connecting rod bearing being replaced.



CAUTION: **The main bearing cap bolts are tightened using a torque plus angle procedure. The bolts must be examined BEFORE reuse. If the threads are necked down the bolts must be replaced.**

17. Check the main bearing cap bolts for necking by holding a scale or straight edge against the threads. If all the threads do not contact the scale (2) the bolt must be replaced.

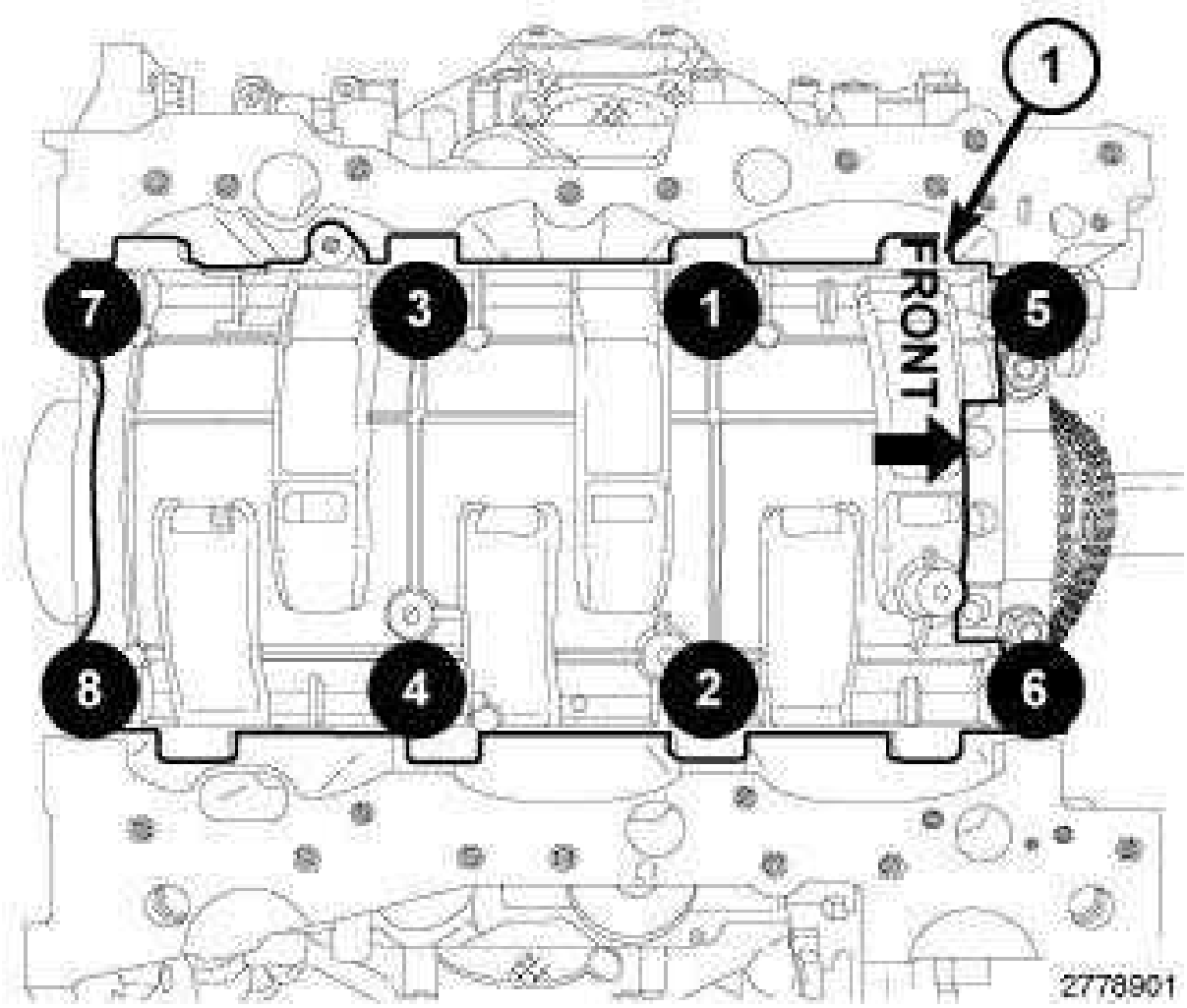


Fig. 13: Main Bearing Cap Bolts Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

1 - Windage Tray

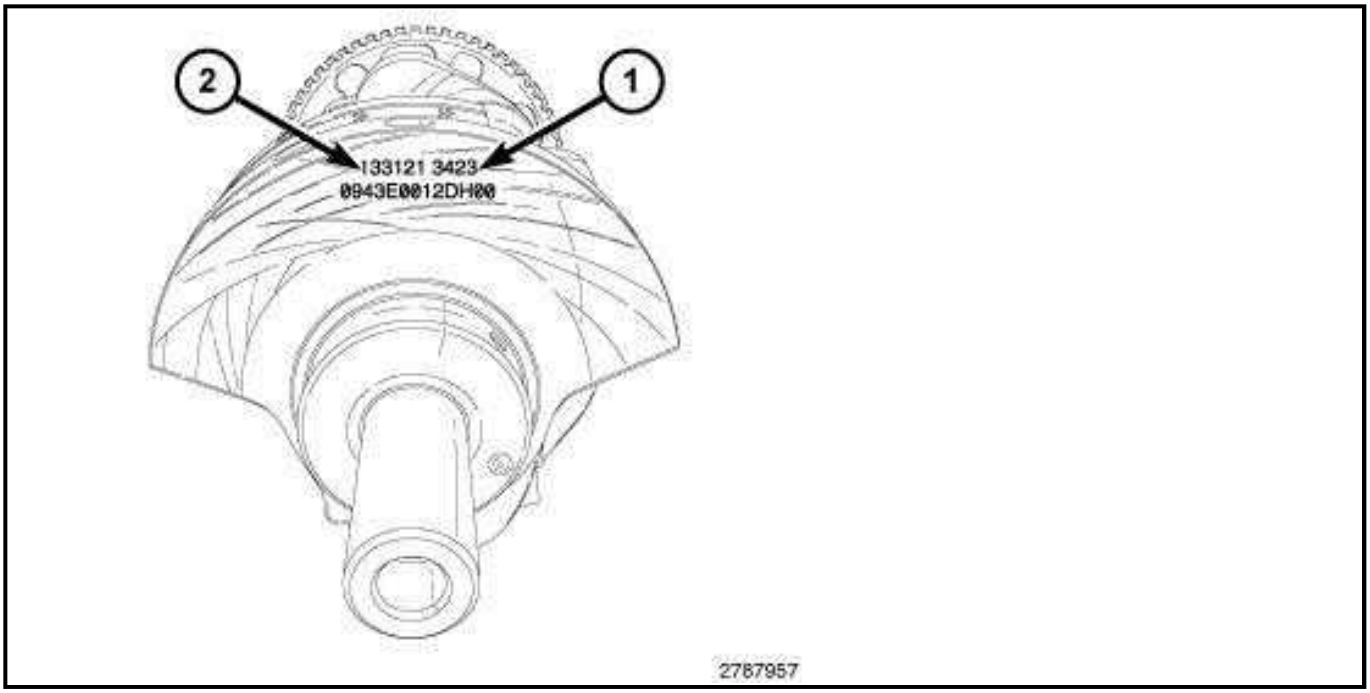
18. Install the windage tray with eight main bearing cap bolts. Tighten the bolts in the sequence shown to 21 N. m (16 ft. lbs.) plus an additional 90B° turn.
19. Install the engine oil pump, oil pump pick-up and oil pan. Refer to **PUMP, ENGINE OIL, REMOVAL AND INSTALLATION**.
20. Install the spark plugs and ignition coils. Refer to **SPARK PLUG, REMOVAL AND INSTALLATION**.
21. If removed, install the oil filter and fill the engine crankcase with the proper oil to the correct level. Refer to **ENGINE OIL AND FILTER CHANGE** .
22. Operate the engine until it reaches normal operating temperature.

BEARING(S), CRANKSHAFT, MAIN

STANDARD PROCEDURE

MAIN BEARING FITTING

NOTE: **Crankshaft thrust washers are not selectable and are only available in a single thickness.**



1 - Main Bearing Sizes
2 - Rod Bearing Sizes

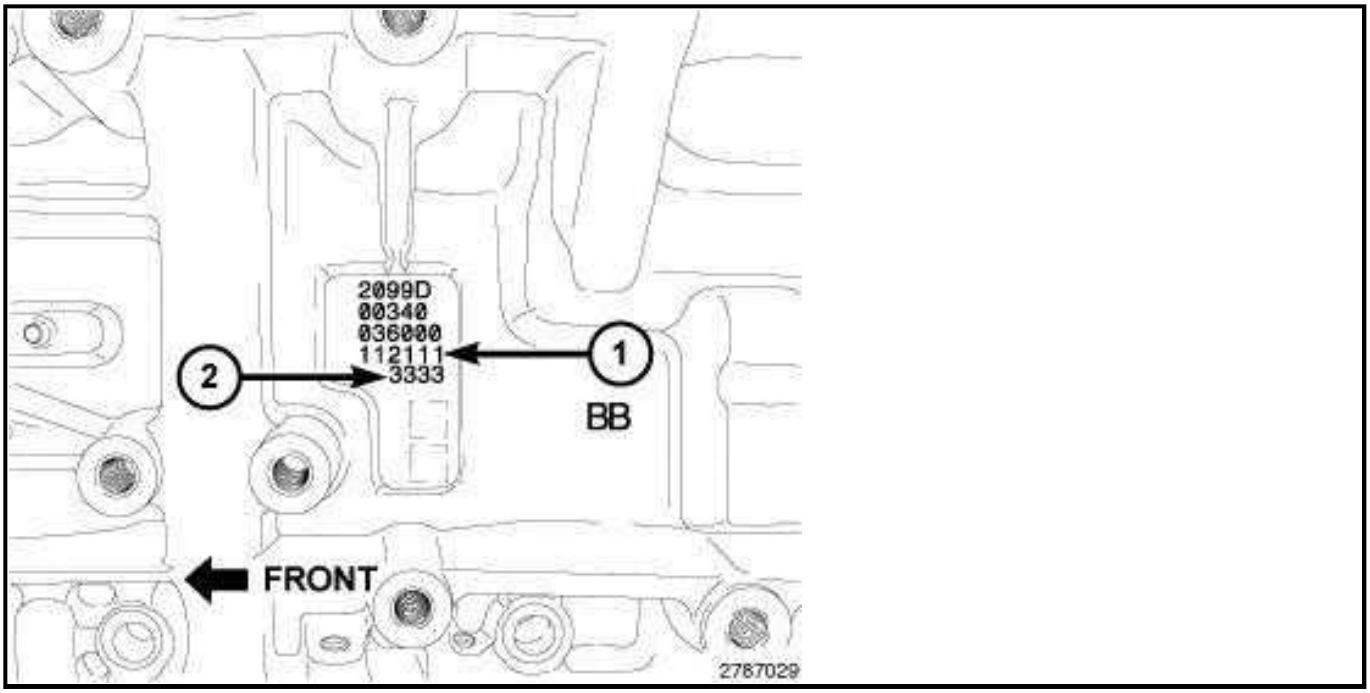
The upper and lower main bearings are "select fit" to achieve proper oil clearances. Crankshaft main bearing journal diameter grade markings are stamped into the front crankshaft counterweight. These marks are read from left to right, corresponding with journal number 1, 2, 3, 4.

NOTE: **There are a string of ten (10) digits on the front of the counterweight. The FIRST 6 correspond to the Rod Bearing Sizes. The LAST 4 correspond to the Main Bearing Sizes.**

NOTE: **There are times were the human readable pin stamp on the #1 counterweight is difficult to read. If necessary there is another way to obtain the bearing classification from the crankshaft. Using a barcode scanner or a 2D reader APP, available for most Smart phones, scan the 2D Matrix located on the #8 crankshaft counterweight. The last ten of the scanned digits are used in the same manner as the grade markings typically on the #1 counterweight.**

Crankshaft main bearing journal diameter grade markings correspond to specific journal diameters. The chart below identifies the five crankshaft grade markings and their associated journal diameters.

Crankshaft Marking	Journal Size mm (in.)
1	67.9870 - 67.9905 mm (2.6766 - 2.6767 in.)
2	67.9906 - 67.9941 mm (2.6768 - 2.6769 in.)
3	67.9942 - 67.9977 mm (2.6769 - 2.6771 in.)
4	67.9978 - 68.0013 mm (2.6771 - 2.6772 in.)
5	68.0014 - 68.0050 mm (2.6772 - 2.6773 in.)



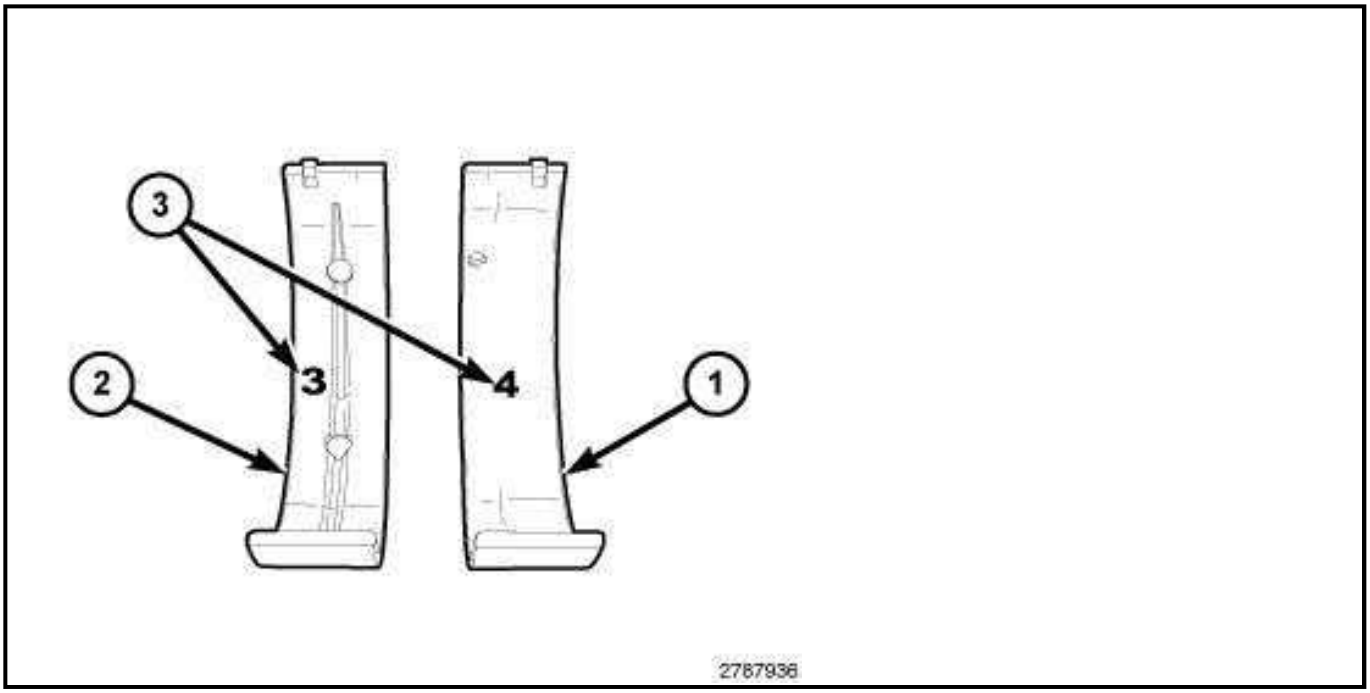
Engine block main bearing journal diameter grade markings (2) are stamped into the left side of the engine block. These marks are read from left to right, corresponding with journal number 1, 2, 3, 4.

Engine block main bearing journal grade markings correspond to specific journal diameters. The chart below identifies the five engine block grade markings and their associated journal diameters.

Engine Block Marking	Journal Size mm (in.)
1	73.0055 - 73.0090 mm (2.8742 - 2.8744 in.)
2	73.0019 - 73.0054 mm (2.8741 - 2.8742 in.)
3	72.9983 - 73.0018 mm (2.8739 - 2.8741 in.)
4	72.9947 - 72.9982 mm (2.8738 - 2.8739 in.)
5	72.9910 - 72.9946 mm (2.8736 - 2.8738 in.)

For upper and lower main bearing selection, obtain the grade identification marks from the crankshaft and engine block. Main bearings are available in five sizes. Upper and lower sizes can be mixed on a journal in order to achieve the desired oil clearance. The chart below identifies the five sizes available and how they should be selected based on crankshaft and engine block grade markings.

Engine Block Marking	Crankshaft Marking				
	1	**2**	**3**	**4**	**5**
1	1/1	1/2	2/2	2/3	3/3
2	1/2	2/2	2/3	3/3	3/4
3	2/2	2/3	3/3	3/4	4/4
4	2/3	3/3	3/4	4/4	4/5
5	3/3	3/4	4/4	4/5	5/5
B	UPPER/LOWER Main Bearings to Achieve 0.024 - 0.050 mm (0.0009 - 0.0020 in.) Oil Clearance				



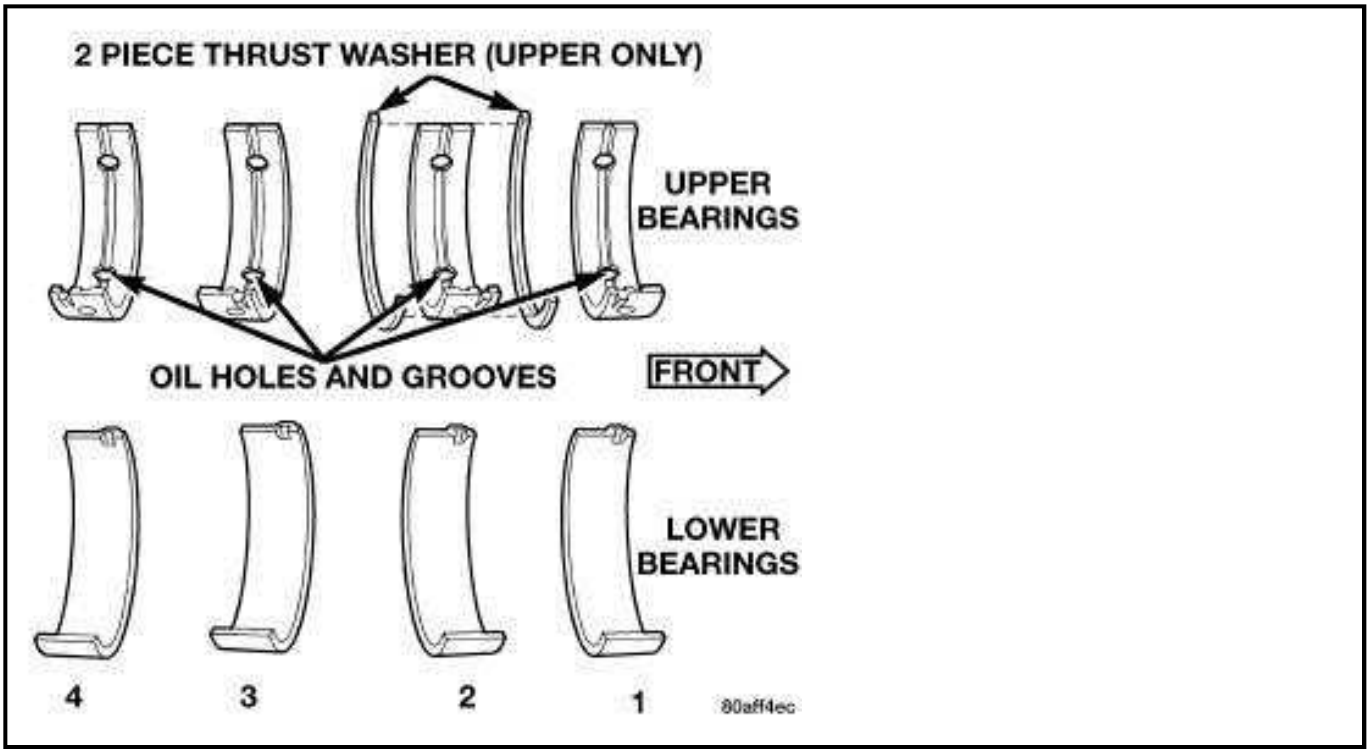
1 - Upper Main Rod Bearing
2 - Lower Main Rod Bearing
3 - Bearing Size

The upper main bearing shell and lower main bearing shell are marked with the bearing size on the bearing lining surface. The upper and lower bearings are available in five different sizes and can be mixed on a journal in order to achieve the proper oil clearance.

Upper and lower main bearing shells are available in five sizes. The chart below identifies the five bearing sizes.

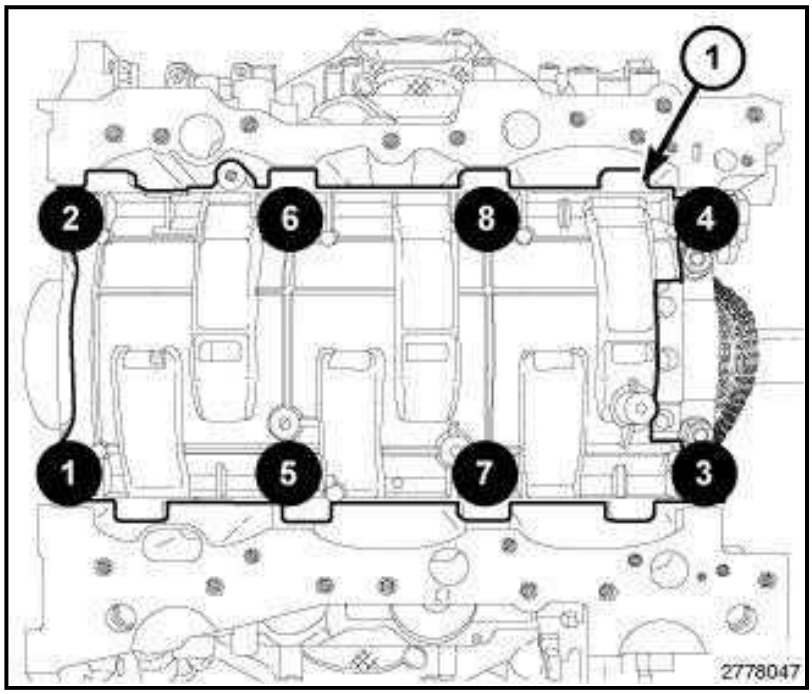
Bearing Marking	Size mm (in.)
1	2.4951 - 2.4987 mm (0.0982 - 0.0984 in.)
2	2.4915 - 2.4951 mm (0.0981 - 0.0984 in.)
3	2.4879 - 2.4915 mm (0.0979 - 0.0981 in.)
4	2.4843 - 2.4879 mm (0.0978 - 0.0979 in.)
5	2.4807 - 2.4843 mm (0.0977 - 0.0978 in.)

MAIN BEARING REPLACEMENT



The main bearings are serviced in-vehicle. They must be replaced one-at-a-time in order to properly support the crankshaft. The upper and lower main bearing shells are NOT interchangeable. The upper and lower main bearings are "select fit" to achieve proper oil clearances. Refer to **BEARING(S), CRANKSHAFT, MAIN, STANDARD PROCEDURE**.

1. Disconnect and isolate the negative battery cable. If equipped with an Intelligent Battery Sensor (IBS), disconnect the IBS connector first before disconnecting the negative battery cable.



2. Remove the oil pan, oil pump pick-up and engine oil pump. Refer to **PUMP, ENGINE OIL, REMOVAL AND INSTALLATION**.
3. Remove the eight main bearing cap bolts from the windage tray in the sequence shown and remove the windage tray (1).

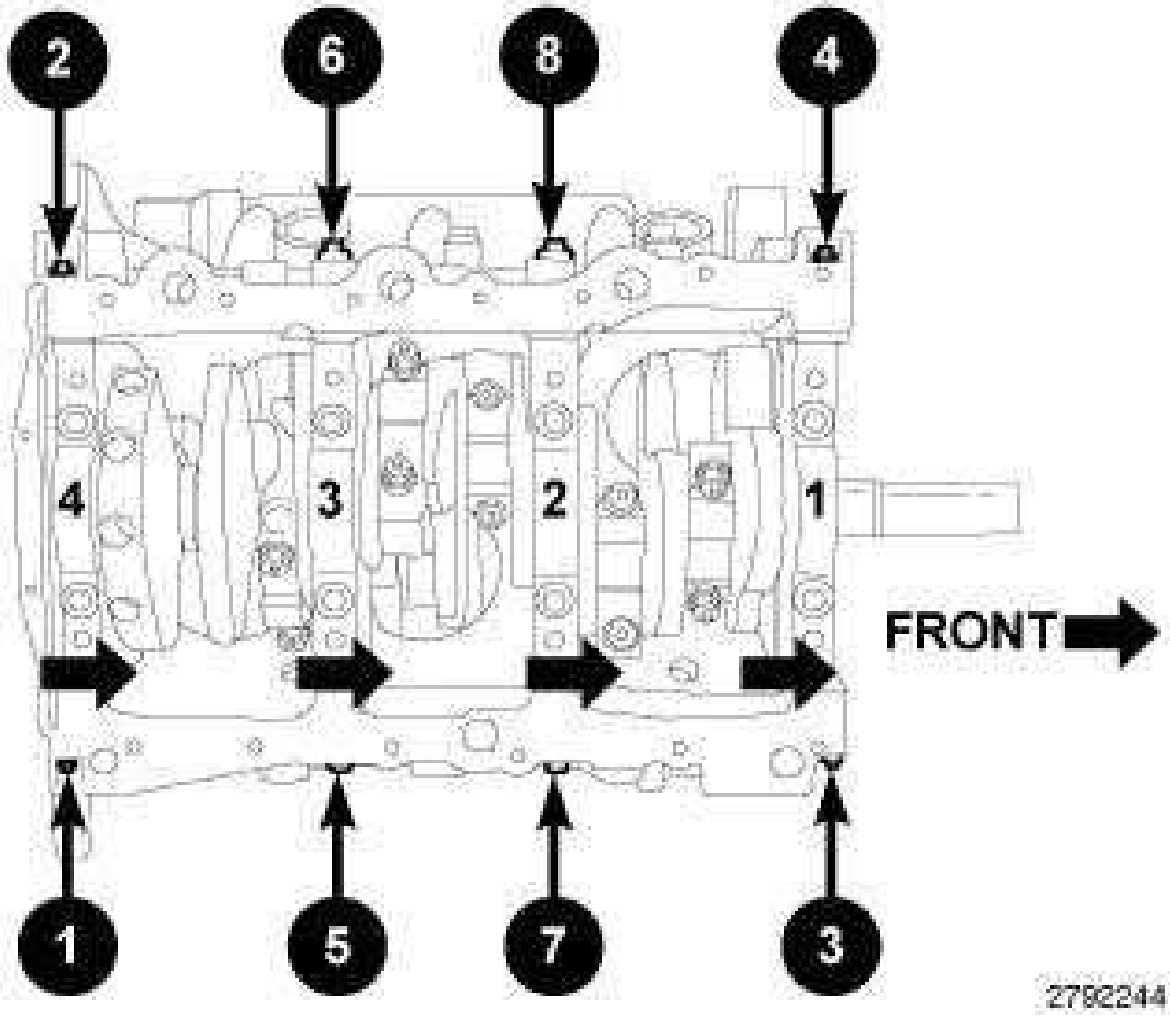


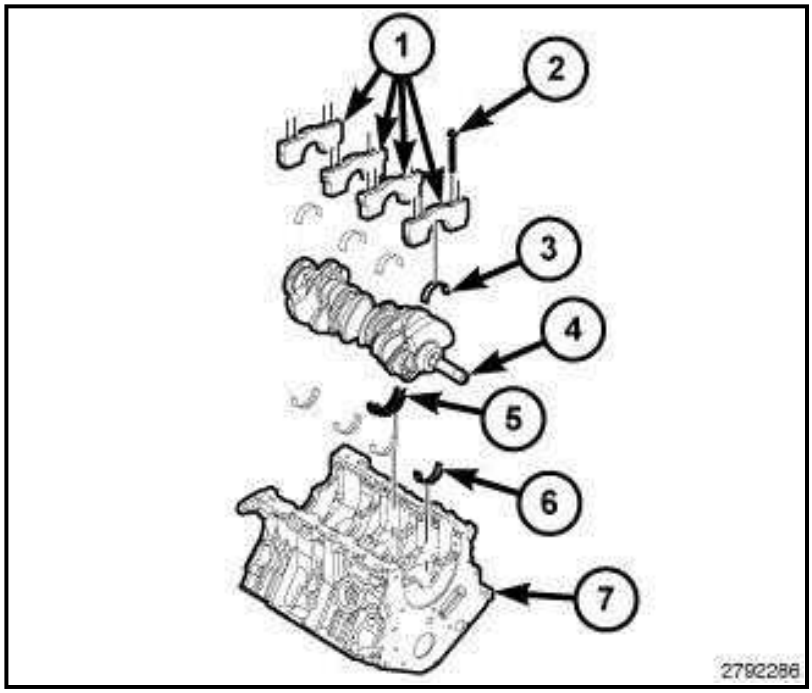
Fig. 14: Main Bearing Tie Bolts Removal Sequence
Courtesy of CHRYSLER GROUP, LLC

4. Remove the eight main bearing tie bolts in the sequence shown.

CAUTION: **DO NOT use a number stamp or a punch to mark main bearing caps, as damage to main bearings could occur.**

NOTE: **Main bearing caps are not interchangeable and are marked to insure correct assembly.**

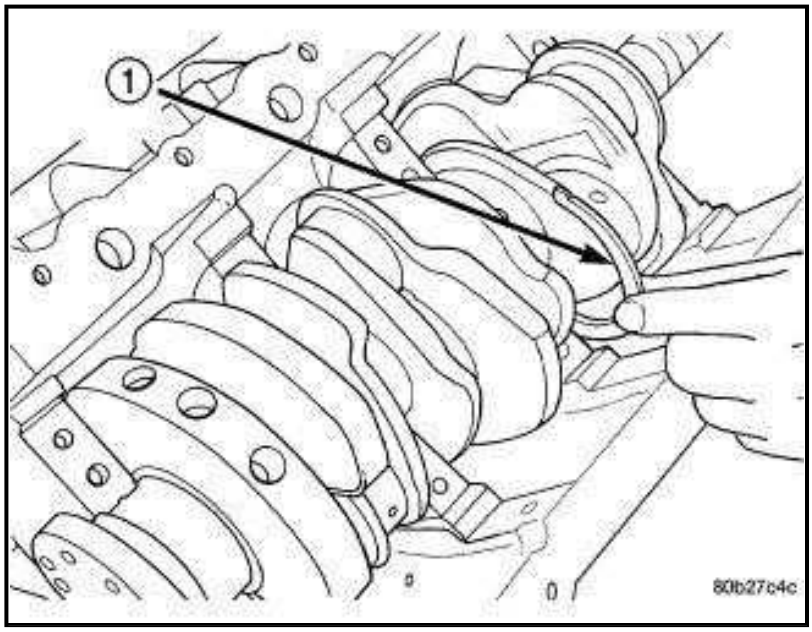
5. Mark the main bearing cap positions using a permanent ink marker or a scribe tool.



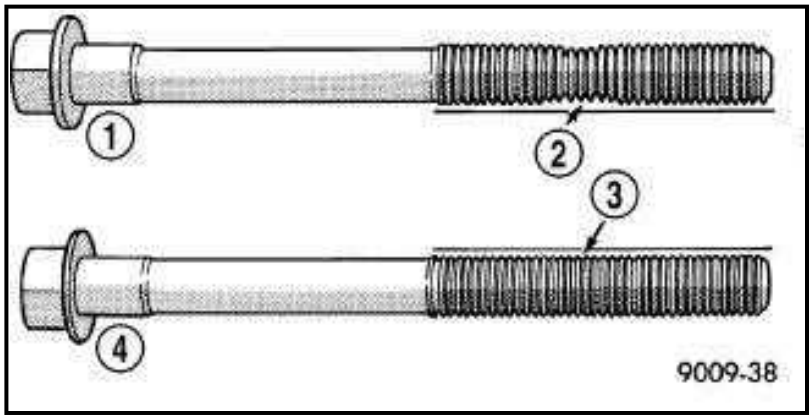
CAUTION: **Replace only one main bearing at a time while all other main bearing caps remain properly tightened. If all main bearing caps are removed, the weight of the unsupported crankshaft will damage the crankshaft oil seals.**

NOTE: **Replace the main bearings in the following order; 2, 3, 1, 4.**

6. Remove the two cap bolts (2) and remove the main bearing cap (1).
7. When removing the No. 2 bearing cap, also remove the thrust washers (5).
8. Slide the upper main bearing half (6) out from between the crankshaft and the engine block.
9. Inspect the crankshaft and bearings for abnormal wear patterns, scoring, grooving, fatigue, pitting and for metal or other foreign material imbedded in the lining. Refer to **ENGINE BLOCK, INSPECTION**.
10. If required, check the crankshaft bearing clearances by the use of Plastigage or equivalent. Refer to **STANDARD PROCEDURE** .
11. If required, select fit new main bearings to the engine block. Refer to **BEARING(S), CRANKSHAFT, MAIN, STANDARD PROCEDURE**.
12. Lubricate the upper main bearing half (6) with clean engine oil and slide the bearing into position.

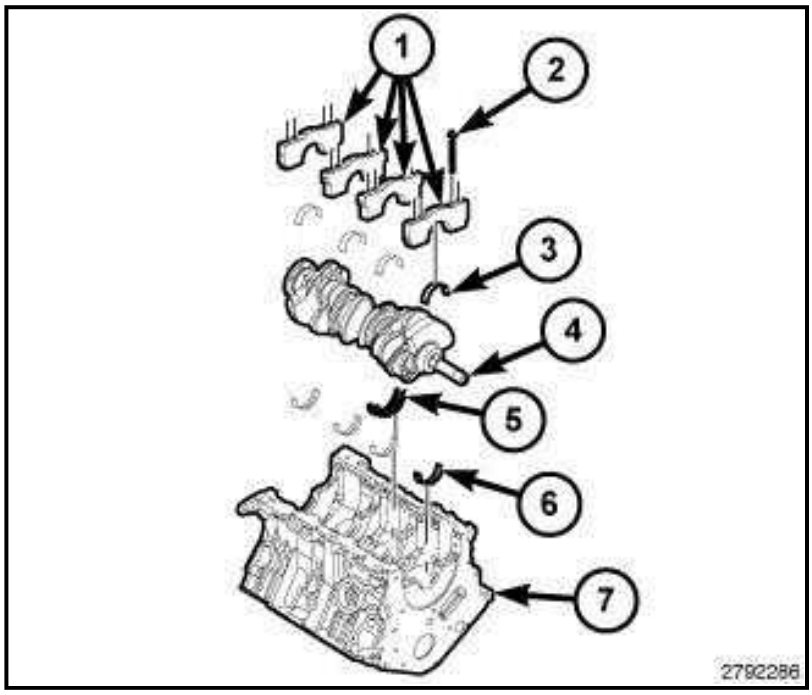


13. When installing the thrust washers (1) at the No. 2 main bearing location, use the following procedure:
    a. Move the crankshaft forward to the limit of travel. Lubricate and install the front thrust washer (1) by rolling the washer onto the machined shelf between the No. 2 upper main bulk head and crankshaft thrust surface.
    b. Move the crankshaft rearward to the limit of travel. Lubricate and install the rear thrust washer by rolling the washer onto the machined shelf between the No. 2 upper main bulk head and crankshaft thrust surface.

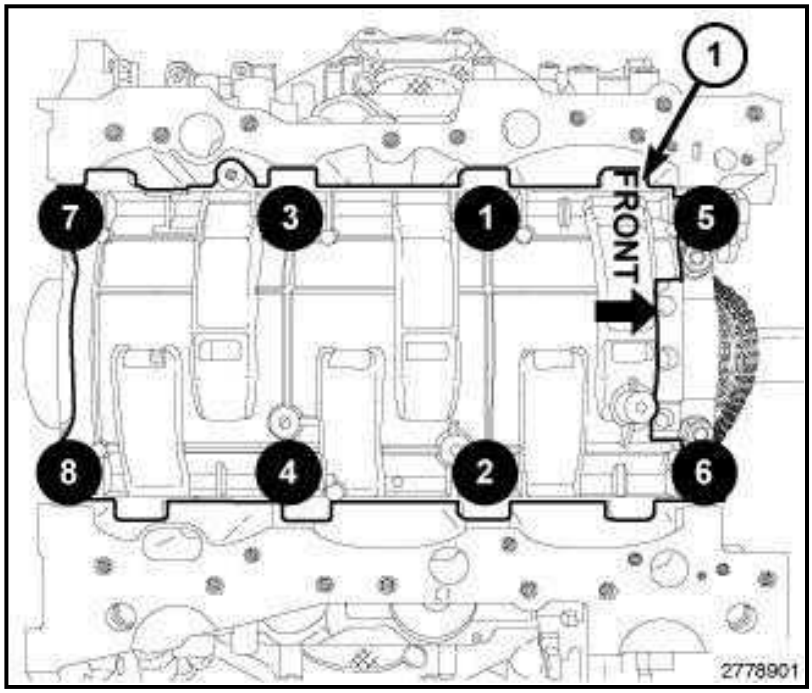


CAUTION: **The main bearing cap bolts are tightened using a torque plus angle procedure. The bolts must be examined BEFORE reuse. If the threads are necked down the bolts must be replaced.**

14. Check the main bearing cap bolts for necking by holding a scale or straight edge against all of the threads. If all of the threads do not contact the scale (2) the bolt must be replaced.



15. Lubricate and install the lower bearing half (3) onto the main cap (1).
16. Install the main bearing cap (1) with two inner main bearing cap bolts (2). Partially thread the bolts prior to fully inserting the bearing caps to ensure correct alignment. Tighten to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .
17. Repeat the previous steps for main bearings 3, 1 and 4.
18. Measure crankshaft end play. Refer to **CRANKSHAFT, STANDARD PROCEDURE**.



19. Position the windage tray on to the engine block.
20. Install the windage tray with eight main bearing cap bolts. Tighten the bolts in the sequence shown to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .

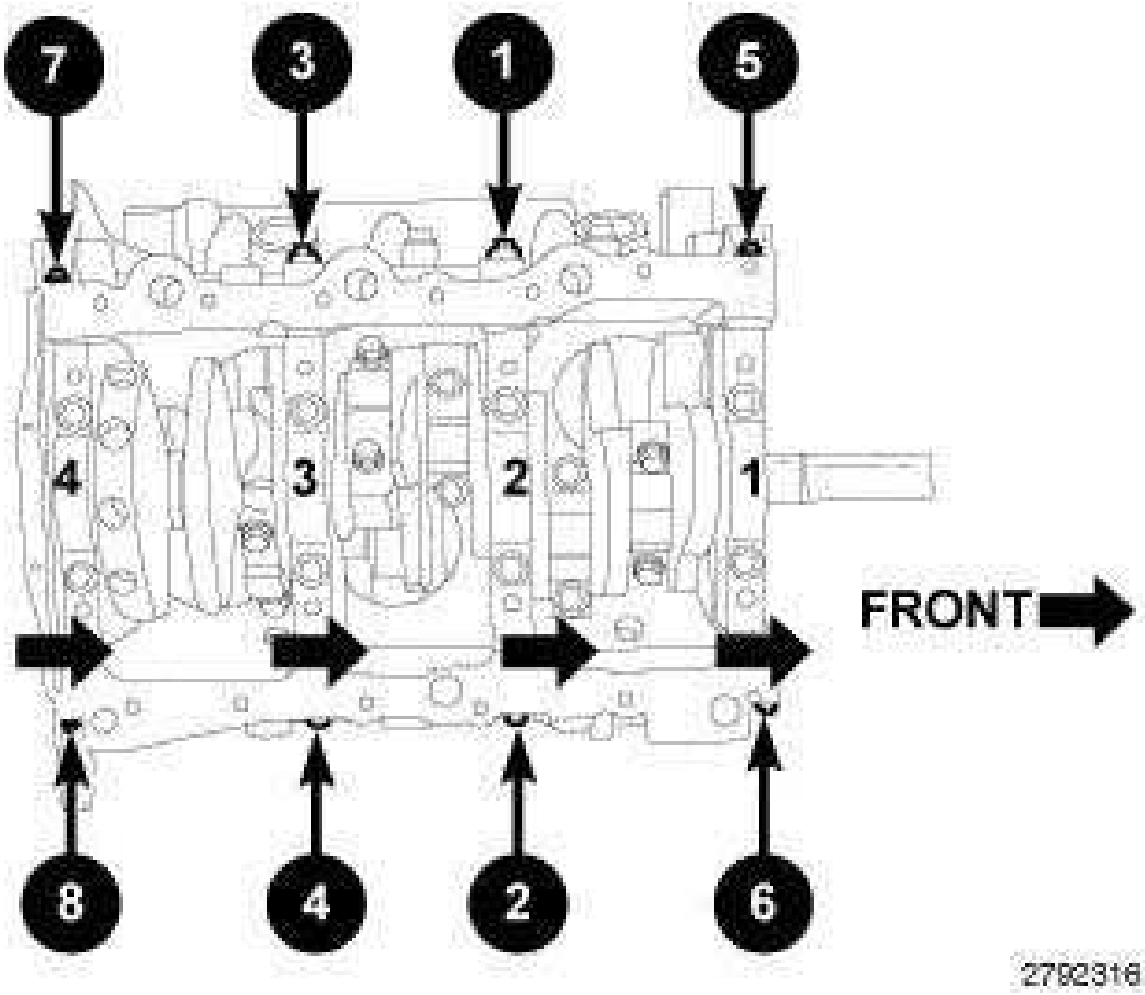


Fig. 15: Main Bearing Tie Bolts Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

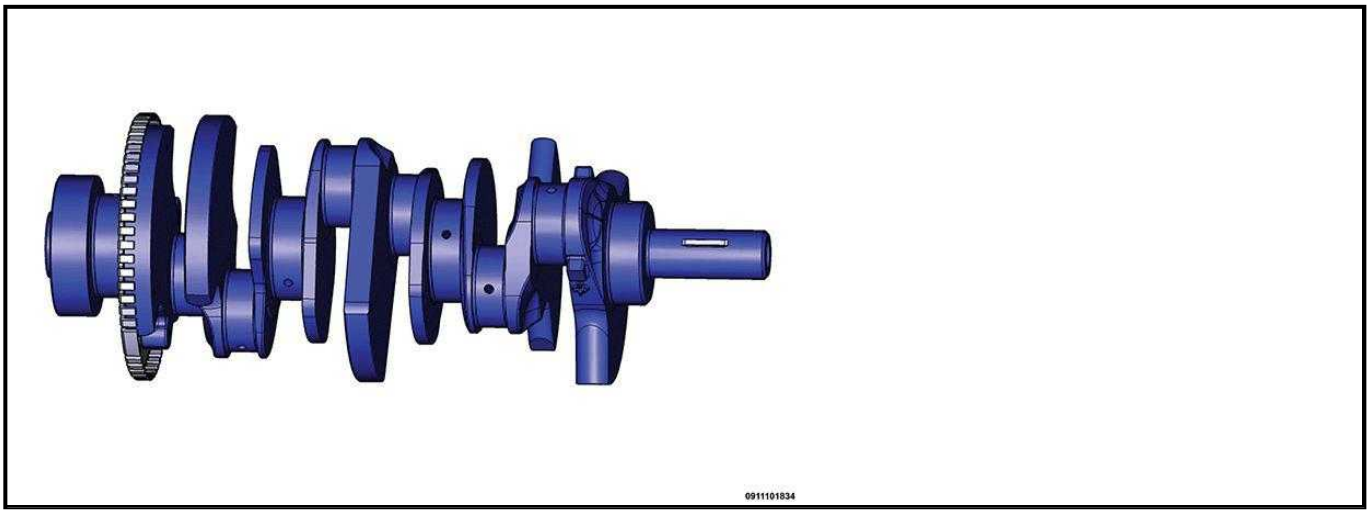
21. Install the eight main bearing tie bolts. Tighten the bolts in the sequence shown to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .

22. Install the engine oil pump, oil pump pick-up and oil pan. Refer to **PUMP, ENGINE OIL, REMOVAL AND INSTALLATION**.
23. Install the spark plugs and ignition coils. Refer to **SPARK PLUG, REMOVAL AND INSTALLATION**.
24. Install a new oil filter and fill the engine crankcase with the proper oil to the correct level. Refer to **FILTER, ENGINE OIL** .
25. Connect the negative battery cable. If equipped with an Intelligent Battery Sensor (IBS), connect the IBS connector.
26. Operate the engine until it reaches normal operating temperature and inspect for leaks.

CRANKSHAFT

DESCRIPTION AND OPERATION

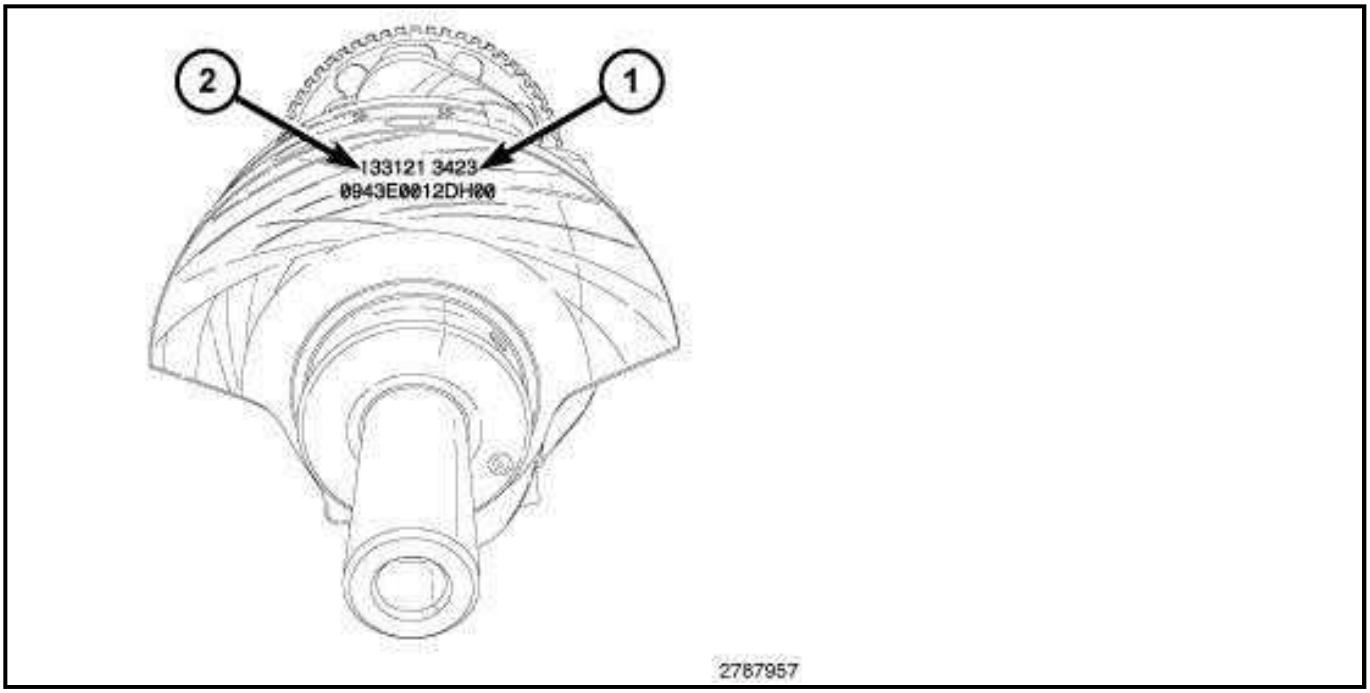
CRANKSHAFT



The crankshaft is a cast design and is constructed using ductile iron. The crankshaft is a three throw split pin design with counterweights for balancing purposes. The main journals are crossed drilled for rod bearing lubrication. The crankshaft is supported by four select fit main bearings with number 2 serving as the thrust washer location. The rear counterweight has provisions for crankshaft position sensor target wheel mounting. Both the front and rear seals are a single piece design and are mounted to the timing cover and cylinder block.

STANDARD PROCEDURE

CONNECTING ROD BEARING FITTING



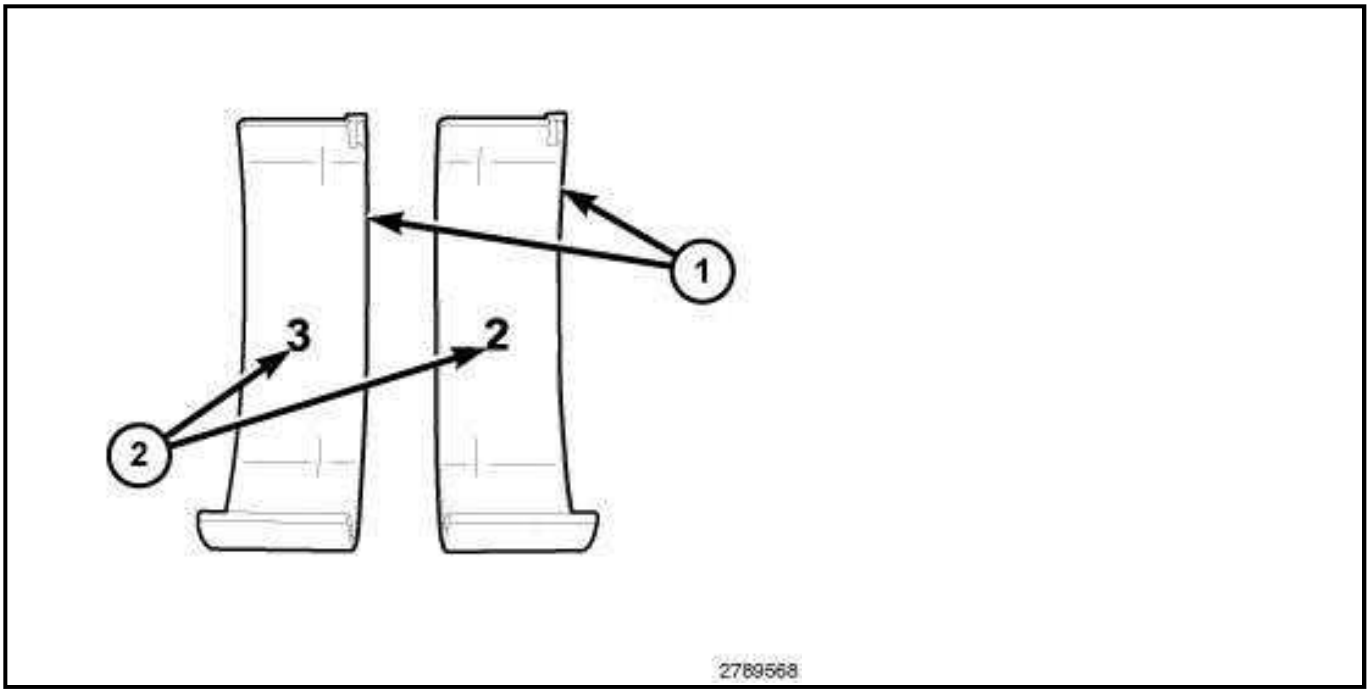
1 - Main Bearing Sizes
2 - Rod Bearing Sizes

The connecting rod bearings are "select fit" to achieve proper oil clearance. Connecting rod bearing journal diameter grade markings are stamped into the front crankshaft counterweight. These marks are read from left to right, corresponding with journal number 1, 2, 3, 4, 5, 6. Select the bearing size that corresponds to the crankshaft markings for each rod bearing journal.

NOTE: **There are a string of ten (10) digits on the front of the counterweight. The FIRST 6 correspond to the Rod Bearing Sizes. The LAST 4 correspond to the Main Bearing Sizes.**

Connecting rod bearing journal diameter grade markings correspond to specific journal diameters. The chart below identifies the three crankshaft grade markings and their associated journal diameters.

Crankshaft Marking	Journal Size mm (in.)
1	53.9910 - 53.9969 mm (2.1256 - 2.1258 in.)
2	53.9970 - 54.0029 mm (2.1259 - 2.1261 in.)
3	54.0030 - 54.0090 mm (2.1261 - 2.1263 in.)



1 - Connecting Rod Bearings
2 - Bearing Size

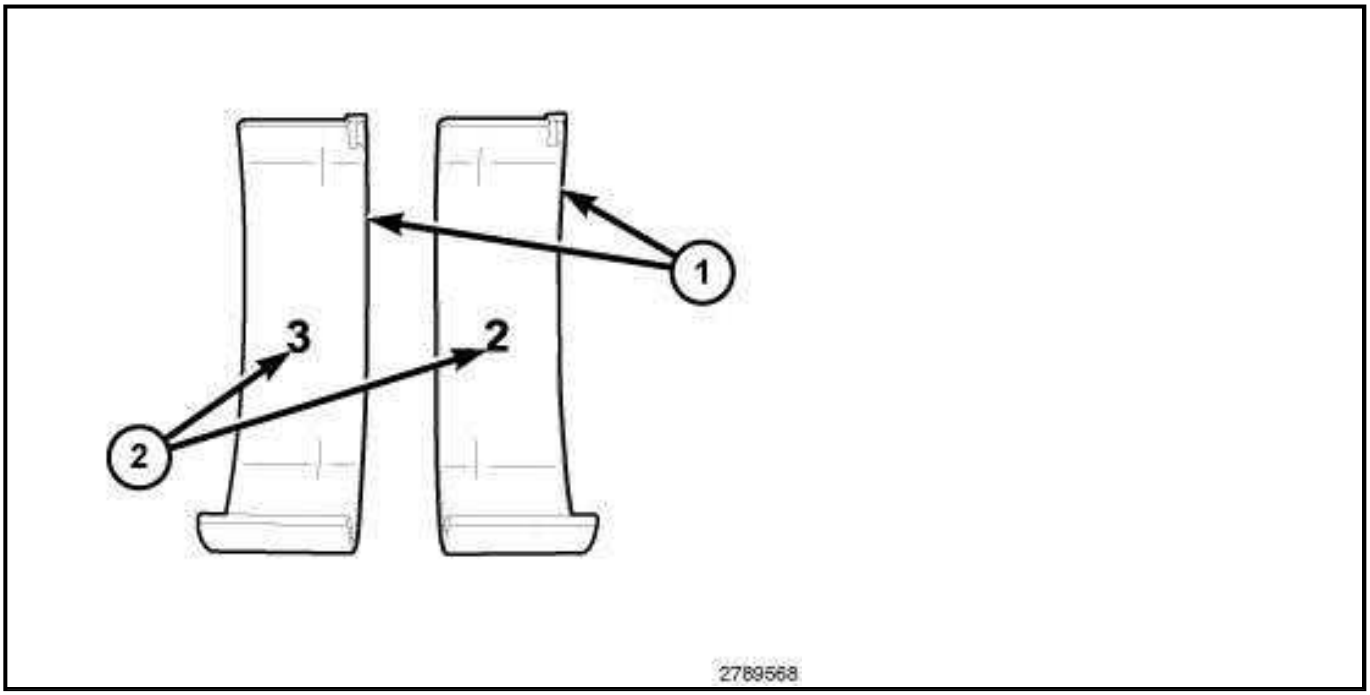
NOTE: **Install the rod bearings in pairs. Do not mix sizes or use a new bearing half with an old bearing half.**

The connecting rod bearing shells are marked with the bearing size on the bearing lining surface. The bearings are available in three different sizes in order to achieve the desired oil clearance.

Rod bearing shells are available in three sizes. The chart below identifies the three bearing sizes.

Bearing Marking	Size mm (in.)
1	1.583 - 1.580 mm (0.0623 - 0.0622 in.)
2	1.580 - 1.577 mm (0.0622 - 0.0620 in.)
3	1.577 - 1.574 mm (0.0621 - 0.0619 in.)

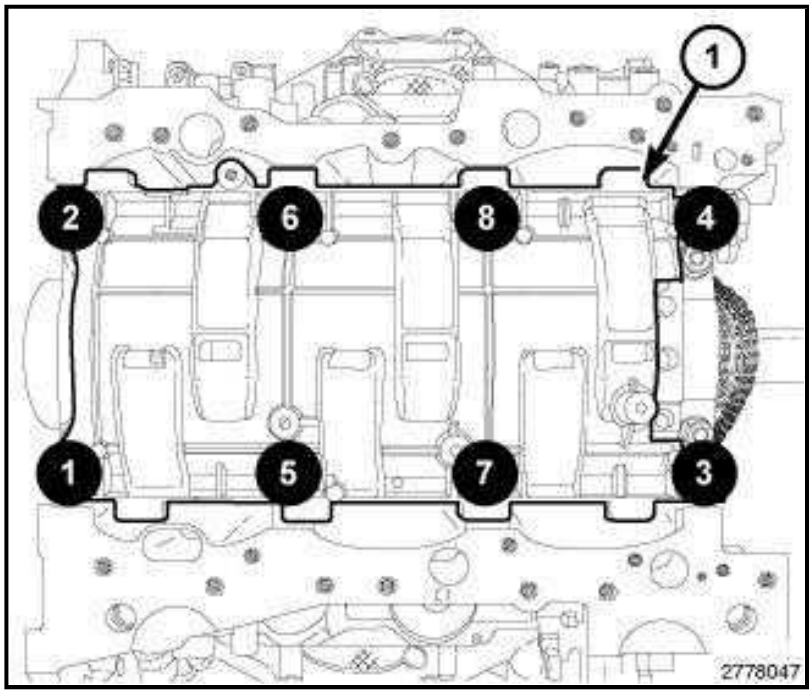
CONNECTING ROD BEARING



1 - Connecting Rod Bearings
2 - Bearing Size

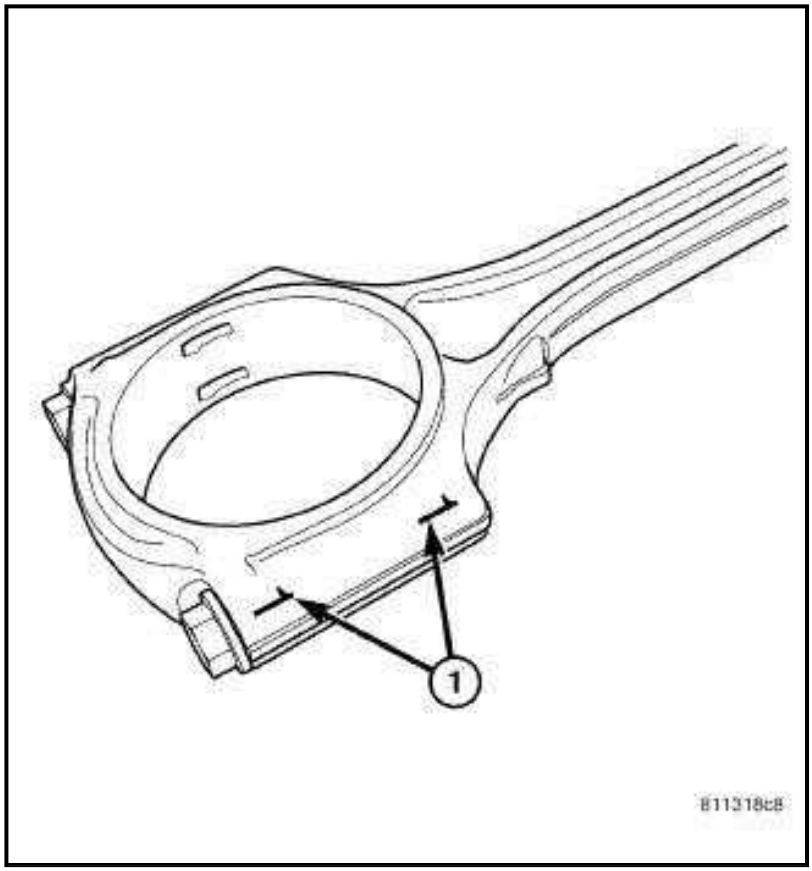
The connecting rod bearings can be serviced in-vehicle. They must be replaced one-at-a-time in order to prevent the pistons from contacting the valves. The connecting rod bearings are "select fit" to achieve proper oil clearances. Refer to **BEARING(S), CONNECTING ROD, STANDARD PROCEDURE**.

1. Remove the spark plugs. Refer to **SPARK PLUG, REMOVAL AND INSTALLATION**.
2. Remove the oil pan, oil pump pick-up and engine oil pump. Refer to **PUMP, ENGINE OIL, REMOVAL AND INSTALLATION**.



1 - Windage Tray

3. Remove the eight main bearing cap bolts from the windage tray in the sequence shown and remove the windage tray.

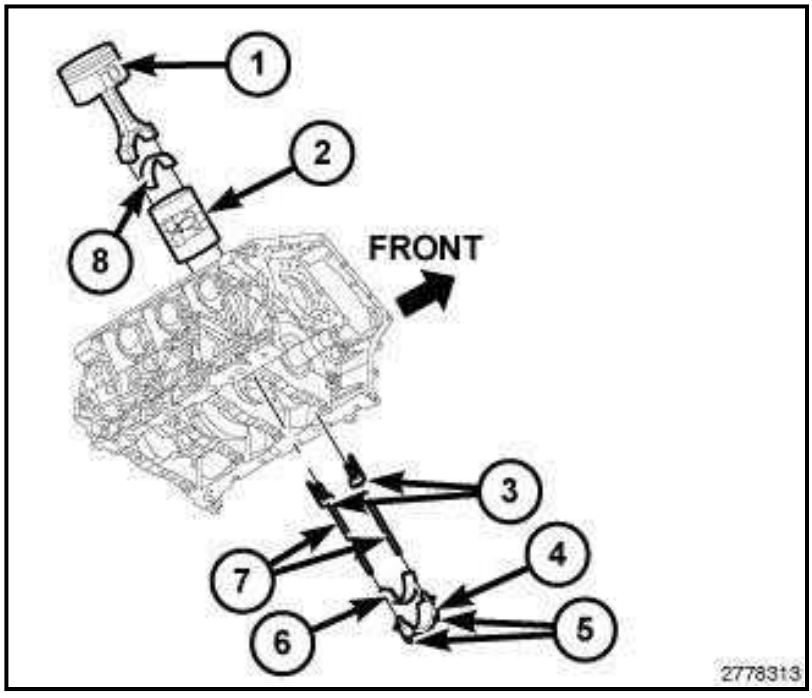


1 - Connecting Rod and Cap Marking Location

CAUTION: **DO NOT use a number stamp or a punch to mark connecting rods or caps, as damage to connecting rods could occur.**

NOTE: **Connecting rods and bearing caps are not interchangeable and should be marked before removing to ensure correct reassembly.**

4. Mark connecting rod and bearing cap positions using a permanent ink marker or scribe tool.



1 - Piston and Connecting Rod	5 - Connecting Rod Cap Bolts
2 - Piston Installer Tool	6 - Lower Connecting Rod Bearing

3 - Plastic Guide Plates	7 - Guide Pins
4 - Connecting Rod Cap	8 - Upper Connecting Rod Bearing

CAUTION: **Replace only one connecting rod bearing at a time while all other connecting rod bearing caps remain properly tightened. If all connecting rod bearing caps are removed, crankshaft rotation will result in valve or piston damage.**

CAUTION: **Care must be taken not to damage the fractured rod and cap joint face surfaces, as engine damage may occur.**

5. Remove the connecting rod cap bolts and the connecting rod cap. Discard the cap bolts.
6. Remove the plastic guide plates from the Guide Pins (special tool #8189, Guide Pins) and install the Guide Pins to the connecting rod being removed.

CAUTION: **Care must be taken not to nick crankshaft journals, as engine damage may occur.**

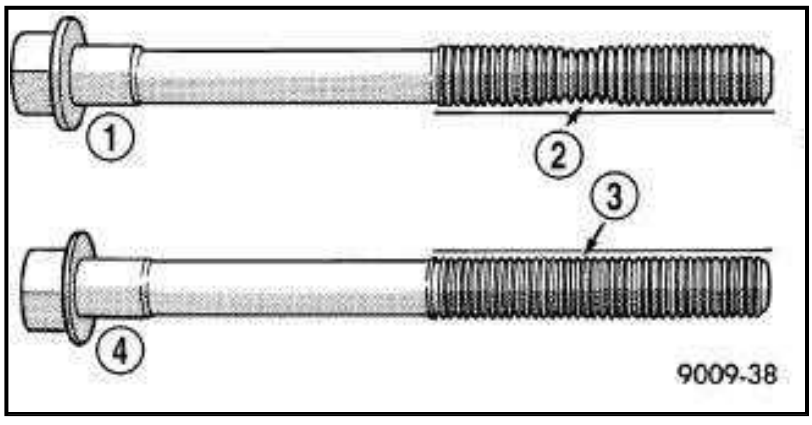
7. Rotate the crankshaft away from the connecting rod and remove the bearing shell.
8. Inspect the rods and bearings for abnormal wear patterns, scoring, grooving, fatigue, pitting and for metal or other foreign material imbedded in the lining. Refer to **ENGINE BLOCK, INSPECTION**.
9. If required, check the connecting rod bearing clearances by the use of Plastigage or equivalent. Refer to **STANDARD PROCEDURE** .
10. If required, select and fit new bearings to the connecting rod. Refer to **BEARING(S), CONNECTING ROD, STANDARD PROCEDURE**.
11. Install the bearing shell on the connecting rod with the tang inserted into the machined groove in the rod. Lubricate the bearing surface with clean engine oil.
12. Rotate the crankshaft while guiding the connecting rod into position over the rod journal.

CAUTION: **The connecting rod bolts must not be reused. Always replace the connecting rod bolts whenever they are loosened or removed.**

13. Install the bearing shell on the connecting rod cap with the tang inserted into the machined groove in the cap. Lubricate the bearing surface with clean engine oil.

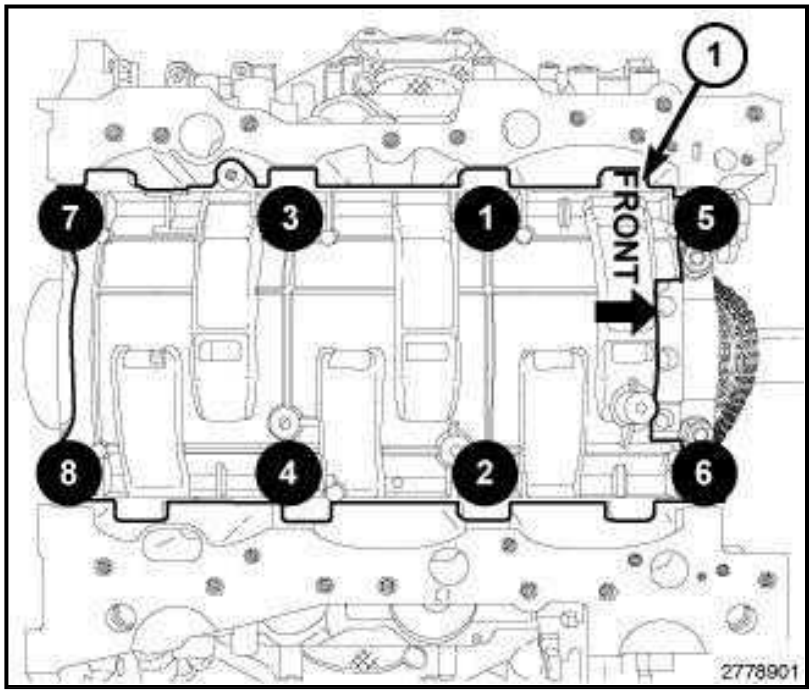
NOTE: **Do not lubricate the threads of the connecting rod cap bolts.**

14. Install the connecting rod cap and bearing with the tang on the same side as the rod. Tighten the **NEW** connecting rod cap bolts to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .
15. If required, check the connecting rod side clearance. Refer to **ROD, PISTON AND CONNECTING, STANDARD PROCEDURE**.
16. Repeat the previous steps for each connecting rod bearing being replaced.



CAUTION: **The main bearing cap bolts are tightened using a torque plus angle procedure. The bolts must be examined BEFORE reuse. If the threads are necked down the bolts must be replaced.**

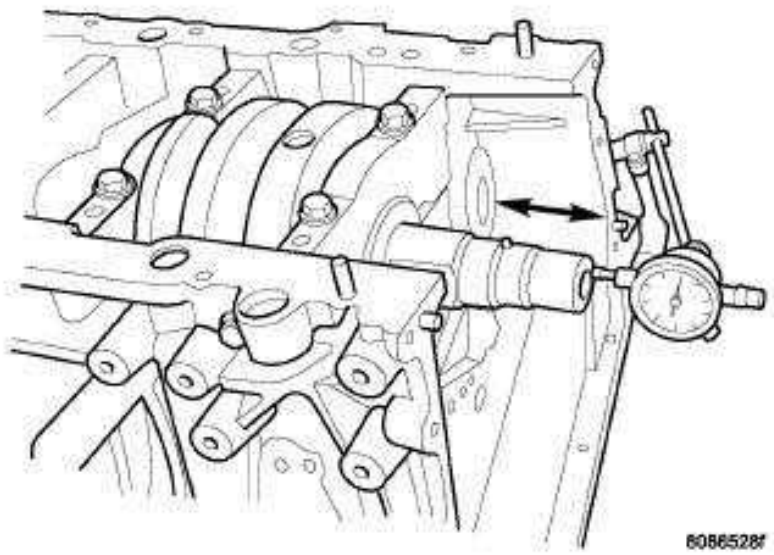
17. Check the main bearing cap bolts for necking by holding a scale or straight edge against the threads. If all the threads do not contact the scale (2) the bolt must be replaced.



1 - Windage Tray

18. Install the windage tray with eight main bearing cap bolts. Tighten the bolts in the sequence shown to 21 N. m (16 ft. lbs.) plus an additional 90B° turn.
19. Install the engine oil pump, oil pump pick-up and oil pan. Refer to **PUMP, ENGINE OIL, REMOVAL AND INSTALLATION**.
20. Install the spark plugs and ignition coils. Refer to **SPARK PLUG, REMOVAL AND INSTALLATION**.
21. If removed, install the oil filter and fill the engine crankcase with the proper oil to the correct level. Refer to **ENGINE OIL AND FILTER CHANGE** .
22. Operate the engine until it reaches normal operating temperature.

CRANKSHAFT END PLAY

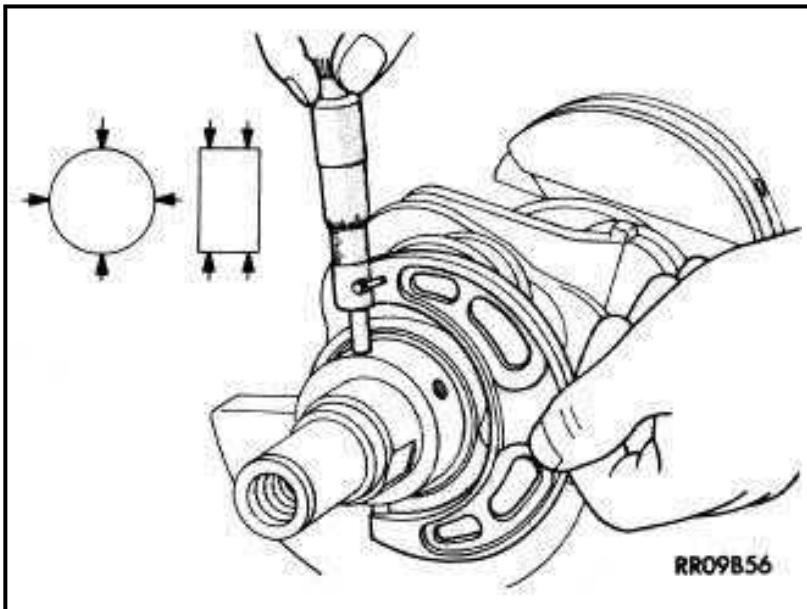


1. Mount Dial Indicator Set (special tool #C-3339A, Set, Dial Indicator) to a stationary point at the front of the engine. Locate the probe perpendicular against the nose of the crankshaft.
2. Move the crankshaft all the way to the rear of its travel.
3. Zero the dial indicator.
4. Move the crankshaft forward to the limit of travel and read the dial indicator. Compare the measured end play to the specification. Refer to **ENGINE SPECIFICATIONS** .

NOTE: **Crankshaft thrust washers are not selectable and are only available in a single thickness.**

INSPECTION

CRANKSHAFT



NOTE: **Typical crankshaft journal measurements shown.**

1. Clean the oil off of the bearing journals.

2. Determine the maximum diameter of the journals with a micrometer. Measure at two locations 90B° apart at each end of the journals.
3. Compare the measured rod journal diameter to the crankshaft connecting rod bearing journal diameter grade marking chart. Refer to **BEARING(S), CONNECTING ROD, STANDARD PROCEDURE**. Select the bearing size that corresponds to the crankshaft markings for each rod bearing journal that will provide the proper oil clearance.
4. Compare the measured main bearing journal diameter to the crankshaft main bearing journal diameter grade marking chart. Refer to **BEARING(S), CRANKSHAFT, MAIN, STANDARD PROCEDURE**. Obtain the main bearing journal grade identification marks from the engine block and select the upper and lower main bearing sizes that will provide the proper oil clearance.
5. For connecting rod journals, verify that the maximum taper and maximum out of round are within specifications. Refer to **ENGINE SPECIFICATIONS** .
6. For main bearing journals, verify that the maximum taper and maximum out of round are within specifications. Refer to **ENGINE SPECIFICATIONS** .

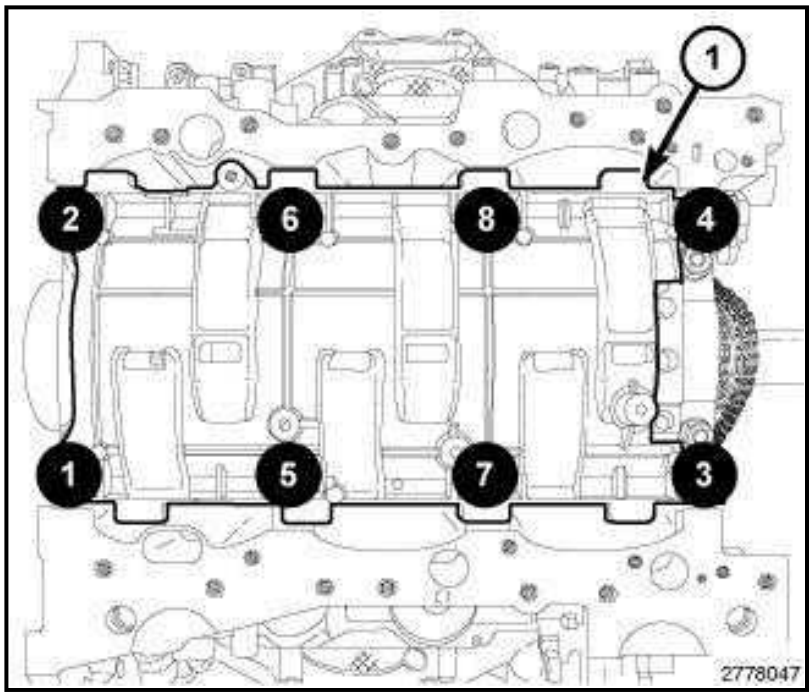
REMOVAL AND INSTALLATION

REMOVAL AND INSTALLATION

REMOVAL

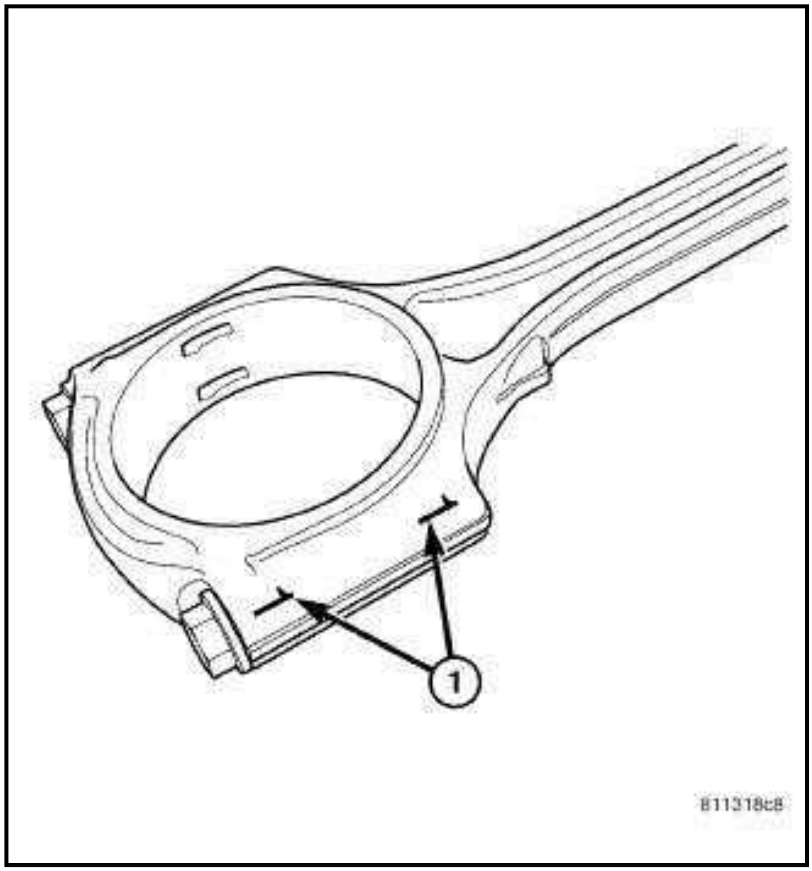
NOTE: To remove the crankshaft from the engine, the engine must be removed from the vehicle.

1. Remove the engine. Refer to **ENGINE ASSEMBLY, REMOVAL AND INSTALLATION** .
2. Remove the cylinder head covers, spark plugs, oil pan, engine timing cover, timing chain and sprockets. Refer to **CHAIN AND SPROCKETS, TIMING, REMOVAL AND INSTALLATION** .
3. Remove the flexplate and the rear crankshaft oil seal. Refer to **SEAL, CRANKSHAFT OIL, REAR, REMOVAL AND INSTALLATION**.
4. Remove the oil pump pick-up and engine oil pump. Refer to **PUMP, ENGINE OIL, REMOVAL AND INSTALLATION**.



1 - Windage Tray/Main Bearing Cap Bolts Removal Sequence

5. Remove the eight main bearing cap bolts from the windage tray in the sequence shown and remove the windage tray.

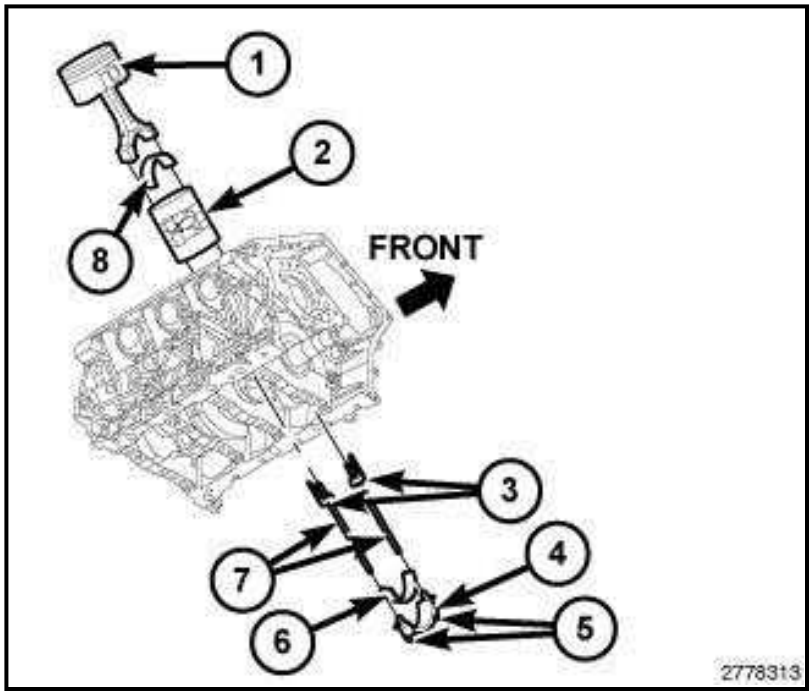


1 - Connecting Rod And Bearing Cap Position

CAUTION: **DO NOT use a number stamp or a punch to mark connecting rods or caps, as damage to connecting rods could occur.**

NOTE: **Connecting rods and bearing caps are not interchangeable and should be marked before removing to ensure correct reassembly.**

6. Mark connecting rod and bearing cap positions using a permanent ink marker or scribe tool.



1 - Piston
2 - Piston Ring Compressor

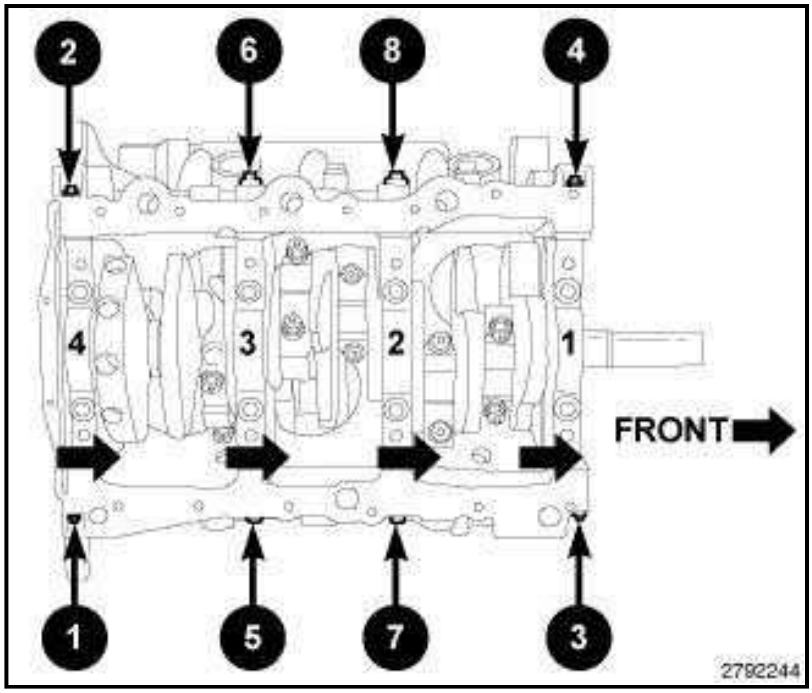
3 - Plastic Guide Plates
4 - Connecting Rod Cap
5 - Connecting Rod Cap Bolts
6 - Bearing Shell
7 - Guide Pins
8 - Bearing Shell

CAUTION: **Care must be taken not to damage the fractured rod and cap joint face surfaces, as engine damage may occur.**

7. Remove the connecting rod cap bolts and the connecting rod caps. Discard the cap bolts.
8. Remove the plastic guide plates from the Guide Pins (special tool #8189, Guide Pins) (7) and install the Guide Pins to the connecting rod.

CAUTION: **Care must be taken not to nick crankshaft journals, as engine damage may occur.**

9. Push the connecting rod and piston into the cylinder until the connecting rod is clear of the crankshaft journal. Remove the guide pins. Repeat this procedure at each cylinder until all of the connecting rods are clear of the crankshaft.



1 - Main Bearing Tie Bolts Removal Sequence

CAUTION: **DO NOT use a number stamp or a punch to mark main bearing caps, as damage to main bearings could occur.**

NOTE: **If necessary, mark the main bearing cap positions using a permanent ink marker or a scribe tool.**

NOTE: **Main bearing caps are not interchangeable and are marked to insure correct assembly.**

10. Remove the main bearing cross bolts in the sequence shown.

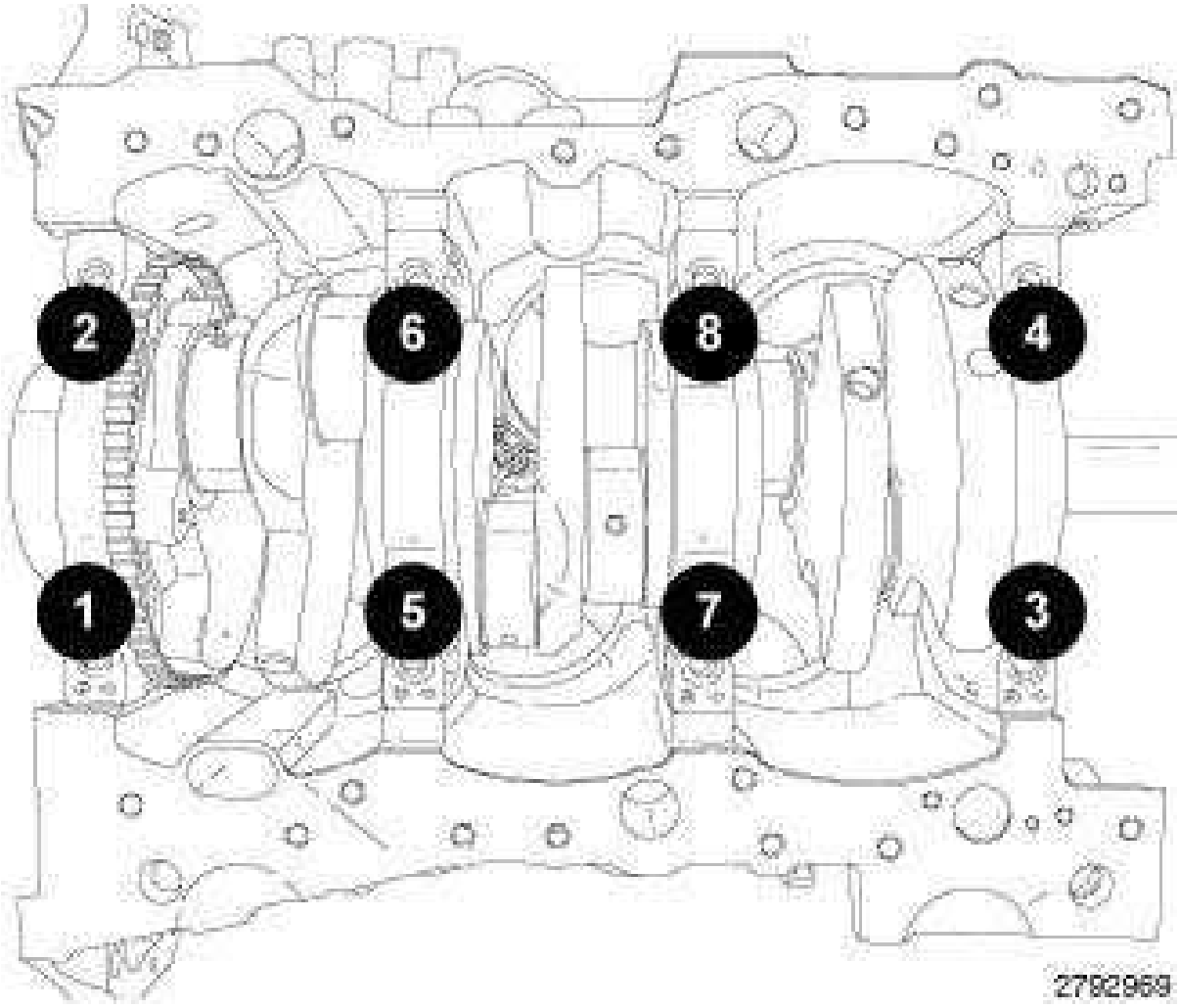
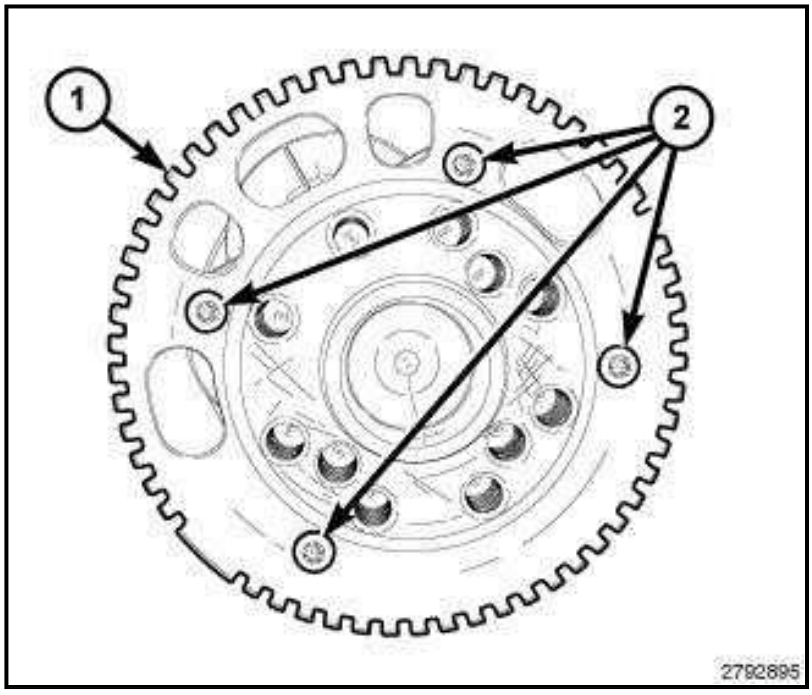


Fig. 16: Main Bearing Cap Bolts Loosening Sequence
Courtesy of CHRYSLER GROUP, LLC

1 - Main Bearing Cap Bolts Removal Sequence

11. Remove the eight main bearing cap bolts in the sequence shown and remove the main bearing caps.



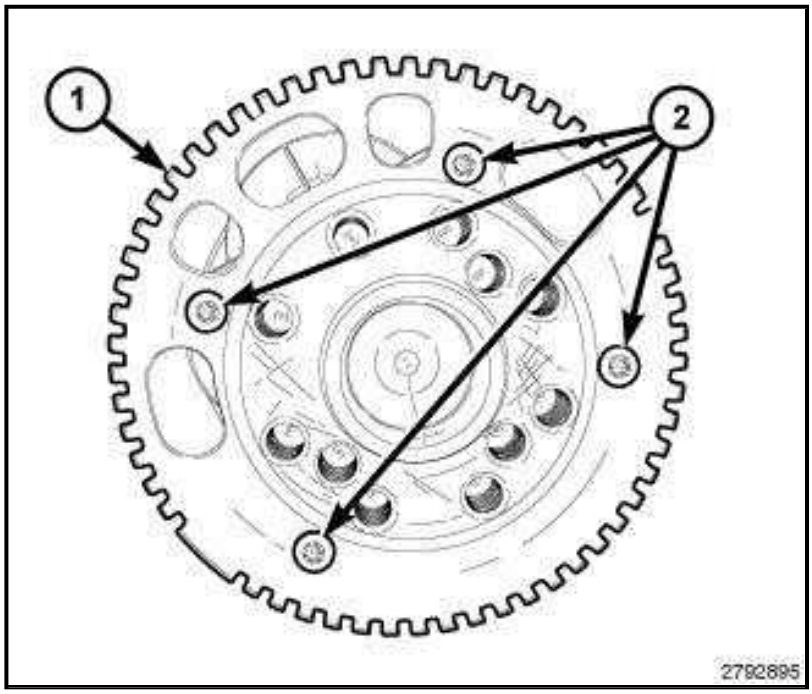
1 - Target Wheel
2 - Target Wheel Bolts

CAUTION: **Do not rest the crankshaft on the target wheel (1). Damaged or bent target wheel teeth will destroy the target wheels ability to correctly relay crankshaft position to the crankshaft position sensor.**

12. Remove the crankshaft from the engine block.
13. If required, remove the four target wheel bolts and the target wheel. Discard the four bolts.

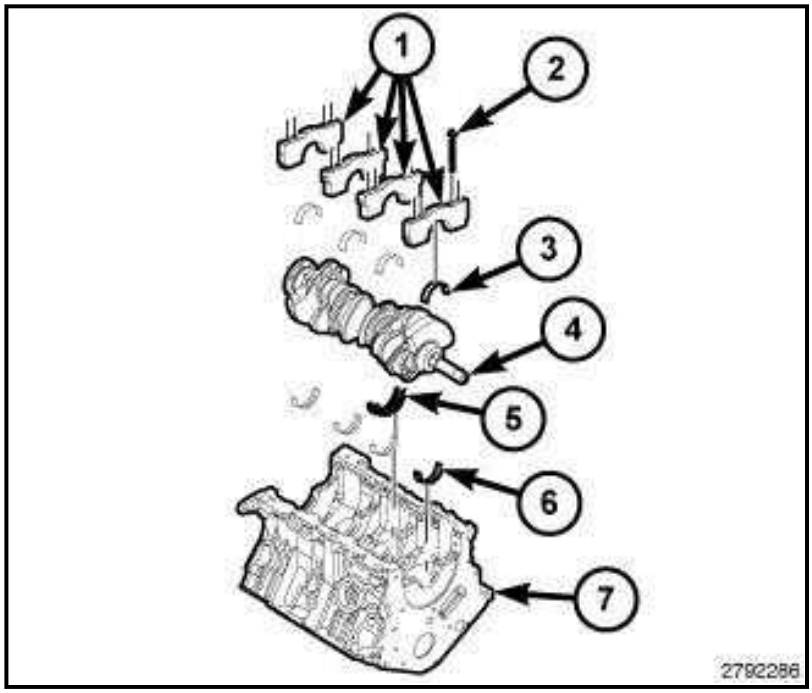
INSTALLATION

1. If required, select and fit new crankshaft main bearings to the engine block. Refer to **BEARING(S), CRANKSHAFT, MAIN, STANDARD PROCEDURE**.
2. If required, select and fit new bearings to the connecting rod. Refer to **BEARING(S), CONNECTING ROD, STANDARD PROCEDURE**.



1 - Target Wheel
2 - Target Wheel Bolts

3. If removed, install the target wheel to the crankshaft with four new bolts. Ensure the threaded holes in the crankshaft are free of residual thread lock adhesive. Tighten the bolts to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .

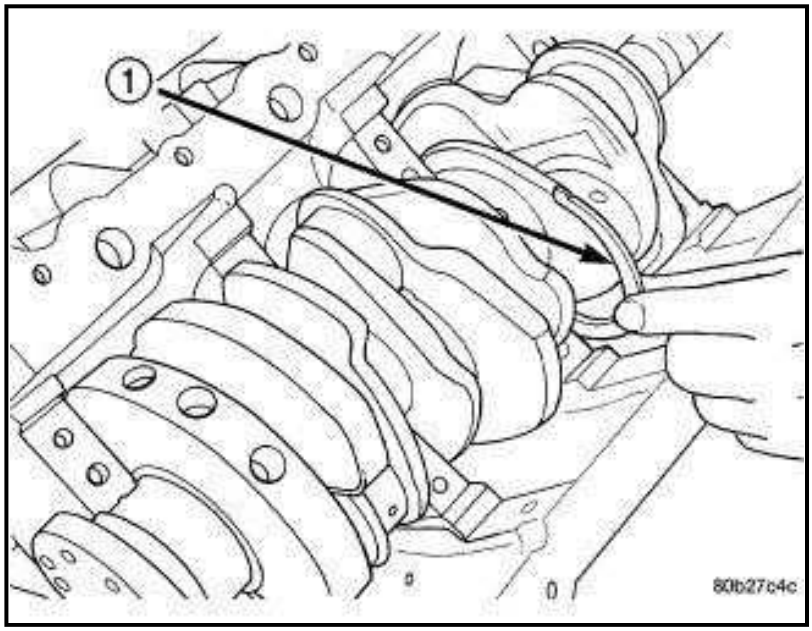


1 - Main Caps	5 - Thrust Washer
2 - Inner Main Bearing Cap Bolts	6 - Upper Main Bearing
3 - Lower Main Bearing	7 - Engine Block
4 - Crankshaft	B

4. If removed, lubricate and install the upper main bearing halves into the engine block.

CAUTION: **When installing the crankshaft, use care not to damage bearing surfaces on the crankshaft.**

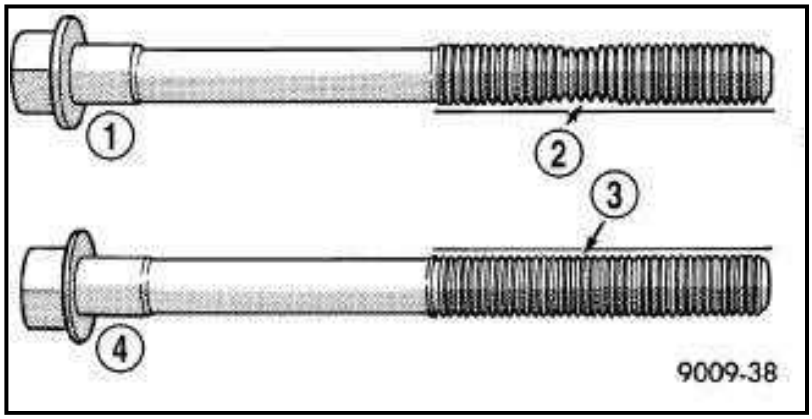
5. Install the crankshaft into the engine block.



1 - Thrust Washer

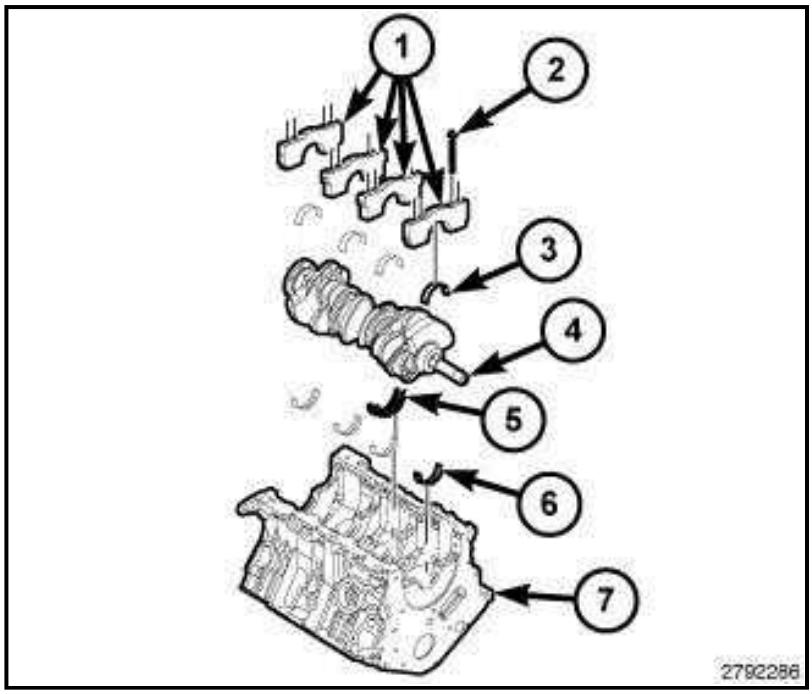
6. Installing thrust washers at the No. 2 main bearing location, using the following procedure:
    a. Move the crankshaft forward to the limit of travel. Lubricate and install the rear thrust washer) by rolling the washer onto the machined shelf between the No. 2 upper main bulk head and crankshaft thrust surface.

b. Move the crankshaft rearward to the limit of travel. Lubricate and install the front thrust washer by rolling the washer onto the machined shelf between the No. 2 upper main bulk head and crankshaft thrust surface.



CAUTION: **The main bearing cap bolts are tightened using a torque plus angle procedure. The bolts must be examined BEFORE reuse. If the threads are necked down the bolts must be replaced.**

7. Check the main bearing cap bolts for necking by holding a scale or straight edge against the threads. If all the threads do not contact the scale (2) the bolt must be replaced.



1 - Main Caps	5 - Thrust Washer
2 - Inner Main Bearing Cap Bolts	6 - Upper Main Bearing
3 - Lower Main Bearing	7 - Engine Block
4 - Crankshaft	B

8. If removed, lubricate and install the lower main bearing halves onto the main caps.
9. Install the main bearing caps with two inner main bearing cap bolts.

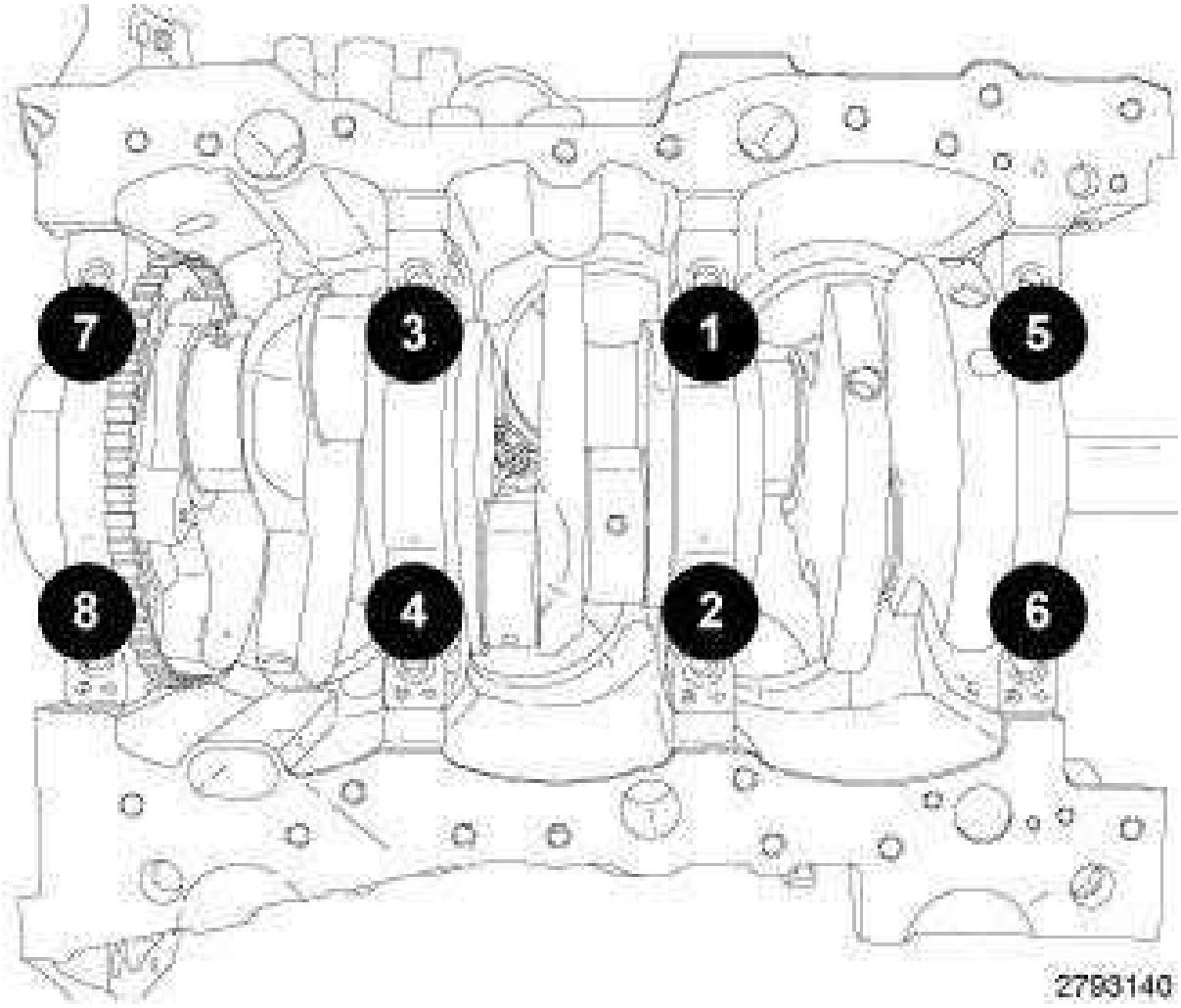
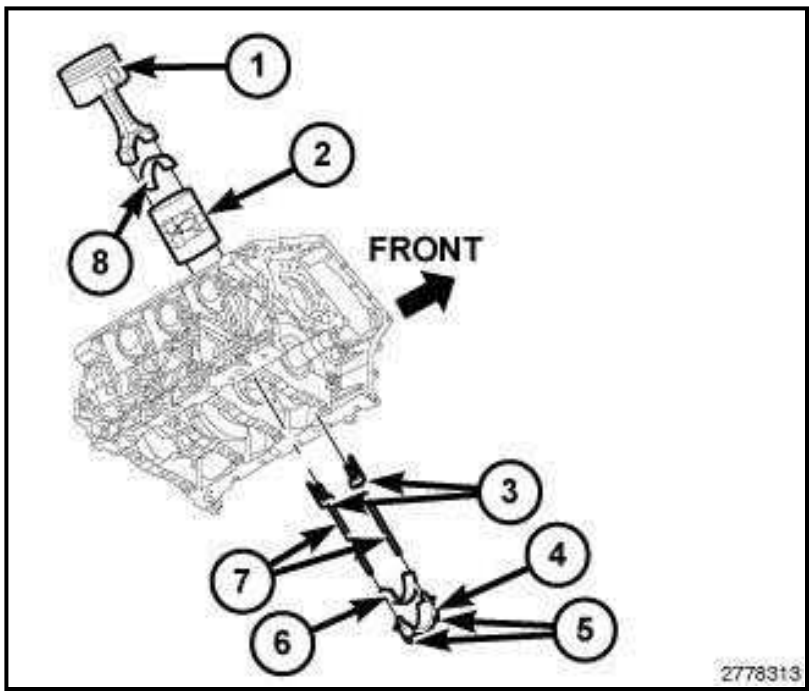


Fig. 17: Inner Main Bearing Cap Bolts Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

10. Tighten the inner main bearing cap bolts in the sequence shown to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .
11. Measure crankshaft end play. Refer to **CRANKSHAFT, STANDARD PROCEDURE**.



1 - Piston and Connecting Rod	5 - Connecting Rod Cap Bolts
2 - Piston Installer Tool	6 - Lower Connecting Rod Bearing

3 - Plastic Guide Plates	7 - Guide Pins
4 - Connecting Rod Cap	8 - Upper Connecting Rod Bearing

12. If removed, install the bearing shell on the connecting rod with the tang inserted into the machined groove in the rod. Lubricate the bearing surface with clean engine oil.
13. Remove the plastic guide plates from the Guide Pins (special tool #8189, Guide Pins) and install the Guide Pins to the connecting rod.

CAUTION: **Care must be taken not to nick crankshaft journals, as engine damage may occur.**

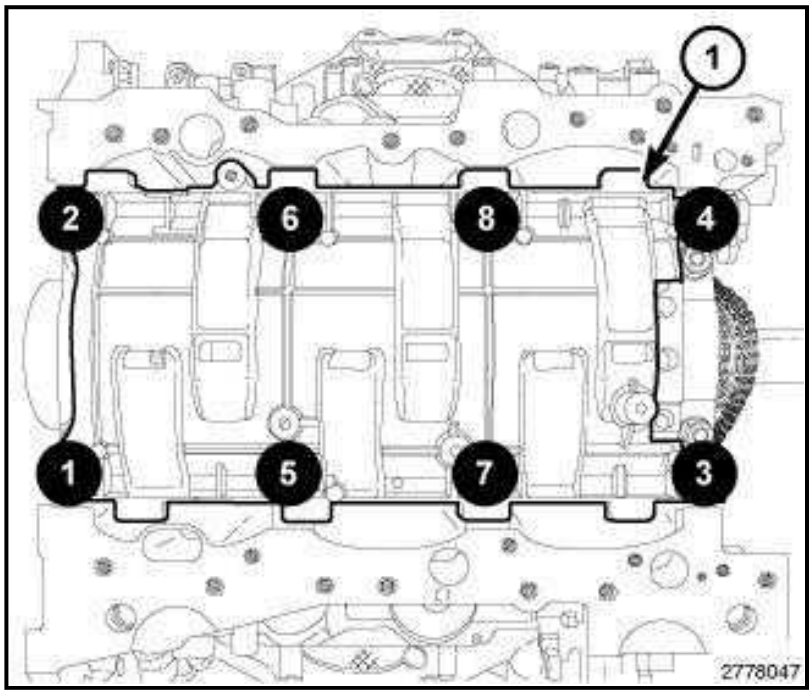
14. Pull the connecting rod and piston toward the crankshaft until the connecting rod is seated on the crankshaft journal. Remove the guide pins.

CAUTION: **The connecting rod bolts must not be reused. Always replace the connecting rod bolts whenever they are loosened or removed.**

15. If removed, install the bearing shell on the connecting rod cap with the tang inserted into the machined groove in the cap. Lubricate the bearing surface with clean engine oil.

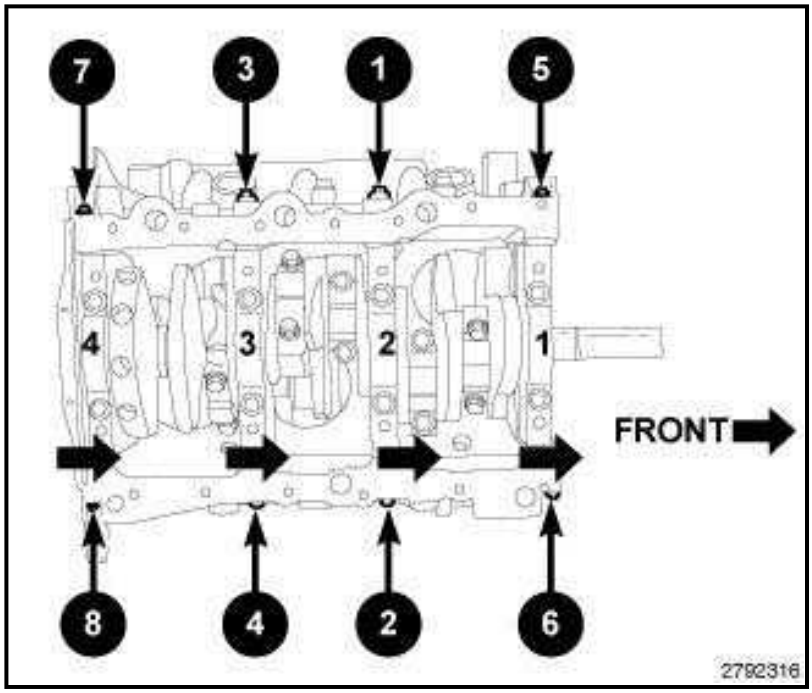
NOTE: **Do not lubricate the threads of the connecting rod cap bolts.**

16. Install the connecting rod cap and bearing with the tang on the same side as the rod. Tighten the **NEW** connecting rod cap bolts to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .
17. If required, check the connecting rod side clearance. Refer to **ROD, PISTON AND CONNECTING, STANDARD PROCEDURE**.
18. Repeat the previous steps for the remaining connecting rods.



1 - Windage Tray

19. Install the windage tray with eight main bearing cap bolts. Tighten the bolts in the sequence shown to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .



20. Install the eight main bearing tie bolts. Tighten the bolts in the sequence shown to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .
21. Install the engine oil pump and oil pump pick-up. Refer to **PUMP, ENGINE OIL, REMOVAL AND INSTALLATION**.
22. Install the rear crankshaft oil seal and flexplate. Refer to **SEAL, CRANKSHAFT OIL, REAR, REMOVAL AND INSTALLATION**.
23. Install the timing chain and sprockets, engine timing cover, oil pans, spark plugs and cylinder head covers. Refer to **CHAIN AND SPROCKETS, TIMING, REMOVAL AND INSTALLATION** .
24. Install the engine. Refer to **ENGINE ASSEMBLY, REMOVAL AND INSTALLATION** .
25. If removed, install the oil filter and fill the engine crankcase with the proper oil to the correct level. Refer to **LUBRICATION** .
26. Operate the engine until it reaches normal operating temperature. Check cooling system for correct fluid level.

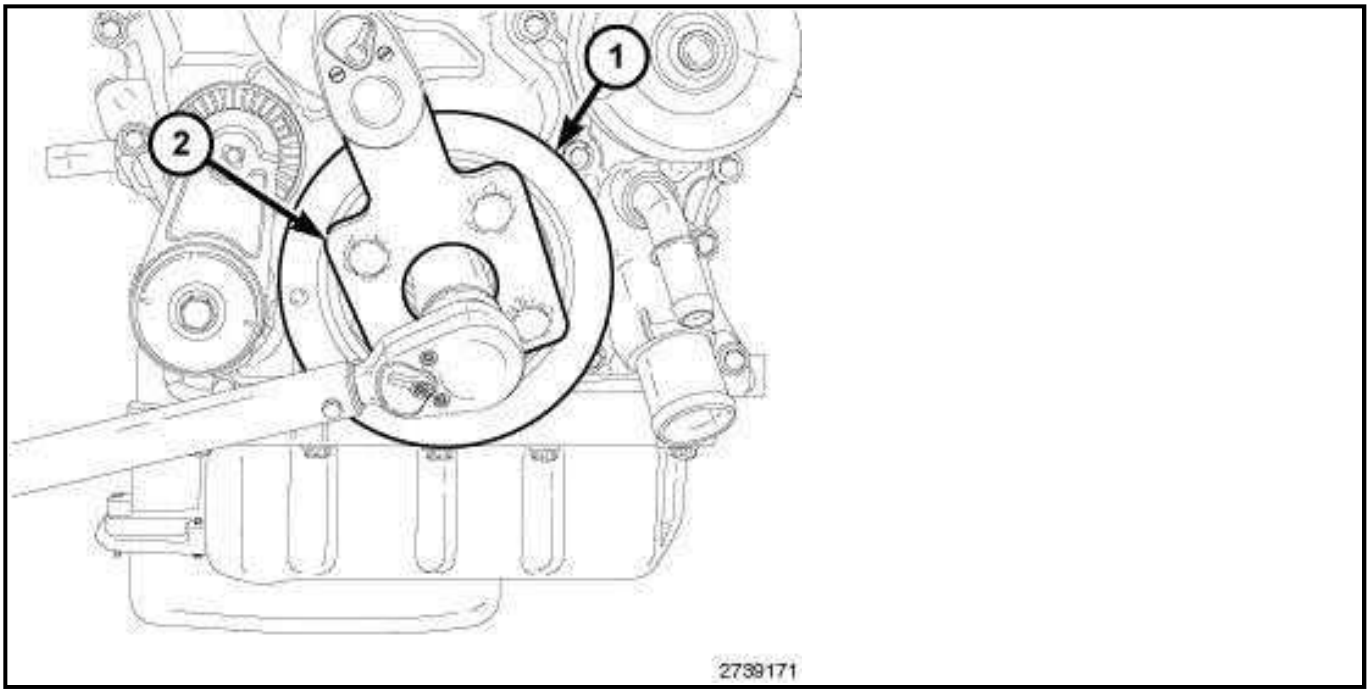
NOTE: **The Cam/Crank Variation Relearn procedure must be performed using the scan tool anytime there has been a repair/replacement made to a powertrain system, for example: flywheel, valvetrain, camshaft and/or crankshaft sensors or components.**

DAMPER, VIBRATION

REMOVAL AND INSTALLATION

VIBRATION DAMPER

REMOVAL



1 - Vibration Damper
2 - Vibration Damper Holder

1. Remove the accessory drive belt. Refer to **BELT, SERPENTINE, REMOVAL AND INSTALLATION** .

NOTE: **A force greater than 350 N.m (260 Ft. Lbs.) may be required to remove the crankshaft vibration damper bolt.**

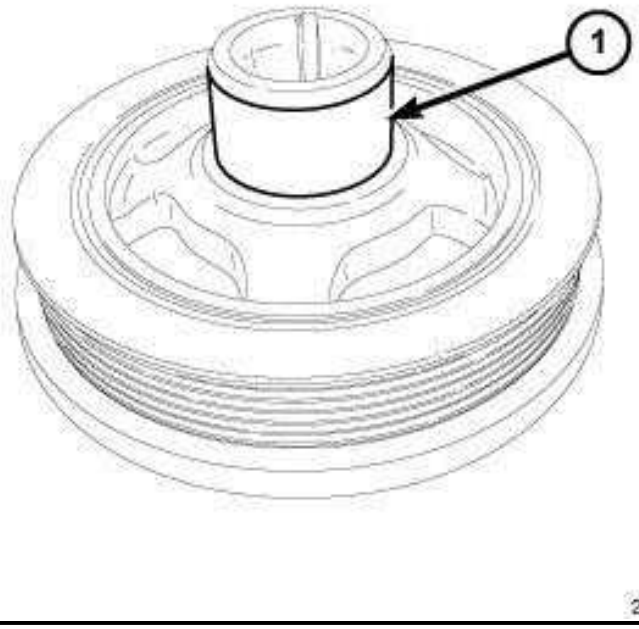
2. Hold the vibration damper with Vibration Damper Holder (special tool #10198, Holder, Vibration Damper) and remove the vibration damper bolt.
3. Pull the vibration damper off of the crankshaft.

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.

- Align the vibration damper to the flywheel key on the crankshaft and install the damper. Seat the damper on the crankshaft sprocket.
- Hold the vibration damper with Vibration Damper Holder (special tool #10198, Holder, Vibration Damper) and tighten the crankshaft vibration damper bolt to the proper torque specification in the torque table.

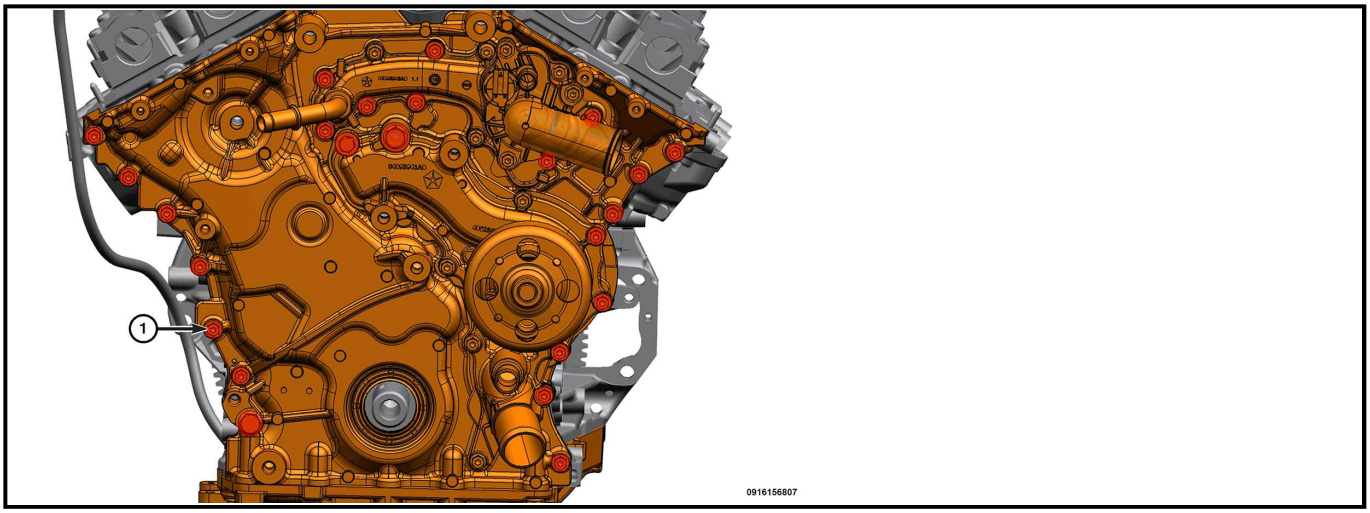


1 - Front Crankshaft Seal Surface

TORQUE SPECIFICATIONS

FRONT ENGINE

DESCRIPTION	SPECIFICATION	COMMENTS
Center Idler Pulley Bracket Bolts	**M8 Bolts - 25 N.m (18 Ft. Lbs.)** **M10 Bolts - 55 N.m (41 Ft. Lbs.)**	-
Center Idler Pulley Bracket to Generator Bolts	**24 N.m (18 Ft. Lbs.)**	-
Center Idler Pulley Bolt	**50 N.m (37 Ft. Lbs.)**	-
Left Idler Pulley Bolt	**25 N.m (18 Ft. Lbs.)**	-
Right Idler Pulley Bracket Bolts	**24 N.m (18 Ft. Lbs.)**	-
Right Idler Pulley Bolt	**25 N.m (18 Ft. Lbs.)**	-
Vibration Damper M16 Bolt	**Torque Procedure:** 1. **40 N.m (30 Ft. Lbs.)** 2. **Rotate additional + 105B°**	-
Belt Tensioner Bolt	**50 N.m (37 Ft. Lbs.)**	-
Engine Timing Cover M6 Bolts Engine Timing Cover M8 Bolt Engine Timing Cover M10 Bolts	**12 N.m (9 Ft. Lbs.)** **25 N.m (18 Ft. Lbs.)** **55 N.m (41 Ft. Lbs.)**	**Tighten in a criss-cross pattern**

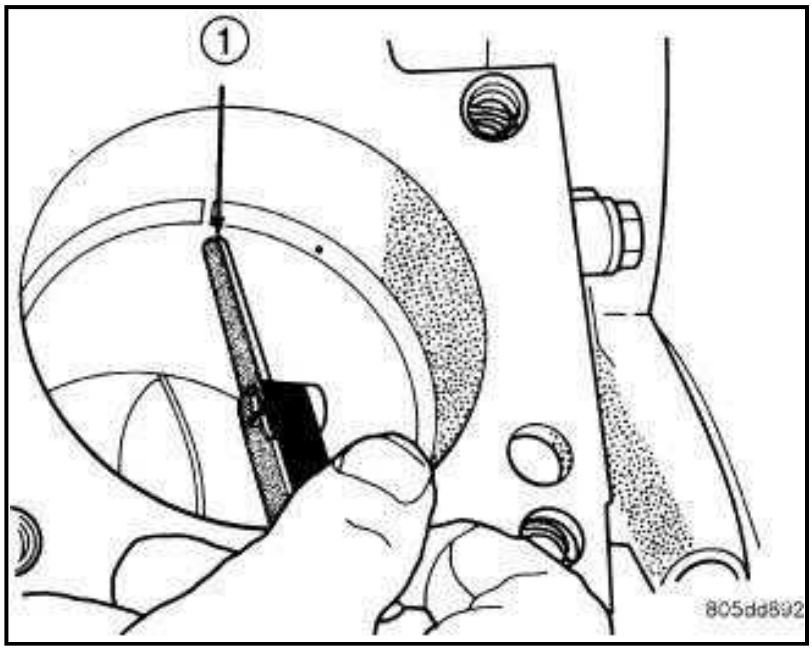


RING(S), PISTON

STANDARD PROCEDURE

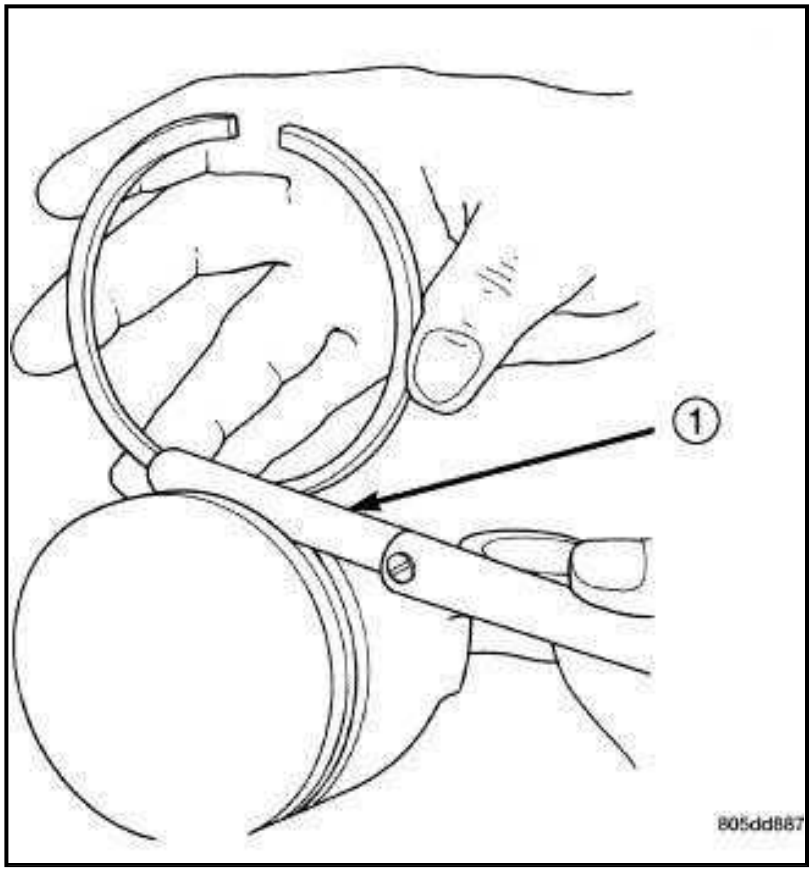
PISTON RING FITTING

1. Wipe the cylinder bore clean.
2. Using a piston, to ensure that the ring is squared in the cylinder bore, slide the ring downward into the cylinder to a position 12 mm (0.47 in.) from the top of the cylinder bore.



1 - Feeler Gauge

3. Using a feeler gauge, check the ring end gap. Replace any rings not within specification. Refer to **ENGINE SPECIFICATIONS** .



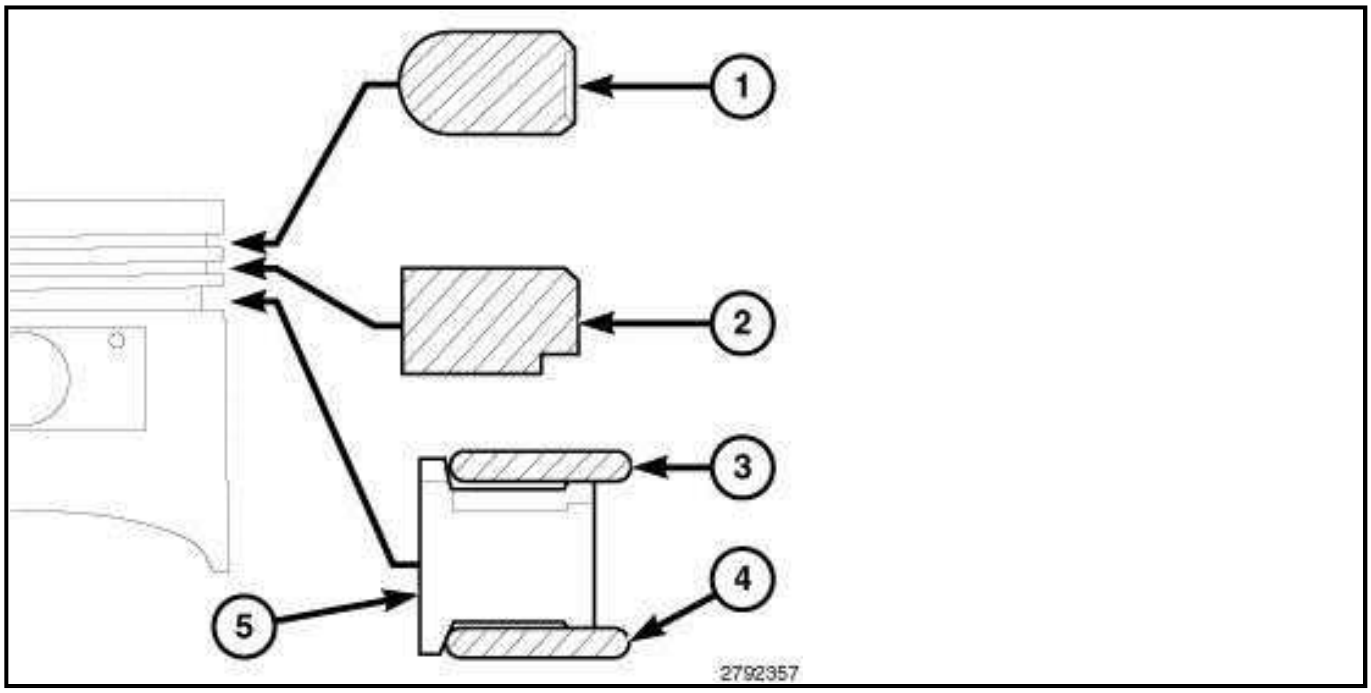
1 - Feeler Gauge

4. Clean the piston ring grooves. Remove any nicks or burrs.
5. Measure the ring side clearance as shown. Make sure the feeler gauge fits snugly between the ring land and the ring. Replace any ring not within specification. Refer to **ENGINE SPECIFICATIONS** .

REMOVAL AND INSTALLATION

REMOVAL AND INSTALLATION

REMOVAL

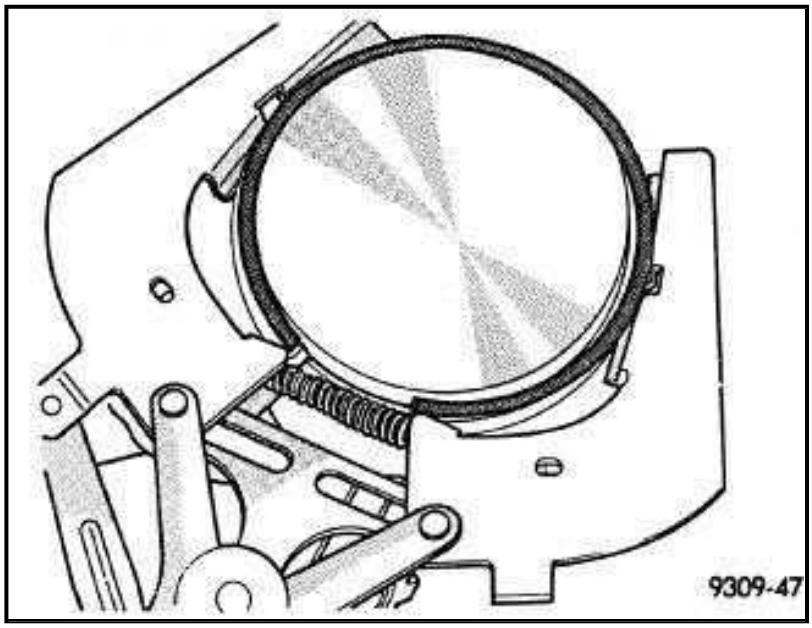


NOTE: **Typical piston shown.**

1. Remove the piston and connecting rod(s). Refer to **ROD, PISTON AND CONNECTING, REMOVAL AND INSTALLATION**.

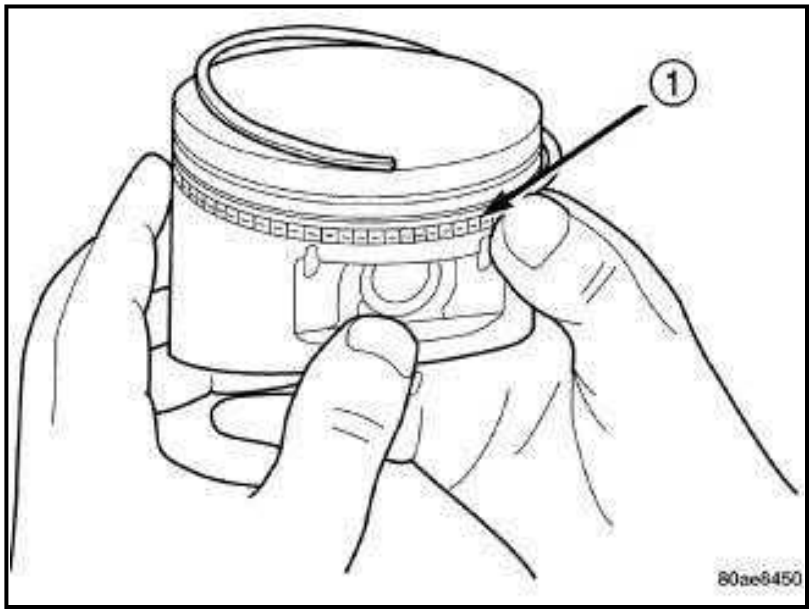
CAUTION: **To avoid damage to the piston rings, they must be removed in the following order:**

- **No. 1 (upper) piston ring (1)**
- **No. 2 (intermediate) piston ring (2)**
- **Oil ring upper side rail (3)**
- **Oil ring lower side rail (4)**
- **Oil ring expander (5)**



NOTE: **Typical piston shown.**

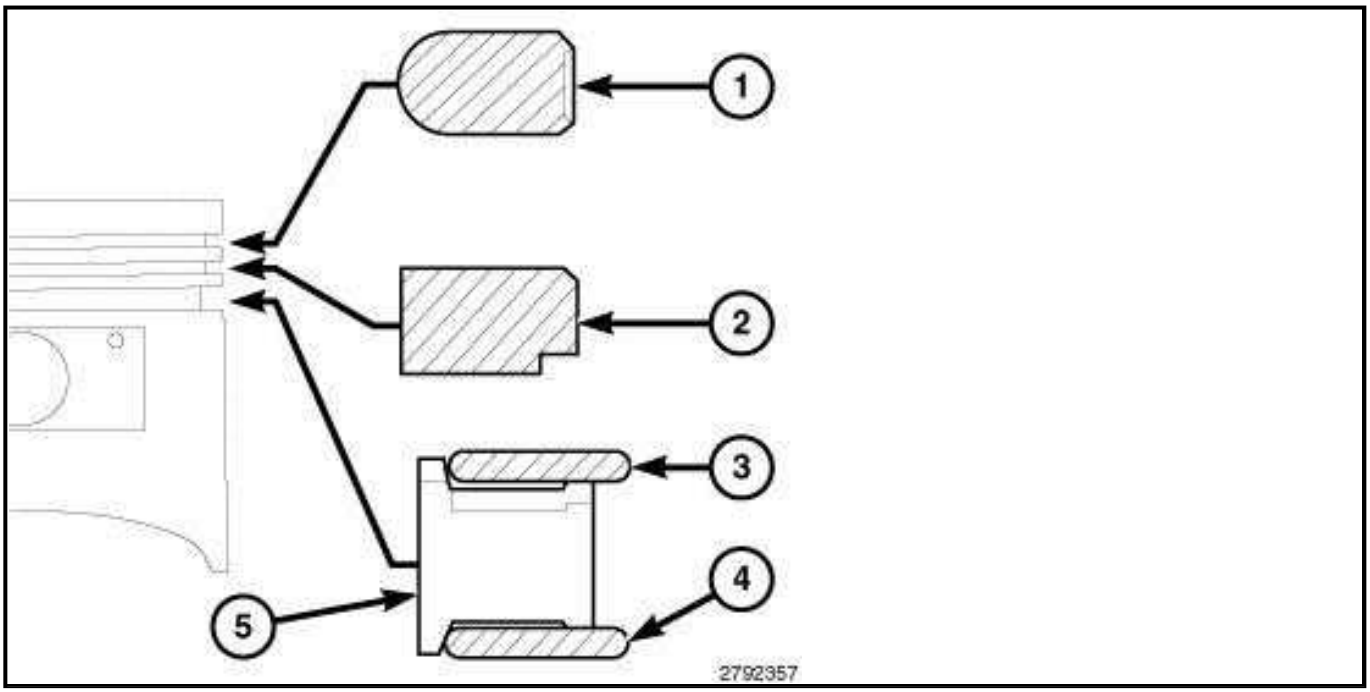
2. Remove the No. 1 (upper) piston ring using a ring expander tool.
3. Remove the No. 2 (intermediate) piston ring using a ring expander tool.



NOTE: **Typical piston shown. Do not use a piston ring expander to remove the oil ring side rails.**

4. Remove the oil ring upper side rail.
5. Remove the oil ring lower side rail.
6. Remove the oil ring expander (1).

INSTALLATION

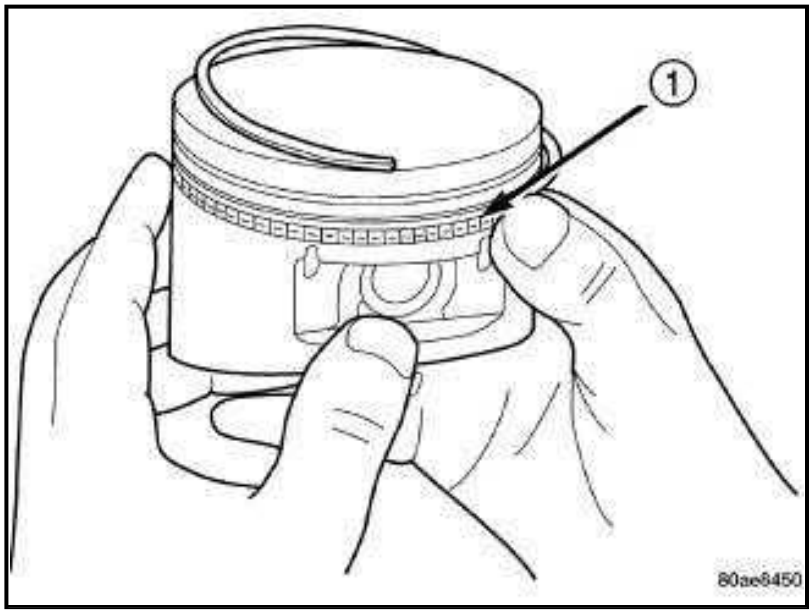


NOTE: **Typical piston shown.**

1. If required, fit new rings to the piston. Refer to **RING(S), PISTON, STANDARD PROCEDURE**.

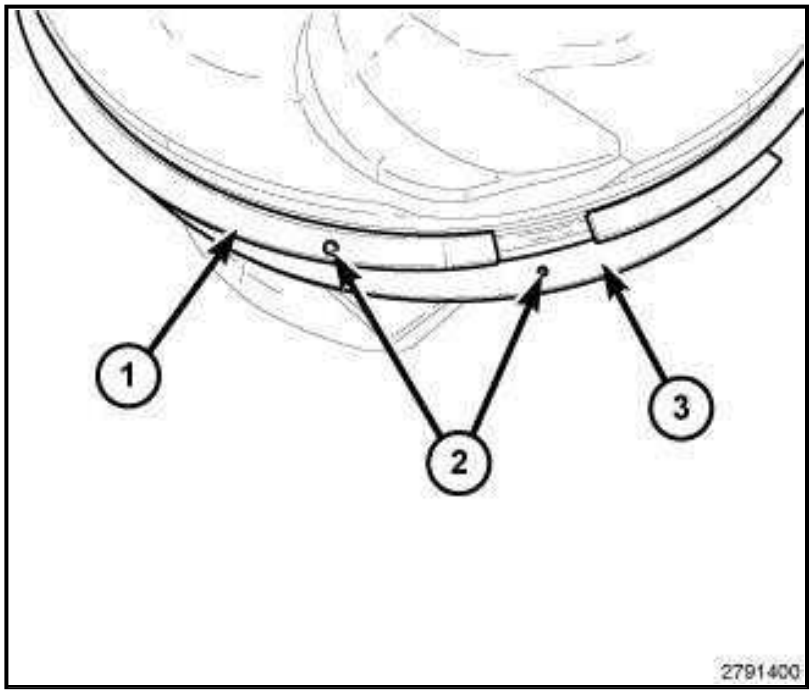
CAUTION: **To avoid damage to the piston rings, they must be installed in the following order:**

- **Oil ring expander (5)**
- **Oil ring lower side rail (4)**
- **Oil ring upper side rail (3)**
- **No. 2 (intermediate) piston ring (2)**
- **No. 1 (upper) piston ring (1)**

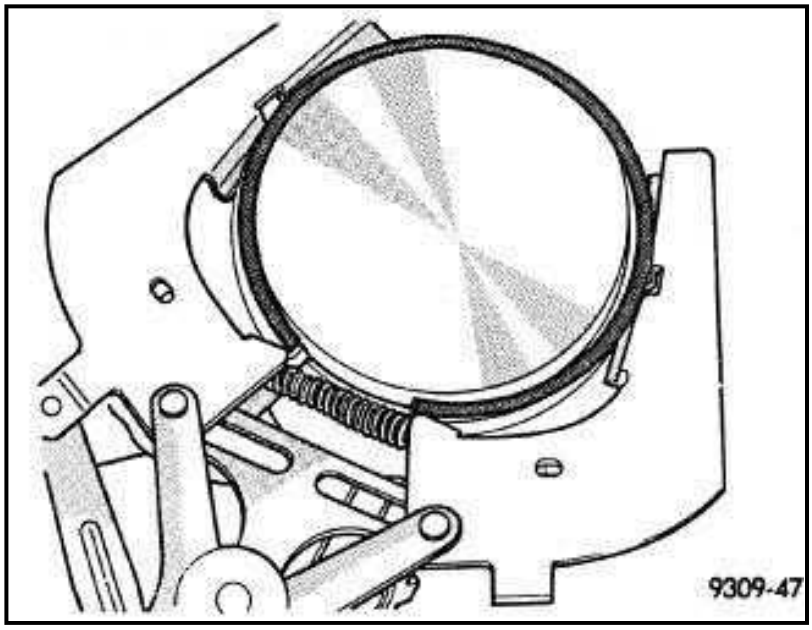


NOTE: **Typical piston shown. Do not use a piston ring expander to install the oil ring side rails.**

2. Install the oil ring expander (1).
3. Install the oil ring lower side rail by placing one end between the piston ring groove and the oil ring expander. Hold this end firmly and press down the portion to be installed until the side rail is in position.
4. Install the oil ring upper side rail in the same manner as the lower side rail.

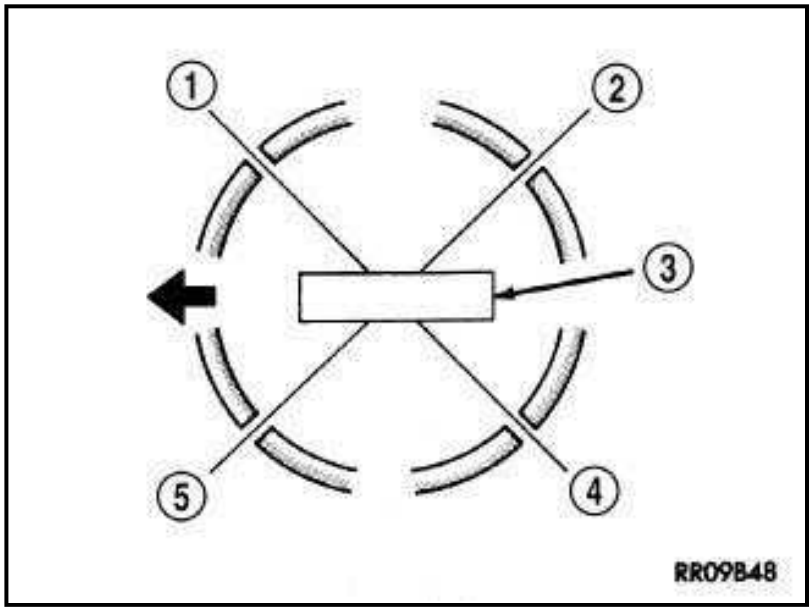


NOTE: **The No. 1 (upper) piston ring (1) and No. 2 (intermediate) piston ring (3) have a different cross section. Install the rings with manufacturers I.D. mark (dot) (2) facing up, towards the top of the piston.**



NOTE: **Typical piston shown.**

5. Install the No. 2 (intermediate) piston ring using a ring expander tool.
6. Install the No. 1 (upper) piston ring using a ring expander tool.
7. Rotate the rings around the piston, the rings must rotate in the grooves with out binding.

