Service Manual: ENGINE CONTROLS AND FUEL - 2.0L (LTG)
- DESCRIPTION AND OPERATION

DESCRIPTION AND OPERATION > CAMSHAFT ACTUATOR SYSTEM DESCRIPTION > CIRCUIT/SYSTEM DESCRIPTION

The camshaft position actuator solenoid valve - Intake and camshaft position actuator solenoid valve - exhaust system enables the engine control module (ECM) to change camshaft timing while the engine is running. The camshaft position actuator assembly varies camshaft position in response to directional changes in oil pressure. The camshaft position actuator solenoid valve - Intake and camshaft position actuator solenoid valve - exhaust controls the oil pressure that is applied to advance or retard the camshaft. Modifying camshaft timing under changing engine demand provides better balance between the following performance concerns:

- Engine power output
- Fuel economy
- Lower exhaust emissions

The camshaft position actuator solenoid valve - Intake and camshaft position actuator solenoid valve - exhaust is controlled by the ECM. The crankshaft position sensor and the camshaft position sensor - intake and camshaft position sensor - exhaust are used to monitor changes in camshaft position. The ECM uses information from the following sensors in order to calculate the desired camshaft position:

- The engine coolant temperature (ECT) sensor
- The mass air flow (MAF) sensor
- The throttle position sensor
- The vehicle speed sensor (VSS)

cardiagn.com

DESCRIPTION AND OPERATION > CAMSHAFT ACTUATOR SYSTEM DESCRIPTION > CAMSHAFT POSITION ACTUATOR SYSTEM OPERATION

The ECM operates the camshaft position actuator solenoid valve - Intake and camshaft position actuator solenoid valve - exhaust by pulse width modulation (PWM) of the solenoid coil. The higher the PWM duty cycle, the larger the change in camshaft timing. Oil pressure that is applied to the advance side of the fixed vanes will rotate the camshaft in a clockwise direction. The clockwise movement of the camshaft will advance the timing up to a maximum of 21°. When oil pressure is applied to the return side of the vanes, the camshaft will rotate counterclockwise until returning to 0°.

Oil flowing to the camshaft position actuator solenoid valve - intake and camshaft position actuator solenoid valve - exhaust housing from the camshaft position actuator solenoid valve - Intake and camshaft position actuator solenoid valve - exhaust advance passage applies pressure to the advance side of the vane wheel in the camshaft position actuator assembly. At the same time the camshaft position actuator solenoid valve - Intake and camshaft position actuator solenoid valve - exhaust retard passage is open, allowing oil pressure to decrease on the retard side of the vane wheel. These two simultaneous actions cause the vane wheel to rotate clockwise, advancing camshaft advance timing.

When the oil flowing to the camshaft position actuator solenoid valve - Intake and camshaft position actuator solenoid valve - exhaust housing is from the camshaft position actuator solenoid valve - Intake and camshaft position actuator solenoid valve - exhaust retard passage, oil pressure is applied to the retard side of the vane wheel. Because the solenoid advance passage is open, allowing oil pressure to decrease on the advance side of the vane wheel, the camshaft position retards.

The ECM can also command the camshaft position actuator solenoid valve - Intake and camshaft position actuator solenoid valve - exhaust to stop oil flow from both passages in order to hold the current camshaft position. The ECM is continuously comparing camshaft position sensor - intake and camshaft position sensor - exhaust input with camshaft position actuator solenoid valve - Intake and camshaft position actuator solenoid valve - exhaust input in order to monitor camshaft position and detect any system malfunctions. The following table provides camshaft phase commands for common driving conditions:

Driving Conditions	Change in Camshaft Position	Objective	Result
Idle	No change	Minimize valve overlap	Stabilize idle speed
Light engine load	Retard valve timing	Decrease valve overlap	Stable engine output
Medium engine load	Advance valve timing	Increase valve overlap	Better fuel economy with lower emissions
High RPM with heavy load	Retard valve timing	Retard intake valve closing	Improve engine output

DESCRIPTION AND OPERATION > CAMSHAFT ACTUATOR SYSTEM DESCRIPTION > INTAKE CAMSHAFT MID PARK LOCK (IF EQUIPPED)

The intake camshaft position actuator park lock solenoid valve is supplied a dedicated ground control circuit from the ECM and an ignition voltage supply circuit. The ECM operates the intake camshaft position actuator park lock solenoid valve by applying ground to the solenoid valve control circuit to control the oil flow that applies the pressure to disengage the intake camshaft actuator park pin. This allows the ECM to advance or retard the camshaft. When the ECM determines that cam phasing is not desired, it will command the camshaft to the lock position at 0°. At that stage, the ECM control circuit ground is then removed from the solenoid, oil pressure is unapplied, and the camshaft actuator park pin will re-engage preventing cam phasing. The ECM can also determine if the park pin is engaged by applying a slight amount of camshaft advance or retard to verify if movement is present.

DESCRIPTION AND OPERATION > ENGINE CONTROL MODULE DESCRIPTION

The Engine Control Module (ECM) interacts with many emission related components and systems, and monitors emission related components and systems for deterioration. OBD II diagnostics monitor the system performance and a diagnostic trouble code (DTC) sets if the system performance degrades. The ECM is part of a network and communicates with various other vehicle control modules.

Malfunction indicator lamp (MIL) operation and DTC storage are dictated by the DTC type. A DTC is ranked as a Type A or Type B if the DTC is emissions related. Type C is a non-emissions related DTC.

The ECM is the control center of the engine controls system. Review the components and wiring diagrams in order to determine which systems are controlled by the ECM.

The ECM constantly monitors the information from various sensors and other inputs, and controls the systems that affect engine performance and emissions. The ECM also performs diagnostic tests on various parts of the system and can turn on the MIL when it recognizes an operational problem that affects emissions. When the ECM detects a malfunction, the ECM stores a DTC. The condition area is identified by the particular DTC that is set. This aids the technician in making repairs.

DESCRIPTION AND OPERATION > ENGINE CONTROL MODULE DESCRIPTION > ECM FUNCTION

The ECM can supply 5 V or 12 V to various sensors or switches. This is done through pull-up resistors to regulated power supplies within the ECM. In some cases, even an ordinary shop voltmeter will not give an accurate reading due to low input resistance. Therefore, a digital multimeter (DMM) with at least 10 megaohms input impedance is required in order to ensure accurate voltage readings.

The ECM controls the output circuits by controlling the ground or the power feed circuit through transistors or a device called an output driver module.

DESCRIPTION AND OPERATION > ENGINE CONTROL MODULE DESCRIPTION > EEPROM

The electronically erasable programmable read only memory (EEPROM) is an integral part of the ECM. The EEPROM contains program and calibration information that the ECM needs in order to control engine operation.

Special equipment, as well as the correct program and calibration for the vehicle, are required in order to reprogram the ECM.

DESCRIPTION AND OPERATION > ENGINE CONTROL MODULE DESCRIPTION > DATA LINK CONNECTOR (DLC)

The data link connector (DLC) provides serial data communication for ECM diagnosis. This connector allows the technician to use a scan tool in order to monitor various serial data parameters, and display DTC information. The DLC is located inside the driver's compartment, underneath the instrument panel.

DESCRIPTION AND OPERATION > ENGINE CONTROL MODULE DESCRIPTION > MALFUNCTION INDICATOR LAMP (MIL)

The malfunction indicator lamp (MIL) is inside the instrument panel cluster (IPC). The MIL is controlled by the ECM and illuminates when the ECM detects a condition that affects vehicle emissions.

cardiagn.com

DESCRIPTION AND OPERATION > ENGINE CONTROL MODULE DESCRIPTION > ECM SERVICE PRECAUTIONS

The ECM, by design, can withstand normal current draws that are associated with vehicle operations. However, care must be used in order to avoid overloading any of these circuits. When testing for opens or shorts, do not ground or apply voltage to any of the ECM circuits unless the diagnostic procedure instructs you to do so. These circuits should only be tested with a DMM unless the diagnostic procedure instructs otherwise.

DESCRIPTION AND OPERATION > ENGINE CONTROL MODULE DESCRIPTION > EMISSIONS DIAGNOSIS FOR STATE I/M PROGRAMS

This OBD II equipped vehicle is designed to diagnose any conditions that could lead to excessive levels of the following emissions:

- Hydrocarbons (HC)
- Carbon monoxide (CO)
- Oxides of nitrogen (NOx)
- Evaporative emission (EVAP) system losses

Should this vehicle's on-board diagnostic system (ECM) detect a condition that could result in excessive emissions, the ECM turns ON the MIL and stores a DTC that is associated with the condition.

DESCRIPTION AND OPERATION > ENGINE CONTROL MODULE DESCRIPTION > AFTERMARKET (ADD-ON) ELECTRICAL AND VACUUM EQUIPMENT

> ⚠ *CAUTION:*
>
> *Do not attach add-on vacuum operated equipment to this vehicle. The use of add-on vacuum equipment may result in damage to vehicle components or systems.*

> ⚠ *CAUTION:*
>
> *Connect any add-on electrically operated equipment to the vehicle's electrical system at the 12 V battery (power and ground) in order to prevent damage to the vehicle.*

Aftermarket, add-on, electrical and vacuum equipment is defined as any equipment installed on a vehicle after leaving the factory that connects to the vehicle's electrical or vacuum systems. No allowances have been made in the vehicle design for this type of equipment.

Add-on electrical equipment, even when installed to these strict guidelines, may still cause the powertrain system to malfunction. This may also include equipment not connected to the vehicle

cardiagn.com

electrical system, such as portable telephones and radios. Therefore, the first step in diagnosing any powertrain condition is to eliminate all of the aftermarket electrical equipment from the vehicle. After this is done, if the problem still exists, the problem may be diagnosed in the normal manner.

DESCRIPTION AND OPERATION > ENGINE CONTROL MODULE DESCRIPTION > ELECTROSTATIC DISCHARGE (ESD) DAMAGE

> *NOTE:*
>
> *In order to prevent possible electrostatic discharge damage to the ECM, DO NOT touch the connector pins on the ECM.*

The electronic components that are used in the control systems are often designed to carry very low voltage. These electronic components are susceptible to damage caused by electrostatic discharge. Less than 100 V of static electricity can cause damage to some electronic components. By comparison, it takes as much as 4, 000 V for a person to even feel a static discharge.

There are several ways for a person to become statically charged. The most common methods of charging are by friction and by induction. An example of charging by friction is a person sliding across a car seat.

Charging by induction occurs when a person with well insulated shoes stands near a highly charged object and momentarily touches ground. Charges of the same polarity are drained off leaving the person highly charged with the opposite polarity. Static charges can cause damage, therefore, it is important to use care when handling and testing electronic components.

cardiagn.com

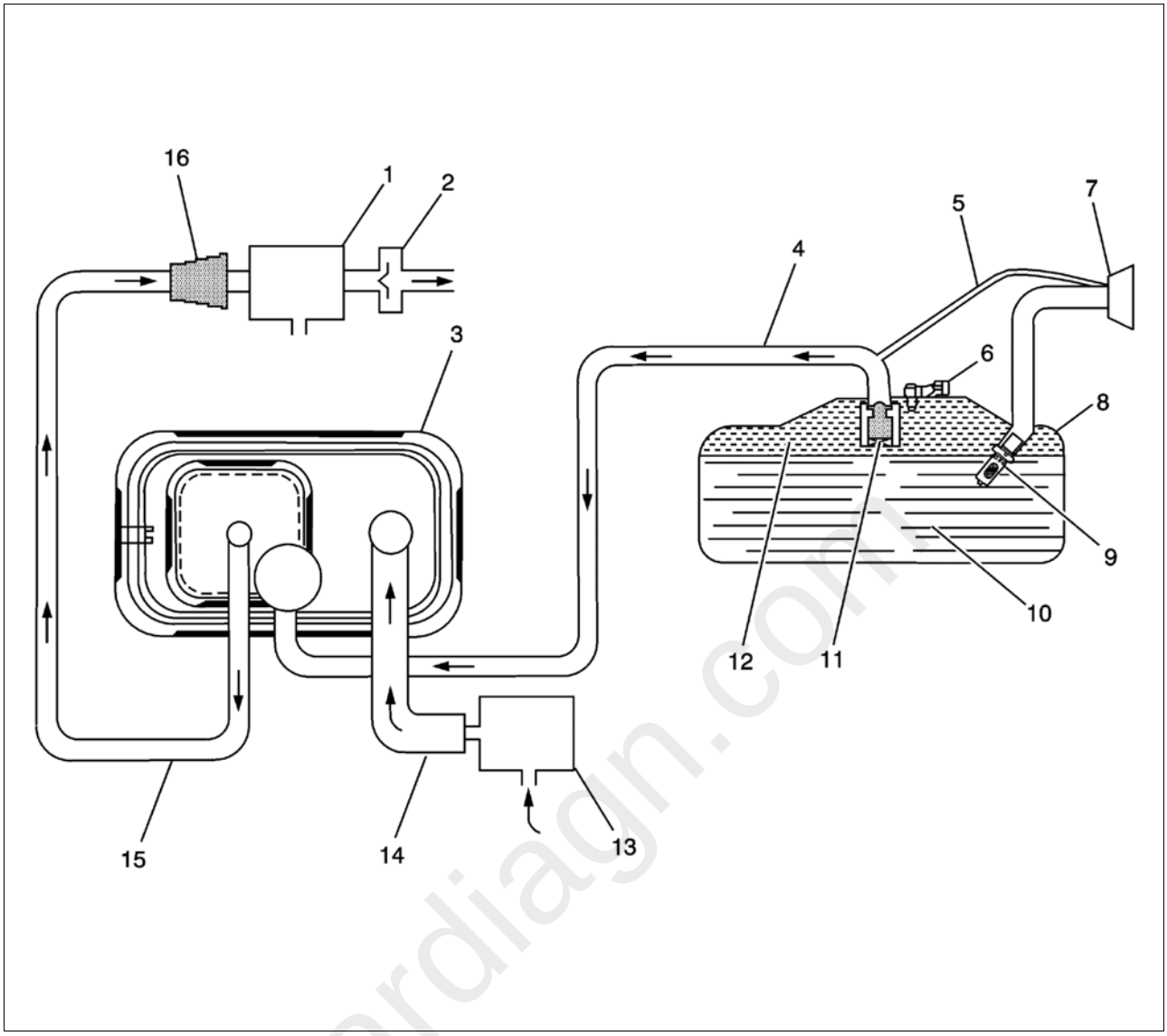
DESCRIPTION AND OPERATION > ENGINE CONTROL MODULE DESCRIPTION > EMISSIONS CONTROL INFORMATION LABEL

The underhood Vehicle Emissions Control Information Label contains important emission specifications. This identifies the year, the displacement of the engine in liters, and the class of the vehicle.

This label is located in the engine compartment of every General Motors vehicle. If the label has been removed, it can be ordered from GM service parts operations (GMSPO).

DESCRIPTION AND OPERATION > EVAPORATIVE EMISSION CONTROL SYSTEM DESCRIPTION > TYPICAL EVAPORATIVE EMISSION (EVAP) SYSTEM HOSE ROUTING DIAGRAM > EDIT TO ADD FLVV INFO BELOW. NECESSARY TO REORDER CALL-OUTS FROM #8 ON BECAUSE OF ART WORK CALL OUT DIRECTIONS. MUST BE IN A CLOCKWISE NUMERIC ORDER.

Fig 1: Typical Evaporative Emission (EVAP) System Hose Routing Diagram



Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

Callout	Component Name
1	Evaporative Emissions (EVAP) Purge Solenoid Valve
2	Purge Tube Check Valve, Turbo-Charged Applications Only
3	EVAP Canister
4	EVAP Vapor Tube
5	Vapor Recirculation Tube (ORVR)
6	Fuel Tank Pressure Sensor
7	Fuel Filler Cap (Some Vehicles May Have A Capless Design)
8	Fuel Tank
9	Fuel Fill Pipe Inlet Check Valve

10	Liquid Fuel
11	Fill Limit Vent Valve (FLVV)
12	Fuel Vapor
13	EVAP Canister Vent Solenoid Valve
14	Vent hose
15	EVAP Purge Tube
16	EVAP Canister Purge Tube Connector

DESCRIPTION AND OPERATION > EVAPORATIVE EMISSION CONTROL SYSTEM DESCRIPTION > EVAP SYSTEM OPERATION

The EVAP control system limits fuel vapors from escaping into the atmosphere. Fuel tank vapors are allowed to move from the fuel tank, due to pressure in the tank, through the EVAP vapor tube, into the EVAP canister. Carbon in the canister absorbs and stores the fuel vapors. Excess pressure is vented through the vent hose and EVAP vent solenoid valve to the atmosphere. The EVAP canister stores the fuel vapors until the engine is able to use them. At an appropriate time, the engine control module (ECM) will command the EVAP purge solenoid valve ON, allowing engine vacuum to be applied to the EVAP canister. With the normally open EVAP vent solenoid valve OFF, fresh air is drawn through the vent solenoid valve and the vent hose to the EVAP canister. Fresh air is drawn through the canister, pulling fuel vapors from the carbon. The air/fuel vapor mixture continues through the EVAP purge tube and EVAP purge solenoid valve into the intake manifold to be consumed during normal combustion. The ECM uses several tests to determine if the EVAP system is leaking or restricted.

DESCRIPTION AND OPERATION > EVAPORATIVE EMISSION CONTROL SYSTEM DESCRIPTION > PURGE SOLENOID VALVE LEAK TEST

If the EVAP purge solenoid valve does not seal properly fuel vapors could enter the engine at an undesired time, causing driveability concerns. The ECM tests for this by commanding the EVAP purge solenoid valve OFF and the vent solenoid valve ON which seals the system. With the engine running, the ECM then monitors the fuel tank pressure sensor for an increase in vacuum. The ECM will set a DTC if a vacuum develops in the tank under these test conditions.

DESCRIPTION AND OPERATION > EVAPORATIVE EMISSION CONTROL SYSTEM DESCRIPTION > LARGE LEAK TEST

This diagnostic creates a vacuum condition in the EVAP system. When the enabling criteria has been met, the ECM commands the normally open EVAP vent solenoid valve closed and the EVAP purge solenoid valve open, creating a vacuum in the EVAP system. The ECM then monitors the fuel tank pressure sensor voltage to verify that the system is able to reach a predetermined level of vacuum within a set amount of time. Failure to achieve the expected level of vacuum indicates the presence of a large leak in the EVAP system or a restriction in the purge path. The ECM will set a DTC if it detects a weaker than expected vacuum level under these test conditions.

DESCRIPTION AND OPERATION > EVAPORATIVE EMISSION CONTROL SYSTEM DESCRIPTION > CANISTER VENT RESTRICTION TEST

If the EVAP vent system is restricted, fuel vapors will not be properly purged from the EVAP canister. The ECM tests this by commanding the EVAP purge solenoid valve ON while commanding the EVAP vent solenoid valve OFF, and then monitoring the fuel tank pressure sensor for an increase in vacuum. If the vacuum increases more than the expected amount, in a set amount of time, a fault will be logged by the ECM.

DESCRIPTION AND OPERATION > EVAPORATIVE EMISSION CONTROL SYSTEM DESCRIPTION > SMALL LEAK TEST

The engine off natural vacuum diagnostic is the small-leak detection diagnostic for the EVAP system. The engine off natural vacuum diagnostic monitors the EVAP system pressure with the ignition OFF. Because of this, it may be normal for the ECM to remain active for up to 40 min after the ignition is turned OFF. This is important to remember when performing a parasitic draw test on vehicles equipped with engine off natural vacuum.

When the vehicle is driven, the temperature rises in the tank due to heat transfer from the exhaust system. After the vehicle is parked, the temperature in the tank continues to rise for a period of time, then starts to drop. The engine off natural vacuum diagnostic relies on this temperature change, and the corresponding pressure change in a sealed system, to determine if an EVAP system leak is present.

The engine off natural vacuum diagnostic is designed to detect leaks as small as 0.51 mm (0.020 in).

DESCRIPTION AND OPERATION > EVAPORATIVE EMISSION CONTROL SYSTEM DESCRIPTION > EVAP SYSTEM COMPONENTS

The EVAP system consists of the following components:

EVAP Purge Solenoid Valve

The EVAP purge solenoid valve controls the flow of vapors from the EVAP system to the intake manifold. The purge solenoid valve opens when commanded ON by the ECM. This normally closed valve is pulse width modulated (PWM) by the ECM to precisely control the flow of fuel vapor to the engine. The valve will also be opened during some portions of the EVAP testing when the engine is running, allowing engine vacuum to enter the EVAP system.

Purge Tube Check Valve

> *NOTE:*
>
> *The presence of this one-way check valve prevents pressure testing the EVAP system for leaks at the EVAP canister purge tube connector.*

cardiagn.com

Turbocharged vehicles have a check valve in the purge tube between the EVAP purge solenoid valve and the intake manifold to prevent pressurization of the EVAP system under boost conditions. Some applications may have this check valve between the EVAP purge solenoid valve and the EVAP canister.

EVAP Canister

The canister is filled with carbon pellets used to absorb and store fuel vapors. Fuel vapor is stored in the canister until the ECM determines that the vapor can be consumed in the normal combustion process.

Vapor Recirculation Tube

A vapor path between the fuel fill pipe and the vapor tube to the carbon canister is necessary for Vehicle Onboard Diagnostics to fully diagnose the EVAP system. It also accommodates service diagnostic procedures by allowing the entire EVAP system to be diagnosed from either end of the system.

The On-Board Refueling Vapor Recovery System is an on-board vehicle system designed to recover fuel vapors during the vehicle refueling operation. The flow of liquid fuel down the fuel filler pipe provides a liquid seal which prevents vapor from leaving the fuel filler pipe. An EVAP pipe transports the fuel vapor to the EVAP canister for use by the engine.

Fuel Tank Pressure Sensor

The fuel tank pressure sensor measures the difference between the pressure or vacuum in the fuel tank and outside air pressure. Depending on the vehicle, the sensor can be located in the vapor space on top of the fuel tank, in the vapor tube between the canister and the tank, or on the EVAP canister. A high fuel tank pressure sensor voltage indicates a low fuel tank pressure or vacuum. A low fuel tank pressure sensor voltage indicates a high fuel tank pressure.

Fuel Fill Pipe Check Valve

The check valve on the fuel fill pipe is there to prevent spit-back during refueling.

EVAP Vent Solenoid Valve

The EVAP vent solenoid valve controls fresh airflow into the EVAP canister. The valve is normally open. The canister vent solenoid valve is closed only during EVAP system tests performed by the ECM like large leak and engine off natural vacuum test.

Fuel Fill Cap

The fuel fill cap is equipped with a seal and a vacuum relief valve and is tethered. A torque-limiting device prevents the cap from being over tightened. To install the cap, turn the cap clockwise until you hear clicks. This indicates that the cap is correctly torqued and fully seated. A built-in device indicates that the fuel filler cap is fully seated. A fuel filler cap that is not fully seated may cause a malfunction in the emission system.

Capless Fuel Fill

Some vehicles may have a capless fuel fill design behind a locking fuel door. There is no fuel fill cap to remove. One just fully inserts the fuel nozzle into the fill neck, making sure it latches before refueling. Flapper valves close to seal this interface once the fill nozzle is removed.

Fill Limit Vent Valve

This acts as a shut off valve during refueling. This will vary based on fuel tank design. The fuel limit vent valve has the following functions:

cardiagn.com

- The fuel limit vent valve is located on the inside top of the fuel tank
- This valve is not serviced separately
- Controls the fuel tank fill level by closing the primary vent from the fuel tank and forcing the fuel fill nozzle to shut off.
- Prevents liquid fuel from exiting the fuel tank via the EVAP pipe to the canister.
- Provides fuel-spillage protection in the event of a vehicle rollover by closing the vapor path from the tank to the EVAP canister.

DESCRIPTION AND OPERATION > ELECTRONIC IGNITION SYSTEM DESCRIPTION

The electronic ignition system produces and controls a high-energy secondary spark. This spark is used to ignite the compressed air/fuel mixture at precisely the correct time. This provides optimal performance, fuel economy, and control of exhaust emissions. This ignition system uses an individual coil for each cylinder. The ignition coils are mounted in the center of each camshaft cover with short integrated boots connecting the coils to the spark plugs. The driver modules within each ignition coil are commanded ON/OFF by the Engine Control Module (ECM). The ECM primarily uses engine speed, the mass air flow (MAF) sensor signal, and position information from the crankshaft position and the camshaft position sensors. This controls the sequence, dwell, and timing of the spark. The electronic ignition system consists of the following components:

DESCRIPTION AND OPERATION > ELECTRONIC IGNITION SYSTEM DESCRIPTION > CRANKSHAFT POSITION SENSOR

The crankshaft position sensor works in conjunction with a reluctor wheel on the crankshaft (front mounted crankshaft position sensor) or a reluctor wheel that is part of the flywheel (rear mounted crankshaft position sensor). The ECM monitors the voltage frequency on the crankshaft position sensor signal circuit. As each reluctor wheel tooth rotates past the sensor, the sensor creates a digital ON/OFF pulse. This digital signal is processed by the ECM. This creates a signature pattern that enables the ECM to determine the crankshaft position. The ECM uses the signal to determine which pair of cylinders is approaching top dead center based on the crankshaft position signal alone. The camshaft position sensor signals are used in order to determine which of these 2 cylinders is on a firing stroke, and which is on the exhaust stroke. The ECM uses this to properly synchronize the ignition system, the fuel injectors, and the knock control. This sensor is also used in order to detect misfire.

The ECM also has a dedicated replicated crankshaft position sensor signal output circuit that may be used as an input signal to other modules for monitoring engine RPM.

DESCRIPTION AND OPERATION > ELECTRONIC IGNITION SYSTEM DESCRIPTION > CAMSHAFT POSITION SENSOR

This engine uses a camshaft position sensor for each camshaft. The camshaft position sensor signals are a digital ON/OFF pulse and output 4 times per revolution of the camshaft. The camshaft position sensor does not directly affect the operation of the ignition system. The camshaft position sensor information is used by the ECM to determine the position of the camshaft relative to the crankshaft

position. By monitoring the camshaft position and crankshaft position signals the ECM can accurately time the operation of the fuel injectors. The ECM supplies the camshaft position sensor with a 5 V reference circuit and a low reference circuit. The camshaft position sensor signals are an input to the ECM. These signals are also used to detect camshaft alignment with the crankshaft.

The ECM also has a dedicated replicated camshaft position sensor signal output circuit that may be used as an input signal to other modules for monitoring engine RPM.

DESCRIPTION AND OPERATION > ELECTRONIC IGNITION SYSTEM DESCRIPTION > KNOCK SENSOR

The knock sensor system enables the ECM to control the ignition timing for the best possible performance while protecting the engine from potentially damaging levels of detonation, also known as spark knock. The knock sensor system uses 1 or 2 flat response 2-wire sensors. The sensor uses piezo-electric crystal technology that produces an AC voltage signal of varying amplitude and frequency based on the engine vibration or noise level. The amplitude and frequency depend upon the level of knock that the knock sensor detects. The ECM receives the knock sensor signal through the high and low signal circuits.

The ECM learns a minimum noise level, or background noise, at idle from the knock sensor and uses calibrated values for the rest of the RPM range. The ECM uses the minimum noise level to calculate a noise channel. A normal knock sensor signal will ride within the noise channel. As engine speed and load change, the noise channel upper and lower parameters will change to accommodate the normal knock sensor signal, keeping the signal within the channel. In order to determine which cylinders are knocking, the ECM only uses knock sensor signal information when each cylinder is near top dead center (TDC) of the firing stroke. If knock is present, the signal will range outside of the noise channel.

If the ECM has determined that knock is present, it will retard the ignition timing to attempt to eliminate the knock. The ECM will always try to work back to a zero compensation level, or no spark retard. An abnormal knock sensor signal will stay outside of the noise channel or will not be present. Knock sensor diagnostics are calibrated to detect faults with the knock sensor circuitry inside the ECM, the knock sensor wiring, or the knock sensor voltage output. Some diagnostics are also calibrated to detect constant noise from an outside influence such as a loose/damaged component or excessive engine mechanical noise.

DESCRIPTION AND OPERATION > ELECTRONIC IGNITION SYSTEM DESCRIPTION > IGNITION COILS

Each ignition coil contains a solid state driver module as its primary element. The engine ECM (ECM) signals the coil driver to initiate a firing event by applying ignition control circuit voltage for the appropriate amount of time otherwise known as dwell. When the voltage is removed the coil fires the spark plug.

DESCRIPTION AND OPERATION > ELECTRONIC IGNITION SYSTEM DESCRIPTION > ENGINE CONTROL MODULE (ECM)

The ECM controls all ignition system functions and constantly corrects the spark timing. The ECM

monitors information from various sensor inputs that may include the following components, if applicable:

- Throttle position sensor
- Engine coolant temperature (ECT) sensor
- Mass air flow (MAF) sensors
- Intake air temperature (IAT) sensors
- Vehicle speed sensor (VSS)
- Transmission gear position or range information sensors
- Engine knock sensors
- Ambient pressure sensors (BARO)

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL SYSTEM OVERVIEW

The fuel system is an electronic returnless on-demand design. A returnless fuel system reduces the internal temperature of the fuel tank by not returning hot fuel from the engine to the fuel tank. Reducing the internal temperature of the fuel tank results in lower evaporative emissions.

An electric turbine style fuel pump attaches to the primary fuel tank fuel pump module inside the fuel tank. The fuel pump supplies fuel through the fuel feed pipe to the high pressure fuel pump. The high pressure fuel pump supplies fuel to a variable-pressure fuel rail. Fuel enters the combustion chamber through precision multi-hole fuel injectors. The high pressure fuel pump, fuel rail pressure, fuel injection timing, and injection duration are controlled by the engine control module (ECM).

The primary fuel tank fuel pump module also contains a primary jet pump and a secondary jet pump. Fuel pump flow loss, caused by vapor expulsion in the pump inlet chamber, is diverted to the primary jet pump and the secondary jet pump through a restrictive orifice located on the pump cover. The primary jet pump fills the reservoir of the primary fuel tank fuel pump module. The secondary jet pump creates a venturi action which causes the fuel to be drawn from the secondary side of the fuel tank, through the fuel transfer pipe, to the primary side of the fuel tank.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > ELECTRONIC RETURNLESS FUEL SYSTEM

The electronic returnless fuel system is a microprocessor controlled fuel delivery system which transports fuel from the tank to the fuel rail. It functions as an electronic replacement for a traditional, mechanical fuel pressure regulator. A pressure relief regulator valve within the fuel tank provides an added measure of over pressure protection. Desired fuel pressure is commanded by the engine control module (ECM), and transmitted to the chassis control module via a GMLAN serial data message. A liquid fuel pressure sensor provides the feedback the chassis control module requires for Closed Loop fuel pressure control.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > CHASSIS CONTROL MODULE

The chassis control module is a serviceable GMLAN module. The chassis control module receives the desired fuel pressure message from the engine control module (ECM) and controls the fuel pump located within the fuel tank to achieve the desired fuel pressure. The chassis control module sends a 25 kHz PWM signal to the fuel pump, and pump speed is changed by varying the duty cycle of this signal. Maximum current supplied to the fuel pump is 15 A. A liquid fuel pressure sensor provides fuel pressure feedback to the chassis control module.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL PRESSURE SENSOR

The fuel pressure sensor is a serviceable 5 V, 3-pin device. It is located on the fuel feed line forward of the fuel tank, and receives power and ground from the chassis control module through a vehicle wiring harness. The sensor provides a fuel pressure signal to the chassis control module, which is used to provide Closed Loop fuel pressure control.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL TANK

The fuel tank stores the fuel supply. The fuel tank is located in the rear of the vehicle. The fuel tank is held in place by 2 metal straps that attach to the frame. The fuel tank is molded from high-density polyethylene.

The fuel tank is a saddle configuration in order to provide space for a driveshaft through the center area of the fuel tank. Because of the saddle shape of the tank, two fuel pump modules are required.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL FILL PIPE

The fuel fill pipe has a built-in restrictor in order to prevent refueling with leaded fuel.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL TANK FUEL PUMP MODULE

An electric turbine style fuel pump attaches to the primary fuel tank fuel pump module inside the fuel tank. The fuel pump supplies fuel through the fuel feed pipe to the high pressure fuel pump. The fuel tank fuel pump module contains a reverse flow check valve. The check valve maintains fuel pressure in the fuel feed pipe in order to prevent long cranking times.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > PRIMARY FUEL TANK FUEL PUMP MODULE

cardiagn.com

The primary fuel tank fuel pump module is located inside of the right side of the fuel tank. The primary fuel tank fuel pump module consists of the following major components:

- The fuel level sensor
- The fuel pump and reservoir assembly
- The fuel filter
- The pressure relief regulator valve
- The fuel strainer
- The primary jet pump
- The secondary jet pump

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > SECONDARY FUEL TANK FUEL PUMP MODULE

The secondary fuel tank fuel pump module is located inside of the left side of the fuel tank. The secondary fuel tank fuel pump module consists of the following major components:

- The fuel level sensor
- The fuel pick-up

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL LEVEL SENSOR

The fuel level sensor consists of a float, a wire float arm, and a ceramic resistor card. The position of the float arm indicates the fuel level. The fuel level sensor contains a variable resistor which changes resistance in correspondence with the position of the float arm. The engine control module (ECM) sends the fuel level information via the serial data circuit to the instrument panel cluster (IPC) in order to control the fuel gauge. The control module monitors the signal circuits of the primary fuel level sensor and the secondary fuel level sensor in order to determine the fuel level.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL PUMP

The fuel pump is mounted in the fuel tank fuel pump module reservoir. The fuel pump is an electric pump. Fuel is pumped to the high pressure fuel pump at a pressure that is based on feedback from the fuel pressure sensor. The fuel pump delivers a constant flow of fuel even during low fuel conditions and aggressive vehicle maneuvers. The fuel pump flex pipe acts to dampen the fuel pulses and noise generated by the fuel pump.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL FILTER

cardiagn.com

The fuel filter is located in the primary fuel tank fuel pump module. The paper filter element traps particles in the fuel that may damage the fuel injection system.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > PRESSURE RELIEF REGULATOR VALVE

The pressure relief regulator valve replaces the typical fuel pressure regulator used on a mechanical returnless fuel system. The pressure relief regulator valve is closed during normal vehicle operation. The pressure relief regulator valve is used to vent pressure during hot soaks and also functions as a fuel pressure regulator in the event of the chassis control module defaulting to 100% pulse width modulation (PWM) of the fuel pump. Due to variation in the fuel system pressures, the opening pressure for the pressure relief regulator valve is set higher than the pressure that is used on a mechanical returnless fuel system pressure regulator.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL STRAINER

The fuel strainer attaches to the lower end of the primary fuel tank fuel pump module. The fuel strainer is made of woven plastic. The functions of the fuel strainer are to filter contaminants and to wick fuel. The fuel strainer normally requires no maintenance. Fuel stoppage at this point indicates that the fuel tank contains an abnormal amount of sediment or contamination.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > PRIMARY AND SECONDARY JET PUMPS

The primary jet pump is located in the primary fuel tank fuel pump module. Fuel pump flow loss, caused by vapor expulsion in the pump inlet chamber, is diverted to the primary jet pump and the secondary jet pump through a restrictive orifice located on the pump cover. The primary jet pump fills the reservoir of the primary fuel tank module.

The secondary jet pump creates a venturi action which causes the fuel to be drawn from the secondary side of the fuel tank, through the transfer pipe, to the primary side of the fuel tank.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > NYLON FUEL PIPES

WARNING:

In order to reduce the risk of fire and personal injury observe the following items:

- *Replace all nylon fuel pipes that are nicked, scratched or damaged during installation, do not attempt to repair the sections of the nylon fuel pipes*
- *Do not hammer directly on the fuel harness body clips when installing new fuel pipes. Damage to the nylon pipes may result in a fuel leak.*

cardiagn.com

- *Always cover nylon vapor pipes with a wet towel before using a torch near them. Also, never expose the vehicle to temperatures higher than 115°C (239°F) for more than one hour, or more than 90°C (194°F) for any extended period.*
- *Apply a few drops of clean engine oil to the male pipe ends before connecting fuel pipe fittings. This will ensure proper reconnection and prevent a possible fuel leak. (During normal operation, the O-rings located in the female connector will swell and may prevent proper reconnection if not lubricated.)*

Nylon pipes are constructed to withstand maximum fuel system pressure, exposure to fuel additives, and changes in temperature.

Heat resistant rubber hose or corrugated plastic conduit protect the sections of the pipes that are exposed to chafing, high temperature, or vibration.

Nylon fuel pipes are somewhat flexible and can be formed around gradual turns under the vehicle. However, if nylon fuel pipes are forced into sharp bends, the pipes kink and restrict the fuel flow. Also, once exposed to fuel, nylon pipes may become stiffer and are more likely to kink if bent too far. Take special care when working on a vehicle with nylon fuel pipes.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > QUICK-CONNECT FITTINGS

Quick-connect fittings provide a simplified means of installing and connecting fuel system components. The fittings consist of a unique female connector and a compatible male pipe end. O-rings, located inside the female connector, provide the fuel seal. Integral locking tabs inside the female connector hold the fittings together.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > HIGH PRESSURE FUEL PUMP

The high fuel pressure necessary for direct injection is supplied by the high pressure fuel pump. The pump is mounted on the rear of the engine and is driven by a three-lobe cam on the camshaft. This pump also regulates the fuel pressure using an actuator in the form of an internal solenoid-controlled valve. In order to keep the engine running efficiently under all operating conditions, the engine control module (ECM) requests pressure ranging from 2 to 15 MPa (290 to 2176 psi), depending on engine speed and load. Output drivers in the ECM provide the pump control circuit with a 12 V pulse-width modulated (PWM) signal, which regulates fuel pressure by closing and opening the control valve at specific times during pump strokes. This effectively regulates the portion of each pump stroke that is delivered to the fuel rail. When the control solenoid is NOT powered, the pump operates at maximum flow rate. In the event of pump control failure, the high pressure system is protected by a relief valve in the pump.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL RAIL ASSEMBLY

cardiagn.com

The fuel rail assembly attaches to the cylinder head and distributes the high pressure fuel to the fuel injectors. The fuel rail assembly consists of the following components:

- The direct fuel injectors
- The fuel rail pressure sensor

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL INJECTORS

The fuel injection system is a high pressure, direct injection, returnless on-demand design. The fuel injectors are mounted in the cylinder head beneath the intake ports and spray fuel directly into the combustion chamber. Direct injection requires high fuel pressure due to the fuel injector's location in the combustion chamber. Fuel pressure must be higher than compression pressure requiring a high pressure fuel pump. The fuel injectors also require more electrical power due to the high fuel pressure. The ECM supplies a separate high voltage supply circuit and a high voltage control circuit for each fuel injector. The injector high voltage supply circuit and the high voltage control circuit are both controlled by the ECM. The ECM energizes each fuel injector by grounding the control circuit. The ECM controls each fuel injector with 65 V. This is controlled by a boost capacitor in the ECM. During the 65 V boost phase, the capacitor is discharged through an injector, allowing for initial injector opening. The injector is then held open with 12 V.

The fuel injector assembly is an inside opening electrical magnetic injector. The injector has six precision machined holes that generate a cone shaped oval spray pattern. The fuel injector has a slim extended tip in order to allow a sufficient cooling jacket in the cylinder head.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL INJECTION FUEL RAIL FUEL PRESSURE SENSOR

The fuel rail pressure sensor detects fuel pressure within the fuel rail. The engine control module (ECM) provides a 5 V reference voltage on the 5 V reference circuit and ground on the low reference circuit. The ECM receives a varying signal voltage on the signal circuit. The ECM monitors the voltage on the fuel rail pressure sensor circuits. When the fuel pressure is high, the signal voltage is high. When the fuel pressure is low, the signal voltage is low.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL METERING MODES OF OPERATION

The ECM monitors voltages from several sensors in order to determine how much fuel to give the engine. The ECM controls the amount of fuel delivered to the engine by changing the fuel injector pulse width. The fuel is delivered under one of several modes.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > STARTING MODE

The ECM supplies voltage to the chassis control module when the ECM detects that the ignition is ON. The voltage from the ECM to the chassis control module remains active for 2 s, unless the engine is in

Crank or Run. While this voltage is being received, the chassis control module closes the ground switch of the fuel tank fuel pump module and also supplies a varying voltage to the fuel tank fuel pump module in order to maintain the desired fuel line pressure. The ECM calculates the air/fuel ratio based on inputs from the engine coolant temperature (ECT), manifold absolute pressure (MAP), mass air flow (MAF), and throttle position sensors. The system stays in starting mode until the engine speed reaches a predetermined RPM.

During a cold start, the engine control module (ECM) commands dual-pulse mode during Open Loop operation to improve cold start emissions. In dual-pulse mode, the injectors are energized twice during each injection event.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > CLEAR FLOOD MODE

If the engine floods, the engine can be cleared by pressing the accelerator pedal down to the floor and then cranking the engine. When the throttle position sensor is at wide open throttle (WOT), the ECM reduces the fuel injector pulse width in order to increase the air to fuel ratio. The ECM holds this injector rate as long as the throttle stays wide open and the engine speed is below a predetermined RPM. If the throttle is not held wide open, the ECM returns to the starting mode.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > RUN MODE

The run mode has 2 conditions called Open Loop and Closed Loop. When the engine is first started and the engine speed is above a predetermined RPM, the system begins Open Loop operation. The ECM ignores the signal from the heated oxygen sensor (HO2S). The ECM calculates the air/fuel ratio based on inputs from the engine coolant temperature (ECT), manifold absolute pressure (MAP), mass air flow (MAF), and throttle position sensors. The system stays in Open Loop until meeting the following conditions:

- The HO2S has varying voltage output, showing that the HO2S is hot enough to operate properly.
- The ECT sensor is above a specified temperature.
- A specific amount of time has elapsed after starting the engine.

Specific values for the above conditions exist for each different engine, and are stored in the electrically erasable programmable read-only memory (EEPROM). The system begins Closed Loop operation after reaching these values. In Closed Loop, the ECM calculates the air/fuel ratio, injector ON time, based upon the signal from various sensors, but mainly from the HO2S. This allows the air/fuel ratio to stay very close to 14.7:1.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > ACCELERATION MODE

When the driver pushes on the accelerator pedal, air flow into the cylinders increases rapidly. To prevent possible hesitation, the ECM increases the pulse width to the injectors to provide extra fuel during acceleration. This is also known as power enrichment. The ECM determines the amount of fuel required based upon throttle position, engine coolant temperature (ECT), manifold absolute pressure (MAP), mass

air flow (MAF), and engine speed.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > DECELERATION MODE

When the driver releases the accelerator pedal, air flow into the engine is reduced. The ECM monitors the corresponding changes in throttle position, mass air flow (MAF), and manifold absolute pressure (MAP). The ECM shuts OFF fuel completely if the deceleration is very rapid, or for long periods, such as long, closed-throttle coast-down. The fuel shuts OFF in order to prevent damage to the catalytic converters.

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > BATTERY VOLTAGE CORRECTION MODE

When the battery voltage is low, the ECM compensates for the weak spark delivered by the ignition system in the following ways:

- Increasing the amount of fuel delivered
- Increasing the idle RPM
- Increasing the ignition dwell time

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL CUTOFF MODE

The ECM cuts OFF fuel from the fuel injectors when the following conditions are met in order to protect the powertrain from damage and improve driveability:

- The ignition is OFF. This prevents engine run-on.
- The ignition is ON but there is no ignition reference signal. This prevents flooding or backfiring.
- The engine speed is too high, above red line.
- The vehicle speed is too high, above rated tire speed.
- During an extended, high speed, closed throttle coast down-This reduces emissions and increases engine braking.
- During extended deceleration, in order to prevent damage to the catalytic converters

DESCRIPTION AND OPERATION > FUEL SYSTEM DESCRIPTION > FUEL TRIM

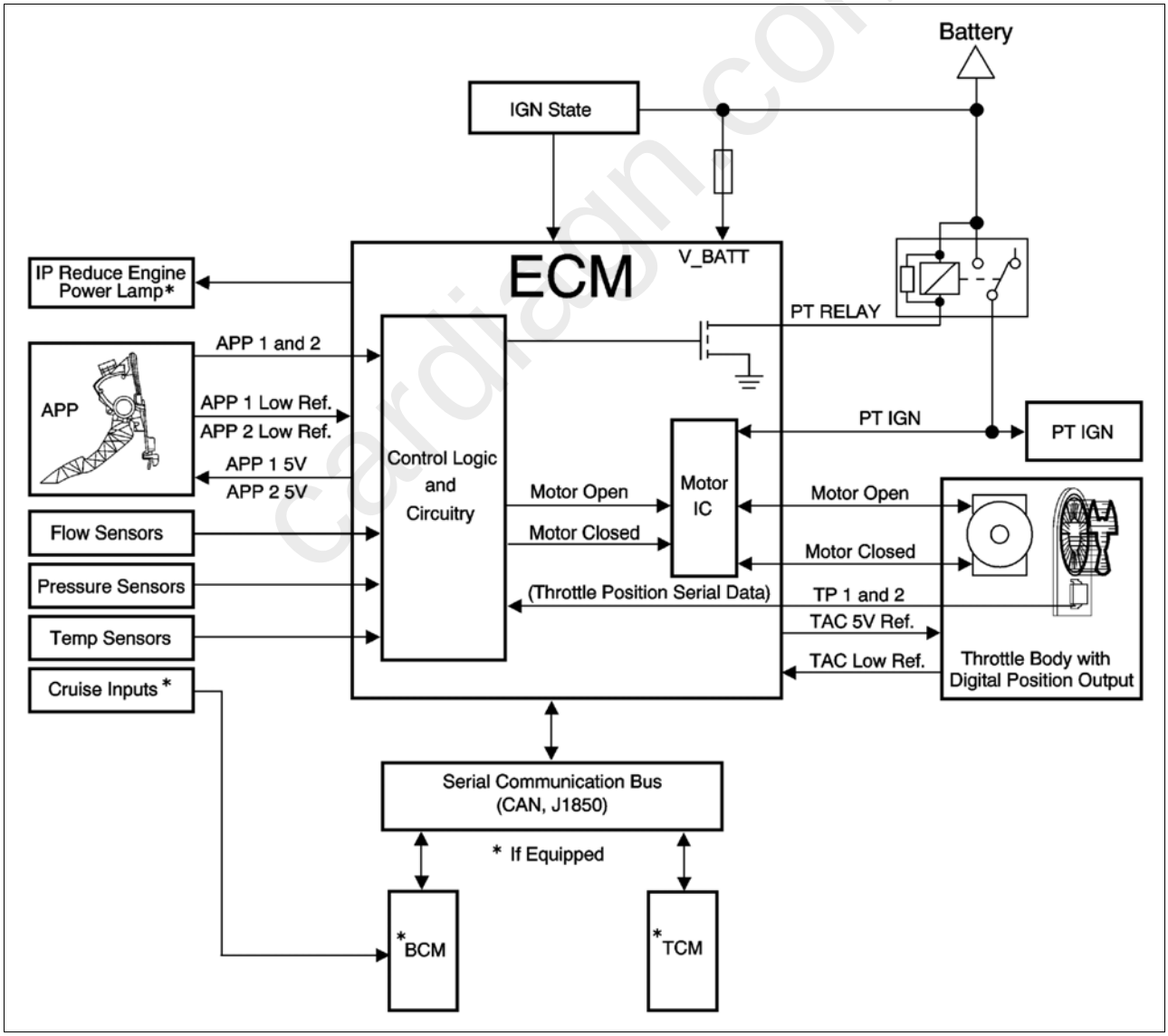
The ECM controls the air/fuel metering system in order to provide the best possible combination of driveability, fuel economy, and emission control. The ECM monitors the heated oxygen sensor (HO2S)

cardiagn.com

signal voltage while in Closed Loop and regulates the fuel delivery by adjusting the pulse width of the injectors based on this signal. The ideal fuel trim values are around 0 percent for both short and long term fuel trim. A positive fuel trim value indicates the ECM is adding fuel in order to compensate for a lean condition by increasing the pulse width. A negative fuel trim value indicates that the ECM is reducing the amount of fuel in order to compensate for a rich condition by decreasing the pulse width. A change made to the fuel delivery changes the long and short term fuel trim values. The short term fuel trim values change rapidly in response to the HO2S signal voltage. These changes fine tune the engine fueling. The long term fuel trim makes coarse adjustments to fueling in order to re-center and restore control to short term fuel trim. A scan tool can be used to monitor the short and long term fuel trim values. The long term fuel trim diagnostic is based on an average of several of the long term speed load learn cells. The ECM selects the cells based on the engine speed and engine load. If the ECM detects an excessively lean or rich condition, the ECM will set a fuel trim diagnostic trouble code (DTC).

DESCRIPTION AND OPERATION > THROTTLE ACTUATOR CONTROL (TAC) SYSTEM DESCRIPTION

Fig 1: Throttle Actuator Control (TAC) System Description



Courtesy of GENERAL MOTORS COMPANY

The engine control module (ECM) is the control center for the throttle actuator control (TAC) system. The ECM determines the driver's intent based on input from the accelerator pedal position sensors, then calculates the appropriate throttle response based on the throttle position sensors. The ECM achieves throttle positioning by providing a pulse width modulated voltage to the throttle actuator motor. The throttle blade is spring loaded in both directions, and the default position is slightly open.

DESCRIPTION AND OPERATION > THROTTLE ACTUATOR CONTROL (TAC) SYSTEM DESCRIPTION > MODES OF OPERATION

Normal Mode

During the operation of the TAC system, several modes, or functions, are considered normal. The following modes may be entered during normal operations:

- Minimum pedal value-At key-up, the ECM updates the learned minimum pedal value.
- Minimum throttle position values-At key-up, the ECM updates the learned minimum throttle position value. In order to learn the minimum throttle position value, the throttle blade is moved to the Closed position.
- Ice break mode-If the throttle blade is not able to reach a predetermined minimum throttle position, the ice break mode is entered. During the ice break mode, the ECM commands the maximum pulse width several times to the throttle actuator motor in the closing direction.
- Battery saver mode-After a predetermined time without engine speed, the ECM commands the battery saver mode. During the battery saver mode, the TAC module removes the voltage from the motor control circuits, which removes the current draw used to maintain the idle position and allows the throttle to return to the spring loaded default position.

Reduced Engine Power Mode

When the ECM detects a condition with the TAC system, the ECM may enter a reduced engine power mode. Reduced engine power may cause one or more of the following conditions:

- Acceleration limiting-The ECM will continue to use the accelerator pedal for throttle control, however, the vehicle acceleration is limited.
- Limited throttle mode-The ECM will continue to use the accelerator pedal for throttle control, however, the maximum throttle opening is limited.
- Throttle default mode-The ECM will turn OFF the throttle actuator motor, and the throttle will return to the spring loaded default position.
- Forced idle mode-The ECM will perform the following actions:
    - Limit engine speed to the idle position
    - Ignore the accelerator pedal input.
- Engine shutdown mode-The ECM will disable fuel and de-energize the throttle actuator.

Throttle/Idle Learn

The engine control module (ECM) learns the airflow through the throttle body to ensure the correct idle.

cardiagn.com

The learned airflow values are stored within the ECM. These values are learned to adjust for production variation and will continuously learn during the life of the vehicle to compensate for reduced airflow due to throttle body coking. Anytime the throttle body airflow rate changes, for example due to cleaning or replacing, the values must be relearned.

An engine that had a heavily coked throttle body that has been cleaned or replaced may take several drive cycles to unlearn the coking. To accelerate the process, the scan tool has the ability to reset all learned values back to zero. A new ECM will also have values set to zero.

The idle may be unstable or a DTC may set if the learned values do not match the actual airflow.

A un-metered air leak in the induction system or a small vacuum leak may not set a DTC. If the condition goes undetected, the ECM may learn an incorrect Throttle Body Idle Airflow Compensation value over time. The incorrectly learned value may cause various symptoms to occur such as rough or unstable idle speeds, and/or engine stall. If this condition is detected and repaired it will be necessary perform the Idle Learn procedure to ensure any symptoms are corrected.

DESCRIPTION AND OPERATION > TURBOCHARGER SYSTEM DESCRIPTION > TURBOCHARGER DESCRIPTION AND OPERATION

A turbocharger is a compressor that is used to increase the power output of an engine by increasing the mass of the oxygen and therefore the fuel entering the engine. The dual-scroll turbocharger is mounted either to the exhaust manifold or directly to the head. The turbine is driven by the energy generated by the flow of the exhaust gases. The turbine is connected by a shaft to the compressor which is mounted in the induction system of the engine. The centrifugal compressor blades compress the intake air above atmospheric pressure, thereby increasing the density of the air entering the engine.

The turbocharger incorporates a wastegate that is controlled by the ECM, by means of a pulse width modulated (PWM) solenoid, to control boost pressure. A turbocharger bypass valve (compressor recirculation valve), controlled by the ECM, is used to prevent compressor surging and damage by opening during abrupt closed throttle conditions. The bypass valve opens during closed throttle deceleration conditions, which allows the air to recirculate to the turbocharger compressor inlet. During a wide open throttle command, the bypass valve closes to optimize turbo response.

The turbocharger is connected to the engine oiling system by a supply and drain pipe. The oil is required for the bearing system function and also serves to carry some heat from the turbocharger. There is a cooling system circuit in the turbocharger that further reduces operating temperatures and passively dissipates bearing housing heat away from the turbocharger on shut down.

DESCRIPTION AND OPERATION > TURBOCHARGER SYSTEM DESCRIPTION > WASTEGATE SOLENOID VALVE

The wastegate valve opens and closes a bypass passage beside the turbine wheel. A spiral spring works in the closing direction while the pressure in the diaphragm works in the opening direction. The ECM supplies a PWM signal to the solenoid valve, which then allows pressure from the turbo to come through. When the pressure overcomes the spring force the actuator rod begins to move, opening the wastegate valve to a corresponding degree. The ECM changes wastegate valve opening by varying the PWM signal, which regulates the turbine speed.

At low loads, the wastegate valve is closed. All the exhaust gas then passes through the turbine. At high

loads, the volume of exhaust gas is greater, which makes the turbine wheel rotate faster. This delivers a greater air displacement to the engine.

When the air displacement becomes so large that the current air mass per combustion cannot be controlled with the throttle alone, the turbo must be regulated. This is done by opening the wastegate valve so that some of the exhaust gas passes through the wastegate. Consequently, this gas does not contribute to driving the turbine and the turbine speed will be regulated so that the turbo air displacement will be correct.

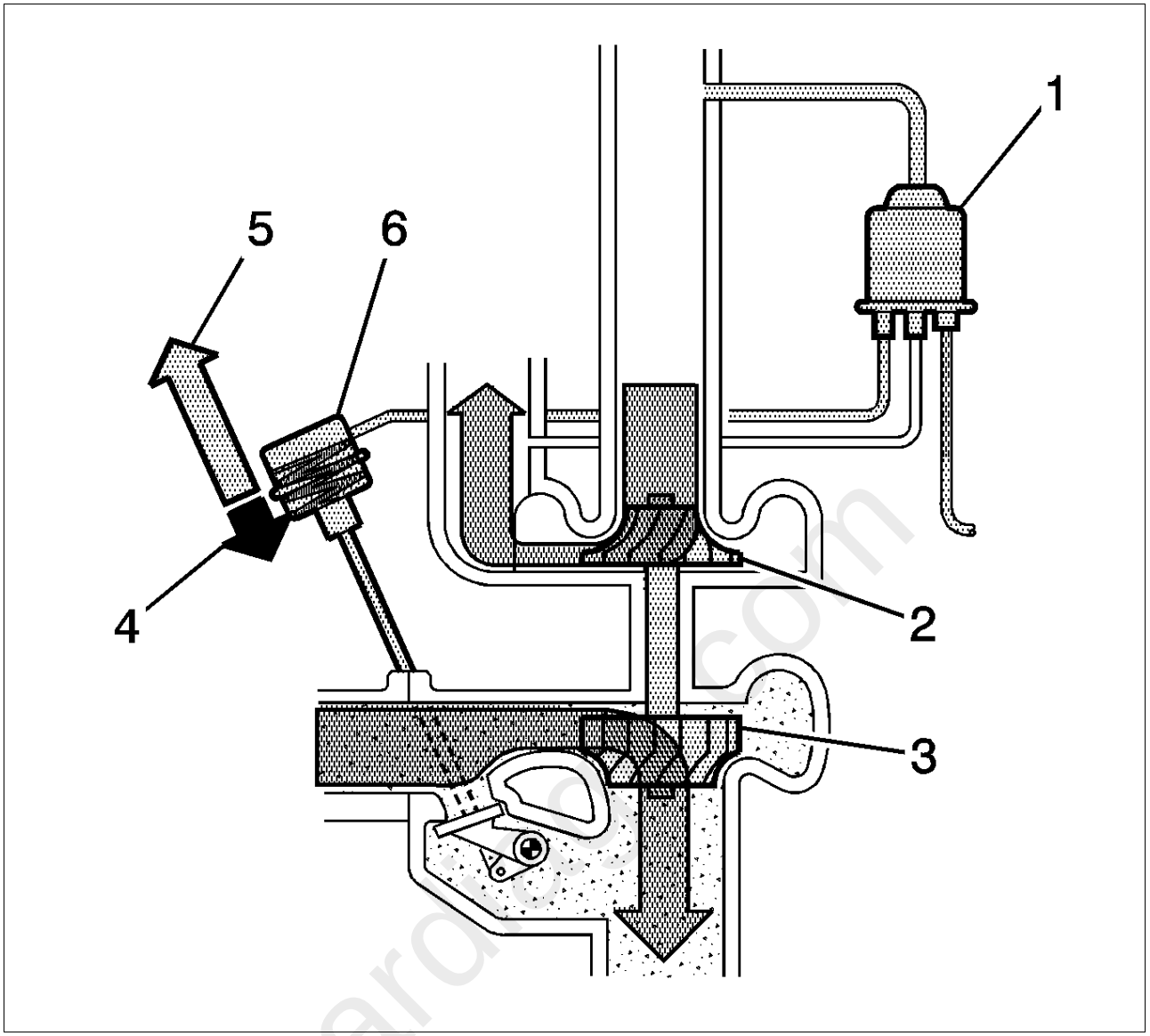
When certain DTCs are set the ECM will limit the amount of available boost pressure. Limiting boost pressure is accomplished by the ECM controlling the wastegate actuator solenoid valve and maintaining the duty cycle at 0 %. This means that the ECM will not actively close the wastegate during greater engine loads. The system at this point is limited to mechanical boost. Mechanical boost means that the wastegate will still move, but the amount of motion is limited by the mechanical properties of the return spring within the diaphragm valve, the pneumatic properties of the actuator, and the physics of the exhaust gas flow in the exhaust system.

The following diagrams illustrate the turbocharger wastegate closed and open conditions:

cardiagn.com

DESCRIPTION AND OPERATION > TURBOCHARGER SYSTEM DESCRIPTION > WASTEGATE SOLENOID VALVE > TURBOCHARGER WASTEGATE CLOSED

Fig 1: TC Wastegate Closed



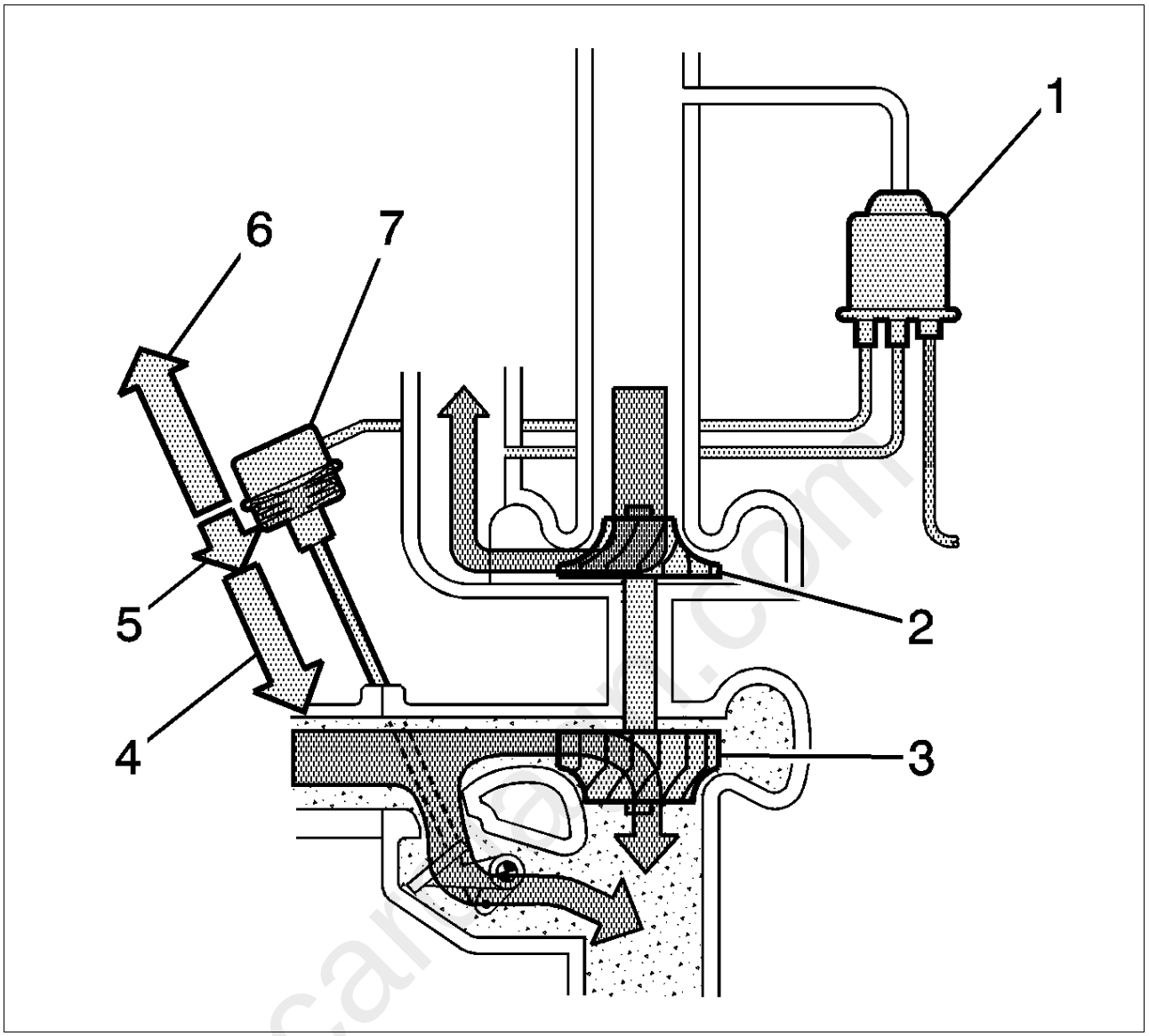
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Turbocharger Wastegate Actuator Solenoid Valve with Duty Cycle at 100 percent
2	Compressor
3	Turbine
4	Exhaust Gas Pressure
5	Spring Force
6	Turbocharger Wastegate Diaphragm Valve

DESCRIPTION AND OPERATION > TURBOCHARGER SYSTEM DESCRIPTION >

WASTEGATE SOLENOID VALVE > TURBOCHARGER WASTEGATE OPEN

Fig 1: TC Wastegate Open



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Turbocharger Wastegate Actuator Solenoid Valve with Duty Cycle at 0 percent
2	Compressor
3	Turbine
4	Regulating Pressure
5	Exhaust Gas Pressure
6	Spring Force
7	Turbocharger Wastegate Diaphragm Valve

The wastegate is completely closed at idle. All of the exhaust energy is passing through the turbine.

During normal operation, when wide open throttle is requested at lower engine speeds, the ECM commands the wastegate solenoid with a duty cycle of 100 % to minimize any turbo lag. During engine loads in the middle and upper RPM ranges, the ECM commands the solenoid with a duty cycle of 65-80 %.

DESCRIPTION AND OPERATION > TURBOCHARGER SYSTEM DESCRIPTION > BYPASS SOLENOID VALVE (COMPRESSOR RECIRCULATION VALVE)

The turbocharger bypass valve prevents the turbo from exceeding the surge limit of the compressor at low flow and high pressure. This occurs when the engine is running with a load and the throttle suddenly closes. In this case, flow is almost null and pressure is very high. This not only is damaging to the turbocharger, but also generates noise and decelerates turbine speed. The ECM supplies a voltage signal to the solenoid valve output driver, which regulates the open or closed valve position.

Accelerator Pedal Depressed

The bypass valve is closed. The force in the return spring integrated in the valve presses the valve cone against its seat in the turbo housing. The valve is turned OFF.

Accelerator Pedal Released

In order to avoid pressure spikes in the intake manifold and unloading or overrunning the turbo, the ECM sends a voltage signal to the bypass valve, which will then open. The compressed air on the pressure side of the turbo is led to the intake via the open valve. When the pressure drops, the turbine speed can be kept relatively high and the turbocharger is prevented from exceeding the surge limit of the compressor.

DESCRIPTION AND OPERATION > TURBOCHARGER SYSTEM DESCRIPTION > CHARGE AIR COOLER

The turbocharger intake system is supported by an air-to-air charge air cooler system, which uses fresh air drawn through a heat exchanger to reduce the temperature of the hot compressed air exiting the turbo compressor, prior to delivery to the engine combustion system. Inlet air temperature can be reduced by up to 100°C (180°F), which enhances performance. This is due to the higher density of oxygen in the cooled air, which promotes optimal combustion. The charge air cooler is connected to the turbocharger and to the throttle body by flexible ductwork that requires the use of special high torque fastening clamps. In order to prevent any type of air leak when servicing the ductwork, the tightening specifications, cleanliness and proper positioning of the clamps is critical, and must be strictly adhered to.

cardiagn.com

Service Manual: ENGINE CONTROLS AND FUEL - 2.0L (LTG)
- REPAIR INSTRUCTIONS

REPAIR INSTRUCTIONS > WIRE TO WIRE REPAIR - ENGINE CONTROLS AND FUEL

Special Tools

- **EL-38125-10** Splice Sleeve Crimping Tool (non GMNA)
- **J-38125-5A** Ultra Torch Special Tool
- **J-38125-8** Splice Sleeve Crimping Tool (GMNA)

For equivalent regional tools, refer to Special Tools .

WARNING:

In order to reduce the risk of personal injury, loss of high voltage isolation to ground and higher system impedance, do not attempt to repair any HV wiring, connector, or terminal that is damaged. High voltage coaxial type cables are not repairable. Never attempt to repair a coaxial type cable. The entire cable/harness or component must be replaced. In order to maintain system integrity and personal safety, never attempt to repair any high voltage wiring, cables, or terminals. Performing this procedure on high voltage circuits may result in serious injury or death.

NOTE:

If the wiring harness internal to the transmission is damaged, the wiring harness must be replaced. The use of splice sleeves in an attempt to repair the internal transmission wires, connectors, or terminals could result in performance issues.

NOTE:

Do not splice wires in Door Harness Grommets.

NOTE:

The DuraSeal splice sleeves have the following 2 critical features:

- *A special heat shrink sleeve environmentally seals the splice. The heat shrink sleeve contains a sealing adhesive inside.*
- *A cross hatched (knurled) core crimp provides the necessary low resistance contact integrity for these sensitive, low energy circuits.*

cardiagn.com

Use only DuraSeal splice sleeves to form a one-to-one splice on all types of insulation except high voltage and specialty cables. Use DuraSeal splice sleeves where there are special requirements such as moisture sealing. Follow the instructions below in order to splice copper wire using DuraSeal splice sleeves.

Splice Sleeve Selection

Splice Sleeve Color	Crimp Tool Nest Color		Wire Gauge mm^2 / (AWG)
	3 Crimp Nests	4 Crimp Nests	
Salmon (Yellow-Pink) 19300089	Red (1) or Red/Green (1)	Red (2)	0.22-0.8/(18-26)
Blue 19168447	Blue (2)	Blue (3)	1.0-2.0/(14-16)
Yellow 19168448	Yellow (3)	Yellow (4)	3.0-5.0/(10-12)

NOTE:

You must perform the following procedures in the listed order. Repeat the procedure if any wire strands are damaged. You must obtain a clean strip with all of the wire strands intact.

1. Open the harness by removing any tape:
    1. Use a sewing seam ripper, available from sewing supply stores, in order to cut open the harness in order to avoid wire insulation damage.
    2. Use the DuraSeal splice sleeves on all types of insulation except Tefzel and coaxial.
    3. Do not use the crimp and DuraSeal splice sleeve to form a splice with more than 2 wires coming together.
2. Cut as little wire off the harness as possible. You may need the extra length of wire in order to change the location of a splice.

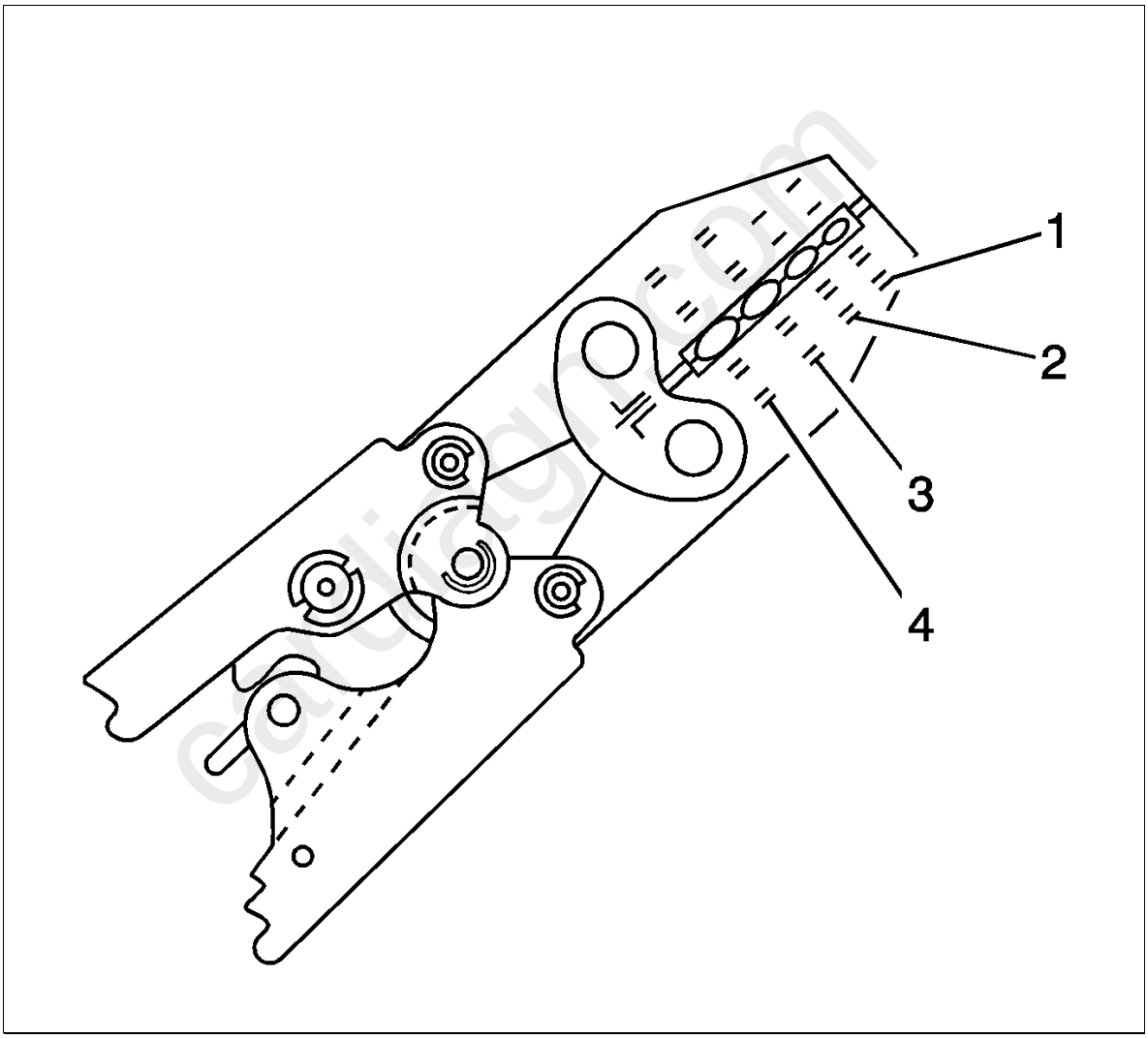
   Adjust splice locations so that each splice is at least 40 mm (1.5 in) away from the other splices, harness branches, or connectors.
3. Strip the insulation:
    1. When adding a length of wire to the existing harness, use the same size wire as the original wire.
    2. Perform one of the following items in order to find the correct wire size:
        1. Find the wire on the schematic and convert to regional wiring gauge size.
        2. If you are unsure of the wire size, begin with the largest opening in the wire stripper and work down until achieving a clean strip of the insulation.

cardiagn.com

3. Strip approximately 5.0 mm (0.20 in) of insulation from each wire to be spliced.
4. Do not nick or cut any of the strands. Inspect the stripped wire for nicks or cut strands.
5. If the wire is damaged, repeat this procedure after removing the damaged section.

4. For high temperature wiring, slide a section of high temperature SCT1 shrink tubing down the length of wire to be spliced. Ensure that the shrink tubing will not interfere with the splice procedure.
5. Select the proper DuraSeal splice sleeve according to the wire size. Refer to the above table at the beginning of the repair procedure for the color coding of the DuraSeal splice sleeves and the crimp tool nests.

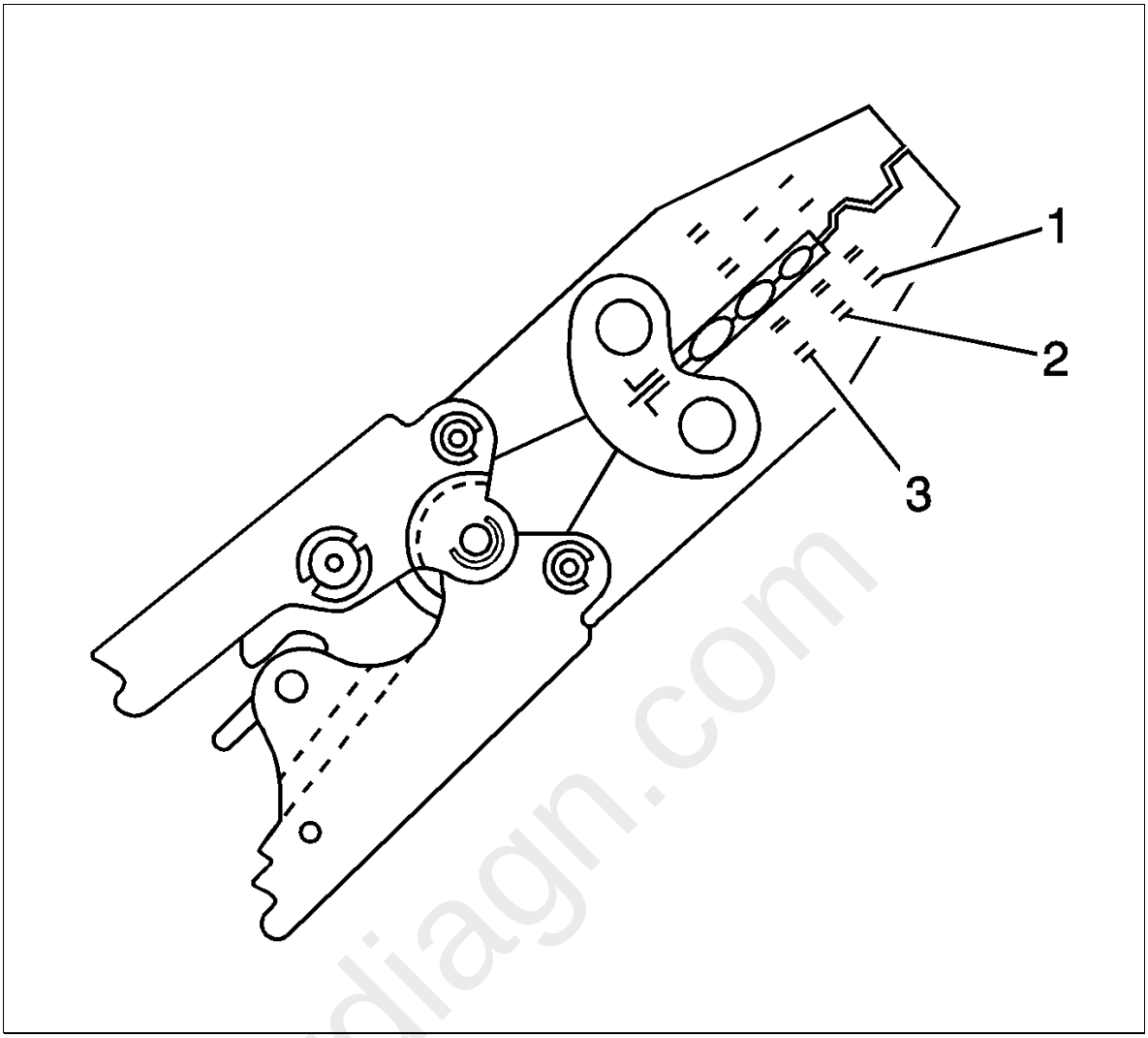
Fig 1: Crimping Tool



Courtesy of GENERAL MOTORS COMPANY

6. The **EL-38125-10** splice sleeve crimping tool has four crimp nests. The largest crimp nest (4) is used for crimping 10 and 12 gauge wires. The second largest crimp nest (3) is used for crimping 14 and 16 gauge wires. The third largest crimp nest (2) is used for crimping 18 and 20 gauge wires. The smallest crimp nest (1) is used for crimping 22 to 26 gauge wires. The crimp nests are referenced in the table (farther above) under the crimp tool nest color.

Fig 2: Splice Crimp Tool Nests Terminal Identification



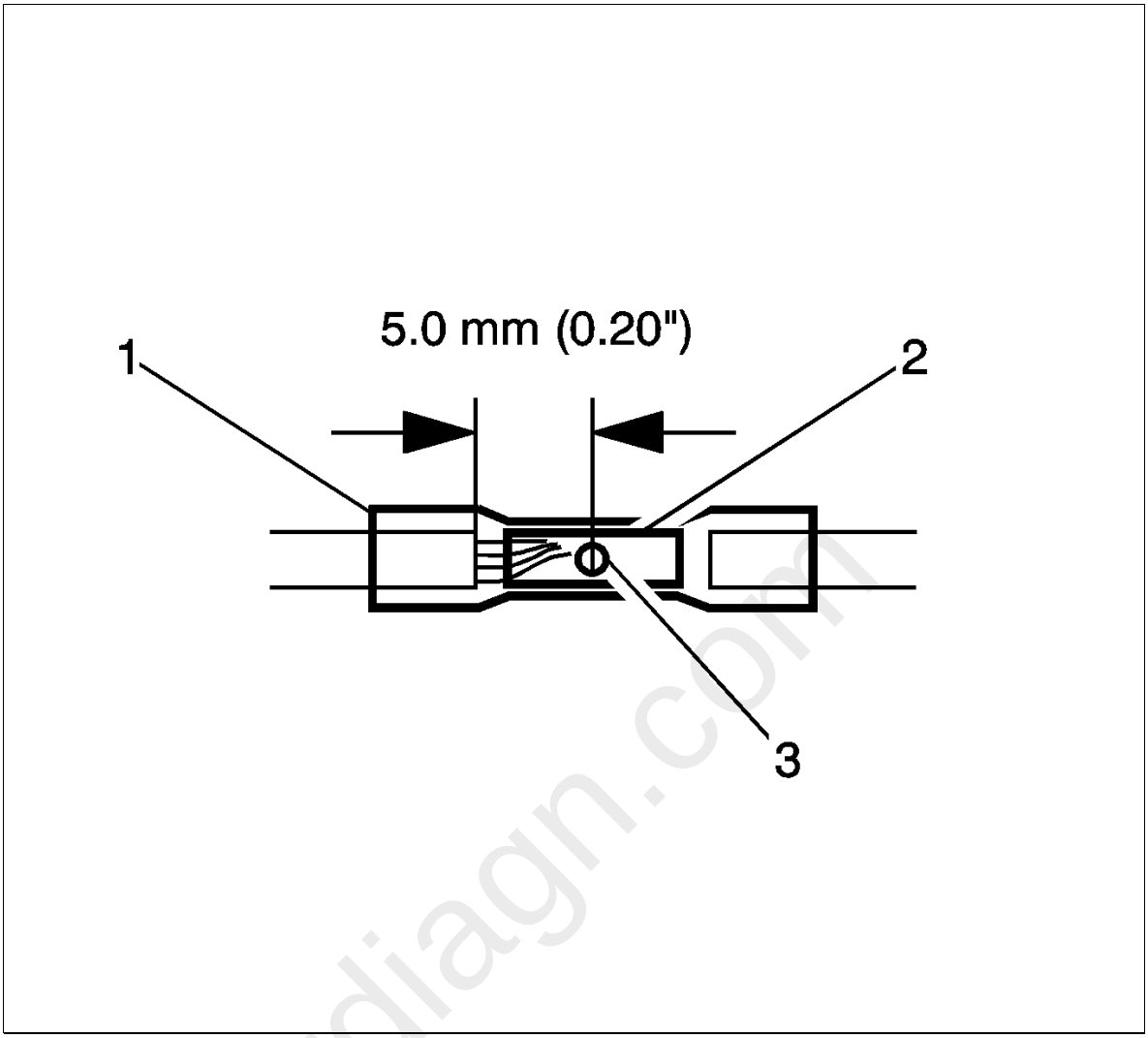
Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

7. The **J-38125-8** splice sleeve crimping tool has three crimp nests. The largest crimp nest (3) is used for crimping 10 and 12 gauge wires. The second largest crimp nest (2) is used for crimping 14 and 16 gauge wires. The smallest crimp nest (1) is used for crimping 18 to 20 gauge wires. The crimp nests are referenced in the table (farther above) under the crimp tool nest color.

8. Use the splice sleeve crimp tool in order to position the DuraSeal splice sleeve in the proper color nest of the splice sleeve crimp tool. For the four crimp nest tool, use the three largest crimp nests to crimp the splice sleeves. For the three crimp nest tool, use all three crimp nests to crimp the splice sleeves. Use the four and three crimp tool diagrams (above) and the table (farther above) to match the splice sleeve with the correct crimp nest. The crimp tool diagram callout numbers match the numbers in the table (under crimp tool nest color).

Fig 3: Duraseal Splice Sleeve

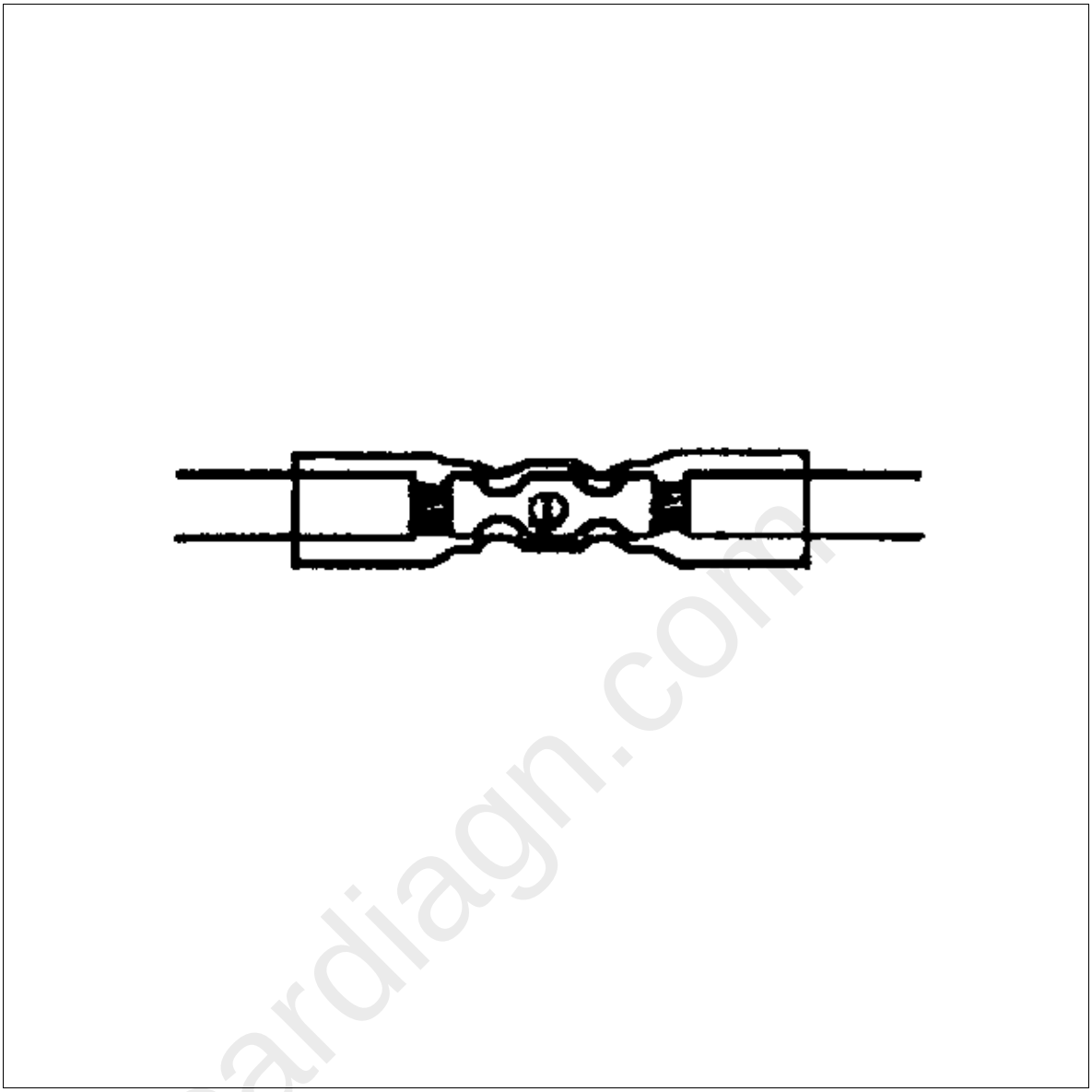


Courtesy of GENERAL MOTORS COMPANY

9. Place the DuraSeal splice sleeve in the nest. Ensure that the crimp falls midway between the end of the barrel and the stop. The sleeve has a stop (3) in the middle of the barrel (2) in order to prevent the wire (1) from going further. Close the hand crimper handles slightly in order to firmly hold the DuraSeal splice sleeve in the proper nest.

cardiagn.com

Fig 4: Crimped Duraseal Splice Sleeve



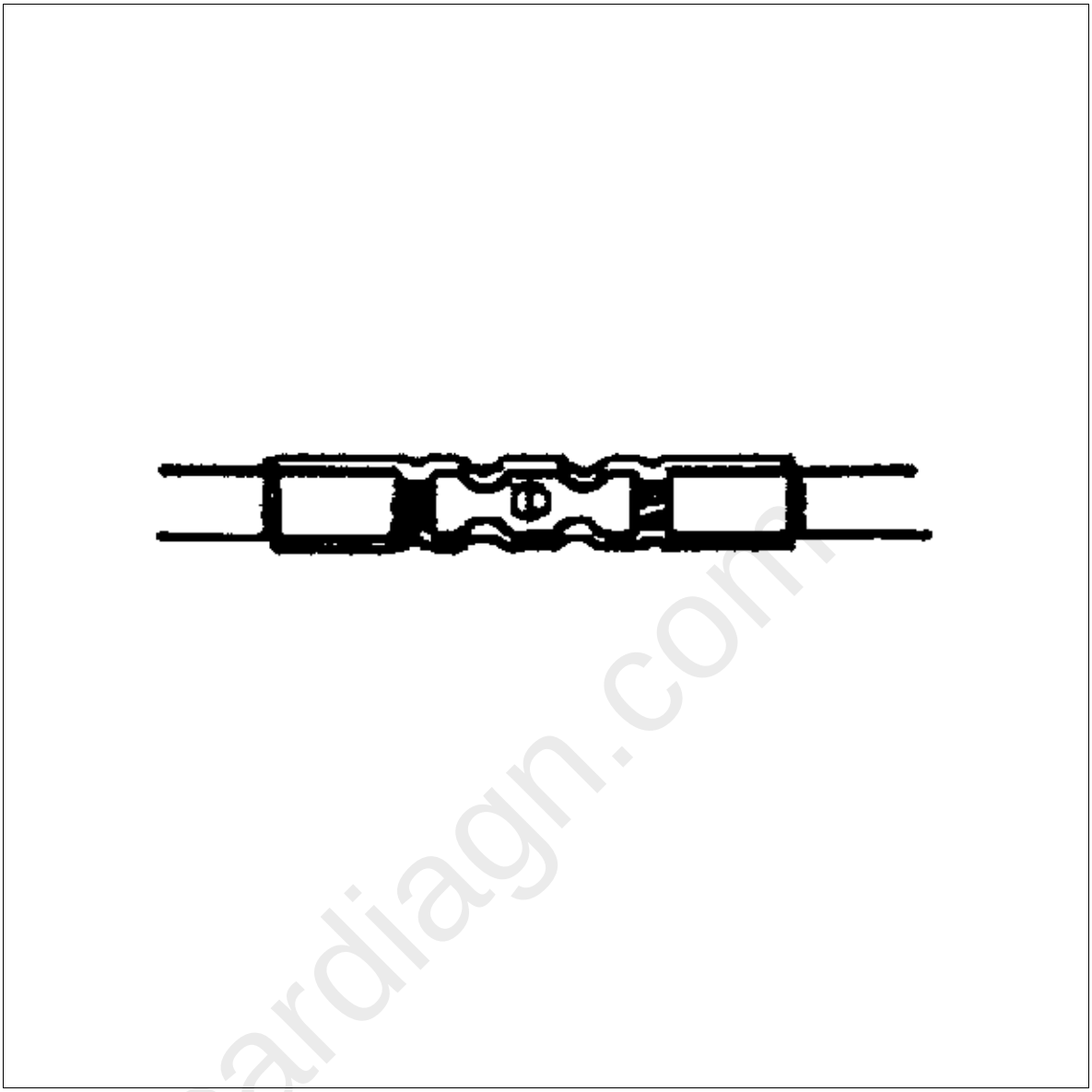
Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

10. Insert the wire into the splice sleeve barrel until the wire hits the barrel stop. Refer to Folded-Over Wire Repair for splicing wires of 0.35 mm or less (22, 24, 26 gauge sizes) and for splicing wires of different gauges.
11. Tightly close the handles of the crimp tool until the crimper handles open when released.

    The crimper handles will not open until you apply the proper amount of pressure to the DuraSeal splice sleeve. Repeat steps 4 and 6 for the opposite end of the splice.

Fig 5: Crimped Duraseal Splice Sleeve



Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

12. Using the heat torch, apply heat to the crimped area of the barrel.
13. Start in the middle and gradually move the heat barrel to the open ends of the tubing:
    1. The tubing will shrink completely as the heat is moved along the insulation.
    2. A small amount of sealant will come out of the end of the tubing when sufficient shrinkage is achieved.

REPAIR INSTRUCTIONS > WIRE TO WIRE REPAIR - ENGINE CONTROLS AND FUEL > HIGH TEMPERATURE WIRING REPAIRS

Use the following procedures to perform high temperature wiring repairs:

1. Center the high temperature SCT1 shrink tube over the DuraSeal splice sleeve.
2. Using the heat torch, apply heat to the high temperature heat shrink tubing.
3. Gradually move the heat from the center to the open end of the tubing:
    1. The tubing will shrink completely as the heat is moved along the insulation.
    2. A small amount of sealant will come out of the end of the tubing when sufficient shrinkage is achieved.
4. Replace any reflective tape and clips that may have been removed during the repair.

REPAIR INSTRUCTIONS > CONNECTOR RECONNECTION - ENGINE CONTROLS AND FUEL

Special Tools

EL-35616 Terminal Test Probe Kit

For equivalent regional tools, refer to Special Tools .

When the condition is not currently present, but is indicated in DTC history, the cause may be intermittent. An intermittent may also be the cause when there is a customer complaint, but the symptom cannot be duplicated. Refer to the Symptom Table of the system that is suspect of causing the condition before trying to locate an intermittent condition.

Most intermittent conditions are caused by faulty electrical connections or wiring. Inspect for the following items:

- Wiring broken inside the insulation
- Poor connection between the male and female terminal at a connector
- Poor terminal to wire connection - Some conditions which fall under this description are poor crimps, poor solder joints, crimping over the wire insulation rather than the wire itself, and corrosion in the wire to terminal contact area, etc.
- Pierced or damaged insulation can allow moisture to enter the wiring causing corrosion. The conductor can corrode inside the insulation, with little visible evidence. Look for swollen and stiff sections of wire in the suspect circuits.
- Wiring which has been pinched, cut, or its insulation rubbed through may cause an intermittent open or short as the bare area touches other wiring or parts of the vehicle.
- Wiring that comes in contact with hot or exhaust components
- Refer to Inducing Intermittent Fault Conditions in order to duplicate the conditions required, in order to verify the customer concern.
- Refer to Testing for Electrical Intermittents for test procedures to detect intermittent open, high resistance, short to ground, and short to voltage conditions.
- Refer to Scan Tool Snapshot Procedure for advanced intermittent diagnosis and Vehicle Data Recorder operation.

cardiagn.com

REPAIR INSTRUCTIONS > CONNECTOR RECONNECTION - ENGINE CONTROLS AND FUEL > TESTING FOR TERMINAL FRETTING

Some intermittent conditions can be caused by wire terminal fretting corrosion. Fretting corrosion is a build-up of insulating, oxidized wear debris that can form when there is a small motion between electrical contacts. The oxidized wear debris can pile up enough at the electrical contact spots that the electrical resistance across the connection increases. Movement between the contacting surfaces as small as 10 to 100 microns can cause fretting. To put this in perspective, a sheet of paper is about 100 microns thick, so fretting motion is small and hard to see. Vibration and thermal expansion/contraction are the main sources that create fretting motion. Since vehicles vibrate and can experience large temperature swings, they are a good source for fretting motion. Tin, copper, nickel, and iron surfaces are all susceptible to fretting corrosion. Fretting corrosion can be difficult to see but it looks like small, dark smudges on the terminals contact surface.

To correct a fretting condition disconnect the suspect connector and add dielectric grease / lubricant (Nyogel 760G or equivalent, meeting GM specification 9986087) to both sides of the connector terminals. Then reconnect the connector and wipe away any excess lubricant. This will correct the additional terminal contact resistance due to the terminal fretting corrosion.

REPAIR INSTRUCTIONS > CONNECTOR RECONNECTION - ENGINE CONTROLS AND FUEL > TESTING FOR PROPER TERMINAL CONTACT

It is important to test terminal contact at the component and any inline connectors before replacing a suspect component. Mating terminals must be inspected to ensure good terminal contact. A poor connection between the male and female terminal at a connector may be the result of contamination or deformation.

Contamination may be caused by the connector halves being improperly connected. A missing or damaged connector seal, damage to the connector itself, or exposing the terminals to moisture and dirt can also cause contamination. Contamination, usually in the underhood or underbody connectors, leads to terminal corrosion, causing an open circuit or intermittently open circuit.

Deformation is caused by probing the mating side of a connector terminal without the proper adapter. Always use the **EL-35616** kit when probing connectors. Other causes of terminal deformation are improperly joining the connector halves, or repeatedly separating and joining the connector halves. Deformation, usually to the female terminal contact tang, can result in poor terminal contact causing an open or intermittently open circuit.

Testing for Proper Terminal Contact in Bussed Electrical Centers

It is very important to use the correct test adapter when testing for proper terminal contact of fuses and relays in a bussed electrical center. Use the **EL-35616** kit to test for proper terminal contact. Failure to use the **EL-35616** kit can result in improper diagnosis of the bussed electrical center.

Follow the procedure below in order to test terminal contact:

1. Separate the connector halves.
2. Visually inspect the connector halves for contamination. Contamination may result in a white or green build-up within the connector body or between terminals. This causes high terminal

resistance, intermittent contact, or an open circuit. An underhood or underbody connector that shows signs of contamination should be replaced in its entirety: terminals, seals, and connector body.

3. Using an equivalent male terminal/terminated lead, verify that the retention force is significantly different between a known good terminal and the suspect terminal. Replace the female terminal in question.

Flat Wire Connectors

There are no serviceable parts for flat wire connectors on the harness side or the component side.

Follow the procedure below in order to test terminal contact:

1. Remove the component in question.
2. Visually inspect each side of the connector for signs of contamination. Avoid touching either side of the connector as oil from your skin may be a source of contamination as well.
3. Visually inspect the terminal bearing surfaces of the flat wire circuits for splits, cracks, or other imperfections that could cause poor terminal contact. Visually inspect the component side connector to ensure that all of the terminals are uniform and free of damage or deformation.
4. Insert the appropriate adapter into the flat wire harness connector in order to test the circuit in question.

REPAIR INSTRUCTIONS > CONNECTOR RECONNECTION - ENGINE CONTROLS AND FUEL > CONTROL MODULE/COMPONENT VOLTAGE AND GROUNDS

Poor voltage or ground connections can cause widely varying symptoms.

- Test all control module voltage supply circuits. Many vehicles have multiple circuits supplying voltage to a control module. Other components in the system may have separate voltage supply circuits that may also need to be tested. Inspect connections at the module/component connectors, fuses, and any intermediate connections between the voltage source and the module/component. A test lamp or a DMM may indicate that voltage is present, but neither tests the ability of the circuit to carry sufficient current. Operate the component to test the ability of the circuit to carry sufficient current. Refer to Circuit Testing , and Power Distribution Schematics .
- Test all control module ground and system ground circuits. The control module may have multiple ground circuits. Other components in the system may have separate grounds that may also need to be tested. Inspect grounds for clean and tight connections at the grounding point. Inspect the connections at the component and in splice packs, where applicable. Operate the component to test the ability of the circuit to carry sufficient current. Refer to Circuit Testing , and Ground Distribution Schematics .