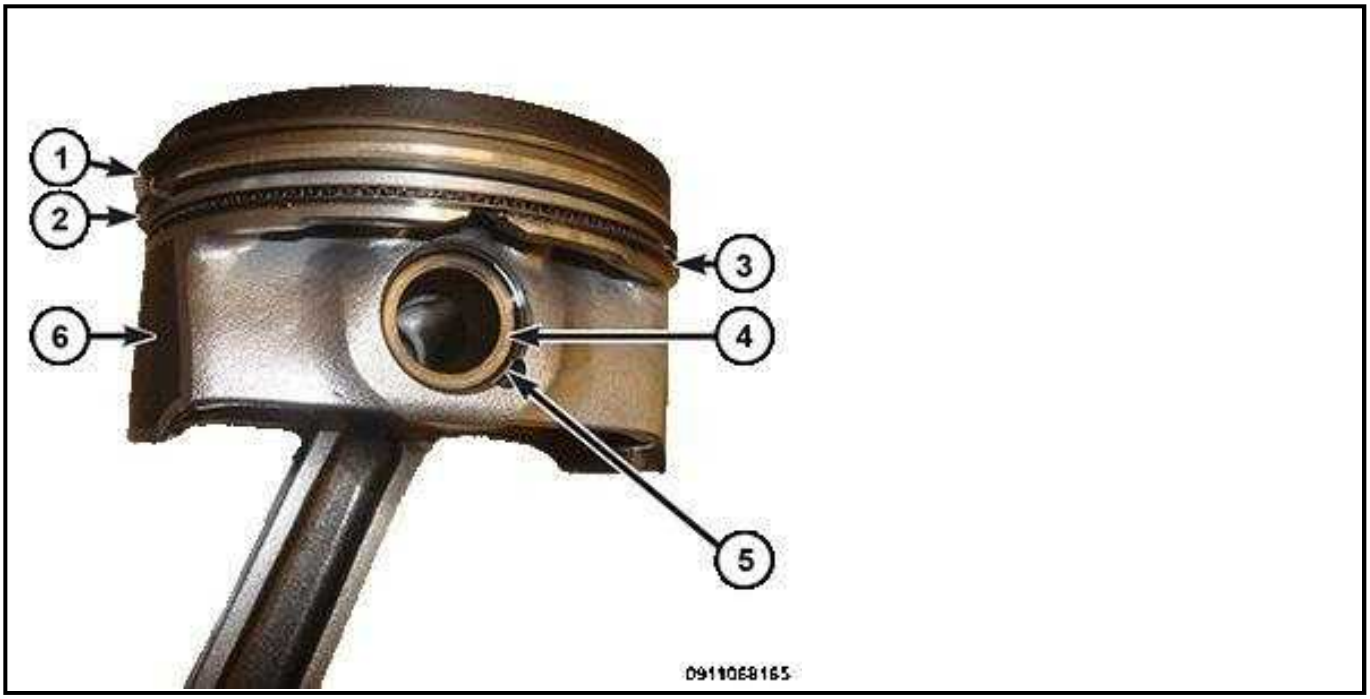


8. Position the piston ring end gaps as follows:
    - Oil ring expander gap (5)
    - Oil ring lower side rail end gap (4)
    - Oil ring upper side rail end gap (1)
    - No. 2 (intermediate) ring end gap (5)
    - No. 1 (upper) ring end gap (2)
9. Install the piston and connecting rod(s). Refer to **ROD, PISTON AND CONNECTING, REMOVAL AND INSTALLATION**.

ROD, PISTON AND CONNECTING

DESCRIPTION AND OPERATION

PISTON AND CONNECTING ROD



1 - Upper Compression Ring
2 - Intermediate Compression Ring
3 - Oil Control Ring
4 - Locking Clip

5 - Pin
6 - Piston Skirt

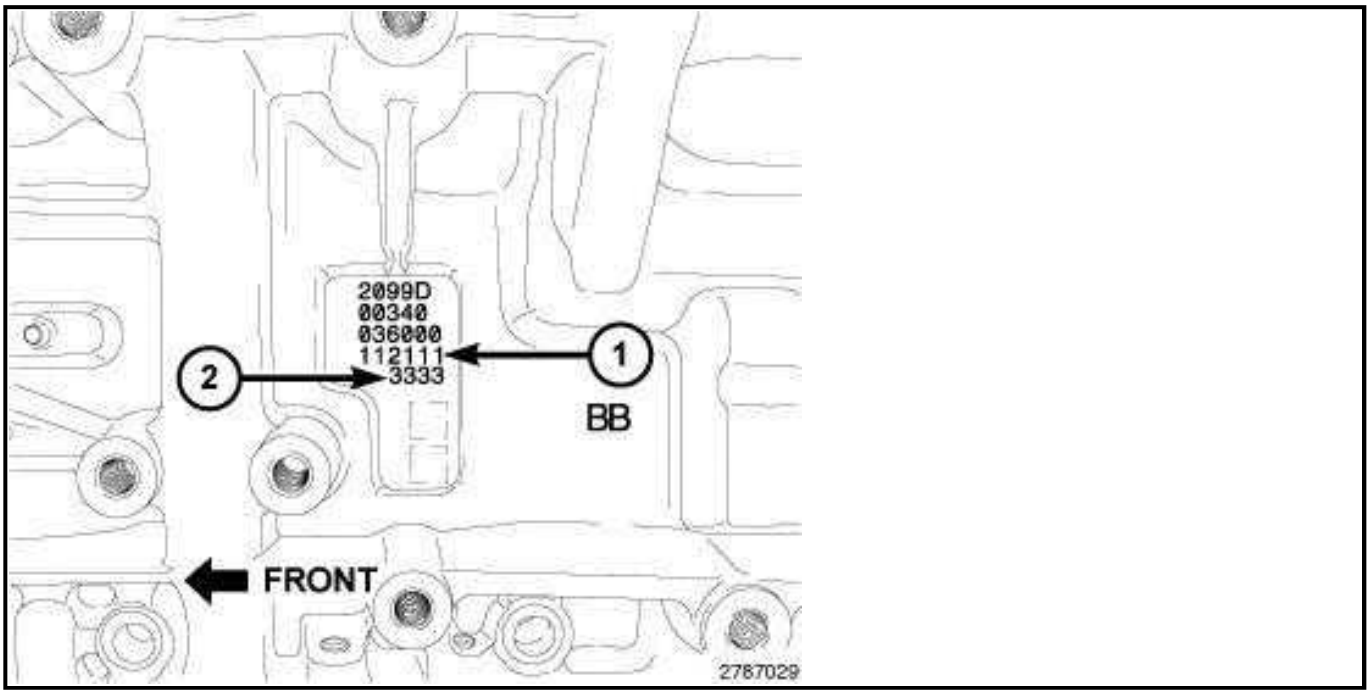
CAUTION: **Do not use a metal stamp to mark connecting rods as damage may result, instead use ink or a scratch awl.**

The pistons are a lightweight design with ultra low tension piston rings for improved fuel economy:

- The pistons are made of a high strength aluminum alloy and the piston skirt has a MolyTB® coating.
- The top piston ring land has an anodized coating for improved wear performance.
- The piston is connected to the rod using a full floating pin with a locking clip on both sides.
- The connecting rod is forged steel with a bolted cracked cap design. The connecting rod bolts are not reusable.
- Pistons are available in two diameters with grade markings for each bore indicated on the side of the cylinder block.
- The upper compression ring is a 1.0 mm steel ring with thermal spray coating.
- The intermediate compression ring is 1.0 mm micro napier design.
- Both compression rings have a dot or a mark on the piston ring. The marked side of the ring must face the top of the piston.
- The 2 mm three piece oil control ring is very thin.

STANDARD PROCEDURE

PISTON FITTING



The pistons are "select fit" to achieve proper oil clearance. Engine block cylinder bore diameter grade markings (1) are stamped into the left side of the engine block. These marks are read from left to right, corresponding with cylinder number 1, 2, 3, 4, 5, 6.

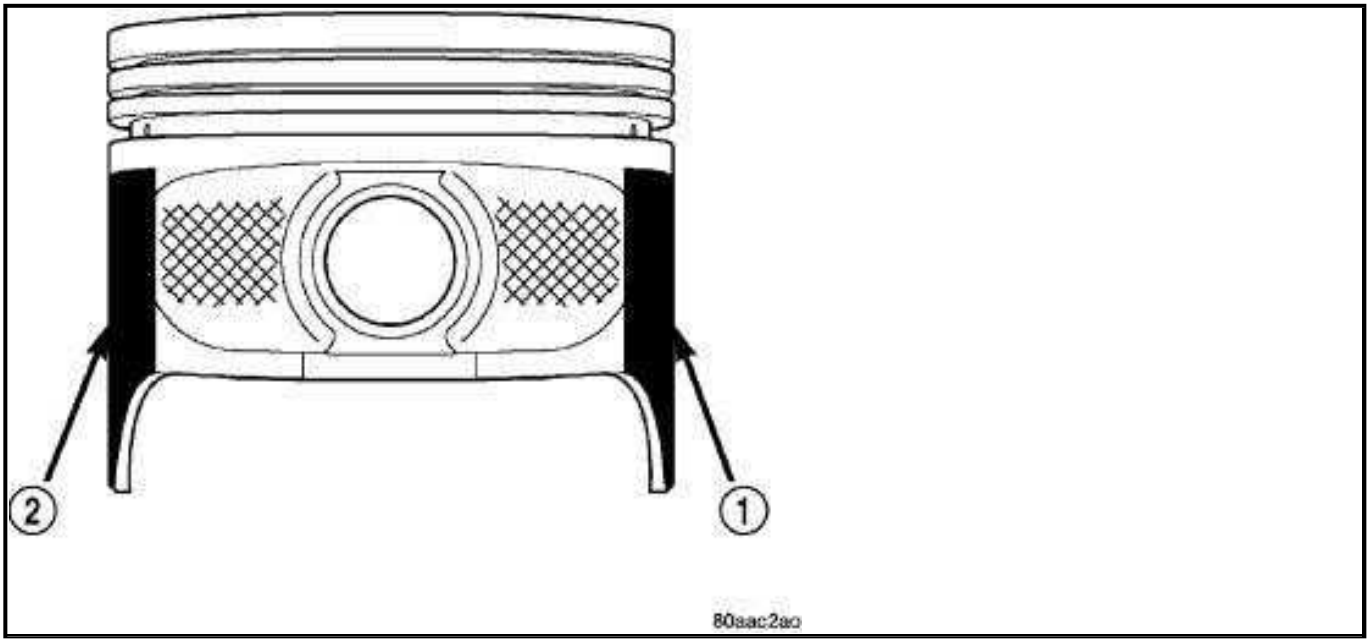
Engine block cylinder bore diameter grade markings correspond to specific cylinder bore diameters. The chart below identifies the two engine block grade markings and their associated cylinder bore diameters.

Engine Block Marking	Cylinder Bore Size mm (in.)
1	95.995 B± 0.005 mm (3.7793 B± 0.0002 in.)
2	96.005 B± 0.005 mm (3.7797 B± 0.0002 in.)

The piston is marked with the piston size 1 and 2 on the piston crown. The pistons are available in two different sizes in order to achieve the desired oil clearance. Select the piston size that corresponds to the engine block cylinder bore diameter grade markings for each cylinder.

Pistons are available in two sizes. The chart below identifies the two piston sizes.

Piston Marking	Size mm (in.)	
	Metal to Metal	Metal to Coating
1	95.995 B± 0.005 mm (3.7793 B± 0.0002 in.)	95.970 - 96.000 mm (3.7783 - 3.7795 in.)
2	95.965 B± 0.005 mm (3.7781 B± 0.0002 in.)	95.980 - 96.010 mm (3.7787 - 3.7799 in.)



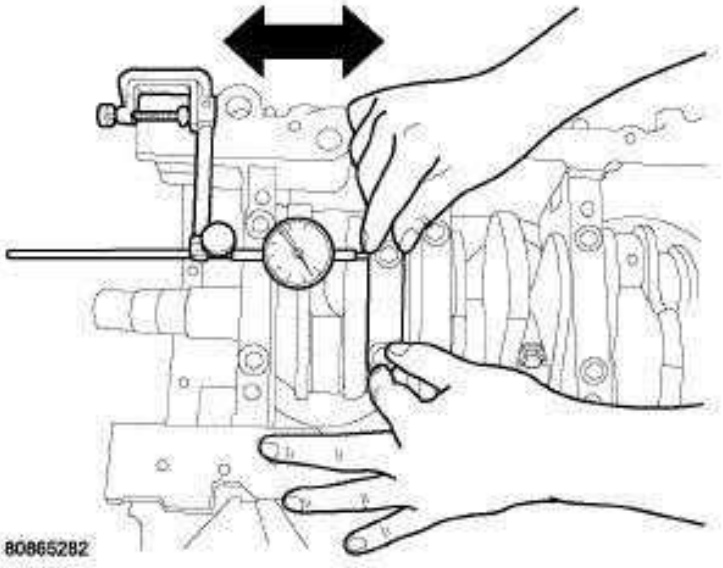
1 - Coating Material
2 - Coating Material

NOTE: Typical coated piston shown.

The coated pistons are serviced with the piston pin and connecting rod pre-assembled. The coating material is applied to the piston after the final piston machining process. Piston installation into the cylinder bore requires slightly more pressure than that required for non-coated pistons. The bonded coating on the piston will give the appearance of a line-to-line fit with the cylinder bore.

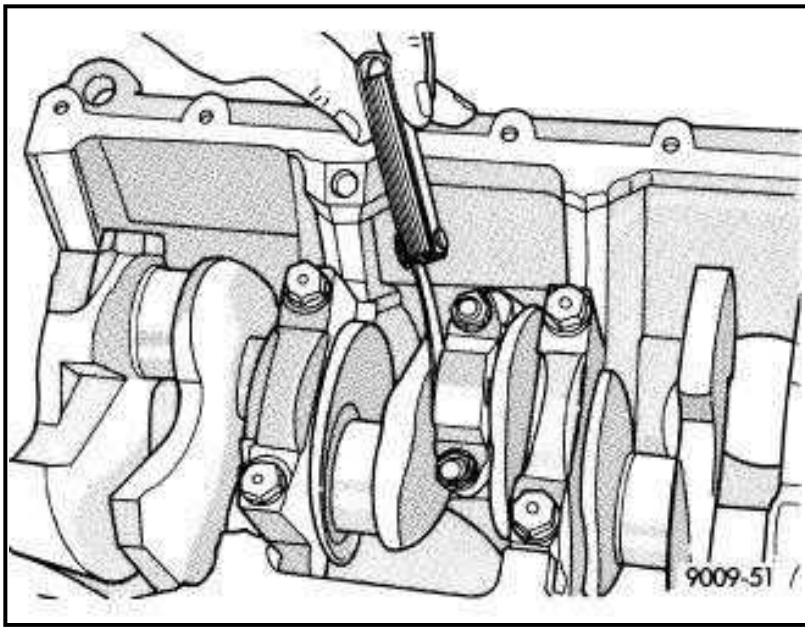
CONNECTING ROD SIDE CLEARANCE

DIAL INDICATOR



1. Mount Dial Indicator Set (special tool #C-3339A, Set, Dial Indicator) to a stationary point on the engine. Locate the probe perpendicular to and resting against the connecting rod cap being checked.
2. Move the connecting rod all the way to the rear of its travel.
3. Zero the dial indicator.
4. Move the connecting rod forward to the limit of travel and read the dial indicator. Compare the measured side clearance to the. Refer to **ENGINE SPECIFICATIONS** .
5. Repeat this procedure for each connecting rod. Rotate the crankshaft for connecting rod accessibility.

FEELER GAUGE



1. Slide a snug-fitting feeler gauge between the connecting rod and crankshaft journal flange. Compare the measured side clearance to the proper specifications. Refer to **ENGINE SPECIFICATIONS** .
2. Repeat this procedure for each connecting rod. Rotate the crankshaft for connecting rod accessibility.

CLEANING

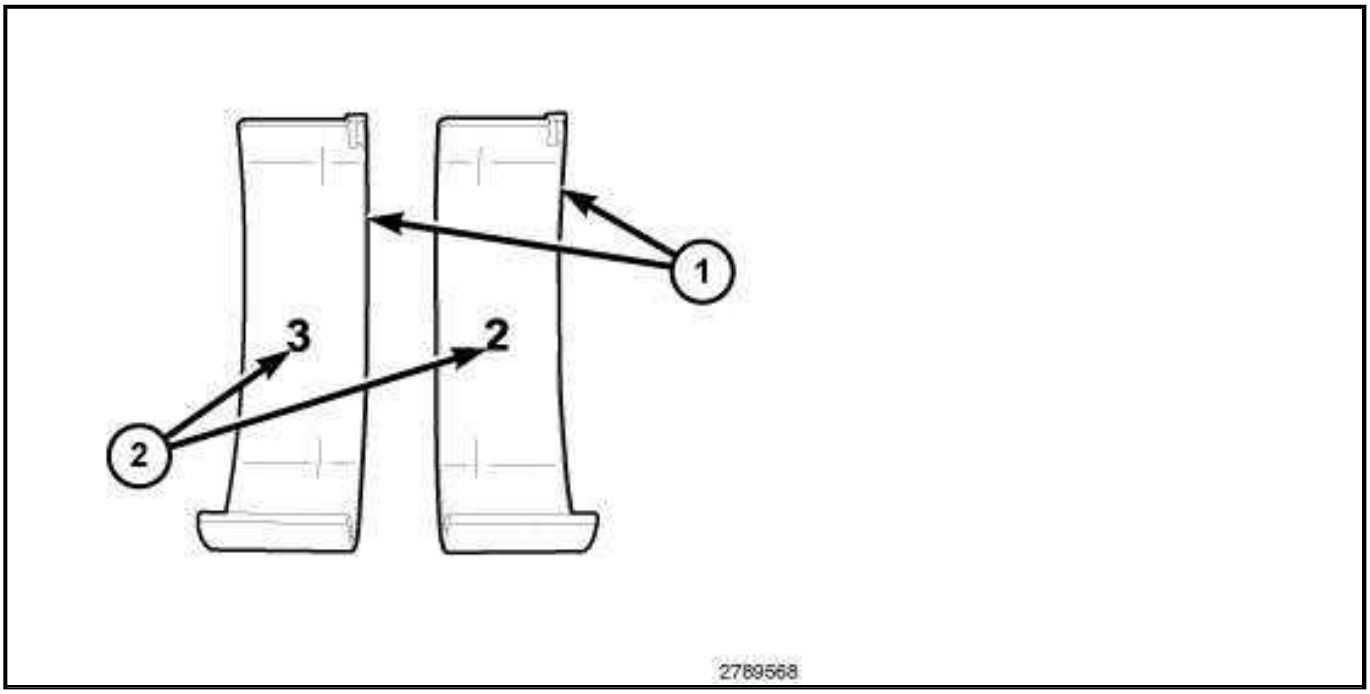
CAUTION: **DO NOT use a wire wheel or other abrasive cleaning devise to clean the pistons or connecting rods. The pistons have a Moly coating, this coating must not be damaged.**

CAUTION: **Do not remove the piston pin from the piston and connecting rod assembly.**

1. Clean the pistons in warm water using a suitable cleaning solvent and then towel dry.
2. Use a wood or plastic scraper to clean the ring land grooves.

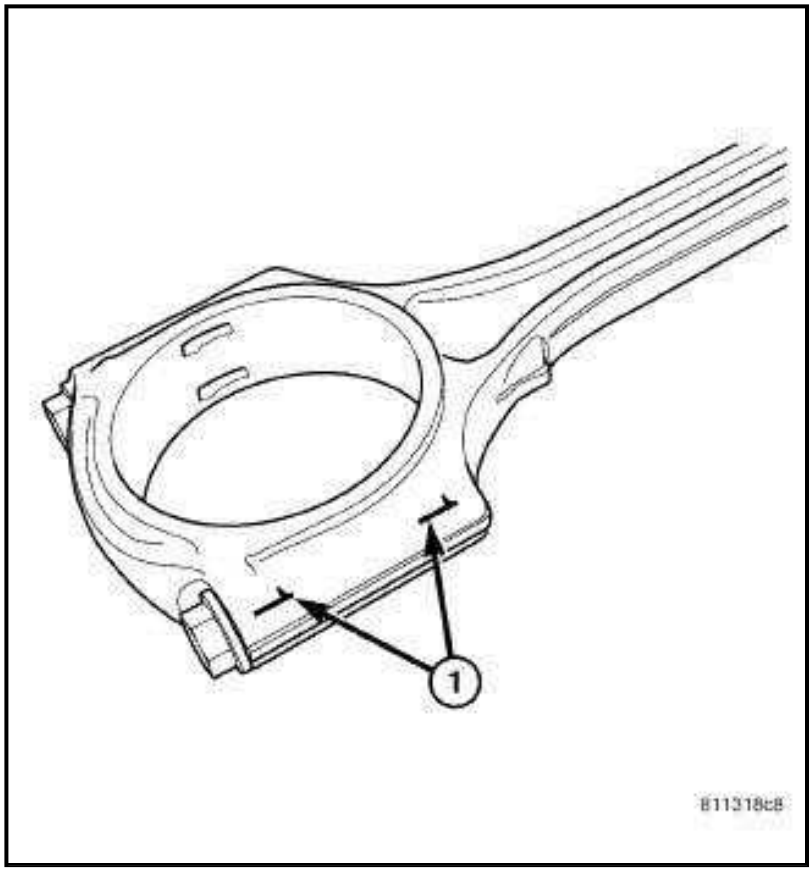
INSPECTION

PISTON AND CONNECTING ROD



1 - Rod Bearing
2 - Rod Bearing

1. Wipe the inserts clean.
2. Inspect the inserts for abnormal wear patterns, scoring, grooving, fatigue, pitting and for metal or other foreign material imbedded in the lining.
3. Inspect the back of the inserts for fractures, scrapes, or irregular wear patterns.
4. Inspect the insert locking tabs for damage.
5. Replace any bearing that shows abnormal wear. Refer to **BEARING(S), CONNECTING ROD, STANDARD PROCEDURE**.



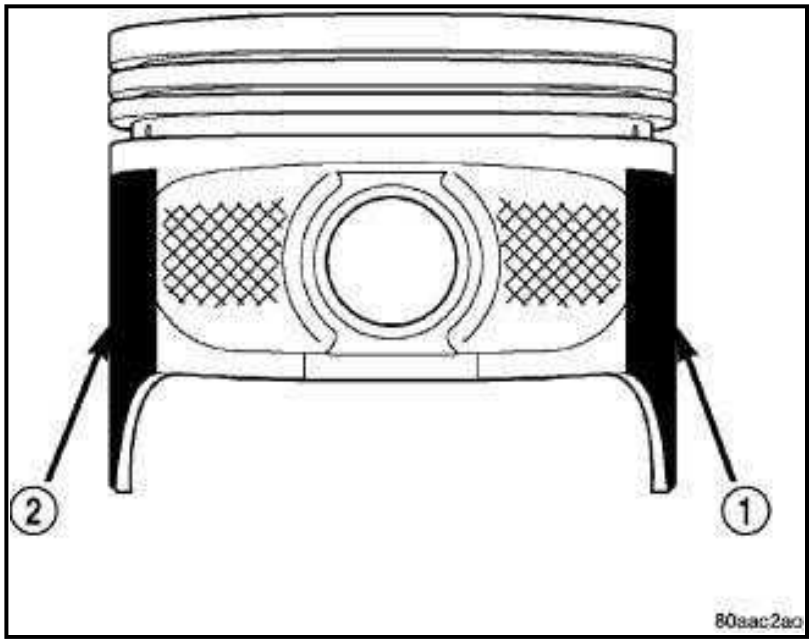
1 - Position Indicator

6. Inspect the connecting rod bearing bores for signs of scoring, nicks and burrs.

NOTE: **Misaligned or bent connecting rods can cause abnormal wear on pistons, piston rings, cylinder walls, connecting rod bearings and crankshaft connecting rod journals. If wear patterns or damage to any of these components indicate the probability of a misaligned connecting rod, inspect it for correct rod alignment.**

7. Replace misaligned, bent or twisted connecting rods.

NOTE: **Connecting rods are serviced with the piston pre-assembled. The pistons are "select fit" to achieve proper oil clearance. Refer to ROD, PISTON AND CONNECTING, STANDARD PROCEDURE.**



1 - Coating Material
2 - Coating Material

NOTE: **Typical coated piston shown.**

8. Inspect the piston for scoring or scraping marks in the piston skirts. Check the ring lands for cracks and/or deterioration.
9. Check the piston for taper and out of round shape.

NOTE: **The coating material is applied to the piston after the final piston machining process. Measuring the outside diameter of a coated piston will not provide accurate results. Therefore measuring the inside diameter of the cylinder bore with a dial Bore Gauge is MANDATORY . Refer to ENGINE BLOCK, INSPECTION.**

10. Compare the measured cylinder bore diameter to the engine block cylinder bore grade marking chart. Refer to **ROD, PISTON AND CONNECTING, STANDARD PROCEDURE**. Select the piston size that corresponds to the engine block markings for each cylinder to provide the proper oil clearance.

NOTE: **Piston installation into the cylinder bore requires slightly more pressure than that required for non-coated pistons. The bonded coating on the piston will give the appearance of a line-to-line fit with the cylinder bore.**

NOTE: **The coated pistons will be serviced with the piston pin and connecting rod pre-assembled.**

REMOVAL AND INSTALLATION

REMOVAL AND INSTALLATION

REMOVAL

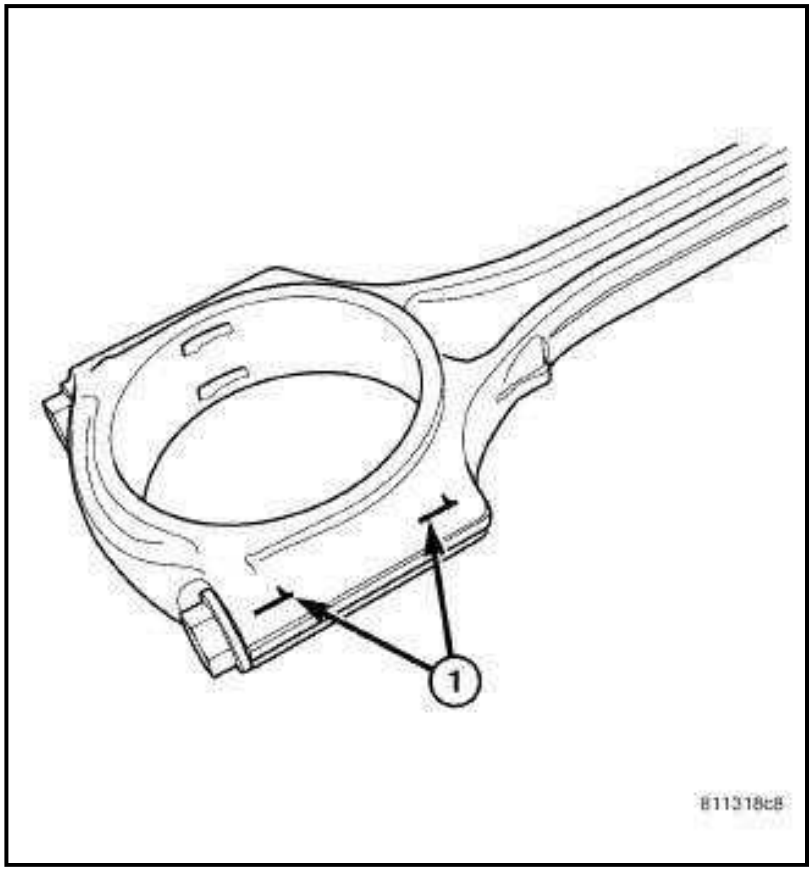
1. Remove the oil pan, engine timing cover and cylinder head(s). Refer to **CYLINDER HEAD ASSEMBLY, REMOVAL AND INSTALLATION**.

NOTE: **It is only necessary to remove the corresponding cylinder head.**

2. Remove the engine oil pump. Refer to **PUMP, ENGINE OIL, REMOVAL AND INSTALLATION**.

Fig. 18: Main Bearing Cap Bolts Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

3. Remove the eight main bearing cap bolts from the windage tray reversing the sequence shown, starting with 8 then ending with 1 and remove the windage tray.

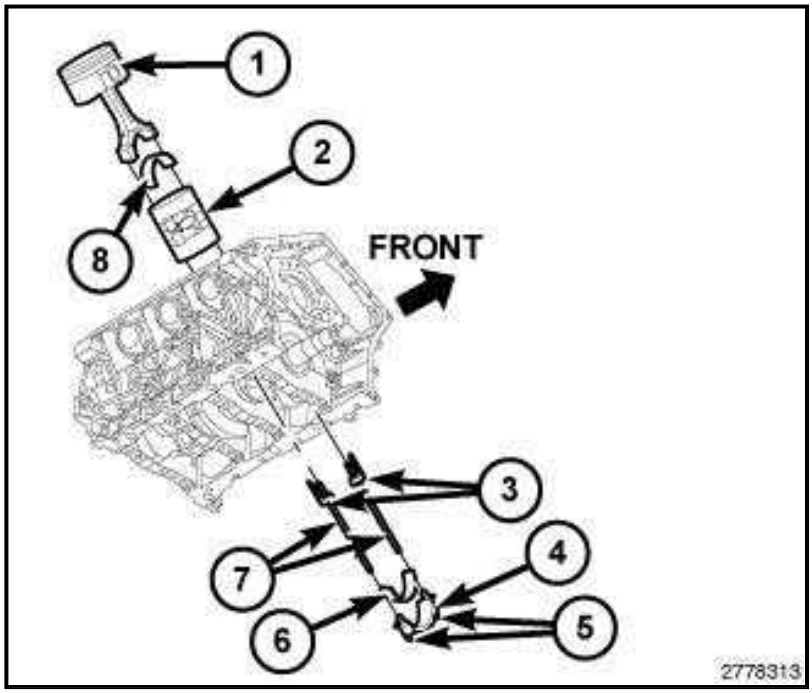


4. If necessary, remove the top ridge of the cylinder bores with a reliable ridge reamer before removing the pistons from the engine block. **Be sure to keep the tops of pistons covered during this operation.** Pistons and connecting rods must be removed from the top of the engine block. When removing piston and connecting rod assemblies from the engine, rotate the crankshaft clockwise so that each connecting rod is centered in the cylinder bore.

CAUTION: **DO NOT use a number stamp or a punch to mark connecting rods or caps, as damage to connecting rods could occur.**

NOTE: **Connecting rods and bearing caps are not interchangeable and should be marked before removing to ensure correct reassembly.**

5. Mark connecting rod and bearing cap positions (1) using a permanent ink marker or scribe tool.



NOTE: **Typical V6 engine configuration shown.**

CAUTION: **Care must be taken not to damage the fractured rod and cap joint face surfaces, as engine damage may occur.**

6. Remove the connecting rod cap bolts (5) and the connecting rod cap (4). Discard the cap bolts.

CAUTION: **Care must be taken not to nick crankshaft journals, as engine damage may occur.**

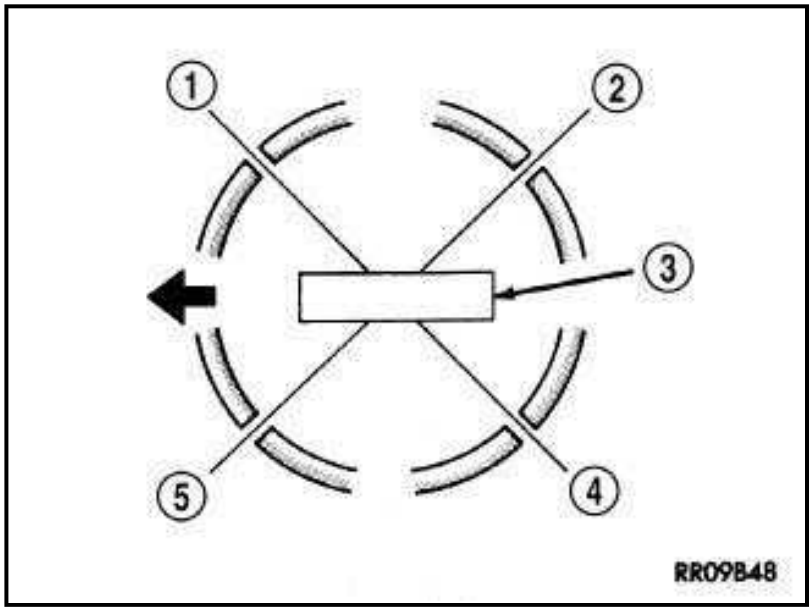
7. Remove the plastic guide plates (3) from the Guide Pins (special tool #8189, Guide Pins) (7) and install the Guide Pins to the connecting rod being removed.

CAUTION: **Avoid contact with the piston oil cooler jet(s). Positioning of the oil cooler jet(s) is critical for proper engine operation.**

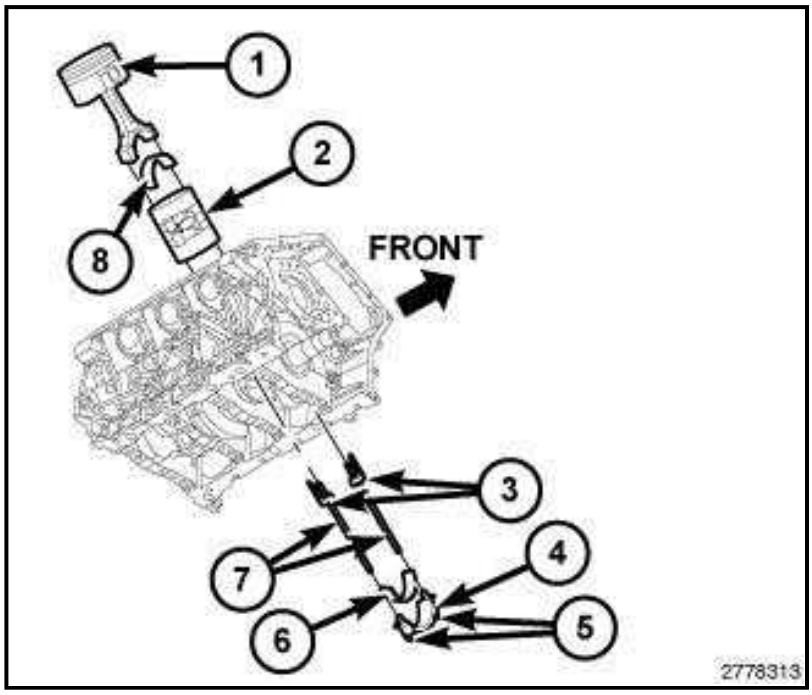
8. Remove the piston and connecting rod (1) from cylinder bore.
9. Repeat the previous steps for each piston being removed.
10. Immediately after piston and connecting rod removal, reinstall the bearing cap (4) on the mating connecting rod to prevent damage to the fractured cap and rod surfaces.
11. If required, remove the piston rings. Refer to **RING(S), PISTON, REMOVAL AND INSTALLATION**.
12. Repeat the previous steps for each piston being removed.

INSTALLATION

1. If required, select and fit new piston and connecting rod assemblies to the engine block. Refer to **ROD, PISTON AND CONNECTING, STANDARD PROCEDURE**.
2. If required, select and fit new bearings to the connecting rod. Refer to **BEARING(S), CONNECTING ROD, STANDARD PROCEDURE**.
3. If required, hone the cylinder bores. Refer to **CYLINDER BORE DEGLAZING** .
4. If removed, install the piston rings. Refer to **RING(S), PISTON, REMOVAL AND INSTALLATION**.



5. Position the piston ring end gaps as follows:
   - Oil ring expander gap (5)
   - Oil ring lower side rail end gap (4)
   - Oil ring upper side rail end gap (1)
   - No. 2 (intermediate) ring end gap (5)
   - No. 1 (upper) ring end gap (2)



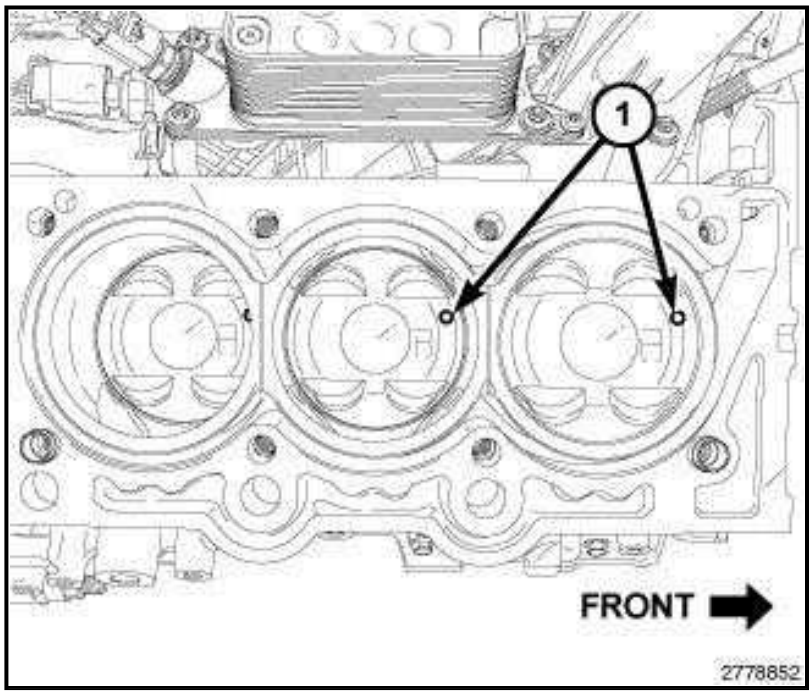
NOTE: **Typical V6 engine configuration shown.**

NOTE: **Ensure the position of the ring end gaps does not change when installing the ring compressor.**

6. Lubricate the piston rings with clean engine oil. Position Piston Compressor (special tool #C-385, Compressor, Piston) (2) over the piston and rings. Tighten the compressor (2).

NOTE: **Install the rod bearings in pairs. Do not mix sizes or use a new bearing half with an old bearing half.**

7. Install the bearing shell (8) on the connecting rod with the tang inserted into the machined groove in the rod. Lubricate the bearing surface with clean engine oil.
8. Remove the plastic guide plates (3) from the Guide Pins (special tool #8189, Guide Pins) (7) and install the Guide Pins to the connecting rod being installed.

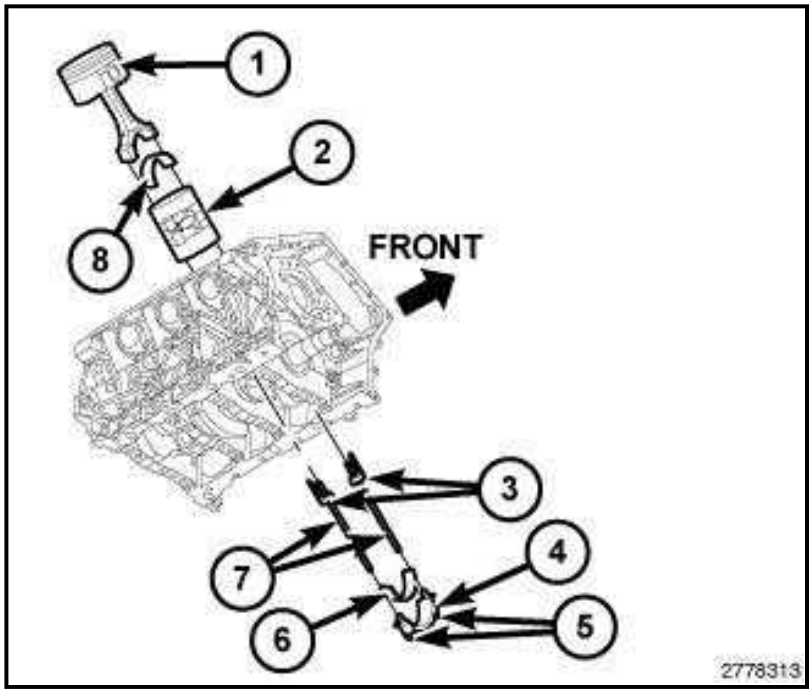


NOTE: **Right cylinder bank shown, left cylinder bank similar.**

9. The pistons crowns are stamped with a mark (1) indicating installation position. This mark must be positioned toward the front of engine on both cylinder banks.
10. Wipe the cylinder bore clean and lubricate with clean engine oil.
11. Rotate the crankshaft until the connecting rod journal is on the center of cylinder bore.

CAUTION: **Avoid contact with the piston oil cooler jet(s). Positioning of the oil cooler jet(s) is critical for proper engine operation.**

12. Insert the piston and connecting rod into the cylinder bore and carefully position the guide pins over the crankshaft journal.
13. Tap the piston down in the cylinder bore using a hammer handle while guiding the connecting rod into position over the rod journal.



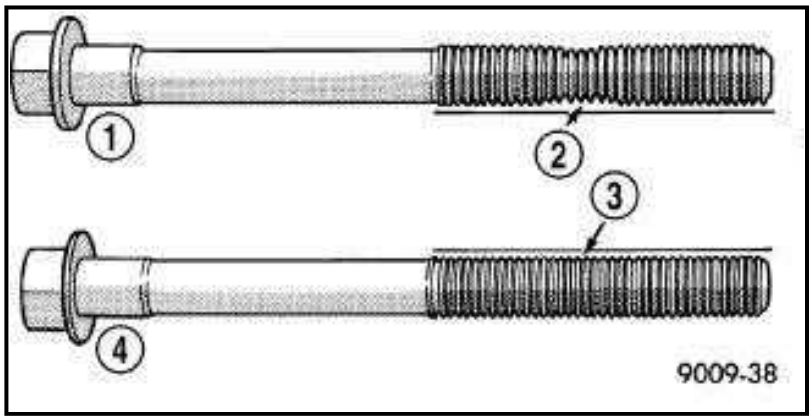
NOTE: **Typical V6 engine configuration shown.**

CAUTION: **The connecting rod bolts must not be reused. Always replace the connecting rod bolts whenever they are loosened or removed.**

14. Install the bearing shell (6) on the connecting rod cap (4) with the tang inserted into the machined groove in the cap. Lubricate the bearing surface with clean engine oil.

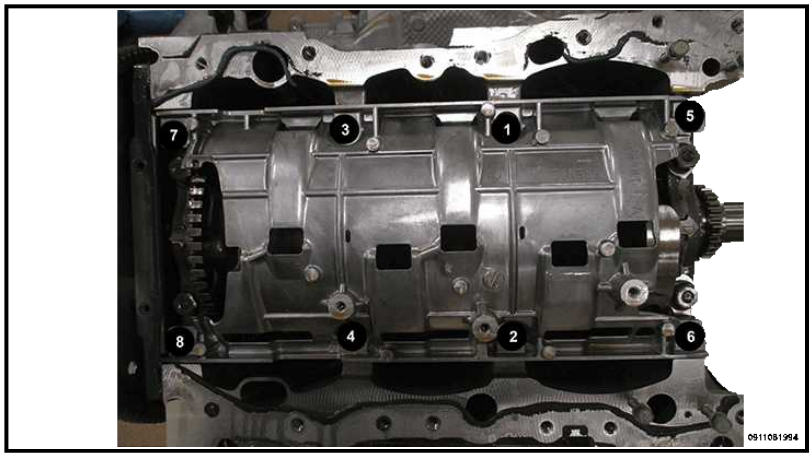
NOTE: **Do not lubricate the threads of the connecting rod cap bolts (5).**

15. Install the connecting rod cap and bearing with the tang on the same side as the rod. Tighten the **NEW** connecting rod cap bolts (5) to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .
16. If required, check the connecting rod side clearance. Refer to **ROD, PISTON AND CONNECTING, STANDARD PROCEDURE**.
17. Repeat the previous steps for each piston being installed.



CAUTION: **The main bearing cap bolts are tightened using a torque plus angle procedure. The bolts must be examined BEFORE reuse. If the threads are necked down the bolts must be replaced.**

18. Check the main bearing cap bolts for necking by holding a scale or straight edge against the threads. If all the threads do not contact the scale (2) the bolt must be replaced.



19. Install the windage tray with eight main bearing cap bolts. Tighten the bolts in the sequence shown to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .
20. Install the engine oil pump and oil pump pick-up. Refer to **PUMP, ENGINE OIL, REMOVAL AND INSTALLATION**.
21. Install the cylinder head(s), engine timing cover and oil pan. Refer to **CYLINDER HEAD ASSEMBLY, REMOVAL AND INSTALLATION**.
22. Install a **NEW** oil filter and fill the engine crankcase with the proper oil to the correct level. Refer to **LUBRICATION** .
23. Operate the engine until it reaches normal operating temperature. Check cooling system for correct fluid level.

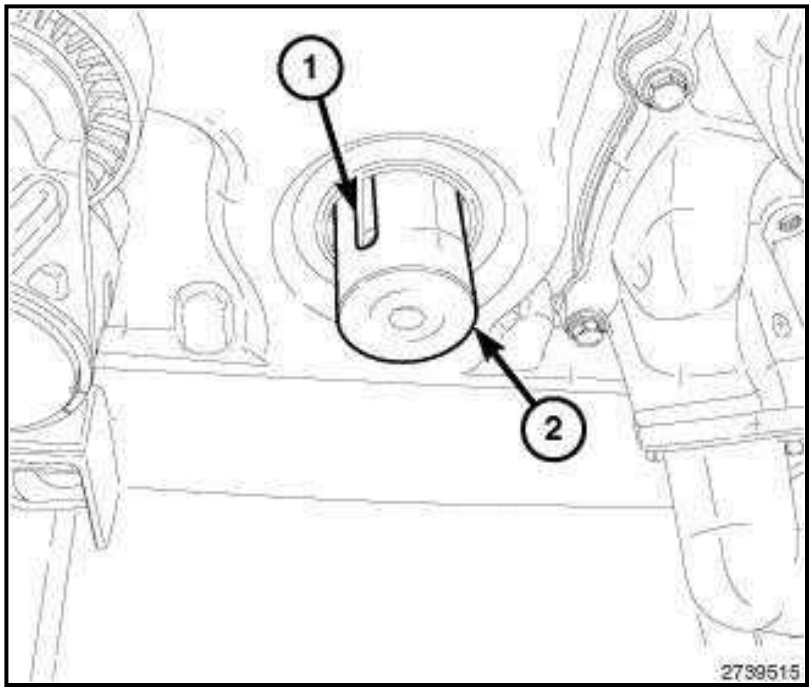
SEAL, CRANKSHAFT OIL, FRONT

REMOVAL AND INSTALLATION

FRONT CRANKSHAFT OIL SEAL

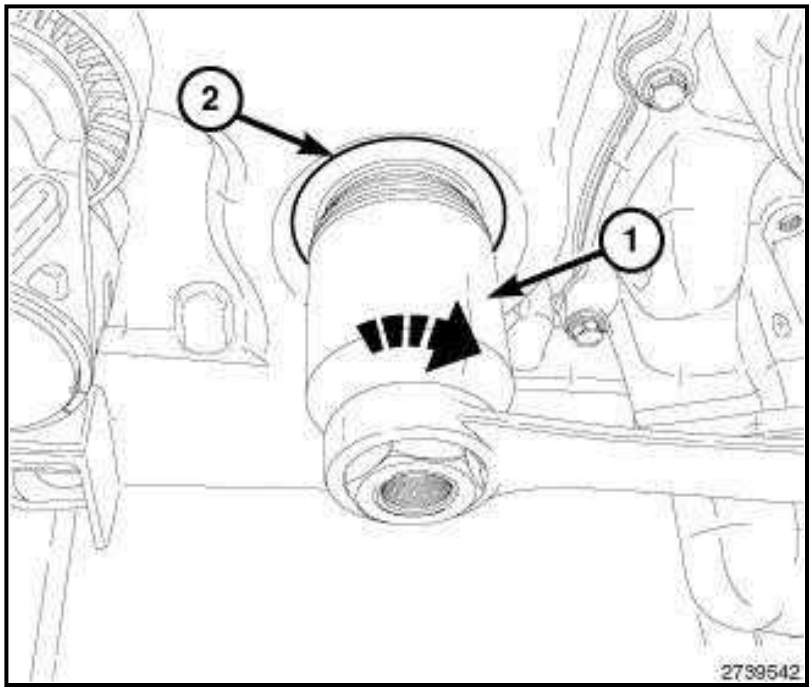
REMOVAL

1. Remove the crankshaft vibration damper. Refer to **DAMPER, VIBRATION, REMOVAL AND INSTALLATION**.



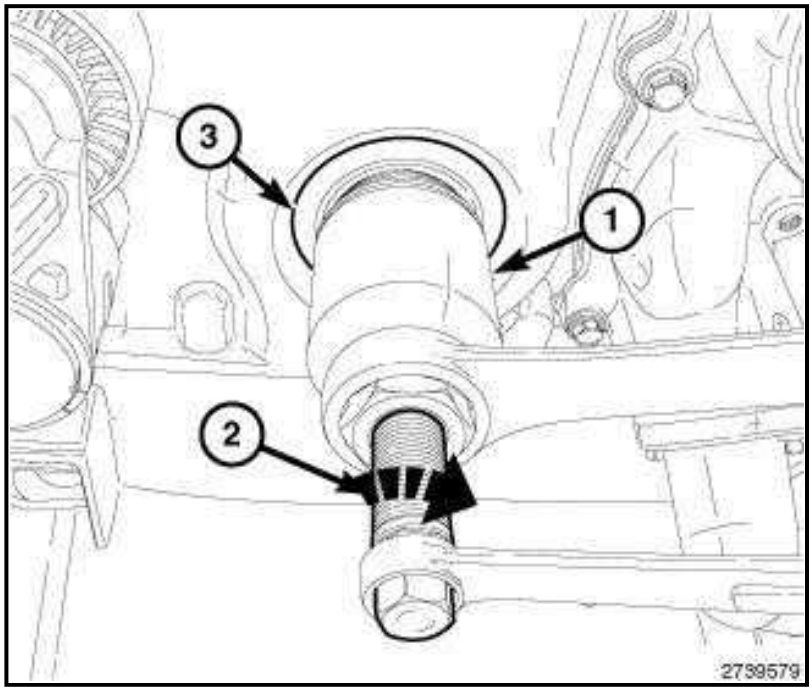
1 - Flywheel Key
2 - Sleeve

2. Install the sleeve from Seal Remover (special tool #8511, Remover, Seal) around the flywheel key and onto the nose of the crankshaft.



1 - Screw Seal Remover
2 - Front Crankshaft Oil Seal

3. Install the Screw Seal Remover (special tool #8511, Remover, Seal) into the front crankshaft oil seal.

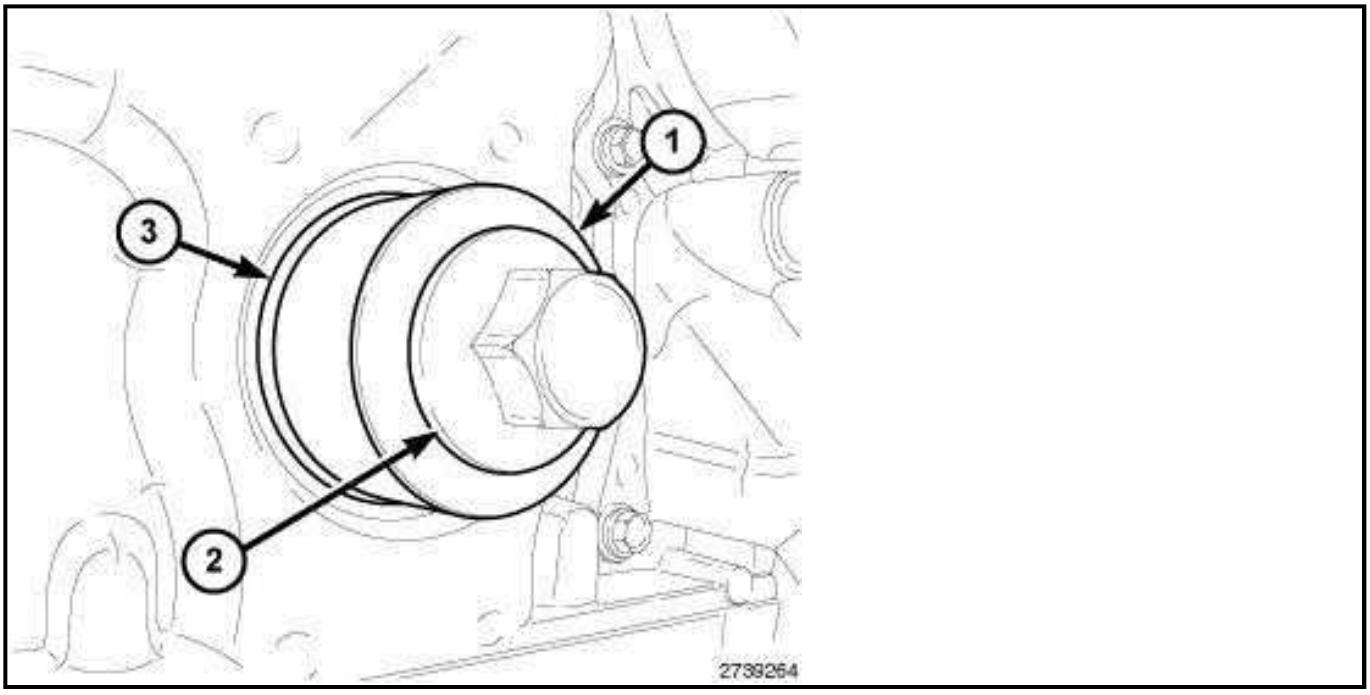


1 - Seal Remover
2 - Extractor Screw
3 - Front Crankshaft Oil Seal

4. Install the extractor screw into the Seal Remover (special tool #8511, Remover, Seal). Hold the seal remover stationary and tighten the extractor screw against the sleeve until the front crankshaft oil seal is removed from the engine timing cover.

INSTALLATION

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



1 - Front Crankshaft Seal Installer
2 - Vibration Damper Bolt
3 -Front Crankshaft Oil Seal

1. Position the front crankshaft oil seal to engine timing cover.
2. Align the Front Crankshaft Seal Installer (special tool #10199, Installer, Crankshaft Front Oil Seal) to the flywheel key on the crankshaft and against the front crankshaft oil seal.

CAUTION: **Only tighten the crankshaft vibration damper bolt until the oil seal is seated in the cover. Overtightening of the bolt can crack the front timing cover.**

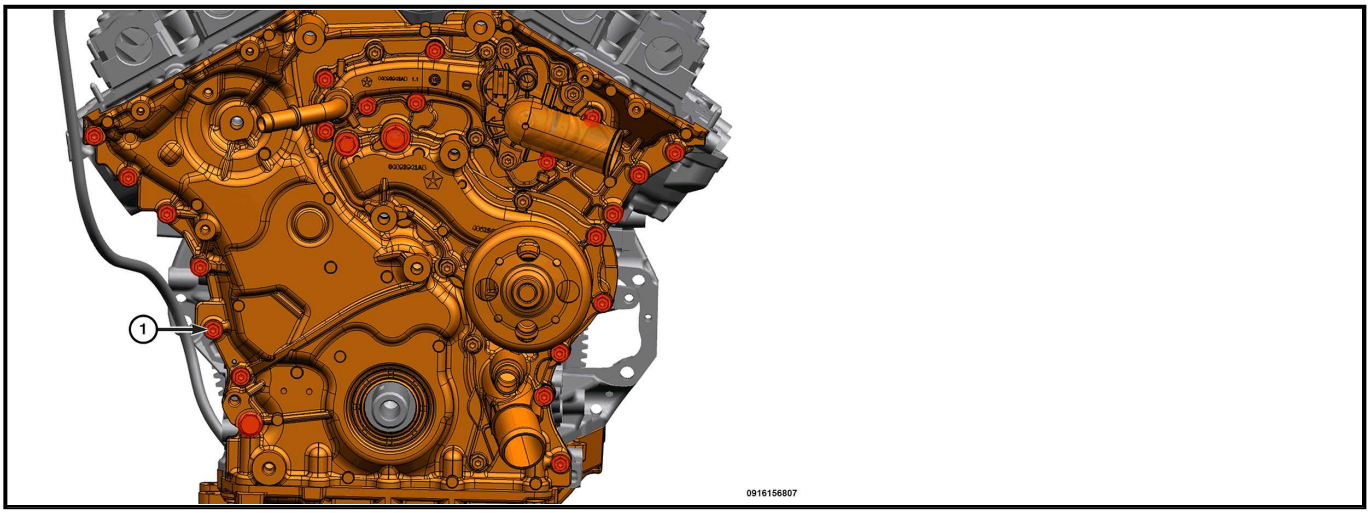
3. Install and tighten the vibration damper bolt until the crankshaft oil seal is seated in the engine timing cover.
4. Install the vibration damper. Refer to **DAMPER, VIBRATION, REMOVAL AND INSTALLATION**.

TORQUE SPECIFICATIONS

FRONT ENGINE

DESCRIPTION	SPECIFICATION	COMMENTS
Center Idler Pulley Bracket Bolts	**M8 Bolts - 25 N.m (18 Ft. Lbs.) M10 Bolts - 55 N.m (41 Ft. Lbs.)**	-
Center Idler Pulley Bracket to Generator Bolts	**24 N.m (18 Ft. Lbs.)**	-
Center Idler Pulley Bolt	**50 N.m (37 Ft. Lbs.)**	-
Left Idler Pulley Bolt	**25 N.m (18 Ft. Lbs.)**	-
Right Idler Pulley Bracket Bolts	**24 N.m (18 Ft. Lbs.)**	-
Right Idler Pulley Bolt	**25 N.m (18 Ft. Lbs.)**	-
Vibration Damper M16 Bolt	**Torque Procedure:**	-

DESCRIPTION	SPECIFICATION	COMMENTS
	1. **40 N.m (30 Ft. Lbs.)** 2. **Rotate additional + 105B°**	
Belt Tensioner Bolt	**50 N.m (37 Ft. Lbs.)**	-
Engine Timing Cover M6 Bolts Engine Timing Cover M8 Bolt Engine Timing Cover M10 Bolts	**12 N.m (9 Ft. Lbs.)** **25 N.m (18 Ft. Lbs.)** **55 N.m (41 Ft. Lbs.)**	**Tighten in a criss-cross pattern**



SEAL, CRANKSHAFT OIL, REAR

REMOVAL AND INSTALLATION

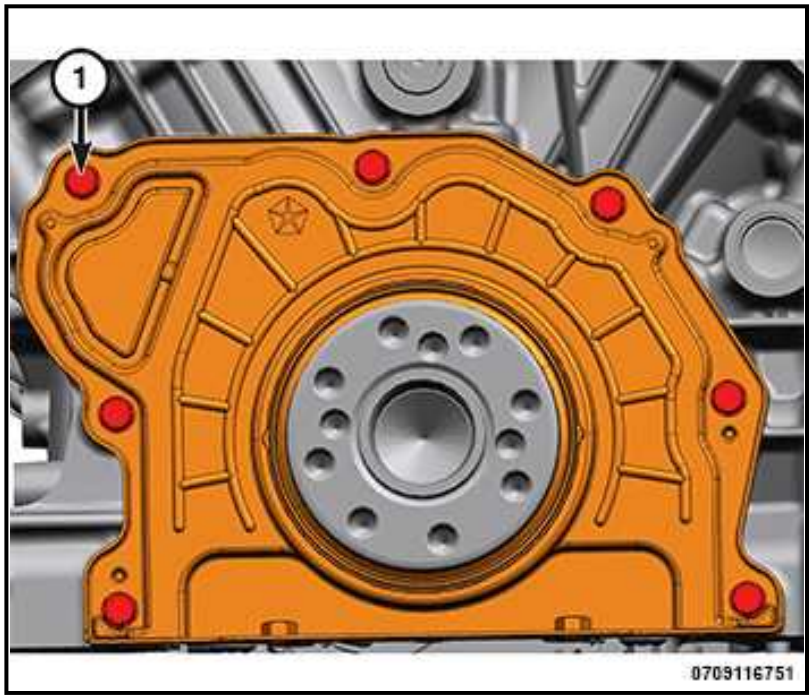
REMOVAL AND INSTALLATION

REMOVAL

1. Remove the oil pan. Refer to **PAN, OIL, REMOVAL AND INSTALLATION**.

CAUTION: **Do not attempt to support the weight of the engine on the windage tray. The windage tray is a thin cast aluminum construction and can be easily damaged.**

2. Support the rear of the engine with a screw-jack when removing the transmission. Position the support on the engine oil pan flange and not the windage tray.
3. Remove the flexplate. Refer to **FLEXPLATE, REMOVAL AND INSTALLATION** .



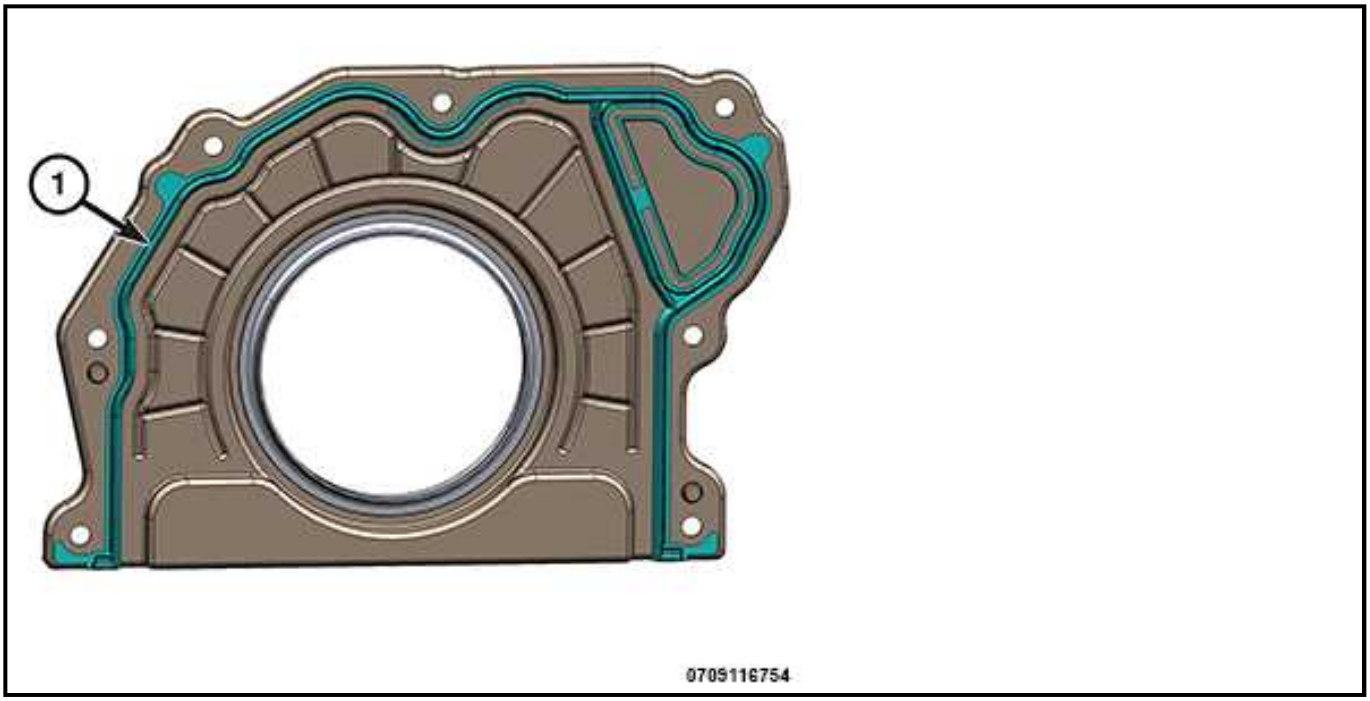
1 - Rear Oil Seal Retainer Bolts

NOTE: **The rear crankshaft oil seal is incorporated into the seal retainer and can not be removed from the retainer. The rear crankshaft oil seal and seal retainer are serviced as an assembly.**

4. Remove the seven seal retainer mounting bolts.
5. Remove and discard the seal retainer.

INSTALLATION

CAUTION: **Whenever the crankshaft is replaced, the rear crankshaft oil seal must also be replaced. Failure to do so may result in engine fluid leakage.**

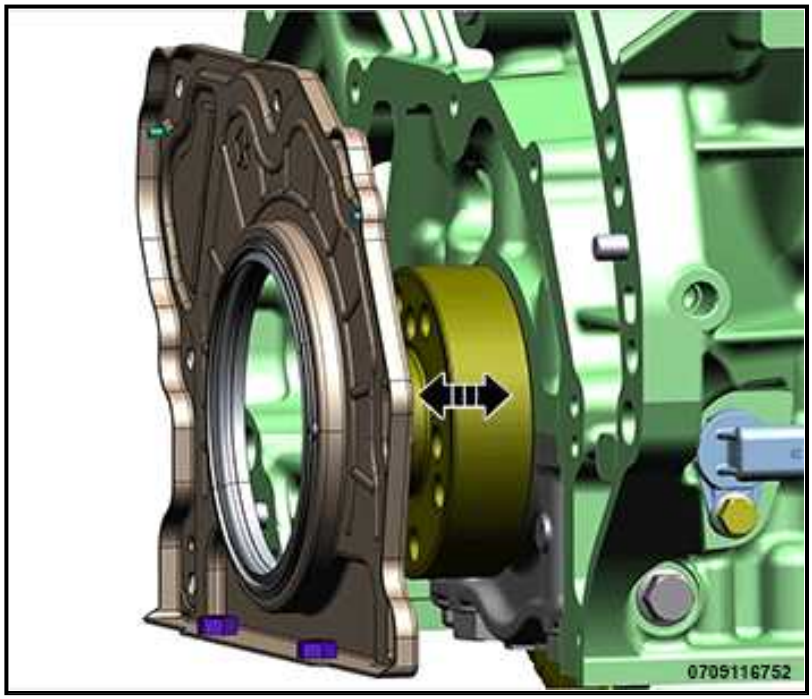


1 - Rear Oil Seal Retainer Gasket

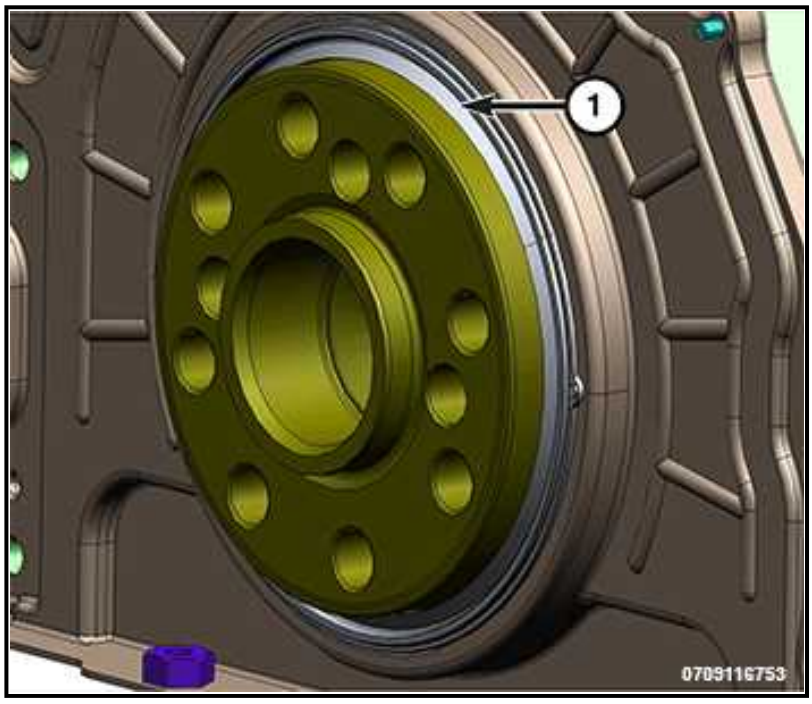
1. Inspect the gasket for damage. If any issues are found, the seal retainer must be replaced.

2. Inspect the crankshaft to make sure there are no nicks or burrs on the seal surface.
3. Clean the engine block sealing surfaces thoroughly.

NOTE: **It is not necessary to lubricate the seal or the crankshaft when installing the seal retainer. Residual oil following installation can be mistaken for seal leakage.**

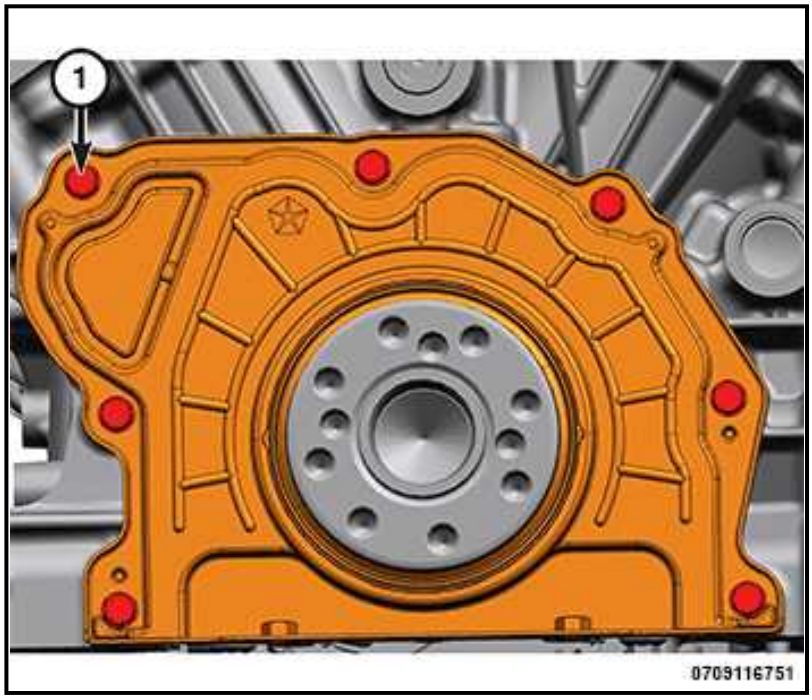


4. Carefully position the oil seal retainer assembly, and seal protector on the crankshaft and push firmly into place on the engine block (during this step, the seal protector will be pushed from the rear oil seal assembly as a result of installing the rear oil seal).



1 - Rear Oil Seal Lip

5. Verify that the seal lip on the retainer is uniformly curled inward toward the engine on the crankshaft.



1 - Rear Oil Seal Retainer Bolts

NOTE: **Make sure that the seal retainer flange is flush with the engine block oil pan sealing surface.**

6. Install the seven seal retainer bolts (1) and tighten to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .
7. Install the flexplate. Refer to **FLEXPLATE, REMOVAL AND INSTALLATION** .
8. Install the oil pan. Refer to **PAN, OIL, REMOVAL AND INSTALLATION**.
9. Fill the engine crankcase with the proper oil to the correct level. Refer to **CAPACITIES AND RECOMMENDED FLUIDS, SPECIFICATIONS** .

ENGINE MOUNTING

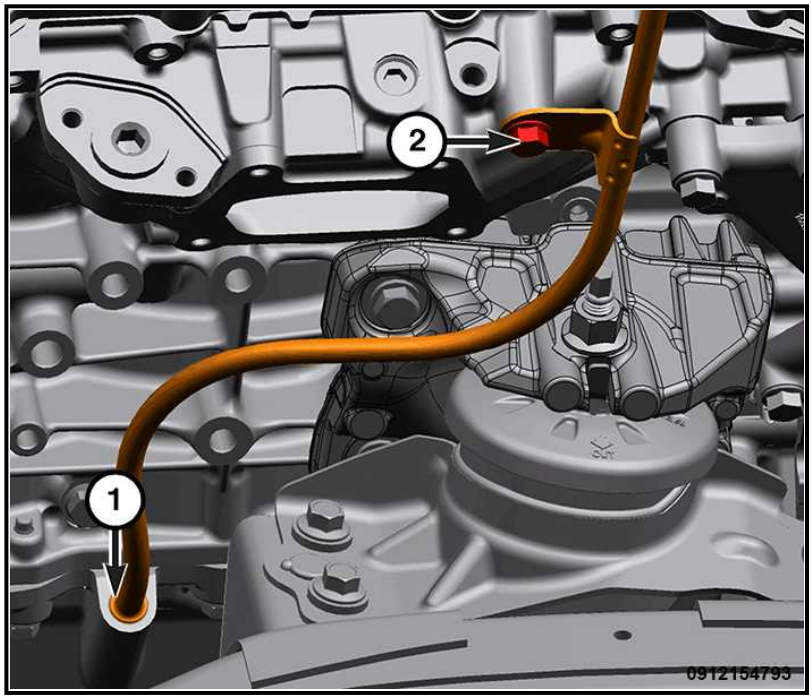
INSULATOR, ENGINE MOUNT, LEFT

REMOVAL AND INSTALLATION

LEFT ENGINE MOUNT

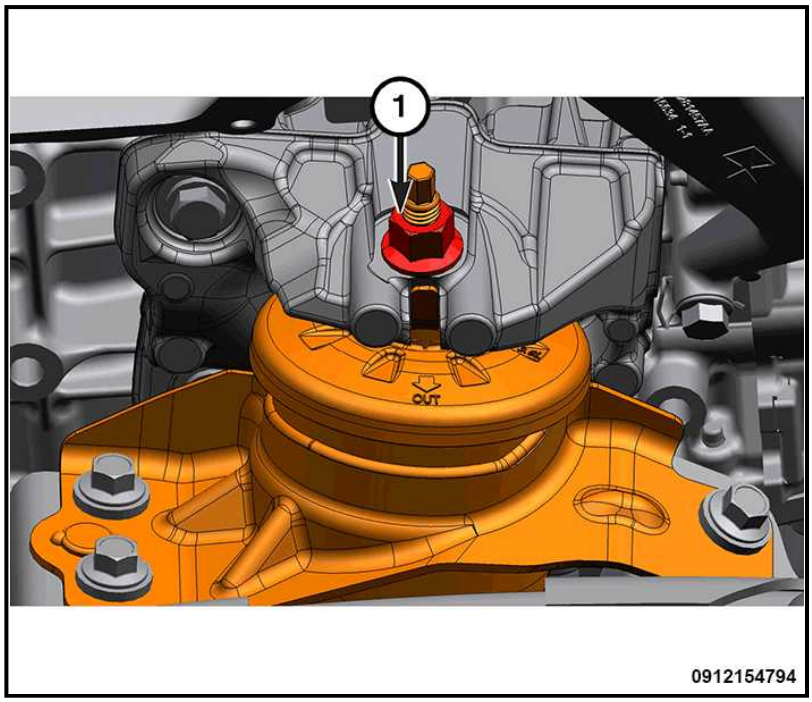
REMOVAL

1. Remove the front tires and wheels. Refer to **REMOVAL AND INSTALLATION** .
2. Remove the right front splash shield. Refer to **SHIELD, SPLASH, REAR WHEELHOUSE, REMOVAL AND INSTALLATION** .



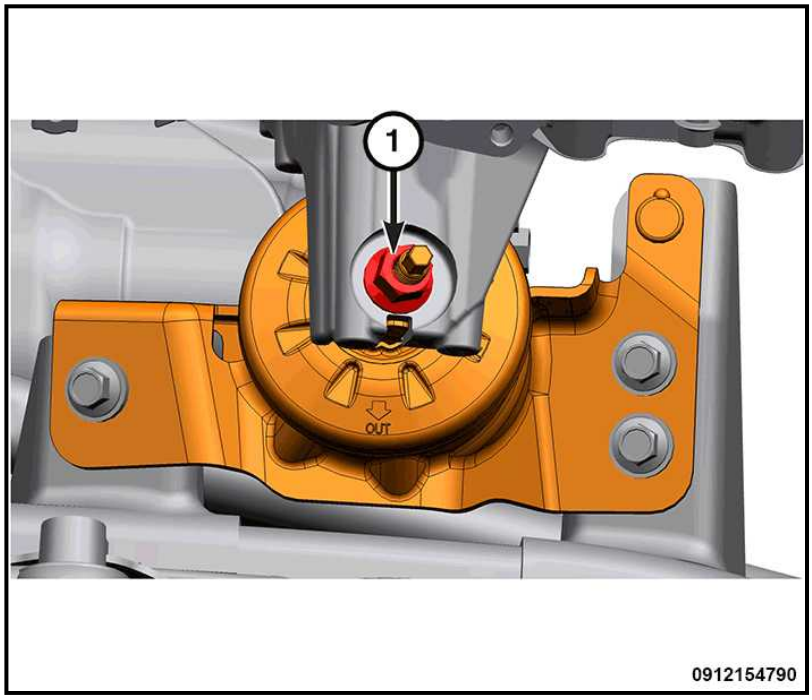
1 - Oil Level Indicator Tube
2 - Oil Level Indicator Tube Bolt

3. Remove the oil level indicator tube bolt and remove the oil level indicator tube from the engine block.



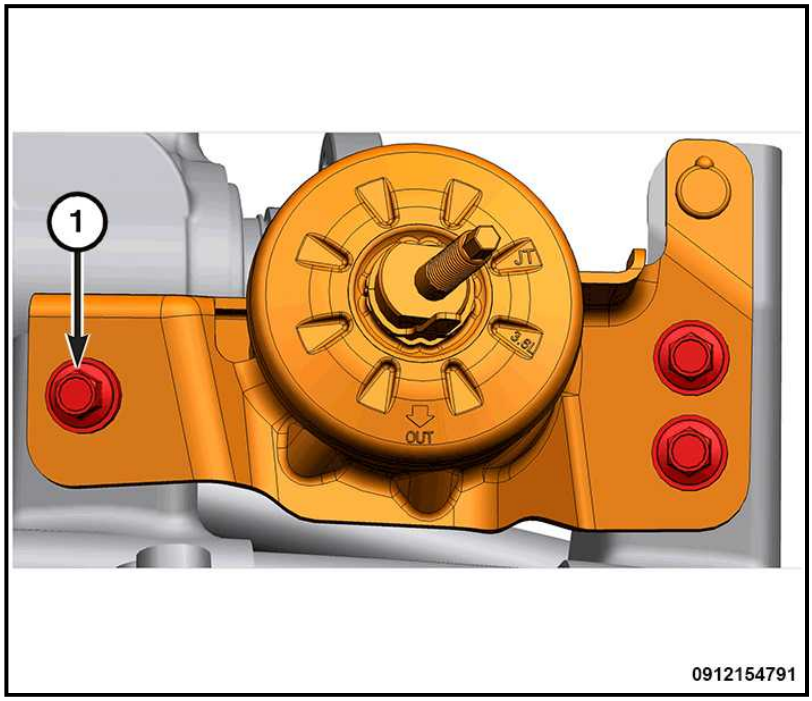
1 - Right Engine Mount Isolator to Bracket Nut

4. Remove the right engine mount isolator to engine mount bracket nut.



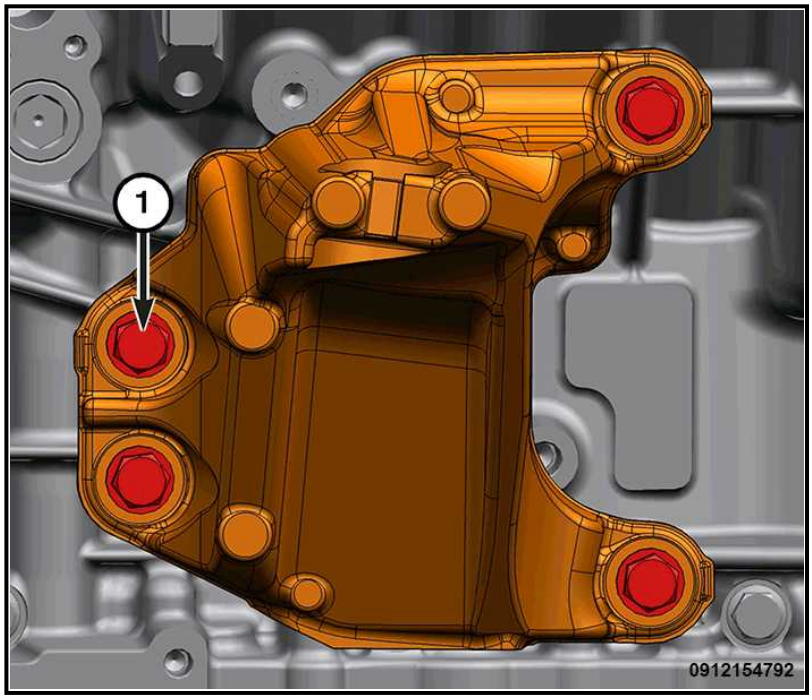
1 - Left Engine Mount Isolator to Bracket Nut

5. Remove the left engine mount isolator to engine mount bracket nut.
6. Remove the transmission to transmission crossmember nuts. Refer to **CROSSMEMBER, TRANSMISSION, REMOVAL AND INSTALLATION** .
7. Using a jack stand, raise the engine until the weight is off of the isolator.



1 - Left Engine Mount to Frame Bolts

8. Remove the left engine mount to frame bolts and remove the left engine mount.



1 - Left Engine Mount Bracket to Engine Bolts

9. If necessary, remove the bolts and the left engine mount bracket from the engine block.

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.

- After installing the mount, lower the engine and verify that all mounts are aligned.

TORQUE SPECIFICATIONS

ENGINE MOUNTING

RIGHT ENGINE MOUNT

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Mount Isolator to Engine Mount Bracket	**122 N.m (90 Ft. Lbs.)**	-
Engine Mount Bracket to Engine Block	**65 N.m (48 Ft. Lbs.)**	-
Engine Mount Isolator to Frame	**55 N.m (41 Ft. Lbs.)**	-

LEFT ENGINE MOUNT

DESCRIPTION	SPECIFICATION	COMMENTS
Left Engine Mount Bracket to Engine Block	**65 N.m (48 Ft. Lbs.)**	-
Left Engine Mount Isolator to Engine Mount Bracket	**122 N.m (90 Ft. Lbs.)**	-
Left Engine Mount Isolator to Frame	**55 N.m (41 Ft. Lbs.)**	-

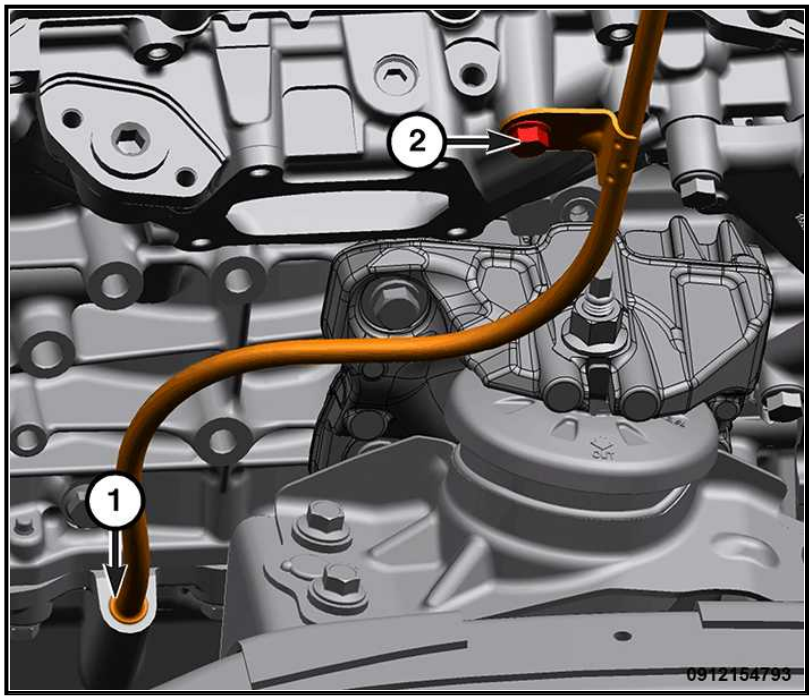
INSULATOR, ENGINE MOUNT, RIGHT

REMOVAL AND INSTALLATION

RIGHT ENGINE MOUNT

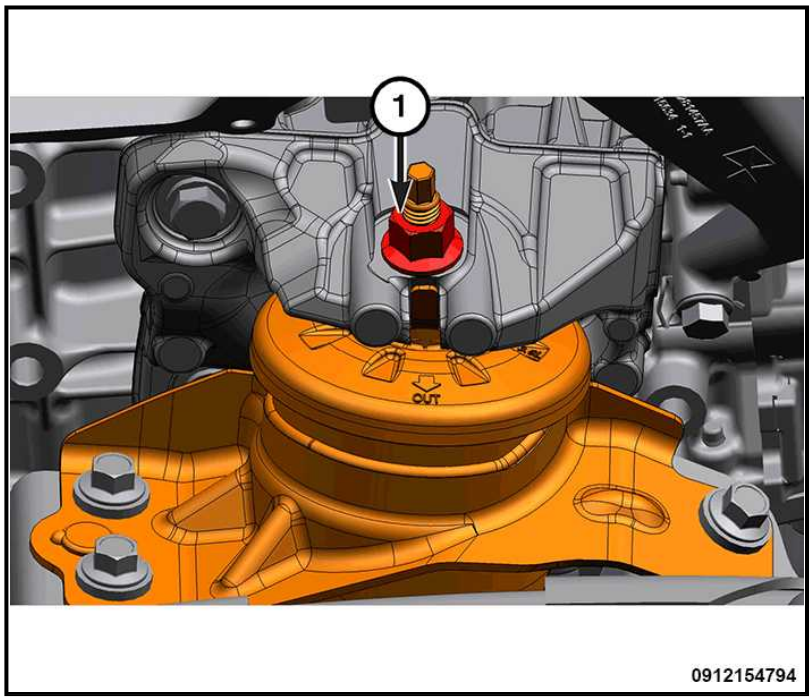
REMOVAL

1. Remove the front tires and wheels. Refer to **REMOVAL AND INSTALLATION** .
2. Remove the right front wheelhouse inner splash shield. Refer to **SHIELD, SPLASH, REAR WHEELHOUSE, REMOVAL AND INSTALLATION** .
3. Disengage the wire harness retainer from the right engine mount bracket.



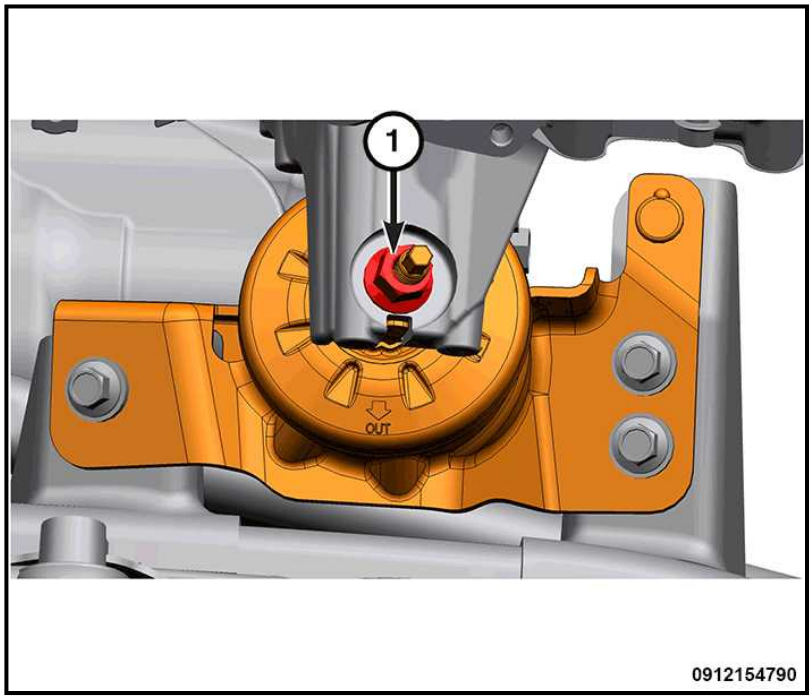
1 - Oil Level Indicator Tube
2 - Oil Level Indicator Tube Bolt

4. Remove the oil level indicator tube retaining bolt and remove the oil level indicator tube from the engine block.



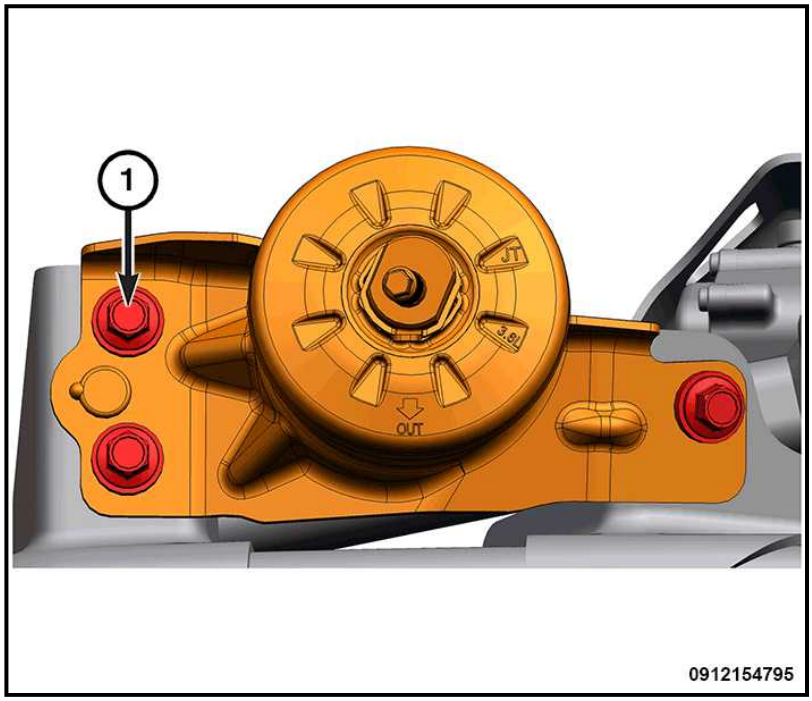
1 - Right Engine Mount Isolator to Bracket Nut

5. Remove the right engine mount isolator to engine mount bracket nut.



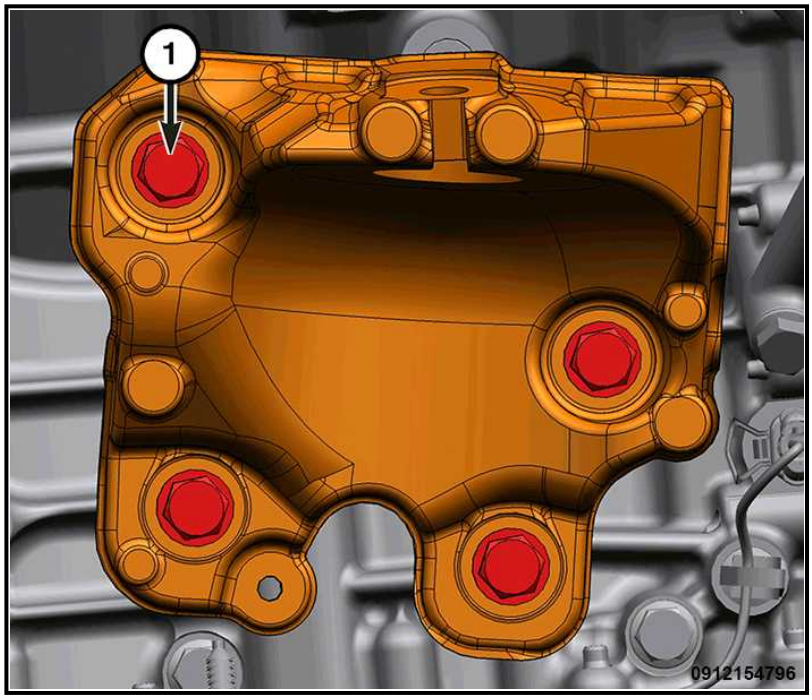
1 - Left Engine Mount Isolator to Bracket Nut

6. Remove the left engine mount isolator to engine mount bracket nut.
7. Remove the transmission to transmission crossmember nuts. Refer to **CROSSMEMBER, TRANSMISSION, REMOVAL AND INSTALLATION** .



1 - Right Engine Mount to Frame Bolts

8. Using a suitable jack stand, raise the engine until the weight is off of the isolator.
9. Remove the right engine mount to frame bolts and remove the right engine mount isolator.



1 - Left Engine Mount Bracket to Engine Bolts

10. If necessary, remove the bolts and the right engine mount bracket from the engine block.

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.

- After installing the mount, lower the engine and verify that all mounts are aligned.

TORQUE SPECIFICATIONS

ENGINE MOUNTING

RIGHT ENGINE MOUNT

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Mount Isolator to Engine Mount Bracket	**122 N.m (90 Ft. Lbs.)**	-
Engine Mount Bracket to Engine Block	**65 N.m (48 Ft. Lbs.)**	-
Engine Mount Isolator to Frame	**55 N.m (41 Ft. Lbs.)**	-

LEFT ENGINE MOUNT

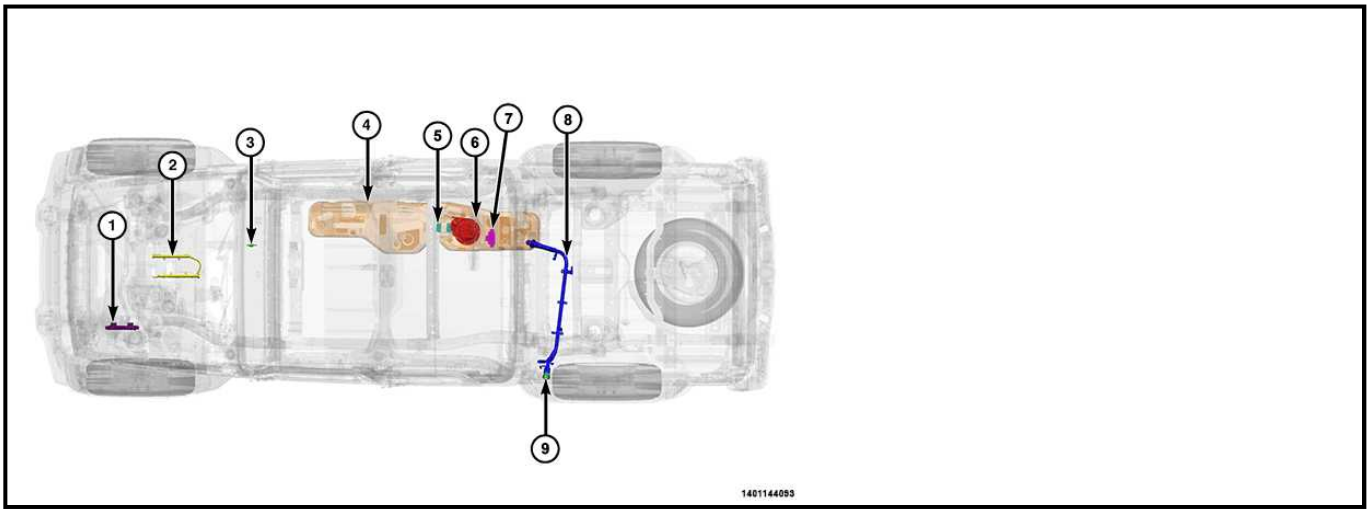
DESCRIPTION	SPECIFICATION	COMMENTS
Left Engine Mount Bracket to Engine Block	**65 N.m (48 Ft. Lbs.)**	-
Left Engine Mount Isolator to Engine Mount Bracket	**122 N.m (90 Ft. Lbs.)**	-
Left Engine Mount Isolator to Frame	**55 N.m (41 Ft. Lbs.)**	-

FUEL SYSTEM

DESCRIPTION AND OPERATION

FUEL DELIVERY SYSTEM

DESCRIPTION



The Fuel Delivery System is made up of the following:

COMPONENT INDEX

1.	Refer to **POWERTRAIN CONTROL MODULE (PCM)**.
2.	Refer to **FUEL RAIL**.
3.	Refer to **FUEL PRESSURE SENSOR**.
4.	Refer to **FUEL TANK**.
5.	Refer to **FUEL LEVEL SENSOR**.
6.	Refer to **FUEL PUMP MODULE**.
7.	Refer to **FUEL PUMP CONTROL MODULE (FPCM)**.
8.	Refer to **FUEL TANK FILLER TUBE**.
9.	Refer to **FUEL CAP**.

OPERATION

Fuel is picked up in the fuel tank by the fuel pump module. A fuel return system is provided within the fuel pump module by using check valves verses a separate fuel return line from the engine to the tank. The fuel pressure regulator and the main fuel filter are combined within the fuel pump module for servicing.

FUEL CAP

Refer to **COMPONENT INDEX**.

The fuel filler cap acts as a seal to allow the system to build pressure/vacuum. If pressure/vacuum inside the fuel tank gets too high because of a stuck ESIM valve then the fuel cap valve opens to relieve the high pressure/vacuum.

FUEL LEVEL SENSOR

Refer to **COMPONENT INDEX**.

The fuel gauge sending unit is attached to the side of the fuel pump module. The fuel gauge sending unit consists of a float arm and a variable resistor track (card). The fuel level sensor signal is hard-wired to the BCM. The BCM broadcasts the signal over the CAN Bus for the other modules that need the fuel level sensor information.

FUEL PRESSURE SENSOR

Refer to **COMPONENT INDEX**.

The fuel pressure sensor is located in the fuel supply line. The sensor can be serviced separately from the line. The PCM uses this sensor to monitor the fuel rail pressure. The sensor element, a semiconductor device, converts the pressure to an electric signal mounted on the diaphragm. The signal generated by the sensor is monitored by the PCM.

FUEL PUMP CONTROL MODULE (FPCM)

Refer to **COMPONENT INDEX**.

The FPCM is located on the top of the fuel tank. When the PCM receives a START or RUN signal, it energizes the fuel pump relay which sends voltage to the FPCM. The PCM also sends a Pulse Width Modulated (PWM) control signal directly to the FPCM which regulates the PWM voltage that will be sent to the fuel pump module. The PWM will vary from 10-100% depending on the input of the fuel rail pressure sensor and other engine demands. The PCM receives a PWM signal from the FPCM representing the state of all inputs and outputs of the FPCM. This system is a variable pressure fuel system. The pressure can change during different modes of engine load and operation. Ambient temperature, altitude, and fuel temperature can also contribute to fuel pressure changes. The pressure is raised during high ambient temperatures to prevent boiling of the fuel. If a pressure sensor fails or other failures are present then the duty cycle goes to a default setting of 80% to maintain adequate fuel pressure.

FUEL PUMP MODULE

Refer to **COMPONENT INDEX**.

The fuel pump module is mounted inside the fuel tank and contains the following components:

- Mounting flange
- Electric fuel pump
- Fuel pump reservoir
- Inlet strainer
- Fuel pressure regulator
- Fuel level sending unit
- Fuel filter

The FPCM controls the fuel pump control module using a High Side Driver (HSD) PWM control circuit. The fuel pump ground circuit is also connected to the FPCM.

The fuel level sending unit is the only serviceable component of the primary fuel pump module. If the electric fuel pump, fuel pressure regulator or fuel filter requires service, the primary fuel pump module must be replaced as an assembly.

The electric fuel pump is located within the fuel pump module assembly. The electric fuel pump is a positive displacement, immersible pump with a permanent magnet electric motor capable of creating 860 kPa (125 psi) of operating pressure. The fuel pressure regulator's operating range is 400 kPa (58 psi) to 552 kPa (80 psi).

FUEL RAIL

Refer to **COMPONENT INDEX**.

The fuel rail supplies the necessary fuel to each individual fuel injector. High pressure from the fuel pump is routed to the fuel rail. The fuel rail then supplies the necessary fuel to each individual fuel injector. The fuel injection fuel rail is a composite design. The fuel rail and fuel injectors must be installed into the lower intake manifold as an assembly. Do not attempt to install the fuel rail when the injectors are in the manifold. Always install new O-rings on the fuel injectors. A quick-connect fitting with a safety latch clip is used to attach the fuel line to the fuel rail. The fuel rail is not repairable.

FUEL TANK

Refer to **COMPONENT INDEX**.

The fuel tank is constructed of a plastic material. Its main functions are for fuel storage and for placement of the Fuel Pump Control Module, and Onboard Refueling Vapor Recovery (ORVR) components. The fuel tank is equipped with fuel and vapor controls that allow the vehicle to pass a full 360B° rollover without fuel leakage.

FUEL TANK FILLER TUBE

Refer to **COMPONENT INDEX**.

A fuel tank filler tube is secured to the fuel tank and provides a fuel delivery passage to the fuel tank as well as provides separate liquid and vapor connection from the tank.

POWERTRAIN CONTROL MODULE (PCM)

Refer to **COMPONENT INDEX**.

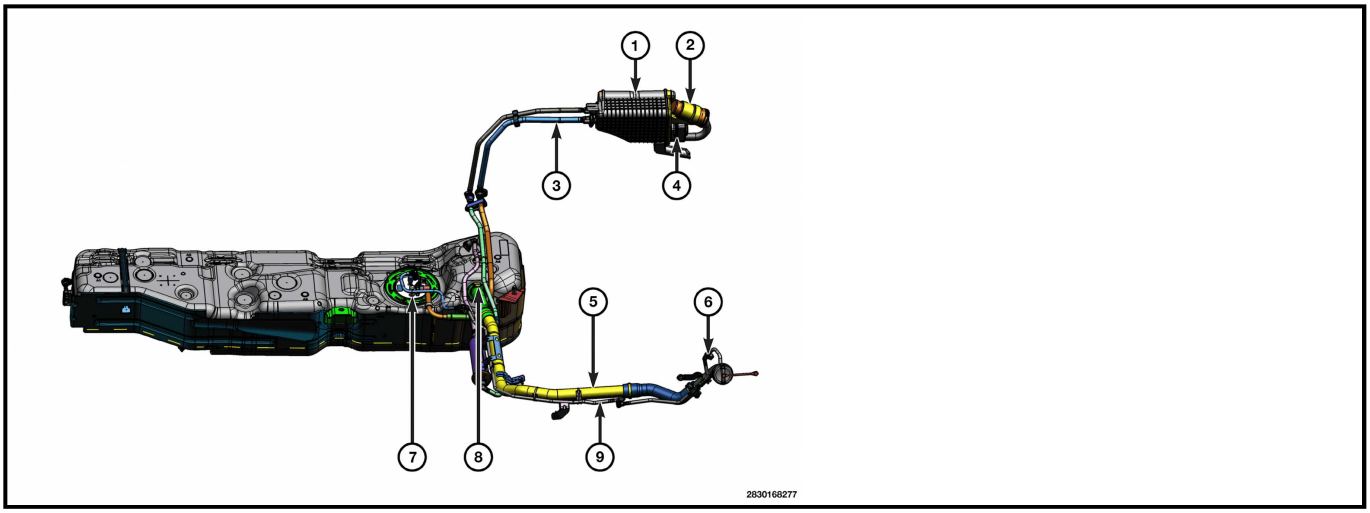
The PCM commands the fuel pump PWM signal to be activated through a dedicated relay located in the Power Distribution Center (PDC) which in turn sends a voltage supply to the FPCM. The PCM energizes the fuel pump relay using a Low Side Driver (LSD) control circuit. The relay provides a wake up signal to the FPCM when energized. The PCM monitors the fuel system pressure and performance using the fuel pressure sensor feedback. It sends commands to the FPCM through the PWM command circuit and receives feedback, including system diagnostics from the FPCM on the PWM Feedback circuit. Any faults in the FPCM or fuel pump circuitry are communicated to the PCM from the FPCM. The PCM receives the pressure information from the fuel rail pressure sensor and sends a PWM signal on a dedicated signal circuit to the fuel pump control Module.

DIAGNOSIS AND TESTING

HARD TO FILL WITH FUEL

The components that are used for tank venting, and will be diagnosed in this procedure are basically the same for every non PHEV vehicle. The only differences are the locations of the components within the system on each vehicle. The graphic below is intended for reference and depicts the general configuration of the system components for the JL/JT vehicles with gas engines.

CALL-OUT	DESCRIPTION
1	Charcoal Canister
2	Fresh Air Filter
3	Canister Tube
4	Evaporative System Integrity Monitor (ESIM)
5	Fuel Filler Tube/Hose
6	Fuel Tank Pressure Sensor
7	Fuel Delivery Pump/Level Sensor Module
8	Inlet Check Valve (ICV)
9	Recirculation (Recirc) Tube



DIAGNOSTIC TEST

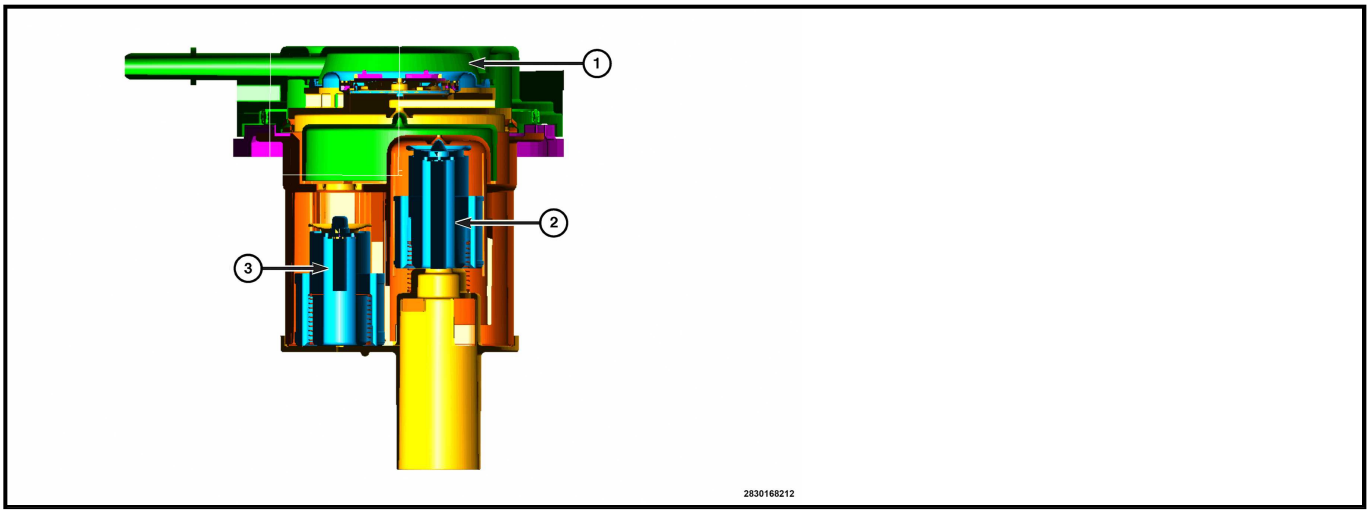
During a re-fueling event, as fuel enters the Fuel Tank, the fuel vapors in the tank must be vented to prevent early fuel shut off. On a properly functioning system the vapors escape the tank through the MFCV or Liquid/Vapor Separator and Drain Valve (LVS), into the Canister Tube and flow to the Charcoal Canister. The fuel vapors are trapped by the charcoal in the canister. The clean air vents through the ESIM, to the Fresh Air Filter, and out to the atmosphere. When the fuel level in the tank rises and the liquid fuel reaches the MFCV or LVS, the float closes the vapor venting orifice inside the valve. The pressure inside the tank will increase causing the ICV to close and fuel to back up inside the filler tube. When the fuel reaches the sensing port aspirator in the fuel fill nozzle, the fuel flow shuts off. This prevents fuel from spilling out of the fuel filler tube.

NOTE: **For customer complaints of gas station nozzles not shutting off and causing fuel to spill over from the fill tube, please be aware that this would be a concern with the nozzle at the station and not the vehicle.**

If there is a restriction or blockage in the venting path, an early fuel shut off condition will be present. A vehicle can experience a hard to fill condition related to the following three reasons:

1. Fuel nozzle sensitivity.
2. There is a blockage in the tank venting.
3. There is a blockage in the venting on the fresh air side of the system.

For the MFCV (shown below) to vent properly, the top diaphragm portion of the valve must be able to adjust to atmosphere through the Recirculation tubing when the Gas Cap is removed, or the Capless Filler door is opened.

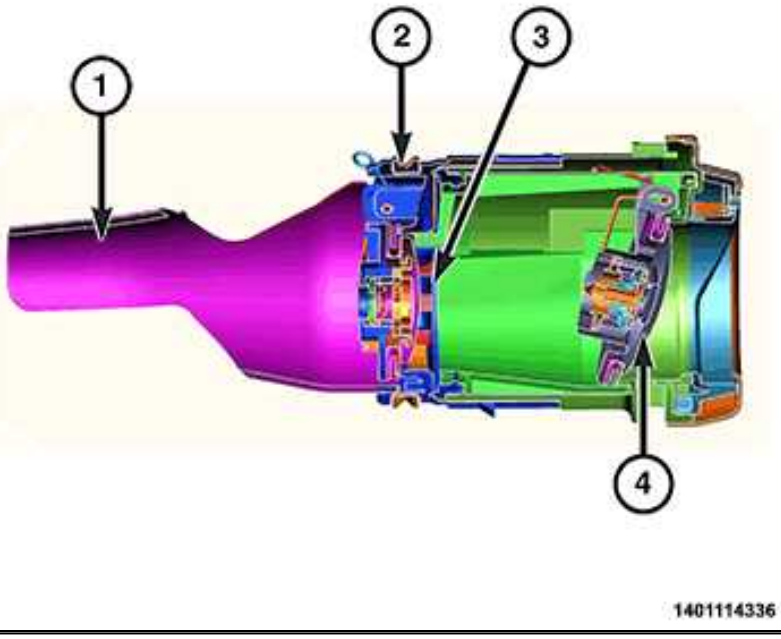


CALL OUT	DESCRIPTION
1	Diaphragm
2	Run/Loss Float
3	Refueling Float

NOTE: **Capless Fuel Unit - Image is for reference only (if equipped).**

CALL OUT	DESCRIPTION
1	Nozzle Flow Guide
2	Capless Unit
3	Internal Door
4	External Door

The following diagnostic procedure should help to determine which issue is causing the hard to fill condition.



DIAGNOSTIC PROCEDURE:

1. Ask the customer the following questions:
    1. Is the condition present at only one station or multiple gas stations?
    2. Does the nozzle turn off immediately after a few seconds or after a few gallons?
    3. If you pull the nozzle out slightly or turn the nozzle to different positions does the early shut off condition stop?

    If the early shut off condition is only present at certain stations, happens consistently after the first few seconds of fueling, or stops after repositioning the nozzle, the issue is most likely due to a nozzle sensitivity issue. The only other possible issue could be if the Inlet Check Valve is stuck or sticking and not allowing fuel to flow freely into the tank. If the condition happens regular at multiple stations, or after a few gallons are filled, it is most likely a venting issue. Continue diagnosing in step 2.

2. Some of the conditions that can cause a hard to refuel condition will also set other evaporative system faults. Use the scan tool to check for any evaporative system DTCs. If DTCs are present perform the DTC diagnostic procedure first before continuing. If no DTCs are present, continue diagnosing in step 3.
3. **If equipped with a capless fuel filler,** use the emergency funnel to inspect both doors, and the filler tube for any foreign objects or debris. Verify the doors can open and close properly. A bore scope may be used to inspect inside the filler tube. If the capless doors are damaged or any obstructions are found the entire

fill tube assembly should be replaced. If there are no obstructions/damage or the vehicle does not have a capless fuel filler, continue diagnosing in step 4.

4. Raise the vehicle and visually inspect for a kinked or pinched Filler Tube, Canister Tube, Recirc Tube, or ESIM Vent Hose/Filter. Repair or replace any obvious issues. If the tubes appear okay, continue diagnosing in step 5.

NOTE: **JL and JT do not have a MFCV or a LVS. There is a pass through in the Fuel Delivery Module (FDM). If there is fuel in the Recirc tube or the charcoal canister, it is possible the line has come off inside the fuel tank. This condition may also set DTC P0441. Replace the Charcoal Canister and check for a disconnected or broken line to the Fuel Delivery Flange inside the Fuel Tank. Reconnect the line and confirm proper retention or replace if necessary. Perform the "ESIM/Purge Flow Forced Monitor" test to confirm system is repaired. Verify hard to fill condition is no longer present.**

NOTE: **TECH TIP: The fresh air side may be able to be evaluated before continuing to step 5 and disconnecting tubes and attempting to refuel at a filling station. Start the engine, allow purge to activate and observe the Fuel Tank Pressure reading in the scan tool data. Typically, the system pressure will drop below the ESIM regulation point and stabilize between approximately -600 and -800 Pa. After turning the engine off the vacuum relief weight inside the ESIM will vent the pressure near the regulation point (approximately -500 Pa). If the vacuum created is far greater than normal and doesn't vent to the regulation point when the engine is turned off, there is likely a blockage on the fresh air side of the system. Try removing the hose between the ESIM and Fresh Air Filter and testing again. If the system functions normally with the hose disconnected, the Fresh Air Filter or hose is blocked.**

5. **This step is designed to split the system between the tank side and fresh air side.** The fuel level should be low enough to allow enough fuel to be put into the vehicle to make a proper determination (example: less than 1/2 tank). Also, do not refill from a storage tank. Use a gas station filling pump to refill. Disconnect the Canister Tube either at the Fuel Tank or Charcoal Canister. The Canister Tube will be the larger of the tubes connected at either the tank or canister. Attempt to refill the vehicle.

NOTE: **Read through the entire test before going to the fuel station and attempting to refuel. Some of the other checks may be able to be done while at the pump refueling.**

    1. If fuel flows freely without early shut off, the issue is with the fresh air side of the system (Canister or ESIM vent/filter). Continue diagnosing in step 6.
    2. If the early fuel shut off condition is still occurring, the issue is with the tank side of the system (MFCV LVS, or Recirc Tubing). Continue diagnosing in step 7.

6. Reconnect the Canister Tube. Remove the vent hose at the ESIM or Fresh Air Filter and attempt to refill.
    1. If fuel flows freely without early shut off, replace the Fresh Air Filter or repair the restriction in the vent hose.
    2. If the early fuel shut off condition is still occurring, replace the Charcoal Canister. If the Canister Tube was disconnected at the Fuel Tank, check the tube for a restriction before replacing the Charcoal Canister.
7. Disconnect the Recirc line at the Fuel Tank or Fuel Filler Tube and attempt to refill.
    1. If fuel flows freely without early shut off, replace or clear the Recirc Tube or check for an obstruction in the Recirc Tube portion of the fill tube.
    2. If early fuel shut off is still occurring, drain the fuel from the tank, remove the fuel filler hose and check for an obstructed or hard to open Inlet Check Valve. If the Inlet Check Valve is not

obstructed and opens freely, the MFCV or LVS is restricted and will require replacement. Replace the Fuel Tank or Fuel Pump assembly depending on the MFCV or LVS location in the system.

NOTE: **On some vehicles the MFCV or LVS is welded into the Fuel Tank. On other vehicles the MFCV or LVS is part of the Fuel Pump Assembly. If the MFCV or LVS is not visible on the tank or pump, it is mounted inside the Fuel Tank. If the MFCV or LVS is mounted on the Fuel Pump Module, it should be replaced before replacing the Fuel Tank.**

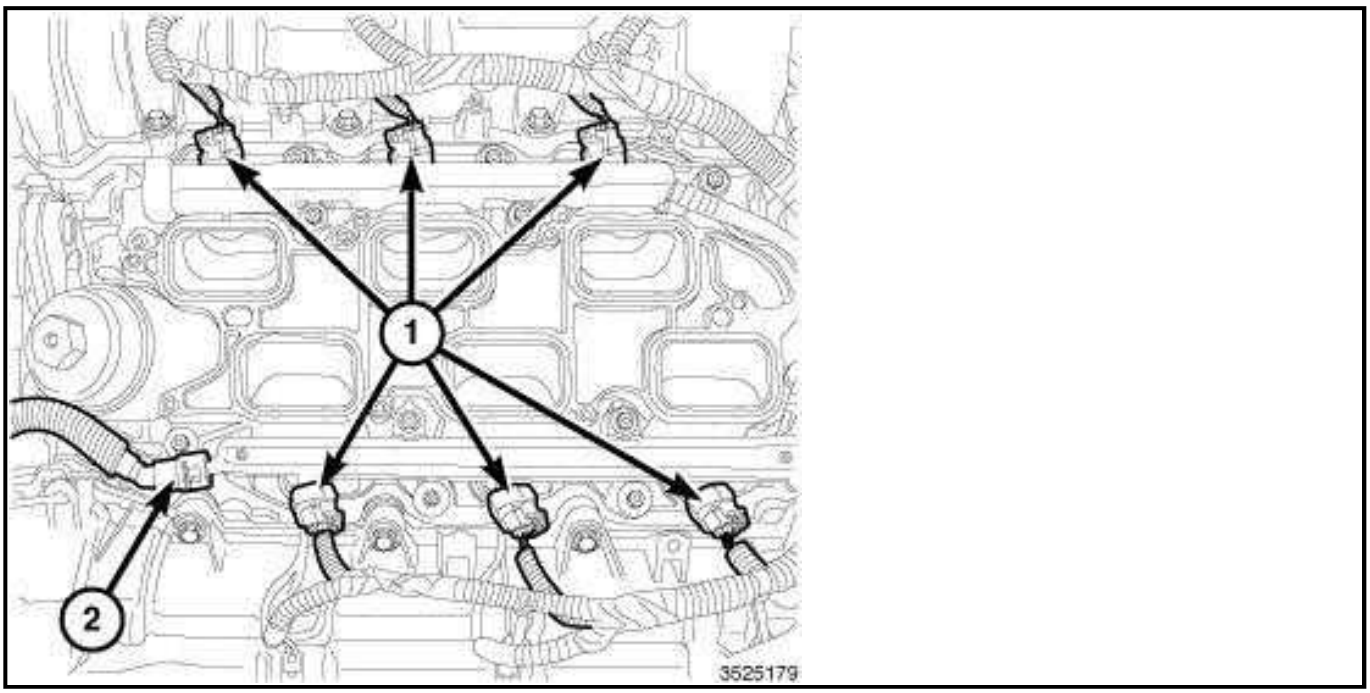
STANDARD PROCEDURE

DRAINING FUEL TANK

CONVENTIONAL PROCEDURE

WARNING: **The fuel system is under constant high pressure even with engine off. Until the fuel pressure has been properly released from the system, do not attempt to open the fuel system. Do not smoke or use open flames/sparks when servicing the fuel system. Wear protective clothing and eye protection. Make sure the area in which the vehicle is being serviced is in a well ventilated area and free of flames/sparks. Failure to comply may result in serious or fatal injury.**

WARNING: **No sparks, open flames or smoking. Risk of poisoning from inhaling and swallowing fuel. Pour fuel only into appropriately marked OSHA approved containers. Wear protective clothing. Risk of injury to eyes and skin from contact with fuel.**

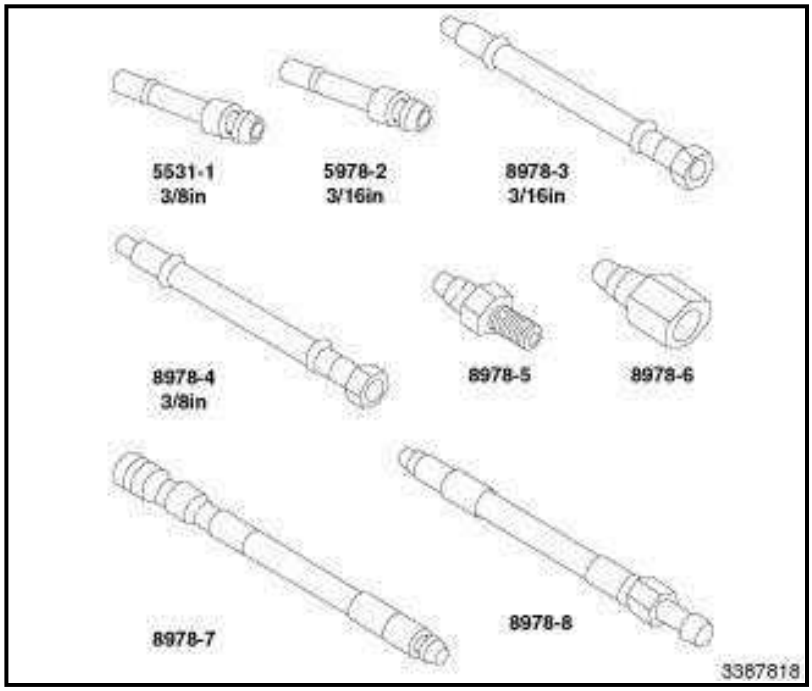


Due to a one-way check valve installed into the fuel fill fitting at the tank, the tank cannot be drained at the fuel fill cap.

1. Perform the fuel system pressure release procedure Refer to **FUEL SYSTEM PRESSURE RELEASE** .

CAUTION: **When removing the fuel supply line from the fuel inlet tube at the fuel rail, care must be taken that the fuel inlet tube is not being over-flexed. Damage to the fuel rail inlet tube may occur.**

2. Disconnect the fuel supply line (2) from the fuel rail Refer to **FUEL SYSTEM** .



3. Install the appropriate fuel line adapter fitting from the (special tool #8978A, Decay Tool, Fuel) to the fuel supply line. Route the opposite end of this hose to an Occupational Safety and Health Administration (OSHA) approved fuel storage tank such as the JohnDow Gas Caddy 320-FC-P30-A or equivalent.

NOTE: **Activation of the fuel pump module may time out and need to be restarted several times to completely drain the fuel tank.**

4. Using a diagnostic scan tool, activate the fuel pump module until the fuel tank has been evacuated.

ALTERNATIVE PROCEDURE

NOTE: **If the electric fuel pump is not operating, the fuel tank must be removed and drained through the fuel pump module opening of the fuel tank.**

1. Disconnect and isolate the negative battery cable.
2. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .
3. Remove the fuel pump module. Refer to **ASSEMBLY, FUEL PUMP, REMOVAL AND INSTALLATION**.
4. Position a 3/8" hose into the fuel pump module opening of the fuel tank.
5. Attach the opposite end of this hose to an OSHA approved fuel storage tank such as the JohnDow Gas Caddy 320-FC-P30-A or equivalent.
6. Using the gas caddy, evacuate the fuel tank.

FUEL SYSTEM PRESSURE RELEASE

1. Remove the fuel fill cap.

NOTE: **If equipped with a capless fuel system, insert funnel or equivalent into capless unit to release pressure.**

2. Remove the fuel pump fuse from the Power Distribution Center (PDC). For location of the fuel pump fuse, refer to label on the underside of the PDC cover or. Refer to **FUSE - RELAY LOCATIONS AND TYPES, SPECIFICATIONS** .
3. Start and run the engine until it stalls.
4. Attempt restarting the engine until it will no longer run.
5. Turn the ignition key to the OFF position.

6. Place a rag or towel below the fuel supply line quick-connect fitting located near the cowl.
7. Disconnect the fuel supply line quick-connect fitting at the fuel supply line. Refer to **FUEL SYSTEM** .
8. Return the fuel pump fuse to the PDC.

NOTE: **One or more Diagnostic Trouble Codes (DTC) may have been stored in the PCM memory due to fuel pump fuse removal. A diagnostic scan tool must be used to erase a DTC.**

QUICK-CONNECT FITTINGS

CAUTION: **Before separating a Quick-Connect fitting, pay attention to what type of fitting is being used. This will prevent unnecessary fitting or fitting latch breakage.**

CAUTION: **The interior components (O-rings, clips) of quick-connect fittings are not serviced separately, but new plastic spacers and latches are available for some types. If service parts are not available, do not attempt to repair the damaged fitting or fuel line (tube). If repair is necessary, replace the complete fuel line (tube) assembly.**

Different types of quick-connect fittings are used to attach the various fuel system components, lines and tubes. There are specific methods required to release each type of fitting without damaging the fitting or components that they are attached to. Some are equipped with safety latch clips. Some quick-connect fittings require the use of a special tool for disconnection and removal.

NOTE: **Care must be used when separating fittings. Over-flexing may cause the tube to become deformed or damaged.**

The following are the various types of automotive quick-connect fittings:

- Redundant Latch Single Button Type Fitting
- Single Button Type Fitting
- Pinch Type Fitting
- Pinch Type Fitting With Lock Tab
- Single Tab Type Fitting
- Two Tab Type Fitting
- Plastic Retainer Ring Type Fitting
- Latch Clip Type 1 Fitting
- Latch Clip Type 2 Fitting
- Two Button Type Fitting
- Wing Type Fitting

DISCONNECTING

WARNING: **On vehicles equipped with gasoline engines, the fuel system is under a constant pressure (even with engine off). Before servicing any fuel system hose, fitting or line, fuel system pressure must be released.**

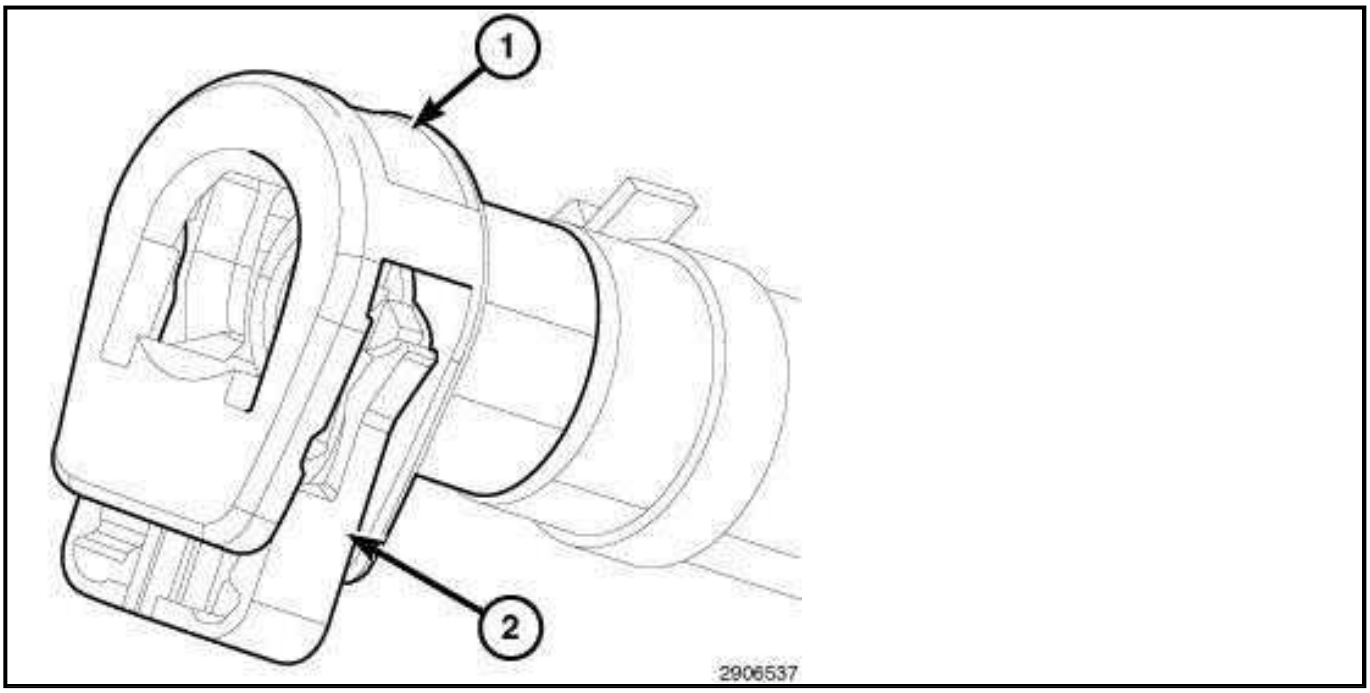
For the fuel system pressure release procedure. Refer to **FUEL SYSTEM PRESSURE RELEASE** .

CAUTION: **Before separating a Quick-Connect fitting, pay attention to what type of fitting is being used. This will prevent unnecessary fitting or fitting latch breakage.**

CAUTION: **The interior components (O-rings, clips) of quick-connect fittings are not serviced separately, but new plastic spacers and latches are available for some**

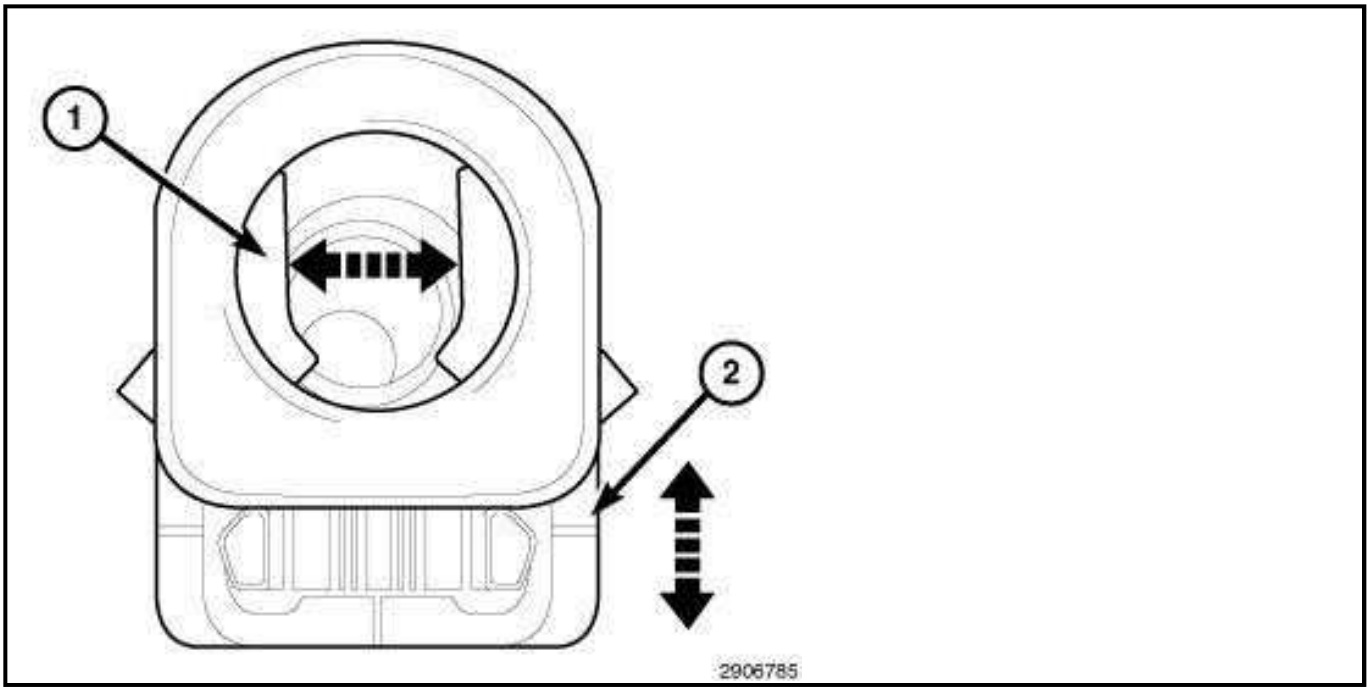
types. If service parts are not available, do not attempt to repair the damaged fitting or fuel line (tube). If repair is necessary, replace the complete fuel line (tube) assembly.

REDUNDANT LATCH SINGLE BUTTON TYPE FITTING:



1 - Single Push Button
2 - Redundant Latch

This type of quick-connect fitting is equipped with a redundant latch and a single push button that releases two internal latches located in the quick-connect fitting. Special tools are not required for removal.

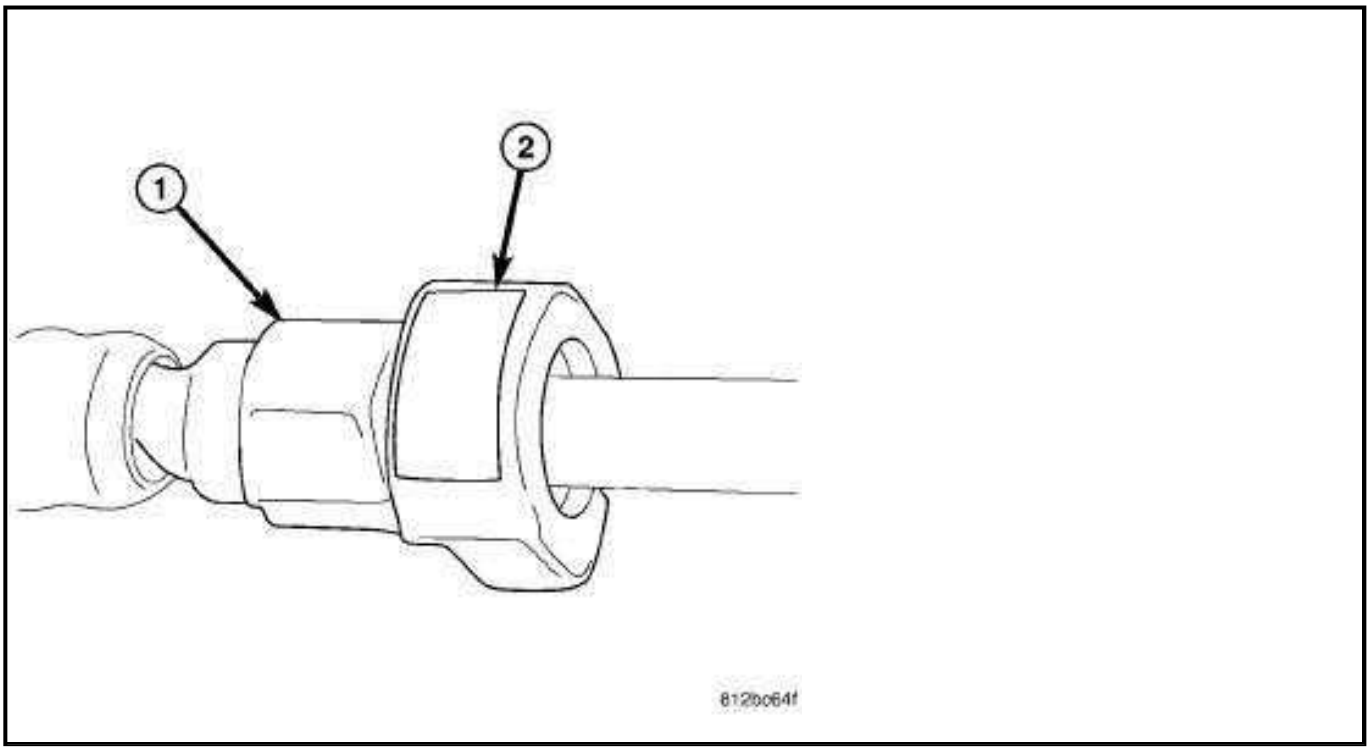


1 - Internal Latches
2 - Redundant Latch

CAUTION: **Do not pry or pull up on the push button as damage to the latches of the quick-connect fitting will occur.**

1. Pull the redundant latch out away from the quick-connect fitting.
2. Press on the push button with your thumb, release the internal latches and remove the quick-connect fitting from the fuel system component.

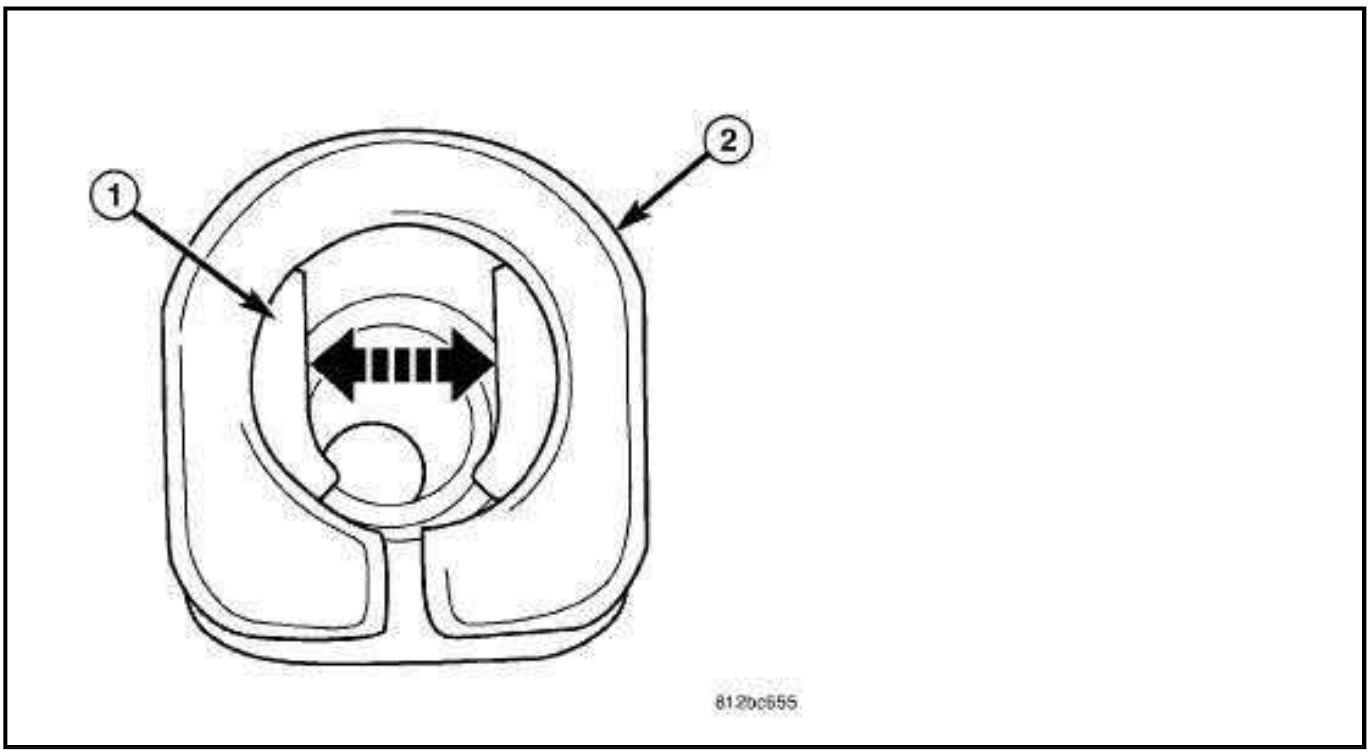
SINGLE BUTTON TYPE FITTING:



1 - Quick-Connect Fitting
2 - Single Push Button

CAUTION: **Do not pry or pull up on the push button as damage to the latches of the quick-connect fitting will occur.**

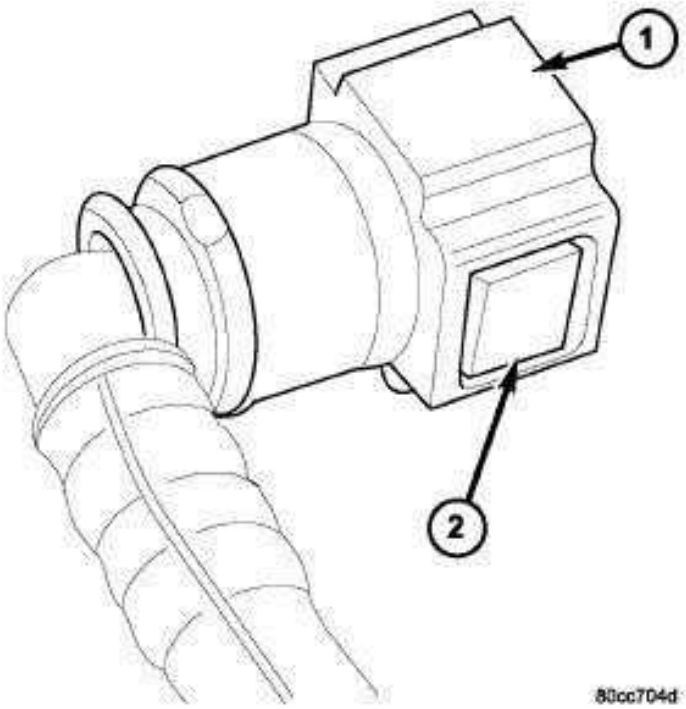
This type of quick-connect fitting is equipped with a single push button that releases two internal latches located in the quick-connect fitting. Special tools are not required for removal.



1 - Internal Latches
2 - Quick-Connect Fitting

1. Press on the push button with your thumb, release the internal latches.
2. Remove the quick-connect fitting from the fuel system component.

2 BUTTON TYPE FITTING

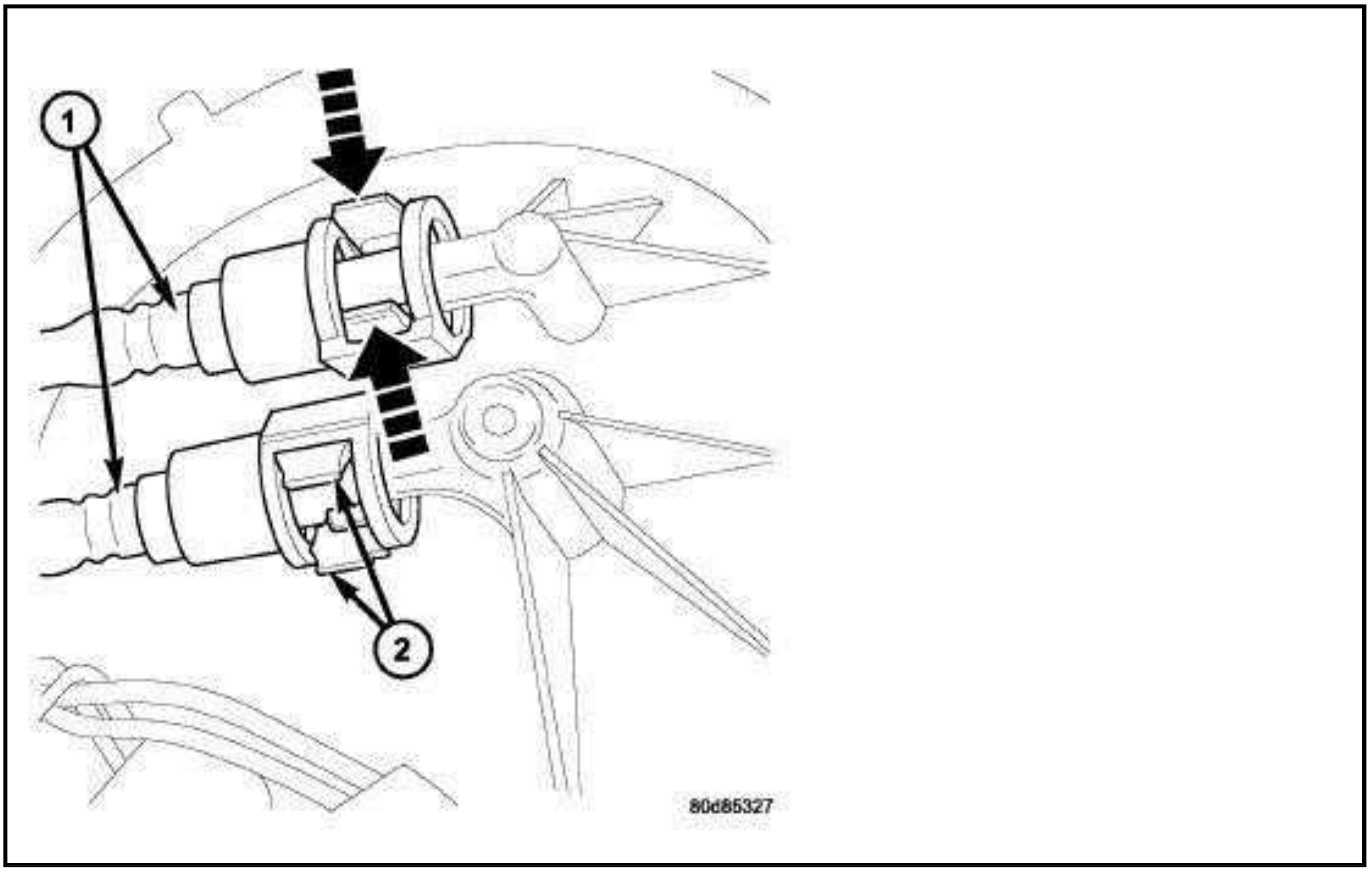


1 - Quick-Connect Fitting
2 - Two Push Buttons

This type of quick-connect fitting is equipped with two push buttons that releases two internal latches located in the quick-connect fitting. Special tools are not required for removal.

1. Press on both push buttons with your thumb, release the internal latches.
2. While holding the two push buttons simultaneously, remove the quick-connect fitting from the fuel system component.