REPAIR INSTRUCTIONS > CONNECTOR RECONNECTION - ENGINE CONTROLS AND FUEL > TEMPERATURE SENSITIVITY

- An intermittent condition may occur when a component/connection reaches normal operating temperature. The condition may occur only when the component/connection is cold, or only when

the component/connection is hot.

- Freeze Frame, Failure Records, Snapshot, or Vehicle Data Recorder data may help with this type of intermittent condition, where applicable.
- If the intermittent is related to heat, review the data for a relationship with the following:
    - High ambient temperatures
    - Underhood/engine generated heat
    - Circuit generated heat due to a poor connection, or high electrical load
    - Higher than normal load conditions, towing, etc.
- If the intermittent is related to cold, review the data for the following:
    - Low ambient temperatures - In extremely low temperatures, ice may form in a connection or component. Inspect for water intrusion.
    - The condition only occurs on a cold start.
    - The condition goes away when the vehicle warms up.
- Information from the customer may help to determine if the trouble follows a pattern that is temperature related.
- If temperature is suspected of causing an intermittent fault condition, attempt to duplicate the condition. Refer to Inducing Intermittent Fault Conditions in order to duplicate the conditions required.

REPAIR INSTRUCTIONS > CONNECTOR RECONNECTION - ENGINE CONTROLS AND FUEL > ELECTROMAGNETIC INTERFERENCE AND ELECTRICAL NOISE

Some electrical components/circuits are sensitive to electromagnetic interference or other types of electrical noise. Inspect for the following conditions:

- A mis-routed harness that is too close to high voltage/high current devices such as secondary ignition components, motors, generator etc. - These components may induce electrical noise on a circuit that could interfere with normal circuit operation.
- Electrical system interference caused by a malfunctioning relay, or a control module driven solenoid or switch - These conditions can cause a sharp electrical surge. Normally, the condition will occur when the malfunctioning component is operating.
- Installation of non-factory or aftermarket add on accessories such as lights, 2-way radios, amplifiers, electric motors, remote starters, alarm systems, cell phones, etc. - These accessories may create interference in other circuits while operating and the interference would disappear when the accessory is not operating. Refer to Checking Aftermarket Accessories .
- Test for an open diode across the A/C compressor clutch and for other open diodes. Some relays may contain a clamping diode.
- The generator may be allowing AC noise into the electrical system.

cardiagn.com

REPAIR INSTRUCTIONS > CONNECTOR RECONNECTION - ENGINE CONTROLS AND FUEL > INCORRECT CONTROL MODULE

- There are only a few situations where reprogramming a control module is appropriate:
    - A new service control module is installed.
    - A control module from another vehicle is installed.
    - Revised software/calibration files have been released for this vehicle.

> *NOTE:*
>
> *DO NOT re-program the control module with the SAME software/calibration files that are already present in the control module. This is not an effective repair for any type of concern.*

- Verify that the control module contains the correct software/calibration. If incorrect programming is found, reprogram the control module with the most current software/calibration. Refer to Control Module References for replacement, setup, and programming.

REPAIR INSTRUCTIONS > BRAKE PEDAL POSITION SENSOR LEARN > CALIBRATION CRITERIA

> *NOTE:*
>
> *Do not apply the brake pedal during the brake pedal position sensor calibration procedure. Any movement of the brake pedal during this procedure will cause the calibration procedure to fail. If this occurs, the brake pedal position sensor calibration must be repeated.*

Brake pedal position sensor calibration must be performed after the brake pedal position sensor, body control module (BCM), or engine control module (ECM) have been serviced. The calibration procedure will set the brake pedal position sensor home value. This value is used by the BCM and ECM to determine the action of the driver applying the brake system and to provide this information to the vehicle subsystems via serial data.

REPAIR INSTRUCTIONS > BRAKE PEDAL POSITION SENSOR LEARN > CALIBRATION PROCEDURE

1. Apply the parking brake.
2. Ignition ON, engine OFF, place the transmission in the PARK position for automatic

cardiagn.com

transmission or NEUTRAL position for manual transmission.

3. Install a scan tool.
4. Clear all DTCs before proceeding.
5. Navigate to the Configuration/Reset Functions menu of the BCM.
6. Select the Brake Pedal Position Sensor Learn procedure and follow the directions displayed on the screen.
7. Navigate to the Configuration/Reset Functions menu of the ECM.
8. Select the Learn Functions menu.
9. Select the Brake Pedal Position Sensor Learn procedure and follow the directions displayed on the screen.

REPAIR INSTRUCTIONS > Q38 THROTTLE BODY: THROTTLE/IDLE LEARN > DESCRIPTION

The engine control module (ECM) learns the airflow through the throttle body to ensure the correct idle. The learned airflow values are stored within the ECM. These values are learned to adjust for production variation and will continuously learn during the life of the vehicle to compensate for reduced airflow due to throttle body coking. Anytime the throttle body airflow rate changes, for example due to cleaning or replacing, the values must be relearned.

An engine that had a heavily coked throttle body that has been cleaned or replaced may take several drive cycles to unlearn the coking. To accelerate the process, the scan tool has the ability to reset all learned values back to zero. A new ECM will also have values set to zero.

The idle may be unstable or a DTC may set if the learned values do not match the actual airflow.

REPAIR INSTRUCTIONS > Q38 THROTTLE BODY: THROTTLE/IDLE LEARN > CONDITIONS FOR RUNNING THE THROTTLE LEARN PROCEDURE

Scan tool Idle Learn or Idle Learn Reset Procedure

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0116, P0117, P0118, P0120, P0122, P0123, P0128, P0171, P0172, P0174, P0175, P0201-P0208, P0220, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300-P0308, P0351-P0358, P0496, P0601, P0604, P0606, P060D, P0641, P0651, P0697, P06A3, P06D2, P1248, P1249, P124A, P124B, P1516, P16A0-P16A2, P2101, P2119, P2120, P2122, P2123, P2125, P2127, P2128, P2135, P2138, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P217B, P217C, P217E, P217F, P2176, P2300, P2301, P2303, P2304, P2306, P2307, P2309, P2310, P2312, P2313, P2315, P2316, P2318, P2319, P2321, or P2322 are not set.
- Ignition ON, engine OFF.
- The vehicle speed sensor (VSS) is 0 km/h (0 mph).

cardiagn.com

Service Bay/On Road Learn Procedure

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0116, P0117, P0118, P0120, P0122, P0123, P0128, P0171, P0172, P0174, P0175, P0201-P0208, P0220, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300-P0308, P0351-P0358, P0496, P0601, P0604, P0606, P060D, P0641, P0651, P0697, P06A3, P06D2, P1248, P1249, P124A, P124B, P1516, P16A0-P16A2, P2101, P2119, P2120, P2122, P2123, P2125, P2127, P2128, P2135, P2138, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P217B, P217C, P217E, P217F, P2176, P2300, P2301, P2303, P2304, P2306, P2307, P2309, P2310, P2312, P2313, P2315, P2316, P2318, P2319, P2321, or P2322 are not set.
- The engine speed is between 450-4, 000 RPM.
- The manifold absolute pressure (MAP) is greater than 5 kPa.
- The mass air flow (MAF) is greater than 2 g/s.
- The ignition voltage is greater than 10 volts.

REPAIR INSTRUCTIONS > Q38 THROTTLE BODY: THROTTLE/IDLE LEARN > DIAGNOSTIC AIDS

A un-metered air leak in the induction system or a small vacuum leak may not set a DTC. If the condition goes undetected, the ECM may learn an incorrect Throttle Body Idle Airflow Compensation value over time. The incorrectly learned value may cause various symptoms to occur such as rough or unstable idle speeds, and/or engine stall. If this condition is detected and repaired it will be necessary perform the Idle Learn procedure to ensure any symptoms are corrected.

REPAIR INSTRUCTIONS > Q38 THROTTLE BODY: THROTTLE/IDLE LEARN > THROTTLE LEARN

Scan Tool Idle Learn or Idle Learn Reset Procedure - Performed after the throttle body is cleaned or replaced

1. Ignition ON, engine OFF, perform the Idle Learn or Idle Learn Reset in Configuration/Reset or Module Setup.
2. Engine idling, verify the scan tool Throttle Body Idle Airflow Compensation value is equal 0% and the engine is idling at a normal idle speed.
3. Clear the DTCs and return to the diagnostic that referred you here.

Service Bay/On Road Idle Learn Procedure - Performed after the ECM is programmed or replaced

cardiagn.com

> *NOTE:*
>
> *Do NOT perform this procedure if any DTCs are set. Refer to Diagnostic Trouble Code (DTC) List - Vehicle .*

1. Engine idling for 3 m.
2. The ECM will start to learn the new idle cells and the scan tool Desired Idle Speed should start to decrease.
3. Ignition OFF for 60 s.
4. Start and idle the engine for 3 m.
5. Verify the engine is idling normally.
    1. **If the engine idle is not correct**

        > *NOTE:*
        >
        > *During the drive cycle the check engine light may come on with idle speed DTCs. If idle speed codes are set, clear codes so the ECM can continue to learn.*

        1. Operate the vehicle at speeds above 70 km/h (44 mph) with several decelerations and extended idles.
        2. Verify the engine is idling normally.
            1. If the engine idle is not correct.

                Ignition OFF for 60 s, repeat step 5.1.

            1. If the engine idle is correct.
        3. Clear any DTCs and return to the diagnostic that referred you here.

    1. **If the engine idle is correct**
6. Clear any DTCs and return to the diagnostic that referred you here.

REPAIR INSTRUCTIONS > CRANKSHAFT POSITION VARIATION LEARN

The Crankshaft Position Variation Learn procedure is required when the following service procedures have been performed, regardless of whether DTC P0315 is set:

- An engine replacement.
- A engine control module (ECM) replacement.

cardiagn.com

- A crankshaft balancer replacement.
- A crankshaft replacement.
- A crankshaft position sensor replacement.
- Any engine repairs which disturb the crankshaft to crankshaft position sensor relationship.

The ECM monitors certain component signals to determine if all the conditions are met to continue with the Crankshaft Position Variation Learn procedure. The scan tool only displays the condition that inhibits the procedure. The scan tool displays the signals of the components listed below:

- Crankshaft position sensors activity: If there is a crankshaft position sensor condition, refer to the applicable DTC set.
- Camshaft position sensor signal activity: If there is a camshaft position sensor signal condition, refer to the applicable DTC set.
- Engine coolant temperature (ECT): If the engine coolant temperature is not warm enough, idle the engine until the engine coolant temperature reaches the correct temperature.

1. Verify no DTCs are set.
    1. **If any DTCs other than P0300-P0308, or P0315 are set**

       Refer to Diagnostic Trouble Code (DTC) List - Vehicle .

    1. **If DTC P0300-P0308, P0315, or no DTCs are set**

> *NOTE:*
>
> *The Crankshaft Position Variation Learn may have to be repeated up to 5 times before the procedure is successful.*

2. Engine Running at normal operating temperature, perform the scan tool Crankshaft Position Variation Learn procedure and follow the on screen instructions.
3. Verify the scan tool displays Test Passed Successfully when completed.
    1. **If Test Passed Successfully is not displayed**

       Verify that none of the conditions listed below exist:

    1. The ignition switch is in the ON position until there is insufficient system voltage.
    2. An ECM power disconnect with the ignition ON that may have erased the crankshaft position system variation values and set DTC P0315.
    3. Interference in the signal circuit of the crankshaft position sensor.
    4. Debris between the crankshaft position sensor and the reluctor wheel.
    5. A damaged or misaligned reluctor wheel.
    6. Worn crankshaft main bearings.

cardiagn.com

7. Excessive crankshaft runout.
8. A damaged crankshaft.

1. If a condition is exists, repair or replace as necessary.

1. If no conditions exist, replace the K20 Engine Control Module.

1. **If Test Passed Successfully is displayed**

4. Clear all DTCs.
5. Engine Running.
6. Verify a DTC is not set.

1. **If a DTC is set**

   Refer to Diagnostic Trouble Code (DTC) List - Vehicle .

1. **If a DTC is not set**

7. All OK.

REPAIR INSTRUCTIONS > CRANKSHAFT POSITION VARIATION LEARN > REPAIR INSTRUCTIONS

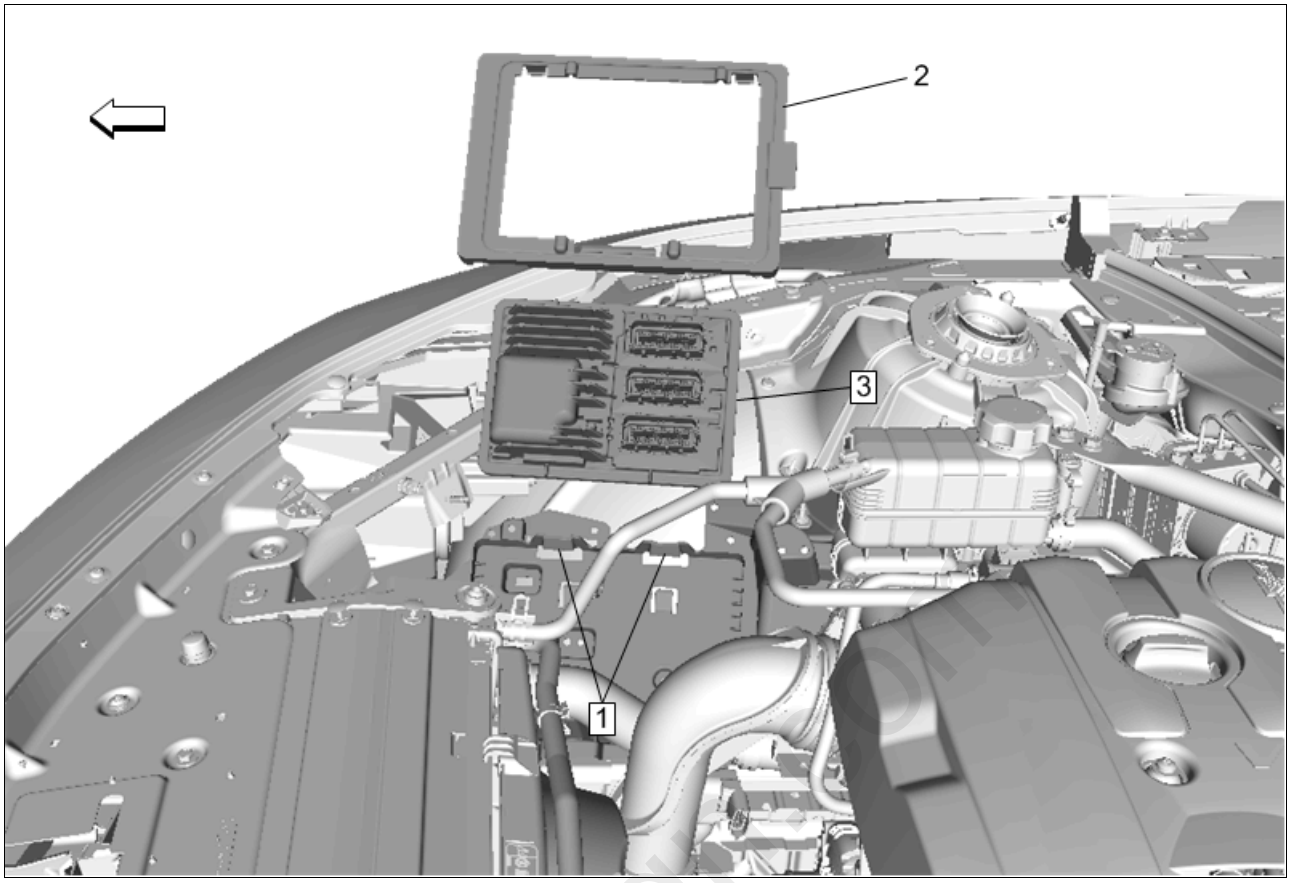
Perform the Diagnostic Repair Verification after completing the repair.

Control Module References for engine control module replacement, programming, and setup.

REPAIR INSTRUCTIONS > ENGINE CONTROL MODULE REPLACEMENT

cardiagn.com

Fig 1: Engine Control Module



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Disconnect the negative battery cable. Battery Negative Cable Disconnection and Connection 2. Engine Wiring Harness Fuse Block Bracket Replacement	
1	Engine Control Module Bracket Retaining Tab (Qty: 2)
2	Engine Control Module
2	*WARNING:* *Refer to Safety Glasses Warning .*
2	*CAUTION:* *Always turn the ignition off when installing or removing the ECM connectors in*

order to prevent damage to the components.

CAUTION:

- *Turn the ignition OFF when installing or removing the control module connectors and disconnecting or reconnecting the power to the control module (battery cable, powertrain control module (PCM)/engine control module (ECM)/transaxle control module (TCM) pigtail, control module fuse, jumper cables, etc.) in order to prevent internal control module damage.*
- *Control module damage may result when the metal case contacts battery voltage. DO NOT contact the control module metal case with battery voltage when servicing a control module, using battery booster cables, or when charging the vehicle battery.*
- *In order to prevent any possible electrostatic discharge damage to the control module, do no touch the connector pins or the soldered components on the circuit board.*
- *Remove any debris from around the control module connector surfaces before servicing the control module. Inspect the control module connector gaskets when diagnosing or replacing the control module. Ensure that the gaskets are installed correctly. The gaskets prevent contaminant intrusion into the control module.*
- *The replacement control module must be programmed.*

Procedure

1. Disconnect the electrical connectors.
2. If replacing, program the ECM. Control Module References .

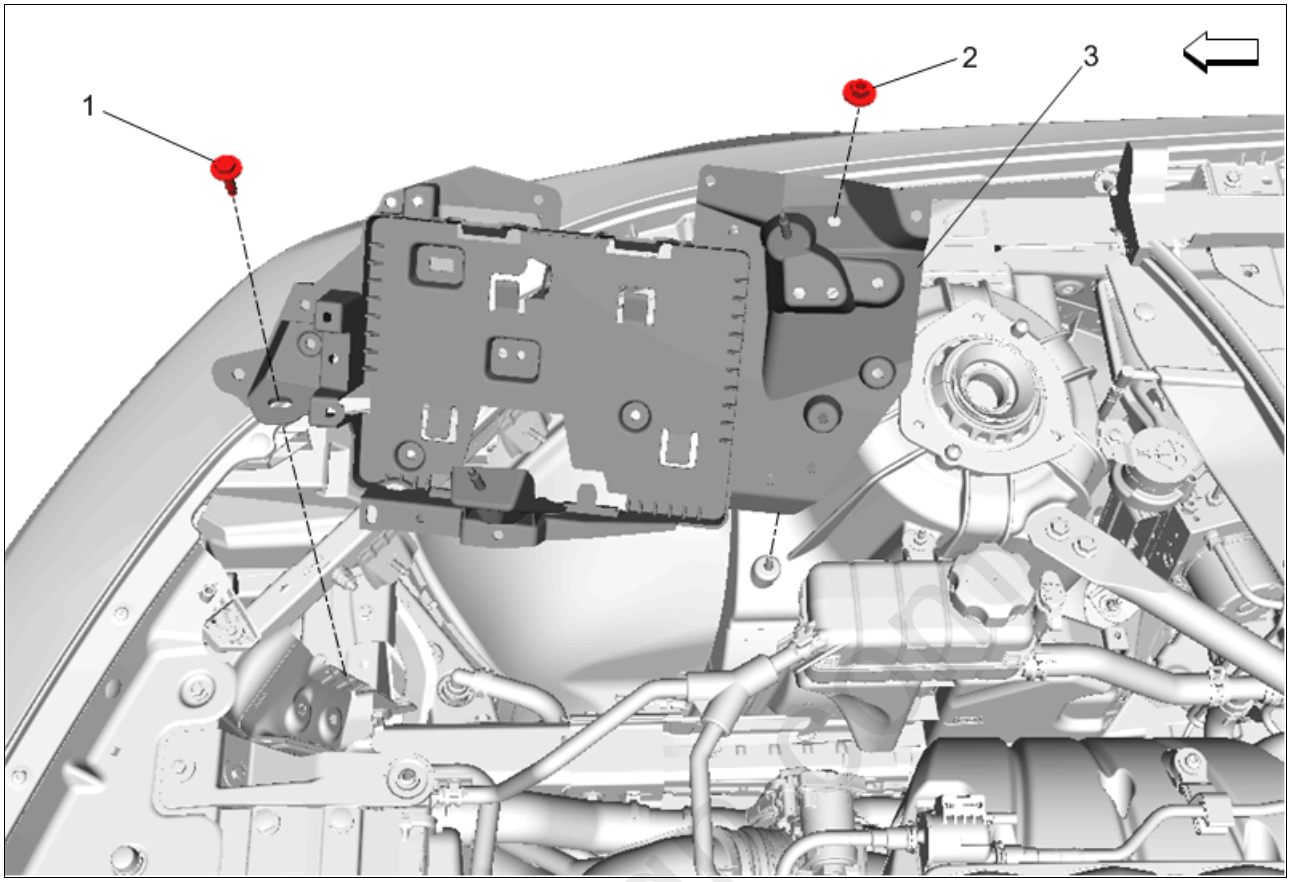
NOTE:

Before removing the engine control module (ECM), record the oil life percentage remaining. Use the scan tool to reset the Engine Oil Life remaining back to the original percentage recorded.

cardiagn.com

REPAIR INSTRUCTIONS > ENGINE CONTROL MODULE BRACKET REPLACEMENT

Fig 1: Engine Control Module Bracket

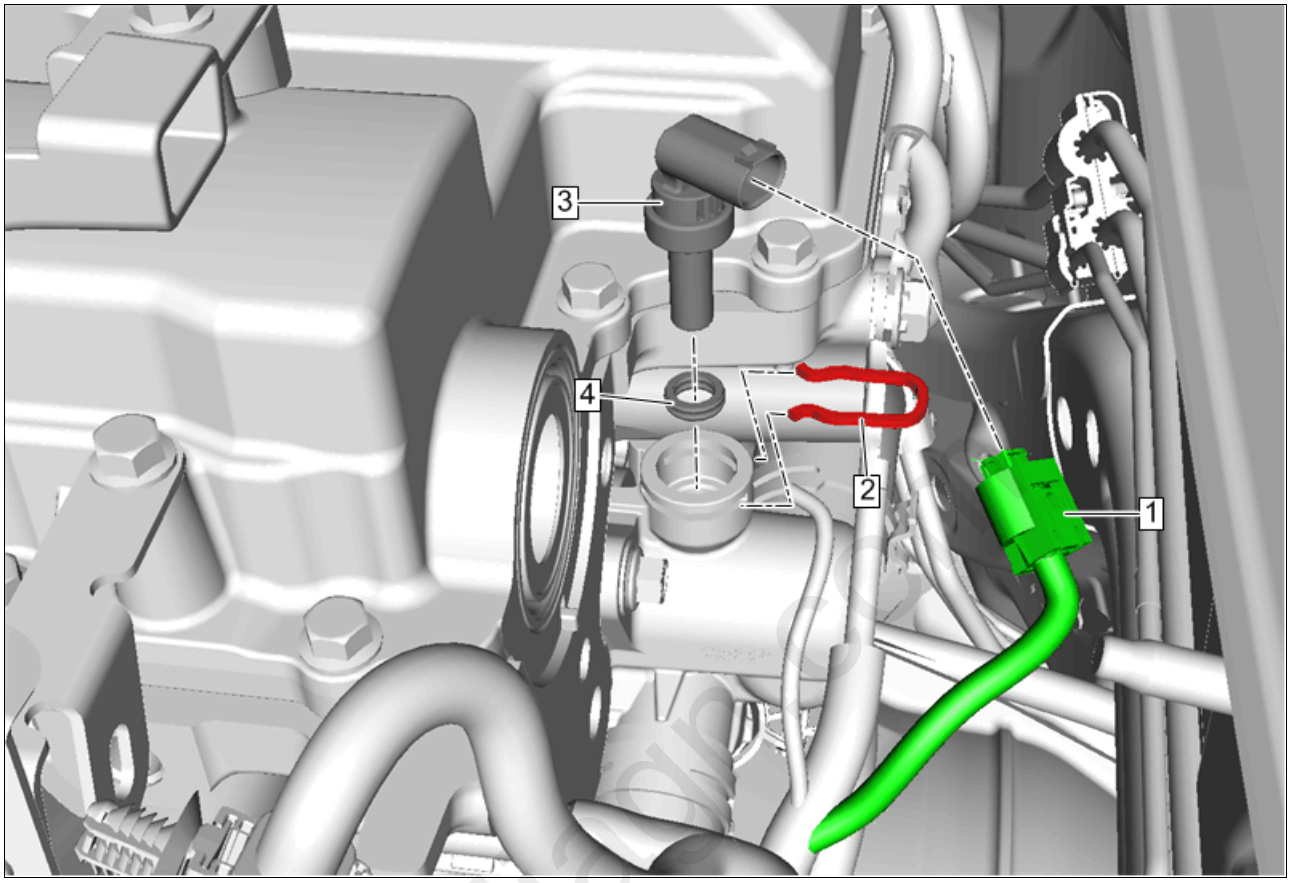


Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Engine Control Module Replacement	
1	Engine Control Module Bracket Bolt *CAUTION:* *Refer to Fastener Caution .* **Tighten** 9 N.m (80 lb in)
2	Engine Control Module Bracket Nut **Tighten** 9 N.m (80 lb in)
3	Engine Control Module Bracket

REPAIR INSTRUCTIONS > ENGINE COOLANT TEMPERATURE SENSOR REPLACEMENT

Fig 1: Engine Coolant Temperature Sensor

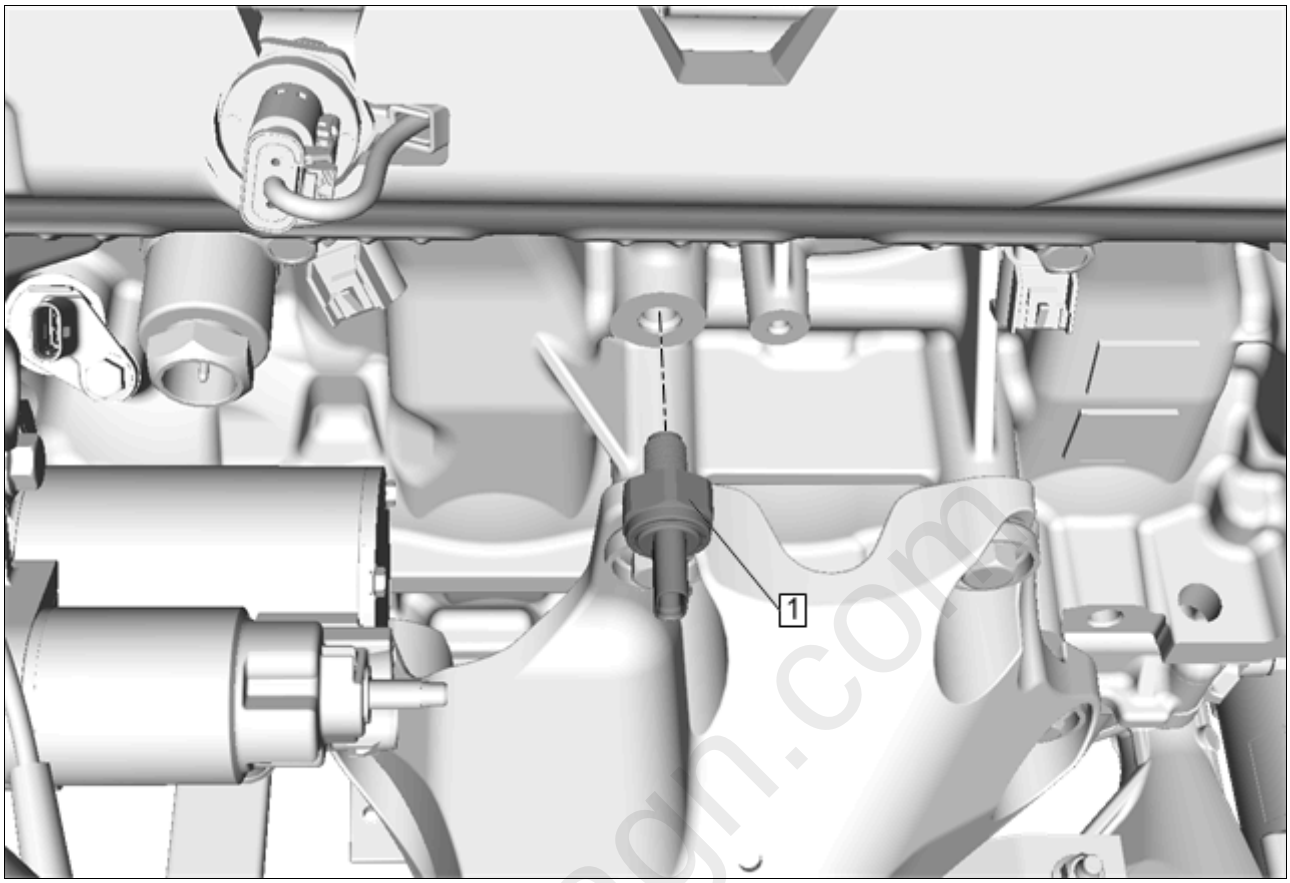


Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Cooling System Draining and Filling (GE 47716) Cooling System Draining and Filling (Static Fill) 2. Vacuum Pump Replacement	
1	Electrical Connector
2	Engine Coolant Temperature Sensor Retaining Clip
3	Engine Coolant Temperature Sensor
4	Engine Coolant Temperature Sensor Seal **Procedure** The seal is reusable, inspect the seal and replace if damaged.

REPAIR INSTRUCTIONS > ENGINE OIL PRESSURE SENSOR REPLACEMENT

Fig 1: Engine Oil Pressure Sensor



Courtesy of GENERAL MOTORS COMPANY

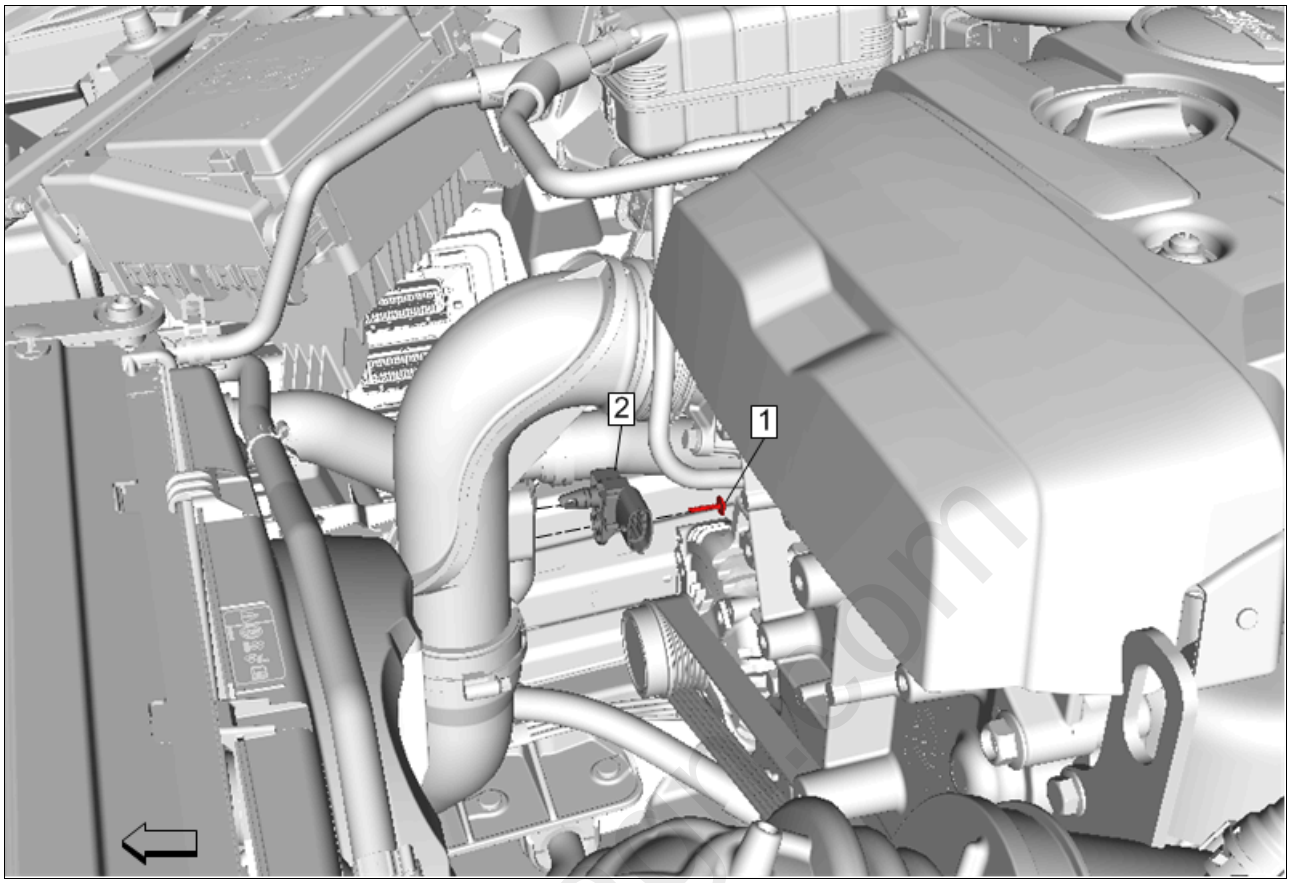
Callout	Engine Oil Pressure Sensor
Preliminary Procedure Intake Manifold Cover Replacement	
1	Engine Oil Pressure Sensor *CAUTION:* *Refer to Component Fastener Tightening Caution .* **Procedure** Disconnect the oil pressure sensor electrical connector. **Tighten** 35 N.m (26 lb ft)

cardiagn.com

REPAIR INSTRUCTIONS > INTAKE AIR PRESSURE AND TEMPERATURE SENSOR

REPLACEMENT

Fig 1: Intake Air Pressure and Temperature Sensor



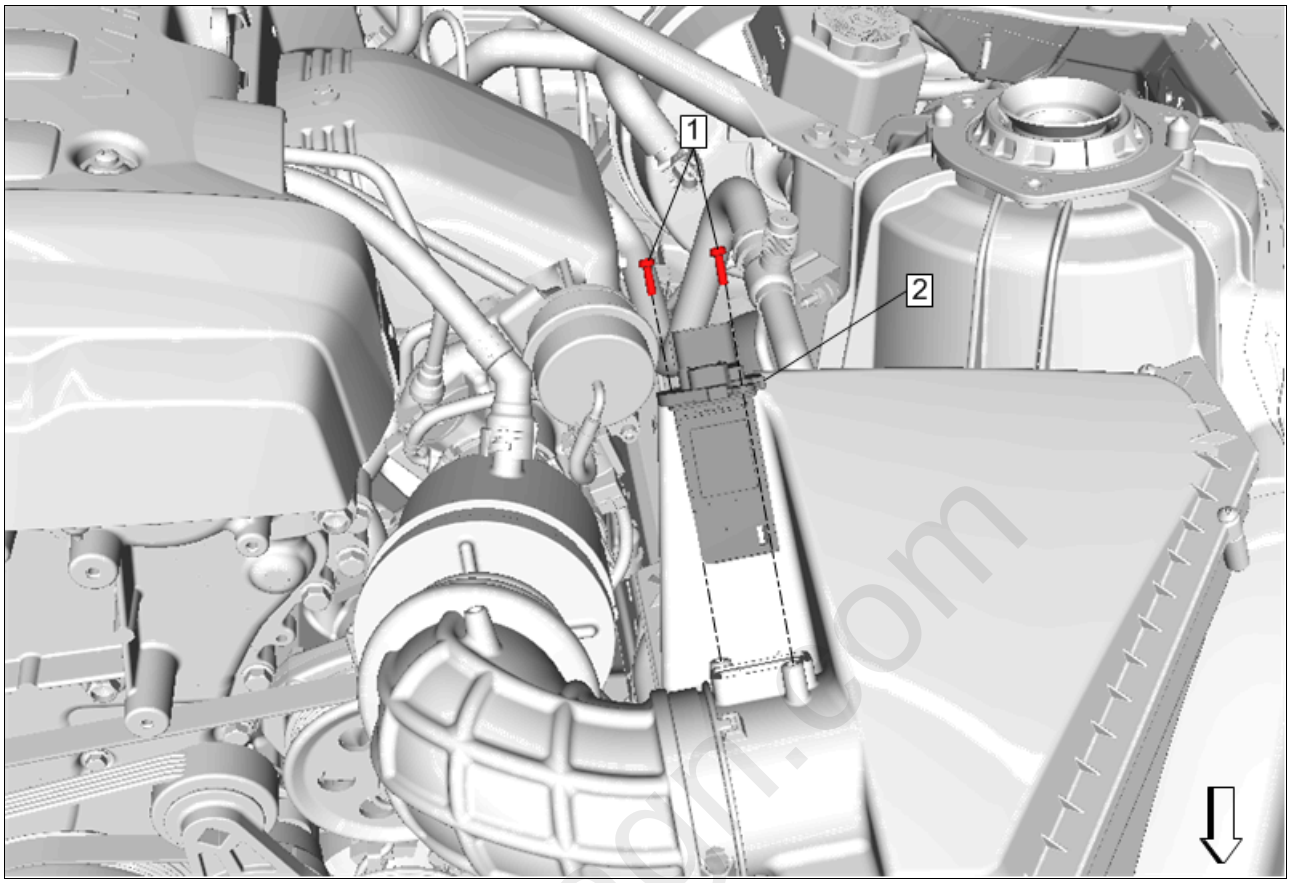
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Disconnect the electrical connector.	
1	Intake Air Pressure and Temperature Sensor Fastener *CAUTION:* *Refer to Fastener Caution .* **Tighten** 4 N.m (35 lb in)
2	Intake Air Pressure and Temperature Sensor

REPAIR INSTRUCTIONS > MASS AIRFLOW SENSOR WITH INTAKE AIR

TEMPERATURE SENSOR REPLACEMENT

Fig 1: Mass Airflow Sensor with Intake Air Temperature Sensor



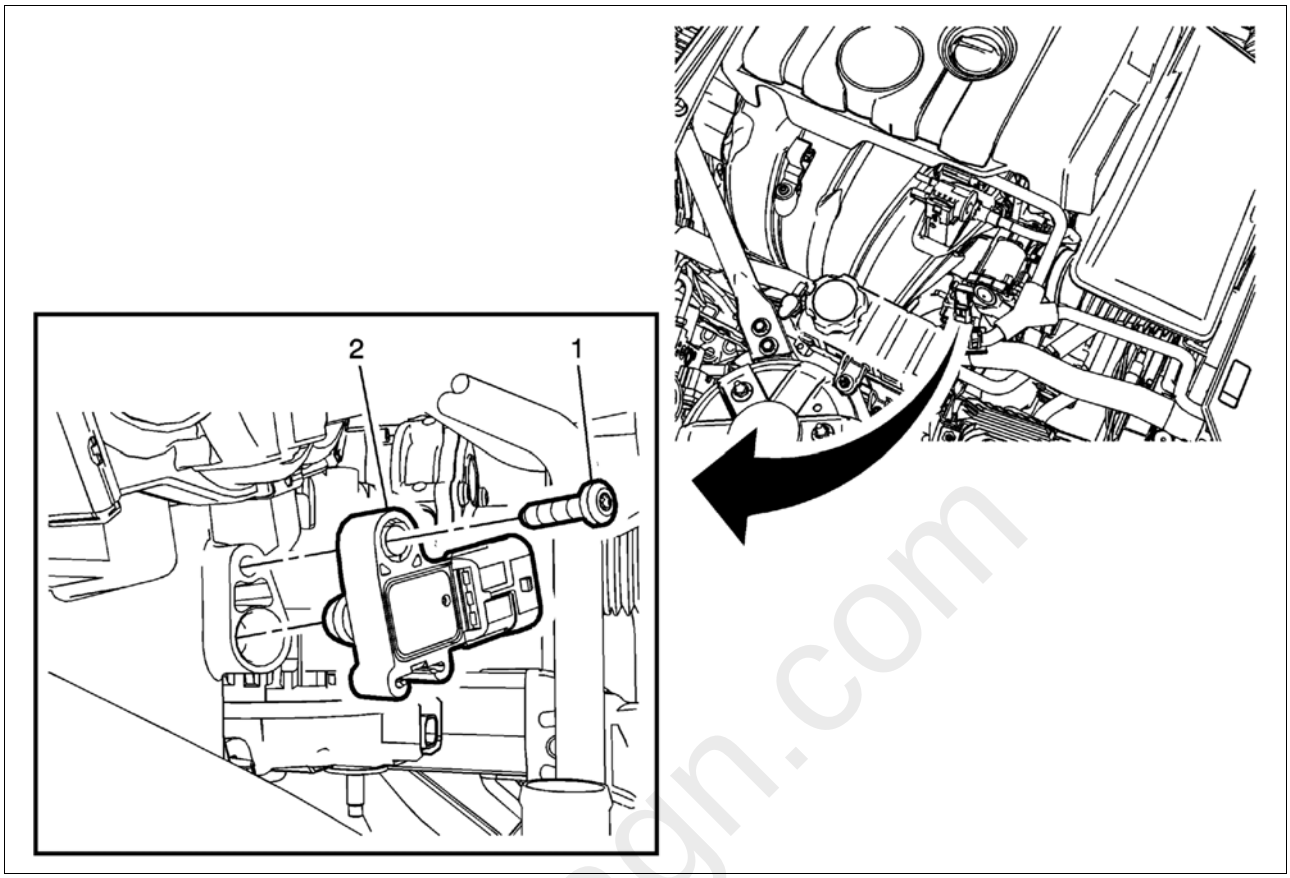
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Mass Airflow Sensor Bolt (Qty: 2) *CAUTION:* *Refer to Fastener Caution .* **Tighten** 4 N.m (35 lb in)
2	Mass Airflow Sensor **Procedure** Disconnect the electrical connector.

REPAIR INSTRUCTIONS > MANIFOLD ABSOLUTE PRESSURE SENSOR

REPLACEMENT

Fig 1: Manifold Absolute Pressure Sensor



Courtesy of GENERAL MOTORS COMPANY

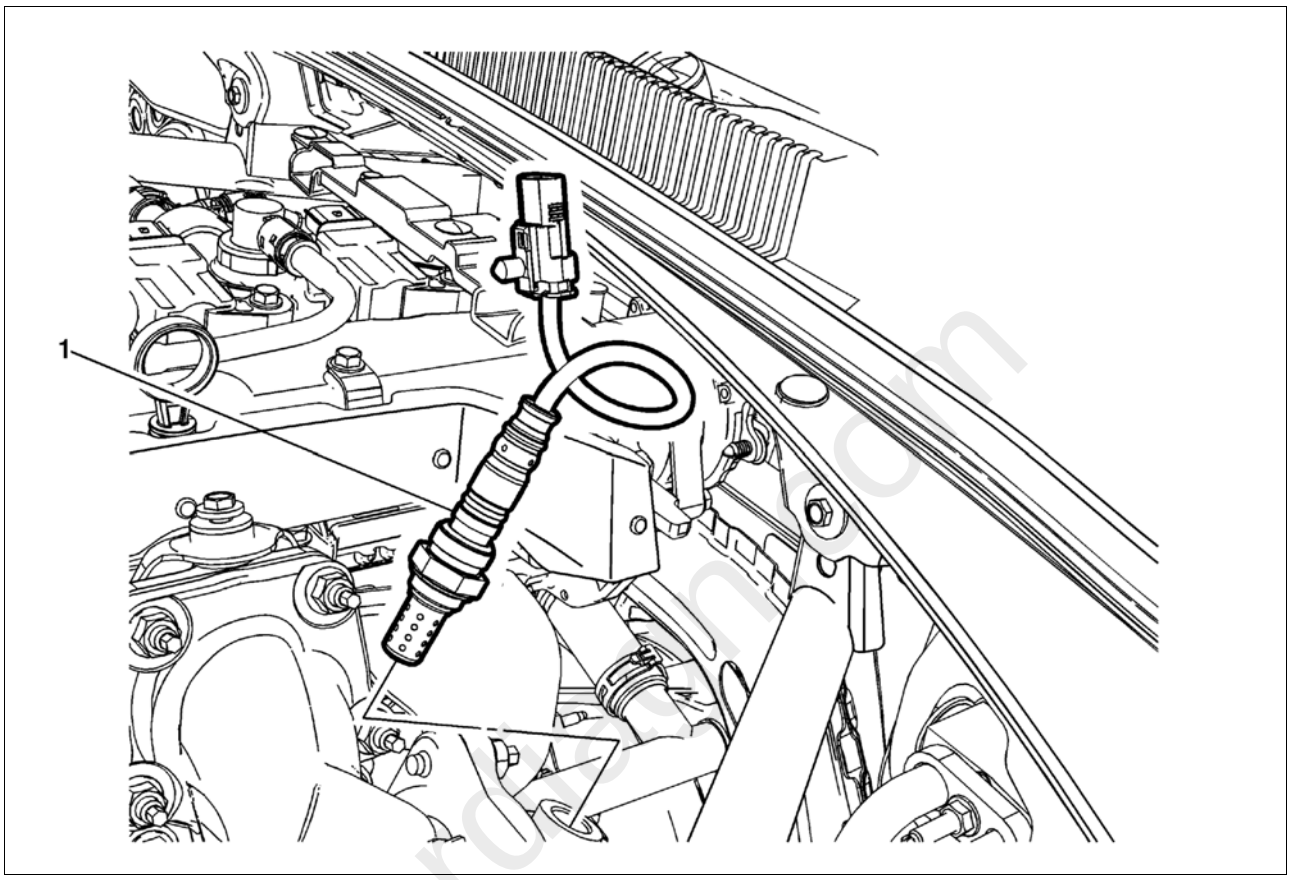
Callout	Component Name
1	Manifold Absolute Pressure Sensor Retaining Fastener *CAUTION:* *Refer to Fastener Caution .* **Tighten** 10 N.m (89 lb in)
2	Manifold Absolute Pressure Sensor Procedure 1. Disconnect the engine wiring harness electrical connector from the manifold absolute pressure sensor. 2. Remove the manifold absolute pressure sensor from the intake manifold.

cardiagn.com

	3. Install a NEW seal if reusing the manifold absolute pressure sensor.

REPAIR INSTRUCTIONS > HEATED OXYGEN SENSOR REPLACEMENT - SENSOR 1

Fig 1: Heated Oxygen Sensor - Sensor 1



Courtesy of GENERAL MOTORS COMPANY

carmanual.com

Callout	Component Name
1	Heated Oxygen Sensor *CAUTION:* *The oxygen sensor uses a permanently attached pigtail and connector. Do not remove the pigtail from the oxygen sensor. Damage to or removal of the pigtail connector could affect proper operation of the oxygen sensor.*

CAUTION:

The use of excessive force may damage the threads in the exhaust manifold/pipe.

CAUTION:

Refer to Heated Oxygen Sensor Resistance Learn Reset Caution .

CAUTION:

Refer to Component Fastener Tightening Caution .

Procedure
Disconnect the electrical connector.

NOTE:

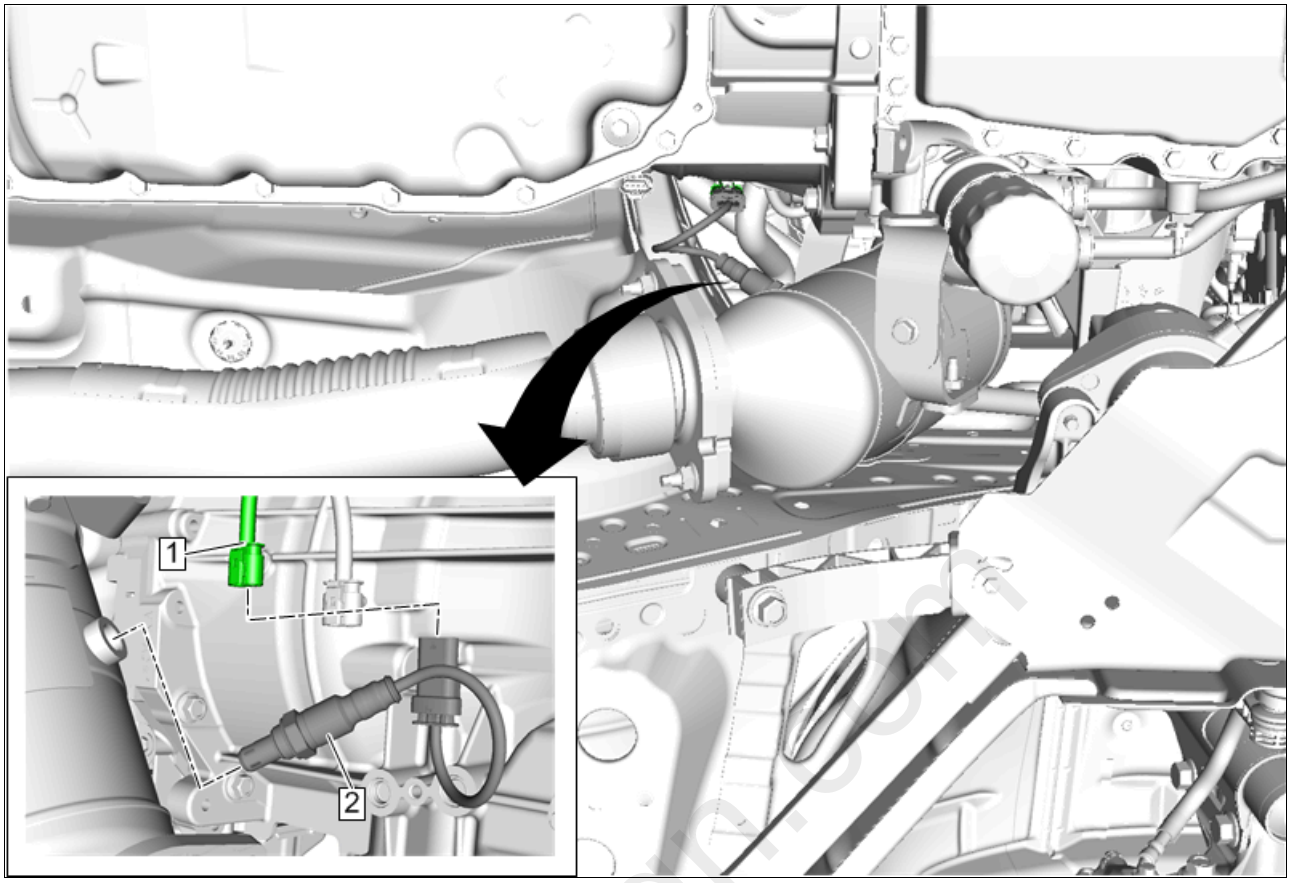
- *The in-line connector and louvered end must be kept clear of grease, dirt or other contaminants. Avoid using cleaning solvents of any type. DO NOT drop or roughly handle the heated oxygen sensor (HO2S).*
- *The HO2S may be difficult to remove when the engine temperature is less than 48°C (120°F).*
- *A special anti-seize compound is used on the HO2S threads. The compound consists of a liquid graphite and glass beads. The graphite will burn away, but the glass beads will remain, making the sensor easier to remove. New or service sensors will have the compound applied to the threads. If a sensor is removed and is to be reinstalled, the threads must have an anti-seize compound applied before installation.*

Tighten
42 N.m (31 lb ft)
Special Tools
J 39194 Oxygen Sensor Wrench
For regional tools refer to Special Tools (Diagnostic Tools)Special Tools (Mechanical Tools) .

carduagn.com

REPAIR INSTRUCTIONS > HEATED OXYGEN SENSOR REPLACEMENT - SENSOR 2

Fig 1: Heated Oxygen Sensor - Sensor 2



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Raise and support the vehicle. Lifting and Jacking the Vehicle (Base)Lifting and Jacking the Vehicle (HP) 2. Transmission Fluid Cooler Inlet and Outlet Pipe Replacement (LTG With M5T, Without V03) Transmission Fluid Cooler Inlet and Outlet Pipe Replacement (LTG With M5T, With V03)	
1	Electrical Connector
2	Heated Oxygen Sensor *CAUTION:* *The oxygen sensor uses a permanently attached pigtail and connector. Do not remove the pigtail from the oxygen sensor. Damage to or removal of the pigtail connector could affect proper operation of the oxygen sensor.*

cardiagn.com

CAUTION:

The use of excessive force may damage the threads in the exhaust manifold/pipe.

CAUTION:

Refer to Heated Oxygen Sensor Resistance Learn Reset Caution .

CAUTION:

Refer to Component Fastener Tightening Caution .

Procedure

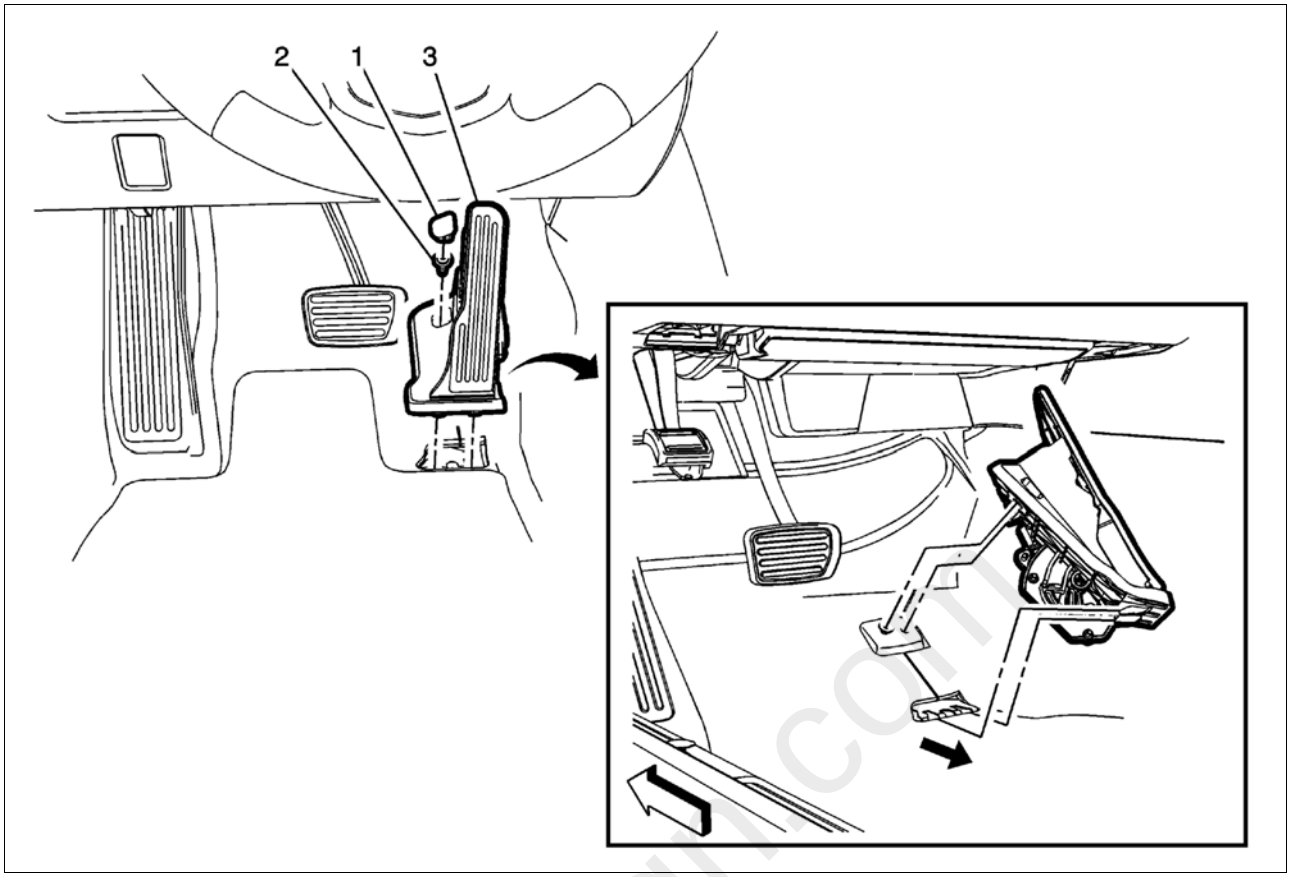
NOTE:

- *The in-line connector and louvered end must be kept clear of grease, dirt or other contaminants. Avoid using cleaning solvents of any type. DO NOT drop or roughly handle the heated oxygen sensor (HO2S).*
- *The HO2S may be difficult to remove when the engine temperature is less than 48°C (120°F).*
- *A special anti-seize compound is used on the HO2S threads. The compound consists of a liquid graphite and glass beads. The graphite will burn away, but the glass beads will remain, making the sensor easier to remove. New or service sensors will have the compound applied to the threads. If a sensor is removed and is to be reinstalled, the threads must have an anti-seize compound applied before installation.*

Tighten
42 N.m (31 lb ft)
Special Tools
J 39194 Oxygen Sensor Wrench
Equivalent regional tools:Special Tools (Diagnostic Tools)Special Tools (Mechanical Tools)

REPAIR INSTRUCTIONS > ACCELERATOR PEDAL WITH POSITION SENSOR ASSEMBLY REPLACEMENT

Fig 1: Accelerator Pedal with Position Sensor Assembly



Courtesy of GENERAL MOTORS COMPANY

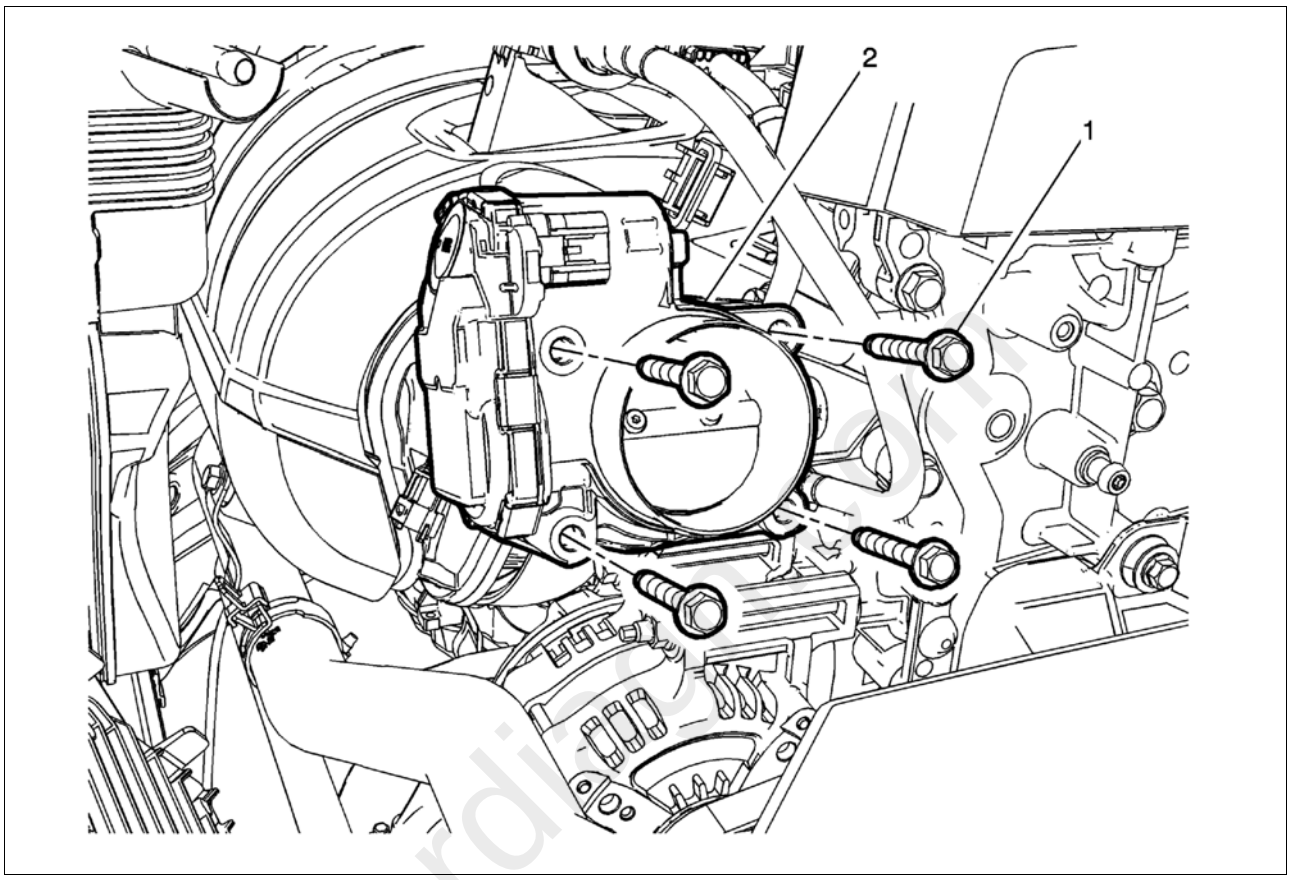
Callout	Component Name
1	Accelerator Pedal Position Sensor Cover
2	Accelerator Pedal Position Sensor Fastener *CAUTION:* *Refer to Fastener Caution .* **Tighten** 9 N.m (80 lb in)
3	Accelerator Pedal Position Sensor Procedure 1. Disconnect the connector from the Accelerator Pedal Position Sensor. 2. Tilt the top of the Accelerator Pedal Position Sensor rearward. 3. Slide the Accelerator Pedal Position Sensor back to disengage its lower

cardiagn.com

	retaining tabs.

REPAIR INSTRUCTIONS > THROTTLE BODY ASSEMBLY REPLACEMENT

Fig 1: Throttle Body Assembly



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

CAUTION:

Do not use solvent of any type when cleaning the gasket surfaces on the intake manifold and the throttle body assembly, as damage to the gasket surfaces and throttle body assembly may result.

Use care in cleaning the gasket surfaces on the intake manifold and the throttle body assembly, as sharp tools may damage the gasket surfaces.

CAUTION:

Do not use any solvent that contains Methyl Ethyl Ketone (MEK). This solvent may damage fuel system components.

NOTE:

DO NOT prop open the throttle blade with the ignition key in the ON position as it may set a diagnostic trouble code (DTC).

Preliminary Procedure Remove the air cleaner outlet duct. Refer to Charge Air Cooler Outlet Air Tube Replacement .

1	Throttle Body Assembly Fasteners (Qty: 4) *CAUTION:* *Refer to Fastener Caution .* **Tighten** 10 N.m (89 lb in)
2	Throttle Body Assembly Procedure 1. Disconnect the engine wiring harness electrical connector from the throttle body assembly. 2. Inspect the throttle body gasket, and replace if necessary. 3. Perform the throttle learn procedure. Refer to Q38 Throttle Body: Throttle/Idle Learn .

cardiagn.com

REPAIR INSTRUCTIONS > THROTTLE BODY CLEANING

WARNING:

Turn OFF the ignition before inserting fingers into the throttle bore. Unexpected movement of the throttle blade could cause personal injury.

CAUTION:

Do not insert any tools into the throttle body bore in order to avoid damage to the throttle

valve plate.

CAUTION:

Do not use any solvent that contains Methyl Ethyl Ketone (MEK). This solvent may damage fuel system components.

1. Remove the air cleaner outlet duct. Refer to Air Cleaner Outlet Duct Replacement .

   NOTE:

   DO NOT prop open the throttle blade with the ignition key in the ON position as it may set a diagnostic trouble code (DTC).

2. Inspect the throttle body bore and the throttle valve plate for deposits. You must open the throttle valve in order to inspect all of the surfaces.
3. Clean the throttle body bore and the throttle valve plate using a clean shop towel and approved cleaner.
4. Install the air cleaner outlet duct. Refer to Air Cleaner Outlet Duct Replacement .
5. Perform the throttle/idle learn procedure. Refer to Control Module References .

REPAIR INSTRUCTIONS > FUEL PRESSURE RELIEF

WARNING:

Fuel that flows out at high pressure can cause serious injury to the skin and eyes. ALWAYS depressurize the fuel system before removing components that are under high fuel pressure.

WARNING:

Remove the fuel tank cap and relieve the fuel system pressure before servicing the fuel system in order to reduce the risk of personal injury. After you relieve the fuel system pressure, a small amount of fuel may be released when servicing the fuel lines, the fuel injection pump, or the connections. In order to reduce the risk of personal injury, cover the fuel system components with a shop towel before disconnection. This will catch any fuel that may leak out. Place the towel in an approved container when the disconnection is complete.

cardiagn.com

Scan Tool Method - Preferred

1. Install a scan tool and turn the ignition ON.
2. Using the scan tool, command the fuel pump OFF allowing the low pressure fuel pump to shut off.
3. Start the vehicle and allow the engine to idle until the engine stops. The engine will stop in approximately 5-20 seconds.
4. Repeat step 3. Using the scan tool, verify pressure has dropped to a minimal level.
5. Turn the ignition OFF.

Alternate Method - If a scan tool is not available

1. Disable the fuel pump by removing the B+ fuel pump control module fuse. Refer to Electrical Center Identification Views .
2. Start the vehicle and allow the engine to idle until the engine stops. The engine will stop in approximately 5-20 seconds.
3. Attempt to restart the vehicle to ensure pressure has dropped to a minimal level.
4. Turn the ignition OFF.

REPAIR INSTRUCTIONS > FUEL PRESSURE GAUGE INSTALLATION AND REMOVAL

Special Tools

- **CH-47831** Fuel Line Disconnect Tool
- **CH-37287-1A** Fuel Pressure Gauge Adapter 3/8"
- **CH-42982** Fuel Pressure Gauge Adapter

Equivalent regional tools:Special Tools (Diagnostic Tools)Special Tools (Mechanical Tools)

REPAIR INSTRUCTIONS > FUEL PRESSURE GAUGE INSTALLATION AND REMOVAL > INSTALLATION PROCEDURE

WARNING:

Gasoline or gasoline vapors are highly flammable. A fire could occur if an ignition source is present. Never drain or store gasoline or diesel fuel in an open container, due to the possibility of fire or explosion. Have a dry chemical (Class B) fire extinguisher nearby.

WARNING:

cardiagn.com

Wrap a shop towel around the fuel pressure connection in order to reduce the risk of fire and personal injury. The towel will absorb any fuel leakage that occurs during the connection of the fuel pressure gauge. Place the towel in an approved container when the connection of the fuel pressure gauge is complete.

⚠ *CAUTION:*

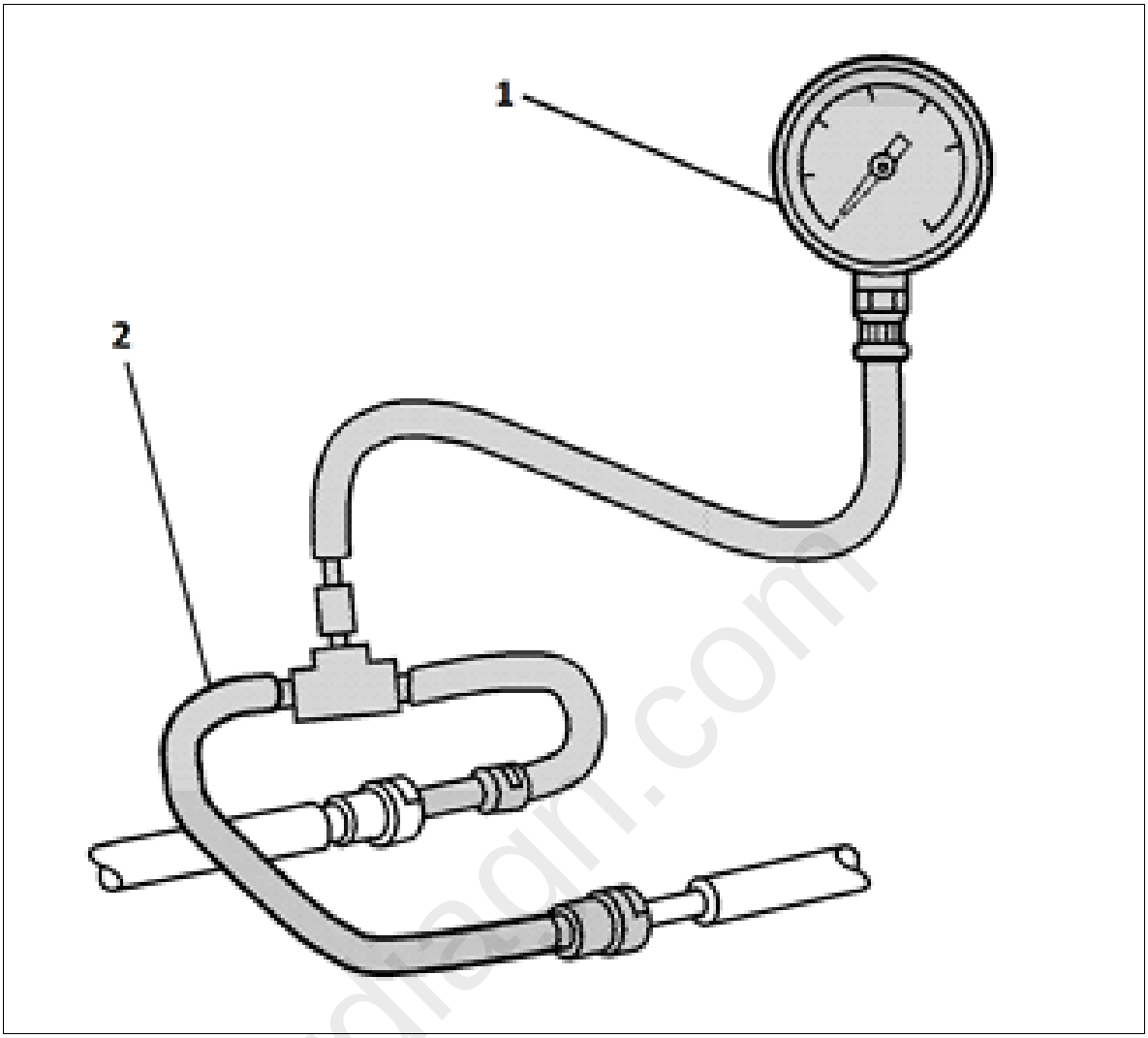
Clean all of the following areas before performing any disconnections in order to avoid possible contamination in the system:

- *The fuel pipe connections*
- *The hose connections*
- *The areas surrounding the connections*

1. Relieve the fuel system pressure. Fuel Pressure Relief
2. Disconnect the quick connect coupling of the fuel feed hose from the fuel feed pipe of the fuel rail. Use a shop towel in order to catch any remaining fuel that may leak.
3. Install the **CH-42982** adapter (2) between the fuel feed pipe of the fuel rail and of the fuel feed hose.

cardiagn.com

Fig 1: Gauge And Adapter



Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

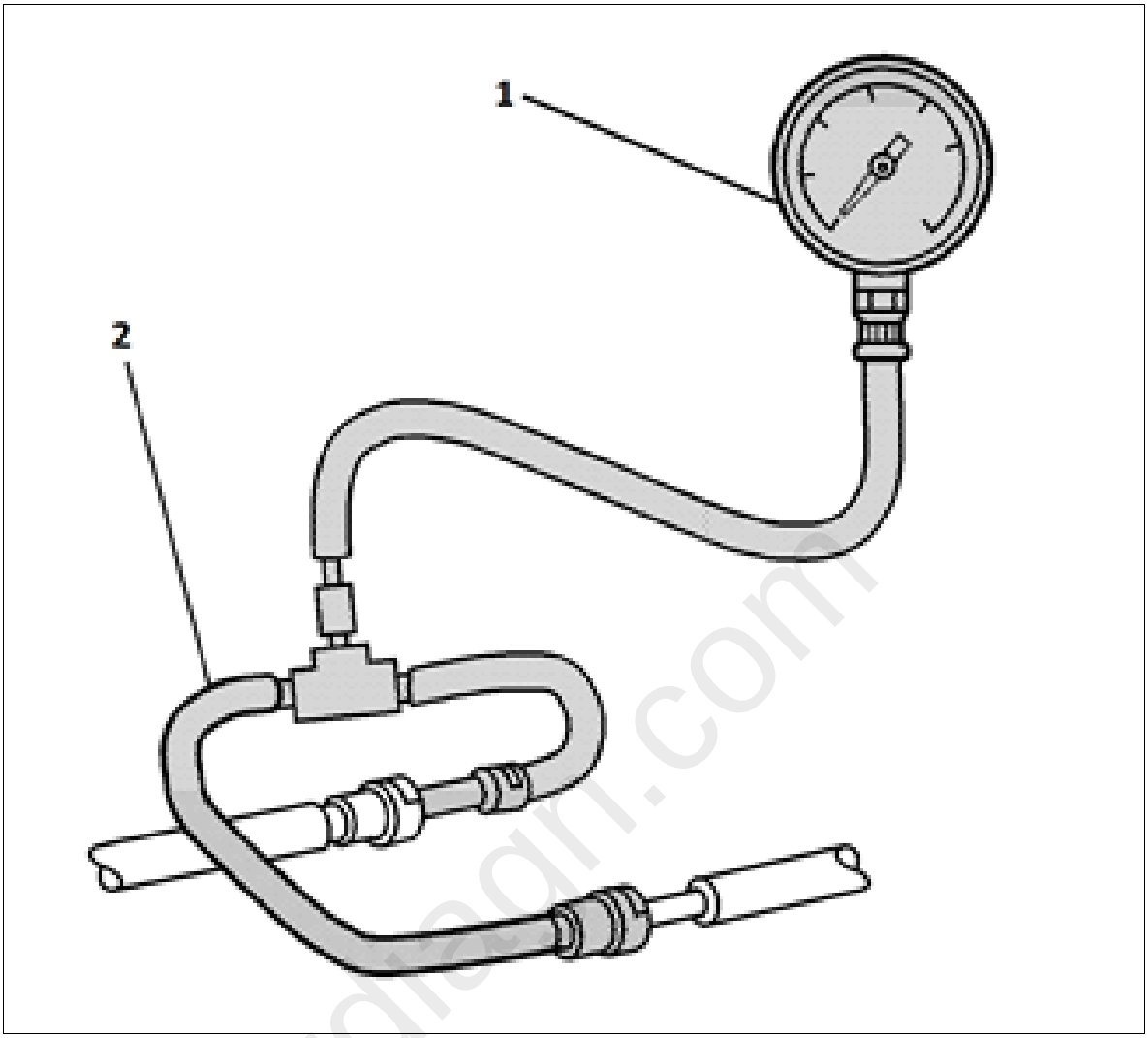
⚠ *CAUTION:*

Refer to Component Fastener Tightening Caution .

4. Install the **CH-37287-1A** gauge (1) to the **CH-42982** adapter (2), and tighten securely.
5. Turn ON the ignition in order to pressurize the fuel system.
6. Turn OFF the ignition.
7. Check for any fuel leaks.

REPAIR INSTRUCTIONS > FUEL PRESSURE GAUGE INSTALLATION AND REMOVAL > REMOVAL PROCEDURE

Fig 1: Gauge And Adapter



Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

1. Relieve the fuel system pressure. Fuel Pressure Relief
2. Remove the **CH-37287-1A** gauge (1) from the **CH-42982** adapter (2).
3. Using the **CH-47831** tool, disconnect the quick connect coupling of the **CH-42982** adapter from the fuel feed pipe of the fuel rail. Use a shop towel in order to catch any remaining fuel that may leak.
4. Disconnect the quick connect coupling of the fuel feed hose from the **CH-42982** adapter (2), and remove the adapter. Use a shop towel in order to catch any remaining fuel that may leak.
5. Connect the quick-connect fitting of the fuel feed hose to the fuel feed pipe of the fuel rail.
6. Turn ON the ignition in order to pressurize the fuel system.
7. Turn OFF the ignition.
8. Check for any fuel leaks.

REPAIR INSTRUCTIONS > METAL COLLAR QUICK CONNECT FITTING SERVICE

Special Tools

- **CH-41769** Fuel Line Disconnect Tool Set
- **CH-44581** Fuel Line Disconnect Tool

For equivalent regional tools, refer to Special Tools (Diagnostic Tools)Special Tools (Mechanical Tools) .

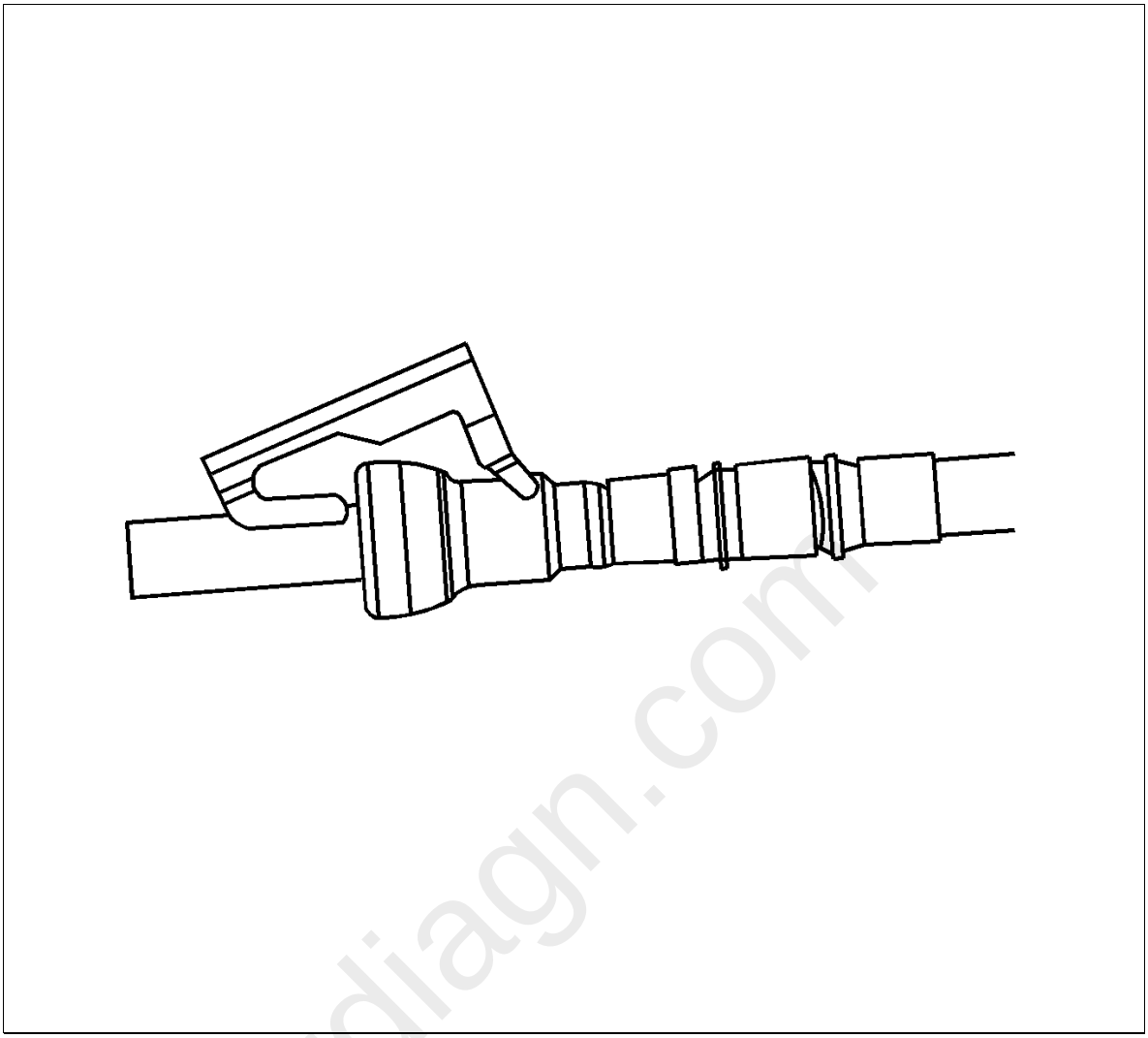
REPAIR INSTRUCTIONS > METAL COLLAR QUICK CONNECT FITTING SERVICE > REMOVAL PROCEDURE

> *WARNING:*
>
> *Refer to Gasoline/Gasoline Vapors Warning .*

1. Relieve the fuel system pressure. Fuel Pressure Relief

cardiagn.com

Fig 1: Quick-Connect Fitting Retainer

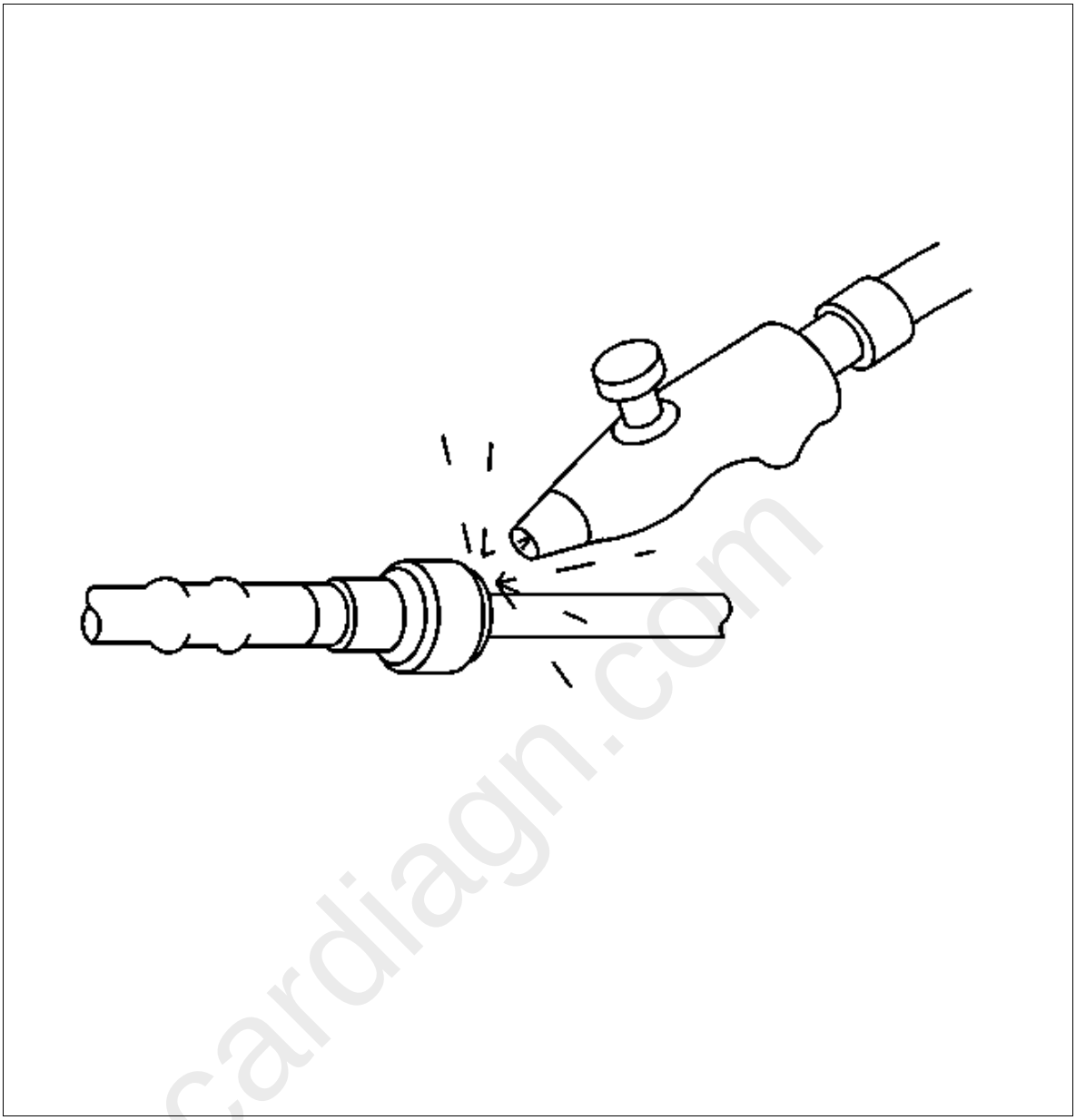


Courtesy of GENERAL MOTORS COMPANY

2. Remove the retainer from the quick-connect fitting.

cardiagn.com

Fig 2: Blowing Dirt Out Of Fitting (Metal Collar)



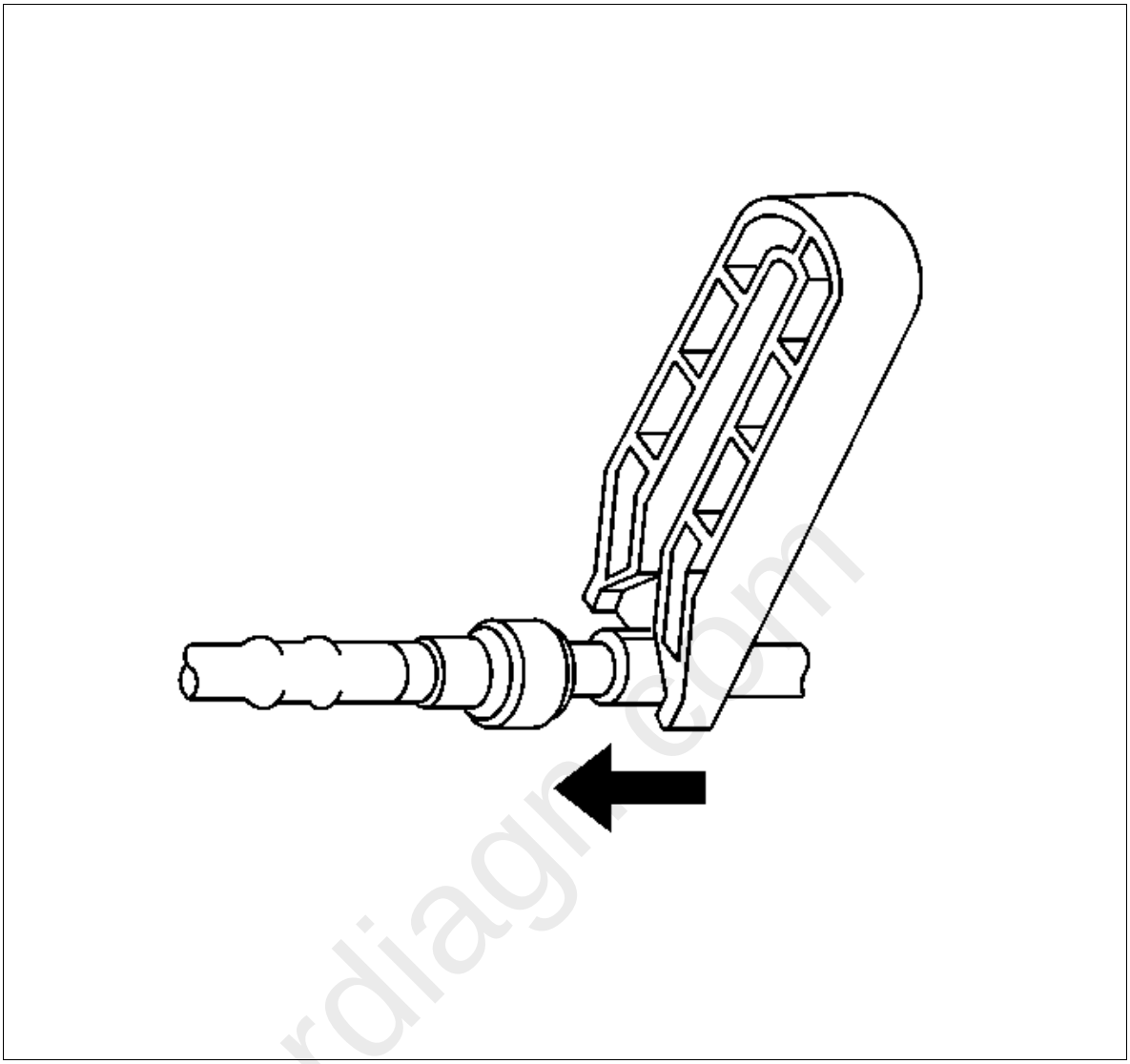
cardiagn.com

Courtesy of GENERAL MOTORS COMPANY

> *WARNING:*
>
> *Wear safety glasses when using compressed air, as flying dirt particles may cause eye injury.*

3. Blow dirt out of the fitting using compressed air.

Fig 3: Quick Connect Locking Tabs (Metal Collar)

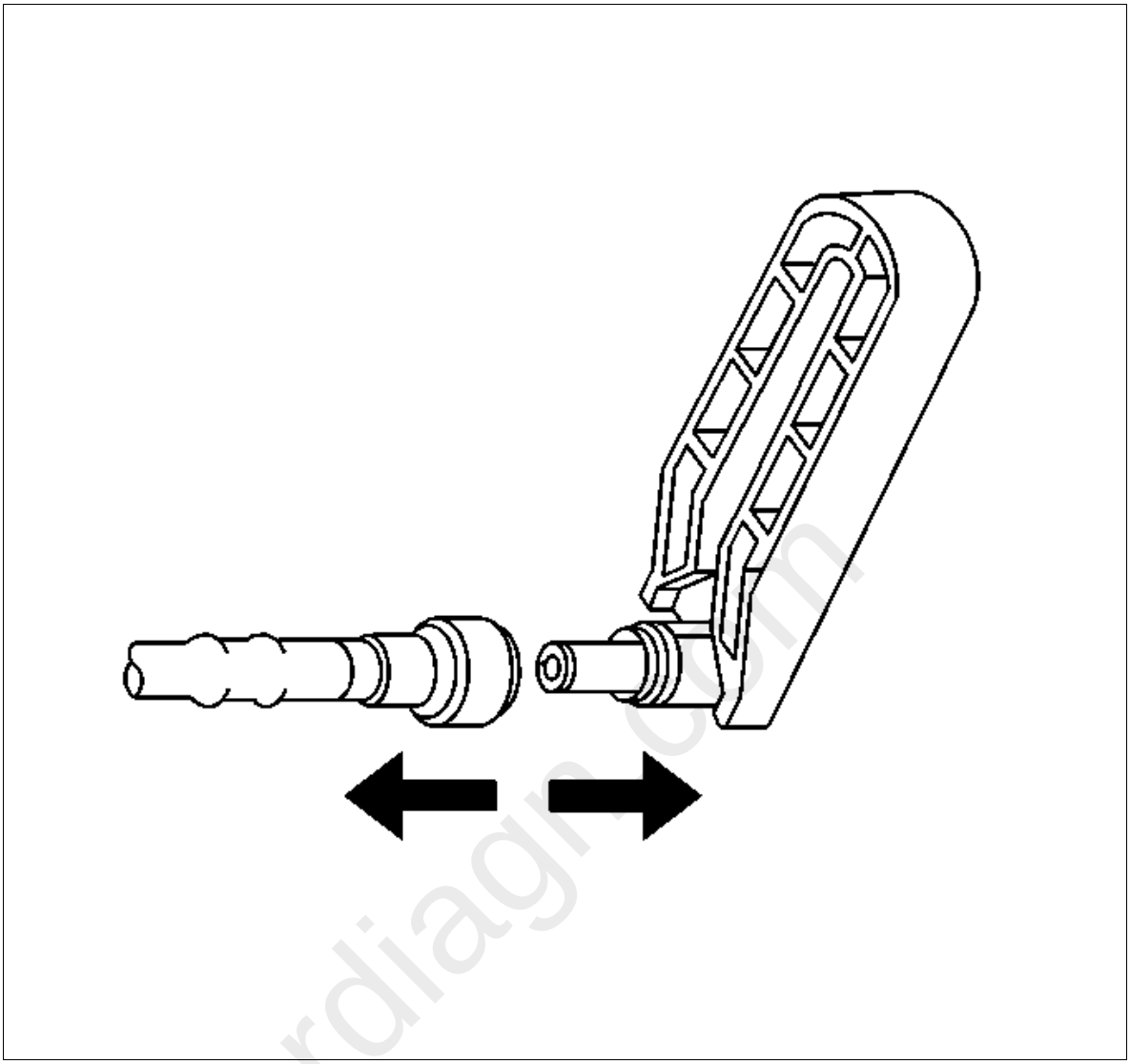


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

4. Depending on the fuel line size and ability to access the fitting, choose the appropriate tool: **CH-41769** fuel line disconnect tool set or **CH-44581** fuel line disconnect tool. Insert the **CH-41769** fuel line disconnect tool set or **CH-44581** fuel line disconnect tool into the female connector, then push inward to release the locking tabs.

Fig 4: Quick Connect Locking Tabs (Metal Collar)



Courtesy of GENERAL MOTORS COMPANY

5. Pull the connection apart.

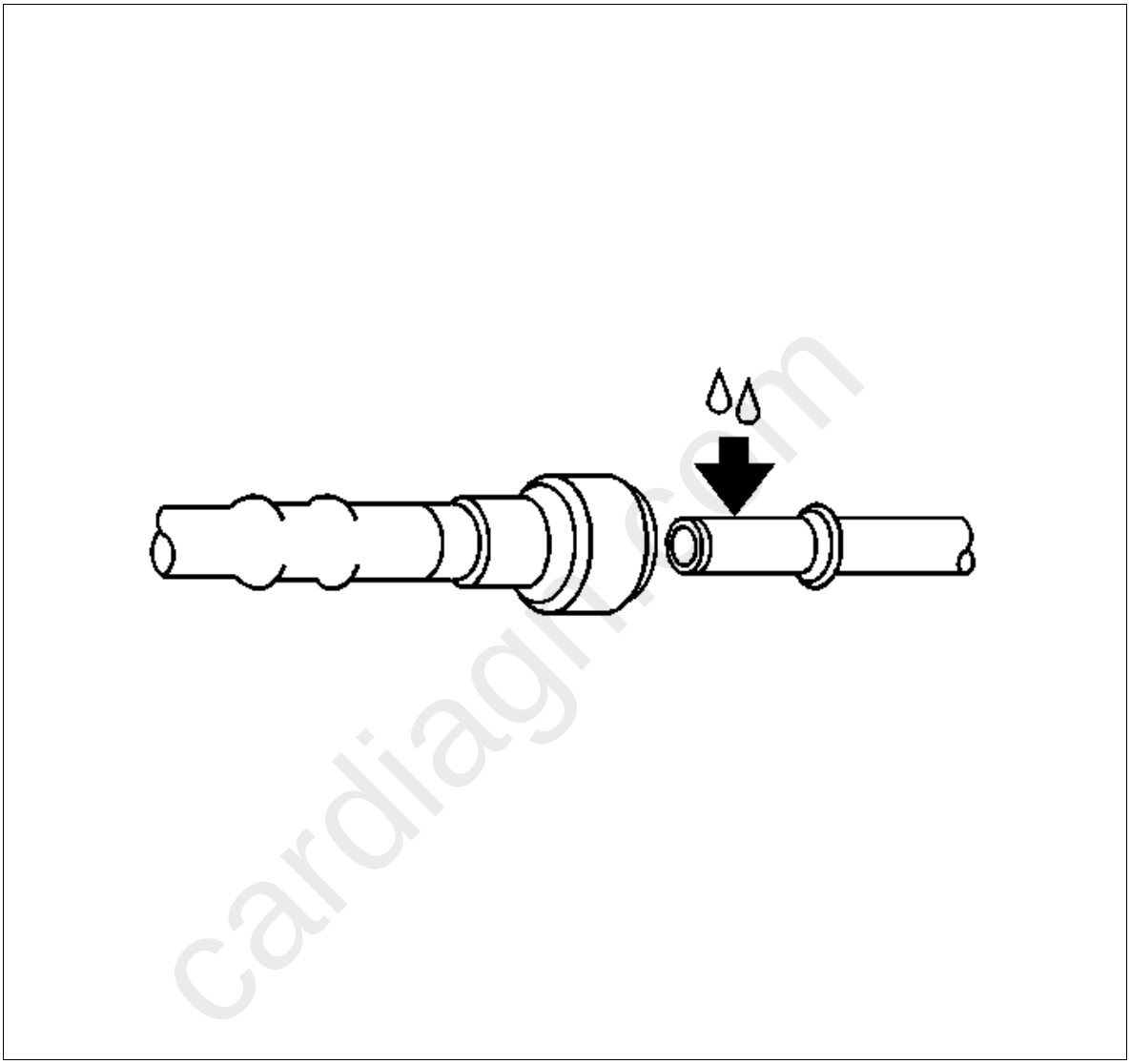
> ⚠ *CAUTION:*
>
> *If necessary, remove rust or burrs from the fuel pipes with an emery cloth. Use a radial motion with the fuel pipe end in order to prevent damage to the O-ring sealing surface. Use a clean shop towel in order to wipe off the male tube ends. Inspect all the connections for dirt and burrs. Clean or replace the components and assemblies as required.*

6. Using a clean shop towel, wipe off the male pipe end.
7. Inspect both ends of the fitting for dirt and burrs.
8. Clean or replace the components as required.

cardiagn.com

REPAIR INSTRUCTIONS > METAL COLLAR QUICK CONNECT FITTING SERVICE > INSTALLATION PROCEDURE

Fig 1: Oiling Male Pipe Ends (Metal Collar)



cardiagn.com

Courtesy of GENERAL MOTORS COMPANY

WARNING:

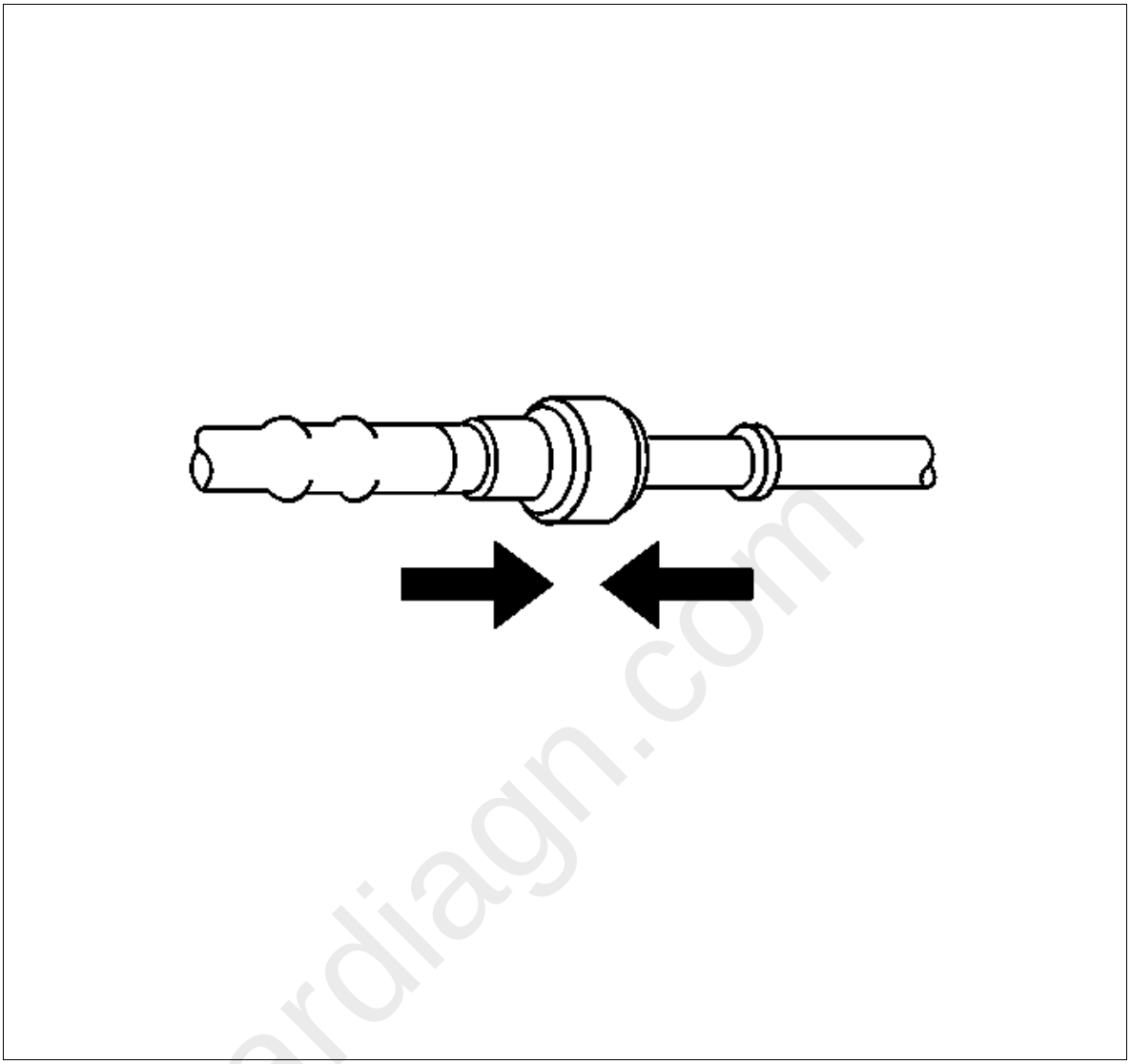
In order to reduce the risk of fire and personal injury, before connecting fuel pipe fittings, always apply a few drops of clean engine oil to the male pipe ends.

This will ensure proper reconnection and prevent a possible fuel leak.

During normal operation, the O-rings located in the female connector will swell and may prevent proper reconnection if not lubricated.

1. Apply a few drops of clean engine oil to the male pipe end.

Fig 2: Connectors (Metal Collar)

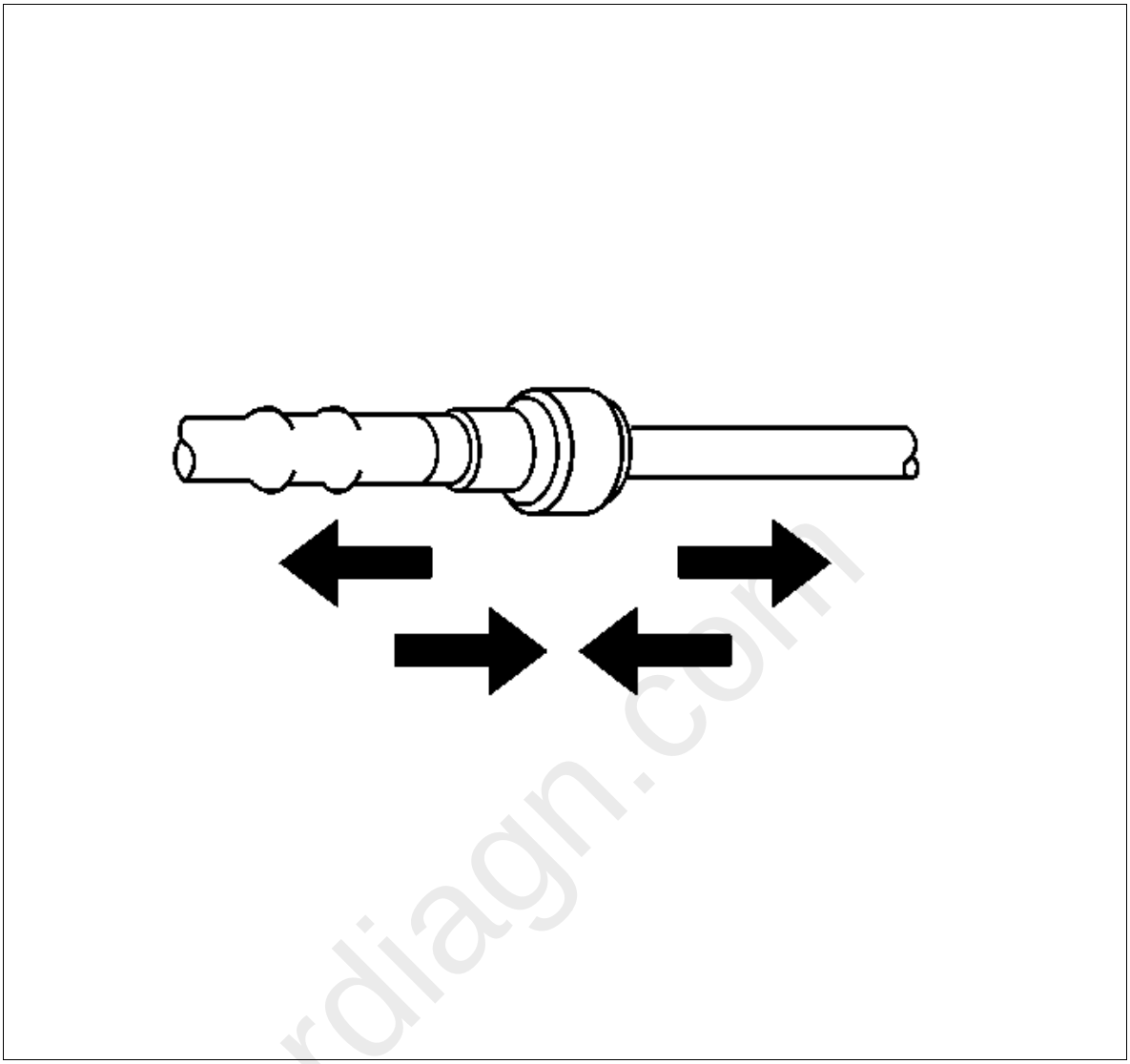


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

2. Push both sides of the quick-connect fitting together to cause the retaining tabs to snap into place.

Fig 3: Connection (Metal Collar) Is Secure

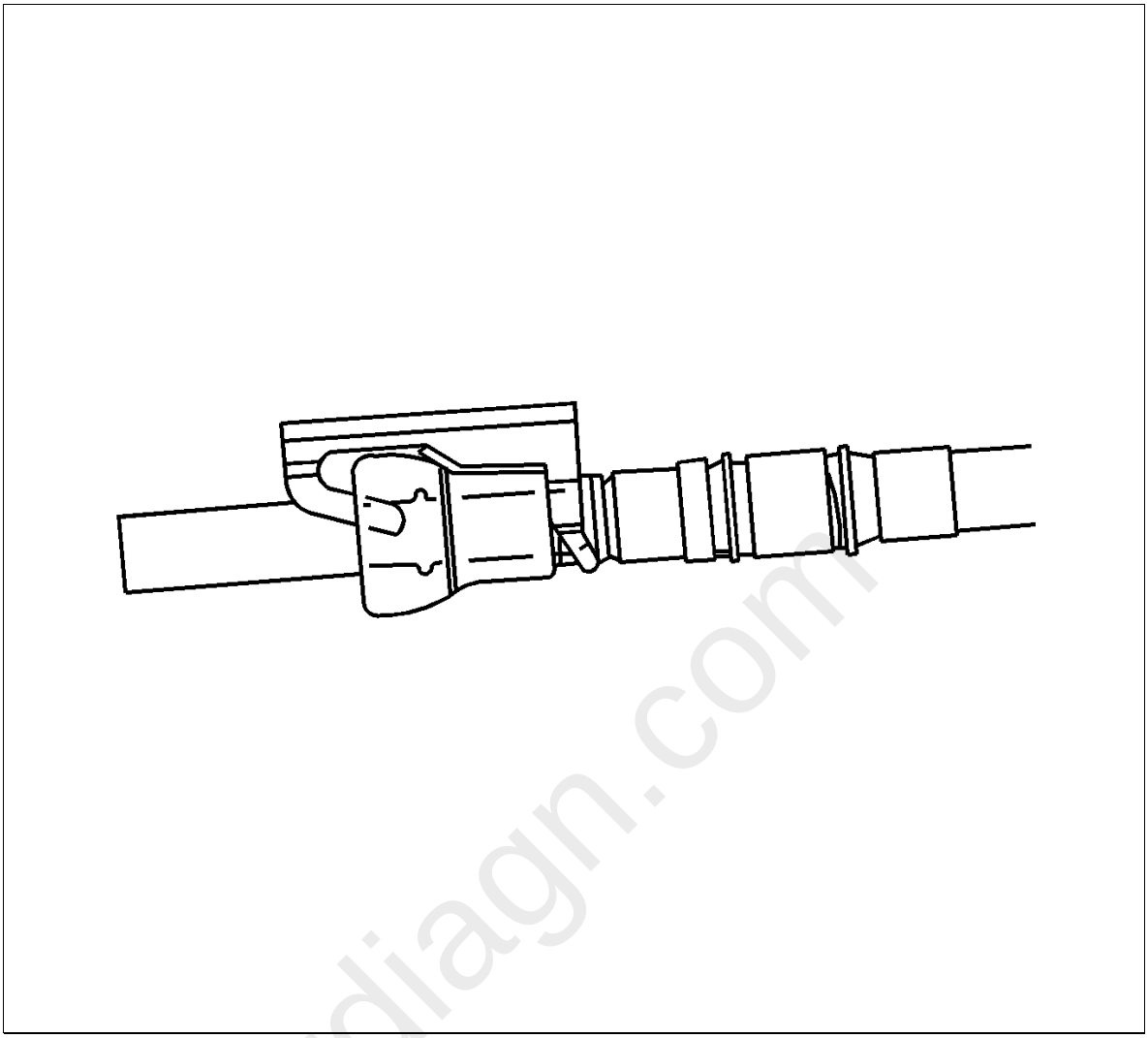


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

3. Pull on both sides of the quick-connect fitting to make sure the connection is secure.

Fig 4: Fuel Pipe Retainer



Courtesy of GENERAL MOTORS COMPANY

4. Install the retainer to the quick-connect fitting.
5. Inspect for leaks using the following procedure:
    1. Turn the ignition ON, with the engine OFF for 2 seconds.
    2. Turn the ignition OFF, for 10 seconds.
    3. Turn the ignition ON, with the engine OFF for 2 seconds.
    4. Turn the ignition OFF.
    5. Inspect for leaks.

REPAIR INSTRUCTIONS > PLASTIC COLLAR QUICK CONNECT FITTING SERVICE > REMOVAL PROCEDURE

cardiagn.com

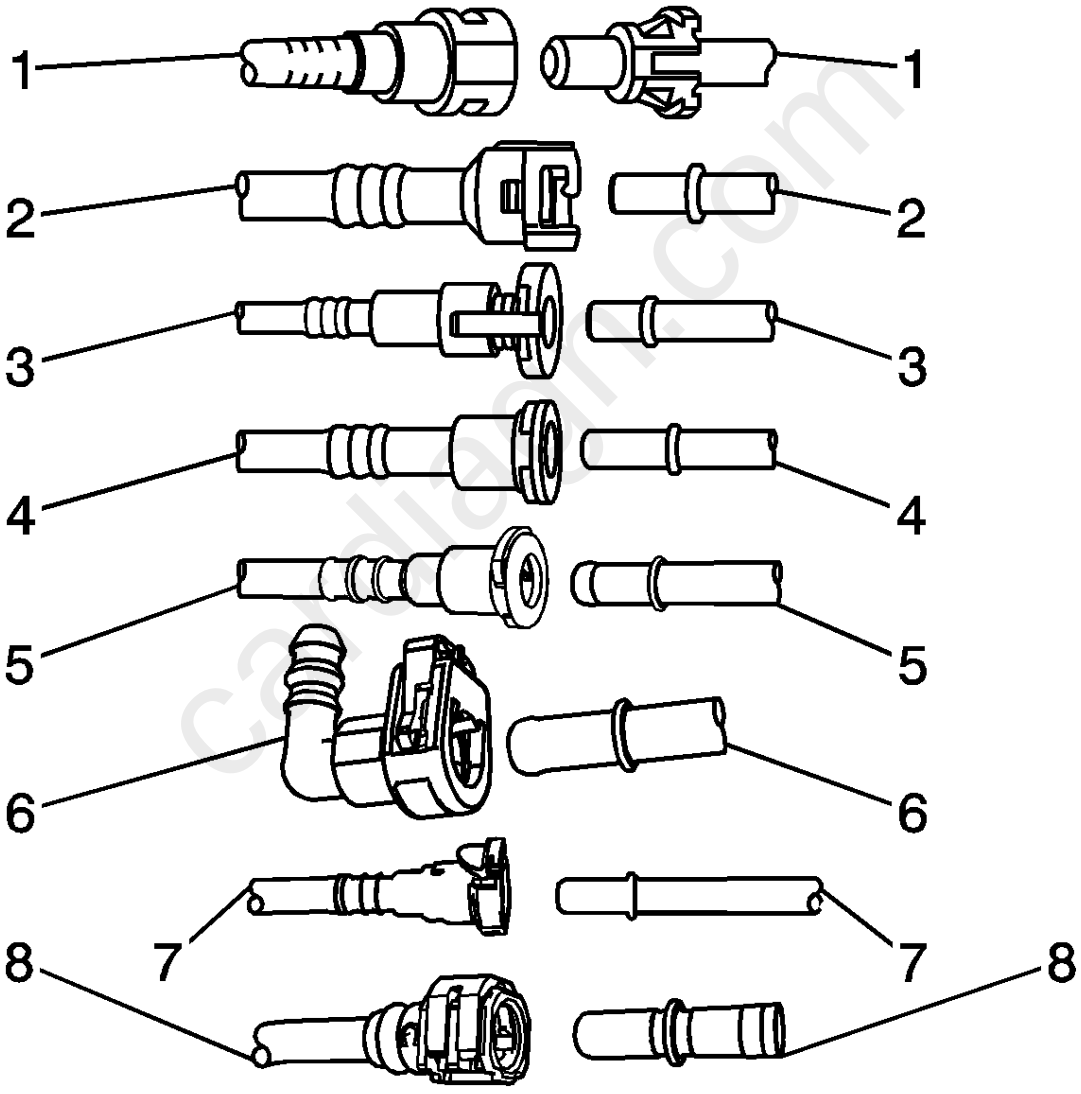
WARNING:

Refer to Gasoline/Gasoline Vapors Warning .

NOTE:

If servicing a fuel system, insure the fuel pressure has been relieved.

Fig 1: Plastic Collar Quick Connect Fitting Service



Courtesy of GENERAL MOTORS COMPANY

NOTE:

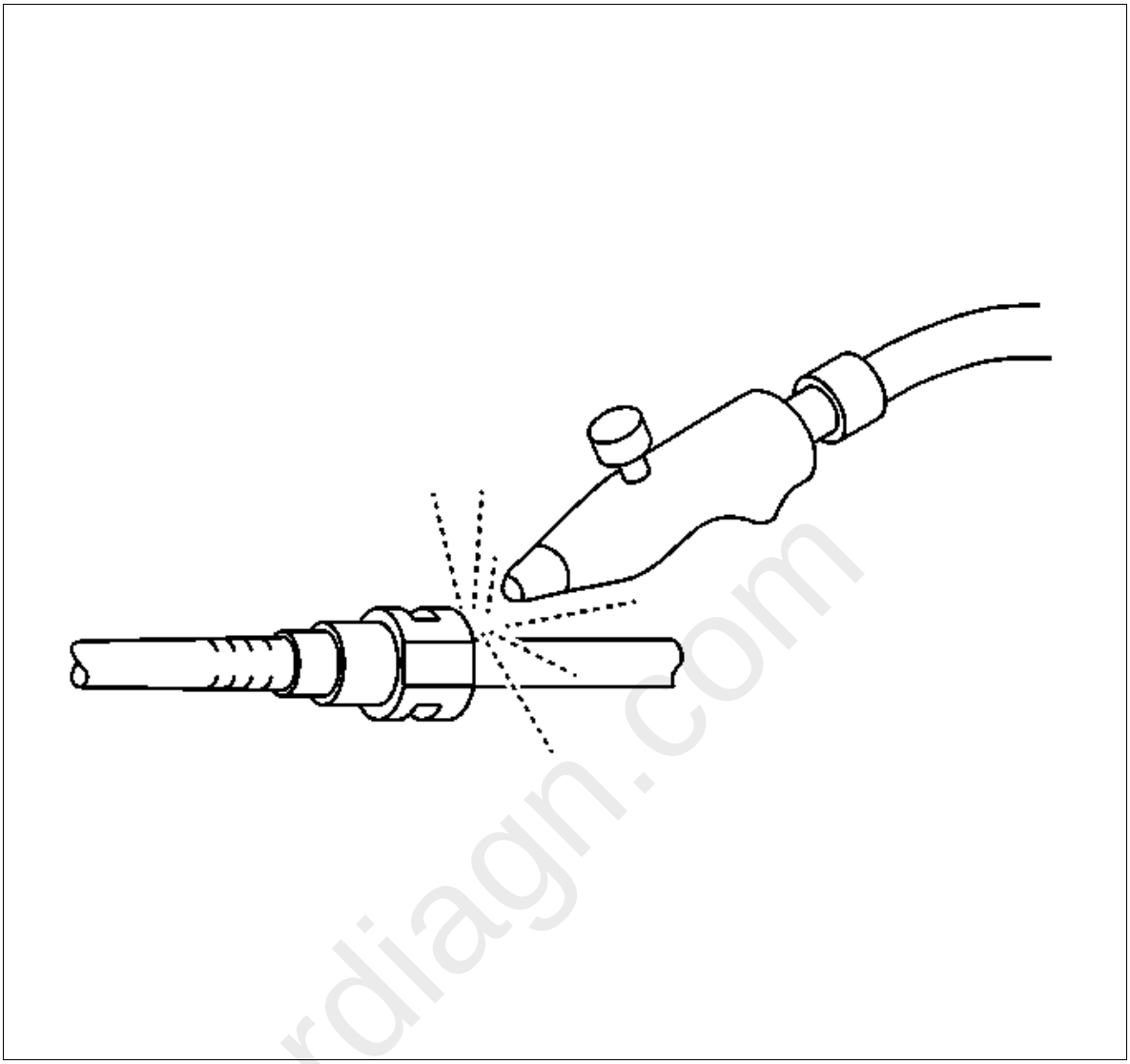
There are several types of plastic collar fuel and evaporative emission quick connect fittings used on this vehicle.

- *Bartholomew (1)*
- *Q Release (2)*
- *Squeeze to Release (3)*
- *Sliding Retainer (4)*
- *Global Connect (5)*
- *TI Loc (6)*
- *Safe Lock (7)*
- *Plastic Connector (8)*

The following instructions apply to all of these types of plastic collar quick connect fittings except where indicated.

cardiagn.com

Fig 2: Blowing Dirt Out Of Fitting (Plastic Collar)



Courtesy of GENERAL MOTORS COMPANY

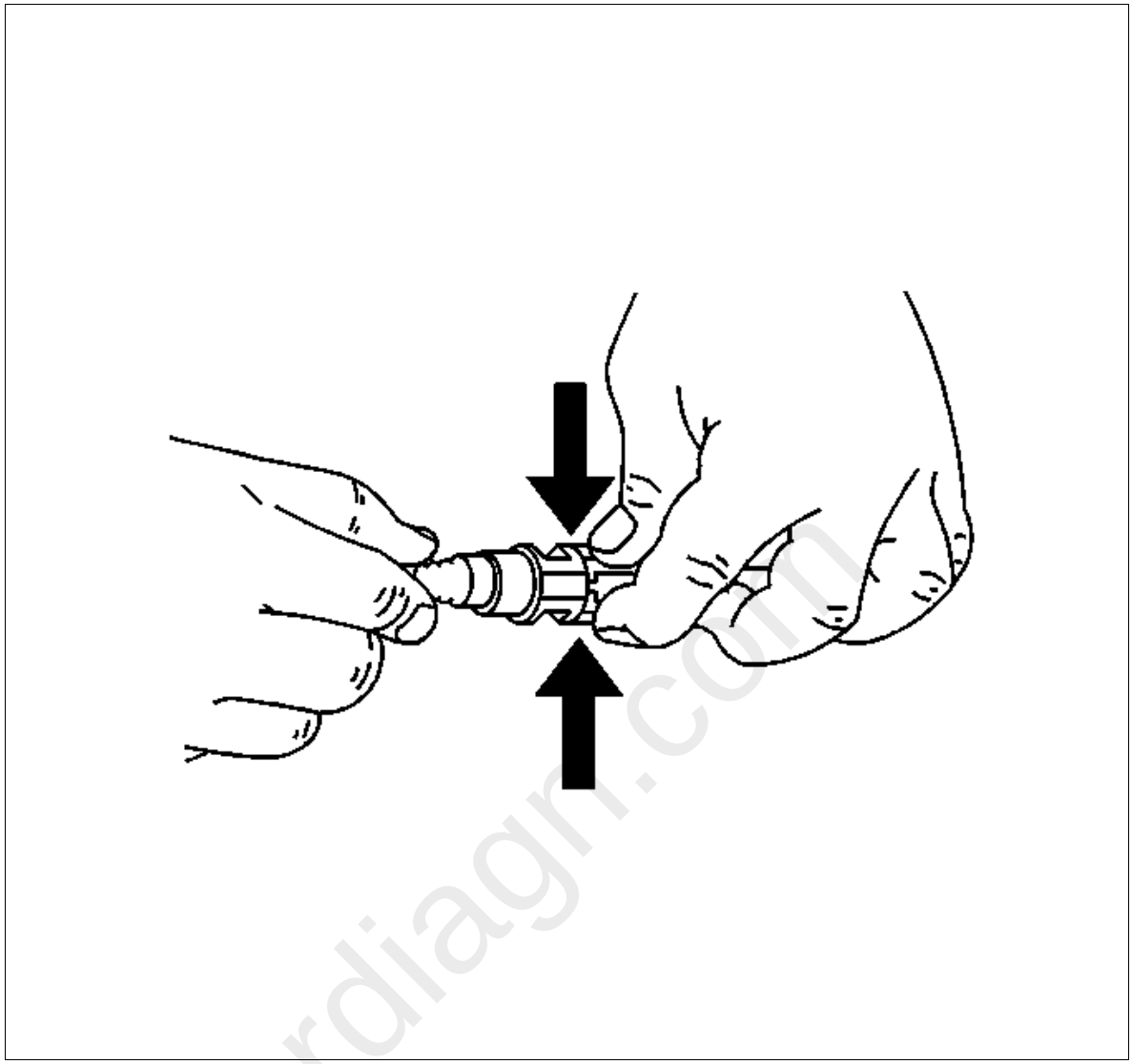
cardiagn.com

WARNING:

Always apply a few drops of clean engine oil to the male pipe ends before connecting the fuel pipe fittings. This will ensure proper reconnection and prevent a possible fuel leak. Always replace O-rings.

1. Using compressed air, blow any dirt out of the quick-connect fitting.

Fig 3: Quick Connect Fitting Release Tabs (Plastic Collar)

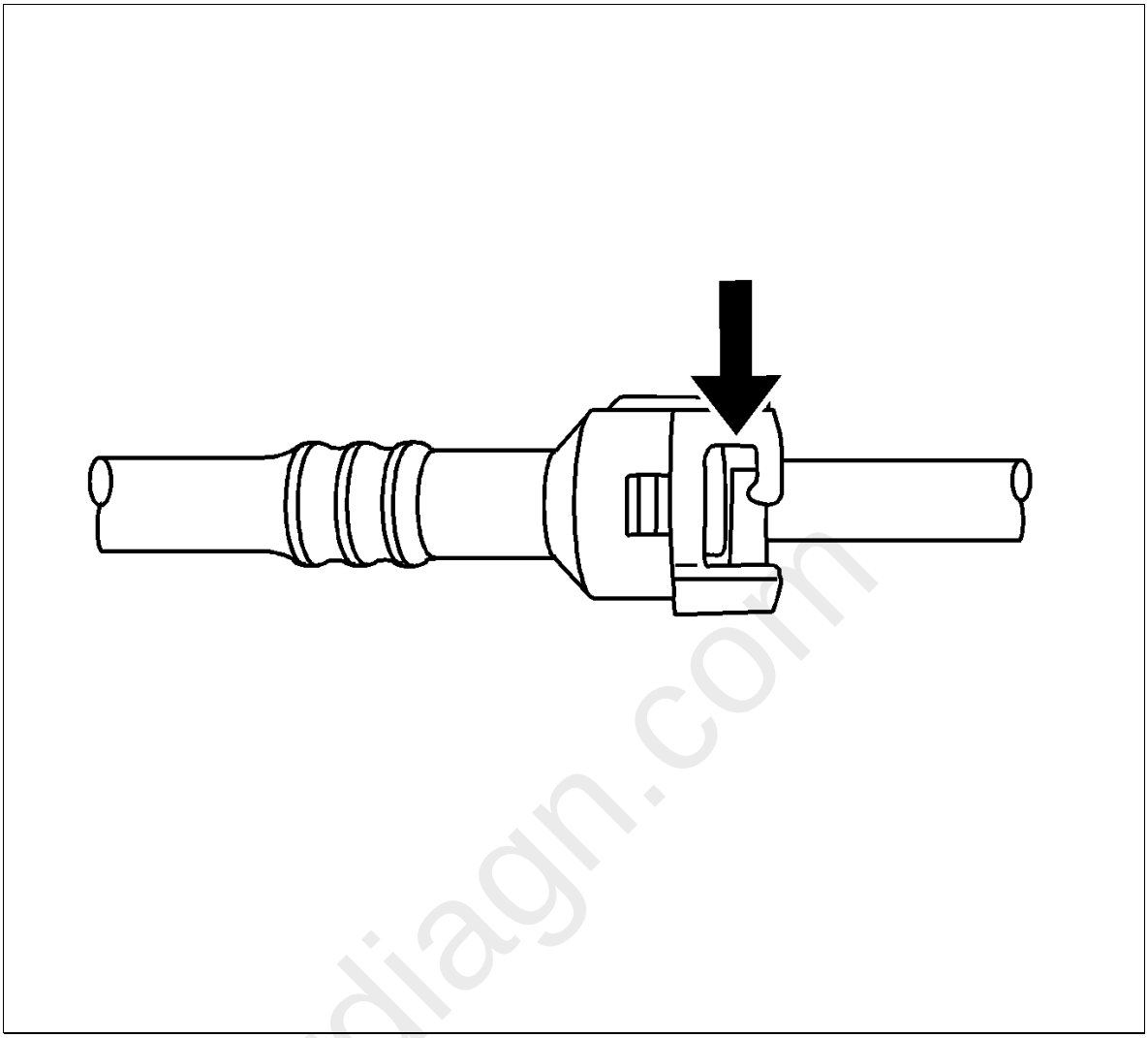


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

2. This step applies to Bartholomew style connectors ONLY. Squeeze the plastic quick-connect fitting release tabs.

Fig 4: Quick Release Style Connectors (Plastic Collar)

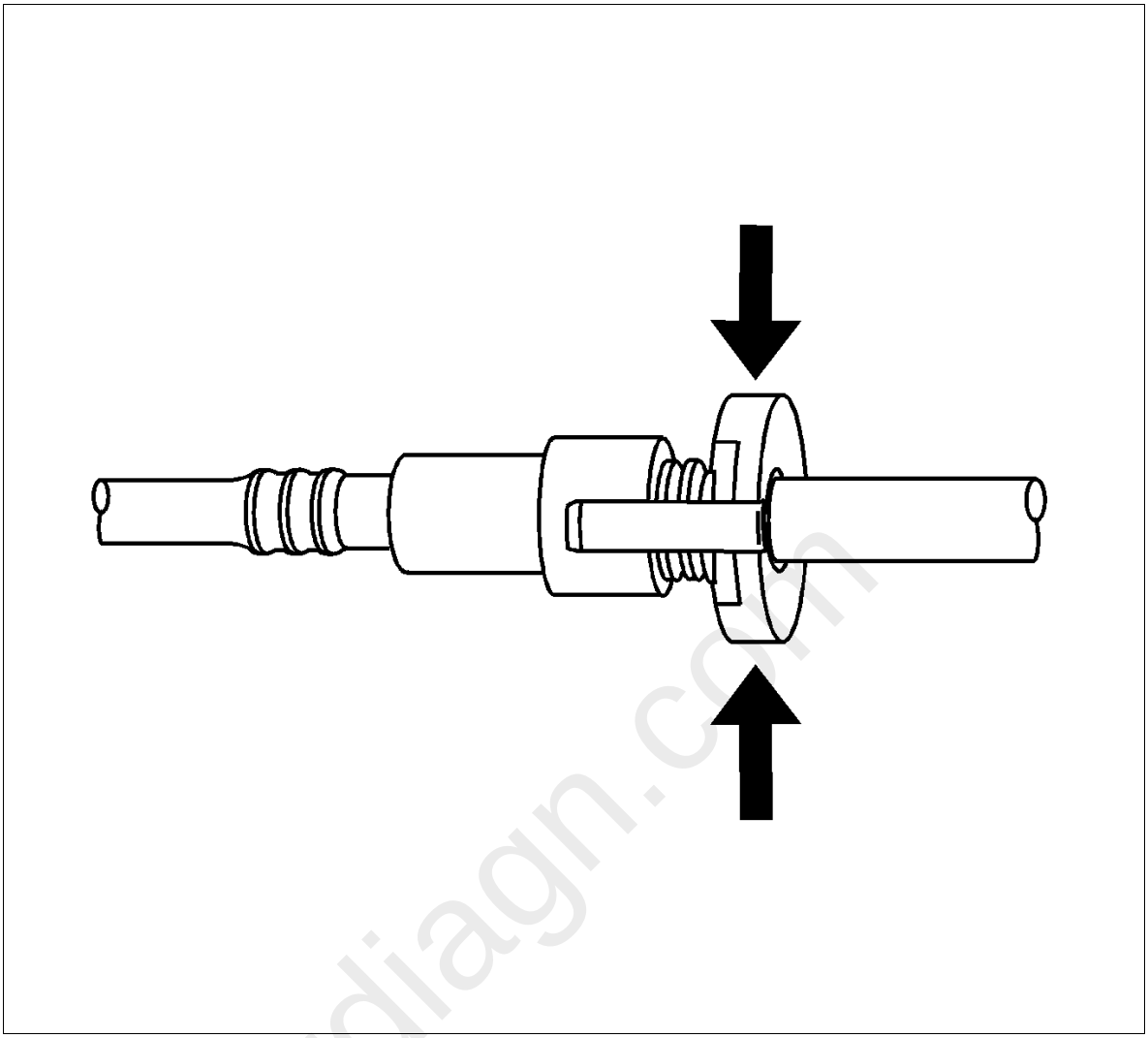


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

3. This step applies to Q Release style connectors ONLY. Release the fitting by Pushing the tab toward the other side of the slot in the fitting.

Fig 5: Quick Connect Fitting (Plastic Collar)

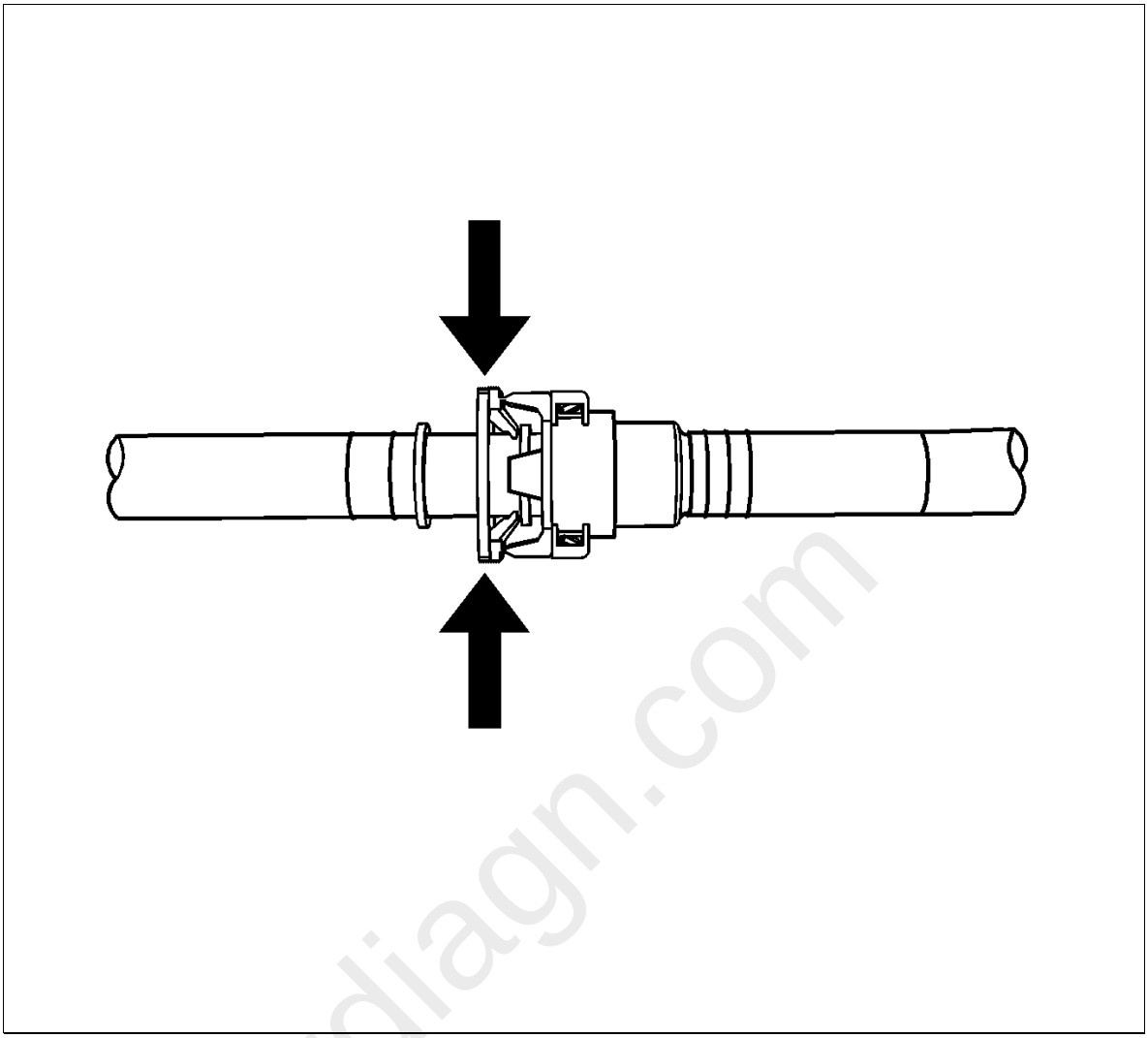


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

4. This step applies to Squeeze to Release style connectors ONLY. Squeeze where indicated by arrows on both sides of the plastic ring surrounding the quick-connect fitting.

Fig 6: Male Side Of Connector

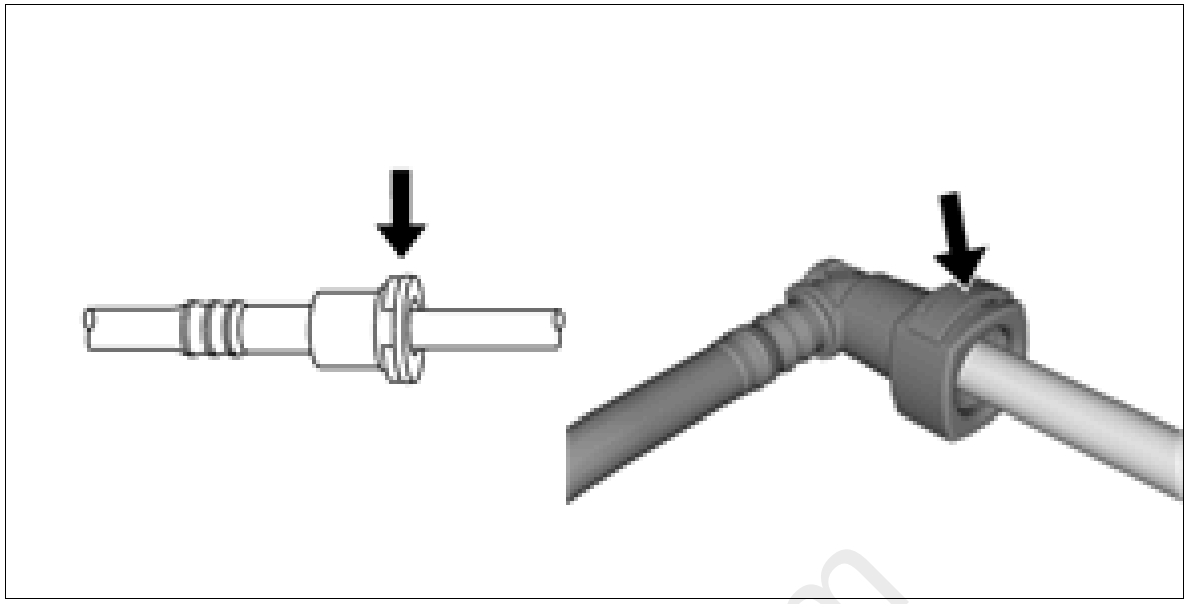


Courtesy of GENERAL MOTORS COMPANY

5. This step applies to Squeeze to Release style connectors ONLY. Push in the male side slightly in order to slide the retainer away from the retainers, squeeze where indicated by arrows on both sides of the plastic ring surrounding the quick-connect fitting.

cardiagn.com

Fig 7: Retainer Style Connectors



Courtesy of GENERAL MOTORS COMPANY

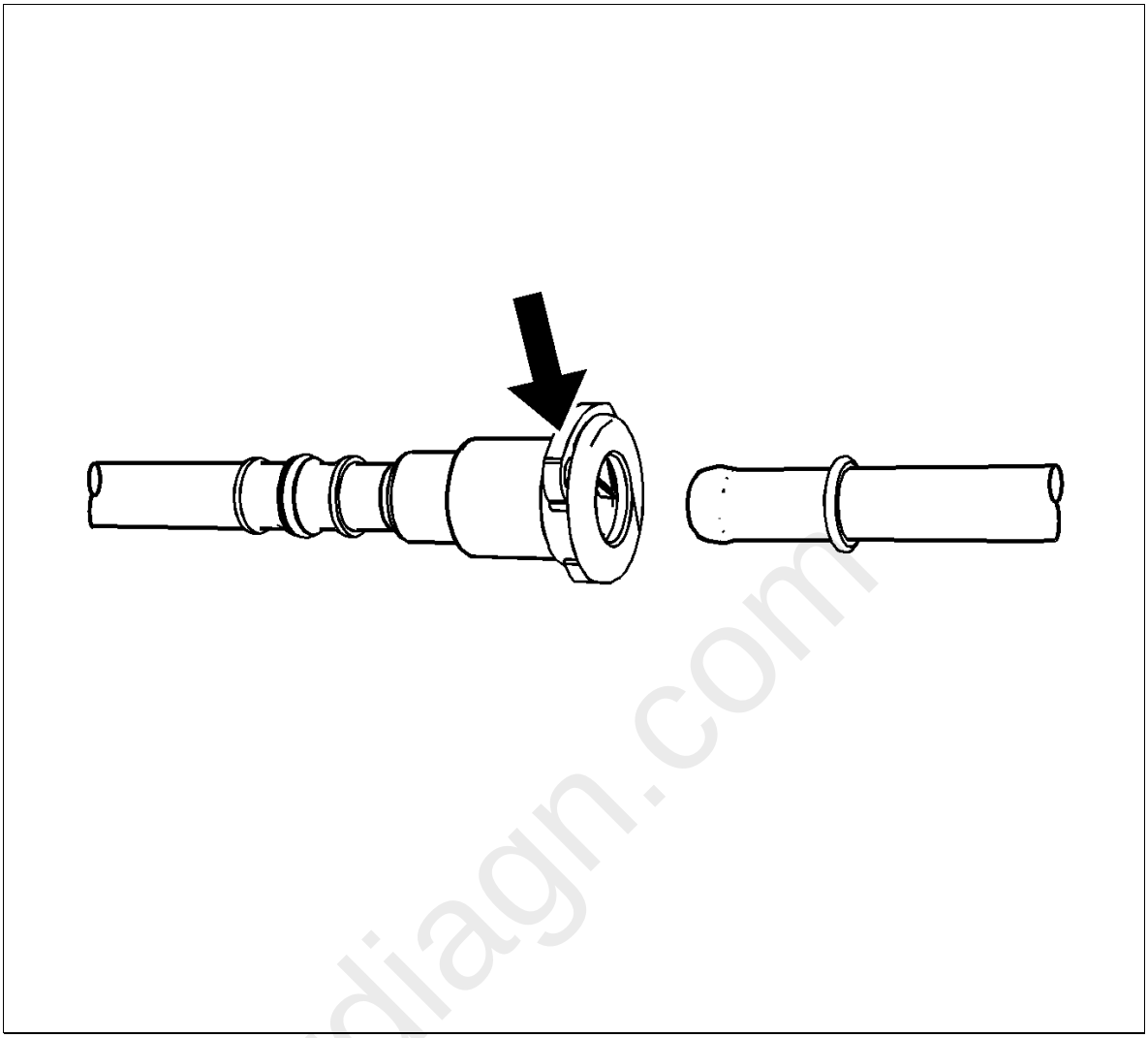
NOTE:

There are two variants of sliding retainer style connectors shown above, both have the same release and installation procedure.

6. This step applies to Sliding Retainer style connectors ONLY. Release the fitting by pressing on one side of the release tab causing it to push in slightly. If the tab doesn't move try pressing the tab in from the opposite side. The tab will only move in one direction.

cardiagn.com

Fig 8: Global Connector Style

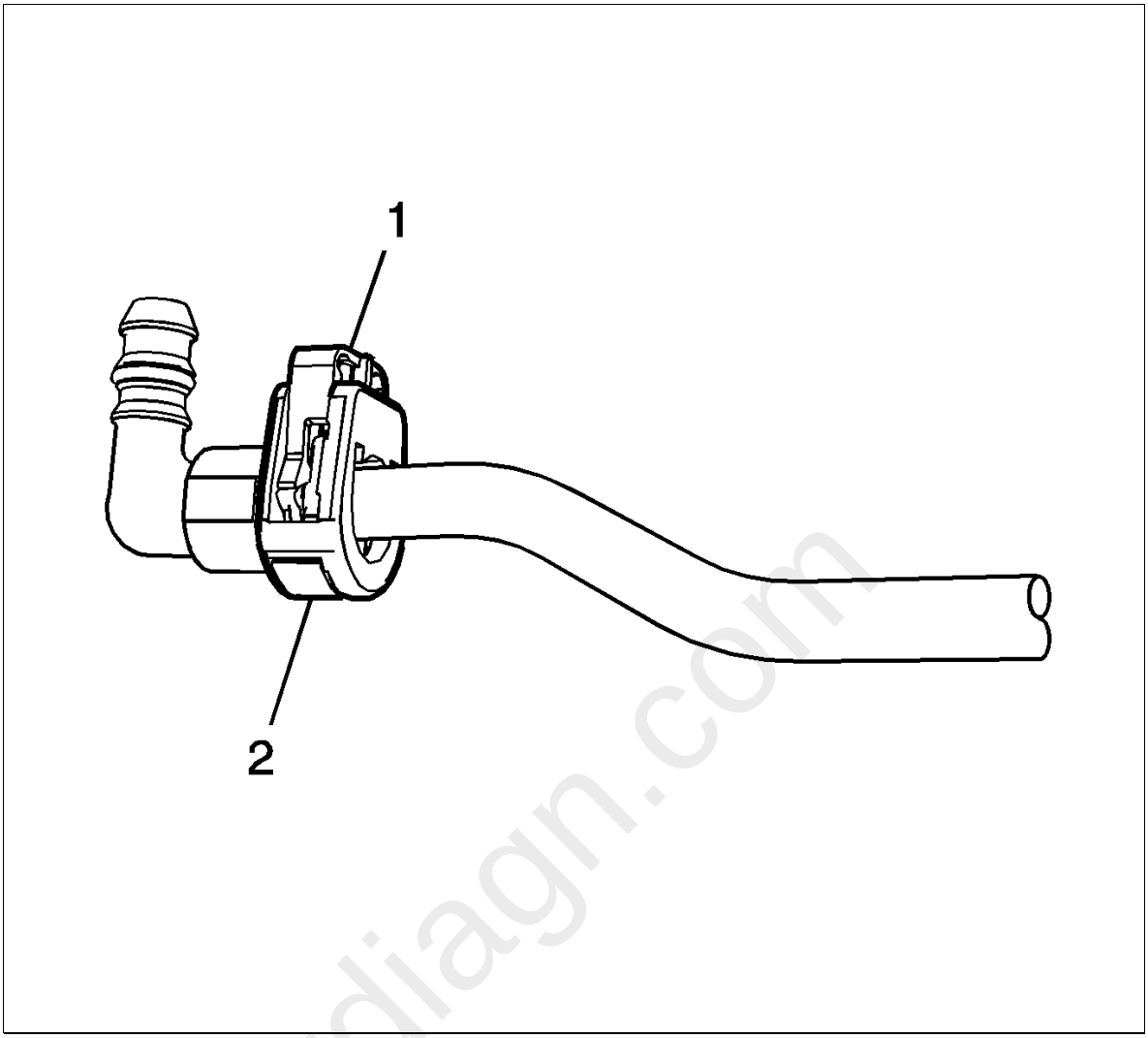


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

7. This step applies to the Global Connector style only. Push the connector toward the tube in order to release the pressure. Press and hold down the release mechanism, and pull the connector straight out.

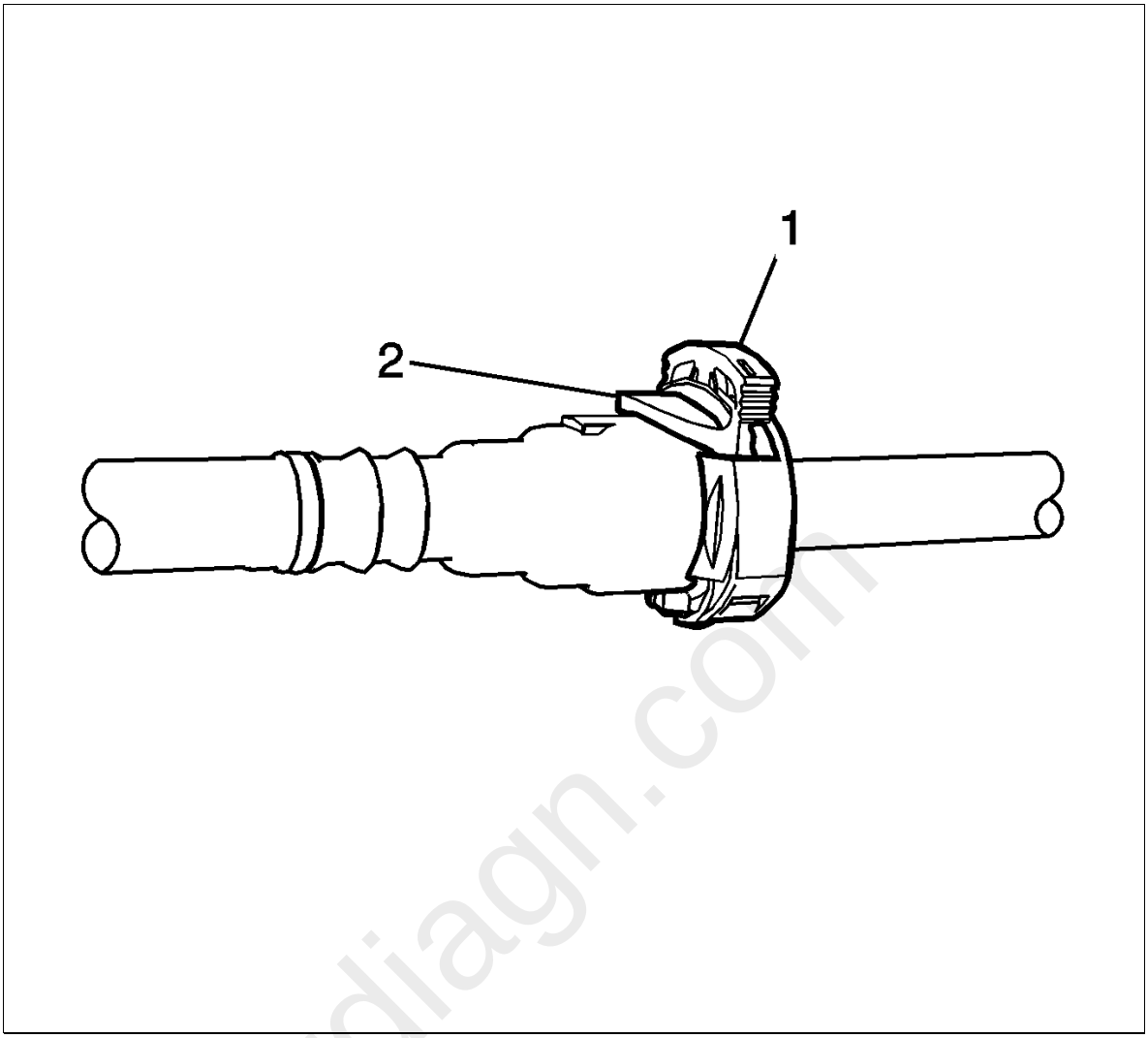
Fig 9: TI Loc style



Courtesy of GENERAL MOTORS COMPANY

8. This step applies to the TI Loc style only. Push the connector toward the tube in order to release the pressure. Release the redundant latch (1) with two fingers or a flat bladed tool. Then press and hold down the bottom release mechanism (2) and pull the connector straight out.

Fig 10: Safe Lock Style



Courtesy of GENERAL MOTORS COMPANY

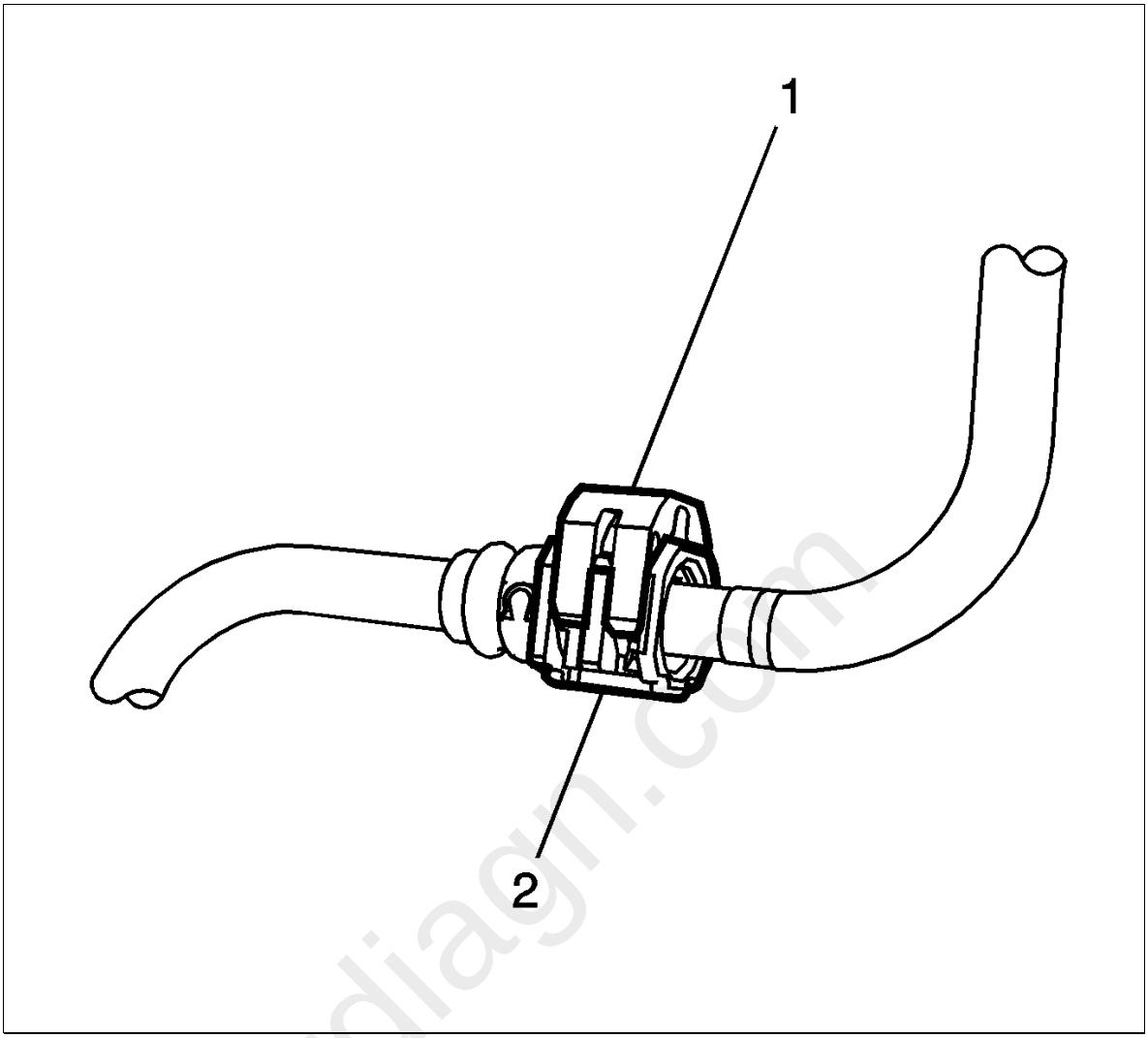
cardiagn.com

WARNING:

Refer to Relieving Fuel Pressure Warning .

9. This step applies to the Safe Lock style only. Push the connector toward the tube in order to release the pressure. Release the second latch (1) with two fingers. Then press and hold down the bottom release mechanism (2) and pull the connector straight out.

Fig 11: Latch And Connector Straight Out

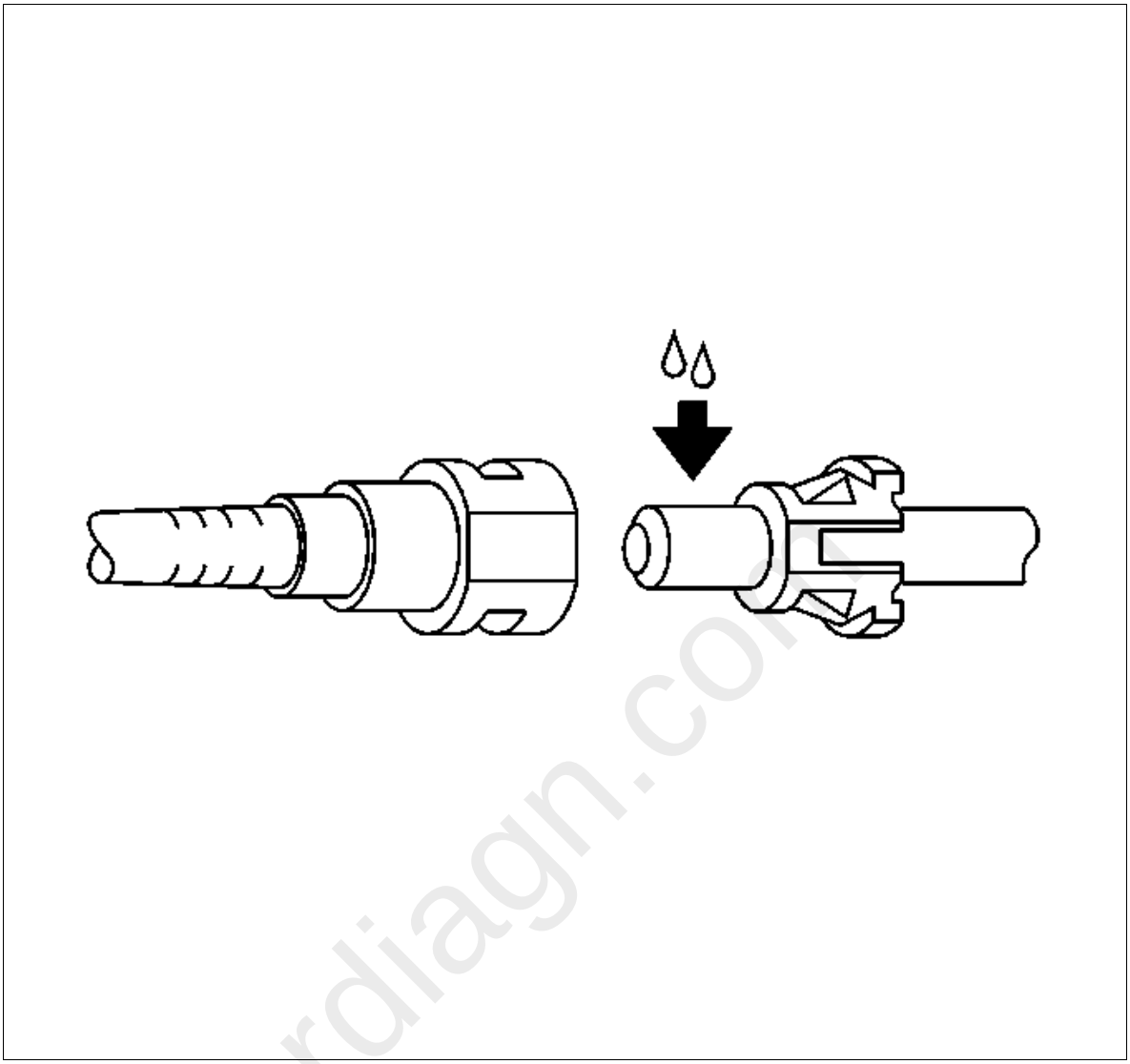


Courtesy of GENERAL MOTORS COMPANY

10. This step applies to the Plastic Connector style 8, push the connector toward the tube in order to release the pressure. Press the latch (1) inward in order to release the pipe, while pulling the connector (2) straight out.
11. Using a clean shop towel, wipe off the male pipe end.
12. Inspect both ends of the fitting for dirt and burrs.
13. Clean or replace components as necessary.

REPAIR INSTRUCTIONS > PLASTIC COLLAR QUICK CONNECT FITTING SERVICE > INSTALLATION PROCEDURE

Fig 1: Lubricating Male Pipe End



Courtesy of GENERAL MOTORS COMPANY

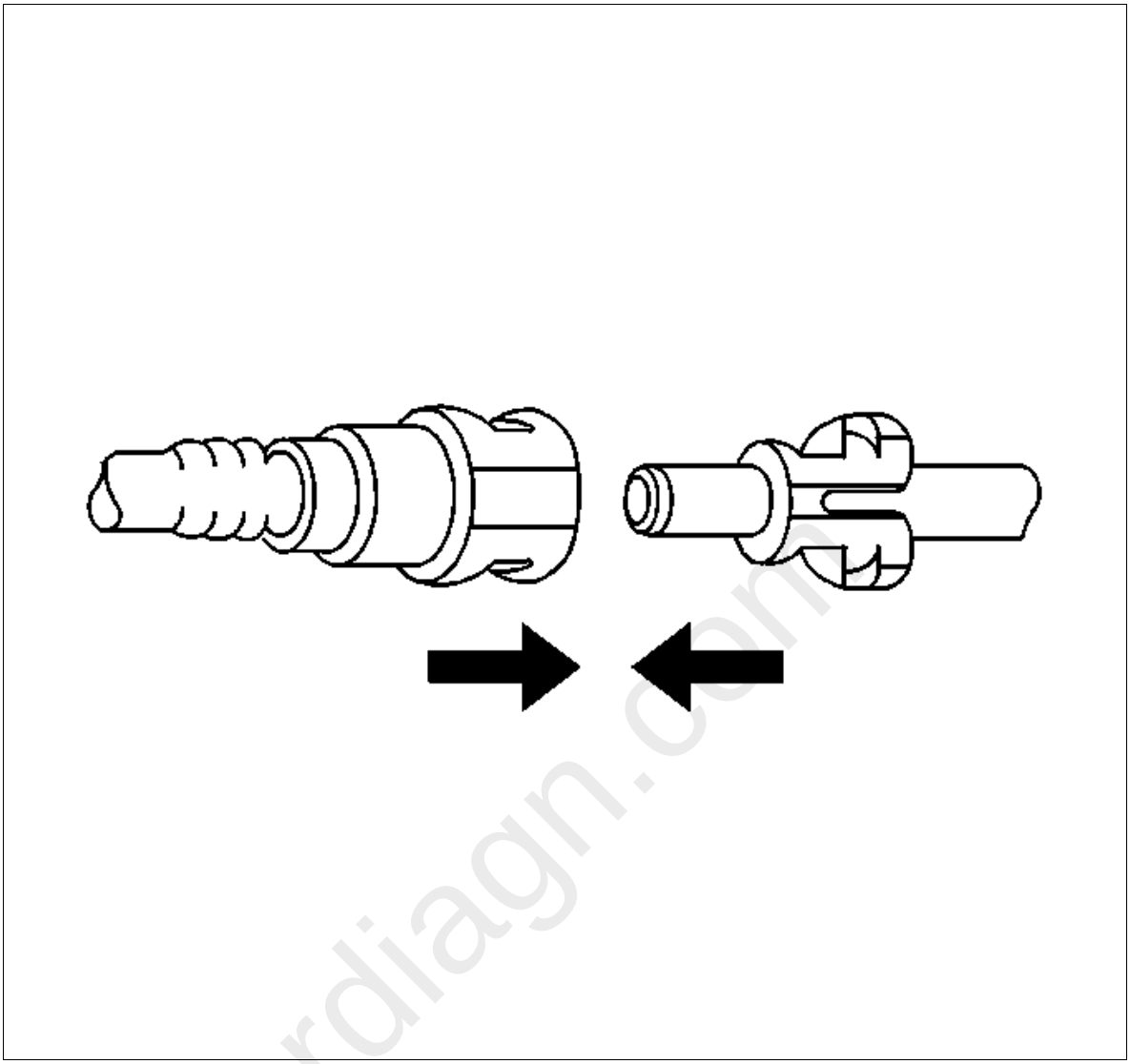
cardiagn.com

WARNING:

Always apply a few drops of clean engine oil to the male pipe ends before connecting the fuel pipe fittings. This will ensure proper reconnection and prevent a possible fuel leak. Always replace O-rings.

1. Apply a few drops of clean engine oil to the male pipe end.

Fig 2: Quick-Connect Fittings

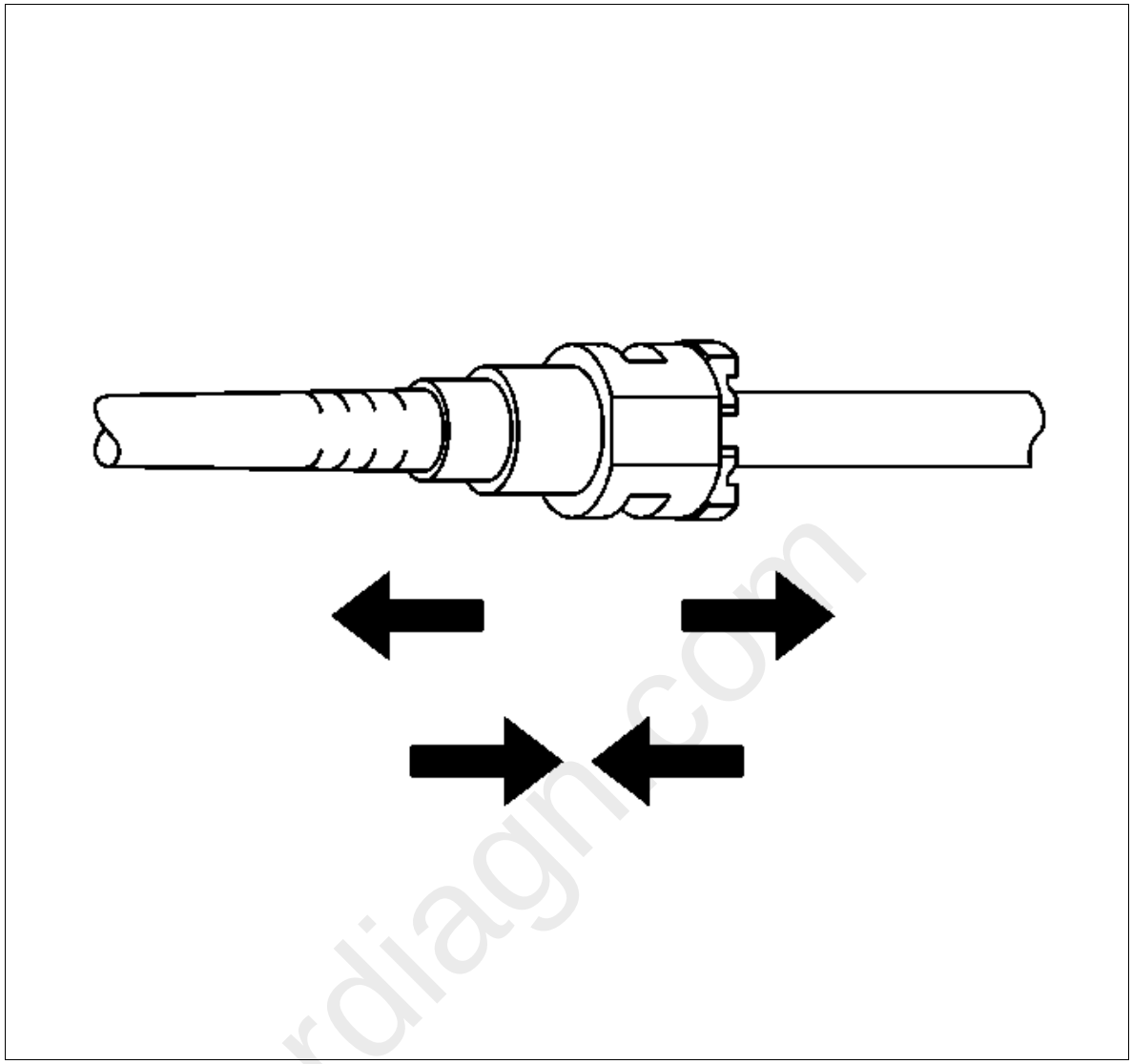


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

2. Push both sides of the quick-connect fitting together in order to cause the retaining feature to snap into place.

Fig 3: Quick-Connect Fitting

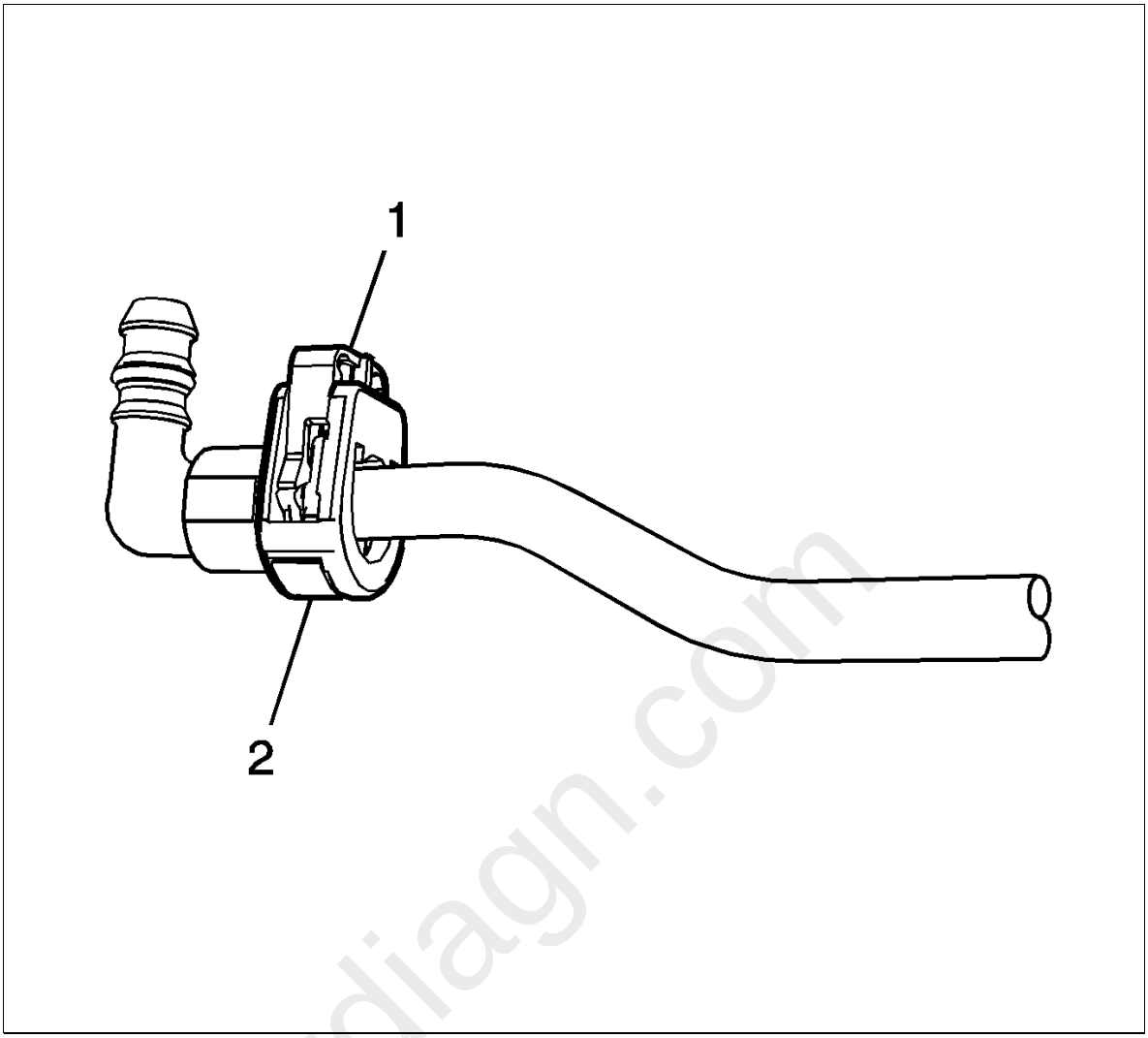


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

3. Pull on both sides of the quick-connect fitting to make sure the connection is secure.

Fig 4: TI Loc style

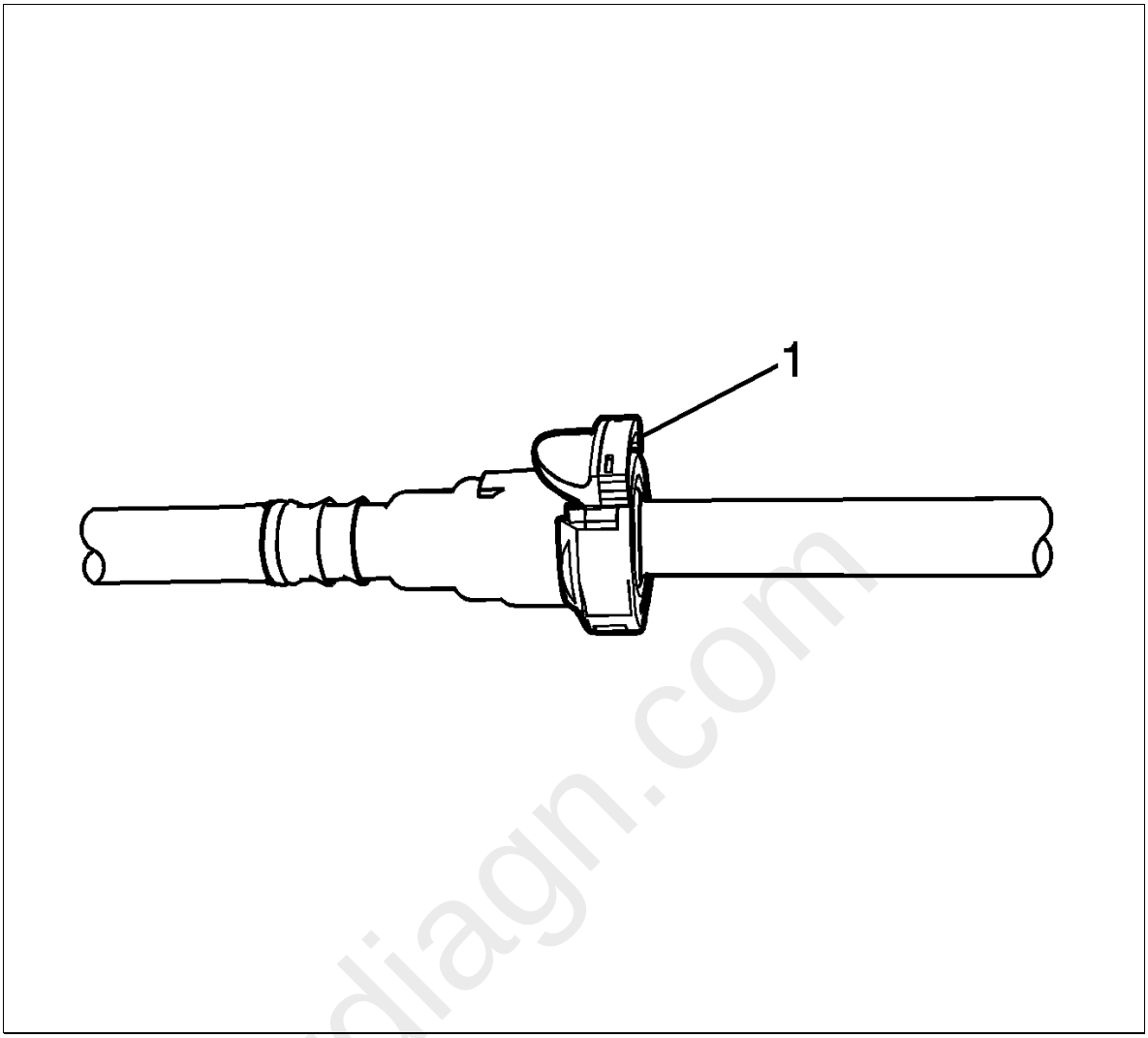


cardiagn.com

Courtesy of GENERAL MOTORS COMPANY

4. Insert the tube in the connector until the retainer snaps in place.
5. Push down on the redundant latch (1) until it is fully engaged and snapped into position.

Fig 5: Redundant Latch

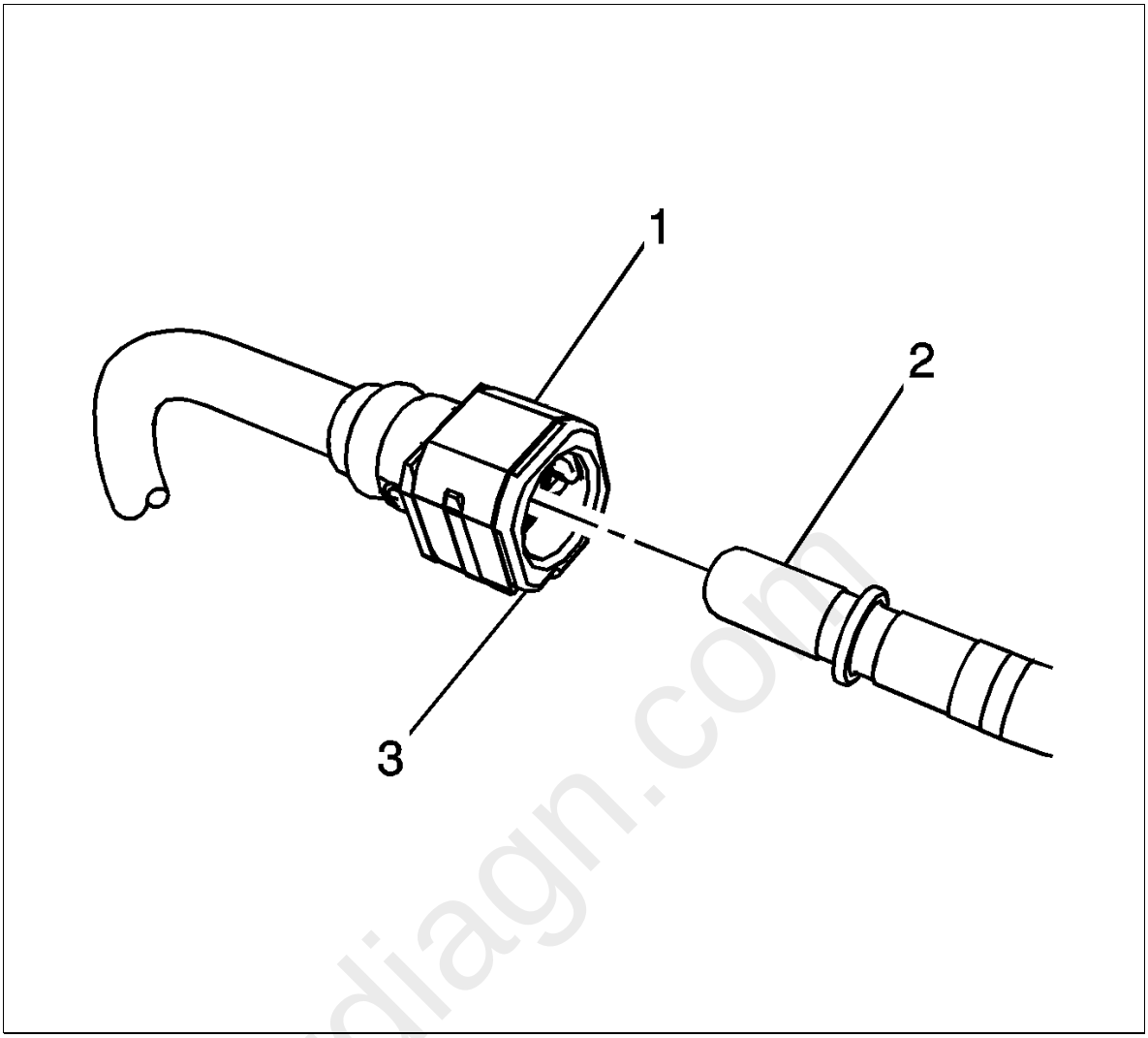


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

6. Insert the tube in the connector until the retainer snaps in place.
7. Push down on the second latch (1) in order to secure the connection.

Fig 6: Latch And Connector



Courtesy of GENERAL MOTORS COMPANY

8. For the plastic connector type 8, depress the latch (1) while inserting the connector (3) on to the pipe (2).
9. Move the latch (1) upward in order to secure the connection.
10. Inspect for leaks using the following procedure:
    1. Turn the ignition ON, with the engine OFF for 2 seconds.
    2. Turn the ignition OFF, for 10 seconds.
    3. Turn the ignition ON, with the engine OFF for 2 seconds.
    4. Turn the ignition OFF.
    5. Inspect for leaks.

REPAIR INSTRUCTIONS > FUEL TANK DRAINING

cardiagn.com

WARNING:

Never drain or store fuel in an open container. Always use an approved fuel storage container in order to reduce the chance of fire or explosion.

WARNING:

Place a dry chemical (Class B) fire extinguisher nearby before performing any on-vehicle service procedures. Failure to follow these precautions may result in personal injury.

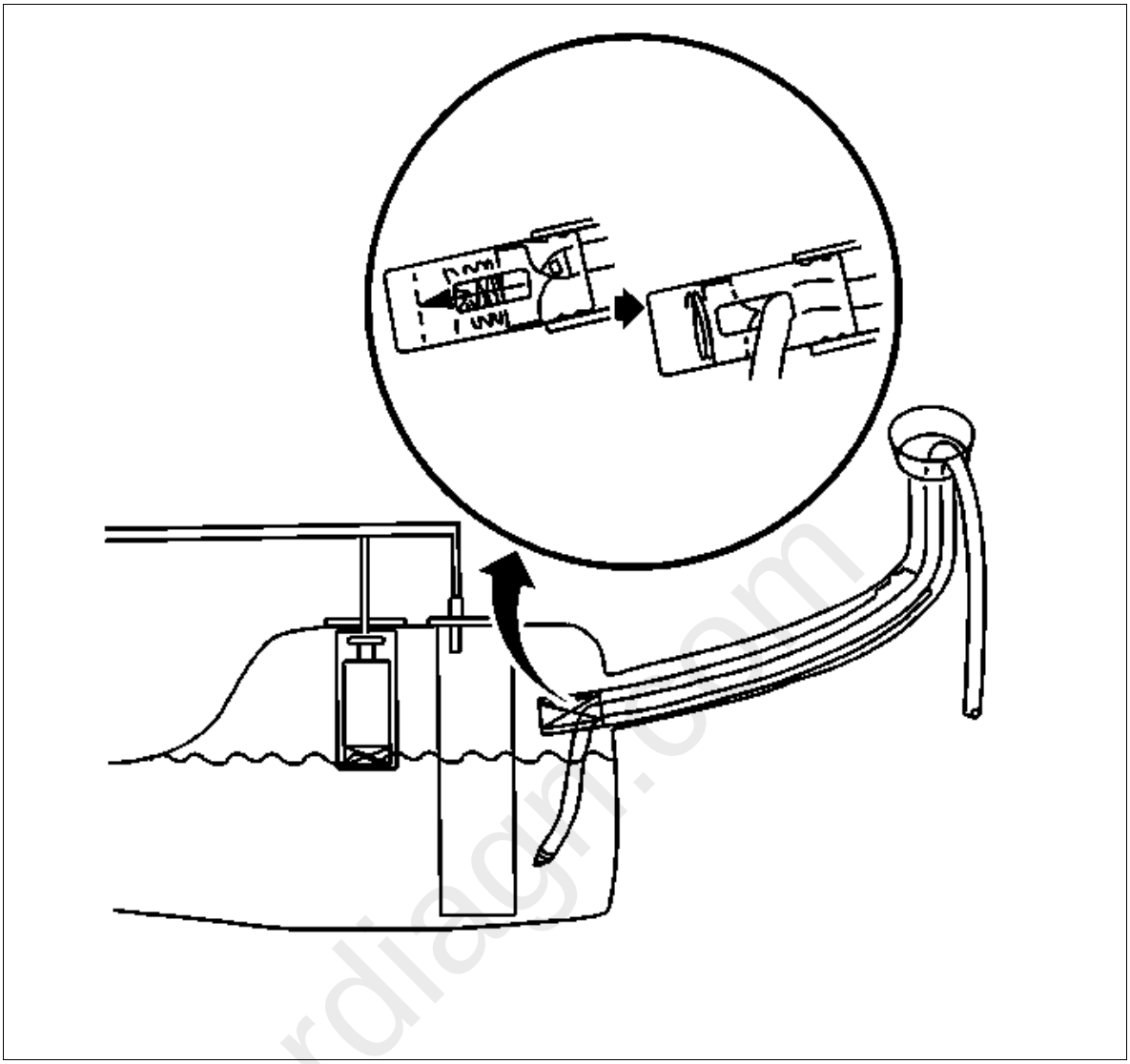
CAUTION:

When performing a fuel tank draining procedure on a capless fuel system, only use the capless adapter funnel or equivalent. Using something other than the capless adapter funnel or equivalent may cause damage to the capless fuel system.

1. Insert the capless adapter funnel or equivalent into the capless fill pipe.

cardiagn.com

Fig 1: Draining Fuel Tank



Courtesy of GENERAL MOTORS COMPANY

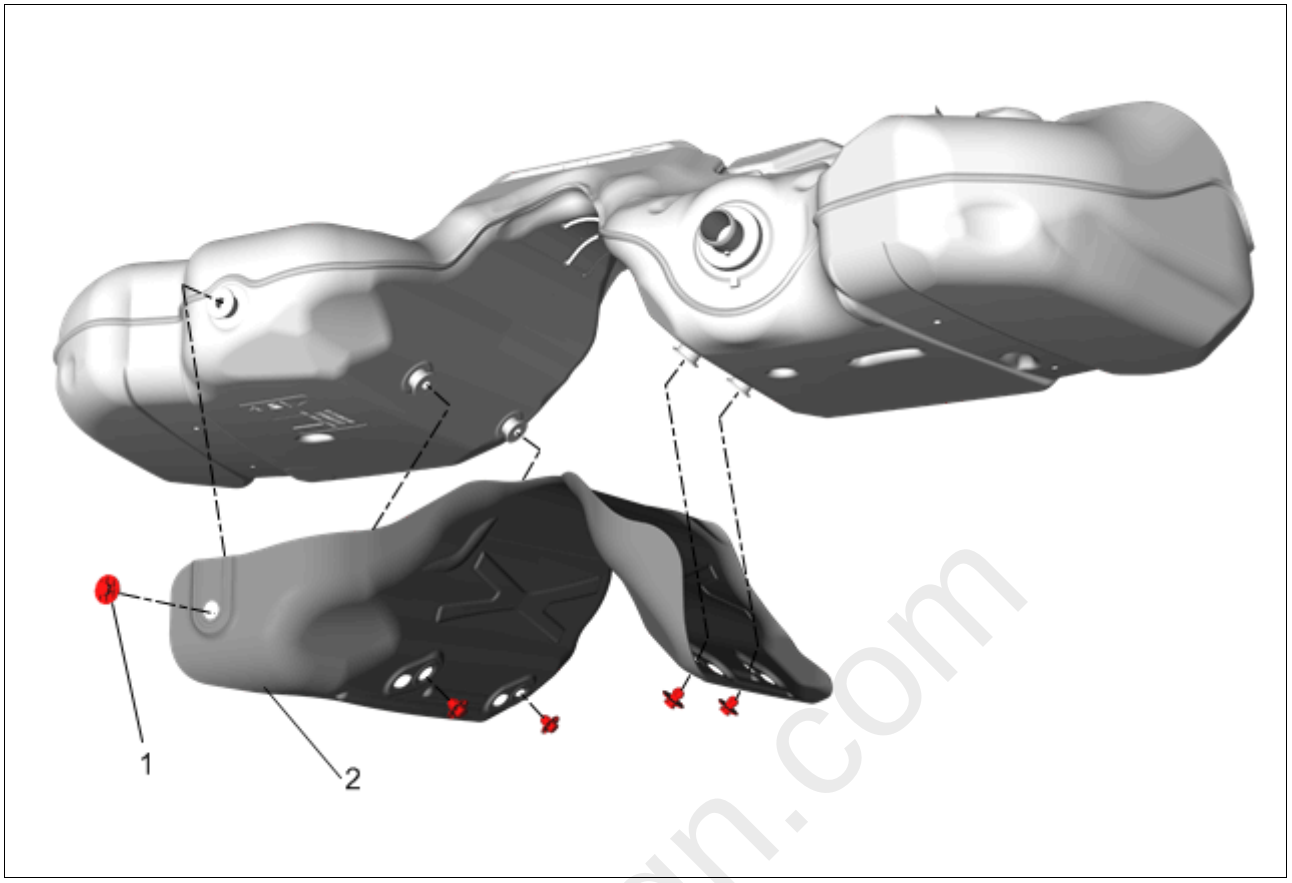
NOTE:

Lubricate the fuel drain hose with Transjel Lubricant or equivalent to aid in hose insertion.

2. Insert the a suitable suction hose into the fuel tank until the bottom is reached.
3. Attach a suitable suction hose to the hose used with the hand or air operated pump device.
4. Use a hand or air operated pump device in order to drain as much fuel through the fuel fill pipe as possible.

REPAIR INSTRUCTIONS > FUEL TANK SHIELD REPLACEMENT

Fig 1: Fuel Tank Shield



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Two-Piece Propeller Shaft Replacement (Coupe MM6, M13) Two-Piece Propeller Shaft Replacement (Convertible MM6, M13) Two-Piece Propeller Shaft Replacement (Coupe M5T, M5U) Two-Piece Propeller Shaft Replacement (Convertible M5T, M5U) .	
1	Fuel Tank Shield Retainer (Qty: 5) *CAUTION:* *Refer to Fastener Caution .*
2	Fuel Tank Shield

REPAIR INSTRUCTIONS > FUEL TANK REPLACEMENT > REMOVAL PROCEDURE

WARNING:

cardiagn.com

To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

WARNING:

Refer to Gasoline/Gasoline Vapors Warning .

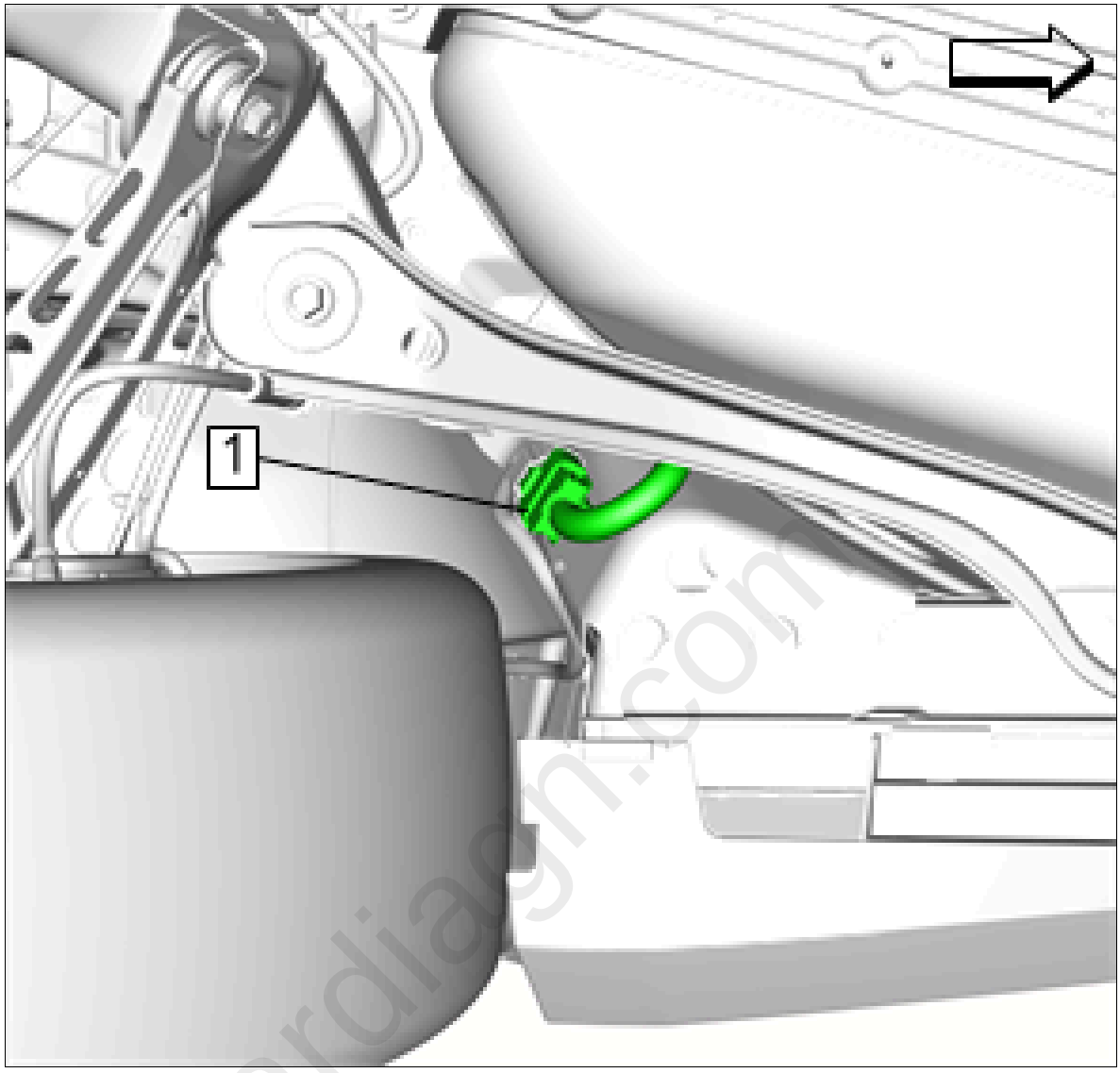
WARNING:

Refer to Safety Glasses Warning .