PINCH TYPE FITTING

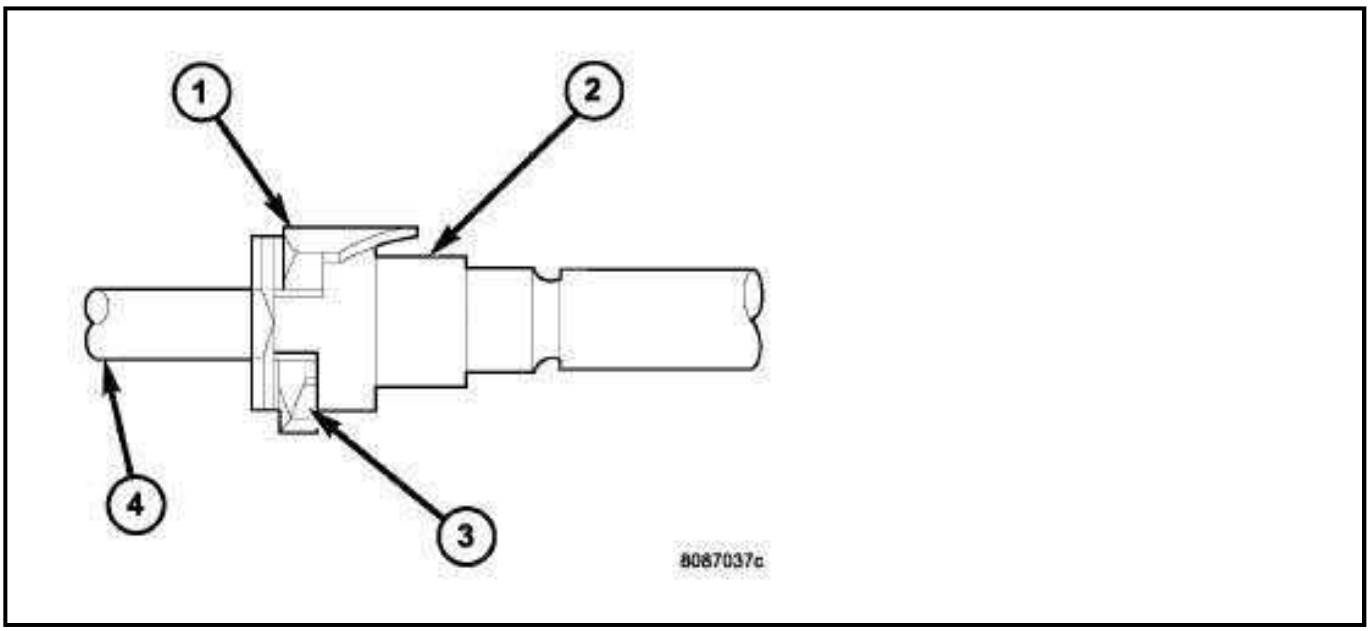


1 - Quick-Connect Fitting
2 - Two Finger Tabs

This type of quick-connect fitting is equipped with two finger tabs. Special tools are not required for removal.

1. Pinch both tabs together and release the quick-connect fitting.
2. Remove the quick-connect fitting from the fuel system component.

SINGLE TAB TYPE FITTING

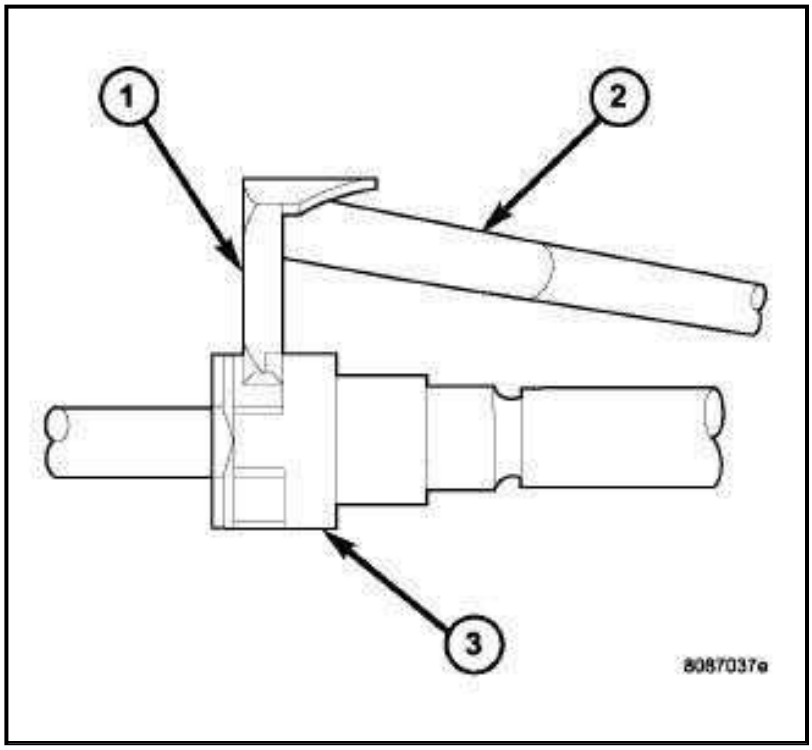


1 - Single Pull Tab
2 - Quick-Connect Fitting
3 - Release Tab
4 - Fuel System Component

This type of quick-connect fitting is equipped with a single pull tab. The tab is removable. After tab is removed, the quick-connect fitting can be separated from the fuel system component. Special tools are not required for removal.

1. Press release tab on side of fitting to release pull tab.

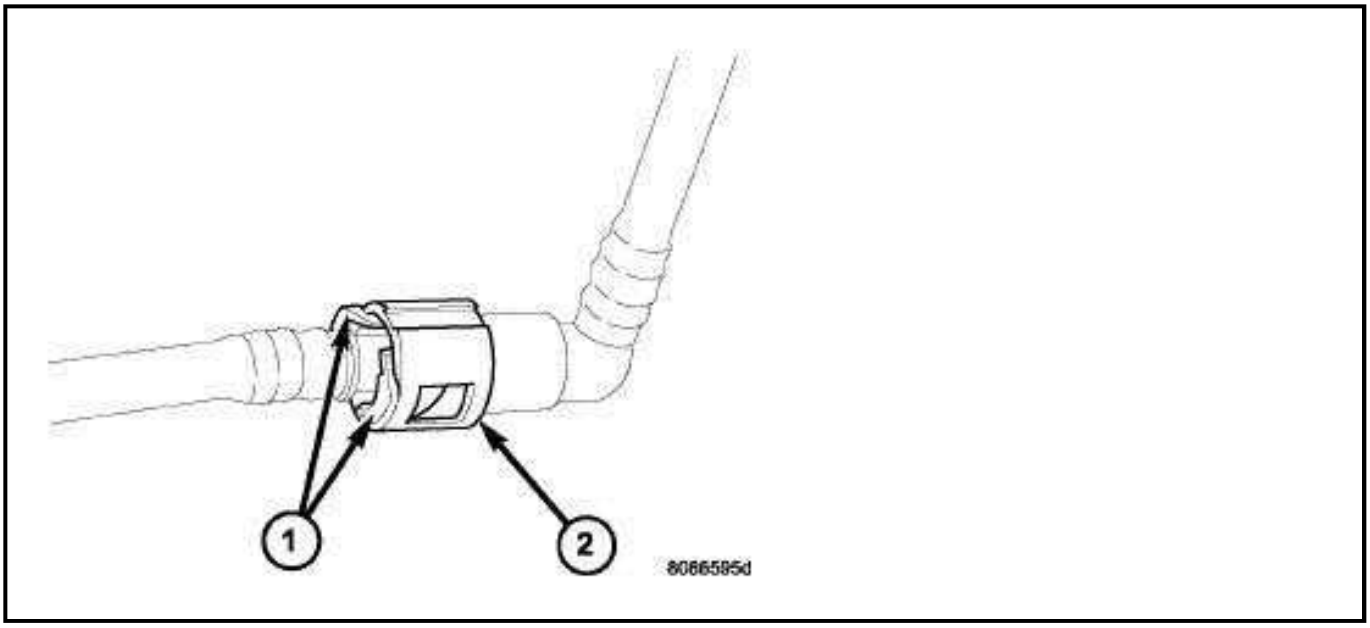
NOTE: **If release tab is not pressed prior to releasing pull tab, pull tab will be damaged.**



1 - Pull Tab
2 - Screwdriver
3 - Quick-Connect Fitting

2. While pressing the release tab on the side of the quick-connect fitting use a screwdriver to pry up the pull tab.
3. Raise the pull tab until it separates from the quick-connect fitting.
4. Remove the quick-connect fitting from the fuel system component.

TWO TAB TYPE FITTING

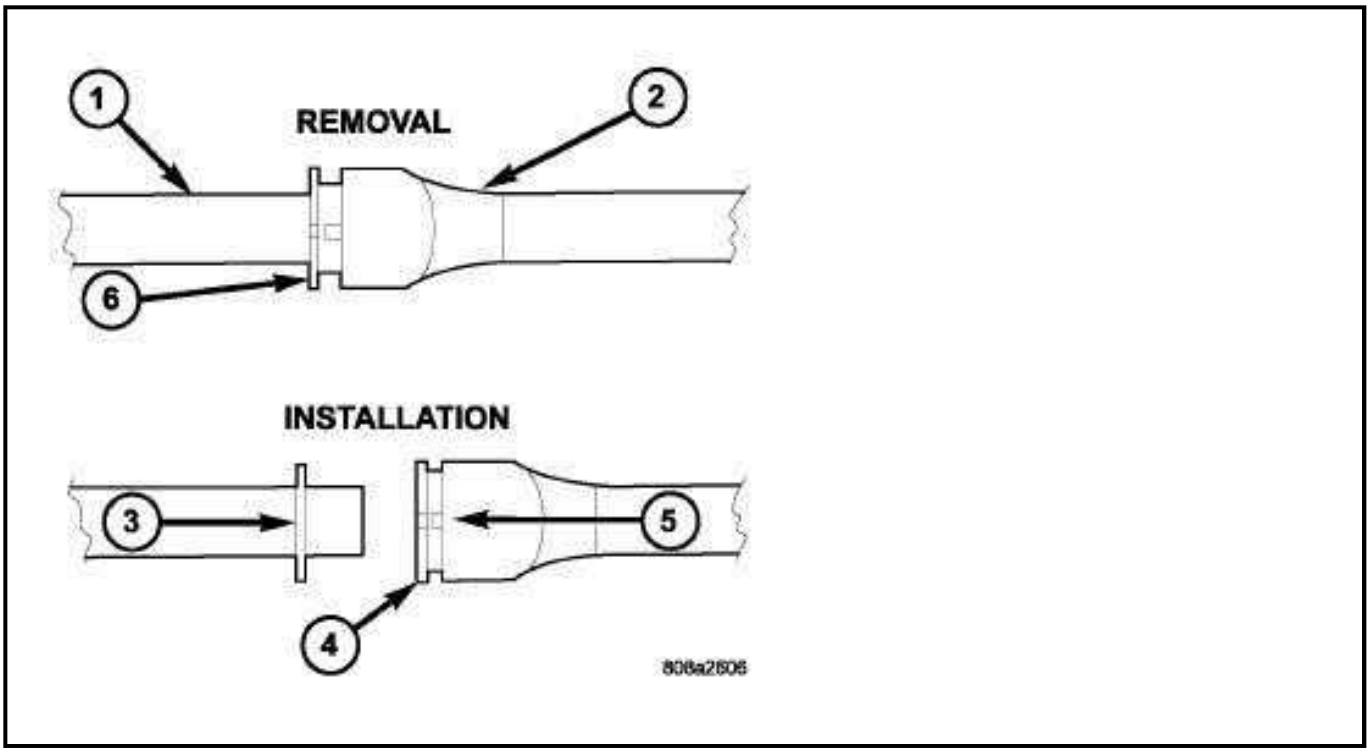


1 - Tabs
2 - Quick-Connect Fitting

This type of quick-connect fitting is equipped with tabs located on both sides of the fitting. These tabs are integral to the fuel system component. The plastic tabs will remain on the component being serviced after the quick-connect fitting is removed. The O-ring and spacer will remain in the quick-connect fitting. Special tools are not required for removal.

1. Squeeze the plastic tabs against the sides of component being serviced with your fingers.
2. Remove the quick-connect fitting from the fuel system component.

PLASTIC RETAINER RING TYPE FITTING



1 - Fuel System Component
2 - Quick-Connect Fitting
3 - Fuel System Component
4 - Round Plastic Retainer Ring

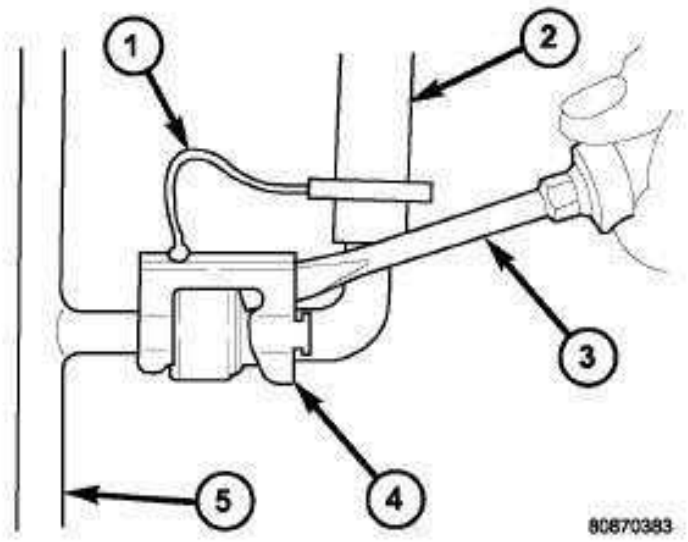
5 - Quick-Connect Fitting
6 - Round Plastic Retainer Ring

This type of fitting can be identified by the use of a round plastic retainer ring usually black in color. Special tools are not required for removal.

NOTE: **The round plastic retainer ring must be pressed squarely into the quick-connect fitting body. If this retainer is cocked during removal it will be difficult to disconnect the quick-connect fitting. Use an open-end wrench on the shoulder of the plastic retainer ring to aid in disconnection.**

1. Firmly push the quick-connect fitting towards the component being serviced while firmly pushing the round plastic retainer ring into the quick-connect fitting. With the round plastic ring depressed, remove the quick-connect fitting from the fuel system component.
2. After removal the plastic retainer ring will remain with the quick-connect fitting.

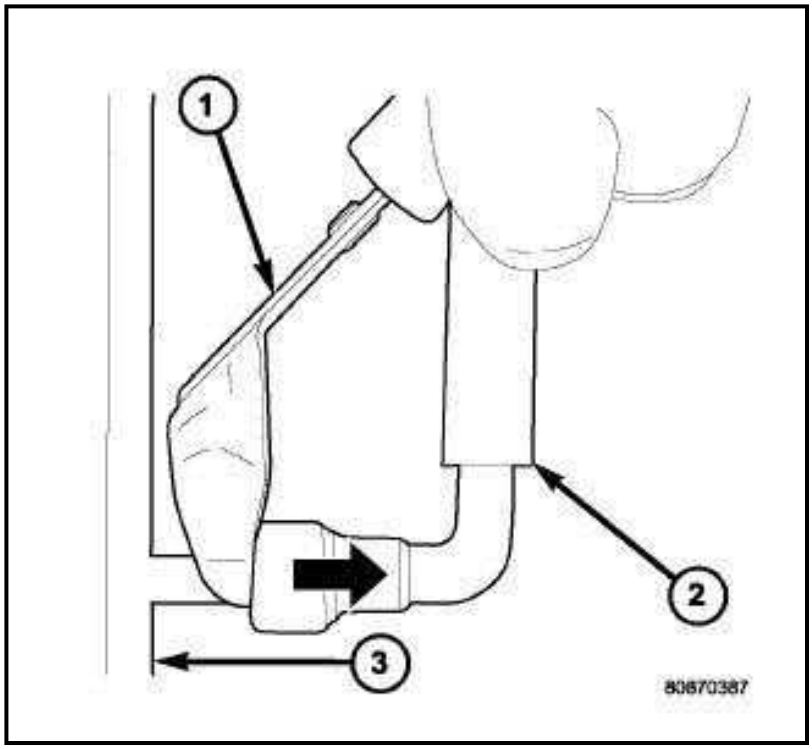
LATCH CLIP TYPE 1 FITTING



1 - Latch Clip Tether
2 - Fuel Line
3 - Screwdriver
4 - Latch Clip
5 - Fuel System Component

Depending on vehicle model and engine, 2 different types of safety latch clips are used. One is tethered to fuel line and the other is not. A special tool will be necessary to disconnect the fuel line after latch clip is removed. The latch clip may be used on certain fuel line and fuel rail connections or to join fuel lines together.

1. Pry up on the latch clip with a screwdriver.
2. Slide the latch clip away from the quick-connect fitting while lifting the screwdriver and position aside.



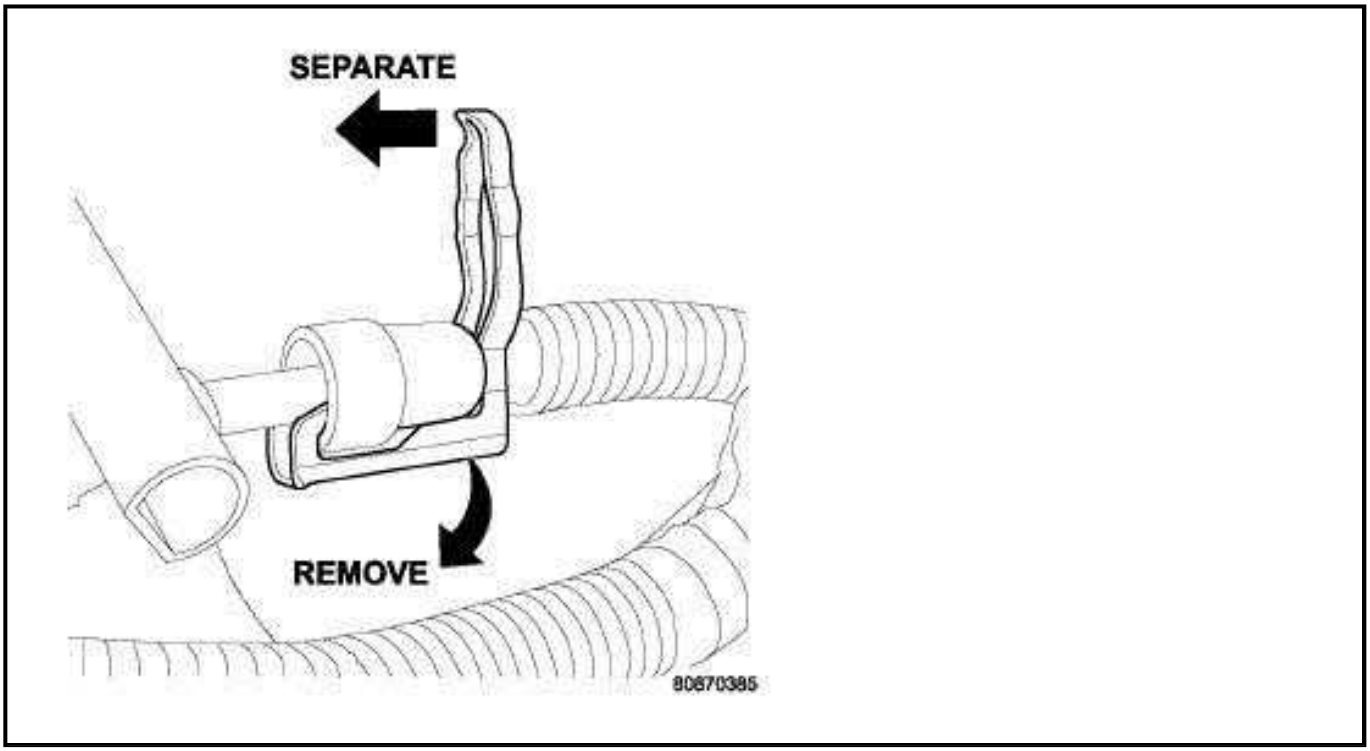
1 - Fuel Line Removal Tool
2 - Fuel Line
3 - Fuel System Component

3. Insert the commercially available fuel line removal tool into the quick-connect fitting and release the internal latches.

NOTE: **After removal the internal latches will remain in the quick-connect fitting.**

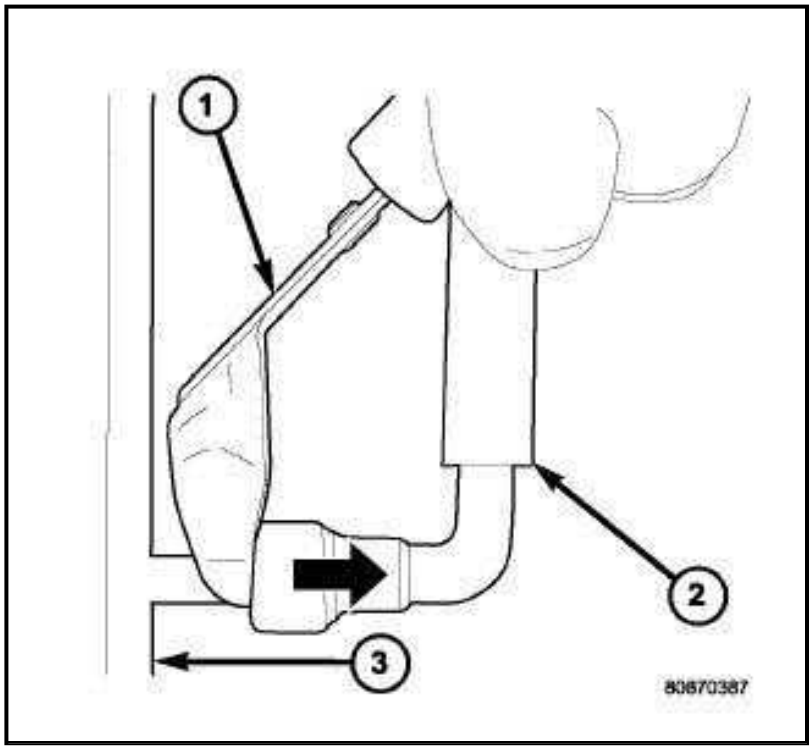
4. With the commercially available fuel line removal tool still inserted, remove the quick-connect fitting from the fuel system component.

LATCH CLIP TYPE 2 FITTING



Depending on vehicle model and engine, 2 different types of safety latch clips are used. One is tethered to the fuel line and the other is not. A special tool will be necessary to disconnect the fuel line after the latch clip is removed. The latch clip may be used on certain fuel line and fuel rail connections or to join fuel lines together.

1. Unlatch the small arms on the end of clip, swing away and separate from the fuel system component.
2. Slide the latch clip away from the quick-connect fitting while lifting with a screwdriver and position aside.



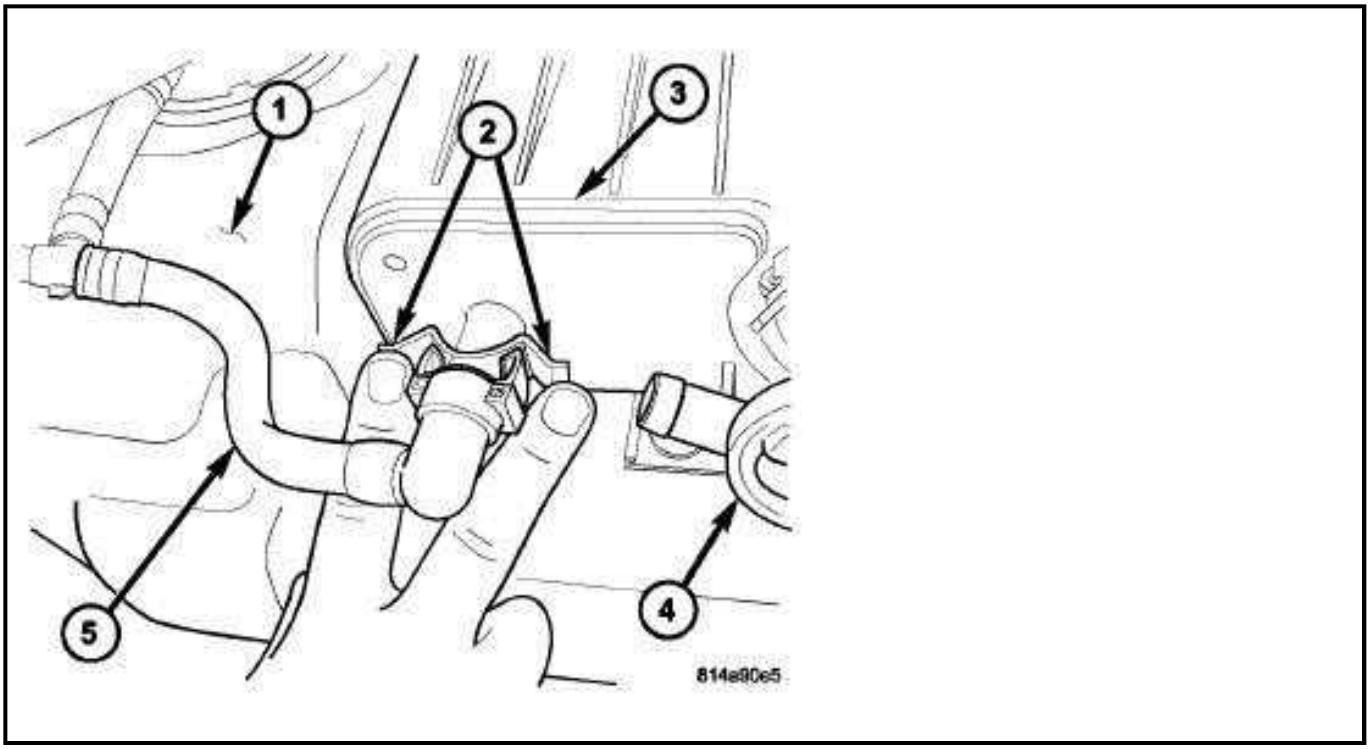
1 - Fuel Line Removal Tool
2 - Fuel Line
3 - Fuel System Component

3. Insert the commercially available fuel line removal tool into the quick-connect fitting and release the internal latches.

NOTE: **After removal the internal latches will remain in the quick-connect fitting.**

4. With the commercially available fuel line removal tool inserted, remove the quick-connect fitting from the fuel system component.

WING TYPE FITTING



1 - Fuel Tank
2 - Wings
3 - EVAP Canister
4 - Emission Component
5 - Vapor Hose

The wing type fitting is used on fuel system and emission components. The wing type fitting is most commonly used on the EVAP canister. Special tools are not required for removal.

1. Using two fingers, press both wings and release the locking tabs.

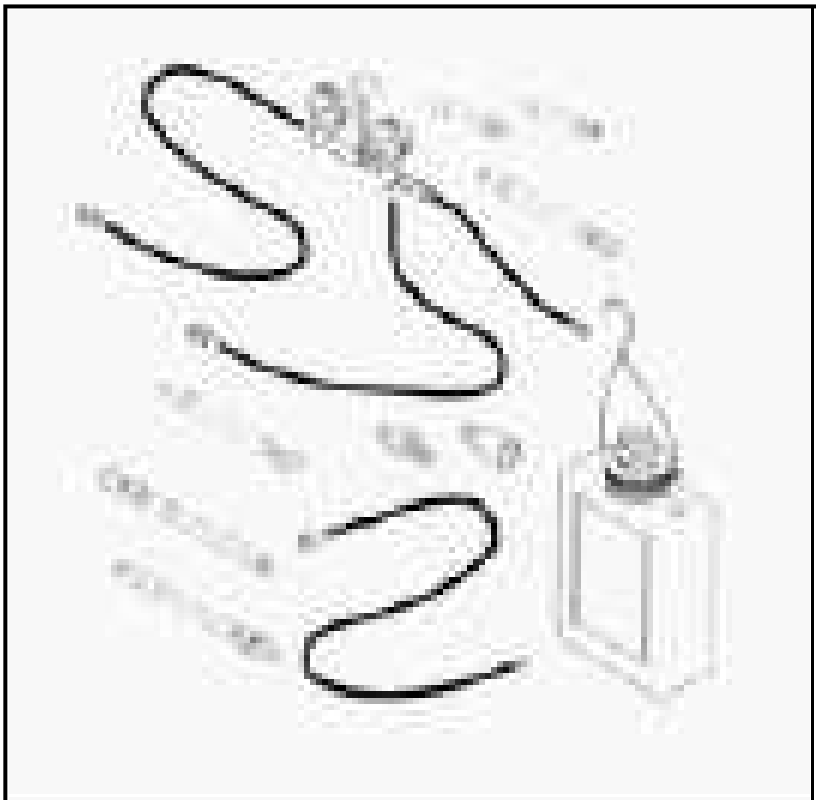
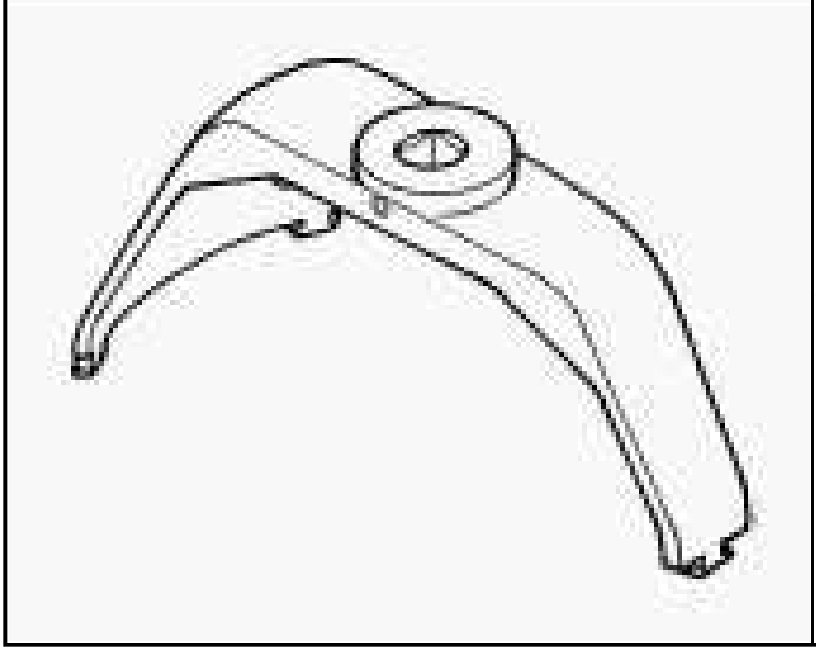
NOTE: **After removal the locking tabs will remain with the quick-connect fitting.**

2. While holding the wings, remove the quick-connect fitting from the fuel system component.

CONNECTING

1. Inspect the quick-connect fitting body and fuel system components for damage. Replace as necessary.
2. Prior to connecting any quick-connect fitting to components, check condition of fitting and components. Clean parts with a lint-free cloth. Lubricate with clean engine oil.
3. Insert the quick-connect fitting onto the fuel tube or fuel system component until the built-in stop on the fuel tube or component rests against the back of fitting.
4. Continue pushing until a click is felt.
5. Perform the specific instructions if equipped with the following quick-connectors:
   - **Redundant Latch Single Button Type Fitting:** Push redundant latch until it locks into position in the quick-connect fitting.
   - **Single Tab Type Fitting:** Push new tab down until it locks into position in the quick-connect fitting.
   - **Latch Clip Type Fitting:** Install latch clip (snaps into position). **If latch clip will not snap into position, this indicates the quick-connect fitting is not properly installed onto fuel system component, recheck the connection.**
6. Verify a locked condition by firmly pulling on the quick-connect fitting connection of the fuel system component.

SPECIAL TOOLS

	8978A - Decay Tool, Fuel
	9340 - SAE Fuel Pump Lock Ring Wrench (Originally Shipped In Kit Number(s) 9327, 9327CC, 9397, 9575.)

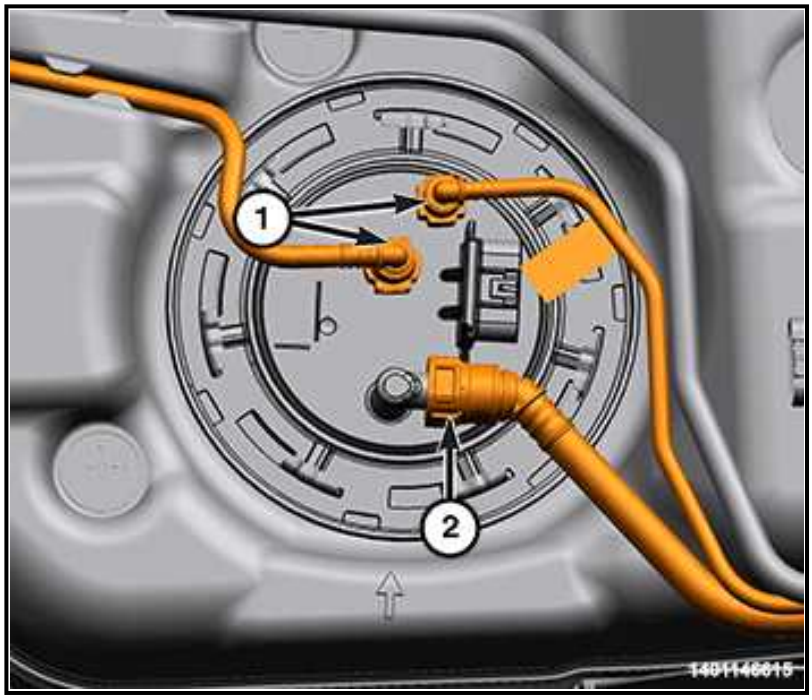
ASSEMBLY, FUEL PUMP

REMOVAL AND INSTALLATION

FUEL PUMP

REMOVAL

1. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
2. Remove the fuel tank. Refer to **TANK, FUEL, REMOVAL AND INSTALLATION**.



1 - Fuel Supply and Return Lines
2 - Fuel Tank Purge Line

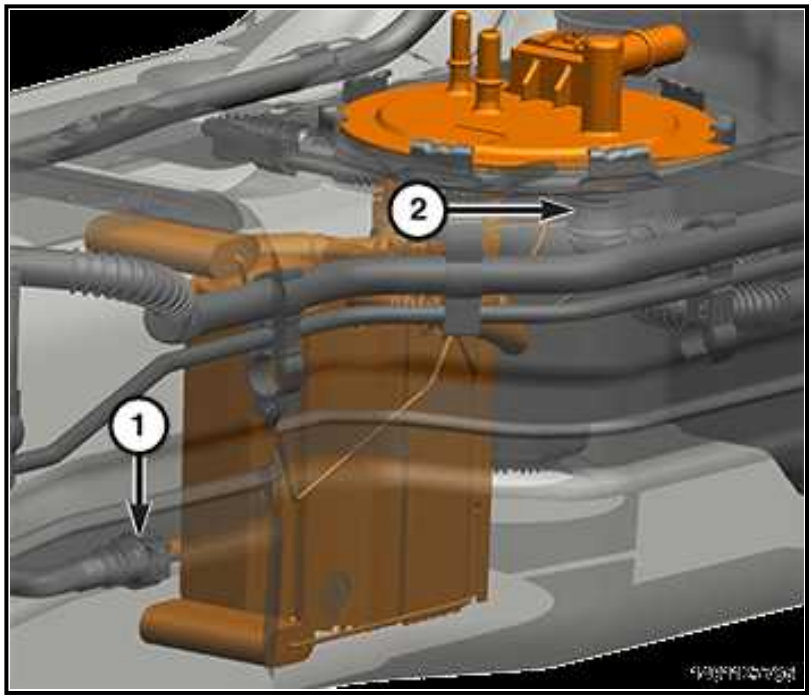
3. Disconnect the fuel supply and return line quick connect fitting. Refer to **FUEL SYSTEM** .
4. Disconnect the fuel tank purge line quick connect fitting. Refer to **FUEL SYSTEM** .

NOTE: **Prior to removing the fuel pump module, use compressed air to remove any accumulated dirt and debris from around fuel tank opening.**

CAUTION: **An indexing arrow is located on top of the main fuel pump module to clock it's position into the fuel tank, note it's location for reassembly.**

5. Position the SAE Fuel Pump Lock Ring Wrench (special tool #9340, SAE Fuel Pump Lock Ring Wrench) into the notches on the outside edge of the lock ring.
6. Install a 1/2 inch drive breaker bar into the SAE Fuel Pump Lock Ring Wrench (special tool #9340, SAE Fuel Pump Lock Ring Wrench).
7. Rotate the breaker bar counterclockwise and remove the lock ring.

CAUTION: **Whenever the fuel pump module is serviced, the rubber O-ring seal must be replaced.**



1 - Fuel Pickup Tube
2 - Internal Vent Line

8. Disconnect the internal tank lines from the fuel pump module while removing from the tank.
9. Remove and discard the rubber O-ring 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.

CAUTION: **An indexing arrow is located on top of the main fuel pump module to clock it's position into the fuel tank. The fuel pump module must be installed in the same position as removed.**

- Use a **NEW** rubber O-ring seal with the fuel pump module.
- Rotate the fuel pump module until the embossed alignment arrow points to the center alignment mark or the same position as noted during removal. This step must be performed to prevent the float from contacting the side of the fuel tank.
- Use the Fuel Pump Lock Ring Wrench (special tool #9340, SAE Fuel Pump Lock Ring Wrench) and a 1/2 inch drive breaker bar to tighten the lock ring.
- Rotate the breaker bar clockwise until all seven notches of the lock ring have engaged.
- Verify that the fuel line quick connect fittings are completely engage and locked on the fuel pump.
- Start the engine and check for leaks at all fuel tank connections.

TORQUE SPECIFICATIONS

FUEL SYSTEM

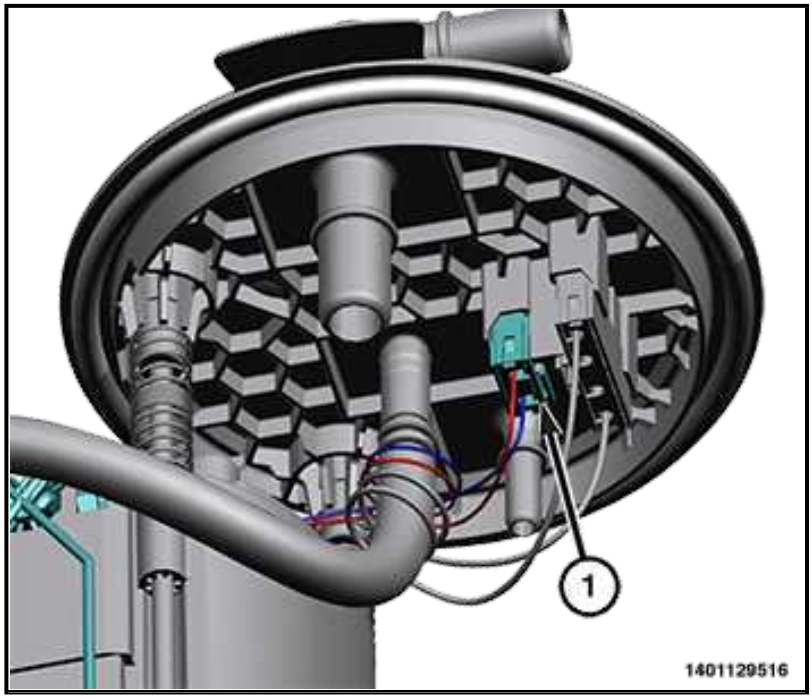
DESCRIPTION	SPECIFICATION	COMMENTS
Accelerator Pedal to Bulkhead Nuts	**12 N. m (9 Ft. Lbs.)**	-
Fuel Filler Tube to Body Bolts	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube to Body Nut(s)	**8 N. m (71 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Fuel Filler Tube Clamp	**4 N. m (35 In. Lbs.)**	-
Fuel Line Bundle to Transmission	**25 N.m (18 Ft. Lbs.)**	-
Fuel Pump Control Module	**6 N.m (53 In. Lbs.)**	-
Fuel Rail to Lower Intake	**7 N.m (62 In. Lbs.)**	-
Fuel Tank Deflector to Cross Member	**8 N.m (71 In. Lbs.)**	-
Fuel Tank Skid Plate Bolts	**95 N. m (70 Ft. Lbs.)**	-
Fuel Tank Strap to Skid Plate	**25 N. m (18 Ft. Lbs.)**	-

FUEL LEVEL SENDING UNIT

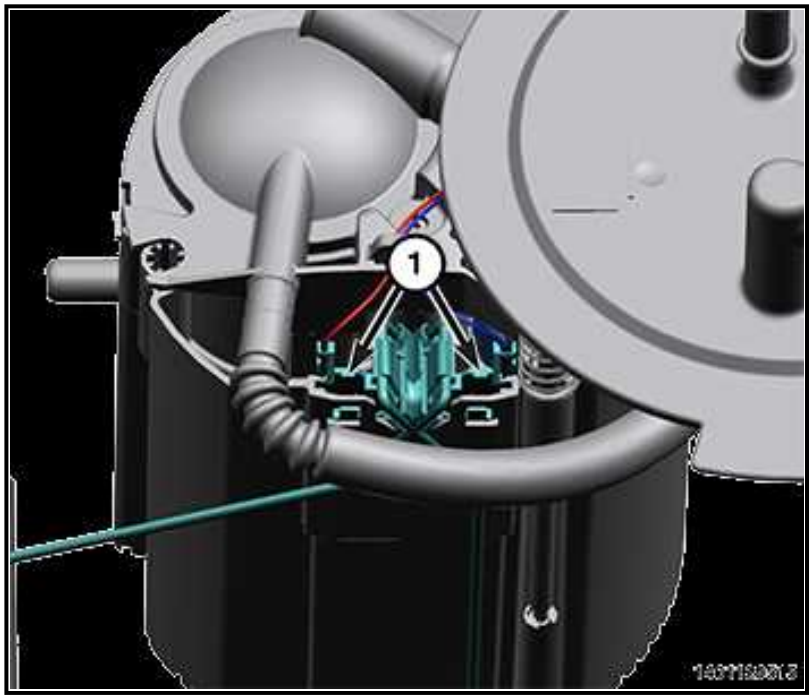
REMOVAL

1. Remove the fuel pump assembly.



1- Fuel Level Sensor Wire Harness Connector

2. Disconnect the wire harness connector for the fuel level sensor.



1- Fuel Level Sensor Retaining Tabs

3. Disengage the fuel level sensor retaining tabs from the fuel pump module housing and remove.

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

FUEL SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
Accelerator Pedal to Bulkhead Nuts	**12 N. m (9 Ft. Lbs.)**	-
Fuel Filler Tube to Body Bolts	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube to Body Nut(s)	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube Clamp	**4 N. m (35 In. Lbs.)**	-
Fuel Line Bundle to Transmission	**25 N.m (18 Ft. Lbs.)**	-
Fuel Pump Control Module	**6 N.m (53 In. Lbs.)**	-
Fuel Rail to Lower Intake	**7 N.m (62 In. Lbs.)**	-
Fuel Tank Deflector to Cross Member	**8 N.m (71 In. Lbs.)**	-
Fuel Tank Skid Plate Bolts	**95 N. m (70 Ft. Lbs.)**	-
Fuel Tank Strap to Skid Plate	**25 N. m (18 Ft. Lbs.)**	-

INJECTOR(S), FUEL

REMOVAL AND INSTALLATION

FUEL INJECTORS

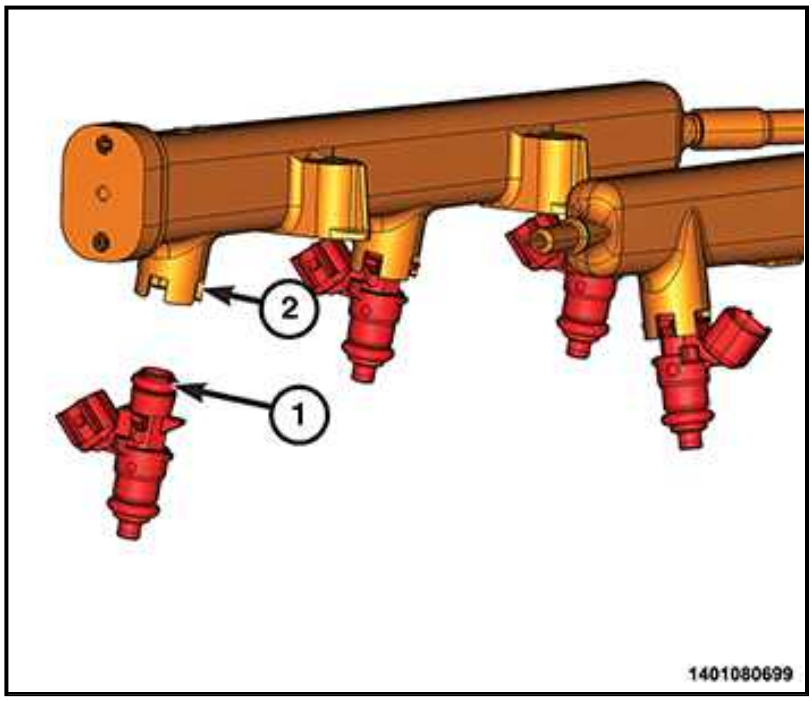
REMOVAL

WARNING: **The fuel system is under constant pressure even with engine off. Before servicing the fuel rail, fuel system pressure must be released.**

1. Release fuel system pressure. Refer to **FUEL SYSTEM PRESSURE RELEASE** .

CAUTION: **When removing the fuel rail from the lower intake manifold, one or more fuel injectors may remain in the intake manifold resulting in residual fuel spilling onto the engine from the fuel rail.**

2. Remove the fuel rail. Refer to **RAIL(S), FUEL, REMOVAL AND INSTALLATION**.



1 - Fuel Injectors
2 - Fuel Rail

3. Remove the fuel injectors from the fuel rail.
4. Remove and **DISCARD** all fuel injector O-rings.

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.

- Lightly lubricate the **NEW** O-ring seals with engine oil and install the O-ring seal onto fuel injector.
- Check the fuel system for leaks.

TORQUE SPECIFICATIONS

FUEL SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
Accelerator Pedal to Bulkhead Nuts	**12 N. m (9 Ft. Lbs.)**	-
Fuel Filler Tube to Body Bolts	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube to Body Nut(s)	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube Clamp	**4 N. m (35 In. Lbs.)**	-
Fuel Line Bundle to Transmission	**25 N.m (18 Ft. Lbs.)**	-
Fuel Pump Control Module	**6 N.m (53 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Fuel Rail to Lower Intake	**7 N.m (62 In. Lbs.)**	-
Fuel Tank Deflector to Cross Member	**8 N.m (71 In. Lbs.)**	-
Fuel Tank Skid Plate Bolts	**95 N. m (70 Ft. Lbs.)**	-
Fuel Tank Strap to Skid Plate	**25 N. m (18 Ft. Lbs.)**	-

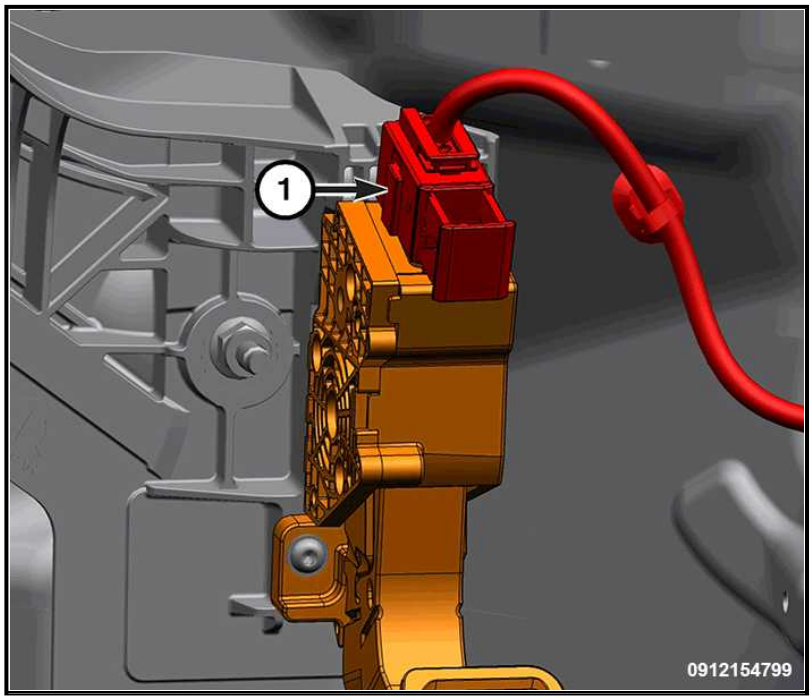
PEDAL, ACCELERATOR

REMOVAL AND INSTALLATION

ACCELERATOR PEDAL

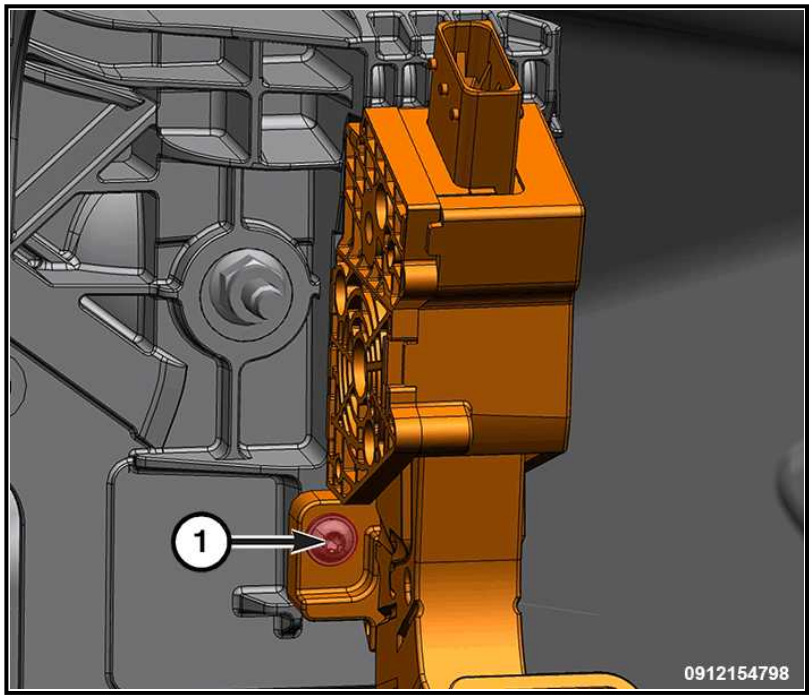
REMOVAL

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



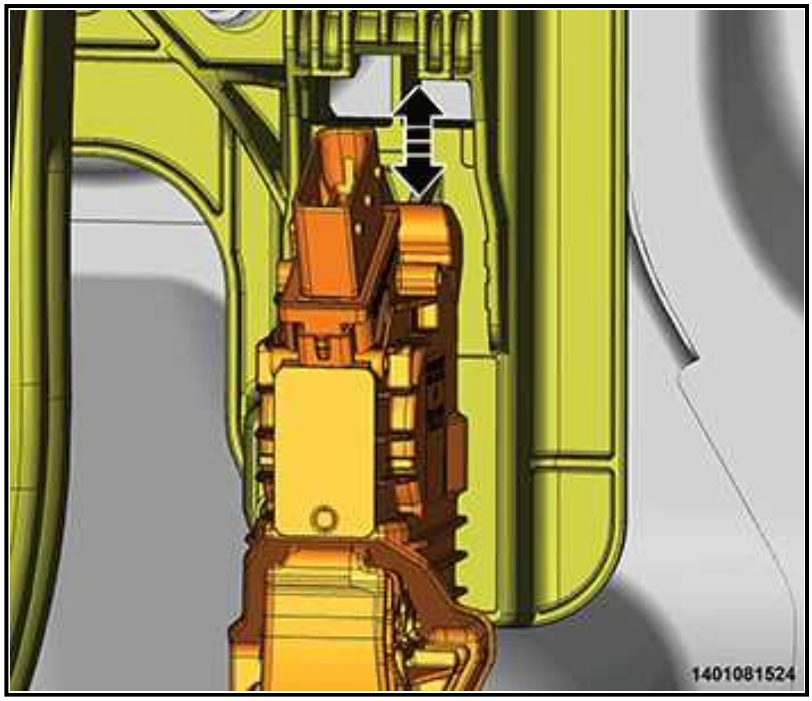
1 - Wire Harness Connector

2. Disconnect the accelerator pedal wire harness connector.



1 - Accelerator Pedal Bolt

3. Remove the accelerator pedal mounting bolt.



4. Push up and remove the accelerator pedal assembly.

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 scan tool and run the ETC RELEARN function to relearn the APPS values.

TORQUE SPECIFICATIONS

FUEL SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
Accelerator Pedal to Bulkhead Nuts	**12 N. m (9 Ft. Lbs.)**	-
Fuel Filler Tube to Body Bolts	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube to Body Nut(s)	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube Clamp	**4 N. m (35 In. Lbs.)**	-
Fuel Line Bundle to Transmission	**25 N.m (18 Ft. Lbs.)**	-
Fuel Pump Control Module	**6 N.m (53 In. Lbs.)**	-
Fuel Rail to Lower Intake	**7 N.m (62 In. Lbs.)**	-
Fuel Tank Deflector to Cross Member	**8 N.m (71 In. Lbs.)**	-
Fuel Tank Skid Plate Bolts	**95 N. m (70 Ft. Lbs.)**	-
Fuel Tank Strap to Skid Plate	**25 N. m (18 Ft. Lbs.)**	-

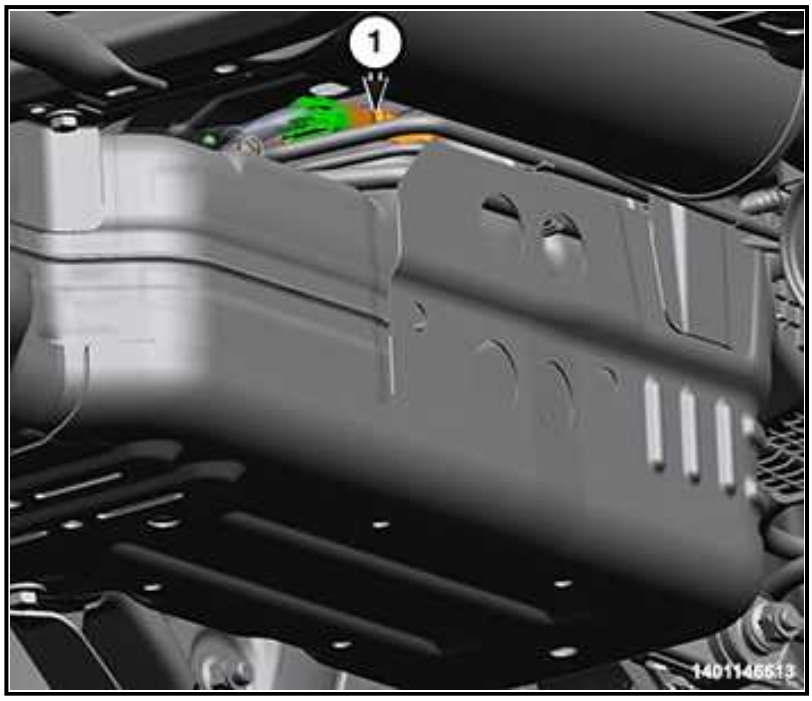
MODULES

REMOVAL AND INSTALLATION

FUEL PUMP CONTROL MODULE (FPCM)

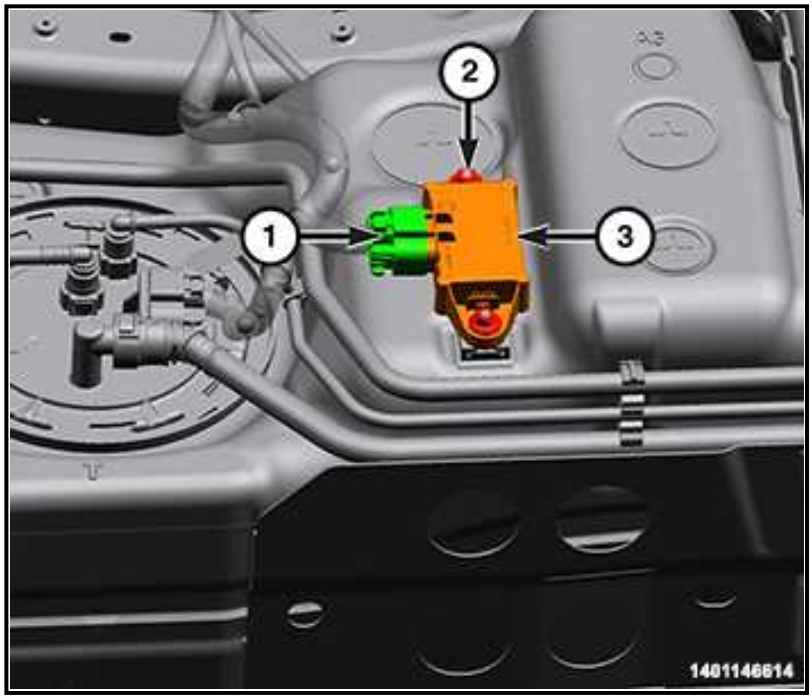
REMOVAL

1. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .



1 - Fuel Pump Control Module

2. Fuel pump control module is mounted to the top of the fuel tank. Support and lower the fuel tank if necessary for access.



1 - FPCM Wire Harness Connector
2 - FPCM Nuts
3 - Fuel Pump Control Module

NOTE: **View of top of fuel tank**

3. Disconnect the wire harness connector from the fuel pump control module.
4. Remove the mounting nuts and remove fuel pump control module.

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

FUEL SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
Accelerator Pedal to Bulkhead Nuts	**12 N. m (9 Ft. Lbs.)**	-
Fuel Filler Tube to Body Bolts	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube to Body Nut(s)	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube Clamp	**4 N. m (35 In. Lbs.)**	-
Fuel Line Bundle to Transmission	**25 N.m (18 Ft. Lbs.)**	-
Fuel Pump Control Module	**6 N.m (53 In. Lbs.)**	-
Fuel Rail to Lower Intake	**7 N.m (62 In. Lbs.)**	-
Fuel Tank Deflector to Cross Member	**8 N.m (71 In. Lbs.)**	-
Fuel Tank Skid Plate Bolts	**95 N. m (70 Ft. Lbs.)**	-
Fuel Tank Strap to Skid Plate	**25 N. m (18 Ft. Lbs.)**	-

RAIL(S), FUEL

REMOVAL AND INSTALLATION

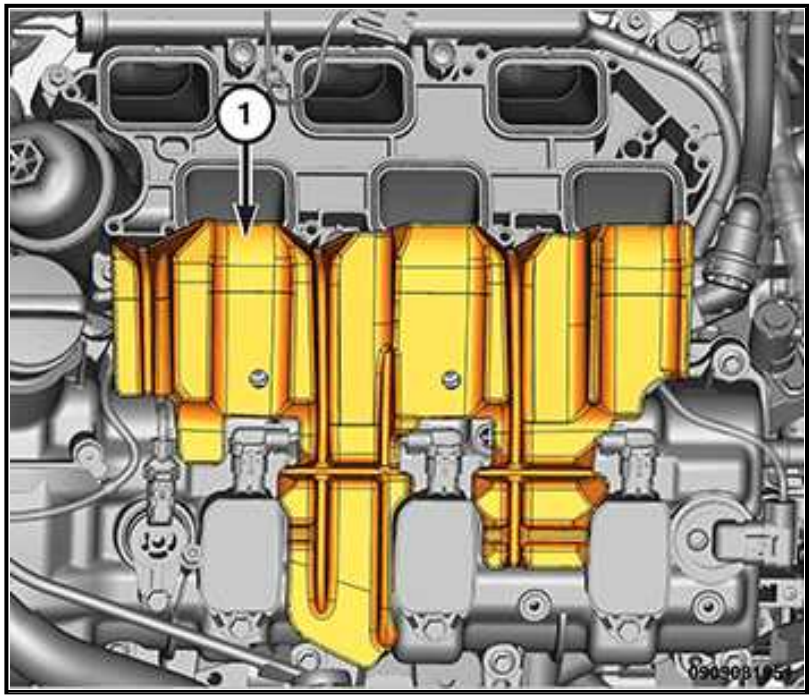
FUEL RAIL

REMOVAL

CAUTION: **When removing the fuel supply line from the fuel inlet tube at the fuel rail, care must be taken that the fuel inlet tube is not being over-flexed. Damage to the fuel rail inlet tube may occur.**

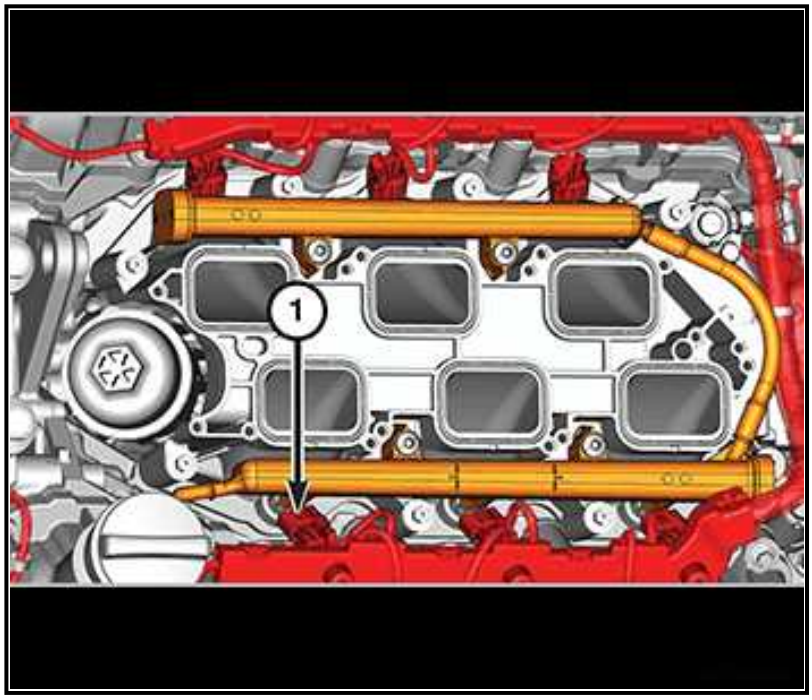
WARNING: **The fuel system is under constant pressure even with engine off. Before servicing the fuel rail, fuel system pressure must be released.**

1. Release the fuel system pressure. Refer to **FUEL SYSTEM PRESSURE RELEASE** .
2. Remove the upper intake manifold. Refer to **MANIFOLD, INTAKE, REMOVAL AND INSTALLATION** .



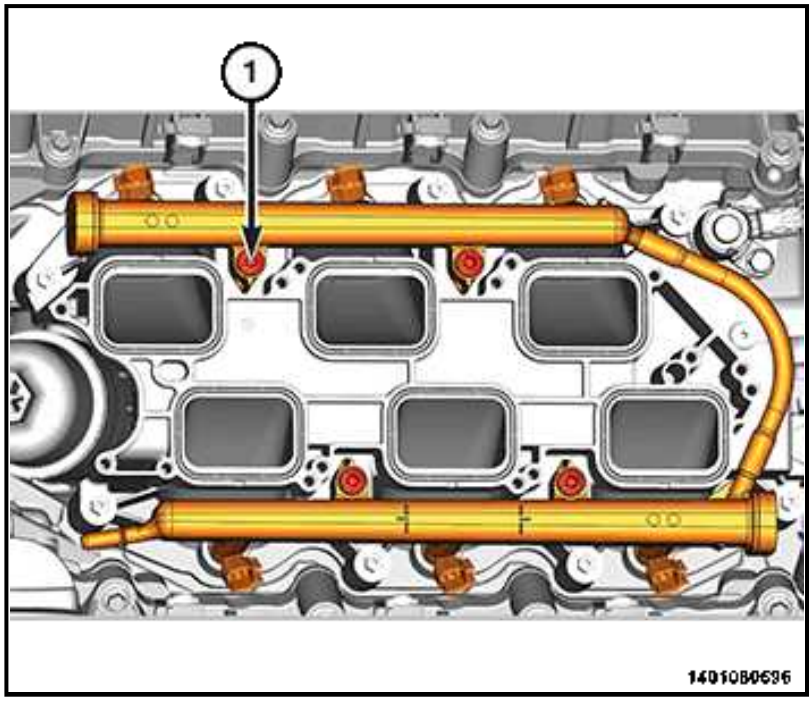
1- Insulator

3. Remove the insulator from the left cylinder head cover.



1- Fuel Injector Wire Harness Connectors

4. Disconnect the fuel injector wire harness connectors.
5. Disconnect the fuel supply hose from the fuel rail. Refer to **FUEL SYSTEM** .



1- Fuel Rail Bolts

CAUTION: **The left and right fuel rails are replaced as an assembly. Do not attempt to separate the rail halves at the connector tube. Due to the design of this tube, it does not use any clamps. Never attempt to install a clamping device of any kind on the tube. When removing the fuel rail assembly for any reason, be careful not to bend or kink the tube.**

6. Remove the four bolts from the fuel rail.

CAUTION: **When removing the fuel rail from the lower intake manifold, one or more fuel injectors may remain in the intake manifold resulting in residual fuel**

spilling onto the engine from the fuel rail.

7. Lift the fuel rail and the fuel injectors from the lower intake manifold.
8. If required, remove any remaining fuel injectors from the lower intake manifold.
9. If required, remove the fuel injectors from the fuel rail. Refer to **INJECTOR(S), FUEL, REMOVAL AND INSTALLATION**.
10. If required, remove and discard all fuel injector O-ring seals.

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 six fuel injectors to the fuel rail with **NEW** O-rings.
- Clean out the fuel injector bores in the lower intake manifold.
- Lubricate each fuel injector O-ring with a small amount of engine oil before installing.
- Check the fuel system for leaks.

TORQUE SPECIFICATIONS

FUEL SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
Accelerator Pedal to Bulkhead Nuts	**12 N. m (9 Ft. Lbs.)**	-
Fuel Filler Tube to Body Bolts	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube to Body Nut(s)	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube Clamp	**4 N. m (35 In. Lbs.)**	-
Fuel Line Bundle to Transmission	**25 N.m (18 Ft. Lbs.)**	-
Fuel Pump Control Module	**6 N.m (53 In. Lbs.)**	-
Fuel Rail to Lower Intake	**7 N.m (62 In. Lbs.)**	-
Fuel Tank Deflector to Cross Member	**8 N.m (71 In. Lbs.)**	-
Fuel Tank Skid Plate Bolts	**95 N. m (70 Ft. Lbs.)**	-
Fuel Tank Strap to Skid Plate	**25 N. m (18 Ft. Lbs.)**	-

TANK, FUEL

REMOVAL AND INSTALLATION

FUEL TANK

REMOVAL

WARNING: **Risk of injury to eyes and skin from contact with fuel. Wear protective clothing and eye protection. Risk of poisoning from inhaling and swallowing fuel. Pour fuel only into appropriately marked and approved containers. Failure to follow these instructions may result in possible serious or fatal injury.**

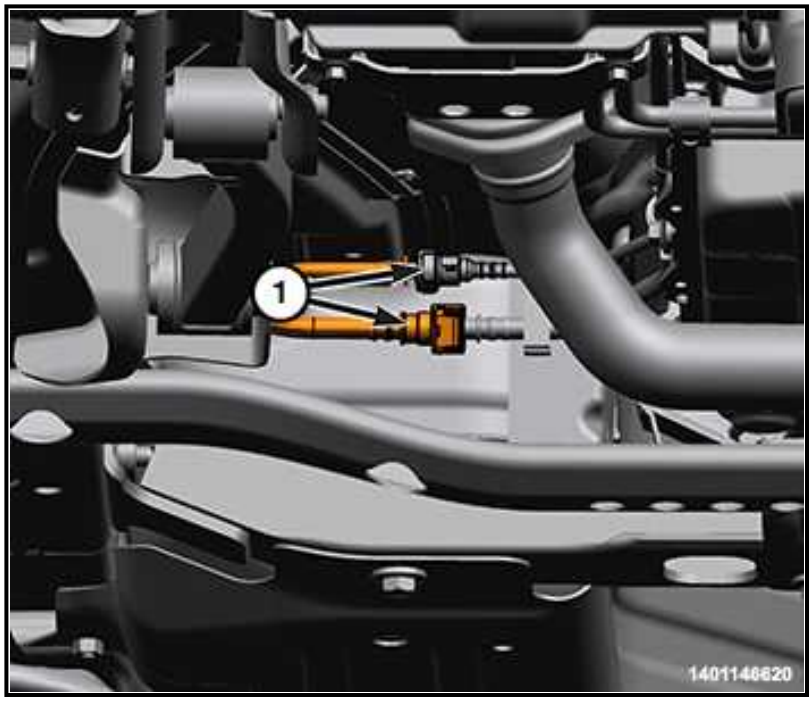
WARNING: **The fuel system is under constant high pressure even with engine OFF. Until the fuel pressure has been properly released from the system, do not attempt to open the fuel system. Do not smoke or use open flames/sparks when servicing the fuel system. Make sure the area in which the vehicle is being**

serviced is in a well ventilated area. Failure to comply may result in serious or fatal injury.

1. Perform Fuel System Pressure Release Procedure. Refer to **FUEL SYSTEM PRESSURE RELEASE** .
2. If possible, drain the fuel tank using the conventional procedure. Refer to **DRAINING FUEL TANK** .
3. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
4. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .

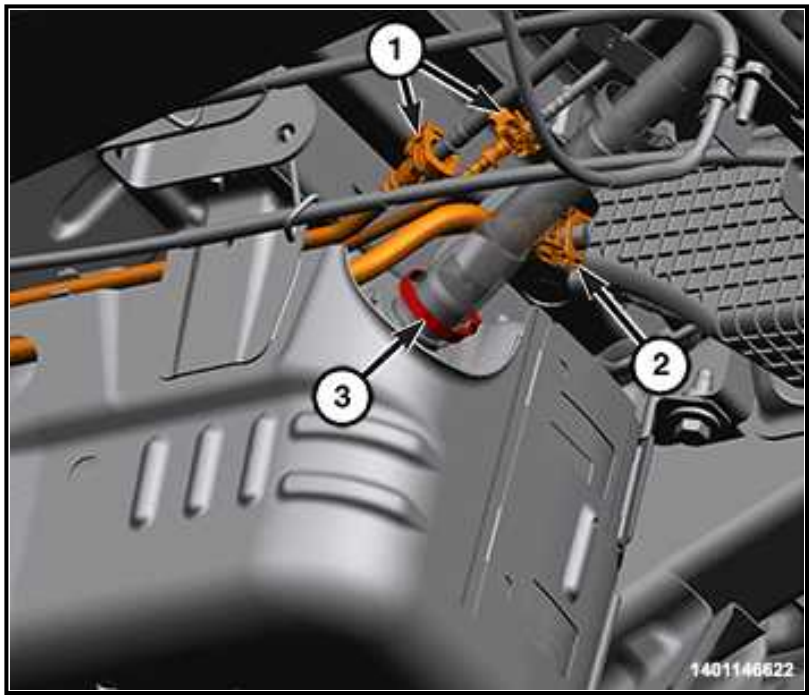
1 - Fuel Line Deflector Nut
2 - Fuel Line Deflector Bolt

5. Remove the front fuel line deflector nut and bolt and remove the front fuel tank deflector.



1 - Fuel Line Quick-Connect Fittings

6. Disconnect the quick-connect fittings at front of fuel tank and remove the lines from the retaining clip. Refer to **FUEL SYSTEM** .

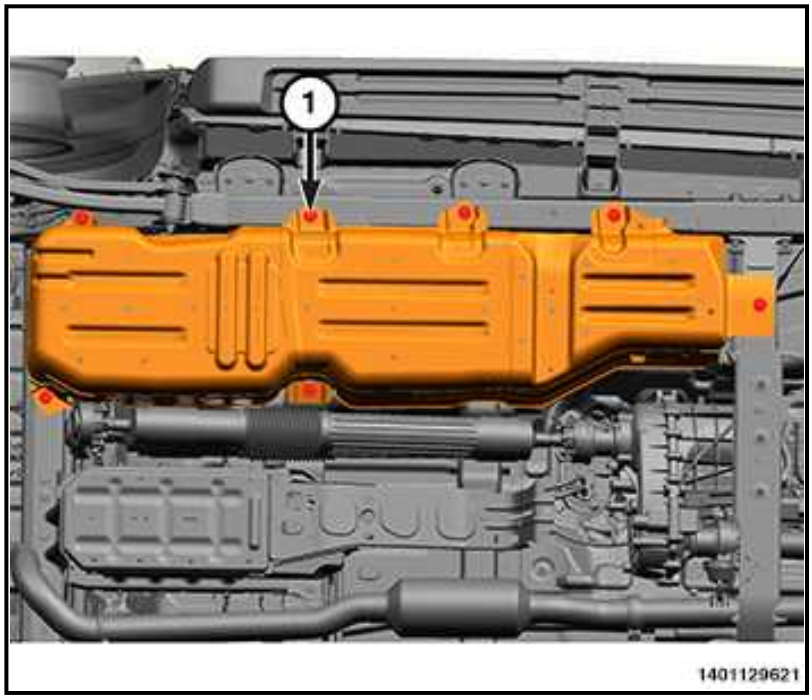


1 - Recirculation Line Quick Connect Fitting
2 -Vapor Line Quick Connect Fitting
3 - Fuel Filler Tube Clamp

7. Loosen the fuel filler tube hose clamp and remove the fuel filler tube from the fuel tank.
8. Disconnect the recirculation line quick-connect fitting at fuel tank. Refer to **FUEL SYSTEM** .
9. Disconnect the quick-connect for the vapor line from canister. Refer to **FUEL SYSTEM** .
10. Remove the transfer case skid plate. Refer to **PLATE, SKID, REMOVAL AND INSTALLATION** , or **PLATE, SKID, FUEL TANK, REMOVAL AND INSTALLATION** , and **PLATE, SKID, TRANSFER CASE, REMOVAL AND INSTALLATION** .

NOTE: **The fuel tank skid plate and the fuel tank assembly are removed at the same time. They share common fasteners.**

11. Position a support fixture under the fuel tank such as OTCB® Fuel Tank Handler 1758 on the OTCB® High-Lift Transmission Jack 1728.



1 - Fuel Tank Mounting Bolts

12. Remove eight bolts and partially lower the fuel tank to gain access to the fuel pump module wire harness connector.
13. Disconnect the wire harness connector from the fuel pump module.
14. Continue lowering the fuel tank for removal.
15. If required, lift the fuel tank from the skid plate.
16. If required, remove the fuel pump module from the fuel tank. Refer to **MODULES, 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.

- The fuel tank skid plate and the fuel tank assembly are installed at the same time. They share common fasteners.

TORQUE SPECIFICATIONS

FUEL SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
Accelerator Pedal to Bulkhead Nuts	**12 N. m (9 Ft. Lbs.)**	-
Fuel Filler Tube to Body Bolts	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube to Body Nut(s)	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube Clamp	**4 N. m (35 In. Lbs.)**	-
Fuel Line Bundle to Transmission	**25 N.m (18 Ft. Lbs.)**	-
Fuel Pump Control Module	**6 N.m (53 In. Lbs.)**	-
Fuel Rail to Lower Intake	**7 N.m (62 In. Lbs.)**	-
Fuel Tank Deflector to Cross Member	**8 N.m (71 In. Lbs.)**	-
Fuel Tank Skid Plate Bolts	**95 N. m (70 Ft. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Fuel Tank Strap to Skid Plate	**25 N. m (18 Ft. Lbs.)**	-

LINES AND TUBES, FUEL

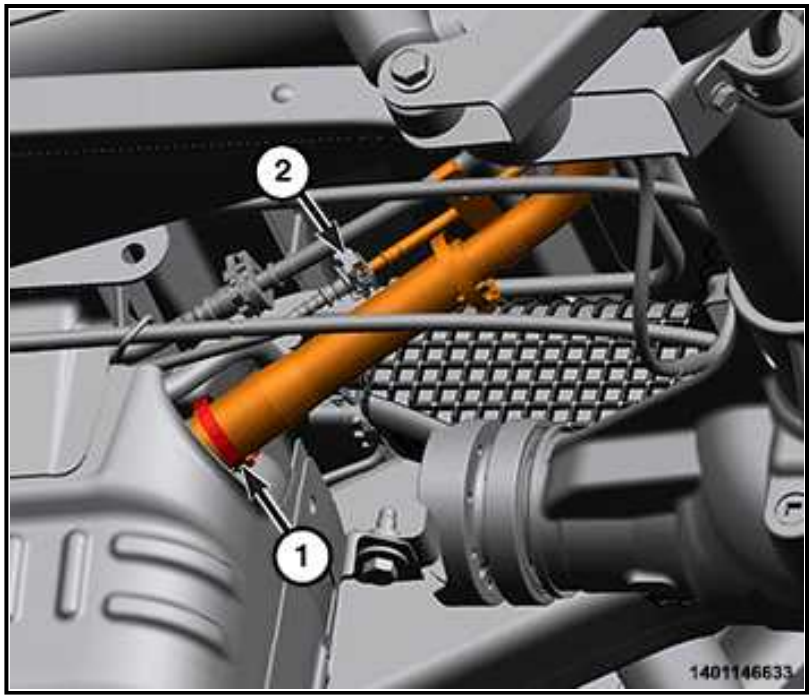
REMOVAL AND INSTALLATION

FUEL FILLER TUBE

REMOVAL

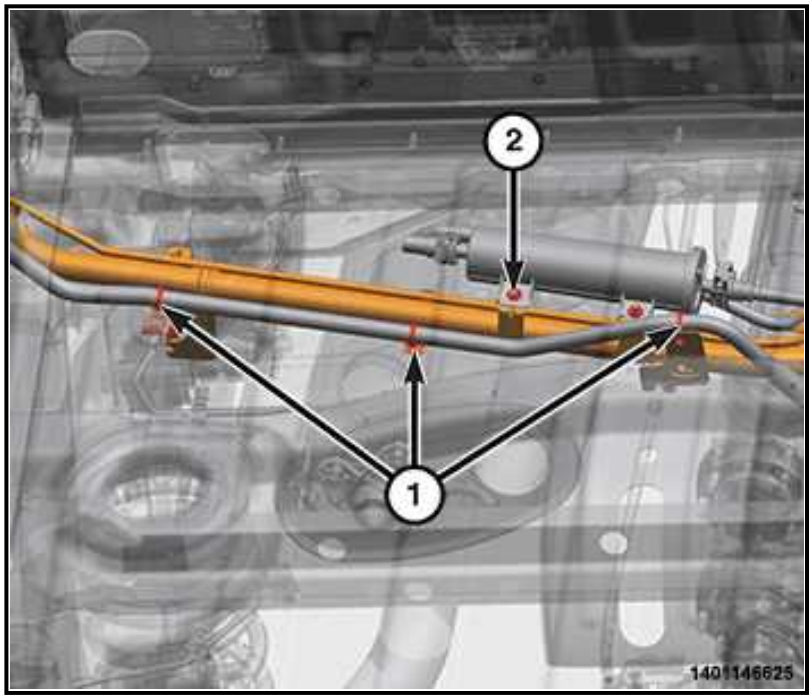
WARNING: **Risk of injury to eyes and skin from contact with fuel. Wear protective clothing and eye protection. Risk of poisoning from inhaling and swallowing fuel. Pour fuel only into appropriately marked and approved containers. Failure to follow these instructions may result in possible serious or fatal injury.**

1. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
2. Remove the fuel filler cap to relieve tank pressure.
3. Remove the exhaust muffler heat shield. Refer to **SHIELD, HEAT, REMOVAL AND INSTALLATION** .



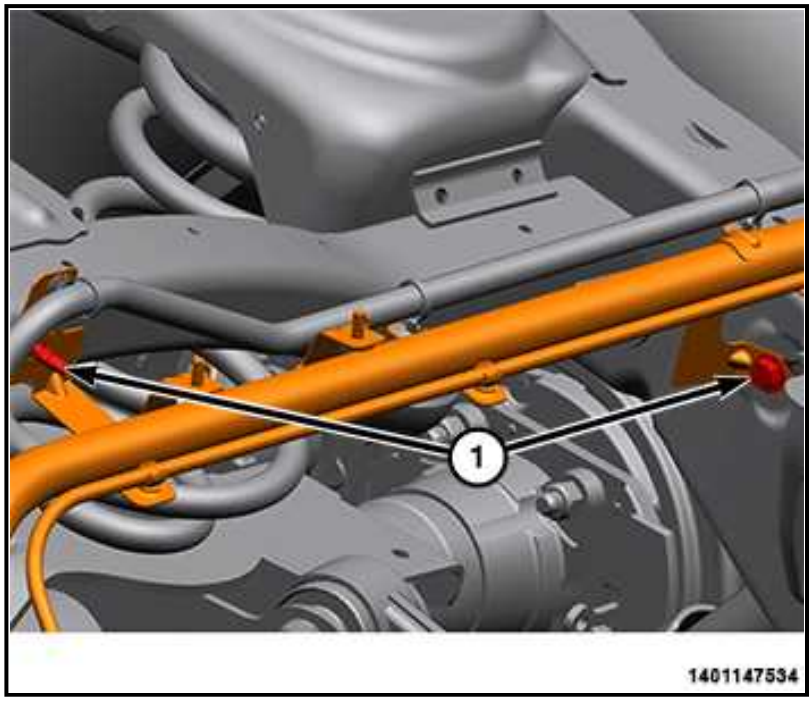
1 - Fuel Filler Tube Clamp to Tank
2 - Recirculation Line Quick-Connect Fitting

4. Loosen the fuel filler tube hose clamp at the fuel tank.
5. Disconnect the recirculation line quick-connect fitting. Refer to **FUEL SYSTEM** .



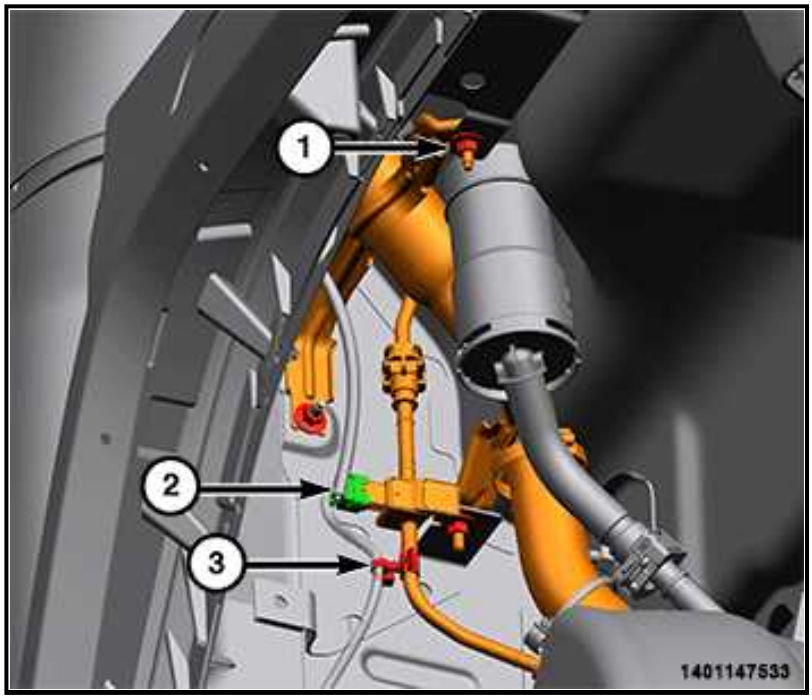
1 - Vent Tube Retaining Clips
2 - Fuel Vapor Vent Bolts

6. Release the vent tube retaining clips from the filler tube.
7. Remove the fasteners and position fuel vapor tube aside.



1 - Fuel Filler Tube Fasteners

8. Remove the two fasteners securing the filler tube to the frame.
9. Remove the left rear wheelhouse splash shield. Refer to **SHIELD, SPLASH, REAR WHEELHOUSE, REMOVAL AND INSTALLATION** .



1 - Fuel Filler Tube Fasteners
2 - Fuel Tank Pressure Sensor Wire Harness Connector
3 - Wire Harness Connector Retainers

10. Remove the three fasteners securing filler tube to body.
11. Disconnect the wire harness connector from the fuel tank pressure sensor.
12. Release the wire harness from the retaining clip.
13. Slide the fuel filler tube out from under the body.
14. Using a downward rotation, remove the fuel filler 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

FUEL SYSTEM

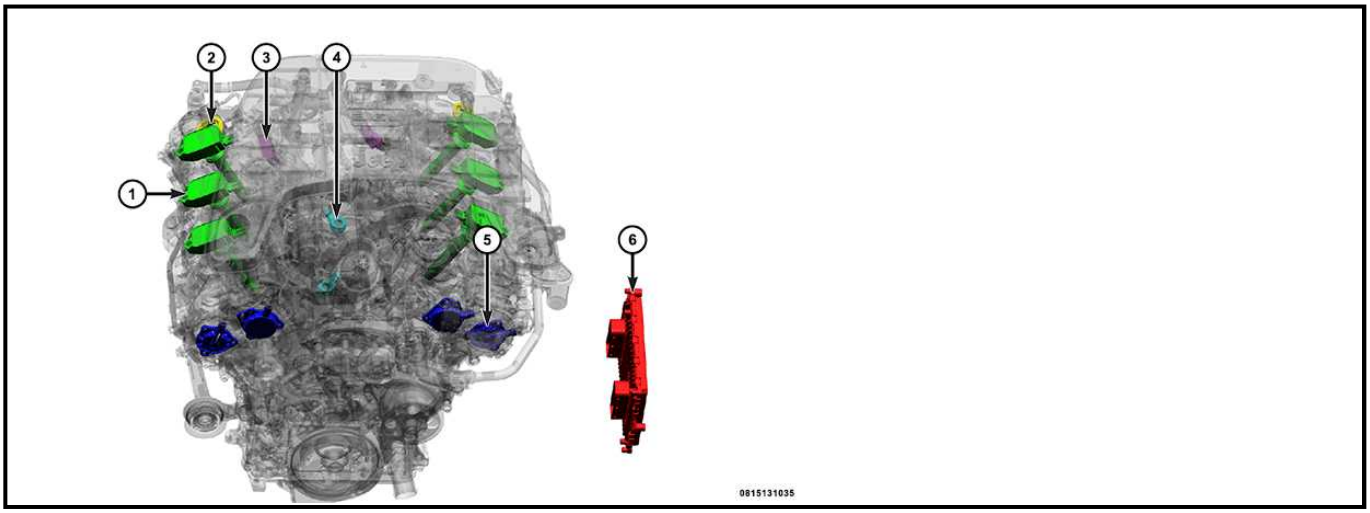
DESCRIPTION	SPECIFICATION	COMMENTS
Accelerator Pedal to Bulkhead Nuts	**12 N. m (9 Ft. Lbs.)**	-
Fuel Filler Tube to Body Bolts	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube to Body Nut(s)	**8 N. m (71 In. Lbs.)**	-
Fuel Filler Tube Clamp	**4 N. m (35 In. Lbs.)**	-
Fuel Line Bundle to Transmission	**25 N.m (18 Ft. Lbs.)**	-
Fuel Pump Control Module	**6 N.m (53 In. Lbs.)**	-
Fuel Rail to Lower Intake	**7 N.m (62 In. Lbs.)**	-
Fuel Tank Deflector to Cross Member	**8 N.m (71 In. Lbs.)**	-
Fuel Tank Skid Plate Bolts	**95 N. m (70 Ft. Lbs.)**	-
Fuel Tank Strap to Skid Plate	**25 N. m (18 Ft. Lbs.)**	-

IGNITION CONTROL

DESCRIPTION AND OPERATION

IGNITION SYSTEM - 3.6L

DESCRIPTION



The ignition system is comprised of the following components:

COMPONENT INDEX

1.	Refer to **IGNITION COIL**.
2.	Refer to **CAMSHAFT POSITION (CMP) SENSOR**.
3.	Refer to **IGNITION CAPACITOR**.
4.	Refer to **KNOCK SENSOR**.
5.	Refer to **VARIABLE VALVE TIME (VVT) SOLENOIDS**.
6.	Refer to **POWERTRAIN CONTROL MODULE (PCM)**.

OPERATION

All engines use a fixed ignition timing system. Basic ignition timing is not adjustable. All spark advance is determined by the Powertrain Control Module (PCM). The ignition system used on these engines is referred to as coil on plug. The system's four main components are the coils, spark plugs, camshaft position sensors, and the crankshaft position sensor. The coil on plug ignition system utilizes an ignition coil for every cylinder (coil over). The ignition coils are mounted directly over each spark plug.

CAMSHAFT POSITION (CMP) SENSOR

Refer to **COMPONENT INDEX**.

The 3.6 liter engine uses a Dual Over Head Camshaft (DOHC) configuration. The camshafts are a nodular cast iron design and have two pressed on magnetic timing wheels that are magnetically encoded. The two CMP sensors are located at the rear of the cylinder head covers. The sensors are bolted to the cylinder head and utilize a radial lip seal where they protrude through the covers. The attaching bolt has an O-ring seal and is captured in the sensor. The CMP sensors are dual read, single element hall effect sensors mounted between the magnetic encoded timing wheels. The magnetic timing wheels are used because of their small diameter allowing for a compact cylinder head design.

IGNITION COIL

Refer to **COMPONENT INDEX**.

An ignition coils are used with each spark plug and are mounted on the spark plug (coil over).

- The Auto Shutdown (ASD) relay provides battery voltage to the ignition coil.
- The PCM provides a ground path with an internal Low Side Driver (LSD).

- When the PCM opens the LSD, the ground path is broken and the energy in the coil primary re-energizes.
- The PCM will de-energize the ASD relay if it does not receive the crankshaft position sensor and camshaft position sensor inputs.

IGNITION CAPACITOR

Refer to **COMPONENT INDEX**.

The coil capacitor helps dampen the amount of conducted electrical noise to the camshaft position sensor, crankshaft position sensor, and throttle position sensor. This noise is generated on the 12 volt supply wire to the ignition coils and fuel injectors. The ignition capacitor also provides a voltage to the ignition coil allowing for less ramp time when the coil is activated.

KNOCK SENSOR

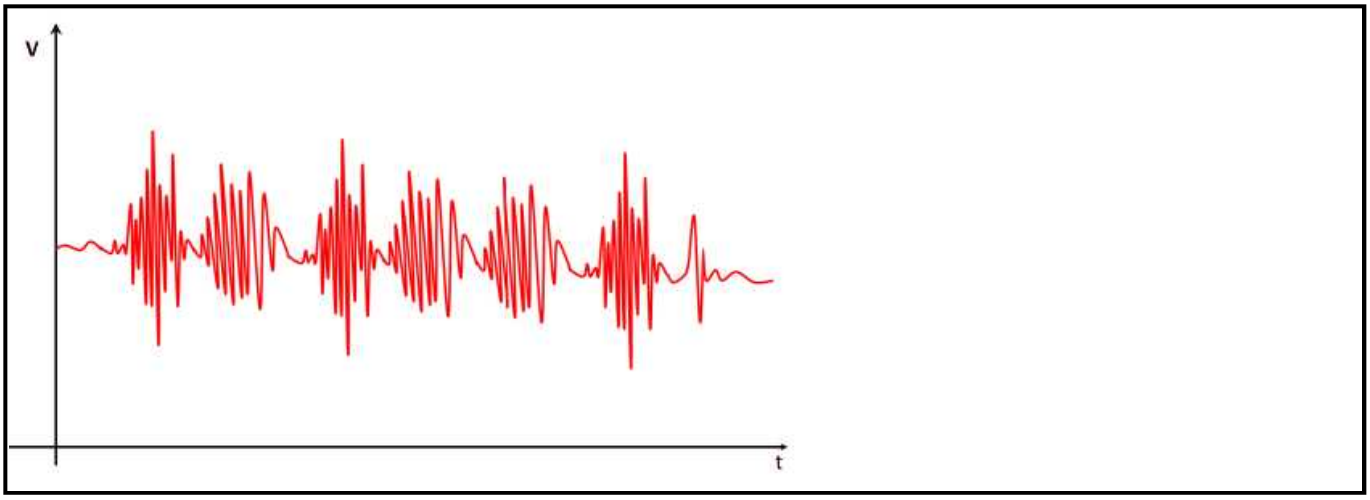
Refer to **COMPONENT INDEX**.

There are two knock sensors mounted under the intake manifold. Depending on the vibration frequency within the cylinder walls the sensor generates voltage proportional to it. The PCM detects the voltage value generated by the sensors rate of change, and as a function of that change, it can understand whether there is knocking in the cylinders. To reduce the knocking. The PCM starts reducing the ignition advance in order to limit the maximum pressure that can be reached in the combustion chamber. The higher the pressure the greater the risk of knocking.

NOTE: **Over or under tightening the sensor mounting bolts can also affect knock sensor performance, possibly causing improper spark control. Always use the specified torque when installing the knock sensors.**

When the knock sensor detects a knock in one of the cylinders on the corresponding bank, it sends an input signal to the PCM. In response, the PCM retards ignition timing for all cylinders by a scheduled amount. Knock sensors contain a piezoelectric crystal which constantly vibrates and sends an input voltage (signal) to the PCM while the engine operates. As the intensity of the crystal's vibration increases, the knock sensor output voltage also increases. The voltage signal produced by the knock sensor increases with the amplitude of vibration. The PCM receives the knock sensor voltage signal as an input. If the signal rises above a predetermined level, the PCM will store that value in memory and retard ignition timing to reduce engine knock. If the knock sensor voltage exceeds a preset value, the PCM retards ignition timing for all cylinders. It is not a selective cylinder retard. The PCM ignores knock sensor input during engine idle conditions. Once the engine speed exceeds a specified value, knock retard is allowed. Knock retard uses its own short term and long term memory program. Long term memory stores previous detonation information in its battery-backed Random Access Memory (RAM). The maximum authority that long term memory has over timing retard can be calibrated. Short term memory is allowed to retard timing up to a preset amount under all operating conditions (as long as Revolutions Per Minute (RPM) is above the minimum RPM) except at Wide Open Throttle (WOT). The PCM, using short term memory can respond quickly to retard timing when engine knock is detected. Short term memory is lost any time the ignition key is turned off.

Knock Sensor Signal:



POWERTRAIN CONTROL MODULE (PCM)

Refer to **COMPONENT INDEX**.

The PCM is located next to the washer solvent reservoir. The PCM is a digital computer containing a micro-controller. The PCM receives input signals from various switches and sensors that are referred to as PCM Inputs. Based on these inputs the PCM adjusts various engine and vehicle operations through devices that are referred to as PCM Outputs. The PCM uses the Controller Area Network-Chassis (CAN-C) bus to perform engine diagnostics and flash operations.

The PCM is a pre-programmed digital computer. The PCM operates the following:

- Fuel system
- Regulates ignition timing
- Air-fuel ratio
- Emission control devices
- Charging system
- Certain transmission features
- Speed control

The PCM can adapt its programming to meet changing operating conditions. It also receives input signals from various switches and sensors. Based on these inputs, the PCM regulates various engine and vehicle operations through different system components. These components are referred to as PCM Outputs.

For more information on the PCM. Refer to **MODULE, POWERTRAIN CONTROL (PCM), DESCRIPTION AND OPERATION** .

VARIABLE VALVE TIME (VVT) SOLENOIDS

Refer to **COMPONENT INDEX**.

The 3.6L engine is equipped with VVT. This system adjusts the timing of all four camshafts independently using solenoids and oil control valves to direct oil pressure into the camshaft phaser assemblies. The camshaft phaser assembly advances and/or retards camshaft timing to improve engine performance, mid-range torque, idle quality, fuel economy, and reduce emissions. The four VVT solenoids are located on the front of the cylinder head covers. The pintle should move freely within the solenoid body. Do not attempt to disassemble the solenoids, they are not serviceable. The solenoids are identical but should be installed in the same location as removed. Camshaft phaser position is adjusted using regulated oil pressure through an Oil Control Valve (OCV). To begin phaser movement, the PCM applies a pulse-width modulated voltage signal to the VVT solenoid to extend or retract the solenoid pintle. The pintle pushes against an internal spool valve within the OCV moving the valve forwards and backwards to direct oil flow. The position of the spool inside the OCV determines which ports and chambers inside the phaser are being fed, either to advance the timing of the phaser sprocket relative to the camshaft, retard it, or hold a desired position.

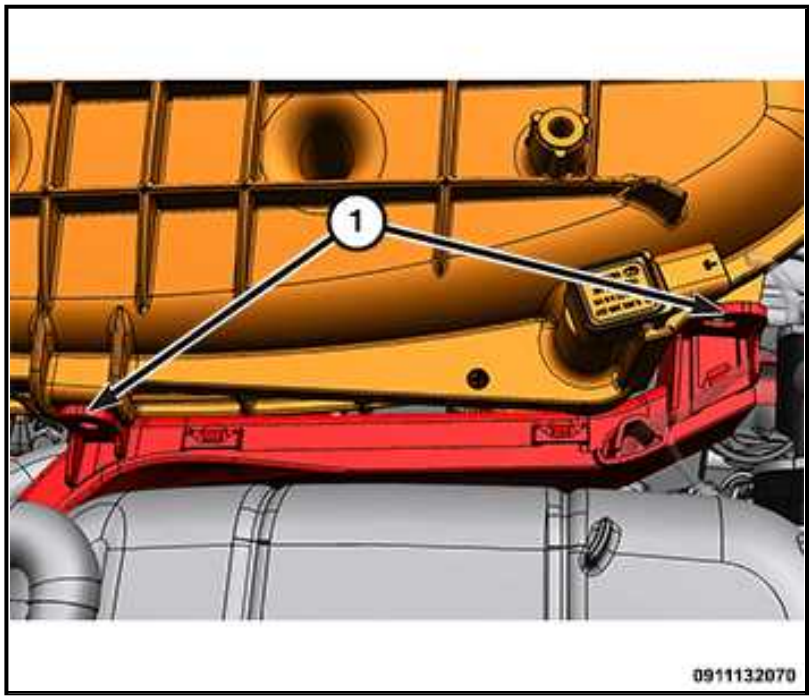
DIAGNOSIS AND TESTING

CAMSHAFT POSITION SENSOR - LEFT

REMOVAL

The Camshaft Position (CMP) sensors are located at the rear of the cylinder head covers and are bolted to the cylinder head.

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** .

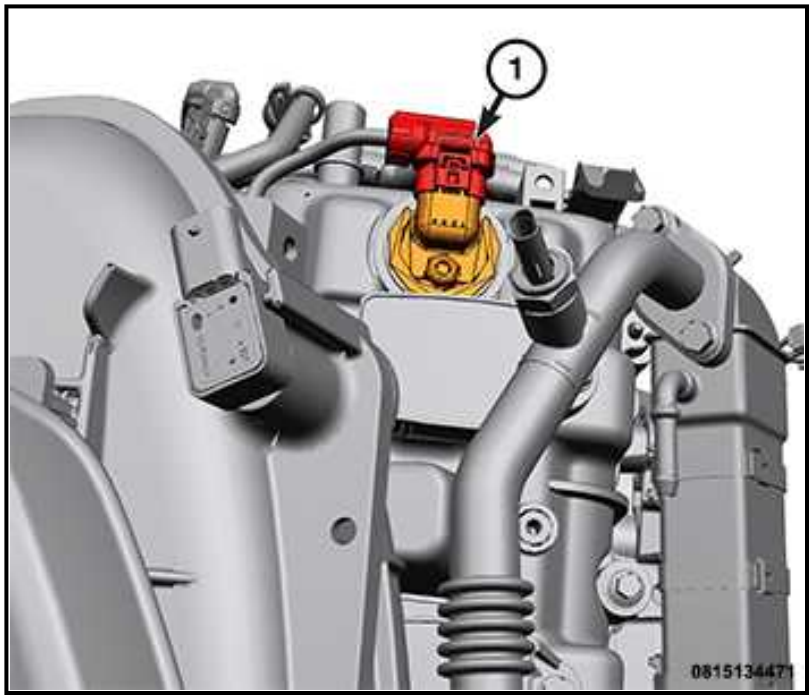


1 - Push Pins

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

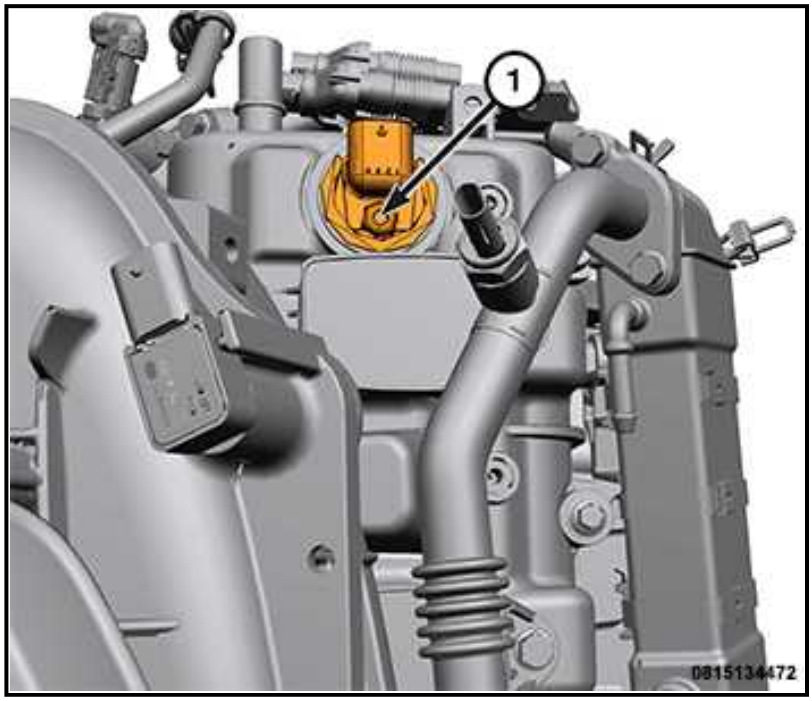
1 - Coolant Bottle

4. Position the coolant bottle aside, without removing the hoses or draining the cooling system. Refer to **BOTTLE, PRESSURIZED COOLANT, REMOVAL AND INSTALLATION** .



1 - CMP Sensor Wire Harness Connector

5. Disconnect the wire harness connector from the CMP sensor.



1 - CMP Sensor Bolt

6. Loosen the CMP sensor mounting bolt.
7. Pull the sensor and mounting bolt from the cylinder head cover.
8. The O-ring seal can be reused if not damaged.

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 out the camshaft position (CMP) sensor mounting bolt hole in cylinder head.
- The CMP sensor seal can be reused if not damaged.
- If required, install a new CMP sensor seal in the cylinder head cover:
  - Lubricate the CMP sensor seal inner and outer diameters with clean engine oil.
  - Place the CMP sensor seal on the Cam Sensor/Spark Plug Tube Seal Installer (special tool #10256, Installer, Cam Installer, Cam Sensor/ Spark Plug Tube Seal).
  - Push the seal into the cylinder head cover until the base of the seal is seated.
  - Remove the tool.

NOTE: **A properly installed CMP sensor seal will have a 1.5 - 2.0 mm (0.06 - 0.08 in.) gap between the cylinder head cover and the seal upper flange.**

- The sensor mounting bolt O-ring can be reused if not damaged.
- Apply a small amount of engine oil to the sensor mounting bolt O-ring.

NOTE: **If both left and right CMP sensors where removed, install them into their original locations.**

NOTE: **The Cam/Crank Variation Relearn procedure must be performed using the scan tool anytime there has been a repair/replacement made to a powertrain system, for example: flywheel, valvetrain, camshaft and/or crankshaft sensors or components.**

TORQUE SPECIFICATIONS

ENGINE SENSORS

DESCRIPTION	SPECIFICATION	COMMENTS
Map Sensor	-	-
Coolant Temperature Sensor	**1/4 Turn to Engage**	-
EGR Temperature Sensor	**37 N. m (27 Ft. Lbs.)**	-
Crankshaft Position (CKP) Sensor Bolt	**12 N.m (9 Ft. Lbs.)**	-
Engine Oil Pressure (EOP) Sensor	**20 N.m (15 Ft. Lbs.)**	-
Camshaft Position (CMP) Sensor to Cylinder Head	**9 N. m (80 In. Lbs.)**	-
Oxygen (O2) Sensor	**43 N.m (32 Ft. Lbs.)**	-
Oil Temperature Sensor to Cylinder Head	**11 N.m (8 Ft. Lbs.)**	-
Knock Sensor	**22 N.m (16 Ft. Lbs.)**	Do not reuse fastener. If removed, a new fastener must be installed and tightened to specifications

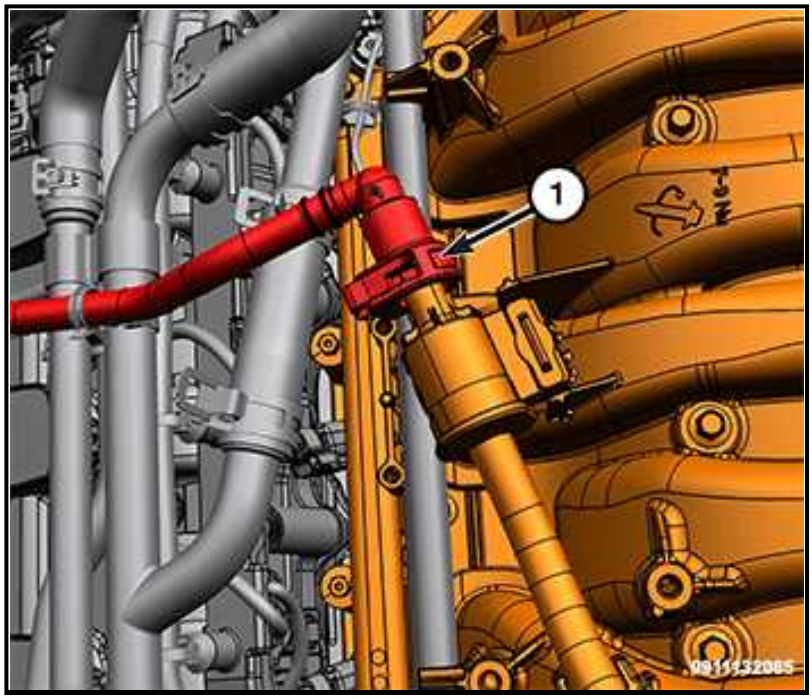
CAMSHAFT POSITION SENSOR - RIGHT

REMOVAL

The Camshaft Position (CMP) sensors are located at the rear of the cylinder head covers and are bolted to the cylinder head.

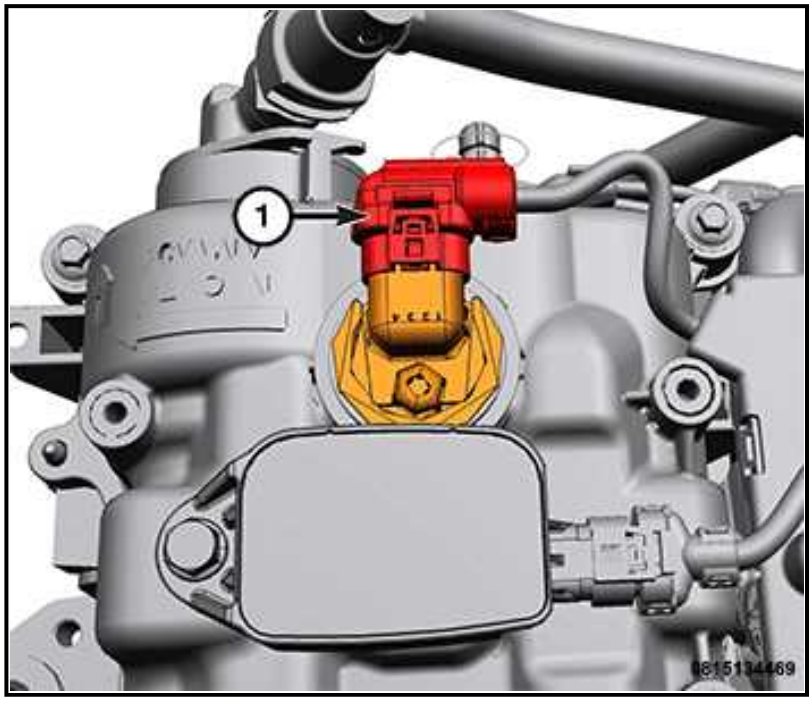
1. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .

2. Remove the engine cover. Refer to **COVER, ENGINE, REMOVAL AND INSTALLATION** .



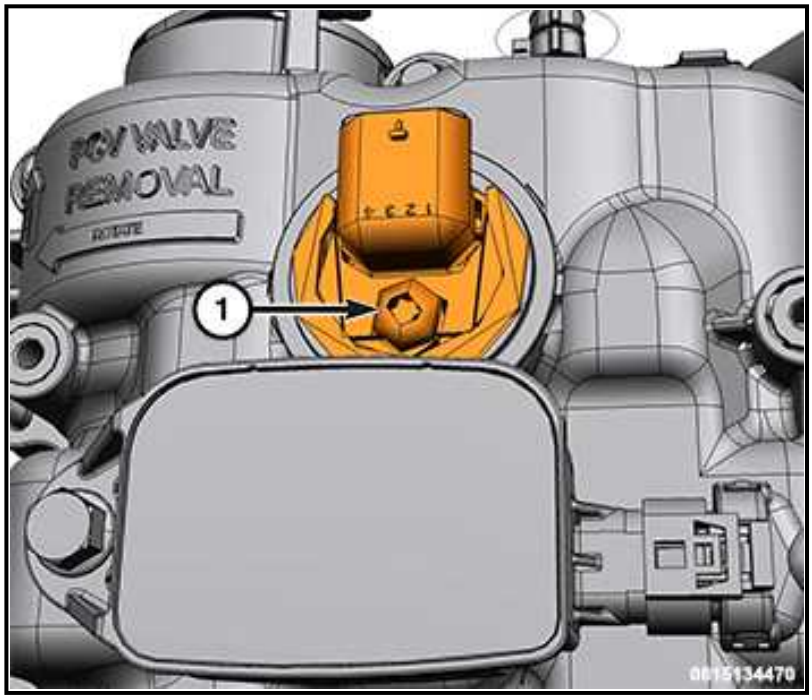
1 - Purge Line

3. Disconnect the purge line from the purge valve, remove from retaining clip and position aside.



1 - CMP Sensor Wire Harness Connector

4. Disconnect the wire harness connector from the CMP sensor.



1 - CMP Sensor Bolt

5. Loosen the CMP sensor mounting bolt.
6. Pull the sensor and mounting bolt from the cylinder head cover.
7. The O-ring seal can be reused if not damaged.

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 out the Camshaft Position (CMP) sensor mounting bolt hole in cylinder head.
- The CMP sensor seal can be reused if not damaged.
- If required, install a new CMP sensor seal in the cylinder head cover:
  - Lubricate the CMP sensor seal inner and outer diameters with clean engine oil.
  - Place the CMP sensor seal on the Cam Sensor/Spark Plug Tube Seal Installer (special tool #10256, Installer, Cam Installer, Cam Sensor/ Spark Plug Tube Seal).
  - Push the seal into the cylinder head cover until the base of the seal is seated.
  - Remove the tool.

NOTE: **A properly installed CMP sensor seal will have a 1.5 - 2.0 mm (0.06 - 0.08 in.) gap between the cylinder head cover and the seal upper flange.**

- The sensor mounting bolt O-ring can be reused if not damaged.
- Apply a small amount of engine oil to the sensor mounting bolt O-ring.

NOTE: **If both RH and LH CMP sensors where removed, install them into their original locations.**

NOTE: **The Cam/Crank Variation Relearn procedure must be performed using the scan tool anytime there has been a repair/replacement made to a powertrain system, for example: flywheel, valvetrain, camshaft and/or crankshaft sensors or components.**

TORQUE SPECIFICATIONS

ENGINE SENSORS

DESCRIPTION	SPECIFICATION	COMMENTS
Map Sensor	-	-
Coolant Temperature Sensor	**1/4 Turn to Engage**	-
EGR Temperature Sensor	**37 N. m (27 Ft. Lbs.)**	-
Crankshaft Position (CKP) Sensor Bolt	**12 N.m (9 Ft. Lbs.)**	-
Engine Oil Pressure (EOP) Sensor	**20 N.m (15 Ft. Lbs.)**	-
Camshaft Position (CMP) Sensor to Cylinder Head	**9 N. m (80 In. Lbs.)**	-
Oxygen (O2) Sensor	**43 N.m (32 Ft. Lbs.)**	-
Oil Temperature Sensor to Cylinder Head	**11 N.m (8 Ft. Lbs.)**	-
Knock Sensor	**22 N.m (16 Ft. Lbs.)**	Do not reuse fastener. If removed, a new fastener must be installed and tightened to specifications

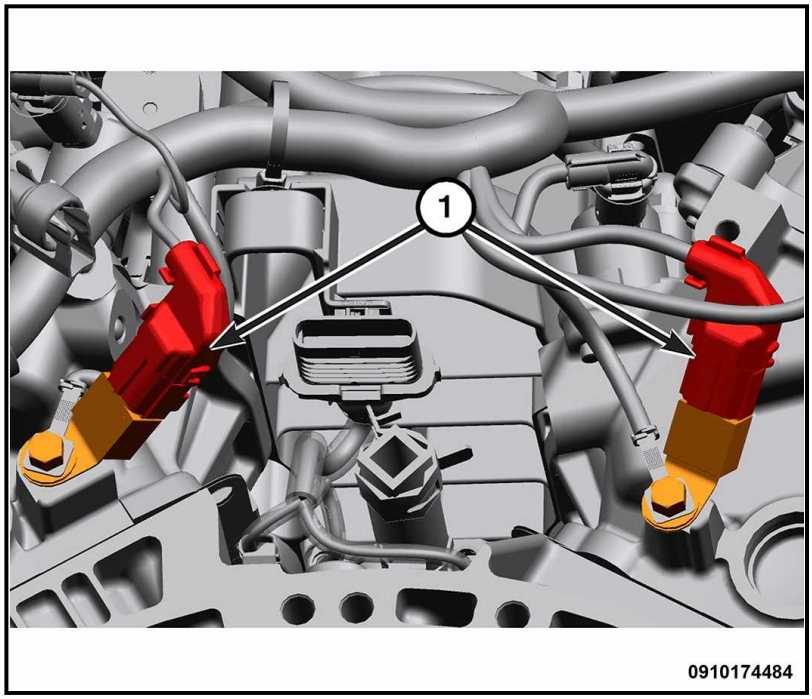
CAPACITOR, IGNITION

REMOVAL AND INSTALLATION

KNOCK SENSOR

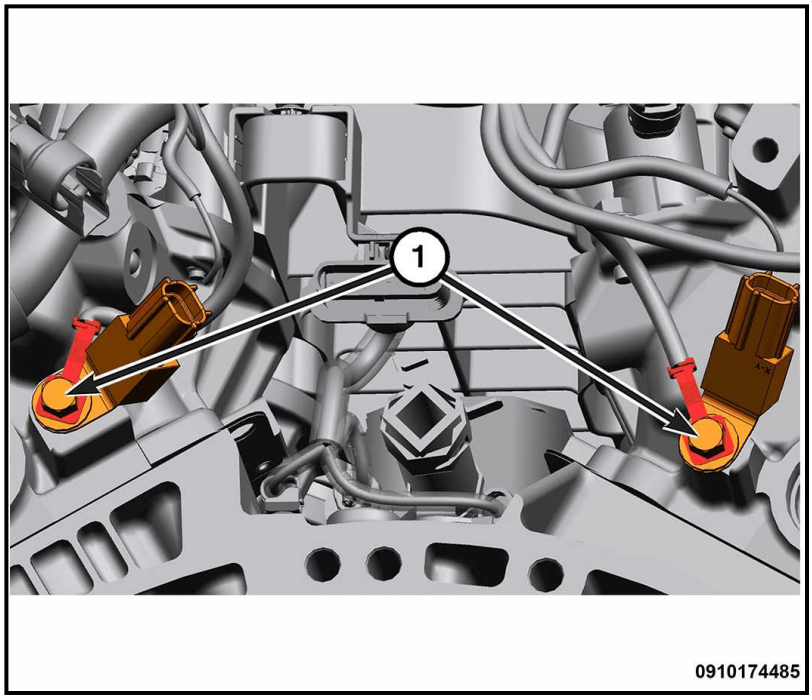
REMOVAL

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 - Ignition Capacitor Wire Harness Connector

3. Remove the ignition capacitor wire harness connector(s).



1 - Ignition Capacitor Bolts

4. Remove the ignition capacitor mounting bolt(s) along with ground cable(s) and the ignition capacitor(s).

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

IGNITION CONTROL - 3.6L

DESCRIPTION	SPECIFICATION	COMMENTS
Ignition Capacitor Bolt	**10 N.m (89 In. Lbs.)**	-
Ignition Coil to Cylinder Head Cover	**8 N. m (71In. Lbs.)**	-
Spark Plugs	**20 N. m (15Ft. Lbs.)**	-

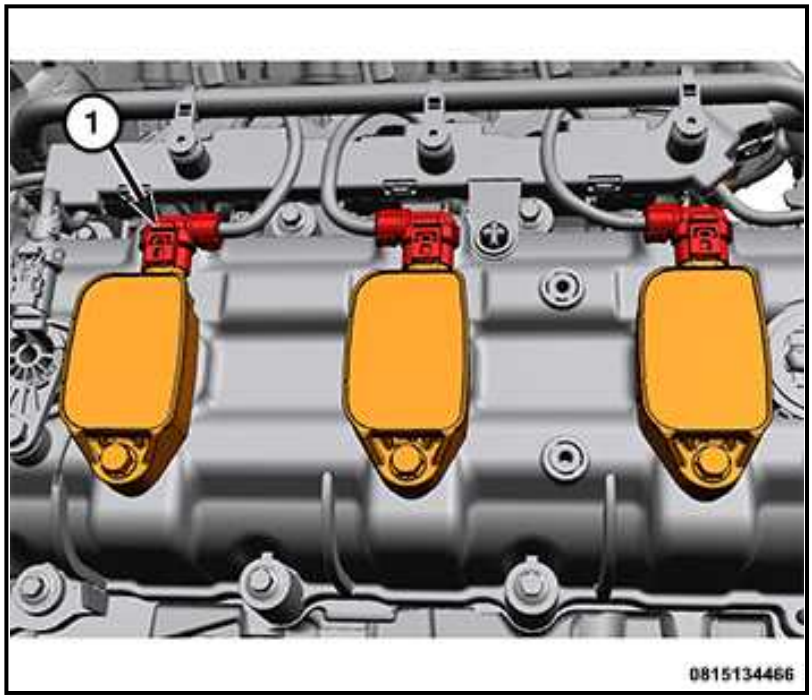
COIL, IGNITION

REMOVAL AND INSTALLATION

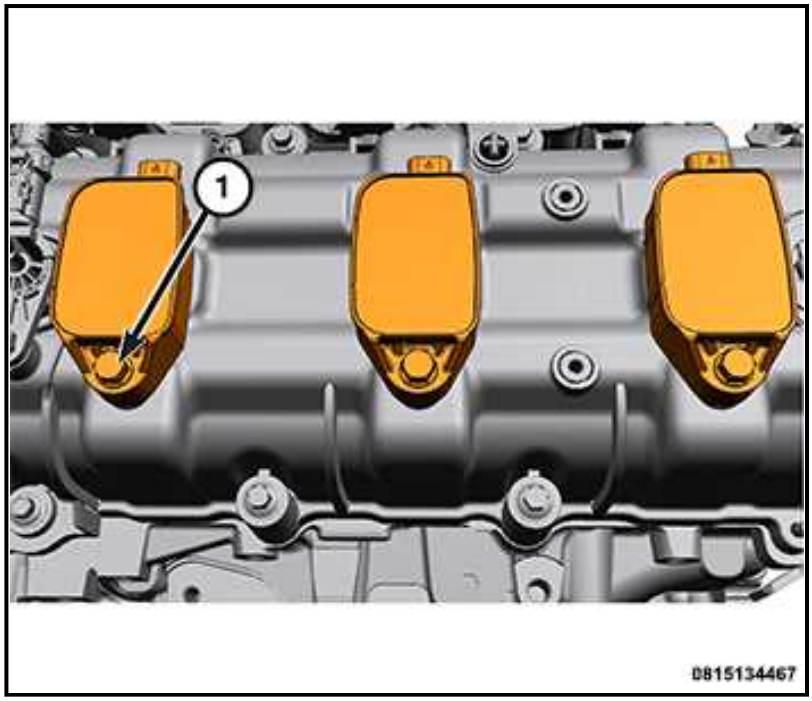
IGNITION COIL - LEFT

REMOVAL

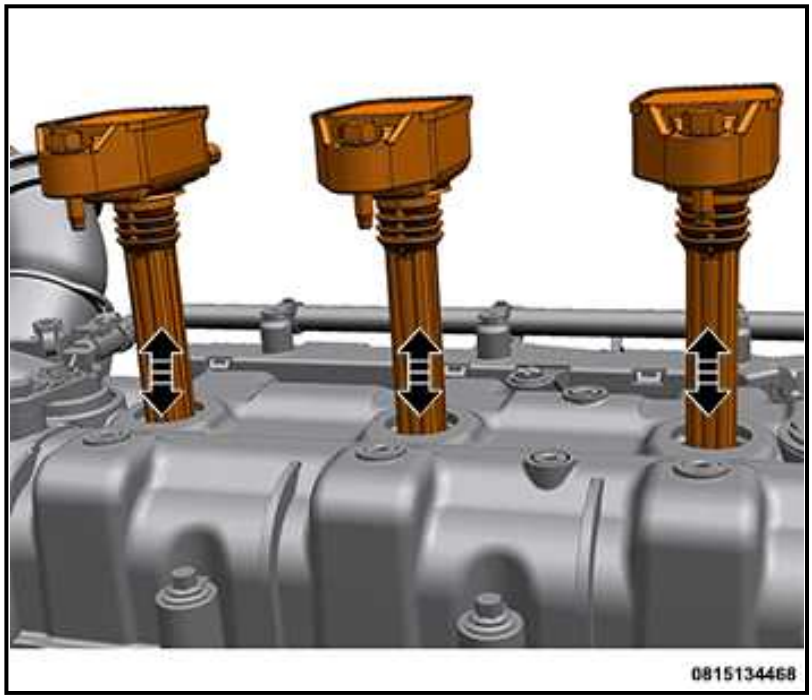
1. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
2. Remove the Exhaust Gas Recirculation (EGR) tube. Refer to **TUBE, EXHAUST GAS RECIRCULATION (EGR), CROSSOVER, REMOVAL AND INSTALLATION** .
3. Remove the upper intake manifold and insulator. Refer to **MANIFOLD, INTAKE, REMOVAL AND INSTALLATION** .



4. Disconnect the wire harness connector(s) (1) from the ignition coil(s).



5. Loosen the ignition coil mounting bolt(s) (1).



6. Firmly pull the ignition coil upward using a slight twisting motion if necessary.

NOTE: **If the boot will not come loose from the spark plug and a tool is necessary to remove it, it is recommended that the coil be replaced.**

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.

CAUTION: **Do not apply a silicone based grease such as MoparB® Dielectric Grease to the ignition coil rubber boot. The silicone based grease will absorb into the boot causing it to stick and tear.**

- Inspect the spark plug tube for presence of dirt or contaminants. Use compressed air to remove any debris found.
- Check the condition of the ignition coil rubber boot. Inspect the opening of the boot for any debris, tears or rips. Carefully remove any debris with a lint free cloth.
- Place a small, 360B° bead of **Mopar B® Molykote G-5008** lubricant along the inside opening of the coil boot approximately 1 to 2 mm from the chamfer edge but not on the chamfered surface.

TORQUE SPECIFICATIONS

IGNITION CONTROL - 3.6L

DESCRIPTION	SPECIFICATION	COMMENTS
Ignition Capacitor Bolt	**10 N.m (89 In. Lbs.)**	-
Ignition Coil to Cylinder Head Cover	**8 N. m (71In. Lbs.)**	-
Spark Plugs	**20 N. m (15Ft. Lbs.)**	-

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.)**	-

AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-

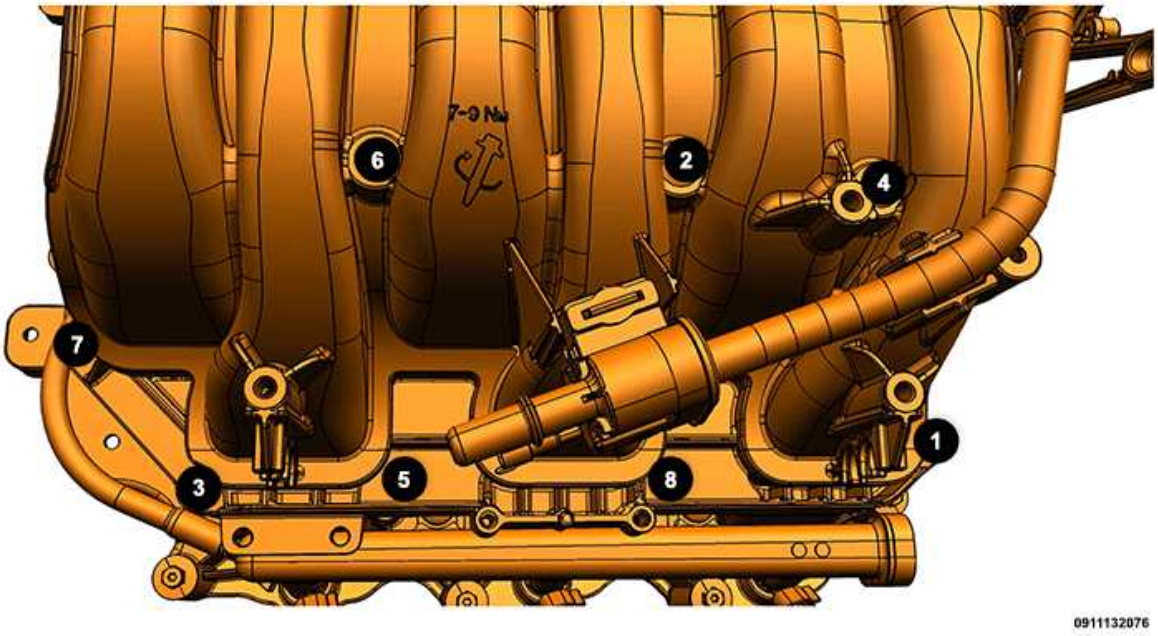
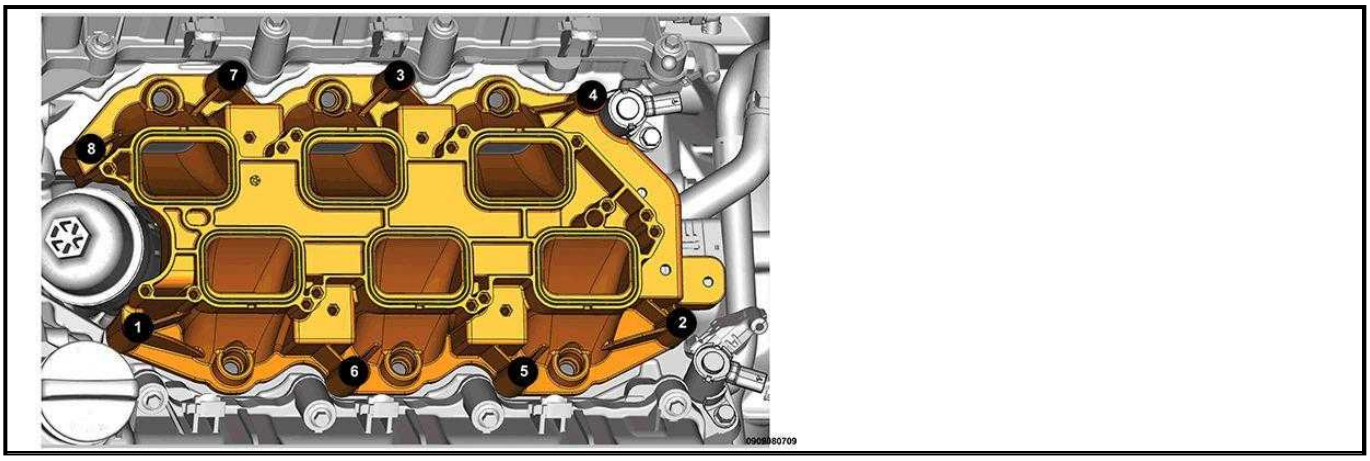


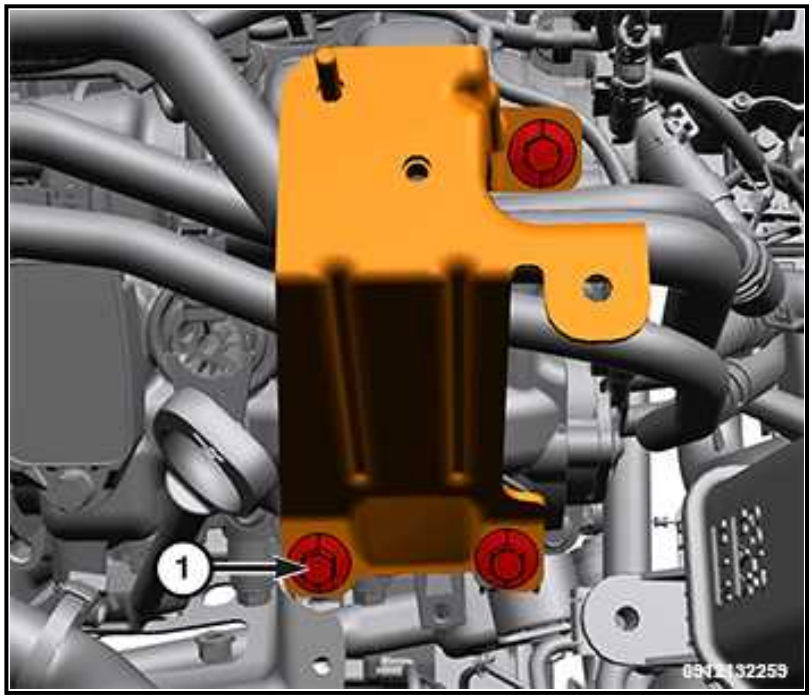
Fig. 19: Upper Intake Manifold Bolts Tightening/Loosening Sequence
Courtesy of CHRYSLER GROUP, LLC



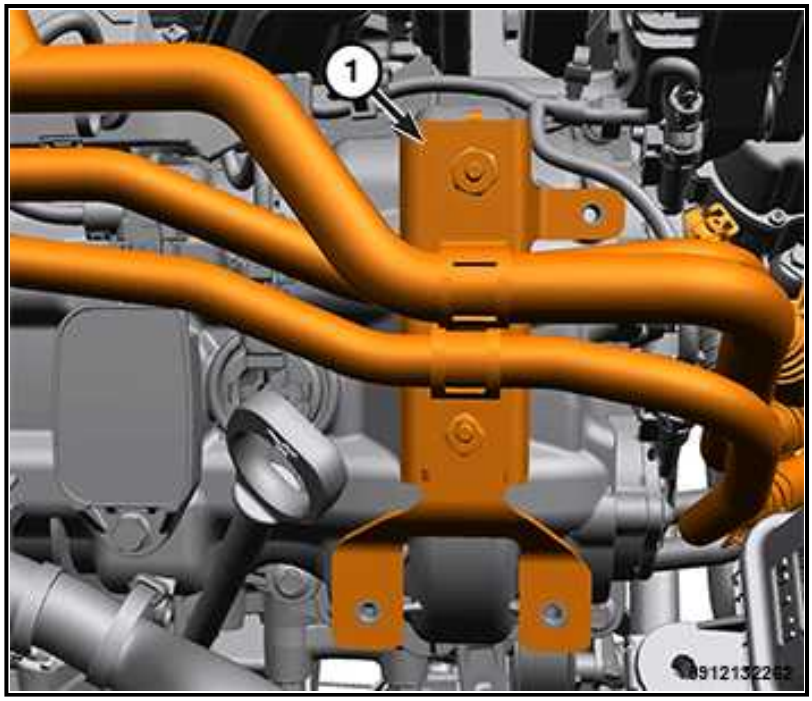
IGNITION COIL - RIGHT

REMOVAL

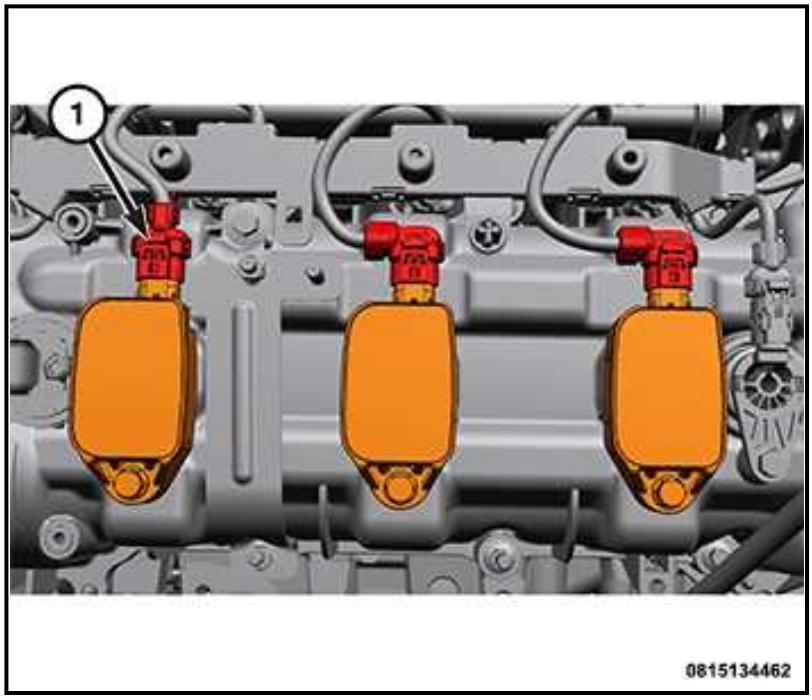
1. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
2. Remove the engine cover. Refer to **COVER, ENGINE, REMOVAL AND INSTALLATION** .



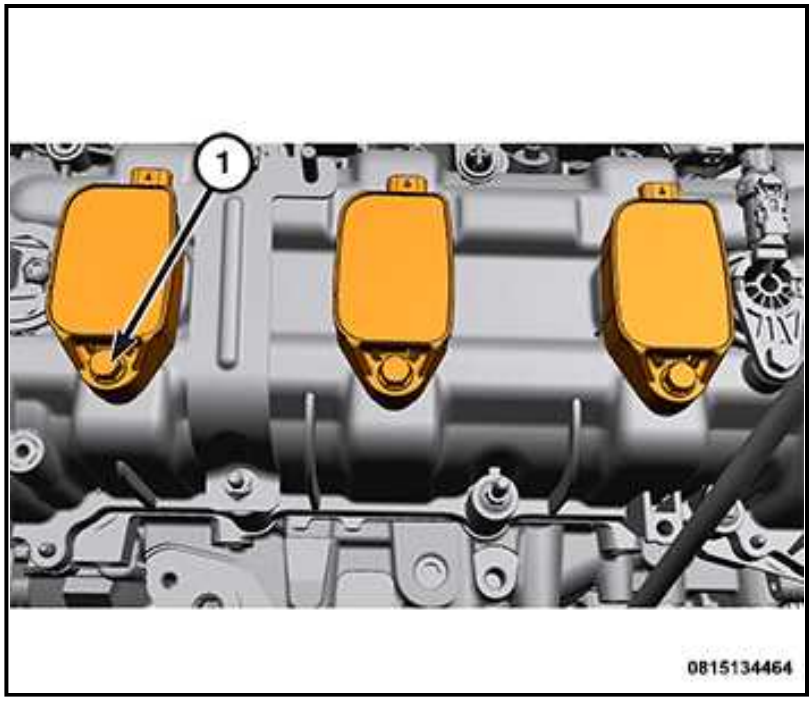
3. Removed the bolts (1) and the engine cover mounting bracket.



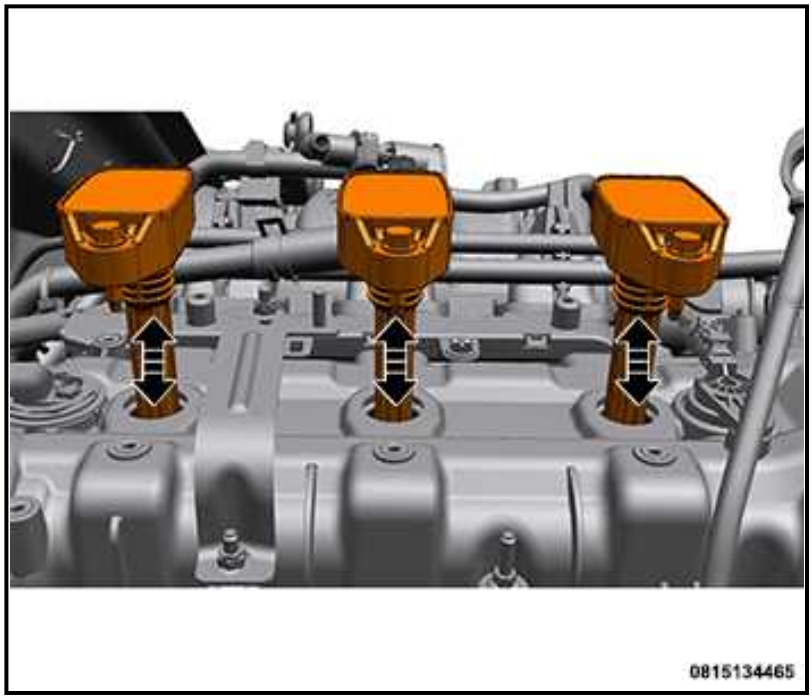
4. Remove heater hose mounting brackets (1) and reposition the heater hoses.



5. Disconnect the wire harness connector(s) (1) from the ignition coil(s).



6. Loosen the ignition coil mounting bolt(s) (1).



7. Firmly pull the ignition coil upward using a slight twisting motion if necessary.

NOTE: **If the boot will not come loose from the spark plug and a tool is necessary to remove it, it is recommended that the coil be replaced.**

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.

CAUTION: **Do not apply a silicone based grease such as MoparB® Dielectric Grease to the ignition coil rubber boot. The silicone based grease will absorb into the boot causing it to stick and tear.**

- Inspect the spark plug tube for presence of dirt or contaminants. Use compressed air to remove any debris found.
- Check the condition of the ignition coil rubber boot. Inspect the opening of the boot for any debris, tears or rips. Carefully remove any debris with a lint free cloth.
- Place a small, 360B° bead of **Mopar B® Molykote G-5008** lubricant along the inside opening of the coil boot approximately 1 to 2 mm from the chamfer edge but not on the chamfered surface.

TORQUE SPECIFICATIONS

IGNITION CONTROL - 3.6L

DESCRIPTION	SPECIFICATION	COMMENTS
Ignition Capacitor Bolt	**10 N.m (89 In. Lbs.)**	-
Ignition Coil to Cylinder Head Cover	**8 N. m (71In. Lbs.)**	-
Spark Plugs	**20 N. m (15Ft. Lbs.)**	-

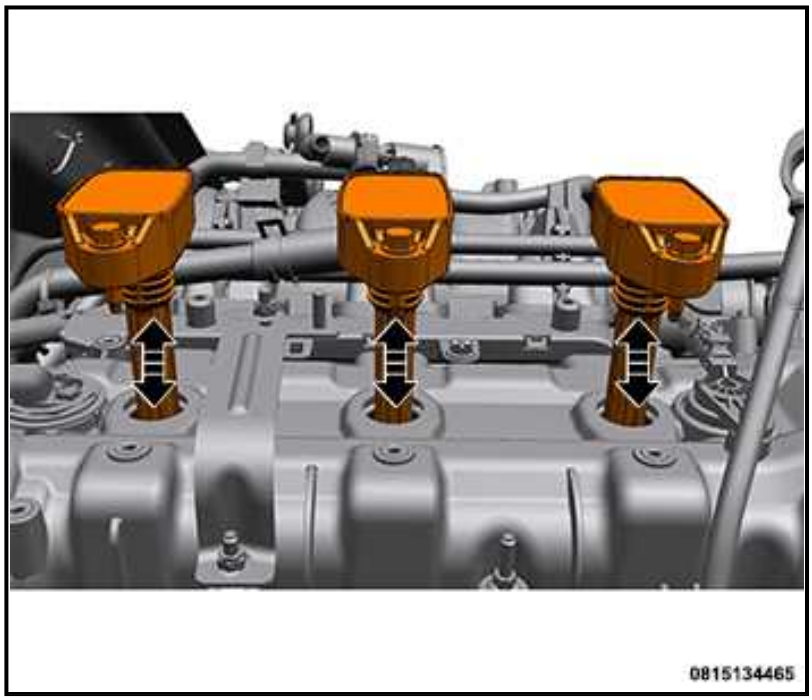
SPARK PLUG

REMOVAL AND INSTALLATION

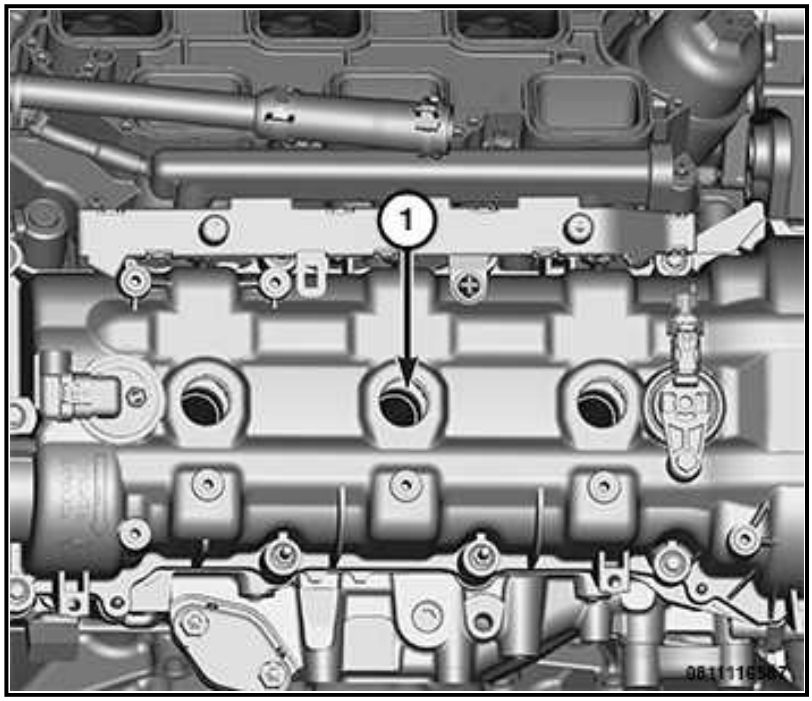
INSTALLATION

REMOVAL

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



2. Remove the ignition coil(s).
3. Prior to removing the spark plug, spray compressed air into the cylinder head opening. This will help prevent foreign material from entering the combustion chamber.



1 - Spark Plug Hole

4. Remove the spark plug from the cylinder head using a quality thin wall socket with a rubber or foam insert.
5. Inspect the spark plug condition.

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.

CAUTION: **Special care should be taken when installing spark plugs into the cylinder head spark plug wells. Be sure the plugs do not drop into the plug wells as electrodes can be damaged.**

- Start the spark plug into the cylinder head by hand to avoid cross threading.