1. Relieve the fuel system pressure. Fuel Pressure Relief
2. Drain the fuel tank. Fuel Tank Draining
3. Remove Two-Piece Propeller Shaft Replacement (Coupe MM6, M13)Two-Piece Propeller Shaft Replacement (Convertible MM6, M13)Two-Piece Propeller Shaft Replacement (Coupe M5T, M5U)Two-Piece Propeller Shaft Replacement (Convertible M5T, M5U)
4. Remove the left front rear suspension bracket. Rear Suspension Bracket Replacement (Rear (Coupe))Rear Suspension Bracket Replacement (Front)

cardiagn.com

Fig 1: Electrical Connector

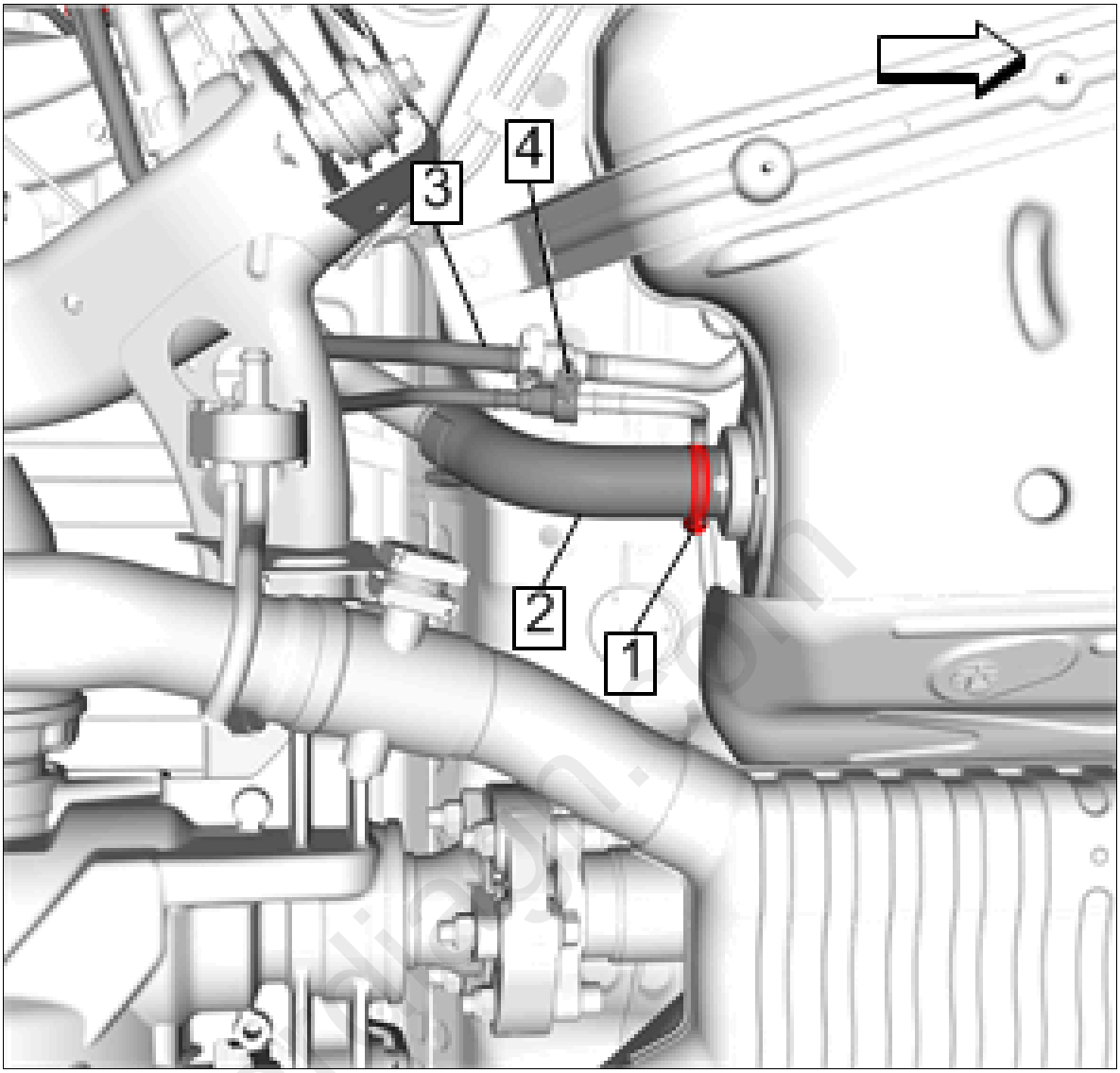


Courtesy of GENERAL MOTORS COMPANY

5. Disconnect Electrical Connector (1)

cardiagn.com

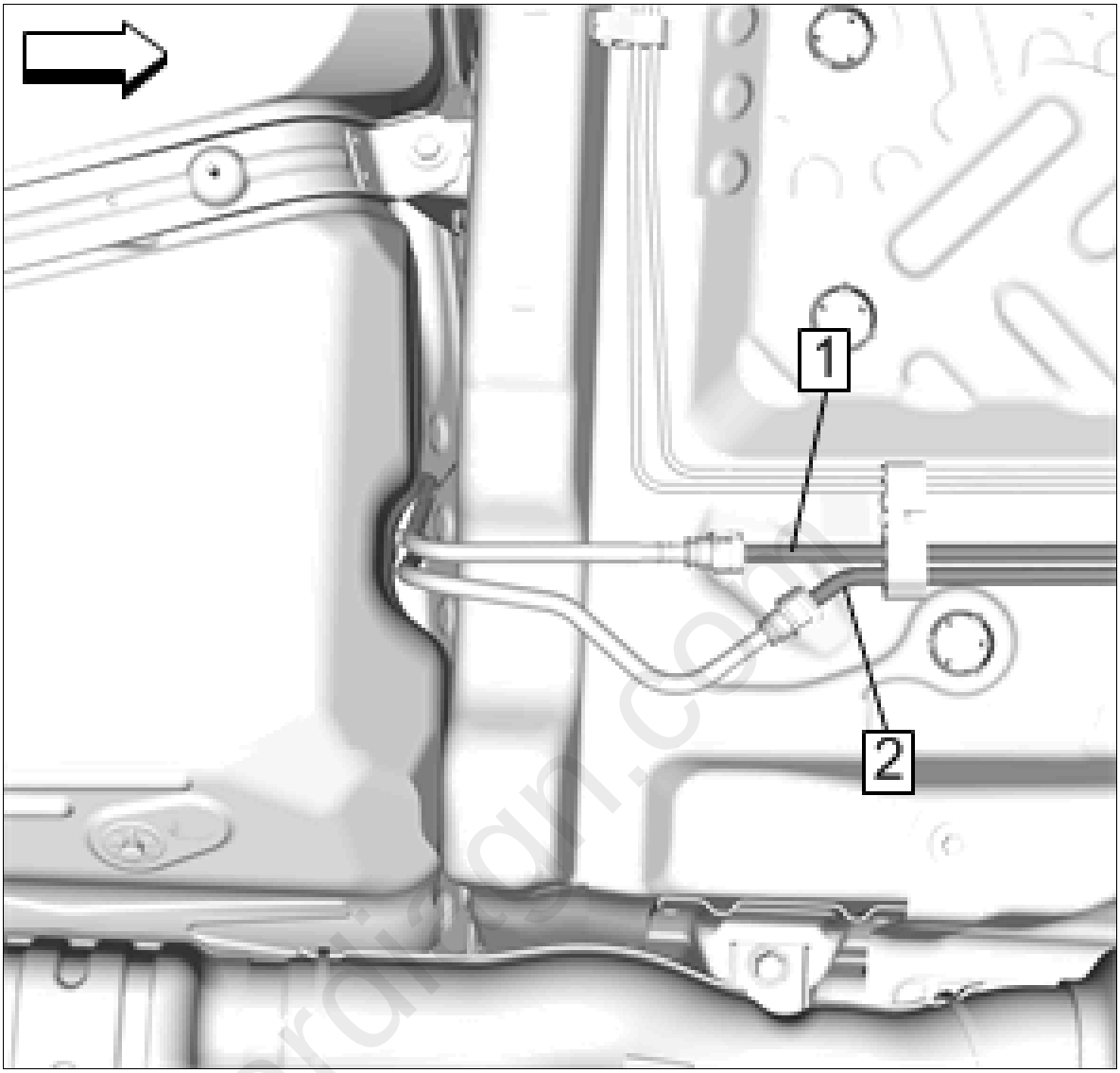
Fig 2: Fuel Tank Filler Hose Clamp



Courtesy of GENERAL MOTORS COMPANY

6. Remove Fuel Tank Filler Hose Clamp (1)
7. Remove Fuel Tank Filler Hose (2)
8. Disconnect Evaporative Emission Canister Hose (3) - Plastic Collar Quick Connect Fitting Service
9. Disconnect Evaporative Emission Canister Purge Hose (4) - Plastic Collar Quick Connect Fitting Service

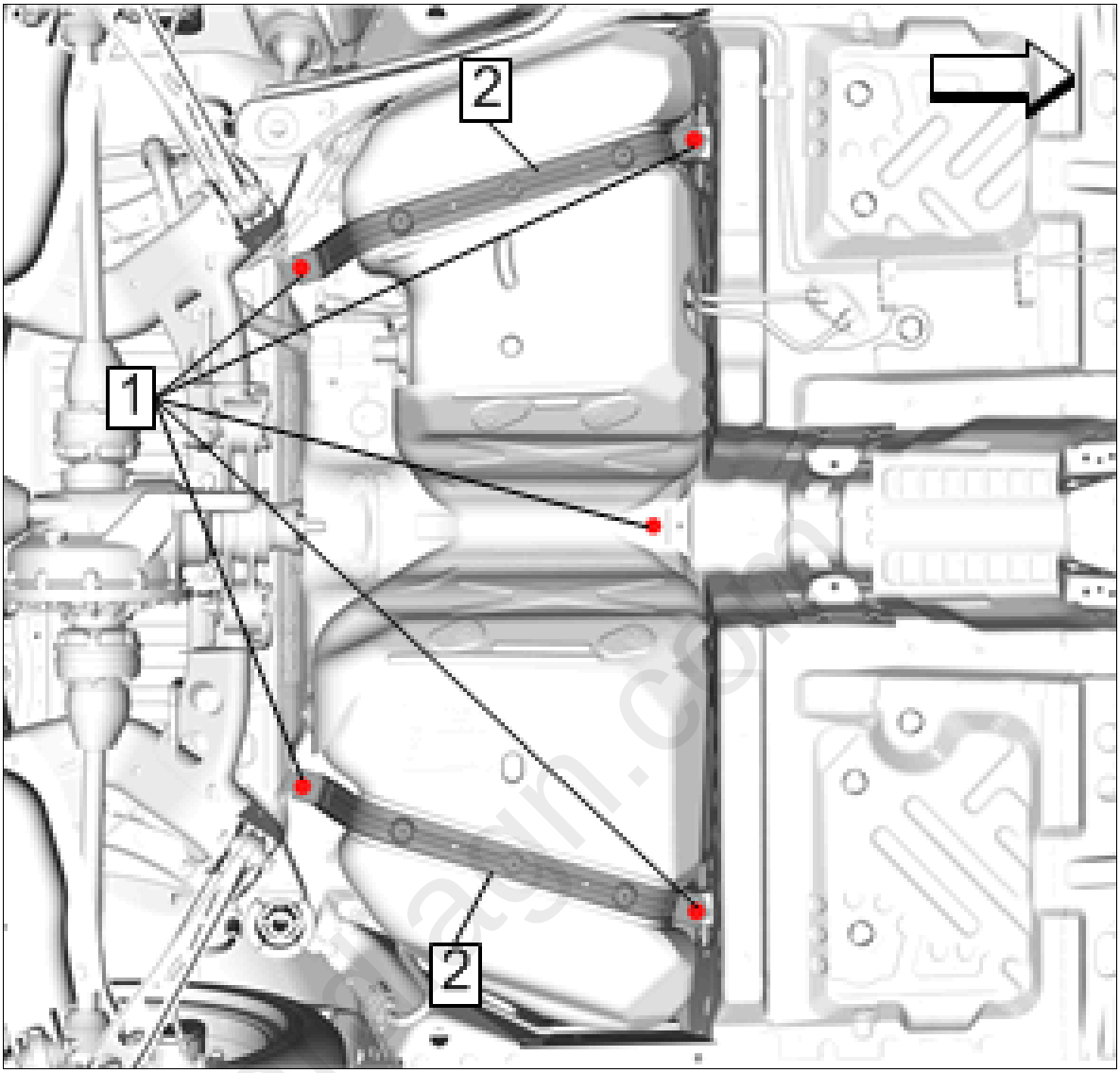
Fig 3: Fuel Feed Pipe



Courtesy of GENERAL MOTORS COMPANY

10. Disconnect Fuel Feed Pipe (1) - Plastic Collar Quick Connect Fitting Service
11. Disconnect Evaporative Emission Pipe (2) - Plastic Collar Quick Connect Fitting Service

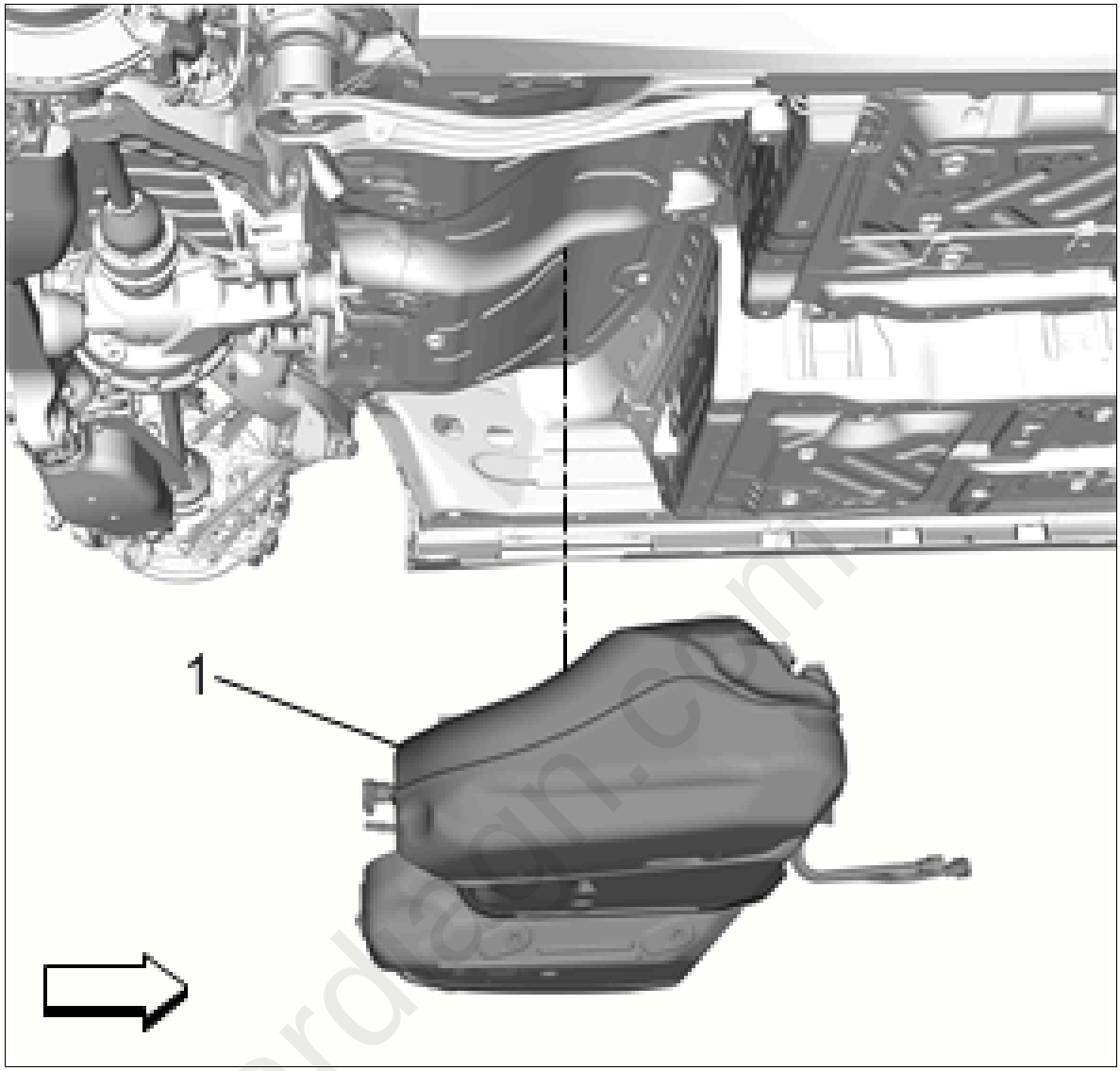
Fig 4: Support Fuel Tank



Courtesy of GENERAL MOTORS COMPANY

12. Support the fuel tank with a suitable jack.
13. Remove Fuel Tank Strap Bolt (1) (Qty: 5)
14. Remove Fuel Tank Strap (2) (Qty: 2)

Fig 5: Fuel Tank

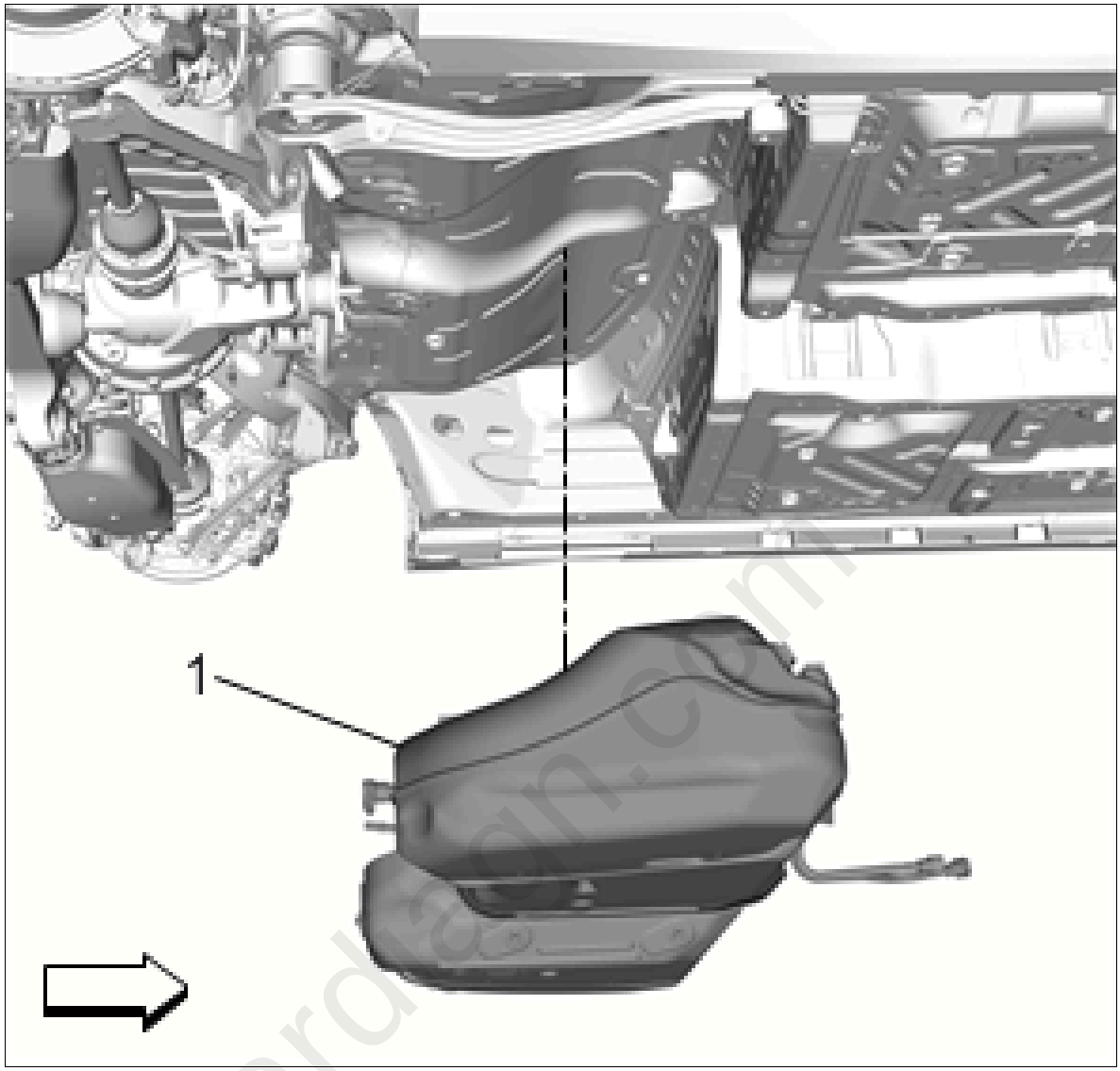


Courtesy of GENERAL MOTORS COMPANY

15. Remove Fuel Tank (1)
16. Transfer components as necessary.

REPAIR INSTRUCTIONS > FUEL TANK REPLACEMENT > INSTALLATION PROCEDURE

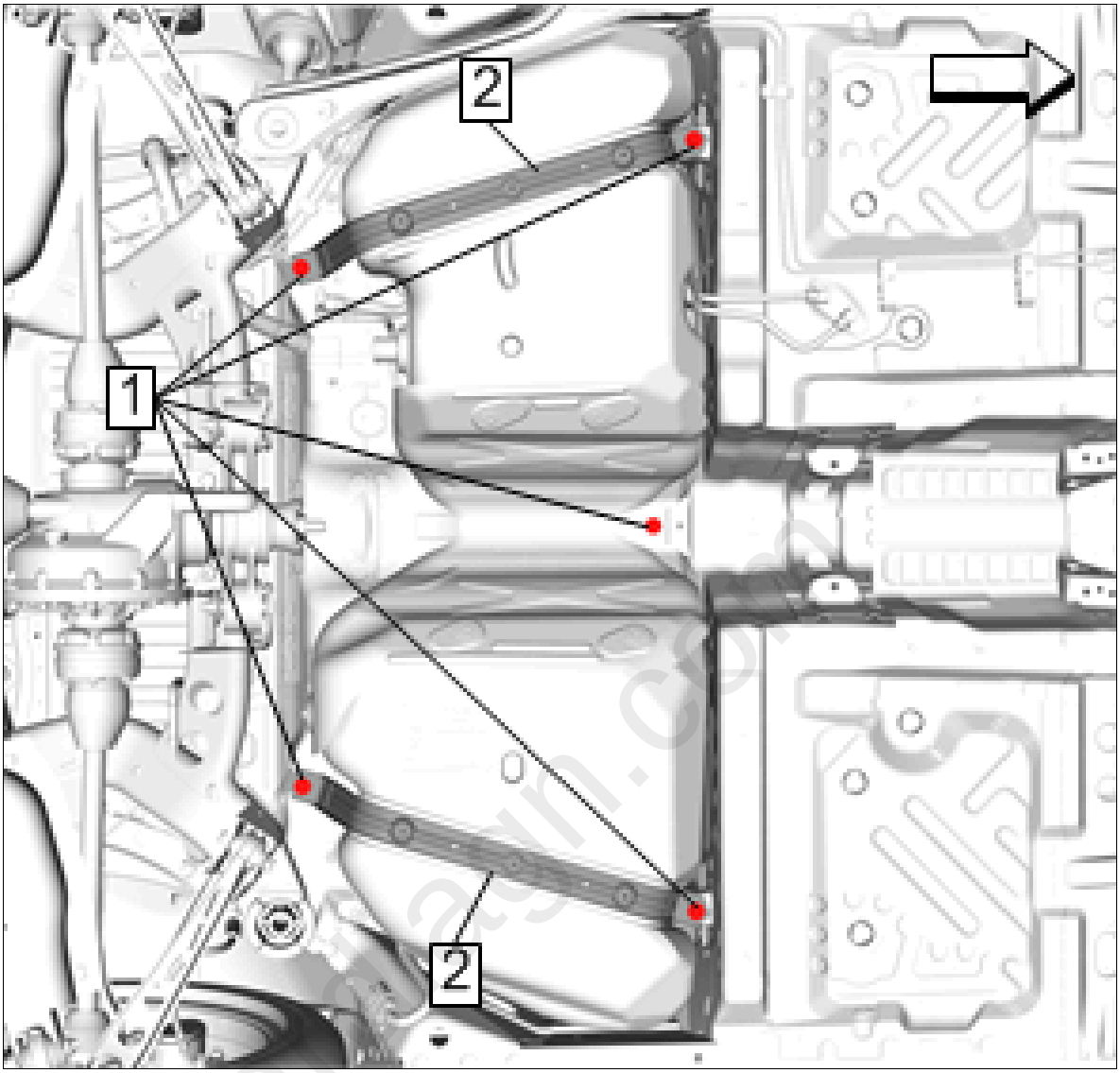
Fig 1: Support Fuel Tank



Courtesy of GENERAL MOTORS COMPANY

1. Support the fuel tank with a suitable jack.
2. Install Fuel Tank (1)

Fig 2: Fuel Tank Strap



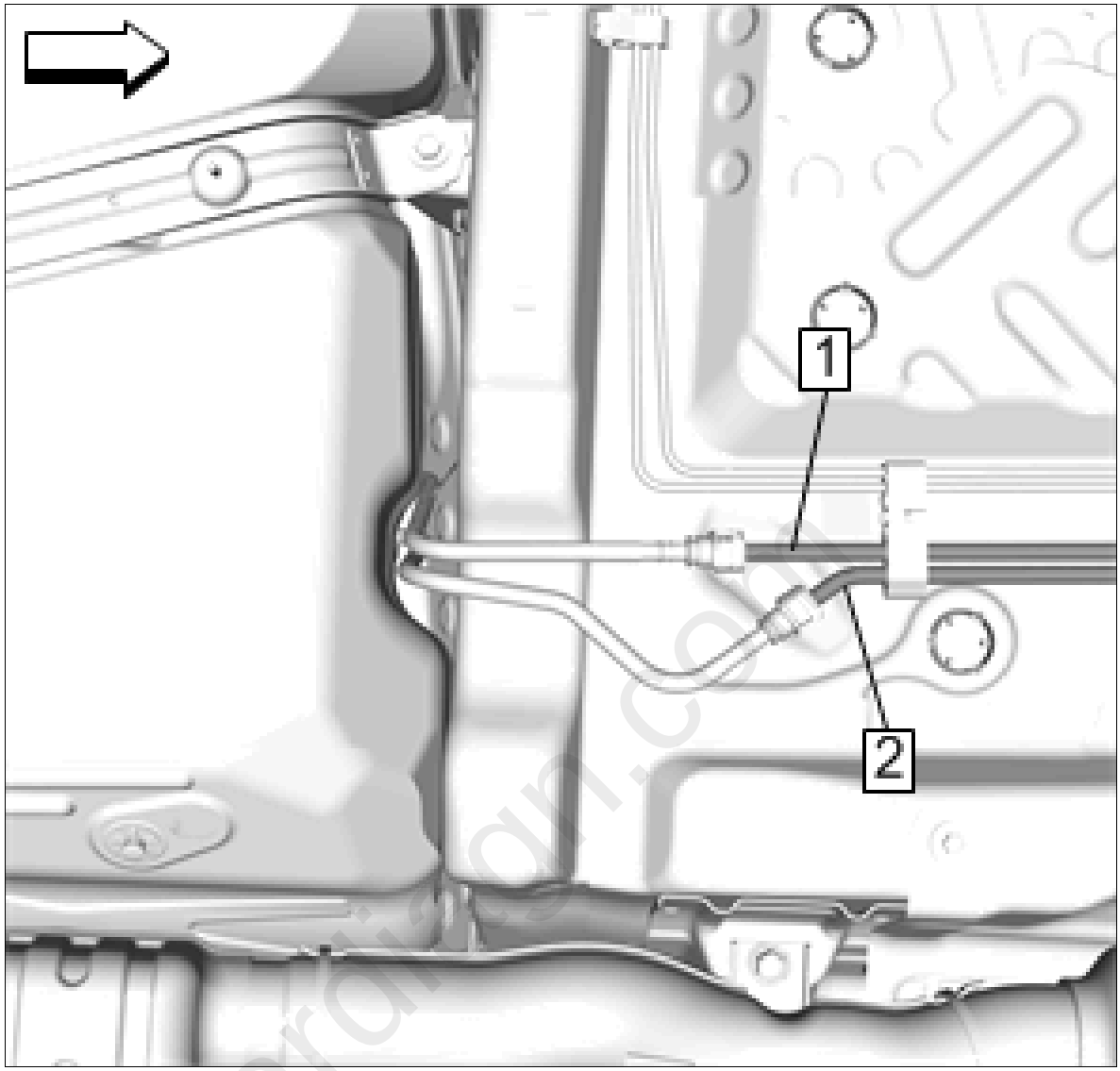
Courtesy of GENERAL MOTORS COMPANY

3. Install Fuel Tank Strap (2) (Qty: 2)

> ⚠ *CAUTION:*
>
> *Refer to Fastener Caution .*

4. Install Fuel Tank Strap Bolt (1) (Qty: 5) to 22 N.m (16 lb ft)

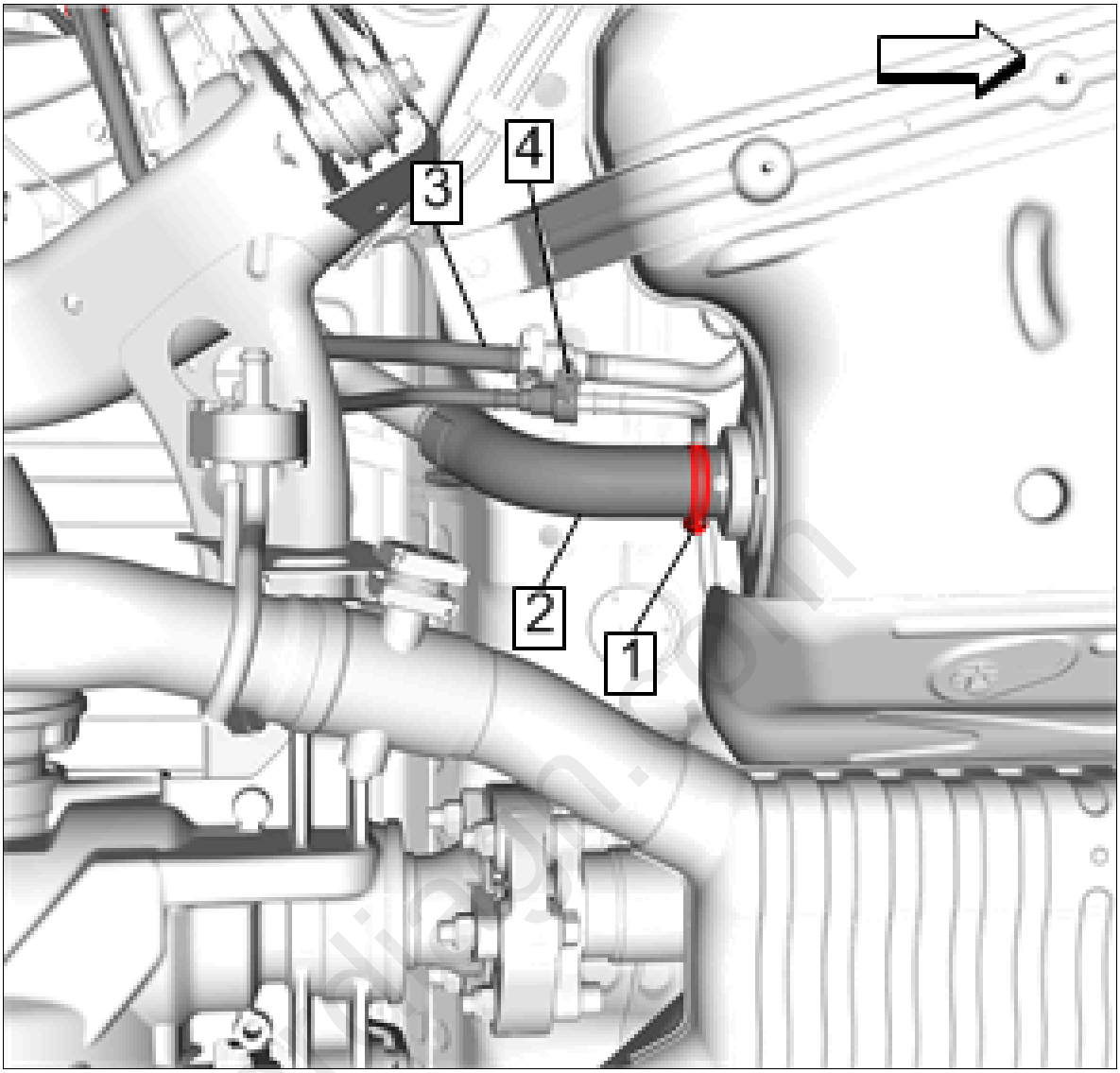
Fig 3: Evaporative Emission Pipe



Courtesy of GENERAL MOTORS COMPANY

5. Connect Evaporative Emission Pipe (2) - Plastic Collar Quick Connect Fitting Service
6. Connect Fuel Feed Pipe (1) - Plastic Collar Quick Connect Fitting Service

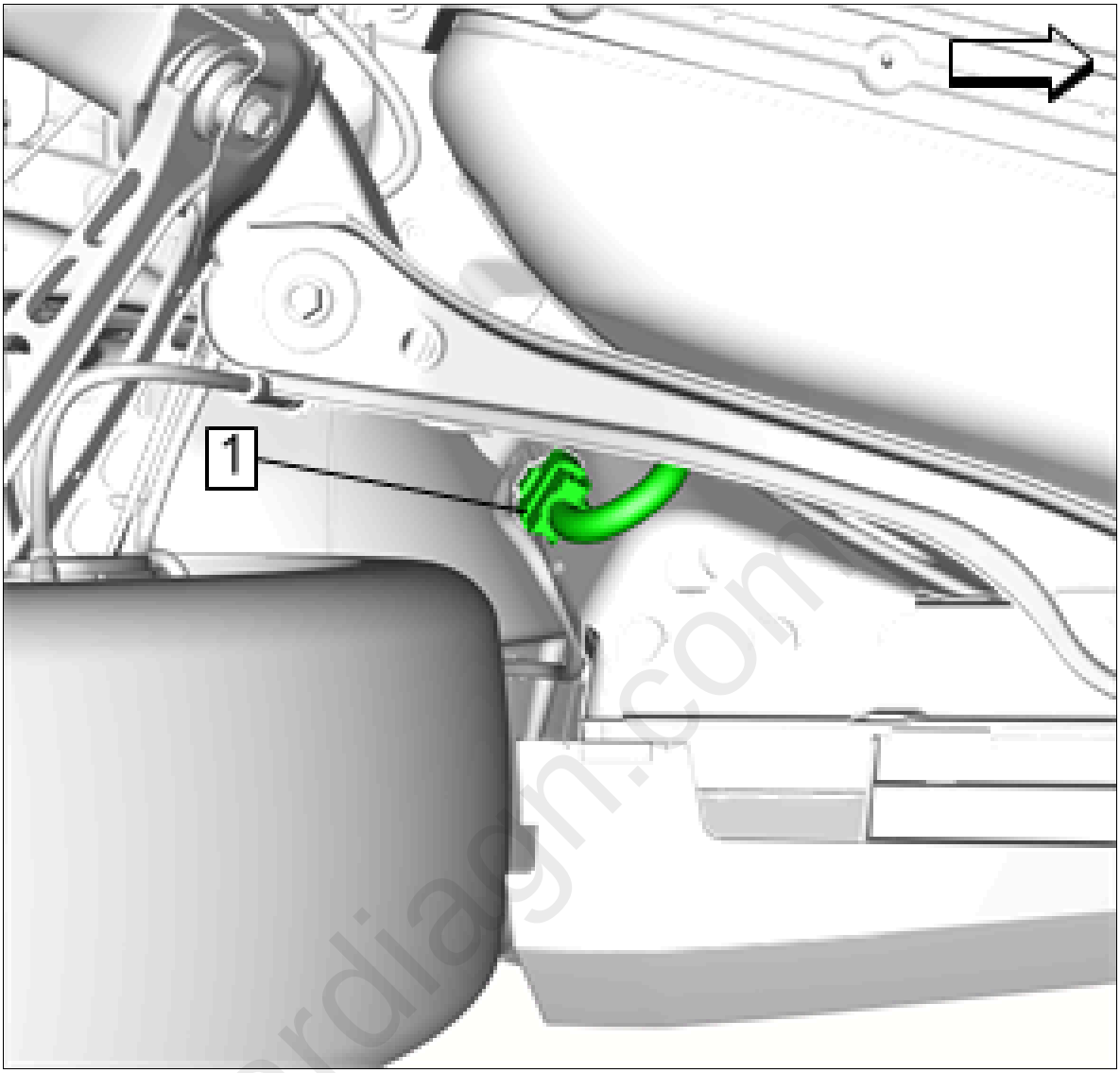
Fig 4: Evaporative Emission Canister Purge Hose



Courtesy of GENERAL MOTORS COMPANY

7. Connect Evaporative Emission Canister Purge Hose (4) - Plastic Collar Quick Connect Fitting Service
8. Connect Evaporative Emission Canister Hose (3) - Plastic Collar Quick Connect Fitting Service
9. Install Fuel Tank Filler Hose (2)
10. Install Fuel Tank Filler Hose Clamp (1) to 3.5 N.m (31 lb in)

Fig 5: Electrical Connector

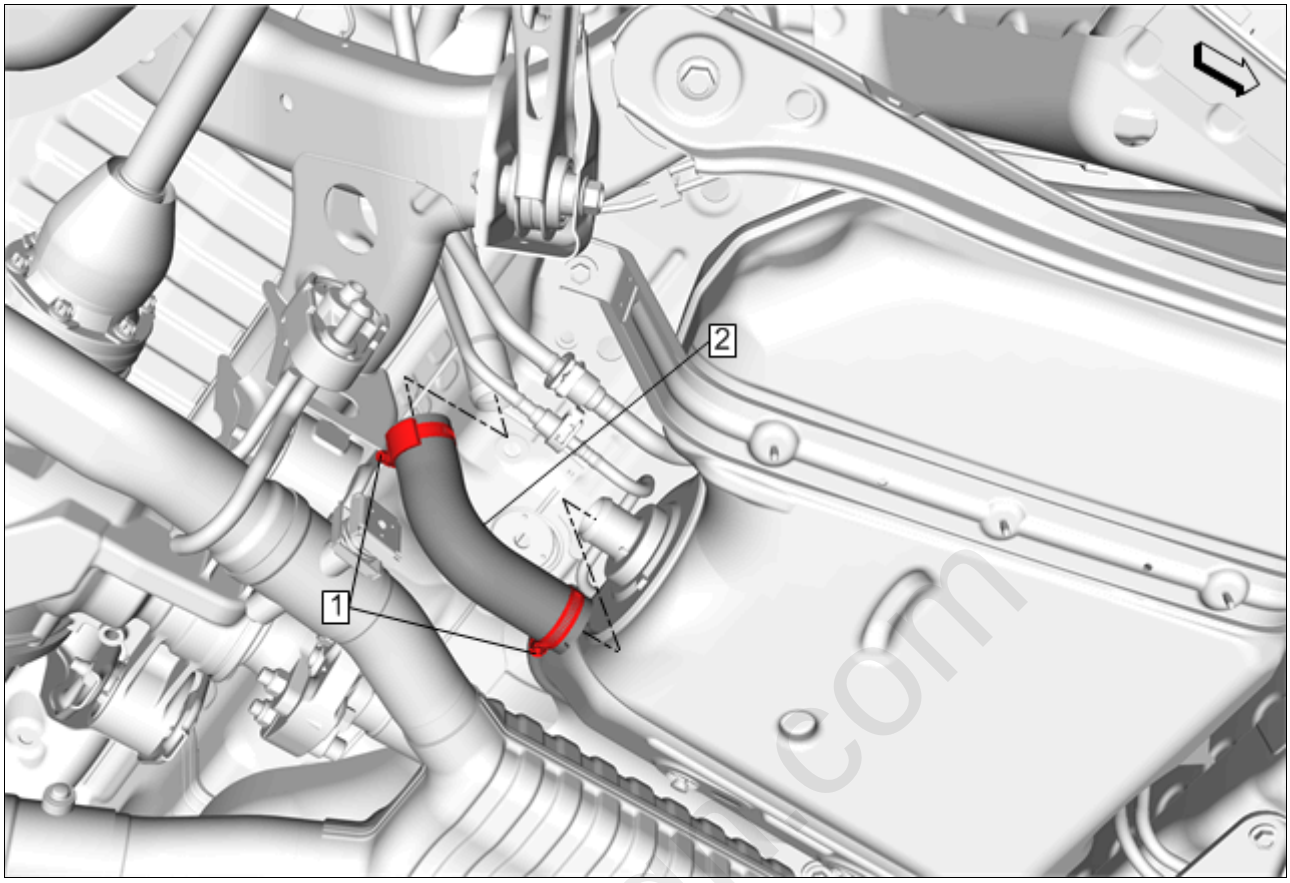


Courtesy of GENERAL MOTORS COMPANY

11. Connect Electrical Connector (1)
12. Install the left front rear suspension bracket. Rear Suspension Bracket Replacement (Rear (Coupe))
13. Install Two-Piece Propeller Shaft Replacement (Coupe MM6, M13)Two-Piece Propeller Shaft Replacement (Convertible MM6, M13)Two-Piece Propeller Shaft Replacement (Coupe M5T, M5U)Two-Piece Propeller Shaft Replacement (Convertible M5T, M5U)
14. Refill the fuel tank.
15. Inspect for fuel leaks.

REPAIR INSTRUCTIONS > FUEL TANK FILLER HOSE REPLACEMENT

Fig 1: Fuel Tank Filler Hose



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
WARNING: *Refer to Gasoline/Gasoline Vapors Warning .*	
WARNING: *Refer to Safety Glasses Warning .*	
Preliminary Procedure Raise and support the vehicle. Lifting and Jacking the Vehicle (Base)Lifting and Jacking the Vehicle (HP) .	
1	Fuel Tank Filler Hose Clamp (Qty: 2)

	CAUTION: *Refer to Fastener Caution .* **Tighten** 3.5 N.m (31 lb in)
2	Fuel Tank Filler Hose

REPAIR INSTRUCTIONS > FUEL SYSTEM CLEANING

NOTE:

When flushing the fuel tank, treat the fuel and water mixture as a hazardous material. Handle the material in accordance with all local, state and federal laws and regulations.

NOTE:

Whenever the fuel tank is cleaned, inspect the fuel pump fuel strainer. If the fuel pump fuel strainer is contaminated, replace the fuel pump fuel strainer and inspect the fuel pump.

NOTE:

Always maintain cleanliness when servicing fuel system components.

1. Remove the fuel tank fuel pump module. Fuel Tank Fuel Pump Module Replacement
2. Inspect the fuel pump inlet for dirt and debris. If dirt and debris are found, replace the fuel pump.
3. Flush fuel tank with hot water.
4. Pour the water out of the fuel sender assembly opening in the fuel tank. Rock the fuel tank in order to ensure that the removal of the water from the fuel tank is complete.
5. Allow tank to dry completely before reassembly.
6. Install the fuel tank fuel pump module. Fuel Tank Fuel Pump Module Replacement

REPAIR INSTRUCTIONS > FUEL TANK FUEL PUMP MODULE REPLACEMENT

cardiagn.com

Special Tools

CH 45722 Fuel Sender Lock Ring Wrench

Equivalent regional tools: Special Tools (Diagnostic Tools)Special Tools (Mechanical Tools)

REPAIR INSTRUCTIONS > FUEL TANK FUEL PUMP MODULE REPLACEMENT > REMOVAL PROCEDURE

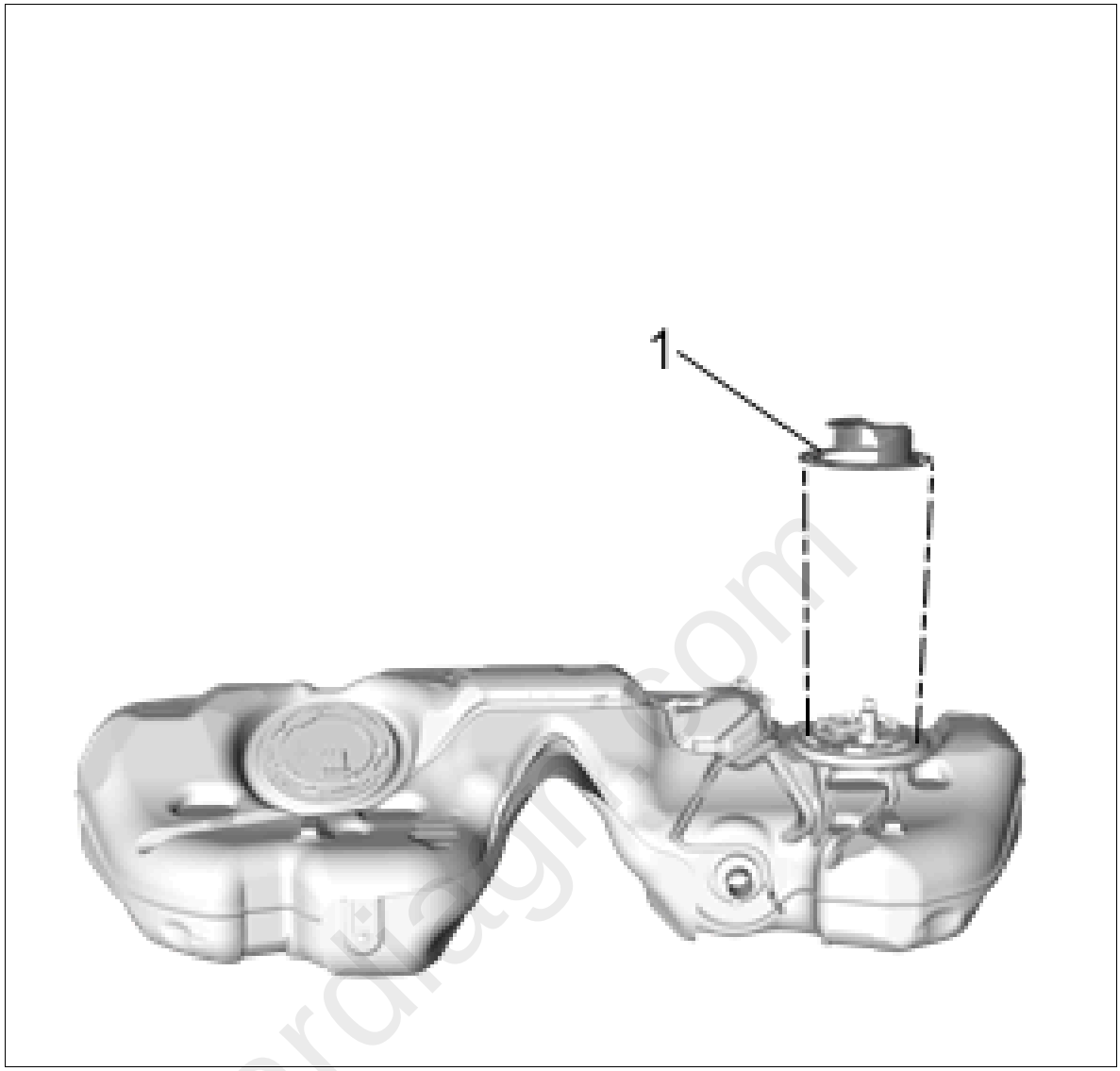
> *WARNING:*
>
> *Refer to Gasoline/Gasoline Vapors Warning .*

> *WARNING:*
>
> *Refer to Safety Glasses Warning .*

1. Remove Fuel Tank Replacement
2. Remove Fuel Tank Vent Valve Hose at Fuel Tank Fuel Pump Module - Fuel Tank Vent Valve Hose Replacement (Fuel Tank Fuel Pump Module)
3. Remove Fuel Pump Fuel Feed Hose Replacement
4. Disconnect the electrical connector.

cardiagn.com

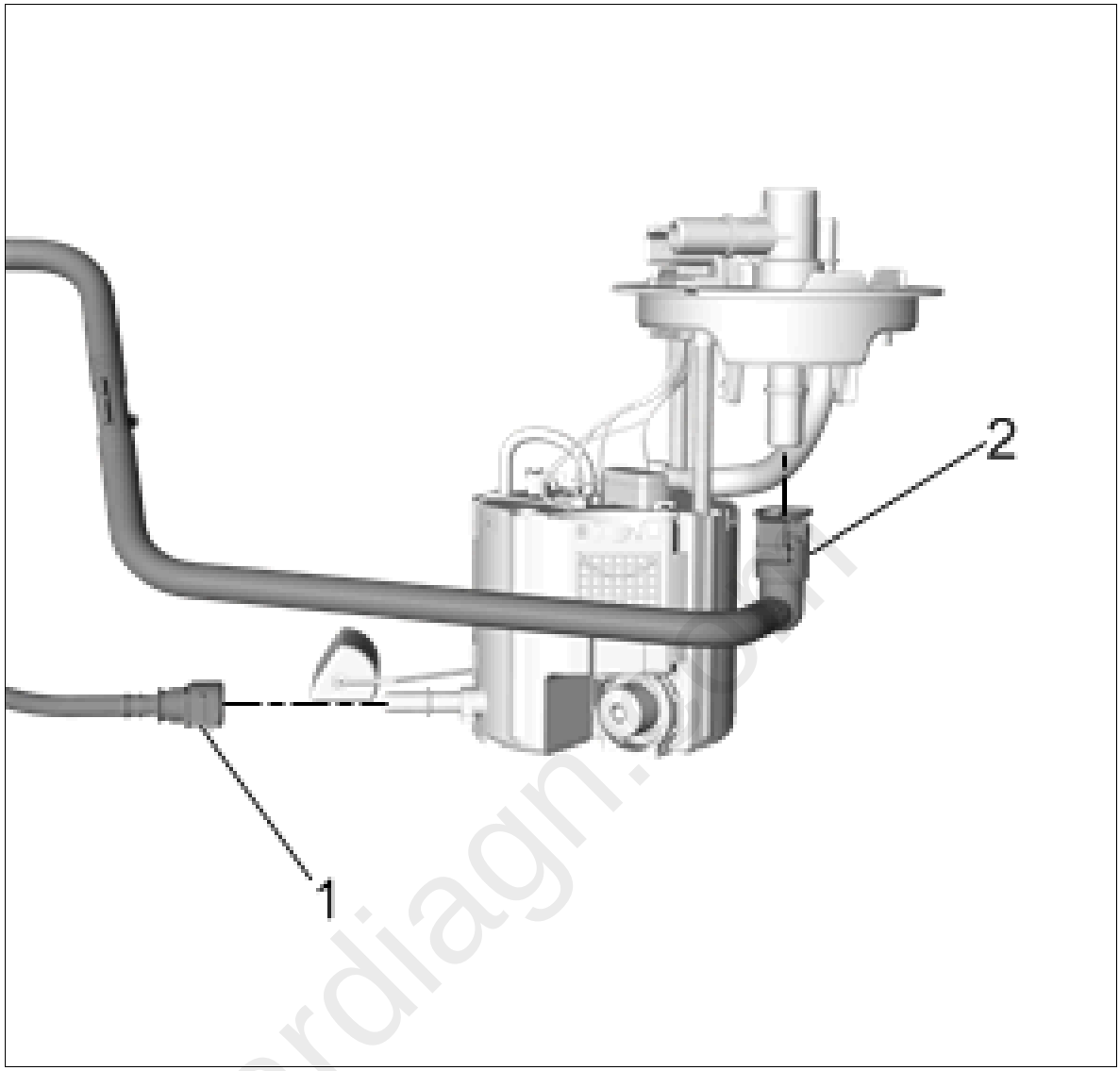
Fig 1: Lock Ring



Courtesy of GENERAL MOTORS COMPANY

5. Use the **CH 45722** wrench by turning counter clockwise and remove the lock ring (1)

Fig 2: Transfer Hose

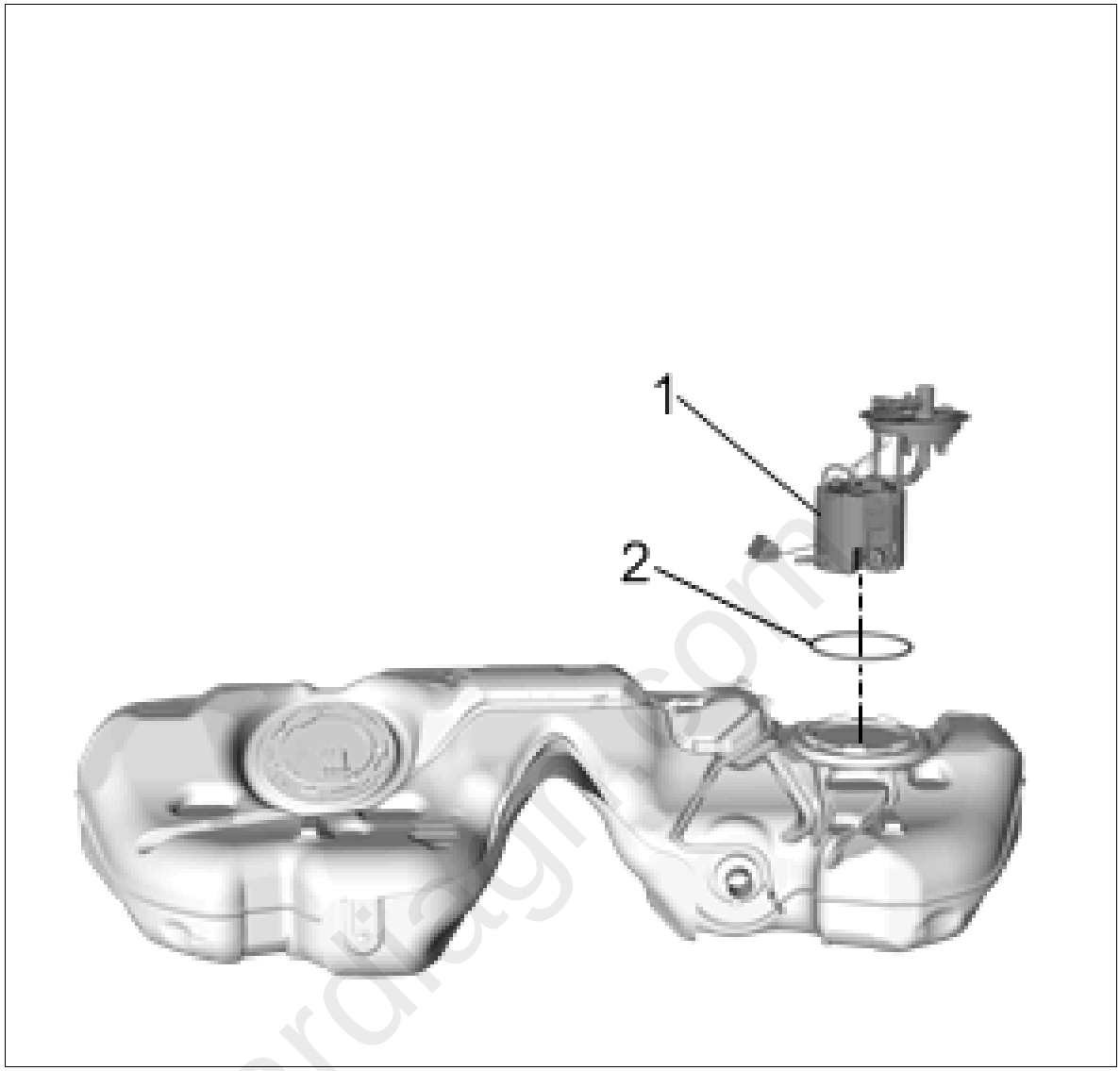


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

6. Disconnect Transfer Hose (1) - Plastic Collar Quick Connect Fitting Service
7. Disconnect Fuel Tank Vent Hose (2) - Plastic Collar Quick Connect Fitting Service

Fig 3: Fuel Tank Fuel Pump Module

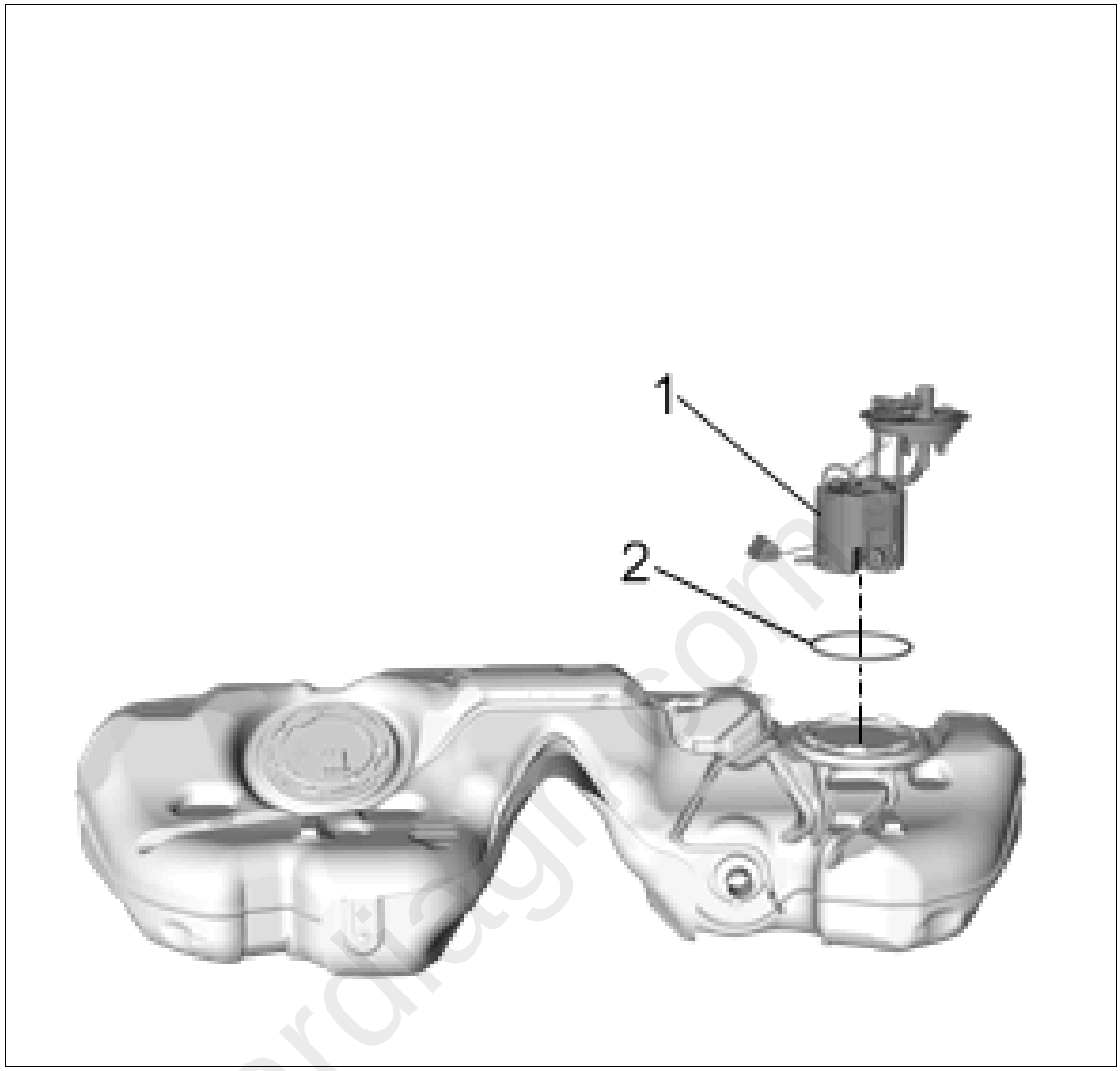


Courtesy of GENERAL MOTORS COMPANY

8. Remove Fuel Tank Fuel Pump Module (1)
9. Remove Fuel Pump Seal (2) and DISCARD

REPAIR INSTRUCTIONS > FUEL TANK FUEL PUMP MODULE REPLACEMENT > INSTALLATION PROCEDURE

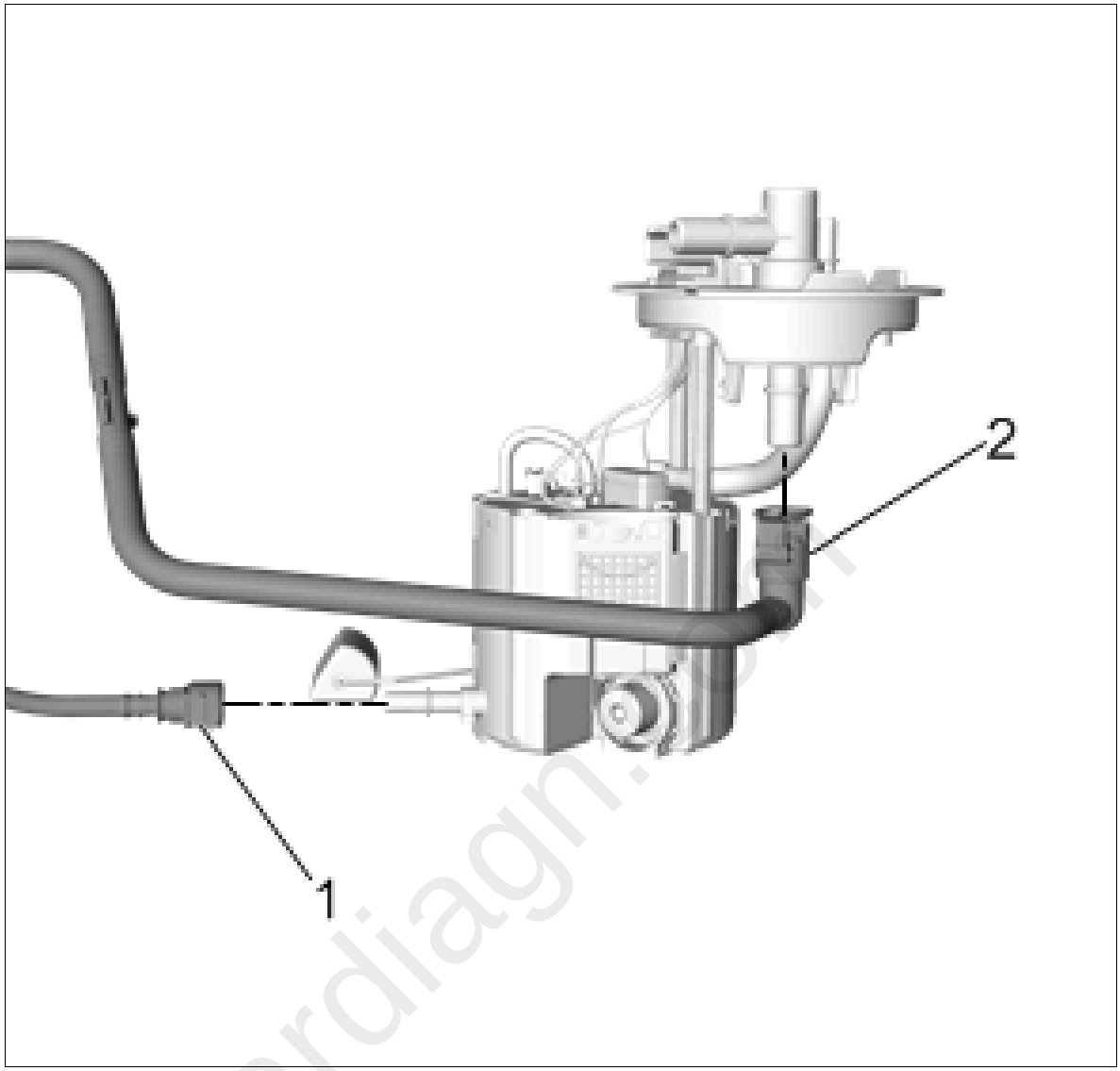
Fig 1: Fuel Pump Seal



Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW Fuel Pump Seal (2)
2. Install Fuel Tank Fuel Pump Module (1)

Fig 2: Fuel Tank Vent Hose

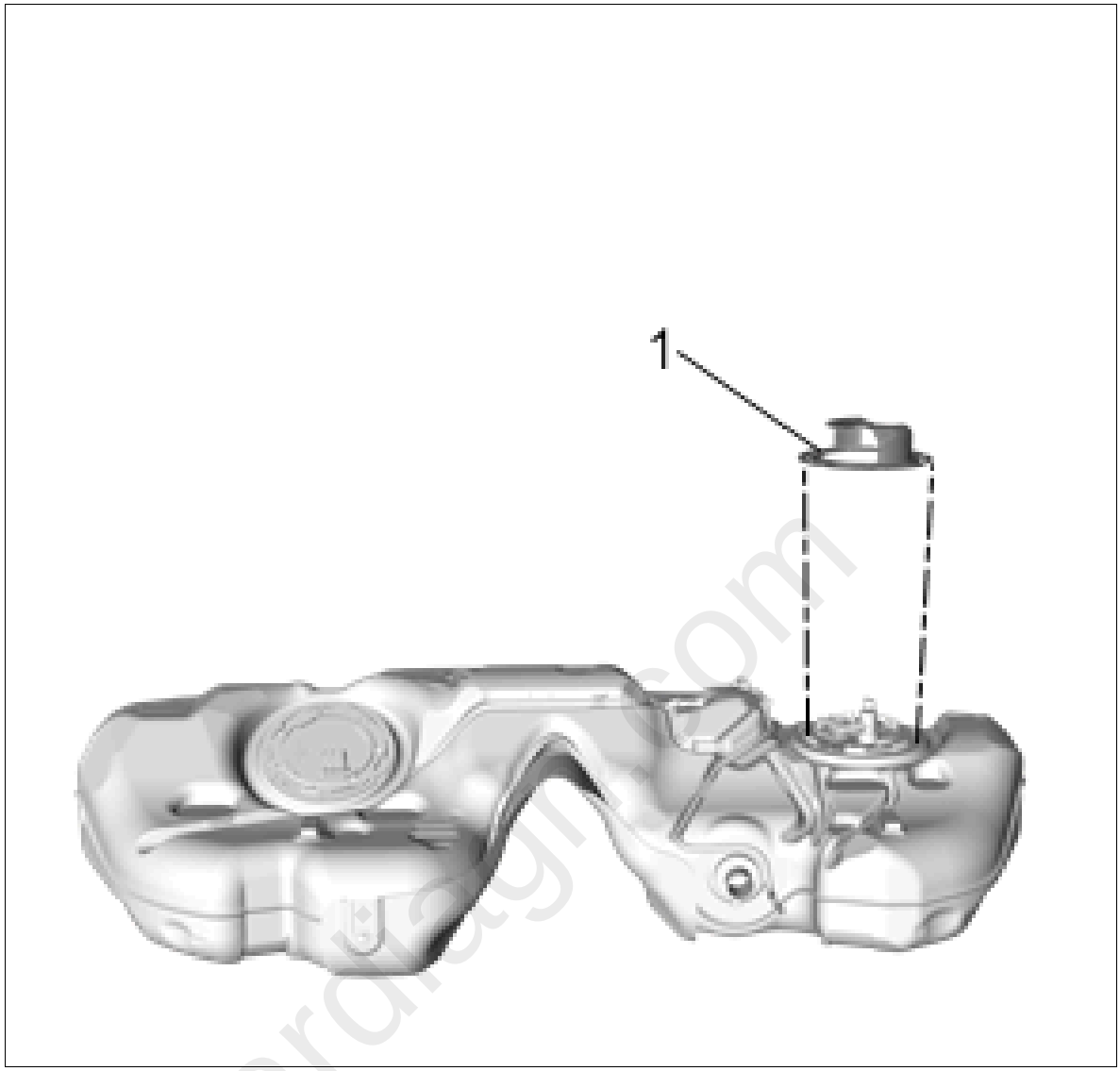


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

3. Connect Fuel Tank Vent Hose (2) - Plastic Collar Quick Connect Fitting Service
4. Connect Transfer Hose (1) - Plastic Collar Quick Connect Fitting Service

Fig 3: Lock Ring

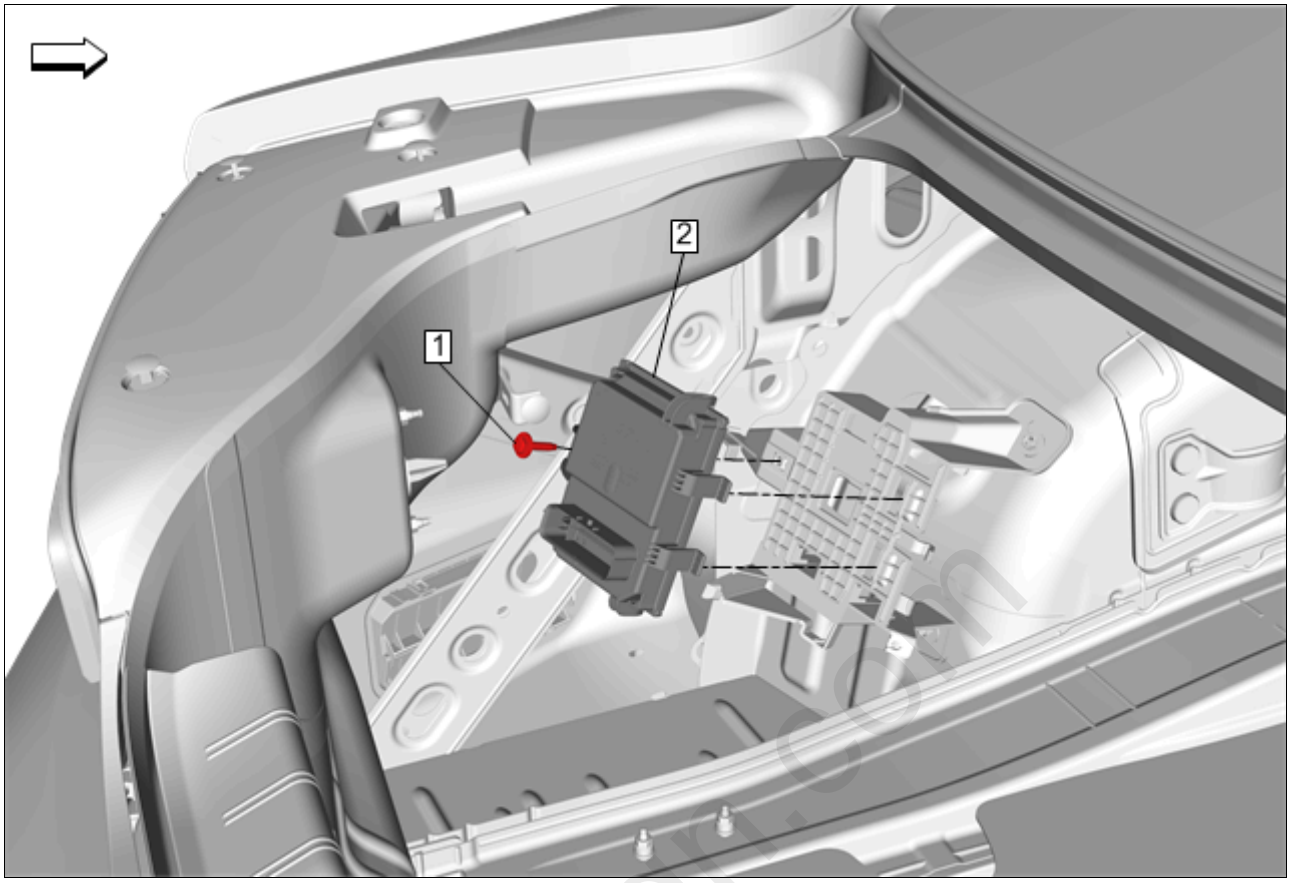


Courtesy of GENERAL MOTORS COMPANY

5. Use the **CH 45722** wrench by turning clockwise and install the lock ring (1)
6. Install Fuel Pump Fuel Feed Hose Replacement
7. Install Fuel Tank Vent Valve Hose at Fuel Tank Fuel Pump Module - Fuel Tank Vent Valve Hose Replacement (Fuel Tank Fuel Pump Module)
8. Connect the electrical connector.
9. Install Fuel Tank Replacement

REPAIR INSTRUCTIONS > CHASSIS CONTROL MODULE REPLACEMENT

Fig 1: Chassis Control Module

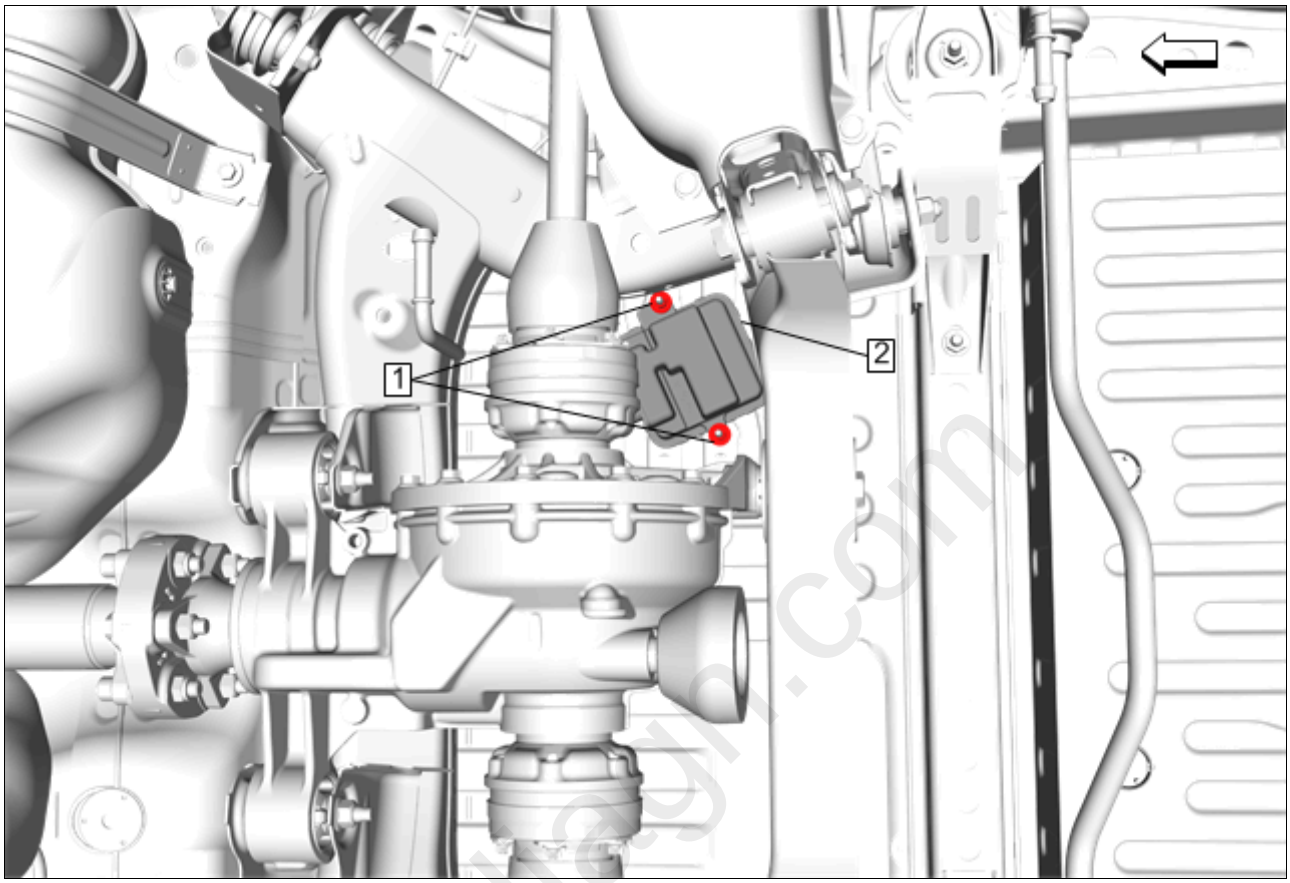


Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Rear Compartment Side Trim Replacement - Left Side (Coupe) Rear Compartment Side Trim Replacement - Left Side (Convertible) .	
1	Chassis Control Module Fastener *CAUTION:* *Refer to Fastener Caution .* **Tighten** 9 N.m (80 lb in)
2	Chassis Control Module Procedure 1. Disconnect the electrical connector. 2. If replacing, reprogram the module. Control Module References

REPAIR INSTRUCTIONS > FUEL PUMP POWER CONTROL MODULE REPLACEMENT

Fig 1: Fuel Pump Power Control Module



Courtesy of GENERAL MOTORS COMPANY

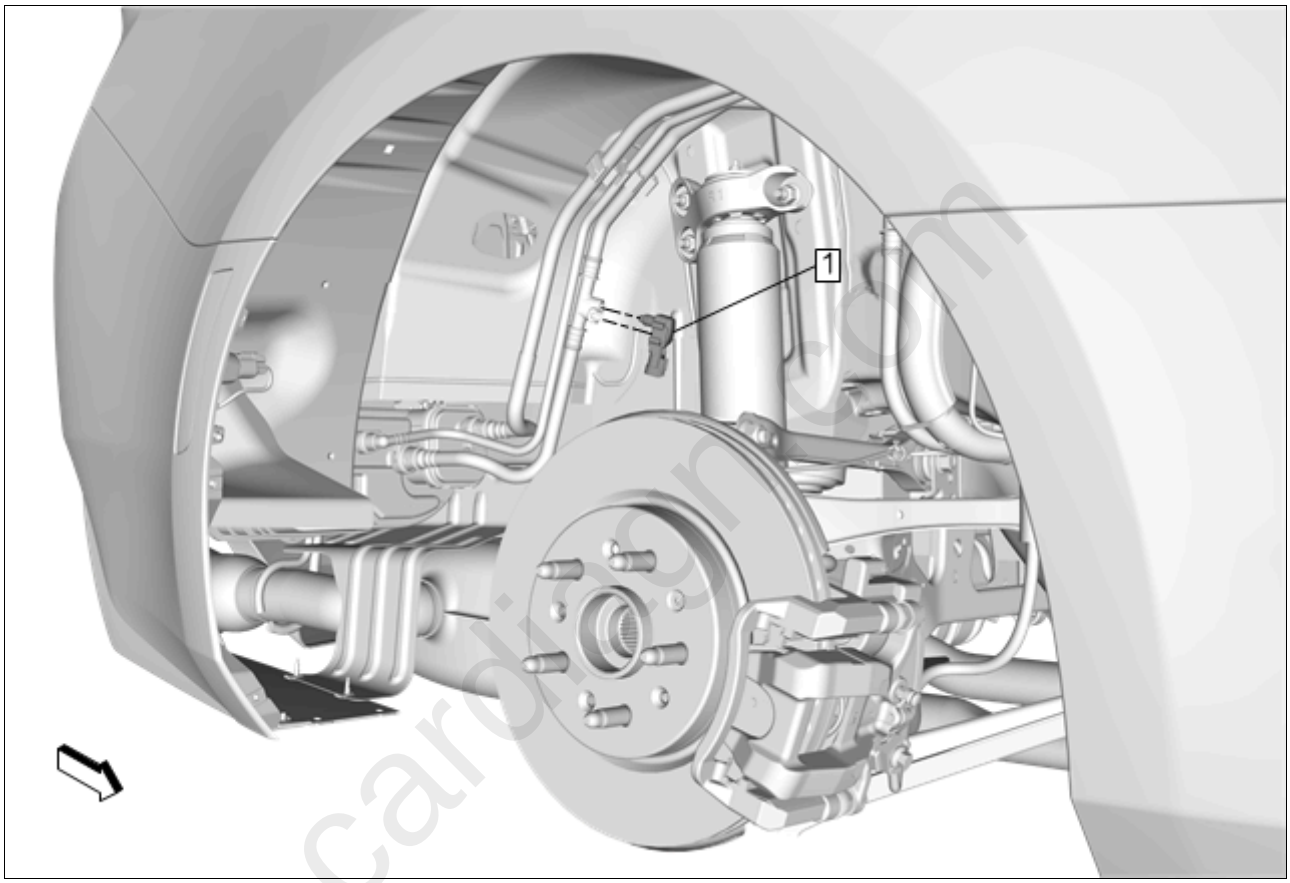
Callout	Component Name
Preliminary Procedure Raise and support the vehicle. Lifting and Jacking the Vehicle (Base)Lifting and Jacking the Vehicle (HP) .	
1	Fuel Pump Power Control Module Fastener (Qty: 2) *CAUTION:* *Refer to Fastener Caution .* **Tighten** 9 N.m (80 lb in)
2	Fuel Pump Power Control Module

cardiagn.com

	Procedure 1. Disconnect the electrical connector. 2. If replacing, reprogram the module. Control Module References

REPAIR INSTRUCTIONS > FUEL TANK PRESSURE SENSOR REPLACEMENT

Fig 1: Fuel Tank Pressure Sensor



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Rear Wheelhouse Liner Replacement	
1	Fuel Tank Pressure Sensor **Procedure** Disconnect the electrical connector.

REPAIR INSTRUCTIONS > FUEL SENDER ASSEMBLY REPLACEMENT

Special Tools

CH 45722 Fuel Sender Lock Ring Wrench

Equivalent regional tools: Special Tools (Diagnostic Tools)Special Tools (Mechanical Tools)

REPAIR INSTRUCTIONS > FUEL SENDER ASSEMBLY REPLACEMENT > REMOVAL PROCEDURE

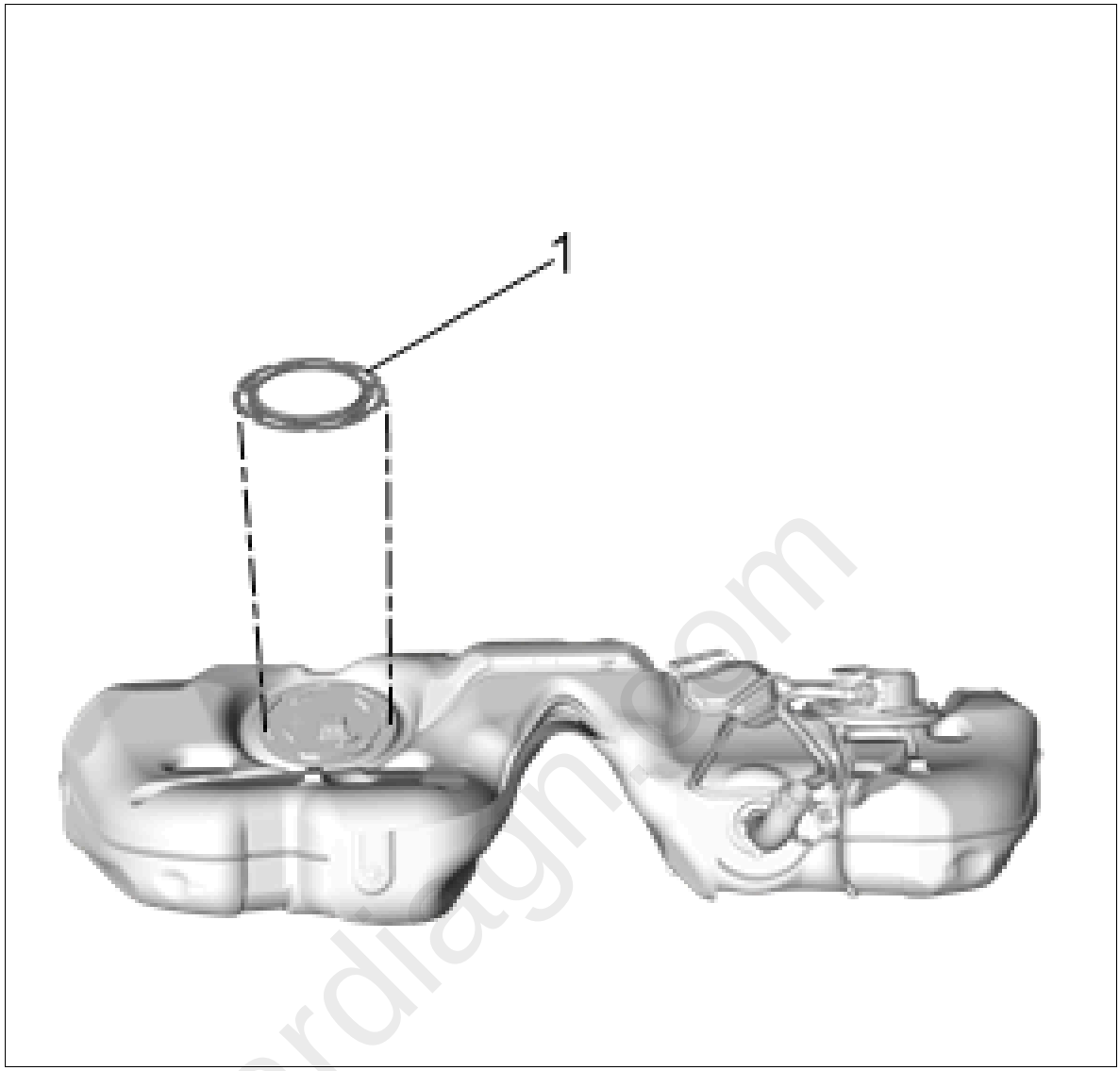
> *WARNING:*
>
> *Refer to Gasoline/Gasoline Vapors Warning .*

> *WARNING:*
>
> *Refer to Safety Glasses Warning .*

1. Remove Fuel Tank Replacement
2. Disconnect the electrical connector.

cardiagn.com

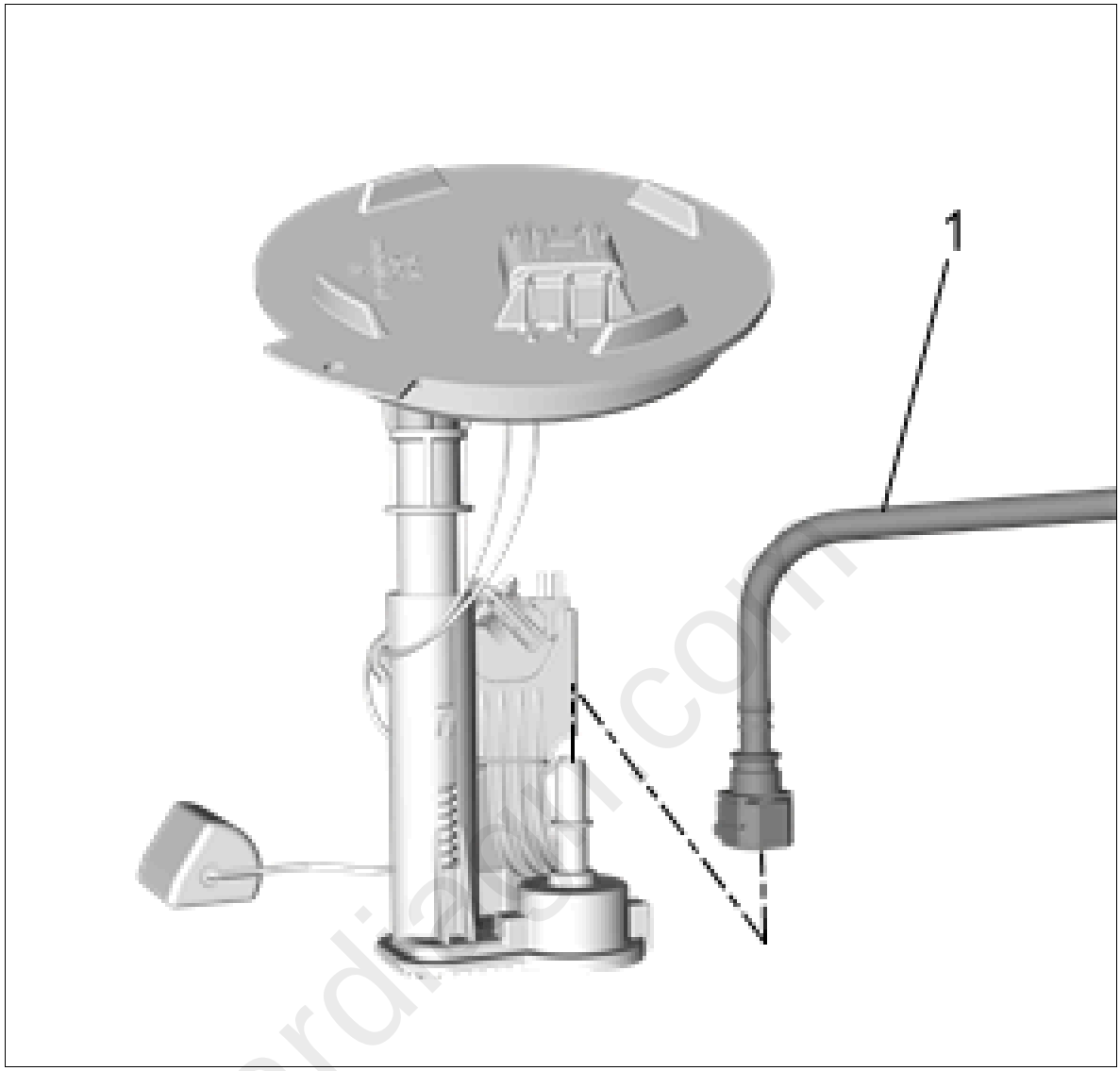
Fig 1: Lock Ring



Courtesy of GENERAL MOTORS COMPANY

3. Use the **CH 45722** wrench by turning counter clockwise and remove the lock ring (1)

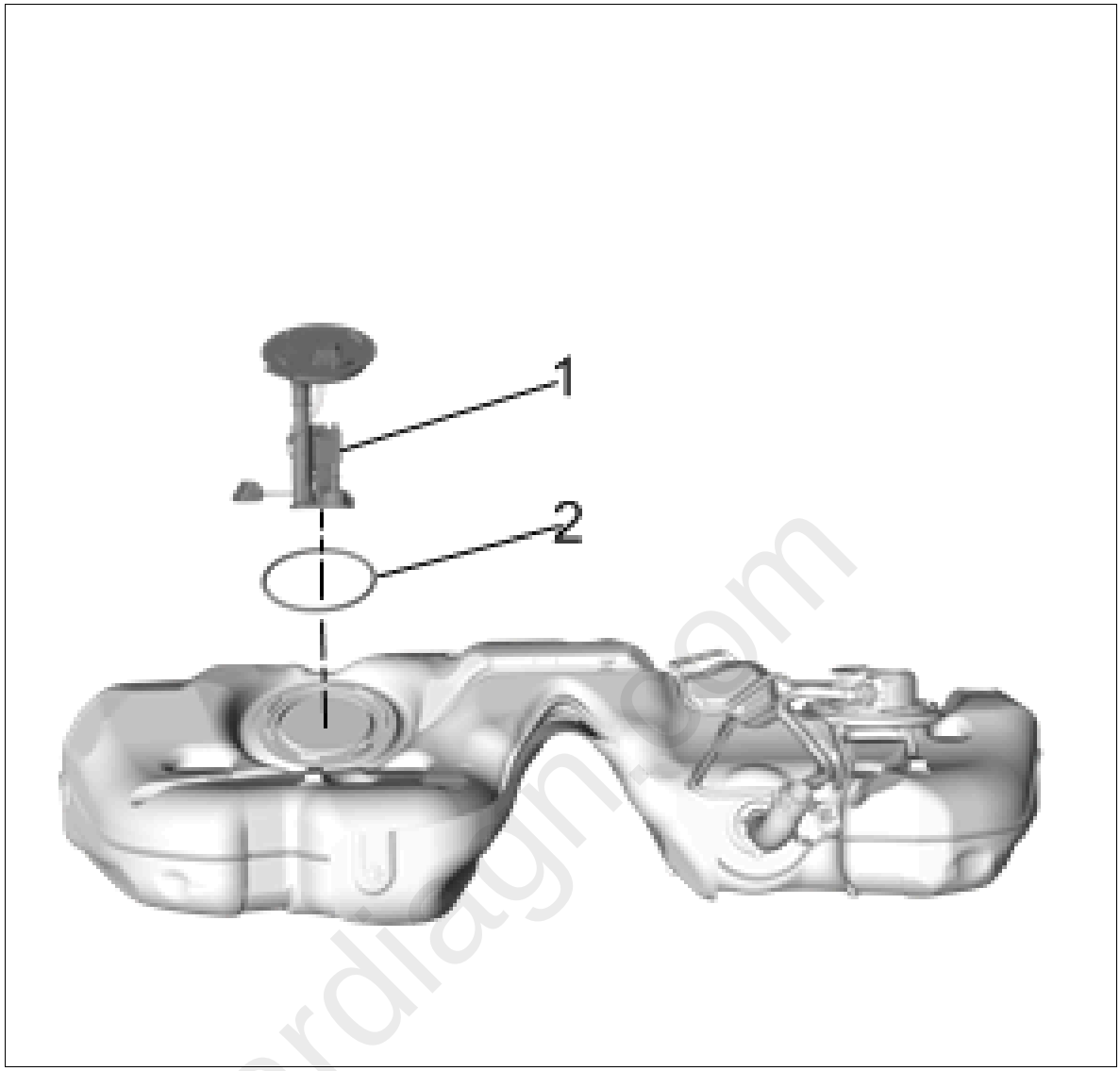
Fig 2: Transfer Hose



Courtesy of GENERAL MOTORS COMPANY

4. Disconnect Transfer Hose (1) - Plastic Collar Quick Connect Fitting Service

Fig 3: Fuel Sender

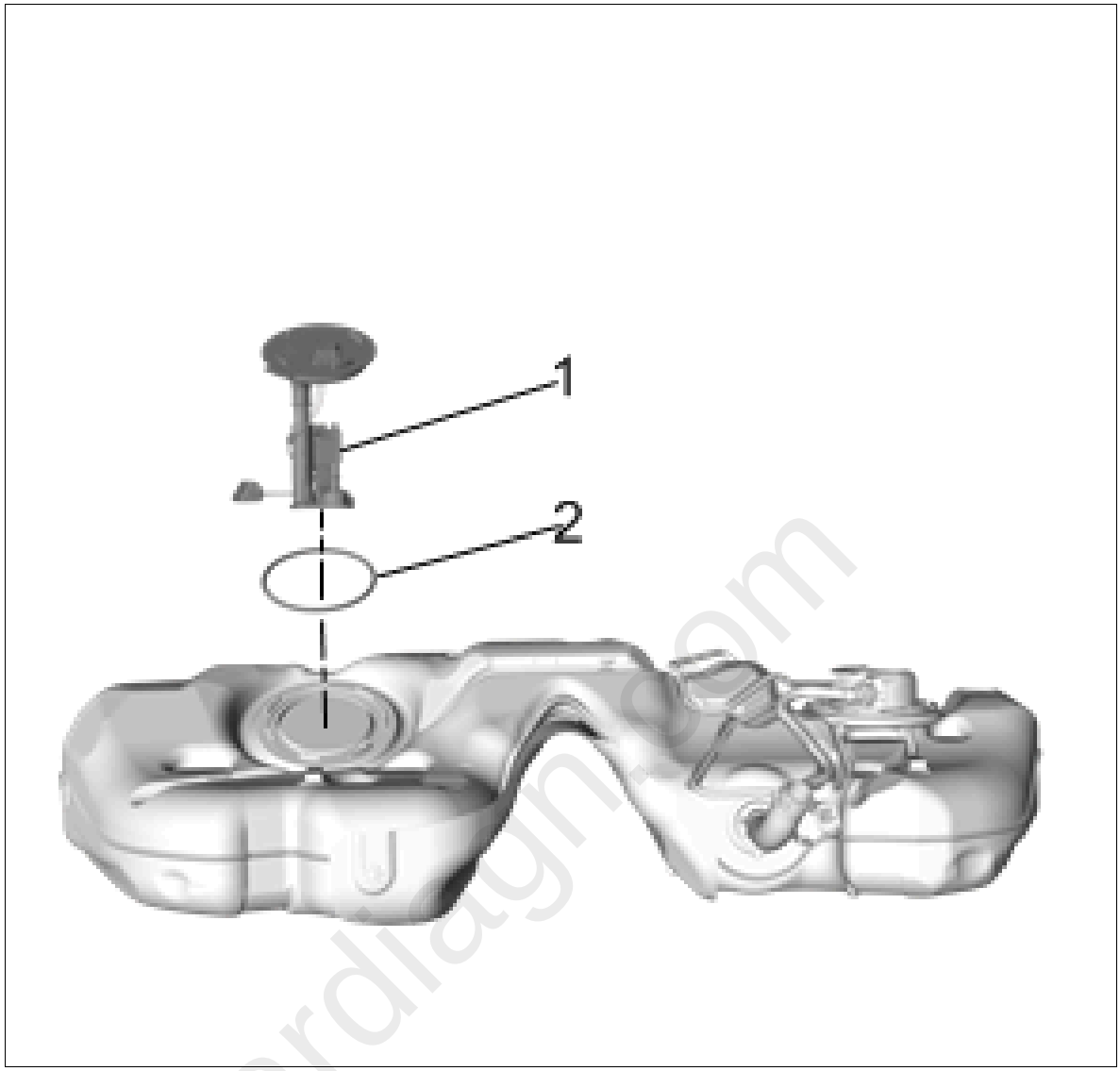


Courtesy of GENERAL MOTORS COMPANY

5. Remove Fuel Sender (1)
6. Remove and DISCARD Fuel Pump Seal (2)

REPAIR INSTRUCTIONS > FUEL SENDER ASSEMBLY REPLACEMENT > INSTALLATION PROCEDURE

Fig 1: Fuel Pump Seal

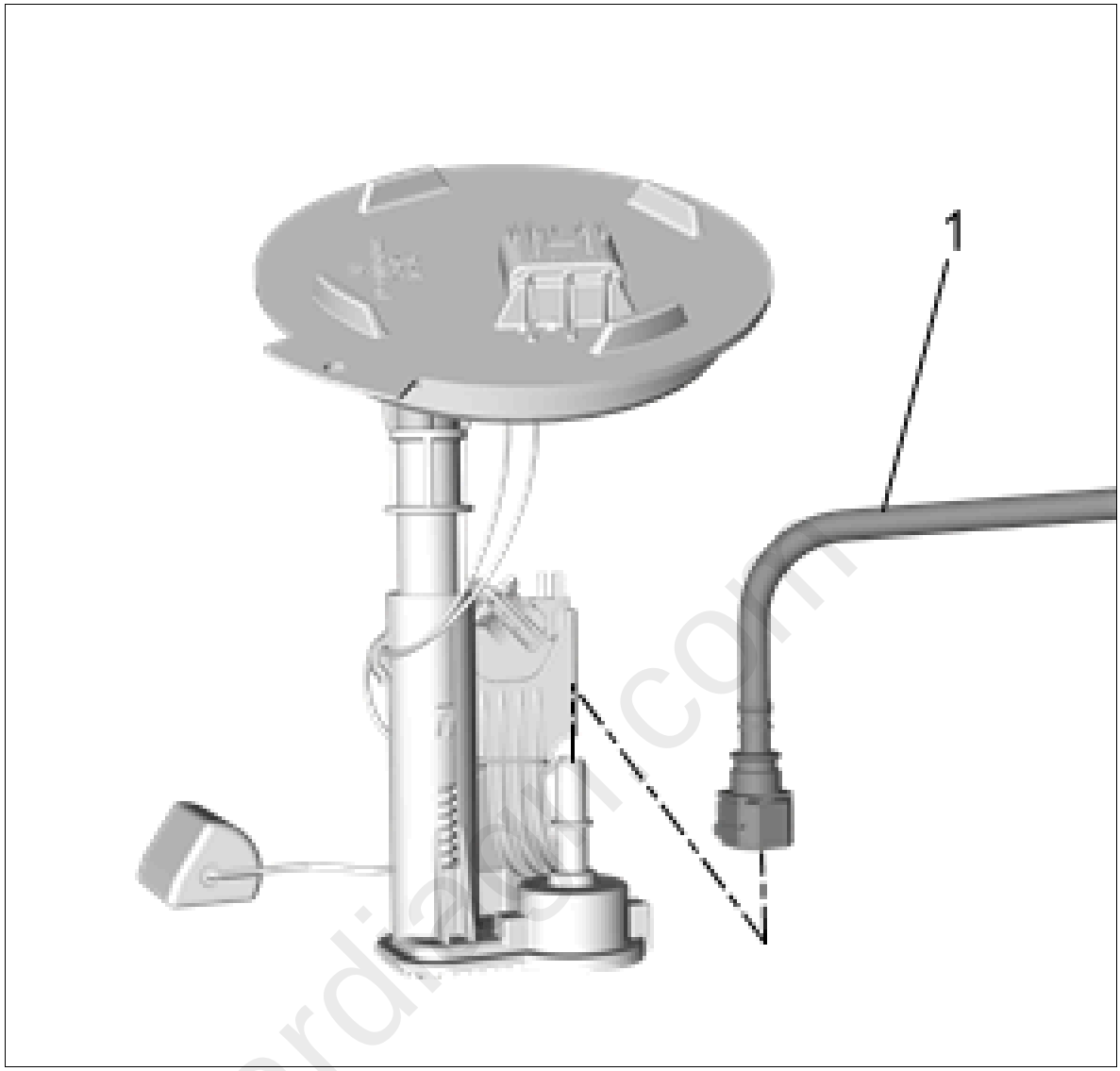


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

1. Install NEW Fuel Pump Seal (2)
2. Install Fuel Sender (1)

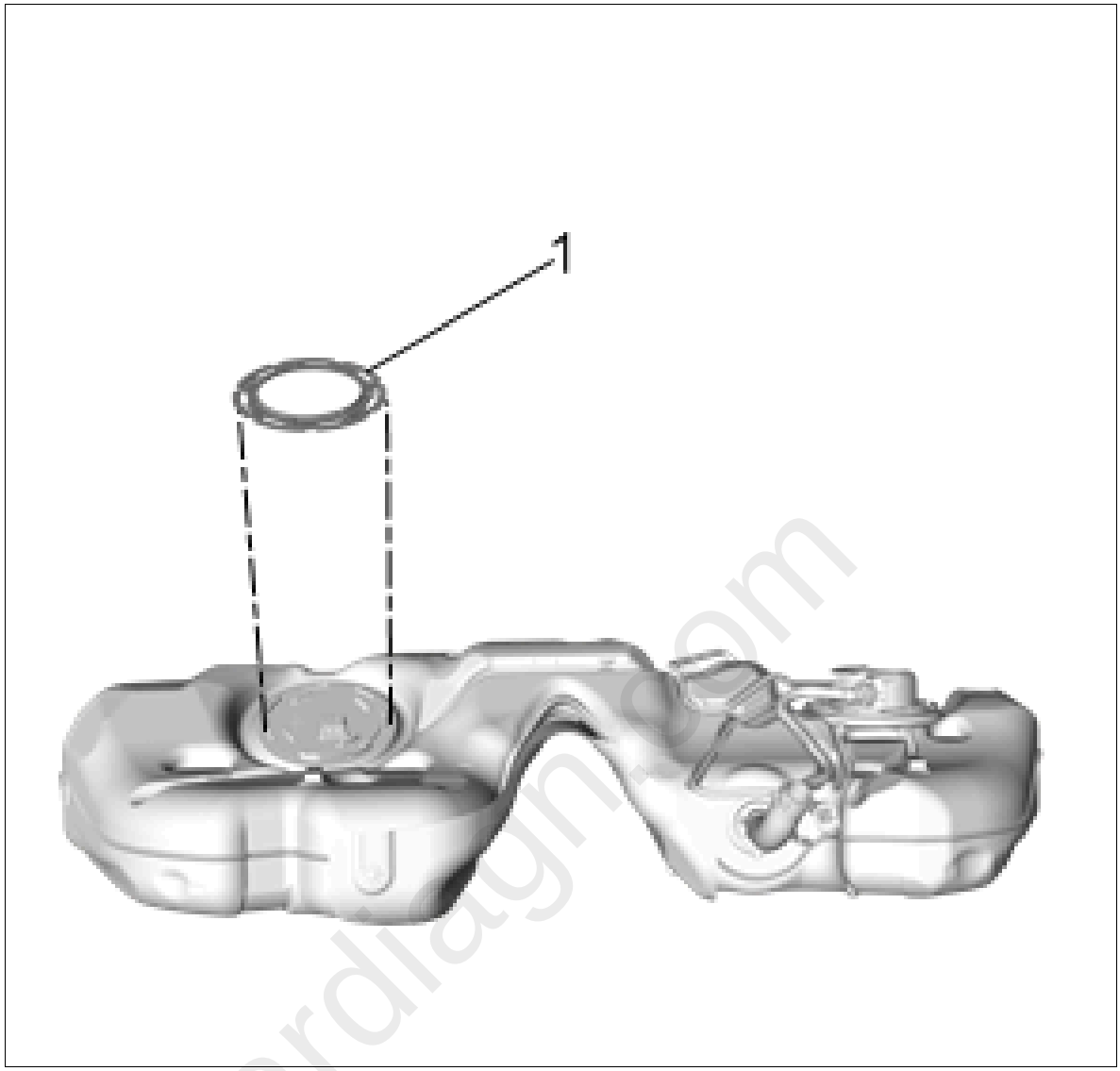
Fig 2: Transfer Hose



Courtesy of GENERAL MOTORS COMPANY

3. Connect Transfer Hose (1) - Plastic Collar Quick Connect Fitting Service

Fig 3: Lock Ring

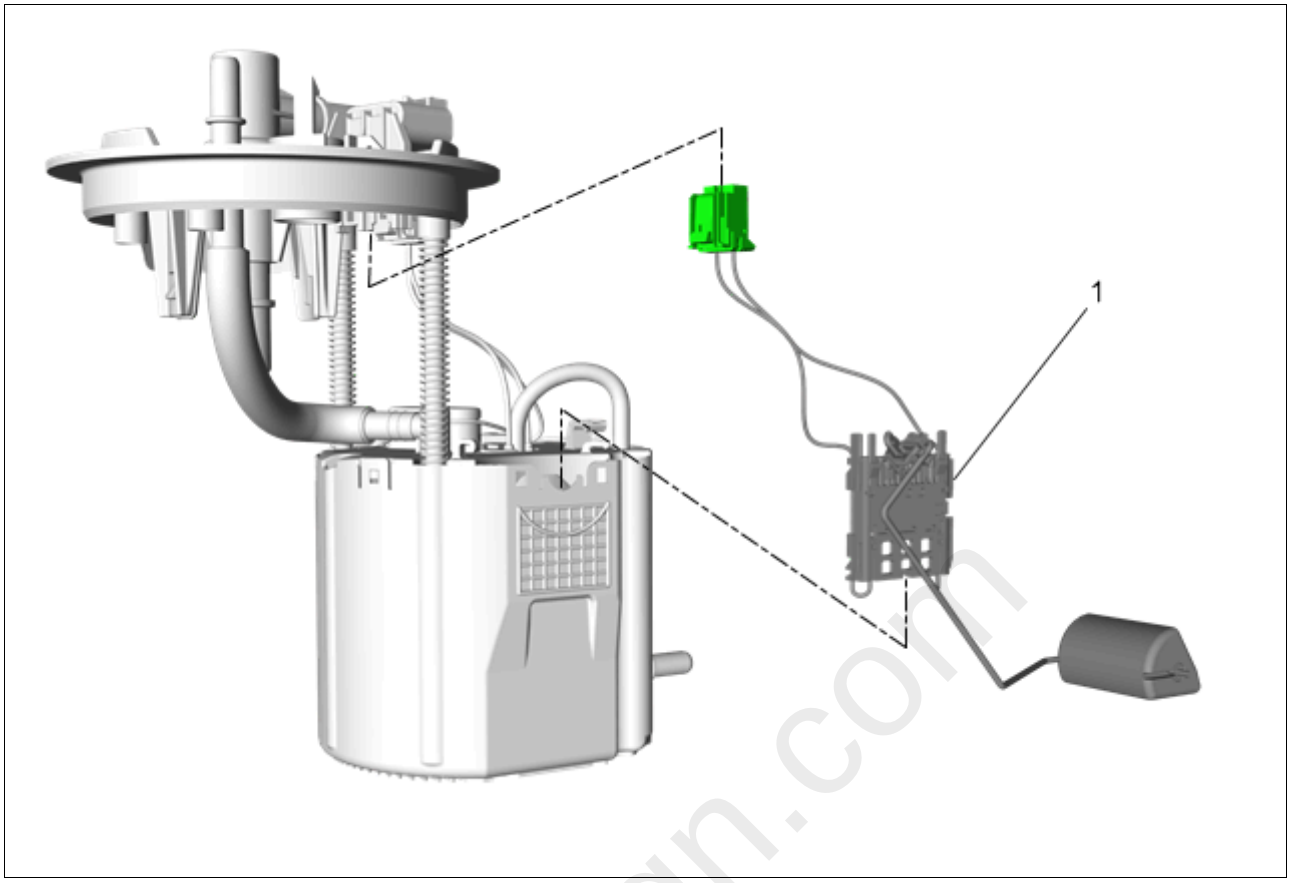


Courtesy of GENERAL MOTORS COMPANY

4. Use the **CH 45722** wrench by turning clockwise and install the lock ring (1)
5. Connect the electrical connector.
6. Install Fuel Tank Replacement