CAUTION: **Spark plug torque is critical and must not exceed the specified value. Overtightening stretches the spark plug shell reducing its heat transfer capability resulting in possible catastrophic engine failure.**

TORQUE SPECIFICATIONS

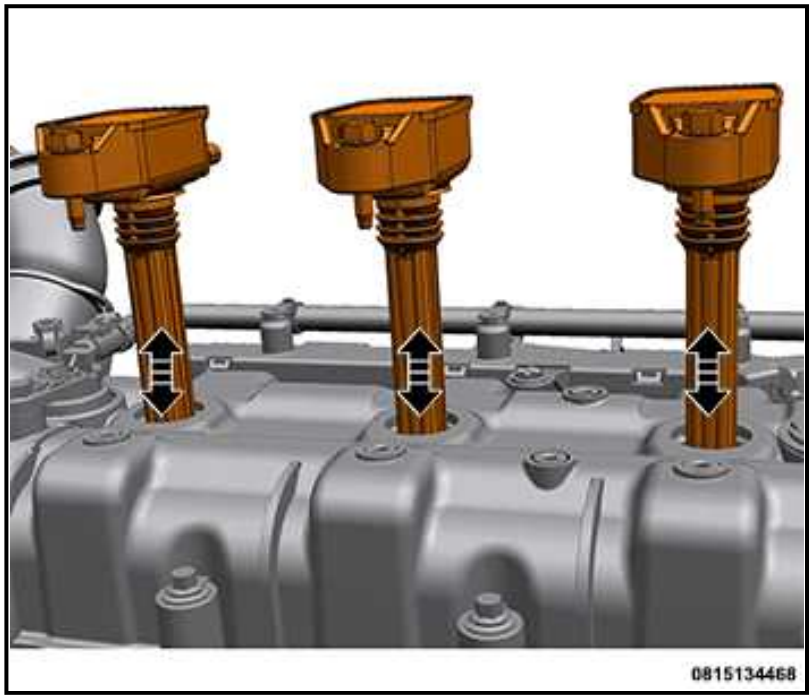
IGNITION CONTROL - 3.6L

DESCRIPTION	SPECIFICATION	COMMENTS
Ignition Capacitor Bolt	**10 N.m (89 In. Lbs.)**	-
Ignition Coil to Cylinder Head Cover	**8 N. m (71In. Lbs.)**	-
Spark Plugs	**20 N. m (15Ft. Lbs.)**	-

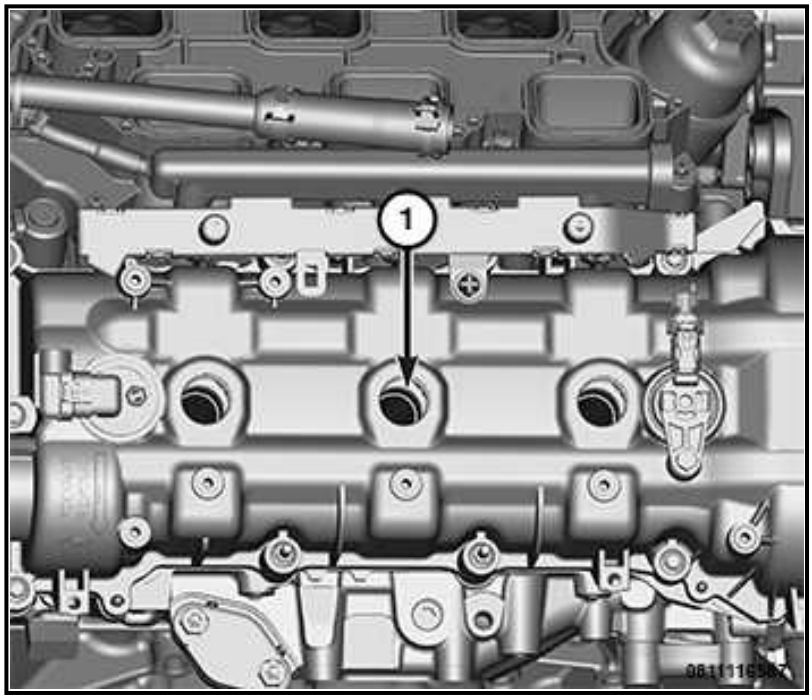
SPARK PLUGS - LEFT SIDE

REMOVAL

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



2. Remove the ignition coil(s).
3. Prior to removing the spark plug, spray compressed air into the cylinder head opening. This will help prevent foreign material from entering the combustion chamber.



1 - Spark Plug Hole

4. Remove the spark plug from the cylinder head using a quality thin wall socket with a rubber or foam insert.
5. Inspect the spark plug condition.

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.

CAUTION: Special care should be taken when installing spark plugs into the cylinder head spark plug wells. Be sure the plugs do not drop into the plug wells as electrodes can be damaged.

- Start the spark plug into the cylinder head by hand to avoid cross threading.

CAUTION: Spark plug torque is critical and must not exceed the specified value. Overtightening stretches the spark plug shell reducing its heat transfer capability resulting in possible catastrophic engine failure.

TORQUE SPECIFICATIONS

IGNITION CONTROL - 3.6L

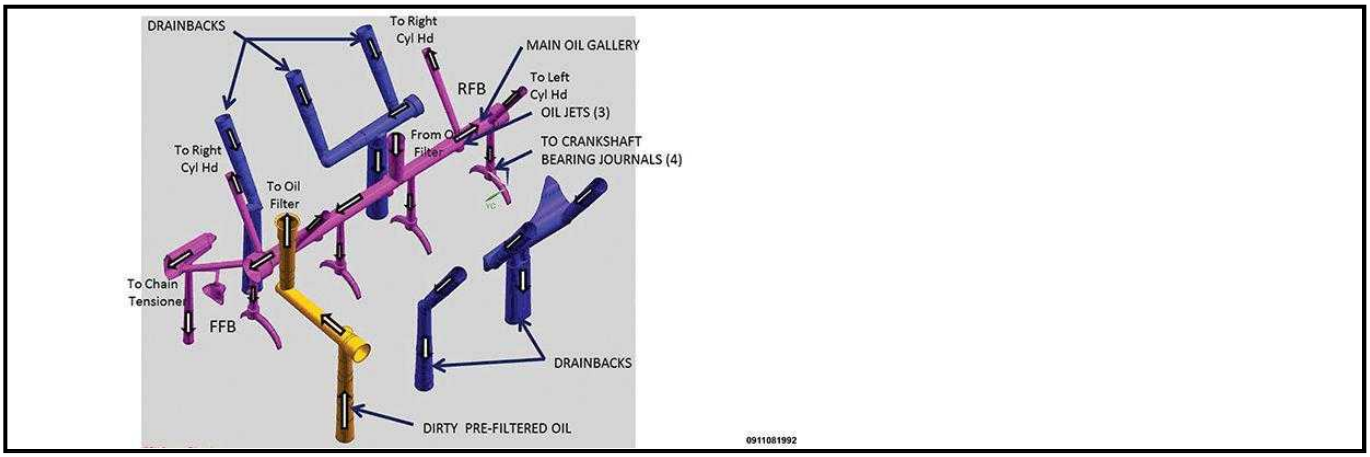
DESCRIPTION	SPECIFICATION	COMMENTS
Ignition Capacitor Bolt	**10 N.m (89 In. Lbs.)**	-
Ignition Coil to Cylinder Head Cover	**8 N. m (71In. Lbs.)**	-
Spark Plugs	**20 N. m (15Ft. Lbs.)**	-

LUBRICATION

DESCRIPTION AND OPERATION

LUBRICATION SYSTEM

The lubrication system is a full flow filtration, pressure feed type lubrication system. The oil pump is mounted to the bottom of the cylinder block and chain driven by the crankshaft sprocket. The oil pump pick-up tube is attached to the oil pump. There are three oil gallery plugs installed in the engine block. A system oil pressure sensor allows oil pressure to be monitored with a diagnostic scan tool. The oil pressure sensor is located on the oil filter housing assembly which is mounted to the top of the engine block between the cylinder heads. The oil temperature sensor is mounted on the rear of the right cylinder head. The oil cooler is mounted to the oil filter housing. There is a pressure relief valve in the oil pump that is only activated on a cold start or for emergency relief since the oil pump output is self-regulating. There are three piston oil cooler jets mounted to the engine block. Each jet cools two pistons.



Oil Flow:

- The oil from the oil pan is pumped by a vane type oil pump mounted to the bottom of the cylinder block that is chain driven by the crankshaft sprocket
- The oil from the pump travels to the oil filter element and then to the oil cooler assembly
- After the oil has been filtered and cooled, the oil enters the main oil gallery
- The pressurized oil travels through the main gallery to the four main journals to lubricate the crankshaft main bearings
- The pressurized oil travels through the crankshaft main journals to cross-drilling supplying oil to the connecting rod journals
- From the number one main bearing galleries, oil travels to the right secondary chain tensioner and to the primary chain idler shaft
- The main oil gallery also supplies oil to three sets of piston oil cooling jets
- From the cylinder block, the oil flows through the galleys into the left and right cylinder heads
- Left cylinder head oil is supplied to the left secondary timing chain tensioner, camshaft journals and hydraulic lash adjusters
- Right cylinder head oil is supplied to the right camshaft journals and hydraulic lash adjusters
- The camshaft valve lobes and rocker arms are lubricated through a small hole in the rocker arm; oil flows through the lash adjuster then through the rocker arm and onto the camshaft lobe
- Oil also flows through each of the four forward camshaft bearings into the camshafts and phasers

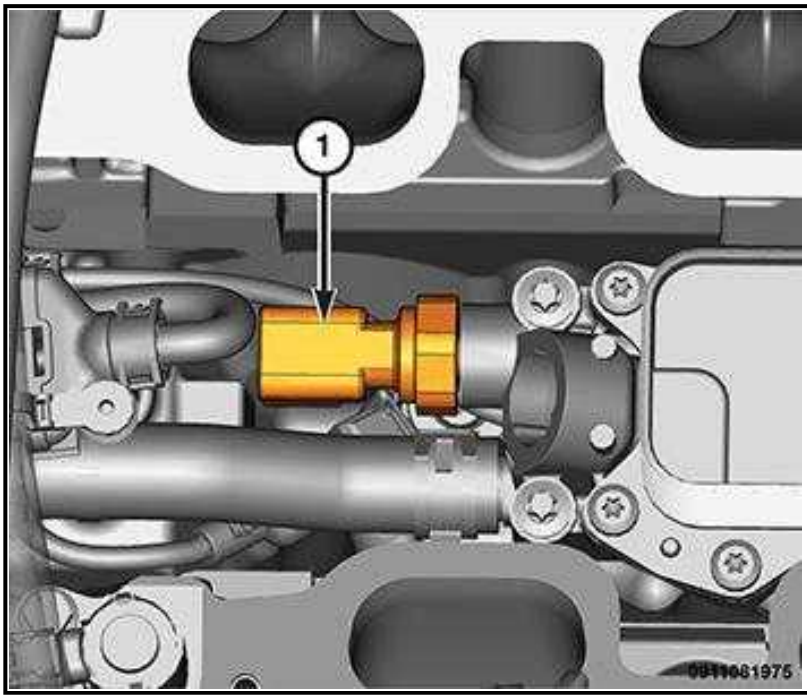
ENGINE LUBRICATION FLOW CHART

FROM	TO
Oil Pickup Tube	Oil Pump
Oil Pump	Oil Filter
Oil Filter	Oil Cooler
Oil Cooler	Block Main Oil Gallery
Block Main Oil Gallery	1. Crankshaft Main Journals 2. Left Cylinder Head

FROM	TO
	3. Right Cylinder Head 4. Piston Cooling Jets
Crankshaft Number One Main Journal	1. Primary Chain Idler Shaft 2. Right Secondary Chain Tensioner 3. Oil Pump Feedback
Crankshaft Main Journals	Crankshaft Rod Journals
Left Cylinder Head	1. Left Secondary Chain Tensioner 2. Hydraulic Lash Adjusters 3. Camshaft Journals 4. Phaser Oil Control Valves
Right Cylinder Head	1. Hydraulic Lash Adjusters 2. Camshaft Journals 3. Phaser Oil Control Valves
Hydraulic Lash Adjusters	1. Rocker Arms 2. Cam Lobes

ENGINE OIL PRESSURE (EOP) SENSOR

DESCRIPTION: The oil pressure sensor is located on the oil filter housing. The oil pressure sensor is a three wire sensor with a tapered threaded sensor port. The sensor port is mounted to the oil filter housing through an access hole. A thread lock patch seals the oil pressure sensor to the oil filter housing.



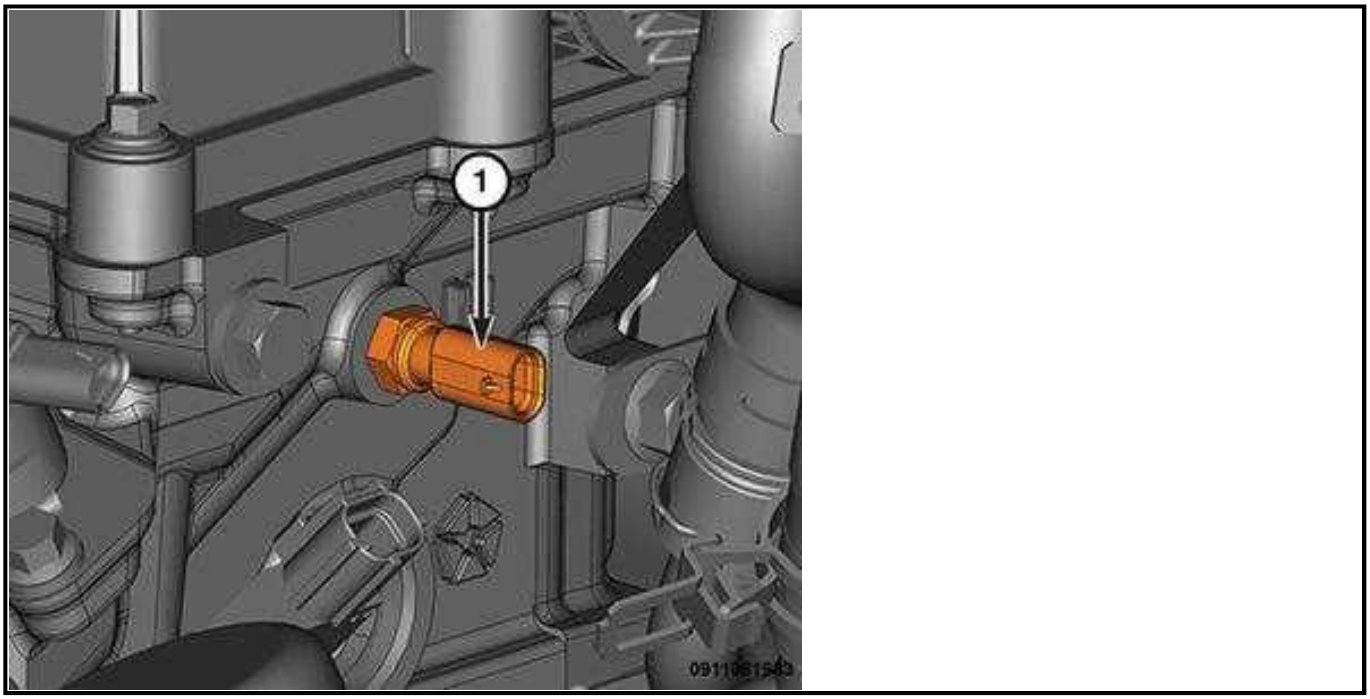
1 - EOP Sensor

OPERATION:

The oil pressure sensor is a silicon based sensing unit that measures the pressure of the engine oil. The Powertrain Control Module (PCM) supplies a 5 volt reference and a ground to the sensor. The input to the PCM occurs on the signal return circuit. The oil pressure sensor is a linear sensor; as pressure changes, voltage changes proportionately and returns a voltage signal to the PCM that reflects oil pressure. The zero pressure reading is 0.5 volt and full scale is 4.5 volt.

ENGINE OIL TEMPERATURE (EOT) SENSOR

DESCRIPTION: The oil temperature sensor is located on the back of the right cylinder head. The oil temperature sensor is a two wire sensor with a tapered threaded sensor probe. The sensor probe is mounted to the cylinder head through an access hole. A thread lock patch seals the oil temperature sensor to the cylinder head.



1 - EOT Sensor

OPERATION:

The oil temperature sensor is a variable resistor that measures the temperature of the engine oil. The Powertrain Control Module (PCM) supplies a 5 volt reference and a ground to the sensors low reference signal circuit. When the oil temperature is low, the sensor resistance is high. When the oil temperature is high, the sensor resistance is low.

DIAGNOSIS AND TESTING

ENGINE OIL LEAK

Begin with a thorough visual inspection of the engine, particularly at the area of the suspected leak. If an oil leak source is not readily identifiable, the following steps should be followed:

1. Do not clean or de-grease the engine at this time because some solvents may cause rubber to swell, temporarily stopping the leak.
2. Add an oil soluble dye (use as recommended by manufacturer). Start the engine and let idle for approximately 15 minutes. Check the oil dipstick to make sure the dye is thoroughly mixed as indicated with a bright yellow color under a black light.
3. Using a black light, inspect the entire engine for fluorescent dye, particularly at the suspected area of the oil leak. If the oil leak is found and identified, repair in accordance to the Service Information.
4. If dye is not observed, drive the vehicle at various speeds for approximately 24 km (15 miles), and repeat the inspection.

   If the oil leak source is not positively identified at this time, proceed with the air leak detection test method.

AIR LEAK DETECTION TEST METHOD

1. Disconnect the make-up air hose from the cylinder head cover. Cap or plug the make-up air hose nipple.

2. Remove the Positive Crankcase Ventilation (PCV) hose from the PCV valve. Cap or plug the PCV valve nipple.
3. Attach an air hose with a pressure gauge and regulator to the dipstick tube.

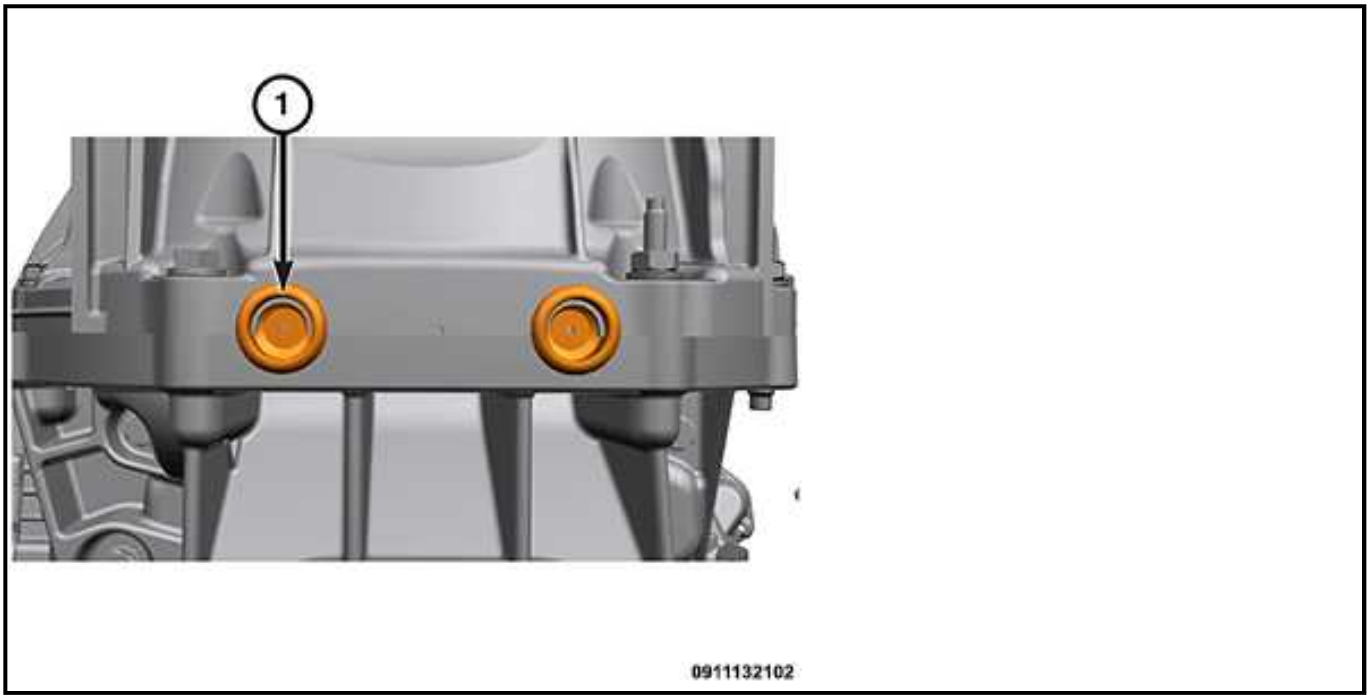
CAUTION: Do not subject the engine assembly to more than 20.6 kPa (3 psi) of test pressure.

4. Gradually increase air pressure from 1 psi to 2.5 psi maximum while applying soapy water at the suspected leak source. Adjust the regulator to a suitable test pressure within this range that provides the best bubble generation which will pinpoint the leak source. If the oil leak is detected and identified, repair in accordance with the Service Information.
5. If the leakage occurs at the rear oil seal area, follow the procedures for rear seal area leaks. Refer to **LUBRICATION, DIAGNOSIS AND TESTING**.
6. If no leaks are detected, turn off the air supply and remove the air hose and all plugs and caps. Install the PCV valve and make-up air hoses.
7. Clean the oil off of the suspect oil leak area using a suitable solvent. Drive the vehicle at various speeds approximately 24 km (15 miles). Inspect the engine for signs of an oil leak by using a black light.

CHECKING ENGINE OIL PRESSURE

1. Remove the oil filter and cap. Refer to **FILTER, ENGINE OIL, REMOVAL AND INSTALLATION**.
2. Transfer the oil filter to the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)
3. Install Pressure Gauge (special tool #C-3292A, Gauge, Pressure) to the Oil Pressure Test Adapter.
4. Install the Oil Pressure Test Adapter to the engine and securely tighten.
5. Start and idle the engine. If oil pressure is 0 at idle, shut off the engine and consult the Engine Lubrication and Diagnostic Table. Refer to **DIAGNOSIS AND TESTING** .
6. Verify that the engine has acceptable oil pressure. Refer to **FUEL SYSTEM PRESSURE RELEASE** .

REAR SEAL AREA LEAKS



Since it is sometimes difficult to determine the source of an oil leak in the rear seal area of the engine, a more involved inspection is necessary. The following steps should be followed to help pinpoint the source of the leak.

If the leakage occurs at the crankshaft rear oil seal area:

1. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
2. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .
3. Remove two rubber plugs (1) covering the rear oil seal retainer flange bolts.
4. Inspect the flexplate and rear of the block for evidence of oil. Use a black light to check for the oil leak:
    a. Circular spray pattern generally indicates seal leakage or crankshaft damage.
    b. Where leakage tends to run straight down, possible causes are a porous block, rear oil seal retainer, oil galley pipe plug and rear seal retainer to oil pan mating surfaces.
5. If no leaks are detected, use the Air Leak Detection Method as outlined in Engine Oil Leak. Refer to **LUBRICATION, DIAGNOSIS AND TESTING**.

CAUTION: **Do not subject the engine assembly to more than 20.6 kPa (3 psi) of test pressure.**

6. If the leak is not detected, very slowly turn the crankshaft and watch for leakage. If a leak is detected between the crankshaft and seal while slowly turning the crankshaft, it is possible the crankshaft seal surface is damaged. The seal area on the crankshaft could have minor nicks or scratches that can be polished out with emery cloth.

CAUTION: **Use extreme caution when crankshaft polishing is necessary to remove minor nicks or scratches. The crankshaft seal flange is specially machined to complement the function of the rear oil seal.**

7. For bubbles that remain steady with shaft rotation, no further inspection can be done until disassembled. Refer to **SEAL, CRANKSHAFT OIL, REAR, REMOVAL AND INSTALLATION**.

VVL SOLENOID OIL PRESSURE TEST

1. Remove the Variable Valve Lift (VVL) Solenoid(s). Refer to **SOLENOID, REMOVAL AND INSTALLATION** .
2. Install the VVL oil pressure test adapters (special tool #2027300090, Kit, VVL Adapters) as indicated in the video.
3. If removed, install the upper intake manifold. Refer to **MANIFOLD, INTAKE, REMOVAL AND INSTALLATION** .
4. Start and idle the engine. If oil pressure is 0 at idle, shut off the engine and consult the Engine Lubrication and Diagnostic Table. Refer to **DIAGNOSIS AND TESTING** .
5. Run the engine until it reaches normal operating temperature.
6. Verify that the engine has acceptable oil pressure. Refer to **ENGINE SPECIFICATIONS** .

STANDARD PROCEDURE

ENGINE OIL AND FILTER CHANGE

ENGINE OIL SERVICE

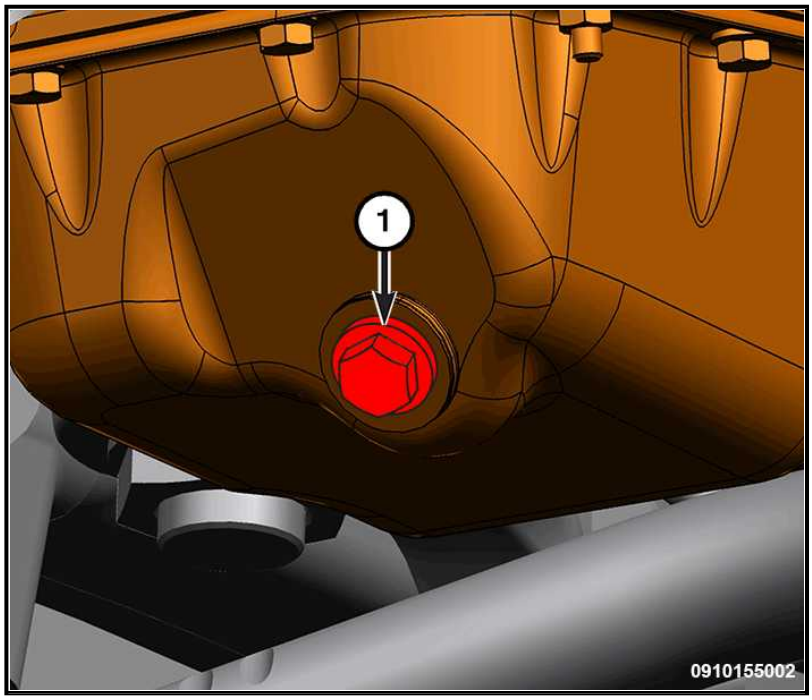
WARNING: **New or used engine oil can be irritating to the skin. Avoid prolonged or repeated skin contact with engine oil. Contaminants in used engine oil, caused by internal combustion, can be hazardous to your health. Thoroughly wash exposed skin with soap and water. Do not wash skin with gasoline, diesel fuel, thinner, or solvents, health problems can result. Do not pollute, dispose of used engine oil properly. Contact your dealer or government agency for location of collection center in your area.**

Change the engine oil and filter at mileage and time intervals described in the Maintenance Schedule. Refer to **MAINTENANCE SCHEDULES, DESCRIPTION** .

1. Run the engine until achieving normal operating temperature.
2. Position the vehicle on a level surface and turn the engine off.

CAUTION: **When performing an engine oil change, the oil filter cap must be removed. Removing the oil filter cap releases oil held within the oil filter cavity and allows it to drain into the sump. Failure to remove the cap prior to reinstallation of the drain plug will not allow complete draining of the used engine oil.**

3. Remove the engine oil filter. Refer to **FILTER, ENGINE OIL, REMOVAL AND INSTALLATION**.
4. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .



5. Place a suitable drain pan under the crankcase drain plug (1).
6. Remove the drain plug from oil pan and allow the oil to drain for five minutes. Inspect the drain plug threads for stretching or other damage. Replace the drain plug and gasket if damaged.
7. Install the drain plug in the oil pan and tighten to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .
8. Remove support and lower the vehicle.
9. Install the engine oil filter. Refer to **FILTER, ENGINE OIL, REMOVAL AND INSTALLATION**.
10. Fill the crankcase with the specified type and amount of engine oil. Refer to **CAPACITIES AND RECOMMENDED FLUIDS, SPECIFICATIONS** .
11. Install the oil fill cap.
12. Start the engine and inspect for leaks.
13. Stop the engine and check the oil level.

OIL FILTER SPECIFICATION

All engines are equipped with a high quality full-flow, disposable type oil filter. When replacing oil filter, use a MoparB® filter or equivalent. Aftermarket oil filters may not adequately function with the OEM bypass valve.

USED ENGINE OIL DISPOSAL

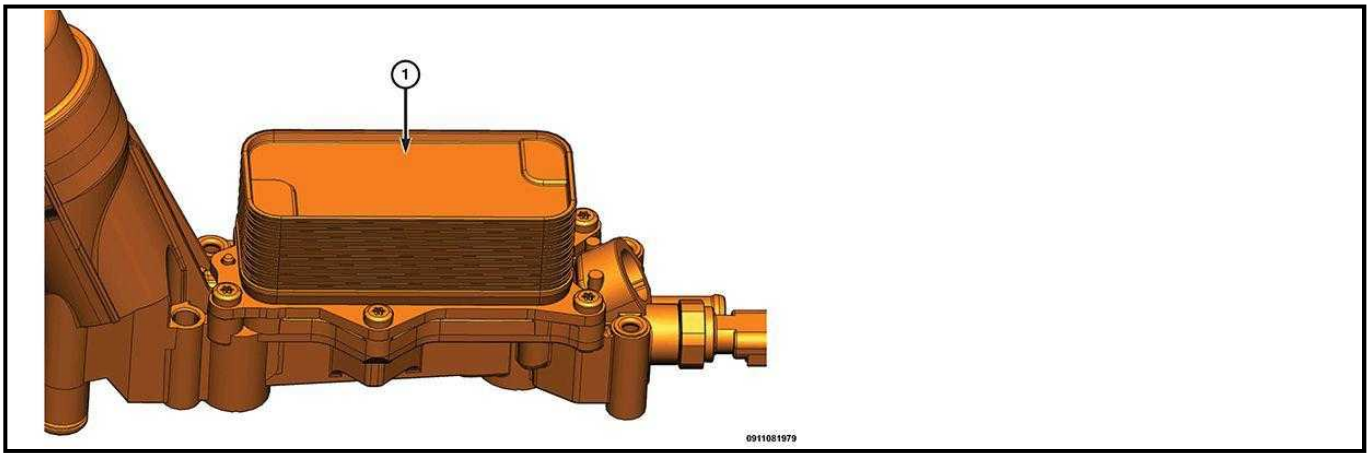
Care should be exercised when disposing of used engine oil after it has been drained from a vehicle engine. Refer to the WARNING listed above.

COOLER, OIL

DESCRIPTION AND OPERATION

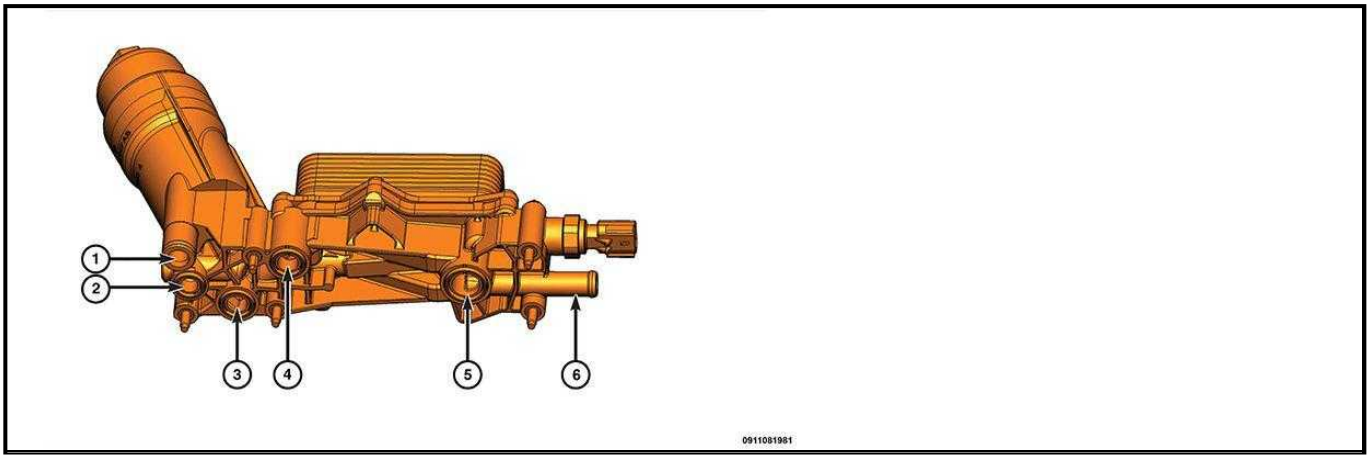
DESCRIPTION AND OPERATION

OIL COOLER



The oil cooler (1) is attached to the top of the oil filter housing which is located in the V of the cylinder block. The oil cooler is a plate style coolant-to-oil heat exchanger.

OPERATION



Oil flows from the engine oil pump to the oil filter housing inlet (1) and to the oil filter element located within the oil filter housing. After the oil is filtered it travels internally through the engine oil cooler and then to the main oil gallery (5).

Coolant flows from the right cylinder block water jacket (3) and from the left cylinder block water jacket (4) into the housing. The coolant flows through the oil cooler and exits the housing from the rear hose nipple (6) where it is returned to the water pump. A coolant by-pass in the housing is designed to direct excessive coolant flow around the oil cooler for continuous circulation.

REMOVAL AND INSTALLATION

ENGINE OIL COOLER

REMOVAL

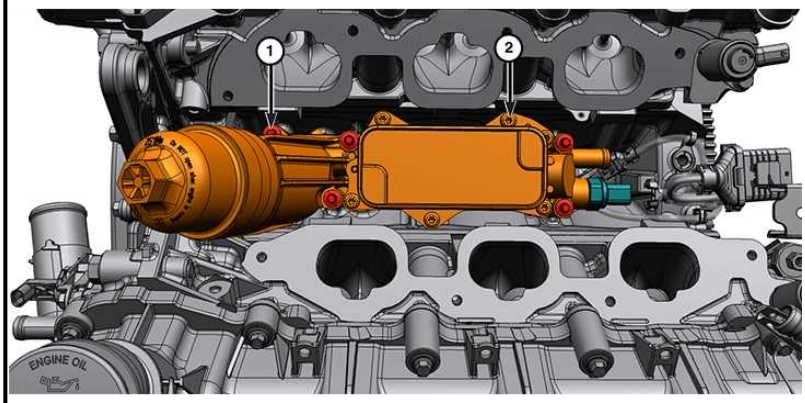
NOTE: **In the event that the oil cooler is contaminated, the oil cooler cannot be flushed out. If the engine requires rebuilding or replacement, replace the oil cooler.**

1. The oil cooler is replaced as an assembly with the oil filter housing, for removal. Refer to **HOUSING, OIL FILTER, REMOVAL AND INSTALLATION**.

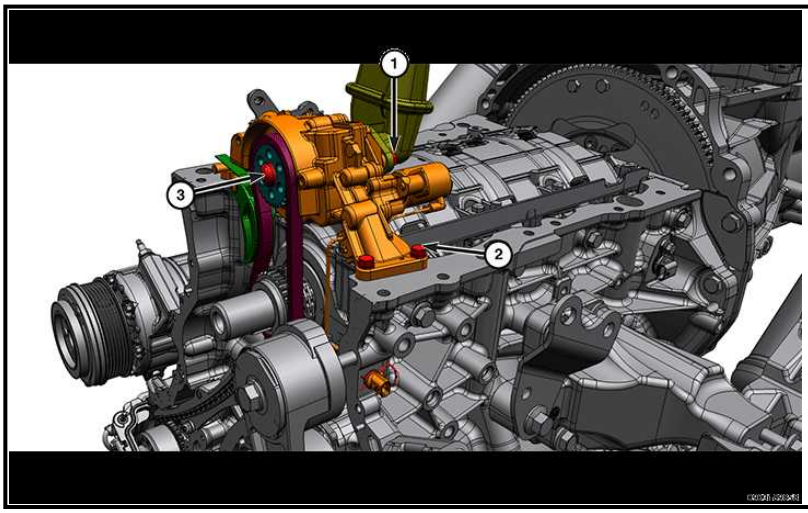
TORQUE SPECIFICATIONS

LUBRICATION

DESCRIPTION	SPECIFICATION	COMMENTS
Upper Oil Pan to Engine Block M8 Bolts	**23 N.m (17 Ft. Lbs.)**	-
Lower Oil Pan to Upper Oil Pan - M6 Bolts	**9 N.m (80 In. Lbs.)**	-
Lower Oil Pan to Upper Oil Nuts	**10 N.m (89 In. Lbs.)**	-
Upper Oil Pan to Rear Seal Retainer M6 Bolts	**10 N.m (89 In. Lbs.)**	-
Oil Pan Drain Plug	**27 N.m (20 Ft. Lbs.)**	-
Oil Level Indicator to Cylinder Head Bolt	**18 N.m (13 Ft. Lbs.)**	-



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Oil Filter Housing/Oil Cooler to Engine Block M6 Bolts	**12 N.m (9 Ft. Lbs.)**	-
2	Oil Cooler to Oil Filter Housing Screws	**12 N.m (9 Ft. Lbs.)**	-
-	Oil Filter Housing Cap	**25 N.m (18 Ft. Lbs.)**	-



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Oil Pump Pick Up Tube to Oil Pump M6 Bolt	**8 N.m (71 In. Lbs.)**	-
-	Oil Pump Pick Up Tube Bracket to Windage Tray Bolt	**8 N.m (80 In. Lbs.)**	-
2	Oil Pump to Engine Block M6 Bolts	**12 N.m (9 Ft. Lbs.)**	-
3	Oil Pump Sprocket M8 Bolt	**26 N.m (18 Ft. Lbs.)**	-

FILTER, ENGINE OIL

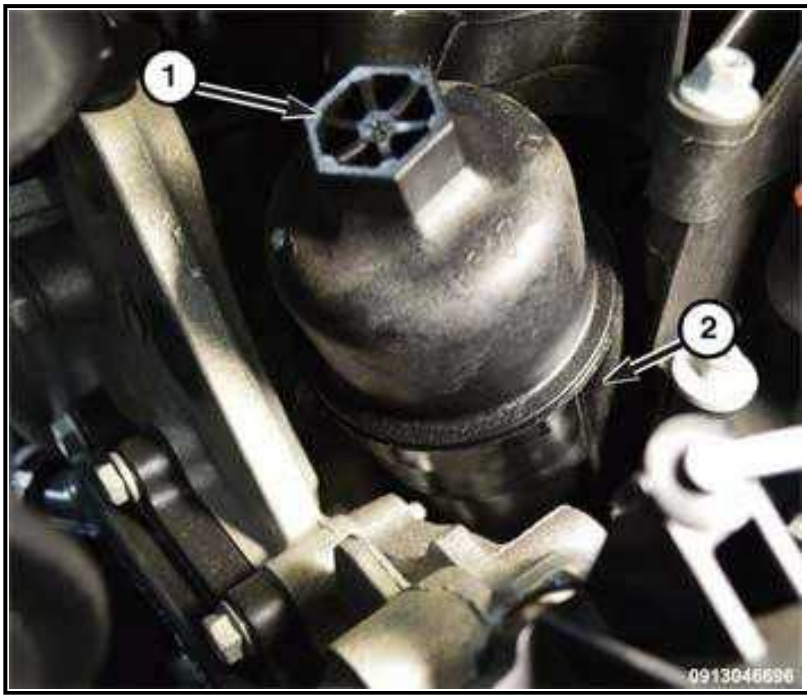
REMOVAL AND INSTALLATION

REMOVAL AND INSTALLATION

REMOVAL

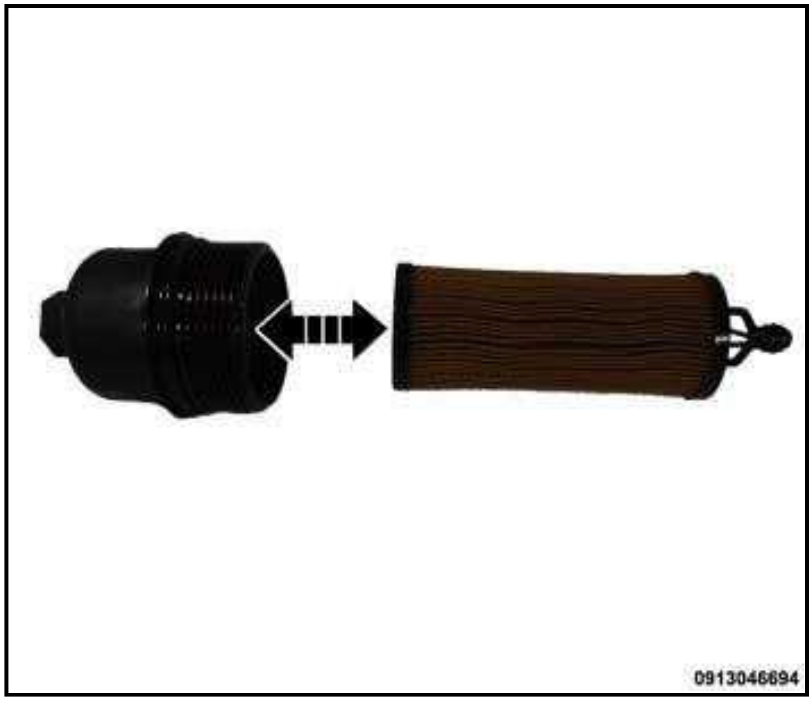
All engines are equipped with a high quality full-flow, disposable type oil filter. A MoparB® or equivalent oil filter is recommended.

CAUTION: **When performing an engine oil change, the oil filter cap must be removed. Removing the oil filter cap releases oil held within the oil filter cavity and allows it to drain into the sump. Failure to remove the cap prior to reinstallation of the drain plug will not allow complete draining of the used engine oil.**



1. Place an oil absorbent cloth around the oil filter housing at the base of the oil filter cap.
2. Use a 15/16" or a 24 mm socket only and rotate the oil filter cap (1) counterclockwise until it is disengaged from the oil filter housing (2).

3. Lifting the oil filter cap upward. Remove the oil filter from the housing pulling in a straight line.



4. Remove the oil filter from the oil filter cap by pulling in a straight line motion.

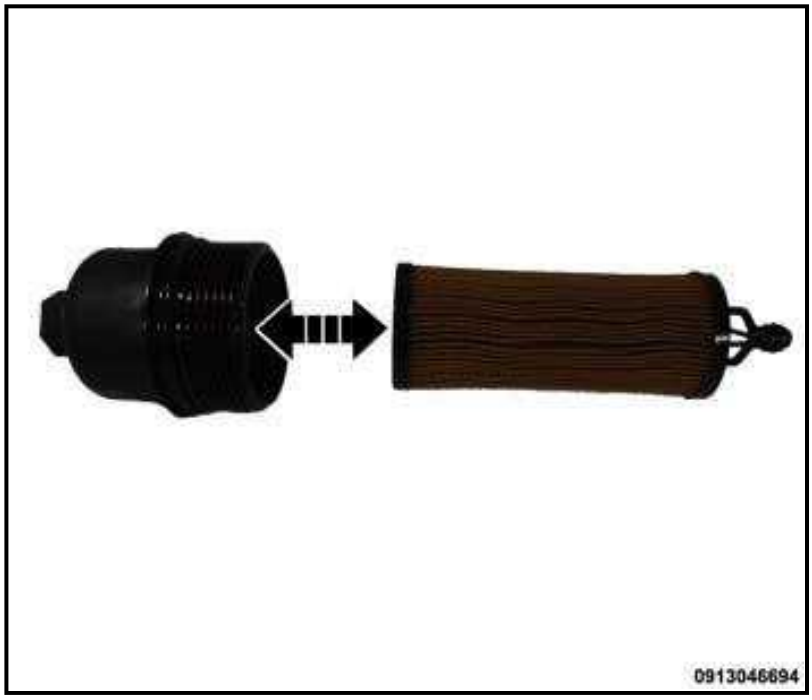
NOTE: **DO NOT use a Pencil Snap motion to remove the filter from the cap. The pencil snap motion can cause the cap to become disassembled, if this happens, it should be reassembled, not discarded.**

5. Remove and discard the O-ring (1).

INSTALLATION

NOTE: **It is not necessary to pre-oil the oil filter or fill the oil filter housing.**

1. Lightly lubricate the **NEW** O-ring (1) with clean engine oil.
2. Install the O-ring on the filter cap.



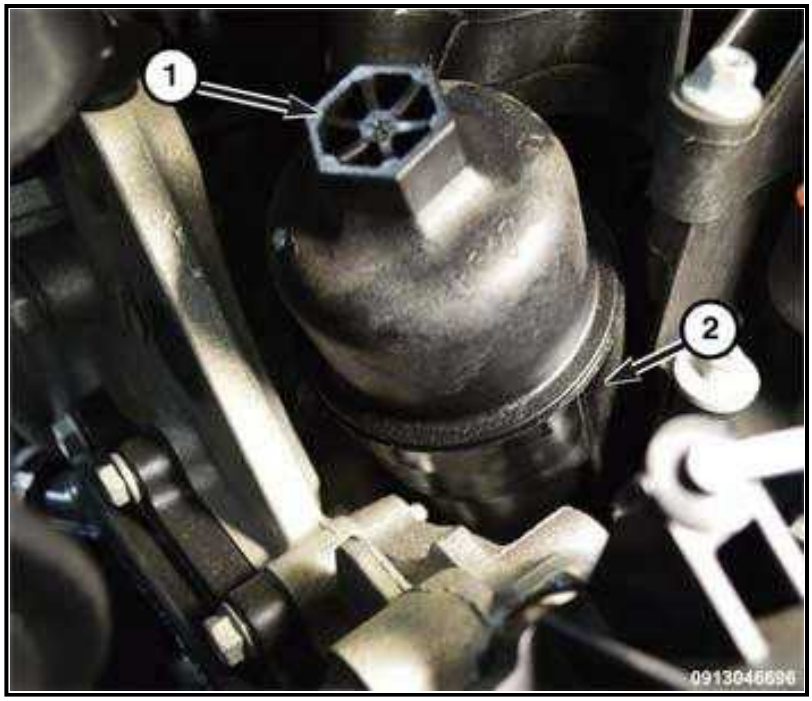
3. Install the

   NEW

   oil filter into the oil filter cap.

NOTE: **If the cap retainer does come out of the new style with supporting ribs in the cap and all of the clips are present, simply put the retainer into the new filter, set the spring in the retainer and carefully reset into the cap with a firm push. Following reassembly, shake the filter and cap assembly to be sure there is no rattle noise heard and install into the Oil Filter Adapter after replacing the cap O-ring with the new one that comes with the NEW filter.**

4. Install the oil filter into oil filter housing.



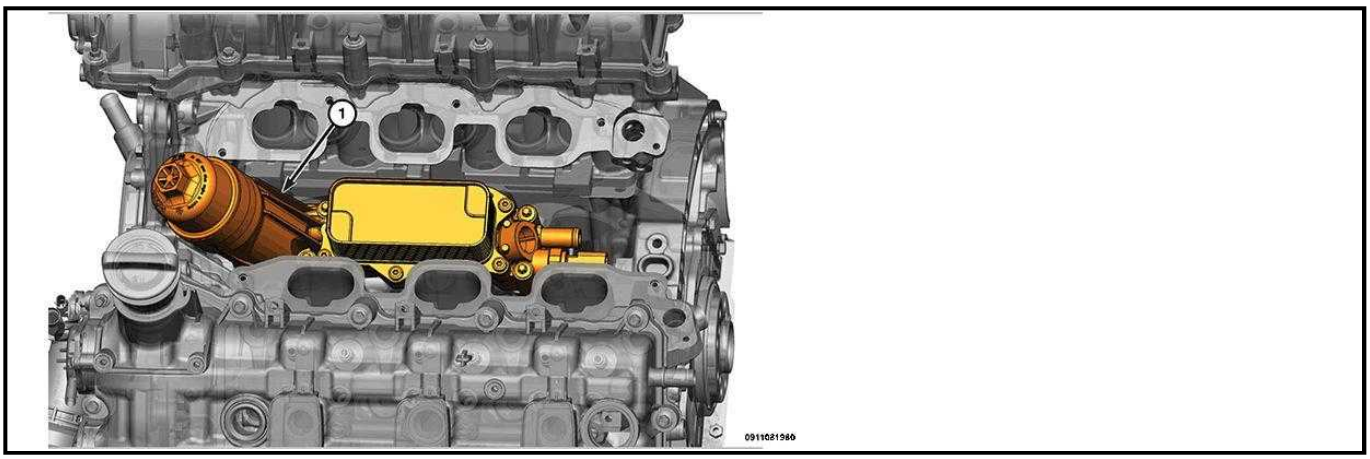
5. Thread the oil filter cap (1) into the oil filter housing (2) and tighten to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .
6. Add oil, verify crankcase oil level and start engine. Inspect for oil leaks. Refer to **STANDARD PROCEDURE** .

HOUSING, OIL FILTER

DESCRIPTION AND OPERATION

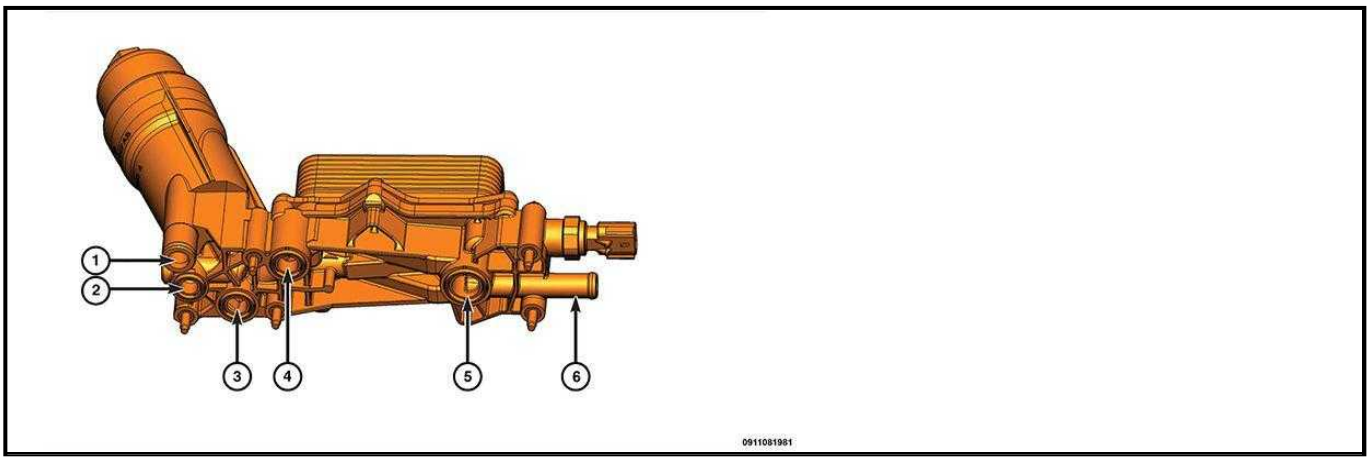
DESCRIPTION AND OPERATION

OIL FILTER HOUSING



The oil filter housing (1) is located in the V of the cylinder block. The oil filter element is located within the housing and the engine oil cooler is attached to the top of the housing. The oil pressure sensor is located at the rear of the housing.

OPERATION



Oil flows from the engine oil pump to the oil filter housing inlet (1) and to the oil filter element located within the oil filter housing. After the oil is filtered and then cooled it travels to the main oil gallery (5). An oil filter by-pass is built into the housing and is not serviceable. Removing the oil filter cap from the housing allows oil to drain from the oil filter cavity into to the crankcase (2).

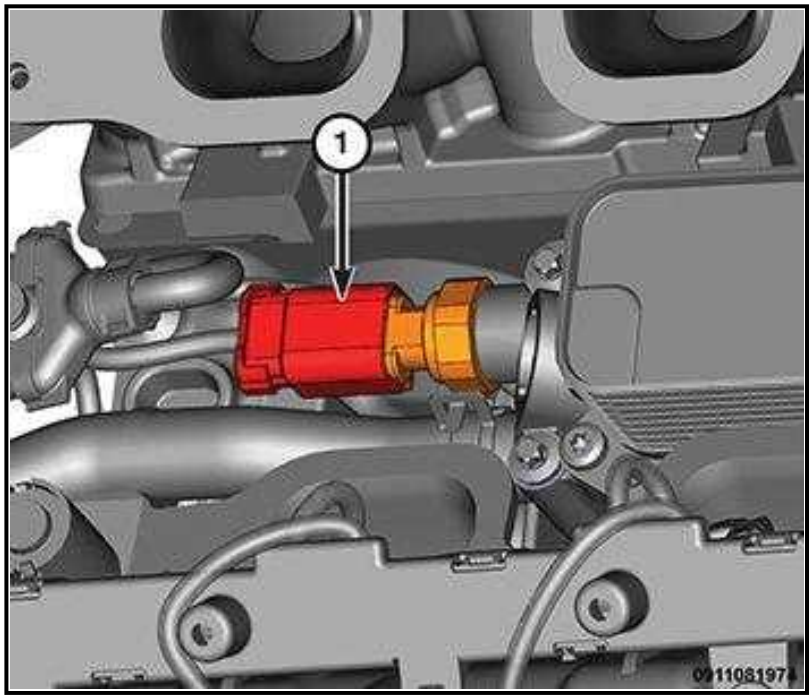
Coolant flows from the right cylinder block water jacket (3) and from the left cylinder block water jacket (4) into the housing. The coolant flows through the oil cooler and exits the housing from the rear hose nipple (6) where it is returned to the water pump. A coolant by-pass in the housing is designed to direct excessive coolant flow around the oil cooler for continuous circulation.

REMOVAL AND INSTALLATION

OIL FILTER HOUSING

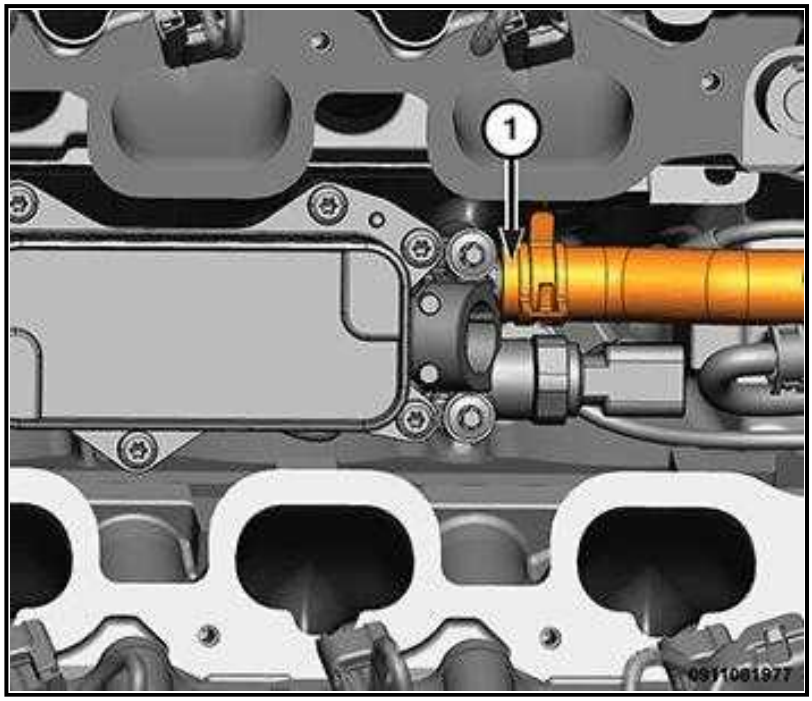
NOTE: **If the Oil Filter Adapter is being removed for an Oil Leak Condition, Oil Dye (P/N - CH5010042AC) MUST be used first do determine the location of the oil leak. (If oil dye has not been used, the repair will not be validated)**

1. Perform the fuel system pressure release procedure. Refer to **FUEL SYSTEM PRESSURE RELEASE** .
2. Drain the engine cooling system. Refer to **DRAINING** .
3. Remove the lower intake manifold. Refer to **MANIFOLD, INTAKE, REMOVAL AND INSTALLATION** .



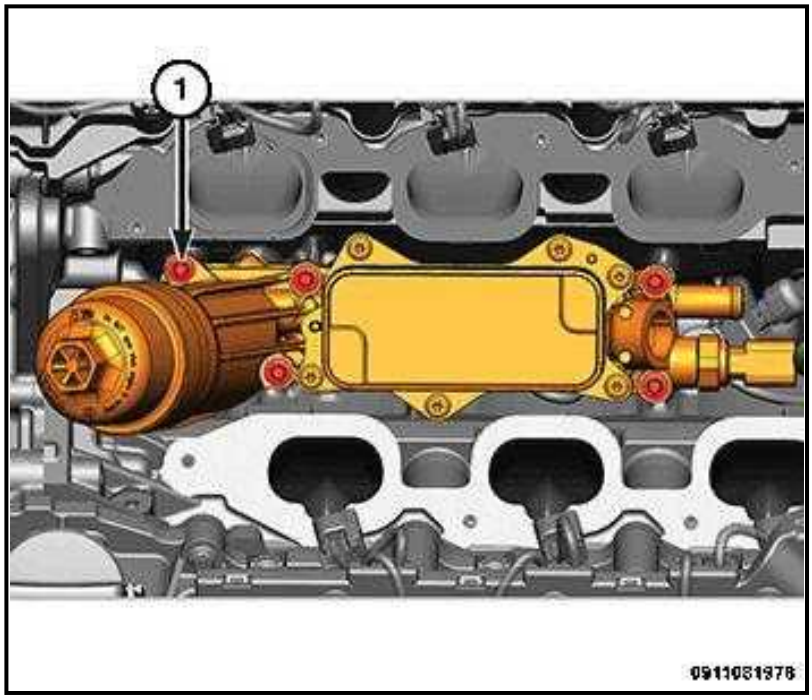
1 - Oil Pressure Sensor Harness Connector

4. Disconnect the oil pressure sensor wire harness connectors.



1 - Heater Hose

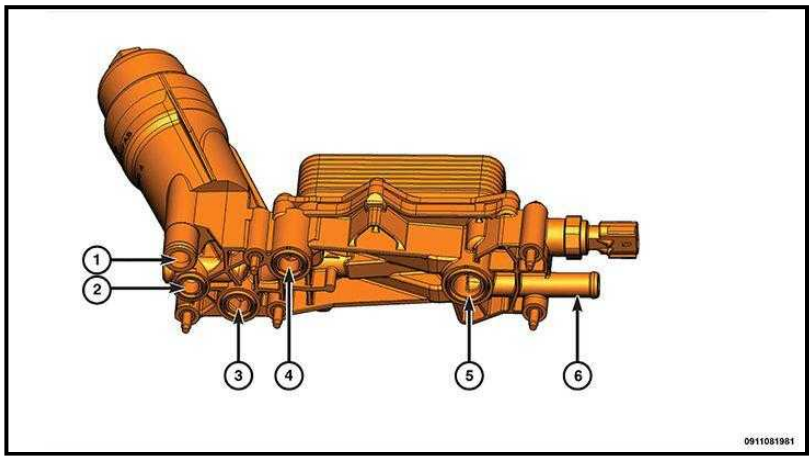
5. Remove the heater hose from the oil filter housing.



1 - Oil Filter Housing Bolts

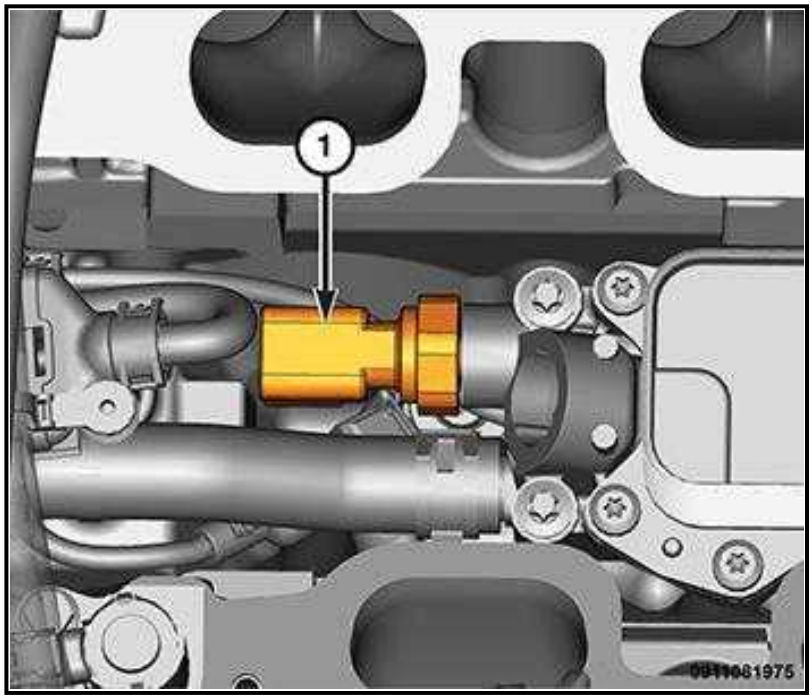
6. Remove five bolts and remove the oil filter housing.

NOTE: **If there is an oil leak (identified by the use of Oil Dye) coming from between the Oil Filter Adapter and the valley deck mating surfaces, replace only the four gaskets and the drain tube O-ring.**



(1-5) - Oil Filter Housing Seals

7. Remove and discard the oil filter housing seals.



1 - Oil Pressure Sensor

8. If there is a need to replace the oil pressure sensor, use a deep well socket of the correct size (1-1/16" or 27mm). Use extreme care to keep the socket in line with the sensor to prevent the sensor insert from turning in the housing creating a potential leak.

INSTALLATION

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

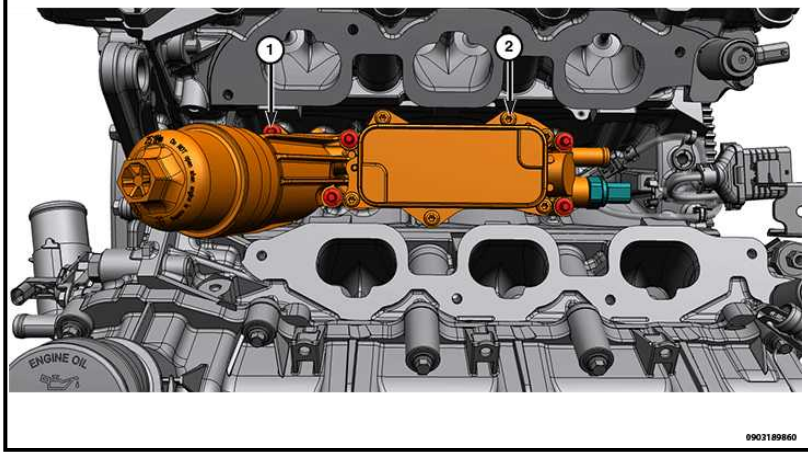
Follow the removal procedure in reverse for general reassembly of the components on the vehicle. The steps listed below are calling out specific procedures that should be followed during installation.

- Always use **NEW** dry seals when installing the oil filter housing. Lubricate the O-ring seals with clean engine oil prior to installation.
- The oil filter housing bolts must be tightened in the sequence shown in the torque table below.
- Fill the cooling system. Refer to **STANDARD PROCEDURE - FILLING** .

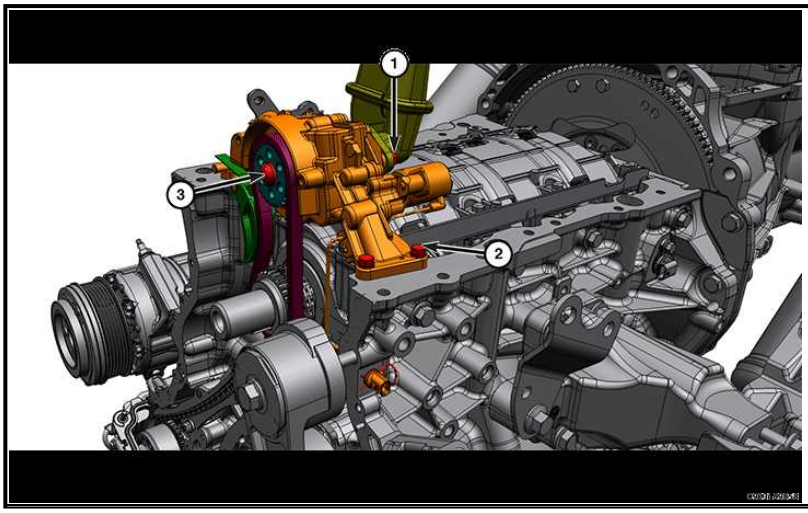
TORQUE SPECIFICATIONS

LUBRICATION

DESCRIPTION	SPECIFICATION	COMMENTS
Upper Oil Pan to Engine Block M8 Bolts	**23 N.m (17 Ft. Lbs.)**	-
Lower Oil Pan to Upper Oil Pan - M6 Bolts	**9 N.m (80 In. Lbs.)**	-
Lower Oil Pan to Upper Oil Nuts	**10 N.m (89 In. Lbs.)**	-
Upper Oil Pan to Rear Seal Retainer M6 Bolts	**10 N.m (89 In. Lbs.)**	-
Oil Pan Drain Plug	**27 N.m (20 Ft. Lbs.)**	-
Oil Level Indicator to Cylinder Head Bolt	**18 N.m (13 Ft. Lbs.)**	-



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Oil Filter Housing/Oil Cooler to Engine Block M6 Bolts	**12 N.m (9 Ft. Lbs.)**	-
2	Oil Cooler to Oil Filter Housing Screws	**12 N.m (9 Ft. Lbs.)**	-
-	Oil Filter Housing Cap	**25 N.m (18 Ft. Lbs.)**	-



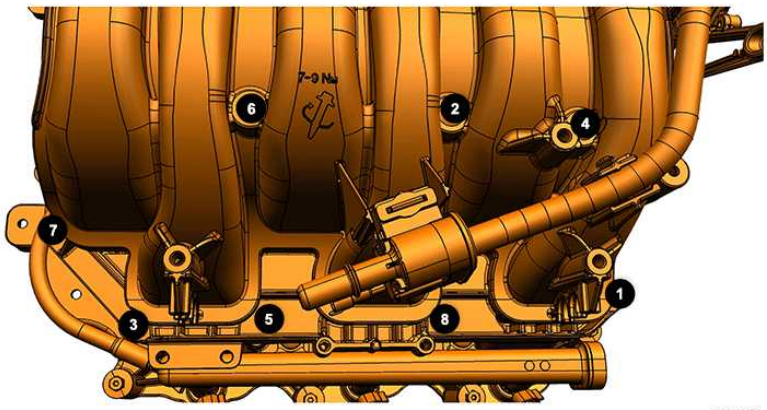
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Oil Pump Pick Up Tube to Oil Pump M6 Bolt	**8 N.m (71 In. Lbs.)**	-
-	Oil Pump Pick Up Tube Bracket to Windage Tray Bolt	**8 N.m (80 In. Lbs.)**	-
2	Oil Pump to Engine Block M6 Bolts	**12 N.m (9 Ft. Lbs.)**	-
3	Oil Pump Sprocket M8 Bolt	**26 N.m (18 Ft. Lbs.)**	-

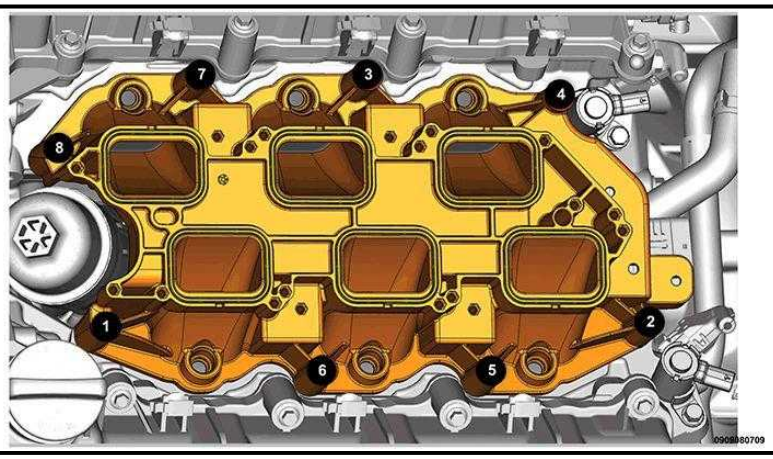
AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-

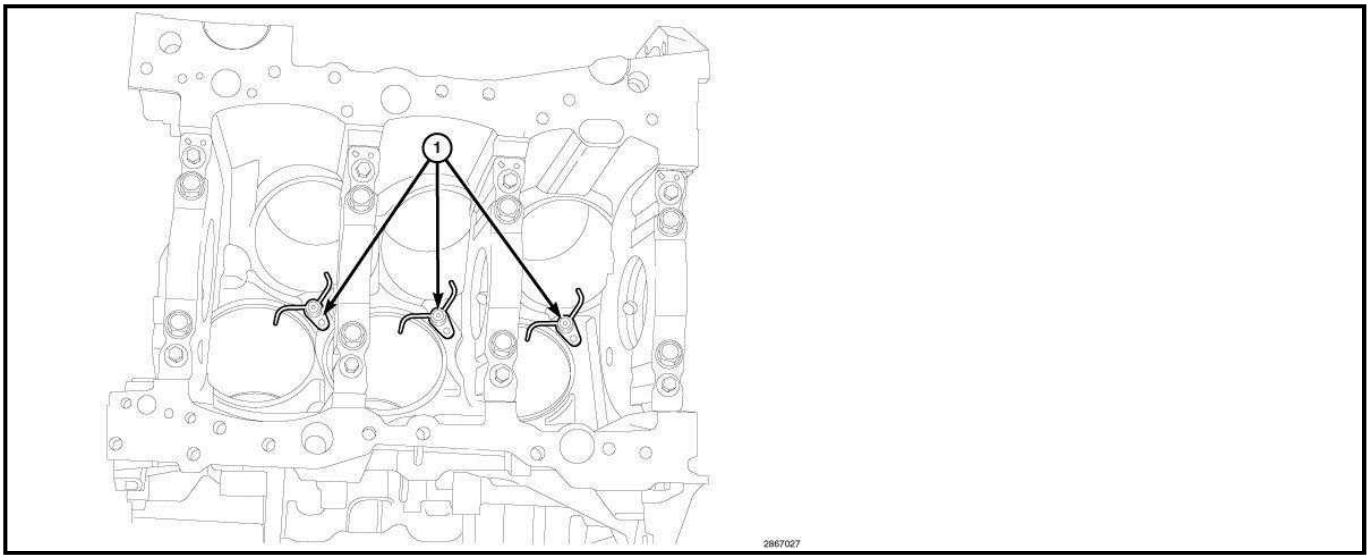




JET, PISTON OIL COOLER

DESCRIPTION AND OPERATION

PISTON OIL COOLER JET



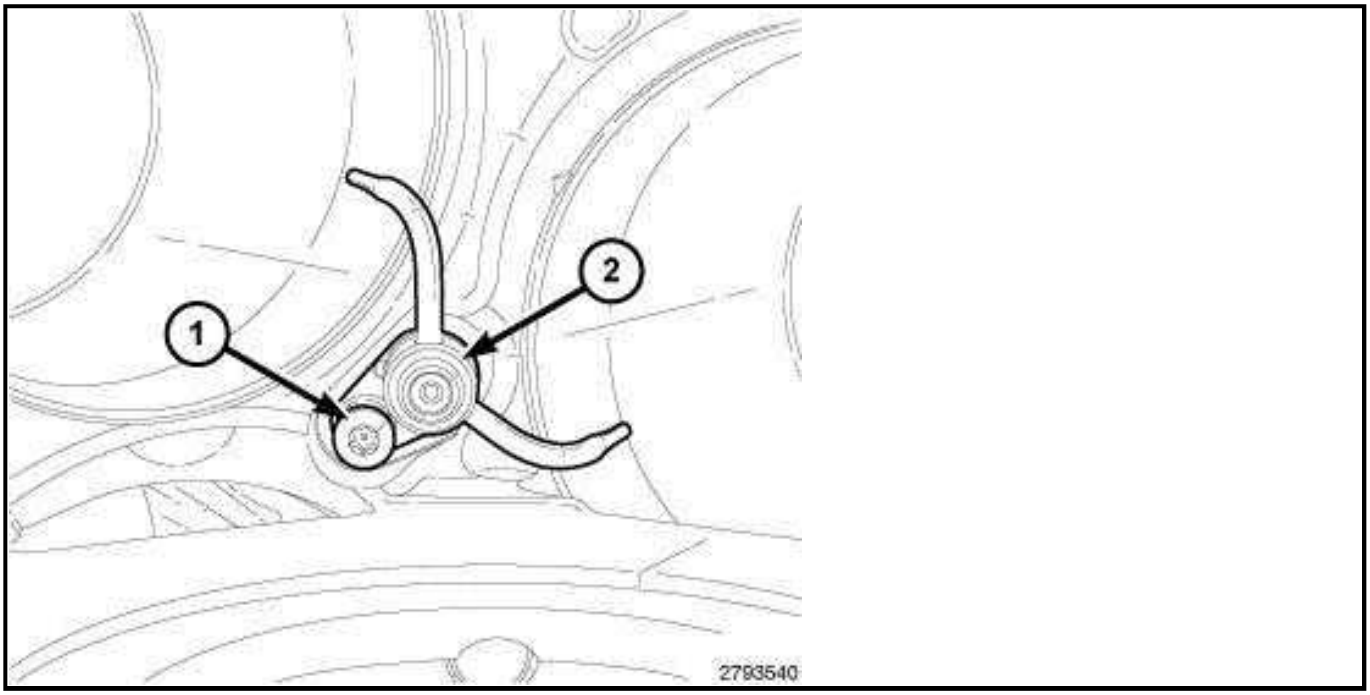
The Piston Oil Cooler Jet (1) is used to aid in the cooling of the pistons and the cylinder walls. There are three Piston Oil Cooler Jets used. Each jet is supplied oil by the main oil gallery. The oil is sprayed upwards onto the bottom of the pistons and sides of the cylinder walls. A Piston Oil Cooler Jet is mounted to the engine block under each pair of opposing cylinders.

Each jet has a check valve that closes below 241 kPa (35 psi) to maintain ample oil pressure at idle. All three oil jets are identical and seal to the engine block using an O-ring and fastener.

REMOVAL AND INSTALLATION

PISTON OIL COOLER JET

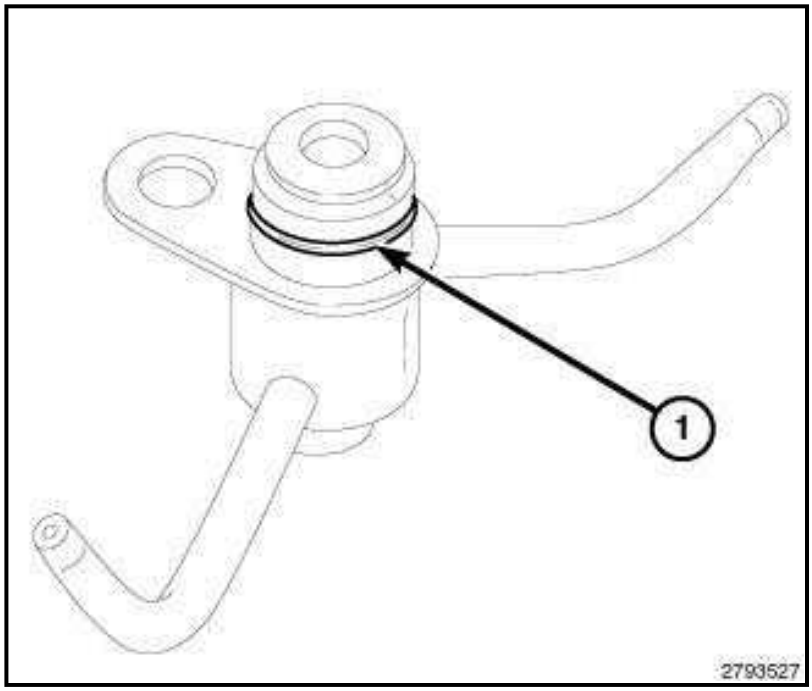
REMOVAL



1 - Piston Oil Cooler Jet Bolt
2 - Piston Oil Cooler Jet

NOTE: **Piston oil cooler jet for cylinders one/two shown. Other piston oil cooler jets are similar.**

1. Remove the crankshaft. Refer to **CRANKSHAFT, REMOVAL AND INSTALLATION**.
2. Remove the bolt and the piston oil cooler jet(s) from the engine block.



1 - Piston Oil Cooler Jet O-ring

3. Remove and discard the O-ring from the piston oil cooler jet(s).

INSTALLATION

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

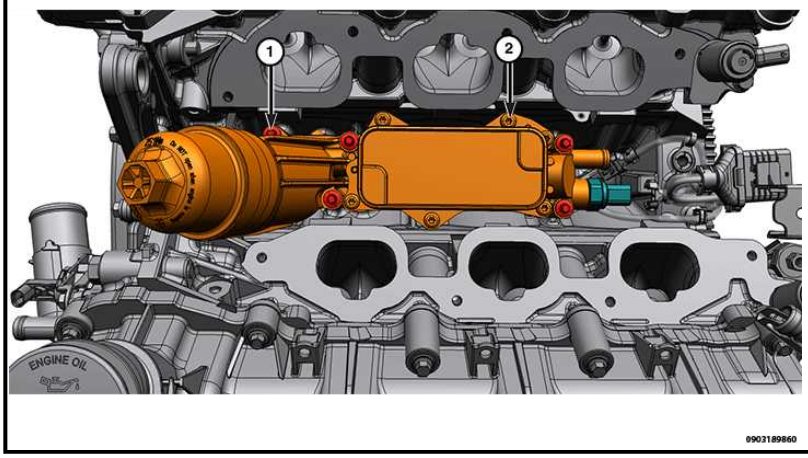
Follow the removal procedure in reverse for general reassembly of the components on the vehicle. The steps listed below are calling out specific procedures that should be followed during installation.

- Lubricate a **NEW** O-ring with engine oil and install on the piston oil cooler jet(s).

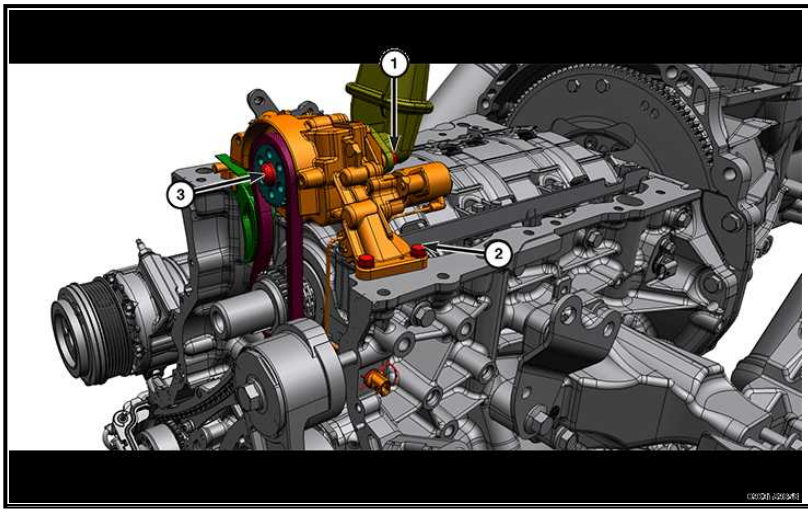
TORQUE SPECIFICATIONS

LUBRICATION

DESCRIPTION	SPECIFICATION	COMMENTS
Upper Oil Pan to Engine Block M8 Bolts	**23 N.m (17 Ft. Lbs.)**	-
Lower Oil Pan to Upper Oil Pan - M6 Bolts	**9 N.m (80 In. Lbs.)**	-
Lower Oil Pan to Upper Oil Nuts	**10 N.m (89 In. Lbs.)**	-
Upper Oil Pan to Rear Seal Retainer M6 Bolts	**10 N.m (89 In. Lbs.)**	-
Oil Pan Drain Plug	**27 N.m (20 Ft. Lbs.)**	-
Oil Level Indicator to Cylinder Head Bolt	**18 N.m (13 Ft. Lbs.)**	-



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Oil Filter Housing/Oil Cooler to Engine Block M6 Bolts	**12 N.m (9 Ft. Lbs.)**	-
2	Oil Cooler to Oil Filter Housing Screws	**12 N.m (9 Ft. Lbs.)**	-
-	Oil Filter Housing Cap	**25 N.m (18 Ft. Lbs.)**	-

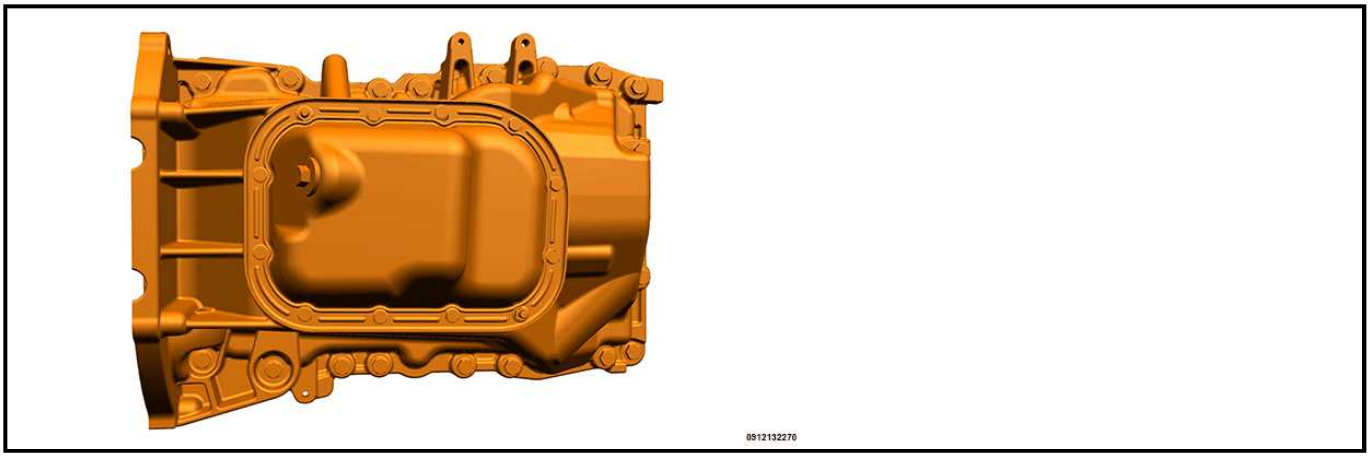


CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Oil Pump Pick Up Tube to Oil Pump M6 Bolt	**8 N.m (71 In. Lbs.)**	-
-	Oil Pump Pick Up Tube Bracket to Windage Tray Bolt	**8 N.m (80 In. Lbs.)**	-
2	Oil Pump to Engine Block M6 Bolts	**12 N.m (9 Ft. Lbs.)**	-
3	Oil Pump Sprocket M8 Bolt	**26 N.m (18 Ft. Lbs.)**	-

PAN, OIL

DESCRIPTION AND OPERATION

OIL PAN



There is an upper and lower oil pan. The upper oil pan is cast aluminum and also serves as the lower end structural support. The lower pan is a stamped steel design. Both upper and lower oil pans are sealed using MoparB® Threebond Engine RTV Sealant. The lower oil pan must be removed in order to access all of the upper oil pan attaching bolts.

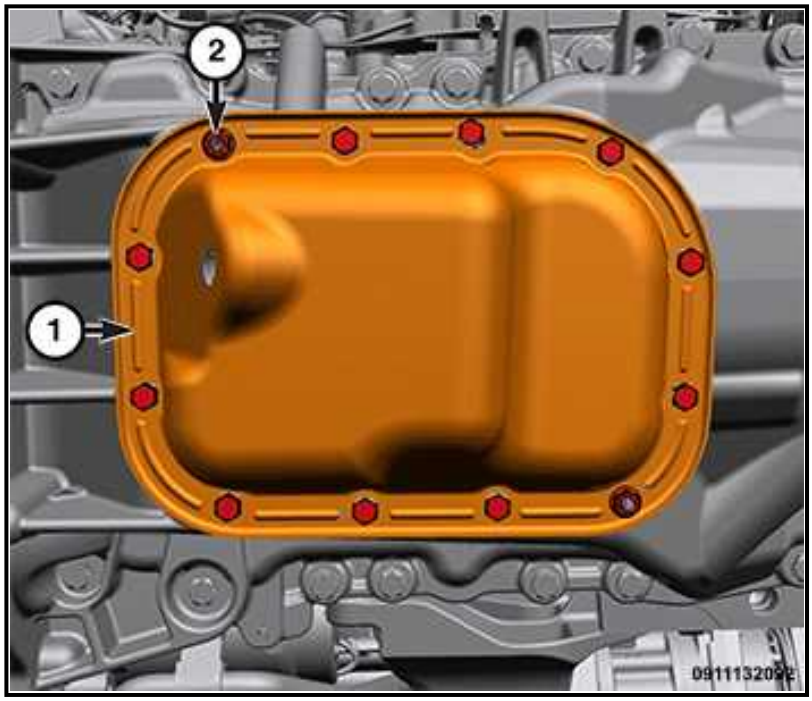
The high pressure die cast aluminum windage tray is mounted to the main bearing caps and is designed to keep oil off of the connecting rods as the crankshaft rotates. When the oil is kept off the connecting rods, the engine rotates easier and oil foaming decreases. Like the oil pan, the windage tray is designed to stiffen the lower end of the engine. The tray is directional and the main bearing cap bolts hold it in place.

REMOVAL AND INSTALLATION

LOWER OIL PAN

REMOVAL

1. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .
2. Drain the engine oil. Refer to the appropriate information .



1 - Lower Oil Pan
2 - Lower Oil Pan Bolts

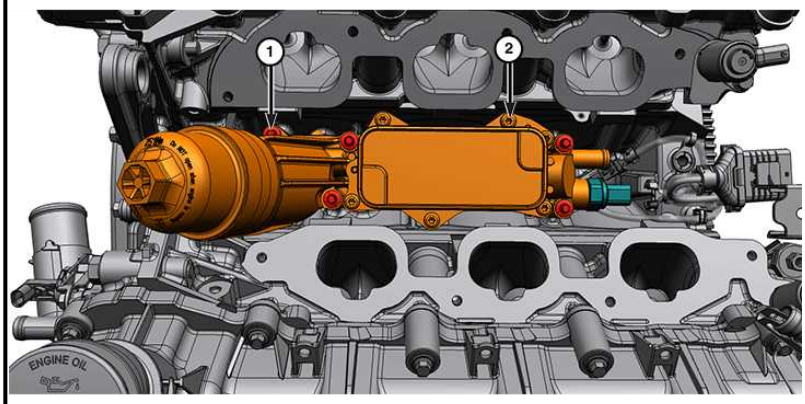
3. Remove bolts, nuts and studs from the flange of the lower oil pan.

CAUTION: **Do not pry on the lower oil pan flange. There are no designated pry points for lower oil pan removal. Prying on only one or a few locations could bend the flange and damage the pan.**

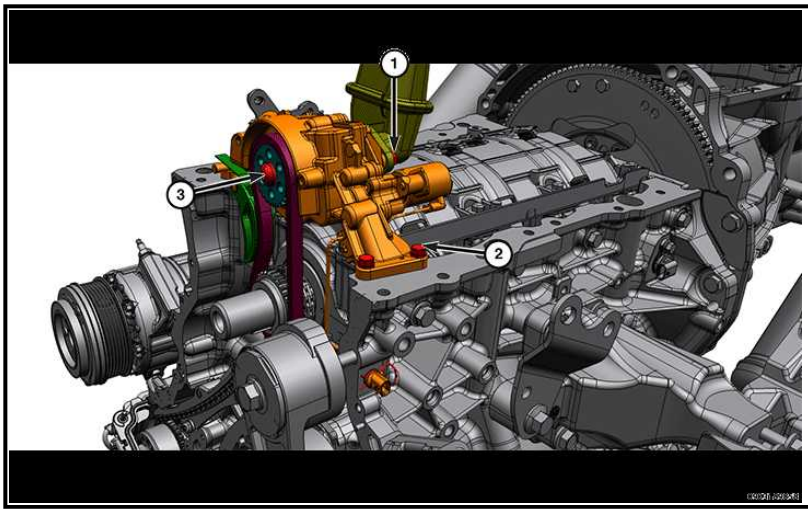
4. Using a gasket scraper or equivalent, loosen the seal around the lower oil pan in order to shear the sealant bond and remove the pan.

LUBRICATION

DESCRIPTION	SPECIFICATION	COMMENTS
Upper Oil Pan to Engine Block M8 Bolts	**23 N.m (17 Ft. Lbs.)**	-
Lower Oil Pan to Upper Oil Pan - M6 Bolts	**9 N.m (80 In. Lbs.)**	-
Lower Oil Pan to Upper Oil Nuts	**10 N.m (89 In. Lbs.)**	-
Upper Oil Pan to Rear Seal Retainer M6 Bolts	**10 N.m (89 In. Lbs.)**	-
Oil Pan Drain Plug	**27 N.m (20 Ft. Lbs.)**	-
Oil Level Indicator to Cylinder Head Bolt	**18 N.m (13 Ft. Lbs.)**	-



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Oil Filter Housing/Oil Cooler to Engine Block M6 Bolts	**12 N.m (9 Ft. Lbs.)**	-
2	Oil Cooler to Oil Filter Housing Screws	**12 N.m (9 Ft. Lbs.)**	-
-	Oil Filter Housing Cap	**25 N.m (18 Ft. Lbs.)**	-



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Oil Pump Pick Up Tube to Oil Pump M6 Bolt	**8 N.m (71 In. Lbs.)**	-
-	Oil Pump Pick Up Tube Bracket to Windage Tray Bolt	**8 N.m (80 In. Lbs.)**	-
2	Oil Pump to Engine Block M6 Bolts	**12 N.m (9 Ft. Lbs.)**	-
3	Oil Pump Sprocket M8 Bolt	**26 N.m (18 Ft. Lbs.)**	-

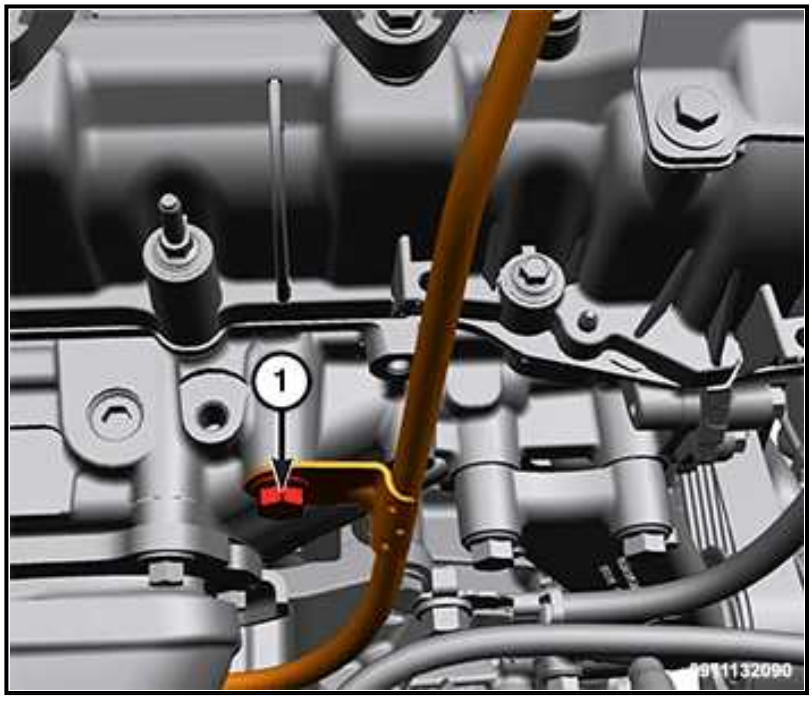
UPPER OIL PAN

REMOVAL

1. Drain the engine oil. Refer to the appropriate information .

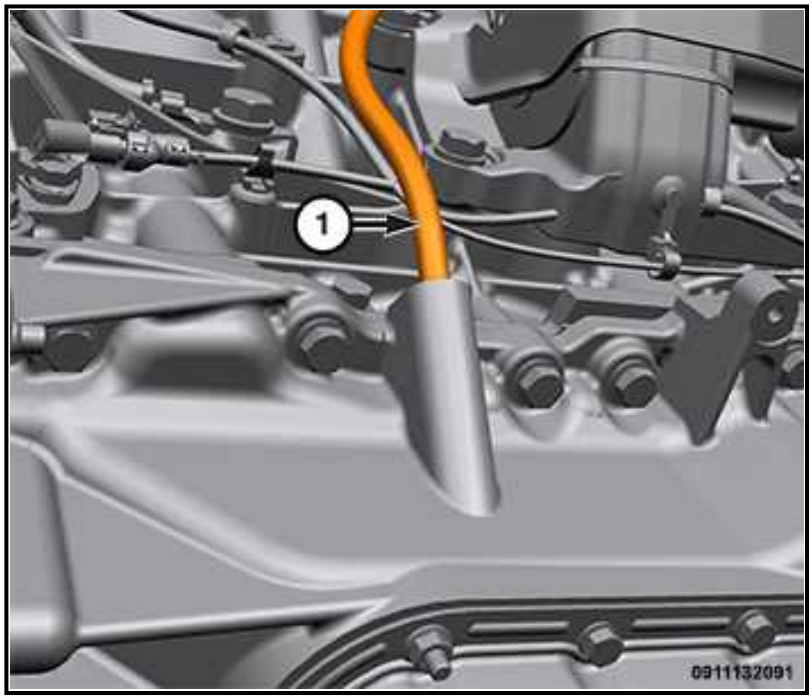
NOTE: **The lower oil pan does not need to be removed when removing the upper oil pan.**

2. If required, remove the lower oil pan. Refer to **PAN, OIL, REMOVAL AND INSTALLATION**.



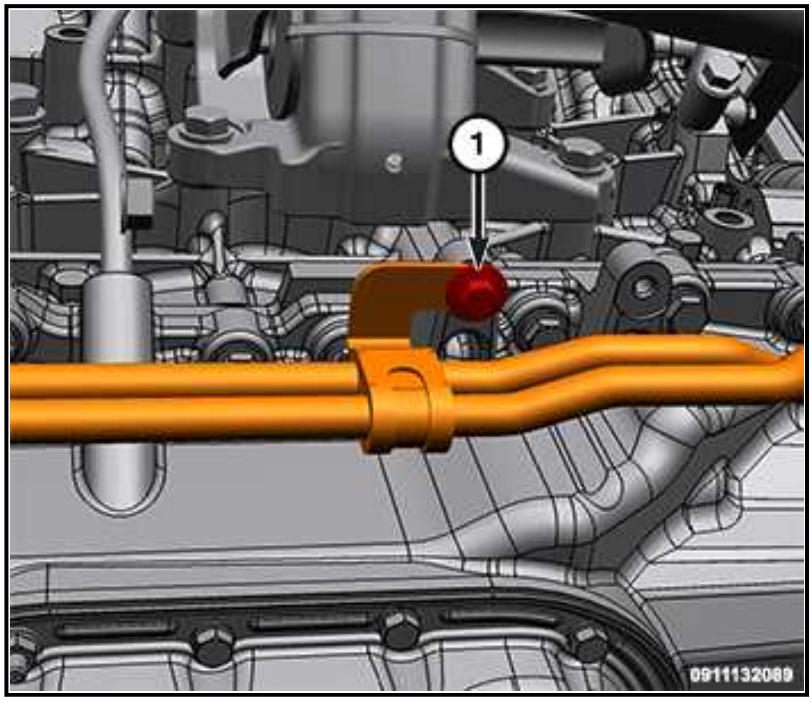
1 - Oil Level Indicator Tube Bolt

3. Remove the bolt securing the oil level indicator tube to the cylinder head.



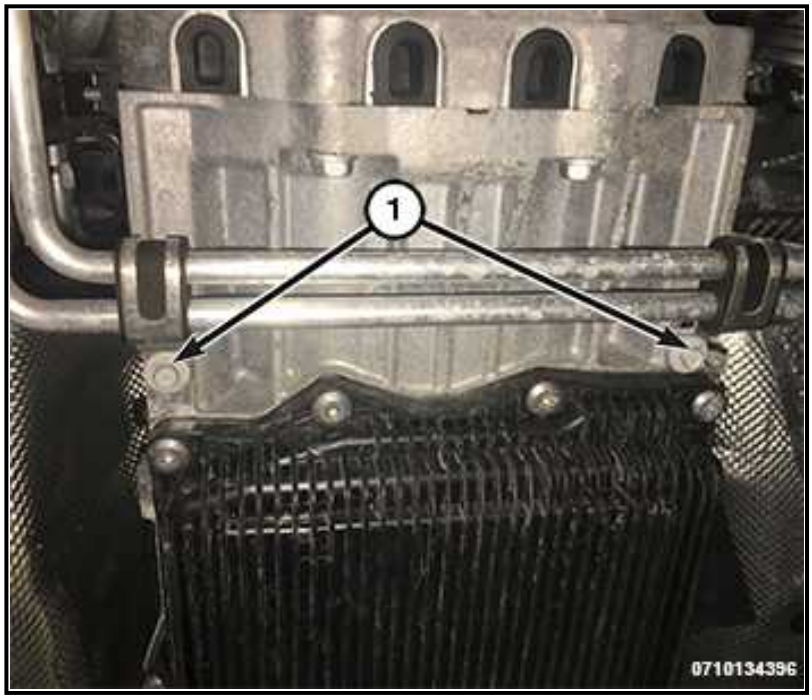
1 - Oil Level Indicator Tube Bolt

4. Remove the oil level indicator tube from the oil pan.



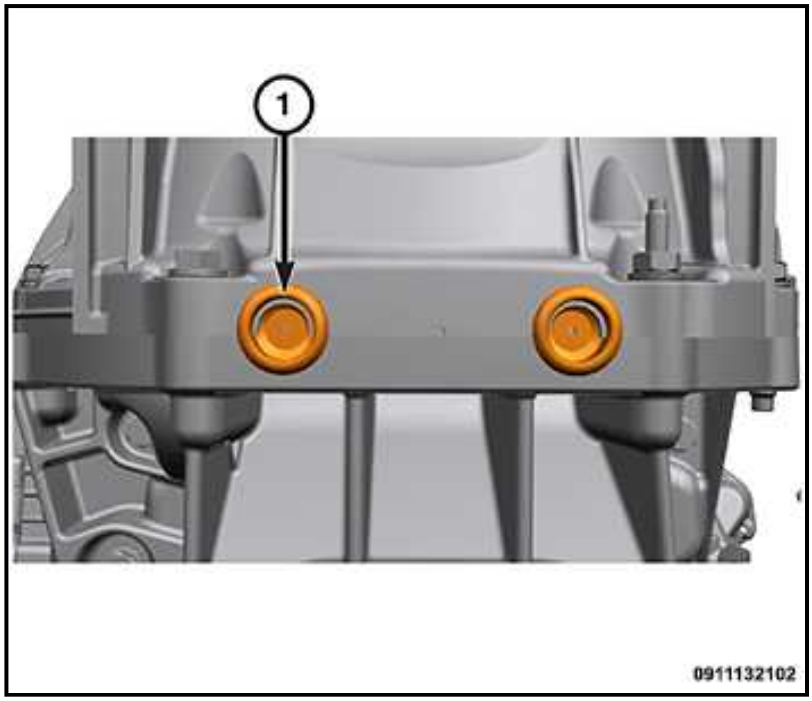
1 - Transmission Cooler Line Bolt

5. Remove the transmission cooler line bolt from the oil pan flange.



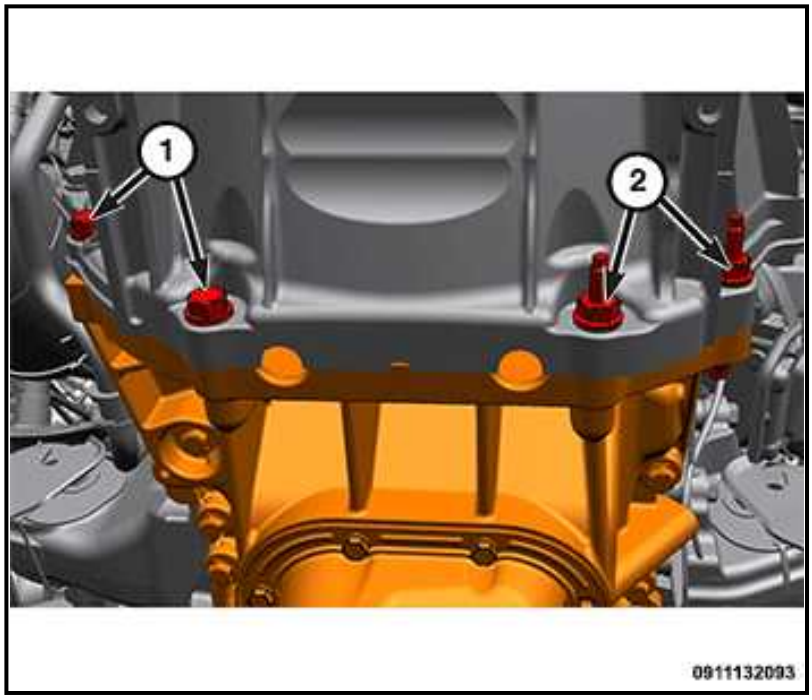
1 - Transmission Cooler Line Bolts

6. Remove the transmission cooler line retaining bolts from the transmission and lower the lines.



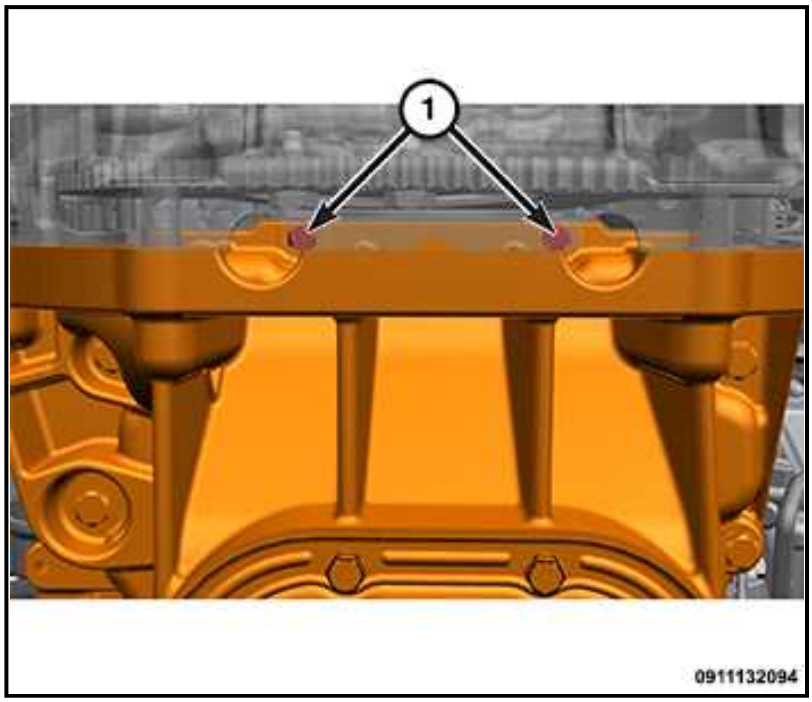
1 - Rubber Plugs

7. Remove two rubber plugs covering the rear oil seal retainer flange bolts.



1 - Transmission to Oil Pan Bolts
2 - Transmission to Oil Pan Bolts

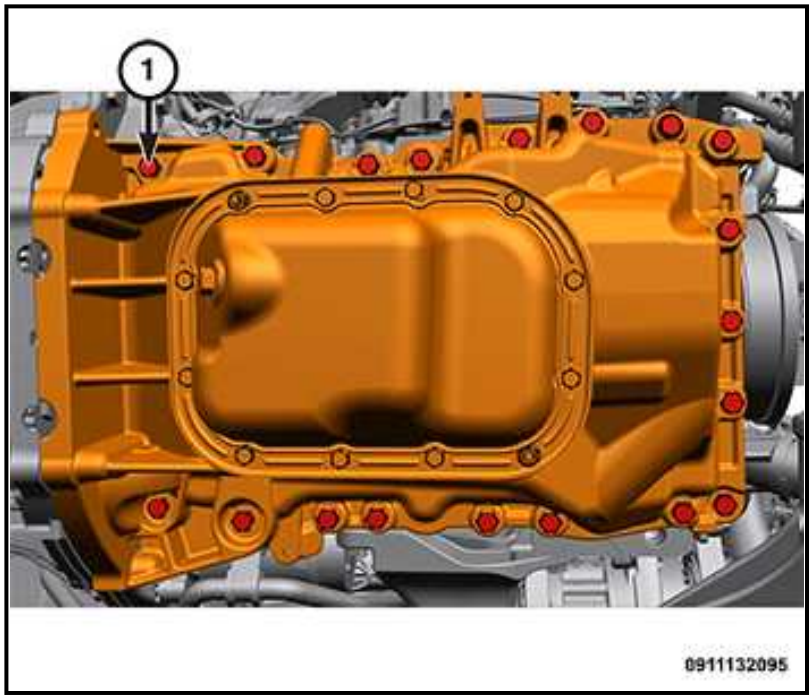
8. Remove four transmission to the engine oil pan bolts.



1 - Rear Oil Seal Retainer Flange Bolts

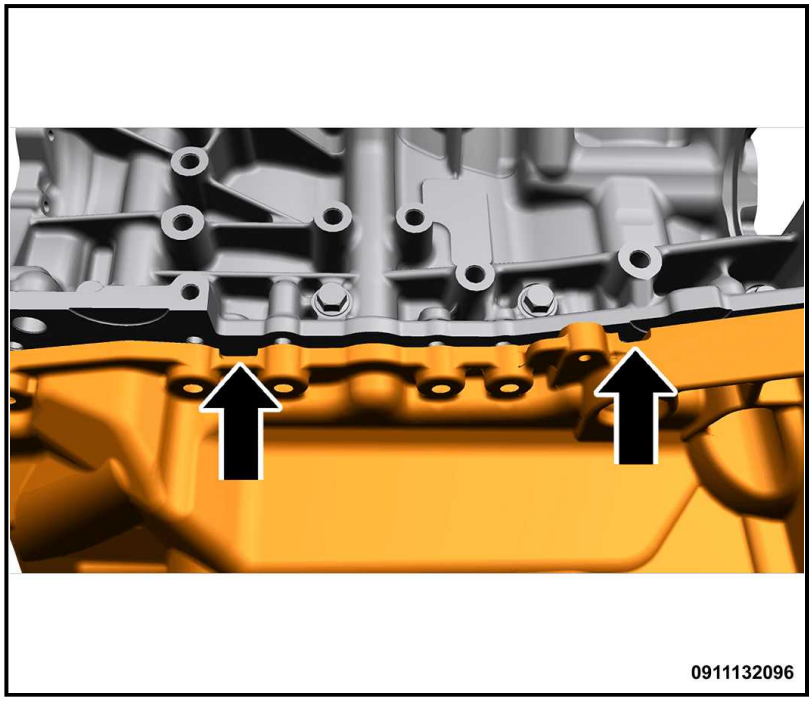
9. Remove two bolts from the rear oil seal retainer flange.

CAUTION: **There are two hidden M6 bolts that must be removed from the rear of the upper oil pan flange. If these bolts are not removed, the rear oil seal retainer flange will be severely damaged.**



1 - Oil Pan Mounting Bolts

10. Remove the oil pan mounting bolts.



11. Using the indicated pry points, carefully remove the upper oil pan.
12. Remove all residual sealant from the upper and lower oil pans, timing chain cover, rear seal retainer and engine block mating surfaces. Refer to cleaning .

CLEANING:

- Clean the upper and lower oil pans, timing chain cover, rear seal retainer and engine block mating surfaces with isopropyl alcohol in preparation for sealant application. Refer to cleaning .

INSTALLATION

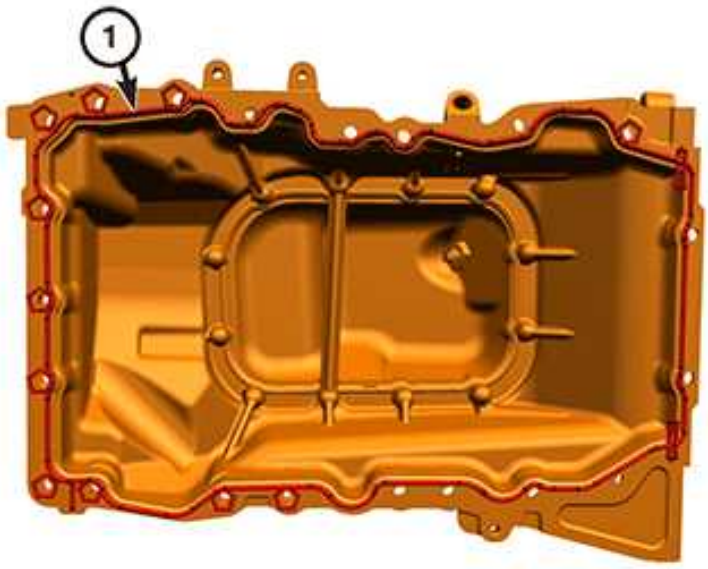
During installation, torque the fasteners to the specifications in the torque table(s) below.

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.

- Apply a 3 to 4 mm wide bead of MoparB® Threebond Engine RTV Sealant to the upper oil pan (1) as shown in the following locations:

CAUTION: **Make sure that the rear face of the oil pan is flush to the transmission bell housing before tightening any of the oil pan mounting bolts. A gap between the oil pan and the transmission could crack the oil pan or transmission casting.**

- Install the oil pan to the engine block and flush to the transmission bell housing. Secure the oil pan to the engine block with oil pan mounting bolts **finger tight** .
- Install the four transmission to the engine oil pan bolts and tighten to the proper torque specification in the torque table below.
- The upper oil pan bolts to the proper torque specification in the torque table below.



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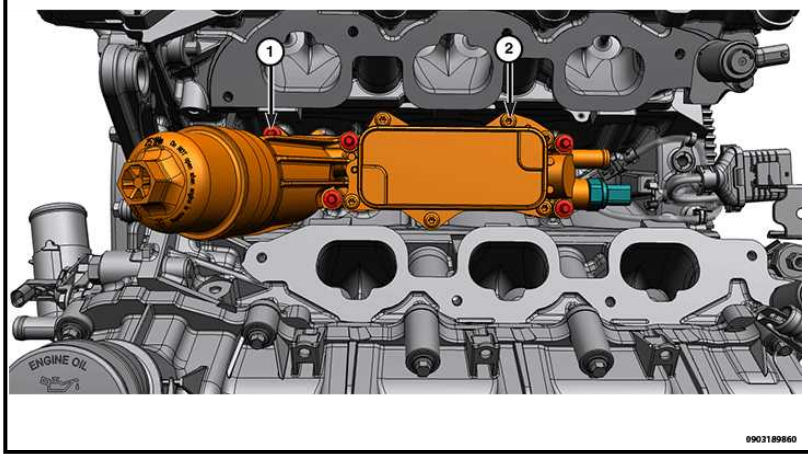
1 - Upper Oil Pan

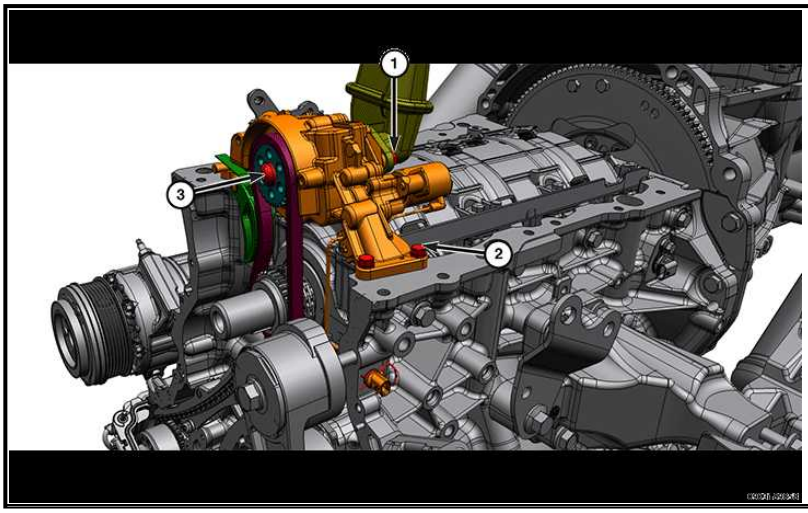
TORQUE SPECIFICATIONS

LUBRICATION

DESCRIPTION	SPECIFICATION	COMMENTS
Upper Oil Pan to Engine Block M8 Bolts	**23 N.m (17 Ft. Lbs.)**	-
Lower Oil Pan to Upper Oil Pan - M6 Bolts	**9 N.m (80 In. Lbs.)**	-
Lower Oil Pan to Upper Oil Nuts	**10 N.m (89 In. Lbs.)**	-
Upper Oil Pan to Rear Seal Retainer M6 Bolts	**10 N.m (89 In. Lbs.)**	-
Oil Pan Drain Plug	**27 N.m (20 Ft. Lbs.)**	-
Oil Level Indicator to Cylinder Head Bolt	**18 N.m (13 Ft. Lbs.)**	-

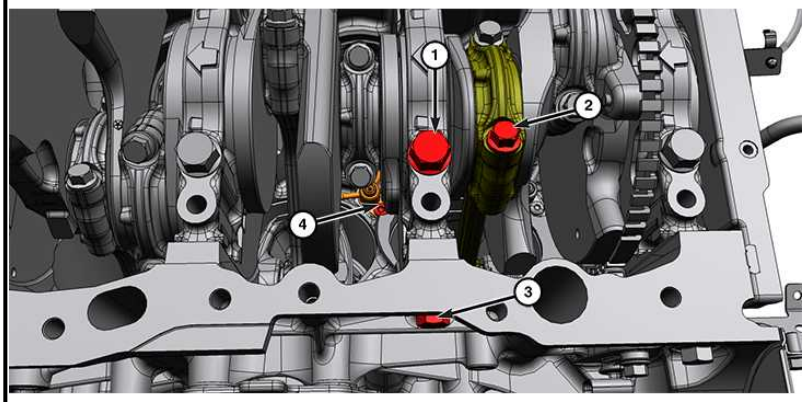


CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Oil Filter Housing/Oil Cooler to Engine Block M6 Bolts	**12 N.m (9 Ft. Lbs.)**	-
2	Oil Cooler to Oil Filter Housing Screws	**12 N.m (9 Ft. Lbs.)**	-
-	Oil Filter Housing Cap	**25 N.m (18 Ft. Lbs.)**	-



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Oil Pump Pick Up Tube to Oil Pump M6 Bolt	**8 N.m (71 In. Lbs.)**	-
-	Oil Pump Pick Up Tube Bracket to Windage Tray Bolt	**8 N.m (80 In. Lbs.)**	-
2	Oil Pump to Engine Block M6 Bolts	**12 N.m (9 Ft. Lbs.)**	-
3	Oil Pump Sprocket M8 Bolt	**26 N.m (18 Ft. Lbs.)**	-

ENGINE BLOCK



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CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Crankshaft Inner Main Bearing Cap M11 Bolts	**Torque Procedure:** 1. **20 N.m (15 Ft. Lbs.)** 2. **Turn additional 90B°**	Tightening Sequence
2	Connecting Rod Cap Bolts	**Torque Procedure:** 1. **20 N.m (15 Ft. Lbs.)** 2. **Turn additional 90B°**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
3	Crankshaft Side Main Bearing Cap (Tie Bolt) M8 Bolts	**30 N.m (22 Ft. Lbs.)**	Tightening Sequence
4	Piston Oil Cooler Jet to Engine Block Bolt	**6 N.m (63 In. Lbs.)**	-
-	Crankshaft Outer Main Bearing Cap and Windage Tray M8 Bolts	**Torque Procedure:** 1. **21 N.m (15 Ft. Lbs.)** 2. **Turn additional 90B°**	Tightening Sequence
-	Crankshaft Target Wheel to Counterweight Bolts	**11 N.m (8 Ft. Lbs.)**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
-	Engine Block Ground Strap Bolt	**23 N.m (17 Ft. Lbs.)**	-
-	Engine Block Ground Strap to Frame Nut	**20 N.m (15 Ft. Lbs.)**	-
-	Engine Lift Bracket	**21 N.m (15 Ft. Lbs.)**	-
-	Rear Crankshaft Oil Seal Retainer Bolts	**12 N.m (9 Ft. Lbs.)**	Tightening Sequence

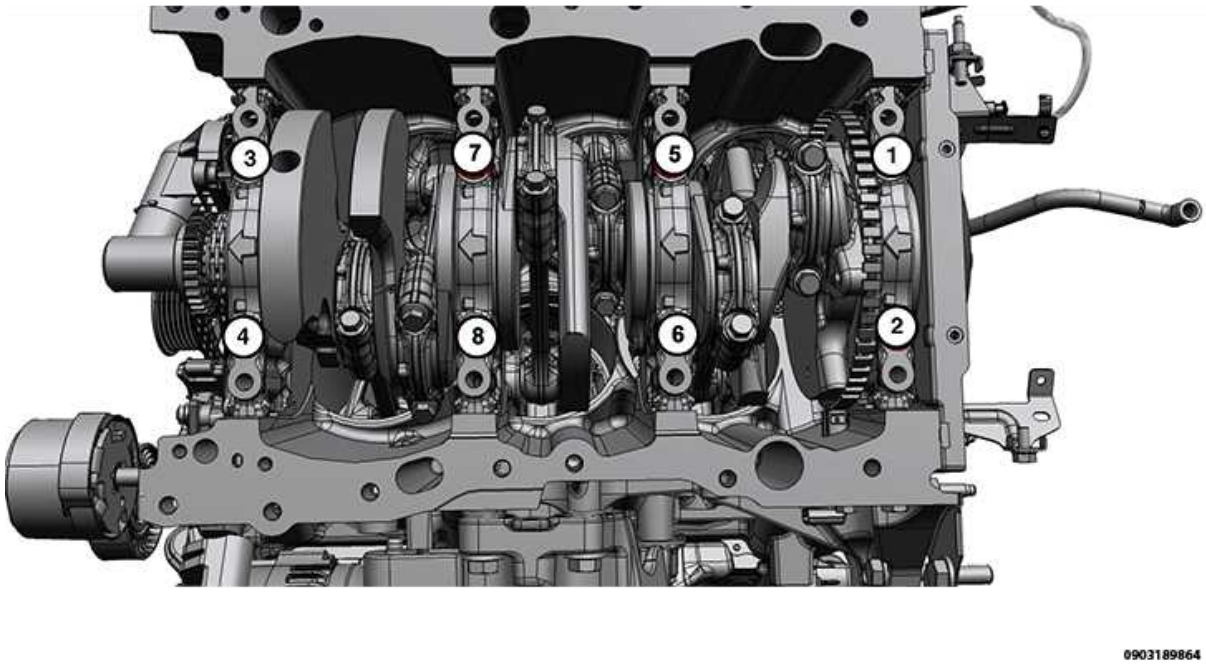
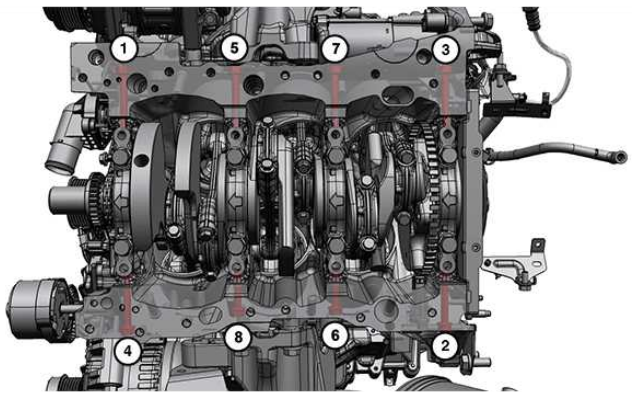


Fig. 20: Crankshaft Inner Main Bearing Cap Bolts Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC



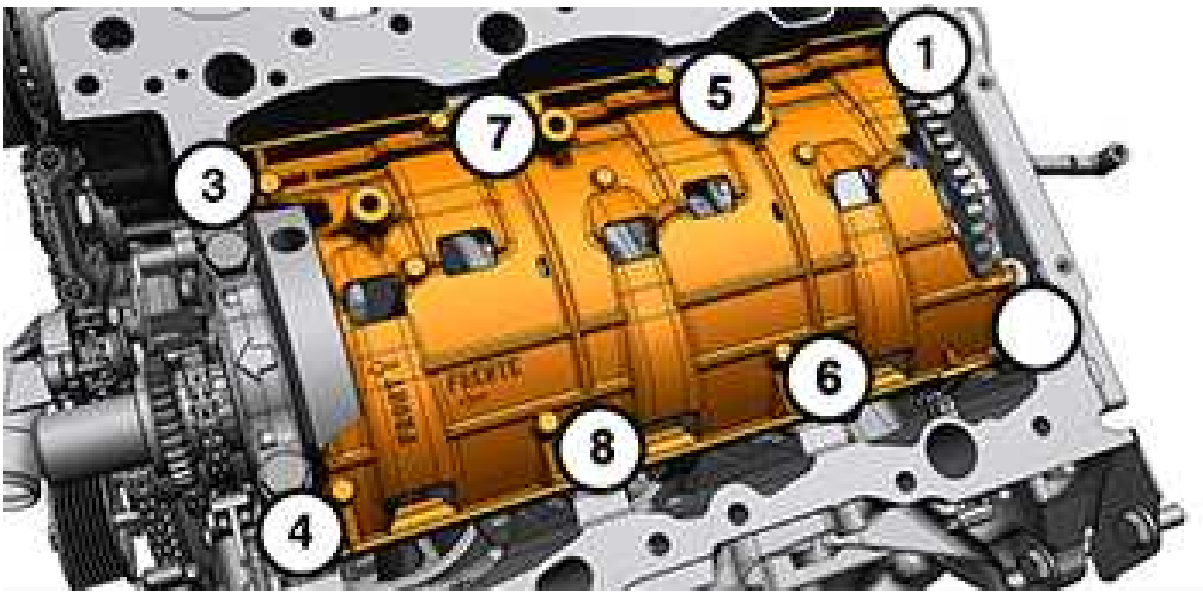
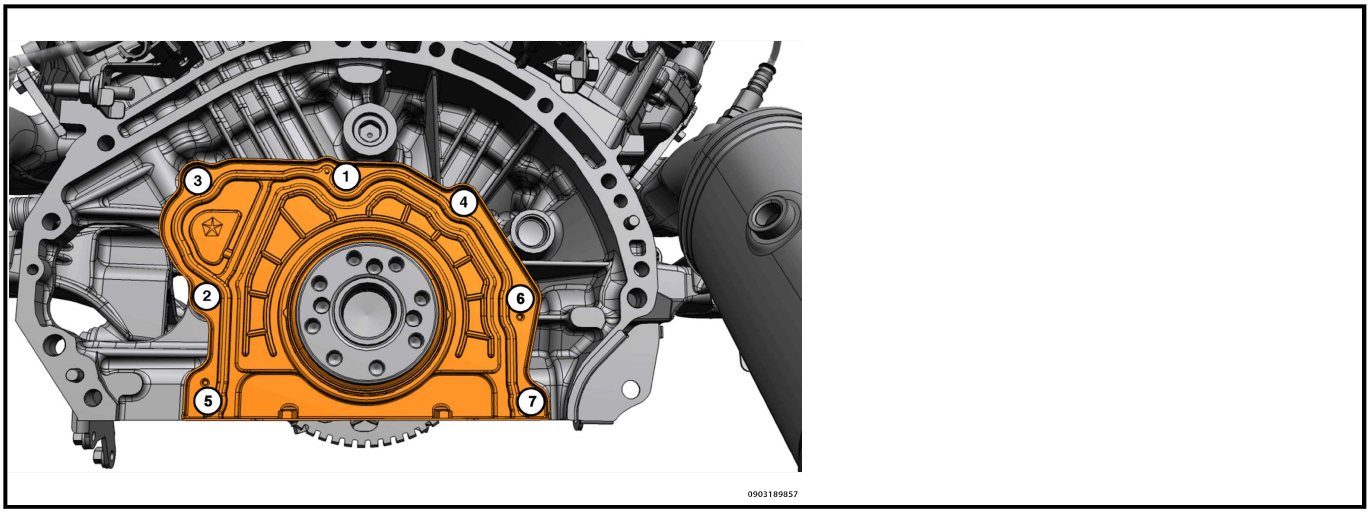


Fig. 21: Crankshaft Outer Main Bearing Cap and Windage Tray Bolts Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC



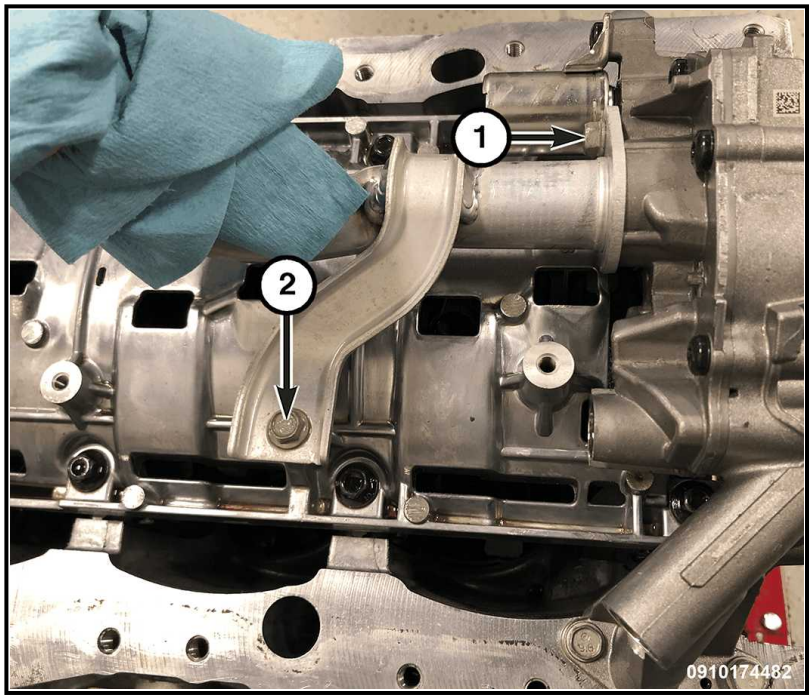
PICK-UP, OIL PUMP

REMOVAL AND INSTALLATION

OIL PUMP PICK-UP TUBE

REMOVAL

1. Remove the oil pan. Refer to **PAN, OIL, REMOVAL AND INSTALLATION**.



1 - Oil Pump Pick-up Tube Bolt
2 - Oil Pump Pick-up Tube to Windage Tray Bolt

2. Remove the oil pick-up tube to oil pump bolt.
3. Remove the oil pick-up tube to windage tray bolt and remove the oil pick-up tube.
4. Remove and discard the O-ring seal from the oil pick-up tube.

INSTALLATION

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

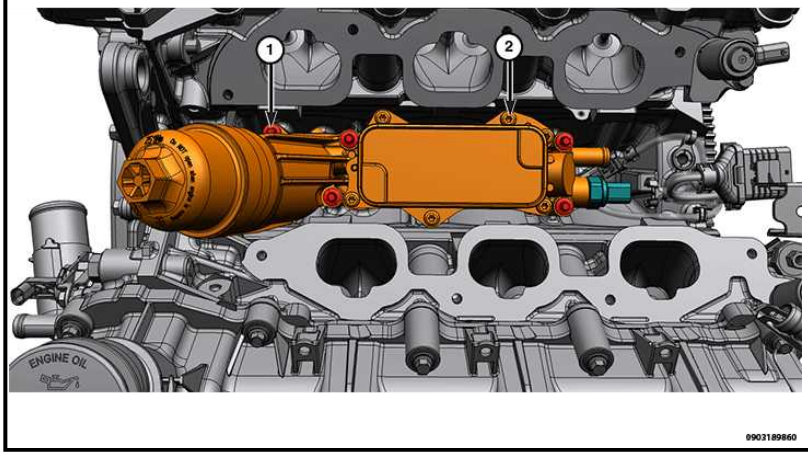
Follow the removal procedure in reverse for general reassembly of the components on the vehicle. The steps listed below are calling out specific procedures that should be followed during installation.

- Lightly lubricate the **NEW** O-ring seal with engine oil and install on the oil pick-up tube.

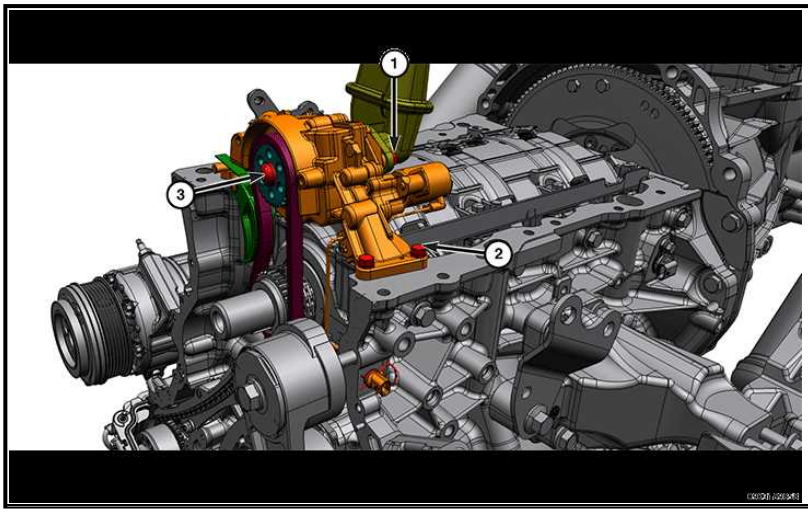
TORQUE SPECIFICATIONS

LUBRICATION

DESCRIPTION	SPECIFICATION	COMMENTS
Upper Oil Pan to Engine Block M8 Bolts	**23 N.m (17 Ft. Lbs.)**	-
Lower Oil Pan to Upper Oil Pan - M6 Bolts	**9 N.m (80 In. Lbs.)**	-
Lower Oil Pan to Upper Oil Nuts	**10 N.m (89 In. Lbs.)**	-
Upper Oil Pan to Rear Seal Retainer M6 Bolts	**10 N.m (89 In. Lbs.)**	-
Oil Pan Drain Plug	**27 N.m (20 Ft. Lbs.)**	-
Oil Level Indicator to Cylinder Head Bolt	**18 N.m (13 Ft. Lbs.)**	-

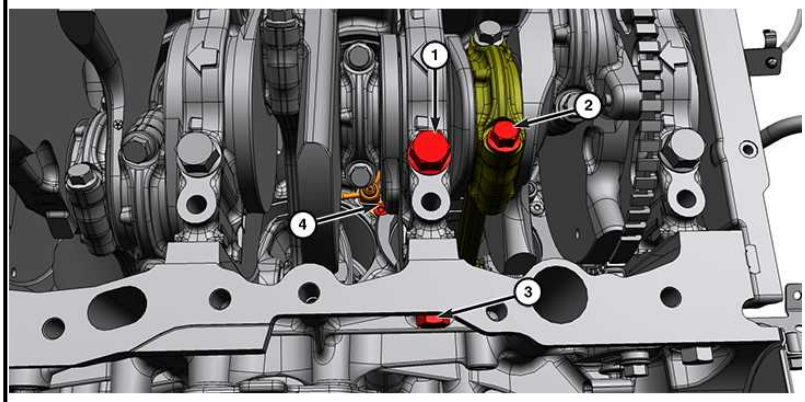


CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Oil Filter Housing/Oil Cooler to Engine Block M6 Bolts	**12 N.m (9 Ft. Lbs.)**	-
2	Oil Cooler to Oil Filter Housing Screws	**12 N.m (9 Ft. Lbs.)**	-
-	Oil Filter Housing Cap	**25 N.m (18 Ft. Lbs.)**	-



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Oil Pump Pick Up Tube to Oil Pump M6 Bolt	**8 N.m (71 In. Lbs.)**	-
-	Oil Pump Pick Up Tube Bracket to Windage Tray Bolt	**8 N.m (80 In. Lbs.)**	-
2	Oil Pump to Engine Block M6 Bolts	**12 N.m (9 Ft. Lbs.)**	-
3	Oil Pump Sprocket M8 Bolt	**26 N.m (18 Ft. Lbs.)**	-

ENGINE BLOCK



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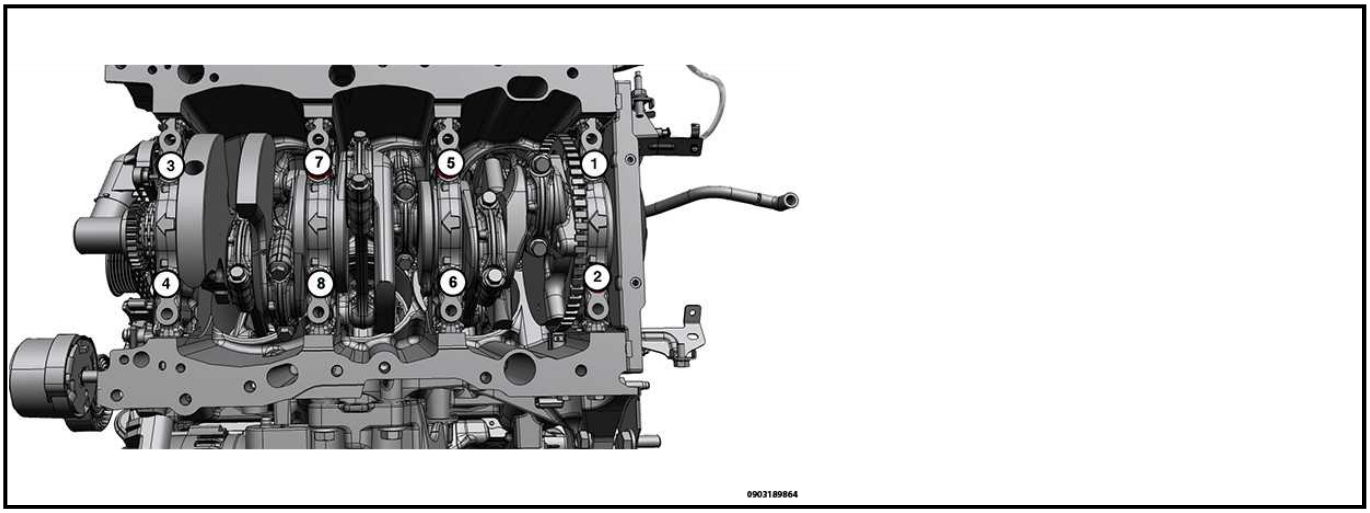
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Crankshaft Inner Main Bearing Cap M11 Bolts	**Torque Procedure:** 1. **20 N.m (15 Ft. Lbs.)** 2. **Turn additional 90B°**	Tightening Sequence
2	Connecting Rod Cap Bolts	**Torque Procedure:** 1. **20 N.m (15 Ft. Lbs.)** 2. **Turn additional 90B°**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
3	Crankshaft Side Main Bearing Cap (Tie Bolt) M8 Bolts	**30 N.m (22 Ft. Lbs.)**	Tightening Sequence
4	Piston Oil Cooler Jet to Engine Block Bolt	**6 N.m (63 In. Lbs.)**	-
-	Crankshaft Outer Main Bearing Cap and Windage Tray M8 Bolts	**Torque Procedure:** 1. **21 N.m (15 Ft. Lbs.)** 2. **Turn additional 90B°**	Tightening Sequence
-	Crankshaft Target Wheel to Counterweight Bolts	**11 N.m (8 Ft. Lbs.)**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
-	Engine Block Ground Strap Bolt	**23 N.m (17 Ft. Lbs.)**	-
-	Engine Block Ground Strap to Frame Nut	**20 N.m (15 Ft. Lbs.)**	-
-	Engine Lift Bracket	**21 N.m (15 Ft. Lbs.)**	-
-	Rear Crankshaft Oil Seal Retainer Bolts	**12 N.m (9 Ft. Lbs.)**	Tightening Sequence



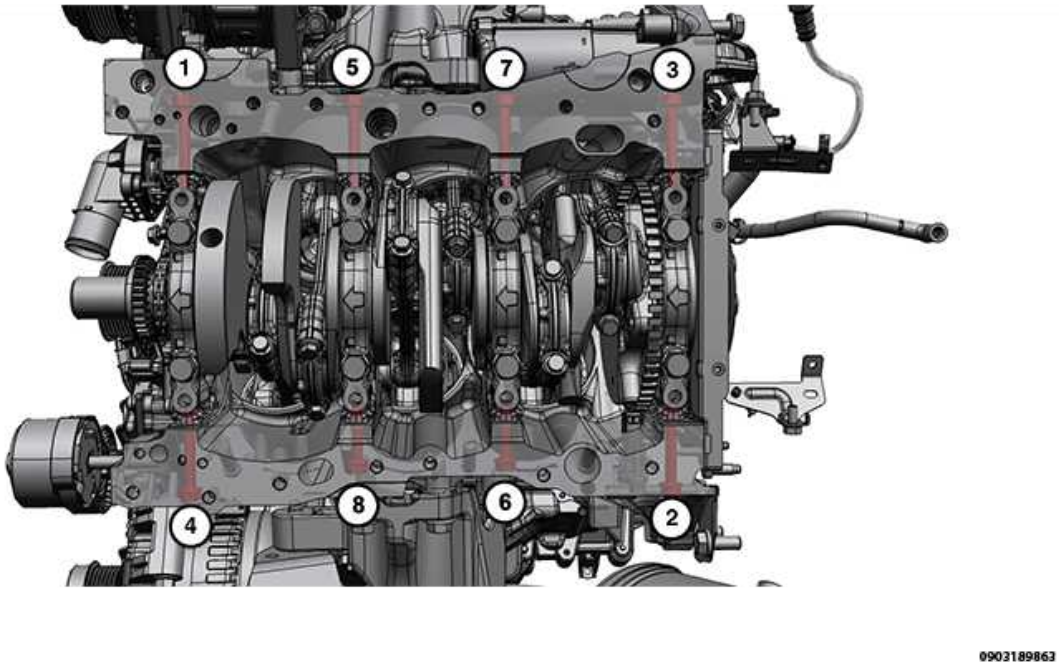
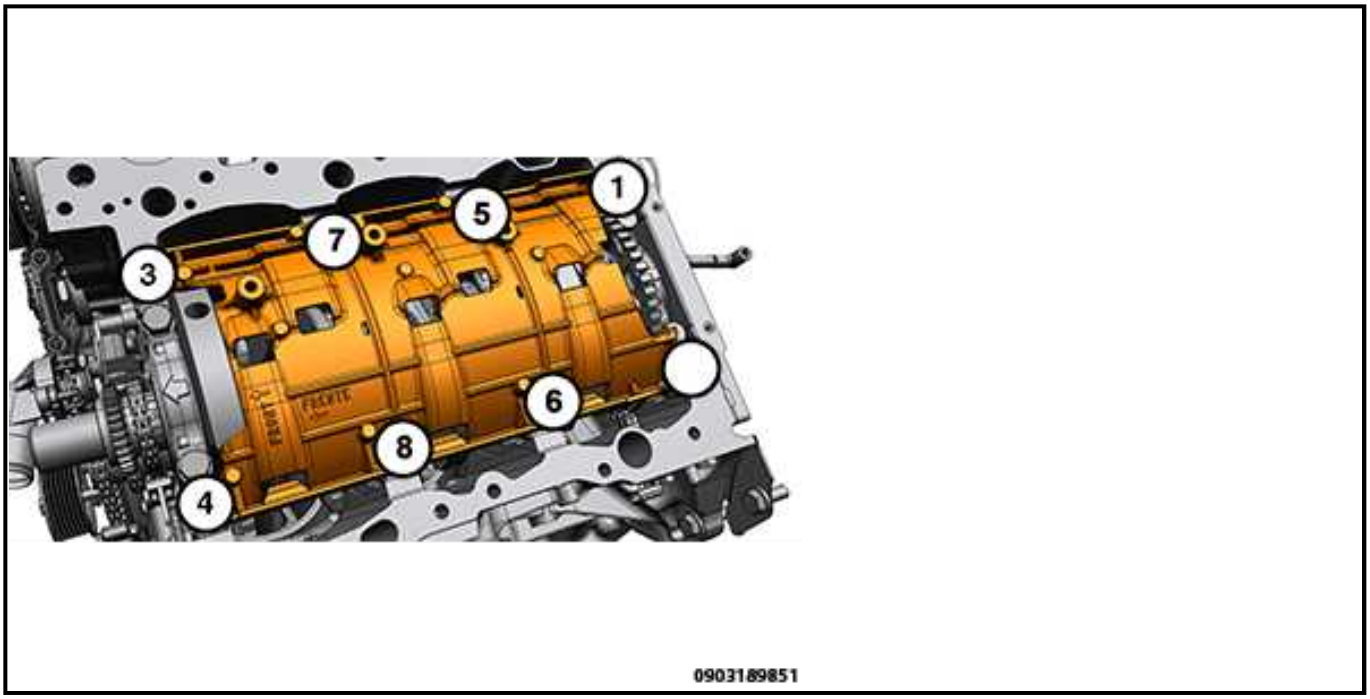


Fig. 22: Crankshaft Side Main Bearing Cap Bolts Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC



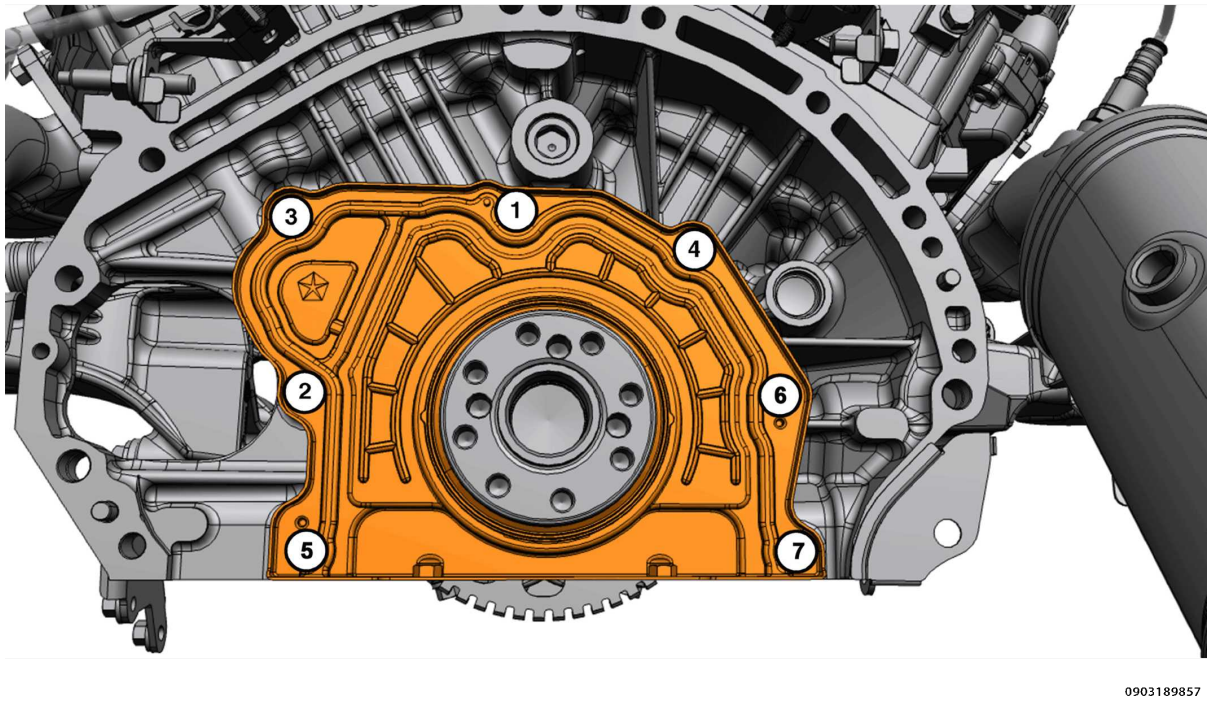


Fig. 23: Rear Crankshaft Oil Seal Retainer Bolts
Courtesy of CHRYSLER GROUP, LLC

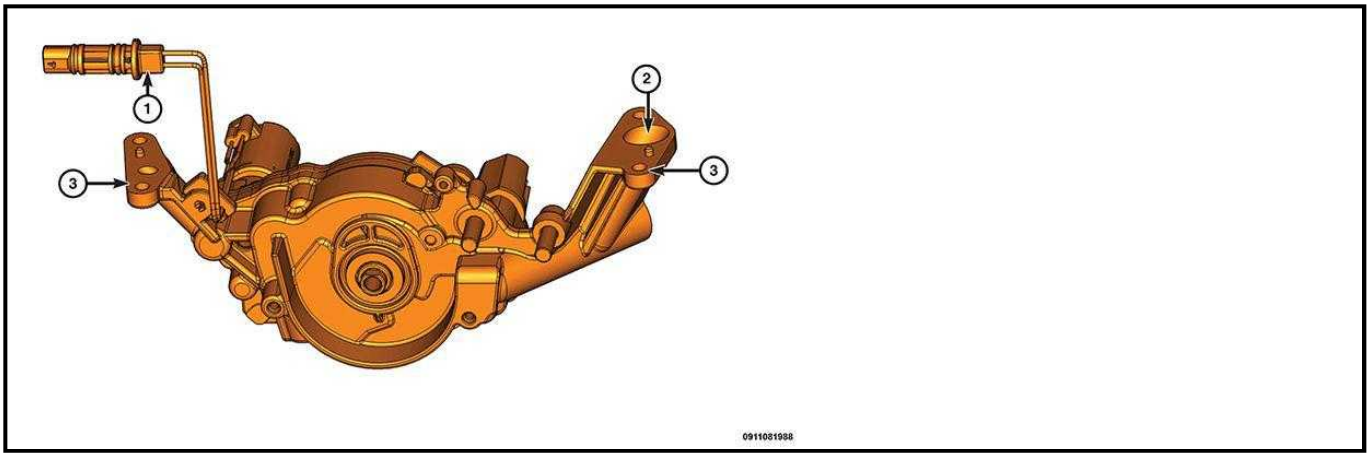
PUMP, ENGINE OIL

DESCRIPTION AND OPERATION

DESCRIPTION AND OPERATION

OIL PUMP

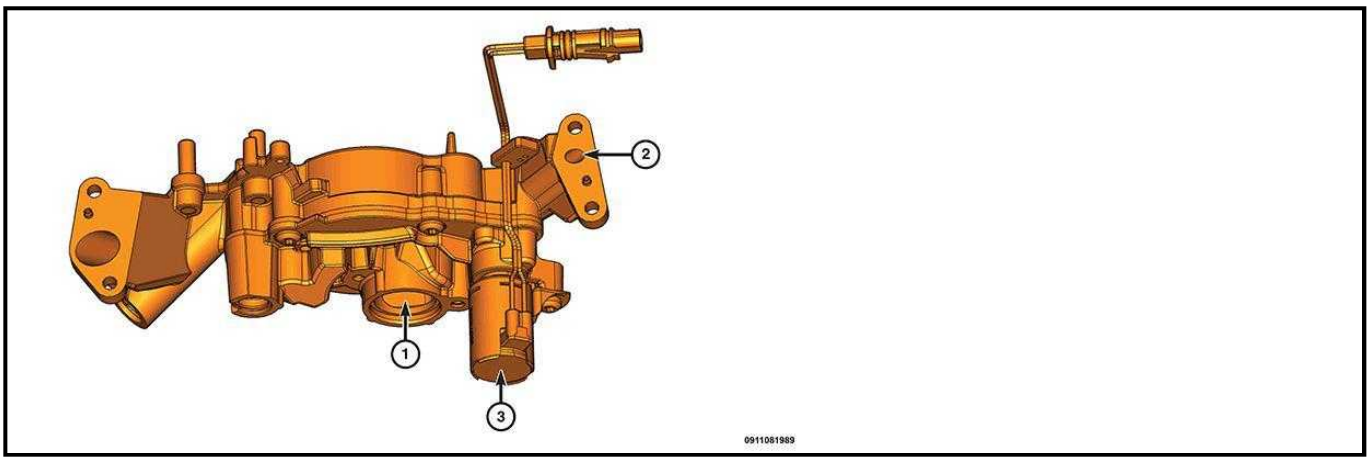
DESCRIPTION



The vane type engine oil pump (2) is mounted to the underside of the cylinder block (3) and is driven by the oil pump chain off the crankshaft at a 1.15:1 drive ratio:

- This pump location improves efficiency compared to an on-crankshaft location
- The pump is driven with a silent chain which is tensioned using a spring loaded tensioner
- The pump is not timed to the engine
- An internal mechanical ball and spring type relief valve prevents excess pressure in the engine by dumping oil into the sump and provides emergency protection at conditions such as a cold start with high engine speed
- The pump has a moving slide mechanism for variable displacement capability and an on-off solenoid for two-stage pressure regulation
- The pump and the solenoid are not to be disassembled
- Both components are non-serviceable items and are to be replaced as a complete assembly

OPERATION



Oil pump operation as follows:

- The engine oil pump (2) features seven vanes and a moving element (1) that continuously adjusts to maintain a regulated oil pressure supply by varying the displacement of the pump
- The pump has two regulated pressure stages of operation controlled by an on/off solenoid (3)
- Low pressure mode regulation (solenoid on) is approximately 200 kPa (29 psi) and high pressure mode regulation (solenoid off) is approximately 450 kPa (65 psi)
- The Powertrain Control Module (PCM) switches the pump between stages based on engine operating conditions, oil and coolant temperatures, speed and load. Under most typical conditions, the pump will run in low mode from idle up to around 3000 RPM, and switch from low to high mode between 3000 and 4000 RPM
- The maximum oil pressure in the engine is limited to 1000 kPa (145 psi) by the relief valve.

- Pressure in the main oil gallery of the engine can be monitored with diagnostic equipment through the oil pressure sensor mounted on the rear of the oil filter module
- The minimum pressure for the engine is 41 kPa (6 psi) at any operating condition
- Anything under this pressure could result in damage to critical moving parts

In high pressure mode regulation (solenoid off) main gallery oil pressure is applied to the moving element. The main gallery oil pressure works against spring pressure to move the element to a more concentric location about the pump driveshaft thus reducing displacement and pump output.

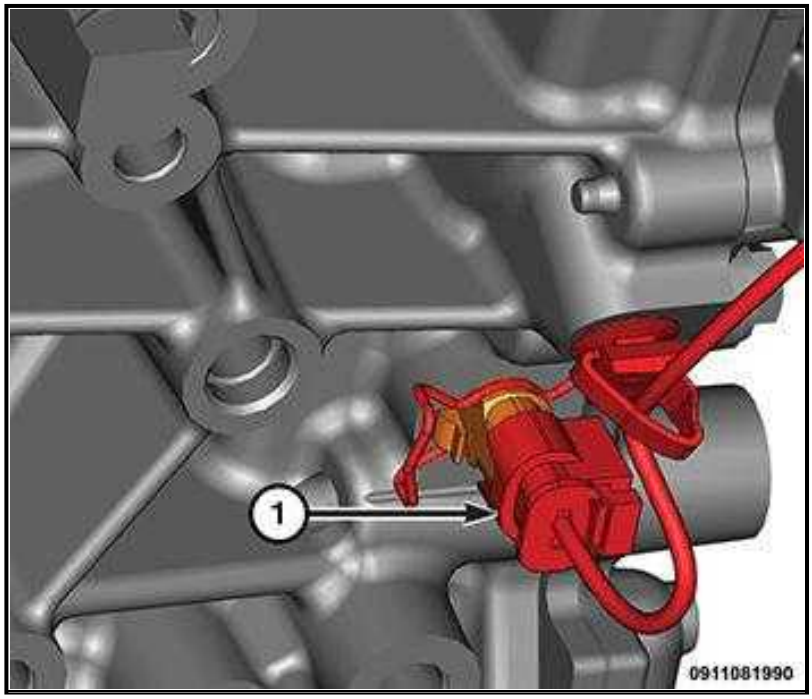
In low pressure mode regulation (solenoid on) the energized solenoid changes internal spring position to main gallery oil pressure increasing the force on the spring to further reduce displacement and output pressure.

REMOVAL AND INSTALLATION

ENGINE OIL PUMP

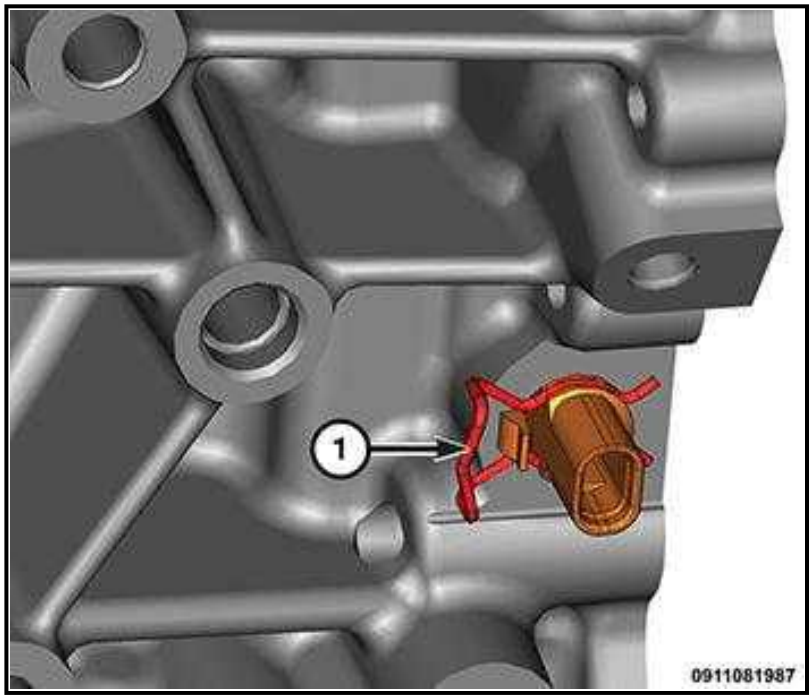
REMOVAL

1. Remove the oil pump pick-up. Refer to **PICK-UP, OIL PUMP, REMOVAL AND INSTALLATION**.



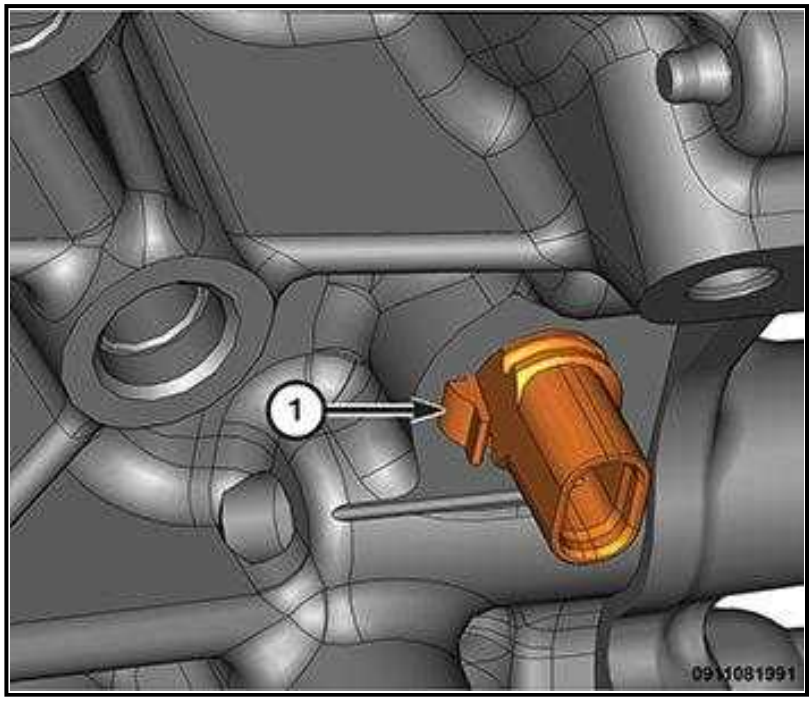
1 - Oil Pump Solenoid Harness Connector

2. Disconnect the engine wire harness from the oil pump solenoid wire harness connector.



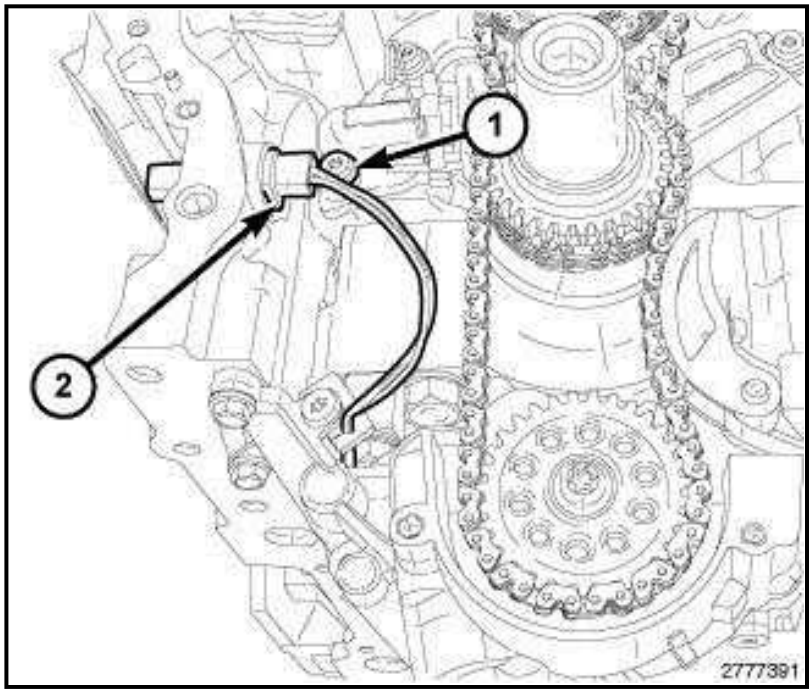
1 - Oil Pump Solenoid Retainer Clip

3. Remove the oil pump solenoid retainer clip.



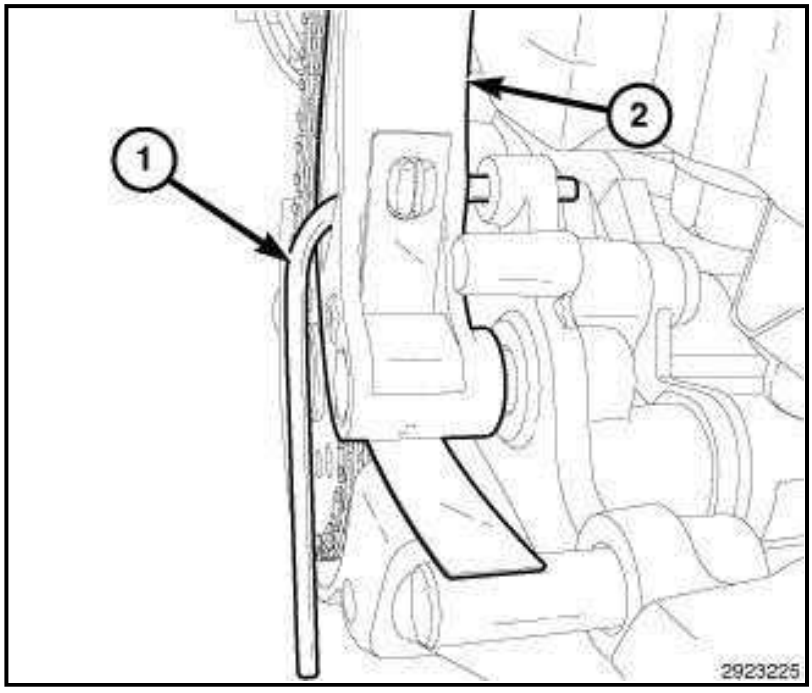
1 - Wire Harness Connector Lock Tab

4. Depress the wire harness connector retention lock tab to disengage the oil pump solenoid wire harness connector from the engine block.



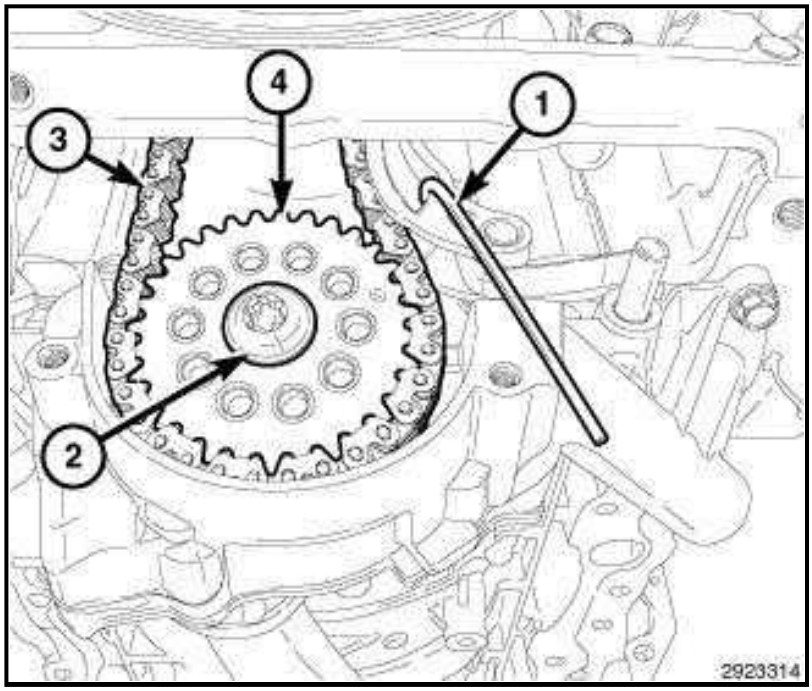
1 - Primary Chain Tensioner Mounting Bolt
2 - Oil Pump Solenoid Harness Connector

5. Push the oil pump solenoid wire harness connector (2) into the engine block, rotate the connector slightly clockwise to push it past the primary chain tensioner mounting bolt and into the engine.



1 - Oil Pump Chain Tensioner
2 - Retaining Pin

6. Push back the oil pump chain tensioner and insert a suitable retaining pin such as a 3 mm Allen wrench.



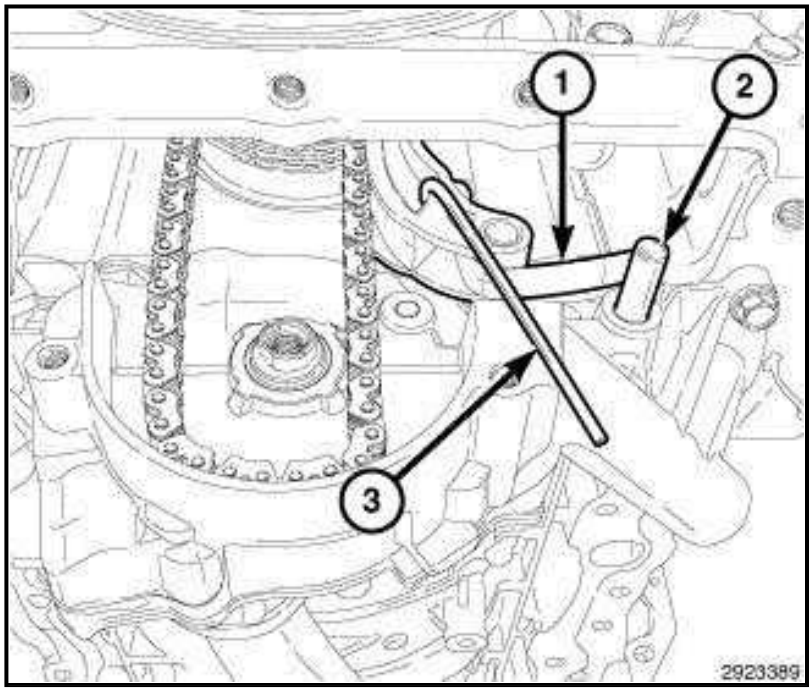
1 - Retaining Pin
2 - Oil Pump Sprocket Bolt
3 - Oil Pump Chain
4 - Oil Pump Sprocket

CAUTION: **Always reinstall timing chains so that they maintain the same direction of rotation. Inverting a previously run chain on a previously run sprocket will result in excessive wear to both the chain and sprocket.**

7. Mark the direction of rotation on the oil pump chain and sprocket using a paint pen or equivalent to aid in reassembly.

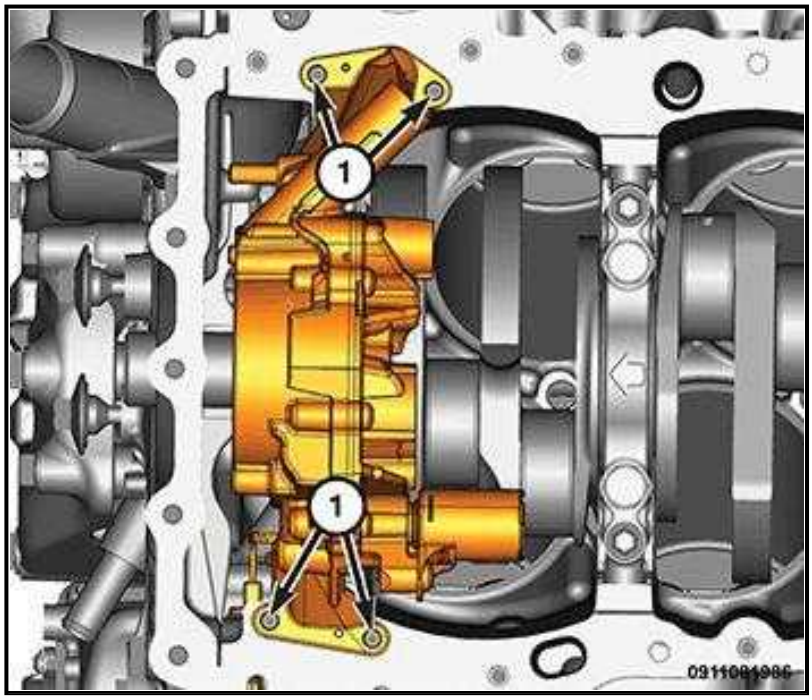
NOTE: **There are no timing marks on the oil pump sprocket or chain. Timing of the oil pump is not required.**

8. Remove the oil pump sprocket T45 retaining bolt and remove the oil pump sprocket.



1 - Oil Pump Chain Tensioner Spring
2 - Dowel Pin
3 - Retaining Pin

9. Remove the retaining pin and disengage the oil pump chain tensioner spring from the dowel pin.
10. Remove the oil pump chain tensioner from the oil pump.



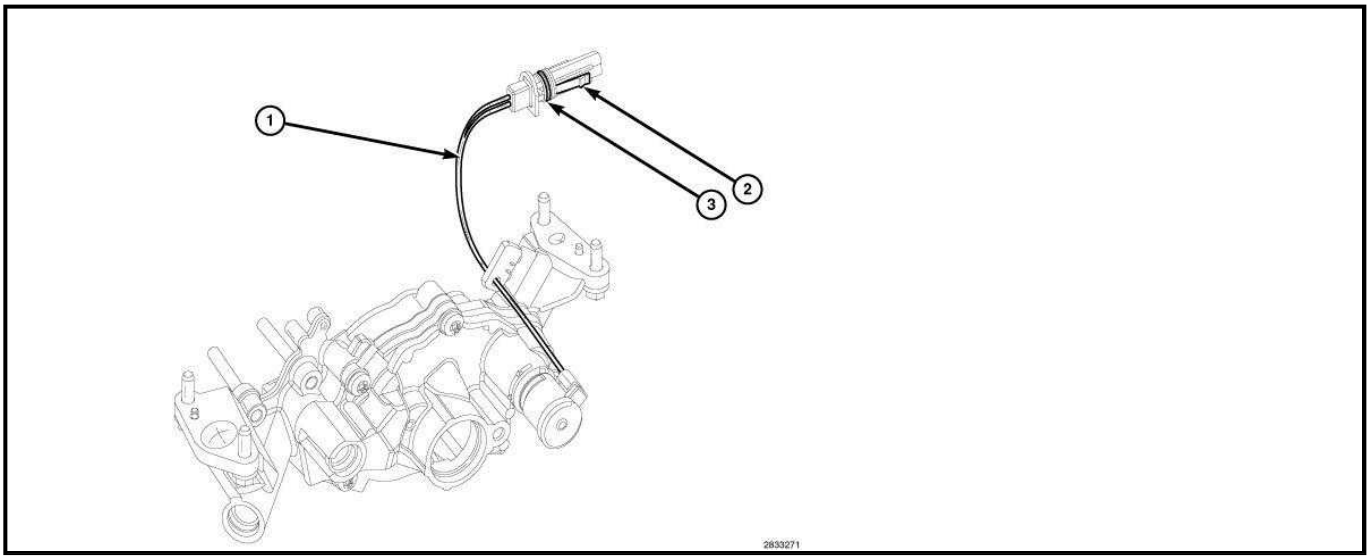
1 - Oil Pump Bolts

11. Remove the oil pump bolts and remove the oil pump.

INSPECTION:

NOTE: **The Oil pump is released as an assembly. The assembly includes both the pump and the solenoid. There are no serviceable sub-assembly components. In the event the oil pump or solenoid are not functioning or out of specification they must be replaced as an assembly.**

1. Inspect the solenoid wires for cuts or chafing.
2. Inspect the condition of the connector O-ring.



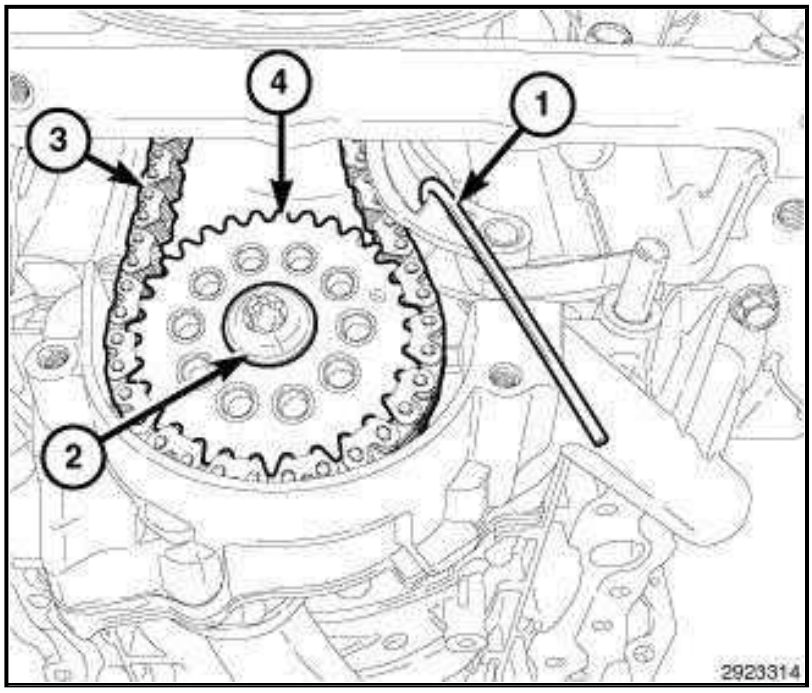
1 - Oil Pump Solenoid Wiring
2 - Harness Connector
3 - O-Ring

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. Perform the following steps to properly install the oil pump chain and tensioner.

- Install the oil pump chain tensioner on the oil pump.
- Position the oil pump chain tensioner spring above the dowel pin.
- Push back the oil pump chain tensioner and insert a suitable retaining pin such as a 3 mm Allen wrench.

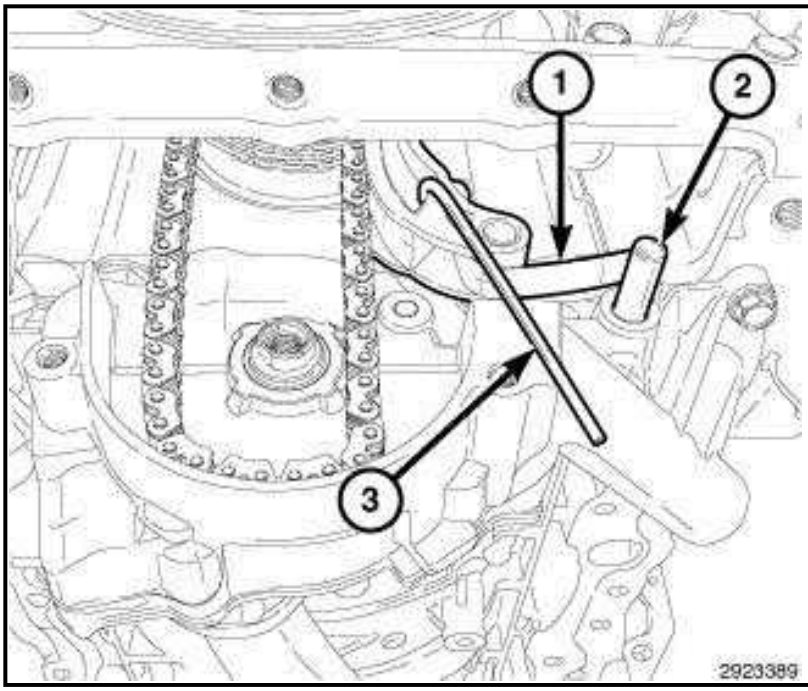


1 - Retaining Pin
2 - Oil Pump Sprocket Bolt
3 - Oil Pump Chain
4 - Oil Pump Sprocket

- Place the oil pump sprocket into the oil pump chain. Align the oil pump sprocket with the oil pump shaft and install the sprocket. Install the T45 retaining bolt and tighten the bolt to the proper torque specification.

NOTE: **There are no timing marks on the oil pump gear or chain. Timing of the oil pump is not required.**

- Remove the retaining pin. Verify that the oil pump chain is centered on the tensioner and crankshaft sprocket.
- Rotate the crankshaft clockwise one complete revolution to verify proper oil pump chain installation.

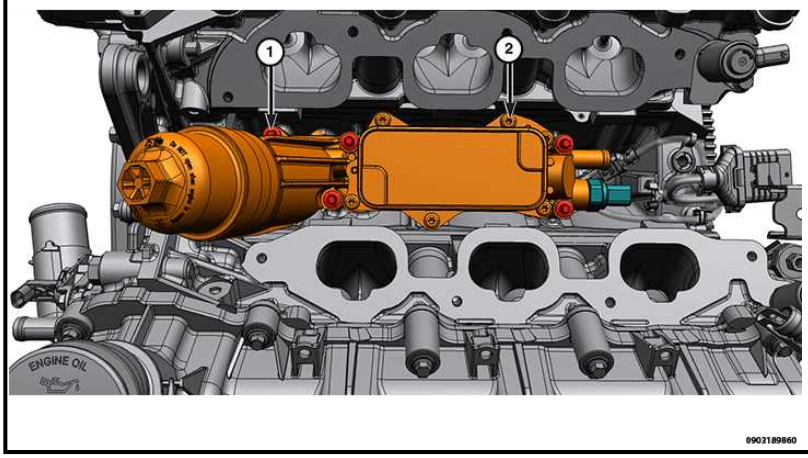


1 - Oil Pump Chain Tensioner Spring
2 - Dowel Pin
3 - Retaining Pin

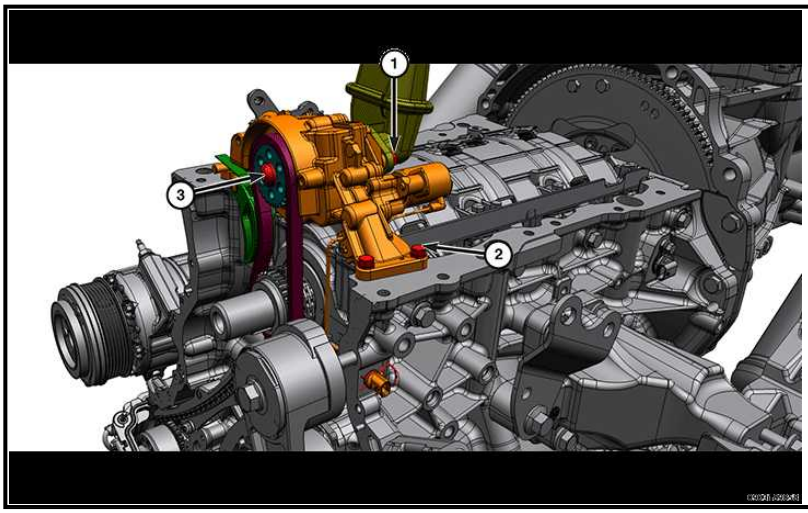
TORQUE SPECIFICATIONS

LUBRICATION

DESCRIPTION	SPECIFICATION	COMMENTS
Upper Oil Pan to Engine Block M8 Bolts	**23 N.m (17 Ft. Lbs.)**	-
Lower Oil Pan to Upper Oil Pan - M6 Bolts	**9 N.m (80 In. Lbs.)**	-
Lower Oil Pan to Upper Oil Nuts	**10 N.m (89 In. Lbs.)**	-
Upper Oil Pan to Rear Seal Retainer M6 Bolts	**10 N.m (89 In. Lbs.)**	-
Oil Pan Drain Plug	**27 N.m (20 Ft. Lbs.)**	-
Oil Level Indicator to Cylinder Head Bolt	**18 N.m (13 Ft. Lbs.)**	-

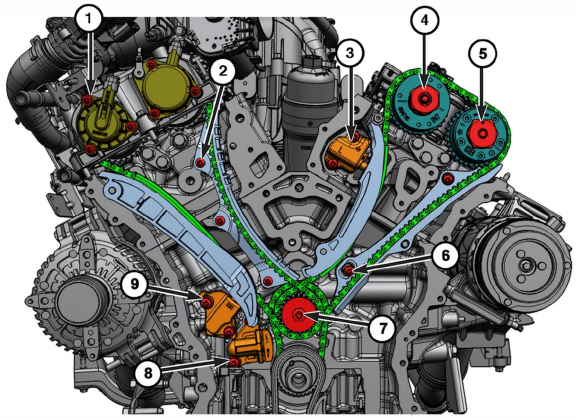


CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Oil Filter Housing/Oil Cooler to Engine Block M6 Bolts	**12 N.m (9 Ft. Lbs.)**	-
2	Oil Cooler to Oil Filter Housing Screws	**12 N.m (9 Ft. Lbs.)**	-
-	Oil Filter Housing Cap	**25 N.m (18 Ft. Lbs.)**	-



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Oil Pump Pick Up Tube to Oil Pump M6 Bolt	**8 N.m (71 In. Lbs.)**	-
-	Oil Pump Pick Up Tube Bracket to Windage Tray Bolt	**8 N.m (80 In. Lbs.)**	-
2	Oil Pump to Engine Block M6 Bolts	**12 N.m (9 Ft. Lbs.)**	-
3	Oil Pump Sprocket M8 Bolt	**26 N.m (18 Ft. Lbs.)**	-

VALVE TIMING



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CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-

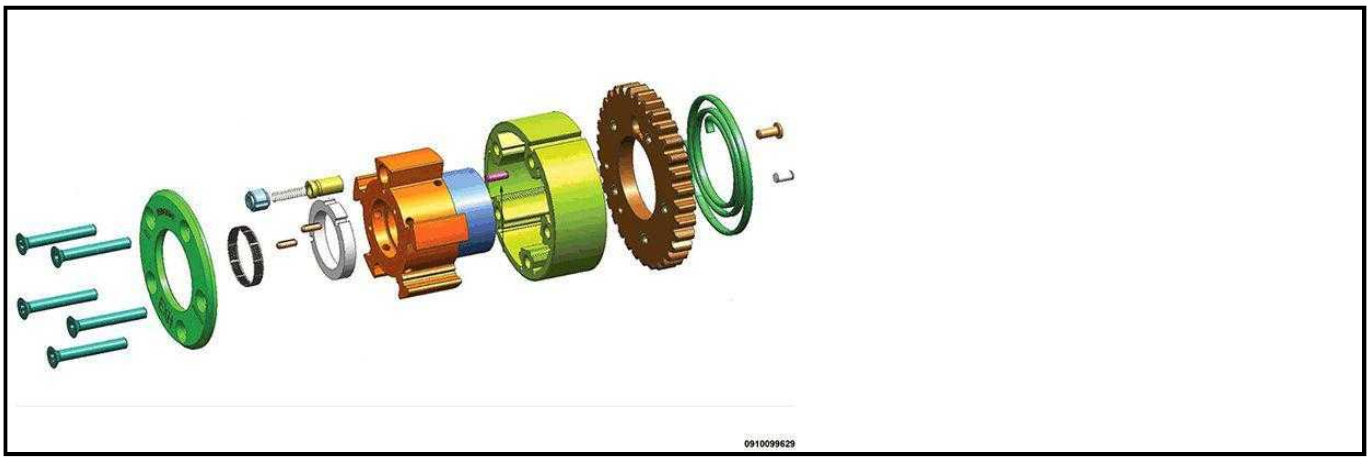
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

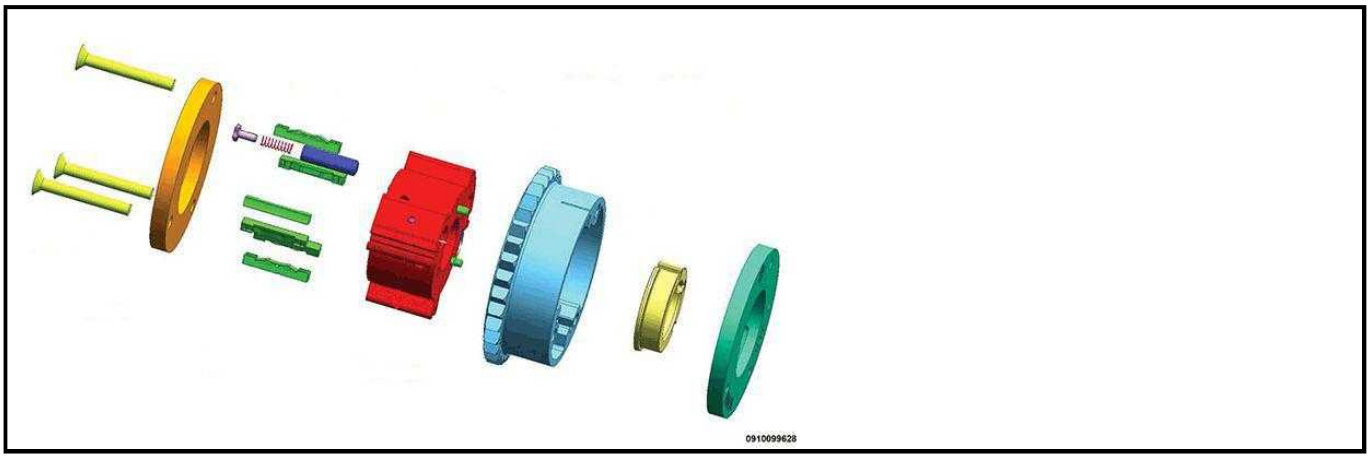
VALVE TIMING

DESCRIPTION AND OPERATION

CAMSHAFT PHASERS

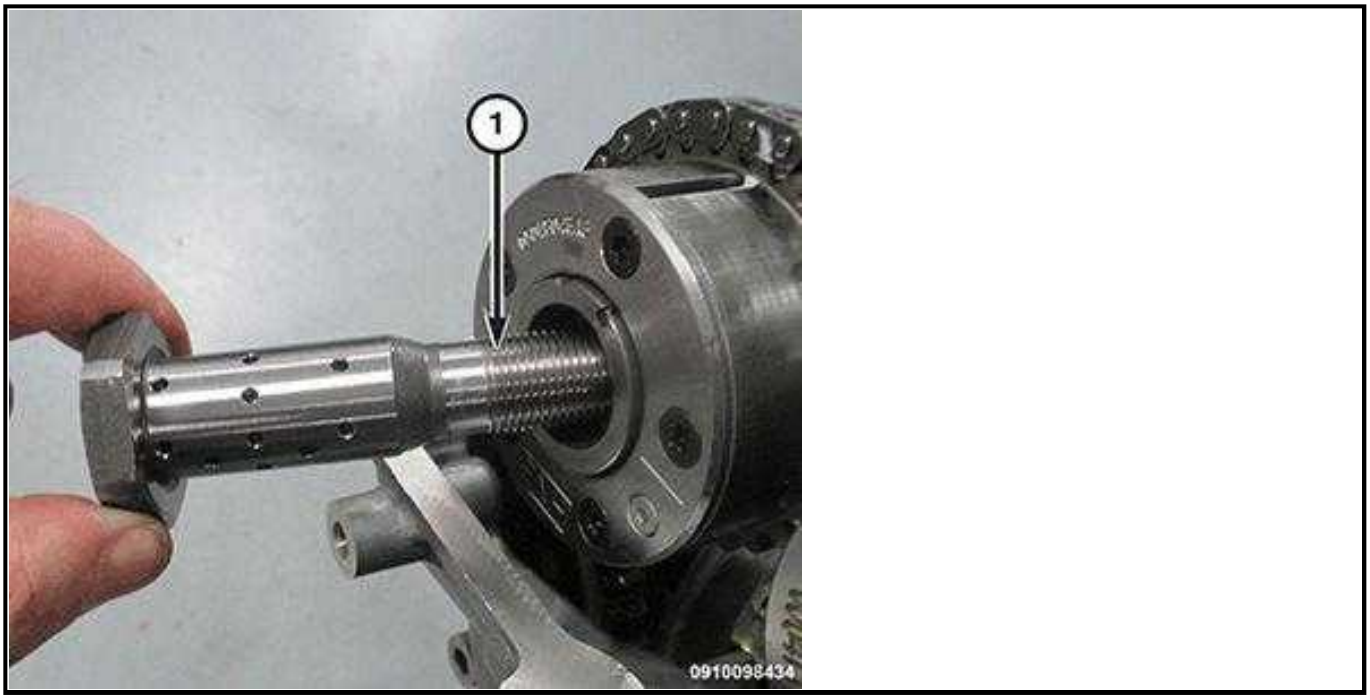
DESCRIPTION:





The engine is equipped with Variable Valve Timing (VVT). This system adjusts the timing of all four camshafts independently using solenoids and oil control valves to direct oil pressure into the camshaft phaser assemblies. The four phasers are located on the front of the camshafts, behind the VVT solenoids, inside of the engine timing cover.

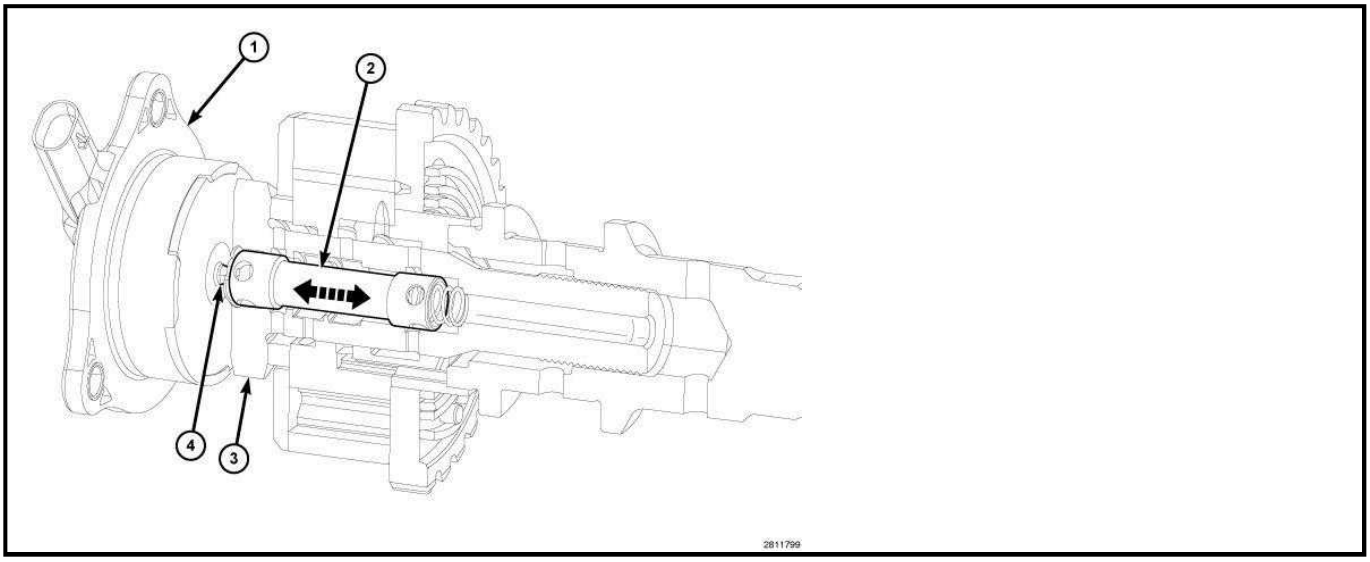
- The camshaft phaser assembly advances and/or retards camshaft timing to improve engine performance, mid-range torque, idle quality, fuel economy, and reduce emissions.
- The exhaust phasers are identified with EXH and the intake phasers are identified with INT.
- The exhaust phaser has a clockspring, the intake phaser does not.
- The camshaft sprockets are integrated with the camshaft phaser and are serviced as an assembly. Do not attempt to disassemble the phasers, they are not serviceable.
- Phasers are interchangeable between the right and left cylinder heads, but should be installed in the same location as removed.



1 - Oil Control Valve (OCV)

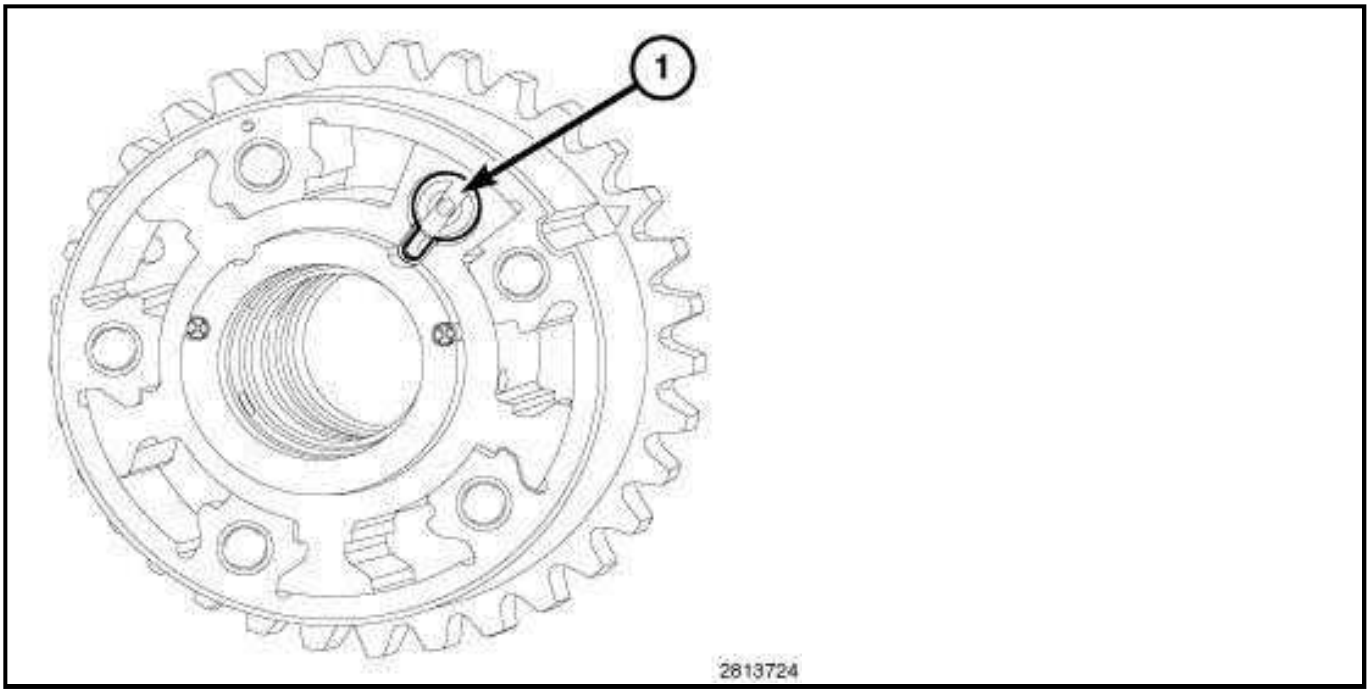
The engine has an Oil Control Valve (OCV) for each phaser. The OCV also acts as a bolt for mounting the Phaser to the camshaft. The OCV spool valves are spring loaded and should move freely within the OCV body.

OPERATION:



1 - Variable Valve Timing (VVT) Solenoid
2 - Internal Spool Valve
3 - Oil Control Valve (OCV)
4 - Solenoid Pintle

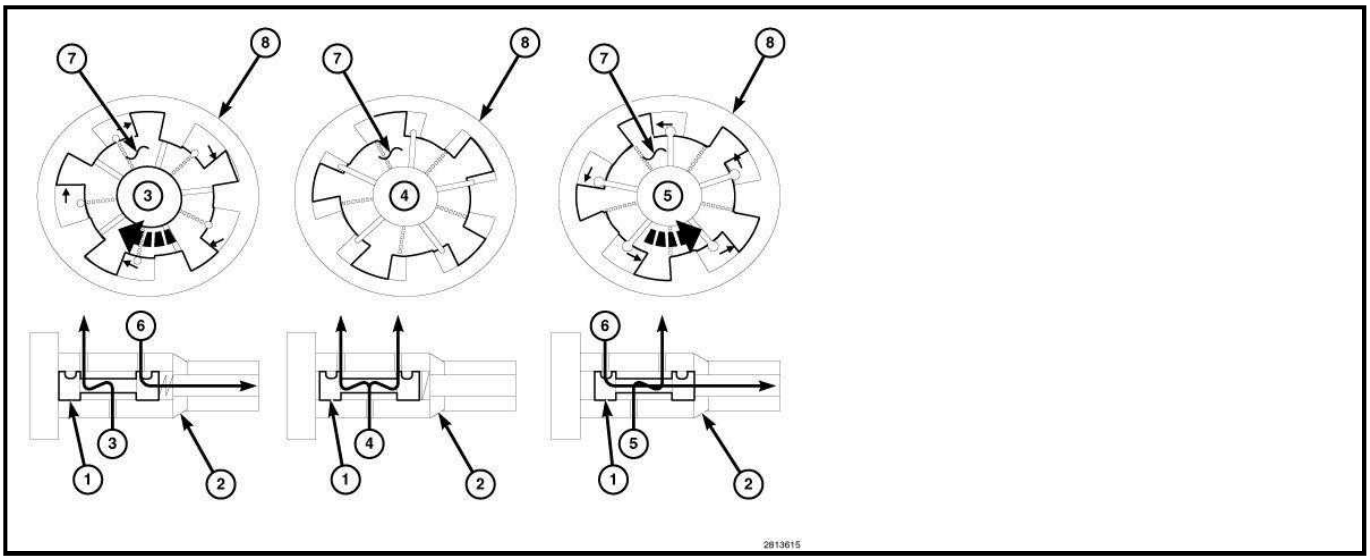
Each phaser position is adjusted using regulated oil pressure through the Oil Control Valve (OCV). To begin phaser movement, a voltage signal is applied to the Variable Valve Timing (VVT) solenoid to extend or retract the solenoid pintle. The pintle pushes against an internal spool valve within the OCV moving the valve forward and backward to direct oil flow.



1 - Phaser Lock Pin

At engine startup, system oil pressure overcomes spring pressure and unlocks the phaser lock-pin in preparation for phasing. The phasers remain in this position until a Powertrain Control Module (PCM) signal is given to pulse-width modulate the VVT solenoid. At engine shutdown, as oil pressure is reduced, both Phasers return to their lock-pin position.

Because the exhaust Phaser needs to travel to a position above and beyond the standard camshaft clockwise rotation, the assistance of a clock spring is required. The intake Phaser on the other hand, simply relies on the torsional resistance from the valvetrain to push it back towards lock-pin position.



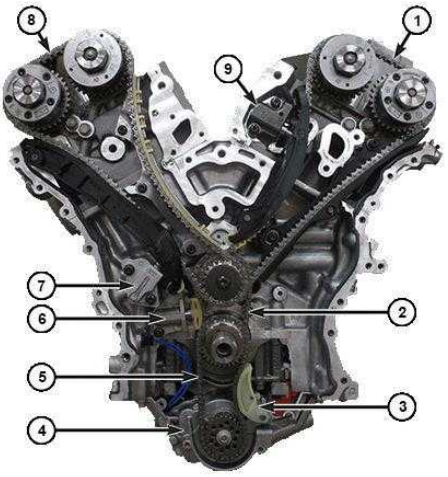
1 - Spool Valve Variable Valve Timing (VVT) Solenoid	5 - Timing Retard Position
2 - Oil Control Valve (OCV)	6 - Oil Flow to Sump
3 - Timing Advance Position	7 - Sprocket
4 - Timing Hold Position	8 - Oil Control Valve (OCV)

The position of the spool valve inside the OCV determines which ports and chambers inside the phaser are being fed, either to advance, hold or retard the timing of the phaser sprocket relative to the camshaft. The spool valve also returns oil from the chambers to the sump. The Camshaft Position (CMP) sensor monitors the position of the camshaft with respect to the crankshaft and provides feedback to the PCM. As oil pressure

pushes against the vanes of the phaser rotor, the rotor begins to move. Since this rotor is physically attached to the camshaft, rotor rotation causes the camshaft position to rotate relative to the standard sprocket position.

VALVE TIMING DRIVE

DESCRIPTION



1 - Left Secondary Camshaft Chain	6 - Primary Timing Chain Tensioner
2 - Primary Timing Chain	7 - Right Timing Chain Tensioner
3 - Oil Pump Chain Spring Loaded Tensioner	8 - Right Secondary Camshaft Chain
4 - Oil Pump	9 - Left Timing Chain Tensioner
5 - Oil Pump Chain	B

The timing drive uses four silent chains. The silent chain link design improves sprocket engagement and reduces Noise, Vibration and Harshness (NVH). One chain drives the oil pump and three chains drive the camshafts in a two stage design. The left secondary camshaft chain uses an oil pressure controlled chain tensioner with a ratcheting device. The right secondary camshaft chain uses an oil pressure controlled tensioner without a ratchet. The primary chain also uses an oil pressure controlled tensioner without a ratchet. A spring loaded tensioner takes up the slack in the oil pump chain. The chain guides and tensioner arms are made of glass filled nylon with nylon wear faces.

OPERATION:

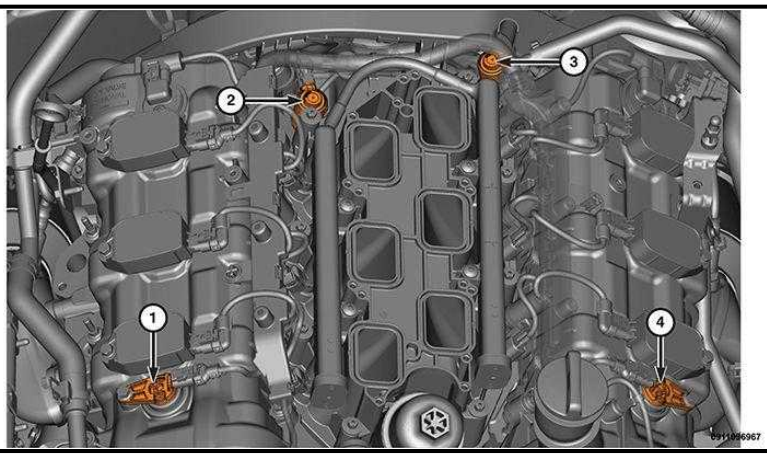
The primary timing chain is a silent type. The primary chain drives the 28 tooth idler sprocket directly from a 21 tooth crankshaft sprocket. This results in a 75% speed reduction to the idler sprocket. The idler sprocket assembly connects the primary chain drive and the secondary chain drive. The idler sprocket assembly consists of two integral 22 tooth sprockets a 28 tooth sprocket. The idler sprocket assembly spins on a stationary idler shaft. The idler shaft is a light press-fit into the cylinder block. A large washer on the idler shaft bolt and the rear flange of the idler shaft are used to control sprocket thrust movement. Pressurized oil is routed through the center of the idler shaft to provide lubrication for the bushings used in the idler sprocket assembly. Primary chain motion is controlled by a hydraulic oil damped tensioner and a fixed guide. The tensioner and the guide both use nylon plastic wear faces for low friction and long wear. The primary chain receives oil splash lubrication.

There are two identical secondary drive chains, both are silent type, one to drive the camshafts in each Double OverHead Camshaft (DOHC) cylinder head. The secondary chains drive the 33 tooth camshaft sprockets directly from the 22 tooth idler sprockets. This speed reduction combined with the crankshaft to idler sprocket speed reduction produces the required 2:1 camshaft drive ratio. A fixed chain guide and a hydraulic oil damped tensioner are used to maintain tension in each secondary chain system. The left hydraulic secondary chain tensioner is fed from the main oil gallery through the cylinder head. The right hydraulic secondary chain tensioner is fed from the number one main bearing journal. Each tensioner incorporates a controlled leak path through a device known as a vent disc located in the nose of the piston to manage chain loads. Only the left tensioner has a mechanical ratchet system that limits chain slack if the tensioner piston bleeds down after

engine shut down. The tensioner arms and guides also utilize nylon wear faces for low friction and long wear. The two secondary timing chains are lubricated by holes in the oil controlled tensioners that spray oil through an opening in the tensioner arms. The holes are protected from clogging by a fine mesh screen which is located on the back of the hydraulic tensioners.

VVL SOLENOID

There are four Variable Valve Lift (VVL) solenoids that control the operation of the Intake rocker arms for all six cylinders. See the figure and table below for the VVL Solenoid locations and cylinder control:



VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED
VVL SOLENOID 1/1	BANK 1 FRONT SOLENOID (1)	CYLINDER 1 INTAKE VALVES
VVL SOLENOID 1/2	BANK 1 REAR SOLENOID (2)	CYLINDERS 3 AND 5 INTAKE VALVES
VVL SOLENOID 2/1	BANK 2 FRONT SOLENOID (4)	CYLINDER 2 INTAKE VALVES
VVL SOLENOID 2/2	BANK 2 REAR SOLENOID (3)	CYLINDERS 4 AND 6 INTAKE VALVES

The Variable Valve Lift (VVL) system is designed to vary the lift and duration of the intake valves, to maximize efficiency and engine torque, depending on engine operation. The VVL system consists of 2 step intake rocker arms that are capable of operating in High Lift or Low Lift mode. The four VVL solenoids control the rocker arm modes using engine oil pressure.

- **Low Lift Mode:** The Powertrain Control Module (PCM) commands the VVL Solenoids on, which supplies 12.0 volts to the VVL solenoids and allows engine oil pressure to pass through the solenoids to the rocker arms. This in turn pushes the lock pins back which allows the center of the rocker arms to move down freely, allowing the rocker arms to operate in Low Lift Mode. It takes approximately 20.0 psi of engine oil pressure at the rocker arms to move the lock pins.
- **High Lift Mode:** The rocker arms default to High Lift mode when no oil pressure is present. This is accomplished with a spring loaded lock pin that keeps the center of the rocker arms in the High Lift position. The PCM commands the VVL Solenoids off when High Lift Mode is desired.

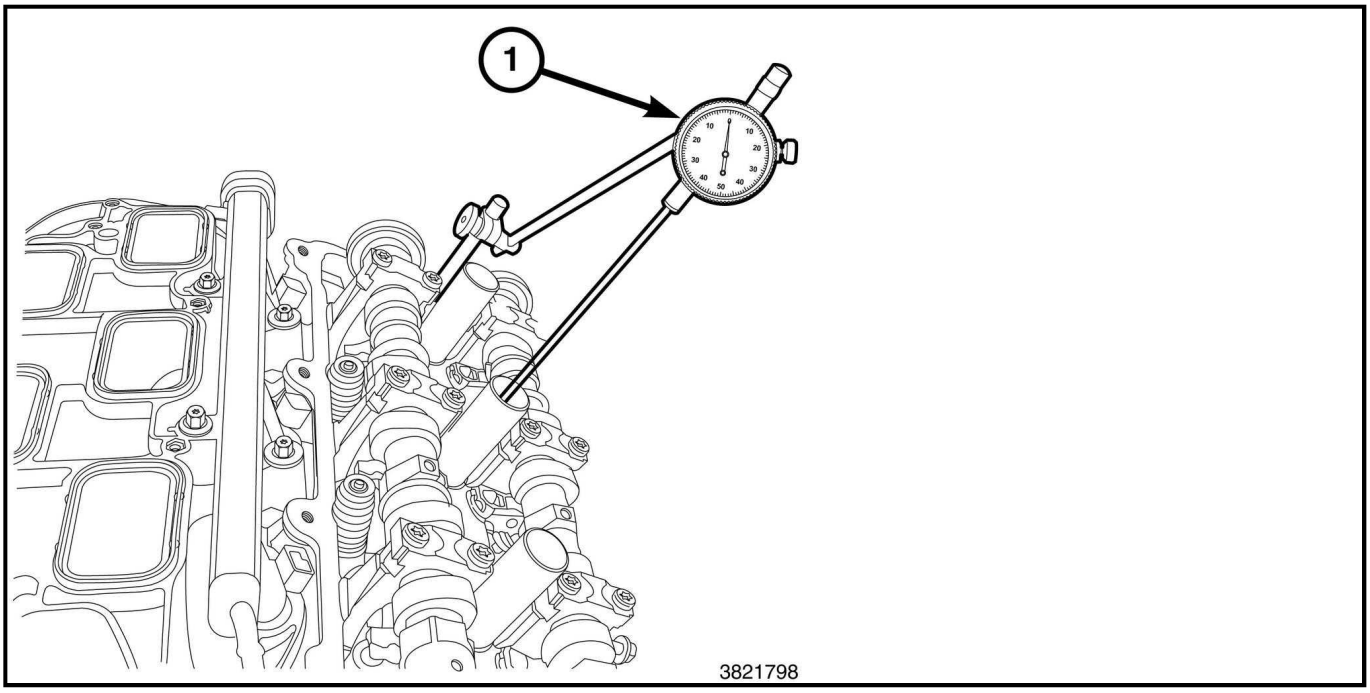
The PCM performs a diagnostic check on each VVL Solenoid High Side Driver Circuit for an open or short in the circuitry. If no circuit faults are detected, the PCM runs a rationality diagnostic to check for any rocker arms that are stuck in the High Lift or Low Lift positions. The PCM can determine this by monitoring for an erratic MAP Sensor signal along with the misfire, knock and Individual Cylinder Fuel Control (ICFC) monitors to detect a rocker arm that is stuck in an incorrect position for a given cylinder. This diagnostic can also detect the mechanical failure of a solenoid or an oil pressure issue to one or more of the rocker arms. When a fault is detected for a rocker arm, the PCM will begin to record **in field** data for diagnostic purposes until the PCM defaults the VVL system to High Lift or Low Lift mode. If the condition goes away during the drive cycle the data collected will also be cleared.

For VVL solenoid oil pressure testing. Refer to **LUBRICATION** .

STANDARD PROCEDURE

ENGINE TIMING VERIFICATION

NOTE: **The magnetic timing wheels must not come in contact with magnets (pickup tools, trays, etc.) or any other strong magnetic field. This will destroy the timing wheels ability to correctly relay camshaft position to the camshaft position sensor.**



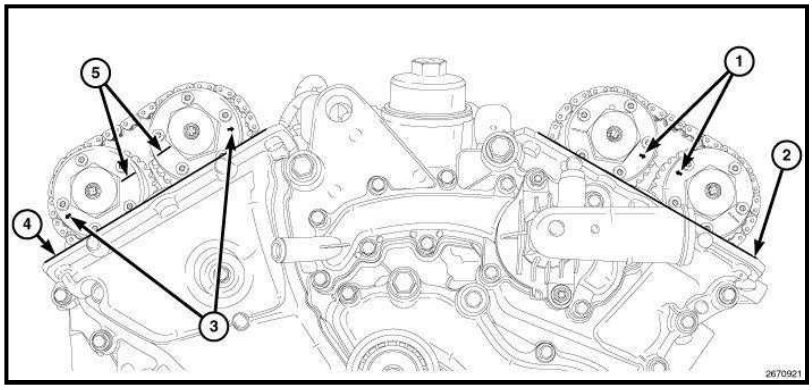
1 - Dial Indicator

Correct timing is critical for the NON free-wheeling designed, 3.6L engine. Engine timing can be verified by using the following procedures:

1. Remove the upper intake manifold and both cylinder head covers. Refer to **COVER(S), CYLINDER HEAD, REMOVAL AND INSTALLATION** .
2. Remove the spark plugs.

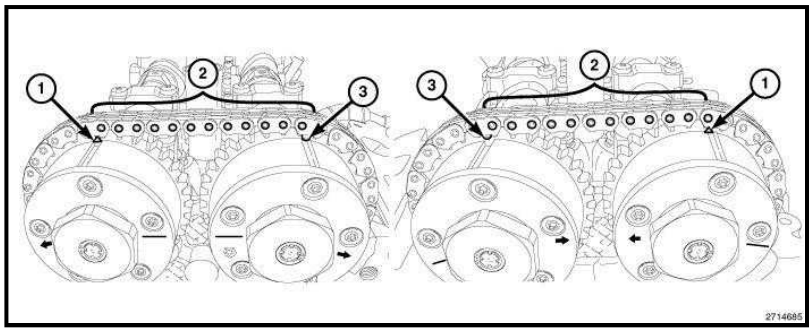
CAUTION: **When aligning timing marks, always rotate engine by turning the crankshaft. Failure to do so will result in valve or piston damage.**

3. Mount Dial Indicator Set (special tool #C-3339A, Set, Dial Indicator) to a stationary point on the engine, such as the left Camshaft Position (CMP) sensor mount. Position the indicator probe into the number four cylinder, rotate the crankshaft clockwise (as viewed from the front) to place the number four cylinder piston at top-dead-center on the compression stroke and set the indicator dial to **ZERO** .



1 - Left Side Cam Phaser Arrows
2 - Left Cylinder Head Cover Mounting Surface
3 - Right Side Cam Phaser Arrows
4 - Right Cylinder Head Cover Mounting Surface
5 - Scribe Lines

4. While maintaining this alignment, verify that the **ARROWS** on the left side cam phasers point toward each other and are parallel to the cylinder head cover mounting surface and that the right side cam phaser **ARROWS** point away from each other and the **SCRIBE LINES** are parallel to the cylinder head cover mounting surface.



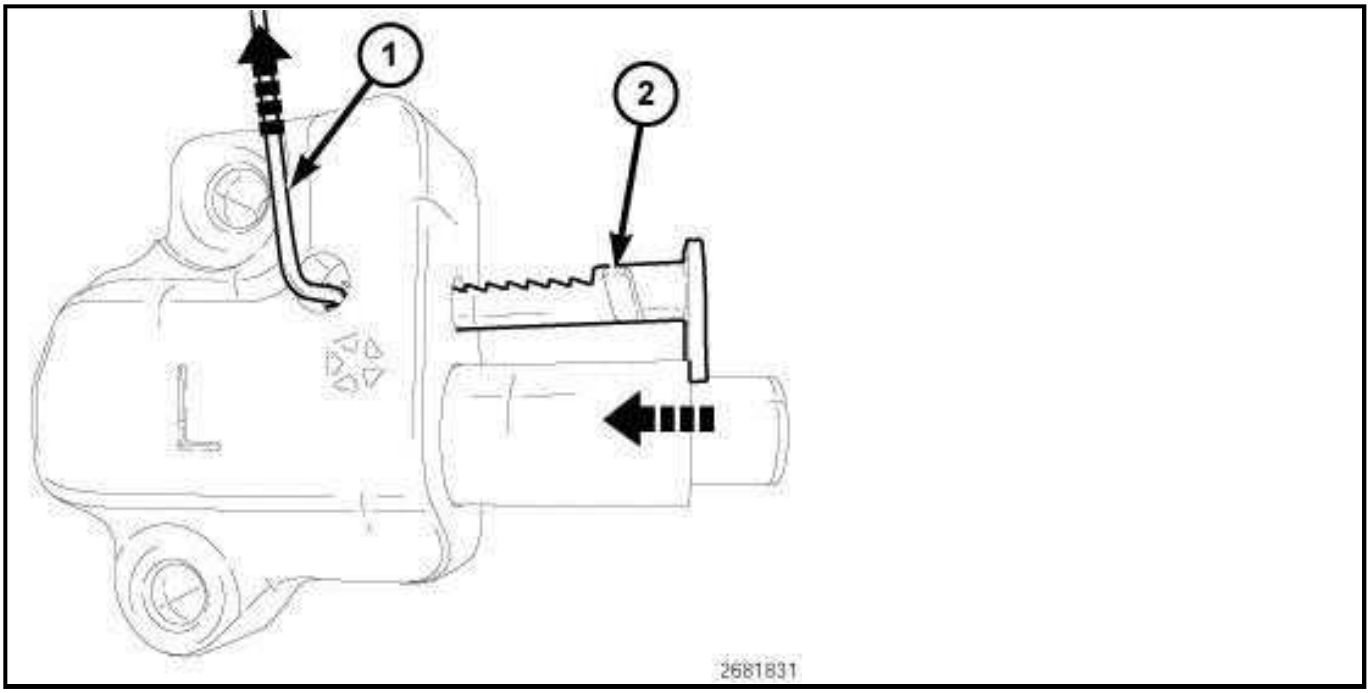
1 - Exhaust Phaser Triangle Marking
2 - Twelve Chain Link Pins Between Markings
3 - Intake Phaser Circle Marking

NOTE: **The phaser markings could align with either an external or internal chain link. Either alignment is acceptable as long as there are twelve chain pins between the markings.**

5. There should be twelve chain pins **BETWEEN** the exhaust cam phaser triangle marking and the intake cam phaser circle marking as viewed from either the front or rear of the cam phasers.
6. If the engine timing is not correct, proceed to Timing Chain and Sprockets for service procedures. Refer to **CHAIN AND SPROCKETS, TIMING, REMOVAL AND INSTALLATION**.

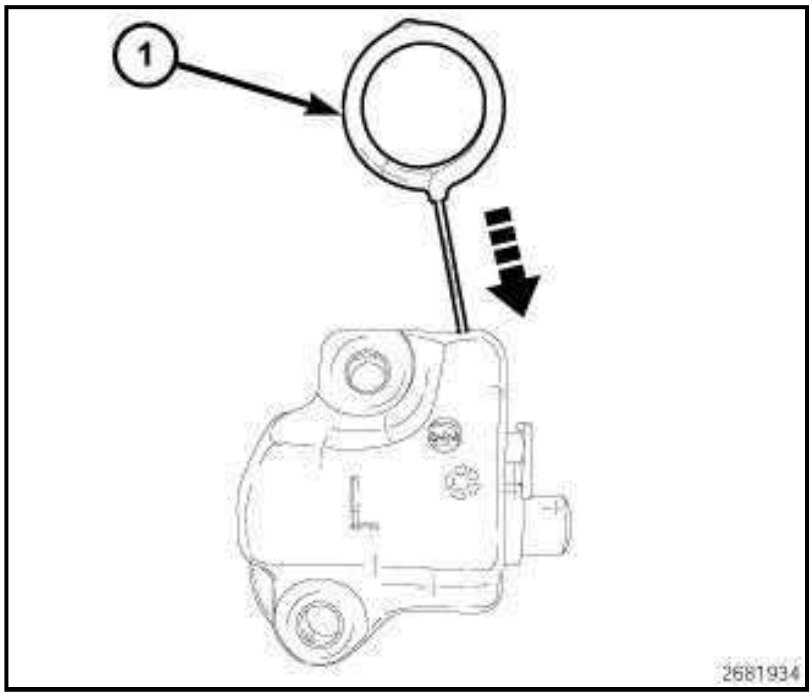
RESETTING LEFT CAM CHAIN TENSIONER

ENGINE TIMING COVER REMOVED



NOTE: **The slot (2) in the rack provides an anchor point for a pin that holds the rack in the retracted position.**

1. Using a suitable tool, such as an Allen wrench (1), lift the pawl off of the rack.
2. While holding the pawl off of the rack, push the rack and the piston into the tensioner body.



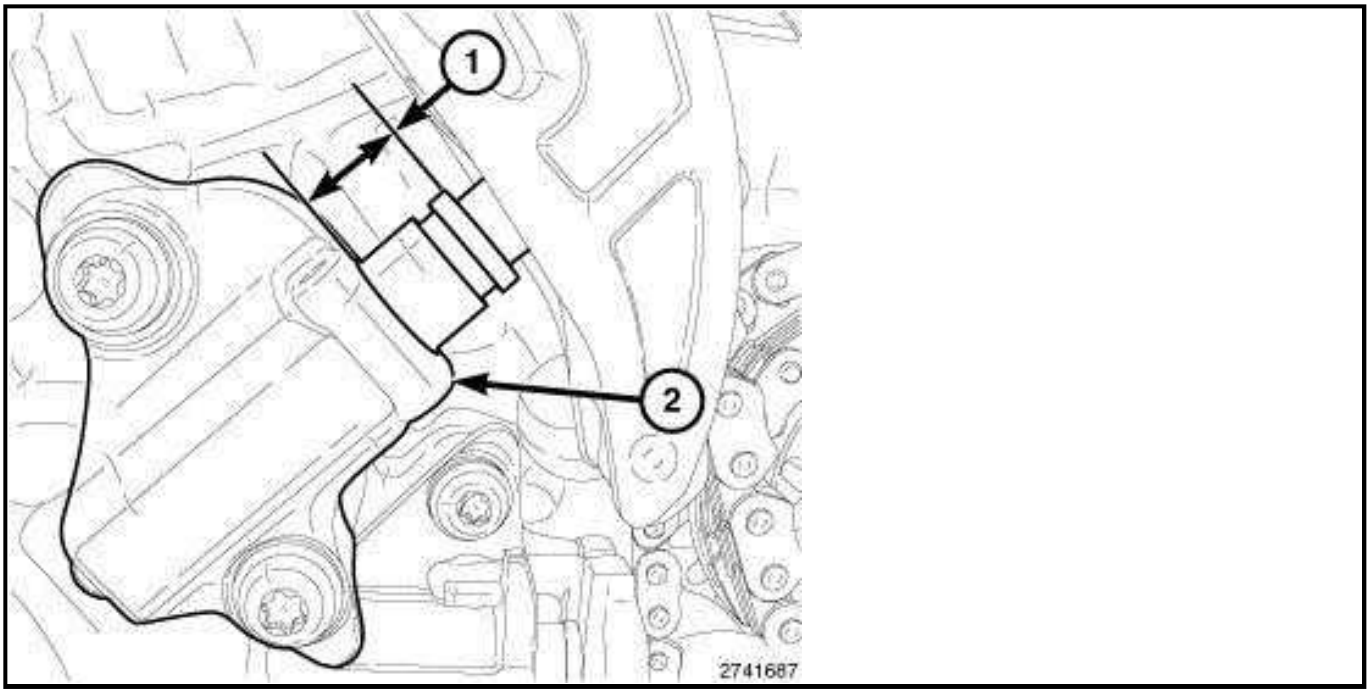
3. When the slot is aligned with the hole in the tensioner body, insert Tensioner Pin (special tool #8514A, Pins, Tensioner) (1) to hold the rack and piston in the retracted position.

ENGINE TIMING COVER INSTALLED

1. Using the (special tool #2025003090, Pin, Chain Tensioner), lift the pawl off of the rack (1).

2. While holding the pawl off of the rack, push (special tool #2025001090, Holder, Timing Chain Tensioner, Left-Front) (1) into place between the cylinder head and the cam chain guide to force the rack and piston back into the tensioner body. The holder must remain in place during service to keep the rack and piston in the retracted position.

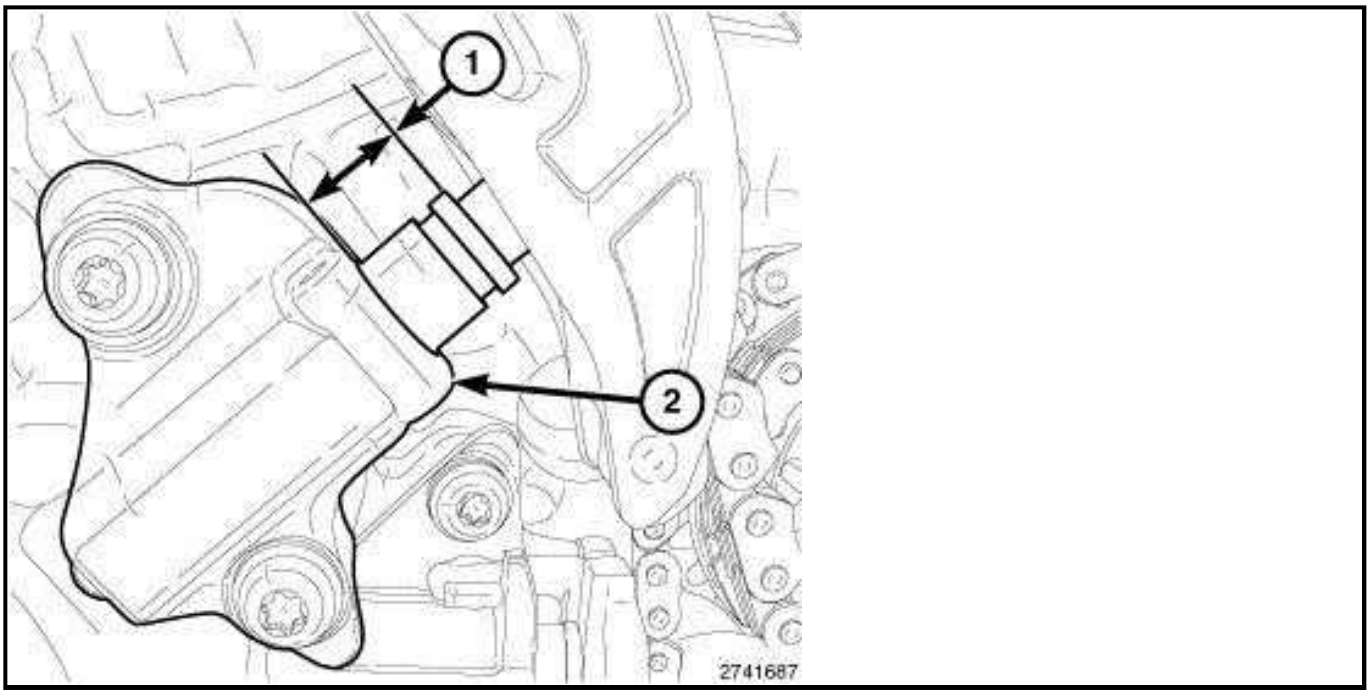
MEASURING TIMING CHAIN WEAR



1. Remove the engine timing chain cover. Refer to **COVER(S), ENGINE TIMING, REMOVAL AND INSTALLATION**.
2. To determine if the timing chains are worn, rotate the crankshaft clockwise until maximum tensioner piston extension (1) is obtained on the RH cam chain tensioner (2). Measure the distance between the secondary timing chain tensioner housing and the step ledge on the tensioner piston. Piston extension must be less than 16 mm (0.630 in.).
3. Piston extension greater than 16 mm (0.630 in.) indicates that all timing chains are worn and require replacement. Refer to **CHAIN AND SPROCKETS, TIMING, REMOVAL AND INSTALLATION**.

CHAIN AND SPROCKETS, TIMING

INSPECTION



Prior to disassembly of the timing chains and sprockets, measure the timing chain wear (1). Refer to **MEASURING TIMING CHAIN WEAR** .

Inspect the following valve timing components:

- Sprockets for excessive tooth wear. Some tooth markings are normal and not a cause for sprocket replacement.
- Idler sprocket assembly bushing and shaft for excessive wear.
- Chain guides and tensioner arms. Replace these parts if grooving in plastic face is more than 1 mm (0.039 in.) deep.
- Secondary chain tensioner piston and ratcheting device. Inspect for evidence of heavy contact between tensioner piston and tensioner arm. If this condition exist the tensioner arm and chain should be replaced.
- Primary chain tensioner plastic faces. Replace as required.

REMOVAL AND INSTALLATION

TIMING CHAINS AND GUIDES

REMOVAL

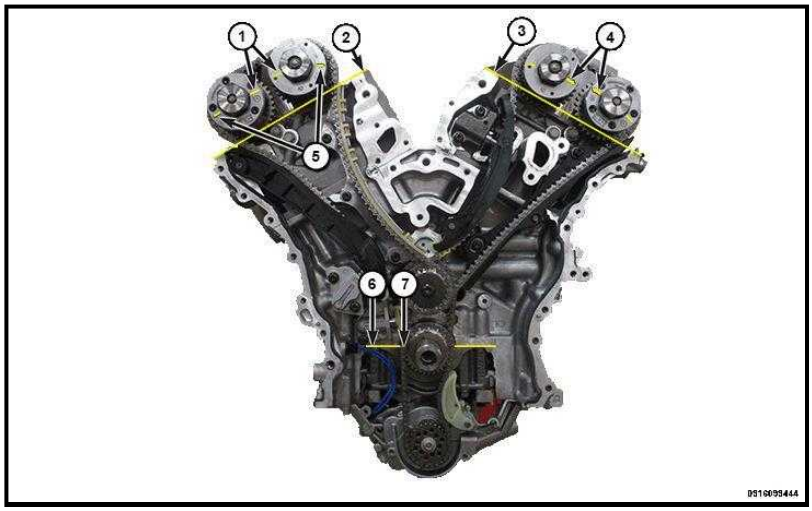
CAUTION: **The magnetic timing wheels (1) must not come in contact with magnets (pickup tools, trays, etc.) or any other strong magnetic field. This will destroy the timing wheels ability to correctly relay camshaft position to the camshaft position sensor.**

CAUTION: **When the timing chains are removed and the cylinder heads are still installed, DO NOT rotate the camshafts or crankshaft without first locating the proper crankshaft position. Failure to do so will result in valve or piston damage.**

The Phasers and Oil Control Valves (OCVs) can be serviced without removing the engine timing cover.

1. Remove the spark plugs. Refer to **SPARK PLUG, REMOVAL AND INSTALLATION** .
2. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .
3. Drain the cooling system. Refer to **DRAINING** .
4. If removing the oil pump chain or primary chain, remove the oil pan. Refer to **PAN, OIL, REMOVAL AND INSTALLATION** .
5. Remove the engine timing cover. Refer to **COVER(S), ENGINE TIMING, REMOVAL AND INSTALLATION**.

NOTE: **Before starting disassembly, measure the timing chain wear. Refer to MEASURING TIMING CHAIN WEAR .**

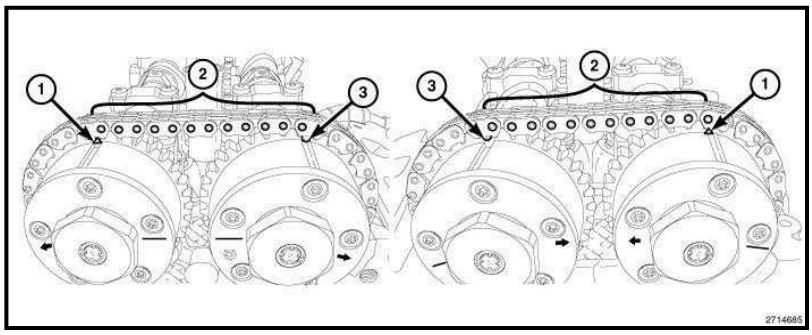


1 - Right Side Cam Phaser Scribe Lines	5 - Right Side Cam Phaser Arrows
2 - Right Cylinder Head Cover Mounting Surface	6 - Block/Main Bearing Cap Mating Surface
3 - Left Cylinder Head Cover Mounting Surface	7 - Crankshaft Dimple

4 - Left Side Cam Phaser Arrows	B

CAUTION: **When aligning timing marks, always rotate engine by turning the crankshaft. Failure to do so will result in valve or piston damage.**

6. Rotate the crankshaft clockwise (as viewed from the front) to place the number one cylinder piston at top-dead-center on the exhaust stroke by aligning the dimple on the crankshaft with the block/main bearing cap mating surface.
7. While maintaining this alignment, verify that the **ARROWS** on the left side camshaft phasers point toward each other and are parallel to the cylinder head cover mounting surface with the right side camshaft phaser **ARROWS** point away from each other and the **SCRIBE LINES** are parallel to the cylinder head cover mounting surface.

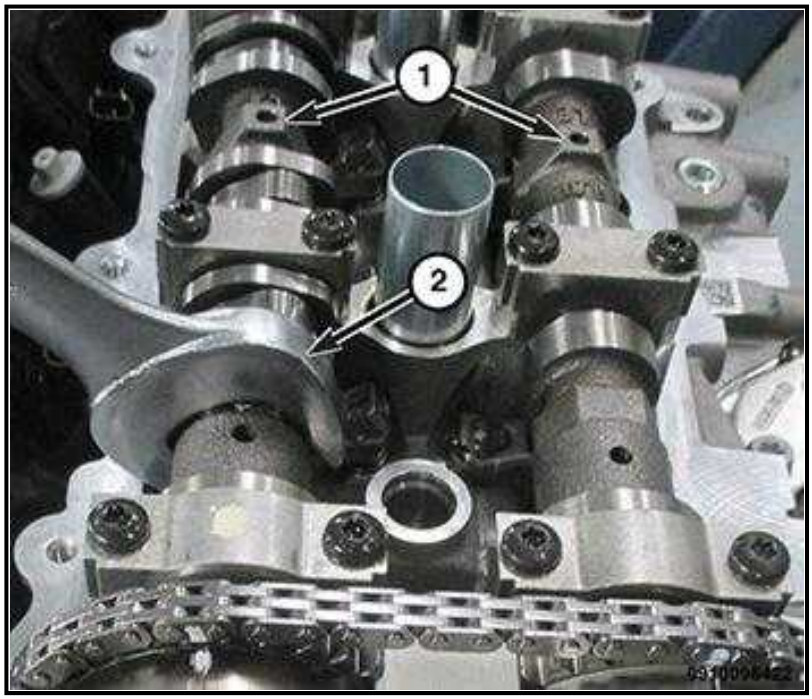


1 - Exhaust Phaser Triangle Marking
2 - Twelve Chain Link Pins Between Markings
3 - Intake Phaser Circle Marking

NOTE: **The phaser markings could align with either an external or internal chain link. Either alignment is acceptable as long as there are twelve chain pins between the markings.**

8. There should be twelve chain pins **BETWEEN** the exhaust camshaft phaser triangle marking and the intake camshaft phaser circle marking as viewed from either the front or rear of the camshaft phasers.

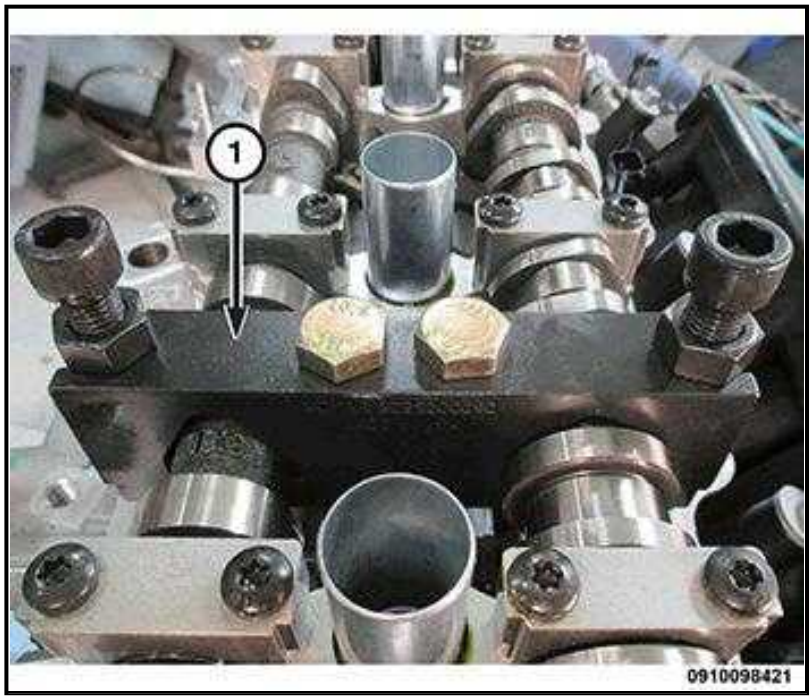
CAUTION: **Always reinstall timing chains so that they maintain the same direction of rotation. Inverting a previously run chain on a previously run sprocket will result in excessive wear to both the chain and sprocket.**



1 - Alignment Holes
2 - Wrench

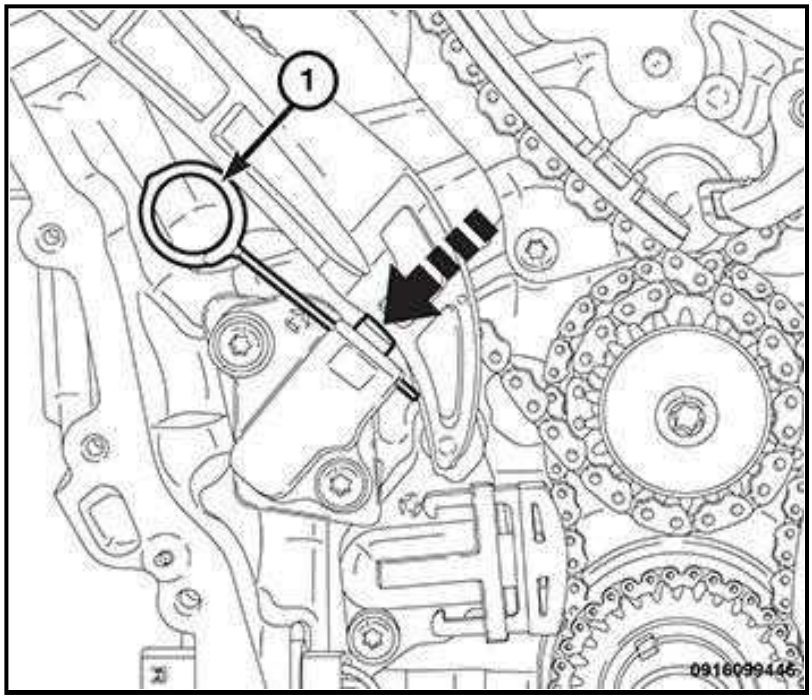
9. Both left and right side camshafts should be at top-dead-center, with the alignment holes positioned vertically.

NOTE: **It may be necessary to rock the camshaft slightly (a few degrees) with a wrench when installing the camshaft holder.**



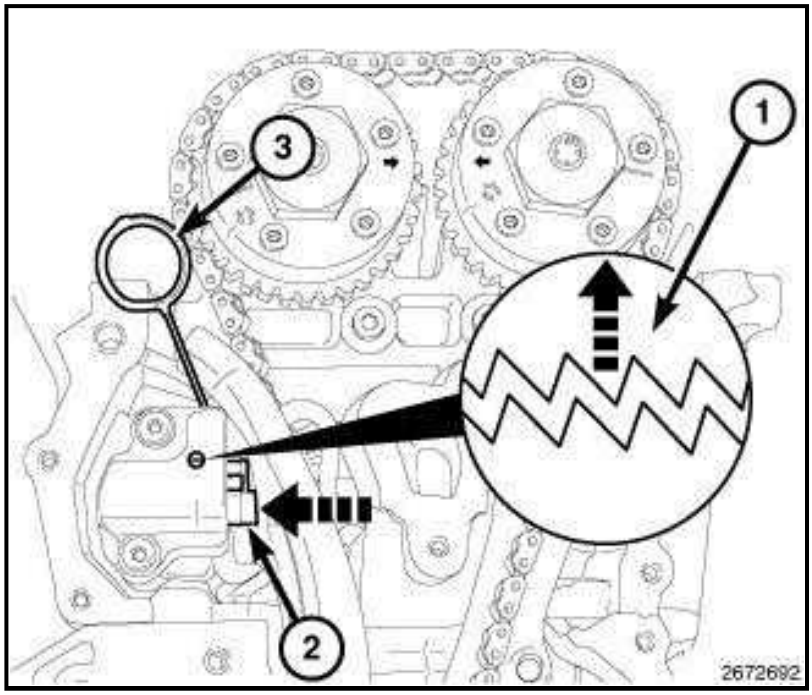
1 - Camshaft Holder Tool

10. Install the (special tool #2025200090, Holder, Camshaft) on both left and right side camshafts.
11. Mark the direction of rotation on the following timing chains using a paint pen or equivalent to aid in reassembly:
    - Left side timing chain
    - Right side timing chain
    - Oil pump chain
    - Primary chain



1 - Tensioner Pin

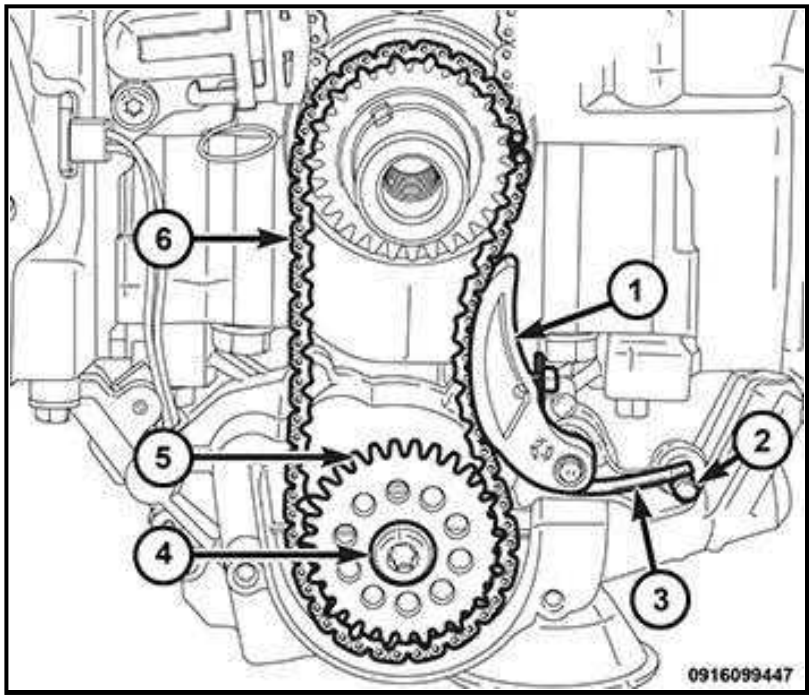
12. Reset the right side timing chain tensioner by pushing back the tensioner piston and installing Tensioner Pin (special tool #8514A, Pins, Tensioner).



1 - Pawl
2 - Piston
3 - Tensioner Pin

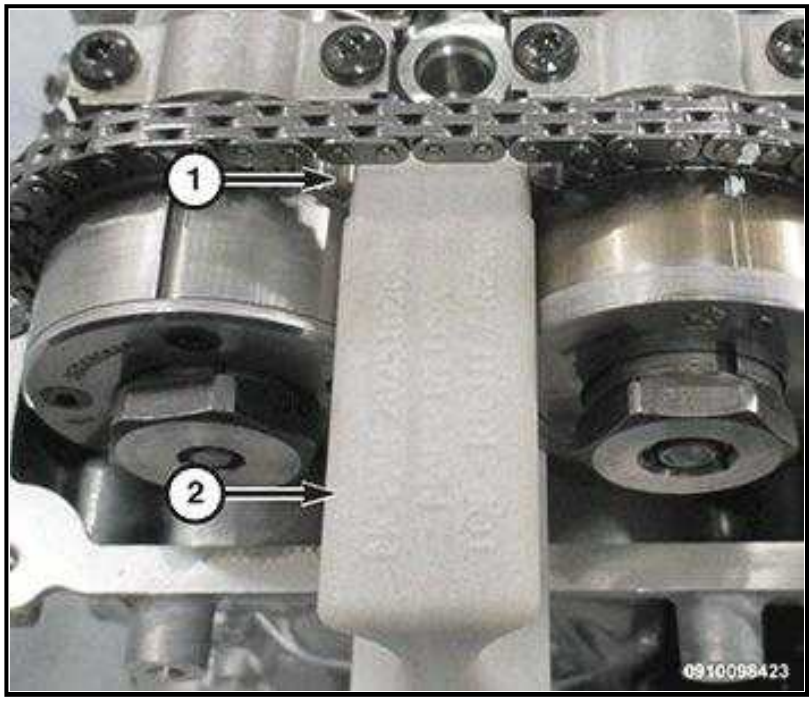
13. Reset the left side timing chain tensioner by lifting the pawl, pushing back the piston and installing Tensioner Pin (special tool #8514A, Pins, Tensioner)

    Refer to **RESETTING LEFT CAM CHAIN TENSIONER** .



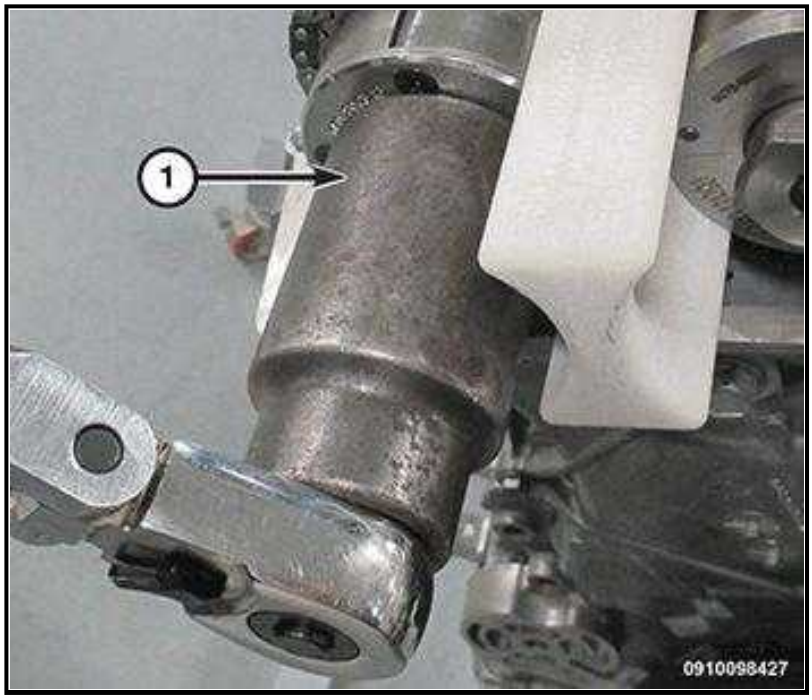
1 - Oil Pump Chain Tensioner	4 - Oil Pump Sprocket Bolt
2 - Dowel Pin	5 - Oil Pump Sprocket
3 - Oil Pump Chain Tensioner Spring	6 - Oil Pump Chain

14. Disengage the oil pump chain tensioner spring from the dowel pin and remove the oil pump chain tensioner.
15. Remove the oil pump sprocket bolt and remove the oil pump sprocket and oil pump chain.



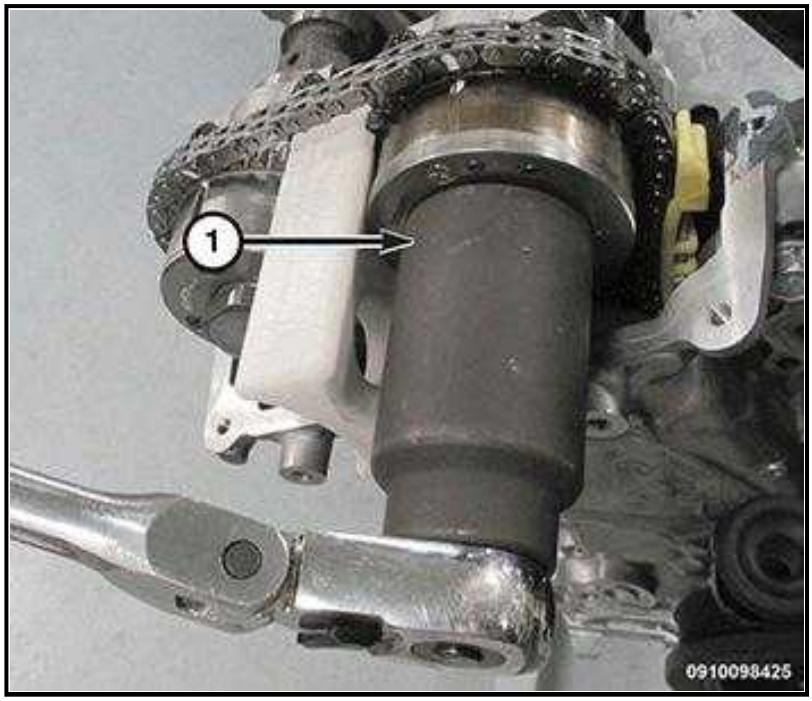
1 - Intake and Exhaust Phasers
2 - Right Cam Phaser Holder Tool

16. Install the (special tool #2025102090, Holder, Camshaft Phaser - Right-Rear Cyl Head) between the right side intake and exhaust phasers, with the tool number facing up.



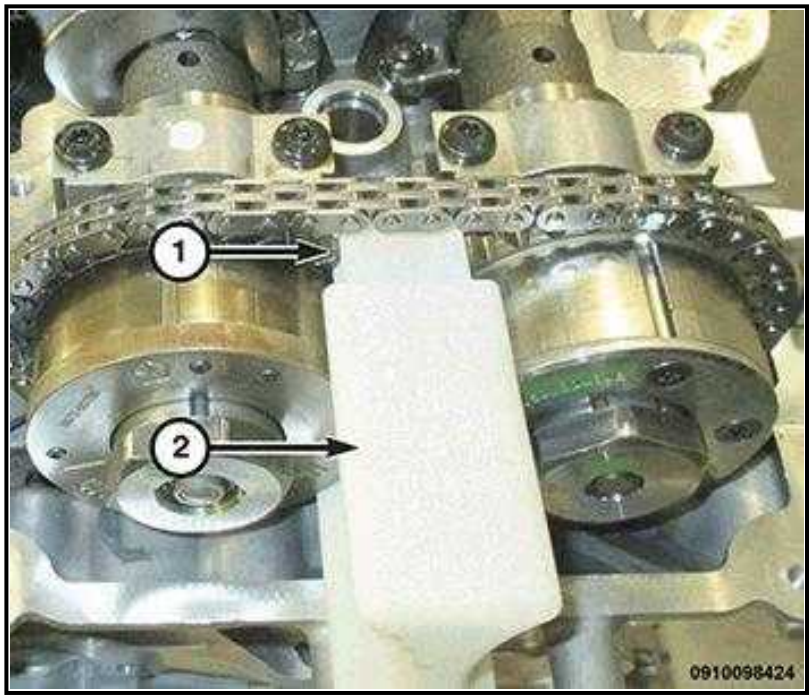
1 - Right Side Exhaust Oil Control Valve

17. Loosen, but do not remove, the right side exhaust oil control valve.



1 - Right Side Intake Oil Control Valve

18. Loosen, but do not remove, the right side intake oil control valve.
19. Remove the (special tool #2025102090, Holder, Camshaft Phaser - Right-Rear Cyl Head).
20. Remove the oil control valve from the right side intake camshaft phaser.
21. Pull the right side intake camshaft phaser off of the camshaft and remove the right side timing chain.
22. If required, remove the oil control valve and pull the right side exhaust camshaft phaser off of the camshaft.



1 - Cam Phaser Holder Installed
2 - Left Cam Phaser Holder Tool

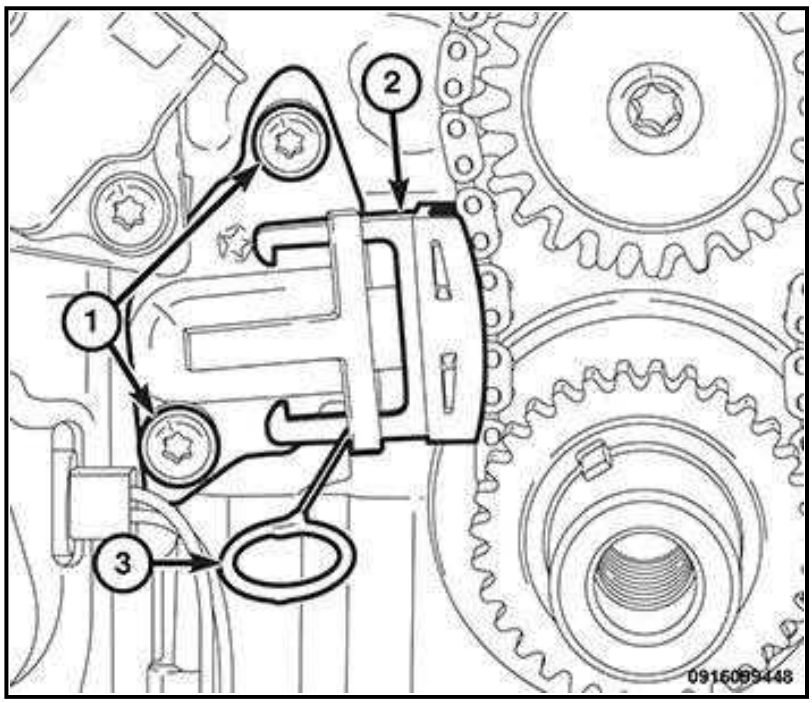
23. Install the (special tool #2025101090, Holder, Camshaft Phaser - Left-Front Cyl Head) between the intake and exhaust phasers, with the tool number facing up.

1 - Left Side Exhaust Oil Control Valve

24. Loosen, but do not remove, the left side exhaust oil control valve.

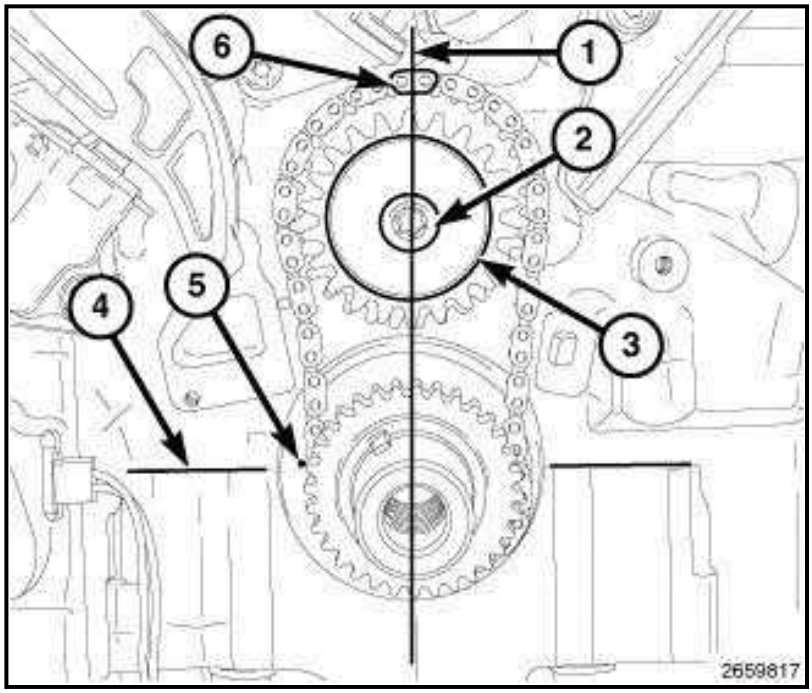
1 - Left Side Intake Oil Control Valve

25. Loosen, but do not remove, the left side intake oil control valve.
26. Remove the (special tool #2025101090, Holder, Camshaft Phaser - Left-Front Cyl Head), leaving the Camshaft Holder in place.
27. Remove the oil control valve from the left side exhaust camshaft phaser.
28. Pull the left side exhaust camshaft phaser off of the camshaft and remove the left side timing chain.
29. If required, remove the oil control valve and pull the left side intake camshaft phaser off of the camshaft.



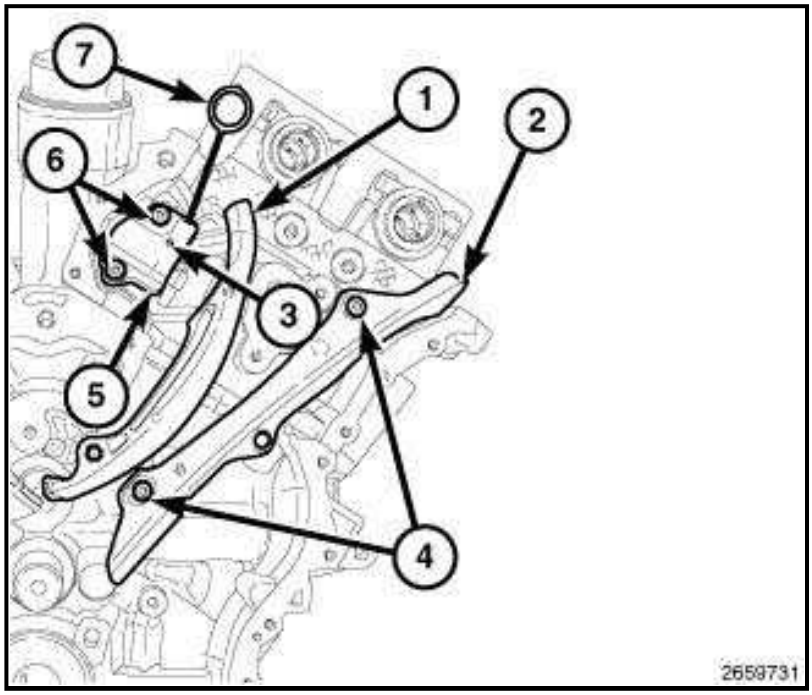
1 - Primary Chain Tensioner Bolts
2 - Primary Chain Tensioner
3 - Tensioner Pin

30. Reset the primary chain tensioner by pushing back the tensioner piston and installing Tensioner Pin (special tool #8514A, Pins, Tensioner). Remove the two bolts and remove the primary chain tensioner.



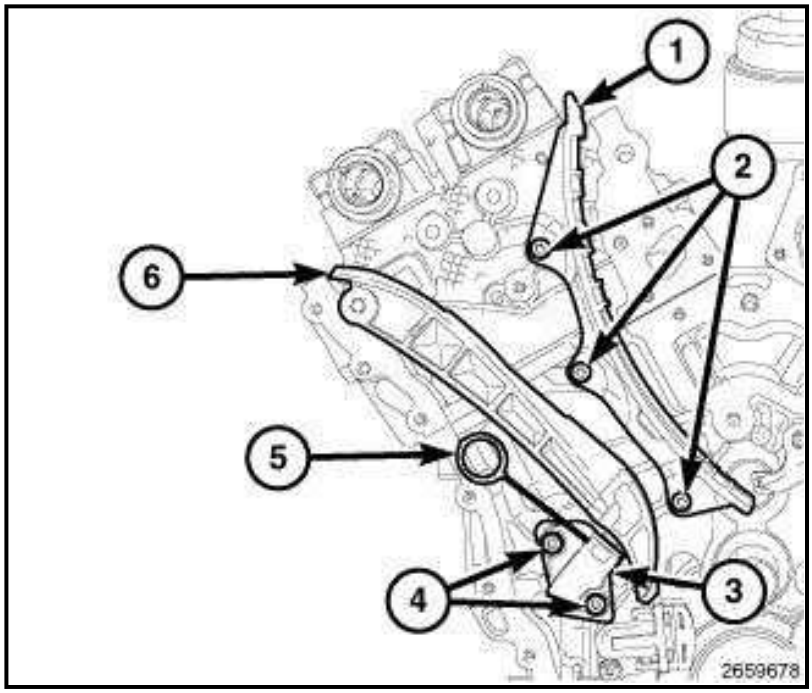
1 - Center-line	4 - Block/Main Bearing Cap Mating Surface
2 - Idler Sprocket Bolt	5 - Crankshaft Dimple
3 - Washer	6 - Painted Link

31. Remove the idler sprocket bolt and washer.
32. Remove the primary chain, idler sprocket and crankshaft sprocket as an assembly.



1 - Left Side Timing Chain Tensioner Arm	5 - Tensioner
2 - Left Side Timing Chain Guide	6 - Left Side Timing Chain Tensioner Bolts
3 - Tensioner Pawl	7 - Tensioner Pin
4 - Left Side Timing Chain Guide Bolts	B

33. If required, remove the bolts and the left side timing chain tensioner.
34. If required, remove the bolts and the left side timing chain guide and tensioner arm.



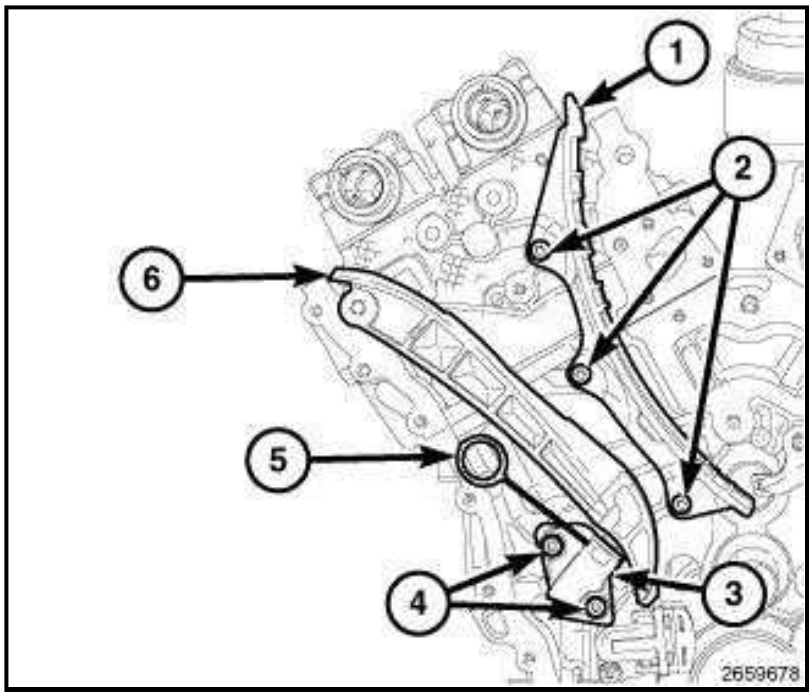
1 - Right Side Timing Chain Guide	4 - Right Side Tensioner Bolts
2 - Right Side Timing Chain Bolts	5 - Tensioner Pin
3 - Right Side Tensioner	6 - Tensioner Arm

35. If required, remove the bolts and the right side timing chain tensioner.
36. If required, remove the bolts and the right side timing chain guide and tensioner arm.
37. Inspect all sprockets and chain guides. Replace if damaged.

INSTALLATION

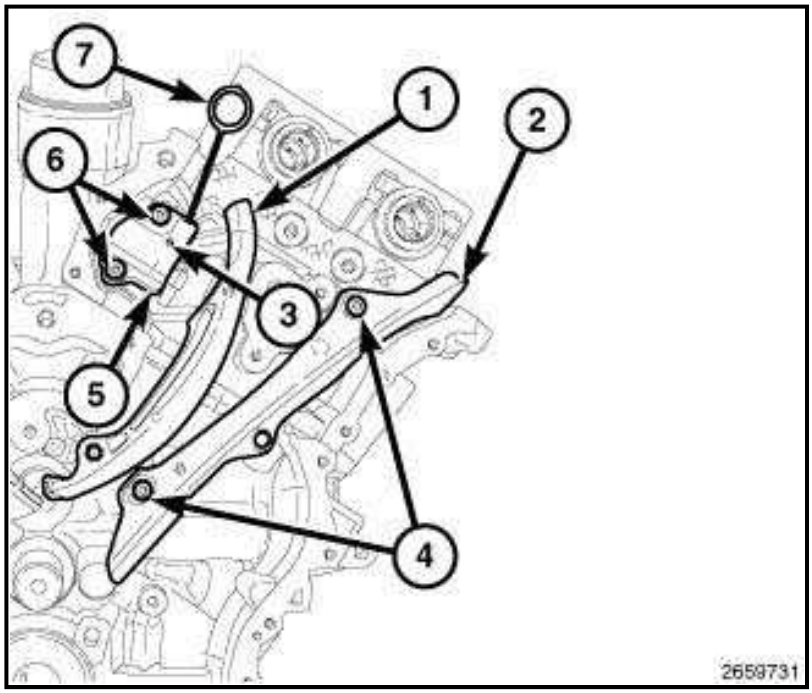
During installation, torque the fasteners to the specifications in the torque table(s) below.

1. Inspect all sprockets and chain guides. Replace if damaged.



1 - Right Side Timing Chain Guide	4 - Right Side Tensioner Bolts
2 - Right Side Timing Chain Bolts	5 - Tensioner Pin
3 - Right Side Tensioner	6 - Tensioner Arm

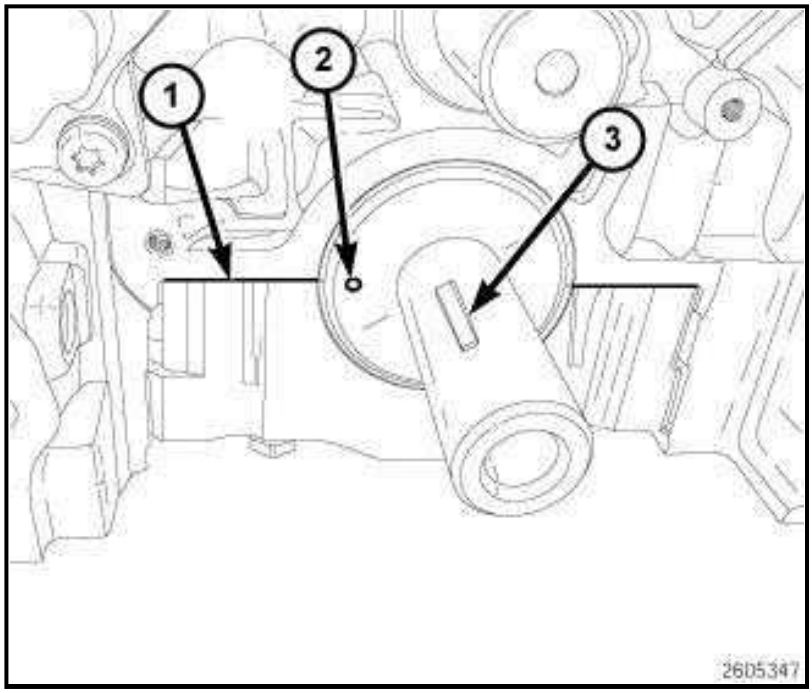
2. If removed, install the right side cam chain guide and tensioner arm and tighten the bolts to the proper torque specification.
3. If removed, install the right side timing chain tensioner to the engine block with two bolts and tighten the bolts to the proper torque specification.
4. Reset the right side timing chain tensioner by pushing back the tensioner piston and installing Tensioner Pin (special tool #8514A, Pins, Tensioner).



1 - Left Side Timing Chain Tensioner Arm	5 - Tensioner
2 - Left Side Timing Chain Guide	6 - Left Side Timing Chain Tensioner Bolts
3 - Tensioner Pawl	7 - Tensioner Pin
4 - Left Side Timing Chain Guide Bolts	B

5. If removed, install the left side timing chain guide and tensioner arm and tighten the bolts to the proper torque specification.
6. If removed, install the left side timing chain tensioner to the cylinder head with two bolts and tighten the bolts to the proper torque specification.
7. Reset the left side timing chain tensioner by lifting the pawl, pushing back the piston and installing Tensioner Pin (special tool #8514A, Pins, Tensioner)

   Refer to **RESETTING LEFT CAM CHAIN TENSIONER** .



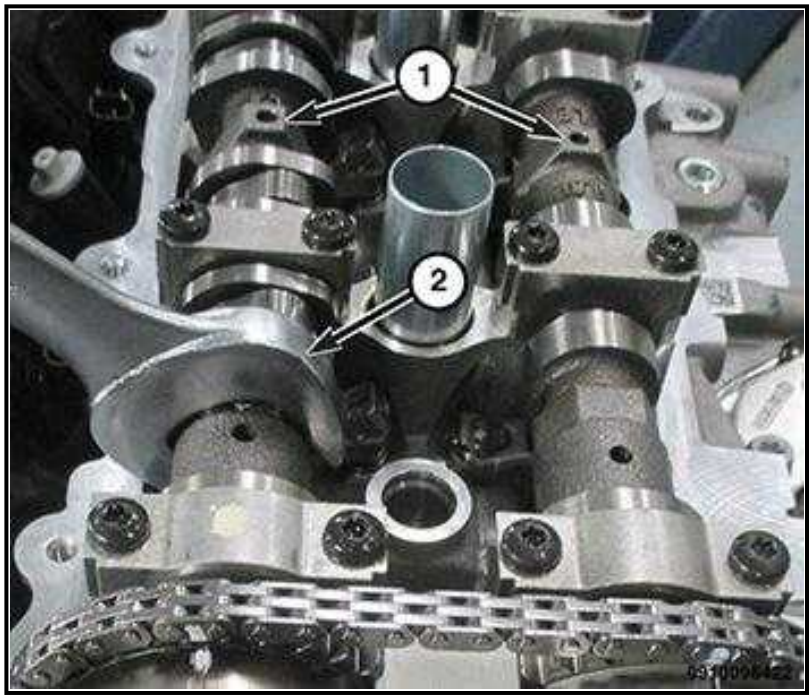
1 - Bearing Cap to Block Junction
2 - Crankshaft Dimple
3 - Woodruff Key

8. Verify that the key is installed in the crankshaft.

CAUTION: **Do not rotate the crankshaft more than a few degrees independently of the camshafts. Piston to valve contact could occur resulting in possible valve damage. If the crankshaft needs to be rotated more than a few degrees, first remove the camshafts.**

CAUTION: **Do not rotate the camshafts more than a few degrees independently of the crankshaft. Valve to piston contact could occur resulting in possible valve damage. If the camshafts need to be rotated more than a few degrees, first move the pistons away from the cylinder heads by rotating the crankshaft counterclockwise to a position 30B° before-top-dead-center. Once the camshafts are returned to their top-dead-center position, rotate the crankshaft clockwise to return the crankshaft to top-dead-center.**

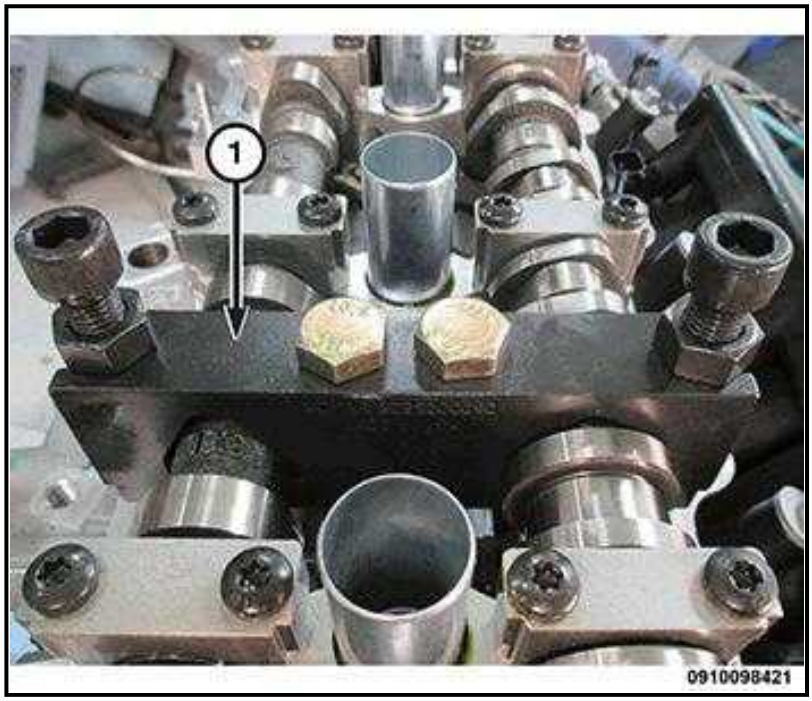
9. Verify that the number one cylinder piston is positioned at top-dead-center by aligning the dimple on the crankshaft with the block/bearing cap junction.



1 - Alignment Holes
2 - Wrench

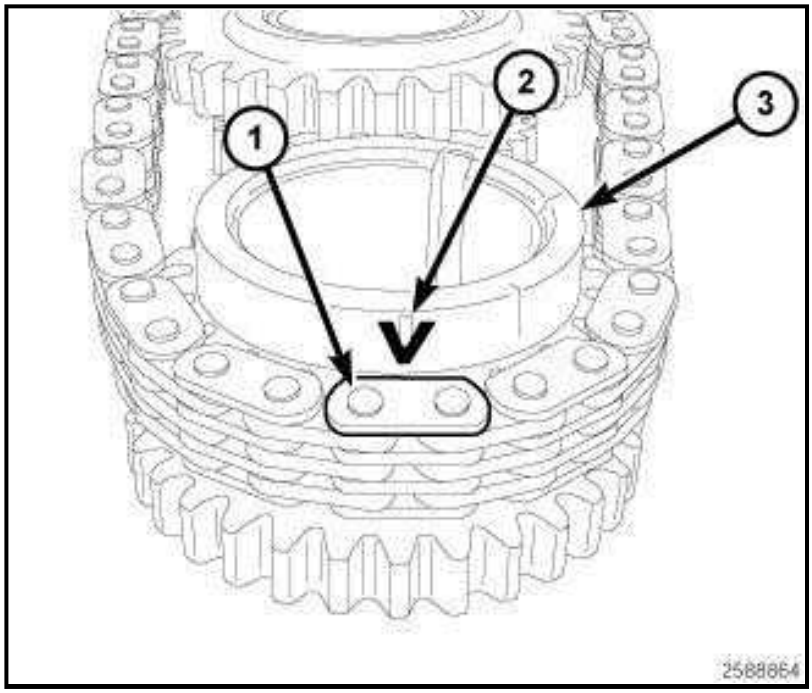
10. If the Camshaft Holders have been removed, verify that the camshafts are set at top-dead-center by positioning the alignment holes vertically.

NOTE: **It may be necessary to rock the camshaft slightly (a few degrees) with a wrench when installing the camshaft holder.**



1 - Camshaft Holder Tool

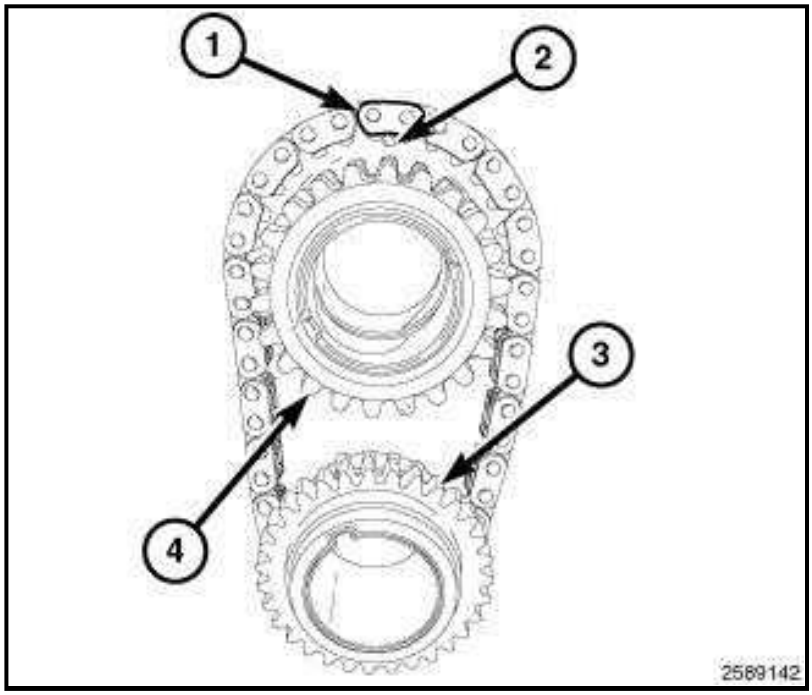
11. Install the (special tool #2025200090, Holder, Camshaft) on both left and right side camshafts.



1 - Plated Link
2 - Arrow
3 - Crankshaft Sprocket

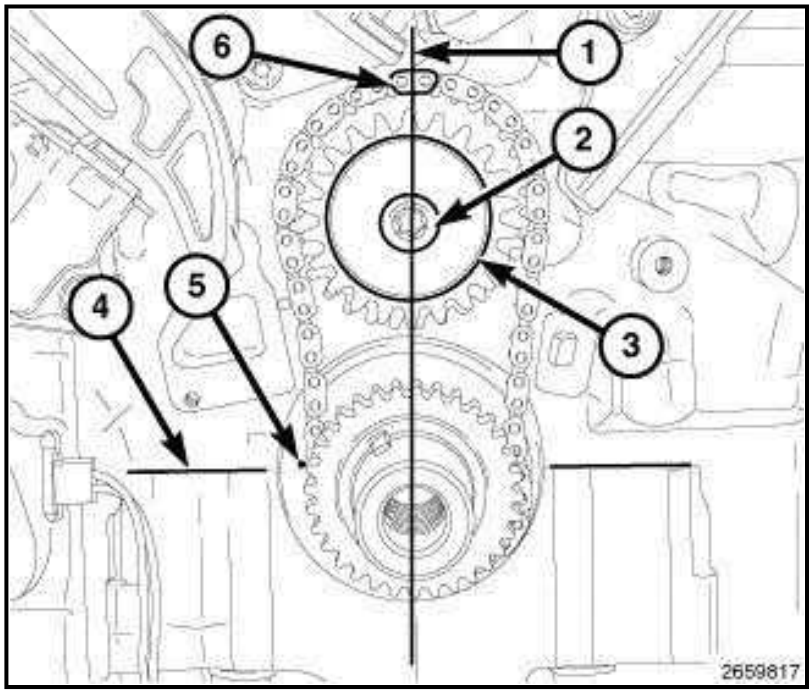
CAUTION: **Always reinstall timing chains so that they maintain the same direction of rotation. Inverting a previously run chain on a previously run sprocket will result in excessive wear to both the chain and sprocket.**

12. Place the primary chain onto the crankshaft sprocket so that the arrow is aligned with the plated link on the timing chain.



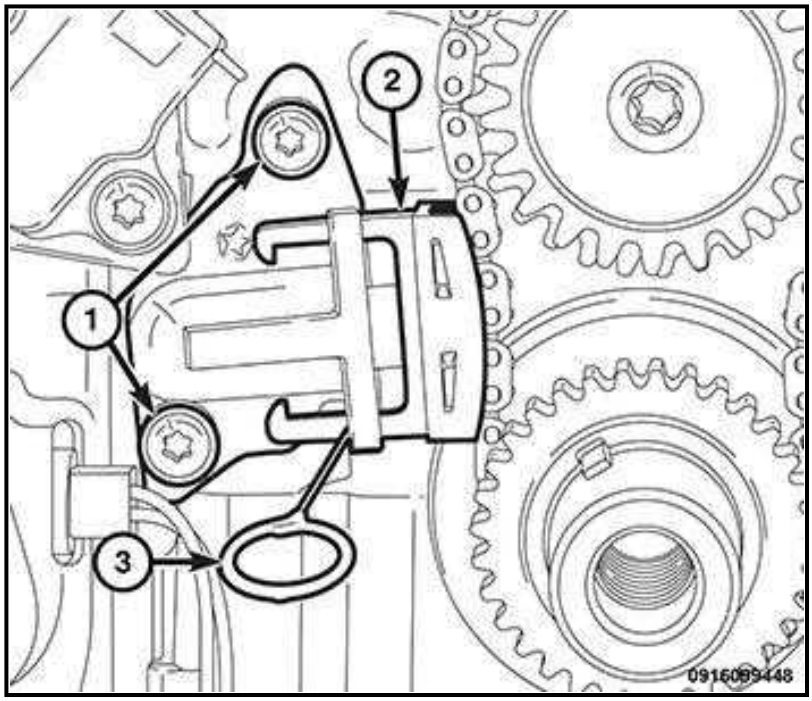
1 - Timing Chain Plated Link
2 - Alignment Dimple
3 - Crankshaft Sprocket
4 - Idler Sprocket

13. While maintaining this alignment, invert the crankshaft sprocket and timing chain and place the idler sprocket into the timing chain so that the alignment dimple is aligned with the plated link on the timing chain.



1 - 12 O'clock Center-line	4 - Block/Main Bearing Cap Mating Surface
2 - Idler Sprocket Bolt	5 - Crankshaft Dimple
3 - Washer	6 - Timing Chain Painted Link

14. While maintaining this alignment, lubricate the idler sprocket bushing with clean engine oil and install the sprockets and timing chain on the engine. To verify that the timing is still correct, the timing chain plated link should be located at 12:00 when the dimple on the crankshaft is aligned with the block/bearing cap junction.
15. Install the idler sprocket retaining bolt and washer and tighten the bolt to the proper torque specification.



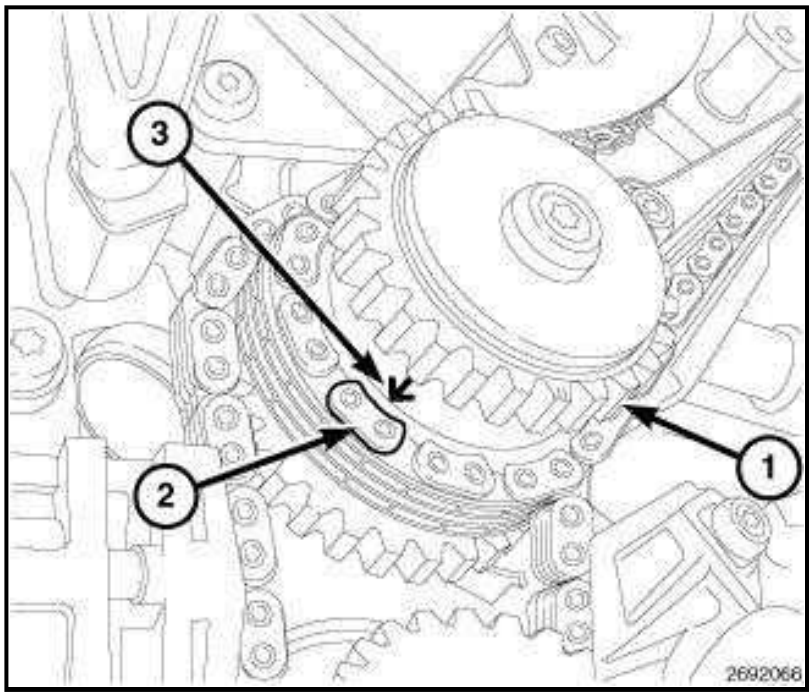
1 - Primary Chain Tensioner Bolts
2 - Primary Chain Tensioner

3 - Tensioner Pin

16. Reset the primary chain tensioner by pushing back the tensioner piston and installing Tensioner Pin (special tool #8514A, Pins, Tensioner).
17. Install the primary chain tensioner to the engine block with two bolts and tighten the bolts to the proper torque specification and remove the Tensioner Pin (special tool #8514A, Pins, Tensioner).

1 - Left Side Intake Oil Control Valve

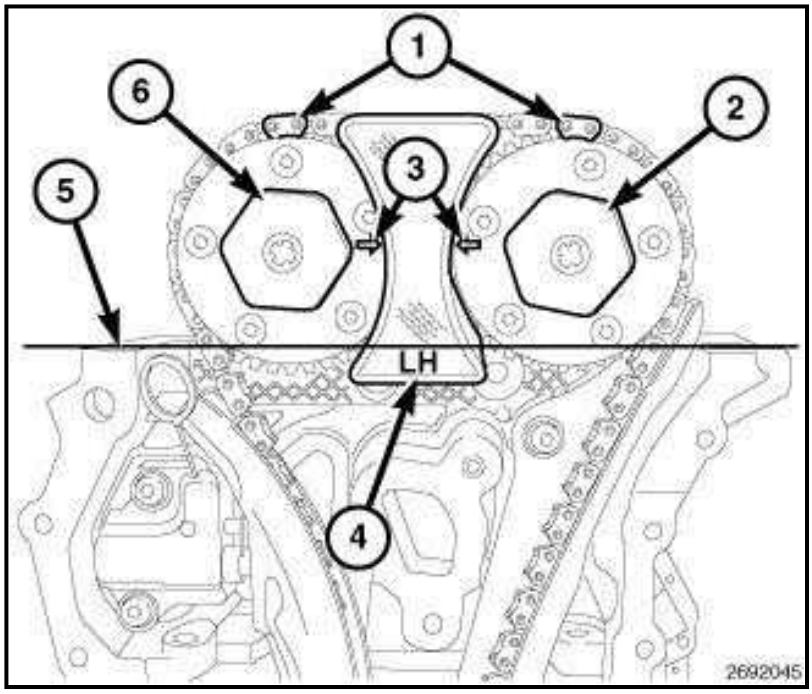
18. Press the left side intake camshaft phaser onto the intake camshaft. Install and hand tighten the oil control valve.



NOTE: **The left side and right side camshaft chains are identical.**

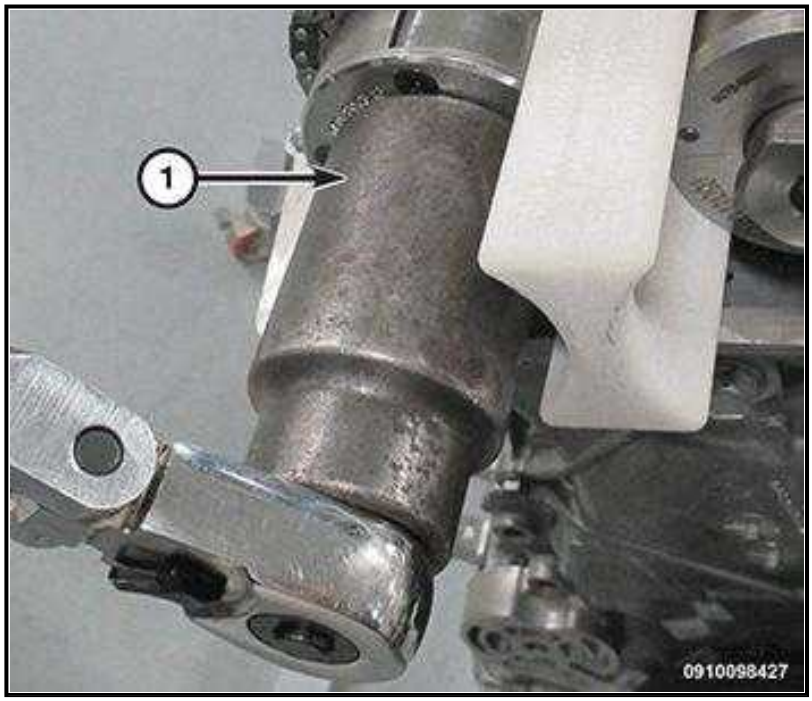
CAUTION: **Always reinstall timing chains so that they maintain the same direction of rotation. Inverting a previously run chain on a previously run sprocket will result in excessive wear to both the chain and sprocket.**

19. Drape the left side timing chain over the left side intake camshaft phaser and onto the idler sprocket so that the arrow is aligned with the plated link on the cam chain.



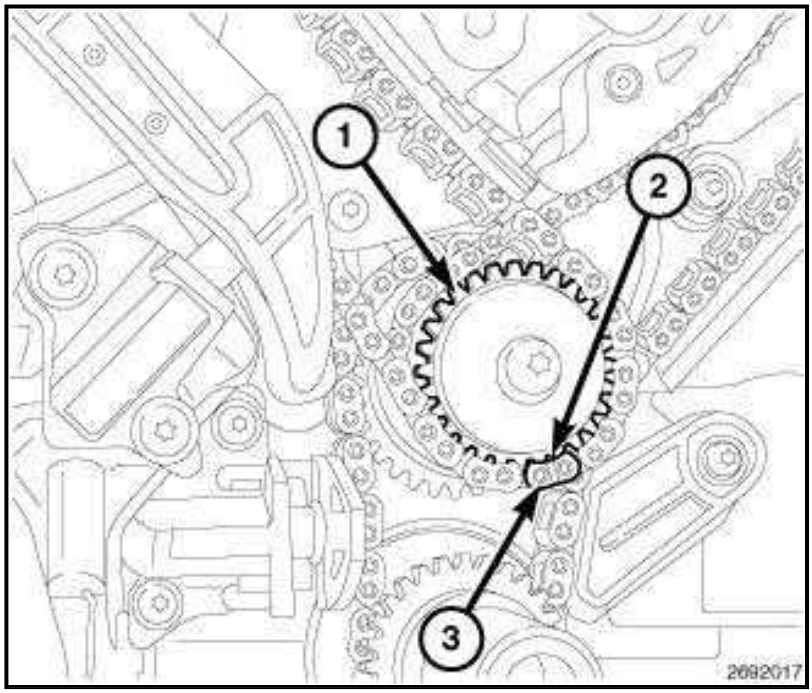
1 - Plated Links	4 - Left Side Cam Phaser Holder
2 - Left Side Exhaust Phaser Oil Control Valve	5 - Cylinder Head Cover Mounting Surface
3 - Alignment Arrows	6 - Left Side Intake Phaser Oil Control Valve

20. While maintaining this alignment, route the timing chain around the exhaust and intake camshaft phasers so that the plated links are aligned with the phaser timing marks. Position the left side camshaft phasers so that the arrows point toward each other and are parallel to the cylinder head cover mounting surface. Press the exhaust cam phaser onto the exhaust cam, install and hand tighten the oil control valve.
21. Install the (special tool #2025101090, Holder, Camshaft Phaser - Left-Front Cyl Head) with the tool number facing up.
22. Tighten the oil control valves and to the proper specifications. Refer to **TORQUE SPECIFICATIONS** .
23. Remove the Camshaft Phaser Holder.



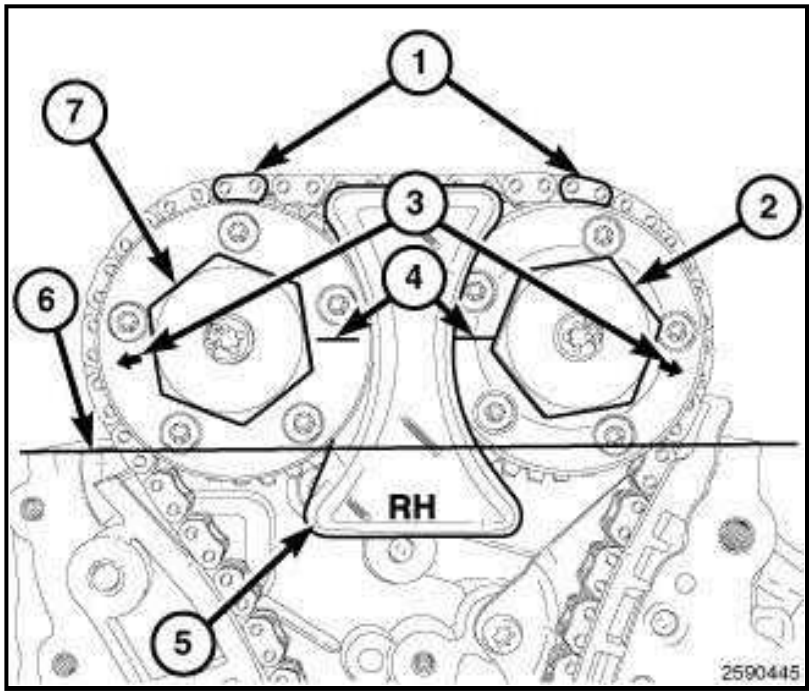
1 - Right Side Exhaust Oil Control Valve

24. Press the right side exhaust camshaft phaser onto the exhaust camshaft. Install and hand tighten the oil control valve.



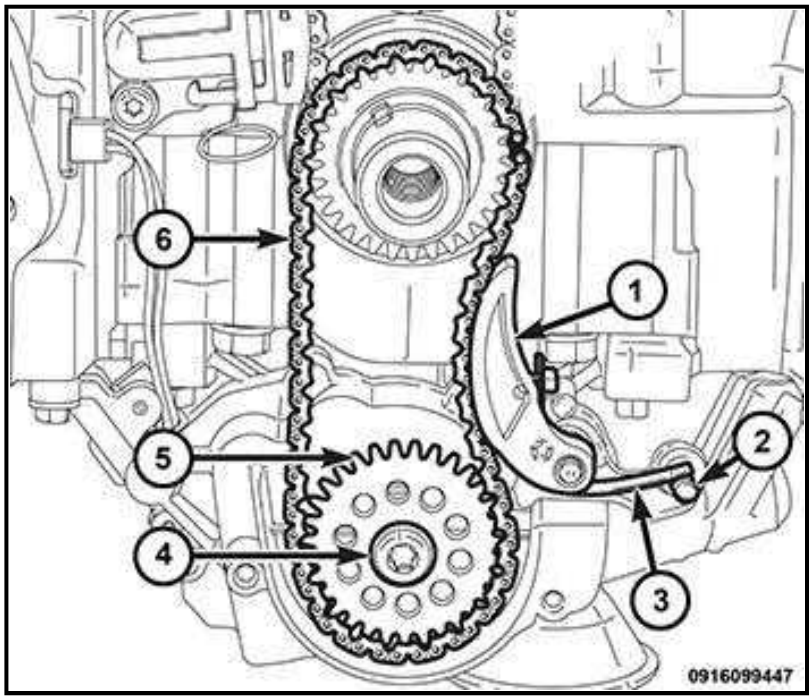
CAUTION: **Always reinstall timing chains so that they maintain the same direction of rotation. Inverting a previously run chain on a previously run sprocket will result in excessive wear to both the chain and sprocket.**

25. Drape the right side timing chain over the right side exhaust camshaft phaser and onto the idler sprocket so that the dimple is aligned with the plated link on the timing chain.



1 - Plated Links	5 - Cylinder Phaser Holder
2 - Oil Control Valve	6 - Cylinder Head Cover Mounting Surface
3 - Camshaft Phaser Arrow	7 - Oil Control Valve
4 - Scribe Line	B

26. While maintaining this alignment, route the camshaft chain around the exhaust and intake camshaft phasers so that the plated links are aligned with the phaser timing marks. Position the right side camshaft phasers so that the arrows point away from each other and the scribe lines are parallel to the cylinder head cover mounting surface. Press the intake camshaft phaser onto the intake camshaft, install and hand tighten the oil control valve.
27. Install the (special tool #2025102090, Holder, Camshaft Phaser - Right-Rear Cyl Head) (5) with the tool number facing up.
28. Tighten the oil control valves and to the proper torque specifications.
29. Remove the Camshaft Phaser Holder.