REPAIR INSTRUCTIONS > FUEL LEVEL SENSOR REPLACEMENT

Fig 1: Fuel Level Sensor



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
	WARNING: *Refer to Gasoline/Gasoline Vapors Warning .*
	WARNING: *Refer to Safety Glasses Warning .*
	Preliminary Procedure Fuel Tank Fuel Pump Module Replacement .
1	Fuel Level Sensor **Procedure** Release the fuel level sensor tabs and disconnect the electrical connector.

cardiagn.com

REPAIR INSTRUCTIONS > FUEL TANK FILLER PIPE REPLACEMENT > REMOVAL

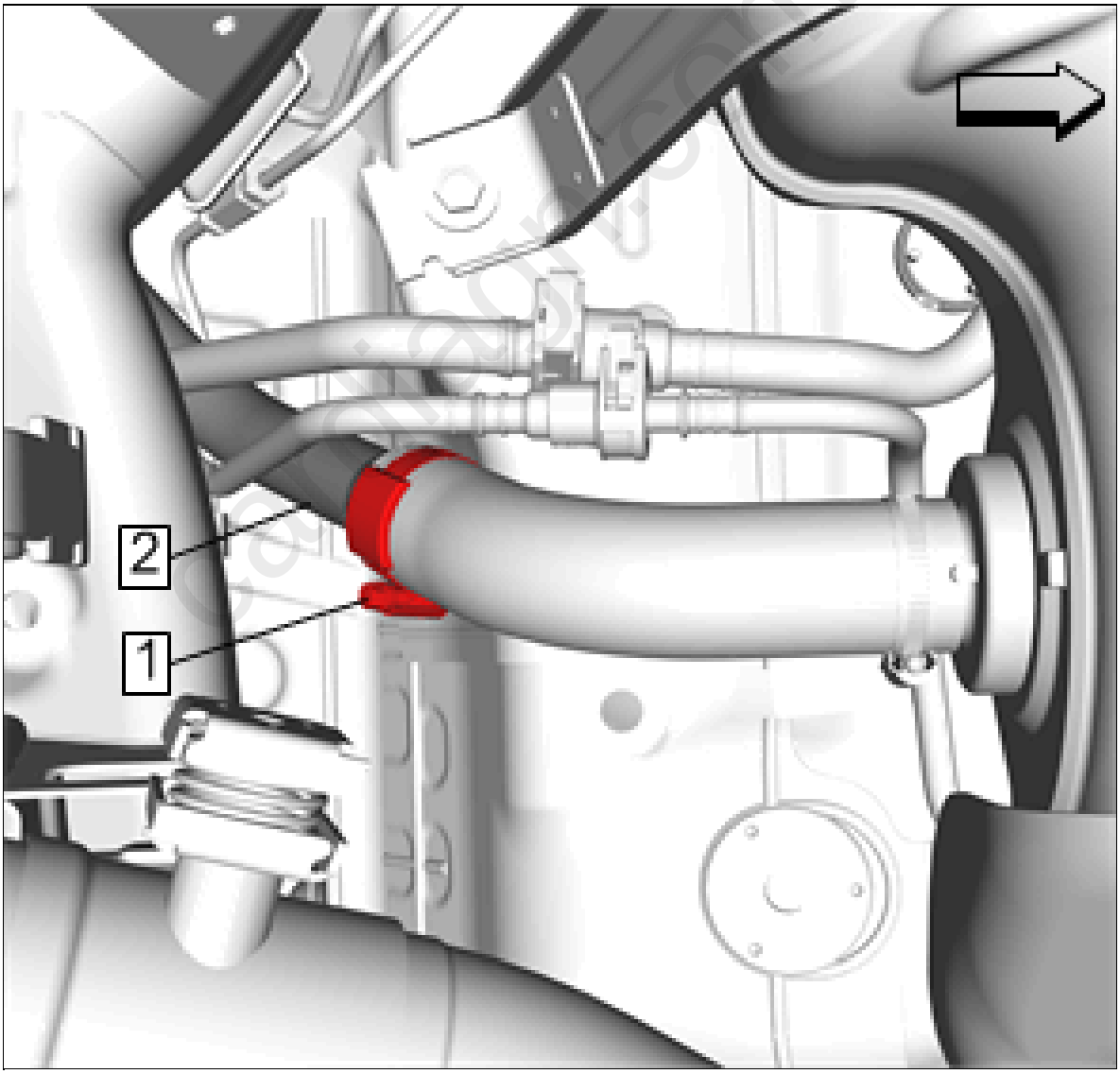
PROCEDURE

> *WARNING:*
>
> *Refer to Gasoline/Gasoline Vapors Warning .*

> *WARNING:*
>
> *Refer to Safety Glasses Warning .*

1. Raise and support the vehicle. Lifting and Jacking the Vehicle (Base)Lifting and Jacking the Vehicle (HP)

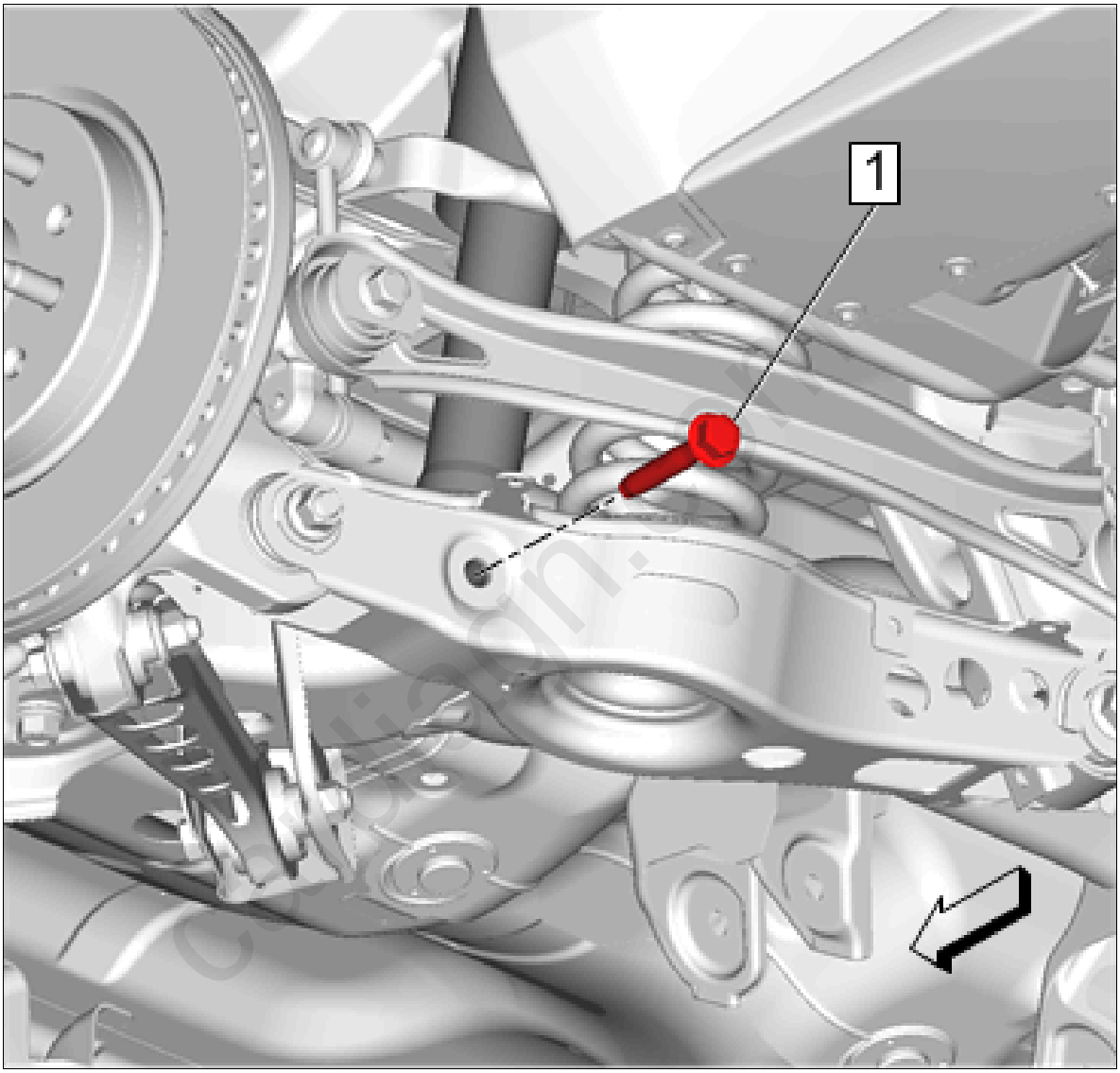
Fig 1: Fuel Tank Filler Pipe Clamp



Courtesy of GENERAL MOTORS COMPANY

2. Remove Fuel Tank Filler Pipe Clamp (1)
3. Remove Fuel Tank Filler Pipe (2)
4. Remove Fuel Tank Filler Pipe Housing Replacement
5. Remove Rear Wheelhouse Liner Replacement

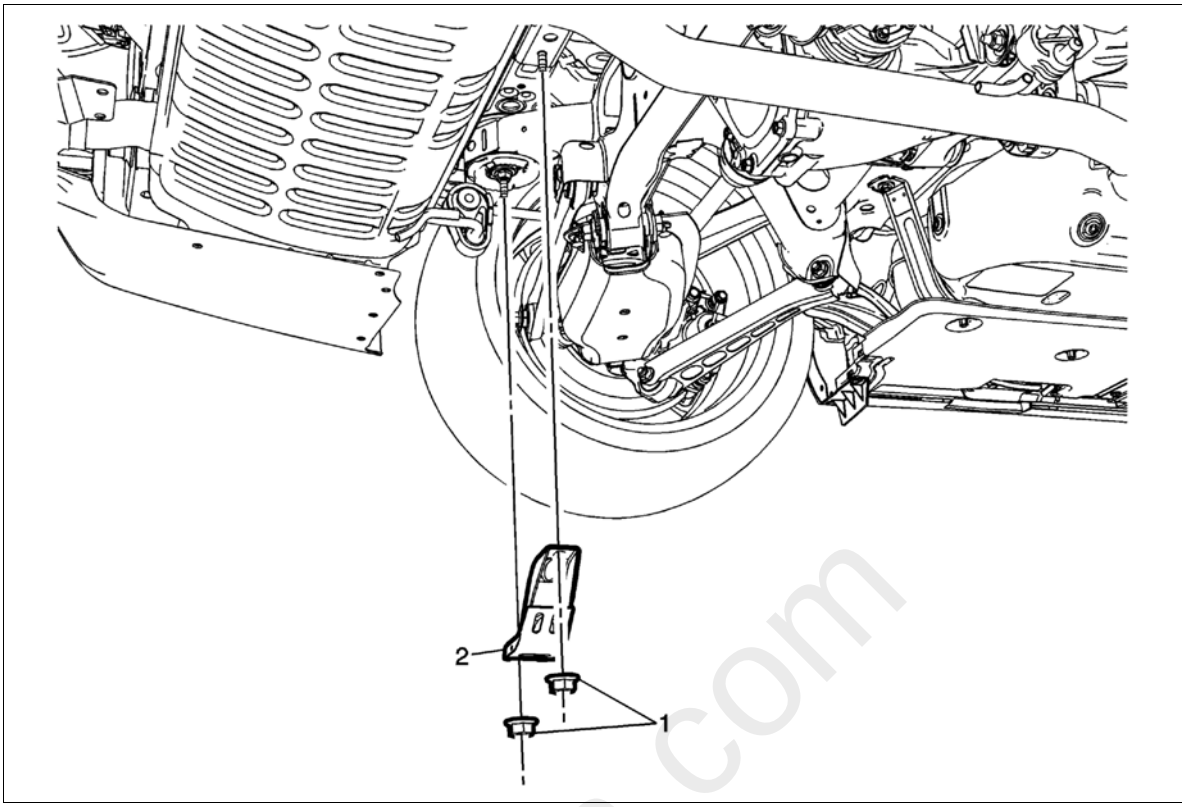
Fig 2: Lower Rear Shock Absorber Bolt



Courtesy of GENERAL MOTORS COMPANY

6. Remove Lower Rear Shock Bolt - Right Side (1) - Shock Absorber Replacement

Fig 3: Rear Suspension Bracket (Rear)

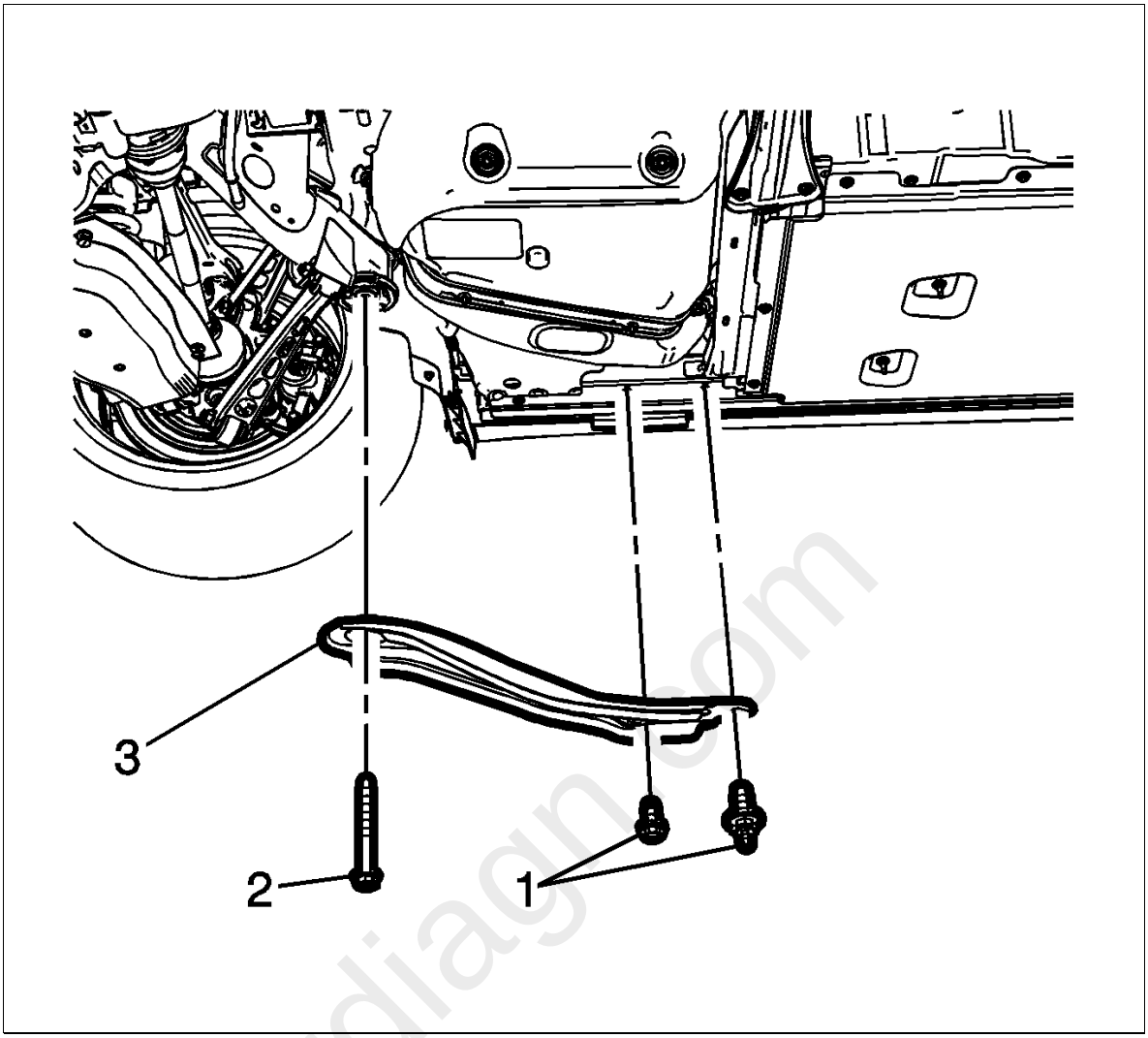


Courtesy of GENERAL MOTORS COMPANY

7. Remove Rear Suspension Bracket - Rear (2) - Rear Suspension Bracket Replacement (Rear (Coupe))

cardiagn.com

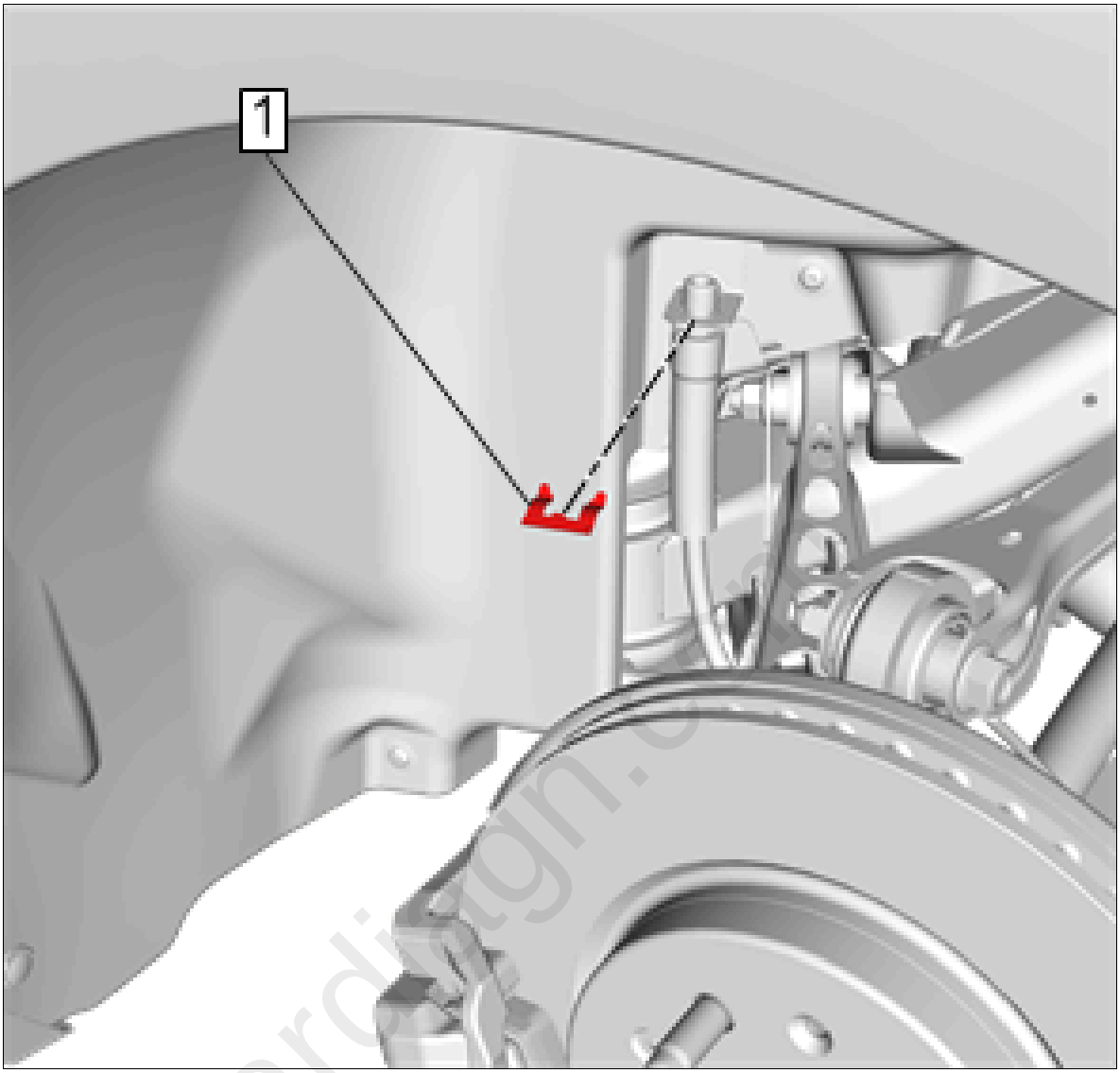
Fig 4: Rear Suspension Bracket & Mounting Bolts



Courtesy of GENERAL MOTORS COMPANY

8. Remove Rear Suspension Bracket - Front Right Side (3) - Rear Suspension Bracket Replacement (Front)

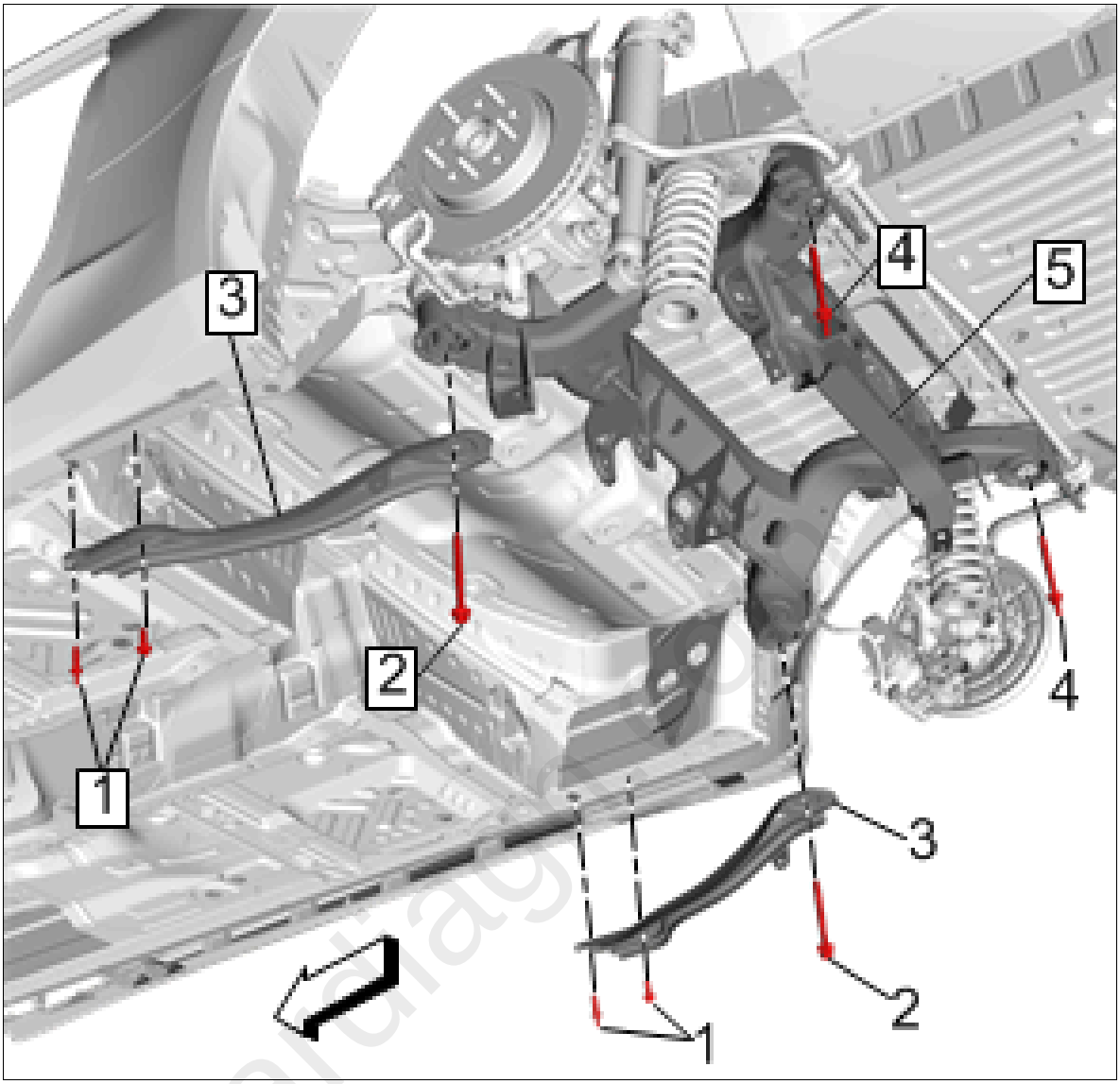
Fig 5: Brake Hose Retainer



Courtesy of GENERAL MOTORS COMPANY

9. Remove Brake Hose Retainer - Right Side (1) - Rear Brake Hose Replacement (JL9, J55)Rear Brake Hose Replacement (J6G)
10. Using a support stand, support the rear suspension cradle.

Fig 6: Rear Suspension Cradle Bolt - Left Side



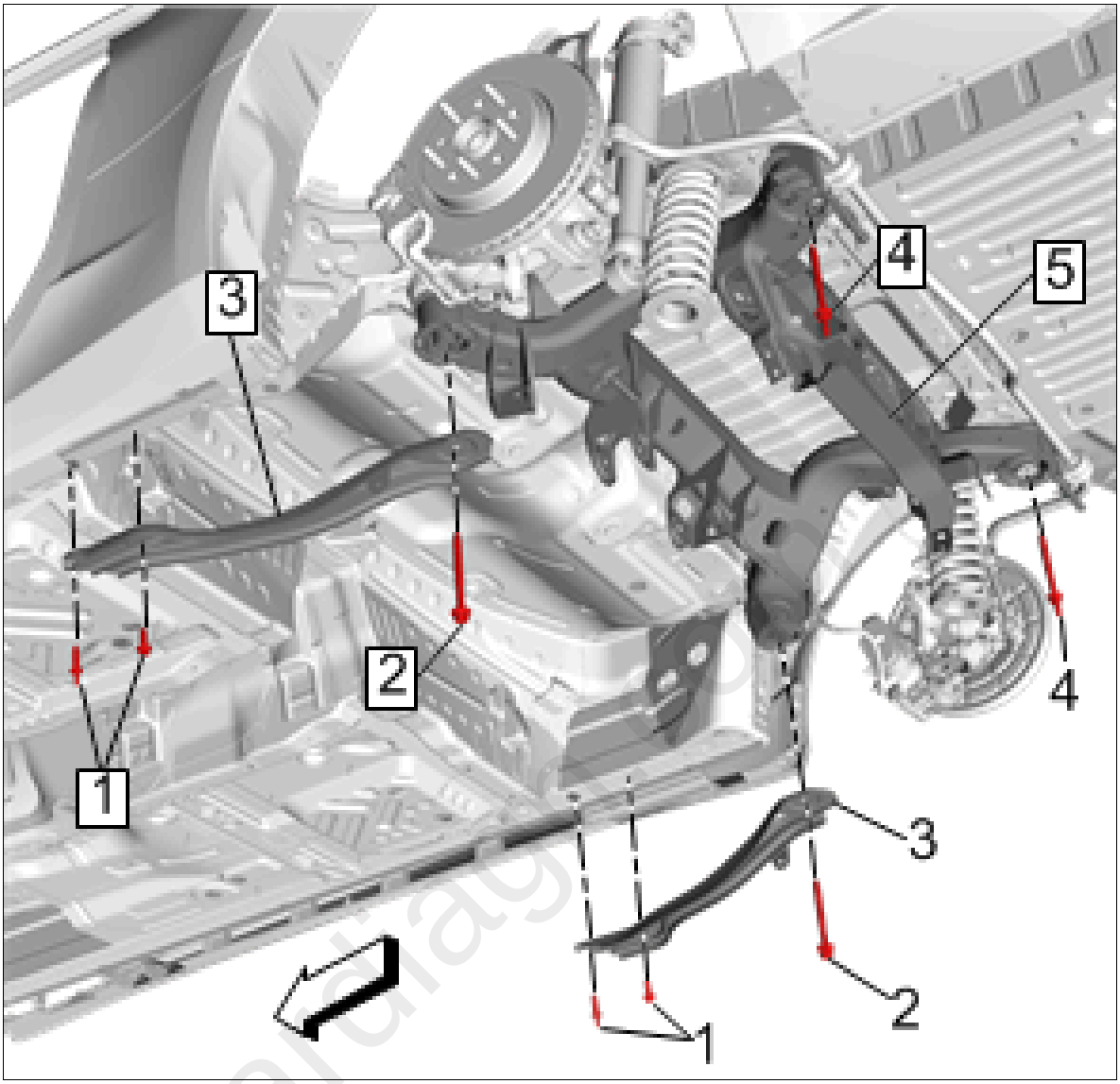
Courtesy of GENERAL MOTORS COMPANY

NOTE:

Bolt is a single use fastener and will need to be replaced.

11. Loosen Rear Suspension Cradle Bolt - Left Side (4) - Rear Suspension Cradle Replacement

Fig 7: Rear Suspension Cradle Bolt - Right Side



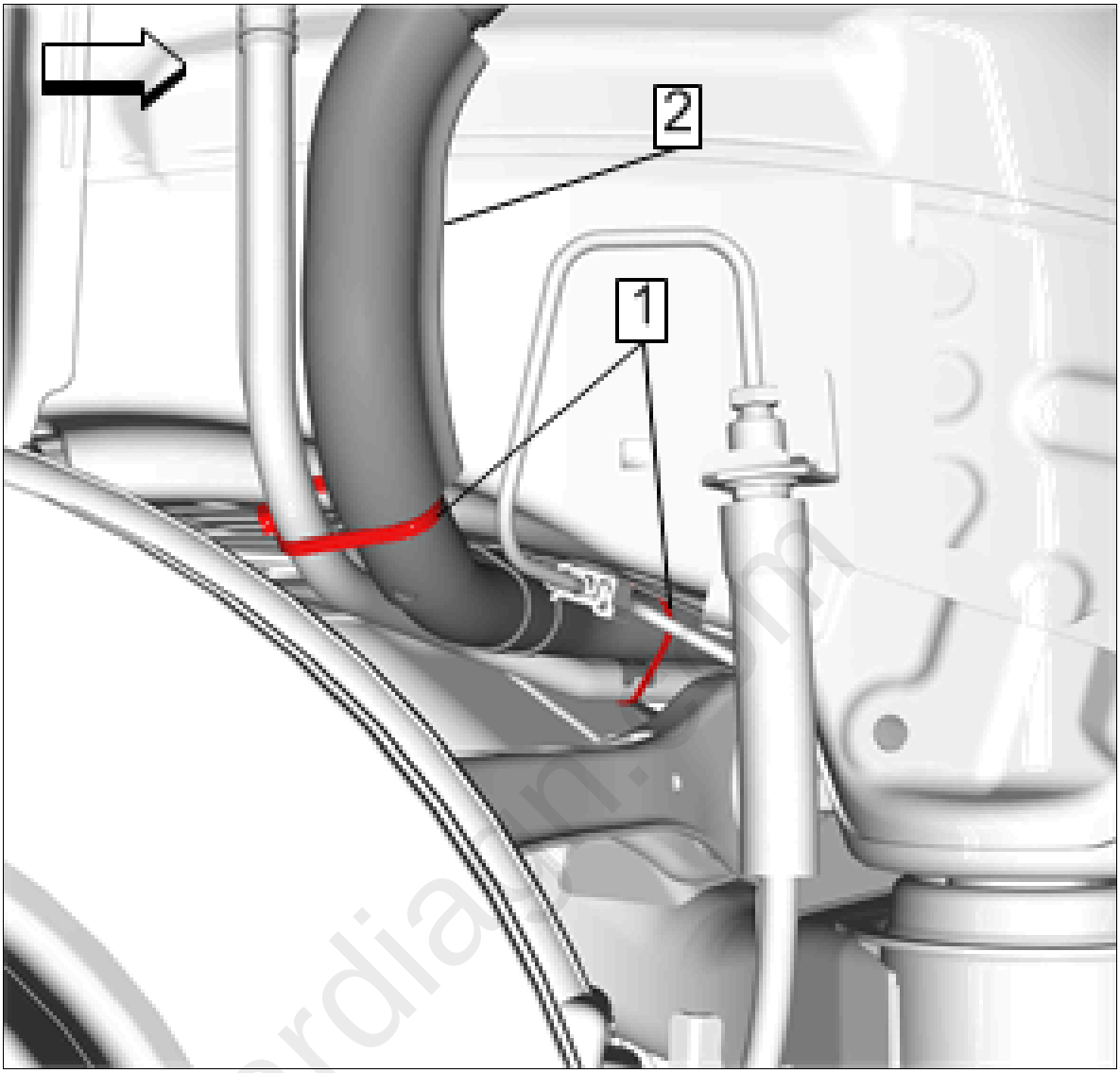
Courtesy of GENERAL MOTORS COMPANY

12. Remove and DISCARD Rear Suspension Cradle Bolt - Right Side (4) - Rear Suspension Cradle Replacement

> *NOTE:*
>
> *Ensure brake hoses are not over-extended as the cradle is lowered.*

13. Lower the right side of the rear suspension cradle to provide clearance for filler pipe removal

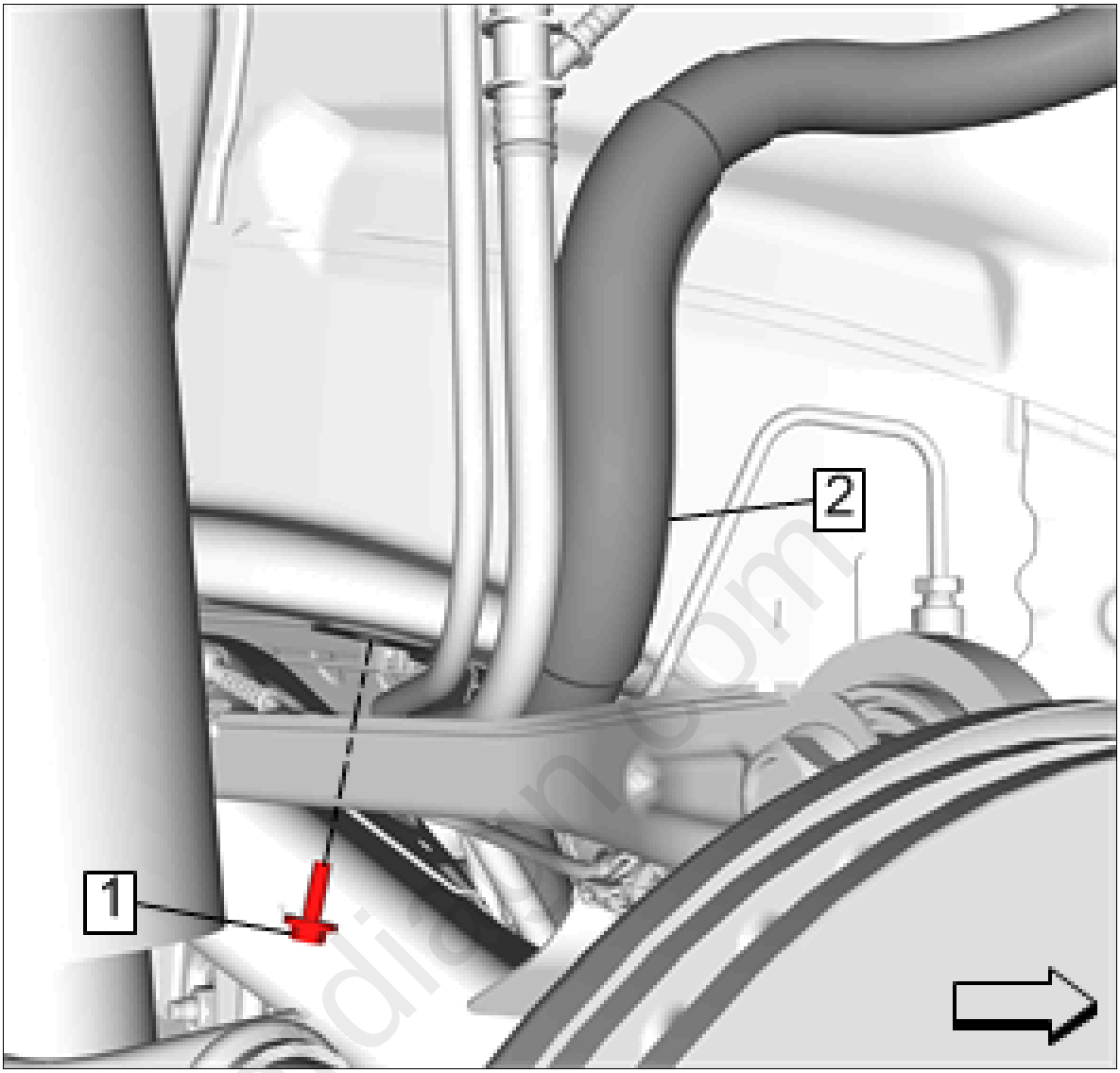
Fig 8: Tie Strap



Courtesy of GENERAL MOTORS COMPANY

14. Remove and DISCARD Tie Strap (1) (Qty: 2) at Fuel Tank Filler Pipe (2)

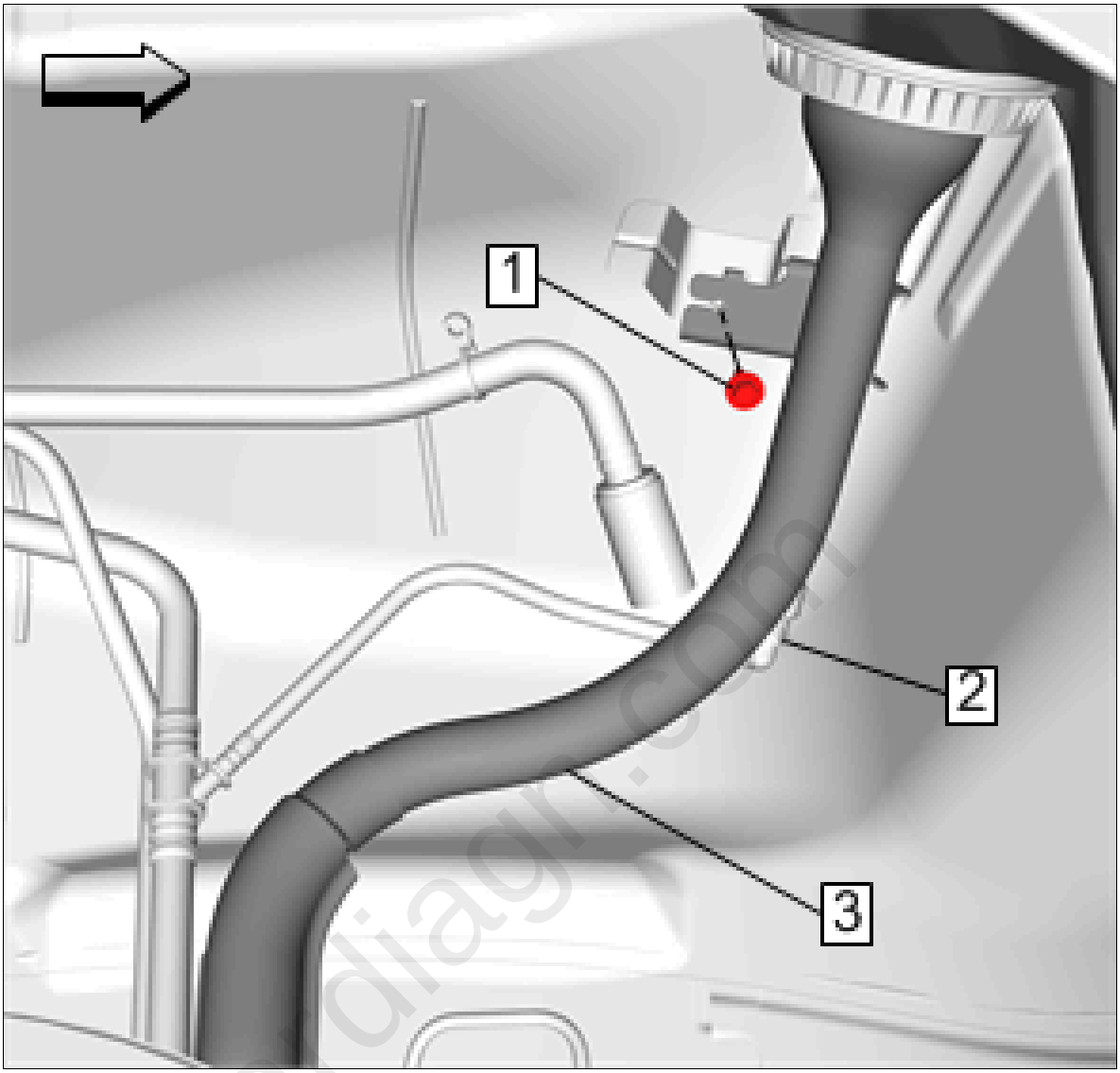
Fig 9: Fuel Tank Filler Pipe Bolt



Courtesy of GENERAL MOTORS COMPANY

15. Remove Fuel Tank Filler Pipe Bolt (1) at Fuel Tank Filler Pipe (2)

Fig 10: Evaporative Emission Canister Hose

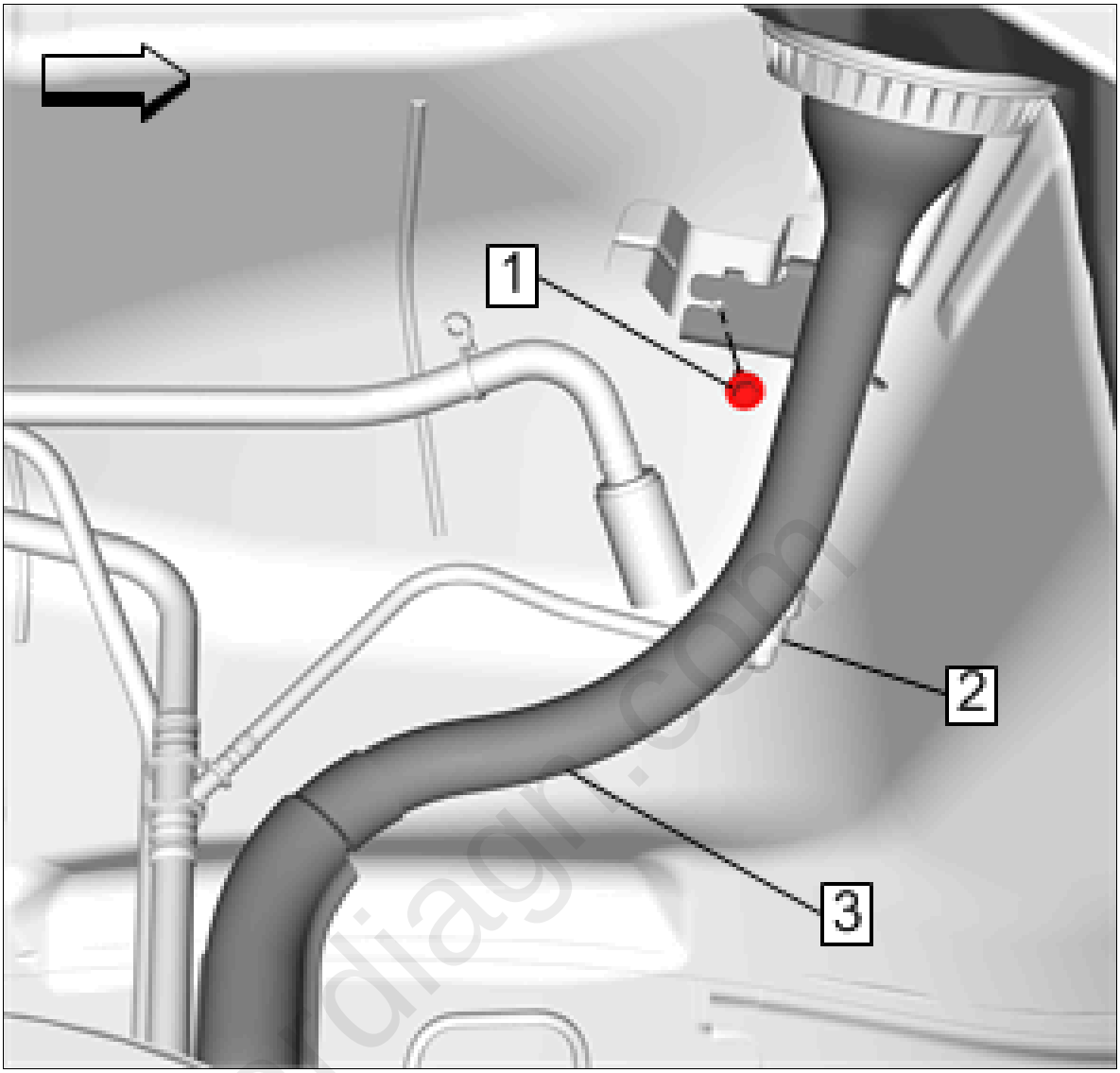


Courtesy of GENERAL MOTORS COMPANY

16. Disconnect Evaporative Emission Canister Hose (2) at Fuel Tank Filler Pipe (3) - Plastic Collar Quick Connect Fitting Service
17. Remove Fuel Tank Filler Pipe Bolt (1) at Fuel Tank Filler Pipe (3)
18. Remove Fuel Tank Filler Pipe (3)

REPAIR INSTRUCTIONS > FUEL TANK FILLER PIPE REPLACEMENT > INSTALLATION PROCEDURE

Fig 1: Fuel Tank Filler Pipe



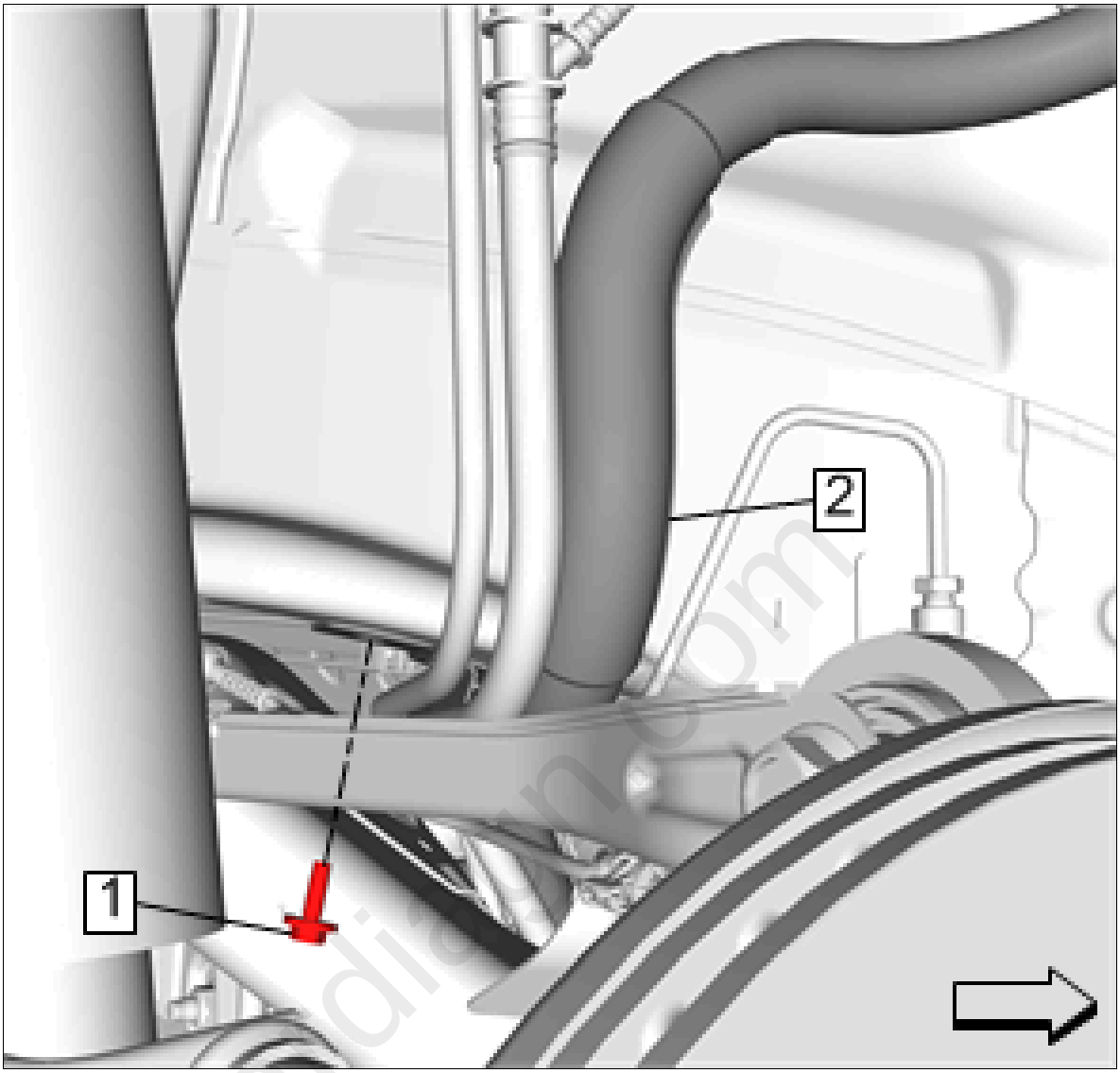
Courtesy of GENERAL MOTORS COMPANY

1. Install Fuel Tank Filler Pipe (3)

> ⚠ *CAUTION:*
>
> *Refer to Fastener Caution .*

2. Install Fuel Tank Filler Pipe Bolt (1) at Fuel Tank Filler Pipe (3) to 2.5 N.m (22 lb in)
3. Connect Evaporative Emission Canister Hose (2) at Fuel Tank Filler Pipe (3) - Plastic Collar Quick Connect Fitting Service

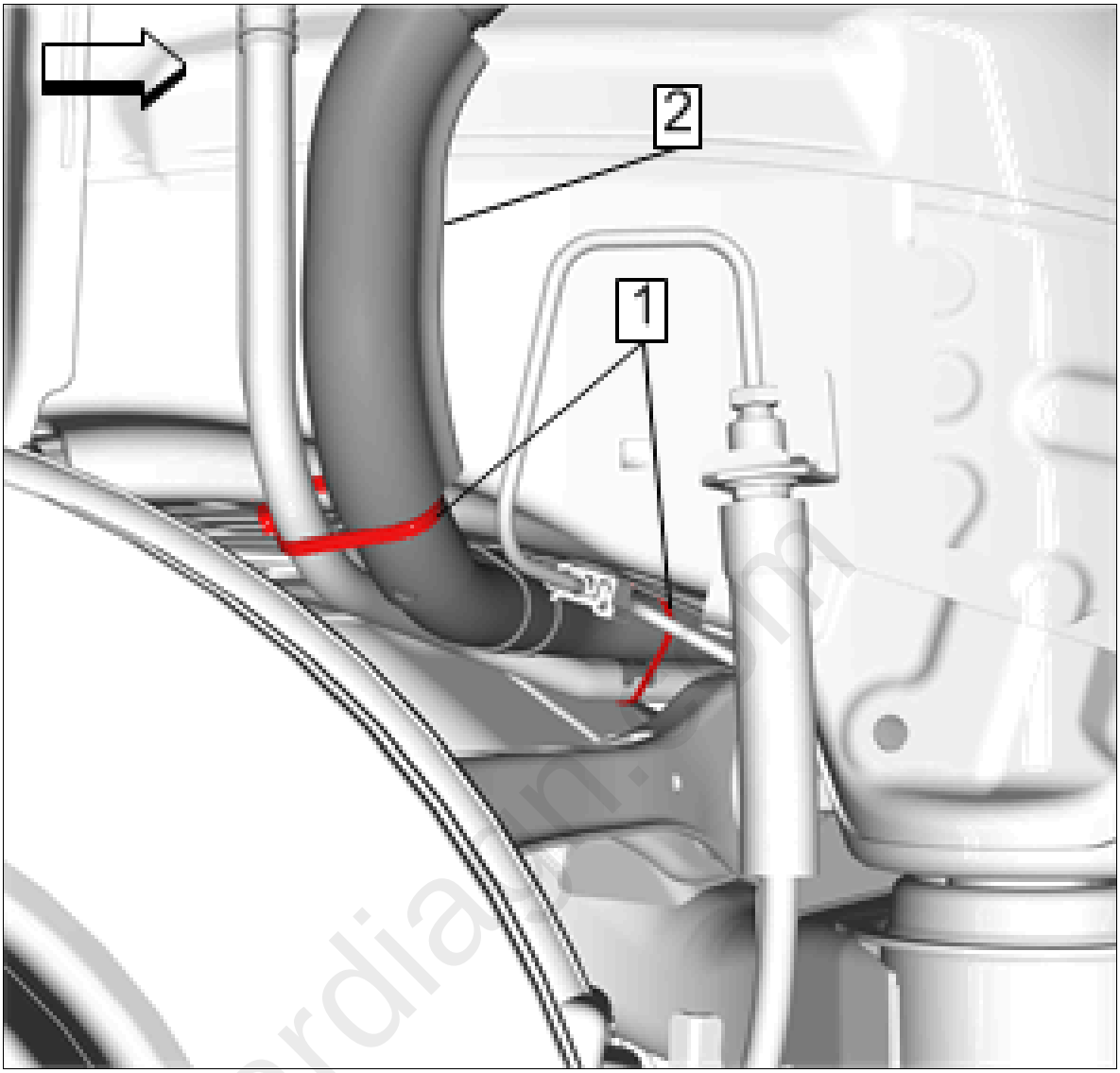
Fig 2: Fuel Tank Filler Pipe Bolt



Courtesy of GENERAL MOTORS COMPANY

4. Install Fuel Tank Filler Pipe Bolt (1) at Fuel Tank Filler Pipe (2) to 9 N.m (80 lb in)

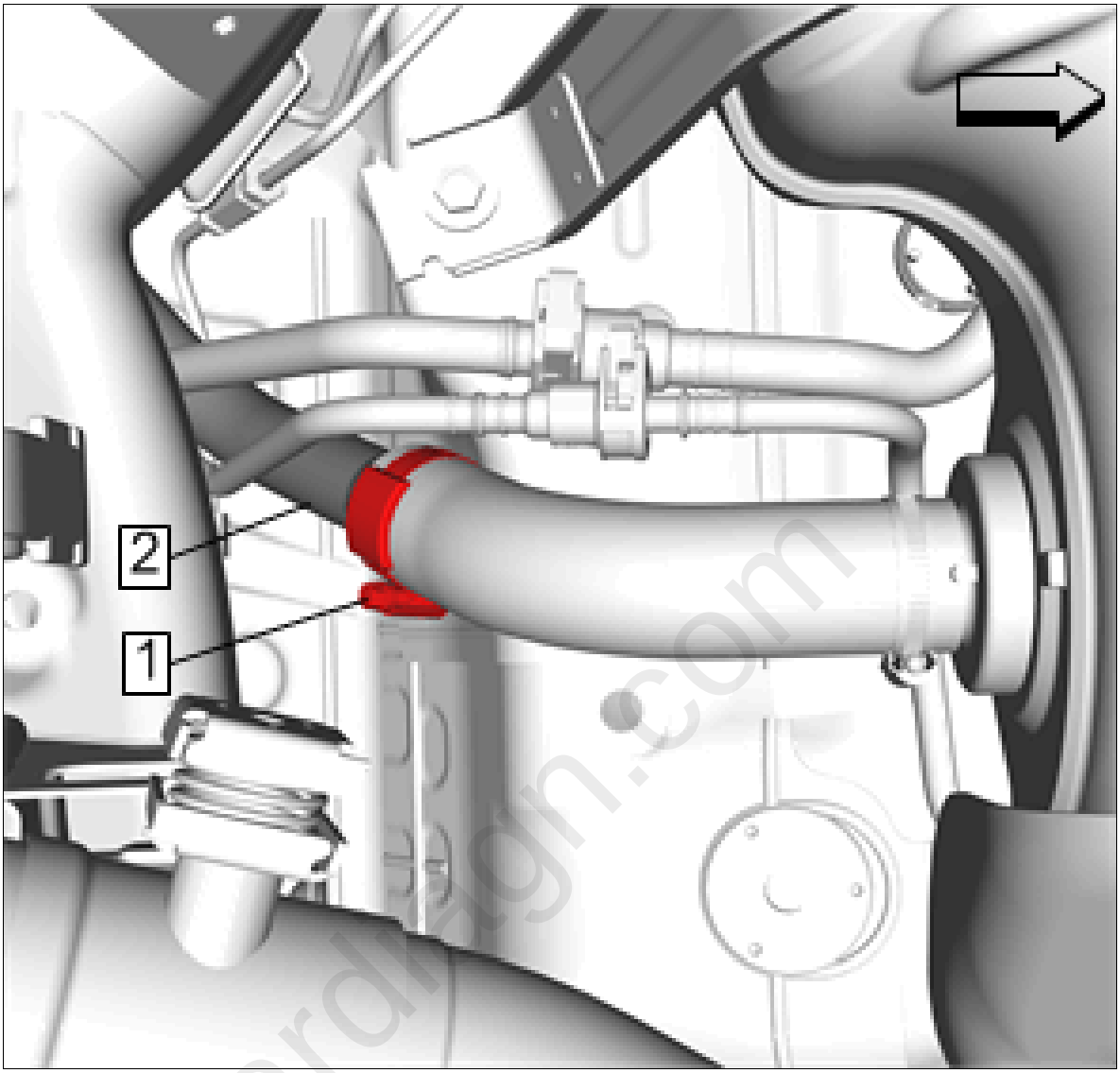
Fig 3: Tie Strap



Courtesy of GENERAL MOTORS COMPANY

5. Install NEW Tie Strap (1) (Qty: 2) at Fuel Tank Filler Pipe (2)

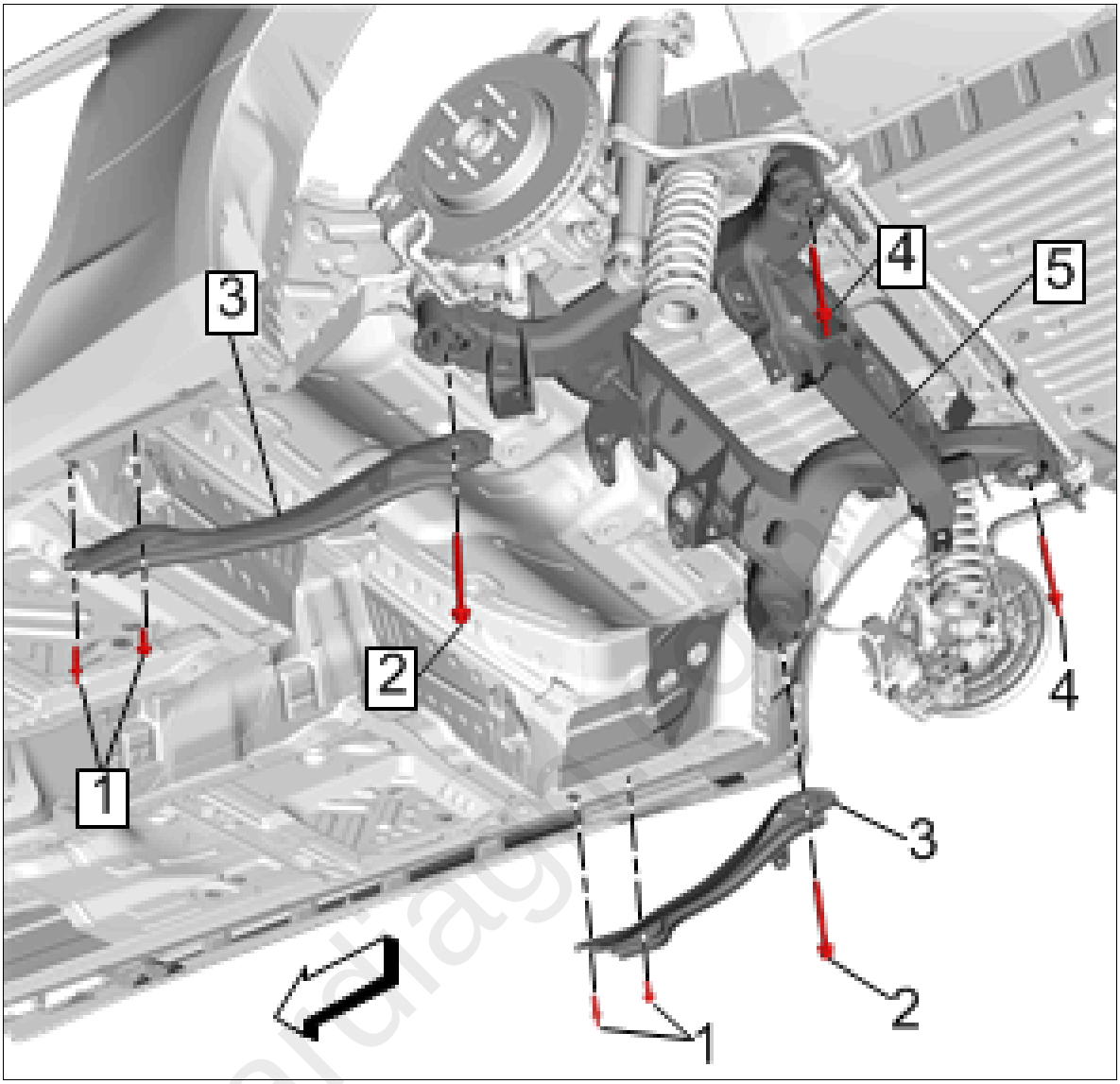
Fig 4: Fuel Tank Filler Pipe Clamp



Courtesy of GENERAL MOTORS COMPANY

6. Install Fuel Tank Filler Pipe (2)
7. Install Fuel Tank Filler Pipe Clamp (1) to 3.5 N.m (31 lb in)
8. Raise the rear suspension cradle back into position.

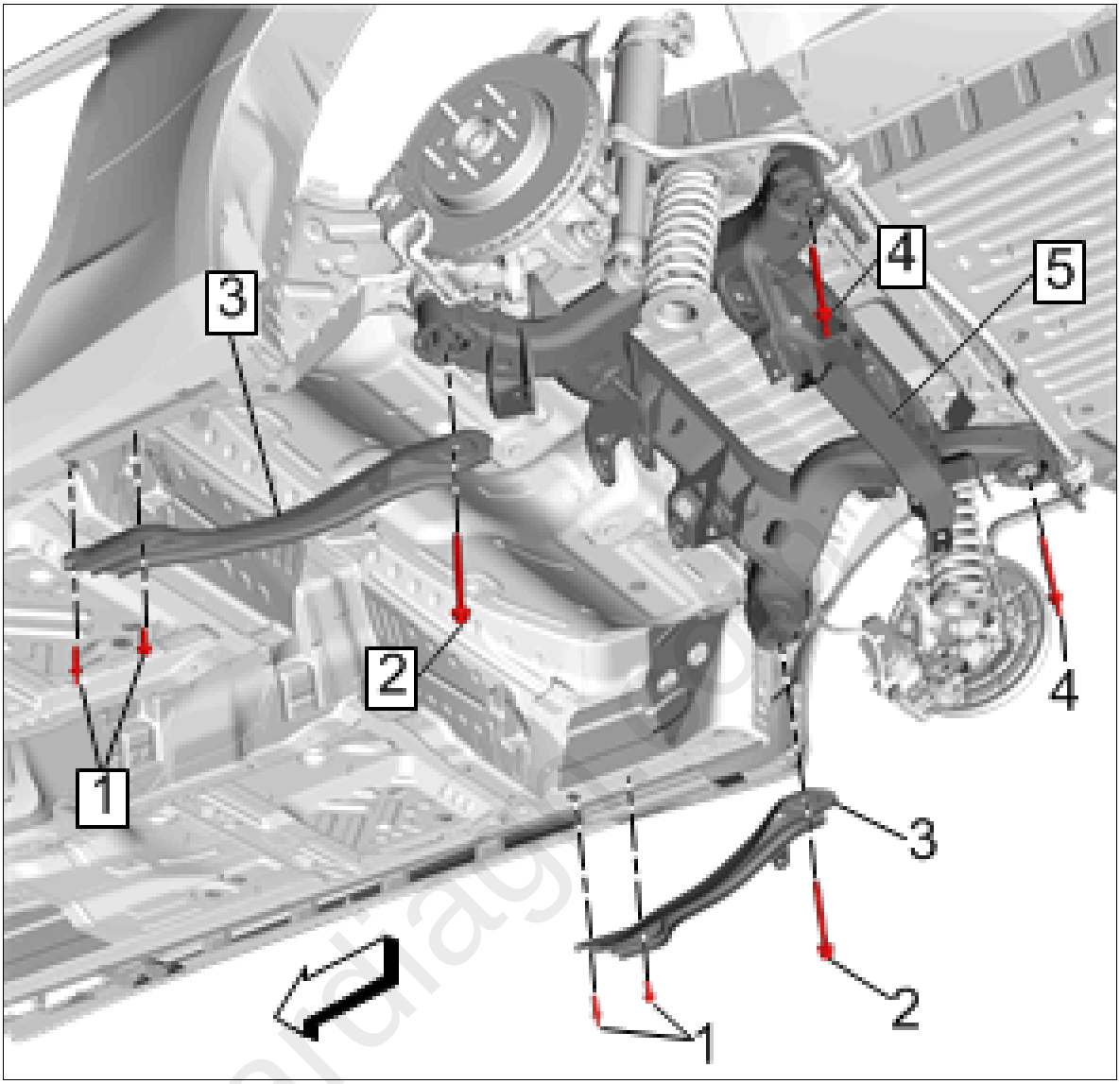
Fig 5: Rear Suspension Cradle Bolt - Right Side



Courtesy of GENERAL MOTORS COMPANY

9. Install NEW Rear Suspension Cradle Bolts - Right Side (4) - Rear Suspension Cradle Replacement

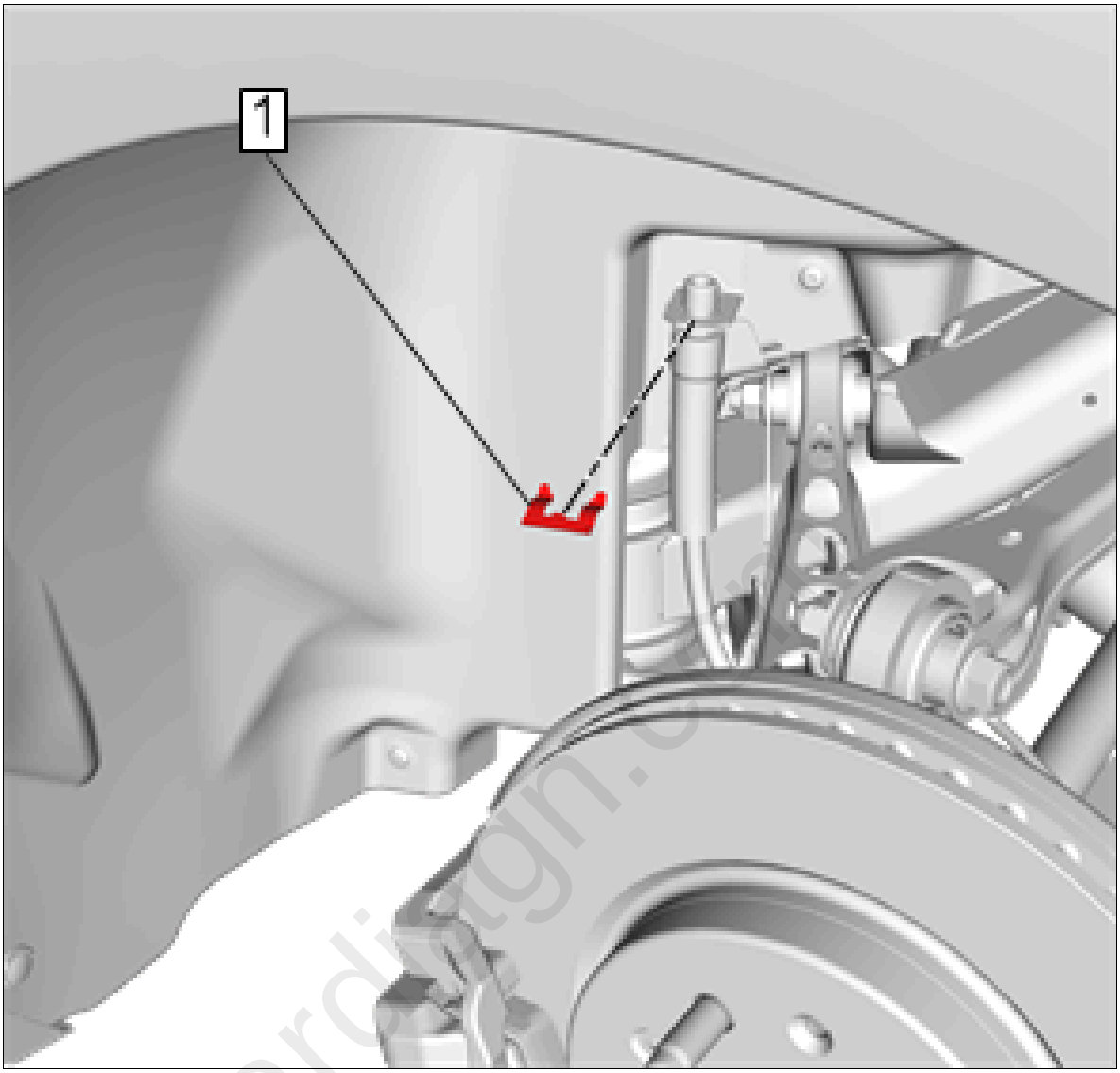
Fig 6: Rear Suspension Cradle Bolt - Right Side



Courtesy of GENERAL MOTORS COMPANY

10. Install NEW Rear Suspension Cradle Bolt - Left Side (4) - Rear Suspension Cradle Replacement

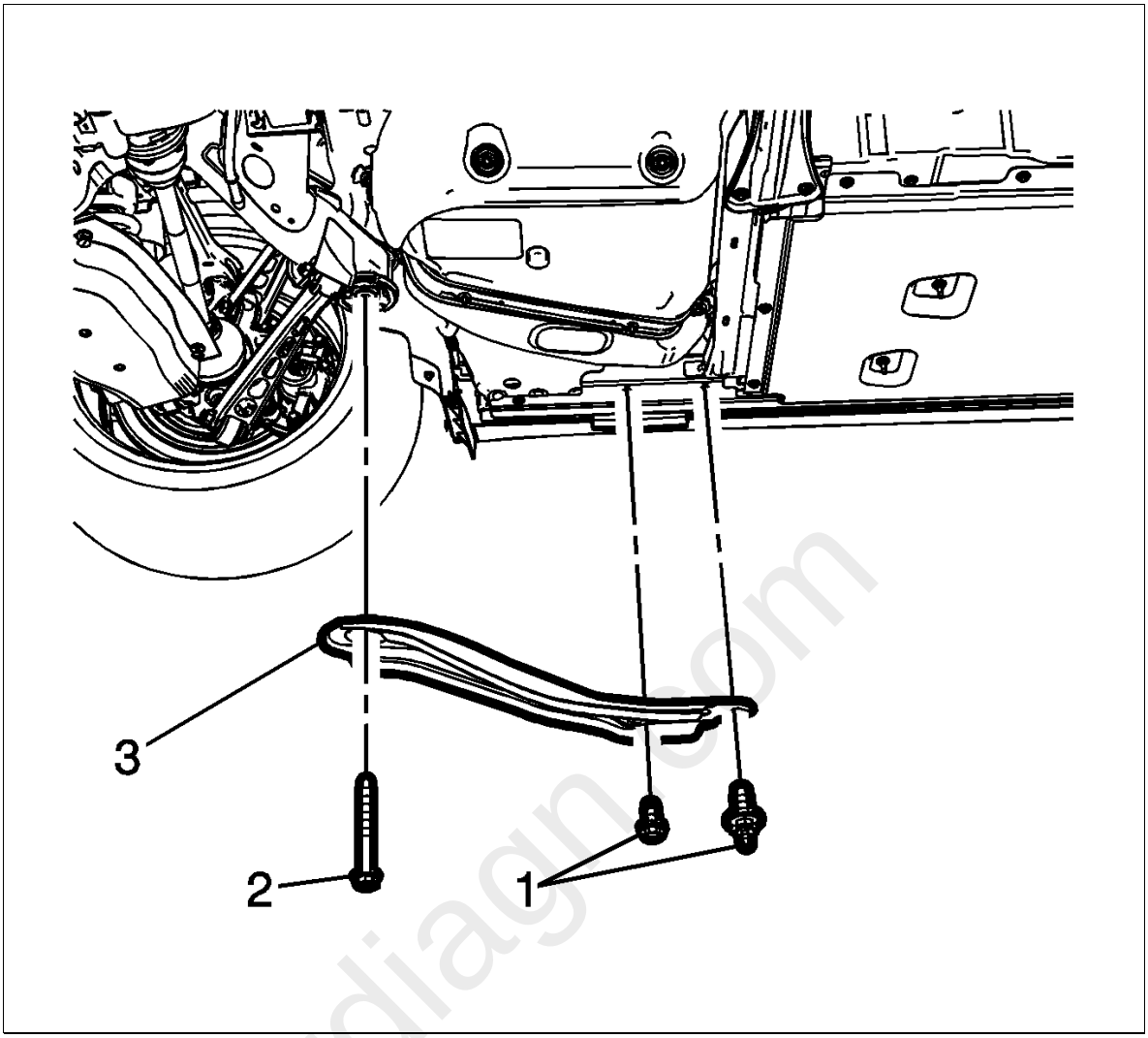
Fig 7: Brake Hose Retainer



Courtesy of GENERAL MOTORS COMPANY

11. Install Brake Hose Retainer - Right Side (1) - Rear Brake Hose Replacement (JL9, J55)Rear Brake Hose Replacement (J6G)

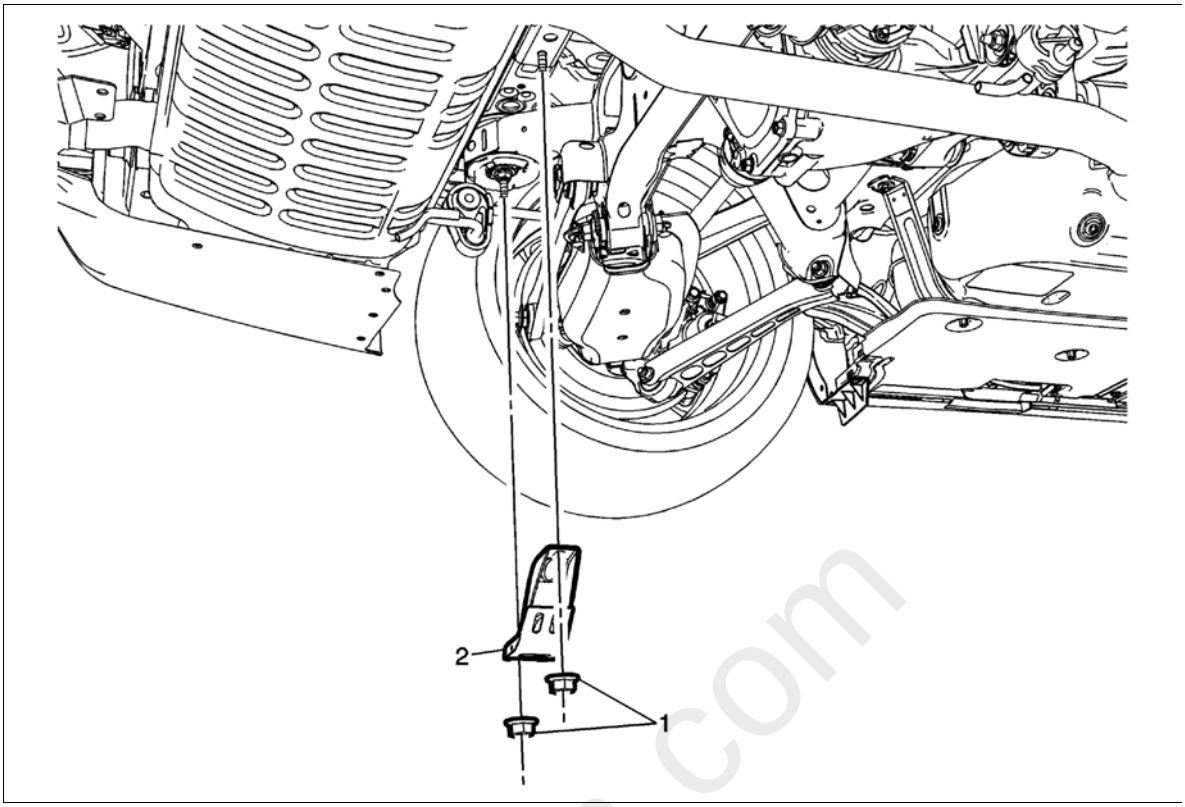
Fig 8: Rear Suspension Bracket & Mounting Bolts



Courtesy of GENERAL MOTORS COMPANY

12. Install Rear Suspension Bracket - Front Right Side (3) - Rear Suspension Bracket Replacement (Front)

Fig 9: Rear Suspension Bracket (Rear)

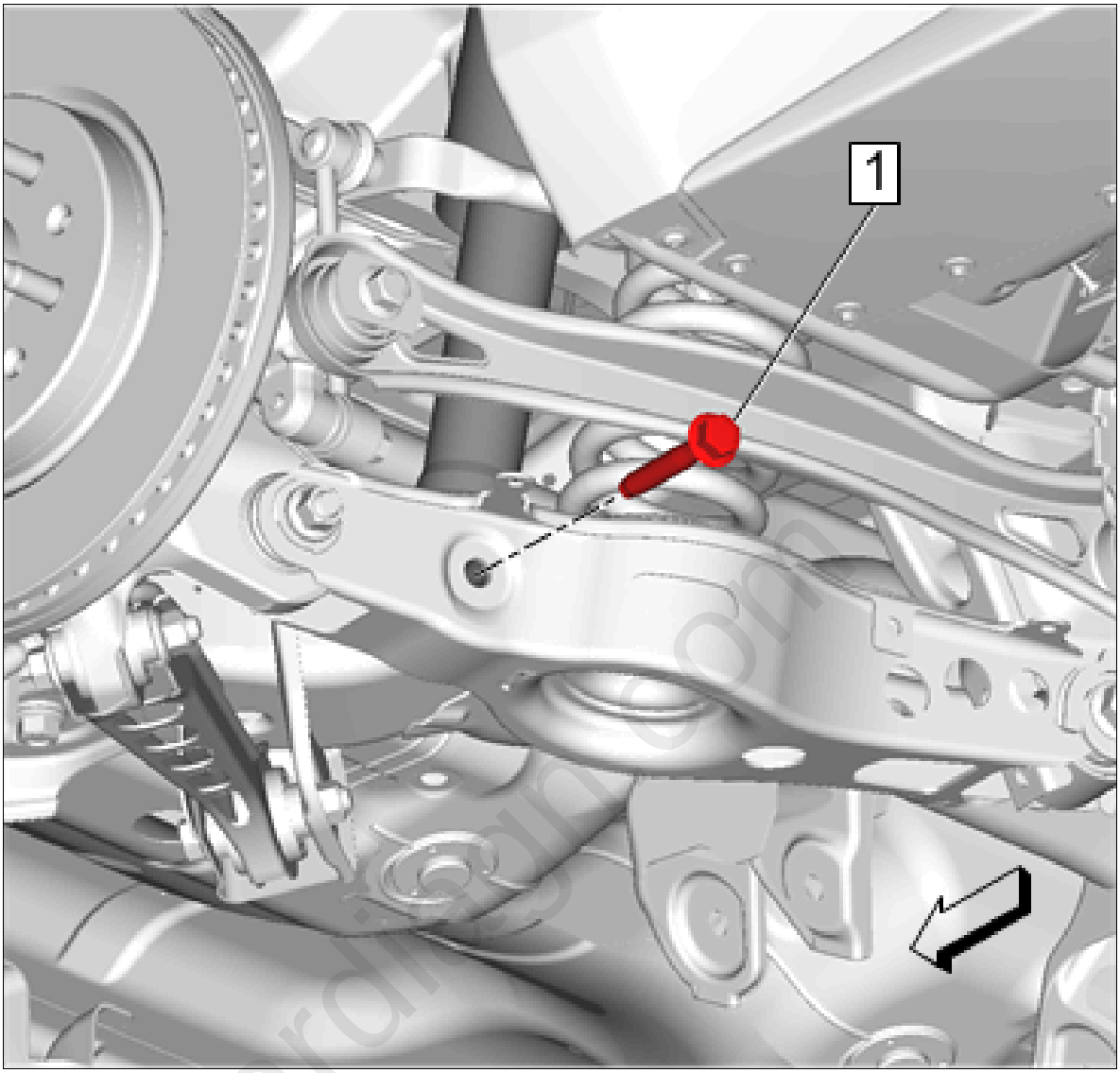


Courtesy of GENERAL MOTORS COMPANY

13. Install Rear Suspension Bracket (2) - Rear Suspension Bracket Replacement (Rear (Coupe))

cardiagn.com

Fig 10: Lower Rear Shock Absorber Bolt

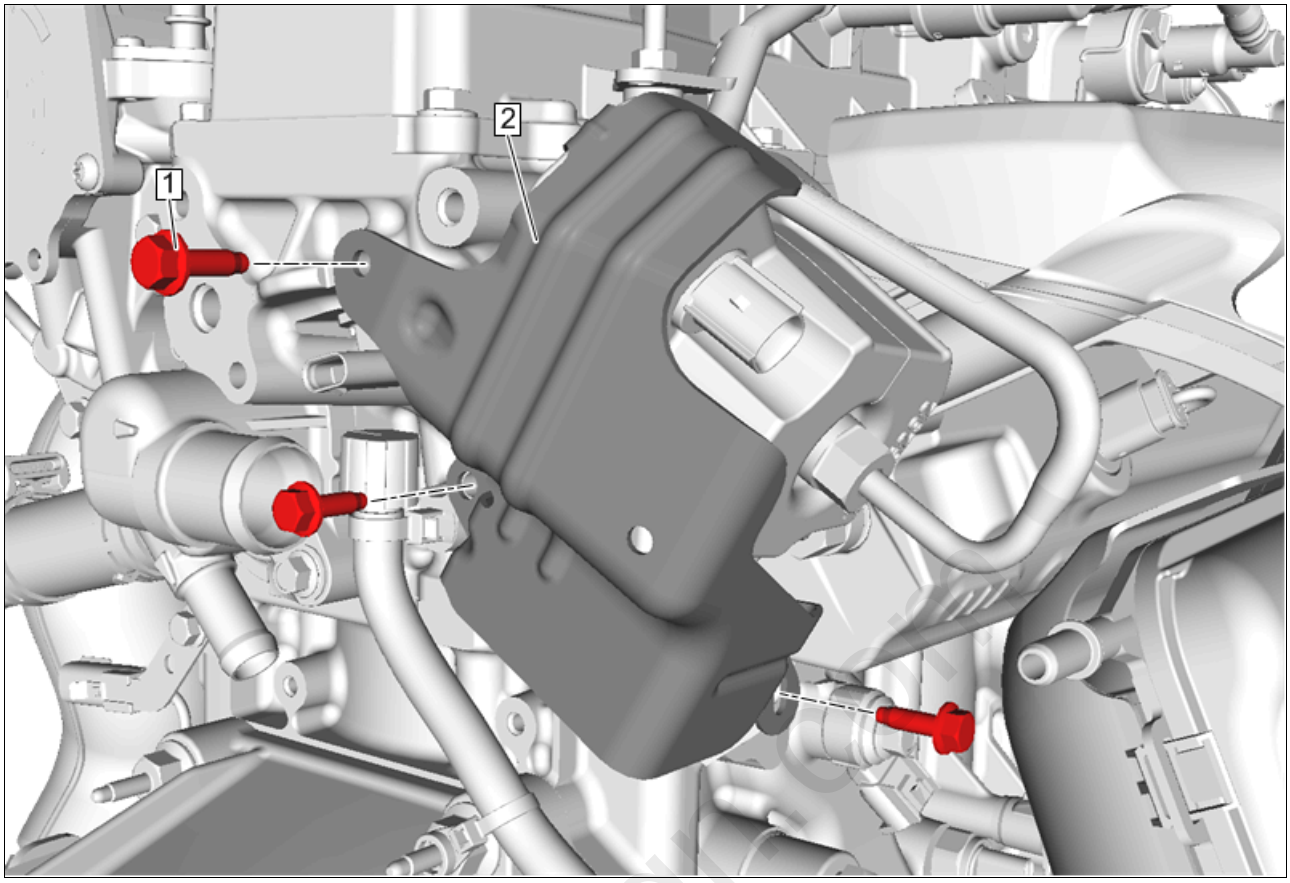


Courtesy of GENERAL MOTORS COMPANY

14. Install Lower Rear Shock Bolt - Right Side (1) - Shock Absorber Replacement
15. Install Rear Wheelhouse Liner Replacement
16. Install Fuel Tank Filler Pipe Housing Replacement
17. Lower the vehicle.

REPAIR INSTRUCTIONS > FUEL PUMP COVER REPLACEMENT

Fig 1: Fuel Pump Cover



Courtesy of GENERAL MOTORS COMPANY

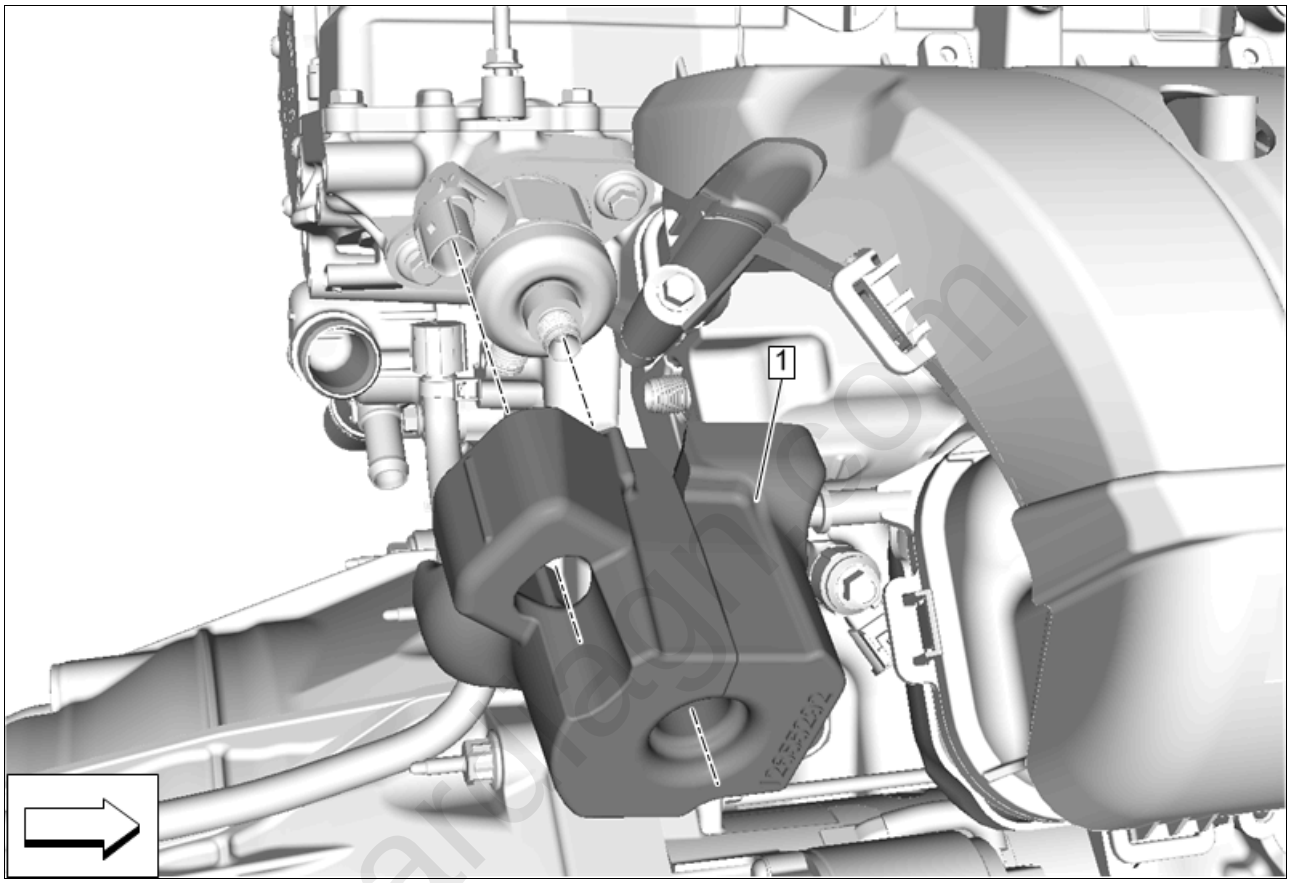
Callout	Component Name
Preliminary Procedures 1. Remove Fuel Pump Insulator - Outer - Fuel Pump Insulator Replacement (Outer) 2. Disconnect the radiator inlet pipe from the water outlet. Radiator Inlet Pipe Replacement (LTG)	
1	Fuel Pump Cover Fastener (Qty: 3) *CAUTION:* *Refer to Fastener Caution .* **Tighten** 10 N.m (89 lb in)

cardiagn.com

2	Fuel Pump Cover **Procedure** Disconnect the electrical wiring harness connector from the fuel pump.

REPAIR INSTRUCTIONS > FUEL PUMP INSULATOR REPLACEMENT (INNER)

Fig 1: Fuel Pump Insulator (Inner)



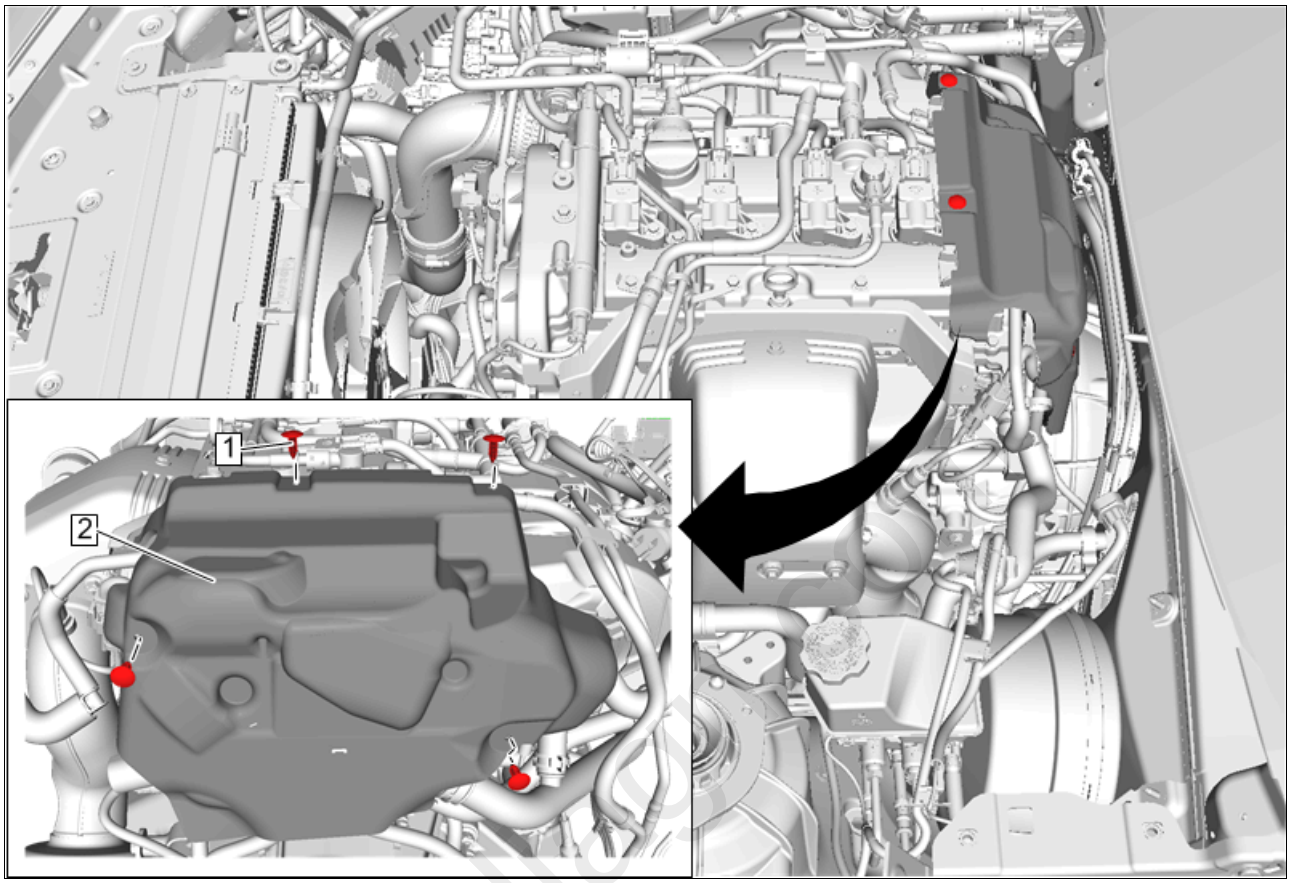
Courtesy of GENERAL MOTORS COMPANY

carmanuals.com

Callout	Component Name
Preliminary Procedure Fuel Pump Cover Replacement	
1	Fuel Pump Insulator *WARNING:* *The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.*

REPAIR INSTRUCTIONS > FUEL PUMP INSULATOR REPLACEMENT (OUTER)

Fig 1: Fuel Pump Insulator (Outer)



Courtesy of GENERAL MOTORS COMPANY

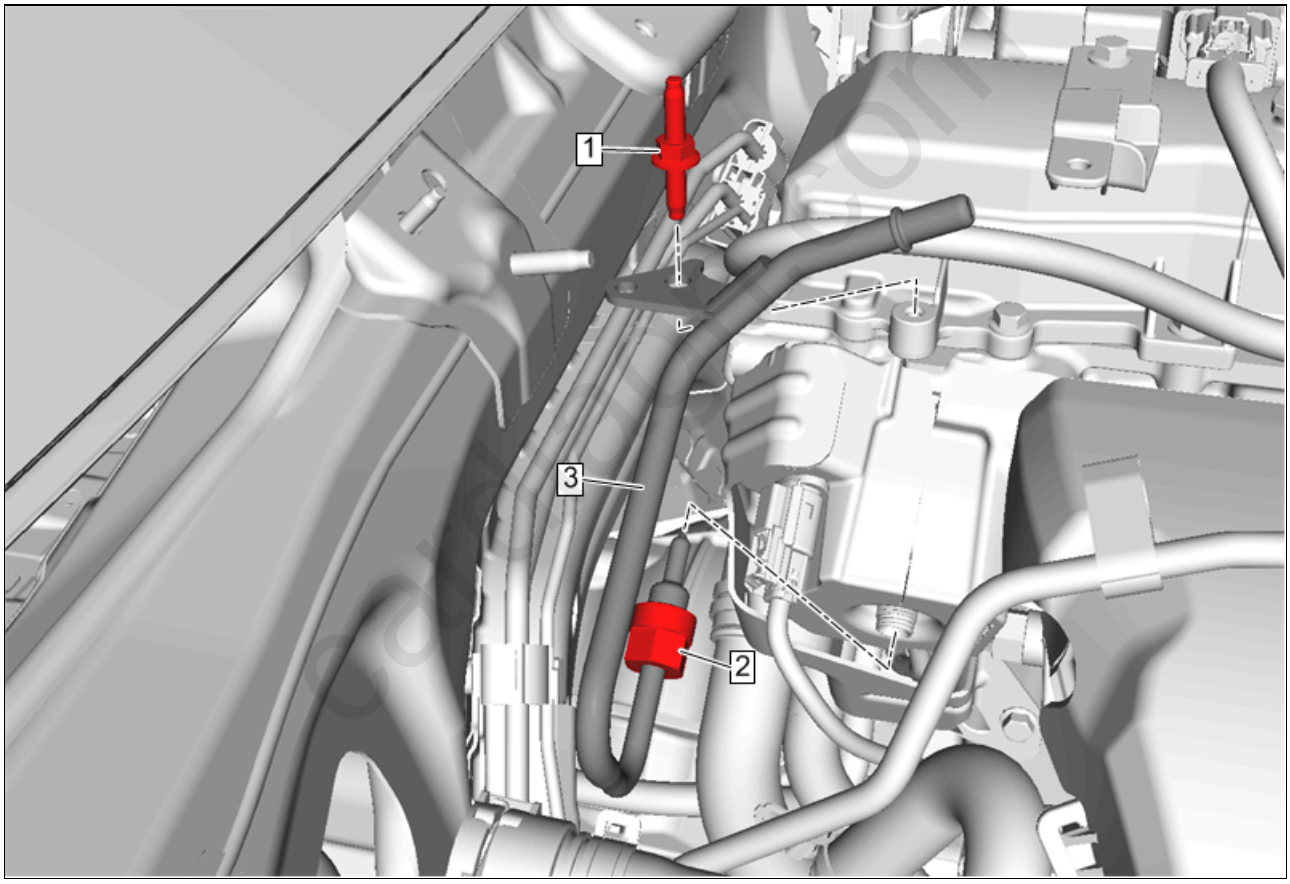
Callout	Component Name
Preliminary Procedures 1. Intake Manifold Cover Replacement 2. Plenum Front Panel Replacement	
1	Fuel Pump Insulator Retainer (Qty: 4)
2	Fuel Pump Insulator

WARNING:

The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.