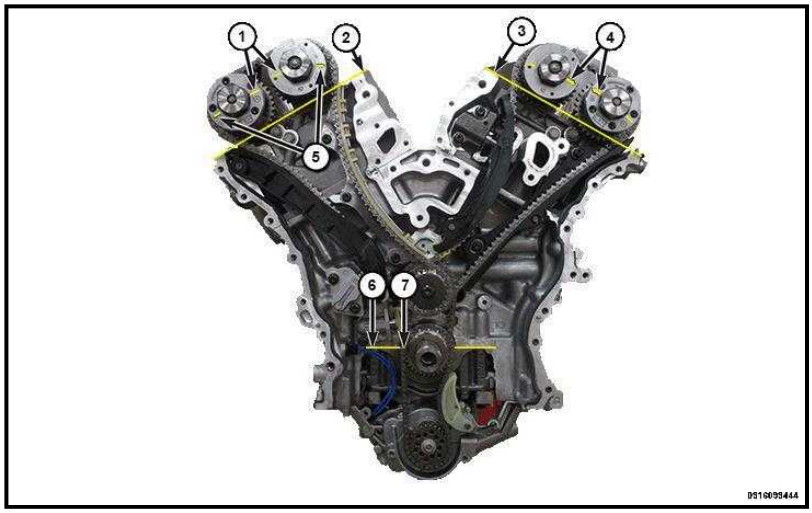


1 - Oil Pump Chain Tensioner	4 - Oil Pump Sprocket Bolt
2 - Dowel Pin	5 - Oil Pump Sprocket
3 - Spring	6 - Oil Pump Chain

NOTE: **There are no timing marks on the oil pump gear or chain.**

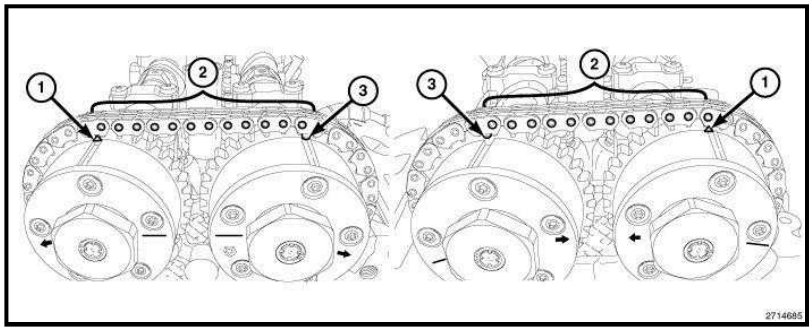
CAUTION: **Always reinstall timing chains so that they maintain the same direction of rotation. Inverting a previously run chain on a previously run sprocket will result in excessive wear to both the chain and sprocket.**

30. Place the oil pump sprocket into the oil pump chain. Place the oil pump chain onto the crankshaft sprocket while aligning the oil pump sprocket with the oil pump shaft. Install the oil pump sprocket retaining bolt and tighten to the proper torque specifications.
31. Install the oil pump chain tensioner. Insure that the spring is positioned above the dowel pin.



1 - Right Side Cam Phaser Scribe Lines	5 - Right Side Cam Phaser Arrows
2 - Right Cylinder Head Cover Mounting Surface	6 - Block/Main Bearing Cap Mating Surface
3 - Left Cylinder Head Cover Mounting Surface	7 - Crankshaft Dimple
4 - Left Side Cam Phaser Arrows	B

32. Remove the Tensioner Pins (special tool #8514A, Pins, Tensioner) from the right side and left side camshaft chain tensioners.
33. Remove the (special tool #2025200090, Holder, Camshaft) from the camshafts.
34. Rotate the crankshaft clockwise (as viewed from the front) two complete revolutions stopping when the dimple on the crankshaft is aligned with the block/bearing cap junction.
35. While maintaining this alignment, verify that the **ARROWS** on the left side camshaft phasers point toward each other and are parallel to the cylinder head cover mounting surface and that the right side camshaft phaser **ARROWS** point away from each other and the **SCRIBE LINES** are parallel to the cylinder head cover mounting surface.



1 - Exhaust Camshaft Phaser Triangle Markings
2 - Twelve Chain Pins
3 - Intake Camshaft Phaser Circle Markings

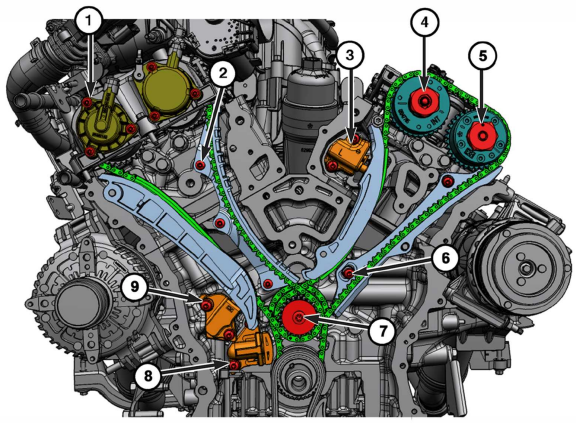
36. There should be 12 chain pins **BETWEEN** the exhaust cam phaser triangle marking and the intake camshaft phaser circle marking as viewed from either the front or rear of the camshaft phasers.
37. If the engine timing is not correct, repeat this procedure.
38. Install the engine timing cover. Refer to **COVER(S), ENGINE TIMING, REMOVAL AND INSTALLATION**.
39. If removed, install the oil pan. Refer to **PAN, OIL, REMOVAL AND INSTALLATION** .
40. Install the spark plugs. Refer to **SPARK PLUG, REMOVAL AND INSTALLATION** .
41. Fill the engine crankcase with the proper oil to the correct level. Refer to **CAPACITIES AND RECOMMENDED FLUIDS, SPECIFICATIONS** .
42. Fill the cooling system. Refer to **STANDARD PROCEDURE - FILLING** .

43. Operate the engine until it reaches normal operating temperature. Check cooling system for correct fluid level. Refer to the appropriate information .

NOTE: **The Cam/Crank Variation Relearn procedure must be performed using the scan tool anytime there has been a repair/replacement made to a powertrain system, for example: flywheel, valvetrain, camshaft and/or crankshaft sensors or components.**

TORQUE SPECIFICATIONS

VALVE TIMING



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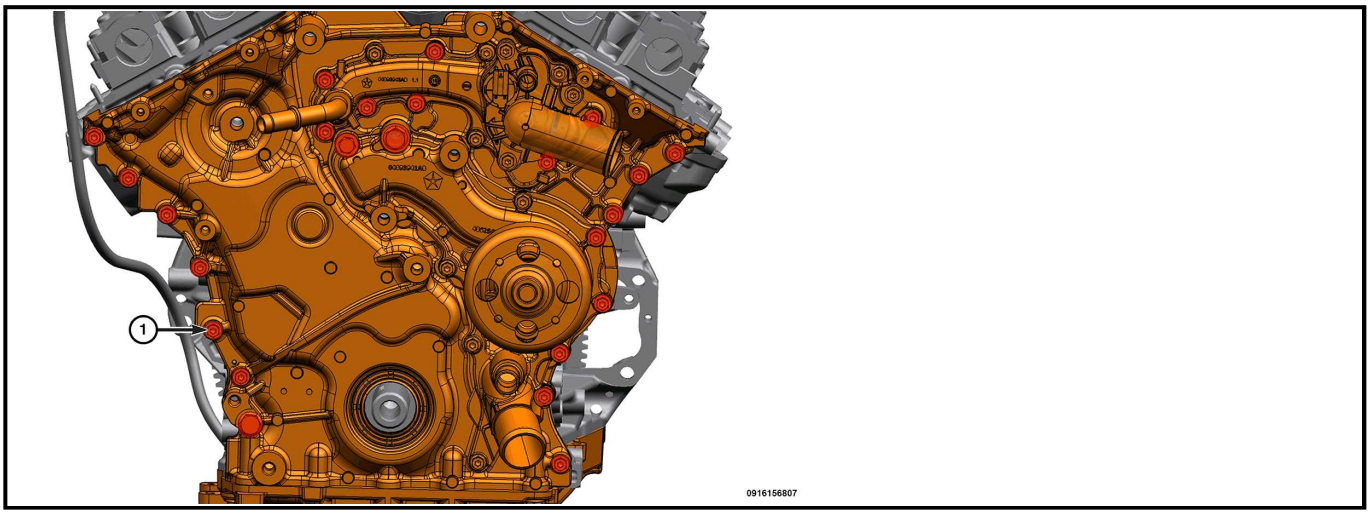
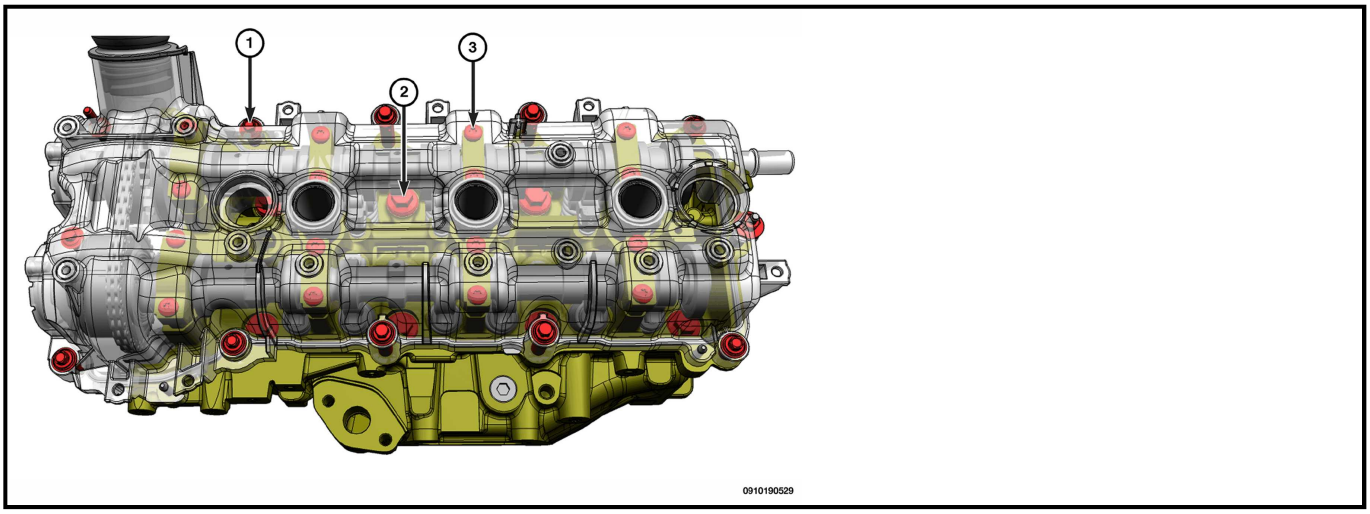
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

FRONT ENGINE

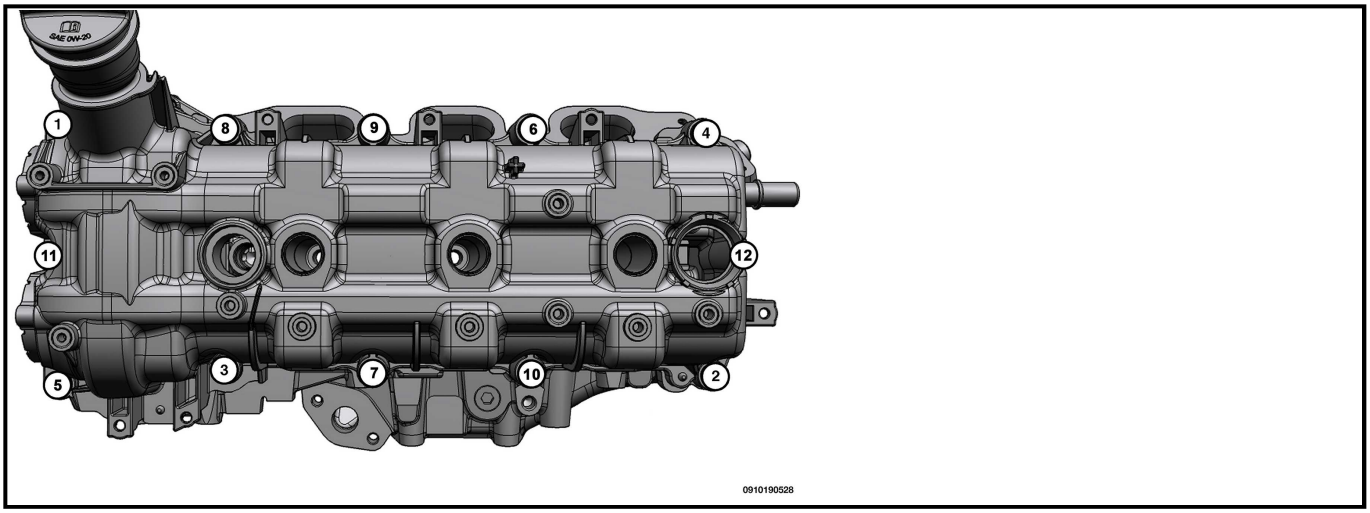
DESCRIPTION	SPECIFICATION	COMMENTS
Center Idler Pulley Bracket Bolts	**M8 Bolts - 25 N.m (18 Ft. Lbs.)** **M10 Bolts - 55 N.m (41 Ft. Lbs.)**	-
Center Idler Pulley Bracket to Generator Bolts	**24 N.m (18 Ft. Lbs.)**	-
Center Idler Pulley Bolt	**50 N.m (37 Ft. Lbs.)**	-
Left Idler Pulley Bolt	**25 N.m (18 Ft. Lbs.)**	-
Right Idler Pulley Bracket Bolts	**24 N.m (18 Ft. Lbs.)**	-
Right Idler Pulley Bolt	**25 N.m (18 Ft. Lbs.)**	-
Vibration Damper M16 Bolt	**Torque Procedure:** 1. **40 N.m (30 Ft. Lbs.)** 2. **Rotate additional + 105B°**	-
Belt Tensioner Bolt	**50 N.m (37 Ft. Lbs.)**	-
Engine Timing Cover M6 Bolts Engine Timing Cover M8 Bolt Engine Timing Cover M10 Bolts	**12 N.m (9 Ft. Lbs.)** **25 N.m (18 Ft. Lbs.)** **55 N.m (41 Ft. Lbs.)**	**Tighten in a criss-cross pattern**



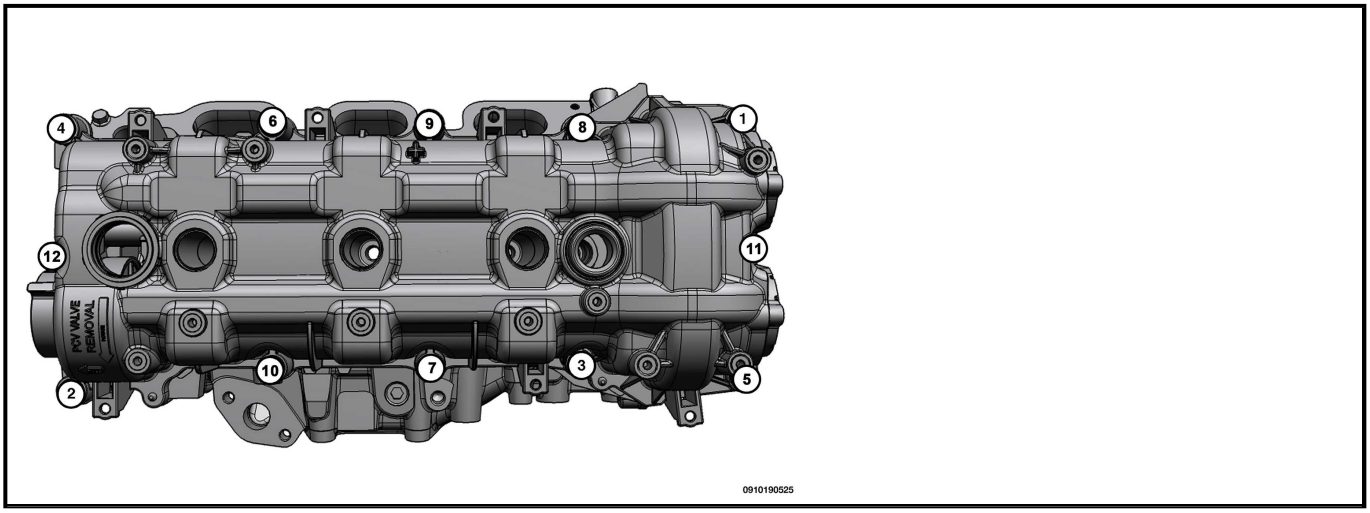
CYLINDER HEAD



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Cylinder Head Cover M6 Bolts	**12 N.m (9 Ft. Lbs.)**	Tightening Sequence - Left
2	Cylinder Head Bolts	**Torque Procedure** For engine builds using a new block follow steps 1-9. For engine re-builds (reuse block) follow step 6-9. 1. 30 N. m (22 ft. lbs.) 2. 45 N. m (33 ft. lbs.) 3. Re-tighten all to 45 N. m (33 ft. lbs.) 4. All + 125B° Turn. Do not use a torque wrench for this step. 5. Loosen all fasteners in reverse of sequence shown 6. All to 30 N. m (22 ft. lbs.) 7. All to 45 N. m (33 ft. lbs.) 8. Re-tighten all to 45 N. m (33 ft. lbs.) 9. All + 130B° Turn. Do not use a torque wrench for this step.	Tightening Sequence - Left
3	Camshaft Bearing Cap Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence - Left
-	Cylinder Head Coolant Pipe Plug	**35 N.m (26 Ft. Lbs.)**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
-	Cylinder Head Oil Galley Plug	**18 N.m (13 Ft. Lbs.)**	-
-	Cylinder Head Oil Restrictor M8 Plug	**15 N.m (11 Ft. Lbs.)**	-
-	Ground Strap Bolt to Right Cylinder Head	**23 N.m (17 Ft. Lbs.)**	-
-	Heater Core Supply Tube to Cylinder Head M8 Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Wire Harness Retainer Bracket to LH Cylinder Head Bolts	**10 N.m (89 In. Lbs.)**	-



Tightening Sequence - Right



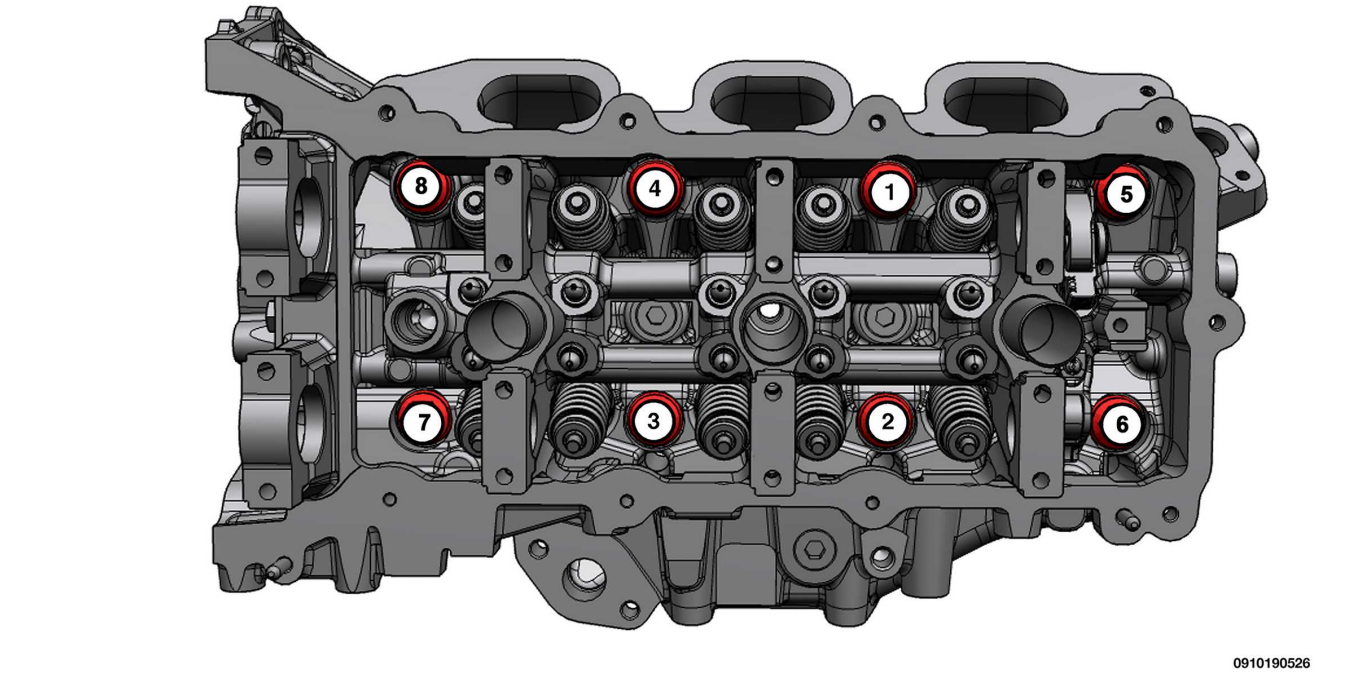
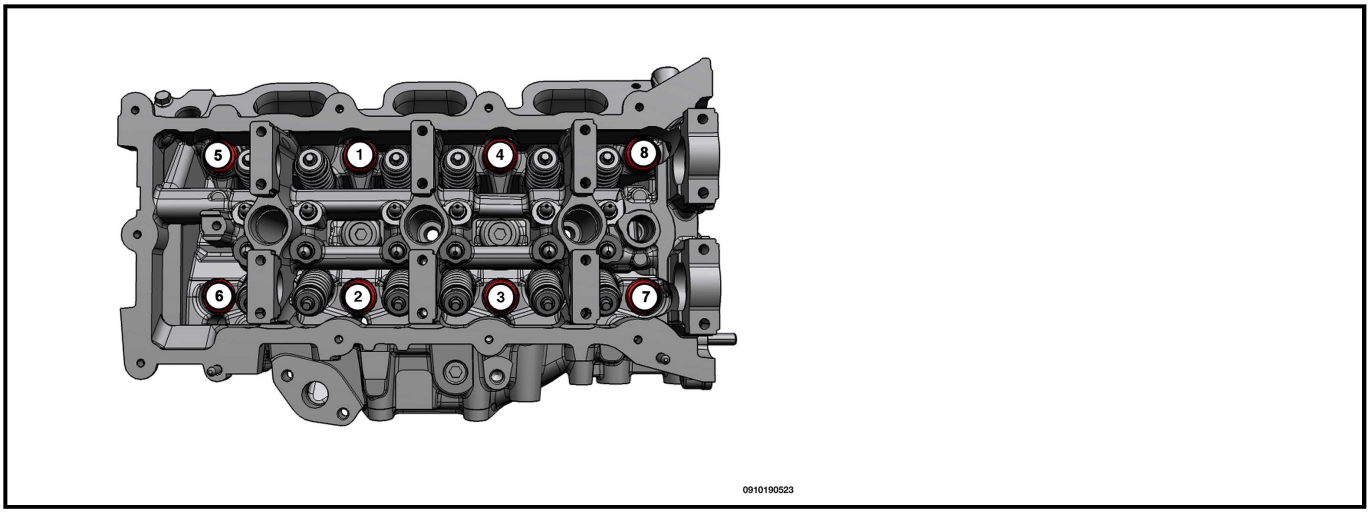
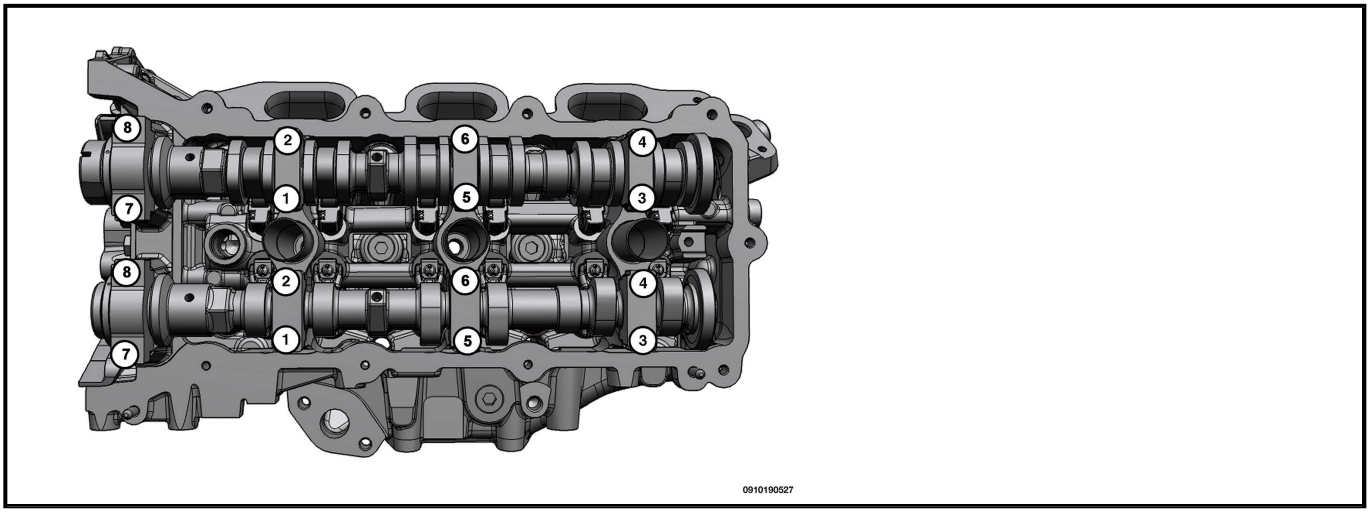


Fig. 1: Cylinder Head Bolts Tightening Sequence (1 of 2)
Courtesy of CHRYSLER GROUP, LLC

Tightening Sequence - Right





Tightening Sequence - Right

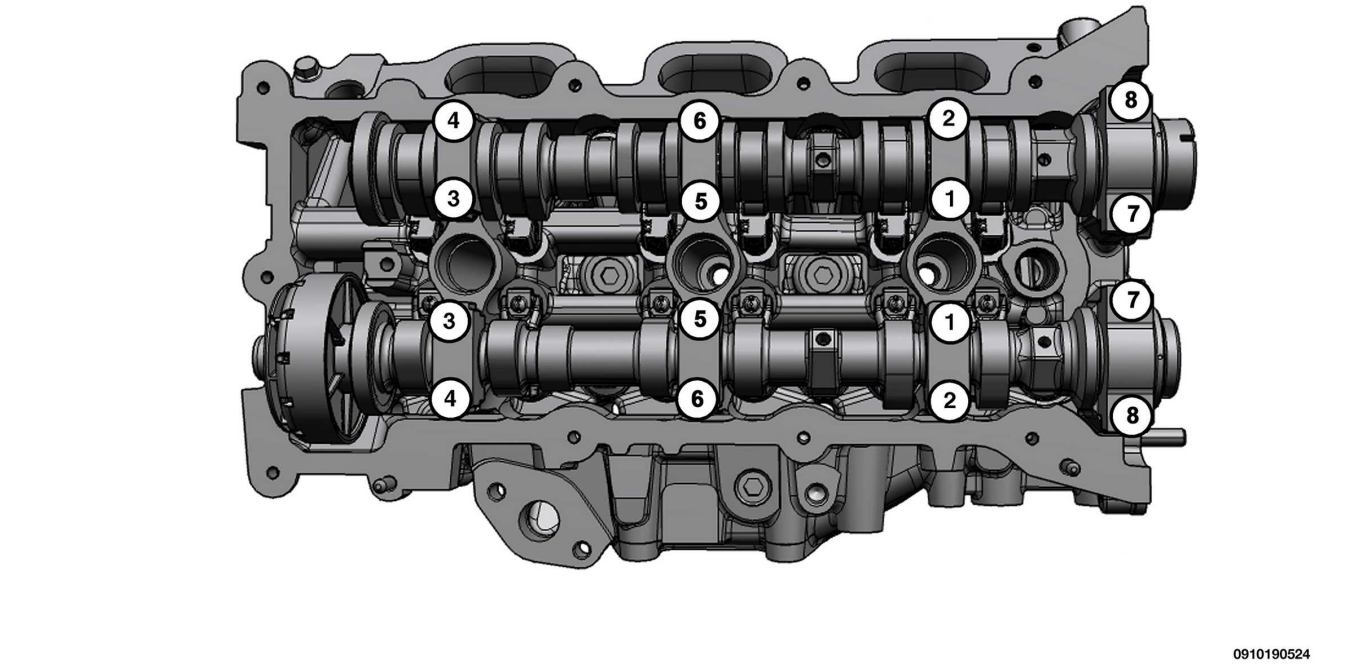


Fig. 2: Camshaft Bearing Cap Bolts Tightening Sequence (2 of 2)
Courtesy of CHRYSLER GROUP, LLC

COVER(S), ENGINE TIMING

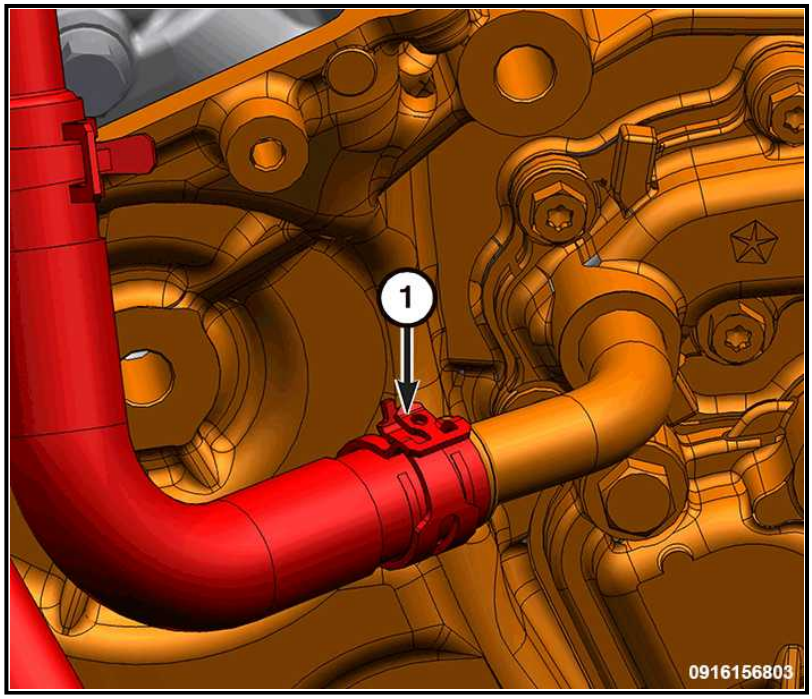
REMOVAL AND INSTALLATION

ENGINE TIMING COVER

REMOVAL

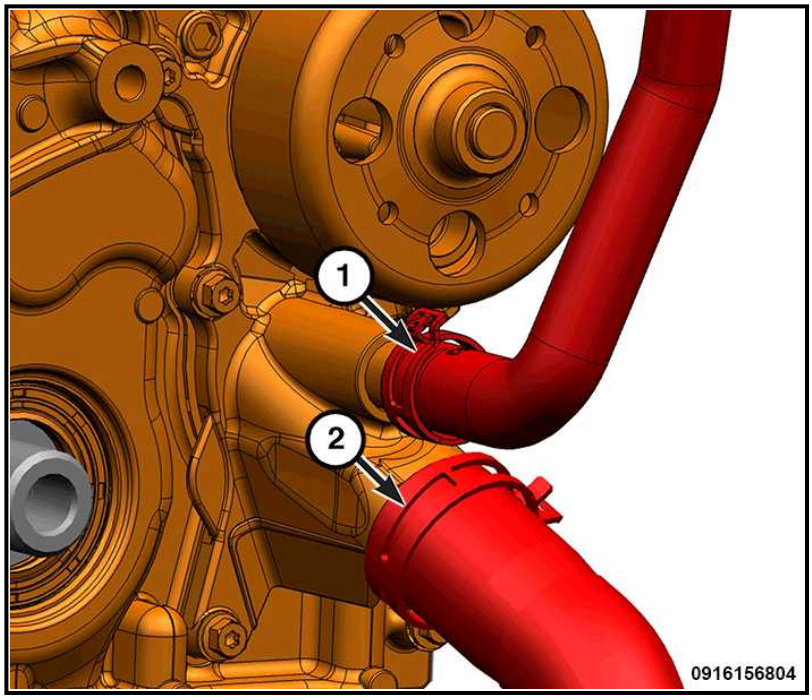
NOTE: **It is NOT necessary to remove the water pump, thermostat or the coolant outlet housing for engine timing cover removal. These components only need to be removed if replacing the timing cover.**

1. Remove the left and right cylinder head covers. Refer to **COVER(S), CYLINDER HEAD, REMOVAL AND INSTALLATION** .
2. Remove the accessory drive belt tensioner. Refer to **TENSIONER, BELT, REMOVAL AND INSTALLATION** .
3. Remove the idler pulleys. Refer to **PULLEY, IDLER, REMOVAL AND INSTALLATION** .
4. Remove the crankshaft vibration damper. Refer to **DAMPER, VIBRATION, REMOVAL AND INSTALLATION** .
5. Drain the cooling system. Refer to **DRAINING** .



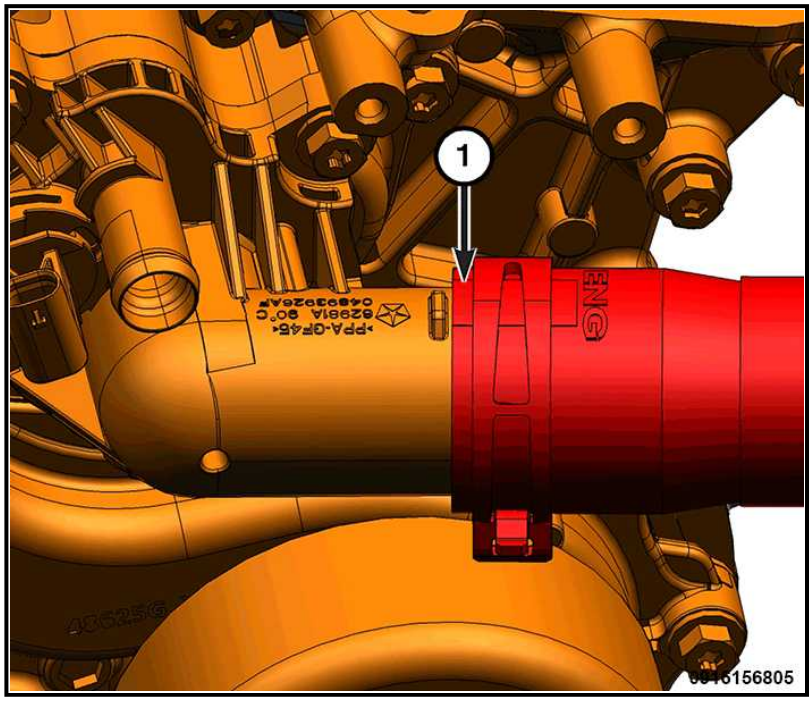
1 - Heater Core Supply Hose

6. Remove the heater core supply hose from the coolant crossover.



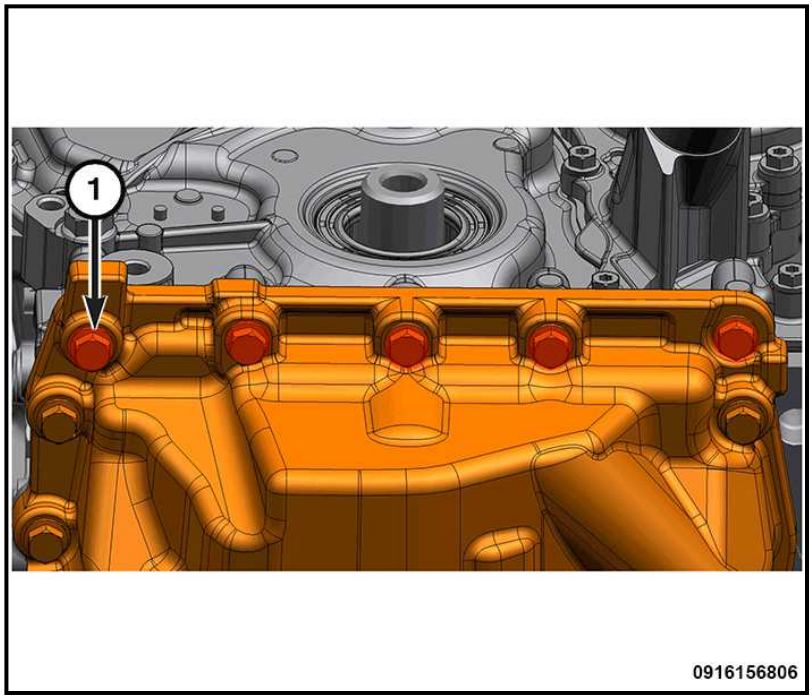
1 - Return Hose
2 - Lower Radiator Hose

7. Remove the return hose from the water pump.
8. Remove the lower radiator hose from the water pump.



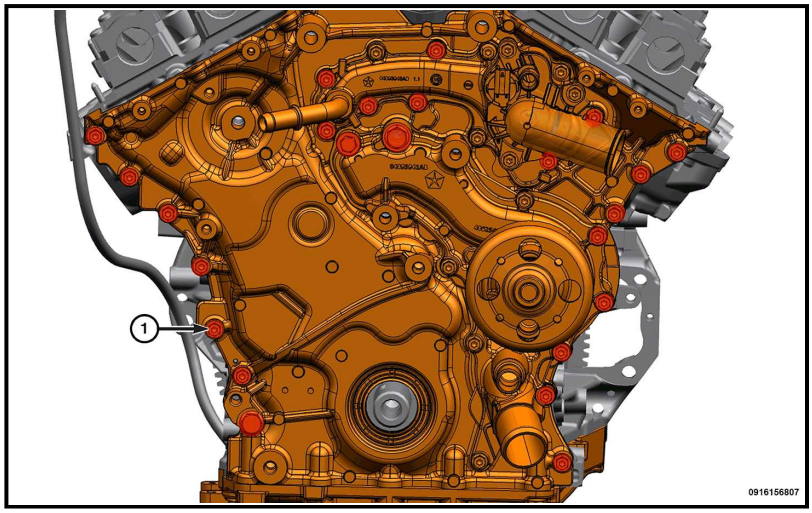
1 - Upper Radiator Hose

9. Remove the upper radiator hose from the thermostat housing.



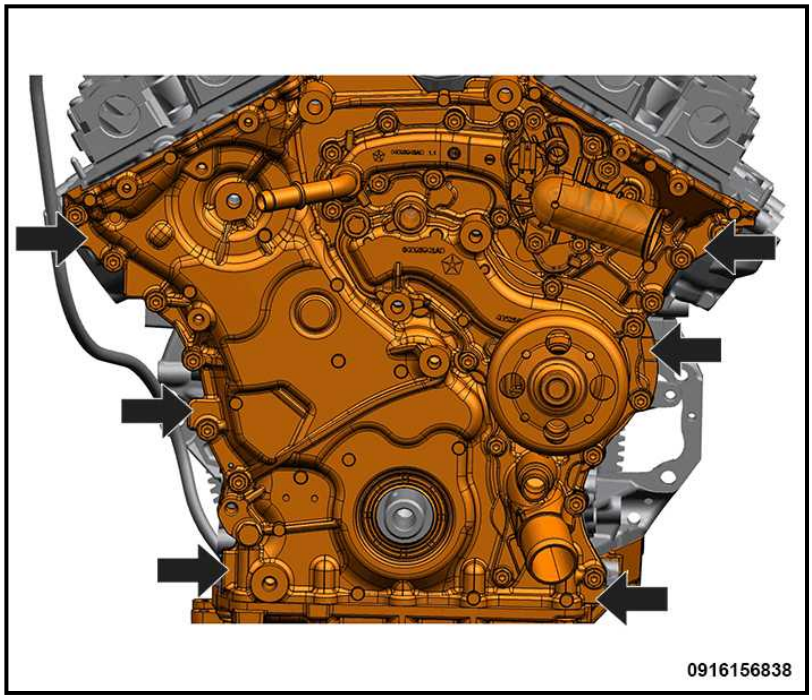
1 - Front Oil Pan to Timing Cover Bolts

10. Remove the five front oil pan to timing cover bolts.



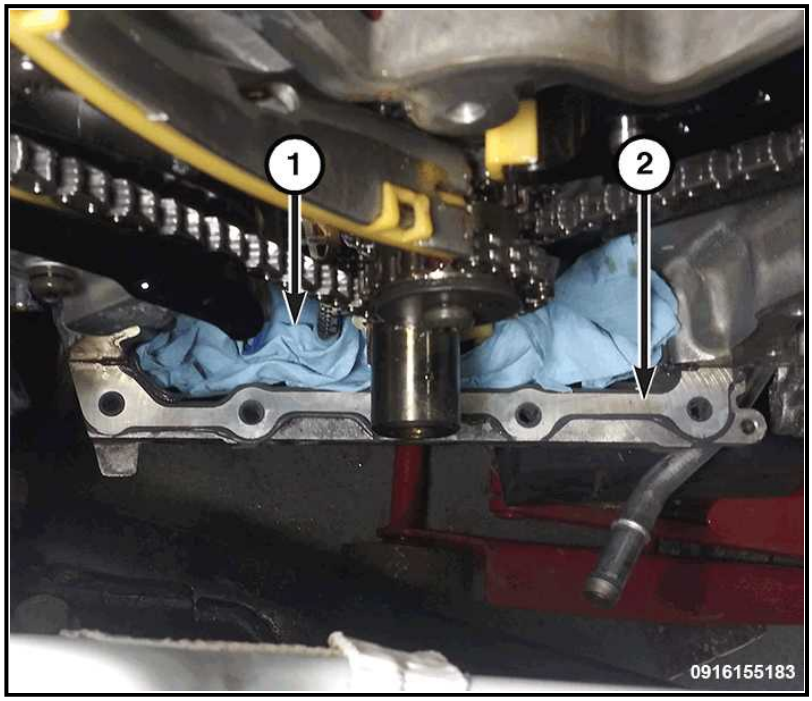
1 - Timing Cover Bolts

11. Remove the bolts from the timing cover.



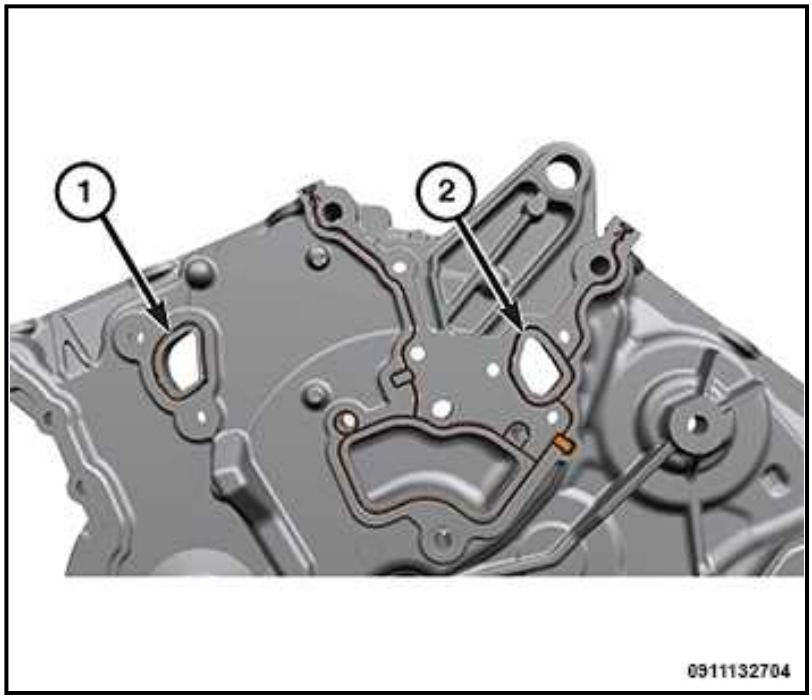
12. Using the indicated pry points, carefully remove the timing cover.

NOTE: **If necessary, the use of a heat gun may assist in removing the timing cover.**



1 - Shop Cloth
2 - Oil Pan to Engine Block Mating Surface

13. Insert a shop cloth into the front opening of the oil pan and remove all residual sealant from the oil pan and engine block mating surfaces. Refer to **CLEANING** .



1 - Coolant Crossover Gasket
2 - Water Pump Gasket

14. Remove and discard the coolant crossover gasket and the water pump gasket.

INSPECTION:

- If necessary, measure the timing chain wear. Refer to **MEASURING TIMING CHAIN WEAR** .

CLEANING:

CAUTION: **Do not use oil based liquids, wire brushes, abrasive wheels or metal scrapers to clean the engine gasket surfaces. Use only isopropyl (rubbing) alcohol, along with plastic or wooden scrapers. Improper gasket surface preparation may result in engine fluid leakage.**

- Remove all residual sealant from the timing chain cover, cylinder head and engine block mating surfaces. Refer to **CLEANING** .
- Clean the engine timing cover, cylinder head and block mating surfaces with isopropyl alcohol in preparation for sealant application. Refer to **CLEANING** .

INSTALLATION

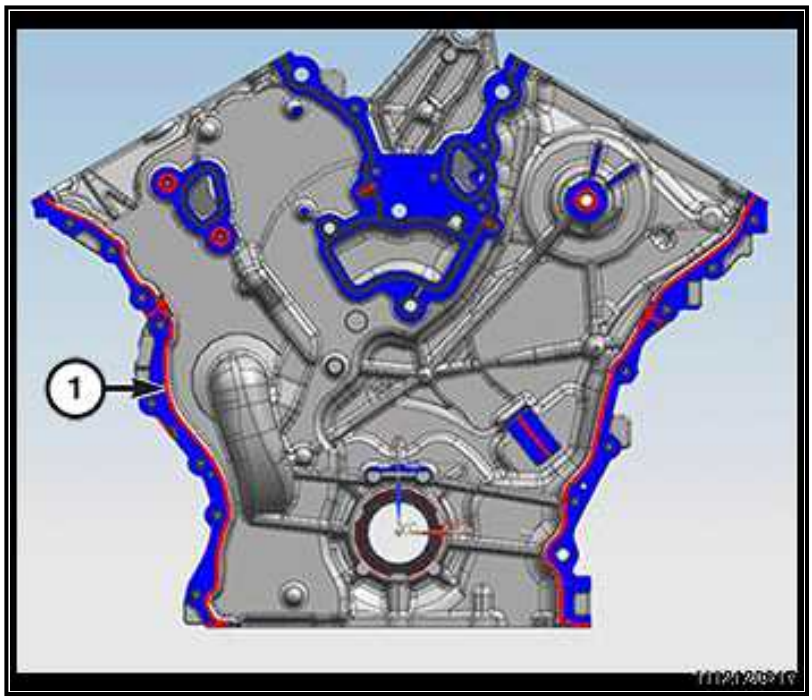
During installation, torque the fasteners to the specifications in the torque table(s) below.

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.

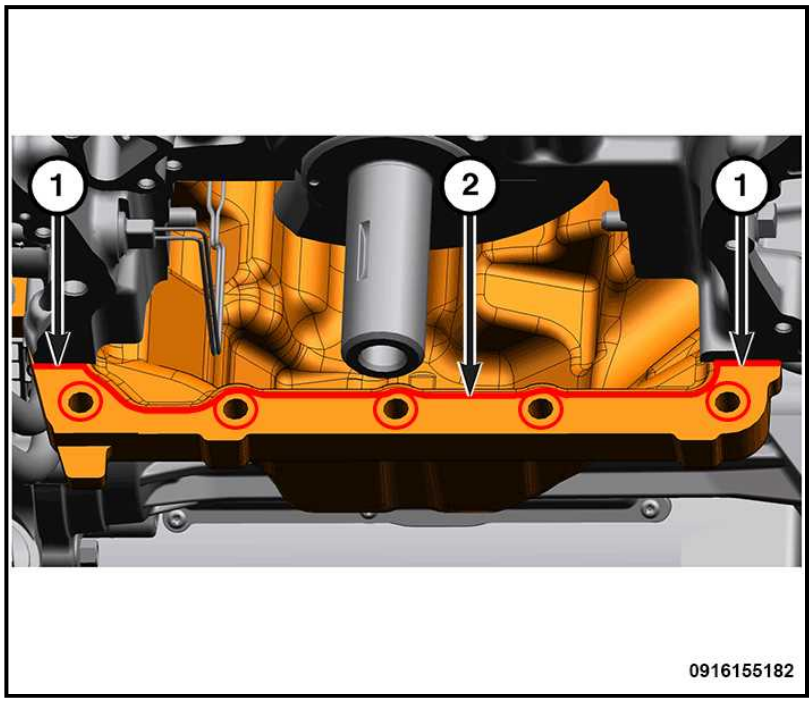
CAUTION: **Engine assembly requires the use of a unique sealant that is compatible with engine oil. Using a sealant other than MoparB® Threebond Engine RTV Sealant may result in engine fluid leakage.**

CAUTION: **Following the application of MoparB® Threebond Engine RTV Sealant to the gasket surfaces, the components must be assembled within 10 minutes and the attaching fasteners must be tightened to specification within 45 minutes. Prolonged exposure to the air prior to assembly may result in engine fluid leakage.**

- After cleaning all surfaces, remove the shop cloth prior to timing cover installation.

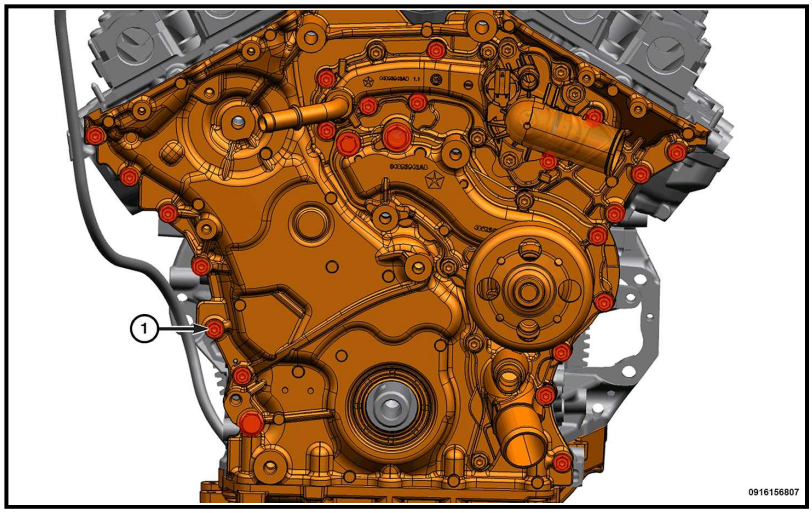


- Apply a 3 to 4 mm wide bead (1) of MoparB® Threebond Engine RTV Sealant to the front cover as shown in red.



1 - T-joints
2 - Oil Pan Surface

- Apply a 3 to 4 mm wide bead of MoparB® Threebond Engine RTV Sealant to the front of the oil pan and T-joints as shown.

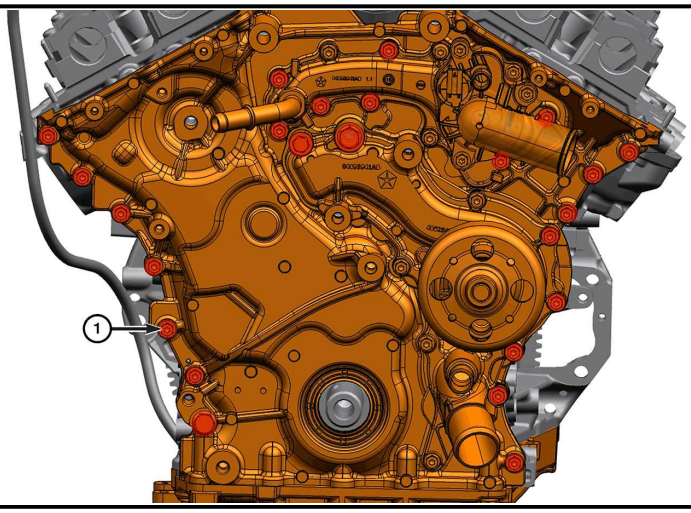


- Keeping the timing cover in a vertical position with a slight outward tip at the top of the timing cover, load the timing cover at the bottom, along the oil pan and rock the top of the timing cover into place, being extremely careful not to wipe or disturb the MoparB® Threebond Engine RTV Sealant pattern.
- The timing cover bolts must be tightened in a crisscross pattern.
- Install a **NEW** oil filter and replace the engine oil. Refer to **ENGINE OIL AND FILTER CHANGE** .
- Fill the cooling system. Refer to **STANDARD PROCEDURE - FILLING** .

TORQUE SPECIFICATIONS

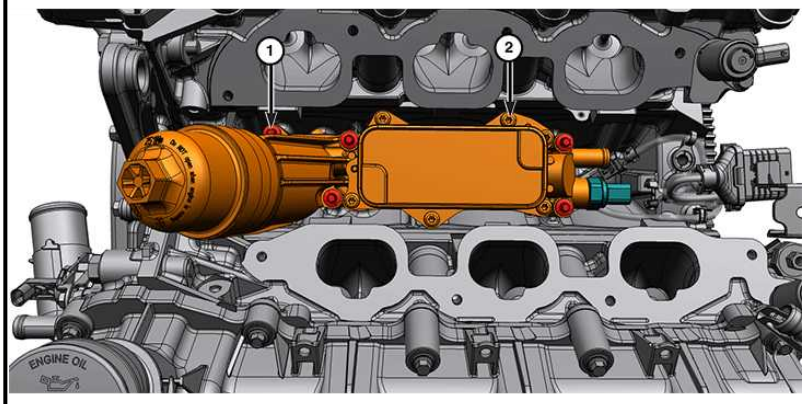
FRONT ENGINE

DESCRIPTION	SPECIFICATION	COMMENTS
Center Idler Pulley Bracket Bolts	**M8 Bolts - 25 N.m (18 Ft. Lbs.)** **M10 Bolts - 55 N.m (41 Ft. Lbs.)**	-
Center Idler Pulley Bracket to Generator Bolts	**24 N.m (18 Ft. Lbs.)**	-
Center Idler Pulley Bolt	**50 N.m (37 Ft. Lbs.)**	-
Left Idler Pulley Bolt	**25 N.m (18 Ft. Lbs.)**	-
Right Idler Pulley Bracket Bolts	**24 N.m (18 Ft. Lbs.)**	-
Right Idler Pulley Bolt	**25 N.m (18 Ft. Lbs.)**	-
Vibration Damper M16 Bolt	**Torque Procedure:** 1. **40 N.m (30 Ft. Lbs.)** 2. **Rotate additional + 105B°**	-
Belt Tensioner Bolt	**50 N.m (37 Ft. Lbs.)**	-
Engine Timing Cover M6 Bolts Engine Timing Cover M8 Bolt Engine Timing Cover M10 Bolts	**12 N.m (9 Ft. Lbs.)** **25 N.m (18 Ft. Lbs.)** **55 N.m (41 Ft. Lbs.)**	**Tighten in a criss-cross pattern**

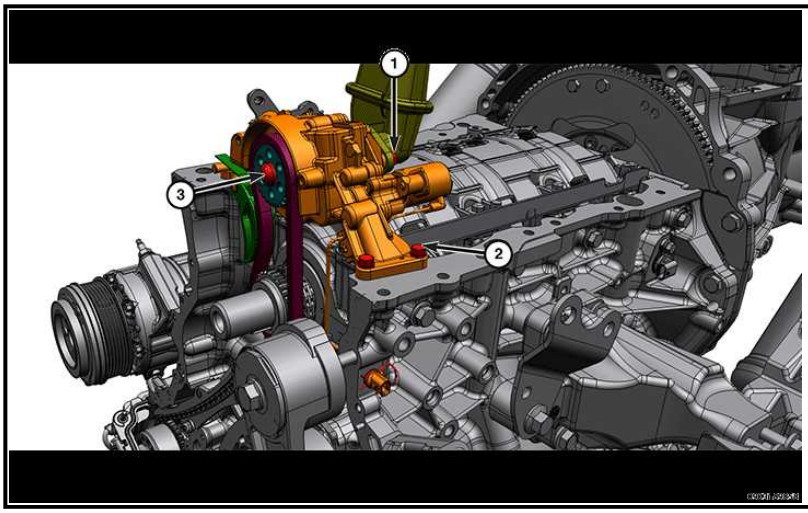


LUBRICATION

DESCRIPTION	SPECIFICATION	COMMENTS
Upper Oil Pan to Engine Block M8 Bolts	**23 N.m (17 Ft. Lbs.)**	-
Lower Oil Pan to Upper Oil Pan - M6 Bolts	**9 N.m (80 In. Lbs.)**	-
Lower Oil Pan to Upper Oil Nuts	**10 N.m (89 In. Lbs.)**	-
Upper Oil Pan to Rear Seal Retainer M6 Bolts	**10 N.m (89 In. Lbs.)**	-
Oil Pan Drain Plug	**27 N.m (20 Ft. Lbs.)**	-
Oil Level Indicator to Cylinder Head Bolt	**18 N.m (13 Ft. Lbs.)**	-



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Oil Filter Housing/Oil Cooler to Engine Block M6 Bolts	**12 N.m (9 Ft. Lbs.)**	-
2	Oil Cooler to Oil Filter Housing Screws	**12 N.m (9 Ft. Lbs.)**	-
-	Oil Filter Housing Cap	**25 N.m (18 Ft. Lbs.)**	-



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Oil Pump Pick Up Tube to Oil Pump M6 Bolt	**8 N.m (71 In. Lbs.)**	-
-	Oil Pump Pick Up Tube Bracket to Windage Tray Bolt	**8 N.m (80 In. Lbs.)**	-
2	Oil Pump to Engine Block M6 Bolts	**12 N.m (9 Ft. Lbs.)**	-
3	Oil Pump Sprocket M8 Bolt	**26 N.m (18 Ft. Lbs.)**	-

PHASER, CAMSHAFT

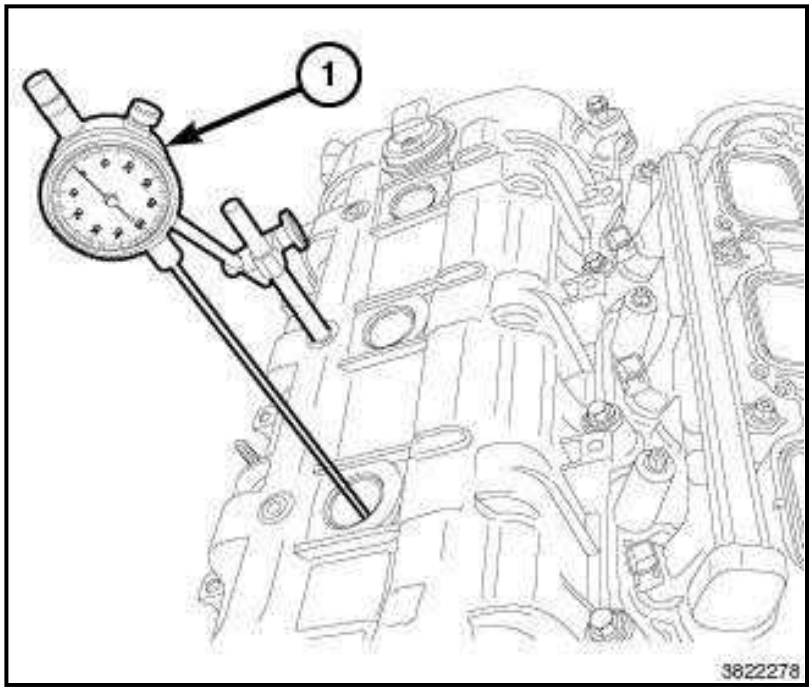
REMOVAL AND INSTALLATION

LEFT CAM PHASER

REMOVAL

NOTE: **The magnetic timing wheels must not come in contact with magnets (pickup tools, trays, etc.) or any other strong magnetic field. This will destroy the timing wheels ability to correctly relay camshaft position to the camshaft position sensor.**

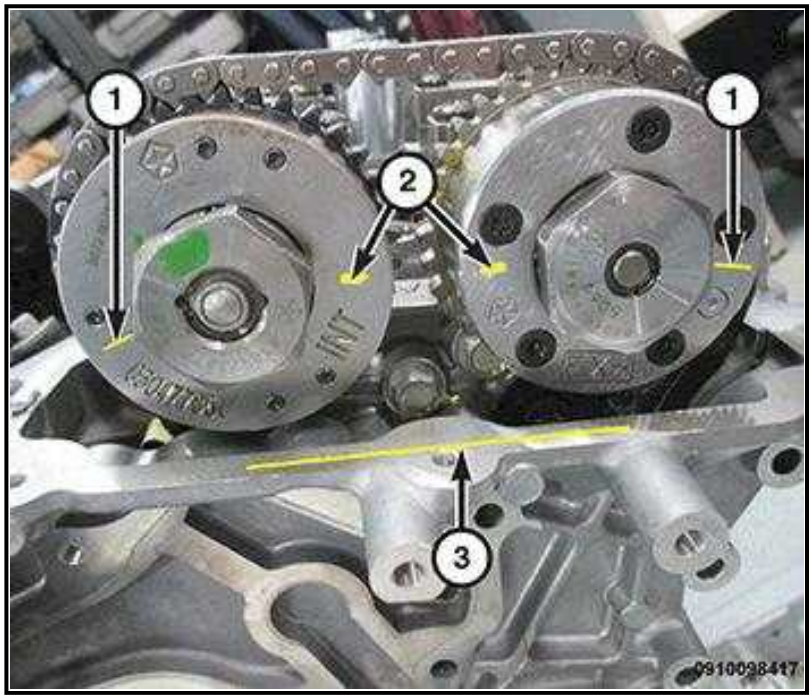
1. Remove the left cylinder head cover. Refer to **COVER(S), CYLINDER HEAD, REMOVAL AND INSTALLATION** .
2. Remove the right side spark plugs. Refer to **SPARK PLUG, REMOVAL AND INSTALLATION** .



1 - Dial Indicator

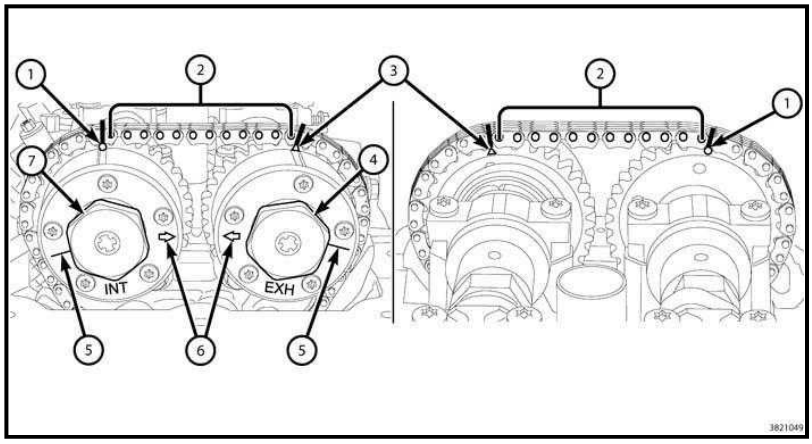
CAUTION: **When aligning timing marks, always rotate engine by turning the crankshaft. Failure to do so will result in valve or piston damage.**

3. Mount the Dial Indicator Set (special tool #C-3339A, Set, Dial Indicator) to a stationary point on the engine, such as the number three cylinder ignition coil mount. Position the indicator probe into the number one cylinder, rotate the crankshaft clockwise (as viewed from the front) to place the number one cylinder piston at top-dead-center on the exhaust stroke and set the indicator dial to zero.



1 - Left Side Cam Phaser Scribe Lines
2 - Left Side Cam Phaser Arrows
3 - Cylinder Head Cover Mounting Surface

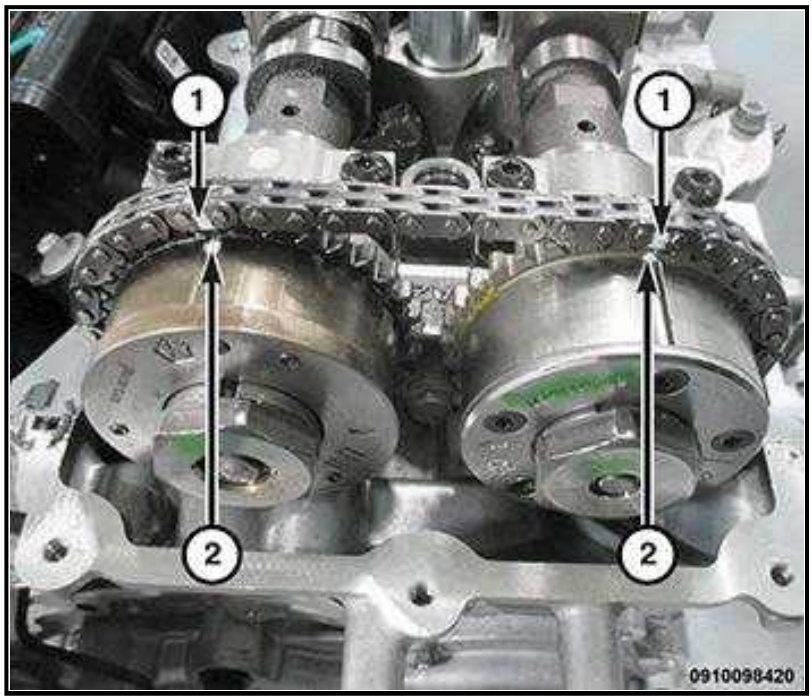
4. The left side cam phaser **SCRIBE LINES** should face away from each other and the **ARROWS** should point toward each other and be parallel to the cylinder head cover mounting surface when the number one cylinder piston is positioned at top-dead-center on the exhaust stroke.



1 - Left Side Intake Cam Phaser Timing Mark	5 - Left Side Cam Phaser Scribe Lines
2 - Showing 12 Timing Chain Pins between Cam Phaser Marks	6 - Left Side Cam Phaser Arrows
3 - Left Side Exhaust Cam Phaser Timing Mark	7 - Intake Phaser Oil Control Valve
4 - Exhaust Phaser Oil Control Valve	B

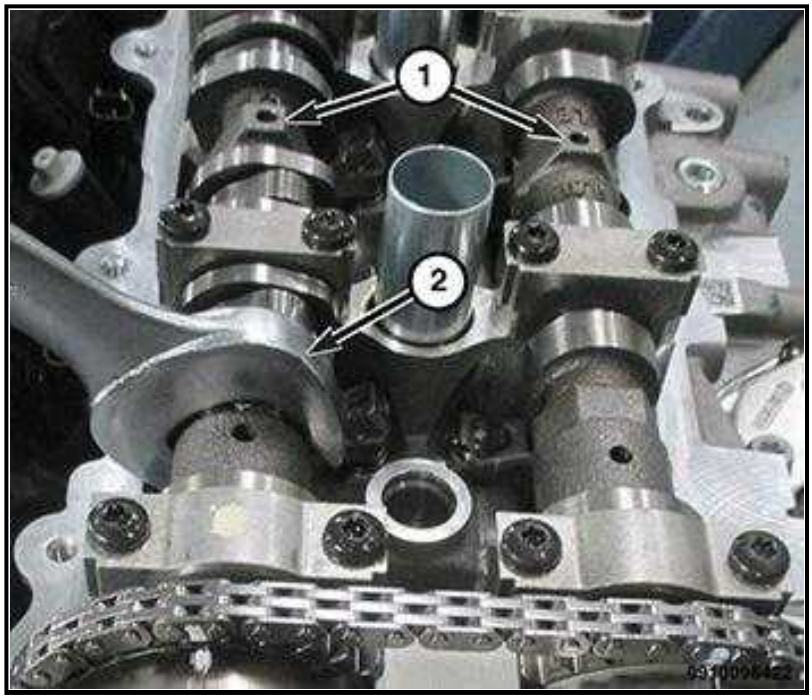
NOTE: **The cam phaser timing markings could align with either an external or internal chain link. Either alignment is acceptable as long as there are twelve chain pins between the markings.**

5. There should be twelve chain pins **BETWEEN** the exhaust cam phaser mark and the intake cam phaser mark as viewed from either the front or rear of the cam phasers.



1 - Timing Chain Marks (Made With Paint Pen)
2 - Left Side Cam Phaser Timing Marks

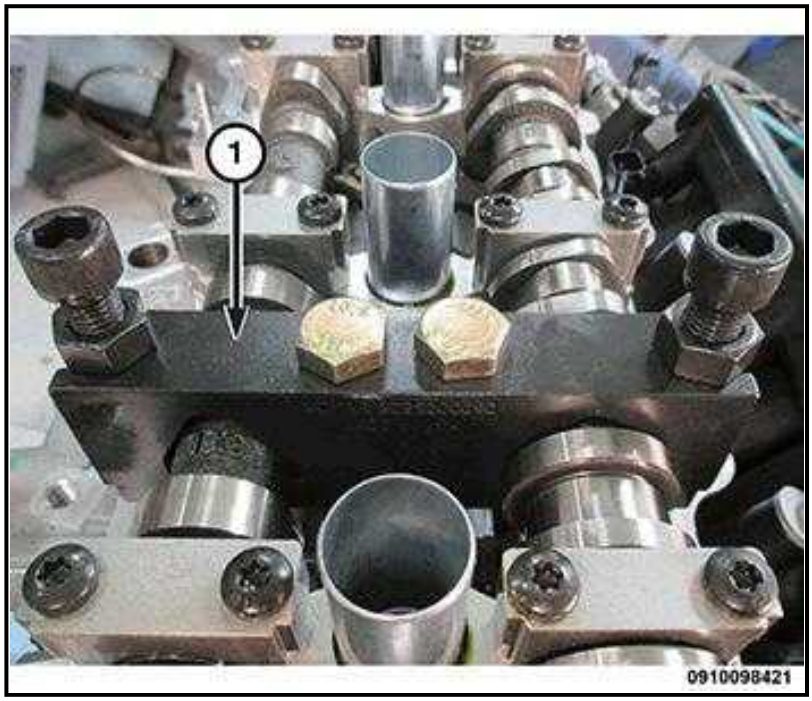
6. Mark both sides of the cam chain at the phaser timing marks using a paint pen or equivalent to aid in reassembly.



1 - Camshaft Alignment Holes
2 - Wrench

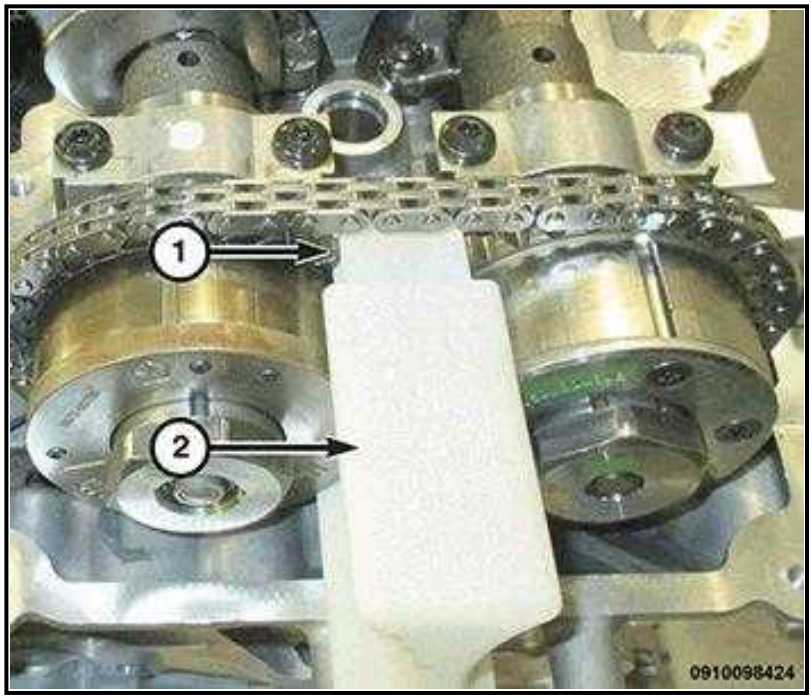
7. The camshafts should be at top-dead-center, with the alignment holes positioned vertically.

NOTE: **It may be necessary to rock the camshaft slightly (a few degrees) with a wrench when installing the camshaft holder.**



1 - Camshaft Holder Tool

8. Install the (special tool #2025200090, Holder, Camshaft).



1 - Left Camshaft Phaser Holder Mounted Between Intake and Exhaust Phasers
2 - Left Camshaft Phaser Holder

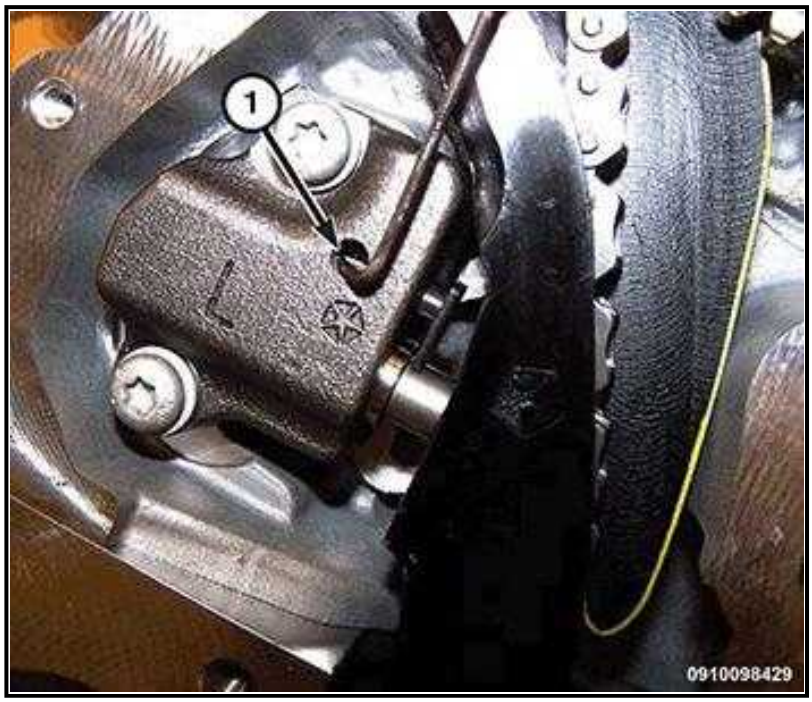
9. Install the (special tool #2025101090, Holder, Camshaft Phaser - Left-Front Cyl Head) against the cylinder head cover mounting surface between the intake and exhaust phasers, with the tool number facing up.

1 - Left Exhaust Phaser Oil Control Valve

10. Loosen, but do not remove, the exhaust oil control valve.

1 - Left Intake Phaser Oil Control Valve

11. Loosen, but do not remove, the intake oil control valve.
12. Remove the (special tool #2025101090, Holder, Camshaft Phaser - Left-Front Cyl Head), leaving the Camshaft Holder in place.



1 - Chain Tensioner Pin

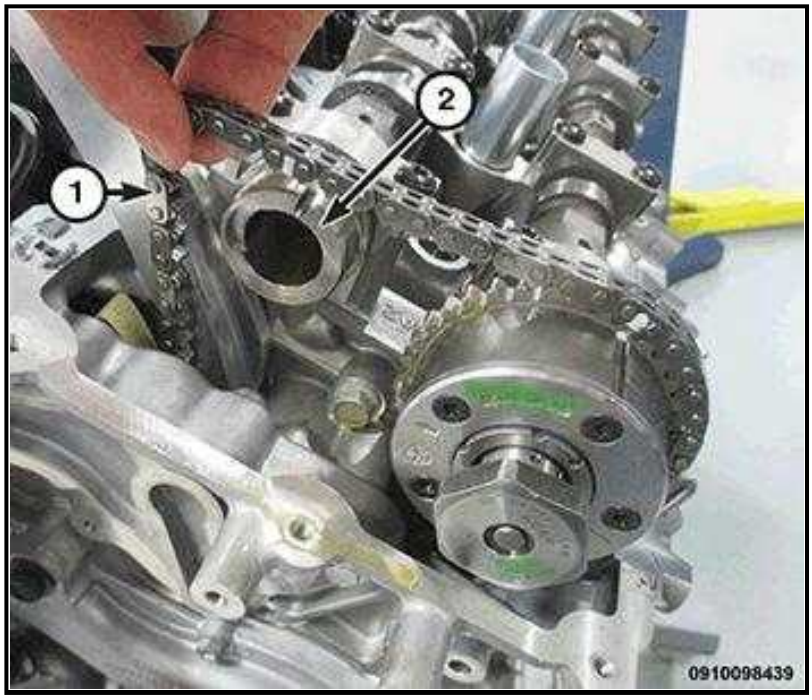
13. Using the (special tool #2025003090, Pin, Chain Tensioner), lift the pawl off of the rack.

1 - Timing Chain Tensioner Holder
2 - Chain Tensioner Pin

14. While holding the pawl off of the rack, push the (special tool #2025001090, Holder, Timing Chain Tensioner, Left-Front) into place between the cylinder head and the cam chain guide to force the rack and piston back into the tensioner body. The holder remains in place while the phasers are removed. Refer to **STANDARD PROCEDURE** .

1 - Camshaft
2 - Timing Chain

15. Remove the oil control valve and pull the left side exhaust cam phaser off of the camshaft while supporting the timing chain.

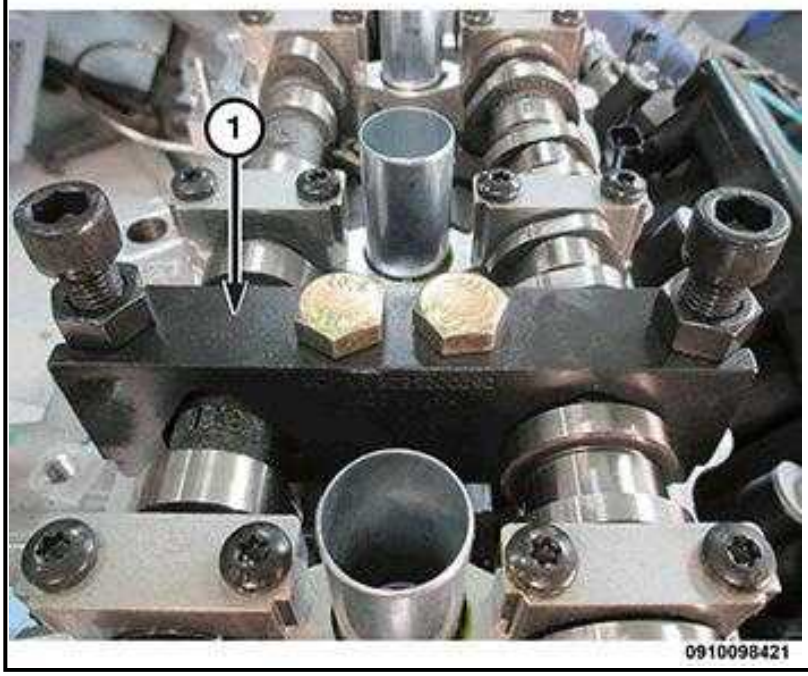


1 - Timing Chain
2 - Camshaft

16. Remove the oil control valve and pull the left side intake cam phaser off of the camshaft while supporting the timing chain.

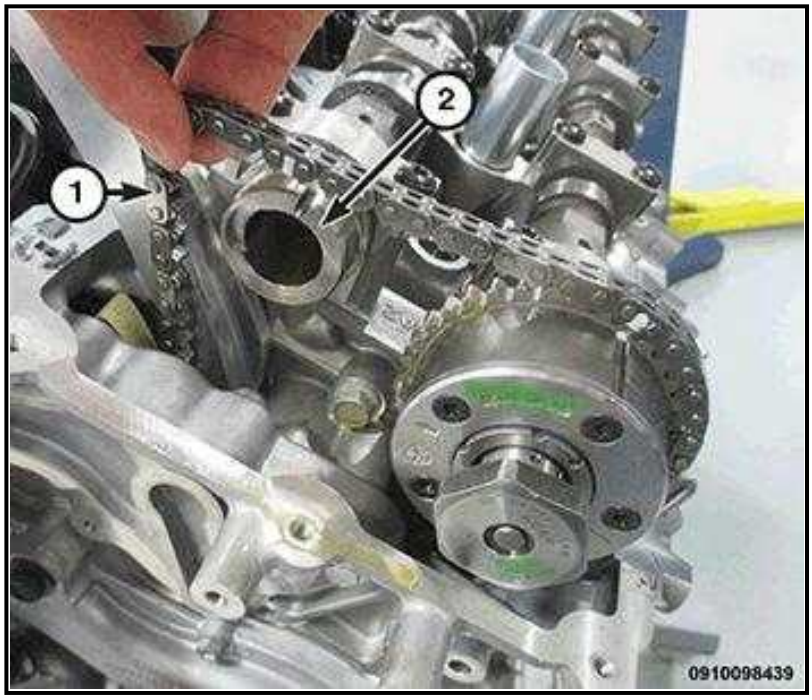
INSTALLATION

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



1 - Camshaft Holder Tool

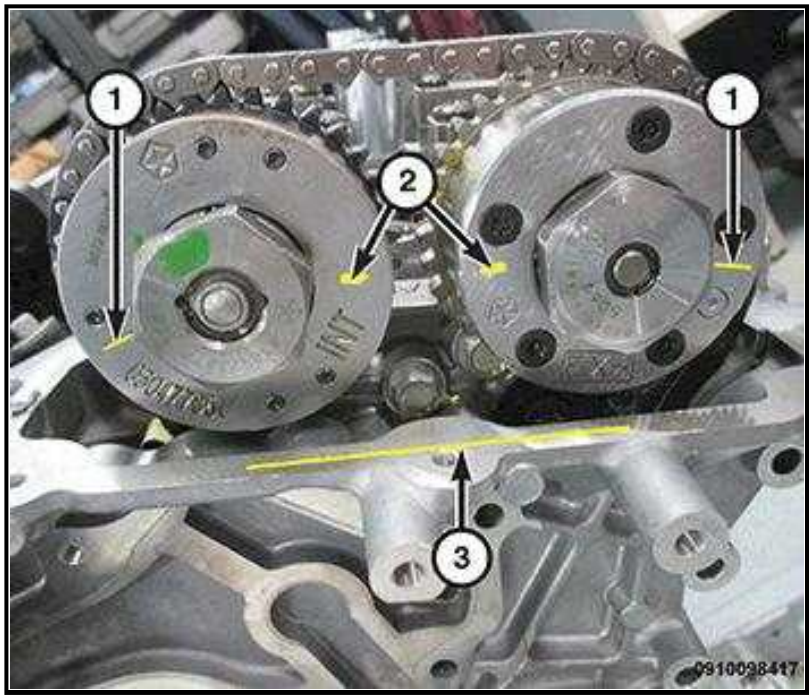
1. The Timing Chain Tensioner Holder and Camshaft Holder should still be in place as installed during the removal procedure. If required, the Timing Chain Tensioner Holder and Camshaft Holder can be installed by repeating the steps within the removal procedure. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION**.



1 - Timing Chain
2 - Camshaft

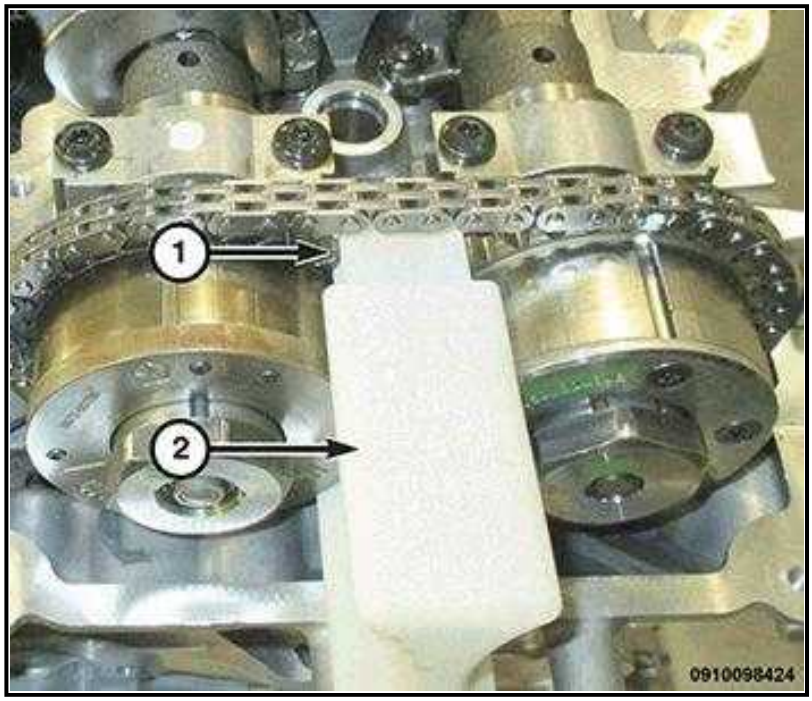
1 - Camshaft
2 - Timing Chain

2. Route the timing chain around the left intake cam phaser while aligning the paint mark with the phaser timing mark. Press the left intake cam phaser onto the intake camshaft. Install and hand tighten the oil control valve.
3. While maintaining this alignment, route the timing chain around the exhaust cam phaser so that the paint mark is aligned with the phaser timing mark. Press the exhaust cam phaser onto the exhaust cam, install and hand tighten the oil control valve.



1 - Left Side Cam Phaser Scribe Lines
2 - Left Side Cam Phaser Arrows
3 - Cylinder Head Cover Mounting Surface

4. The **SCRIBE LINES** on the cam phasers should face away from each other and the **ARROWS** should point toward each other and be parallel to the cylinder head cover mounting surface. There should be twelve chain pins **BETWEEN** the exhaust cam phaser mark and the intake cam phaser mark.



1 - Left Camshaft Phaser Holder Mounted Between Intake and Exhaust Phasers
2 - Left Camshaft Phaser Holder

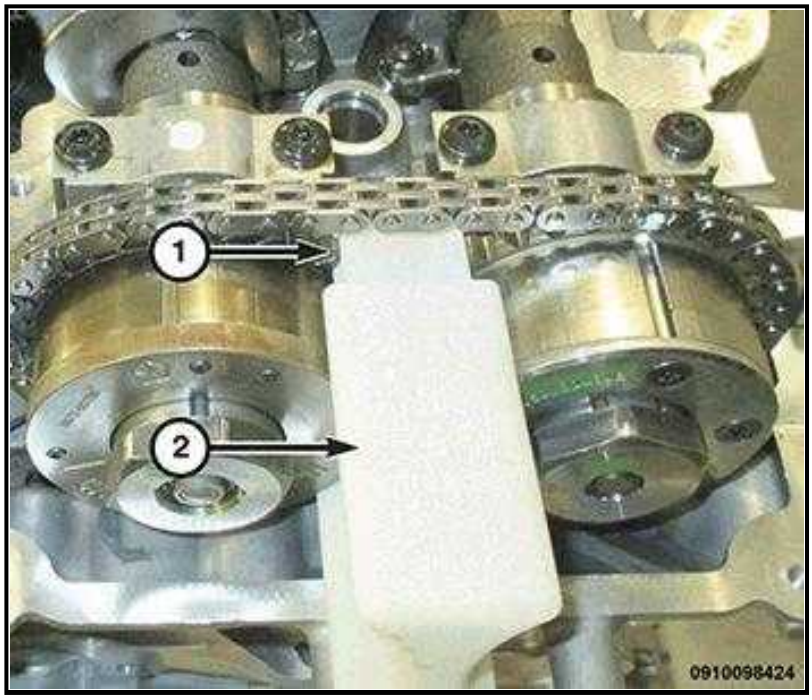
5. Install the (special tool #2025101090, Holder, Camshaft Phaser - Left-Front Cyl Head) against the cylinder head cover mounting surface with the tool number facing up, between the intake and exhaust phasers.

1 - Left Intake Phaser Oil Control Valve

6. Tighten the intake oil control valve to the proper torque specification.

1 - Left Exhaust Phaser Oil Control Valve

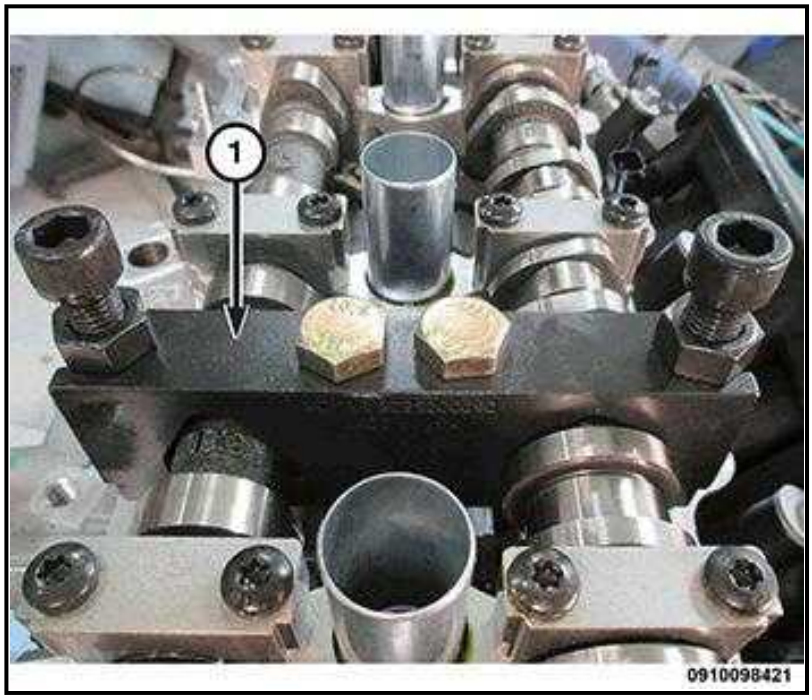
7. Tighten the exhaust oil control valve to the proper torque specification.



8. Remove the (special tool #2025101090, Holder, Camshaft Phaser - Left-Front Cyl Head).

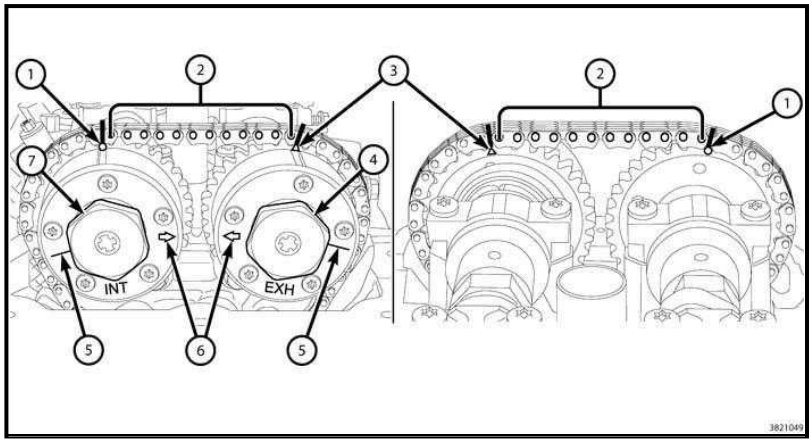
1 - Timing Chain Tensioner Holder
2 - Chain Tensioner Pin

9. Remove the (special tool #2025001090, Holder, Timing Chain Tensioner, Left-Front).



1 - Camshaft Holder Tool

10. Remove the (special tool #2025200090, Holder, Camshaft).



1 - Left Side Intake Cam Phaser Timing Mark	5 - Left Side Cam Phaser Scribe Lines
2 - Showing 12 Timing Chain Pins between Cam Phaser Marks	6 - Left Side Cam Phaser Arrows
3 - Left Side Exhaust Cam Phaser Timing Mark	7 - Intake Phaser Oil Control Valve
4 - Exhaust Phaser Oil Control Valve	B

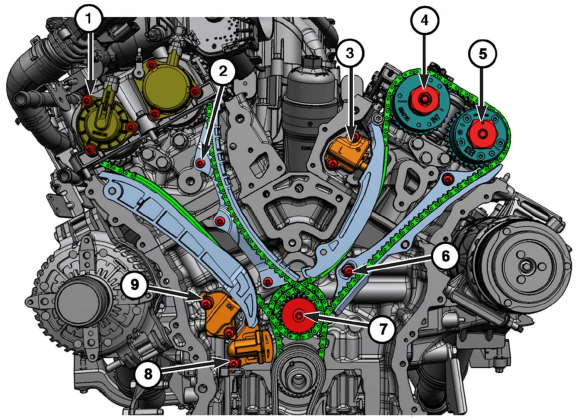
11. Rotate the crankshaft clockwise two complete revolutions stopping when the right side number one cylinder piston is again positioned at top-dead-center on the exhaust stroke. To assure correct engine timing, verify the following;
    - The indicator dial is set to **ZERO** when the right side number one cylinder piston is positioned at top-dead-center on the exhaust stroke.
    - The **SCRIBE LINES** on the left side cam phasers face away from each other.
    - The **ARROWS** on the left side cam phasers point toward each other and are parallel to the cylinder head cover mounting surface.
    - There are twelve chain pins **BETWEEN** the exhaust cam phaser mark and the intake cam phaser mark.
12. If the engine timing is not correct, repeat this procedure.
13. Install the left cylinder head cover. Refer to **COVER(S), CYLINDER HEAD, REMOVAL AND INSTALLATION** .

14. Install the right side spark plugs. Refer to **SPARK PLUG, REMOVAL AND INSTALLATION** .
15. Perform the following scan tool routines:
    - Cam/Crank Variation Relearn
    - Target Coefficient Relearn

NOTE: **Following the first restart after a DTC driven phaser replacement, clear all DTCs and verify that subsequent restarts do not set any additional codes for any DTCs that reset. Refer to 3.6L (GPEC 2A) - DIAGNOSTIC CODE INDEX , or 3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX .**

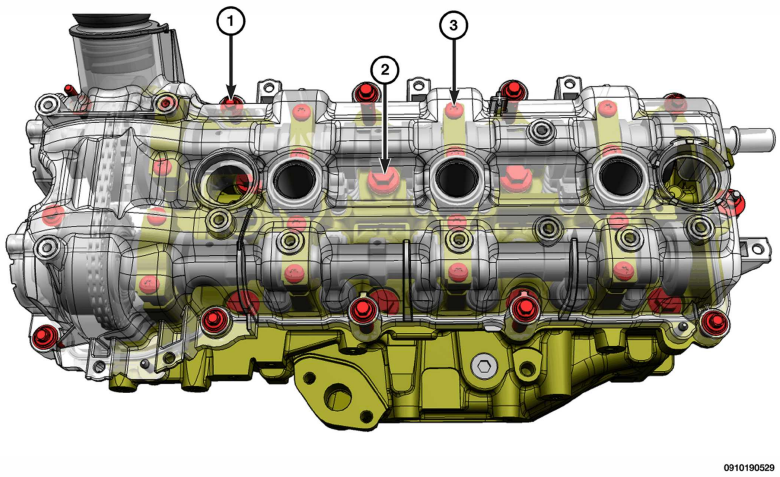
TORQUE SPECIFICATIONS

VALVE TIMING



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

CYLINDER HEAD



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Cylinder Head Cover M6 Bolts	**12 N.m (9 Ft. Lbs.)**	Tightening Sequence - Left
2	Cylinder Head Bolts	**Torque Procedure** For engine builds using a new block follow steps 1-9. For engine re-builds (reuse block) follow step 6-9. 1. 30 N. m (22 ft. lbs.) 2. 45 N. m (33 ft. lbs.) 3. Re-tighten all to 45 N. m (33 ft. lbs.) 4. All + 125B° Turn. Do not use a torque wrench for this step. 5. Loosen all fasteners in reverse of sequence shown 6. All to 30 N. m (22 ft. lbs.) 7. All to 45 N. m (33 ft. lbs.) 8. Re-tighten all to 45 N. m (33 ft. lbs.) 9. All + 130B° Turn. Do not use a torque wrench for this step.	Tightening Sequence - Left
3	Camshaft Bearing Cap Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence - Left
-	Cylinder Head Coolant Pipe Plug	**35 N.m (26 Ft. Lbs.)**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
-	Cylinder Head Oil Galley Plug	**18 N.m (13 Ft. Lbs.)**	-

CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
-	Cylinder Head Oil Restrictor M8 Plug	**15 N.m (11 Ft. Lbs.)**	-
-	Ground Strap Bolt to Right Cylinder Head	**23 N.m (17 Ft. Lbs.)**	-
-	Heater Core Supply Tube to Cylinder Head M8 Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Wire Harness Retainer Bracket to LH Cylinder Head Bolts	**10 N.m (89 In. Lbs.)**	-

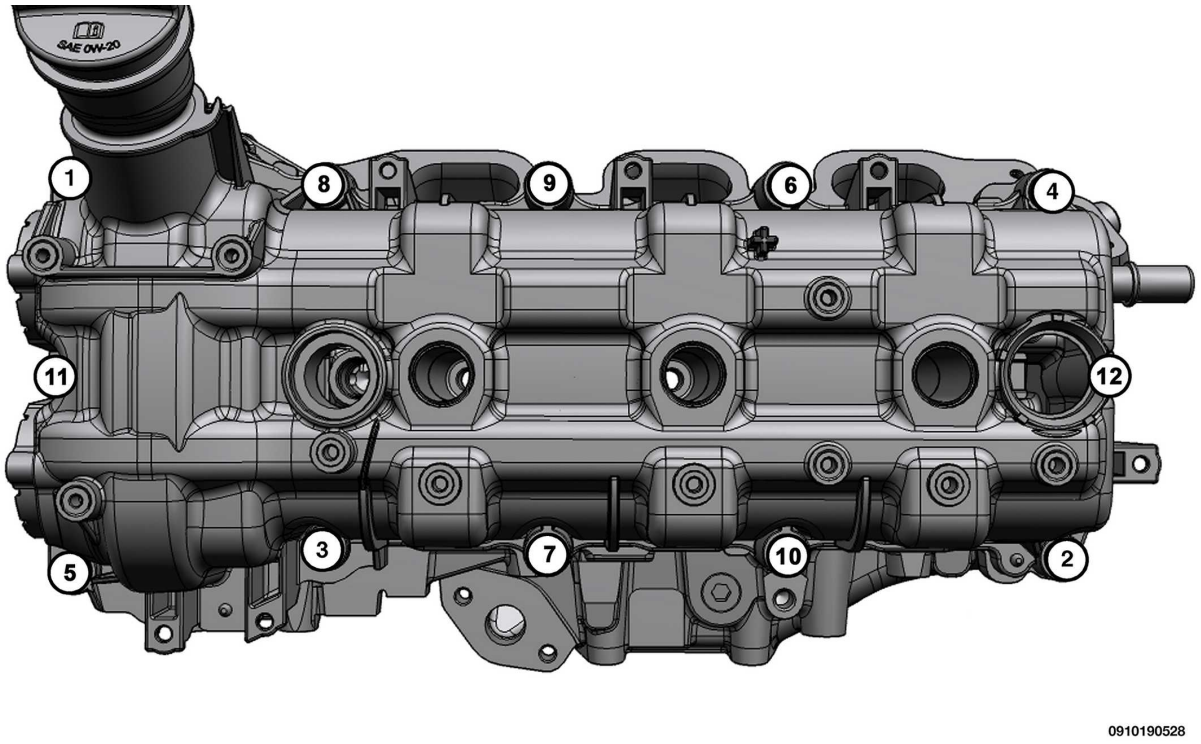


Fig. 3: Cylinder Head Cover Bolts Tightening Sequence (1 of 2)
Courtesy of CHRYSLER GROUP, LLC

Tightening Sequence - Right

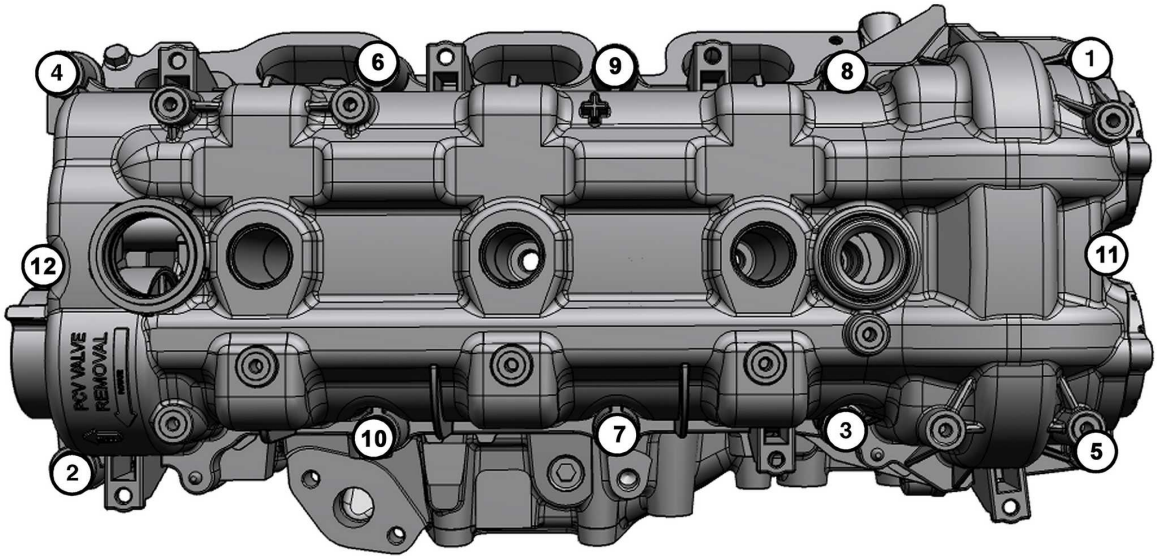
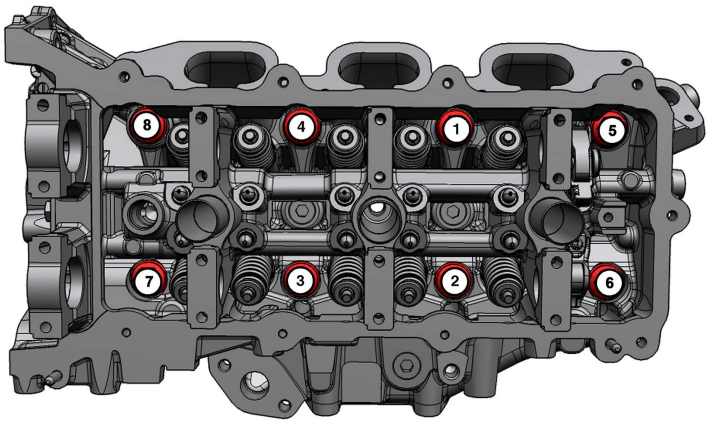
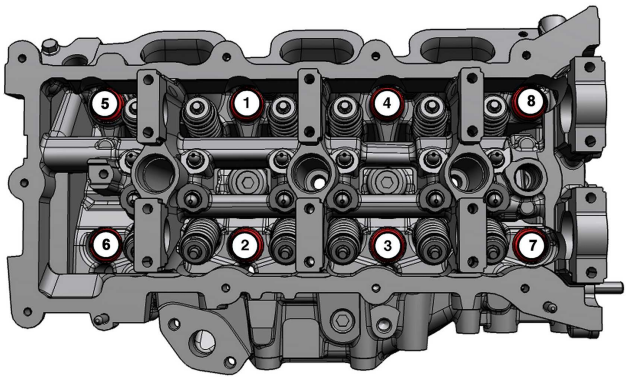


Fig. 4: Cylinder Head Cover Bolts Tightening Sequence (2 of 2)
Courtesy of CHRYSLER GROUP, LLC



Tightening Sequence - Right



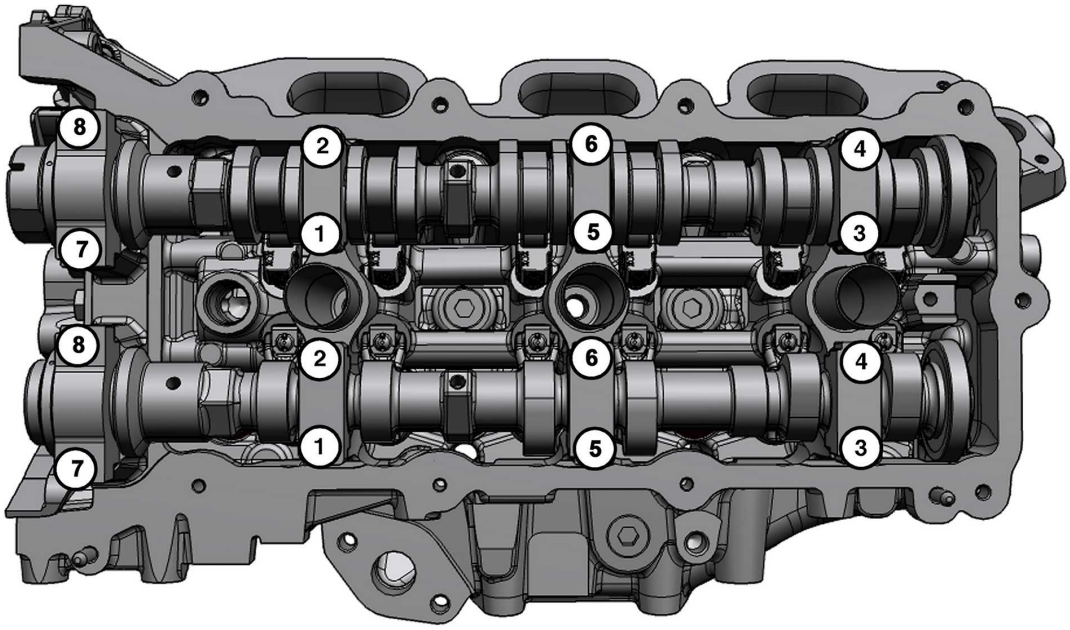
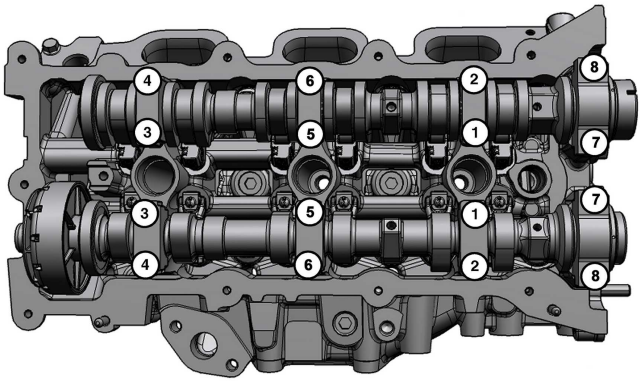


Fig. 5: Camshaft Bearing Cap Bolts Tightening Sequence (1 of 2)
Courtesy of CHRYSLER GROUP, LLC

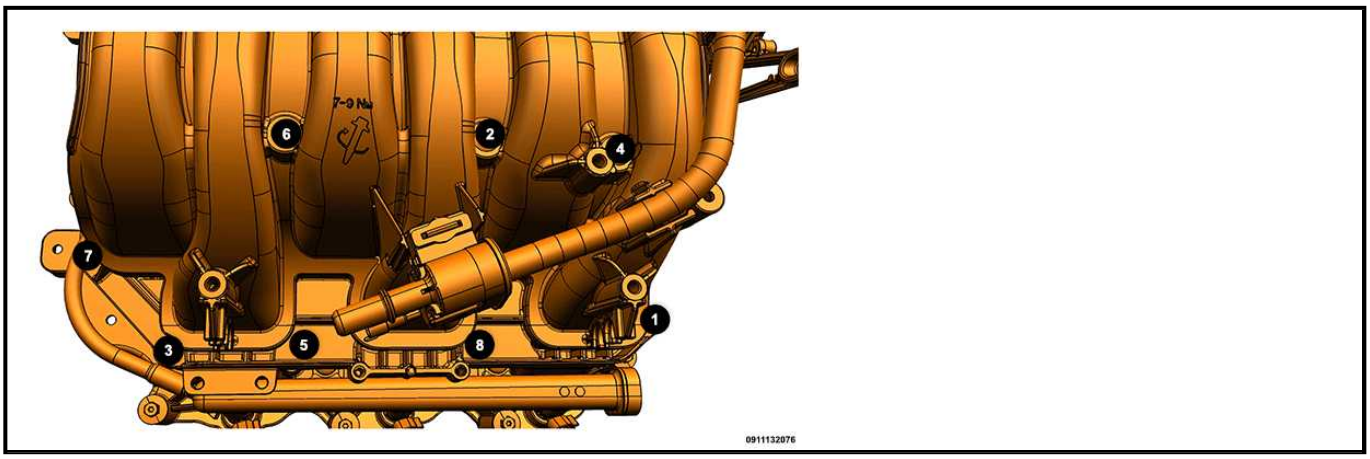
Tightening Sequence - Right



AIR INTAKE

DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-



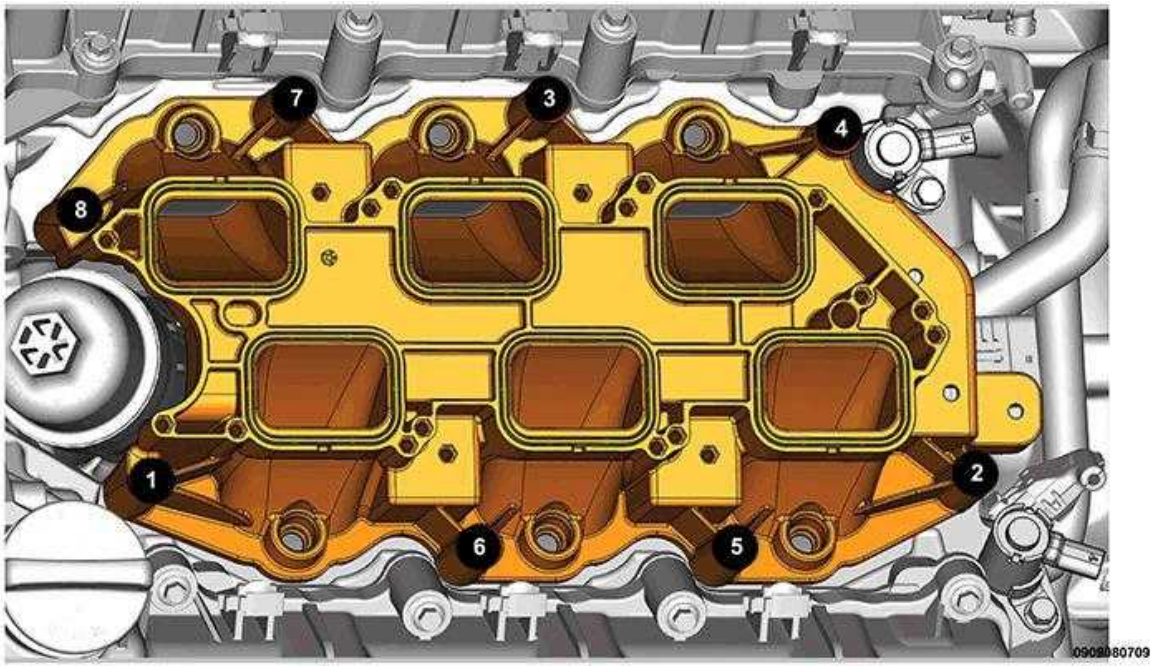


Fig. 6: Lower Intake Manifold Bolt Removal & Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

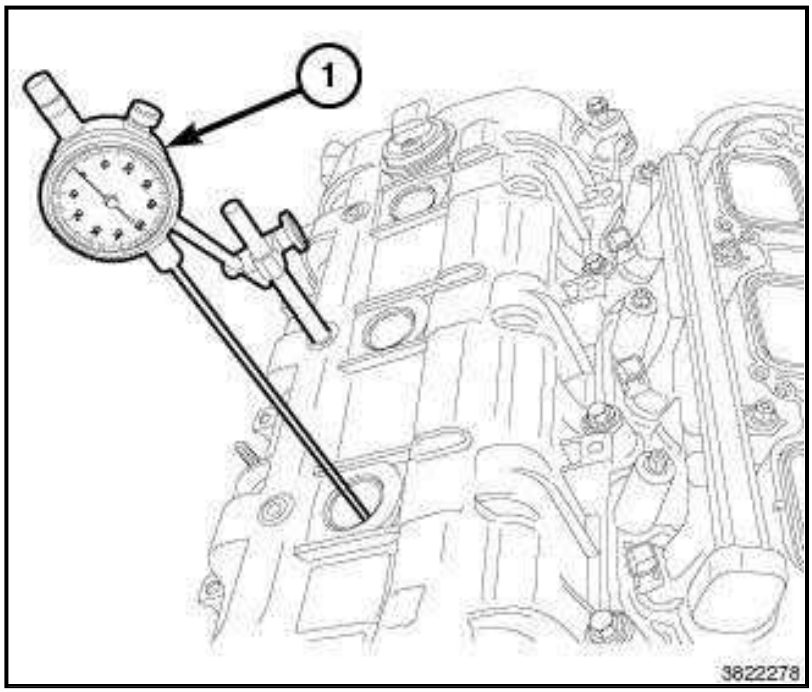
RIGHT CAM PHASER

REMOVAL

NOTE: **The magnetic timing wheels must not come in contact with magnets (pickup tools, trays, etc.) or any other strong magnetic field. This will destroy the timing**

wheels ability to correctly relay camshaft position to the camshaft position sensor.

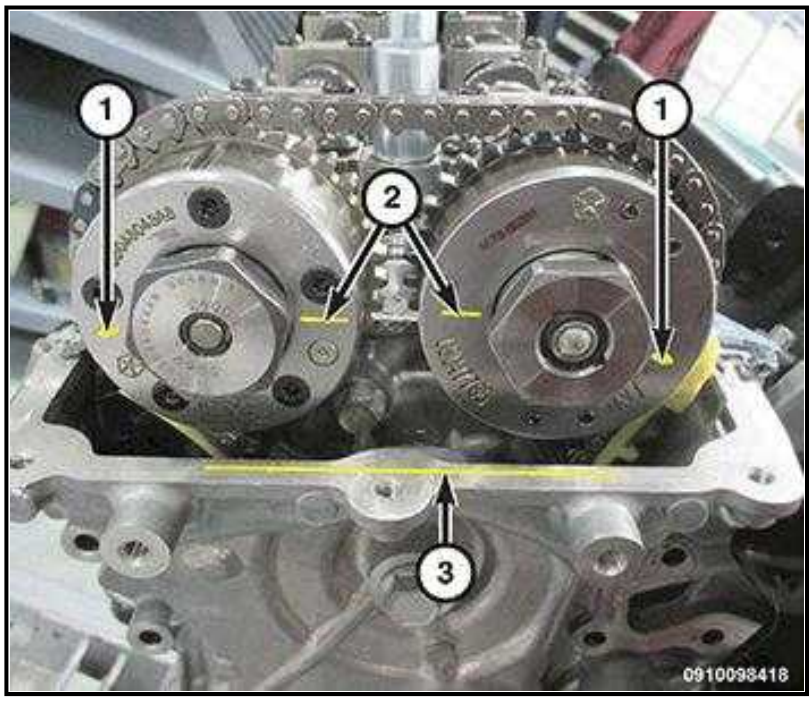
1. Remove the right cylinder head cover. Refer to **COVER(S), CYLINDER HEAD, REMOVAL AND INSTALLATION** .
2. Remove all the left spark plugs. Refer to **SPARK PLUG, REMOVAL AND INSTALLATION** .



1 - Dial Indicator

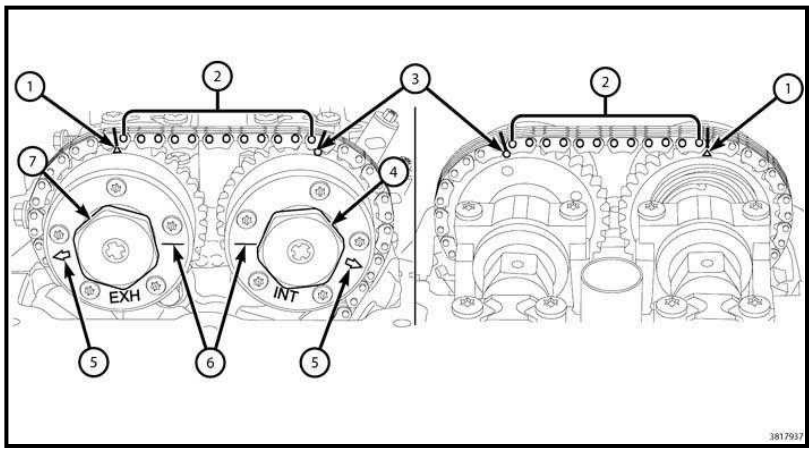
CAUTION: **When aligning timing marks, always rotate engine by turning the crankshaft. Failure to do so will result in valve or piston damage.**

3. Mount the Dial Indicator Set (special tool #C-3339A, Set, Dial Indicator) to a stationary point on the engine, such as the cylinder head cover mounting surface. Position the indicator probe into the number one cylinder, rotate the crankshaft clockwise (as viewed from the front) to place the number one piston at top-dead-center on the exhaust stroke and set the indicator dial to zero.



1 - Right Side Cam Phaser Arrows
2 - Right Side Cam Phaser Scribe Lines
3 - Cylinder Head Cover Mounting Surface

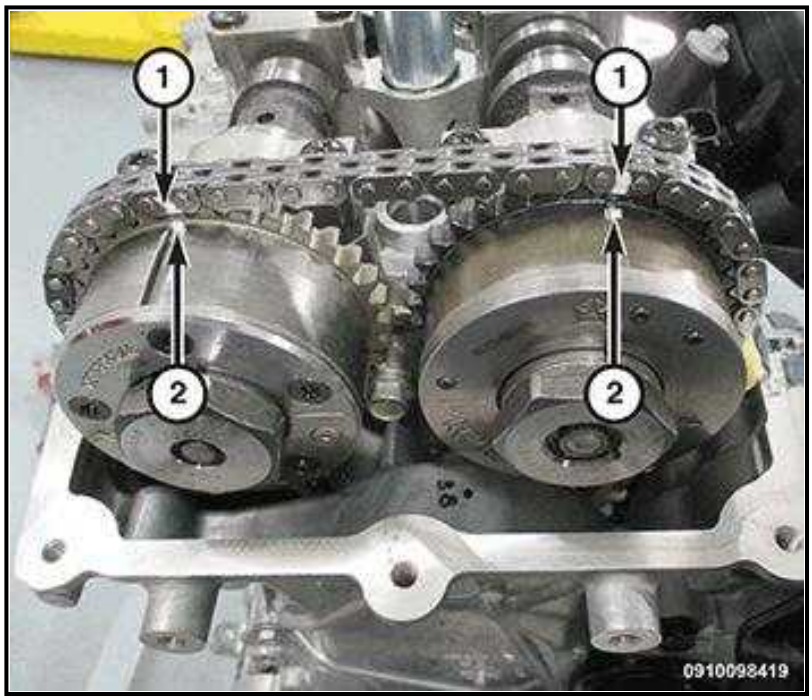
4. The right side cam phaser **ARROWS** should point away from each other and the **SCRIBE LINES** should be parallel to the cylinder head cover mounting surface when the right side number one cylinder piston is positioned at top-dead-center on the exhaust stroke.



1 - Right Side Exhaust Cam Phaser Timing Mark	5 - Right Side Cam Phaser Arrows
2 - Showing 12 Timing Chain Pins between Cam Phaser Marks	6 - Right Side Cam Phaser Scribe Lines
3 - Right Side Intake Cam Phaser Timing Mark	7 - Exhaust Phaser Oil Control Valve
4 - Intake Phaser Oil Control Valve	B

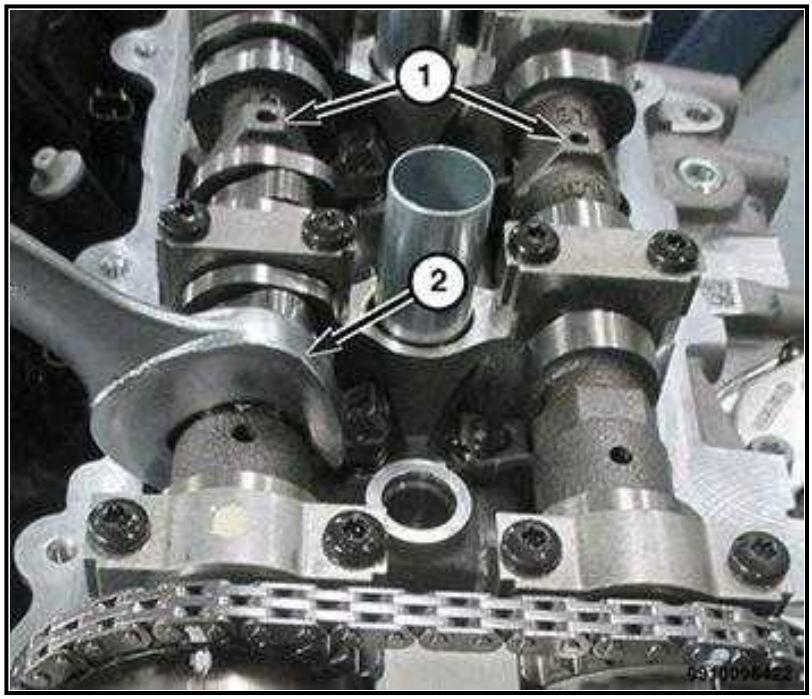
NOTE: **The phaser markings could align with either an external or internal chain link. Either alignment is acceptable as long as there are twelve chain pins between the markings.**

5. There should be twelve chain pins **BETWEEN** the exhaust cam phaser mark and the intake cam phaser mark as viewed from either the front or rear of the cam phasers.



1 - Timing Chain Marks (Made With Paint Pen)
2 - Left Side Cam Phaser Timing Marks

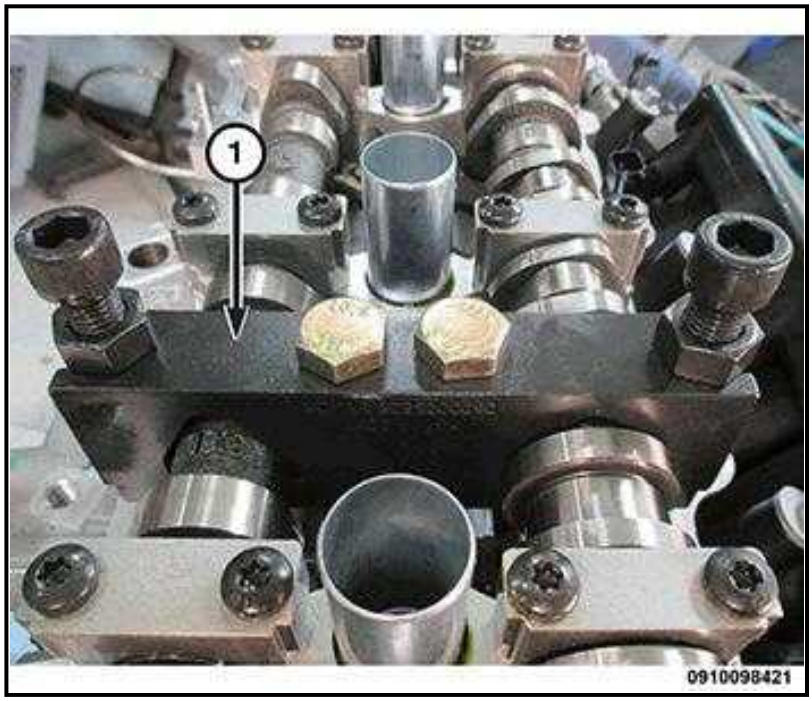
6. Mark both sides of the timing chain at the phaser timing marks using a paint pen or equivalent to aid in reassembly.



1 - Camshaft Alignment Holes
2 - Wrench

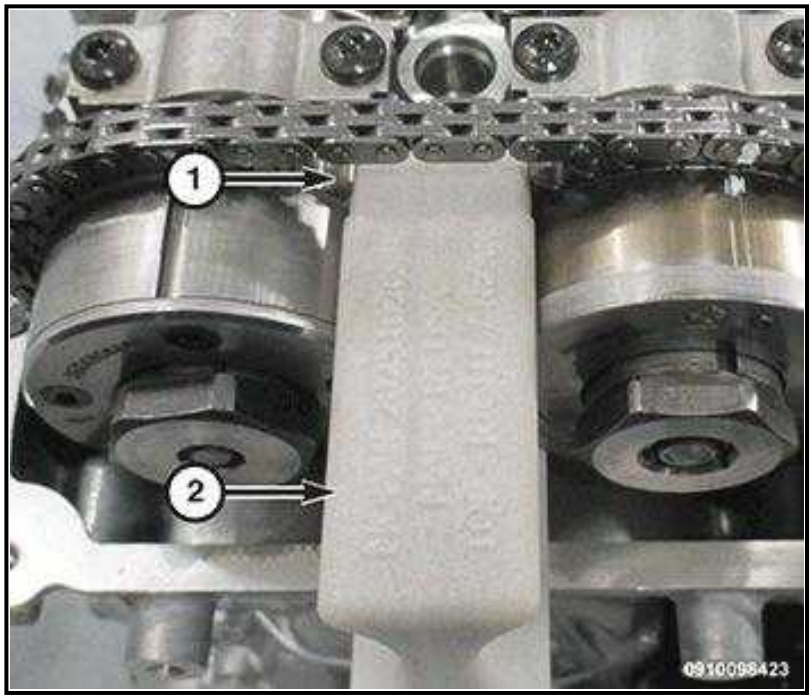
7. The camshafts should be at top-dead-center, with the alignment holes positioned vertically.

NOTE: **It may be necessary to rock the camshaft slightly (a few degrees) with a wrench when installing the camshaft holder.**



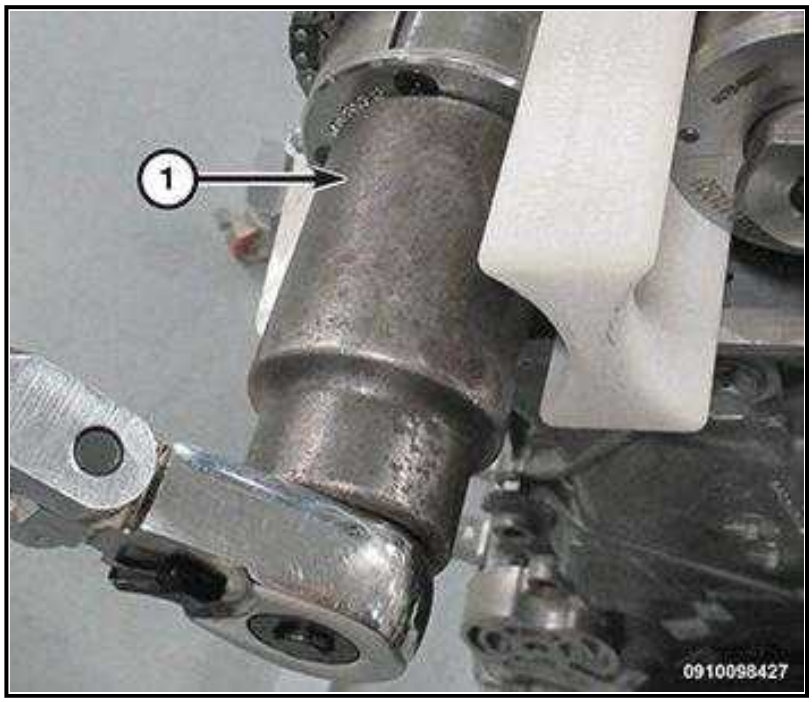
1 - Camshaft Holder Tool

8. Install the (special tool #2025200090, Holder, Camshaft).



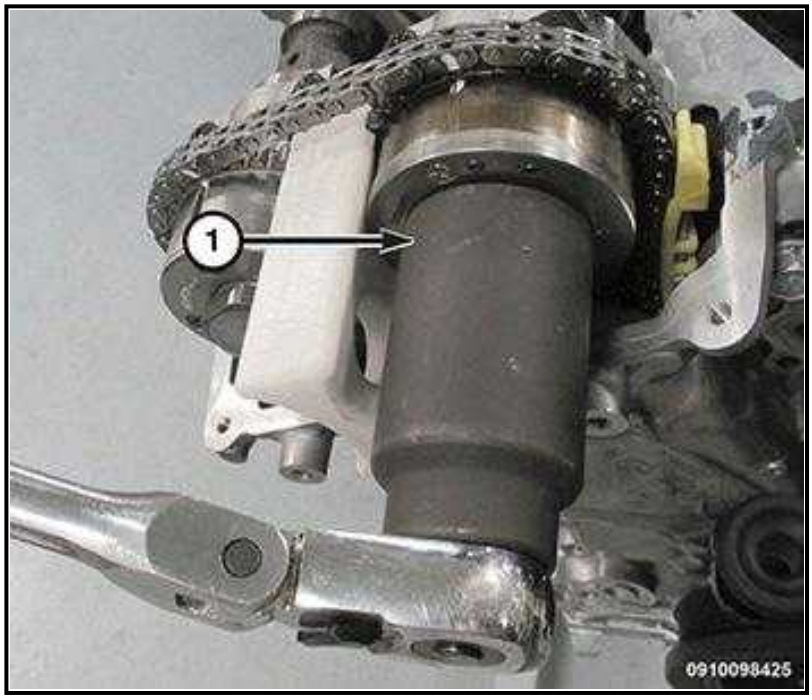
1 - Right Camshaft Phaser Holder Mounted Between Intake and Exhaust Phasers
2 - Right Camshaft Phaser Holder

9. Install the (special tool #2025102090, Holder, Camshaft Phaser - Right-Rear Cyl Head) against the cylinder head cover mounting surface between the intake and exhaust phasers, with the tool number facing up.



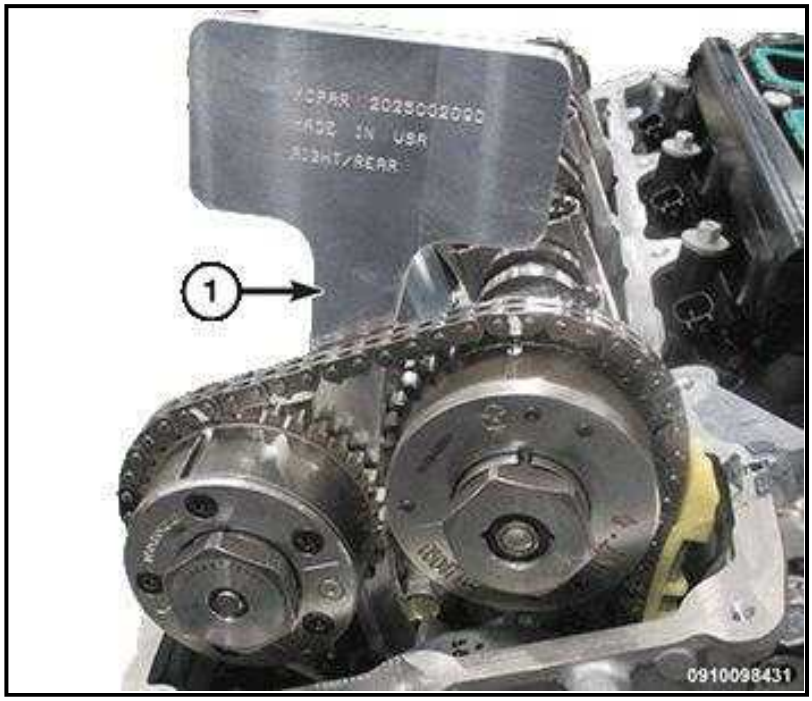
1 - Right Exhaust Phaser Oil Control Valve

10. Loosen, but do not remove, the exhaust oil control valve.



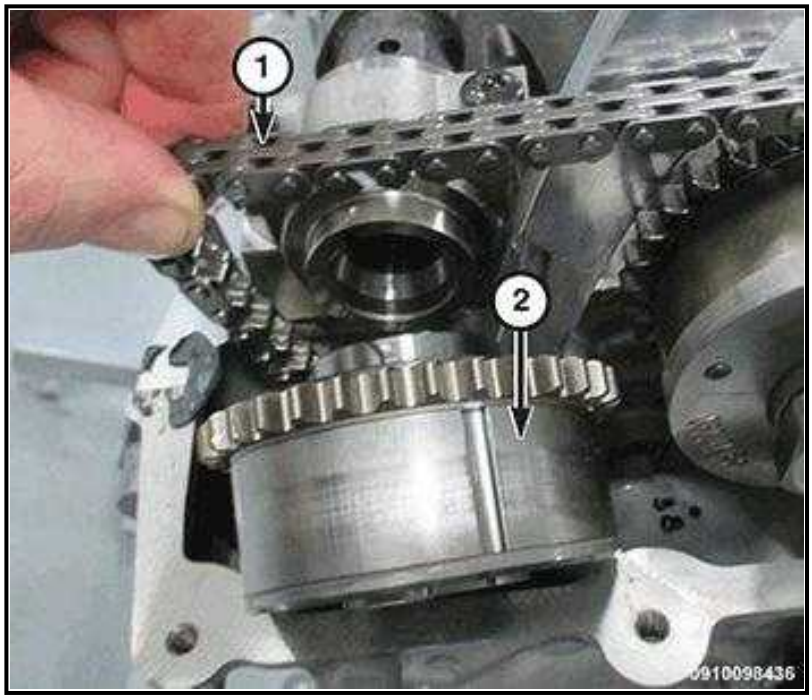
1 - Right Intake Phaser Oil Control Valve

11. Loosen, but do not remove, the intake oil control valve.
12. Remove the (special tool #2025102090, Holder, Camshaft Phaser - Right-Rear Cyl Head).



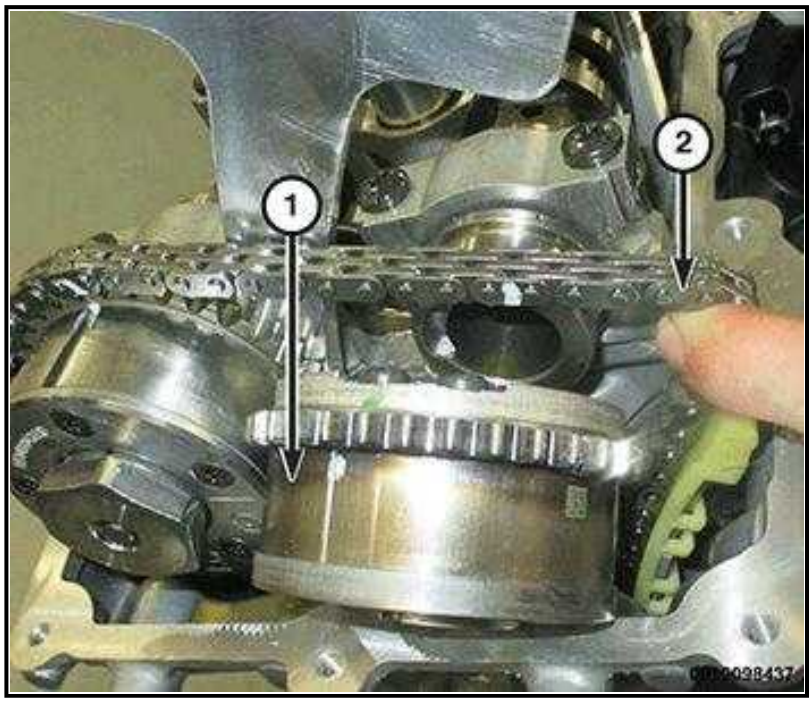
1 - Timing Chain Tensioner Holder

13. Insert the (special tool #2025002090, Holder, Timing Chain Tensioner, Right-Rear) into place between the cylinder head boss and the tensioner arm to hold the tensioner in the compressed position. The Timing Chain Tensioner Holder remains in place while the phasers are removed.



1 - Timing Chain
2 - Camshaft Phaser

14. Remove the oil control valve and pull the right side exhaust cam phaser off of the camshaft while supporting the timing chain.

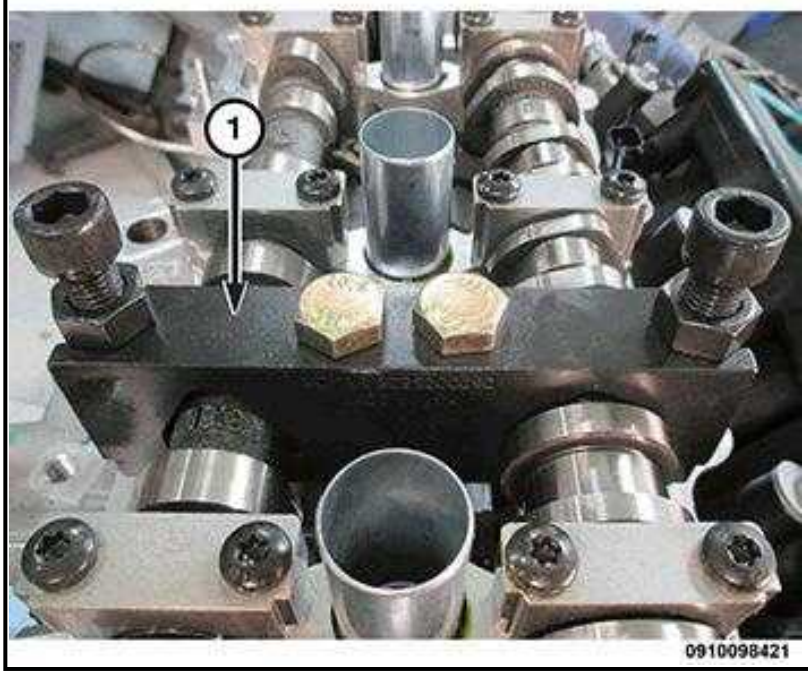


1 - Camshaft Phaser
2 - Timing Chain

15. Remove the oil control valve and pull the right side intake cam phaser off of the camshaft while supporting the timing chain.

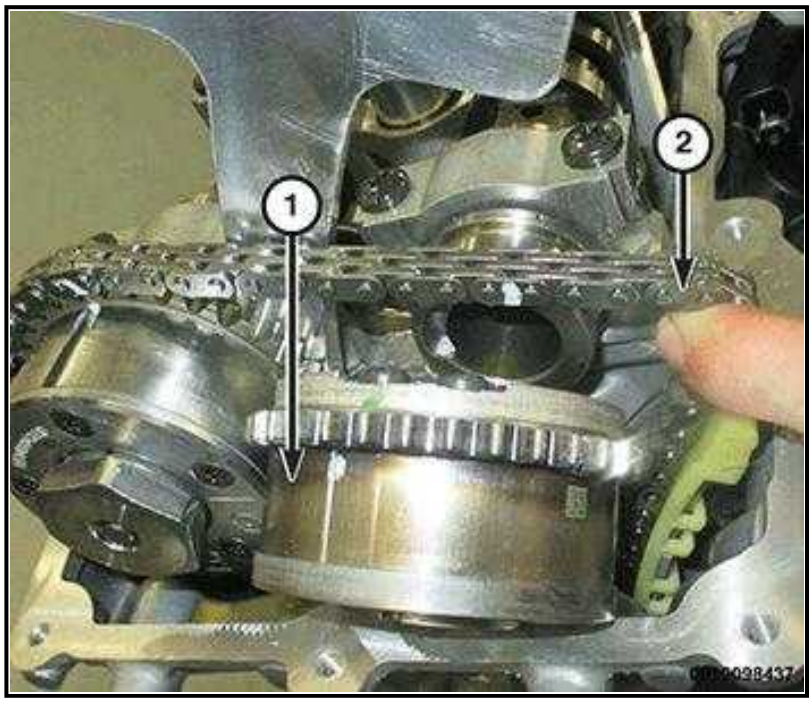
INSTALLATION

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



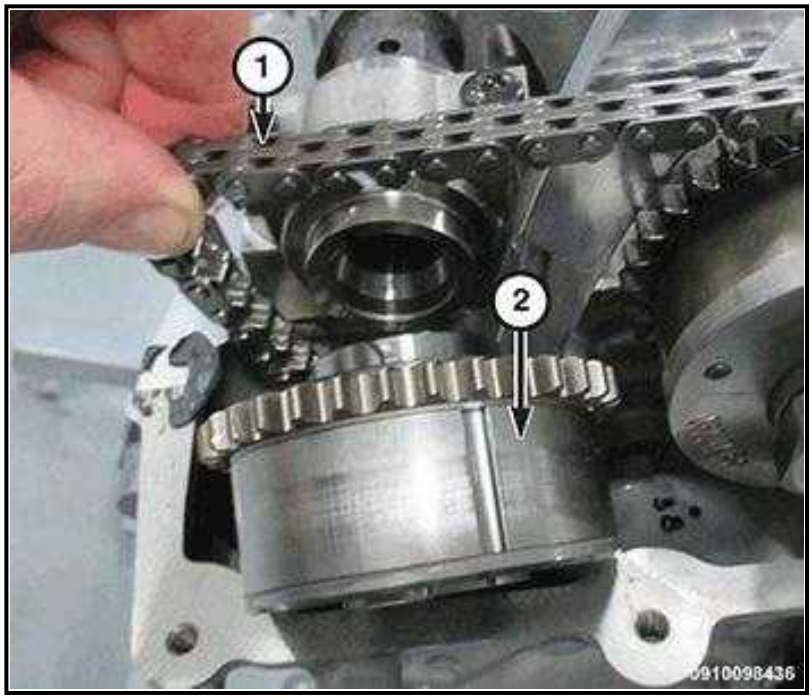
1 - Camshaft Holder Tool

1. The Timing Chain Tensioner Holder and Camshaft Holder should still be in place as installed during the removal procedure. If required, the Timing Chain Tensioner Holder and Camshaft Holder can be installed by repeating the steps within the removal procedure. Refer to **CHAIN AND SPROCKETS, TIMING, REMOVAL AND INSTALLATION**.



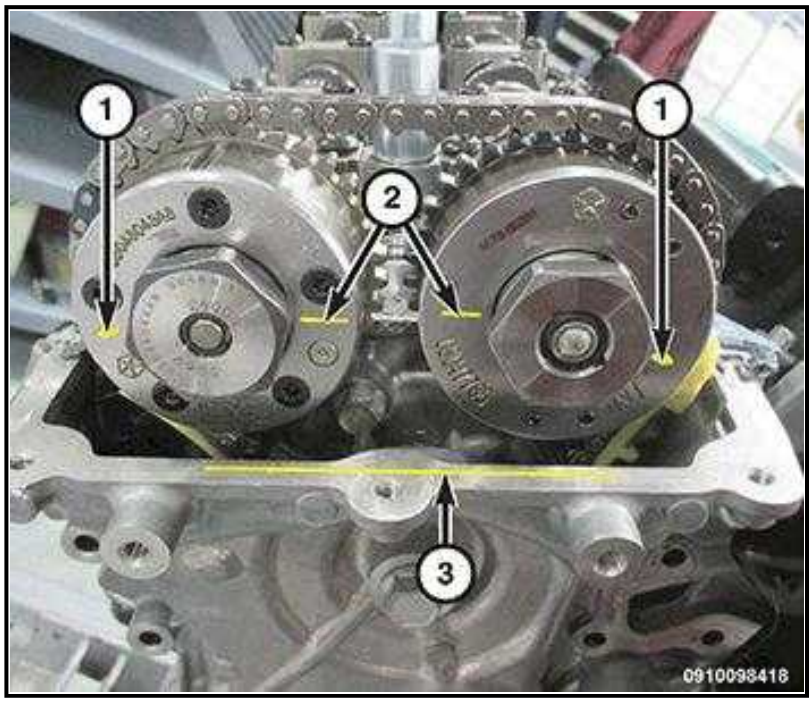
1 - Camshaft Phaser
2 - Timing Chain

2. Route the timing chain around the right intake cam phaser while aligning the paint mark with the phaser timing mark. Press the right intake cam phaser onto the intake camshaft. Install and hand tighten the oil control valve.



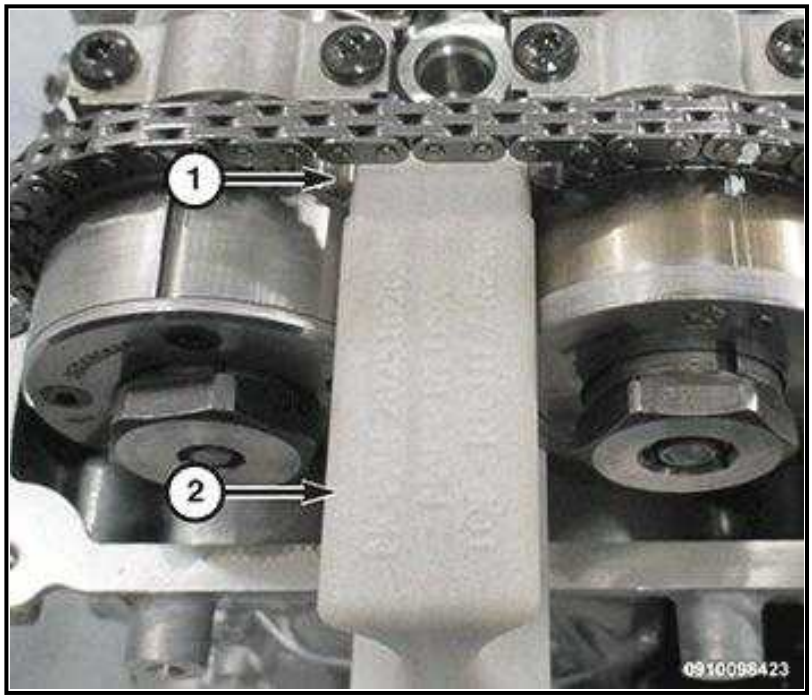
1 - Timing Chain
2 - Camshaft Phaser

3. While maintaining this alignment, route the timing chain around the right exhaust cam phaser while aligning the paint mark with the phaser timing mark. Press the right exhaust cam phaser onto the exhaust camshaft. Install and hand tighten the oil control valve.



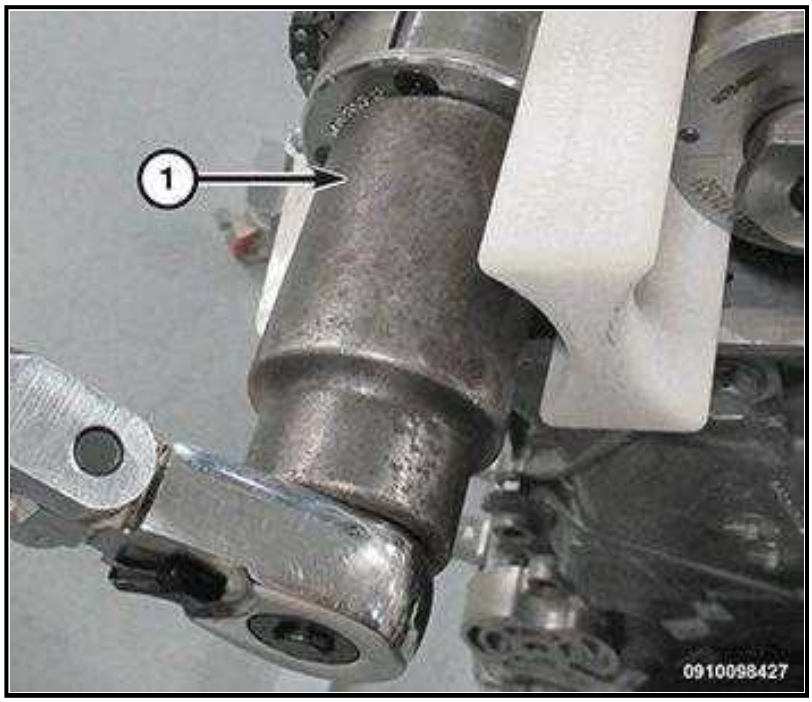
1 - Right Side Cam Phaser Arrows
2 - Right Side Cam Phaser Scribe Lines
3 - Cylinder Head Cover Mounting Surface

4. The **ARROWS** on the cam phasers should point away from each other and the **SCRIBE LINES** should be parallel to the cylinder head cover mounting surface. There should be twelve chain pins **BETWEEN** the exhaust cam phaser mark and the intake cam phaser mark.



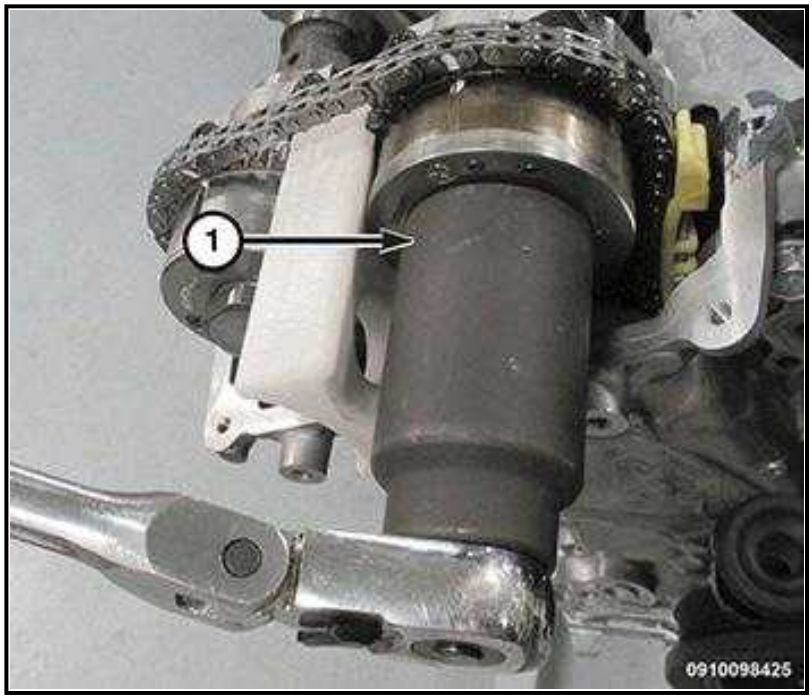
1 - Right Camshaft Phaser Holder Mounted Between Intake and Exhaust Phasers
2 - Right Camshaft Phaser Holder

5. Install the (special tool #2025102090, Holder, Camshaft Phaser - Right-Rear Cyl Head) against the cylinder head cover mounting surface with the tool number facing up, between the intake and exhaust phasers.



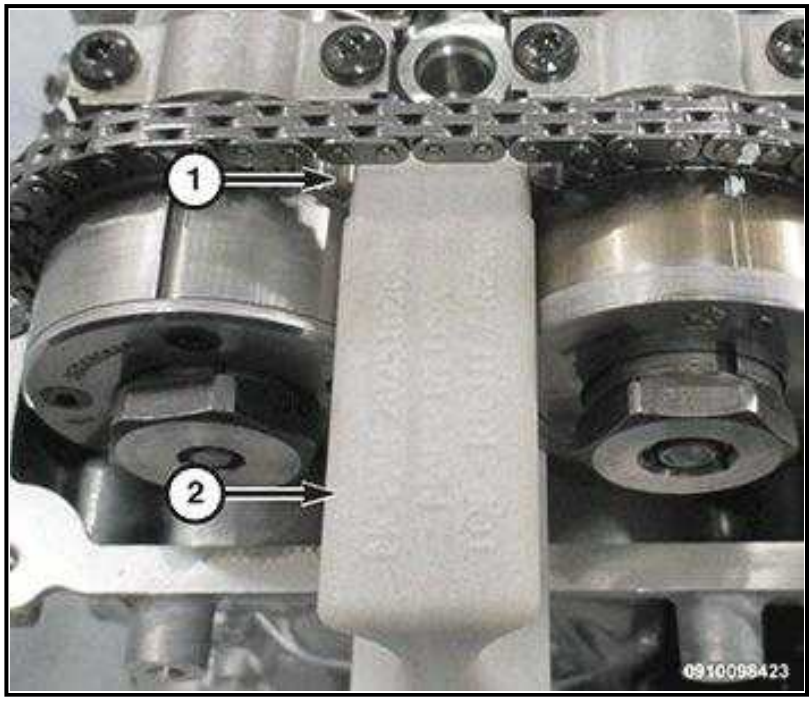
1 - Right Exhaust Phaser Oil Control Valve

6. Tighten the exhaust oil control valve to the proper torque specification listed in the torque table below.



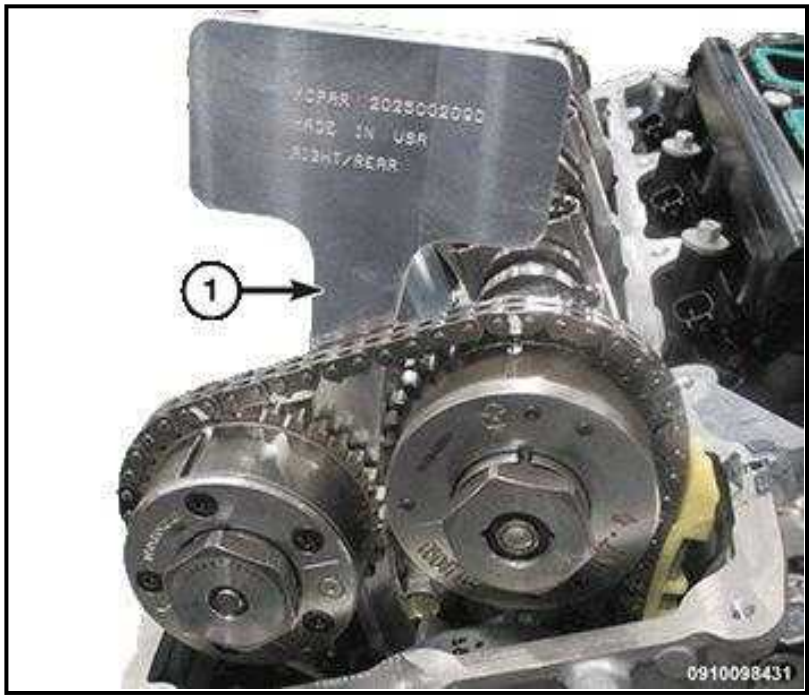
1 - Right Intake Phaser Oil Control Valve

7. Tighten the intake oil control valve to the proper torque specification listed in the torque table below.



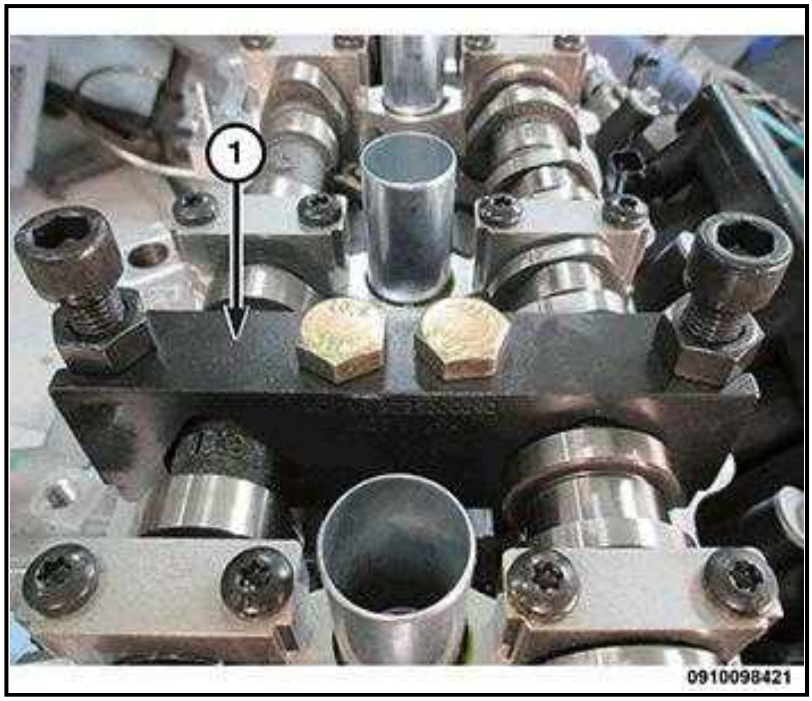
1 - Right Camshaft Phaser Holder Mounted Between Intake and Exhaust Phasers
2 - Right Camshaft Phaser Holder

8. Remove the (special tool #2025102090, Holder, Camshaft Phaser - Right-Rear Cyl Head).



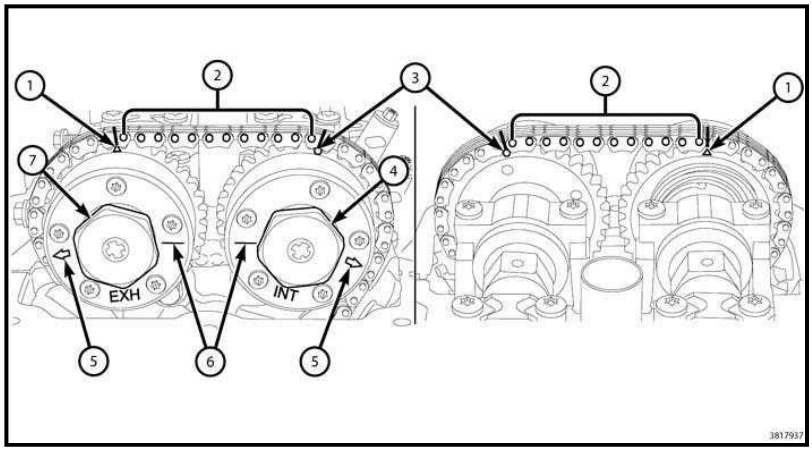
1 - Timing Chain Tensioner Holder

9. Remove the (special tool #2025002090, Holder, Timing Chain Tensioner, Right-Rear).



1 - Camshaft Holder Tool

10. Remove the (special tool #2025200090, Holder, Camshaft).



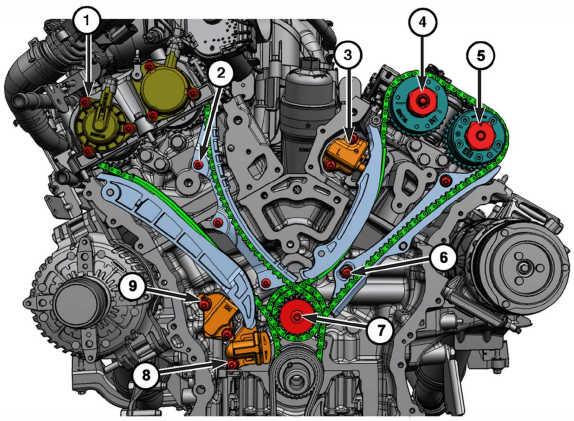
1 - Right Side Exhaust Cam Phaser Timing Mark	5 - Right Side Cam Phaser Arrows
2 - Showing 12 Timing Chain Pins between Cam Phaser Marks	6 - Right Side Cam Phaser Scribe Lines
3 - Right Side Intake Cam Phaser Timing Mark	7 - Exhaust Phaser Oil Control Valve
4 - Intake Phaser Oil Control Valve	B

11. Rotate the crankshaft clockwise two complete revolutions stopping when the right side number one cylinder piston is again positioned at top-dead-center on the exhaust stroke. To assure correct engine timing, verify the following;
    - The indicator dial is set to **ZERO** when the right side number one cylinder piston is positioned at top-dead-center on the exhaust stroke.
    - The **ARROWS** on the right side cam phasers point away from each other.
    - The **SCRIBE LINES** on the right side cam phasers are parallel to the cylinder head cover mounting surface.
    - There are twelve chain pins **BETWEEN** the exhaust cam phaser mark and the intake cam phaser circle mark.
12. If the engine timing is not correct, repeat this procedure.
13. Install the spark plugs. Refer to **SPARK PLUG, REMOVAL AND INSTALLATION** .
14. Install the right cylinder head cover and right ignition coils. Refer to **COVER(S), CYLINDER HEAD, REMOVAL AND INSTALLATION** .
15. Start the engine and perform the following scan tool routines:
    - Cam/Crank Variation Relearn
    - Target Coefficient Relearn

NOTE: **Following the first restart after a DTC driven phaser replacement, clear all DTCs and verify that subsequent restarts do not set any additional codes for any DTCs that reset. Refer to 3.6L (GPEC 2A) - DIAGNOSTIC CODE INDEX , or 3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX .**

TORQUE SPECIFICATIONS

VALVE TIMING



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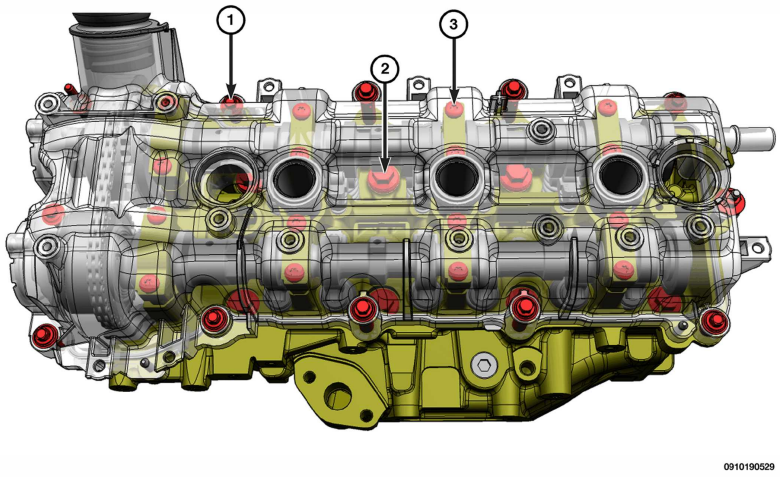
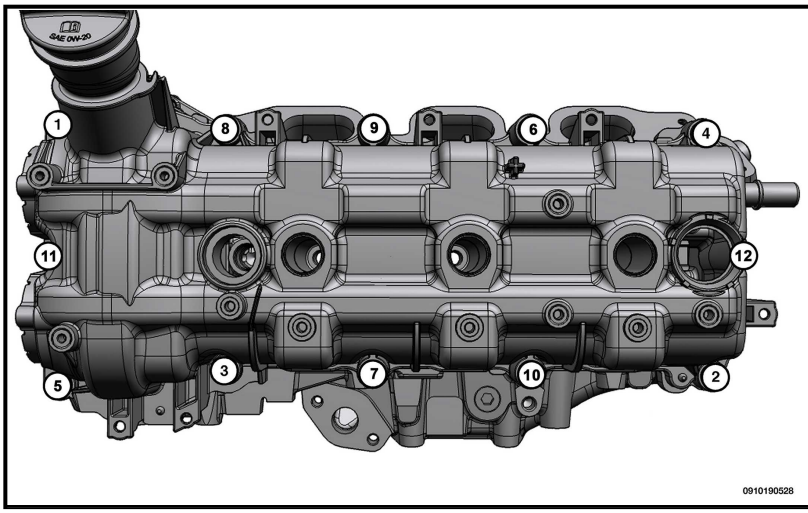
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

CYLINDER HEAD



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Cylinder Head Cover M6 Bolts	**12 N.m (9 Ft. Lbs.)**	Tightening Sequence - Left
2	Cylinder Head Bolts	**Torque Procedure** For engine builds using a new block follow steps 1-9. For engine re-builds (reuse block) follow step 6-9. 1. 30 N. m (22 ft. lbs.) 2. 45 N. m (33 ft. lbs.) 3. Re-tighten all to 45 N. m (33 ft. lbs.) 4. All + 125B° Turn. Do not use a torque wrench for this step. 5. Loosen all fasteners in reverse of sequence shown 6. All to 30 N. m (22 ft. lbs.) 7. All to 45 N. m (33 ft. lbs.) 8. Re-tighten all to 45 N. m (33 ft. lbs.) 9. All + 130B° Turn. Do not use a torque wrench for this step.	Tightening Sequence - Left
3	Camshaft Bearing Cap Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence - Left
-	Cylinder Head Coolant Pipe Plug	**35 N.m (26 Ft. Lbs.)**	Do not reuse these fasteners. If removed, a **NEW** fastener must be installed and tightened to specifications.
-	Cylinder Head Oil Galley Plug	**18 N.m (13 Ft. Lbs.)**	-
-	Cylinder Head Oil Restrictor M8 Plug	**15 N.m (11 Ft. Lbs.)**	-

CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
-	Ground Strap Bolt to Right Cylinder Head	**23 N.m (17 Ft. Lbs.)**	-
-	Heater Core Supply Tube to Cylinder Head M8 Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Wire Harness Retainer Bracket to LH Cylinder Head Bolts	**10 N.m (89 In. Lbs.)**	-



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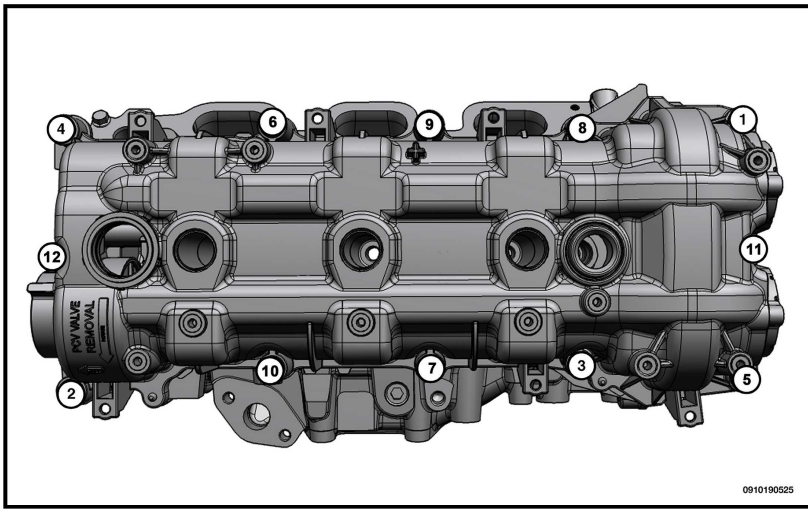
Tightening Sequence - Right



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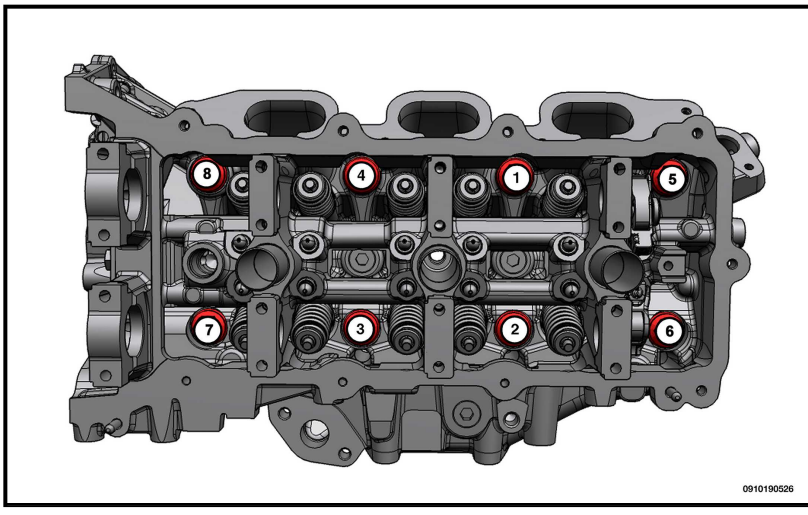

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Tightening Sequence - Right

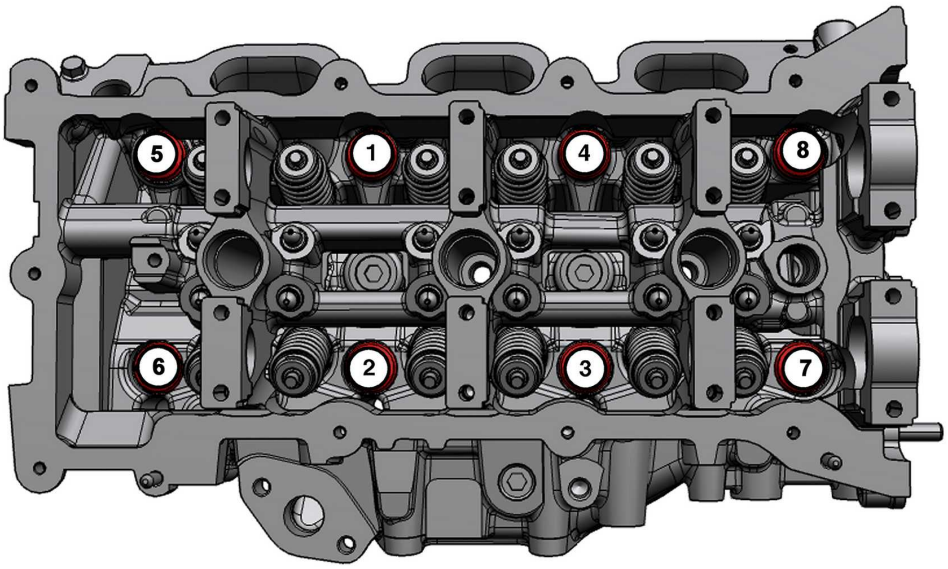
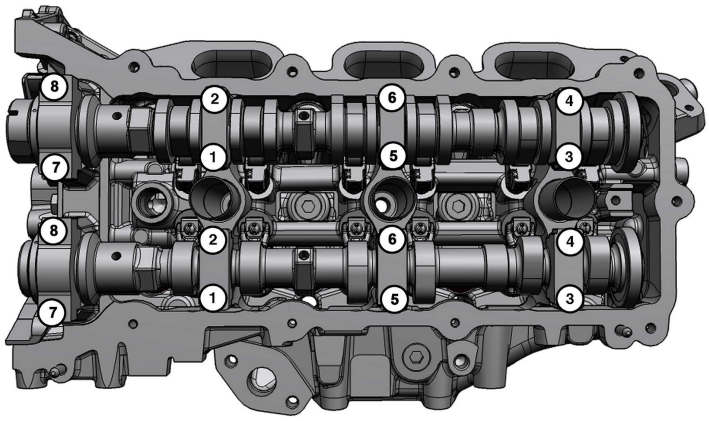
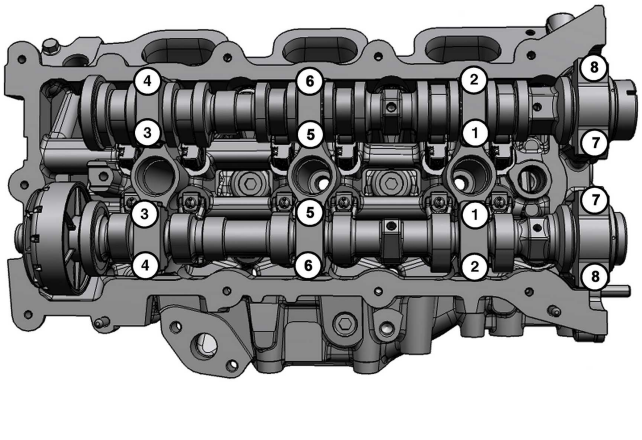


Fig. 7: Cylinder Head Bolts Tightening Sequence (2 of 2)
Courtesy of CHRYSLER GROUP, LLC



Tightening Sequence - Right



DESCRIPTION	SPECIFICATION	COMMENTS
Engine Cover Bracket to Intake Manifold Bolts	**8 N.m (71 In. Lbs.)**	-
Engine Cover Bracket to Cylinder Head Cover Bolts	**7 N.m (62 In. Lbs.)**	-
Engine Cover to Bracket Bolts	**6 N.m (53 In. Lbs.)**	-
Air Cleaner Housing to Side Rail	**5 N.m (44 In. Lbs.)**	-
Air Cleaner Cover Bolts	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator Clamps	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Inlet Duct to Housing	**4 N.m (35 In. Lbs.)**	-
Air Cleaner Resonator to Shroud Bolts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION	SPECIFICATION	COMMENTS
Intake Manifold Support Bracket Upper Nuts	**10 N.m (89 In. Lbs.)**	-
Throttle Body Bolts	**9 N.m (80 In. Lbs.)**	-
Intake Manifold (Upper) M6 Bolts	**10 N.m (89 In. Lbs.)**	Tightening Sequence
Intake Manifold (Lower) M6 Bolts	**9 N.m (80 In. Lbs.)**	Tightening Sequence
Throttle Body Support Bracket Bolts	**10 N.m (7 Ft. Lbs.)**	-
Throttle Body Support Bracket Bolt to Front Cover	**10 N.m (7 Ft. Lbs.)**	-
Intake Manifold Support Bracket Lower Bolt	**25 N.m (18 Ft. Lbs.)**	-

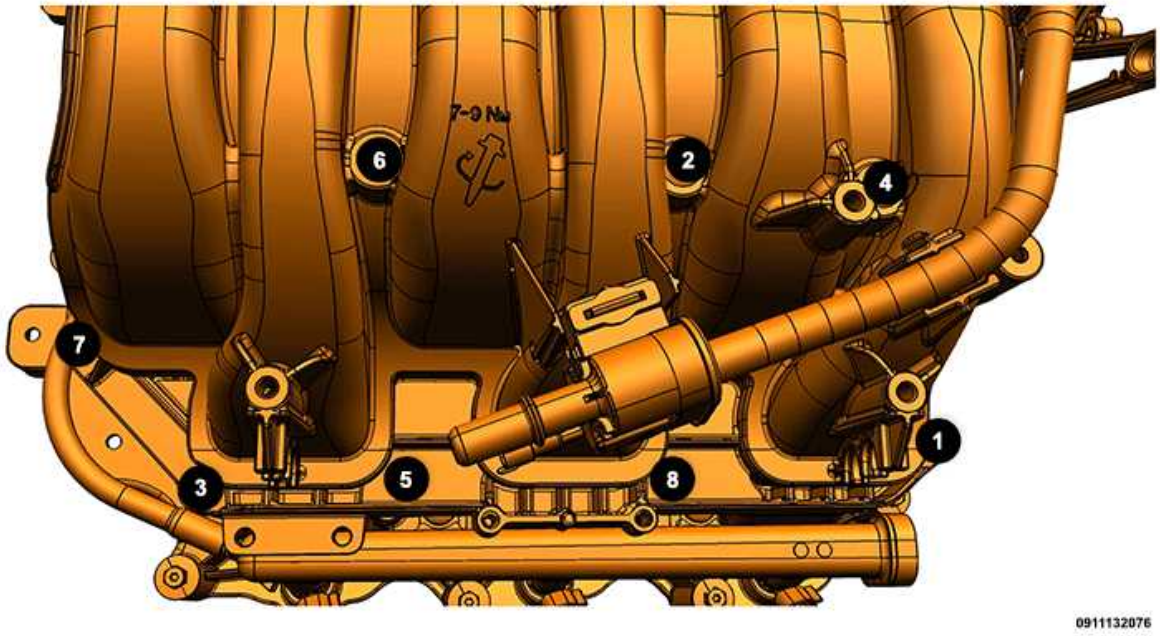
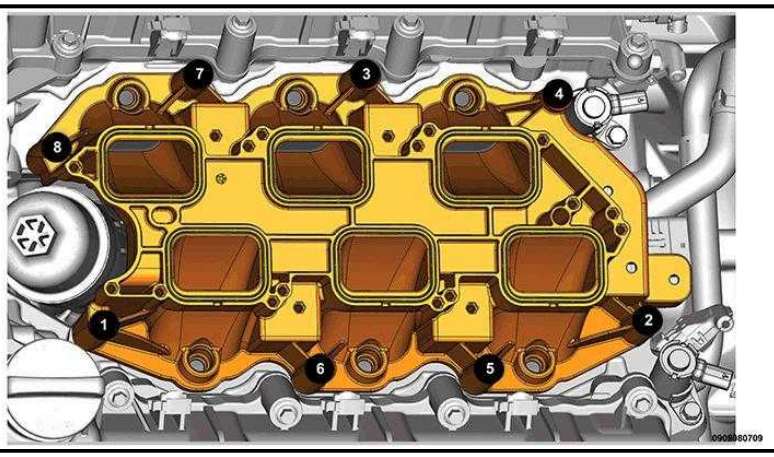


Fig. 8: Upper Intake Manifold Bolts Tightening/Loosening Sequence
Courtesy of CHRYSLER GROUP, LLC



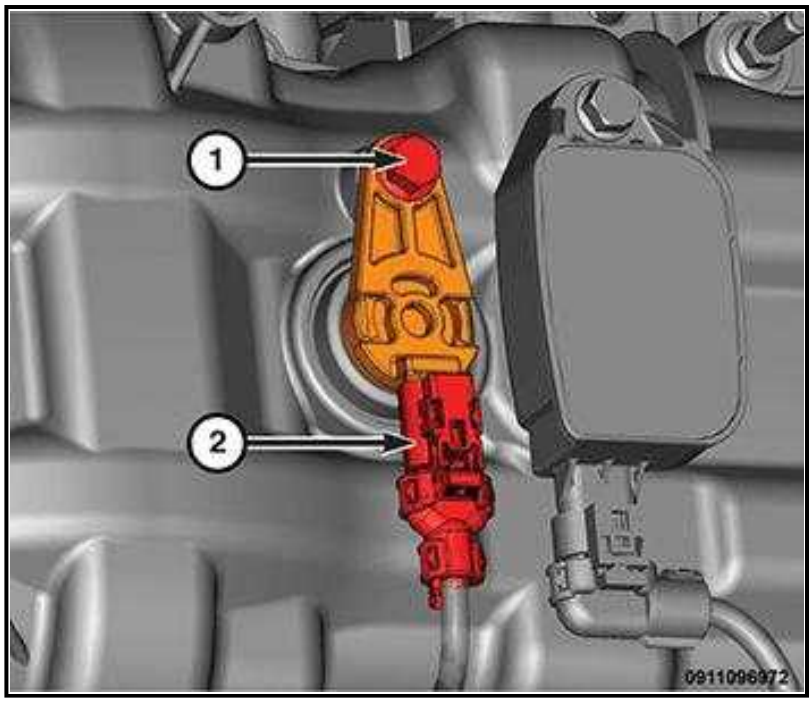
SOLENOID

REMOVAL AND INSTALLATION

VVL SOLENOID - BANK 1 - SOLENOID 1

REMOVAL

1. Remove the engine cover. Refer to **COVER, ENGINE, REMOVAL AND INSTALLATION** .



1 - Variable Valve Lift Solenoid Bolt
2 - Wire Harness Connector

2. Disconnect the Variable Valve Lift (VVL) solenoid wire harness connector.
3. Remove the retaining bolt from the VVL solenoid.
4. Remove the VVL solenoid from the cylinder head cover.
5. The O-rings can be reused if not damaged.

INSTALLATION

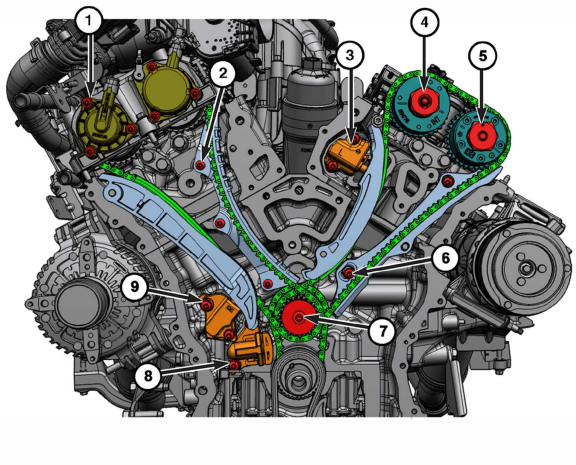
During installation, torque the fasteners to the specifications in the torque table(s) below.

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.

- Carefully inspect the Variable Valve Lift (VVL) solenoid O-ring for nicks or cuts. Replace the O-rings if there is any indication or damage to the O-rings.
- Insert the VVL solenoids straight into the cylinder head cover. **Do Not** insert the VVL solenoid on an angle as this may damage the O-ring seals. **If an O-ring does not seal completely the oil pressure will leak between the passages which can cause the improper operation of the VVL system and driveability issues including misfire.**

TORQUE SPECIFICATIONS

VALVE TIMING

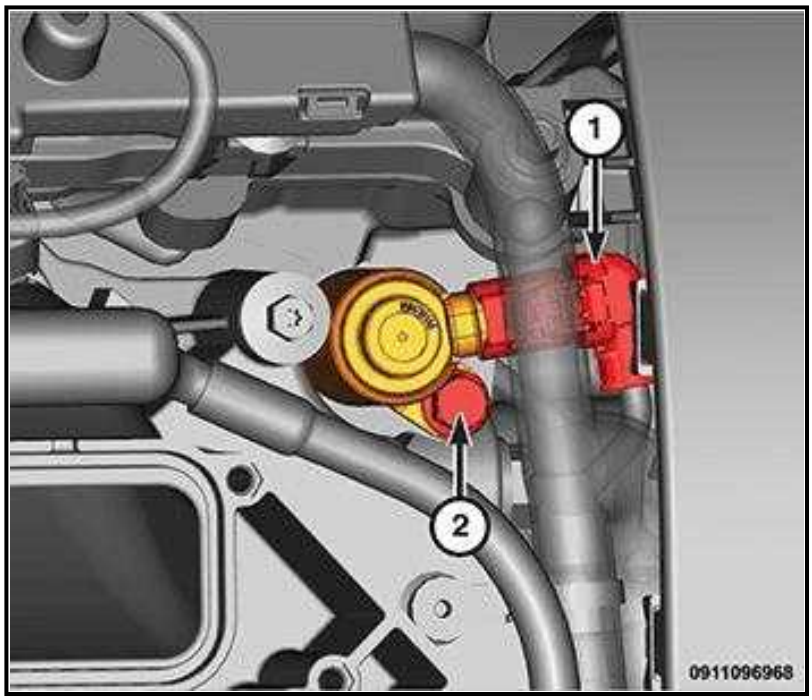


CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

VVL SOLENOID - BANK 1 - SOLENOID 2

REMOVAL

1. Remove the engine cover. Refer to **COVER, ENGINE, REMOVAL AND INSTALLATION** .



1 - Variable Valve Lift Solenoid Bolt
2 - Wire Harness Connector

2. Disconnect the Variable Valve Lift (VVL) solenoid wire harness connector.
3. Remove the VVL solenoid retaining bolt.
4. Remove the VVL solenoid from the cylinder head.
5. The O-rings can be reused if not damaged.

INSTALLATION

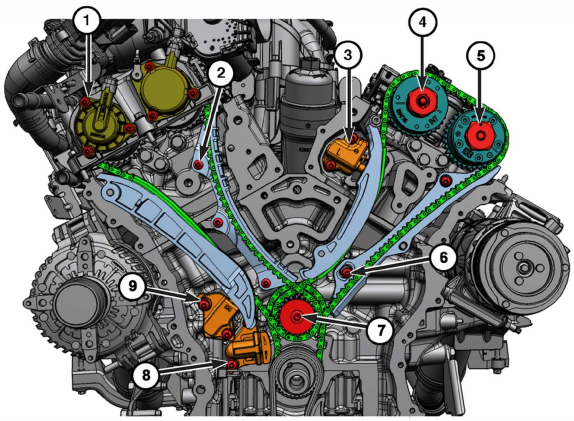
During installation, torque the fasteners to the specifications in the torque table(s) below.

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.

- Carefully inspect the Variable Valve Lift (VVL) solenoid O-ring for nicks or cuts. Replace the O-rings if there is any indication or damage to the O-rings.
- Insert the VVL solenoids straight into the cylinder head. **Do Not** insert the VVL solenoid on an angle as this may damage the O-ring seals. **If an O-ring does not seal completely the oil pressure will leak between the passages which can cause the improper operation of the VVL system and driveability issues including misfire.**

TORQUE SPECIFICATIONS

VALVE TIMING



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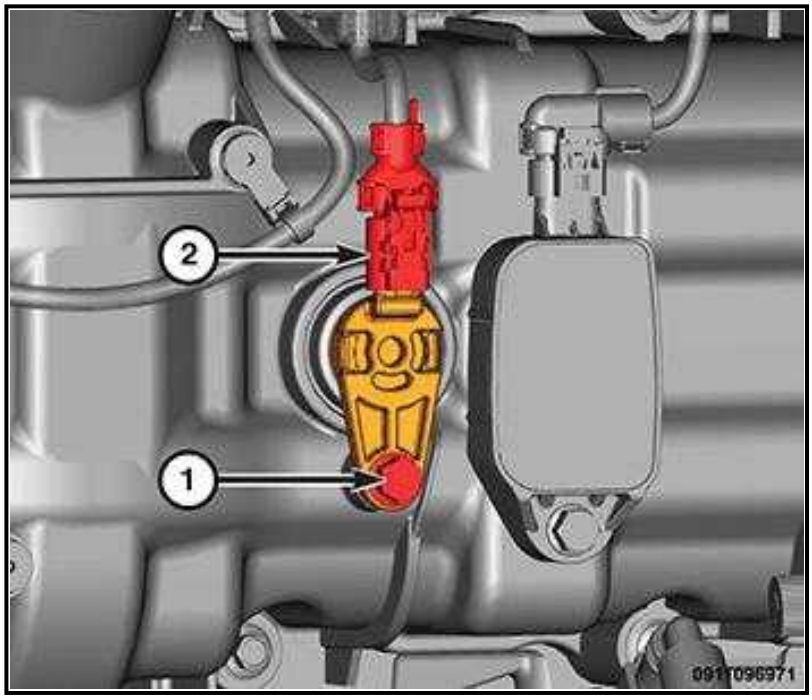
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

VVL SOLENOID - BANK 2 - SOLENOID 1

REMOVAL

1. Remove the upper intake manifold. Refer to **MANIFOLD, INTAKE, REMOVAL AND INSTALLATION** .



1 - Variable Valve Lift Solenoid Bolt
2 - Wire Harness Connector

2. Disconnect the Variable Valve Lift (VVL) solenoid wire harness connector.
3. Remove the retaining bolt from the VVL solenoid.
4. Remove the VVL solenoid from the cylinder head cover.
5. The O-rings can be reused if not damaged.

INSTALLATION

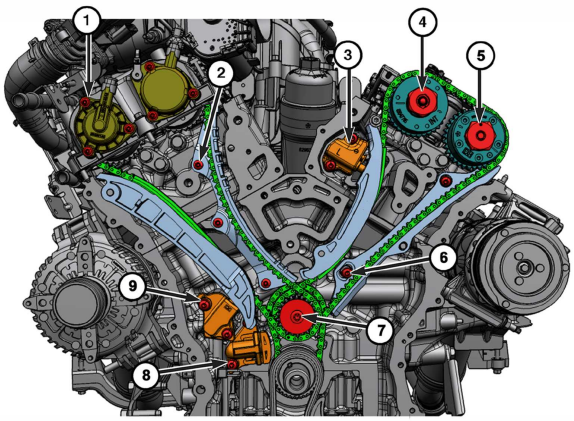
During installation, torque the fasteners to the specifications in the torque table(s) below.

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.

- Carefully inspect the Variable Valve Lift (VVL) solenoid O-ring for nicks or cuts. Replace the O-rings if there is any indication or damage to the O-rings.
- Insert the VVL solenoids straight into the cylinder head cover. **Do Not** insert the VVL solenoid on an angle as this may damage the O-ring seals. **If an O-ring does not seal completely the oil pressure will leak between the passages which can cause the improper operation of the VVL system and driveability issues including misfire.**

TORQUE SPECIFICATIONS

VALVE TIMING



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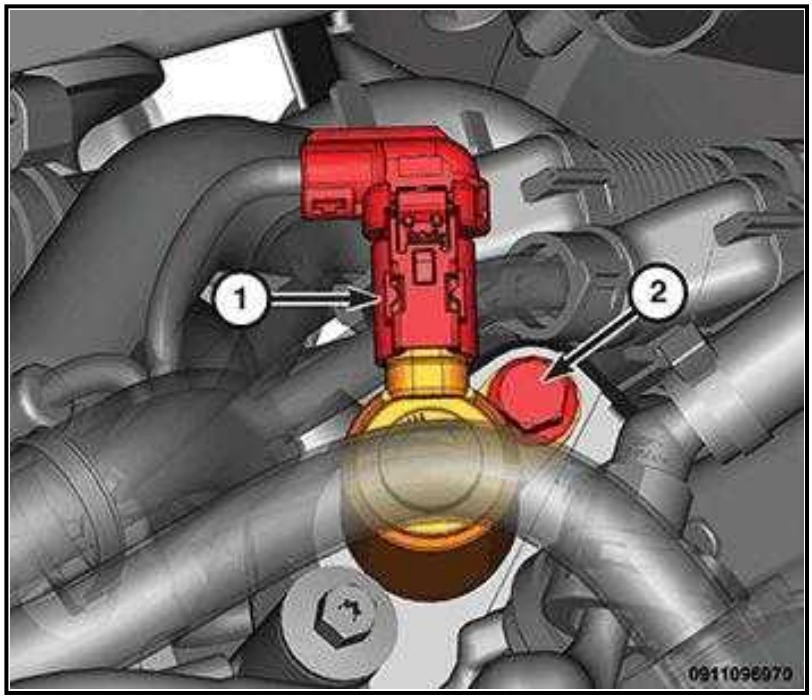
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

VVL SOLENOID - BANK 2 - SOLENOID 2

REMOVAL

1. Remove the upper intake manifold. Refer to **MANIFOLD, INTAKE, REMOVAL AND INSTALLATION** .



1 - Variable Valve Lift Solenoid Bolt
2 - Wire Harness Connector

2. Disconnect the Variable Valve Lift (VVL) solenoid wire harness connector.
3. Remove the VVL solenoid retaining bolt.
4. Remove the VVL solenoid from the cylinder head.
5. The O-rings can be reused if not damaged.

INSTALLATION

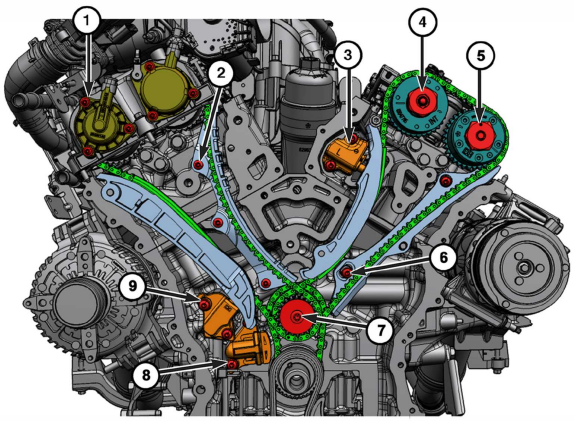
During installation, torque the fasteners to the specifications in the torque table(s) below.

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.

- Carefully inspect the Variable Valve Lift (VVL) solenoid O-ring for nicks or cuts. Replace the O-rings if there is any indication or damage to the O-rings.
- Insert the VVL solenoids straight into the cylinder head. **Do Not** insert the VVL solenoid on an angle as this may damage the O-ring seals. **If an O-ring does not seal completely the oil pressure will leak between the passages which can cause the improper operation of the VVL system and driveability issues including misfire.**

TORQUE SPECIFICATIONS

VALVE TIMING



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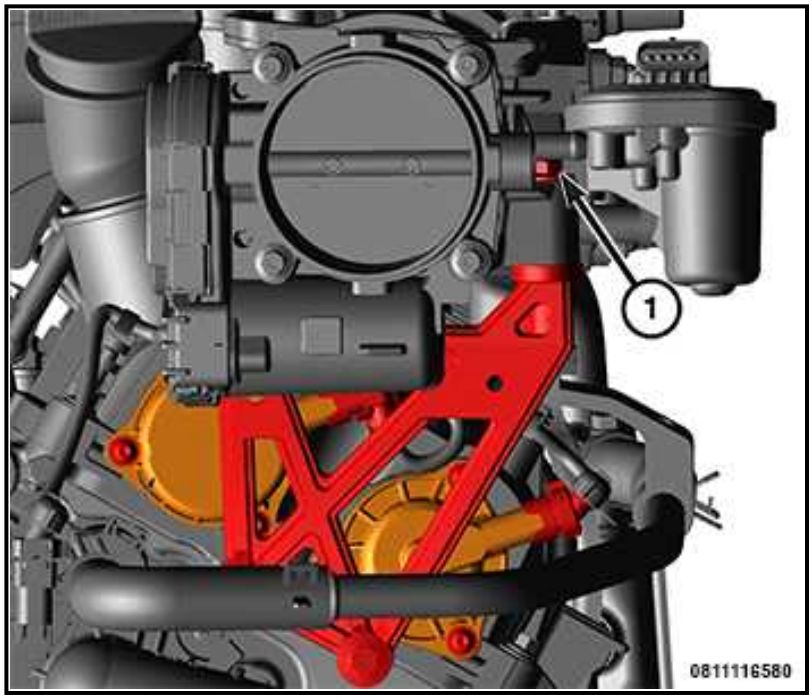
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

VVT SOLENOID - LEFT

REMOVAL

1. Remove the air cleaner resonator. Refer to **RESONATOR, AIR CLEANER, REMOVAL AND INSTALLATION** .

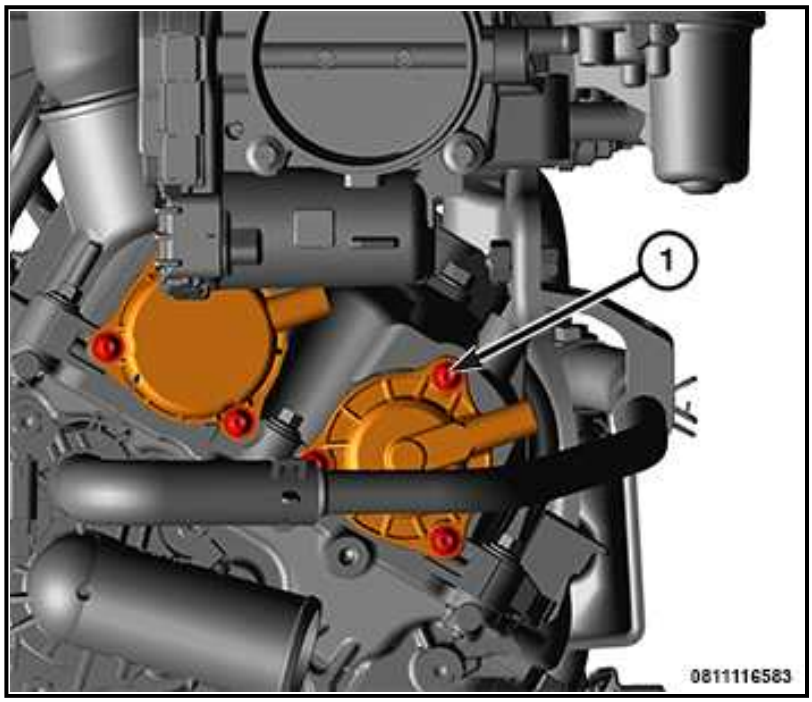


1 - Throttle Body Support Bracket Bolts

2. Remove throttle body support bracket bolts and remove the throttle body support bracket.

NOTE: **Mark the Variable Valve Timing (VVT) solenoid connectors with a paint pen or equivalent so that they may be reinstalled in their original locations.**

3. Disconnect the wire harness connector from the VVT solenoid.



1 - VVT Solenoid Mounting Bolts

4. Remove the VVT solenoid mounting bolts.
5. Pull the VVT solenoid from the cylinder head cover.
6. The seal can be reused if not damaged.

INSTALLATION

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

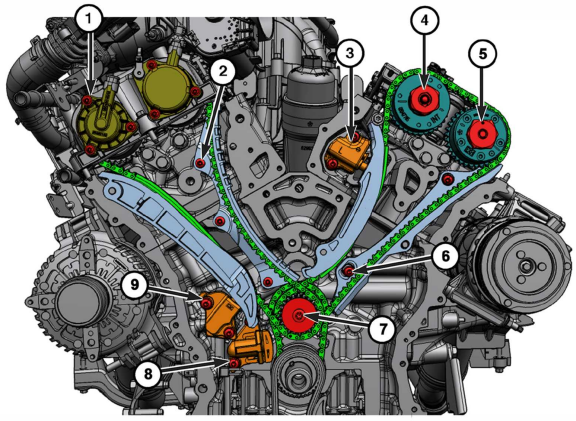
Follow the removal procedure in reverse for general reassembly of the components on the vehicle. The steps listed below are calling out specific procedures that should be followed during installation.

- The Variable Valve Timing (VVT) solenoid seals can be reused if not damaged.
- Refer to the markings made at disassembly and install the intake VVT solenoid and the exhaust VVT solenoid in their original locations.

NOTE: **The Cam/Crank Variation Relearn procedure must be performed using the scan tool anytime there has been a repair/replacement made to a powertrain system, for example: flywheel, valvetrain, camshaft and/or crankshaft sensors or components.**

TORQUE SPECIFICATIONS

VALVE TIMING



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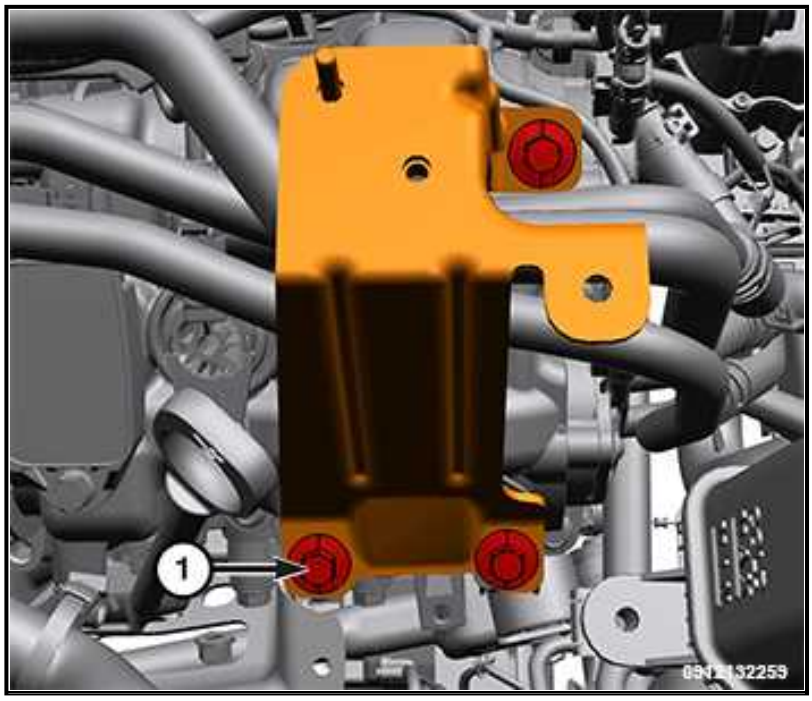
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-

CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

CAM PHASER - RIGHT

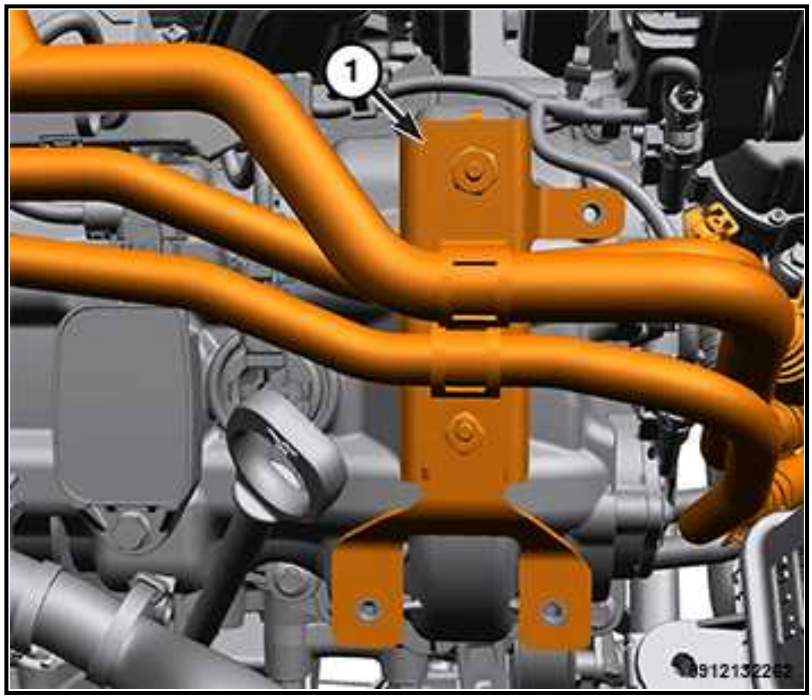
REMOVAL

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. Remove the air cleaner resonator. Refer to **RESONATOR, AIR CLEANER, REMOVAL AND INSTALLATION** .



1 - Engine Cover Mounting Bracket Bolts

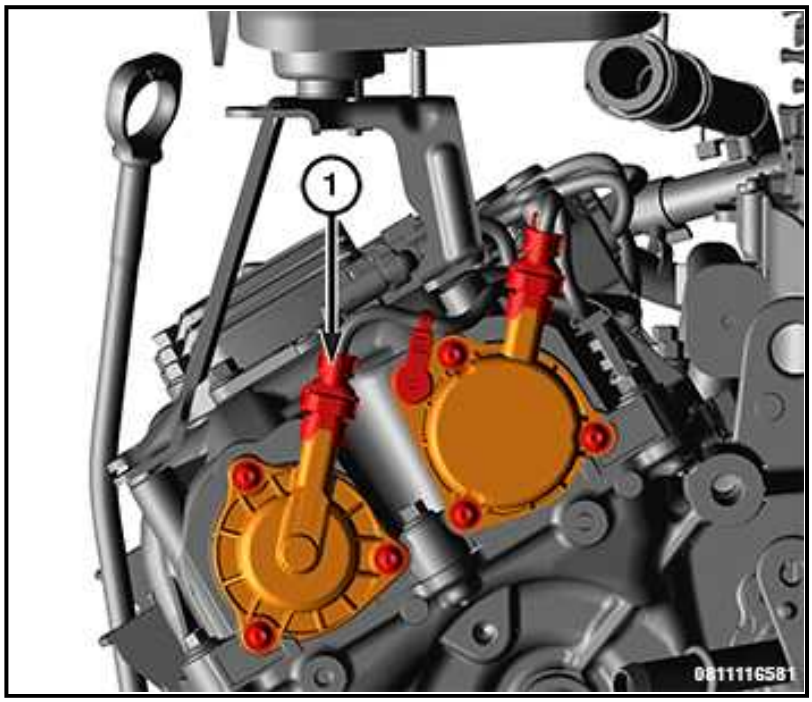
4. Remove the bolts and the engine cover mounting bracket.



1 - Heater Hose Mounting Bracket

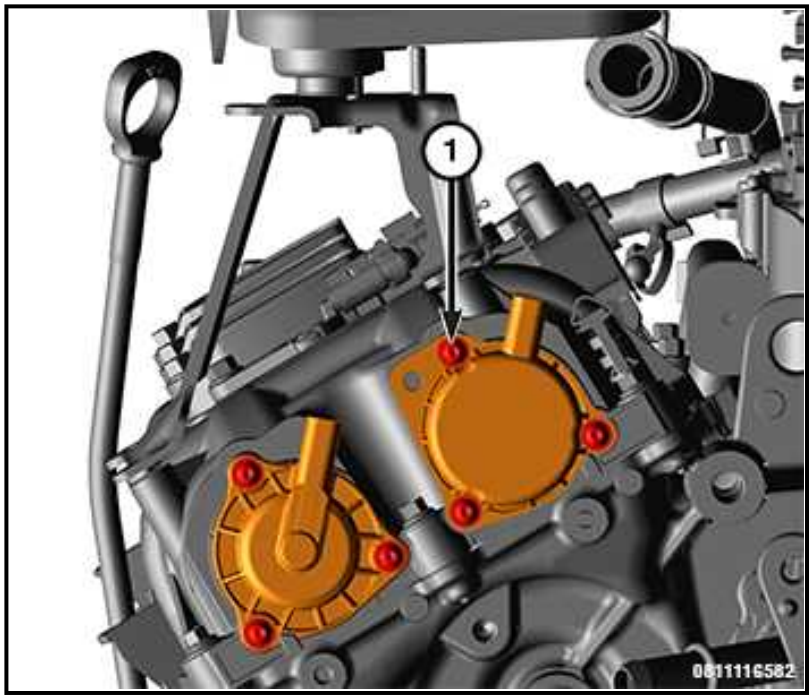
5. Remove heater hose mounting bracket and position the heater hoses aside.

NOTE: **Mark the variable valve timing solenoid connectors with a paint pen or equivalent so that they may be reinstalled in their original locations.**



1 - VVT Solenoid Wire Harness Connector

6. Disconnect the wire harness connector from the Variable Valve Timing (VVT) solenoid.



1 - VVT Solenoid Mounting Bolts

7. Remove the VVT solenoid mounting bolts.
8. Pull the VVT solenoid from the cylinder head cover.
9. The seal can be reused if not damaged.

INSTALLATION

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

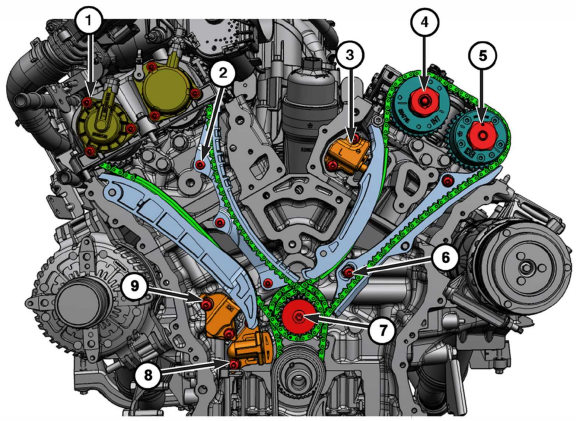
Follow the removal procedure in reverse for general reassembly of the components on the vehicle. The steps listed below are calling out specific procedures that should be followed during installation.

- The Variable Valve Timing (VVT) solenoid seals can be reused if not damaged.
- Refer to the markings made at disassembly and install the intake VVT solenoid and the exhaust VVT solenoid in their original locations.

NOTE: **The Cam/Crank Variation Relearn procedure must be performed using the scan tool anytime there has been a repair/replacement made to a powertrain system, for example: flywheel, valvetrain, camshaft and/or crankshaft sensors or components.**

TORQUE SPECIFICATIONS

VALVE TIMING



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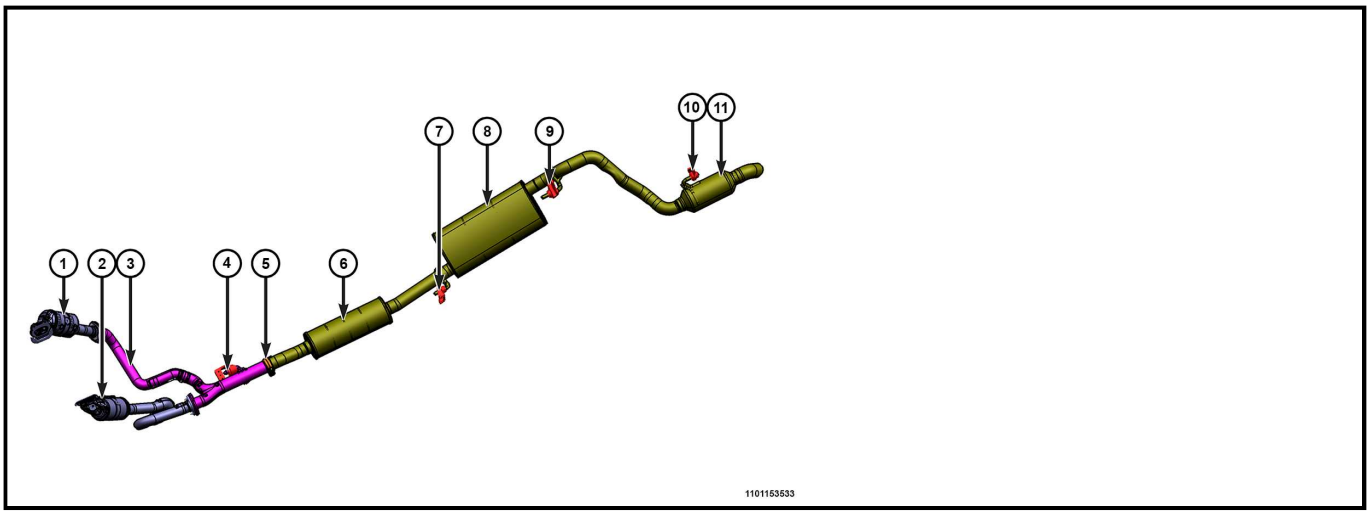
CALLOUT	DESCRIPTION	SPECIFICATION	COMMENTS
1	Variable Valve Timing Solenoids	**10 N. m (7 Ft. Lbs.)**	-
2	Camshaft Chain RH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
3	Camshaft Chain LH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
4	Oil Control Valve/Cam Phaser Bolt - Intake	**Torque Procedure:** 1. **30 N.m (22 Ft. Lbs.)** 2. **Turn additional 45B°**	-
5	Oil Control Valve/Cam Phaser Bolt - Exhaust	**160 N.m (118 Ft. Lbs.)**	-
6	Camshaft Chain LH Guide (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
7	Camshaft Chain Idler Sprocket Bolt	**26 N.m (19 Ft. Lbs.)**	-
-	Camshaft Chain Guide (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
8	Camshaft Chain Tensioner (Primary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
9	Camshaft Chain RH Tensioner (Secondary) Bolt	**12 N.m (9 Ft. Lbs.)**	-
-	Variable Valve Lift Solenoid Bolt	**10 N.m (7 Ft. Lbs.)**	-

DESCRIPTION AND OPERATION

DESCRIPTION AND OPERATION



1 - RIGHT CATALYTIC CONVERTER	7 - EXHAUST ISOLATOR
2 - LEFT CATALYTIC CONVERTER	8 - EXHAUST MUFFLER
3 - EXHAUST-Y-PIPE	9 - EXHAUST ISOLATOR
4 - EXHAUST ISOLATOR	10 - EXHAUST ISOLATOR
5 - EXHAUST CLAMP	11 - EXHAUST TAILPIPE
6 - EXHAUST RESONATOR	B

WARNING: **The normal operating temperature of the exhaust system is very high. Therefore, never work around or attempt to service any part of the exhaust system until it is cooled. Special care should be taken when working near the catalytic converter. The temperature of the converter rises to a high level after a short period of engine operation time.**

CAUTION: **Avoid application of rust prevention compounds or undercoating materials to exhaust system floor pan heat shields. Light overspray near the edges is permitted. Application of coating will result in excessive floor pan temperatures and objectionable fumes.**

- The exhaust resonator (6) and exhaust muffler (8) are serviced as an assembly. The exhaust tailpipe (11) will be serviced separately.
- The exhaust system must be properly aligned to prevent stress, leakage and body contact. If the system contacts any body panel, it may amplify objectionable noises originating from the engine or body.
- When inspecting an exhaust system, critically inspect for cracked or loose joints, stripped screw or bolt threads, corrosion damage and worn, cracked or broken hangers. Replace all components that are badly corroded or damaged. DO NOT attempt to repair.
- When replacement is required, use original equipment parts (or their equivalent). This will assure proper alignment and provide acceptable exhaust noise levels.

DIAGNOSIS AND TESTING

DIAGNOSIS AND TESTING

EXHAUST SYSTEM DIAGNOSIS CHART

CONDITION	POSSIBLE CAUSE	CORRECTION
Excessive Exhaust Noise or Leaking Exhaust Gases	1. Leaks at pipe joints.	1. Tighten clamps/bolts to specified torque at leaking joints.
	2. Rusted or blown out muffler.	2. Replace muffler. Inspect exhaust system.
	3. Broken or rusted out exhaust pipe.	3. Replace exhaust pipe.
	4. Exhaust pipe leaking at manifold flange.	4. Tighten/replace flange attaching nuts/bolts.
	5. Exhaust manifold cracked or broken.	5. Replace exhaust manifold.
	6. Leak between exhaust manifold and cylinder head.	6. Tighten exhaust manifold to cylinder head bolts.
	7. Catalytic converter rusted or blown out.	7. Replace catalytic converter assembly.
	8. Restriction in exhaust system.	8. Remove restriction, if possible. Replace restricted part if necessary.
CAUTION: **When servicing or replacing exhaust system components, disconnect the oxygen sensor connector(s). Allowing the exhaust to hang by the oxygen sensor wires will damage the harness or oxygen sensor.**		

LEAK TESTING

WARNING: **The normal operating temperature of the exhaust system is very high. Therefore, never work around or attempt to service any part of the exhaust system until it is cooled. Special care should be taken when working near the catalytic converter. The temperature of the converter rises to a high level after a short period of engine operation time.**

1. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .

CAUTION: **The air pressure must not exceed 4 psi, otherwise engine damage can occur.**

2. Connect the (special tool #8404-ECT, Exhaust Cone, Truck) to an adjustable air pressure regulator.
3. Attach shop air to the air pressure regulator.
4. Adjust the air pressure regulator to 27.6 kPa (4 psi).

5. Insert the (special tool #8404-ECT, Exhaust Cone, Truck) into the vehicle tail pipe.
6. If the vehicle is equipped with dual exhaust, use an additional (special tool #8404-ECT, Exhaust Cone, Truck) equipped with an attached plug. Plug one side of the dual exhaust pipe. Pressurize the other as described.
7. Apply MoparB® Air Leak Detector or a mixture of liquid dish soap and water to the following areas:
    - All welded joints at least 18 inches rearward of the downstream oxygen sensor and forward to the cylinder head
    - Oxygen sensor seal points
    - Oxygen sensor boss welds
    - Flange/joint connection(s)
    - Exhaust manifold to cylinder head connection(s)
    - EGR solenoid gasket base and tube seal points (if equipped).
8. Watch for the liquid/soapy water to bubble.
9. Use the following definitions to help determine if system or component repair/replacement is necessary:

- **Type 1 Leak** is defined as a leak where very small foam like bubbles 1 mm (0.039 in.) or less appear. Any Type 1 or greater leaks found in welded joints, O2 sensor seal points or O2 sensor boss welds must be repaired or the component must be replaced.
- **Type 2 Leak** is defined as a leak where larger bubbles 8 mm (0.32 in.) or greater appear. A Type 2 Leak may also include at hissing sound (air pressure escaping) if the opening is too large to create bubbles. Any Type 2 or greater leaks found in flange or joint connections, exhaust manifold to cylinder head connections, or EGR gasket and tube seal points must be repaired or the components must be replaced.

Leak Location	Repair required if results at 4 psi reveal bubble size or hissing sound:
Welded joints	Type 1 - 1 mm (0.039 in.) or greater
O2 Sensor seal points	Type 1 - 1 mm (0.039 in.) or greater
O2 Sensor boss welds	Type 1 - 1 mm (0.039 in.) or greater
Flange/joint connections	Type 2 - 8 mm (0.315 in.) or greater
Exhaust Manifold to cylinder head connections	Type 2 - 8 mm (0.315 in.) or greater
EGR gasket and tube seal points (if equipped)	Type 2 - 8 mm (0.315 in.) or greater

If a leak is found that matches the above definition, repair or replace the component as necessary.

Once the repair is complete, repeat the procedure to verify that all leaks have been repaired.

ADJUSTMENTS

A misaligned exhaust system is usually indicated by a vibration, rattling noise, or binding of exhaust system components. These noises are sometimes hard to distinguish from other chassis noises. Inspect exhaust system for broken or loose clamps, heat shields, isolators, and brackets. Replace or tighten as necessary. It is important that exhaust system clearances and alignment be maintained.

Perform the following procedures to align the exhaust system:

1. Loosen clamps and support brackets.
2. Align the exhaust system starting at the front, working rearward.
3. Following the specific installation procedure, tighten all clamps and brackets once alignment and clearances are achieved.

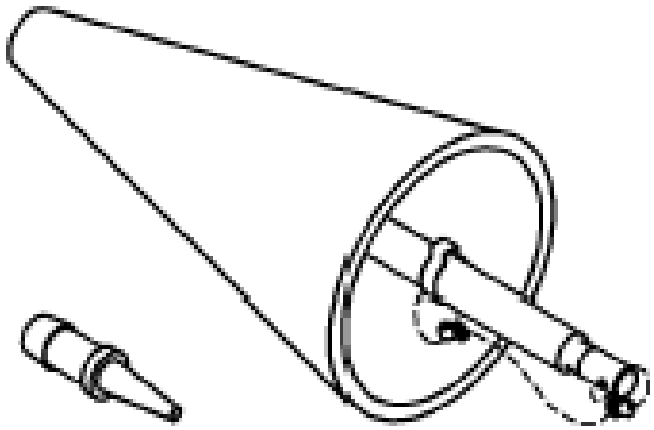
TECHNICAL SPECIFICATIONS

TORQUE SPECIFICATIONS

TORQUE SPECIFICATIONS - 3.6L EXHAUST SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
Catalytic Converter to Cylinder Head Bolts	**24 N. m (18 Ft. Lbs.)**	-
Exhaust Y-Pipe-to-Catalytic Converter Flange Bolts	**18 N. m (13 Ft. Lbs.)**	-
Exhaust Resonator Clamp Bolt	**26 N. m (19 Ft. Lbs.)**	-
Front Exhaust Isolator Bolts	**30 N. m (22 Ft. Lbs.)**	-
Muffler Clamp Nuts	**55 N. m (41 Ft. Lbs.)**	-
Muffler Exhaust Isolator Bolts	**25 N. m (18 Ft. Lbs.)**	-
Heat Shield Nuts	**3 N.m (27 In. Lbs.)**	-

SPECIAL TOOLS

	8404-ECT - Exhaust Cone, Truck (Originally Shipped In Kit Number(s) 8404-ECT.)

CONVERTER, CATALYTIC

INSPECTION

WARNING: **The normal operating temperature of the exhaust system is very high. Therefore, never attempt to service any part of the exhaust system until it is cooled. Special care should be taken when working near the catalytic converter. The temperature of the converter rises to a high level after a short period of engine operation time.**

Visually inspect the catalytic converter element by using a borescope or equivalent. Remove the oxygen sensor(s) and insert borescope. Refer to **SPARK PLUG, REMOVAL AND INSTALLATION** . If borescope is not available, remove converter and inspect element using a flashlight. Inspect element for cracked or melted substrate.

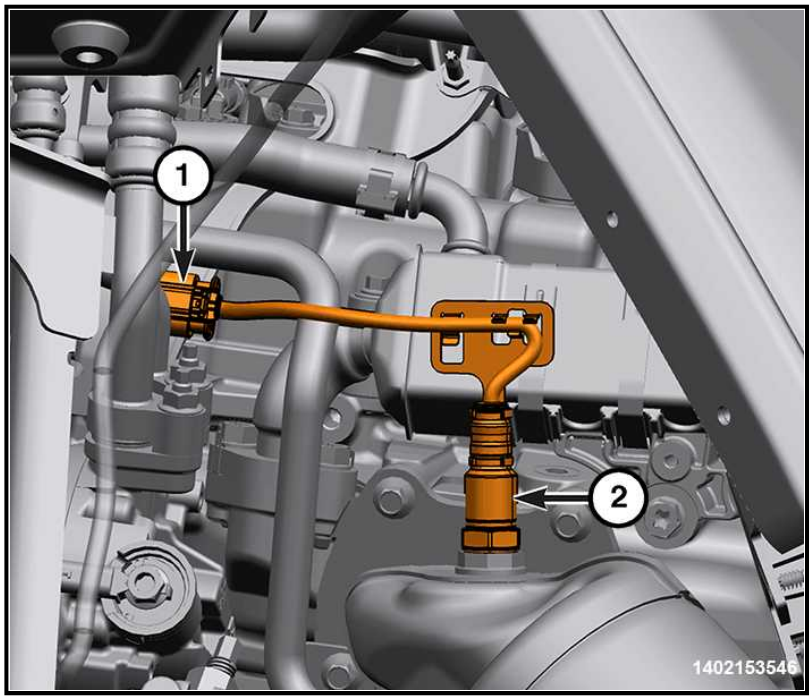
NOTE: **Before replacing a catalytic converter, determine the root cause of failure. Most catalytic converter failures are caused by air, fuel or ignition problems. (Refer to Appropriate Diagnostic Information) for test procedures.**

REMOVAL AND INSTALLATION

CATALYTIC CONVERTER - LEFT SIDE

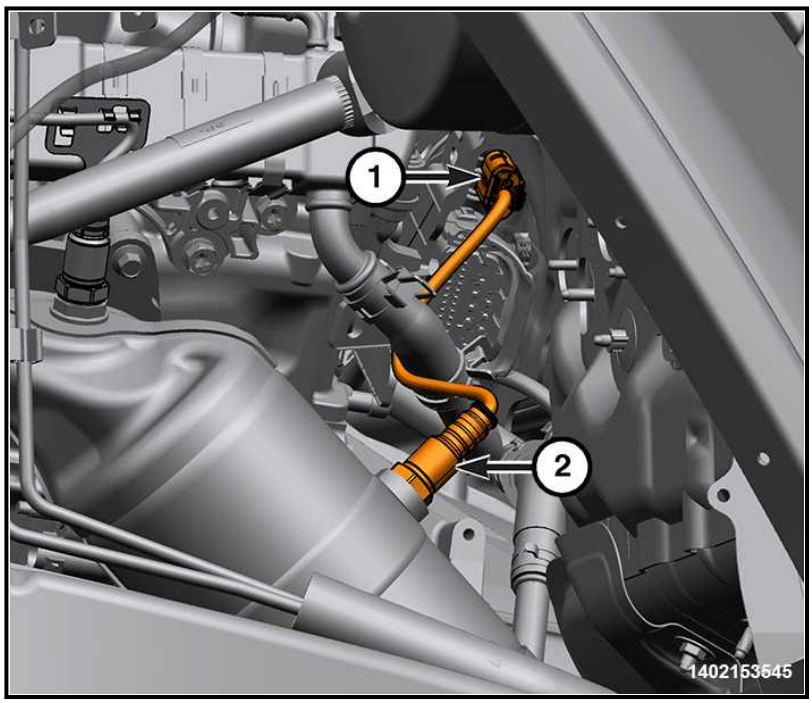
REMOVAL

1. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
2. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .
3. Remove the front propeller shaft. Refer to **REMOVAL AND INSTALLATION** .
4. Remove the exhaust Y-pipe Refer to **Y-PIPE, EXHAUST, REMOVAL AND INSTALLATION**.
5. Remove the left side tire and wheel assembly. Refer to **REMOVAL AND INSTALLATION** .
6. Remove the left side wheelhouse splash shield. Refer to **SHIELD, SPLASH, FRONT WHEELHOUSE, REMOVAL AND INSTALLATION** **SHIELD, SPLASH, REAR WHEELHOUSE, REMOVAL AND INSTALLATION** .



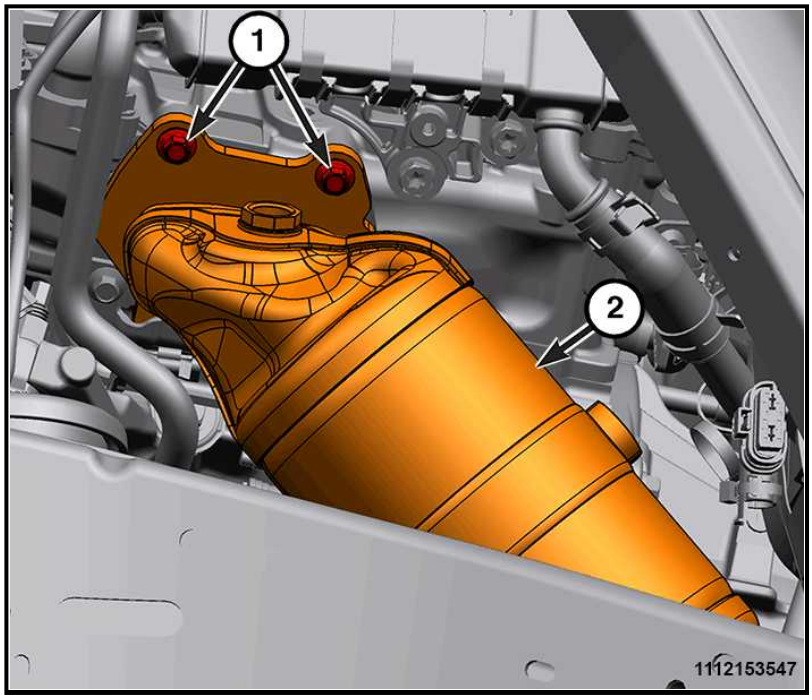
1 - Upstream O2 Sensor Wiring Harness Connector

7. Disconnect the upstream oxygen sensors wiring harness connector.



1 - Downstream O2 Sensor Wiring Harness Connector

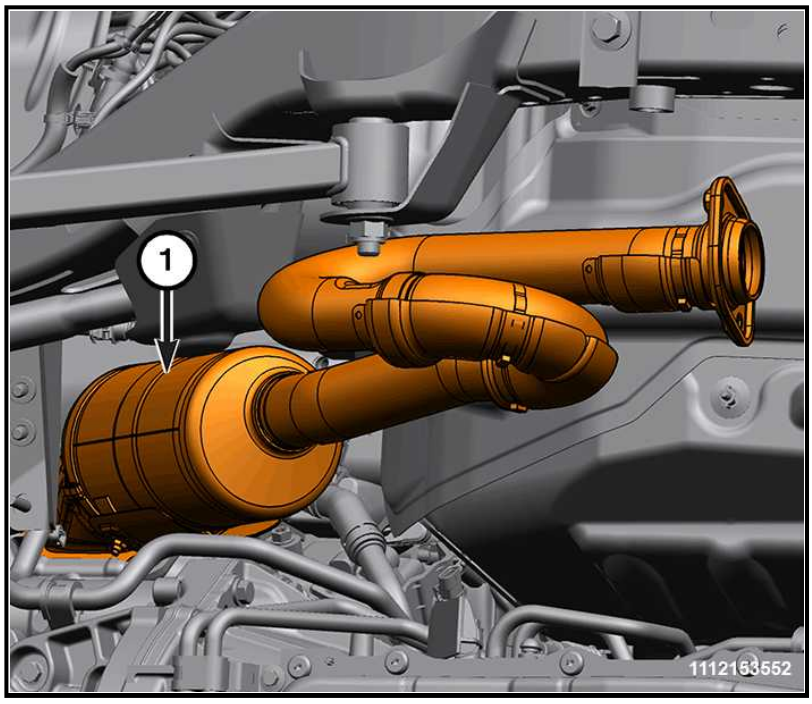
8. Disconnect the downstream oxygen sensors wiring harness connector.



1 - Catalytic Converter Bolts

NOTE: **The catalytic converter flange is secured to the cylinder head. A steel sleeve holds the lower section of the converter flange to the head while two bolts fasten the flange to the cylinder head. The steel sleeve does not need to be removed for catalytic converter removal.**

9. Saturate the bolts with MoparB® Rust Penetrant lubricant. Allow 5 minutes for penetration.
10. Remove the upper catalytic converter flange bolts.
11. Raise and support the vehicle.



1 - Catalytic Converter

NOTE: **The catalytic converter flange is secured to the cylinder head. A steel sleeve holds the lower section of the converter flange to the head while two bolts fasten the flange to the cylinder head. The steel sleeve does not need to be removed for converter removal.**

12. Using care, lift the catalytic converter upward to remove it from the steel sleeve and out from the bottom of the vehicle.

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.

- Using a **NEW** gasket, position the catalytic converter assembly into the steel sleeve on the cylinder head through the bottom of the vehicle.
- Make sure the exhaust pipe/exhaust system is aligned and has the proper clearance. The minimum clearance is 25 mm (1 inch). Make the necessary adjustments, if needed.
- Start the engine and inspect for leaks. Repair exhaust leaks as necessary.

TORQUE SPECIFICATIONS

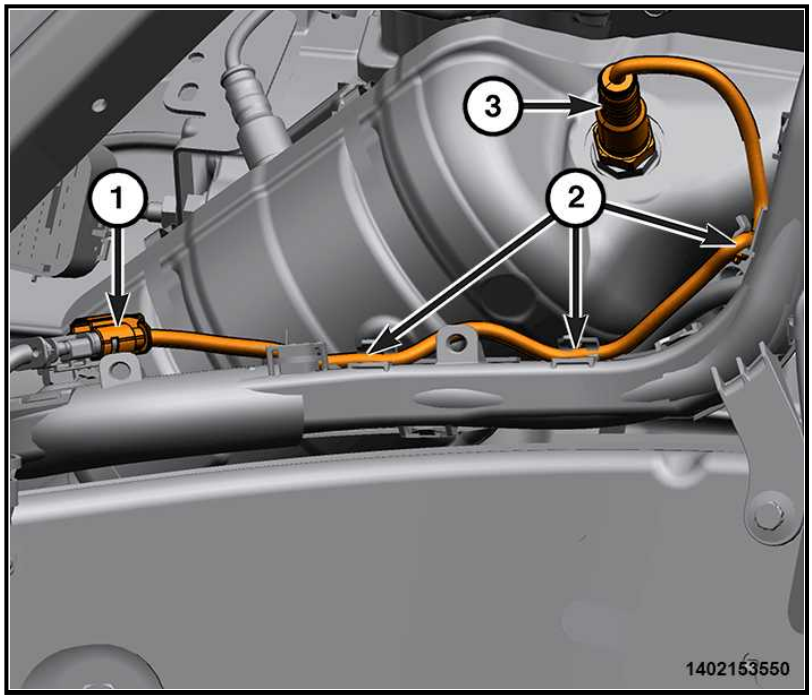
TORQUE SPECIFICATIONS - 3.6L EXHAUST SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
Catalytic Converter to Cylinder Head Bolts	**24 N. m (18 Ft. Lbs.)**	-
Exhaust Y-Pipe-to-Catalytic Converter Flange Bolts	**18 N. m (13 Ft. Lbs.)**	-
Exhaust Resonator Clamp Bolt	**26 N. m (19 Ft. Lbs.)**	-
Front Exhaust Isolator Bolts	**30 N. m (22 Ft. Lbs.)**	-
Muffler Clamp Nuts	**55 N. m (41 Ft. Lbs.)**	-
Muffler Exhaust Isolator Bolts	**25 N. m (18 Ft. Lbs.)**	-
Heat Shield Nuts	**3 N.m (27 In. Lbs.)**	-

CATALYTIC CONVERTER - RIGHT SIDE

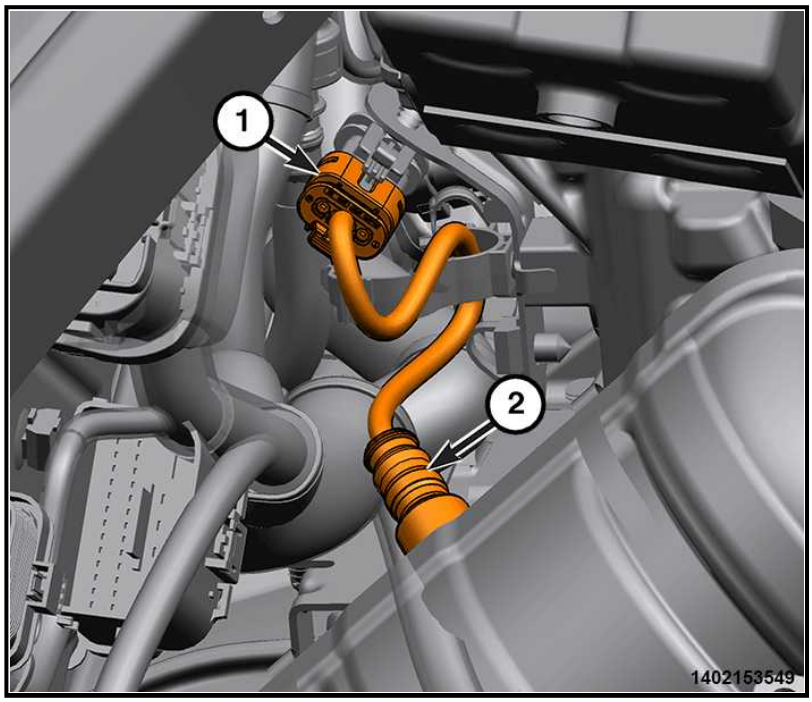
REMOVAL

1. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
2. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .
3. Remove the exhaust Y-pipe. Refer to **Y-PIPE, EXHAUST, REMOVAL AND INSTALLATION**.
4. Remove the support and partially lower the vehicle.
5. Remove the right tire and wheel assembly. Refer to **REMOVAL AND INSTALLATION** .
6. Remove the right side wheelhouse splash shield. Refer to **SHIELD, SPLASH, FRONT WHEELHOUSE, REMOVAL AND INSTALLATION** **SHIELD, SPLASH, REAR WHEELHOUSE, REMOVAL AND INSTALLATION** .



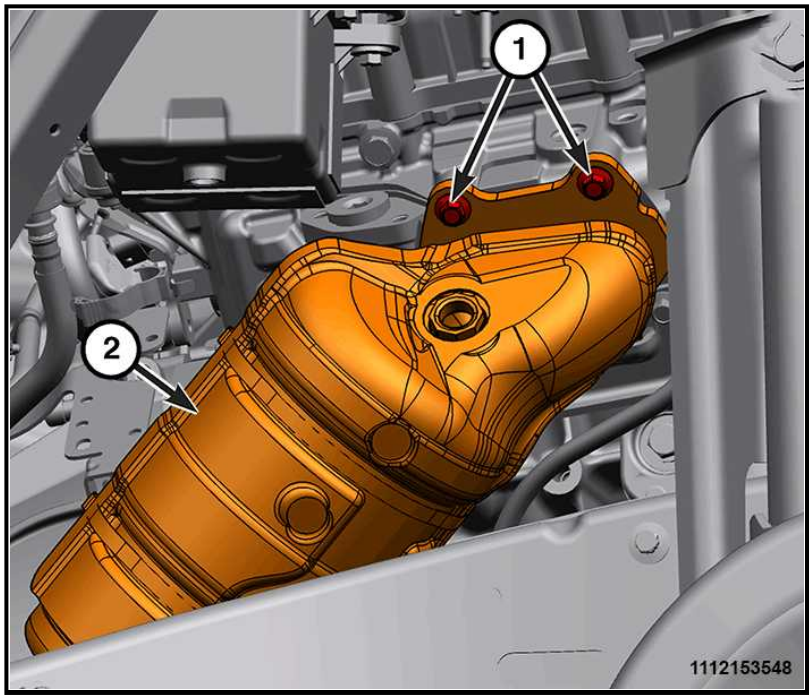
1 - Upstream O2 Sensor Wiring Harness Connector
2 - Upstream O2 Sensor Wiring Harness Retainers
3 - Upstream O2 Sensor

7. Disconnect the upstream oxygen sensor wire harness connector.
8. Detach the oxygen sensor wire harness from the retainers.



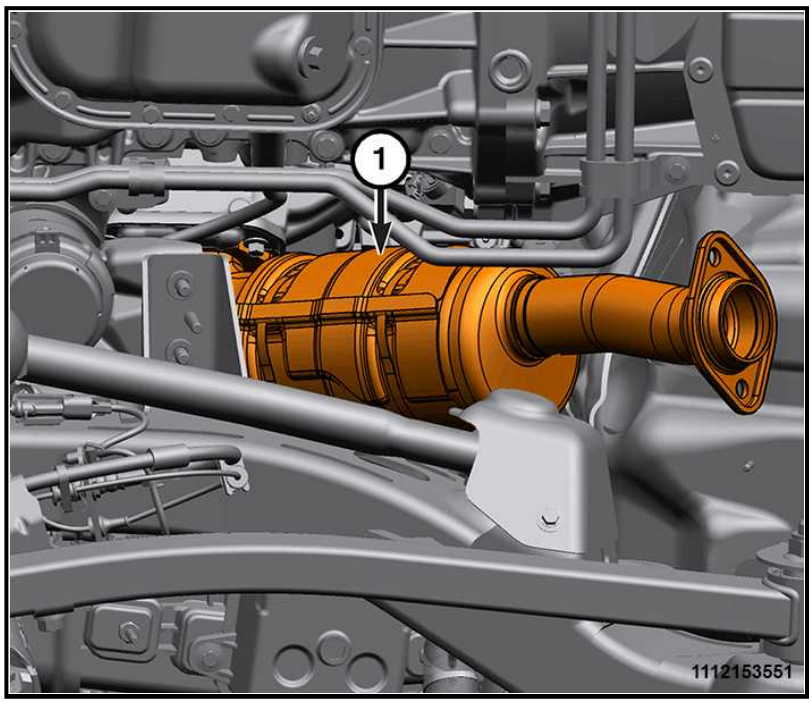
1 - Downstream O2 Sensor Wiring Harness Connector
2 - Downstream O2 Sensor

9. Disconnect the downstream oxygen sensors wire harness connector.



1 - Catalytic Converter Bolts

10. Saturate the bolts with MoparB® Rust Penetrant lubricant. Allow 5 minutes for penetration.
11. Remove the upper catalytic converter flange bolts.
12. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .



1 - Catalytic Converter

NOTE: **The catalytic converter flange is secured to the cylinder head. A steel sleeve holds the lower section of the converter flange to the head while two bolts fasten the flange to the cylinder head. The steel sleeve does not need to be removed for converter removal.**

13. Using care, lift the catalytic converter upwards to remove from the steel sleeve and out from the bottom of the vehicle.

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.

- Using a **NEW** gasket, position the catalytic converter assembly into the steel sleeve on the cylinder head through the bottom of the vehicle.
- Make sure the exhaust pipe/exhaust system is aligned and has the proper clearance. The minimum clearance is 25 mm (1 inch). Make the necessary adjustments, if needed.
- Start the engine and inspect for leaks. Repair exhaust leaks as necessary.

TORQUE SPECIFICATIONS

TORQUE SPECIFICATIONS - 3.6L EXHAUST SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
Catalytic Converter to Cylinder Head Bolts	**24 N. m (18 Ft. Lbs.)**	-
Exhaust Y-Pipe-to-Catalytic Converter Flange Bolts	**18 N. m (13 Ft. Lbs.)**	-
Exhaust Resonator Clamp Bolt	**26 N. m (19 Ft. Lbs.)**	-
Front Exhaust Isolator Bolts	**30 N. m (22 Ft. Lbs.)**	-
Muffler Clamp Nuts	**55 N. m (41 Ft. Lbs.)**	-
Muffler Exhaust Isolator Bolts	**25 N. m (18 Ft. Lbs.)**	-
Heat Shield Nuts	**3 N.m (27 In. Lbs.)**	-

MANIFOLD, EXHAUST

REMOVAL AND INSTALLATION

EXHAUST MANIFOLD

The 3.6L aluminum cylinder heads are a unique design with left and right castings. The exhaust manifolds are integrated into the cylinder heads. If any damaged is found to the exhaust manifold portion, the cylinder head must be removed for repair or replacement. Refer to **CYLINDER HEAD ASSEMBLY, REMOVAL AND INSTALLATION** .

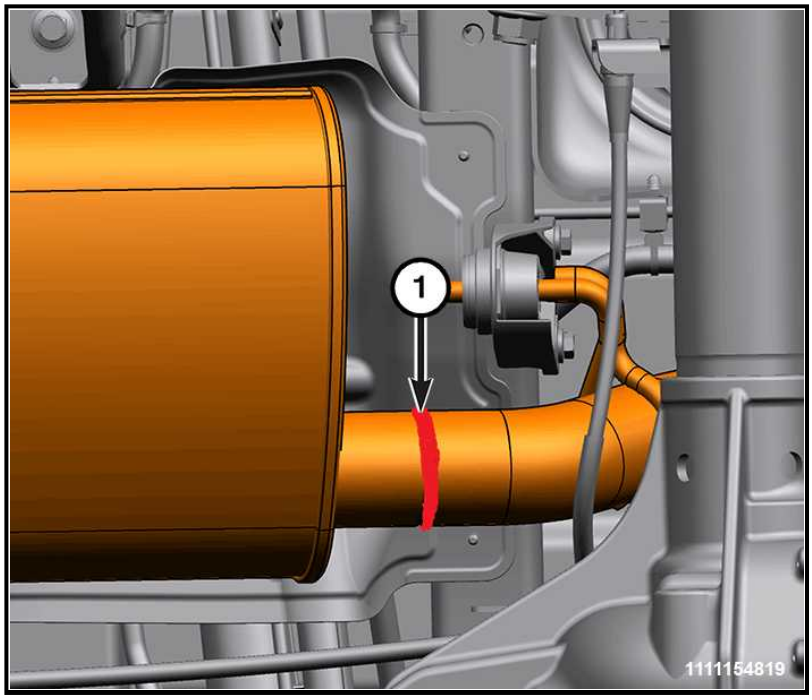
MUFFLER, EXHAUST

REMOVAL AND INSTALLATION

MUFFLER

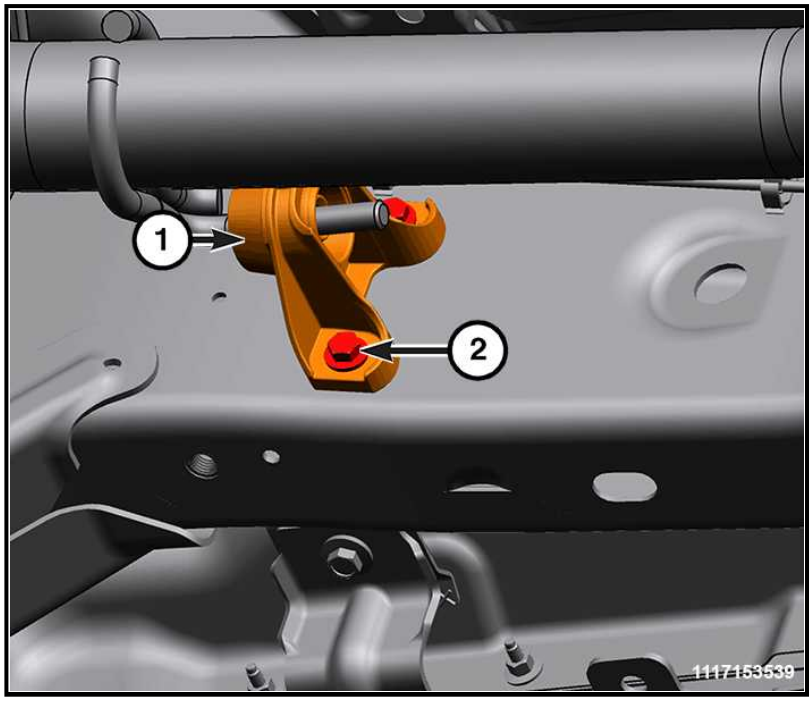
REMOVAL

1. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .
2. Position a safety stand under the exhaust resonator/muffler assembly.



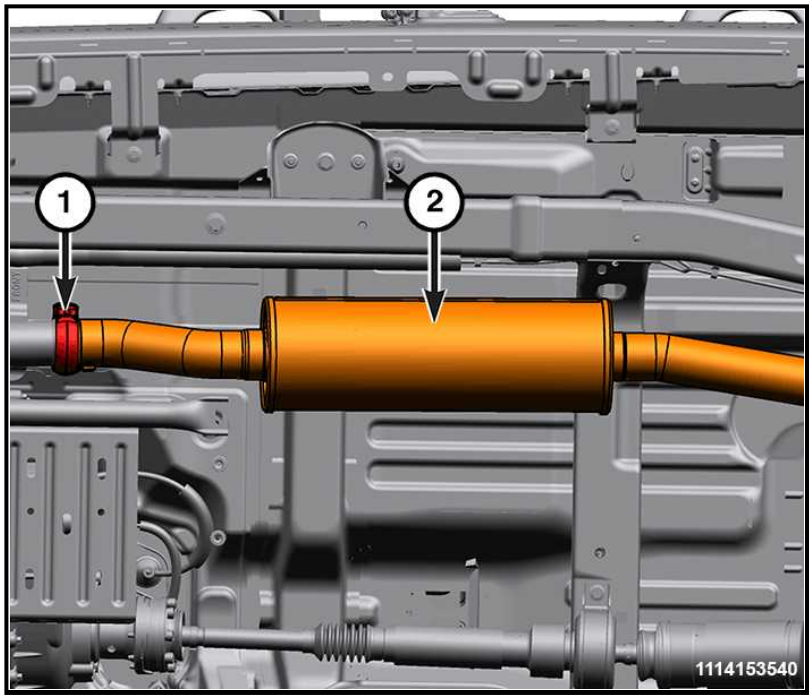
1 - Cut Line

3. Cut the exhaust tail pipe as indicated (red line).



1 - Exhaust Muffler Isolator
2 - Exhaust Muffler Isolator Bolts

4. Remove the bolts and the exhaust muffler isolator.



1 - Exhaust Muffler Clamp Nut
2 - Exhaust Muffler

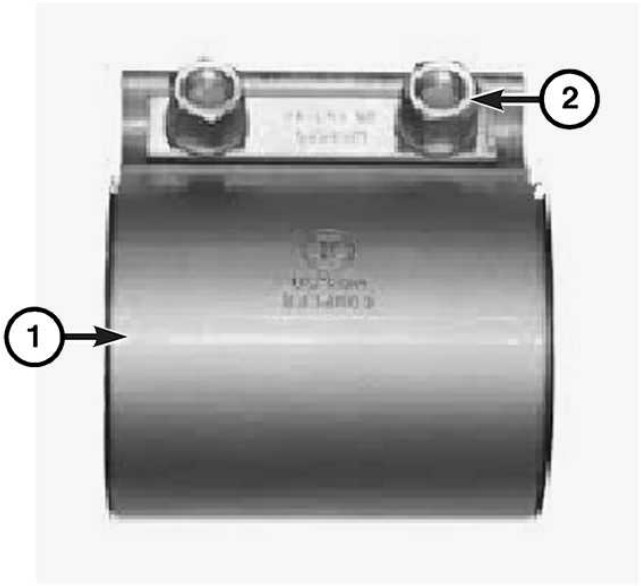
5. Remove the transfer case skid plate. Refer to **PLATE, SKID, REMOVAL AND INSTALLATION** **PLATE, SKID, FUEL TANK, REMOVAL AND INSTALLATION** **PLATE, SKID, TRANSFER CASE, REMOVAL AND INSTALLATION** .
6. Loosen the exhaust clamp nut.
7. Remove the exhaust resonator/muffler.

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 the new exhaust clamp shown between to connect the exhaust muffler to the exhaust tailpipe.
- Make sure the exhaust pipe/exhaust system is aligned and has the proper clearance. The minimum clearance is 25 mm (1 inch). Make the necessary adjustments, if needed.
- Start the engine and inspect for leaks. Repair exhaust leaks as necessary.



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1 - New Exhaust Clamp

TORQUE SPECIFICATIONS

TORQUE SPECIFICATIONS - 3.6L EXHAUST SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
Catalytic Converter to Cylinder Head Bolts	**24 N. m (18 Ft. Lbs.)**	-
Exhaust Y-Pipe-to-Catalytic Converter Flange Bolts	**18 N. m (13 Ft. Lbs.)**	-
Exhaust Resonator Clamp Bolt	**26 N. m (19 Ft. Lbs.)**	-
Front Exhaust Isolator Bolts	**30 N. m (22 Ft. Lbs.)**	-
Muffler Clamp Nuts	**55 N. m (41 Ft. Lbs.)**	-
Muffler Exhaust Isolator Bolts	**25 N. m (18 Ft. Lbs.)**	-
Heat Shield Nuts	**3 N.m (27 In. Lbs.)**	-

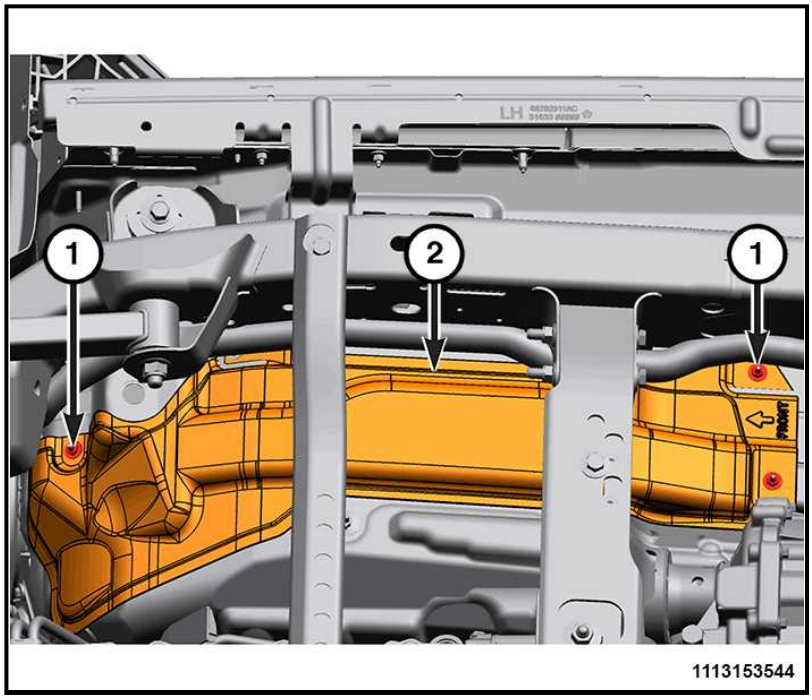
SHIELD, HEAT

REMOVAL AND INSTALLATION

CATALYTIC CONVERTER HEAT SHIELD

REMOVAL

1. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .



1 - Heat Shield Nuts
2 - Heat Shield

NOTE: **Left catalytic converter removed for clarity.**

2. Working above the left catalytic converter, remove the retaining nuts and the heat shield.

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.

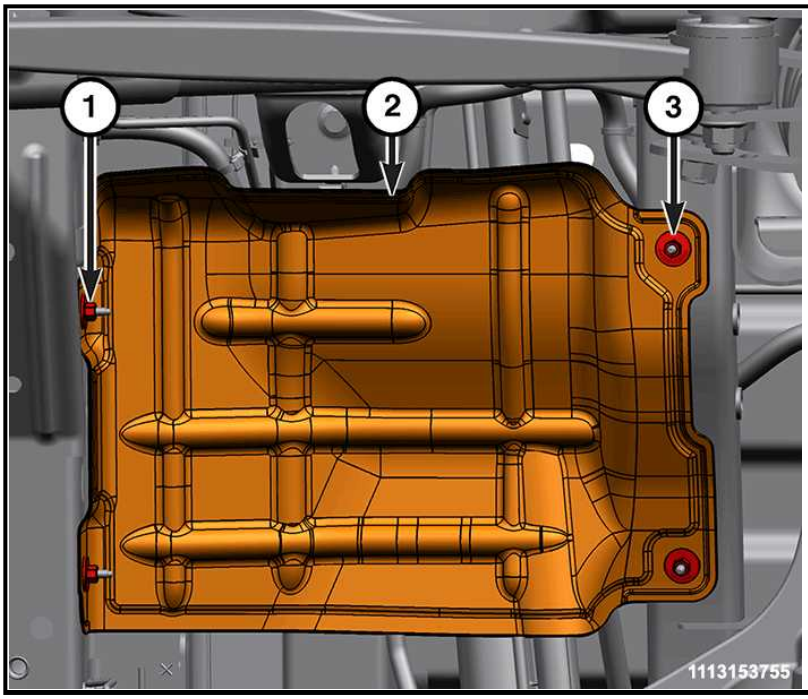
TORQUE SPECIFICATIONS

TORQUE SPECIFICATIONS - 3.6L EXHAUST SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
Catalytic Converter to Cylinder Head Bolts	**24 N. m (18 Ft. Lbs.)**	-
Exhaust Y-Pipe-to-Catalytic Converter Flange Bolts	**18 N. m (13 Ft. Lbs.)**	-
Exhaust Resonator Clamp Bolt	**26 N. m (19 Ft. Lbs.)**	-
Front Exhaust Isolator Bolts	**30 N. m (22 Ft. Lbs.)**	-
Muffler Clamp Nuts	**55 N. m (41 Ft. Lbs.)**	-
Muffler Exhaust Isolator Bolts	**25 N. m (18 Ft. Lbs.)**	-
Heat Shield Nuts	**3 N.m (27 In. Lbs.)**	-

EXHAUST MUFFLER HEAT SHIELD

REMOVAL



1 - Muffler Heat Shield Nuts
2 - Muffler Heat Shield
3 - Muffler Heat Shield Nuts

NOTE: **The exhaust muffler heat shield can be serviced with muffler in place. Shown with muffler removed for clarity.**

1. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .
2. Remove the nuts and the exhaust muffler heat shield.

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.

- Make sure the muffler/exhaust system is aligned and has the proper clearance. The minimum clearance is 25 mm (1 inch). Make the necessary adjustments, if needed.
- Start the engine and inspect for leaks. Repair exhaust leaks as necessary.

TORQUE SPECIFICATIONS

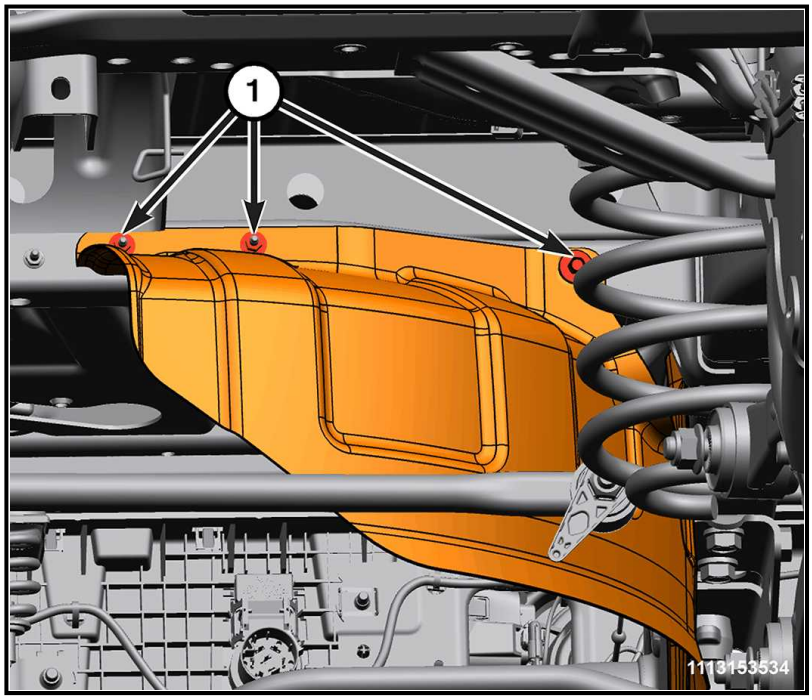
TORQUE SPECIFICATIONS - 3.6L EXHAUST SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
Catalytic Converter to Cylinder Head Bolts	**24 N. m (18 Ft. Lbs.)**	-
Exhaust Y-Pipe-to-Catalytic Converter Flange Bolts	**18 N. m (13 Ft. Lbs.)**	-
Exhaust Resonator Clamp Bolt	**26 N. m (19 Ft. Lbs.)**	-
Front Exhaust Isolator Bolts	**30 N. m (22 Ft. Lbs.)**	-
Muffler Clamp Nuts	**55 N. m (41 Ft. Lbs.)**	-
Muffler Exhaust Isolator Bolts	**25 N. m (18 Ft. Lbs.)**	-
Heat Shield Nuts	**3 N.m (27 In. Lbs.)**	-

TAILPIPE HEAT SHIELD

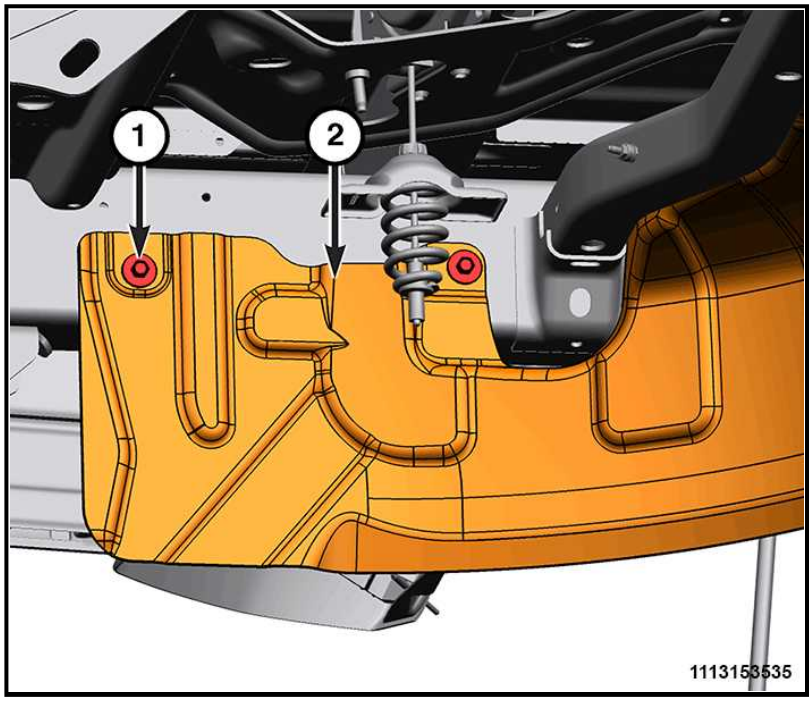
REMOVAL

1. Remove the spare tire and wheel.



1 - Exhaust Tailpipe Shield Fasteners

2. Remove the three outer fasteners securing the exhaust tailpipe heat shield.



1 - Exhaust Tailpipe Shield Bolts
2 - Muffler Heat Shield

3. Remove the bolts and the exhaust tailpipe heat shield.

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.

- Check that the heat shield for damage.

TORQUE SPECIFICATIONS

TORQUE SPECIFICATIONS - 3.6L EXHAUST SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
Catalytic Converter to Cylinder Head Bolts	**24 N. m (18 Ft. Lbs.)**	-
Exhaust Y-Pipe-to-Catalytic Converter Flange Bolts	**18 N. m (13 Ft. Lbs.)**	-
Exhaust Resonator Clamp Bolt	**26 N. m (19 Ft. Lbs.)**	-
Front Exhaust Isolator Bolts	**30 N. m (22 Ft. Lbs.)**	-
Muffler Clamp Nuts	**55 N. m (41 Ft. Lbs.)**	-
Muffler Exhaust Isolator Bolts	**25 N. m (18 Ft. Lbs.)**	-
Heat Shield Nuts	**3 N.m (27 In. Lbs.)**	-

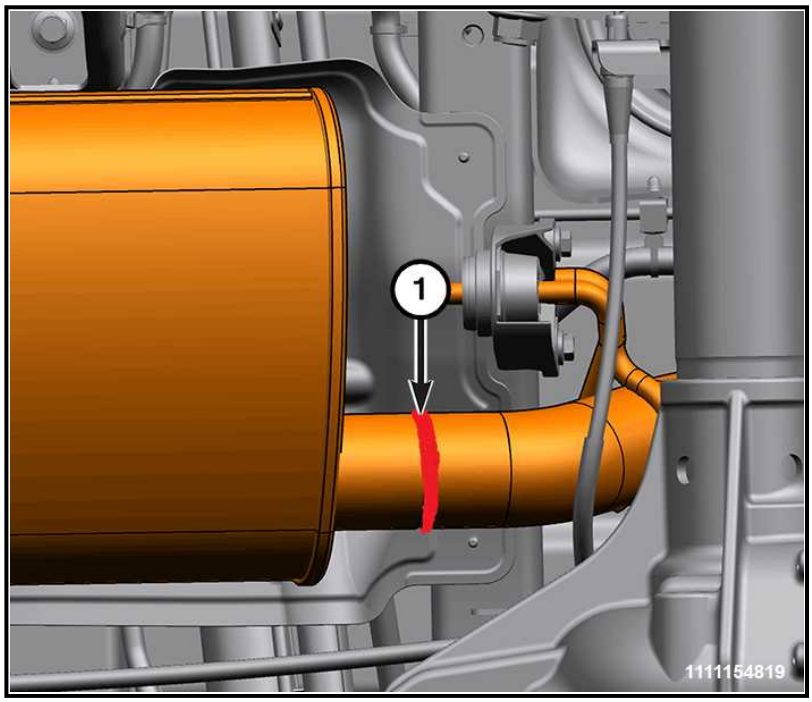
TAILPIPE, EXHAUST

REMOVAL AND INSTALLATION

TAILPIPE

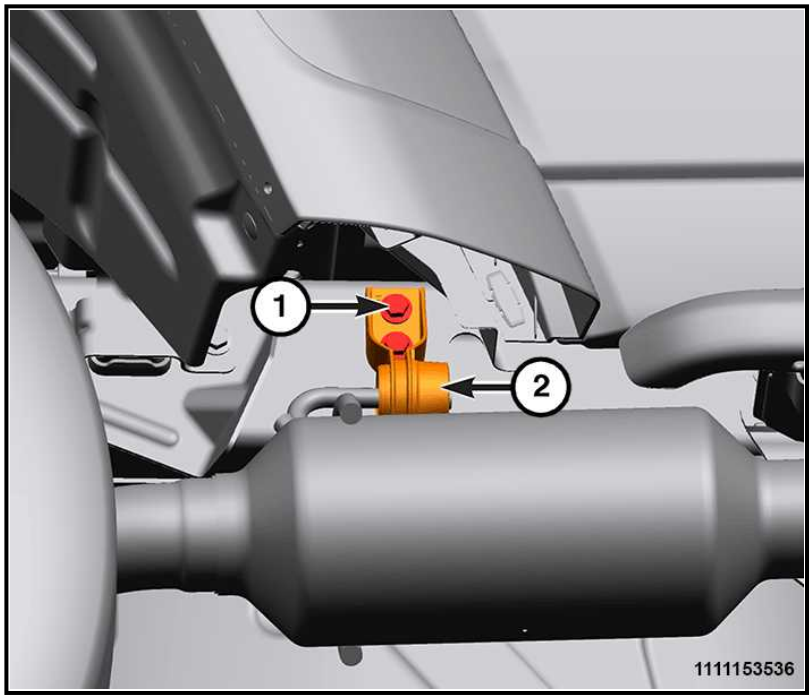
REMOVAL

1. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .



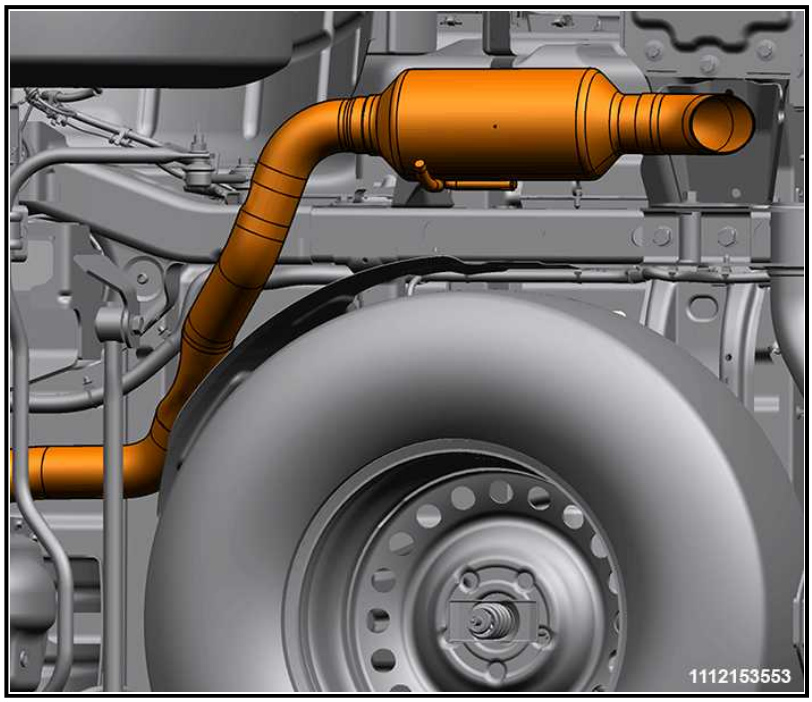
1 - Cut Line

2. Cut the exhaust tail pipe as indicated (red line).



1 - Exhaust Muffler Isolator Bolts
2 - Exhaust Muffler Isolator

3. Remove the bolts and the exhaust isolator.



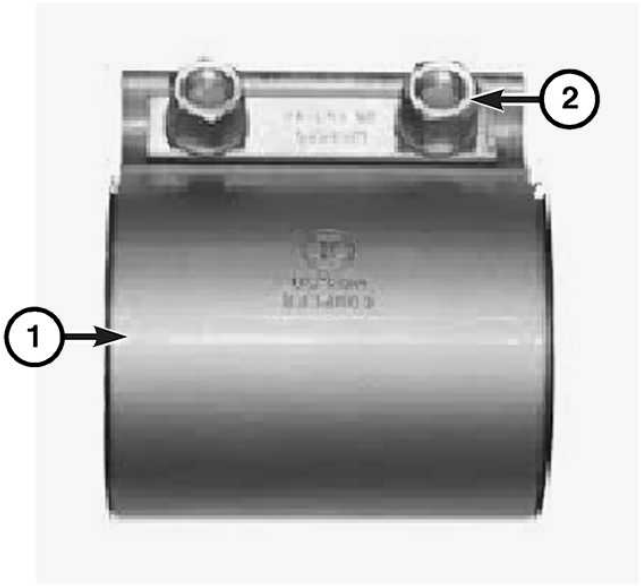
4. Remove the exhaust tailpipe from the vehicle.

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 the new exhaust clamp shown between to connect the exhaust muffler to the exhaust tailpipe.
- Make sure the exhaust pipe/exhaust system is aligned and has the proper clearance. The minimum clearance is 25 mm (1 inch). Make the necessary adjustments, if needed.
- Start the engine and inspect for leaks. Repair exhaust leaks as necessary.



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1 - New Exhaust Clamp

TORQUE SPECIFICATIONS

TORQUE SPECIFICATIONS - 3.6L EXHAUST SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
Catalytic Converter to Cylinder Head Bolts	**24 N. m (18 Ft. Lbs.)**	-
Exhaust Y-Pipe-to-Catalytic Converter Flange Bolts	**18 N. m (13 Ft. Lbs.)**	-
Exhaust Resonator Clamp Bolt	**26 N. m (19 Ft. Lbs.)**	-
Front Exhaust Isolator Bolts	**30 N. m (22 Ft. Lbs.)**	-
Muffler Clamp Nuts	**55 N. m (41 Ft. Lbs.)**	-
Muffler Exhaust Isolator Bolts	**25 N. m (18 Ft. Lbs.)**	-
Heat Shield Nuts	**3 N.m (27 In. Lbs.)**	-

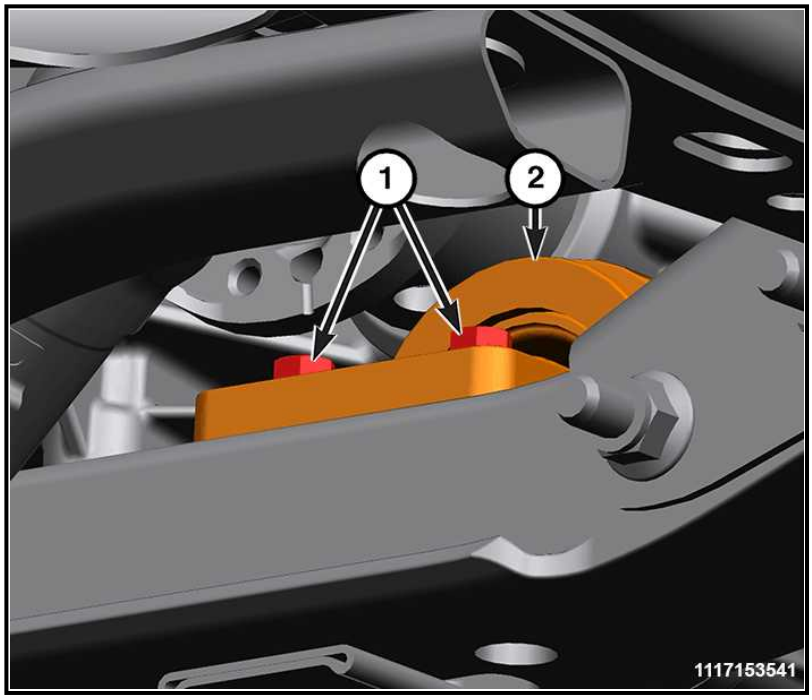
Y-PIPE, EXHAUST

REMOVAL AND INSTALLATION

REMOVAL AND INSTALLATION

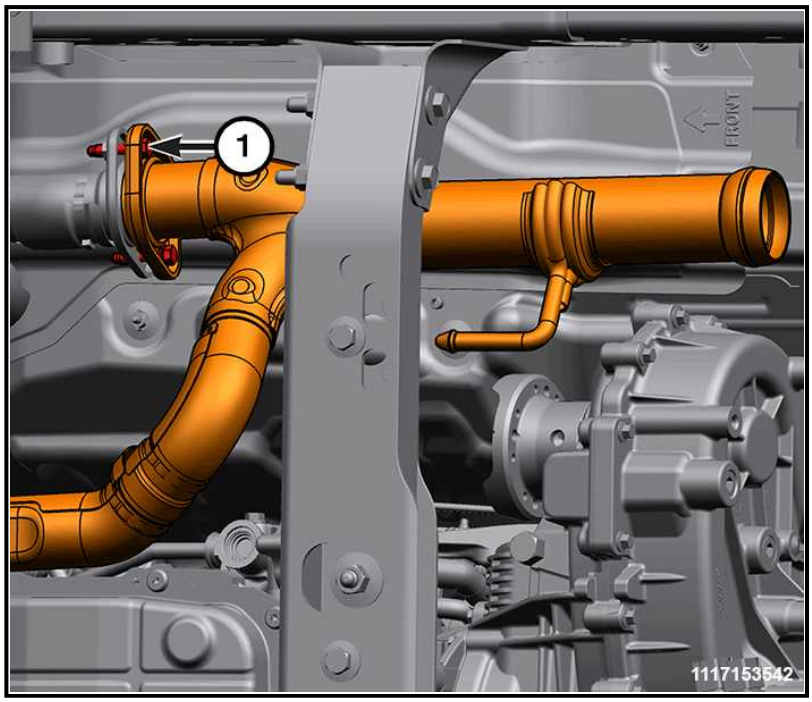
REMOVAL

1. Remove the front crossmember case skid plate. Refer to **CROSSMEMBER, TRANSMISSION, REMOVAL AND INSTALLATION** .
2. Remove the exhaust resonator/muffler. Refer to **MUFFLER, EXHAUST, REMOVAL AND INSTALLATION**.



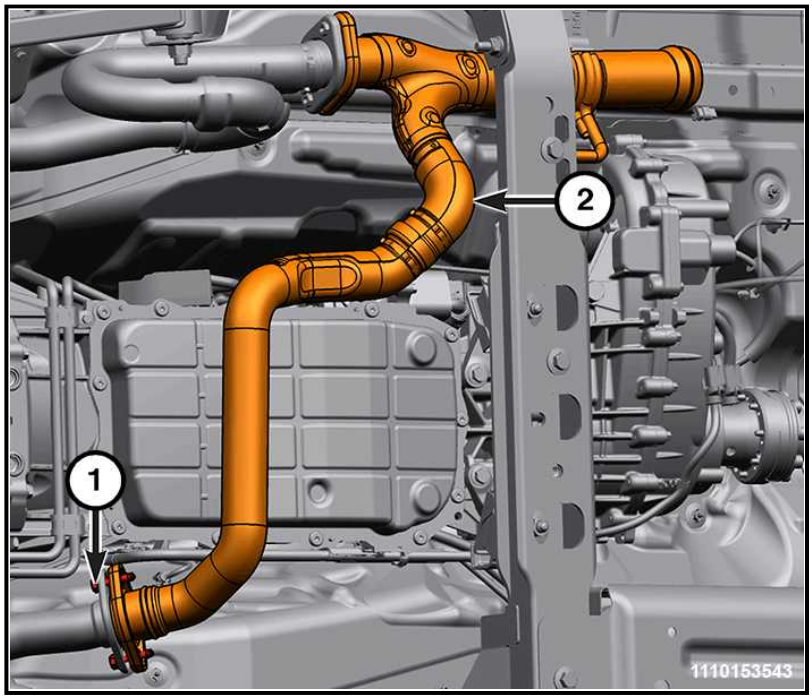
1 - Exhaust Isolator Bolts
2 - Exhaust Isolator

3. Remove the bolts and the exhaust isolator.



1 - Exhaust Y-pipe Bolts

4. Saturate the exhaust Y-pipe bolts with a MoparB® rust penetrant. Allow 5 minutes for penetration.
5. Remove the exhaust Y-pipe bolts.



1 - Exhaust Y-pipe Bolts
2 - Exhaust Y-pipe

6. Saturate the bolts with a MoparB® rust penetrant. Allow 5 minutes for penetration.
7. Remove the bolts and the exhaust Y-pipe from the vehicle.

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 all exhaust Y-pipe bolts and verify proper alignment before tightening the bolts.
- Verify that the exhaust entire exhaust system is aligned and has the proper clearance. The minimum clearance is 25 mm (1 inch). Make the necessary adjustments, if needed.
- Check the exhaust system for contact with the body panels. Make the necessary adjustments, if needed.
- Start the engine and inspect for leaks. Repair exhaust leaks as necessary.

TORQUE SPECIFICATIONS

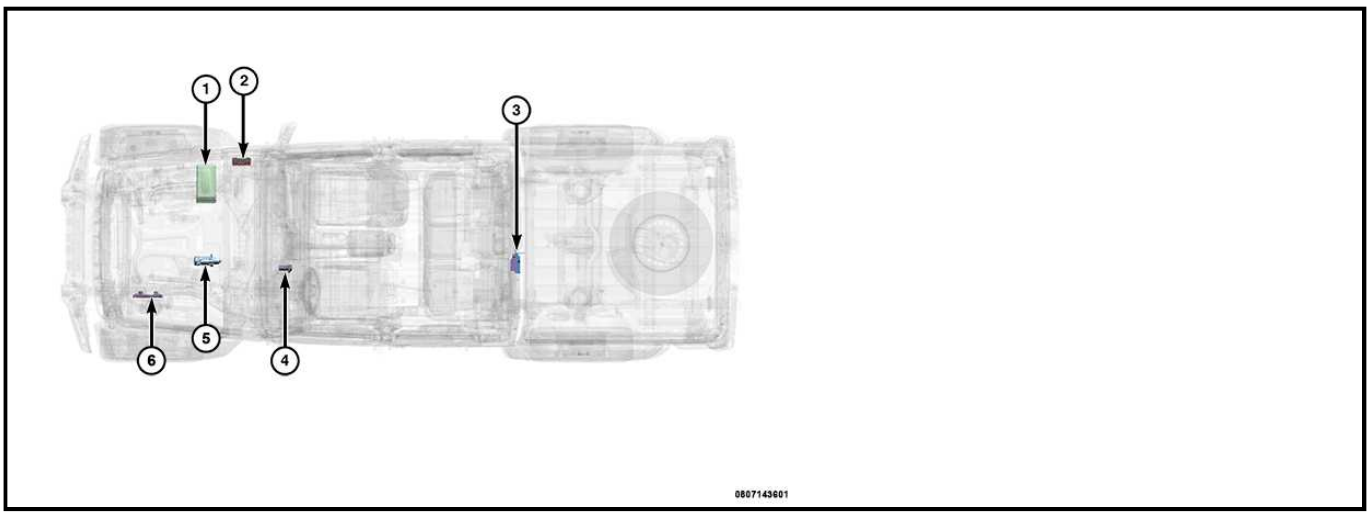
TORQUE SPECIFICATIONS - 3.6L EXHAUST SYSTEM

DESCRIPTION	SPECIFICATION	COMMENTS
Catalytic Converter to Cylinder Head Bolts	**24 N. m (18 Ft. Lbs.)**	-
Exhaust Y-Pipe-to-Catalytic Converter Flange Bolts	**18 N. m (13 Ft. Lbs.)**	-
Exhaust Resonator Clamp Bolt	**26 N. m (19 Ft. Lbs.)**	-
Front Exhaust Isolator Bolts	**30 N. m (22 Ft. Lbs.)**	-
Muffler Clamp Nuts	**55 N. m (41 Ft. Lbs.)**	-
Muffler Exhaust Isolator Bolts	**25 N. m (18 Ft. Lbs.)**	-
Heat Shield Nuts	**3 N.m (27 In. Lbs.)**	-

DESCRIPTION AND OPERATION

BASE STARTING

DESCRIPTION



The standard starting system can consist of the following components:

COMPONENT INDEX

1.	\ STARTER MOTOR RELAY - Located within the Power Distribution Center (PDC).
2.	Refer to BODY CONTROL MODULE (BCM).
3.	Refer to RADIO FREQUENCY HUB (RFH).
4.	Refer to KEYLESS IGNITION NODE (KIN) OR KEYLESS GO BUTTON.
5.	Refer to STARTER MOTOR.
6	Refer to POWERTRAIN CONTROL MODULE (PCM).

The Battery, Starting, and Charging systems operate in conjunction with one another, and must be tested as a complete system. For correct operation of starting/charging systems, all components used in these three systems must perform within specifications. When attempting to diagnose any of these systems, it is important that you keep their interdependency in mind.

The diagnostic procedures used in each of these groups include the most basic conventional diagnostic methods, to the more sophisticated On-Board Diagnostics (OBD) built into the PCM. Use of an induction-type milliampere ammeter, volt / ohmmeter, battery charger, carbon pile rheostat (load tester), and 12-volt test lamp may be required.

OPERATION

The starter is always operated by a single relay positioned in the PDC and activated by the PCM. The activation signal reaches the BCM, which will activate an internal relay of its own, which sends a signal to the relay located in the PDC and activated by the PCM. When the PCM activates the relay, a 12 volt feed arrives at the starter solenoid, which will activate the starter.

Starting System equipped with a RFH:

- Pressing the Keyless Ignition Node (KIN), a request is sent to the RFH via a private Local Interface Network (LIN) bus for authentication.

- The RFH receives the request from the KIN and then looks for the valid key fob by using the Low Frequency (LF) antennas.
- If the RFH detects a valid key fob and if the brake is engaged, the RFH sends a Controller Area Network (CAN) request to the BCM to change the ignition position to START/CRANK.
- Then the BCM sends the command to the PCM to turn the vehicle to CRANK.
- If conditions are correct to start, the PCM turns on the high side of the PCM starter relay and turns the Crank Hold Signal to True. If the BCM is still in crank and the Crank Hold is true then the BCM turns on the low side of the BCM Starter relay and the engine will start cranking.
- Once the engine is started the PCM deactivates the double start over ride.
- The BCM will then deactivate the starter either when the engine starts or the maximum time of 10 seconds has been reach for the tip start.
- The RFH changes the ignition position to RUN if the start type is TIP start or the five second time expires or the engine controller indicates the vehicle is not in park or neutral.
- The engine can be manually shut down by the driver with speeds over 8 km/h (5 mph) in any gear.

BODY CONTROL MODULE (BCM)

Refer to **COMPONENT INDEX**.

- The BCM is responsible for gating messages across the various bus networks.
- The BCM is responsible for actuating the low side of starter relay once commanded by the PCM low side relay CRANK command.
- The BCM communicates over the Local Interface Network (LIN) bus with the Intelligent Battery Sensor (IBS) information about raw battery current, voltage, and temperature levels
- The BCM is responsible for deactivating the starter motor relay driver.

KEYLESS IGNITION NODE (KIN) OR KEYLESS GO BUTTON

Refer to **COMPONENT INDEX**.

- When the operator presses the Keyless Go button, the key fob is validated wirelessly by the RFH. If the key fob is recognized as belonging to the vehicle and is inside the vehicle, the system allows the ignition state of the vehicle to be changed by the operator between the ACCESSORY, RUN, and START ignition states.
- Used to broadcast the start button status.

Light Emitting Diode (LED) Indicator Operation:

The LEDs in the Keyless Go button provide visual indication of the ignition system and button use to aid the driver. The Logic for LED control is implemented in the RFH. The Keyless Go button contains four LEDs:

- OFF Indication
- ACC Indication (Accessory)
- ON Indication (ON or RUN)
- KIN switch indicator (button backlight)

The RFH will log a Diagnostic Trouble Code (DTC) indicating an incorrect ignition status value is present; in this state the ignition status is unknown. This will continue until the correct signal is received by the RFH.

POWERTRAIN CONTROL MODULE (PCM)

Refer to **COMPONENT INDEX**.

- The PCM turns on the high side of the starter relay.
- The PCM turns the crank hold signal to true which enables the BCM to turn on the low side of the starter relay.

- The PCM disables the double start over ride once the engine is started.

RADIO FREQUENCY HUB (RFH)

Refer to **COMPONENT INDEX**.

- Receives the input request to start from the ignition.
- Energizes the key fob transponder in order to read it.
- Sends a random code to the transponder and in return, receives a crypt code from the transponder.
- Validates the key fob using LF antennas.
- Validates that the brake is engaged.
- Sends a request to the BCM to change the ignition state.

STARTER MOTOR

Refer to **COMPONENT INDEX**.

- Incorporates the starter solenoid.
- The starter consists of a Direct Current (DC) motor powered by the battery and an electromagnet exciter.
- The starter is operated by a single relay positioned in the PDC and activated by the PCM.

STARTER MOTOR RELAY

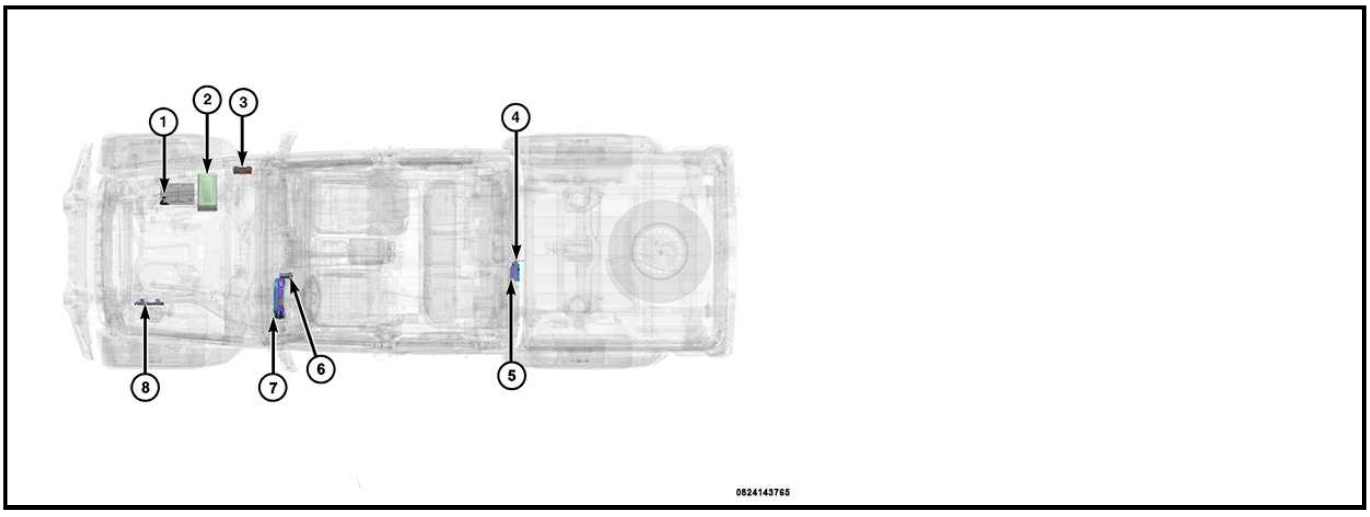
Refer to **COMPONENT INDEX**.

- The starter motor relay is commanded by the PCM and is used to enable the starter power circuit.
- Vehicle with Electric Stop/Start the starter relay receives power through the Stop/Start relay which is controlled by the BCM's Low Side Driver (LSD)

REMOTE START SYSTEM

NOTE: **Available on automatic transmission equipped vehicles only**

DESCRIPTION



In addition to the standard starting system components, the remote starting system can consist of the following components:

COMPONENT INDEX

1.	Refer to **INTELLIGENT BATTERY SENSOR (IBS)**.
2.	Refer to **POWER DISTRIBUTION CENTER (PDC)**.
3	Refer to **BODY CONTROL MODULE (BCM)**.
4.	Refer to **RADIO FREQUENCY HUB (RFH)**.

5.	Refer to **REMOTE START ANTENNA (RSA)**.
6.	Refer to **KEYLESS IGNITION NODE (KIN)**.
7.	Refer to **INSTRUMENT PANEL CLUSTER (IPC)**.
8	Refer to **POWERTRAIN CONTROL MODULE (PCM)**.
-	Refer to **HOOD AJAR SWITCH #2**.
-	Refer to **REMOTE KEYLESS ENTRY (RKE) KEY FOB**.
-	Refer to **REMOTE START INHIBITOR**.

Remote start conveniently starts the engine from outside the vehicle by using the RKE key fob while maintaining security. The system has a targeted range of at least 100 m (328 ft). The vehicle must be locked, the swing gate and hood closed and the transmission in PARK in order to start the engine using the Remote Start button on the key fob.

The remote start system can activate interior illumination, climate control, the optional heated/ventilated seats, and optional heated steering wheel depending on temperatures outside and inside the car. However, operation of the power top and the power windows are inhibited during the remote start event until the driver presses the push start button.

OPERATION

Remote Start Operation:

- The RFH detects that the remote start button has been pressed twice within five seconds. Note that if the remote start button is pressed again, this will terminate the remote start event.
- The RFH authenticates the key fob.
- The RFH then broadcasts several messages over the a Controller Area Network-Chassis (CAN-C) bus to the BCM indicating the physical position of the key fob, if the ignition is in run or start mode and if the vehicle is equipped with an Electronic Steering Lock (ESL) and the ESL's operative state.
- The BCM then receives the "Starter Enable" request over the CAN-C bus from the RFH.
- The BCM challenges and reads the states of the remote start inhibitors.
- If there are no active inhibitors, the BCM broadcasts the ignition commands request over the CAN-C bus, CAN-Interior High Speed (IHS) bus, and the Local Interface Network (LIN) bus networks. Any module or component that needs to use ignition inputs uses ignition outputs controlled by the BCM.
- The PCM receives the "Starter Enable" request over the CAN-C bus.
- The PCM initiates a minikrypt code exchange with the BCM. The BCM responds to this challenge with a verification acknowledgement to the PCM.
- If the minikrypt code exchange was successful, the PCM applies a Low Side Driver (LSD) as needed to energize the starter relay.
- Starter Relay is actuated. This relay is powered by a dedicated fuse in the PDC allowing the starter to crank.

NOTE: **If the minikrypt verification was not successful, the PCM shuts down the engine after two seconds.**

BODY CONTROL MODULE (BCM)

Refer to **COMPONENT INDEX**.

- The BCM is used to convert BUS messages, then broadcasts them from one BUS to another.
- Reads the state of the door, swing gate and hood switches before enabling CRANK
- The BCM is responsible for actuating the starter relay low side driver once commanded by the PCM high side relay CRANK command.
- Receives over LIN bus the IBS information about raw battery current, voltage, and temperature levels.
- Is responsible for deactivating the starter motor.

HOOD AJAR SWITCH #2

Refer to **COMPONENT INDEX**.

- This switch is used to indicate if the hood is in the open or closed state. Indicates the status to the PCM.

INTELLIGENT BATTERY SENSOR (IBS)

Refer to **COMPONENT INDEX**.

- The IBS interacts with the BCM by means of the LIN bus communications. The BCM is its master node.
- Used to give information about raw battery current, voltage, and temperature levels. The battery needs to be at an acceptable charge level for the vehicle to remote start.

INSTRUMENT PANEL CLUSTER (IPC)

Refer to **COMPONENT INDEX**.

The Keyless Go feature requires the vehicle to be equipped with an IPC display for prompts and status information. The display messages are:

- REMOTE START ACTIVE PUSH START BUTTON
- REMOTE START DISABLED START VEHICLE TO RESET
- REMOTE START CANCELLED TIME EXPIRED
- REMOTE START CANCELLED FUEL LOW
- REMOTE START CANCELLED DOOR OPEN
- REMOTE START CANCELLED HOOD OPEN

KEYLESS IGNITION NODE (KIN)

Refer to **COMPONENT INDEX**.

- When the operator presses the START/STOP KIN button, the key fob is validated by the RFH. If the key fob is recognized as belonging to the vehicle and is inside the vehicle, the system allows the ignition state of the vehicle to be changed by the operator between ACCESSORY, RUN, and START.
- Used to broadcast the start button status

Light Emitting Diode (LED) Indicator Operation:

The LEDs in the START/STOP KIN button provide visual indication of the ignition system and button use to aid the driver. The Logic for LED control is implemented in the RFH. The communication of the LED control logic from the RFH to the KIN is done over the LIN bus.