REPAIR INSTRUCTIONS > FUEL FEED PIPE REPLACEMENT (AT FUEL INJECTION PUMP)

Fig 1: Fuel Feed Pipe (At Fuel Injection Pump)



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

WARNING:

Refer to Gasoline/Gasoline Vapors Warning .

Preliminary Procedures

1. Intake Manifold Cover Replacement

> *WARNING:*
>
> *The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.*

2. Remove Fuel Pump Insulator - Outer - Fuel Pump Insulator Replacement (Outer)
3. Fuel Pressure Relief

1	Fuel Feed Pipe Bracket Fastener *CAUTION:* *Refer to Fastener Caution .* Procedure 1. Unclip Engine Wiring Harness Retainer at Fuel Feed Pipe Bracket Fastener 2. Tighten 10 N.m (89 lb in)
2	Fuel Feed Pipe Fitting *CAUTION:* *Refer to Component Fastener Tightening Caution .* Procedure 1. Hand start the NEW fuel feed pipe fitting. 2. Tighten to 30 N.m (22 lb ft)
3	Fuel Feed Pipe **Procedure** Disconnect Quick Connect Fitting - Metal Collar Quick Connect Fitting Service

cardiagn.com

NOTE:

The fuel feed pipe fitting is one time use, always install a NEW fuel feed pipe.

REPAIR INSTRUCTIONS > FUEL FEED PIPE REPLACEMENT (ENGINE TO TANK) > REMOVAL PROCEDURE

WARNING:

Refer to Gasoline/Gasoline Vapors Warning .

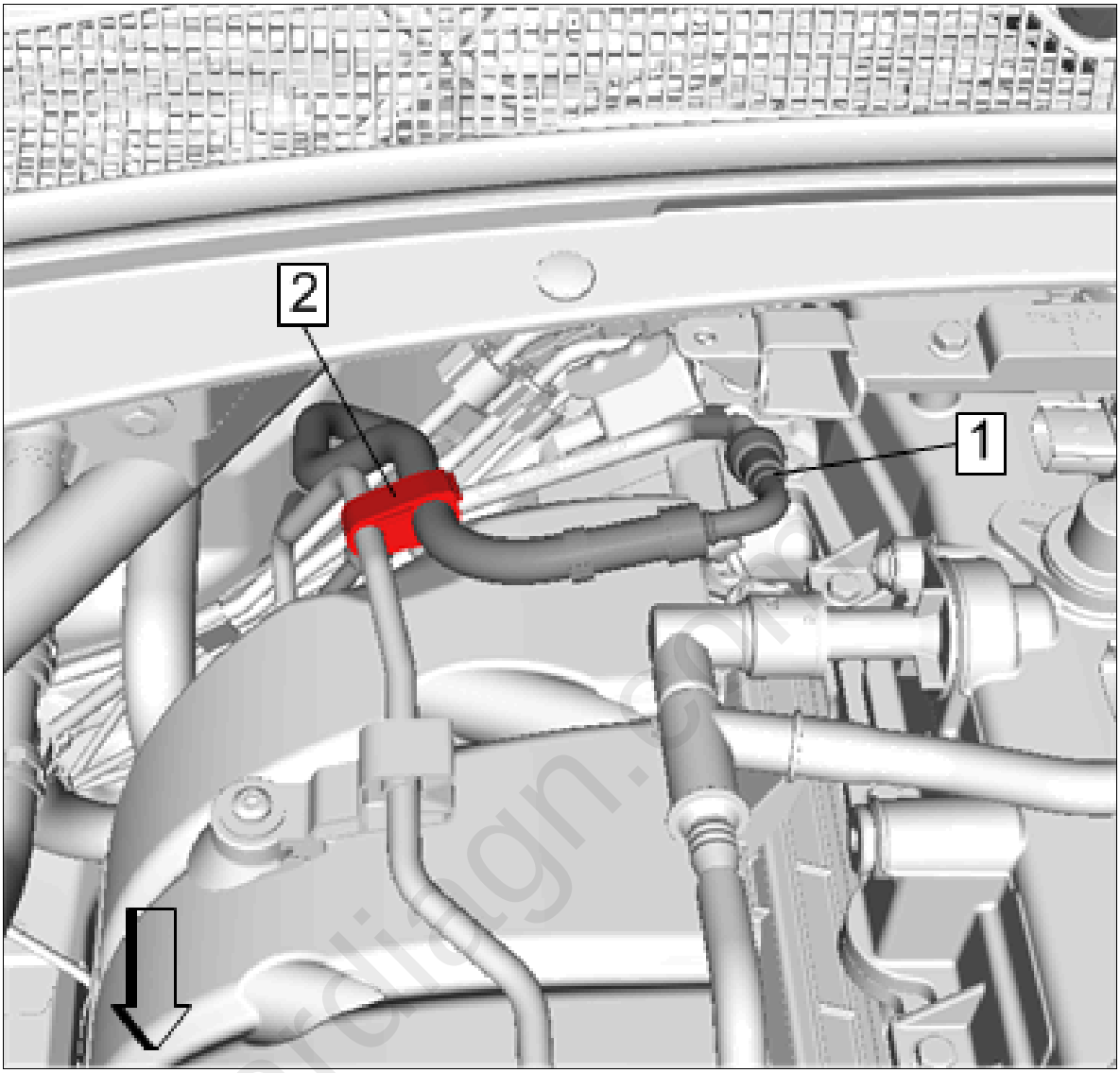
WARNING:

Refer to Safety Glasses Warning .

1. Remove Intake Manifold Cover Replacement
2. Relieve the fuel system pressure. Fuel Pressure Relief

cardiagn.com

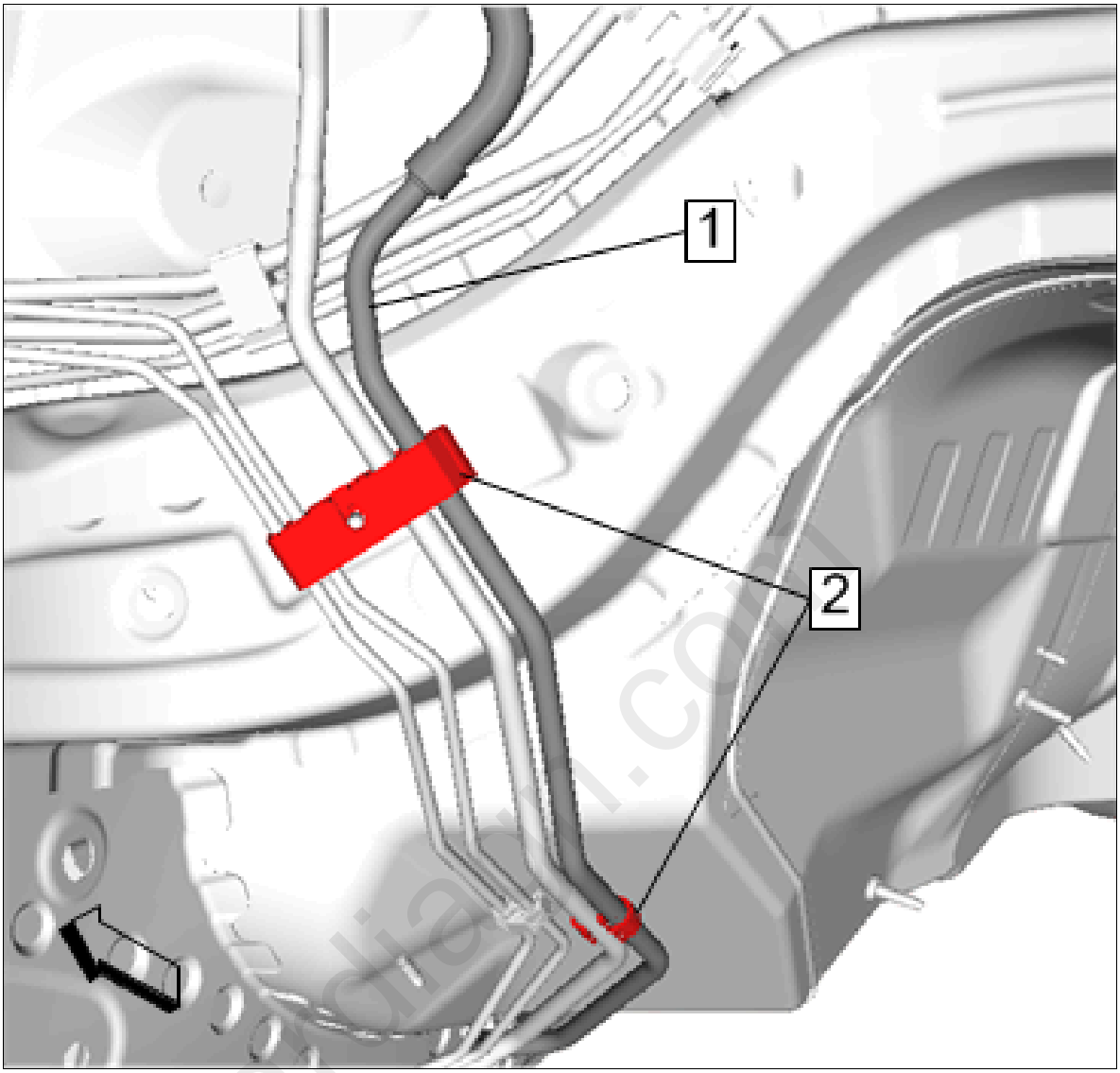
Fig 1: Fuel Feed Pipe



Courtesy of GENERAL MOTORS COMPANY

3. Disconnect Fuel Feed Pipe (1) - Metal Collar Quick Connect Fitting Service
4. Remove Fuel Feed Pipe (1) at Retainer (2)
5. Raise and support the vehicle. Lifting and Jacking the Vehicle (Base)Lifting and Jacking the Vehicle (HP)
6. Remove Underbody Front Air Deflector Replacement - Right Side
7. Remove Front Body Exhaust Heat Shield Replacement (Right)Front Body Exhaust Heat Shield Replacement (Left)

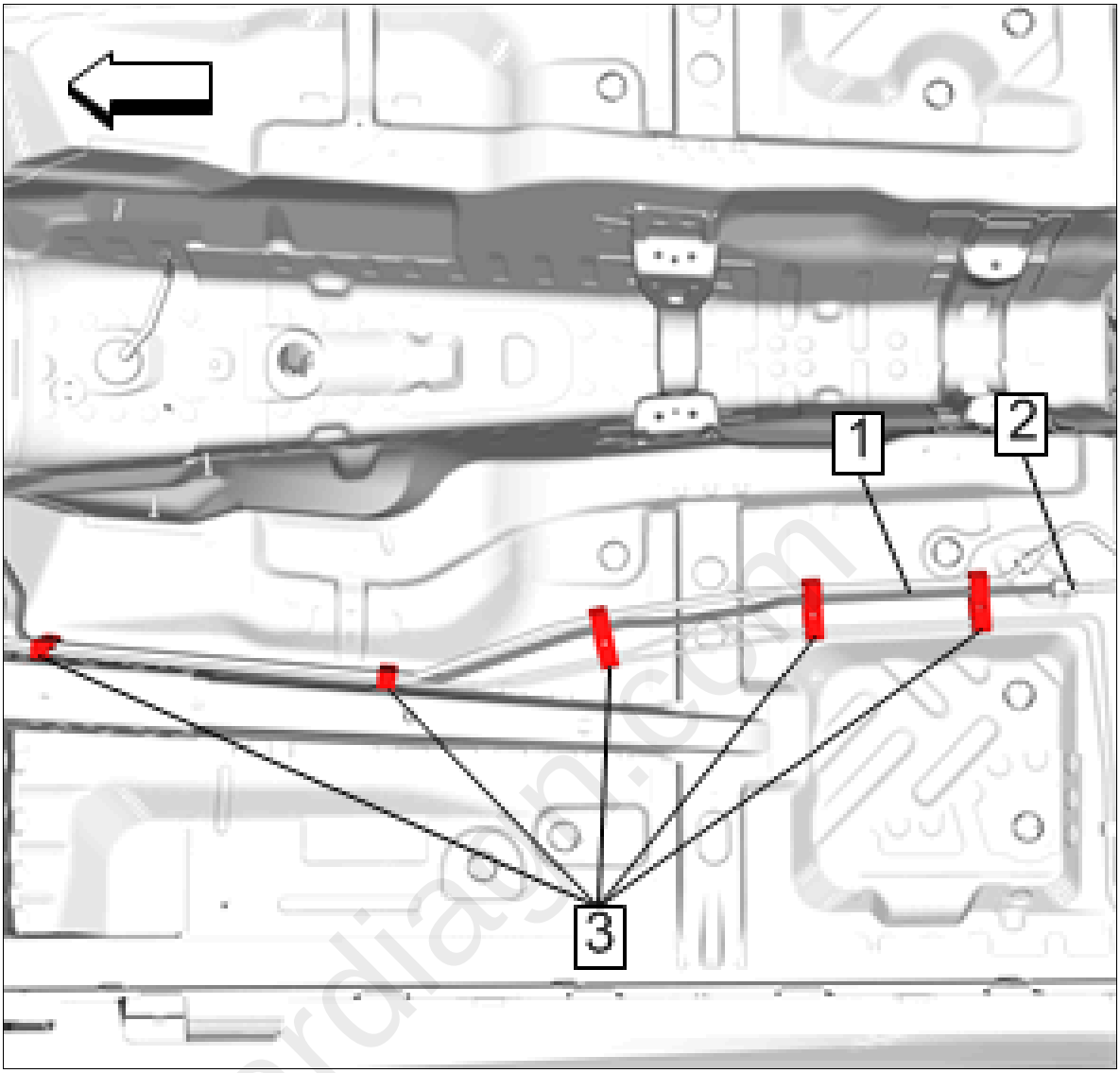
Fig 2: Fuel Feed Pipe



Courtesy of GENERAL MOTORS COMPANY

8. Remove Fuel Feed Pipe (1) at Retainer (2) (Qty: 2)

Fig 3: Fuel Feed Pipe

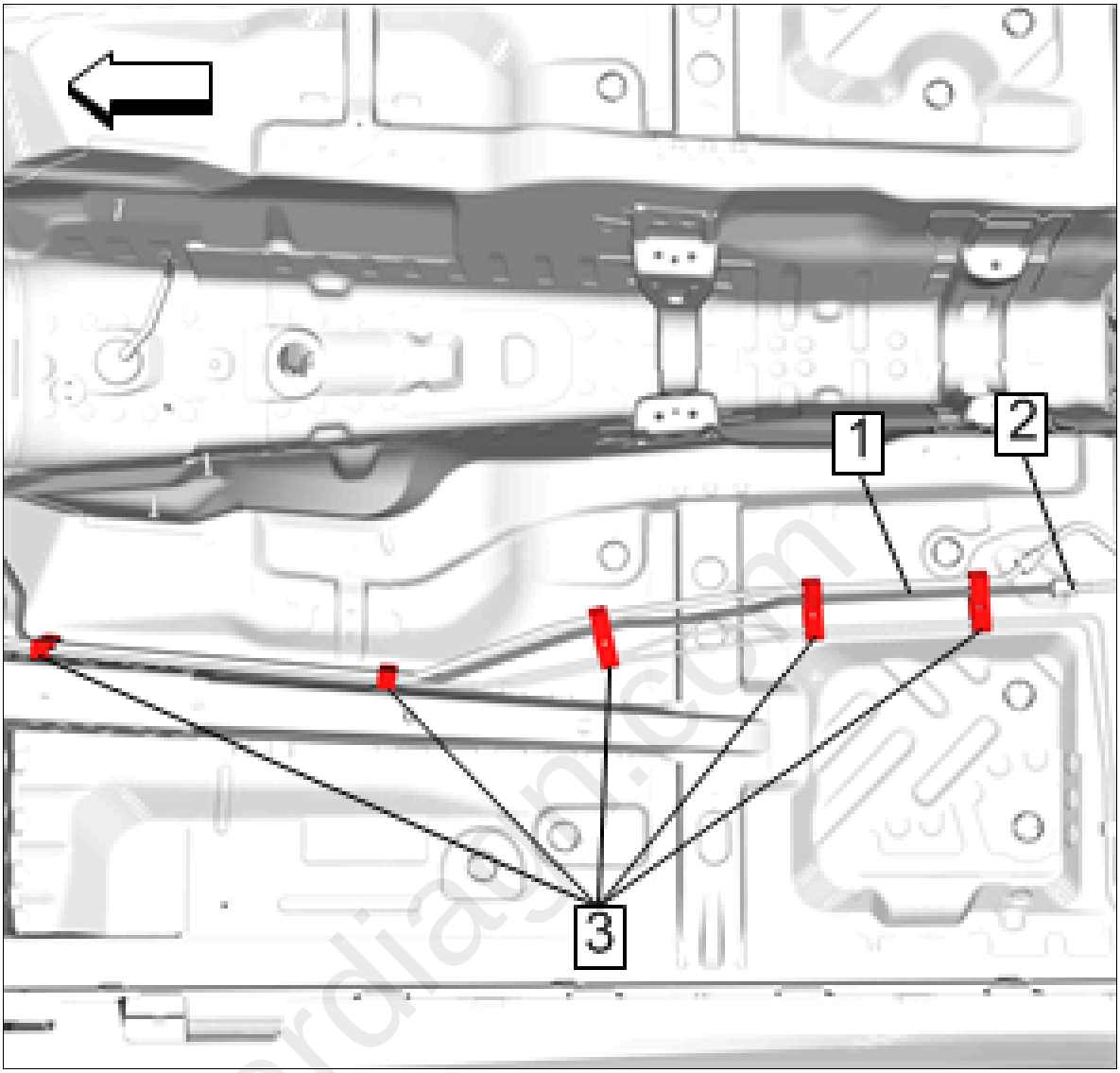


Courtesy of GENERAL MOTORS COMPANY

9. Disconnect Fuel Feed Pipe (1) at Fuel Pump Fuel Feed Hose (2) - Plastic Collar Quick Connect Fitting Service
10. Remove Fuel Feed Pipe (1) Retainer (3) (Qty: 5)

REPAIR INSTRUCTIONS > FUEL FEED PIPE REPLACEMENT (ENGINE TO TANK) > INSTALLATION PROCEDURE

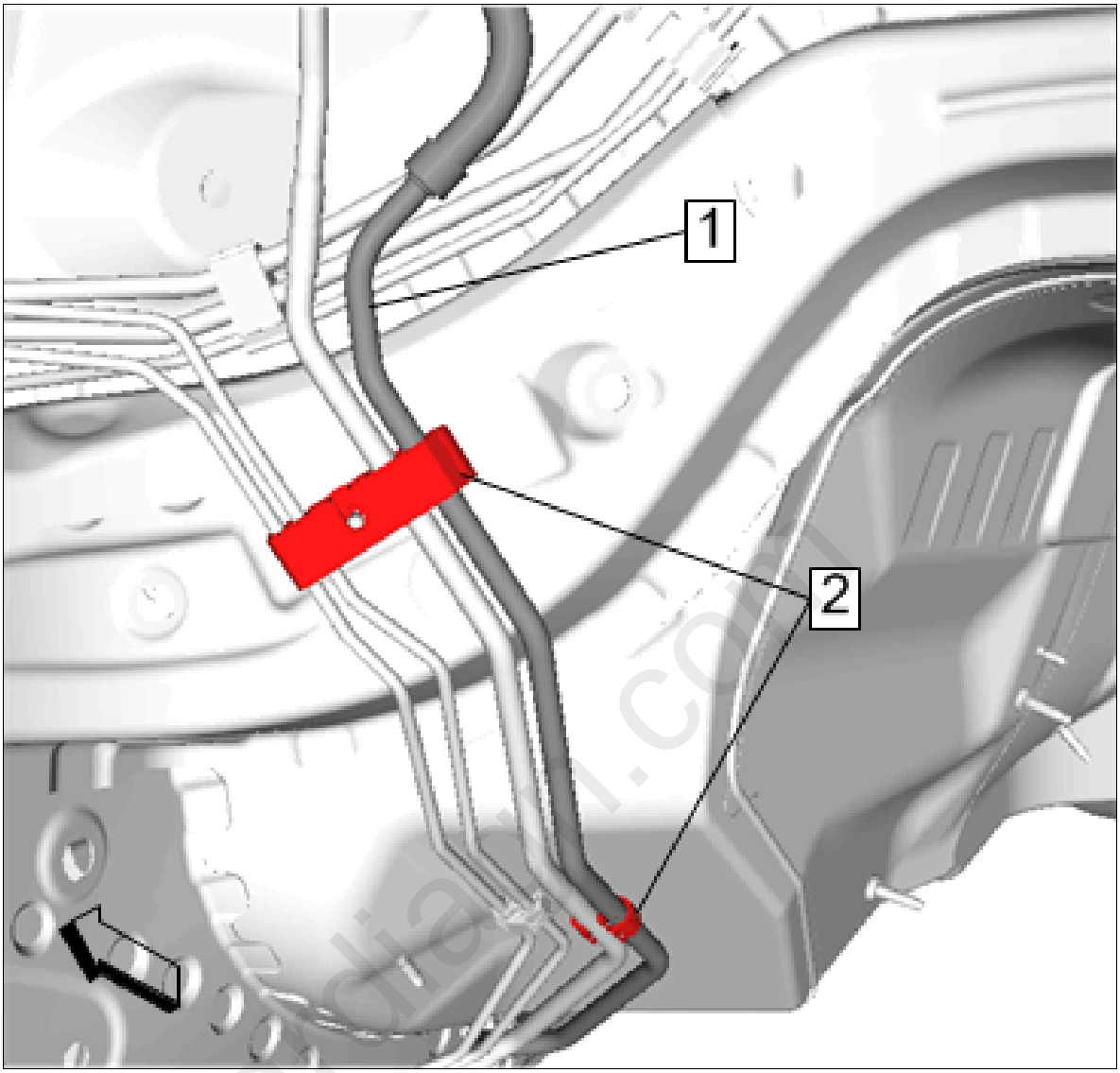
Fig 1: Fuel Feed Pipe



Courtesy of GENERAL MOTORS COMPANY

1. Install Fuel Feed Pipe (1) at Retainer (3) (Qty: 5)
2. Connect Fuel Feed Pipe (1) at Fuel Pump Fuel Feed Hose (2) - Plastic Collar Quick Connect Fitting Service

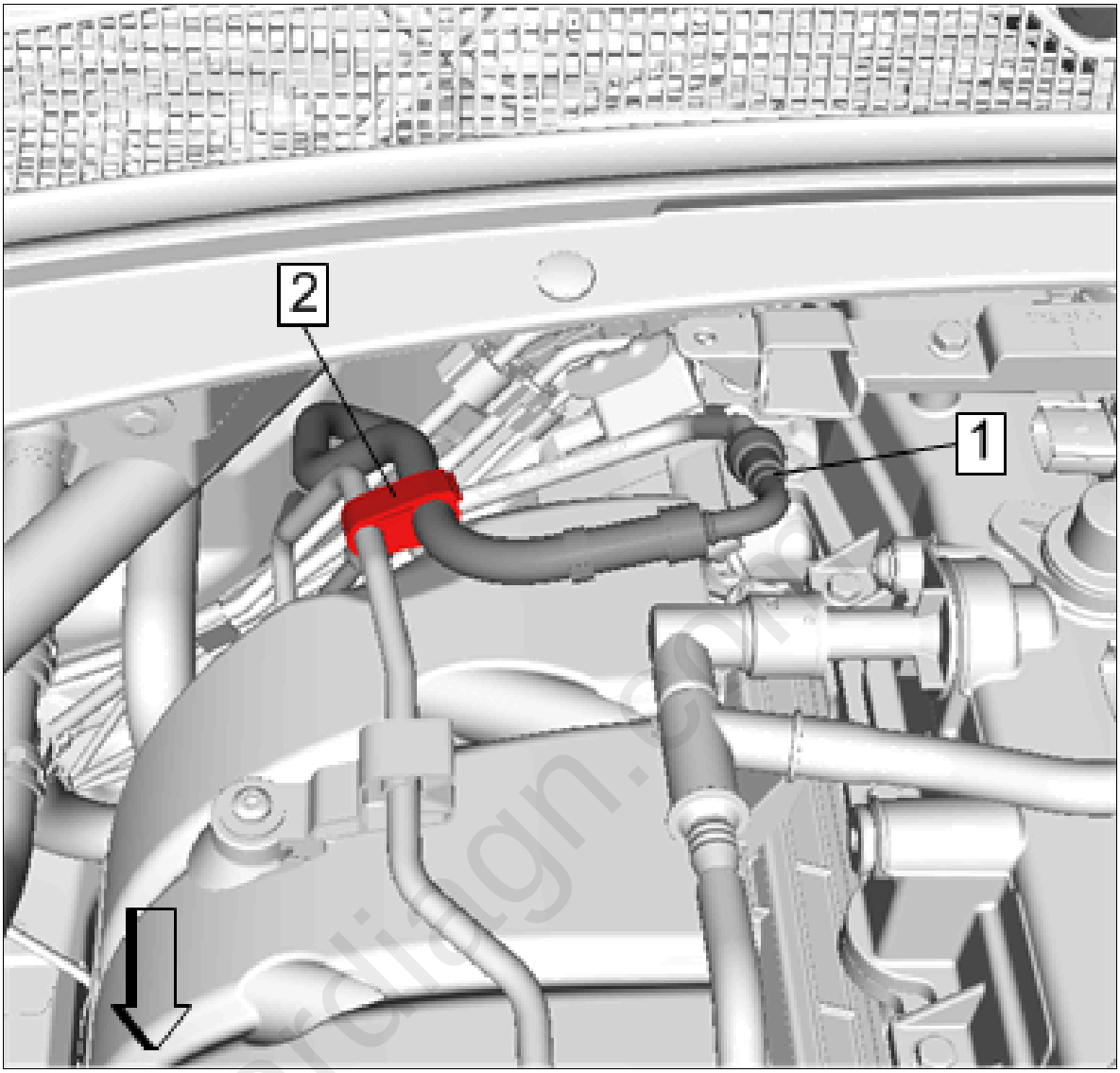
Fig 2: Fuel Feed Pipe



Courtesy of GENERAL MOTORS COMPANY

3. Install Fuel Feed Pipe (1) at Retainer (2) (Qty: 2)
4. Install Front Body Exhaust Heat Shield Replacement (Right)Front Body Exhaust Heat Shield Replacement (Left)
5. Install Underbody Front Air Deflector Replacement - Right Side
6. Lower the vehicle.

Fig 3: Fuel Feed Pipe

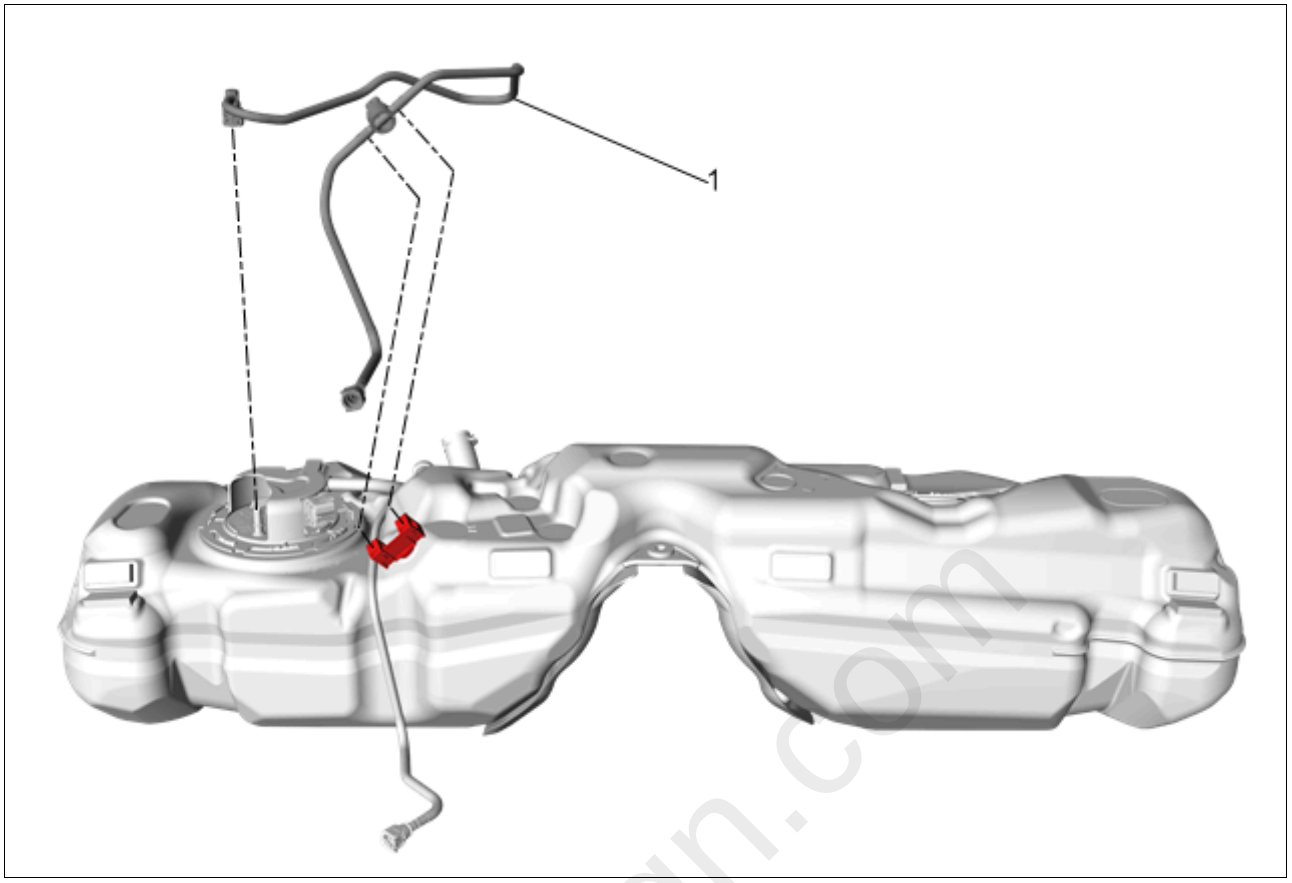


Courtesy of GENERAL MOTORS COMPANY

7. Install Fuel Feed Pipe (1) at Retainer (2)
8. Connect Fuel Feed Pipe (1) - Metal Collar Quick Connect Fitting Service
9. Install Intake Manifold Cover Replacement

REPAIR INSTRUCTIONS > FUEL PRESSURE SENSOR REPLACEMENT - FUEL FEED PIPE

Fig 1: Fuel Pressure Sensor - Fuel Feed Pipe



Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

Callout	Component Name
WARNING: *Refer to Gasoline/Gasoline Vapors Warning .*	
WARNING: *Refer to Safety Glasses Warning .*	
Preliminary Procedure Fuel Tank Replacement	
1	Fuel Pressure Sensor

NOTE:

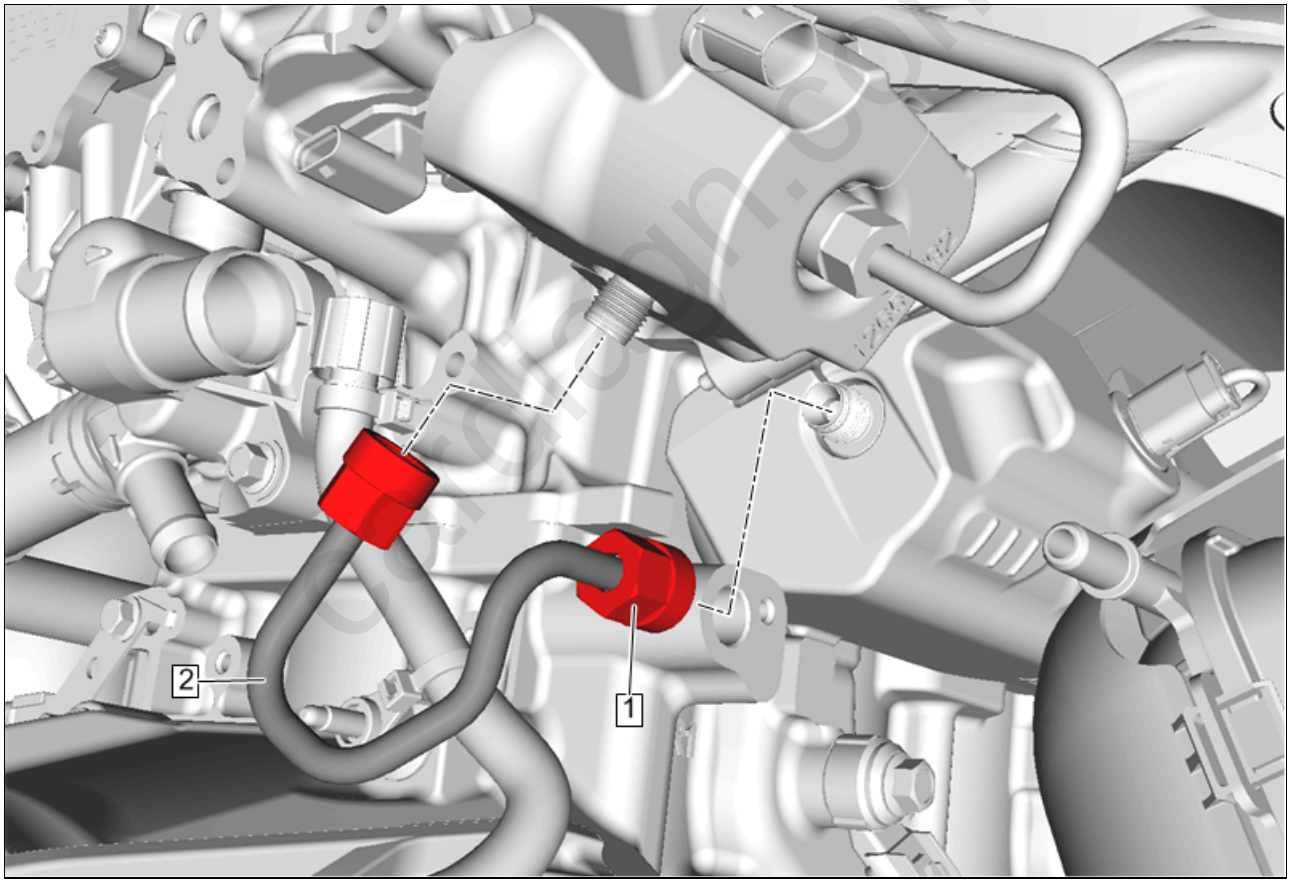
Fuel pressure sensor is serviced as part of fuel pump fuel feed hose assembly.

Procedure

1. Disconnect the electrical connector.
2. Disconnect the fuel pump fuel feed hose from the fuel tank fuel pump module and remove from retainers. Plastic Collar Quick Connect Fitting Service

REPAIR INSTRUCTIONS > FUEL FEED INTERMEDIATE PIPE REPLACEMENT

Fig 1: Fuel Feed Intermediate Pipe



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

WARNING:

Refer to Gasoline/Gasoline Vapors Warning .

Preliminary Procedures

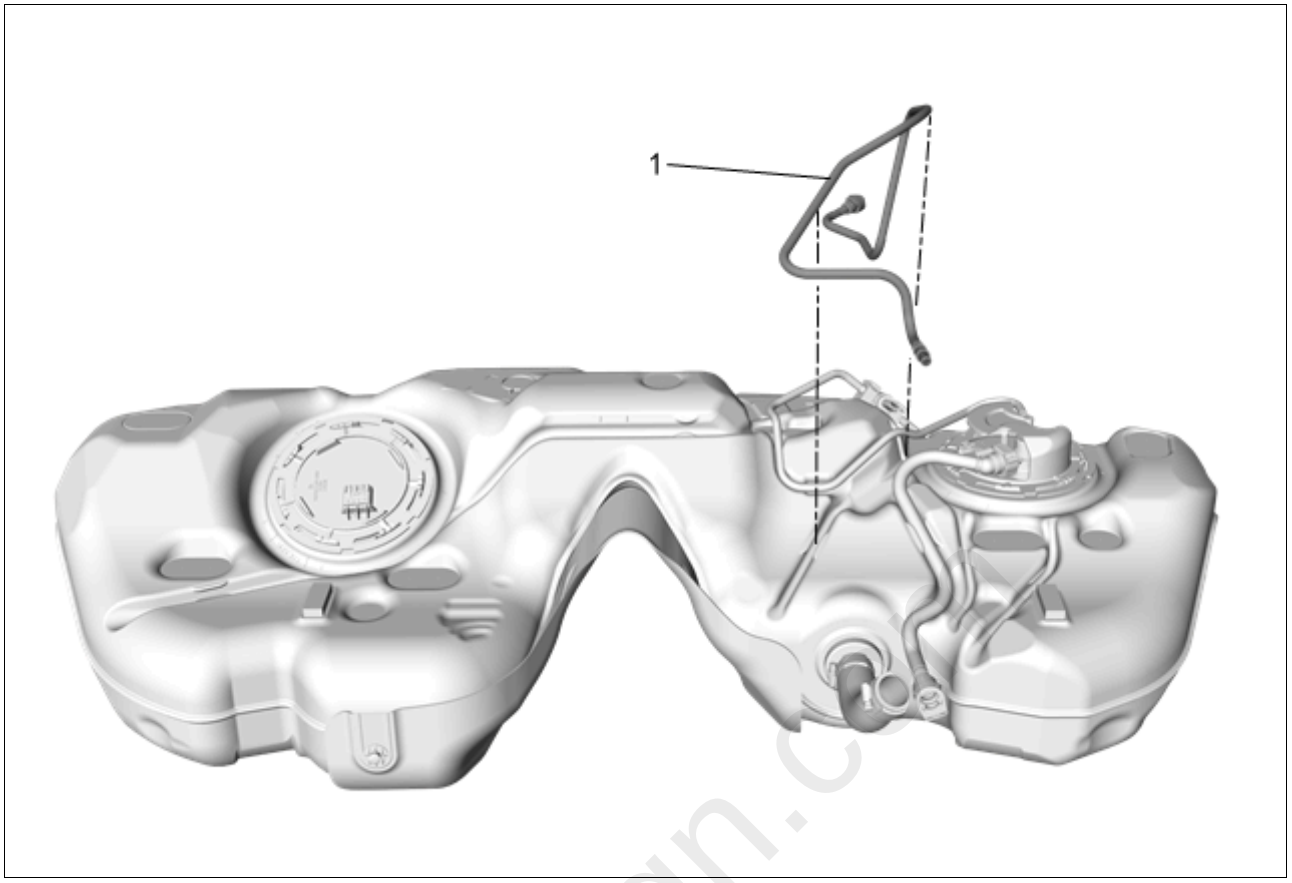
1. Fuel Pump Cover Replacement
2. Relieve the fuel pressure. Fuel Pressure Relief

1	Fuel Feed Intermediate Pipe Fitting (Qty: 2) *CAUTION:* *Refer to Component Fastener Tightening Caution .* **Procedure** 1. Hand start both ends of the NEW fuel feed intermediate pipe. 2. Tighten the fitting nut to the fuel rail to 15 N.m (11 lb ft). 3. Tighten the fitting nut to the fuel pump to 15 N.m (11 lb ft). 4. Tighten the fitting nut to the fuel rail a final pass to 30 N.m (22 lb ft). 5. Tighten the fitting nut to the fuel pump a final pass to 30 N.m (22 lb ft).
2	Fuel Feed Intermediate Pipe *NOTE:* *The pipe fittings are a one time use, always install a NEW fuel feed intermediate pipe.*

cardiagn.com

REPAIR INSTRUCTIONS > FUEL TANK VENT VALVE HOSE REPLACEMENT (AT TANK)

Fig 1: Fuel Tank Vent Valve Hose (At Tank)



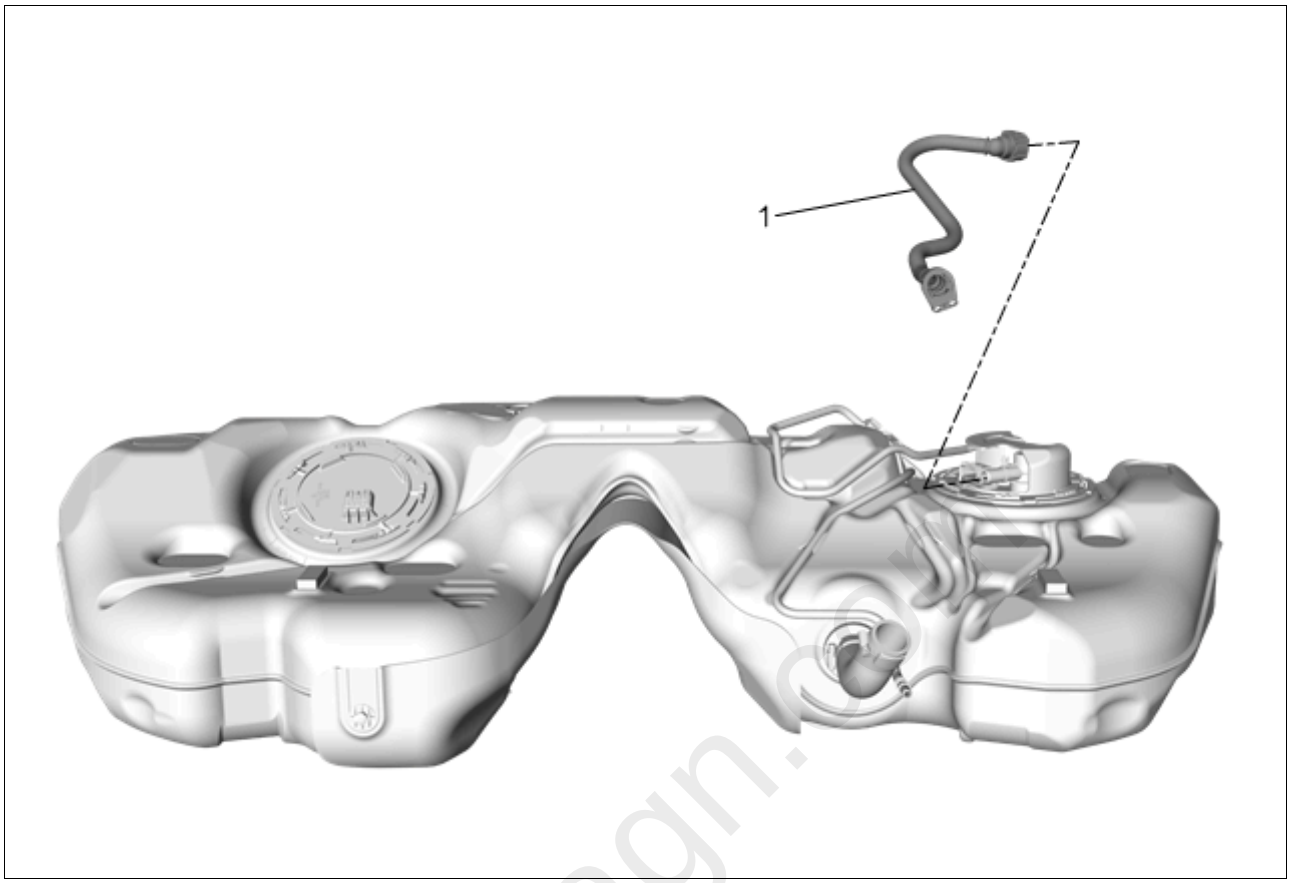
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
	WARNING: *Refer to Gasoline/Gasoline Vapors Warning .*
	WARNING: *Refer to Safety Glasses Warning .*
	Preliminary Procedure Fuel Tank Replacement
1	Fuel Tank Vent Valve Hose **Procedure** Remove the fuel tank vent valve hose from the fuel tank.

REPAIR INSTRUCTIONS > FUEL TANK VENT VALVE HOSE REPLACEMENT (FUEL

TANK FUEL PUMP MODULE)

Fig 1: Fuel Tank Vent Valve Hose (Fuel Tank Fuel Pump Module)



Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

Callout	Component Name
WARNING: *Refer to Gasoline/Gasoline Vapors Warning .*	
WARNING: *Refer to Safety Glasses Warning .*	
Preliminary Procedure Fuel Tank Replacement	
1	Fuel Tank Vent Valve Hose **Procedure** Disconnect the fuel tank vent valve hose from the fuel tank fuel pump module. Plastic Collar Quick Connect Fitting Service

REPAIR INSTRUCTIONS > FUEL PUMP REPLACEMENT

Special Tools

EN-48896 High Pressure Fuel Pump Installation Alignment Gauge

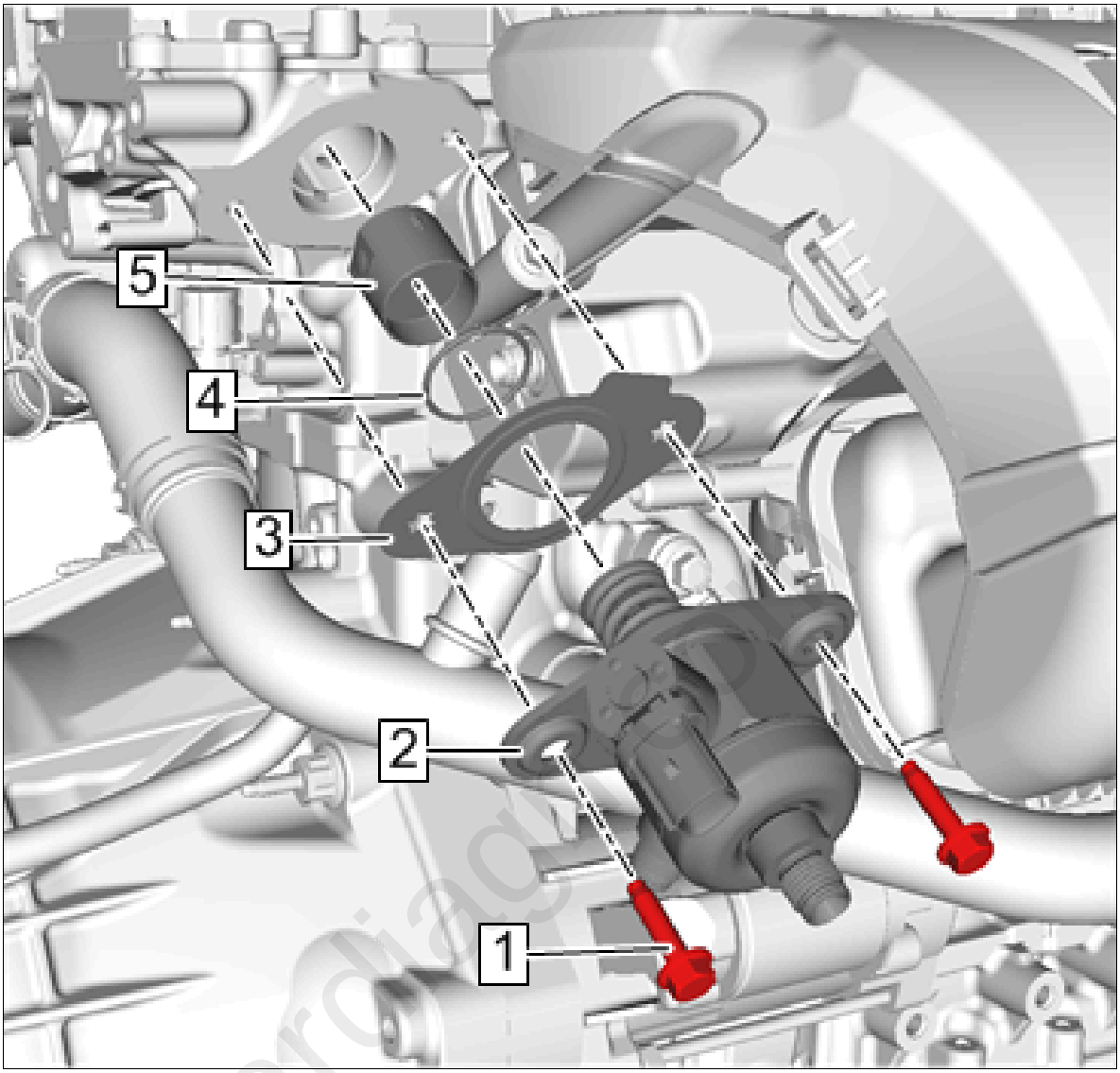
Equivalent regional tools:Special Tools (Diagnostic Tools)Special Tools (Mechanical Tools)

REPAIR INSTRUCTIONS > FUEL PUMP REPLACEMENT > REMOVAL PROCEDURE

1. Relieve the fuel system pressure. Fuel Pressure Relief
2. Remove the inner fuel pump insulator. Fuel Pump Insulator Replacement (Inner)
3. Remove and DISCARD Fuel Feed Pipe at Fuel Injection Pump - Fuel Feed Pipe Replacement (At Fuel Injection Pump)
4. Remove and DISCARD Fuel Feed Intermediate Pipe Replacement

cardiagn.com

Fig 1: Fuel Pump



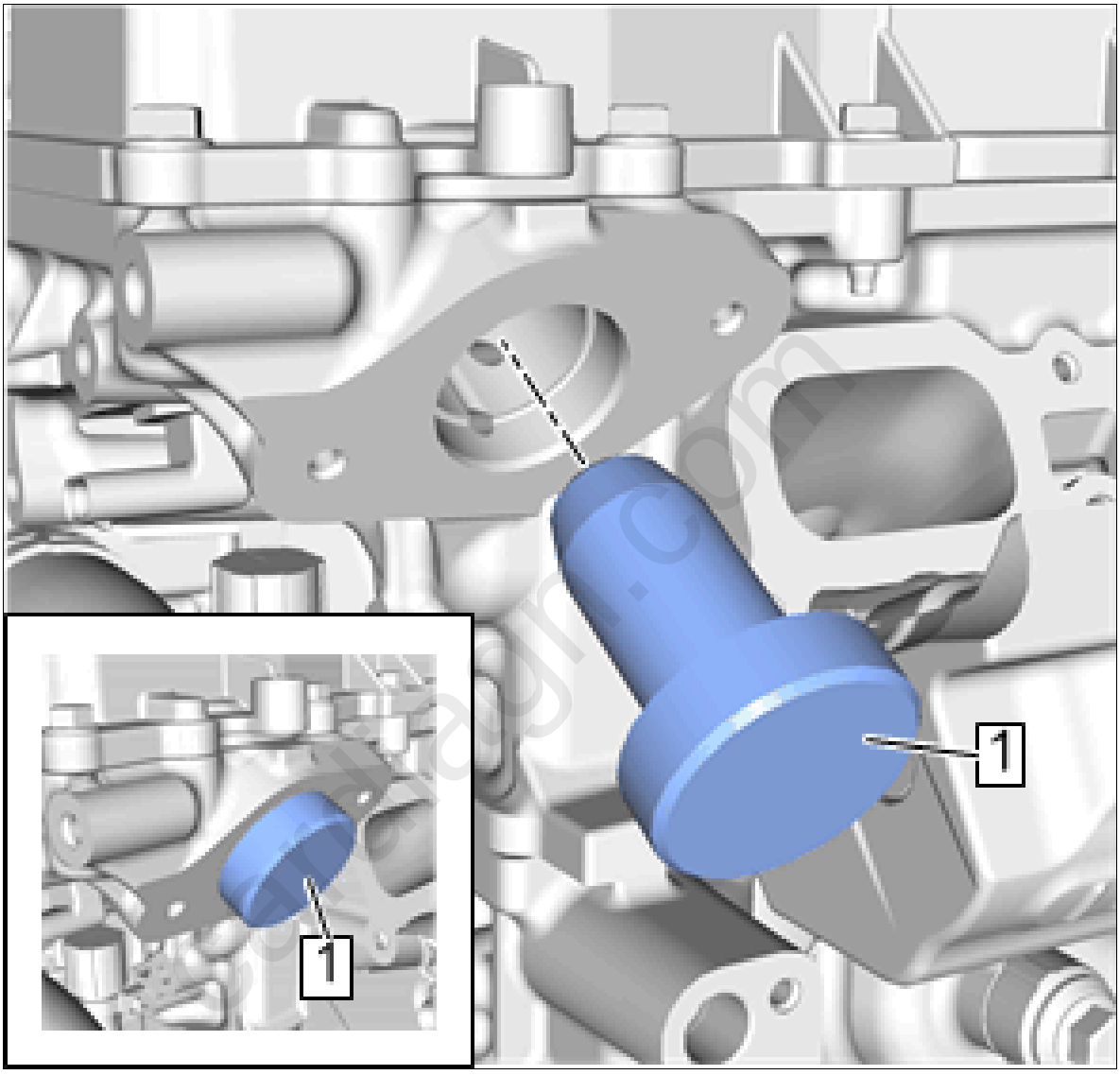
Courtesy of GENERAL MOTORS COMPANY

> ⚠ *CAUTION:*
>
> *Alternately loosen the fuel pump bolts one turn at a time until the pump is fully disengaged from fuel pump lifter follower. Trying to remove the pump bolts without even side-to-side loosening may result in pump plunger damage*

5. Remove Fuel Pump Bolt (1) (Qty: 2)
6. Remove Fuel Pump (2)
7. Remove Fuel Pump Gasket (3) and DISCARD
8. Remove Fuel Pump O-Ring (4) and DISCARD
9. Remove Valve Lifter Follower (5)

REPAIR INSTRUCTIONS > FUEL PUMP REPLACEMENT > INSTALLATION PROCEDURE

Fig 1: Camshaft Alignment Gauge Tool Installed



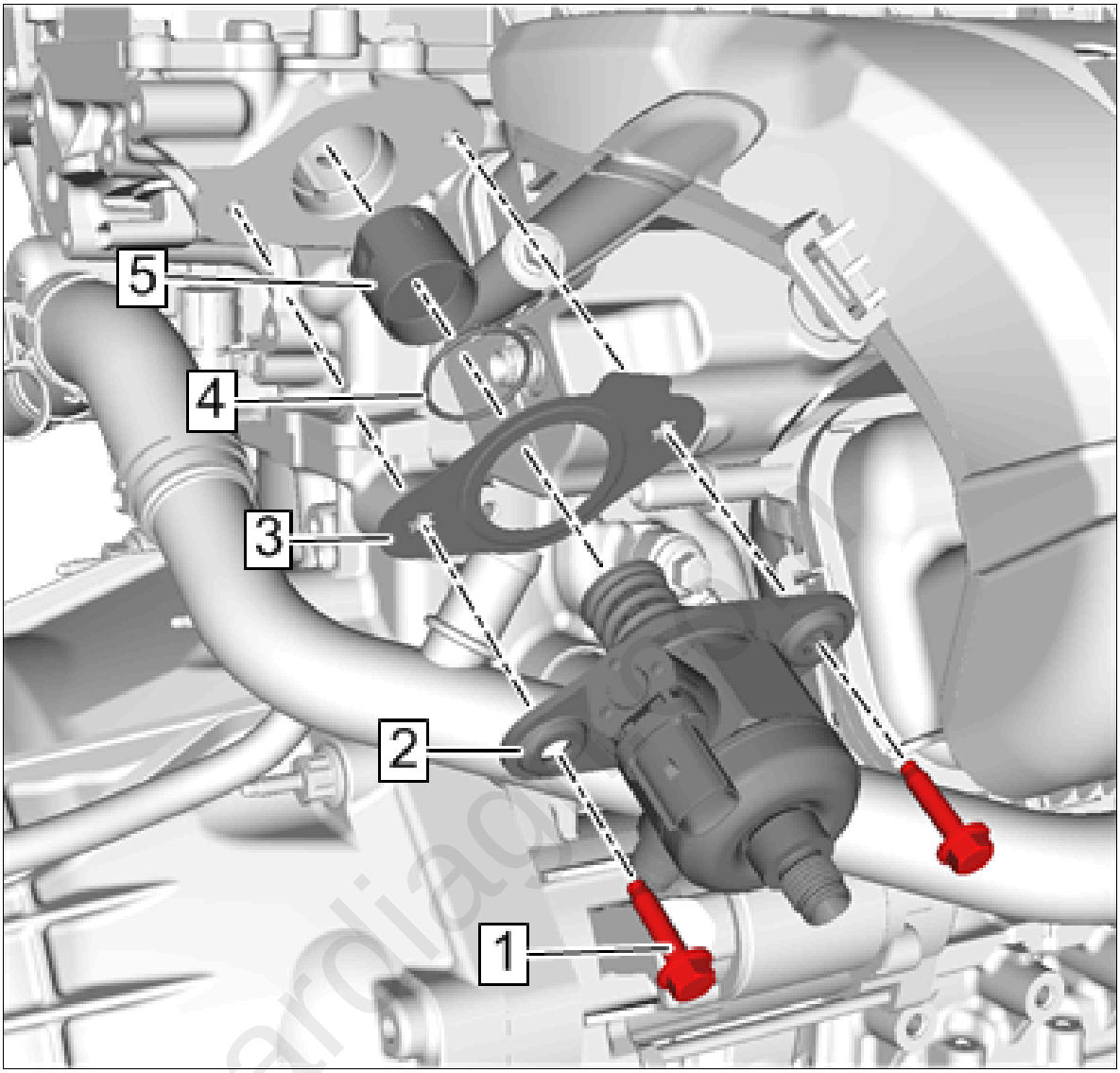
Courtesy of GENERAL MOTORS COMPANY

> *NOTE:*
>
> *The camshaft must be in the base circle position before the high pressure fuel pump is installed.*

1. Use the **EN-48896** alignment gauge (1) to ensure that the camshaft lobe is in the base circle position. At base circle the tool will be flush with the head.
2. Lubricate the high pressure fuel pump cylinder head bore with clean engine oil. Adhesives,

Fluids, Lubricants, and Sealers

Fig 2: Fuel Pump



Courtesy of GENERAL MOTORS COMPANY

3. Using clean engine oil, lubricate then install the Valve Lifter Follower (5).

> *NOTE:*
>
> *Lubricate the NEW O-ring seals with clean engine oil.*

4. Install a NEW Fuel Pump O-Ring seal (4)

> *NOTE:*
>
> *The high pressure fuel pump gasket has a retaining feature to hold the pump retaining bolts in place.*

5. Position the NEW high pressure fuel pump gasket (3) and fuel pump bolts (1) (Qty: 2) to the fuel pump (2).
6. Install Fuel Pump (2)

> *CAUTION:*
>
> *Alternately hand-tighten the fuel pump bolts one turn at a time until the pump is fully seated. Trying to draw down the pump without even side-to-side tightening may result in pump plunger damage.*

7. Start and hand-tighten the fuel pump bolts (1) evenly.

> *CAUTION:*
>
> *Fastener Caution .*

> *NOTE:*
>
> *Add thread locker to the fuel pump fastener threads prior to installing. Adhesives, Fluids, Lubricants, and Sealers*

8. Tighten Fuel Pump Bolt (1) (Qty: 2)
    1. First Pass: 8 N.m (71 lb in)
    2. Final Pass: + 50 Degrees

> *NOTE:*
>
> *Ensure the high pressure fuel pump and fuel rail fittings are clean prior to installing the NEW high pressure pipe.*

9. Install the NEW fuel feed intermediate pipe - Fuel Feed Intermediate Pipe Replacement
10. Connect Fuel Feed Pipe at Fuel Pump - Fuel Feed Pipe Replacement (At Fuel Injection Pump) Fuel Feed Pipe Replacement (Engine to Tank)

cardiagn.com

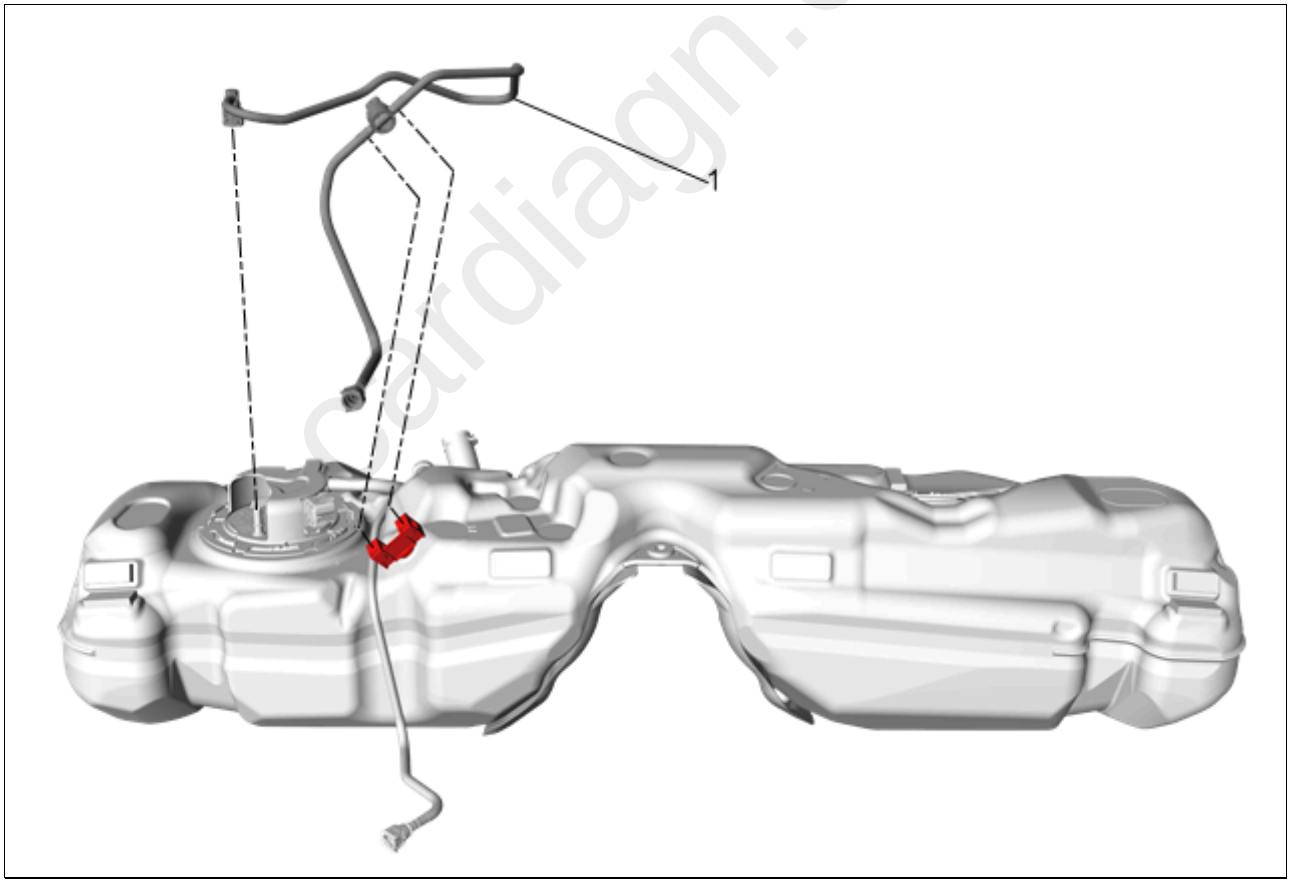
11. Install Fuel Pump Insulator Replacement (Inner) Fuel Pump Insulator Replacement (Outer)

> *NOTE:*
>
> *If a fuel leak occurs at the fuel rail, the fuel rail will need to be replaced along with the one time use high pressure pipe.*

12. Inspect for leaks using the following procedure:
    1. Turn the ignition ON, with the engine OFF for 2 seconds.
    2. Turn the ignition OFF, for 10 seconds.
    3. Turn the ignition ON, with the engine OFF.
    4. Inspect for fuel leaks.

REPAIR INSTRUCTIONS > FUEL PUMP FUEL FEED HOSE REPLACEMENT

Fig 1: Fuel Pressure Sensor - Fuel Feed Pipe



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

cardiagn.com

WARNING:

Refer to Gasoline/Gasoline Vapors Warning .

WARNING:

Refer to Safety Glasses Warning .

Preliminary Procedure Fuel Tank Replacement

1	Fuel Pump Fuel Feed Hose *NOTE:* *Fuel pressure sensor is serviced as part of fuel pump fuel feed hose assembly.* Procedure 1. Disconnect the electrical connector. 2. Disconnect the fuel pump fuel feed hose from the fuel tank fuel pump module and remove from retainers. Plastic Collar Quick Connect Fitting Service

REPAIR INSTRUCTIONS > FUEL INJECTION FUEL RAIL ASSEMBLY REPLACEMENT

Special Tools

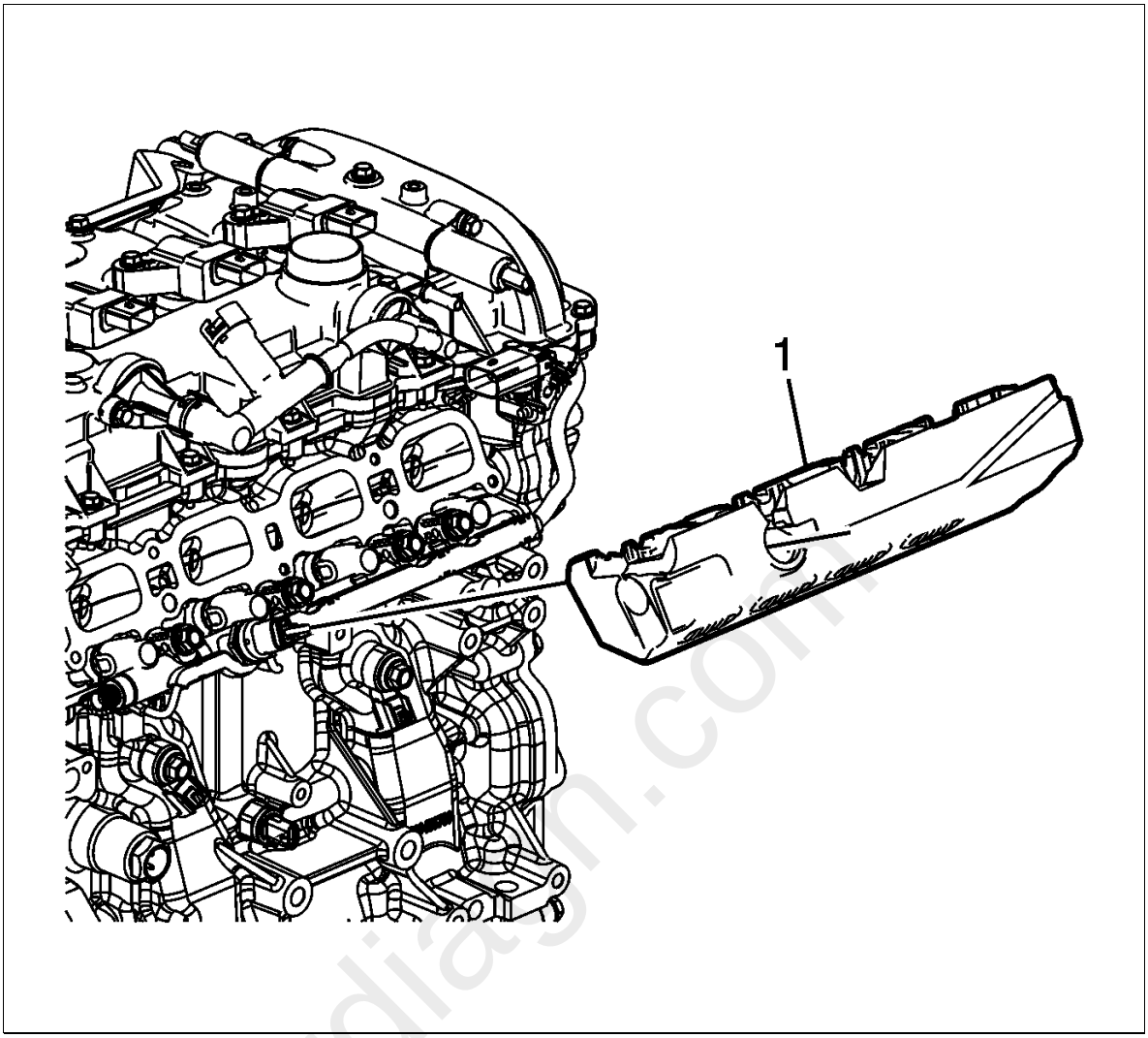
- **EN-49248** Fuel Rail Assembly Remover
- **EN-47909** Injector Bore and Sleeve Cleaning Kit

For equivalent regional tools, refer to Special Tools (Diagnostic Tools)Special Tools (Mechanical Tools) .

REPAIR INSTRUCTIONS > FUEL INJECTION FUEL RAIL ASSEMBLY REPLACEMENT > REMOVAL PROCEDURE

cardiagn.com

Fig 1: Fuel Injection Fuel Rail Noise Shield



Courtesy of GENERAL MOTORS COMPANY

WARNING:

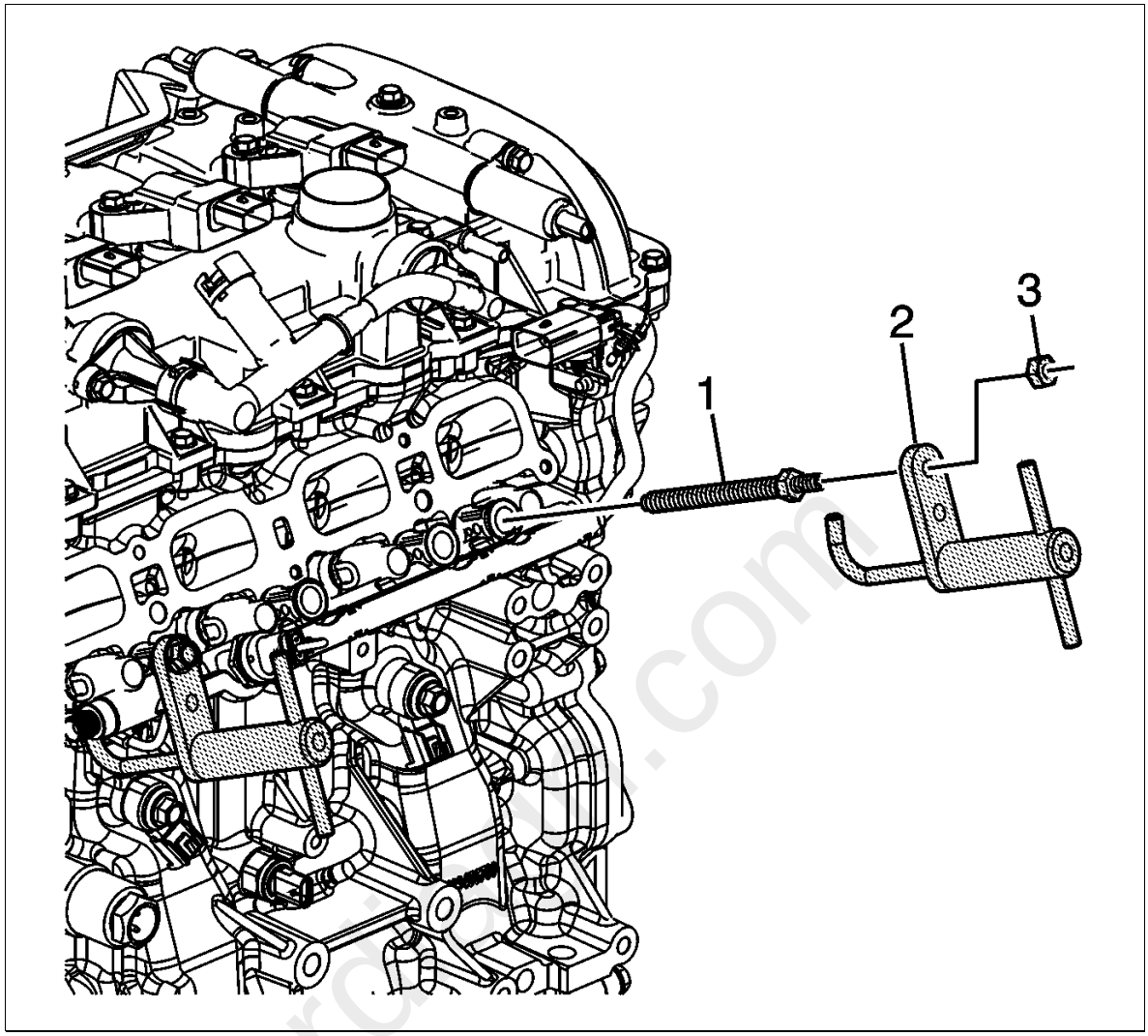
The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.

1. Remove the fuel injection fuel rail noise shield (1). Refer to Fuel Injection Fuel Rail Noise Shield Replacement .
2. Remove the fuel feed intermediate pipe. Refer to Fuel Feed Intermediate Pipe Replacement .
3. Remove the fuel injection fuel rail pressure sensor. Refer to Fuel Injection Fuel Rail Fuel Pressure Sensor Replacement .
4. Disconnect the electrical harness from the fuel rail harness connection.

cardiagn.com

5. Remove the fuel rail assembly retaining bolts and upper rubber grommets, if necessary.

Fig 2: Fuel Rail Assembly Remover Studs



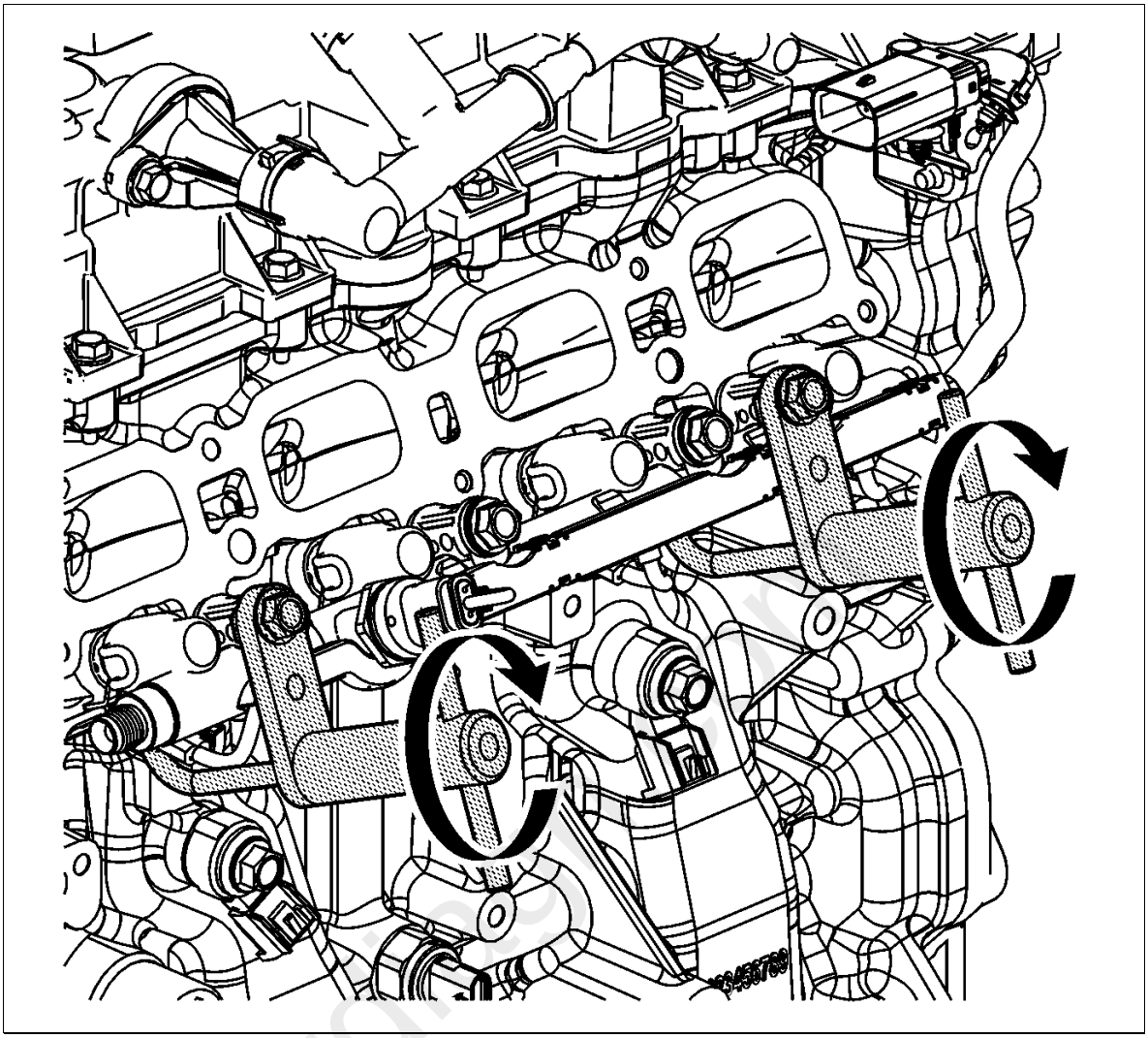
Courtesy of GENERAL MOTORS COMPANY

NOTE:

Use care to avoid contact with the fuel rail harness during special tool installation and fuel rail removal.

6. Install **EN-49248** studs (1) into the 2 outermost fuel rail assembly retaining bolt locations. Tighten the studs to 22 N.m (16 lb ft).
7. Install **EN-49248** remover (2) onto each stud, and engage the hooks to the fuel rail. Install the nuts (3) retaining the remover onto the studs and tighten until snug.

Fig 3: Fuel Rail Assembly Remover



Courtesy of GENERAL MOTORS COMPANY

NOTE:

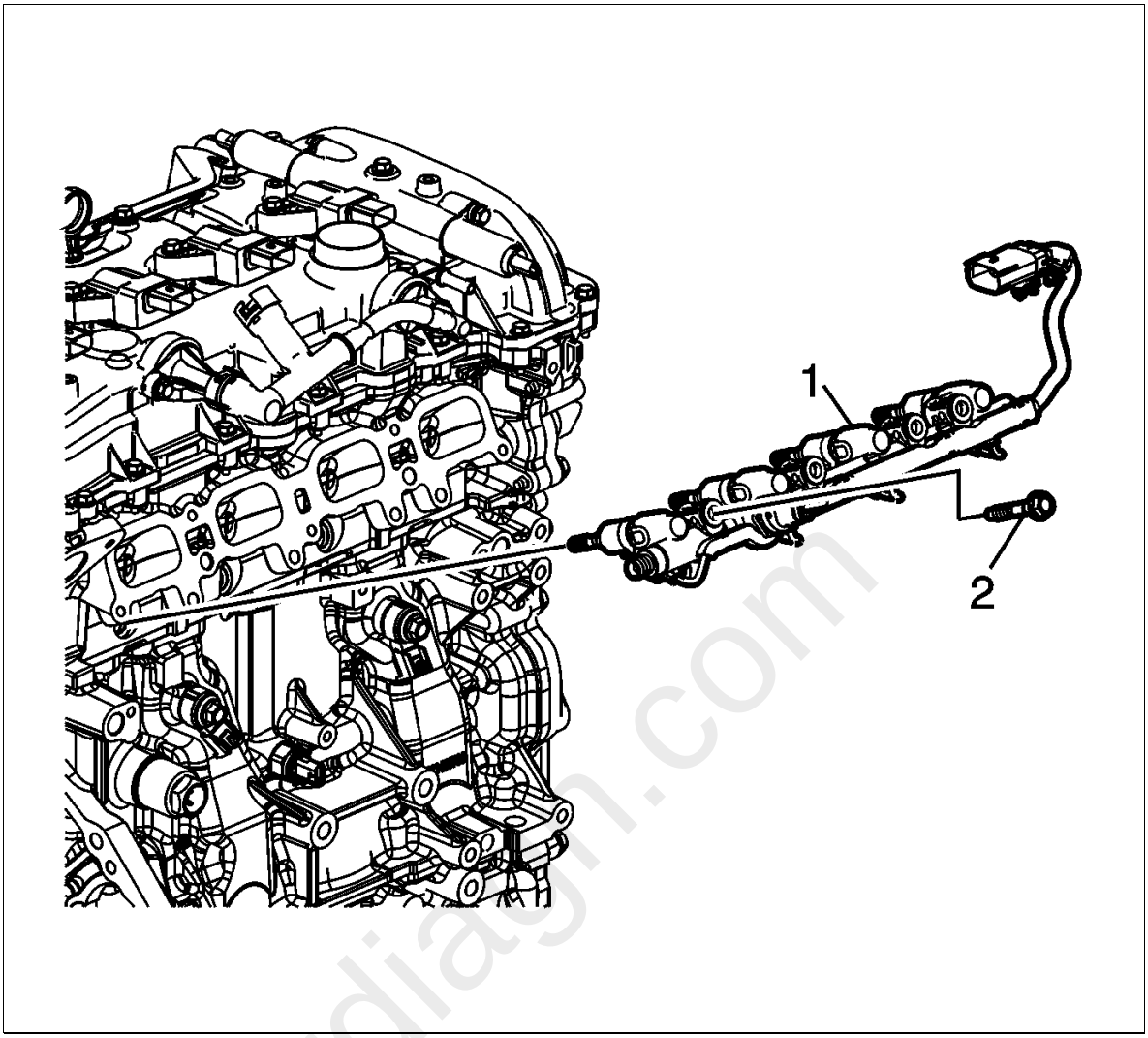
EN-49248 will assist in the proper removal of the fuel rail assembly. Ensure that the following conditions are met:

1. *Turn the handles simultaneously in order to pull the fuel rail straight out along the fuel injector axis.*
2. *DO NOT twist when pulling out on the fuel rail and injector assembly.*

8. Using **EN-49248** remover, remove the fuel rail assembly.

REPAIR INSTRUCTIONS > FUEL INJECTION FUEL RAIL ASSEMBLY REPLACEMENT > INSTALLATION PROCEDURE

Fig 1: Fuel Rail



Courtesy of GENERAL MOTORS COMPANY

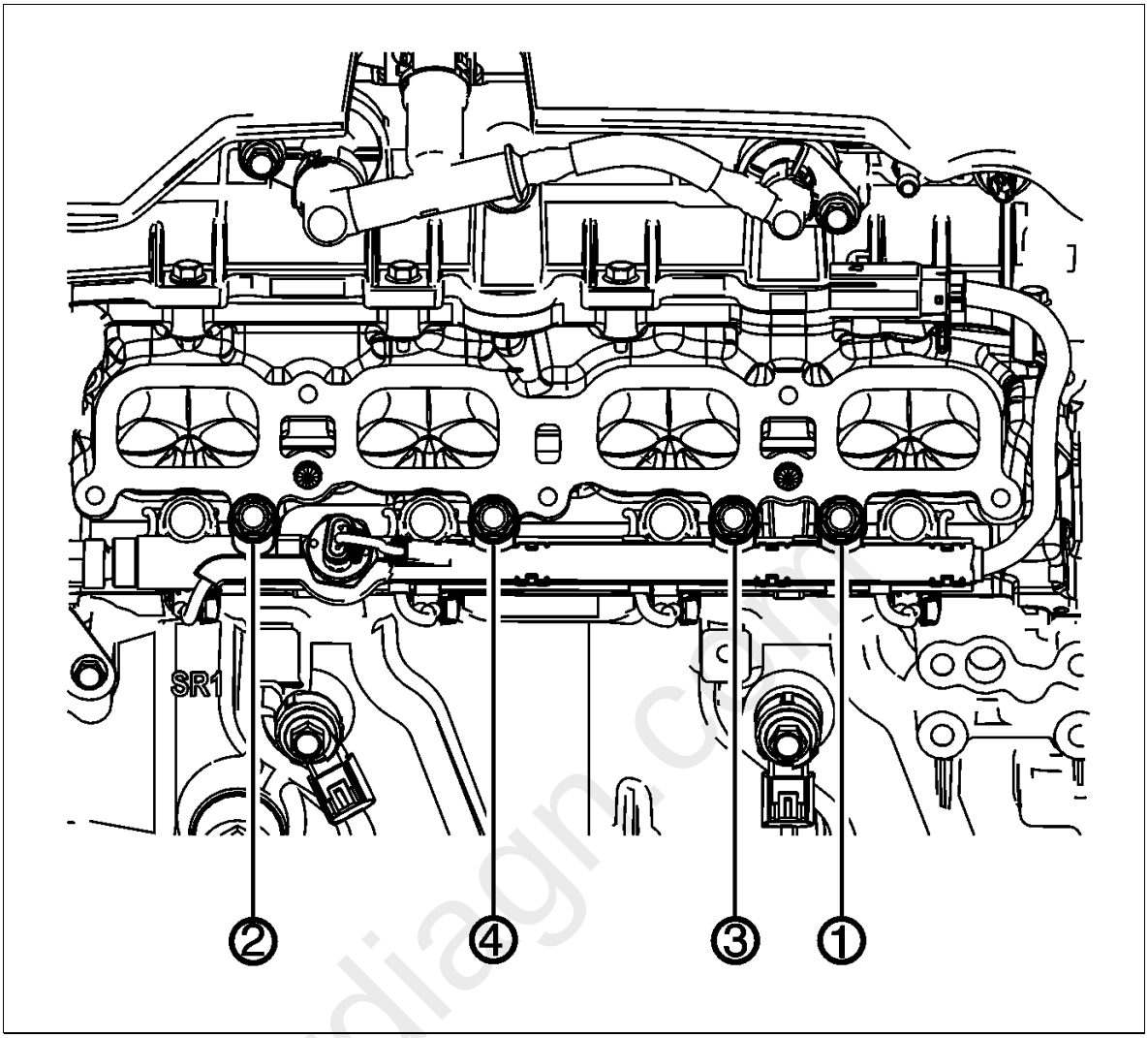
cardiagn.com

1. Clean the fuel injector bore in the cylinder head using the **EN-47909** kit.
2. Replace the fuel rail insulators, if necessary. Refer to Fuel Rail and Injectors Cleaning and Inspection . Replace the fuel rail bolts, if necessary.
3. Install the fuel rail (1) with injectors into the cylinder head evenly.

> *NOTE:*
>
> *Mount the bolts evenly to avoid cocking of the fuel injectors during installation.*

4. Hand start the 2 outer fuel rail bolts (2) to seat the injectors into the injector bores.
5. Hand start the remaining fuel rail bolts.

Fig 2: Fuel Rail Bolt Tightening Sequence



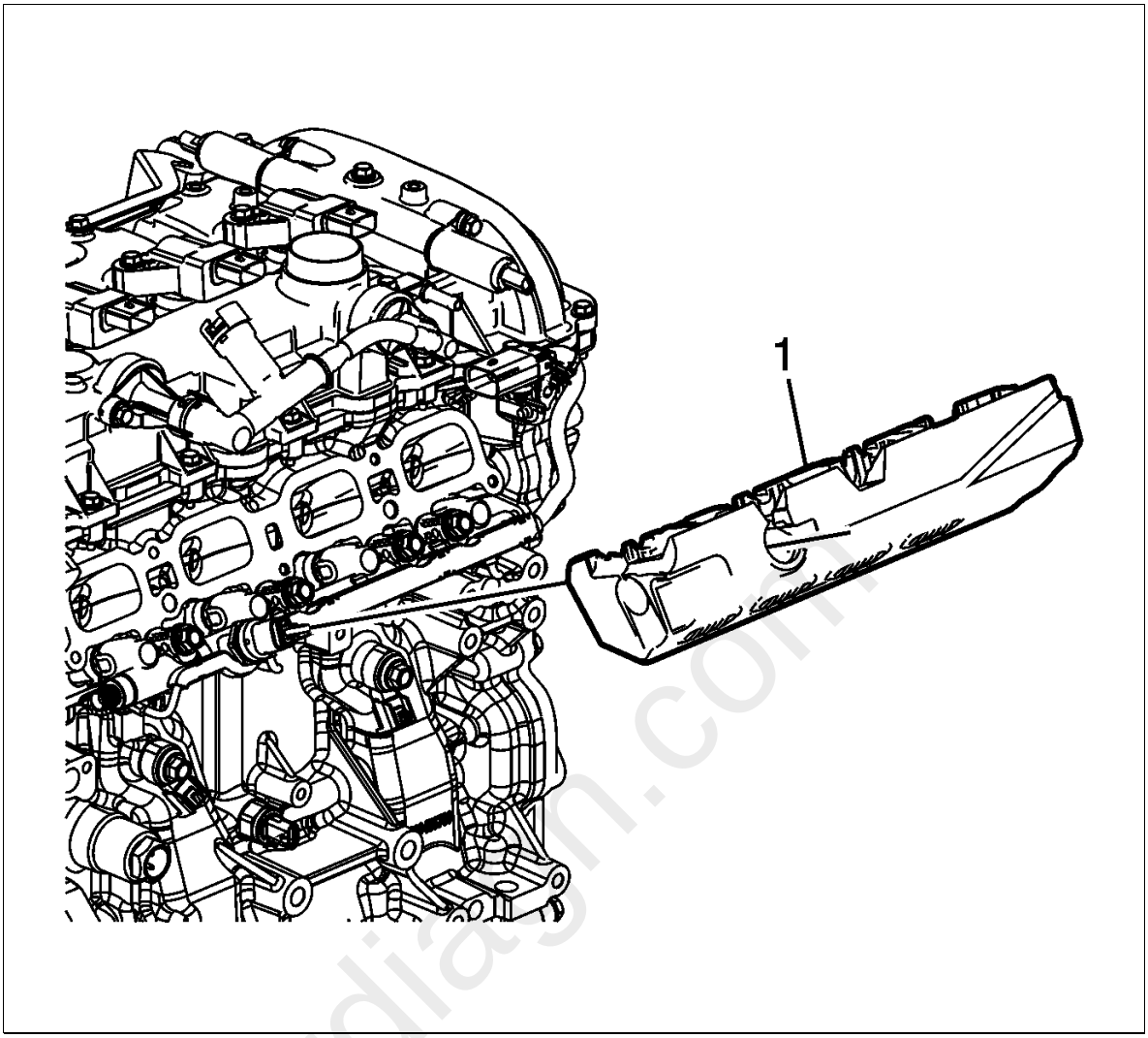
Courtesy of GENERAL MOTORS COMPANY

> ⚠ *CAUTION:*
>
> *Refer to Fastener Caution .*

6. Tighten the fuel rail bolts in sequence to 25 N.m (18 lb ft).
7. Connect the electrical harness to the fuel rail harness connections.
8. Install the fuel injection fuel rail pressure sensor. Refer to Fuel Injection Fuel Rail Fuel Pressure Sensor Replacement .
9. Install the fuel feed intermediate pipe. Refer to Fuel Feed Intermediate Pipe Replacement .

cardiagn.com

Fig 3: Fuel Injection Fuel Rail Noise Shield

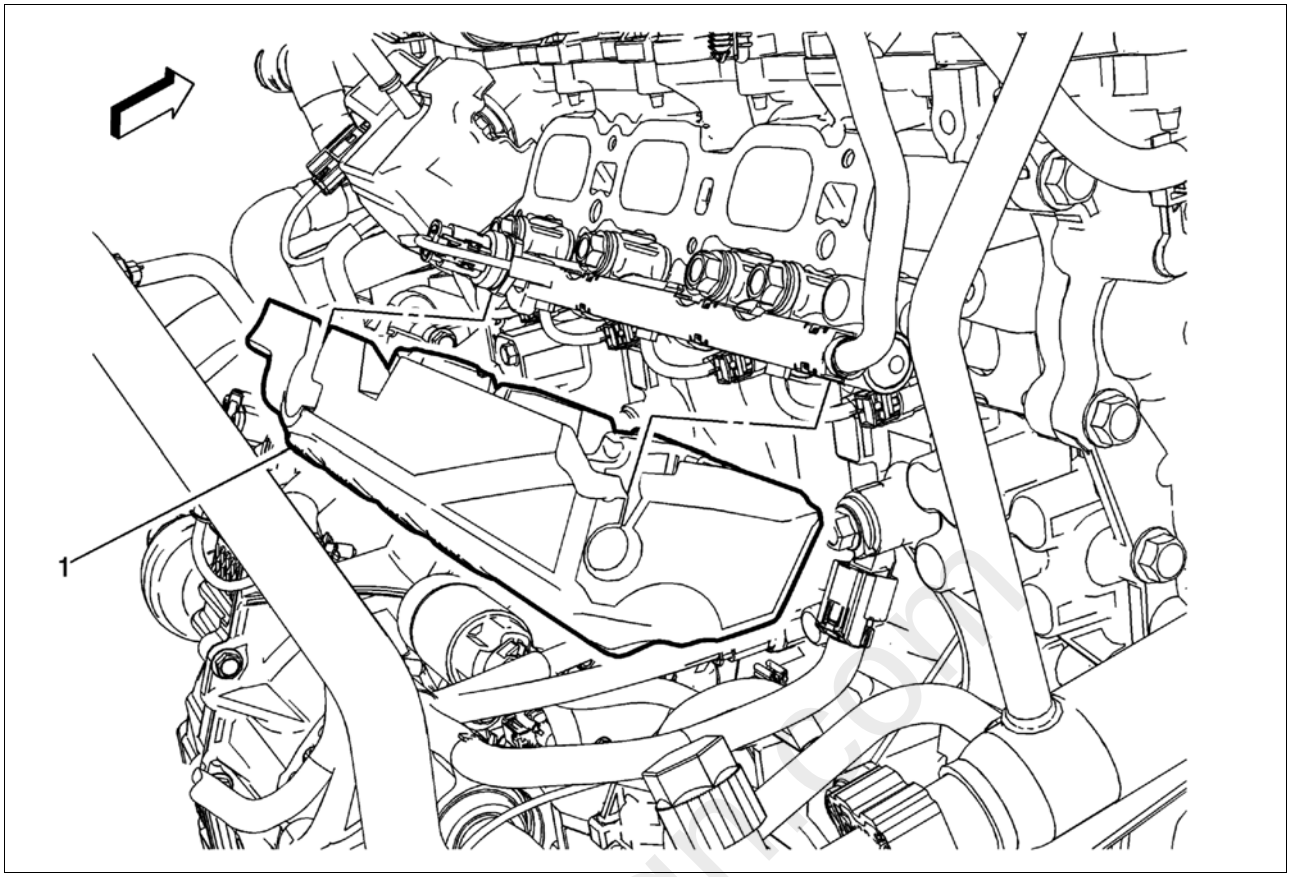


Courtesy of GENERAL MOTORS COMPANY

10. Install the fuel injection fuel rail noise shield (1). Refer to Fuel Injection Fuel Rail Noise Shield Replacement .

REPAIR INSTRUCTIONS > FUEL INJECTION FUEL RAIL NOISE SHIELD REPLACEMENT

Fig 1: Fuel Injection Fuel Rail Noise Shield



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the intake manifold. Refer to Intake Manifold Cover Replacement .	
1	Fuel Injection Fuel Rail Noise Shield *WARNING:* *The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.* *NOTE:* *The fuel injection noise shield just snaps into place.*

cardiagn.com

REPAIR INSTRUCTIONS > FUEL INJECTION FUEL RAIL FUEL PRESSURE SENSOR REPLACEMENT > REMOVAL PROCEDURE

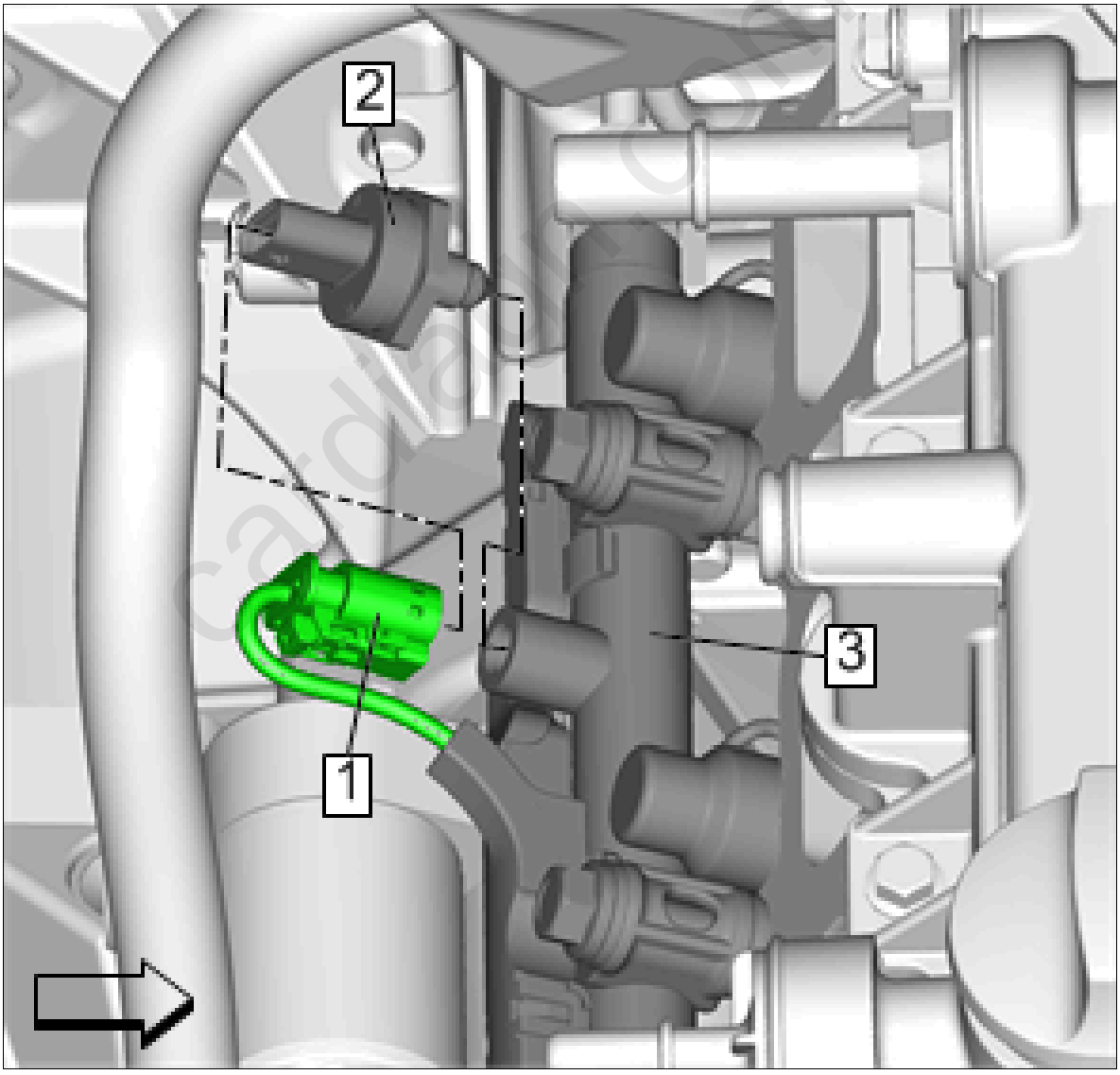
1. Relieve the fuel system pressure Fuel Pressure Relief .