The START/STOP KIN button contain four LEDs:

- OFF Indication
- ACC Indication (Accessory)
- ON Indication (ON or RUN)
- Ignition Switch Indicator (button backlight)

The LEDs indicate the vehicle ignition position and as such are driven by the CAN-C signals related to the ignition position.

The RFH will log a Diagnostic Trouble Code (DTC) indicating an incorrect ignition status value is present; in this state the ignition status is unknown. This will continue until the correct signal is received by the RFH.

POWER DISTRIBUTION CENTER (PDC)

Refer to **COMPONENT INDEX**.

- The PDC houses various fuses used in the starting of the vehicle as well as relays such as the starter solenoid relay and the Engine Start Stop (ESS) ignition relay.

POWERTRAIN CONTROL MODULE (PCM)

Refer to **COMPONENT INDEX**.

The PCM:

- receives input from the hood ajar switch #2 indicating the status of the hood (open or closed).
- turns on the high side of the PCM starter relay
- turns the crank hold signal to true enabling the BCM to turn on the low side of the starter relay
- disables double start over ride once the engine is started

RADIO FREQUENCY HUB (RFH)

Refer to **COMPONENT INDEX**.

The RFH:

- receives the input request to start from the ignition
- energizes the key transponder in the key fob in order to read it
- sends a random code to the transponder and in return, receives a minikrypt code from the transponder
- validates the key fob using LF antennas
- Receives and validates transmission in park via Shift Lock switch (remote start use only)
- validates that the brake is engaged
- sends a request to the BCM to change the ignition state

REMOTE KEYLESS ENTRY (RKE) KEY FOB

Refer to **COMPONENT INDEX**.

- The key fobs are used to start the remote vehicle start request and that requests authentication process by identifying the key transponder.
- The key fob can also be used to terminate a remote start request.

REMOTE START ANTENNA (RSA)

Refer to **COMPONENT INDEX**.

- The RSA is used to provide a greater range for remote start operation and is connected to, and monitored by the RFH. The RFH will perform self diagnostics on the attached RSA to determine if it is connected to the RFH and drawing current.

REMOTE START INHIBITOR

Refer to **COMPONENT INDEX**.

Coolant Temperature Sensor - Used to verify that the engine coolant temperature is within an acceptable range for engine operation.

Ajar Switches - Used to indicate if any vehicle access points on the vehicle or opened or closed. Outputs to the BCM. Challenged by the RFH.

Fuel Level Sensor and Fuel Pump Control Module - Signalled by the PCM to drive the fuel pump to support engine starting if a sufficient amount of fuel is detected.

ESL - An added layer of security that locks the column.

Hazard Switch - The hazard switch needs to be in the OFF position.

Ignition State - The ignition needs to be in the OFF state.

IBS:

- The IBS interacts with the BCM by means of the LIN bus communications. The BCM is its master node.
- The IBS is used to give information about raw battery current, voltage, and temperature levels. The battery needs to be at an acceptable charge level

LF Antennas - Used in validation of the key fob being preset during start request.

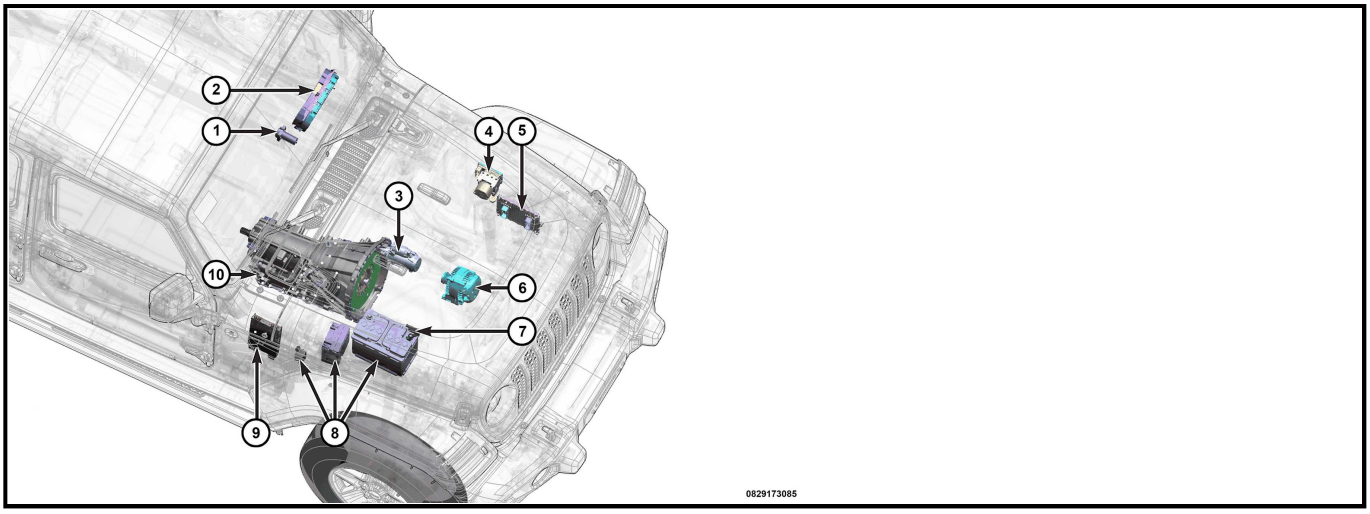
Oil Pressure Sensor - Used to determine that the engine has an acceptable oil pressure range prior to starting the engine.

Transmission Range Sensor (TRS) - Used to indicate the position of the gear shift lever.

Vehicle Speed Sensor (VSS) - Used to verify the vehicle is not moving.

Vehicle Theft Alarm (VTA) or Intrusion Detection System (IDS) - Signal sent indicating the status of the VTA or the IDS system. An active VTA or IDS state will disable the remote start function.

ENGINE STOP START SYSTEM



The following list indicates some of the components involved in the Engine Stop Start (ESS) system:

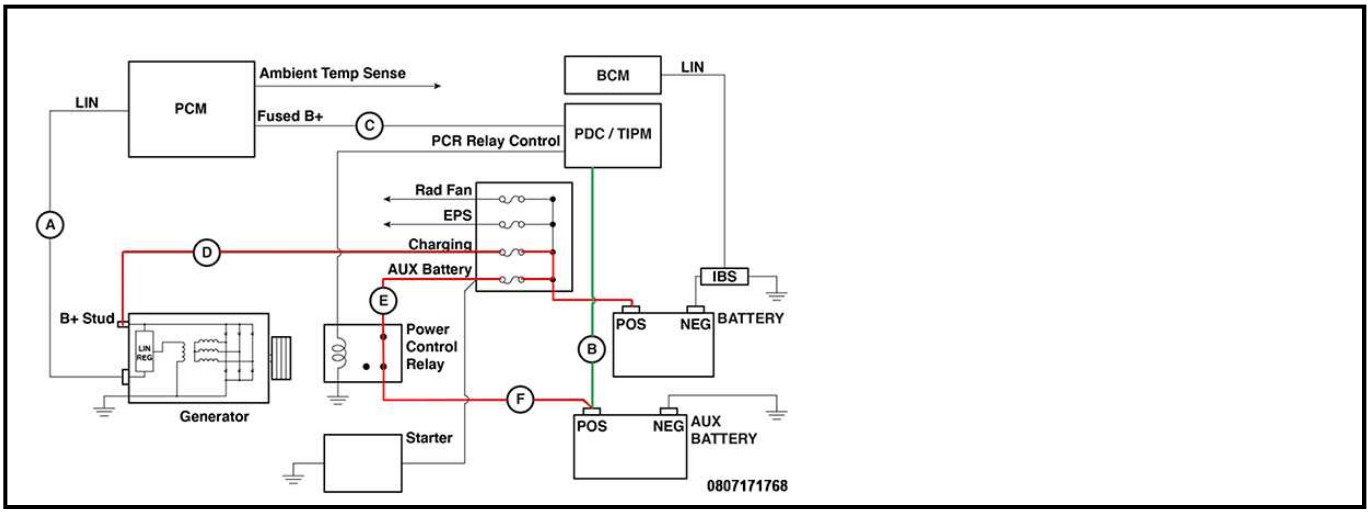
COMPONENT INDEX

1.	STOP/START Off Switch - Located in Instrument Panel
2.	Instrument Panel Cluster (IPC)
3.	Starter Motor
4.	Anti-lock Brake System (ABS) Module
5.	Powertrain Control Module (PCM)
6.	Generator
7.	Intelligent Battery Sensor (IBS)
8.	Dual Battery System and Relays - (Main and Auxiliary Batteries)
9.	Body Control Module (BCM)
10.	Transmission Control Module (TCM) - Automatic Transmissions (ATX) only
-	Starter Motor Relays - Located within the main Power Distribution Center (PDC)
-	Potential ESS System Inhibitors

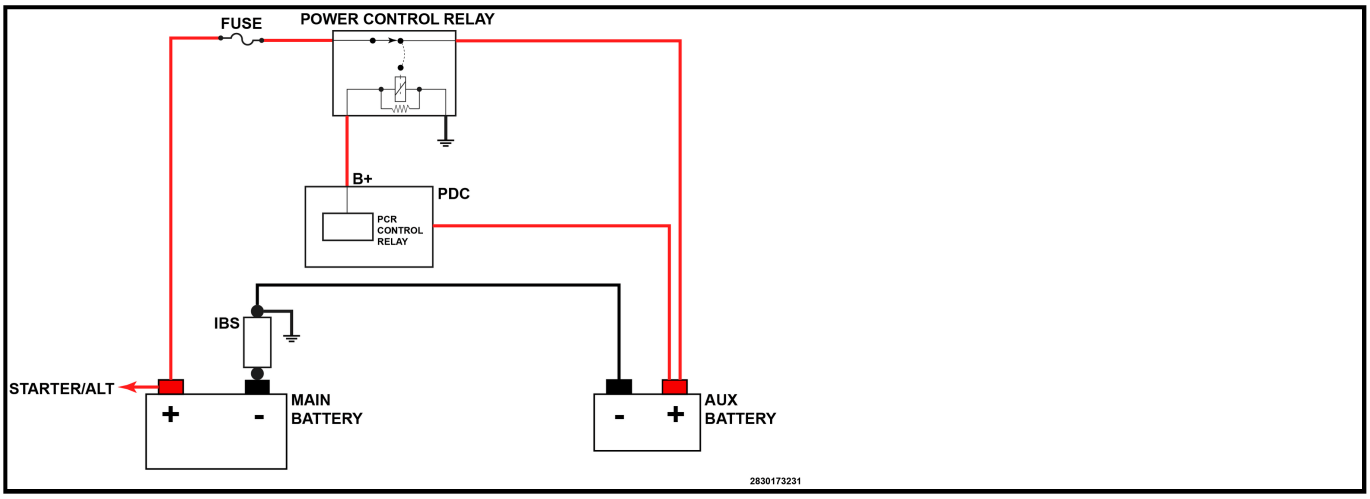
DUAL BATTERY ESS STARTING SYSTEM

DESCRIPTION: The Engine Stop/Start (ESS) system stops and starts the engine when the vehicle is at a stop and certain conditions are met to lower Carbon Dioxide (CO2) emissions. The Powertrain Control Module

(PCM) is the main module controlling operation of the ESS starting system. The system defaults to active on each ignition cycle. There is a customer selectable Stop/Start off switch that will disable the system. The switch is a smart device that sends signals over a LIN bus circuit to the Body Control Module. The Powertrain Control Module (PCM) receives the switch signal message over the CAN bus. The generic graphic below shows most of the system components and the relation between the battery, starting and charging systems. The graphic is depicting a system with a smart alternator. However the ESS starting system operates the same on vehicles equipped with a standard alternator and charging system.



There are four primary components that connect the starting, charging and vehicle electrical systems on the dual battery system. These are the main battery, auxiliary battery, power control relay and dual battery system fuse. The power control relay separates the system into two sides, the main battery side and auxiliary battery side. The generic graphic below shows a simplified diagram of the components for ease in understanding the system configuration.

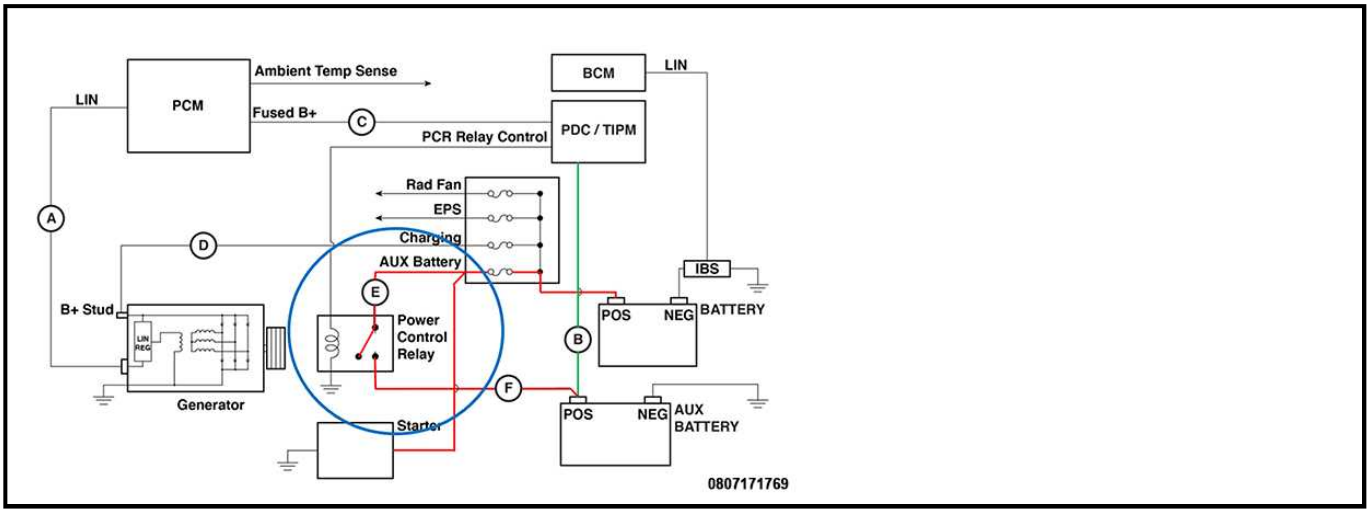


IMPORTANT RELAY NAMING INFORMATION: The information referenced in the list explains the functionality of the relays and how the Powertrain Control Module (PCM) diagnostics are calibrated to view these relays when displaying faults. When diagnosing a battery/starting/charging system issue there can be confusion on the relay naming when referencing the PDC cover and wiring information due to some of the starting system relay names varying between platforms. There are two starter relays wired in series controlling starter motor operation. One is controlled by the Body Control Module (BCM), the other is controlled by the PCM.

- **The first relay in series is controlled by the BCM, but is always considered to be starter relay 2 in the PCM diagnostic calibrations.** When diagnosing any failure mode or PCM DTC referenced as starter relay 2, diagnostics should be focused on the relay that is controlled by the BCM.
- **The second relay in series is controlled by the PCM and is always considered to be starter relay 1 in the PCM diagnostic calibrations.** When diagnosing any failure mode or PCM DTC referenced as starter relay 1, diagnostics should be focused on the relay that is controlled by the PCM.

- The standalone relay that connects the main battery and auxiliary battery on the dual battery systems is referred to as the **power control relay** . This relay is referred to as starter relay 3 in the PCM DTC descriptions.
- The relay located in the Power Distribution Center (PDC) that is directly controlled by the PCM, to indirectly control the power control relay is referred to as the **PCR control relay** .

STARTING SYSTEM OPERATION: The **initial engine cranking event** occurs when the start button is pressed and the engine crank request is sent. Pressing the KIN, a request is sent to the RFH via a private Local Interface Network (LIN) bus for authentication. The RFH receives the request from the KIN and then looks for the valid key fob by using the LF antennas. If the RFH detects a valid key fob and the brake is engaged, the RFH sends a Controller Area Network (CAN) request to the BCM to change the ignition position to START/CRANK. The BCM controlled relay (starter relay 2) and PCM controlled relay (starter relay 1) are closed. The power control relay is momentarily energized by the PCM which separates the connection between the main battery and auxiliary battery for approximately 20-40ms (see graphic below). When separated, only the auxiliary battery is connected to the Power Distribution Center (PDC) and vehicle modules. This allows the PCM to check the State of Charge (SOC) of the auxiliary battery from the Fused B+ circuit voltage at the PCM. After the engine starts (engine speed above a calibrated threshold), the PCM turns off starter relay 1 and the starter is disengaged. Each starter relay is cycled off and on to check for a stuck relay. If both relays test good, starter relay 2 remains closed by the BCM and starter relay 1 is opened. **The PCM controls engine cranking for all subsequent ESS start events by closing starter relay 1.** The power control relay is momentarily energized by the PCM during all ESS crank events. This allows the auxiliary battery to maintain full battery voltage to the PDC, vehicle modules and accessories during the initial starter in-rush so that there is no noticeable difference in vehicle features to the driver. The PCM can also continue to monitor the auxiliary battery voltage on the fused B+ circuit.



On ATX equipped vehicles the PCM sends a signal to TCM to indicate it is ready for an ESS event. The TCM responds it is ready for ESS and enters a hydraulic neutral state while in an auto-stop event and stays in hydraulic neutral during the auto-start event to avoid vehicle movement during engine cranking.

On MTX equipped vehicles the PCM will allow an ESS auto-stop event with the MTX in neutral and the PCM receives the clutch signal from the clutch pedal sensor that the clutch is dis-engaged (pedal released). If the PCM does not see both inputs it will trigger a cluster message to alert the driver to either press the clutch in or shift the transmission into neutral. The PCM allows an ESS auto-start event to occur when the PCM receives a signal that the clutch is engaged (pedal pressed).

LISTED BELOW ARE THE OTHER SYSTEMS AND COMPONENTS THAT CONTRIBUTE TO ESS SYSTEM FUNCTIONALITY

FUNCTIONAL DESCRIPTION - ANTI-LOCK BRAKE SYSTEM (ABS) MODULE

The ABS module incorporates the Electronic Stability Control (ESC) system. On vehicles equipped with Hill Start Assist (HSA), the ABS module also incorporates the HSA strategy.

On vehicles that are not equipped with HSA, there is a brake hold feature designed for the ESS system that should prevent the vehicle from lurching forward during an ESS auto-start on downhill grades. The ESC will attempt to hold the brake system pressure when the ESS system has determined that the vehicle is stopped on a grade and the ABS module has received a bus message indicating the ESS auto-stop engine shutdown is in an active state. The system holds brake system pressure until either a bus message is received indicating that the engine is running again or a message indicating that the accelerator pedal position is greater than 0%. No drive torque balancing is required. Brake system pressure is ramped out quickly as possible when either of those two signals meet the specified values.

On vehicles equipped with the HSA function for the ESS system, this functions only when the engine is running as well as the transmission shifter is in a specified gear location and downhill grade criteria is met. The ESS application is designed to shut off the engine as vehicle braking is applied by the driver. To avoid unintentional rollback, the HSA functionality is required while the engine is off and the vehicle is stopped on a shallower grade. The HSA will remain functional through the supply voltage dip experienced during warm engine cranking.

When the vehicle comes to a stand still and the ESS system state changes to indicate that an ESS auto-stop event is pending, the ABS Module activates the ESS HSA providing that the ESS HSA grade criteria is met and an adequate amount of brake master cylinder pressure is available. Note that the ESS HSA functionality will have a different HSA activation grade threshold to meet the vehicle application. When the ESS HSA function is active, the ESC will isolate the appropriate amount of brake system pressure needed. If the grade is greater than the ESS HSA grade threshold but less than the standard HSA grade threshold, the ESS HSA functions depending on the vehicle application and specified by the ESC system. The ESC system will:

- Deactivate when the ESS engine state changes to engine running.
- Remain active until the HSA timeout or engine drive off torque balancing values are met.

The ESC broadcasts the HSA state and the calculated HSA holding pressure over the Controller Area Network-Chassis (CAN-C) network bus. This signal identifies the following states of the HSA system:

- HSA is not active/pending. This indicates that the HSA activation requirements are yet to be determined or the vehicle is not at a stand still.
- Vehicle stand still has been detected and the HSA is not holding braking system pressure.
- A stand still and grade have been detected and the HSA signal is indicating what the minimum braking system pressure required is needed to hold the vehicle on the grade. This signal must compensate for loss of engine creep/idle torque when the engine shuts down. This signal must quickly transition to the required braking system hold pressure after determining vehicle stand still and detection of the grade. This signal must quickly transition directly to the calculated braking system hold pressure if the grade is greater then the ESS HSA calibrated threshold. The signal can differ from the actual pressure that the HSA system is holding. The PCM will compare the brake master cylinder pressure to the signal to ensure that enough brake system pressure is in the brake system to hold the vehicle before an ESS auto-stop event is performed. If the brake pressure signal is Signal Not Acquired (SNA), all HSA functionality is disabled due to a system fault.
- ESS HSA will not disable when the HSA feature is disabled by the customer using the programmable options menu to turn the HSA system off.

The ABS/ESC module:

- is responsible for reading and reporting the state of the Vehicle Speed Sensor (VSS) as well as the wheel speed Revolution Per Minute (RPM) calculations.
- reports the rolls test bench mode state.
- reports out the current state of the brake pedal position.
- reports out the Yaw rate.
- reports out vehicle longitudinal acceleration and vehicle lateral acceleration readings.

FUNCTIONAL DESCRIPTION - BODY CONTROL MODULE

During the initial engine cranking event, when the BCM receives a crank signal from the Powertrain Control Module (PCM), the BCM energizes the BCM controlled starter relay with an internal high side driver control.

The BCM is the gateway for all bus communications needing to be gated from one bus network to a different bus network. This grants the modules on different busses the ability to interact with each other. If the Local Interface Network (LIN) or CAN bus communications go down, the BCM will set the appropriate DTCs and display SNA values.

Door Ajar Latch Switches - The ajar switches are hard-wired to the BCM. The BCM broadcasts the switch state over the CAN bus to the PCM.

Functional Operation of the Door Ajar Latch Switches: All of the Door Latches are monitored to determine if they are closed or ajar. All of the ajar switches are wake-up signals to the BCM. The Driver Door Latch must be rationalized in order for some vehicle features to function. Unlike the passenger ajar signals that function like traditional open/closed ajar switches, the Driver Door Latch has redundant switches and signals for diagnostic purposes. The two switches share a common sensor ground. The Door Ajar Switch signals use Battery voltage for a reference. The switches operate in the following manner:

- **Driver Door Ajar Switches:** The BCM has an internal pull up 1000 Ohm resistor for each ajar signal. Each switch has an internal 604 Ohm and 1070 Ohm resistor. When the switches are open the resistance through the switches are 1674 Ohms. When the switches are closed the resistance through the switches are 604 Ohms. The switch states are opposing each other, meaning that when the **door latch is closed** , switch 1 is in the open state and switch 2 is in the closed state. The opposite is true when the **door latch is opened** . For more information refer to the tables below.
- **Passenger Ajar Switches:** The ajar switches are open when the latch is closed. When the door latch is ajar the switch closes allowing the signal to connect to ground through the switch. Therefore the signal inputs to the BCM are high when the door is closed and low when the door is ajar.

The resistors in the latch switches allows the BCM to perform diagnostics on the circuits and switches. Unlike the passenger door switches the voltage on the two signals should not be high or low. If the BCM determines that either signal falls into the high or low range, a fault is set. If the door latch positions do not match between the two Driver Door Ajar Switches, a correlation fault will set. **If the door is ajar, or a fault is detected, the ESS system is inhibited. In the event that this occurs during an ESS auto-stop, this failure will inhibit the ESS auto-start function.**

FUNCTIONAL DESCRIPTION - INTELLIGENT BATTERY SENSOR (IBS)

The Intelligent Battery Sensor (IBS) is an electrical shunt with a microprocessor that is mounted in-line with the negative battery cable. The IBS monitors the battery voltage as well as current flow into and out of the battery. The IBS has a built-in thermistor that calculates the battery temperature. The microprocessor uses this data to calculate battery State of Charge (SOC), battery internal resistance, charge received, electrical demand, and time in service. This information is reported through the LIN Bus circuit to the Body Control Module (BCM). The BCM broadcasts the information to the Powertrain Control Module (PCM) over the CAN Bus.

The IBS SOC data is also used by the BCM and other modules to determine when to begin disabling certain vehicle features that draw excessive electrical loads due to a low battery SOC. The SOC threshold for starting to disable features can vary based on vehicle and engine but is typically in the 50% to 60% range.

On the dual battery Stop/Start systems, the IBS is connected to the main battery. Since the two batteries are connected to each other most of the time, the battery SOC reported by the IBS is reporting the average SOC of the two batteries. It is possible for one battery to be fully charged and the other battery discharged causing the overall SOC to be low. If the SOC is low, both batteries should be checked for proper charge and functionality before checking for an issue with the IBS.

The IBS SOC may read low when both batteries test good. The following items can contribute to, and should be considered when diagnosing a low SOC condition before replacing an IBS or battery:

- If the vehicle is jump started at the battery posts bypassing the IBS.

- If the battery is blind charged at the battery posts bypassing the IBS.
- Repeated short trip driving events not allowing enough charge time.
- The IBS accuracy is off and needs to relearn the battery SOC.

Depending on the vehicle, there could be a non-MIL DTC (P057F) set, or an EVIC message indicating a low battery state of charge limiting some features, such as ESS. In some cases, properly charging the batteries through the IBS can raise the IBS SOC enough to regain functionality and repair the issue. However, it can sometimes take two or three, 4-hour BUS off sleep cycles for an IBS to learn and update the battery SOC. The IBS can be initiated into a learning curve by completely disconnecting the IBS from the battery, and disconnecting harness connector for 20 seconds. The IBS battery feed, LIN Bus and ground circuits should be checked before reconnecting the IBS. The IBS should default to approximately 80% SOC when reconnected. However, the IBS accuracy is determined to be low until the IBS can relearn battery SOC. This occurs after an engine run cycle and a subsequent ignition off sleep cycle of between one to four hours. Some features will be disabled until the IBS SOC is updated.

FUNCTIONAL DESCRIPTION - INSTRUMENT PANEL CLUSTER (IPC)

The PCM sends activation signals to the IPC requesting that the IPC displays specific Engine Stop/Start (ESS) system messages. The IPC will display these messages to the driver of the vehicle indicating the status of the ESS system. When the ESS system has been inhibited, the IPC will display a message indicating the reason for the temporary inhibit.

FUNCTIONAL DESCRIPTION - POWERTRAIN CONTROL MODULE (PCM)

During the initial engine cranking event, the PCM energizes the PCM controlled starter relay 1 with an internal low side driver control. The PCM controls all subsequent Engine Stop/Start (ESS) auto-start events in the same manner. When the engine is started (RPM calibrated value detected of greater then 600), the PCM switches off the low side driver control and opens the relay. The PCM monitors the output from the relay through the Crank Sense circuit. The Crank Sense circuit is spliced to the starter relay output inside the Power Distribution Center (PDC) and hard-wired directly to the PCM.

Every engine start (auto or driver induced) is recorded by increments on a counter. The number of allowable ESS start events is a function of the ambient temperature. As the ambient temperature increases, the number of ESS events will decrease. If the count is equal to a calibrated threshold, the ESS auto-stop function is inhibited until a cool down cycle has been run. The quick cool down cycle is defined as a calibrated drive period above a calibrated vehicle speed. The slow cool down cycle is defined as the time from the last crank since the inhibit event was recorded.

If there is an issue that causes the engine to not auto-start within a calibrated period, the starter control relay will be deactivated and an ignition cycle will then be required to start the engine.

The PCM monitors several hard-wired and CAN message inputs to determine the functionality of the ESS system.

- **Crankshaft Position (CKP) Sensor** - In order to protect the engine against damage caused by inadvertently sparking a cylinder following a rollback condition, the PCM utilizes a control that effectively turns off the fuel and spark drivers when below a given RPM. The PCM also utilizes a bidirectional CKP sensor to determine the ESS engine stop position for a fast restart.
- **Brake Pedal Position (BPP) Sensor** - The brake pedal position sensor signal is acquired over the CAN bus from the Brake System Module. The PCM monitors the BPP sensor signal to determine the brake pedal position. The BPP sensor min/max travel thresholds are a learned value in the PCM. The PCM must see the pedal position pressed to allow an auto-stop. When the BPP sensor signal transitions towards the released state the PCM will auto-start the engine.
- **Accelerator Pedal Position (APP) Sensor** - The APP sensor is hard-wired to the PCM. The PCM will only allow an auto-stop when the sensor signal indicates no throttle input is present. If the PCM detects accelerator pedal input during an auto-stop event, the PCM will auto-start the engine.

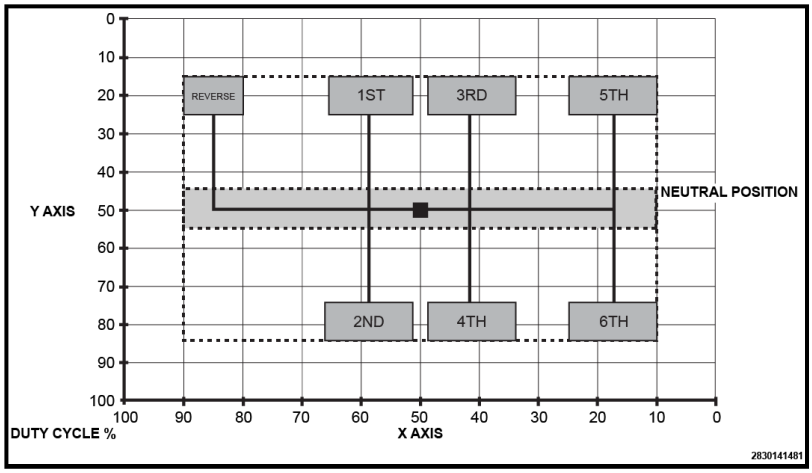
- **Driver Presence Detection Module (DPDM)** - The DPDM, located in the drivers front seat, is responsible for detecting whether the front driver side seat is occupied or unoccupied by the vehicle operator. The signals generated by the DPDM are influential on how the ESS system will operate during ESS auto-stop and ESS auto-start events. The DPDM is used on vehicles that are not equipped with a door ajar sensor. In ATX equipped vehicles, if the PCM recognizes a DPDM failure during an ESS auto-stop event, the PCM will secure the vehicle by requesting a Shift to Park from the TCM and then requires correction of shifter moving out of Park before the engine will auto-start. The PCM determines the status of the driver occupancy presence based on CAN-C network bus message received from the DPDM. If the PCM detects a fault in the DPDM bussed signal, the PCM will inhibit the ESS system in MTX equipped vehicles. If the PCM recognizes a DPDM fault during an ESS auto-stop event, the PCM will force an ESS auto-start event to occur.
- **Hood Ajar Switches** - ESS vehicles are equipped with two hood ajar switches for redundancy. Hood ajar switch 1 signal is a bussed signal from the Body Control Module (BCM). Hood ajar switch 2 is a hard-wired input to the PCM. the PCM performs a rationality check of the two signals. If the input signals do not match, or indicate that the hood is ajar, the PCM will not allow an auto-stop event. If this occurs during an auto-stop event, the transmission must be shifter to park or neutral and manually restarted.

Not all vehicles are equipped with manual transmissions. Also, the sensors used can vary between vehicles. Listed below are all of the devices used for monitoring inputs on manual transmission equipped vehicles. Check the wiring information to determine which devices are used on the vehicle that is being serviced.

- **Clutch Pedal Position Sensor** - On vehicles equipped with a manual transmission, the PCM monitors the Clutch Pedal Position Sensor signal to determine when to allow an auto-stop and auto-start event. The clutch pedal position sensor is a learned value. The PCM also learns the clutch engagement point. The graphic below shows the PCM interpretation of the signal.

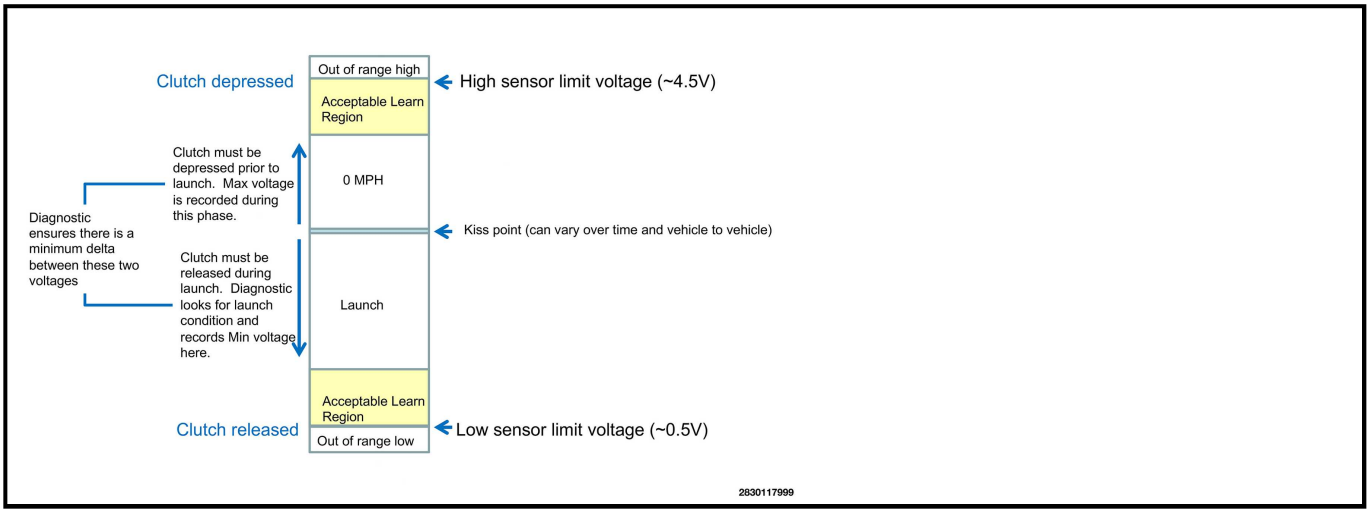
  Vehicles equipped with ESS will also have a Clutch Interlock Switch. The Clutch Interlock Switch is different than the traditional Clutch Pedal Switches in that it only detects the interlock (pedal depressed) position. The switch input is compared to the Clutch Position Sensor signal for the correlation diagnostic. If a correlation fault sets it will affect the ESS system in one of the following ways:

  - If the fault occurs prior to an auto-stop, ESS will be disabled and no auto-stop will occur.
  - If the fault occurs during an auto-stop with the transmission in neutral, the vehicle will auto-stop and ESS will then be disabled.
  - If the fault occurs during an auto-stop with the transmission in gear, vehicle will not start until the shifter is moved into neutral and then ESS will be disabled.
- **Gearshift Position Sensor** - Some vehicles that are equipped with a manual transmission have a gearshift position sensor. The PCM uses the gearshift position sensor in the ESS system during ESS auto-stop and ESS auto-start events. The calculated gear position also has the potential to inhibit the ESS system operation, depending on the detected gear. This is managed from within the PCM as the PCM is the main ESS system controller. The gearshift position sensor has a shared 5.0 volt supply, sensor ground and two position signals from the sensor. The signals to the PCM are in the form of a 5.0 volt square wave duty cycle. The gearshift position sensor quadrants are learned at the plant. These positions will need to be learned if the sensor, or any Transmission Shifter components are replaced. The PCM monitors movement of the shifter along the X and Y axis to determine the shifter position. The X axis is left and right movement of the shifter which detects 4 different quadrants. The Y axis is forward and backward movement of the shifter which detects 3 different quadrants. The PCM uses the two duty cycle signals to make the determination of the shifter position. **See the graph in the figure depicting the gear shifter positions and correlating duty cycles.**



The normal operating duty cycle range for each signal is between 10% and 90%. If the PCM detects that the duty cycle for either signal is above or below the normal duty cycle range a circuit fault will set. The PCM also monitors the rationality of the shifter position by comparing the actual gear shift position feedback to the calculated gear shift position. The gear shift position calculation is based on the transmission being in a forward gear with the clutch pedal not pressed, vehicle speed, engine speed, and calculated engine torque.

- **Neutral Position Sensor** - Some manual transmission equipped vehicles have a neutral position sensor instead of a gearshift position sensor. On these vehicles the PCM is only monitoring for the transmission to be in the neutral position or in any gear position. This is done for the purpose of determining when the ESS system can safely restart the vehicle without the clutch pedal being depressed. The neutral position sensor outputs a PWM signal. The sensor signal will typically be around 50% duty cycle when the shifter is in the neutral position. A duty cycle other than approximately 50% indicates that the shifter is is shifted to a gear range position.



The PCM will send messages over the CAN-C network bus indicating the status and requests of the ESS system. The signals are used in order to inform the overall network nodes the ESS status.

FUNCTIONAL DESCRIPTION - STARTER MOTOR

Vehicles equipped with the Engine Stop/Start (ESS) system are equipped with a heavy duty starter. The starter motor has increased life brushes, needle bearings, pre-loaded pinion gear spring and other changes to enhance longevity and improve Noise, Vibration, Harshness (NVH). The starter also has increased power to compensate for brush losses, and to increase cranking speed.

FUNCTIONAL DESCRIPTION - TRANSMISSION CONTROL MODULE (TCM)

The TCM determines if the following conditions are met to perform an ESS auto-stop event:

- The TCM receives a CAN-C bus message from the PCM that indicates that there is an ESS auto-stop event pending and that the engine itself is ready for the ESS auto-stop event.

- The TCM receives a Electronic Stability Program (ESP) or an Electronic Stability Control (ESC) derived CAN-C bus message from the ABS module which indicates the vehicles speed threshold over a calibrated frame of time.
- The TCM determines that the transmission is not in **R** everse or that the there is not a TCM SNA error. The TCM needs to see that either a forward gear is engaged or that the transmission is in **N** eutral.
- The TCM determines if there are any DTCs on the transmission which can inhibit the ESS auto-stop. If a fault is detected, the TCM busses a fault CAN-C bus message back to the PCM. If no fault is detected, the TCM will bus a no fault CAN-C bus message to the PCM.
- The TCM then determines if it can allow the transmission into **P** ark or **N** eutral.
- The TCM then determines if the PCM CAN-C bus received message indicates that the engine is ready or is not ready for an ESS. A true CAN-C bus message attribute indicates that the CAN-C bus message received from the PCM does indicate that the engine is ready for an ESS event.
- Once the TCM verifies that the CAN-C bus message received from the PCM indicates that the engine is ready for an ESS auto-stop event, the TCM sends a CAN-C bus message back to the PCM indicating that the transmission is prepared and ready for an ESS auto-stop event to occur.
- The TCM then holds the "ready for ESS auto-stop event = True" state during the actual auto-stop event.
- During the actual ESS auto-stop event, the TCM indicates that the transmission is in a pseudo drive hydraulic neutral gear known as D6 and sends a CAN-C bus message to the PCM advising that the transmission is in a neutral state. This D6 gear state is also indicative of the transmission being in an open transmission torque path. D6 must be achieved prior to engaging the starter motor in response to a driver start request. The TCM busses a message indicating the drive state of the transmission being open or not open.

The TCM determines if the following conditions are met to perform an ESS auto-start event:

- The PCM sends a CAN-C network bussed message to the TCM indicating that there is an active request to start the engine.
- If the transmission equipped in this vehicle is equipped with a Hydraulic Impulse Storage (HIS) solenoid, the HIS is released when a CAN-C network bus message from the PCM indicates that the engine is starting.
- The PCM then starts the engine.
- The TCM then engages the appropriate gear.

TCM reaction to a driver departure condition - The TCM can secure the vehicle by shifting into **P** ark if there is a recognized driver departure. The PCM monitors DPDM conditions that indicate driver departure, and if the PCM determines this to be true, the PCM sends a CAN-C network bus message to the TCM requesting that the TCM shift to **P** ark. At this time, the TCM must place the transmission into the **P** ark position.

ENGINE STOP/START (ESS) INHIBITORS

The following conditions must be true for the vehicle to perform an ESS auto stop event:

- An ABS event not present
- Flex fuel learned is true
- ESS related system faults are not present
- Driver seat belt buckled
- Driver door closed
- Driver Presence Detection Module (DPDM) indicates seat is occupied
- If the vehicle is equipped with an ATX, any forward transmission gear state must be detected
- If the vehicle is equipped with a MTX, the transmission must be in neutral with the clutch pedal in a released state
- ESS inhibit START/STOP Off switch is not pressed
- Battery state is at an acceptable level

- ECT is within calibrated range
- Ambient temperature is within calibrated range
- Steering wheel inputs are acceptable
- Engine speed is below a calibrated threshold
- Vehicle speed is below a calibrated threshold (APPS indicates that the throttle pedal is not pressed)
- Vehicle latch speed achieved (ESS auto-stop is permitted)
- Starter motor engagement frequency has not exceeded the calibrated number of allowable attempts
- Brake booster vacuum level is within calibrated range
- Barometric pressure value is within calibrated range
- Hood not open and no rationality faults present
- Hill grade is below calibrated range and HSA is ready
- Fuel level is within calibrated range
- Master cylinder pressure in allowable range to perform auto-stop and HSA
- Engine run time is above a calibrated threshold
- Transfer case status is in acceptable state (not in 4-Low). Reported by the Drivetrain Control Module (DTCM).
- Park maneuver is not detected
- Transmission is ready for ESS operation
- No faults present in the ATX or MTX transmission
- HVAC demand is not present
- Oil temperature is within a calibrated range
- Variable Valve Timing (VVT) is in default position
- Exhaust Gas Recirculation (EGR) is ready (if equipped)
- Multi-air system ready (if equipped)
- Starter diagnostics are not running
- Catalyst light is off

The following conditions allow for engine start:

- No OBDII compliant faults are present or detected
- Hood ajar switches are indicating a closed state.
- No ESS inhibit or ESS disarm conditions are present.
- Starter strategies managed by the PCM indicate that starter operation is allowable.
- RPM readings are below a run threshold calibrated by the PCM.

Certain ESS related system faults and vehicle conditions will inhibit the ESS operation. The following items on this list can be listed due to rationality faults, sensor faults, hardware faults, communication faults or SNA faults:

- Ambient temperature during engine restart
- Catalyst temperature during engine restart
- ECT during engine restart
- Battery temperature during engine restart
- Engine oil temperature during engine restart
- Certain HVAC load demands
- Cam sensor faults; intermittent or otherwise
- Cam/crank rationality; intermittent or otherwise
- Accelerator Pedal Position Sensor (APPS) faults detected

- Steering Angle Sensor (SAS) faults during engine restart
- Driver door ajar switch fault
- Seat belt circuit fault
- Hood detection fault
- Clutch pedal position faults
- Hill Start Assist (HSA) within range to hold the vehicle faults
- Brake booster pressure faults
- Fuel level faults during engine restart
- Torque security faults
- Loss of bus communication during engine restart
- Accelerometer sensor diagnostics
- Starter control. Anything that disables first crank would disable ESS
- Starter relay fault
- Starter relay circuit faults
- Air bag deployment
- Driver Presence Detection Module (DPDM) faults
- PCR Stuck Open Fault
- PCR Stuck Closed Fault
- Auxiliary Battery depleted
- Auxiliary Battery disconnected
- Battery SOC below calibrated threshold
- Vehicle altitude is above a calibrated threshold

DIAGNOSIS AND TESTING

DIAGNOSIS AND TESTING - STARTING SYSTEM

The battery, starting, and charging systems operate in conjunction with one another, and must be tested as a complete system. For correct starting/charging system operation, all of the components involved in these three systems must perform within specifications.

STARTING SYSTEM DIAGNOSIS

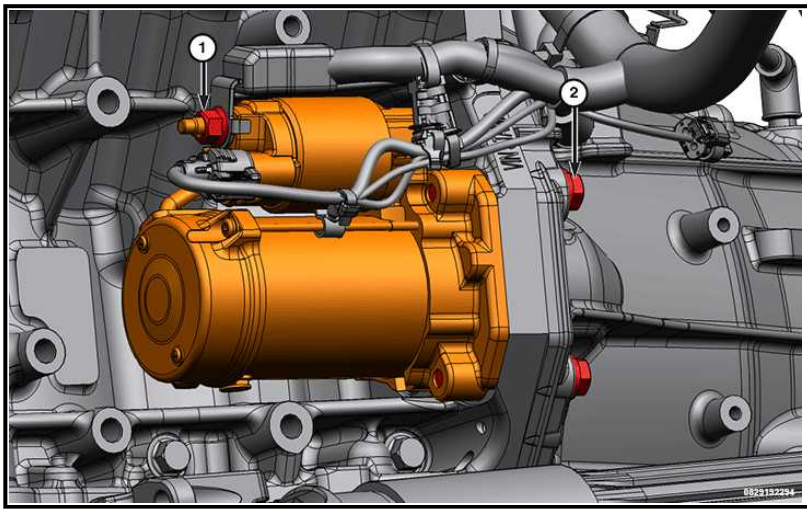
CONDITION	POSSIBLE CAUSE	CORRECTION
STARTER FAILS TO OPERATE	1. Battery discharged or inoperative	1. Charge and test battery. Replace battery, if required.
	2. Starter motor or solenoid inoperative	2. Test the starter motor and solenoid. Replace starter motor, if required.
	3. Starter relay inoperative	3. Refer to the appropriate Wiring Information. Test and replace the starter relay, if required.
	4. Clutch pedal position switch inoperative (if equipped with manual transmission)	4. Refer to the Clutch pedal position switch. Test and adjust or replace switch, if required.
	5. Park/Neutral position switch inoperative (if equipped with automatic transmission)	5. Refer to the Park/Neutral Position Switch. Test and adjust or replace switch, if required.
	6. Starting circuit wiring inoperative	6. Refer to the appropriate Wiring Information. Test and repair starter feed and/or control circuits, if required.

CONDITION	POSSIBLE CAUSE	CORRECTION
STARTER ENGAGES, BUT FAILS TO TURN ENGINE	1. Battery discharged or inoperative	1. Charge and test battery. Replace battery if required.
	2. Starter motor or solenoid inoperative	2. Test the starter motor and solenoid. Replace starter motor if required.
	3. Starting circuit wiring inoperative	3. Refer to the appropriate Wiring Information. Test and repair starter feed and/or control circuits, if required.
	4. Engine seized	4. Refer to - Engine. Test and repair engine as required.
STARTER ENGAGES, THEN DISENGAGES BEFORE ENGINE STARTS	1. Starter motor or solenoid inoperative	1. Test the starter motor and solenoid. Replace starter motor, if required.
	2. Starter ring gear damaged	2. Remove starter motor and inspect starter ring gear. Replace starter ring gear, if required.
STARTER DOES NOT DISENGAGE	1. Starter motor incorrectly installed or solenoid inoperative	1. Inspect and test the starter motor and solenoid. Replace starter motor, if required.
	2. Starter relay inoperative	2. Refer to the appropriate Wiring Information. Test and replace the starter relay, if required.

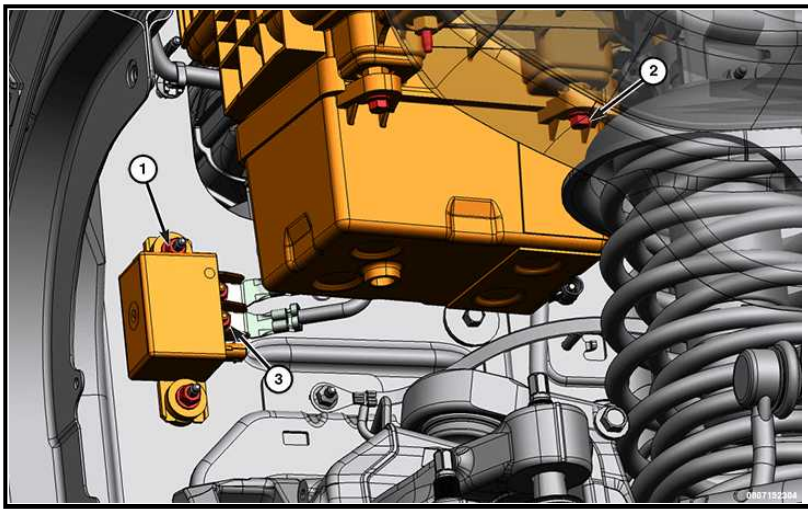
TECHNICAL SPECIFICATIONS

TORQUE SPECIFICATIONS

STARTING SYSTEM



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENT
1	Starter B+ Cable Nut	11 N.m (8 Ft. Lbs.)	-
2	Starter to Engine Block Bolts	47 N.m (35 Ft. Lbs.)	-



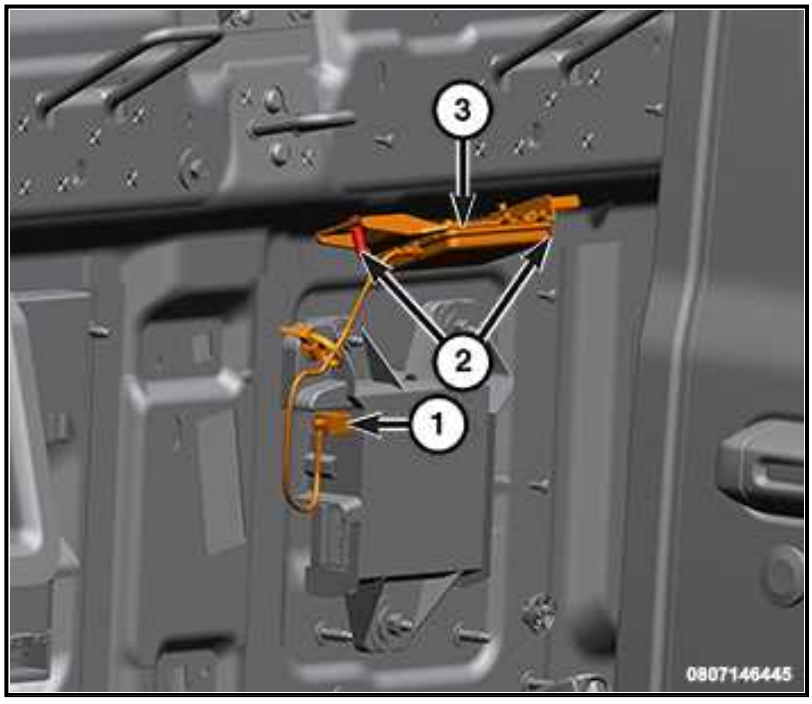
CALLOUT	DESCRIPTION	SPECIFICATIONS	COMMENT
1	PCR Mounting Bolt	**11 N.m (8 Ft. Lbs.)**	-
2	Auxiliary Battery Tray To Battery Tray	**Refer to Battery Torque Table**	-
3	B+ Wire To PCR Positive Terminals	**11 N.m (8 Ft. Lbs.)**	-
-	Ground To PCR Bracket	**9 N.m (80 In. Lbs.)**	Right Hand Drive Only
-	PCR To Chassis Ground	**11 N.m (8 Ft. Lbs.)**	-
-	Remote Start Antenna (RSA) to Cab Back	**6 N.m (53 In. Lbs.)**	-

ANTENNA, REMOTE START

REMOVAL AND INSTALLATION

REMOTE START ANTENNA

1. Remove the cab back trim panel. Refer to **PANEL, CAB BACK TRIM, REMOVAL AND INSTALLATION** .
2. Disconnect the subwoofer wire harness connector.
3. Remove the four fasteners and the subwoofer.



1 - Wire Harness Connector
2 - Nuts
3 - Remote Start Antenna

4. Disconnect the Remote Start Antenna (RSA) wire harness connector.
5. Remove the Remote Start Antenna from the vehicle.

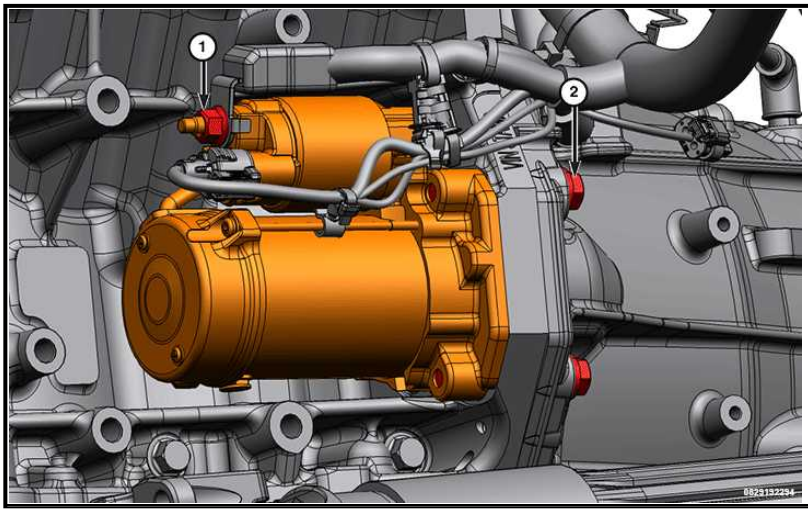
INSTALLATION

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

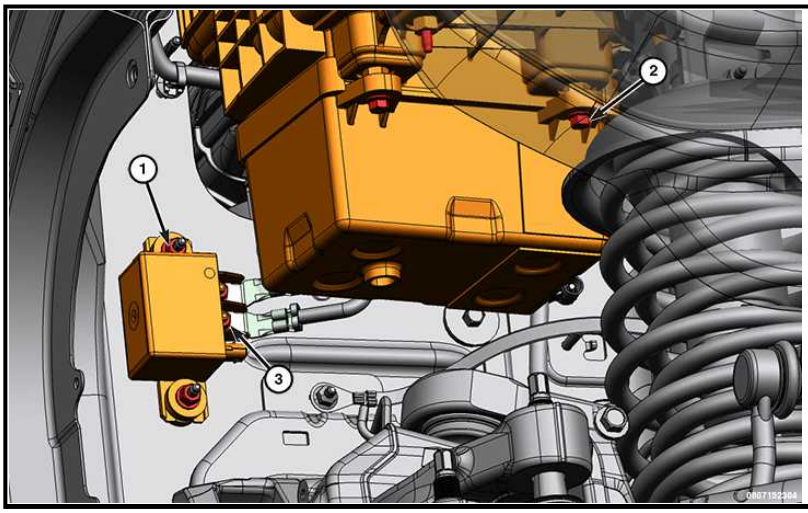
During installation, torque the fasteners to the specifications in the torque table(s) below.

TORQUE SPECIFICATIONS

STARTING SYSTEM



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENT
1	Starter B+ Cable Nut	11 N.m (8 Ft. Lbs.)	-
2	Starter to Engine Block Bolts	47 N.m (35 Ft. Lbs.)	-



CALLOUT	DESCRIPTION	SPECIFICATIONS	COMMENT
1	PCR Mounting Bolt	**11 N.m (8 Ft. Lbs.)**	-
2	Auxiliary Battery Tray To Battery Tray	**Refer to Battery Torque Table**	-

CALLOUT	DESCRIPTION	SPECIFICATIONS	COMMENT
3	B+ Wire To PCR Positive Terminals	**11 N.m (8 Ft. Lbs.)**	-
-	Ground To PCR Bracket	**9 N.m (80 In. Lbs.)**	Right Hand Drive Only
-	PCR To Chassis Ground	**11 N.m (8 Ft. Lbs.)**	-
-	Remote Start Antenna (RSA) to Cab Back	**6 N.m (53 In. Lbs.)**	-

BUTTON, START/STOP

REMOVAL AND INSTALLATION

REMOVAL AND INSTALLATION

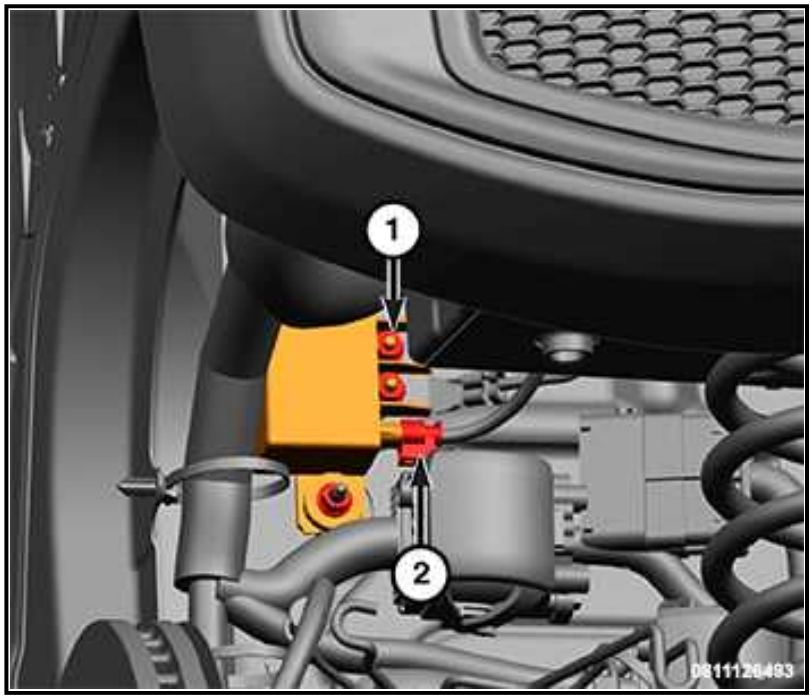
For information on the removal and installation of the Start/Stop button. Refer to **MODULE, KEYLESS IGNITION NODE (KIN), REMOVAL AND INSTALLATION** .

RELAY, POWER CONTROL

REMOVAL AND INSTALLATION

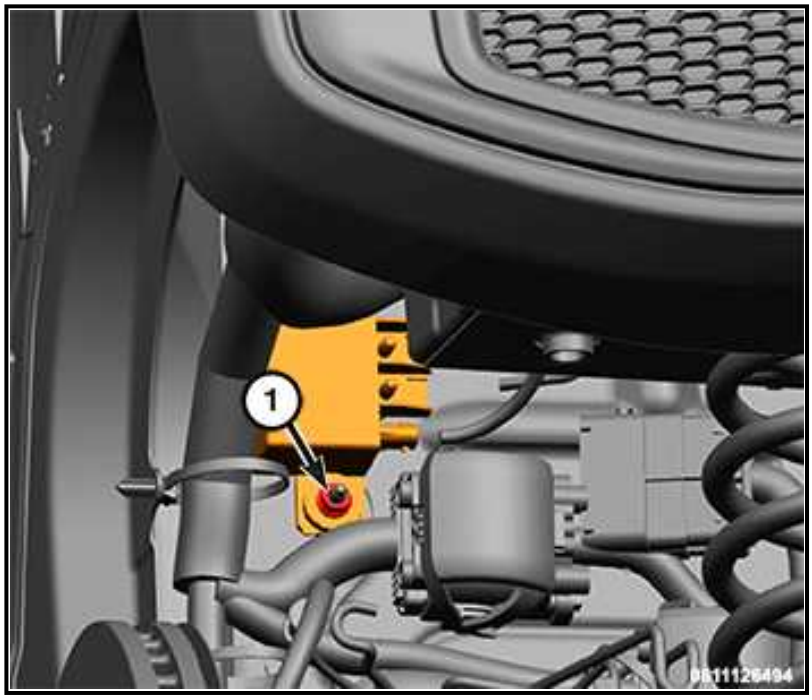
POWER CONTROL RELAY

1. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
2. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .
3. Remove the right inner wheel house. Refer to **SHIELD, SPLASH, FRONT WHEELHOUSE, REMOVAL AND INSTALLATION** **SHIELD, SPLASH, REAR WHEELHOUSE, REMOVAL AND INSTALLATION** .



1 - Power Control Relay B+ Nuts
2 - Wire Harness Connector

4. Remove the nuts on the B+ post of the Power Control Relay.
5. Disconnect the wire harness connector.



1 - Power Control Relay Nuts

6. Remove the two nuts from the power control relay.
7. Remove the power control relay from the vehicle.

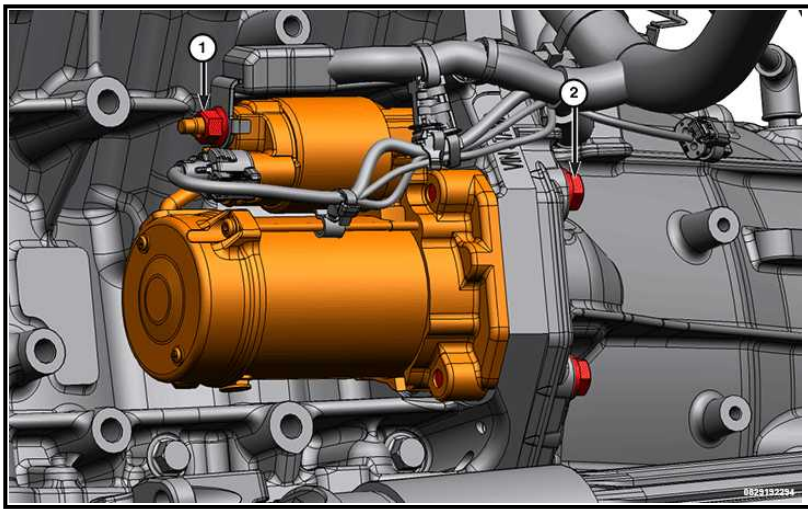
INSTALLATION

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

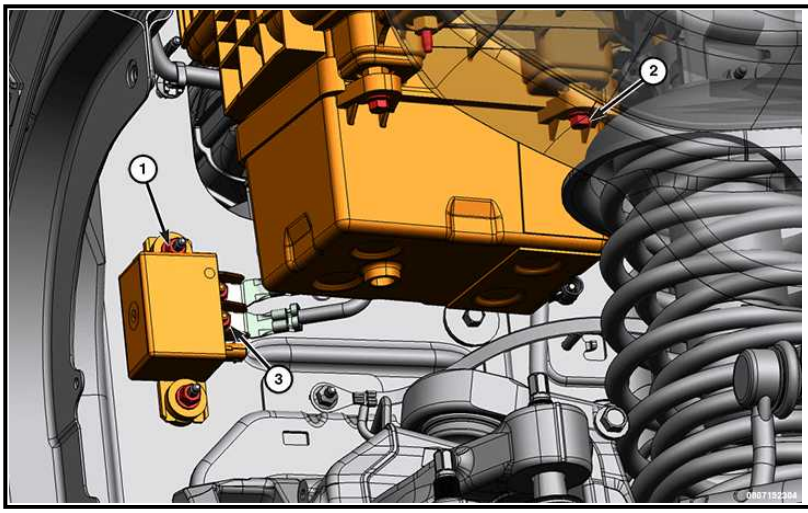
During installation, torque the fasteners to the specifications in the torque table(s) below.

TORQUE SPECIFICATIONS

STARTING SYSTEM



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENT
1	Starter B+ Cable Nut	11 N.m (8 Ft. Lbs.)	-
2	Starter to Engine Block Bolts	47 N.m (35 Ft. Lbs.)	-



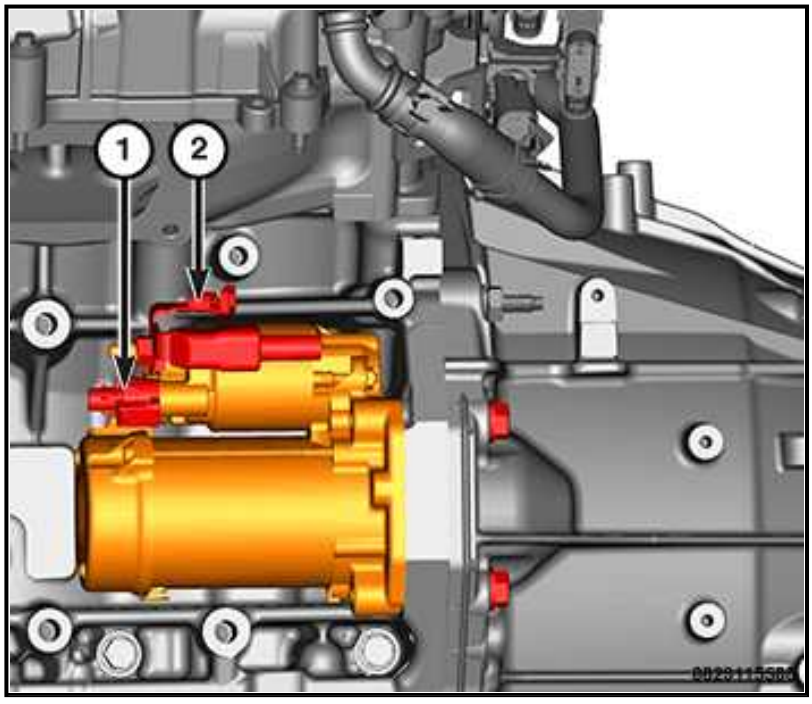
CALLOUT	DESCRIPTION	SPECIFICATIONS	COMMENT
1	PCR Mounting Bolt	**11 N.m (8 Ft. Lbs.)**	-
2	Auxiliary Battery Tray To Battery Tray	**Refer to Battery Torque Table**	-
3	B+ Wire To PCR Positive Terminals	**11 N.m (8 Ft. Lbs.)**	-
-	Ground To PCR Bracket	**9 N.m (80 In. Lbs.)**	Right Hand Drive Only
-	PCR To Chassis Ground	**11 N.m (8 Ft. Lbs.)**	-
-	Remote Start Antenna (RSA) to Cab Back	**6 N.m (53 In. Lbs.)**	-

STARTER

REMOVAL AND INSTALLATION

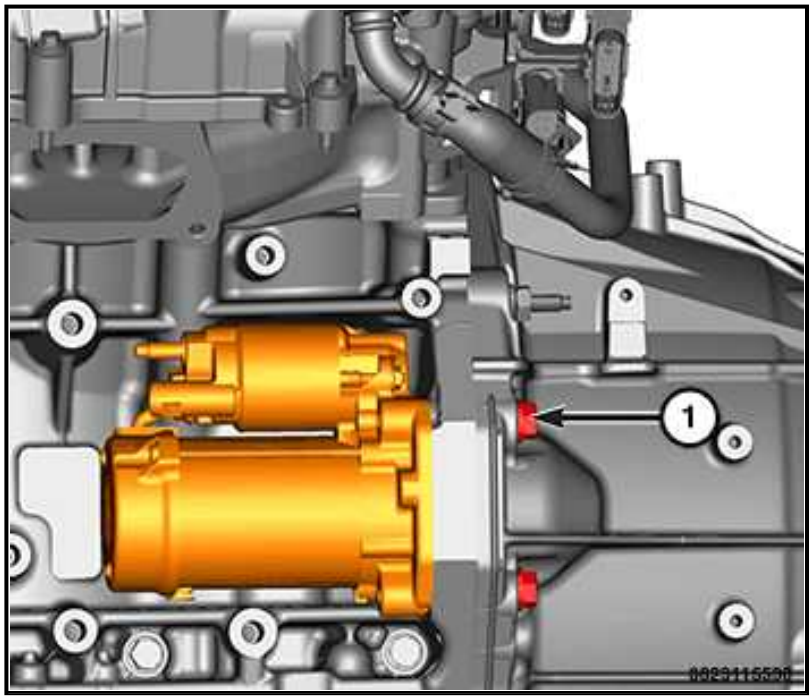
STARTER - 3.6L

1. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
2. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .
3. Remove the left catalytic convertor from the vehicle. Refer to **CONVERTER, CATALYTIC, REMOVAL AND INSTALLATION** .



1 - Wire Harness Connector
2 - B+ Stud Cover

4. Disconnect the starter solenoid wire harness connector from the starter solenoid and remove the B+ cover.
5. Remove the battery cable nut and battery cable from the solenoid stud.



1 - Starter Bolts

6. Remove the starter bolts and starter motor from the transmission.

NOTE: **Due to varied starter sizes it may be necessary to relocate the engine mount.**

7. Support the engine with a suitable jack stand remove the bolts from the engine mount brackets raise the engine to clear the frame and set the mount aside. Refer to **INSULATOR, ENGINE MOUNT, LEFT, REMOVAL AND INSTALLATION** **INSULATOR, ENGINE MOUNT, RIGHT, REMOVAL AND INSTALLATION** .

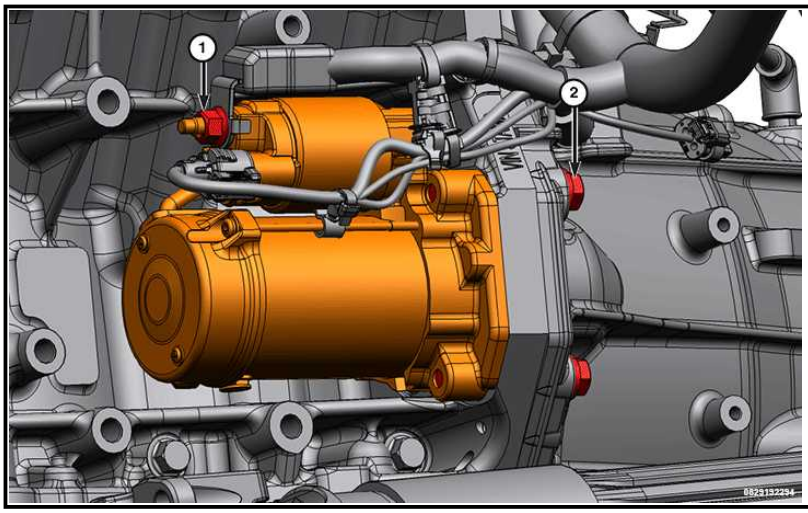
INSTALLATION

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

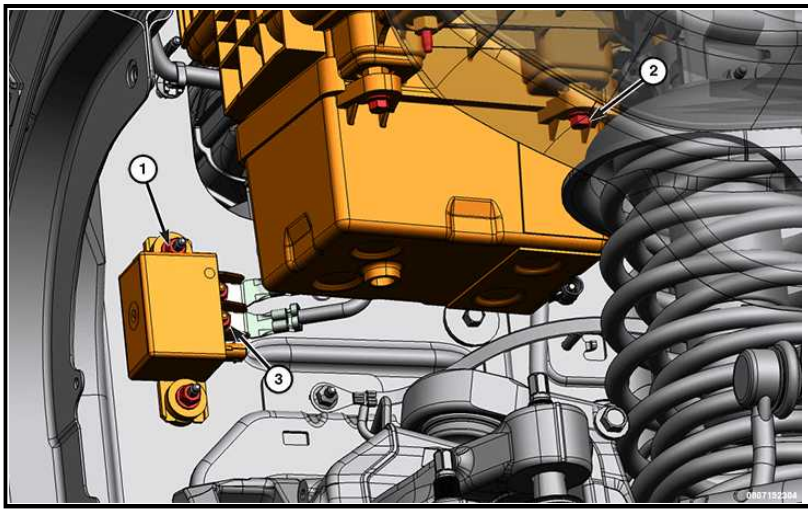
During installation, torque the fasteners to the specifications in the torque table(s) below.

TORQUE SPECIFICATIONS

STARTING SYSTEM



CALLOUT	DESCRIPTION	SPECIFICATION	COMMENT
1	Starter B+ Cable Nut	11 N.m (8 Ft. Lbs.)	-
2	Starter to Engine Block Bolts	47 N.m (35 Ft. Lbs.)	-



CALLOUT	DESCRIPTION	SPECIFICATIONS	COMMENT
1	PCR Mounting Bolt	**11 N.m (8 Ft. Lbs.)**	-
2	Auxiliary Battery Tray To Battery Tray	**Refer to Battery Torque Table**	-
3	B+ Wire To PCR Positive Terminals	**11 N.m (8 Ft. Lbs.)**	-
-	Ground To PCR Bracket	**9 N.m (80 In. Lbs.)**	Right Hand Drive Only
-	PCR To Chassis Ground	**11 N.m (8 Ft. Lbs.)**	-
-	Remote Start Antenna (RSA) to Cab Back	**6 N.m (53 In. Lbs.)**	-

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 (NOx) 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**

	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.
O2 Sensor Signal Low Diagnosis:	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.
O2 Sensor Signal High Diagnosis:	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.
P1621-O2 Sensor Reference (Return) Circuit Low Diagnosis:	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.
P1622-O2 Sensor Reference (Return) Circuit High Diagnosis:	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.

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.

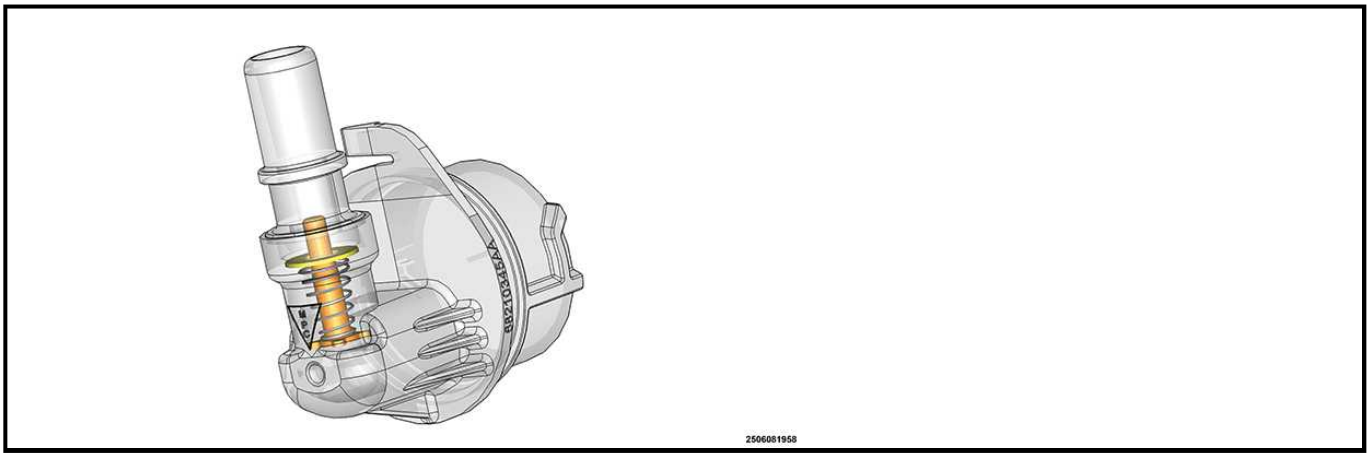
NATURALLY ASPIRATED OPERATION

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

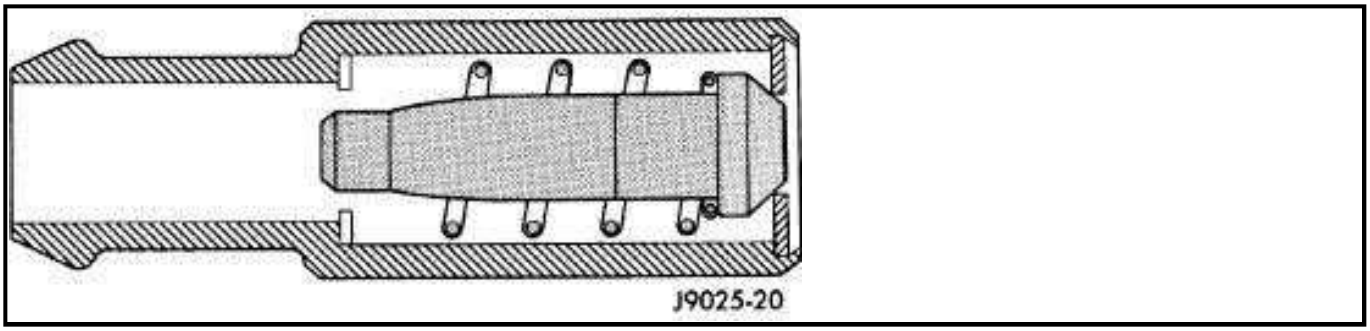
B

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.

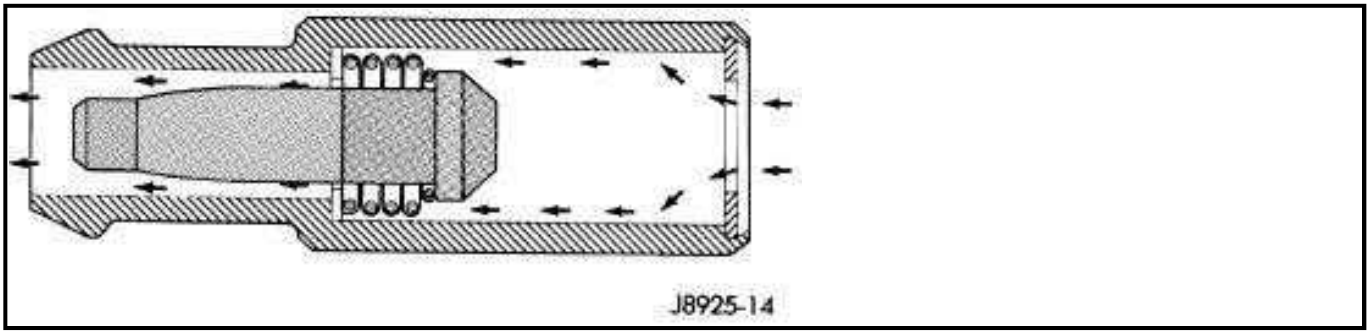


NOTE: **Shown below are the typical views of the PCV Valve operation.**

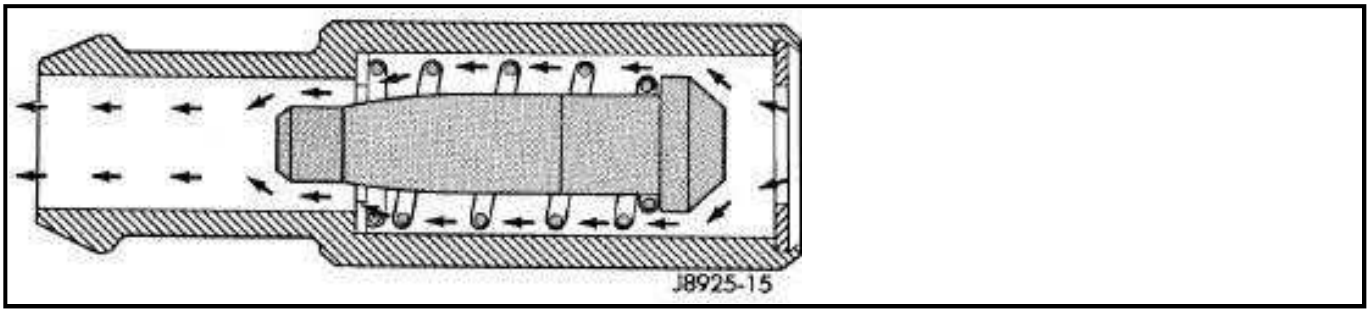
When the engine is not operating or during an engine backfire, the spring forces the plunger back against the seat. This prevents vapors from flowing through the valve.



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

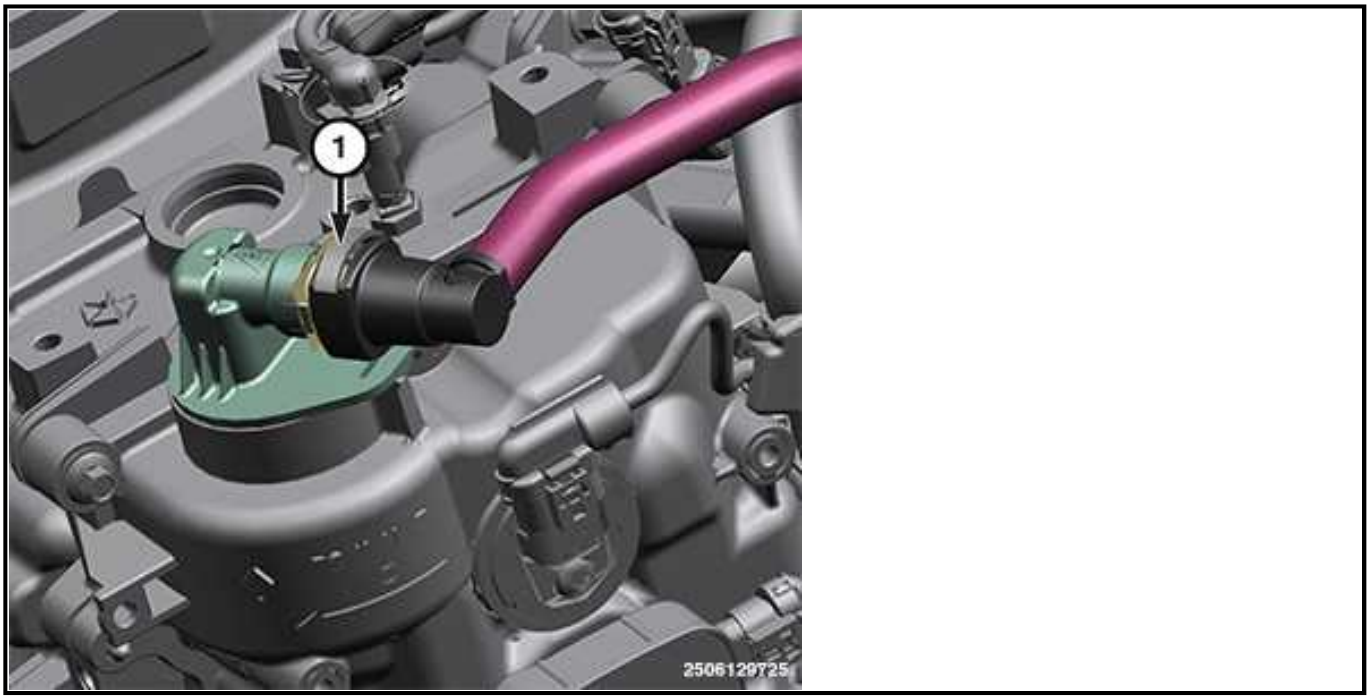
- If the MUA tube is disconnected on the clean air tube, PCV vapors will leak into the atmosphere whenever the engine is in boost. The Crankcase Pressure Sensor is used to diagnose a disconnect in the MUA Tube. The Crankcase Pressure Sensor connects to a fitting on the Clean Air Tube that is also connected 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

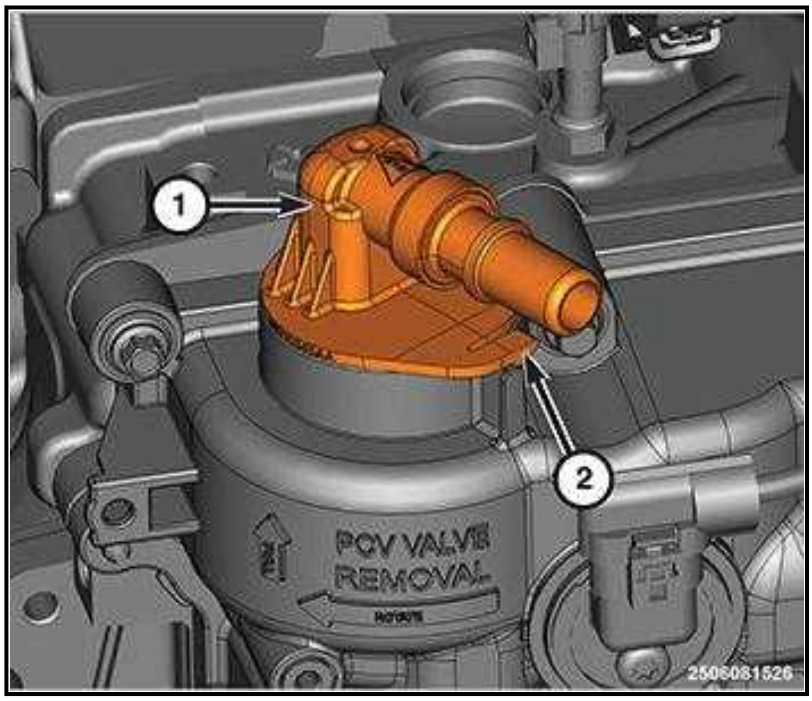
PCV VALVE

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.



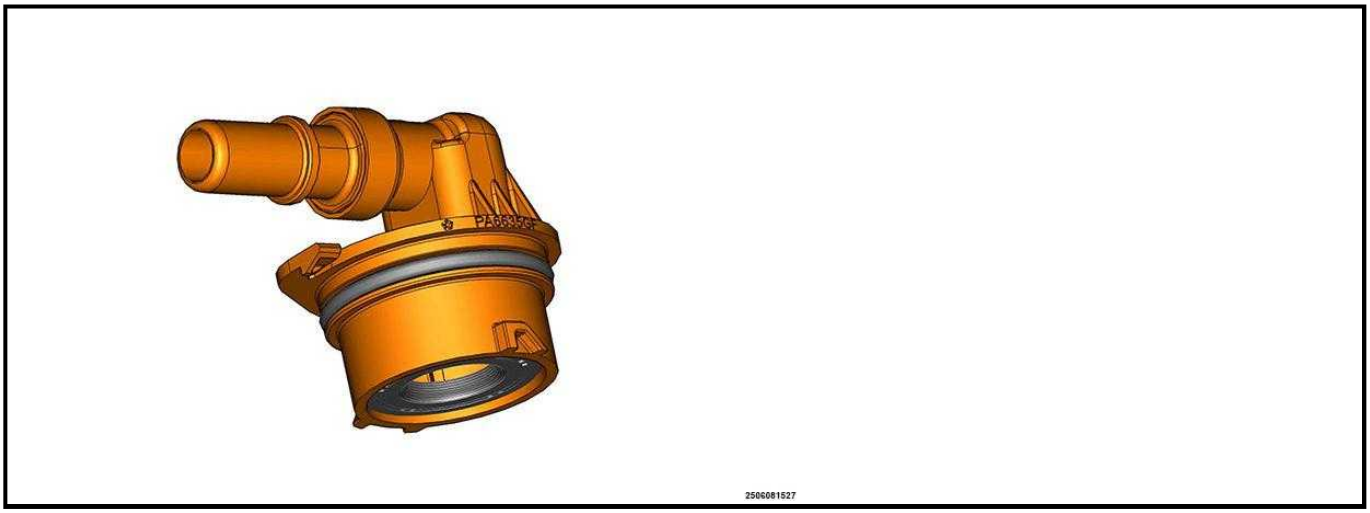
1 - PCV Valve
2 - Lock Tab

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

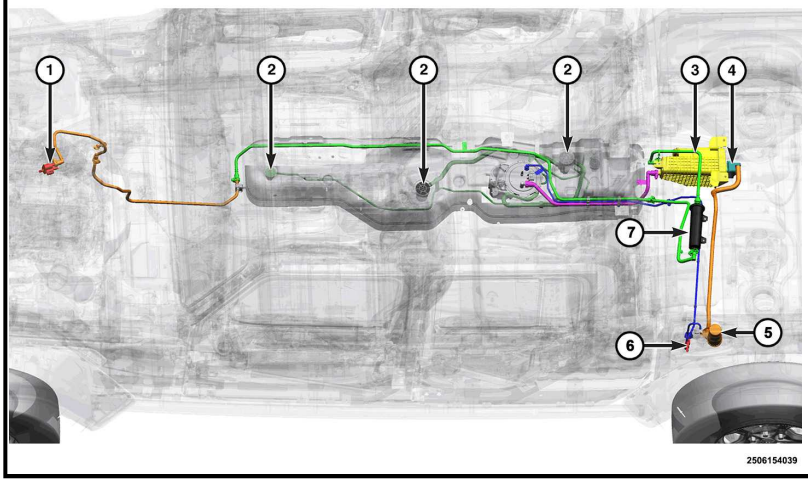
DESCRIPTION

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

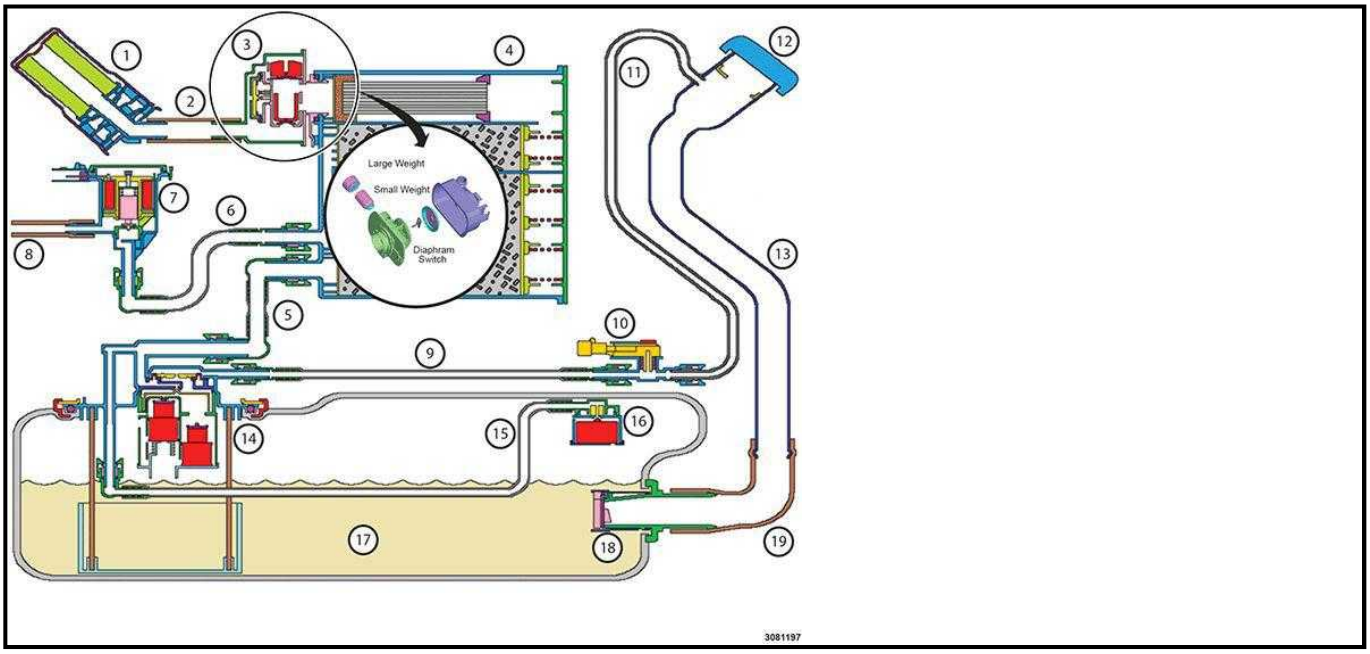


COMPONENT CONFIGURATION VIEW:

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

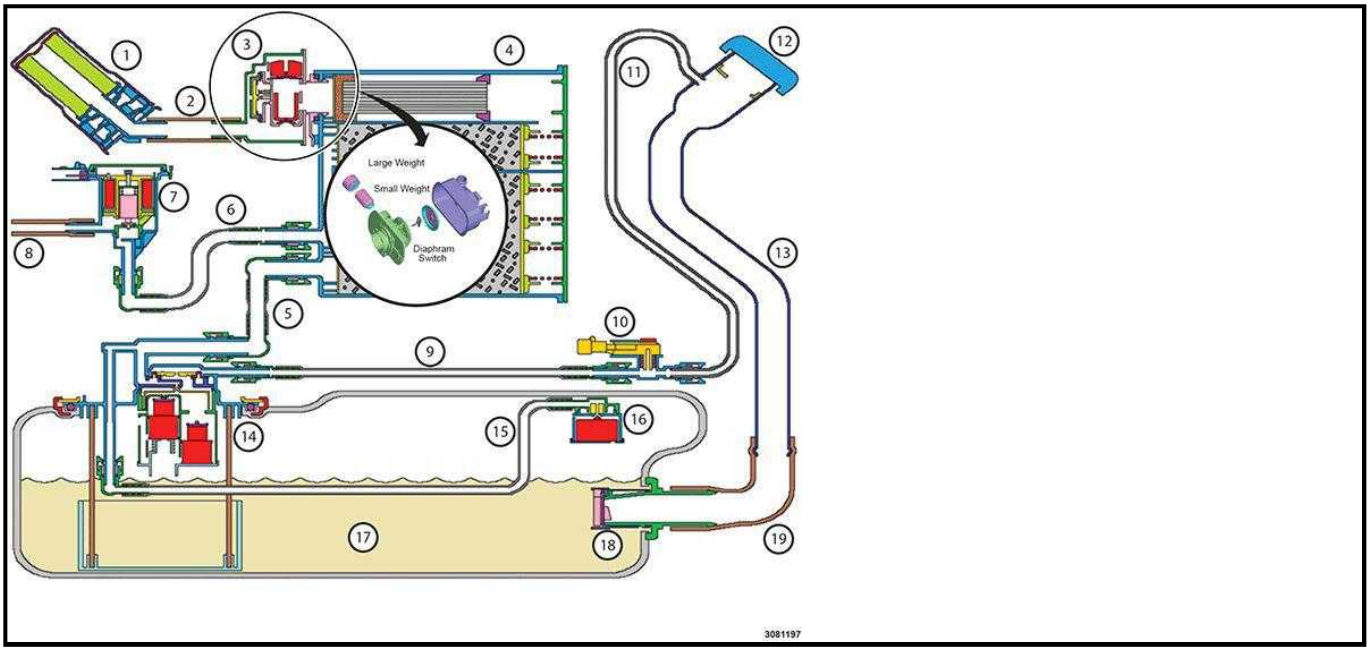
EVAP SYSTEM COMPONENTS			
CALLOUT	DESCRIPTION	CALLOUT	DESCRIPTION
10	Fuel Tank Pressure (FTP) Sensor	B	



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.**

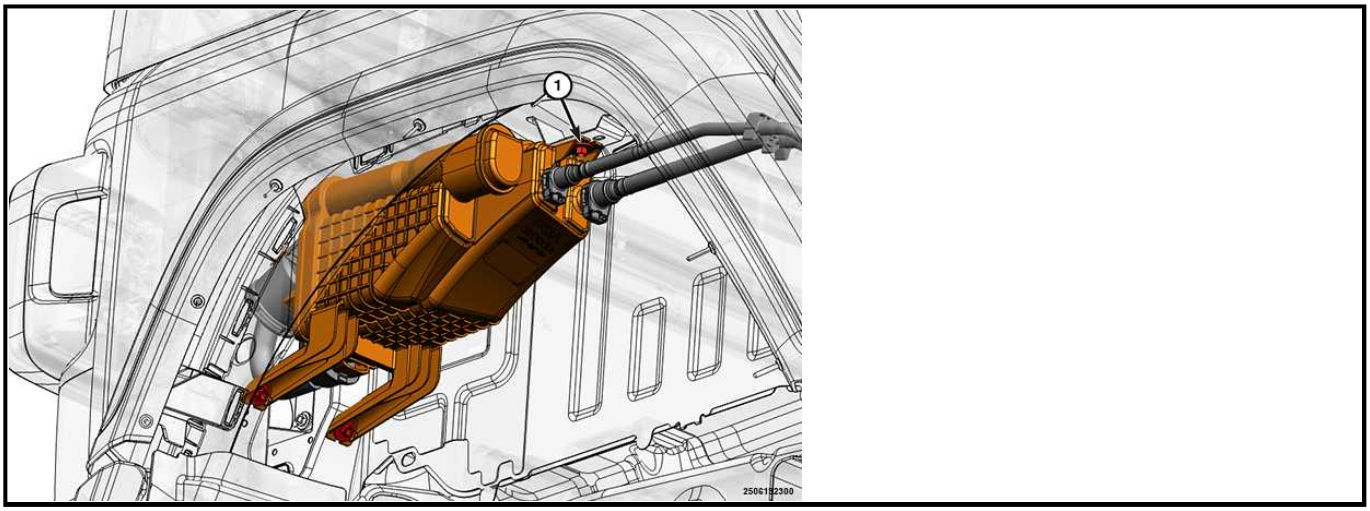
The Purge Flow Monitor Diagnostic will only run if the Small Leak Monitor recorded a pass on the previous ignition OFF event and the test data was valid. Because the leak detection diagnostics can only verify that the fuel tank system is sealed while the purge valve is closed, it cannot determine if 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.)	-

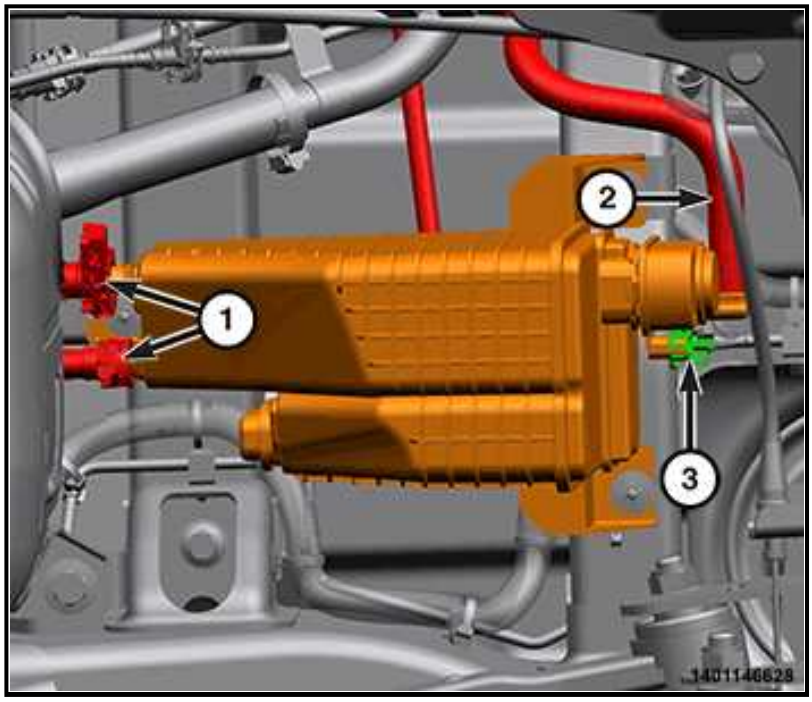
CANISTER, VAPOR

REMOVAL AND INSTALLATION

VAPOR CANISTER

REMOVAL

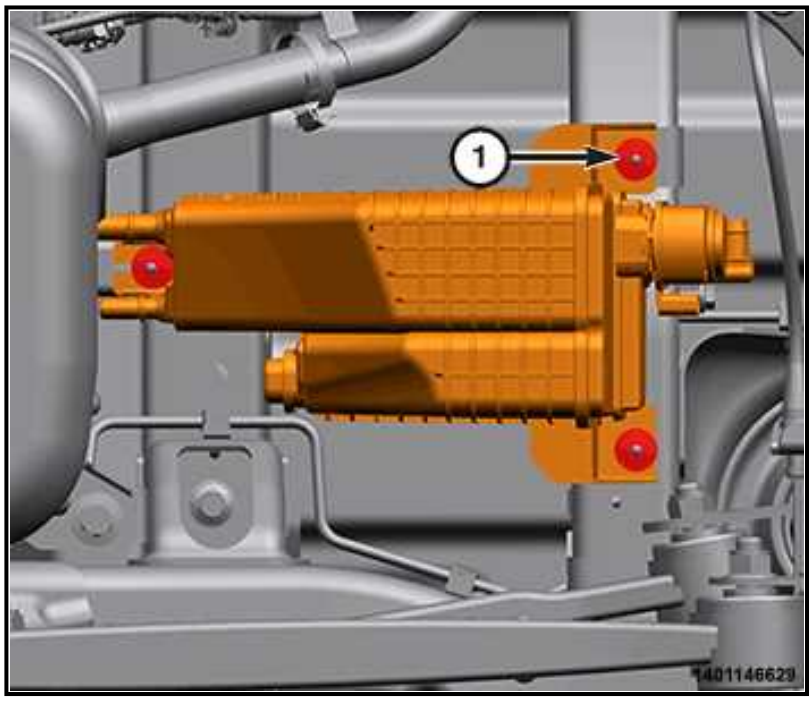
1. Disconnect and isolate the negative battery cable(s). Refer to **CABLES, BATTERY** .
2. Raise and support the vehicle. Refer to **HOISTING, STANDARD PROCEDURE** .



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

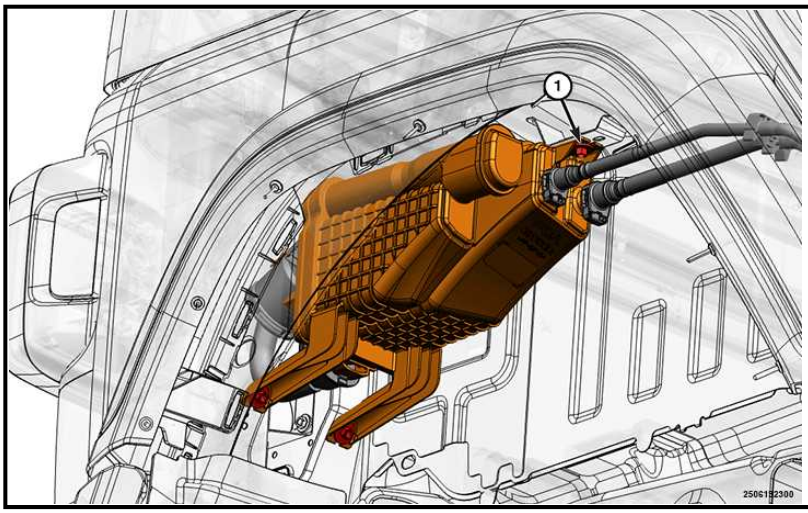
During installation, torque the fasteners to the specifications in the torque table(s) below.

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

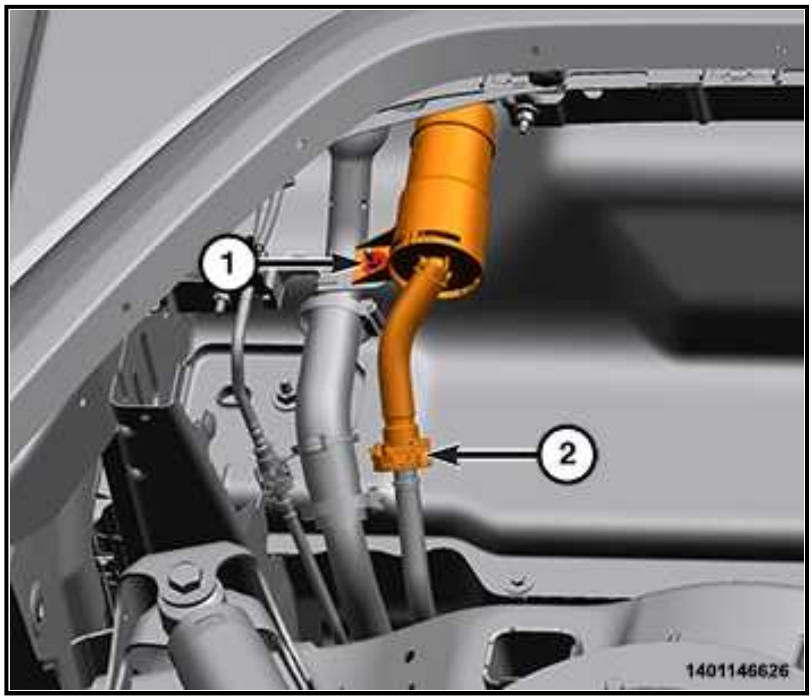
REMOVAL AND INSTALLATION

VAPOR CANISTER FILTER

REMOVAL

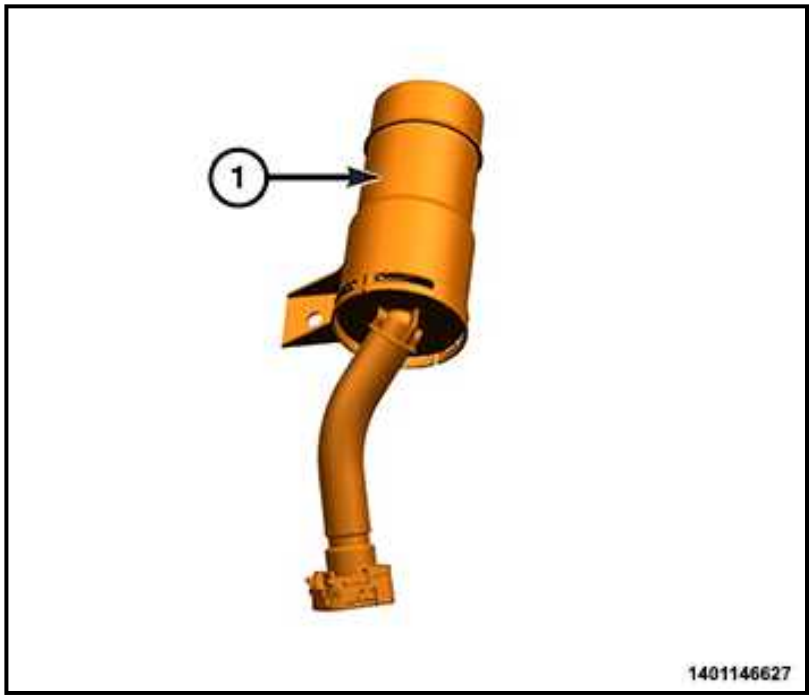
The fresh air filter is located on the side of the vapor canister.

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.

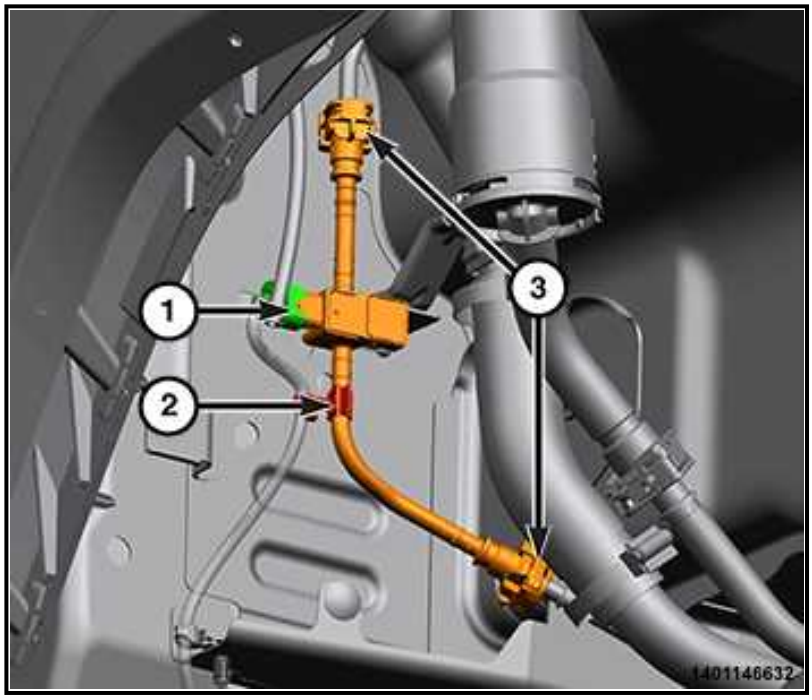
SENSOR, FUEL TANK PRESSURE

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.

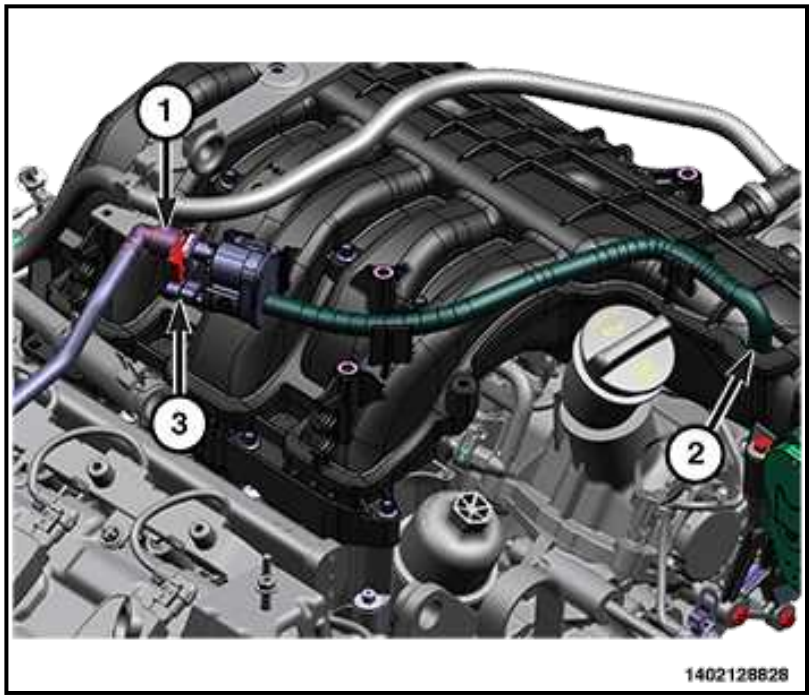
SOLENOID, EVAPORATIVE EMISSIONS PURGE

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

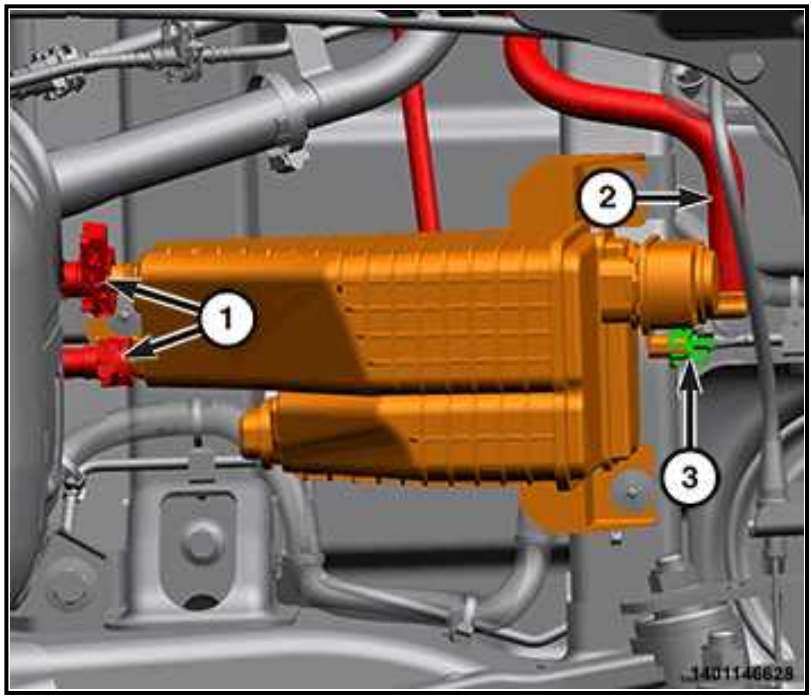
REMOVAL AND INSTALLATION

REMOVAL AND INSTALLATION

REMOVAL

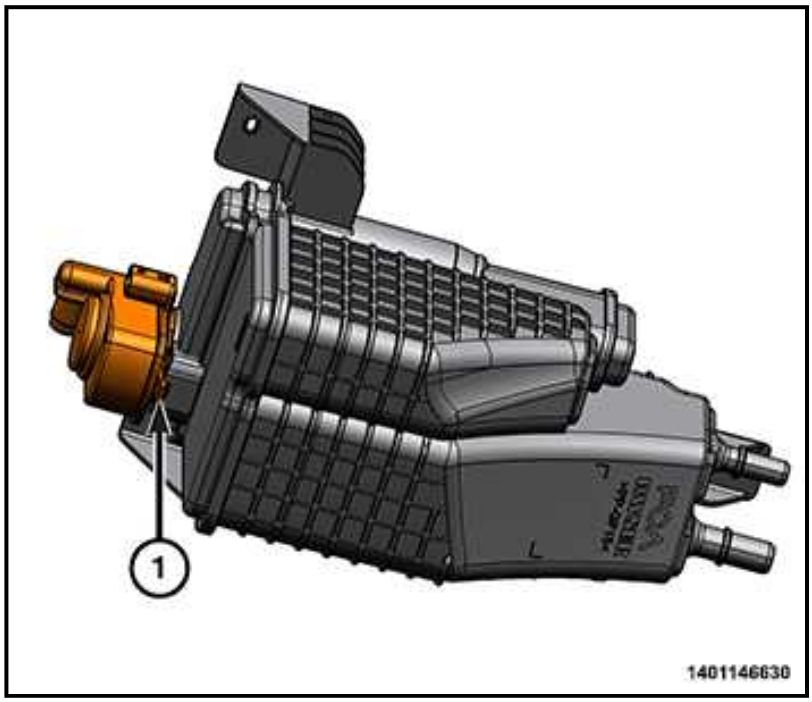
The Evaporative System Integrity Monitor (ESIM) switch is located on the vapor canister.

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

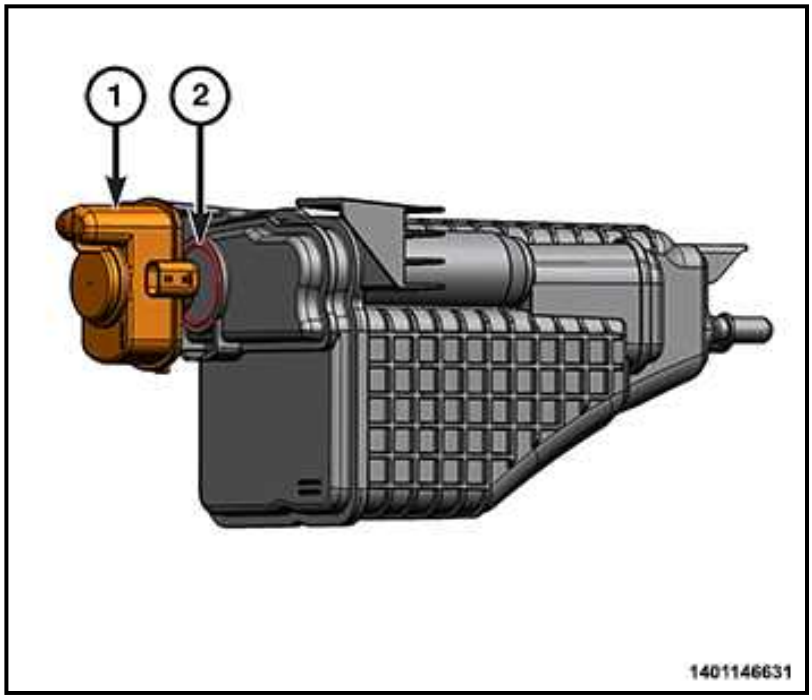
2. Disconnect the hose from the Evaporative System Integrity Monitor (ESIM).
3. Disconnect the wire harness connector from the ESIM.



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.

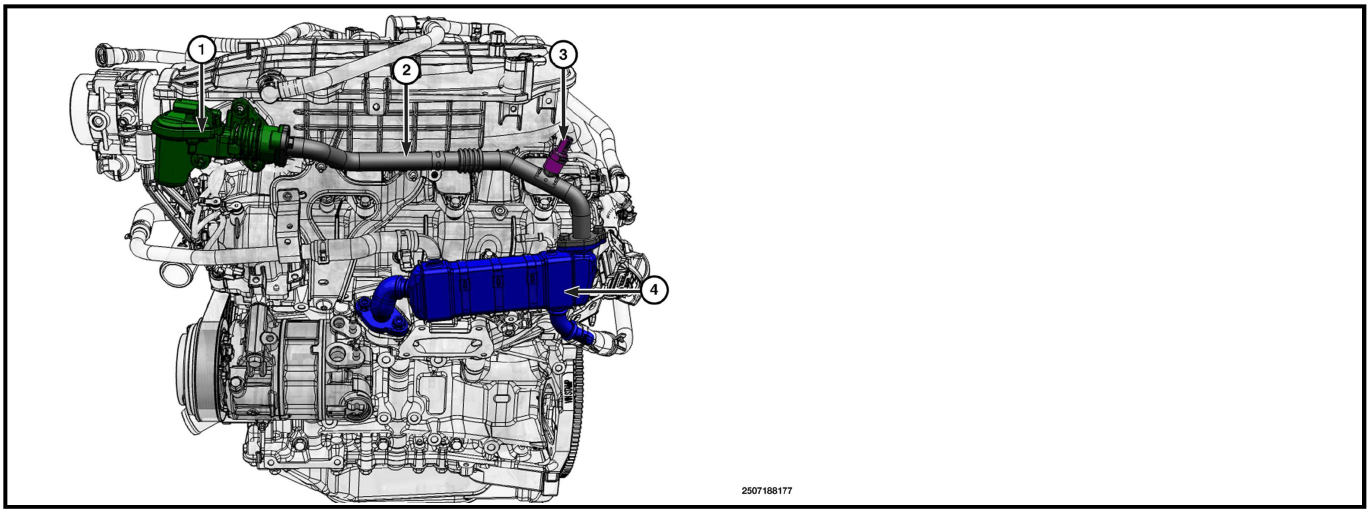
- Install a clean seal into the groove of the vapor canister. The ESIM seal can be lubricated with talcum powder to prevent the seal from binding and turning during installation of the ESIM causing a leak in the system.
- Verify the ESIM is fully engaged and locked. The connector on the ESIM must be 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 reduces 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.

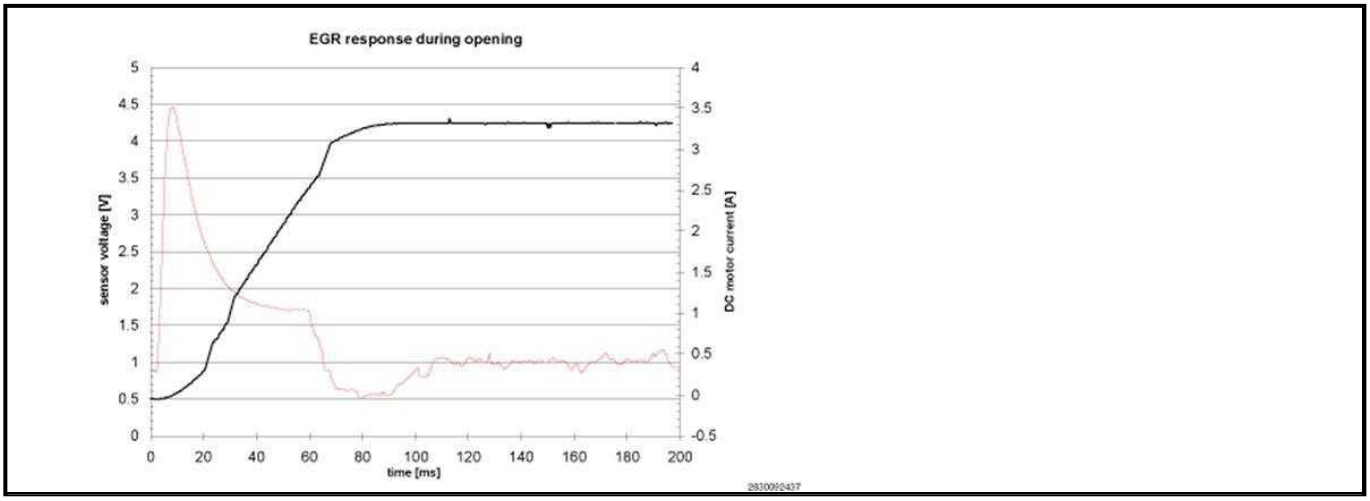
The EGR Valve is operated and monitored in the following manner:

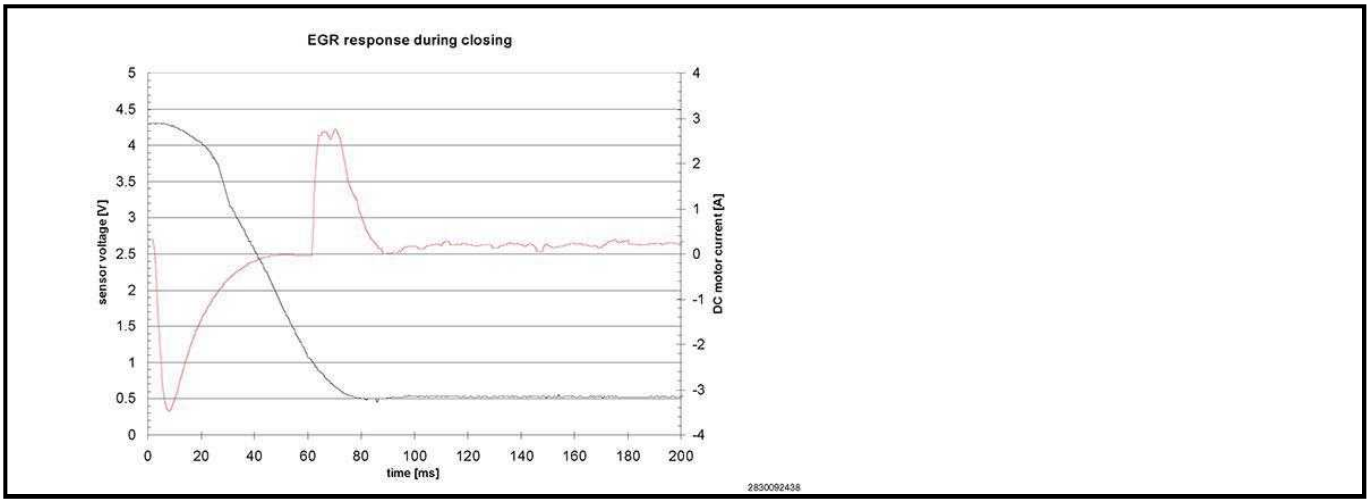
- During the initial opening of the EGR Valve the PCM drives the PWM duty cycle high resulting in a higher current draw. After the valve is fully opened the PCM duty cycle is reduced to maintain the EGR Valve position. This reduces the current draw and protects from overheating the EGR Valve DC Motor.
- 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.)**	-

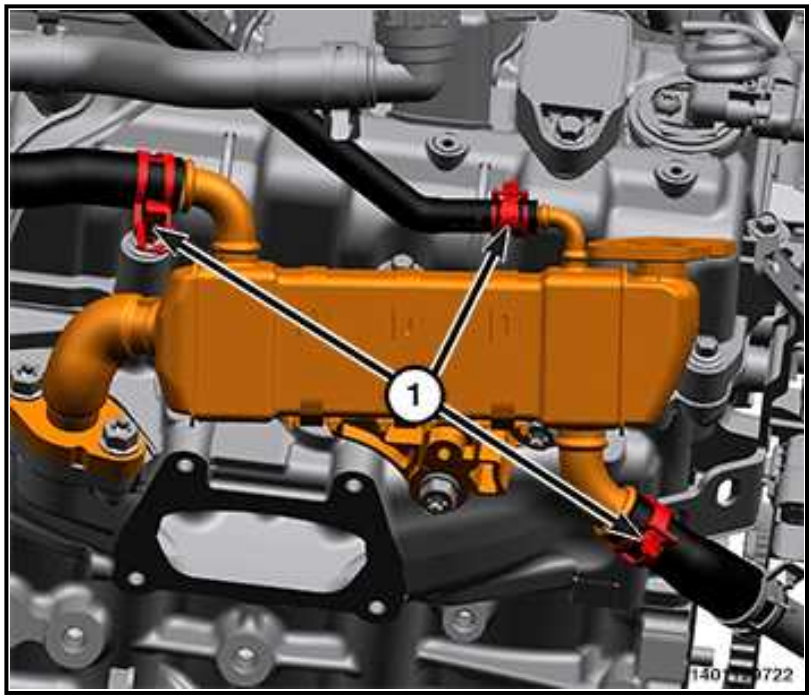
COOLER, EXHAUST GAS RECIRCULATION (EGR)

REMOVAL AND INSTALLATION

REMOVAL AND INSTALLATION

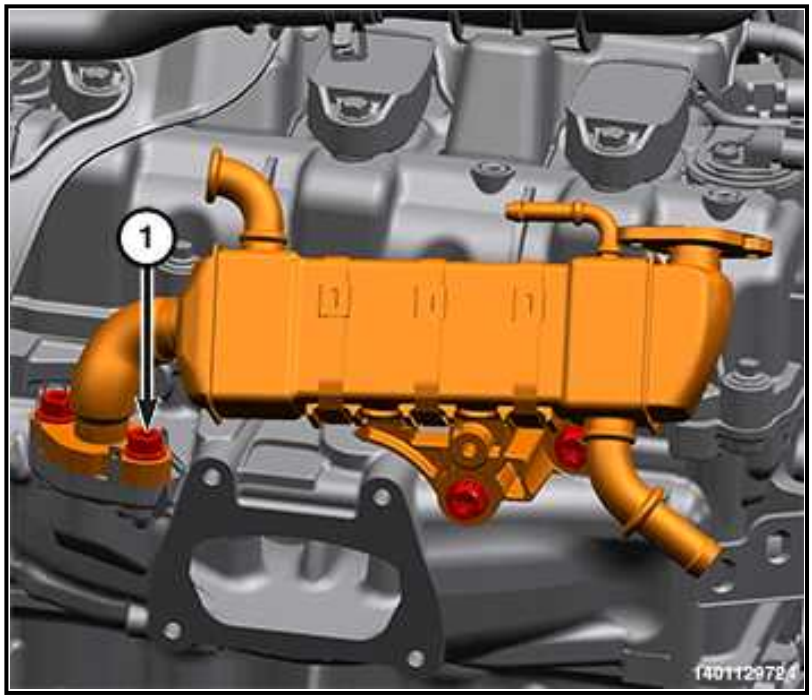
REMOVAL

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.)**	-

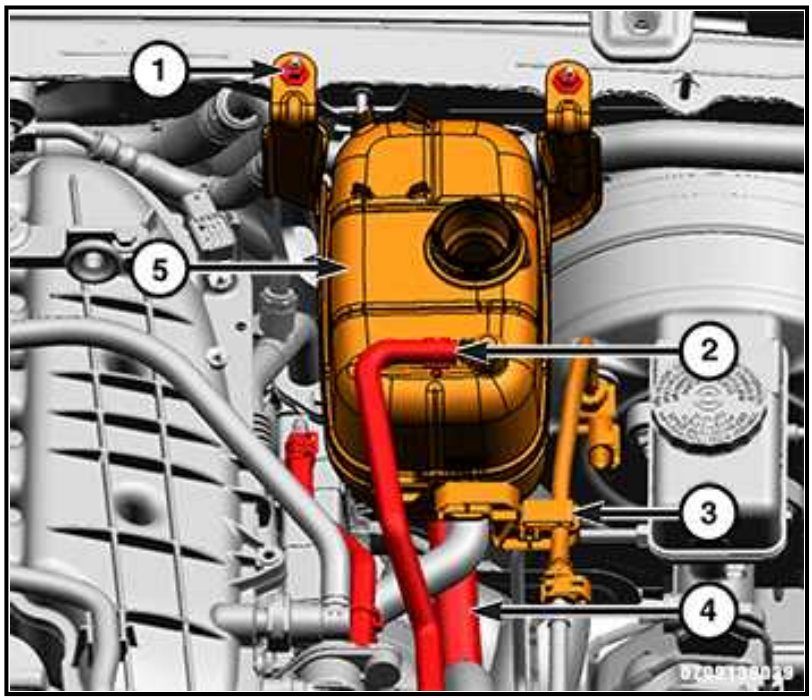
SENSOR, EGR TEMPERATURE

REMOVAL AND INSTALLATION

EGR TEMPERATURE SENSOR

REMOVAL

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

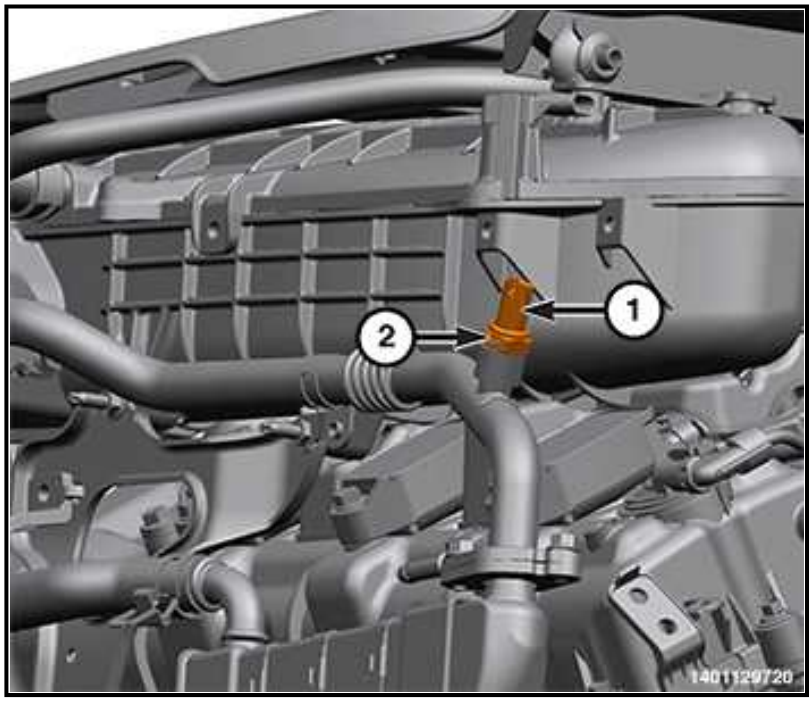


1 - Coolant Bottle Nuts
2 - Coolant Vent Hose
3 - Vacuum Hose Retainer
4 - Coolant Hose
5 - Pressurized Coolant Bottle

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	**Torque Procedure:** **NOTE:** **Bolts (1 - 8) are M6; Bolts (9, 10, 11) are M8; Bolt (12) is M10.** 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

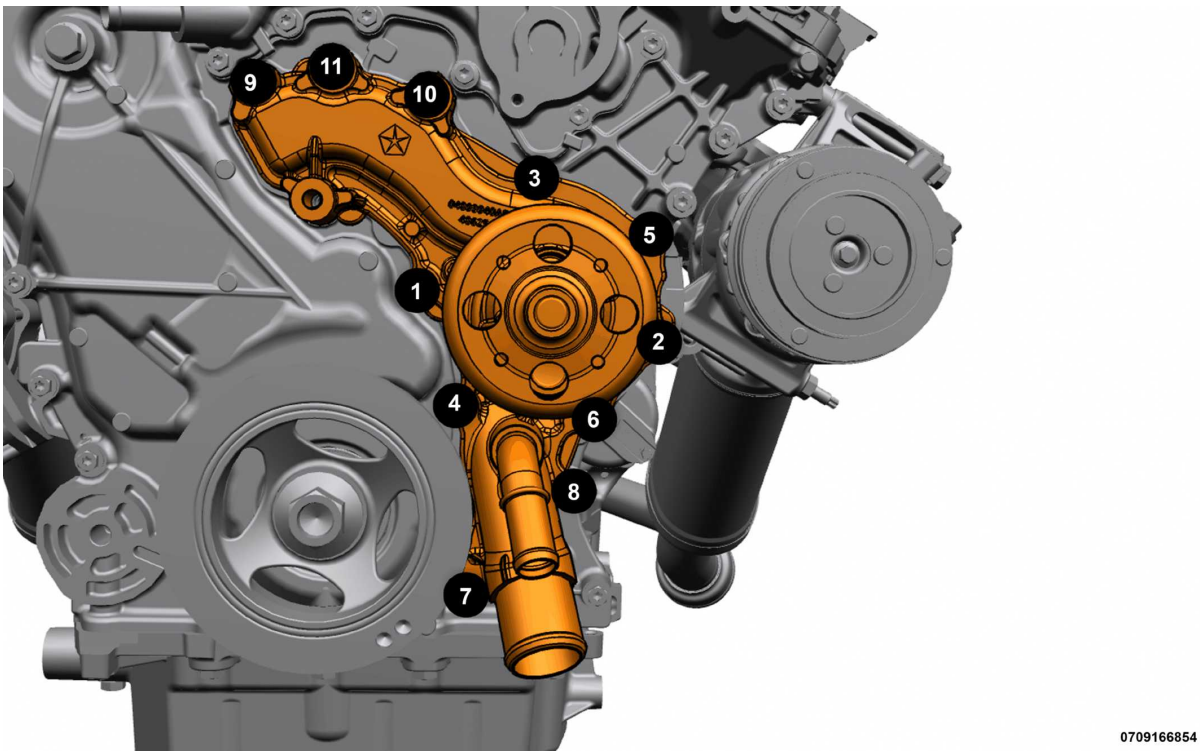


Fig. 1: Water Pump Bolts Tightening Sequence
Courtesy of CHRYSLER GROUP, LLC

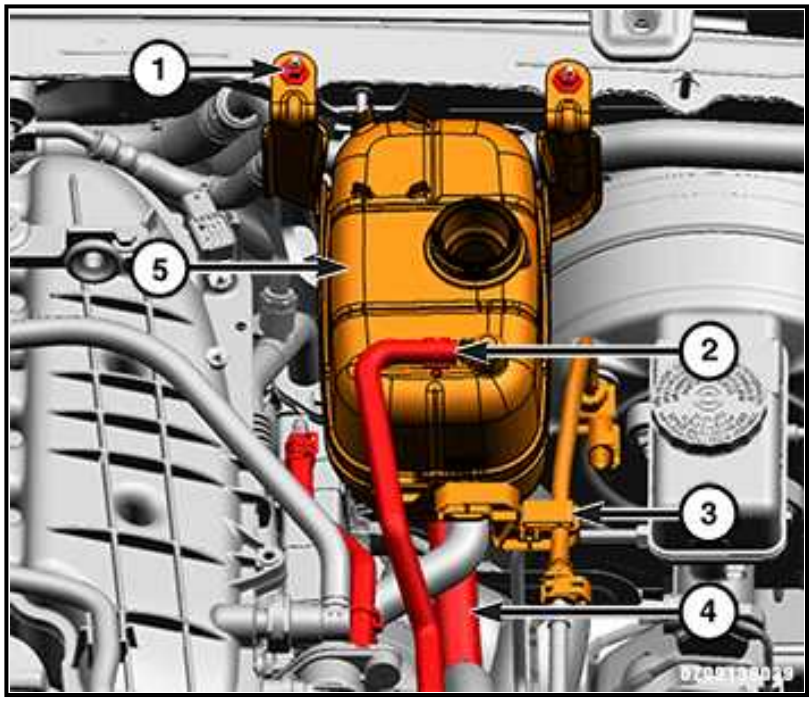
TUBE, EXHAUST GAS RECIRCULATION (EGR), CROSSOVER

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** .



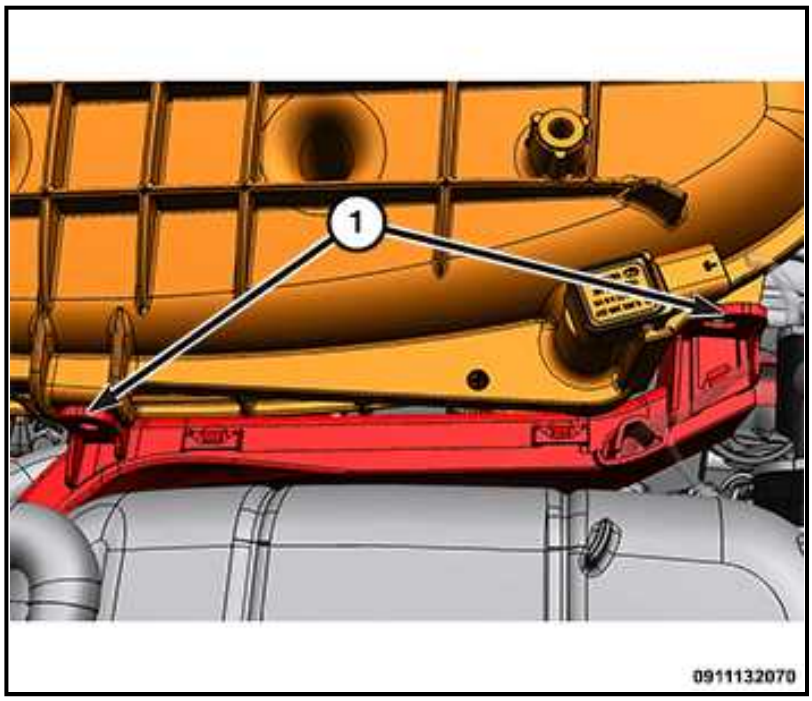
1 - Coolant Bottle Nuts
2 - Coolant Vent Hose

3 - Vacuum Hose Retainer
4 - Coolant Hose
5 - Pressurized Coolant Bottle

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

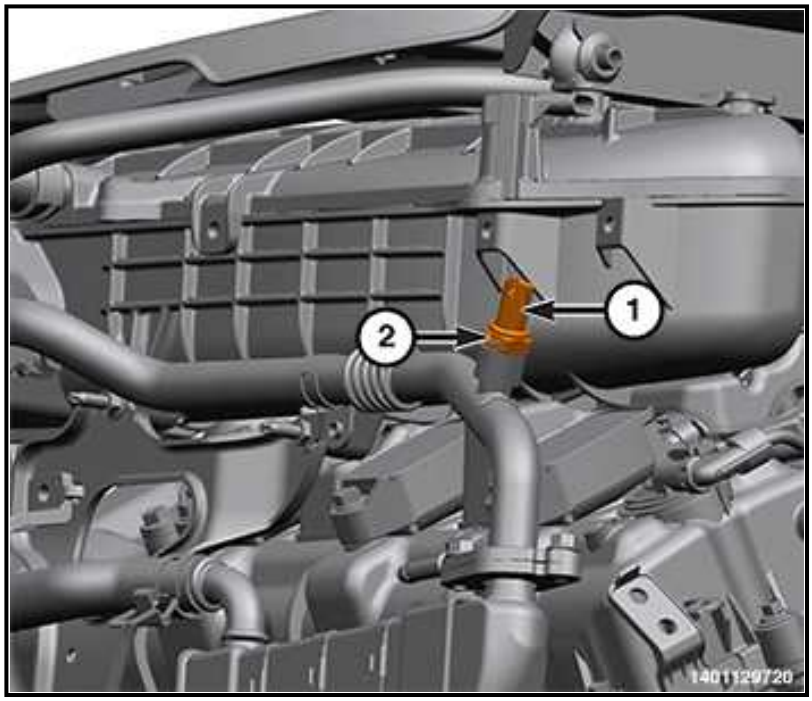
NOTE: **It is not necessary to drain the cooling system.**

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



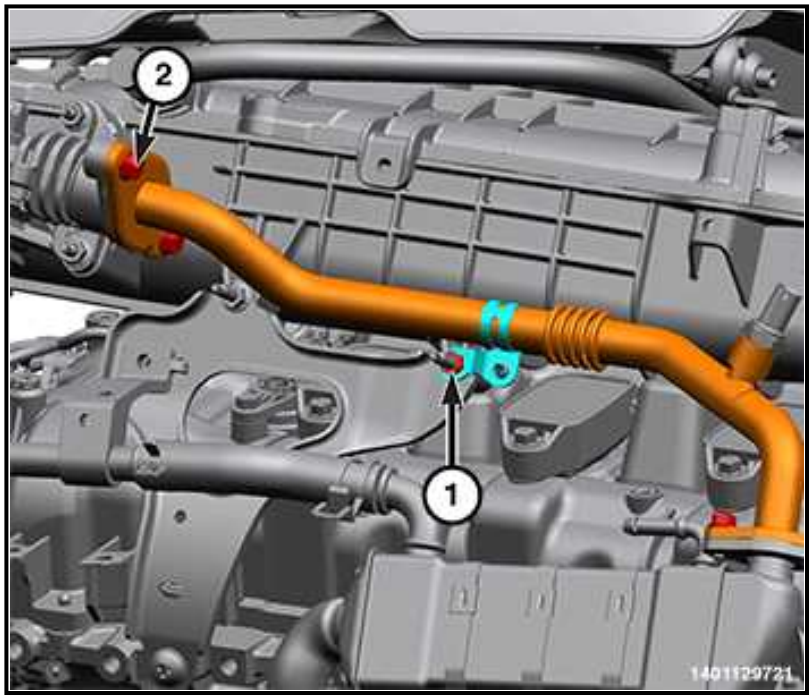
1 - Engine Wire Harness Push Pins

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.

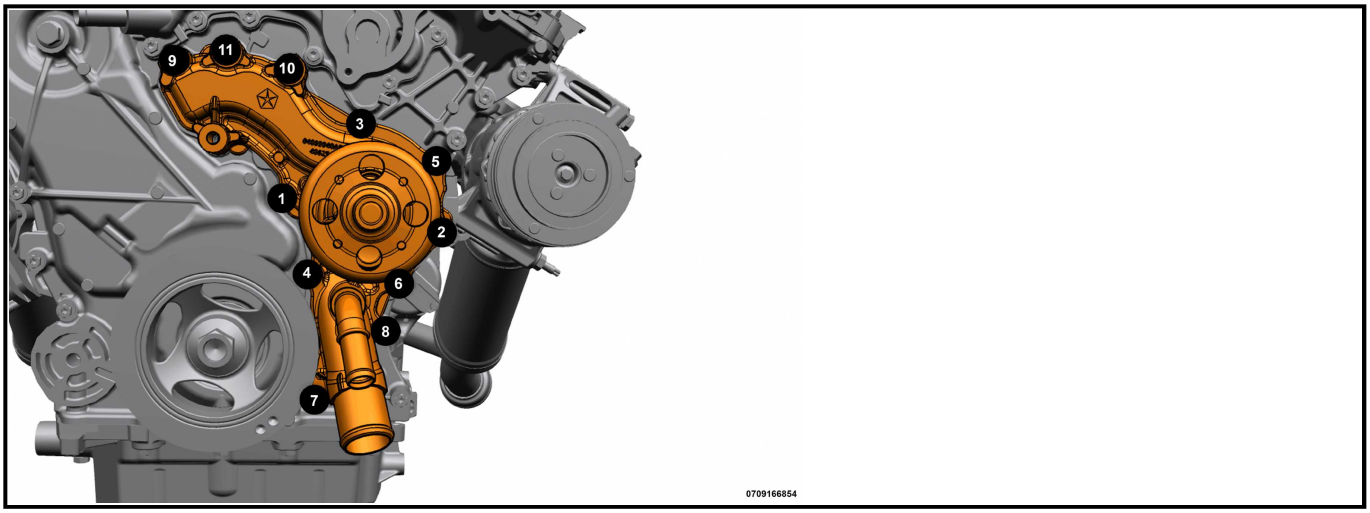
- Clean the gasket mating surfaces.
- Using a **NEW** gasket, install the EGR cooler and hand tighten the inlet tube bolts.
- Install the lower bolts securing the EGR cooler and torque all bolts.
- Connect the lower coolant hose to the pressurized coolant bottle first and then install the pressurized 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	**Torque Procedure:** **NOTE:** **Bolts (1 - 8) are M6; Bolts (9, 10, 11) are M8; Bolt (12) is M10.** 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



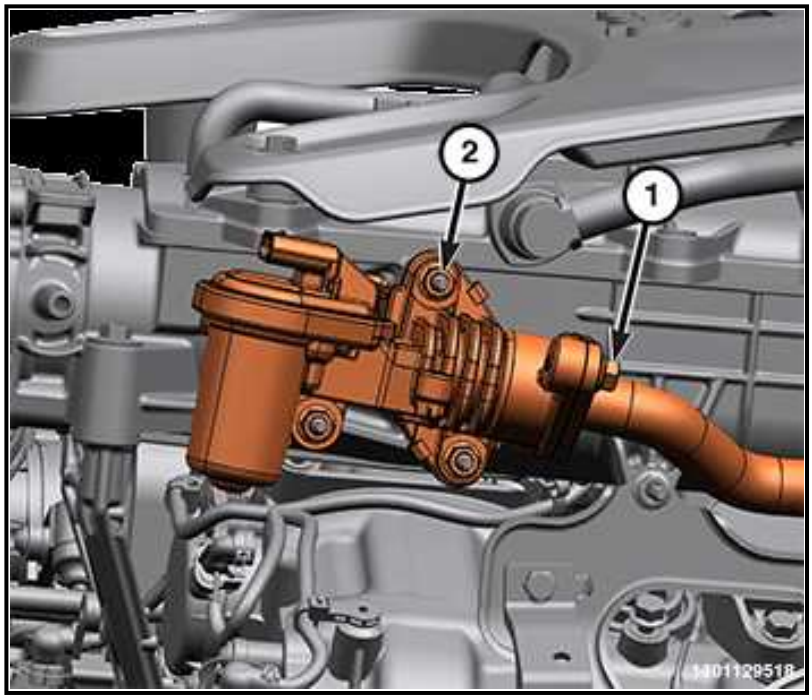
VALVE, EXHAUST GAS RECIRCULATION (EGR)

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.