> *NOTE:*
>
> *It is not necessary to completely remove the intake manifold to gain access to the fuel injection fuel rail fuel pressure sensor.*

2. »Reposition

3. Reposition Fuel Injection Fuel Rail Noise Shield Replacement .

Fig 1: Fuel Rail Pressure Sensor



Courtesy of GENERAL MOTORS COMPANY

> *CAUTION:*
>
> *Refer to Fuel and Evaporative Emission Hose/Pipe Connection Cleaning Caution .*

> *NOTE:*
>
> *Applying force to the plastic housing of the sensor may damage the sensor. To tighten or loosen, apply force only to the attached hexagon.*

4. Disconnect Electrical Connector (1) at Fuel Injection Fuel Rail Fuel Pressure Sensor (2)

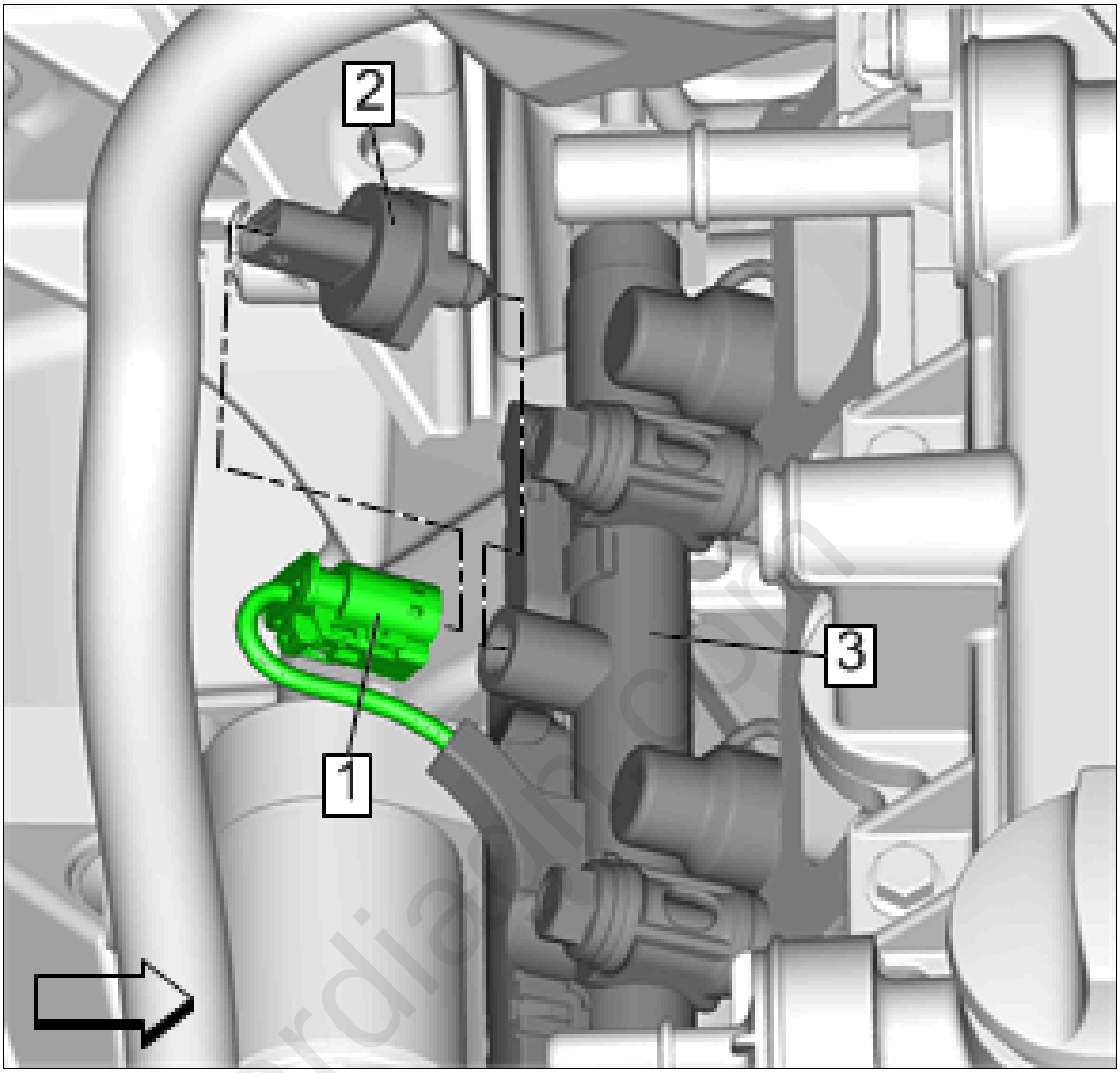
> *NOTE:*
>
> *Some fuel may leak from the fuel rail fuel pressure sensor orifice after the sensor is removed. Dry the area around this orifice after the removal of the sensor using a lint free cloth and inspect the fuel injection fuel rail fuel pressure sensor sealing surface. The surface should be free of fuel, debris, and burrs.*

5. Remove Fuel Injection Fuel Rail Fuel Pressure Sensor (2) at Fuel Injection Fuel Rail (3) and DISCARD

REPAIR INSTRUCTIONS > FUEL INJECTION FUEL RAIL FUEL PRESSURE SENSOR REPLACEMENT > INSTALLATION PROCEDURE

cardiagn.com

Fig 1: Fuel Rail Pressure Sensor



Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

> *NOTE:*
>
> *Applying force to the plastic housing of the sensor may damage the sensor. To tighten or loosen, apply force only to the attached hexagon.*

> *NOTE:*
>
> *Ensure the fuel rail threads are clean and free of any excess fuel, or the fuel injection fuel rail fuel pressure sensor will NOT seal properly.*

1. Lubricate the threads and sealing surface of the NEW fuel injection fuel rail fuel pressure sensor with one drop of clean engine oil.

> *NOTE:*
>
> *Install a NEW fuel injection fuel rail fuel pressure sensor.*

2. Install the NEW fuel injection fuel rail fuel pressure sensor (2) and hand tighten.
3. Remove Fuel Injection Fuel Rail Fuel Pressure Sensor (2) at Fuel Injection Fuel Rail (3) and re-lubricate with one drop of clean engine oil.

> *CAUTION:*
>
> *Refer to Component Fastener Tightening Caution .*

4. Install Fuel Injection Fuel Rail Fuel Pressure Sensor (2) at Fuel Injection Fuel Rail (3) and tighten to 33 N.m (24 lb ft)
5. Connect Electrical Connector (1) at Fuel Injection Fuel Rail Fuel Pressure Sensor (2)

> *NOTE:*
>
> *If a fuel leak occurs at the fuel rail, the fuel rail will need to be replaced.*

6. Pressurize the fuel system and inspect for leaks.
7. Install Fuel Injection Fuel Rail Noise Shield Replacement
8. »Install

cardiagn.com

REPAIR INSTRUCTIONS > FUEL INJECTOR REPLACEMENT

Special Tools

- **EN-47909** Injector Bore and Sleeve Cleaning Kit
- **EN-49245** Fuel Injector Seal Installer and Sizer
- **EN-50791** Fuel Injector Nozzle Installer

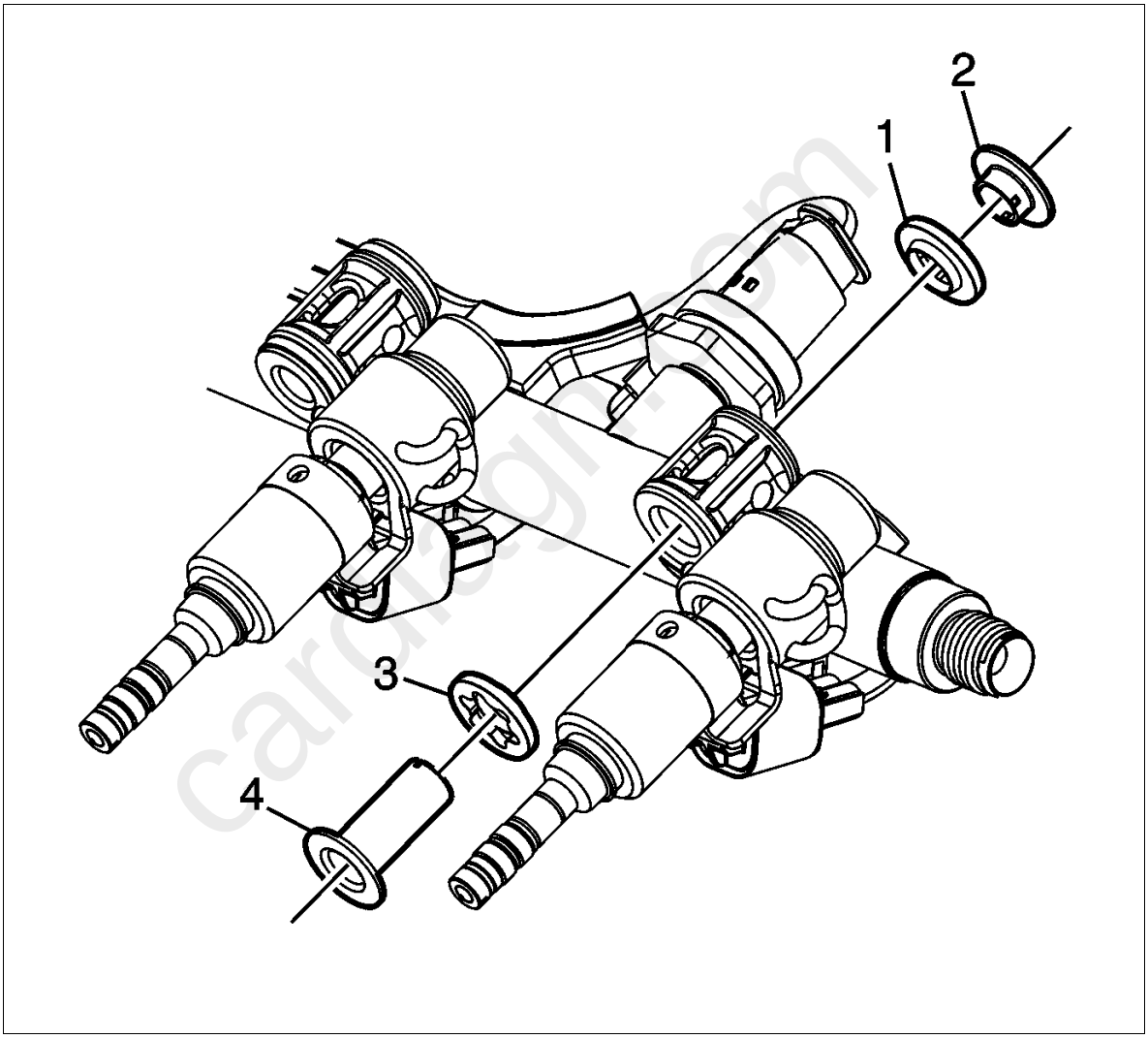
For equivalent regional tools, refer to Special Tools (Diagnostic Tools)Special Tools (Mechanical Tools) .

CAUTION:

Use care in removing the fuel injectors in order to prevent damage to the fuel injector electrical connector pins or the fuel injector nozzles. Do not immerse the fuel injector in any type of cleaner. The fuel injector is an electrical component and may be damaged by this cleaning method.

1. Remove the fuel injection fuel rail assembly. Refer to Fuel Injection Fuel Rail Assembly Replacement .

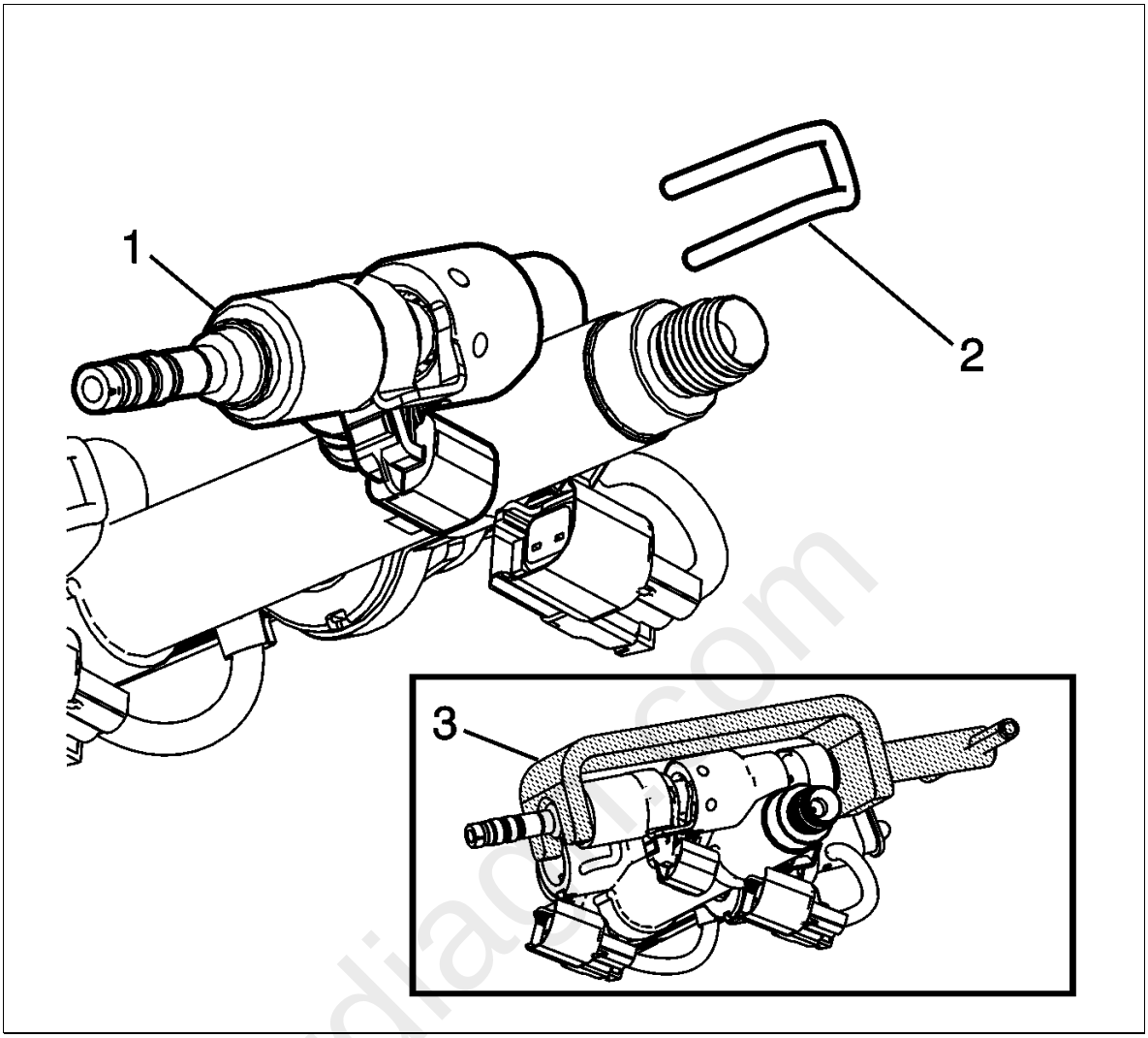
   Fig 1: Fuel Rail Insulator Assemblies



Courtesy of GENERAL MOTORS COMPANY

2. Remove and inspect the fuel rail insulator assemblies (1-4). Replace the entire assembly if any components show signs of wear or the insulators (4) show the following conditions:
   1. Dry or cracked appearance
   2. Flattened or misshapen appearance

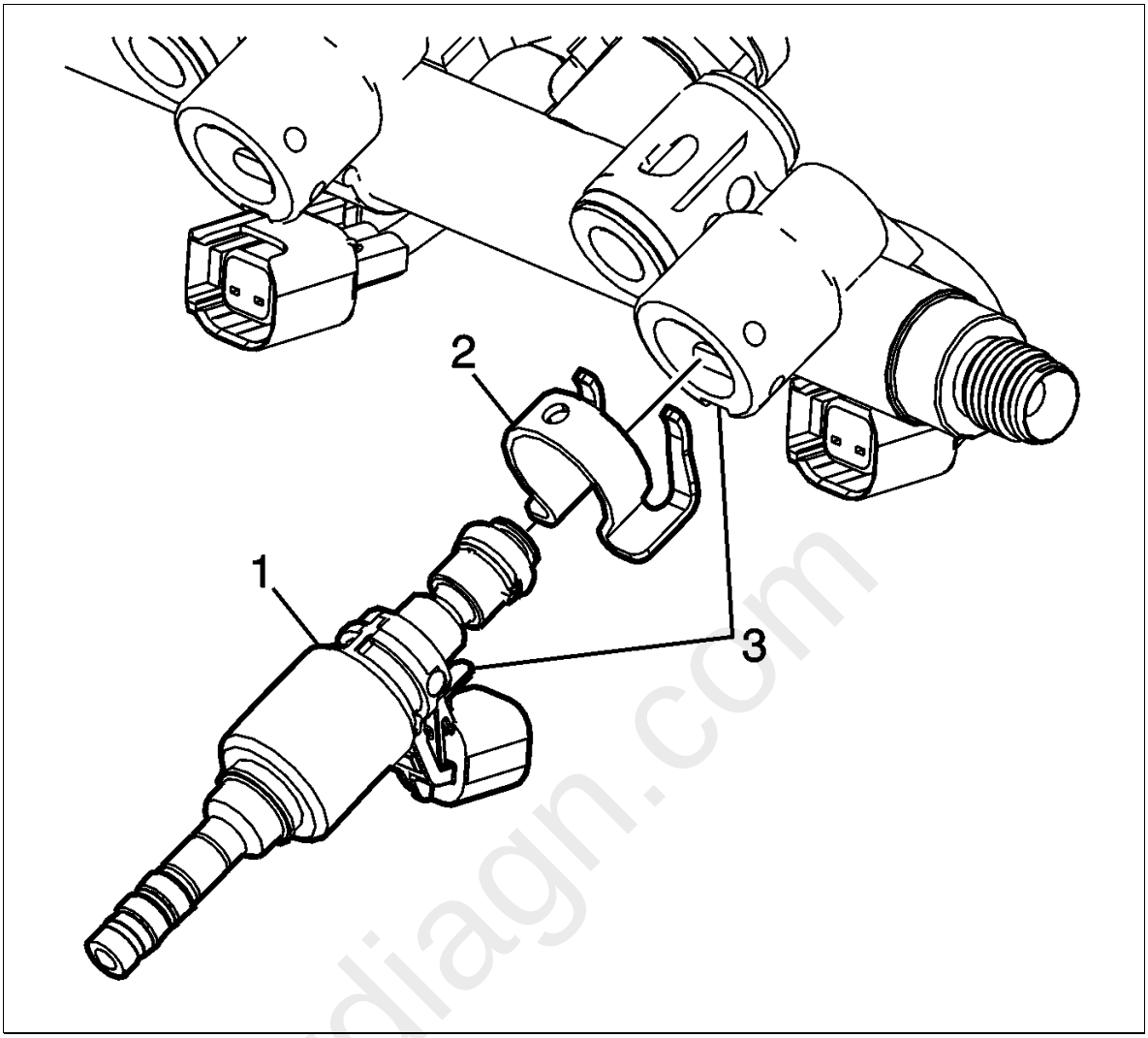
Fig 2: Fuel Injector And Retaining Pin



Courtesy of GENERAL MOTORS COMPANY

3. Disconnect the electrical connections from the fuel injectors.
4. Use **EN-50791** installer (3) to compress the fuel injector (1), and relieve pressure on the retaining pin (2). Remove the fuel injector retaining pin (2). Remove **EN-50791** installer once the retaining pin is removed.

Fig 3: Injectors And Fuel Rail Slot



Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

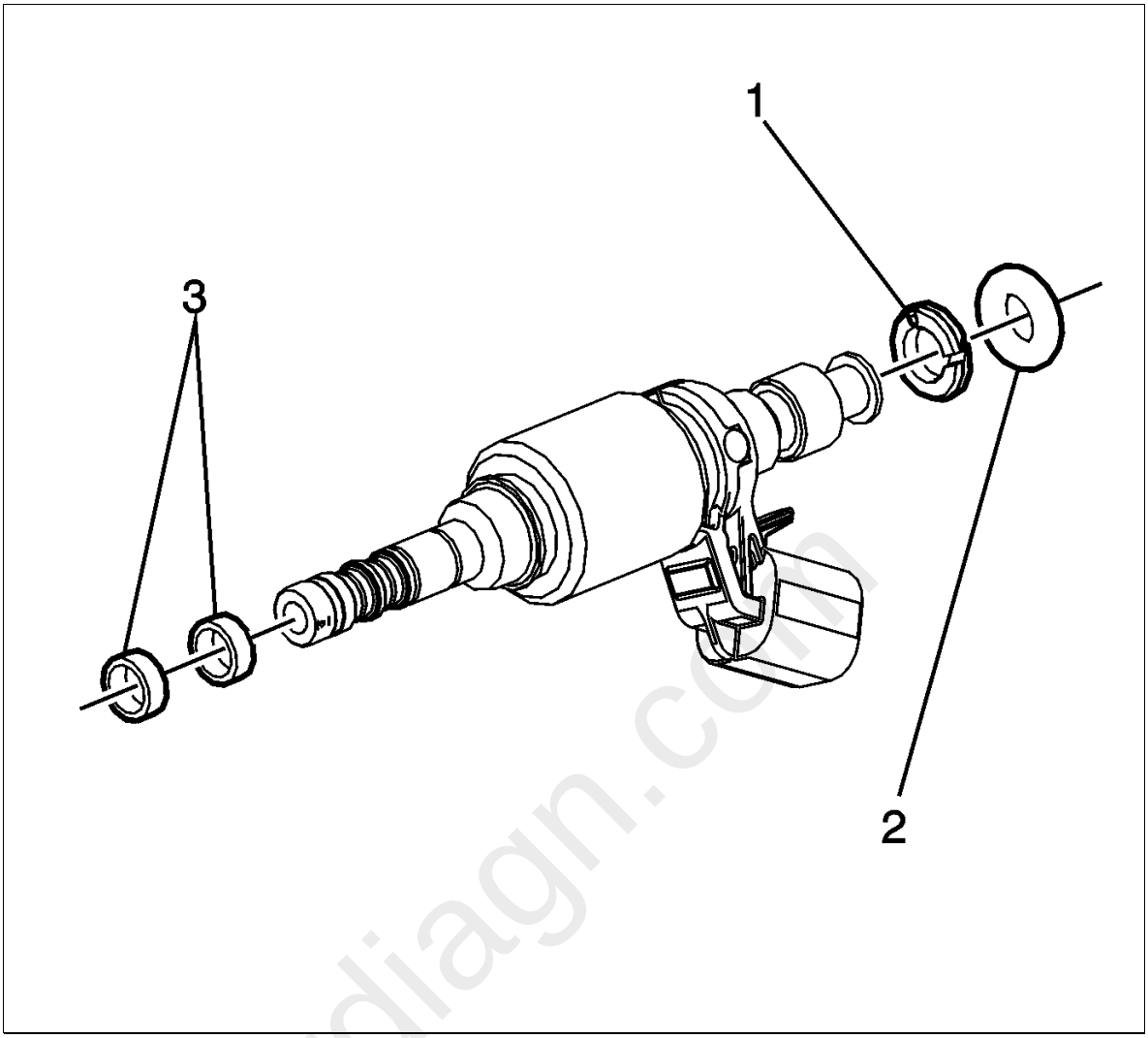
NOTE:

Support the fuel injector at the widest point. Support the fuel rail along the bottom.

1. *DO NOT support or hold the fuel injector by the tip or connector*
2. *DO NOT tilt or excessively twist the injector during removal*

5. Remove the injectors (1) from the fuel rail by pulling straight out along the fuel injector axis. Slight rotation of the fuel injector is acceptable as long as excessive force is not applied to the fuel injector tab while engaged in the fuel rail slot (3).
6. Remove the fuel injector holding clamp (2) from the rear of the fuel injector.

Fig 4: Fuel Injector O-ring And Plastic Spacer

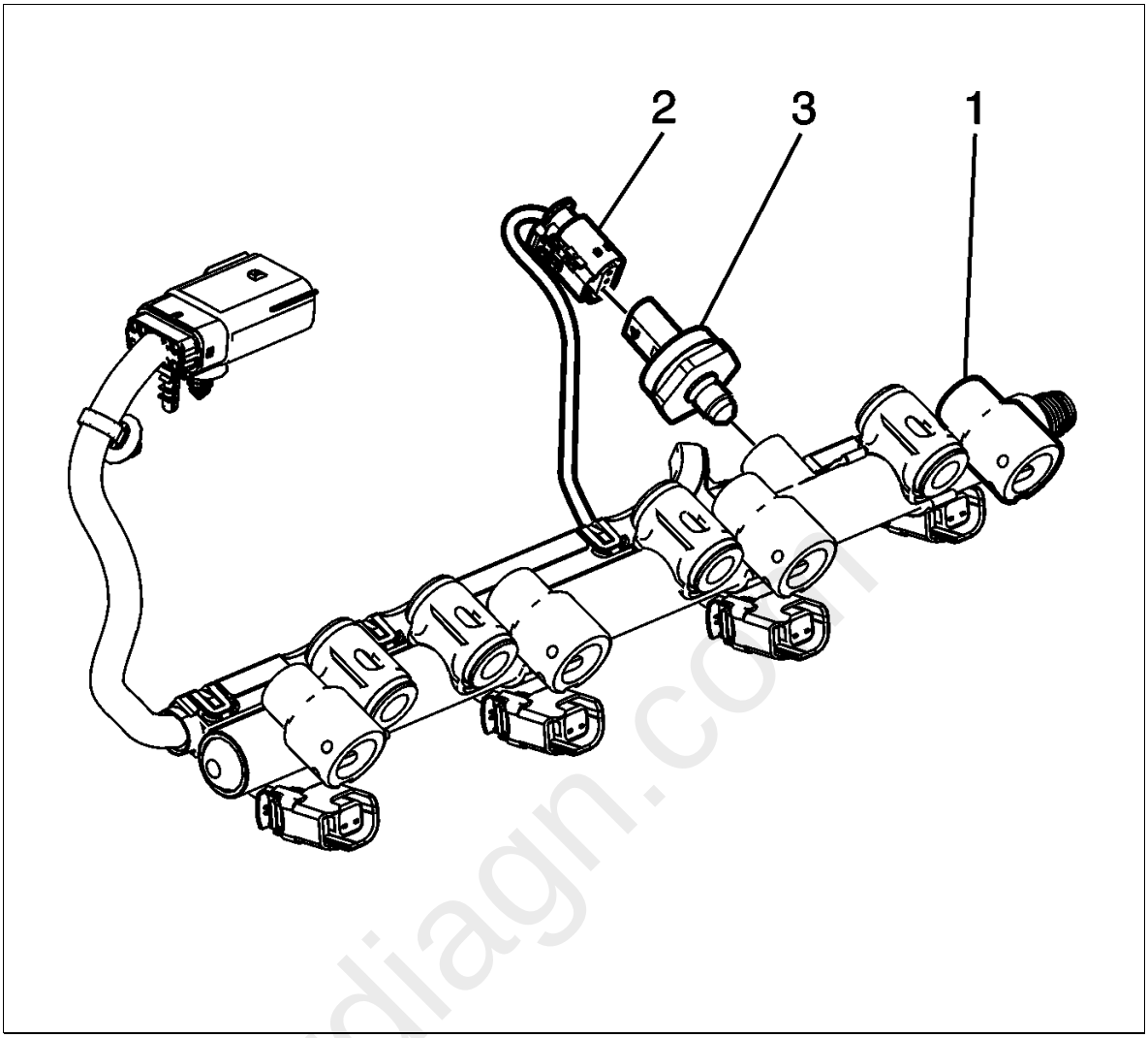


Courtesy of GENERAL MOTORS COMPANY

7. Remove and discard the fuel injector O-ring (2) and plastic spacer (1).
8. Remove and discard the fuel injector seals (3).

cardiagn.com

Fig 5: Fuel Rail



Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

NOTE:

Do not soak or submerge the fuel rail or injectors in solvent. Do not use solvent on the fuel rail label.

9. Clean the exterior of the fuel rail (1) and injectors in solvent.
10. Using **EN-47909** cleaning kit, clean the fuel injector bores and sleeves.
11. Inspect the fuel rail and components for the following conditions:
    1. Damage, debris, or restrictions to the fuel rail
    2. Damage, debris, or restrictions to the fuel ports in the fuel rail
    3. Damage to the mounting area for the fuel rail

4. Damage to the fuel rail mounting bolts
5. Damage to the threads on the fuel rail fuel feed fitting

12. Replace the fuel rail if any damage is found. Do not attempt to repair a fuel rail.

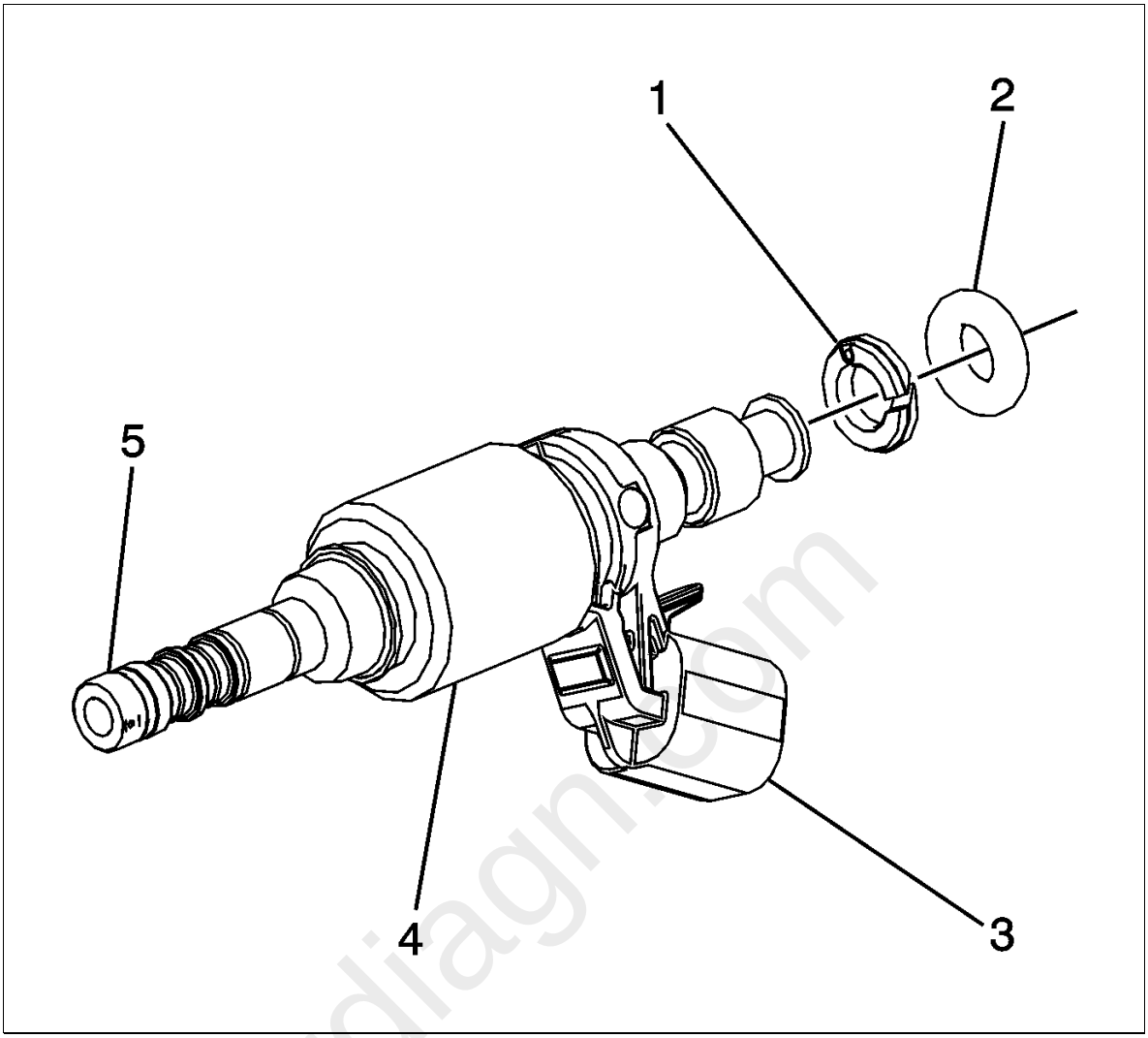
> ⚠ *CAUTION:*
>
> *Refer to Fastener Caution .*

> *NOTE:*
>
> *Remove and inspect the fuel pressure sensor only if the sensor is suspect.*

13. Inspect the fuel pressure sensor (3) for damage.
    1. Disconnect the harness connector (2) from the fuel pressure sensor.
    2. Remove the fuel pressure sensor. Dry the fuel pressure sensor bore in the fuel rail with a lint free cloth. The bore should be free of fuel, debris, and burrs.
    3. Lubricate the fuel rail fuel pressure sensor bore with clean engine oil.
    4. Lubricate the threads and sealing area on the fuel pressure sensor with clean engine oil.
    5. Install the fuel pressure sensor hand tight.
    6. Remove the fuel pressure sensor and re-lubricate the bore, threads, and sealing area.
    7. Install the fuel pressure sensor and tighten to 33 N.m (24 lb ft).
    8. Connect the harness connector to the fuel pressure sensor.

cardiagn.com

Fig 6: Fuel Injector Connector



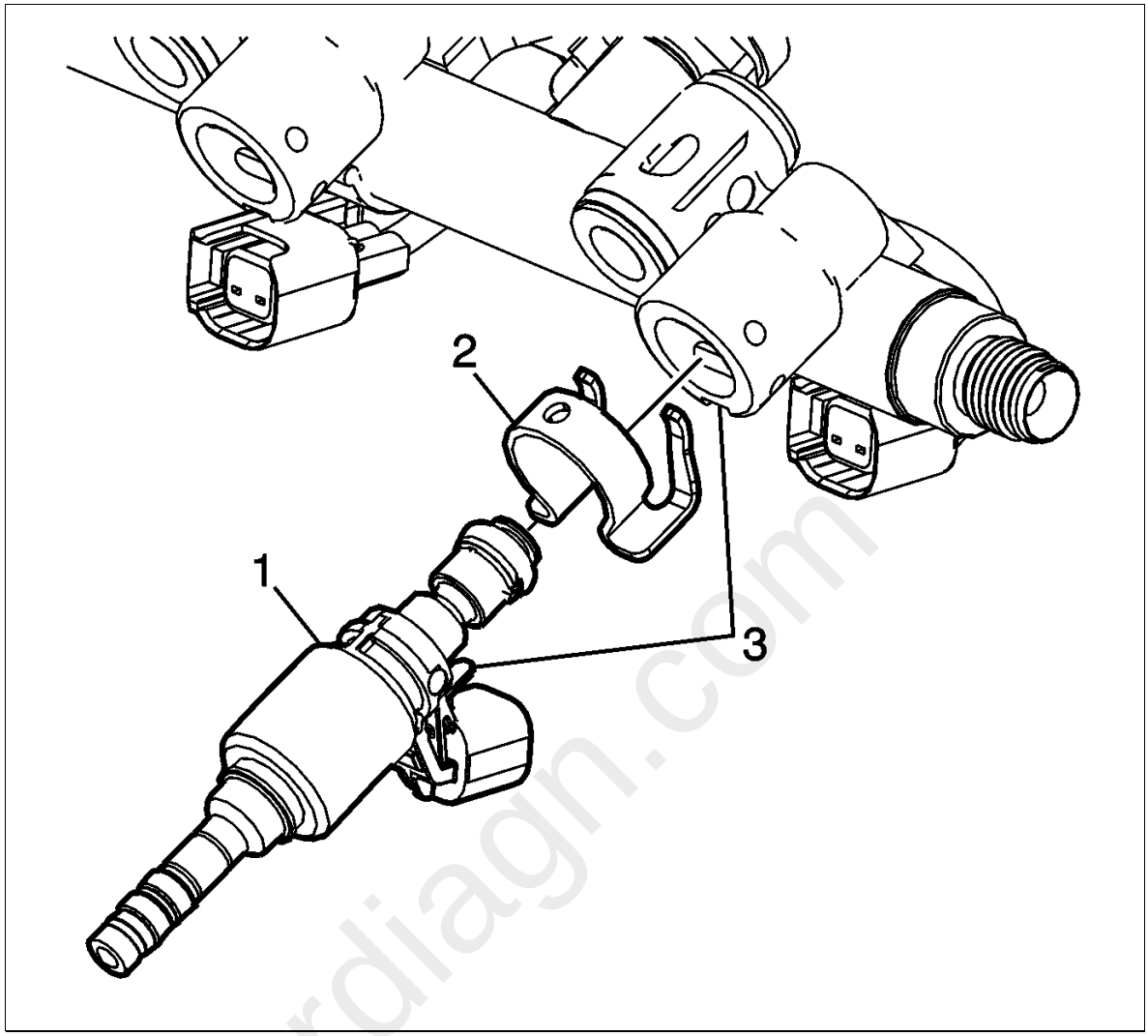
Courtesy of GENERAL MOTORS COMPANY

14. Inspect the fuel injectors for the following conditions:
    1. Damage to the fuel injector connector (3)
    2. Damage to the fuel injector harness connector
    3. Damage to the fuel injector tip (5)
    4. Damage to the fuel injector (4)
15. Replace the fuel injector if any damage is found. Do not attempt to repair a fuel injector.
16. Install the a new fuel injector spacer (1).

> *NOTE:*
>
> *Lubricate the NEW fuel injector O-ring seals with clean engine oil.*

17. Install the O-ring on the injector.

Fig 7: Injectors And Fuel Rail Slot



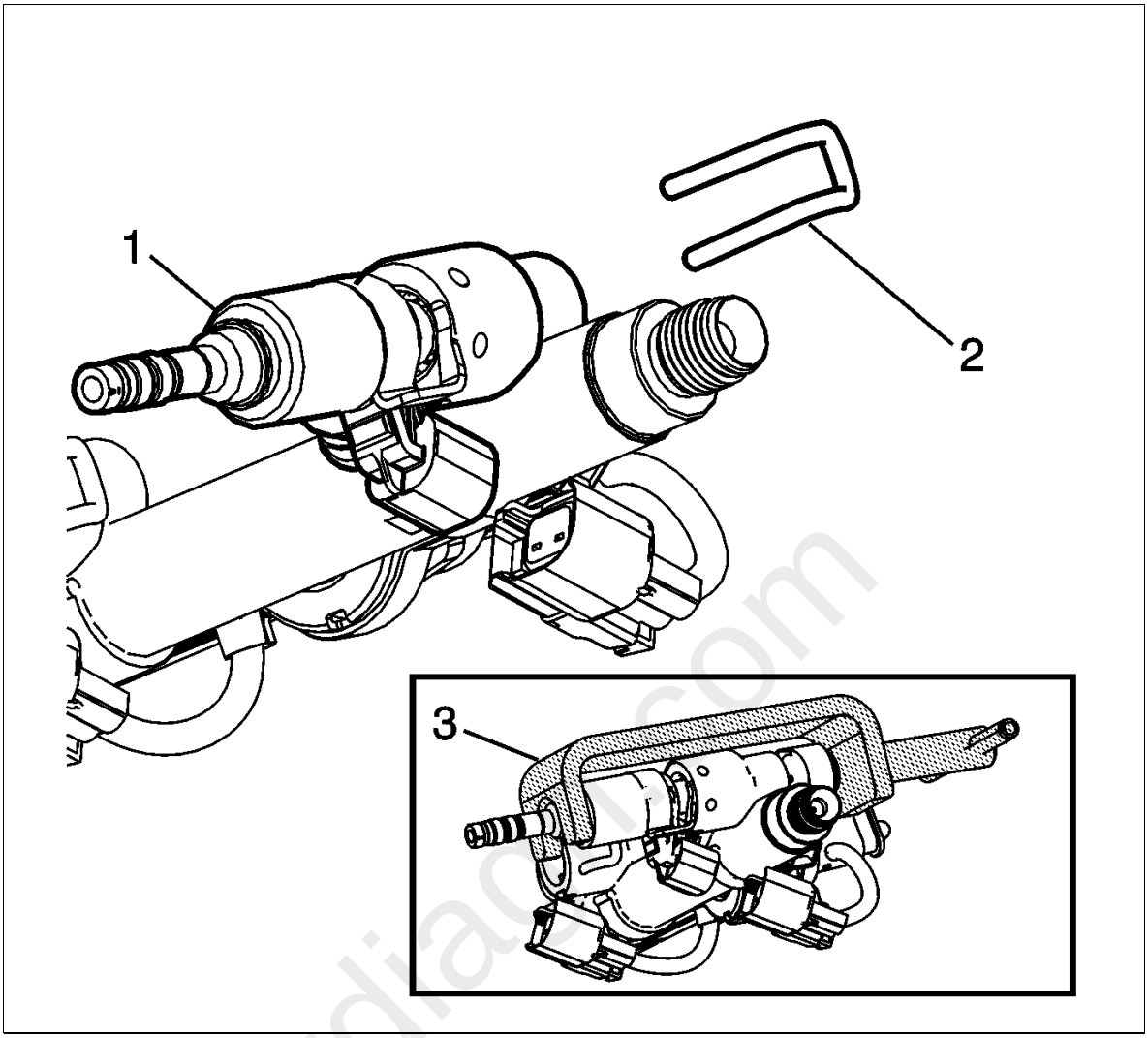
Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

18. Install the fuel injector holding clamp (2) onto the rear of the fuel injector.

19. Hand install fuel injectors (1) to the fuel rail, carefully aligning the fuel injector tab to the slot in the fuel rail (3).

Fig 8: Fuel Injector And Retaining Pin



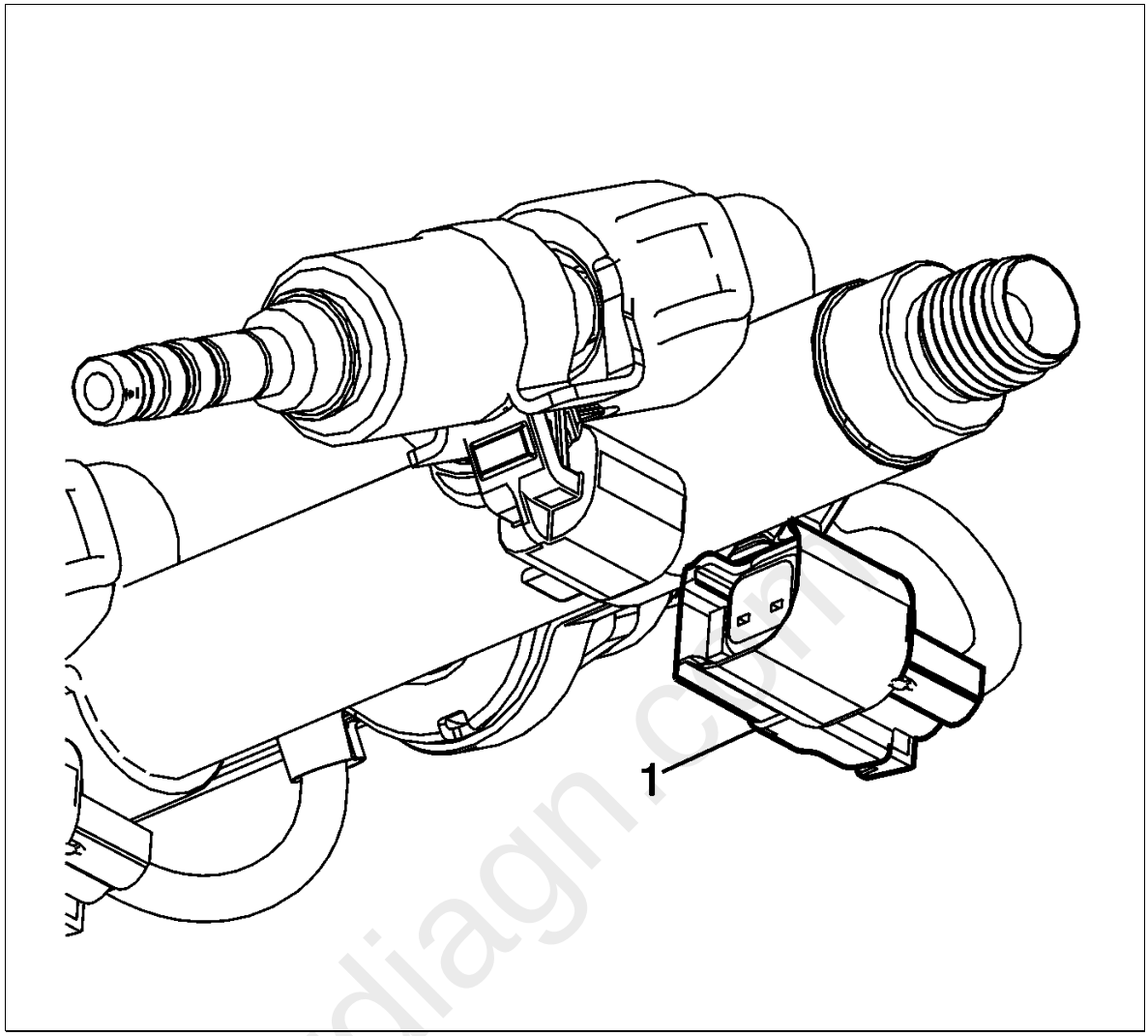
Courtesy of GENERAL MOTORS COMPANY

NOTE:

The injector must be fully installed and properly aligned with the fuel rail before installing the retaining pin.

20. Using **EN-50791** installer (3), compress the fuel injector (1) into the fuel rail.
21. Ensure the fuel injector is fully seated in the fuel rail, and install the fuel injector retaining pin (4).
22. Ensure the fuel injector retaining pin is fully seated in the fuel rail. Remove **EN-50791** installer. Repeat process until all fuel injectors are properly installed to the fuel rail.

Fig 9: Fuel Rail Harness Connectors

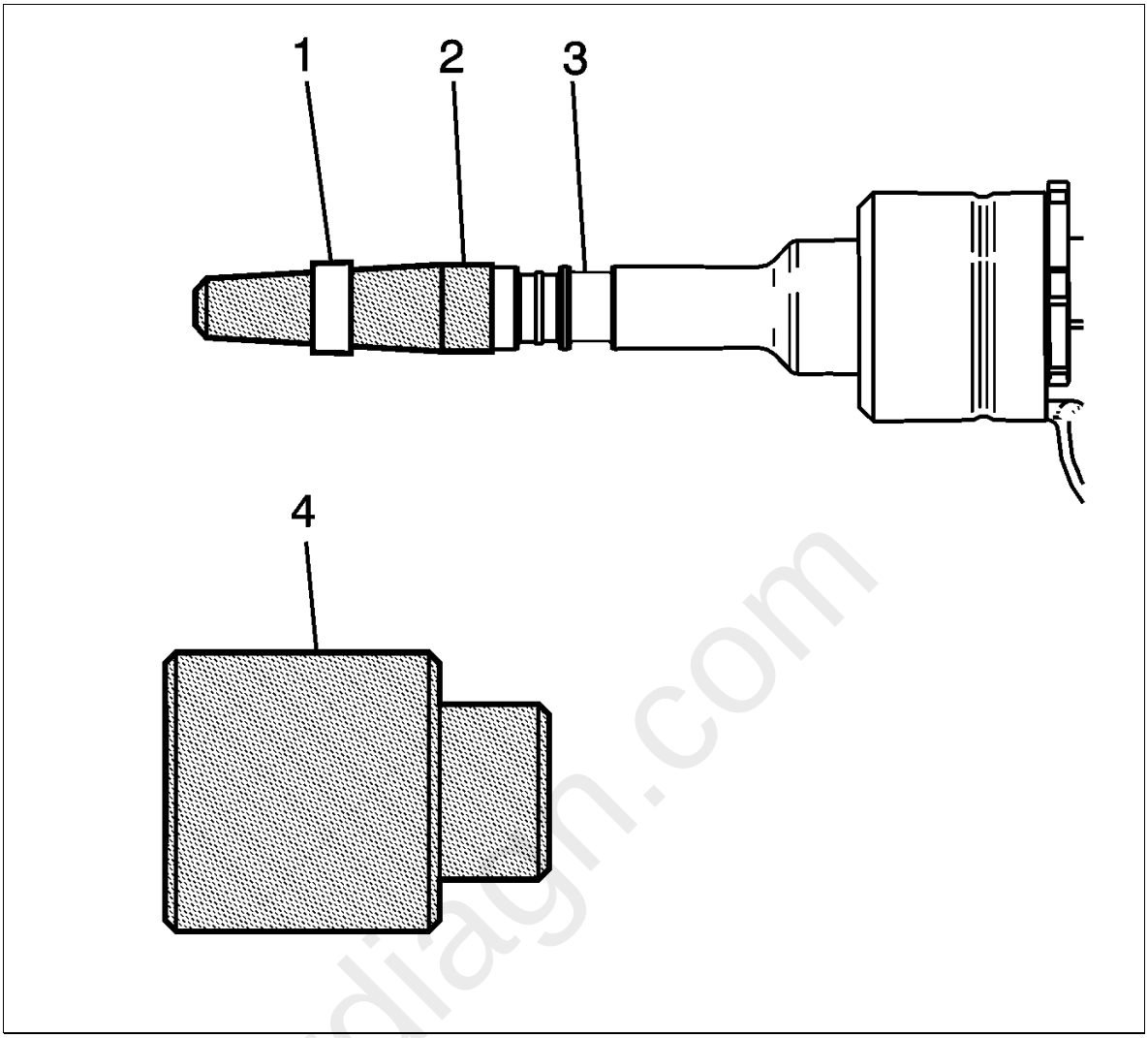


Courtesy of GENERAL MOTORS COMPANY

23. Connect the electrical connection to the fuel rail.
24. Connect the fuel rail harness connectors (1) to the fuel injectors.

cardiagn.com

Fig 10: Second Recessed Area And NEW Seal



Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

NOTE:

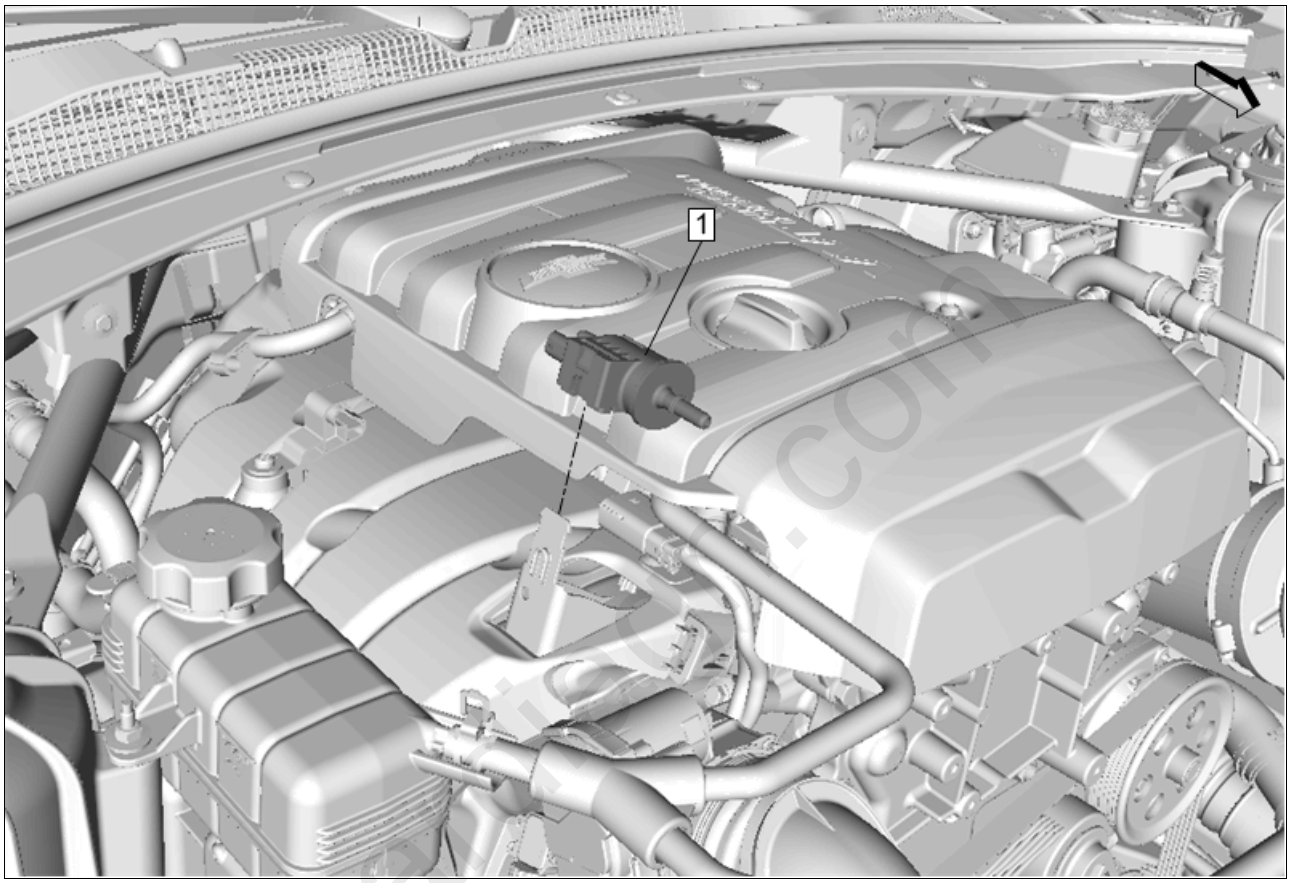
Do not use any type of lubricant when installing the NEW seals on the fuel injector tip.

25. Install **EN-49245** protector (2) onto the fuel injector tip. Place a NEW seal (1) on **EN-49245** protector.
26. Install a seal into the second recessed area (3) of the fuel injector.
27. Compress the seal with your fingers, then resize the seal using the **EN-49245** sizer (4).
28. Place a second NEW seal (1) on **EN-49245** protector.
29. Install the seal into the first recessed area of the fuel injector.
30. Compress the seal with your fingers, then resize the seal using the **EN-49245** sizer (4).

31. Install the fuel injection fuel rail assembly. Refer to Fuel Injection Fuel Rail Assembly Replacement .

REPAIR INSTRUCTIONS > EVAPORATIVE EMISSION CANISTER PURGE SOLENOID VALVE REPLACEMENT

Fig 1: Evaporative Emission Canister Purge Solenoid Valve

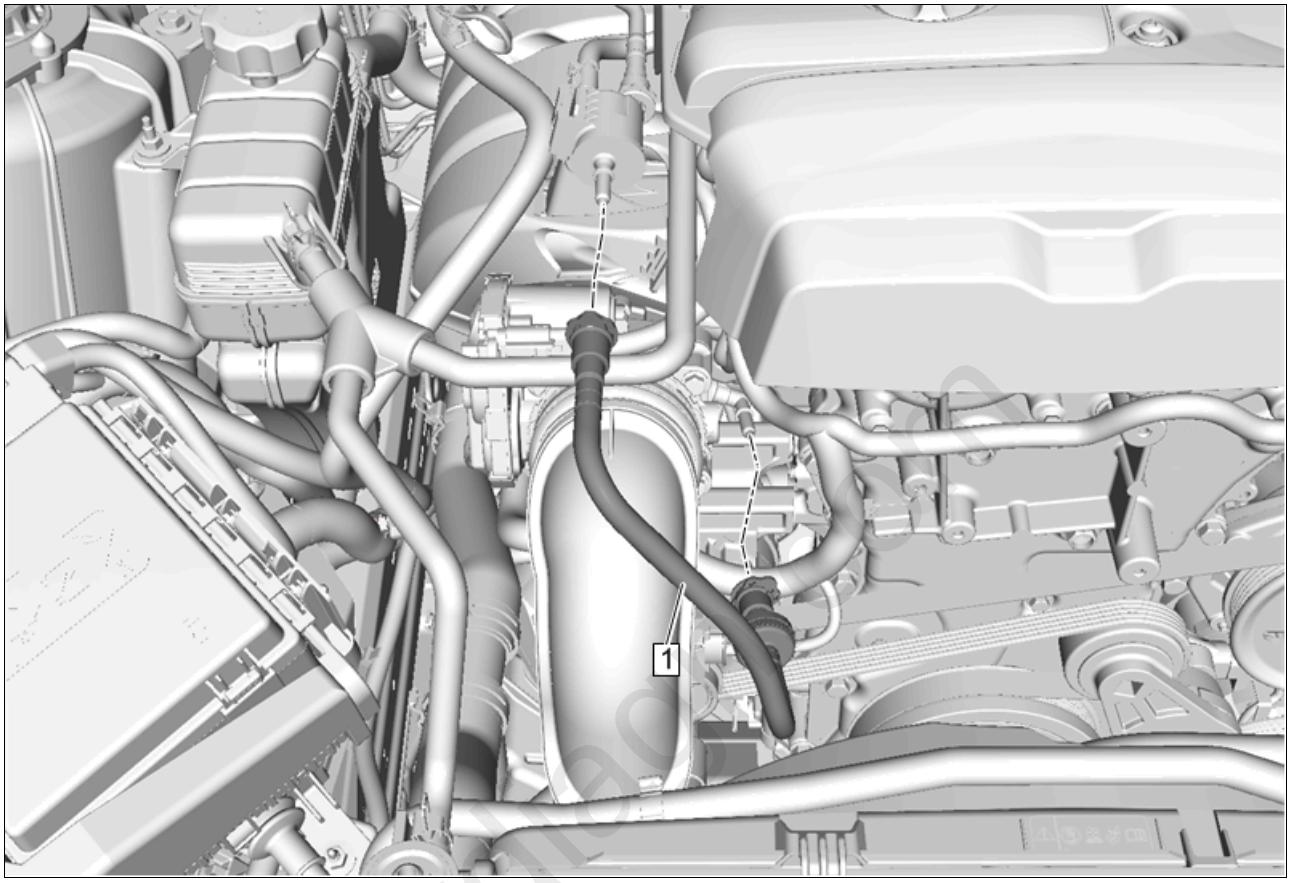


Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Evaporative Emission Canister Purge Tube Replacement 2. Evaporative Emission Line Replacement - Engine to Chassis	
1	Evaporative Emission Canister Purge Solenoid Valve Procedure 1. Disconnect the electrical connector. 2. Release the retaining tab.

REPAIR INSTRUCTIONS > EVAPORATIVE EMISSION CANISTER PURGE TUBE REPLACEMENT

Fig 1: Evaporative Emission Canister Purge Tube



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Evaporative Emission Canister Purge Tube **Procedure** Disconnect the evaporative emission canister purge tube from the intake manifold and the evaporative emission canister purge valve. Plastic Collar Quick Connect Fitting Service

REPAIR INSTRUCTIONS > EVAPORATIVE EMISSION CANISTER PURGE HOSE REPLACEMENT > REMOVAL PROCEDURE

WARNING:

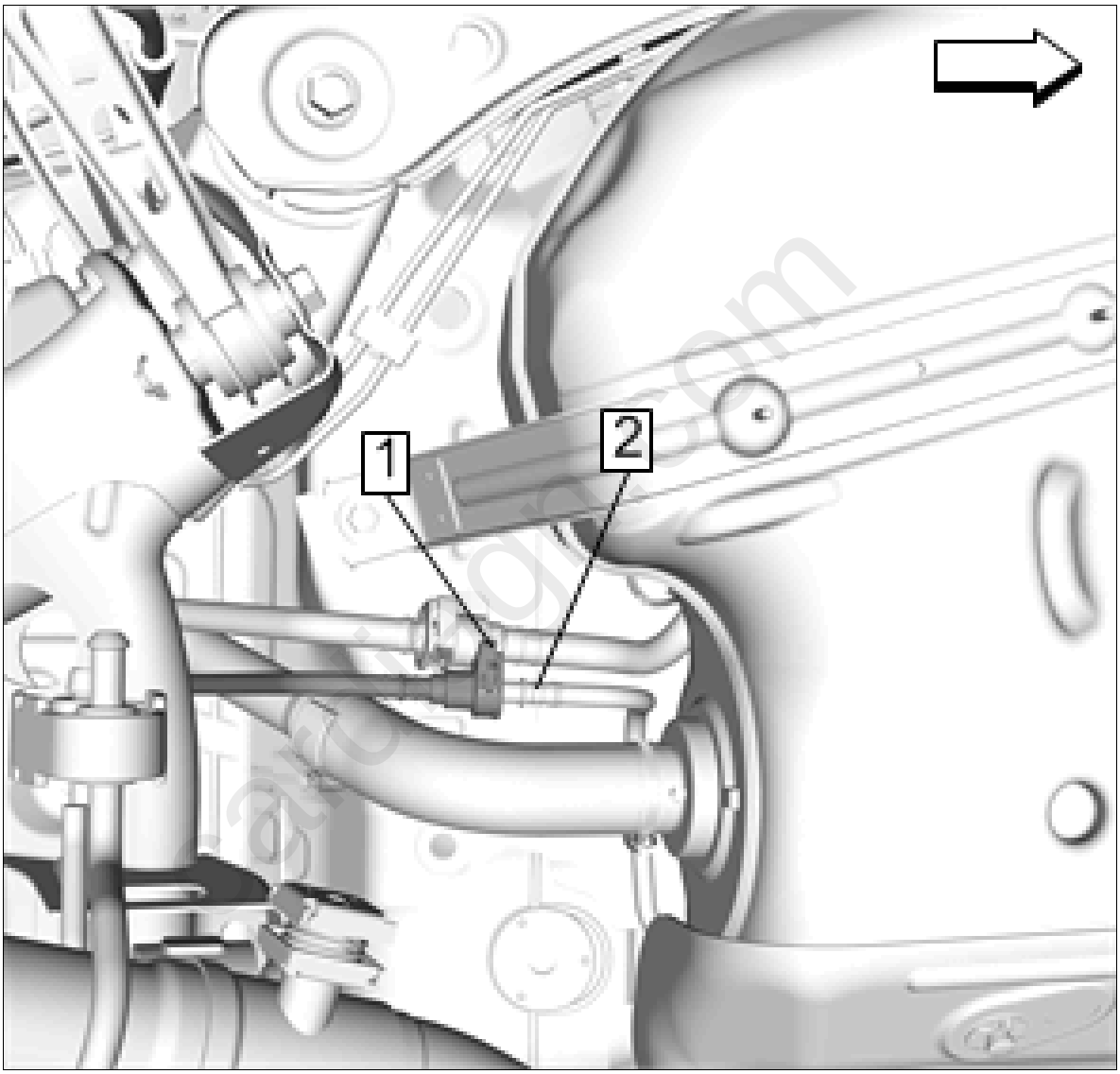
Refer to Gasoline/Gasoline Vapors Warning .

WARNING:

Refer to Safety Glasses Warning .

1. Raise and support the vehicle. Lifting and Jacking the Vehicle (Base)Lifting and Jacking the Vehicle (HP)

   Fig 1: Evaporative Emission Canister Purge Hose

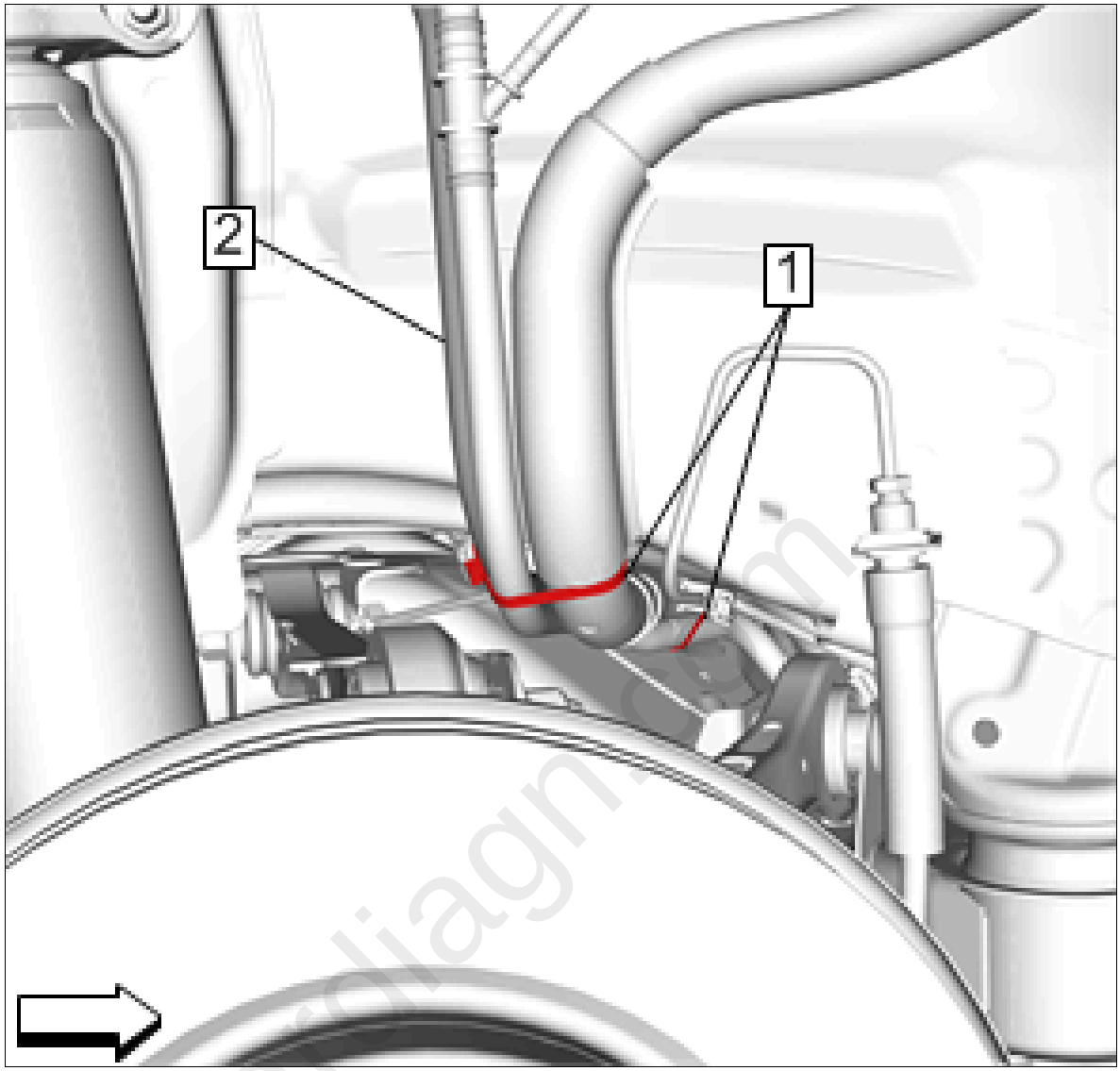


Courtesy of GENERAL MOTORS COMPANY

2. Disconnect Evaporative Emission Canister Purge Hose (1) at Fuel Tank Vent Valve Hose (2) - Plastic Collar Quick Connect Fitting Service

3. Remove Rear Wheelhouse Liner Replacement

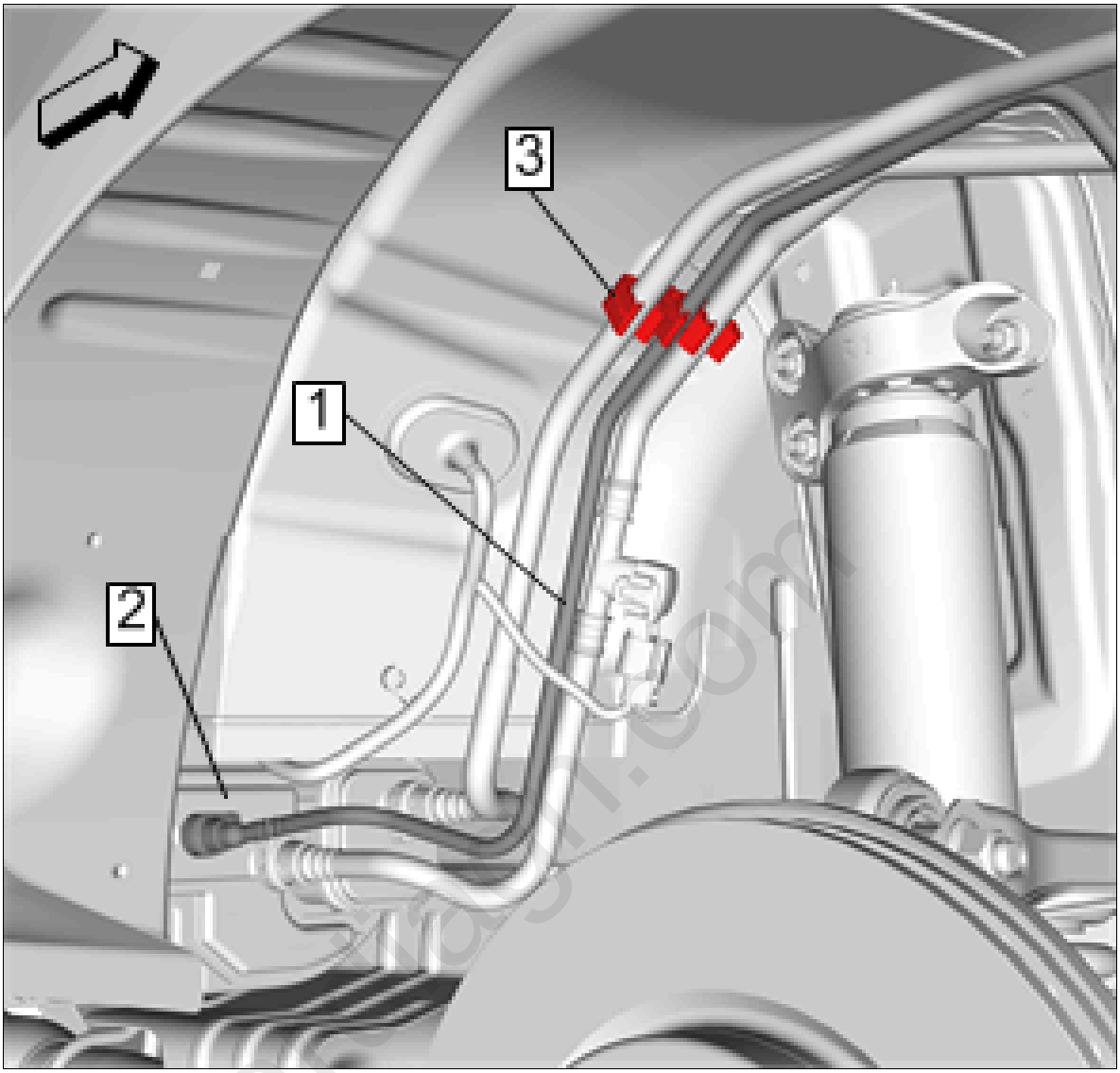
Fig 2: Tie Strap



Courtesy of GENERAL MOTORS COMPANY

4. Remove Tie Strap (1) (Qty: 2) at Evaporative Emission Canister Purge Hose (2) and DISCARD

Fig 3: Evaporative Emission Canister Purge Hose

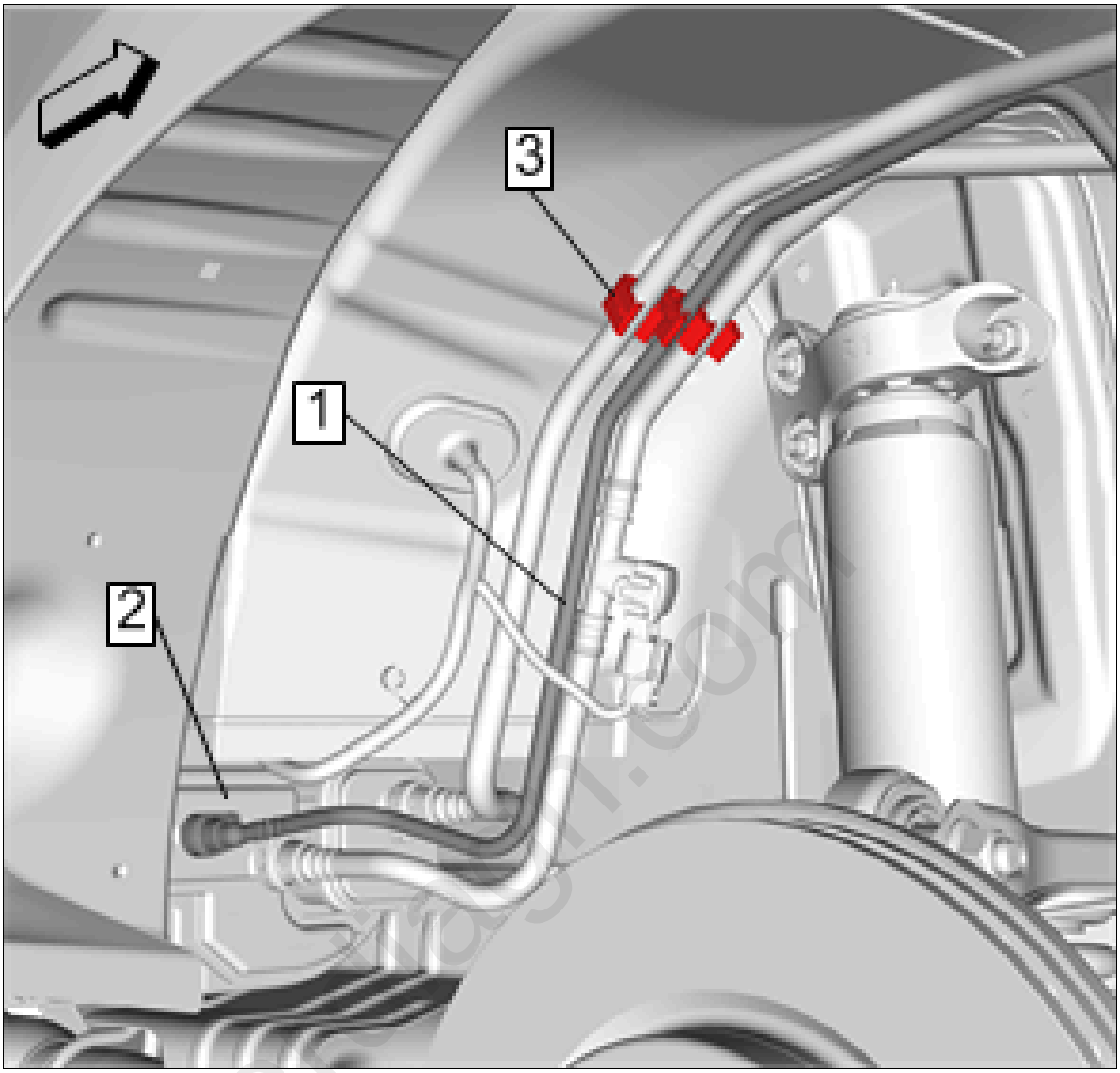


Courtesy of GENERAL MOTORS COMPANY

5. Disconnect Evaporative Emission Canister Purge Hose (1) at Evaporative Emission Canister (2) - Plastic Collar Quick Connect Fitting Service
6. Remove Evaporative Emission Canister Purge Hose (1) at Retainer (3)

REPAIR INSTRUCTIONS > EVAPORATIVE EMISSION CANISTER PURGE HOSE REPLACEMENT > INSTALLATION PROCEDURE

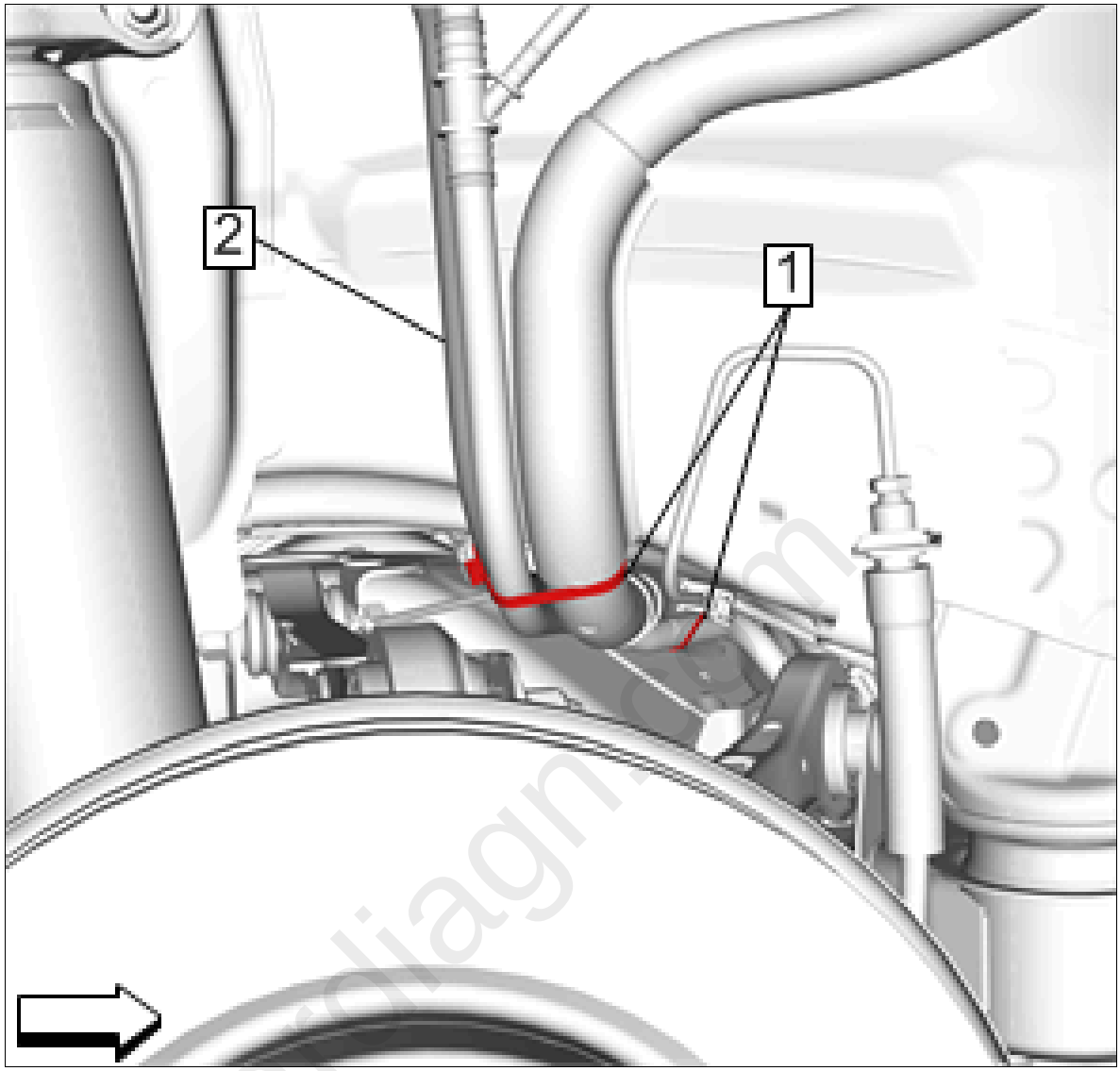
Fig 1: Evaporative Emission Canister Purge Hose



Courtesy of GENERAL MOTORS COMPANY

1. Install Evaporative Emission Canister Purge Hose (1) at Retainer (3)
2. Connect Evaporative Emission Canister Purge Hose (1) at Evaporative Emission Canister (2) - Plastic Collar Quick Connect Fitting Service

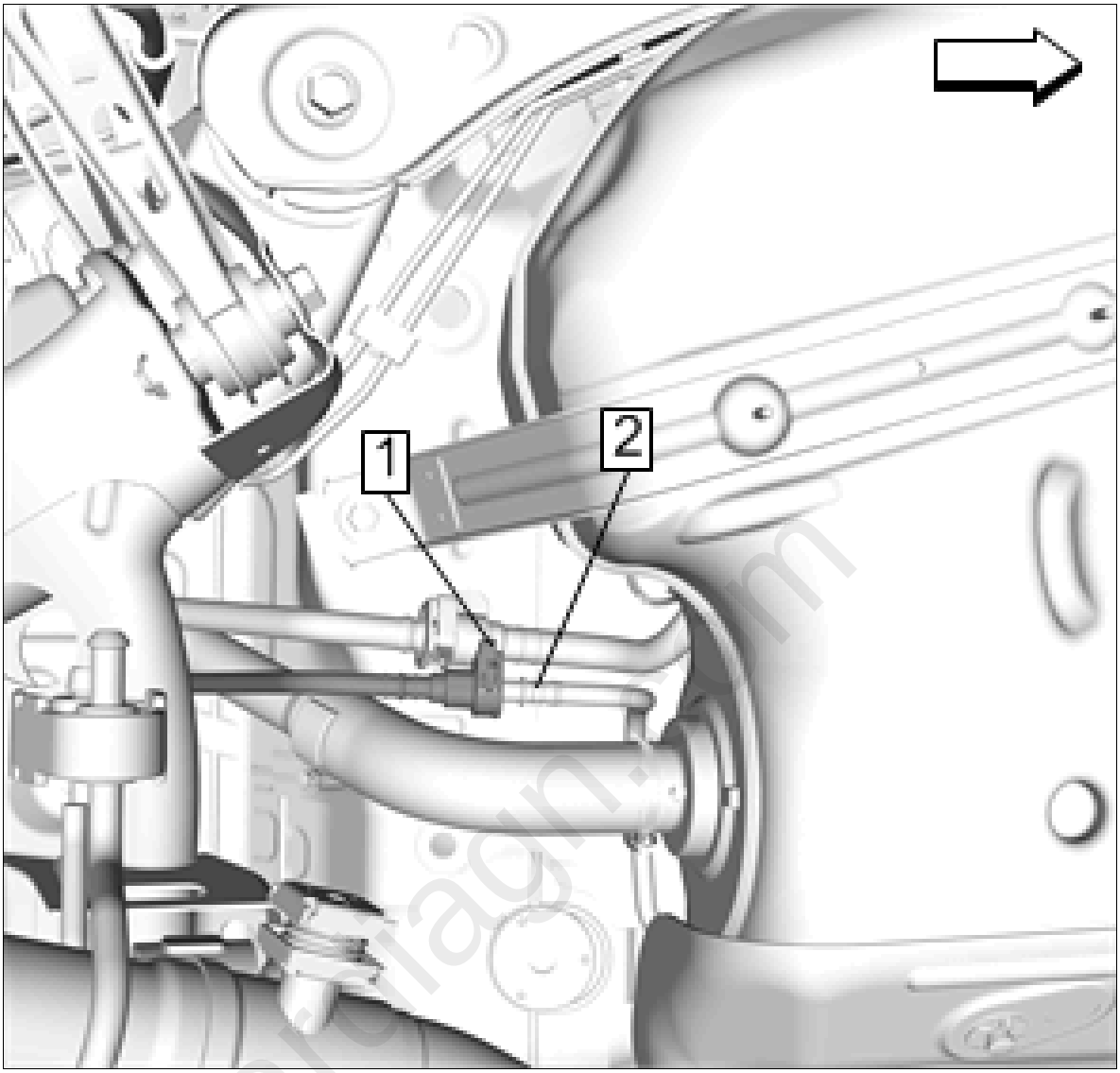
Fig 2: Tie Strap



Courtesy of GENERAL MOTORS COMPANY

3. Install NEW Tie Strap (1) (Qty: 2) at Evaporative Emission Canister Purge Hose (2)
4. Install Rear Wheelhouse Liner Replacement

Fig 3: Evaporative Emission Canister Purge Hose

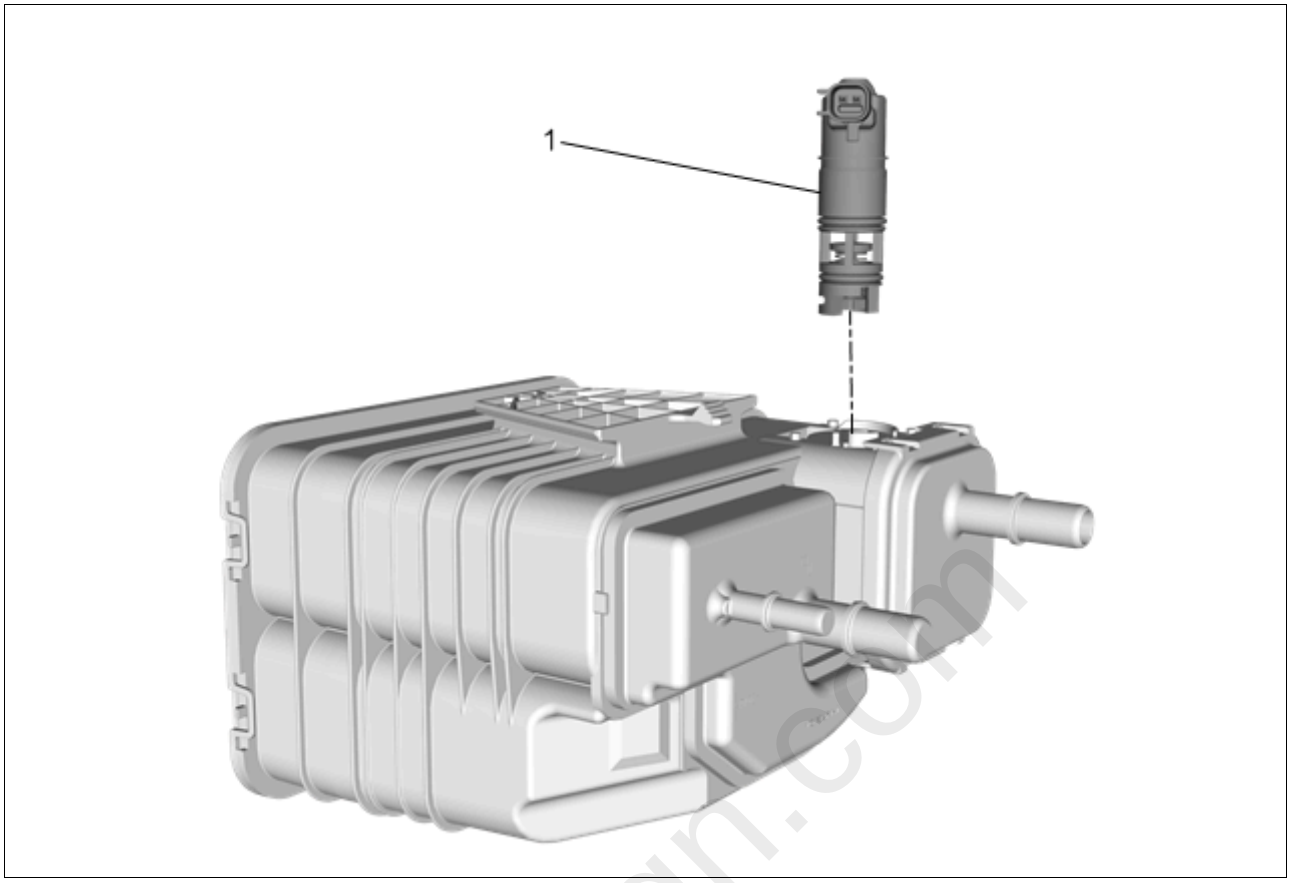


Courtesy of GENERAL MOTORS COMPANY

5. Connect Evaporative Emission Canister Purge Hose (1) at Fuel Tank Vent Valve Hose (2) - Plastic Collar Quick Connect Fitting Service
6. Lower the vehicle.

REPAIR INSTRUCTIONS > EVAPORATIVE EMISSION CANISTER VENT SOLENOID VALVE REPLACEMENT

Fig 1: Evaporative Emission Canister Vent Solenoid Valve



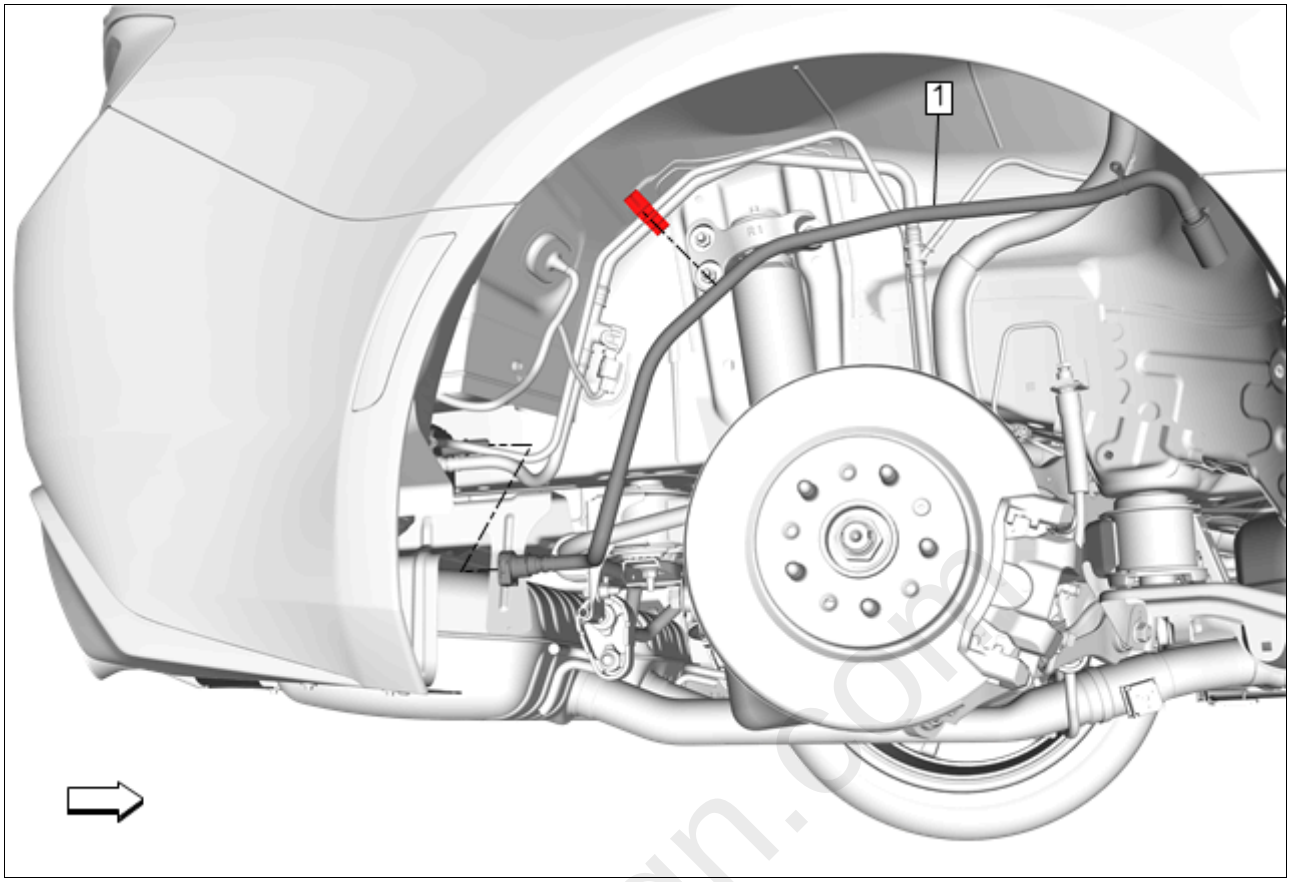
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Evaporative Emission Canister Replacement	
1	Evaporative Emission Canister Vent Solenoid Valve **Procedure** Disconnect the electrical connector.

REPAIR INSTRUCTIONS > EVAPORATIVE EMISSION CANISTER FILTER HOSE REPLACEMENT

Cardiagn.com

Fig 1: Evaporative Emission Canister Filter Hose



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Rear Wheelhouse Liner Replacement	
1	Evaporative Emission Canister Filter Hose **Procedure** Disconnect the evaporative emission canister filter hose from the evaporative emission canister and retainer. Plastic Collar Quick Connect Fitting Service

REPAIR INSTRUCTIONS > EVAPORATIVE EMISSION LINE REPLACEMENT - ENGINE TO CHASSIS > REMOVAL PROCEDURE

WARNING:

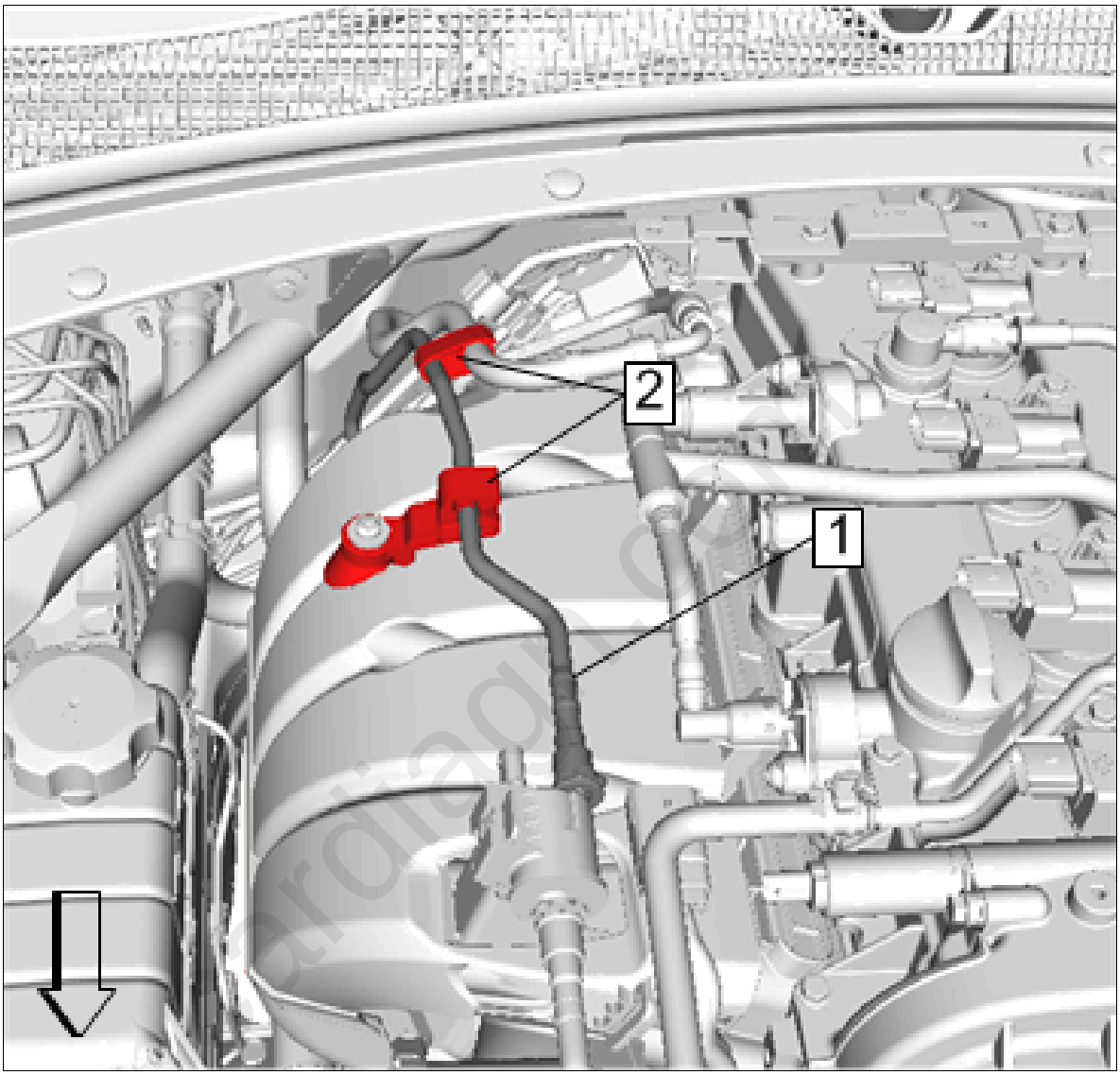
Refer to Gasoline/Gasoline Vapors Warning .

WARNING:

Refer to Safety Glasses Warning .

1. Remove Intake Manifold Cover Replacement

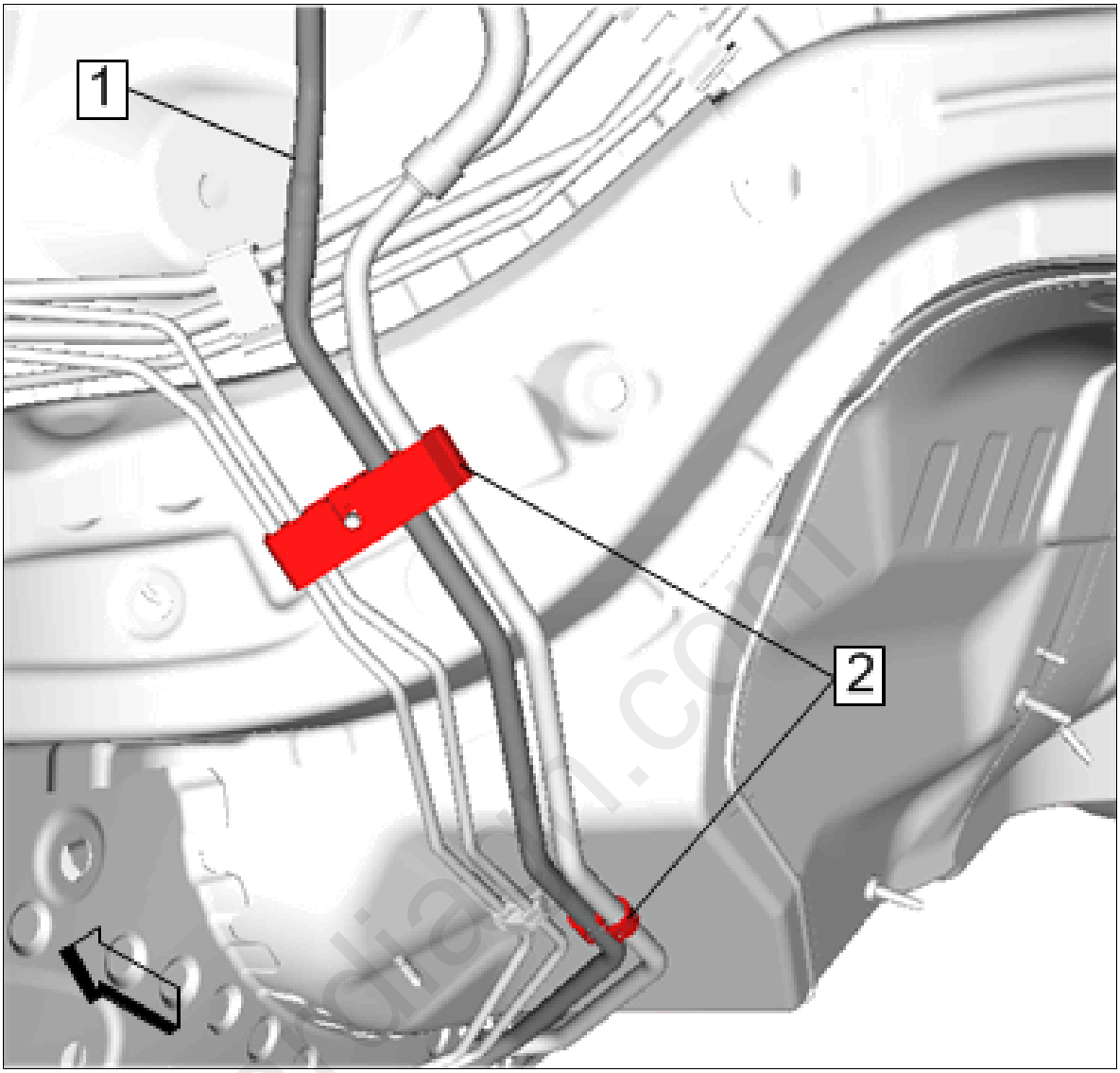
Fig 1: Evaporative Emission Pipe



Courtesy of GENERAL MOTORS COMPANY

2. Disconnect Evaporative Emission Pipe (1) at Evaporative Emission Canister Purge Solenoid Valve - Plastic Collar Quick Connect Fitting Service
3. Remove Evaporative Emission Pipe (1) at Retainer (2) (Qty: 2)
4. Raise and support the vehicle. Lifting and Jacking the Vehicle (Base)Lifting and Jacking the Vehicle (HP)
5. Remove Underbody Front Air Deflector Replacement - Right Side
6. Remove Front Body Exhaust Heat Shield Replacement (Right)Front Body Exhaust Heat Shield Replacement (Left)

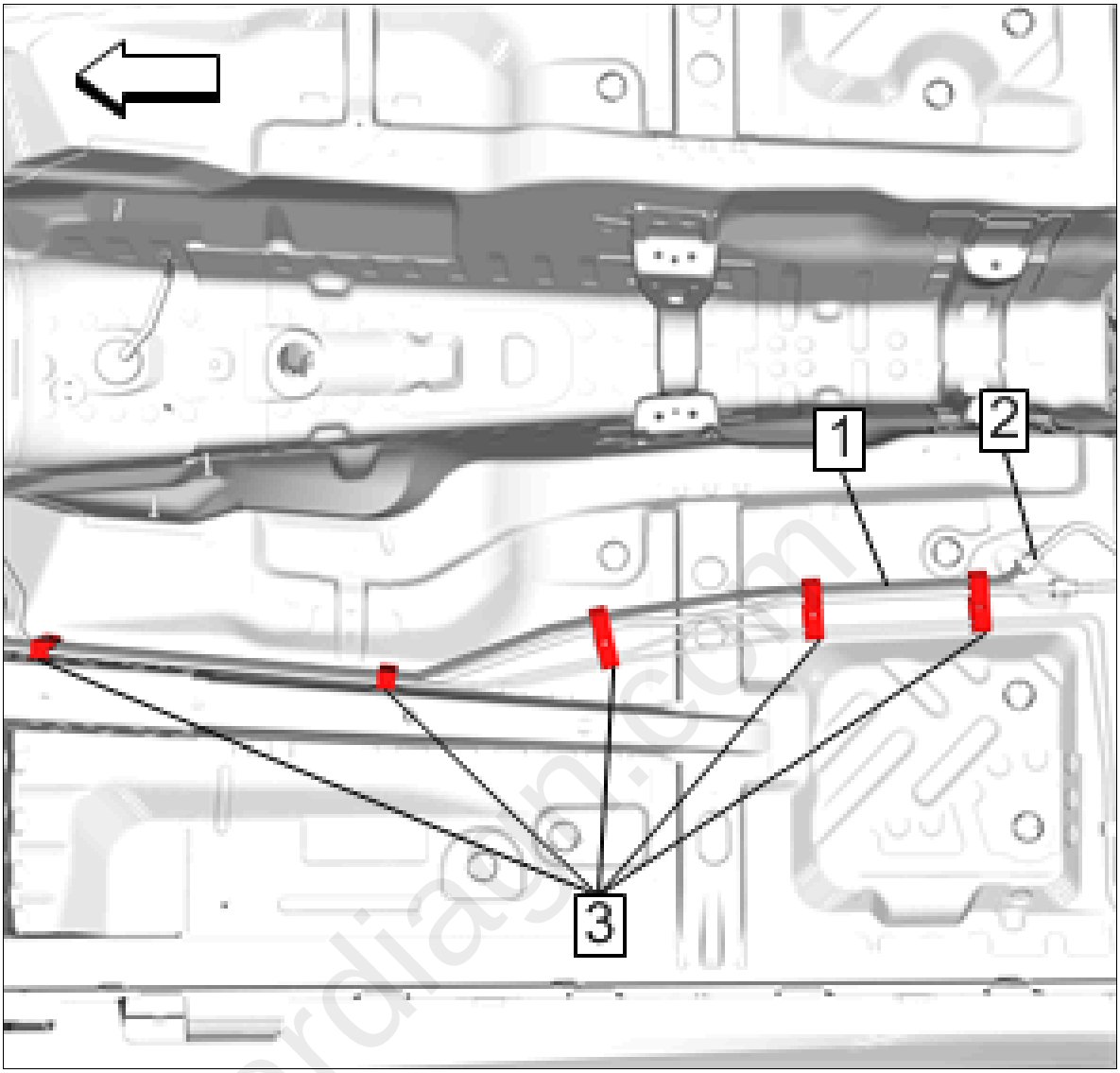
Fig 2: Evaporative Emission Pipe



Courtesy of GENERAL MOTORS COMPANY

7. Remove Evaporative Emission Pipe (1) at Retainer (2) (Qty: 2)

Fig 3: Evaporative Emission Pipe

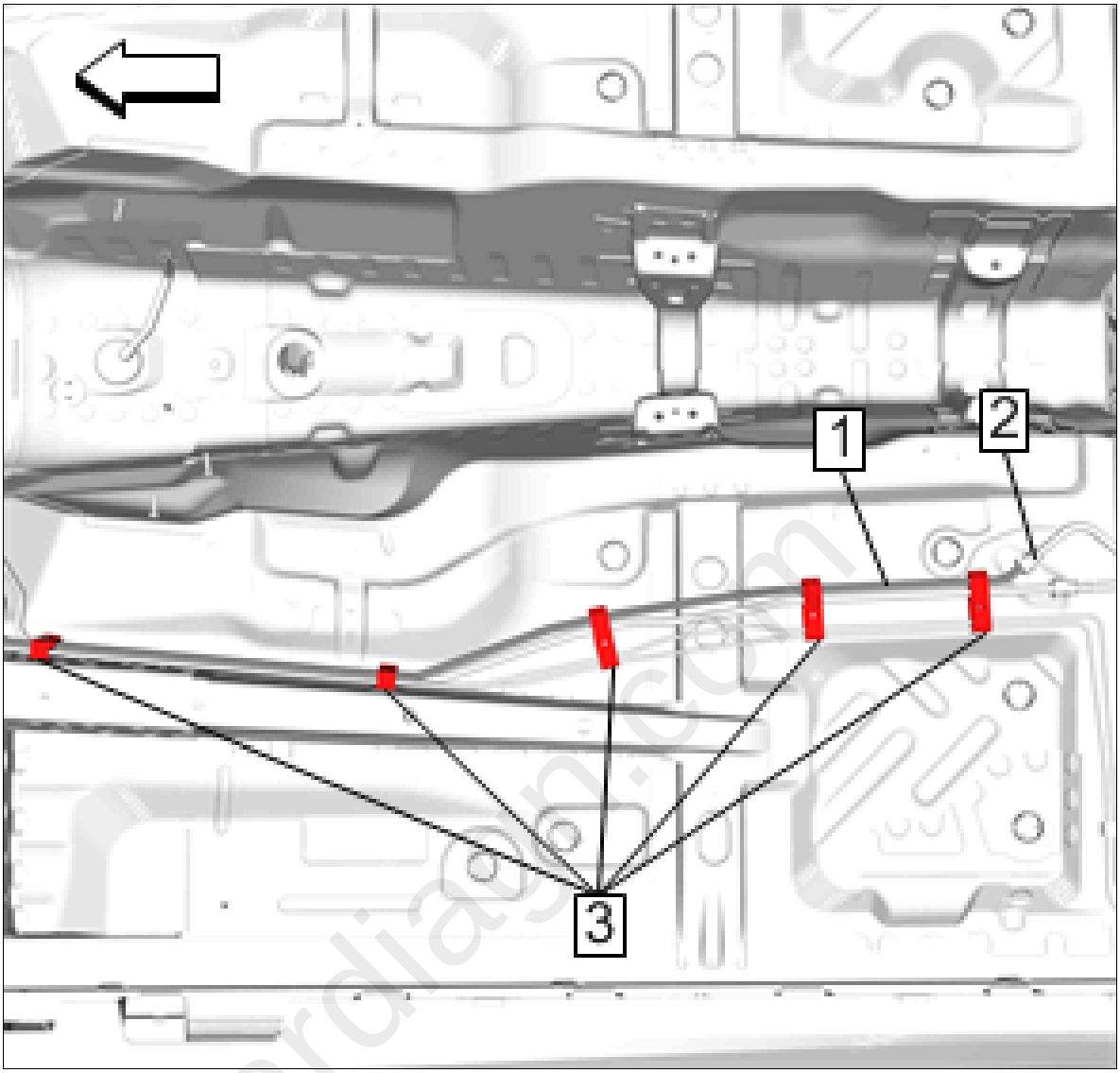


Courtesy of GENERAL MOTORS COMPANY

8. Disconnect Evaporative Emission Pipe (1) at Fuel Tank Vent Valve Hose (2) - Plastic Collar Quick Connect Fitting Service
9. Remove Evaporative Emission Pipe (1) at Retainer (3) (Qty: 5)

REPAIR INSTRUCTIONS > EVAPORATIVE EMISSION LINE REPLACEMENT - ENGINE TO CHASSIS > INSTALLATION PROCEDURE

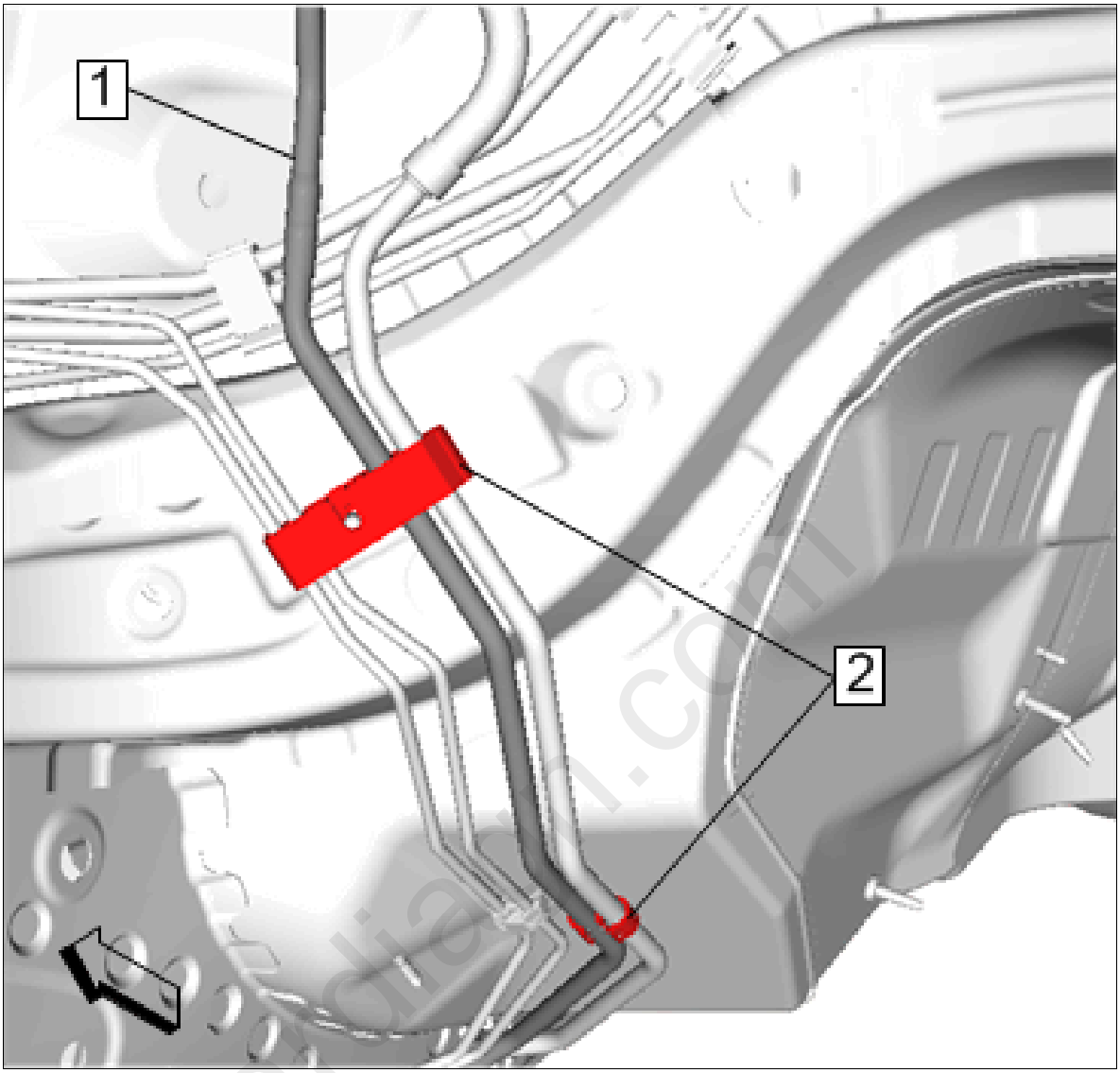
Fig 1: Evaporative Emission Pipe



Courtesy of GENERAL MOTORS COMPANY

1. Install Evaporative Emission Pipe (1) at Retainer (3) (Qty: 5)
2. Connect Evaporative Emission Pipe (1) at Fuel Tank Vent Valve Hose (2) - Plastic Collar Quick Connect Fitting Service

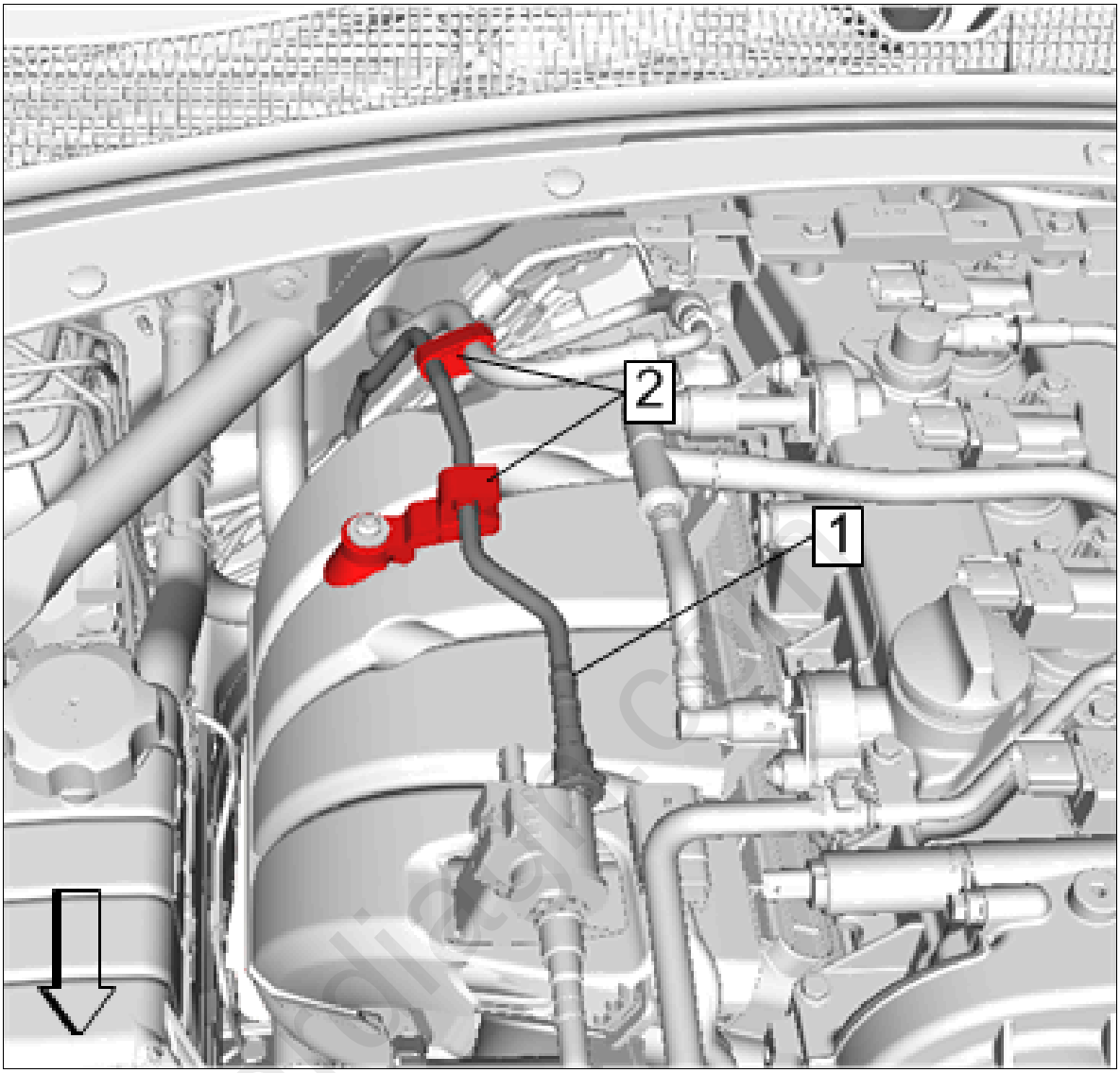
Fig 2: Evaporative Emission Pipe



Courtesy of GENERAL MOTORS COMPANY

3. Install Evaporative Emission Pipe (1) at Retainer (2) (Qty: 2)
4. Install Front Body Exhaust Heat Shield Replacement (Right)Front Body Exhaust Heat Shield Replacement (Left)
5. Install Underbody Front Air Deflector Replacement - Right Side
6. Lower the vehicle.

Fig 3: Evaporative Emission Pipe



Courtesy of GENERAL MOTORS COMPANY

7. Install Evaporative Emission Pipe (1) at Retainer (2) (Qty: 2)
8. Disconnect Evaporative Emission Pipe (1) at Evaporative Emission Canister Purge Solenoid Valve - Plastic Collar Quick Connect Fitting Service
9. Install Intake Manifold Cover Replacement

REPAIR INSTRUCTIONS > EVAPORATIVE EMISSION CANISTER HOSE REPLACEMENT > REMOVAL PROCEDURE

WARNING:

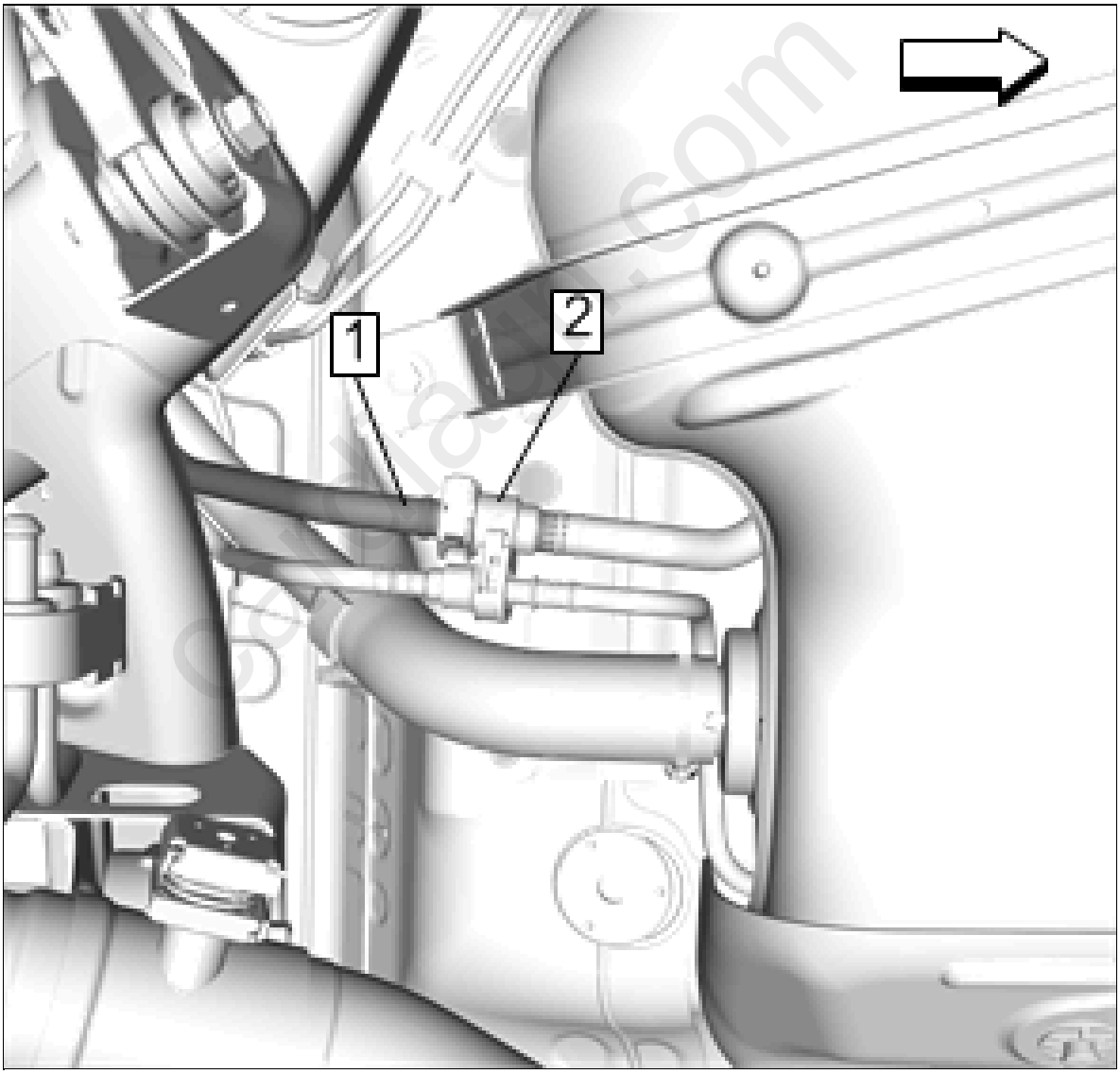
Refer to Gasoline/Gasoline Vapors Warning .

WARNING:

Refer to Safety Glasses Warning .

1. Raise and support the vehicle. Lifting and Jacking the Vehicle (Base)Lifting and Jacking the Vehicle (HP)

   Fig 1: Evaporative Emission Canister Hose

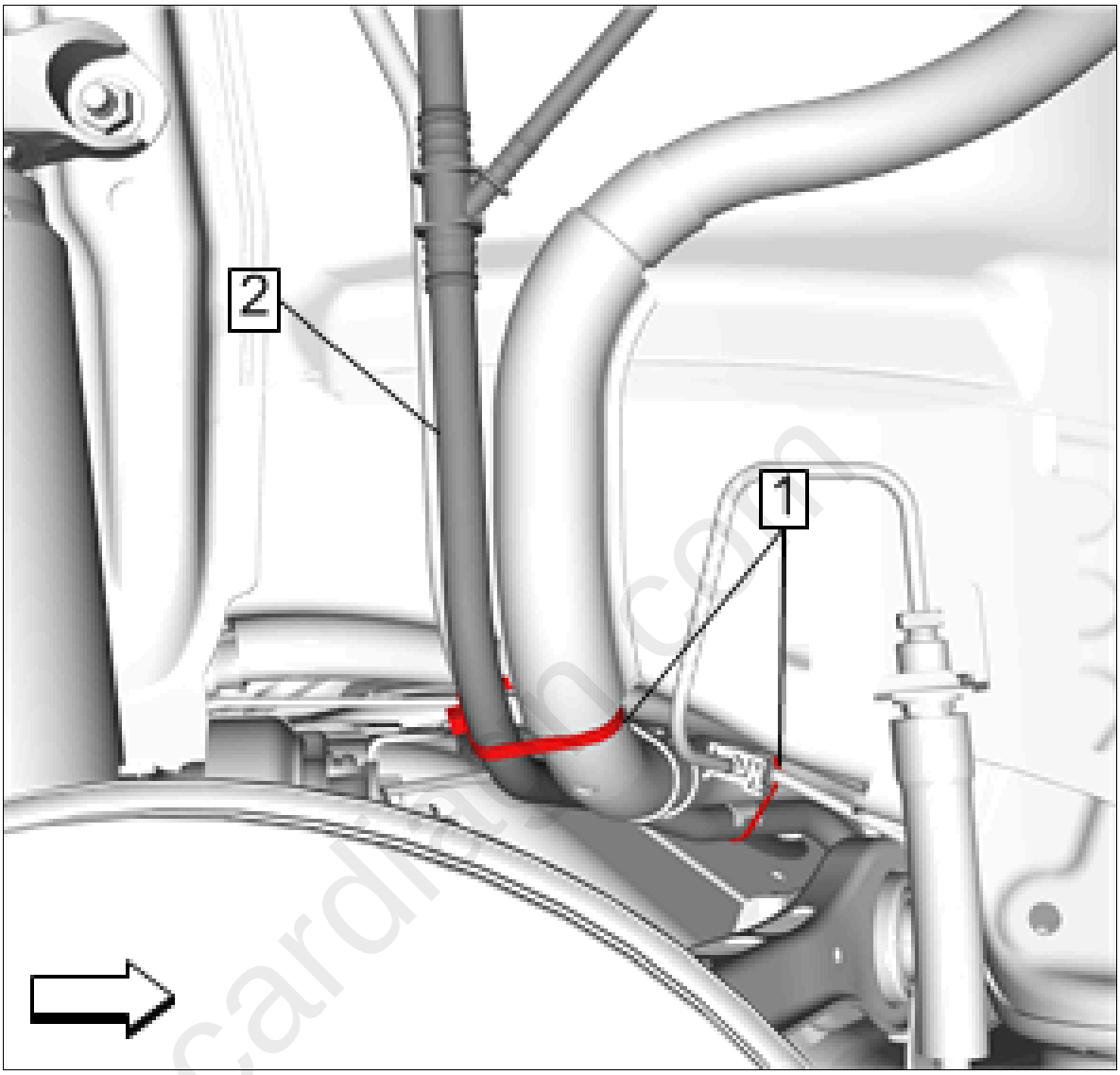


Courtesy of GENERAL MOTORS COMPANY

2. Disconnect Evaporative Emission Canister Hose (1) at Fuel Tank Vent Valve Hose (2) - Plastic Collar Quick Connect Fitting Service

3. Remove Rear Wheelhouse Liner Replacement
4. Remove Fuel Tank Pressure Sensor Replacement

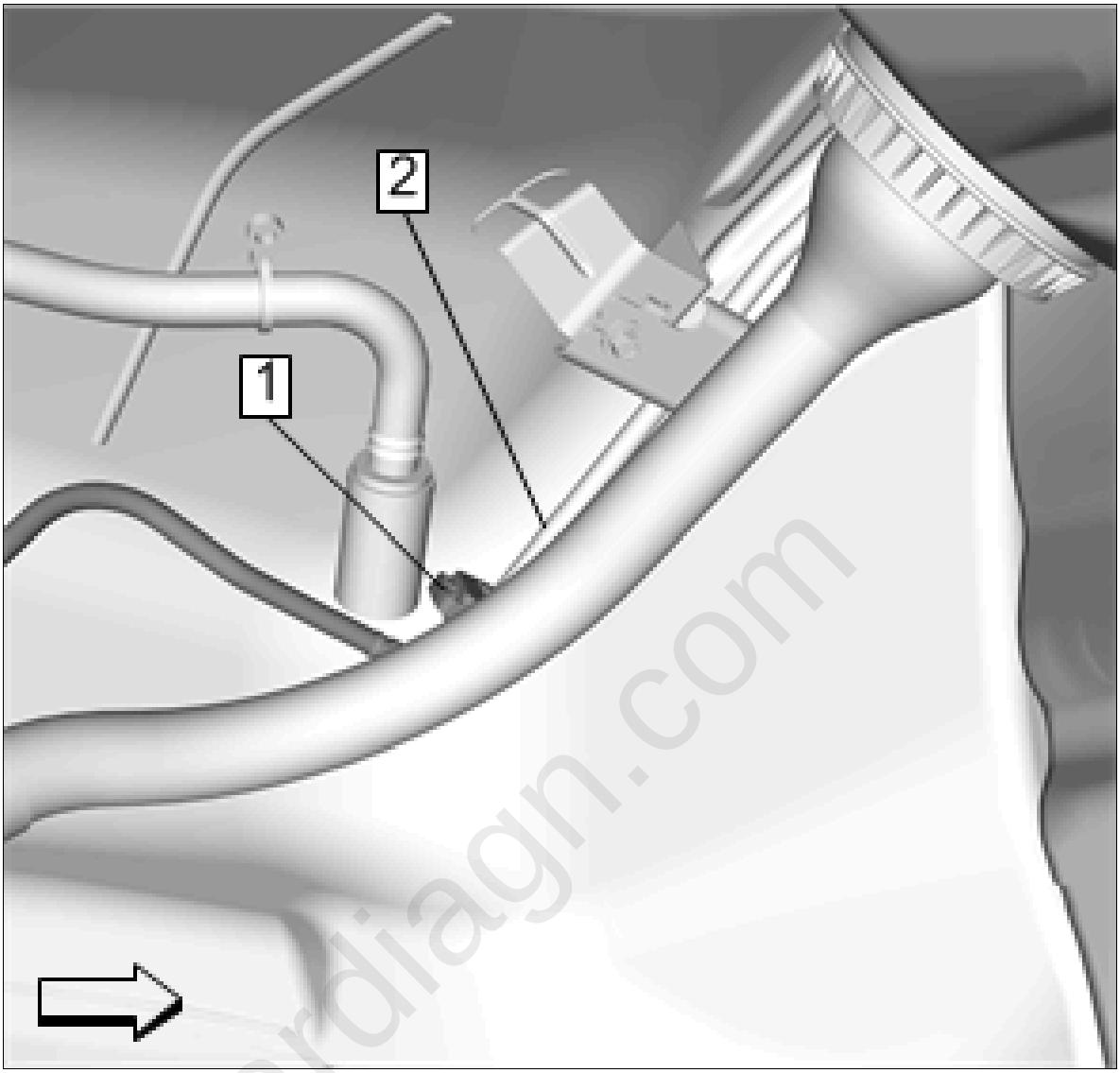
Fig 2: Tie Strap



Courtesy of GENERAL MOTORS COMPANY

5. Remove Tie Strap (1) at Evaporative Emission Canister Hose (2) (Qty: 2) and DISCARD

Fig 3: Evaporative Emission Canister Hose

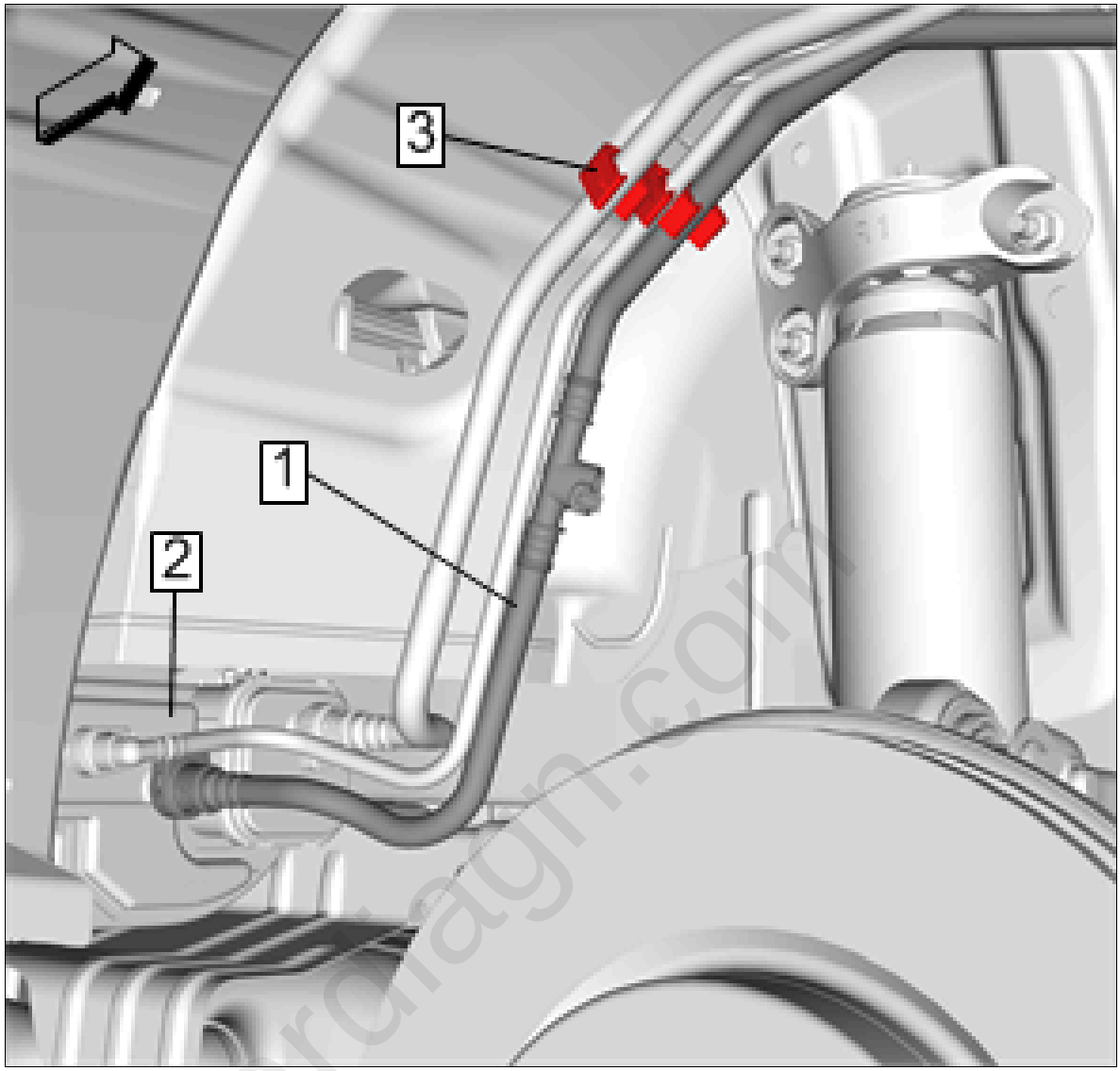


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

6. Disconnect Evaporative Emission Canister Hose (1) at Fuel Tank Filler Pipe (2) - Plastic Collar Quick Connect Fitting Service

Fig 4: Evaporative Emission Canister Hose

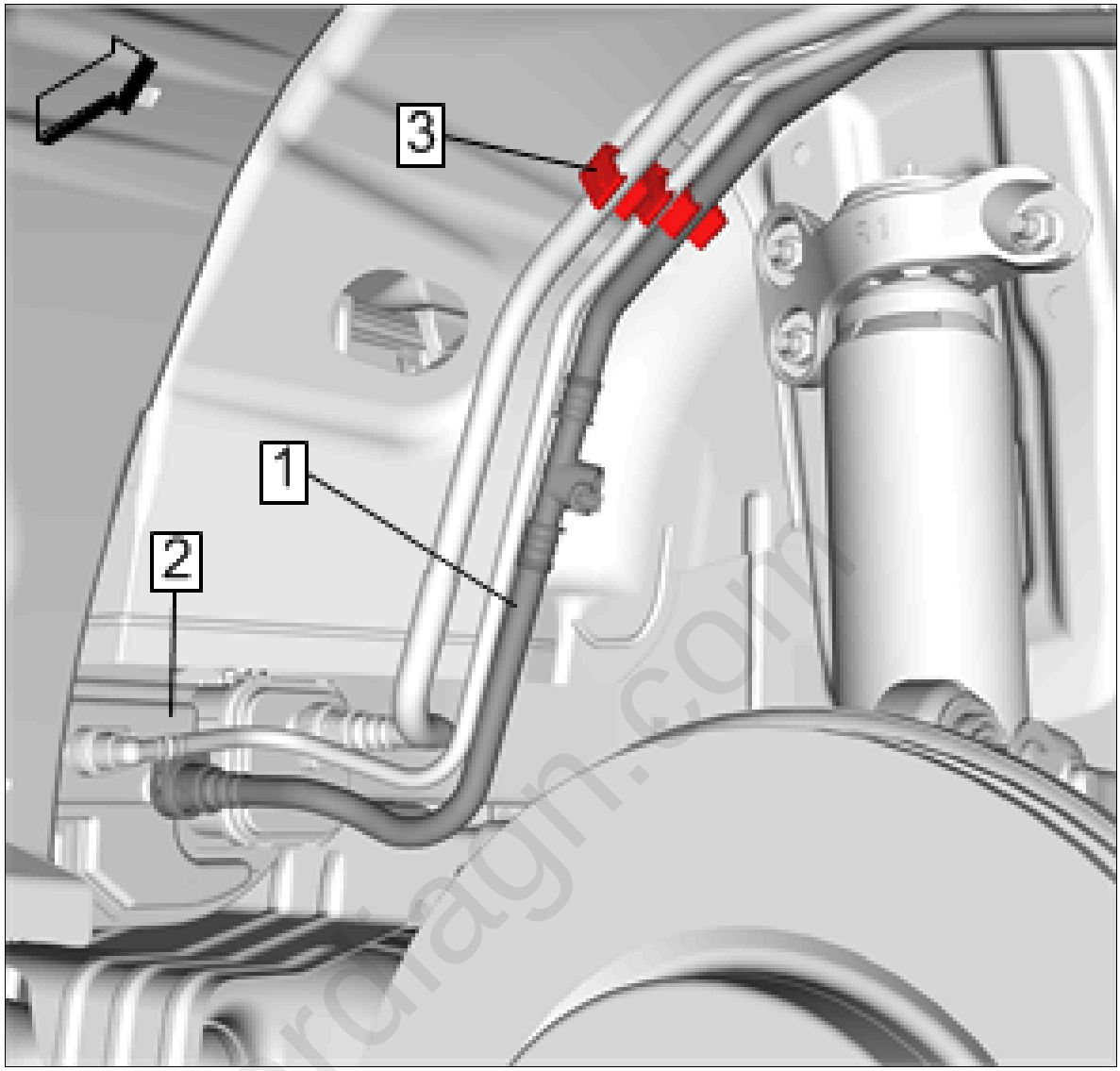


Courtesy of GENERAL MOTORS COMPANY

7. Disconnect Evaporative Emission Canister Hose (1) at Evaporative Emission Canister (2) - Plastic Collar Quick Connect Fitting Service
8. Remove Evaporative Emission Canister Hose (1) at Retainer (3)

REPAIR INSTRUCTIONS > EVAPORATIVE EMISSION CANISTER HOSE REPLACEMENT > INSTALLATION PROCEDURE

Fig 1: Evaporative Emission Canister Hose

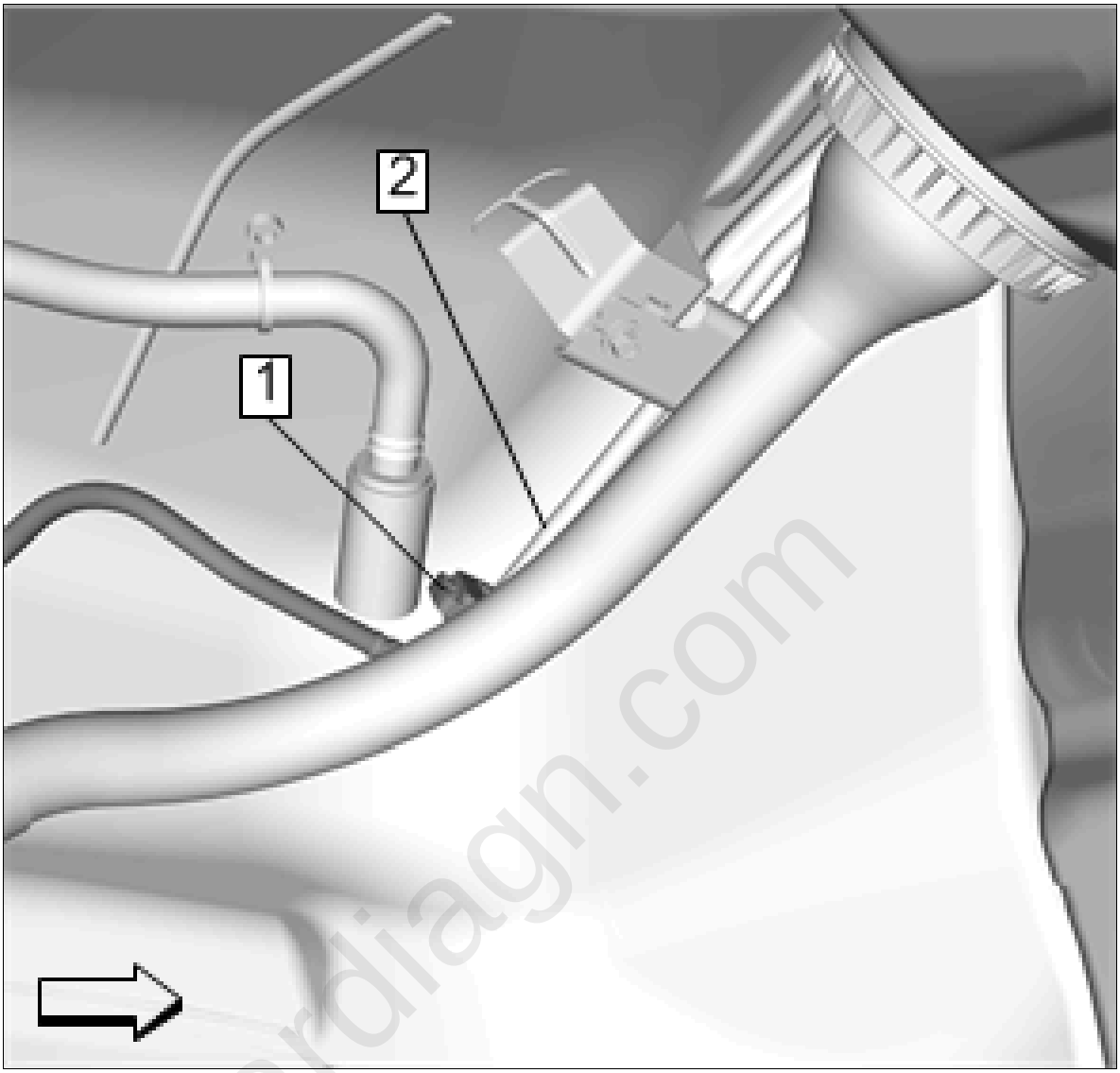


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

1. Install Evaporative Emission Canister Hose (1) at Retainer (3)
2. Connect Evaporative Emission Canister Hose (1) at Evaporative Emission Canister (2) - Plastic Collar Quick Connect Fitting Service

Fig 2: Evaporative Emission Canister Hose

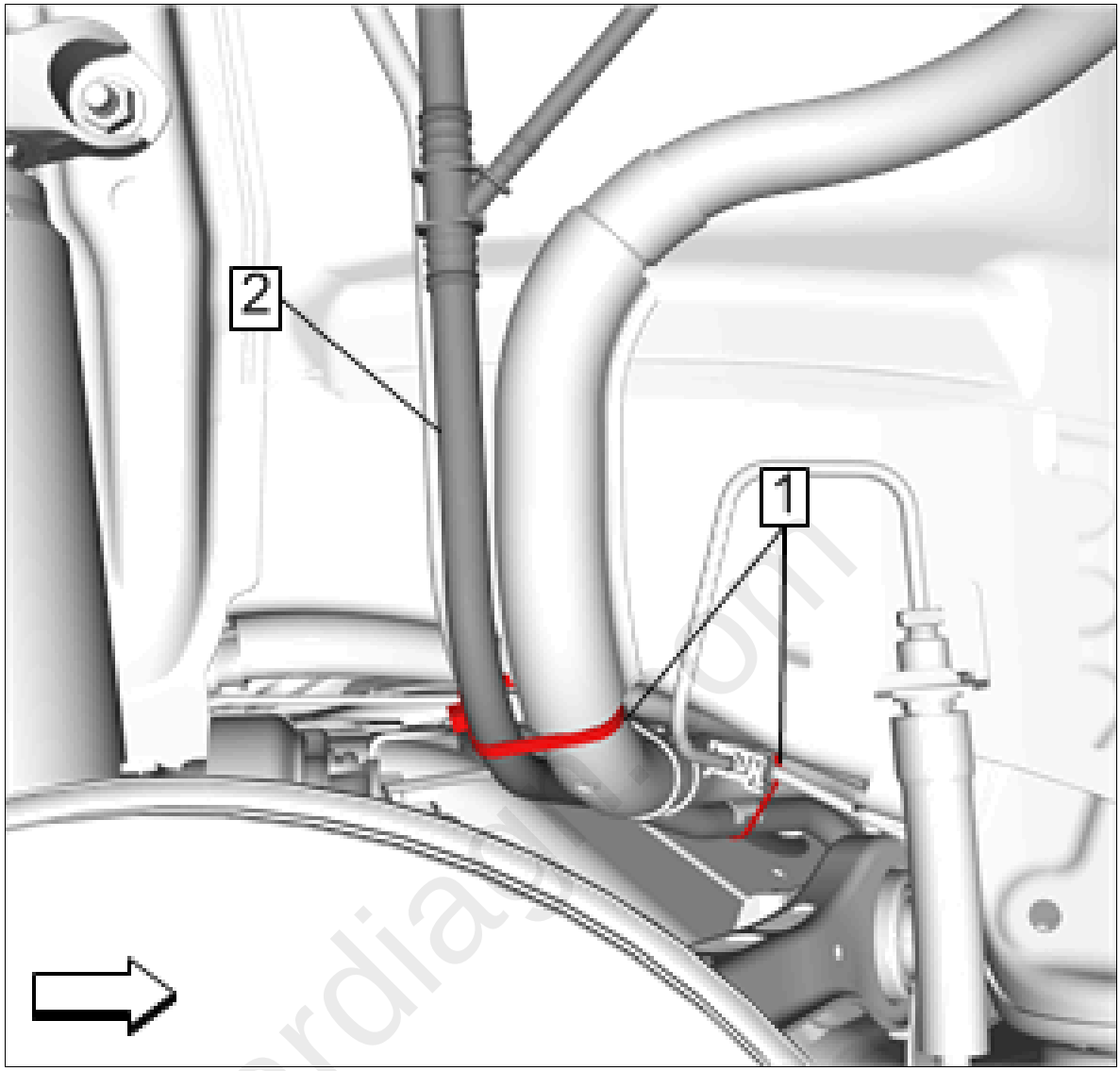


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

3. Connect Evaporative Emission Canister Hose (1) at Fuel Tank Filler Pipe (2) - Plastic Collar Quick Connect Fitting Service

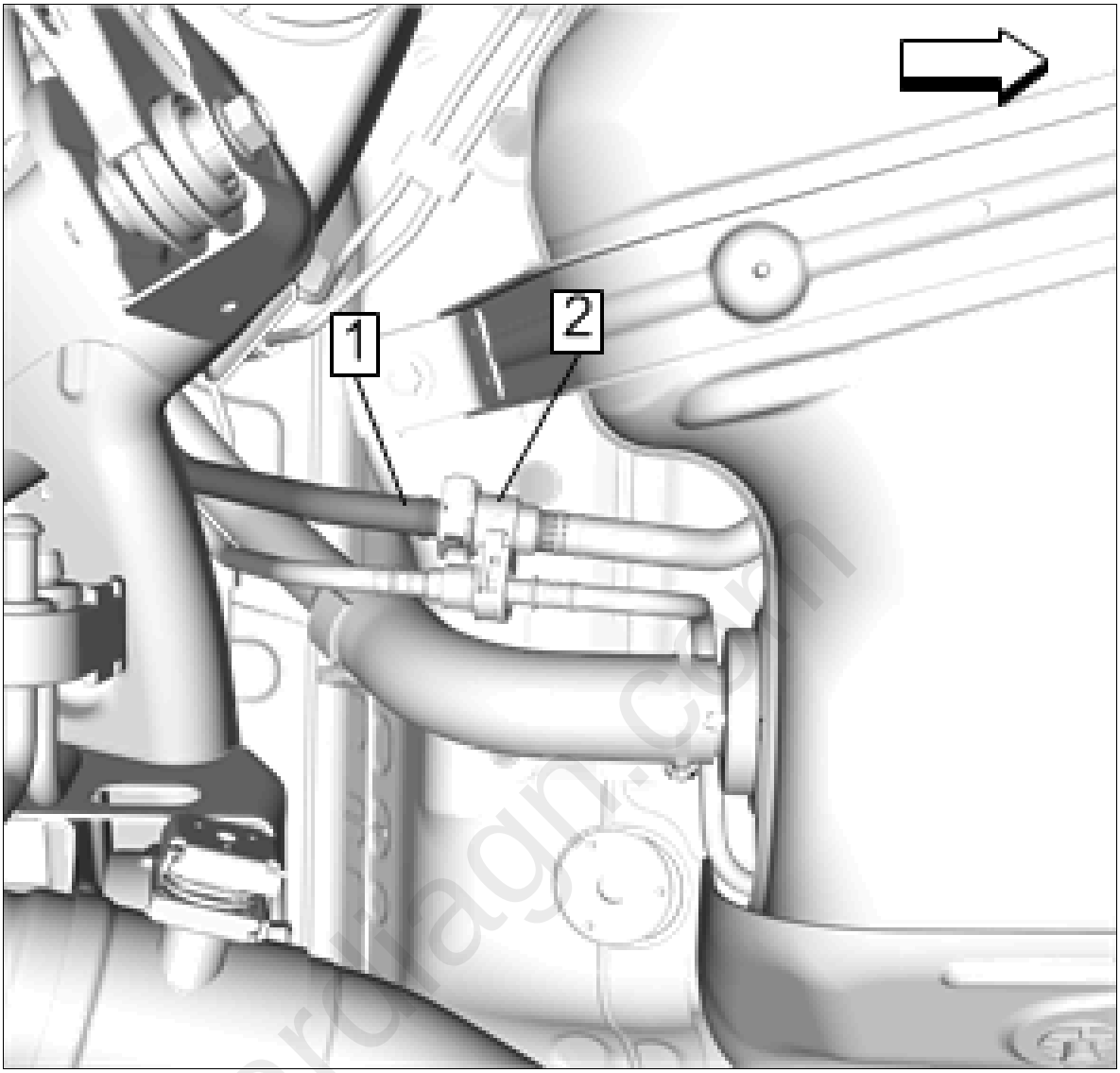
Fig 3: Tie Strap



Courtesy of GENERAL MOTORS COMPANY

4. Install NEW Tie Strap (1) (Qty: 2) at Evaporative Emission Canister Hose (2)
5. Install Fuel Tank Pressure Sensor Replacement
6. Install Rear Wheelhouse Liner Replacement

Fig 4: Evaporative Emission Canister Hose

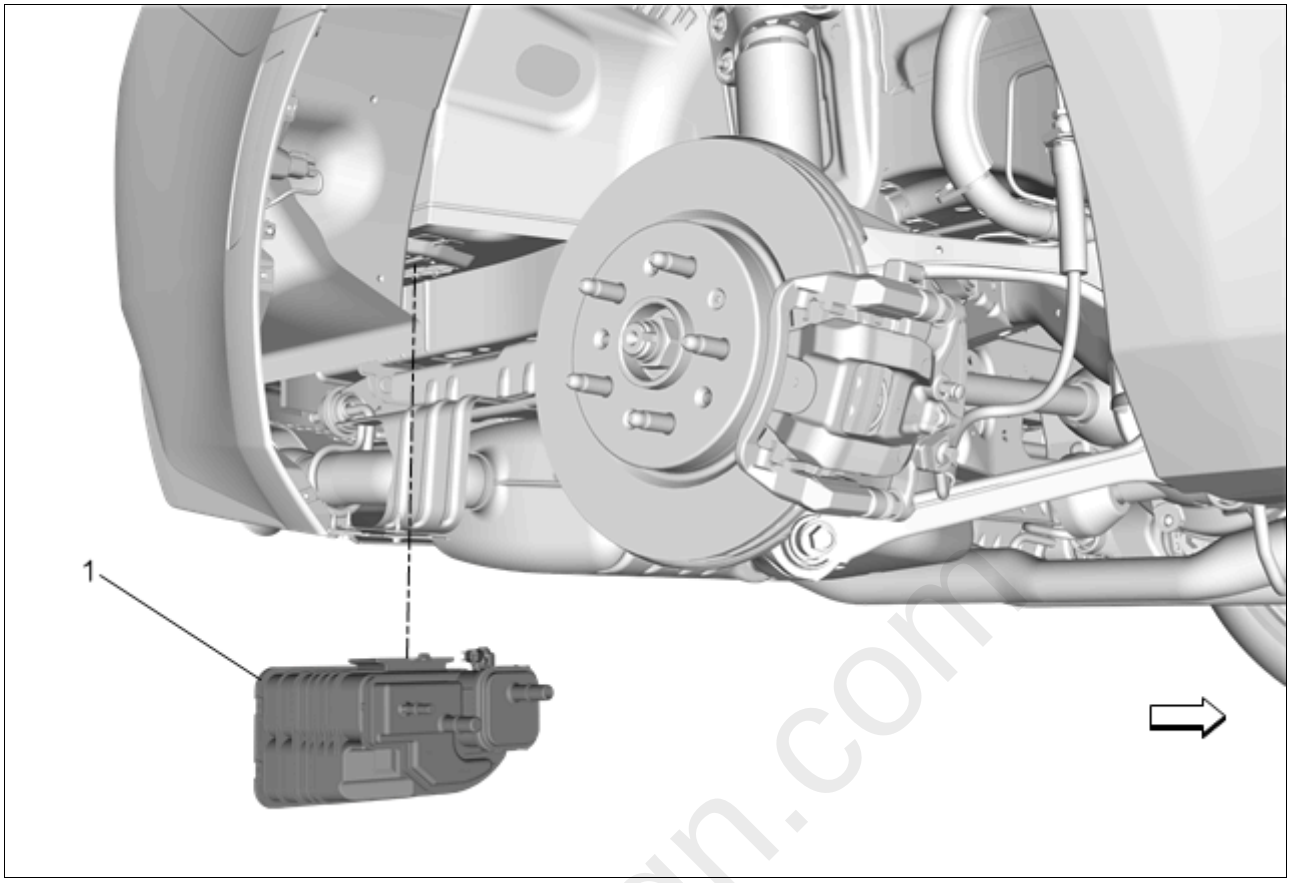


Courtesy of GENERAL MOTORS COMPANY

7. Connect Evaporative Emission Canister Hose (1) at Fuel Tank Vent Valve Hose (2) Connect - Plastic Collar Quick Connect Fitting Service
8. Lower the vehicle.

REPAIR INSTRUCTIONS > EVAPORATIVE EMISSION CANISTER REPLACEMENT

Fig 1: Evaporative Emission Canister



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Rear Wheelhouse Liner Replacement 2. Evaporative Emission Canister Purge Hose Replacement 3. Evaporative Emission Canister Hose Replacement 4. Evaporative Emission Canister Filter Hose Replacement	
1	Evaporative Emission Canister Procedure 1. Disconnect the electrical connector. 2. Depress retaining tab to release evaporative emission canister.

REPAIR INSTRUCTIONS > EVAPORATIVE EMISSION SYSTEM CLEANING

Special Tools

GE 41413-200 Evaporative Pressure and Purge Station

For equivalent regional tools, refer to Special Tools (Diagnostic Tools)Special Tools (Mechanical Tools) .

REPAIR INSTRUCTIONS > EVAPORATIVE EMISSION SYSTEM CLEANING > INSPECTION PROCEDURE

> *CAUTION:*
>
> *Use the Evaporative Emission (EVAP) System Tester **GE 41413-A** in order to provide a clean, dry, low pressure nitrogen gas source. Do not substitute any other pressurized source, gas or otherwise. Damage may result to the EVAP system, test equipment or cause a safety risk.*

> *NOTE:*
>
> *Proceed with the following procedure only if referenced by an evaporative emission (EVAP) diagnostic or repair procedure.*

1. Turn OFF the ignition.
2. Remove the EVAP canister purge valve. Evaporative Emission Canister Purge Solenoid Valve Replacement .
3. Lightly tap the EVAP canister purge valve on a hard surface.
4. Inspect for carbon particles exiting either of the vacuum ports.
    1. If no carbon particles were detected, but a blockage was detected during a diagnostic procedure, install the original EVAP canister purge valve. Continue with the cleaning procedure.
    2. If carbon particles are found during the inspection procedure, continue with the cleaning procedure.
    3. If a diagnostic procedure directed you to replace the EVAP canister purge valve and no carbon particles were detected, replace the EVAP canister purge valve. Return to the published service procedure.

REPAIR INSTRUCTIONS > EVAPORATIVE EMISSION SYSTEM CLEANING > CLEANING PROCEDURE

1. Raise and support the vehicle. Lifting and Jacking the Vehicle (Base)Lifting and Jacking the Vehicle (HP) .

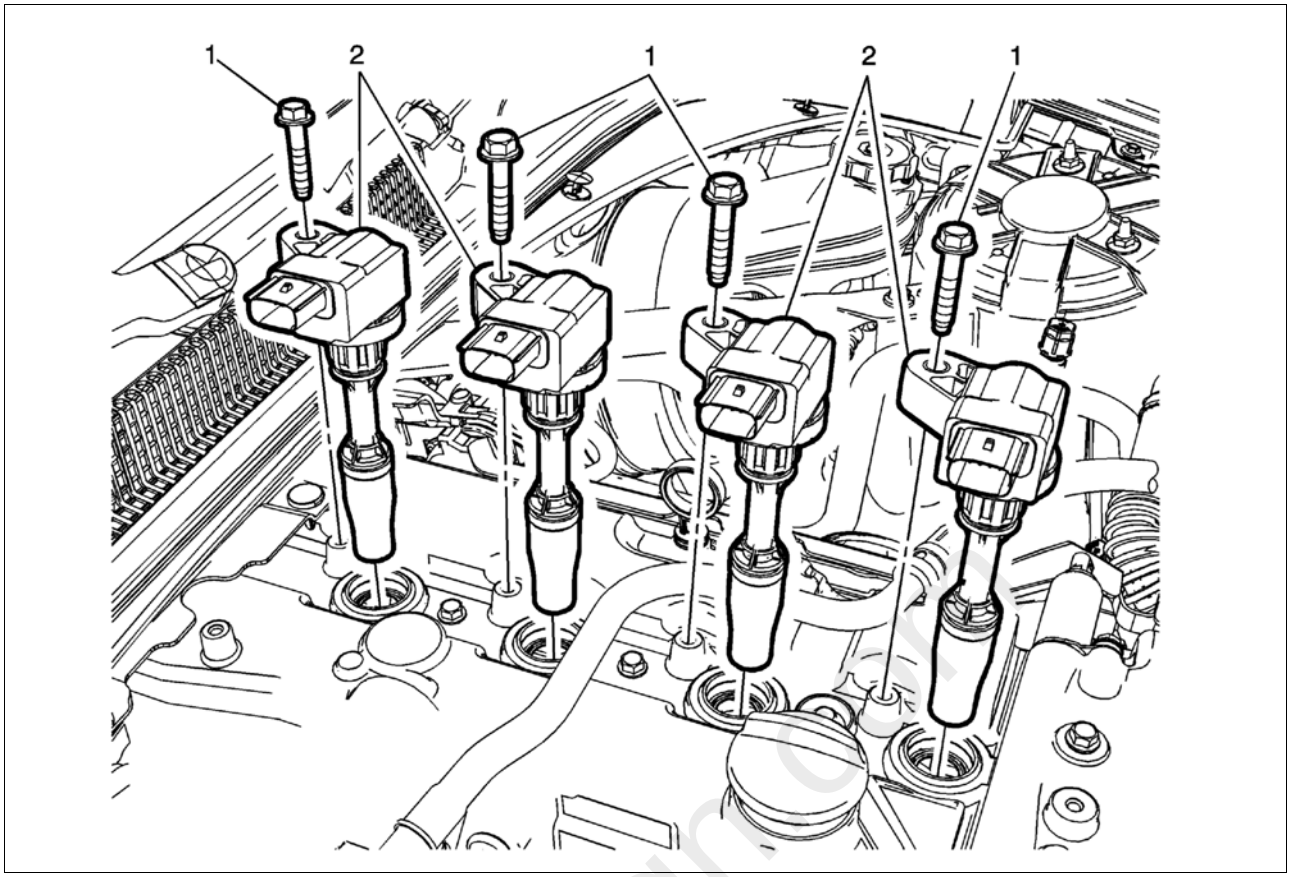
cardiagn.com

2. Remove the EVAP canister. Evaporative Emission Canister Replacement .
3. Turn OFF the main valve on the **GE 41413-200** station.
4. Disconnect the hose from the diagnostic station pressure regulator.
5. Using a section of vacuum hose, connect one end onto the EVAP pressure/purge diagnostic station pressure regulator.
6. Connect the other end of the vacuum hose to the canister side of the purge pipe.
7. Turn ON the main nitrogen cylinder valve and continue to discharge nitrogen for 15 seconds.
8. If the nitrogen does not clear the blockage, replace the purge pipe.
9. Return the EVAP pressure/purge diagnostic station to the stations original condition.
10. Install a new EVAP canister. Evaporative Emission Canister Replacement .
11. Lower the vehicle.
12. Install a new EVAP canister purge valve. Evaporative Emission Canister Purge Solenoid Valve Replacement .
13. Return to the diagnostic table that sent you here.

REPAIR INSTRUCTIONS > IGNITION COIL REPLACEMENT

cardiagn.com

Fig 1: Ignition Coil



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure 1. Remove the intake manifold cover. Refer to Intake Manifold Cover Replacement . 2. If replacing the number 4 ignition coil, remove the upper intake manifold bracket. Refer to Upper Intake Manifold Bracket Replacement .	
1	Ignition Coil Fasteners (Qty: 4) *CAUTION:* *Refer to Fastener Caution .* **Tighten** 10 N.m (89 lb in)
2	Ignition Coils

cardiagn.com

NOTE:

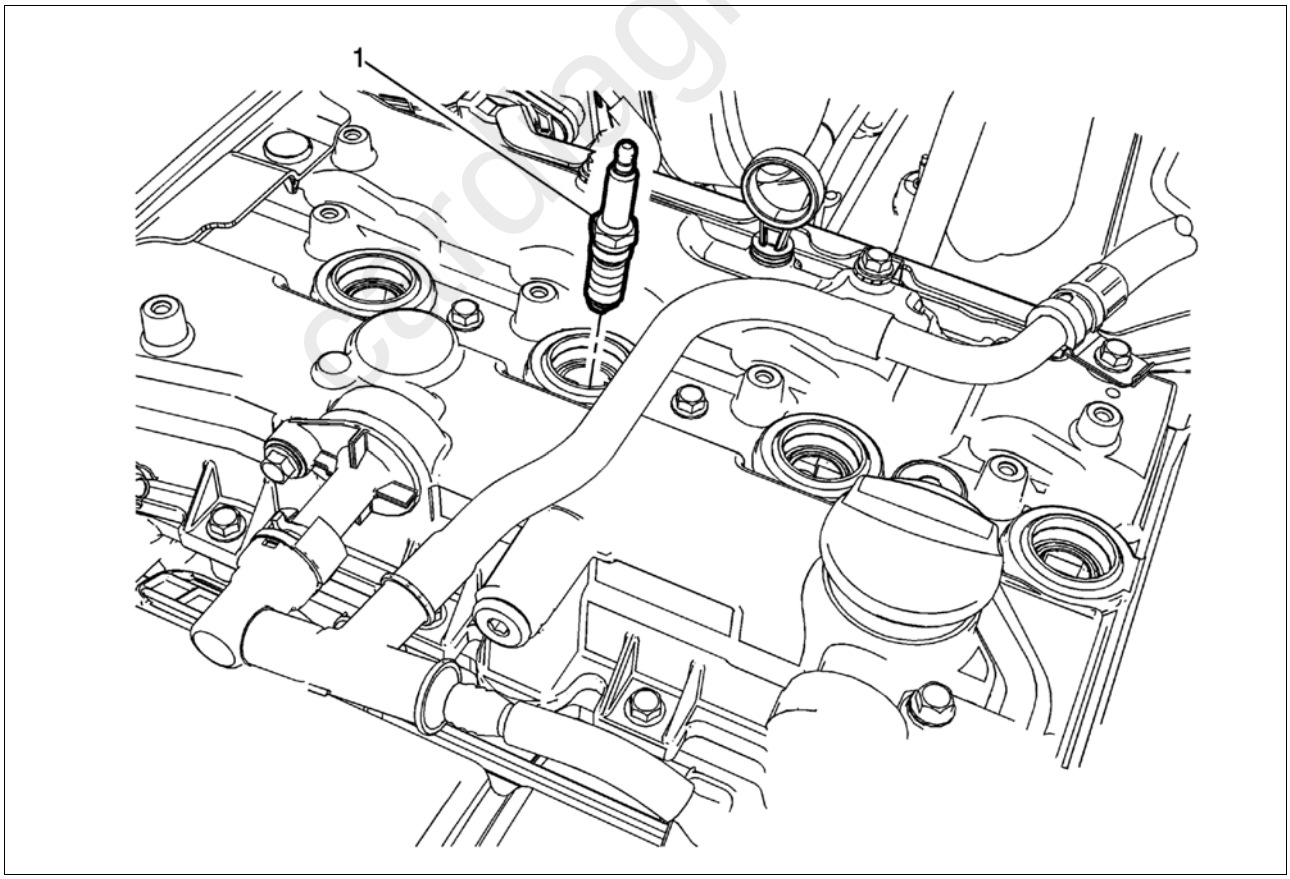
Inspect the inside of the ignition coil rubber boot for a thin, even coat of grease. If there is no grease present or additional grease is necessary, complete the following procedure.

Procedure

1. Disconnect the electrical wiring harness connectors from the ignition coils and remove coils as necessary.
2. Apply a thin coating of dielectric grease to the inside of the ignition coil rubber boot, up to a depth of 15 mm from the end of the boot. Refer to Adhesives, Fluids, Lubricants, and Sealers .
3. Remove any excess grease from around the end of the boot, and ensure there is not an excessive amount within the boot.

REPAIR INSTRUCTIONS > SPARK PLUG REPLACEMENT

Fig 1: Spark Plug



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
	CAUTION: *This engine has aluminum cylinder heads. Do not remove the spark plugs from a hot engine, allow it to cool first. Removing the spark plugs from a hot engine may cause spark plug thread damage or cylinder head damage.* **Preliminary Procedure** Remove the ignition coils. Refer to Ignition Coil Replacement .
1	Spark Plugs (Qty: 4) *CAUTION:* *Refer to Component Fastener Tightening Caution .* **Procedure** If reusing spark plugs, Refer to Spark Plug Inspection . *NOTE:* *If using new spark plugs, do not attempt to check gap. Plugs come pre-gapped.* **Tighten** 20 N.m (15 lb ft)

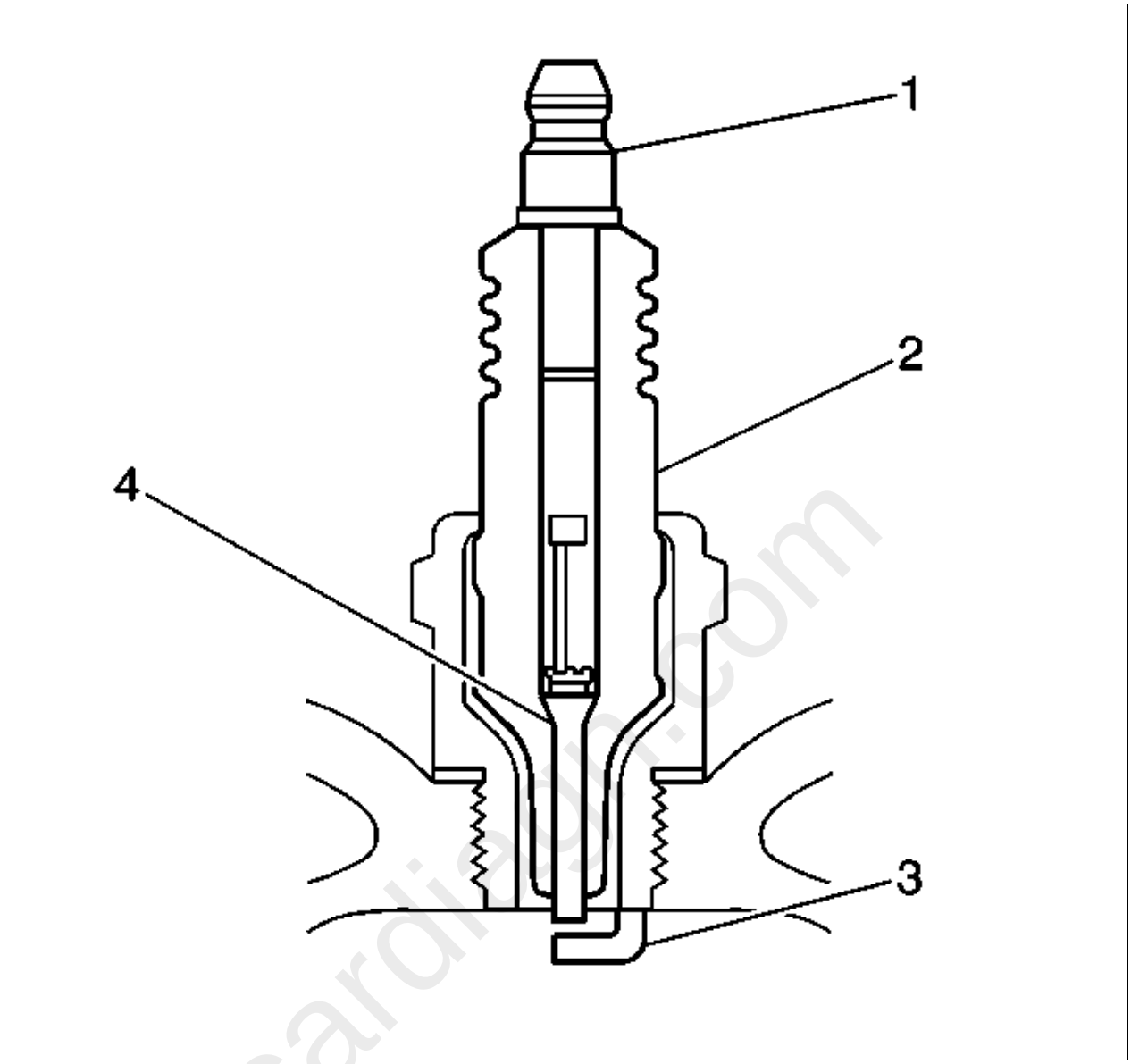
cardiagn.com

REPAIR INSTRUCTIONS > SPARK PLUG INSPECTION > SPARK PLUG USAGE

Ensure that the correct spark plug is installed. An incorrect spark plug causes driveability conditions. Refer to the Electronic Parts Catalog.

REPAIR INSTRUCTIONS > SPARK PLUG INSPECTION > SPARK PLUG INSPECTION

Fig 1: Cross Sectional Spark Plug



Courtesy of GENERAL MOTORS COMPANY

- Inspect the terminal post (1) for damage.
    - Inspect for a bent or broken terminal post (1).
    - Test for a loose terminal post (1) by twisting and pulling the post. The terminal post (1) should NOT move.
- Inspect the insulator (2) for flashover or carbon tracking, soot. This condition is often mistakenly identified as a cracked insulator. This is caused by the electrical charge traveling across the insulator (2) between the terminal post (1) and ground. Inspect for the following conditions:
    - Inspect the spark plug boot for damage.
    - Inspect the spark plug recess area of the cylinder head for moisture, such as oil, coolant, or water. A spark plug boot that is saturated causes arcing to ground.

- Inspect the insulator (2) for cracks. All or part of the electrical charge may arc through the crack instead of the electrodes (3, 4).
- Inspect for evidence of improper arcing.
    - Measure the gap between the center electrode (4) and the side electrode (3) terminals. This must be done carefully in order to avoid damaging the small diameter Iridium center electrode. Refer to Ignition System Specifications . An excessively wide electrode gap can prevent correct spark plug operation.
    - Inspect for the correct spark plug torque. Refer to Ignition System Specifications . Insufficient torque can prevent correct spark plug operation. An over torqued spark plug, causes the insulator (2) to crack.
    - Inspect for signs of tracking that occurred near the insulator tip instead of the center electrode (4).
    - Inspect for a broken or worn side electrode (3).
    - Inspect for a broken, worn, or loose center electrode (4) by shaking the spark plug.
        - A rattling sound indicates internal damage.
        - A loose center electrode (4) reduces the spark intensity.
    - Inspect for bridged electrodes (3, 4). Deposits on the electrodes (3, 4) reduce or eliminates the gap.
    - Inspect for worn or missing platinum pads on the electrodes (3, 4) If equipped.
    - Inspect for excessive fouling.
- Inspect the spark plug recess area of the cylinder head for debris. Dirty or damaged threads can cause the spark plug not to seat correctly during installation.

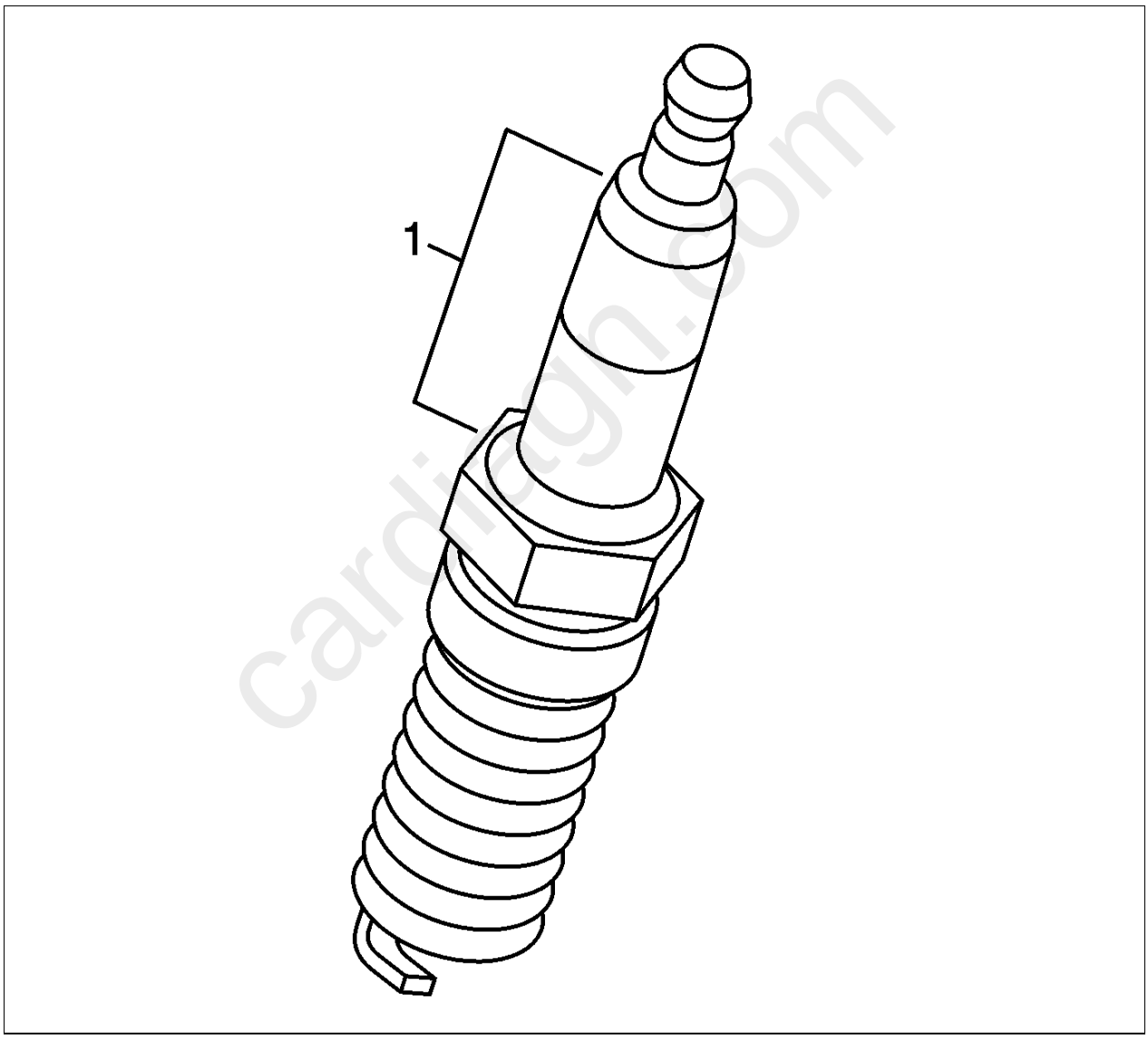
cardiagn.com

REPAIR INSTRUCTIONS > SPARK PLUG INSPECTION > SPARK PLUG VISUAL INSPECTION

- Normal operation-Brown to grayish-tan with small amounts of white powdery deposits are normal combustion by-products from fuels with additives. Reddish orange deposits can indicate MMT fuel additive which is still used in some markets around the world (will cause misfire and cannot be burned off). MMT fuel additive use should be avoided.
- Carbon Fouled-Dry, fluffy black carbon, or soot caused by the following conditions:
    - Rich fuel mixtures
        - Leaking fuel injectors
        - Excessive fuel pressure
        - Restricted air filter element
        - Incorrect combustion

    - Reduced ignition system voltage output
        - Weak coils
        - Worn ignition wires
        - Incorrect spark plug gap
    - Excessive idling or slow speeds under light loads can keep spark plug temperatures so low that normal combustion deposits may not burn off.
- Deposit Fouling-Oil, coolant, or additives that include substances such as silicone, very white coating, reduces the spark intensity. Most powdery deposits will not effect spark intensity unless they form into a glazing over the electrode.

Fig 1: Carbon On Spark Plug Tower



cardiagn.com

Courtesy of GENERAL MOTORS COMPANY

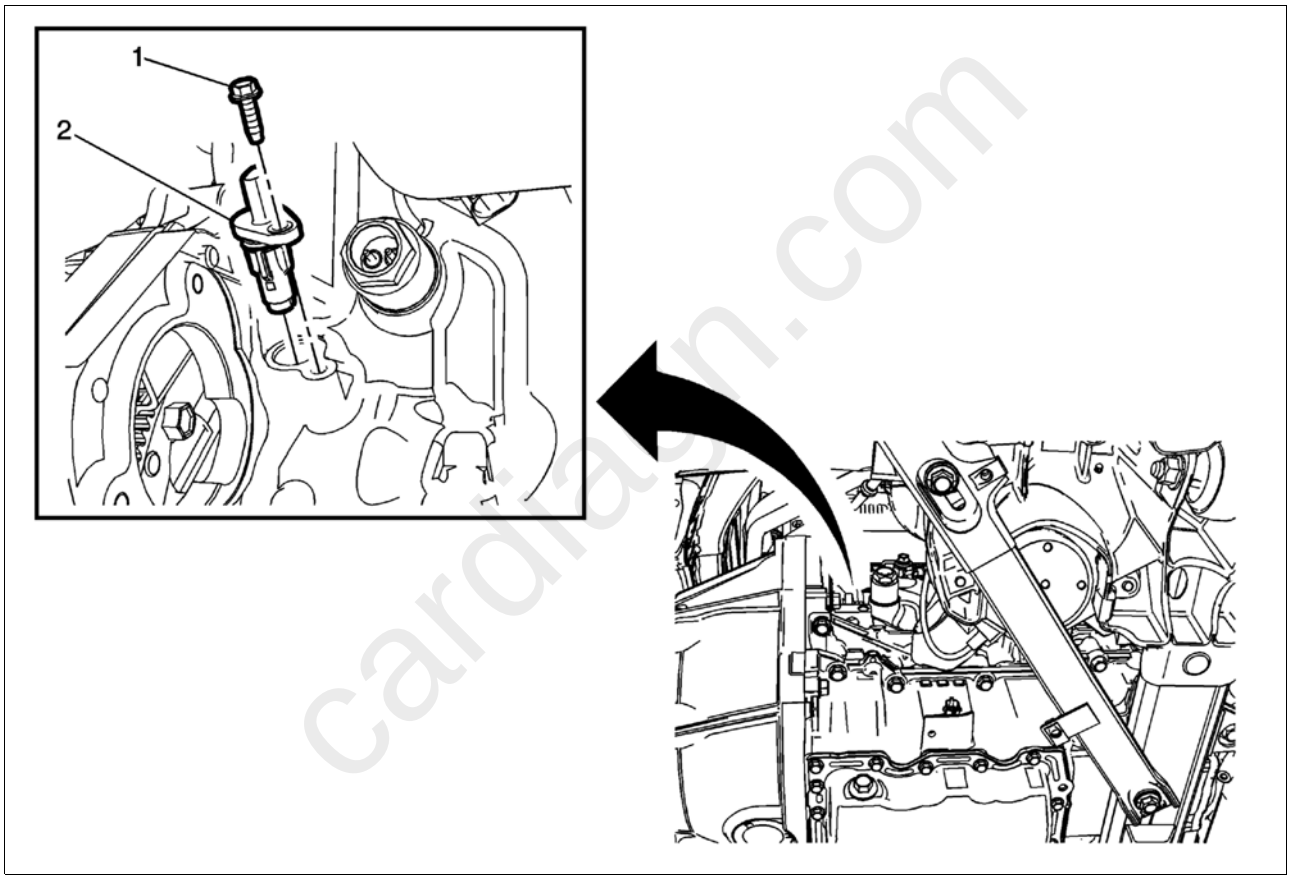
NOTE:

Carbon on spark plug tower means carbon will also be on inside of spark plug wire boot or coil boot and will cause both new spark plug and spark plug wire or coil boot to fail again.

-
- If carbon tracking occurs on spark plug tower (1), replace spark plug and spark plug wire or coil boot.

REPAIR INSTRUCTIONS > CRANKSHAFT POSITION SENSOR REPLACEMENT

Fig 1: Crankshaft Position Sensor



Courtesy of GENERAL MOTORS COMPANY

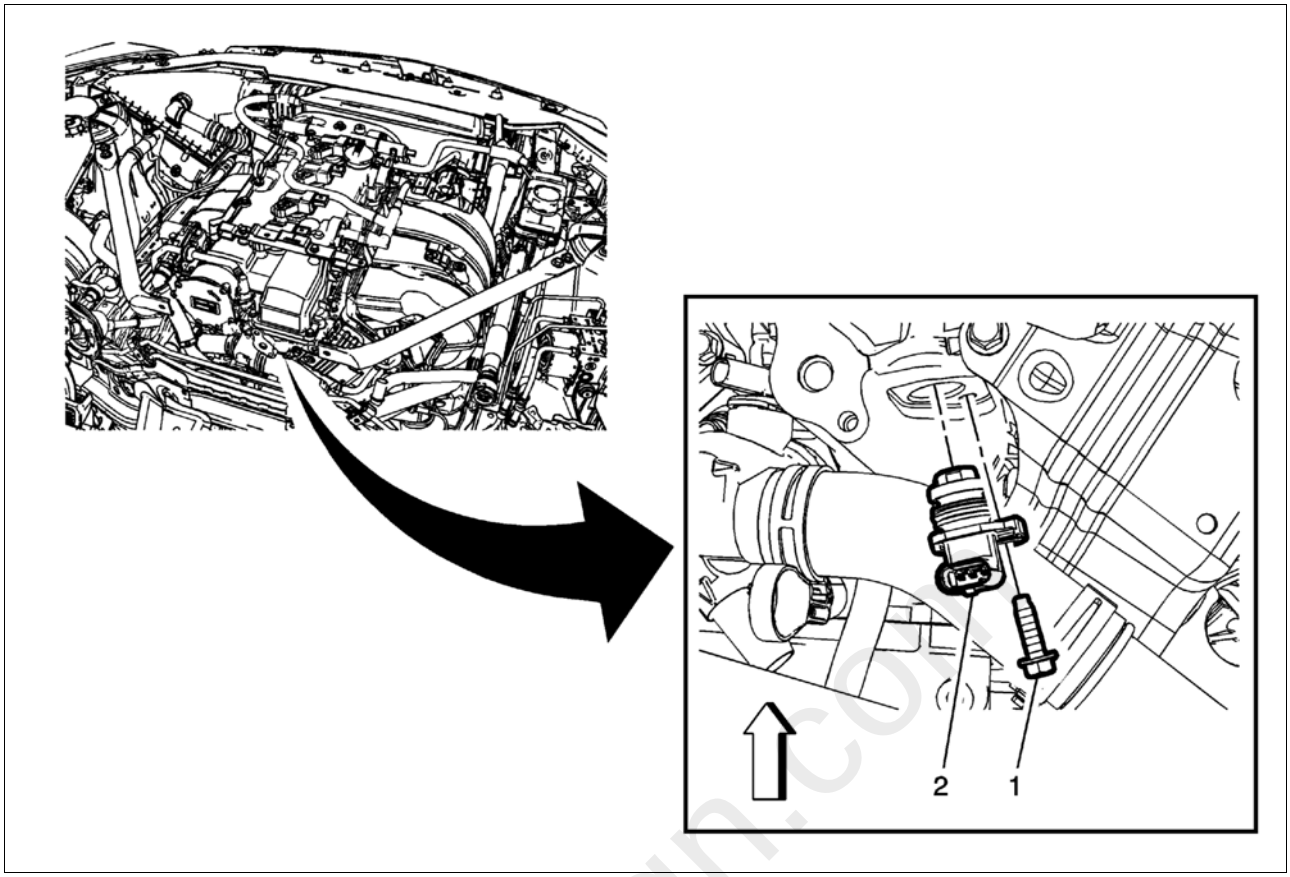
Callout	Component Name
Preliminary Procedure 1. Raise and support the vehicle. Lifting and Jacking the Vehicle (Base)Lifting and Jacking the Vehicle (HP) 2. Front Compartment Lower Noise Shield Replacement (Coupe - LGX, LTG)	

3. Starter Replacement (LTG)	
1	Crankshaft Position Sensor Fastener *CAUTION:* *Refer to Fastener Caution .* **Tighten** 10 N.m (89 lb in)
2	Crankshaft Position Sensor Procedure 1. Disconnect the electrical wiring harness connector from the crankshaft position sensor. 2. If installing a new sensor, perform the crankshaft position system variation learn procedure. Crankshaft Position Variation Learn

REPAIR INSTRUCTIONS > CAMSHAFT POSITION SENSOR REPLACEMENT - INTAKE

cardiagn.com

Fig 1: Camshaft Position Sensor - Intake



Courtesy of GENERAL MOTORS COMPANY

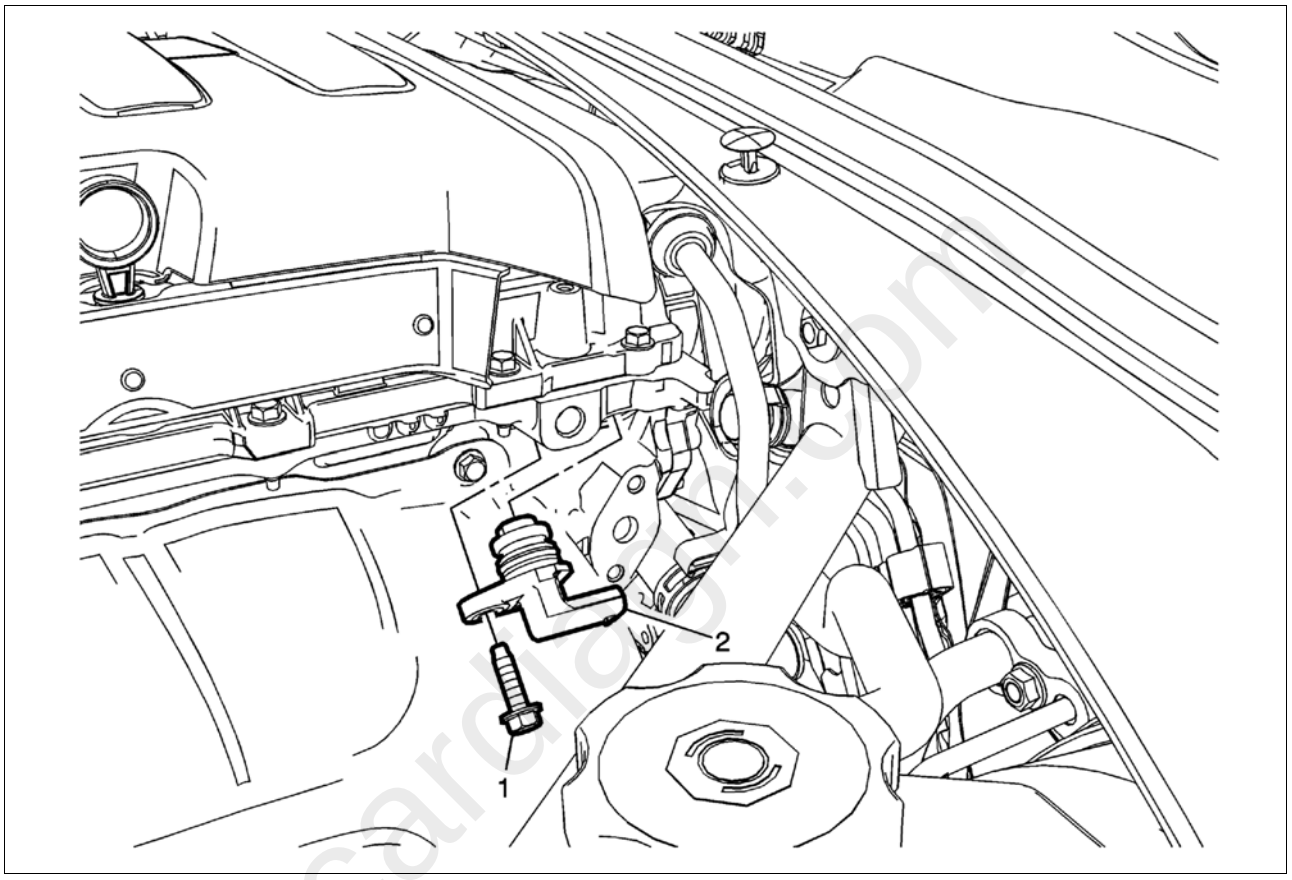
Callout	Component Name
Preliminary Procedure 1. Remove the intake manifold cover. Refer to Intake Manifold Cover Replacement . 2. Remove the plenum front panel. Refer to Plenum Front Panel Replacement . 3. Remove the fuel pump insulator. Refer to Fuel Pump Insulator Replacement (Inner) Fuel Pump Insulator Replacement (Outer) .	
1	Camshaft Position Sensor Fastener *CAUTION:* *Refer to Fastener Caution .* **Tighten** 10 N.m (89 lb in)

cardiagn.com

2	Camshaft Position Sensor **Procedure** Disconnect the electrical wiring harness connector from the camshaft position sensor.

REPAIR INSTRUCTIONS > CAMSHAFT POSITION SENSOR REPLACEMENT - EXHAUST

Fig 1: Camshaft Position Sensor - Exhaust



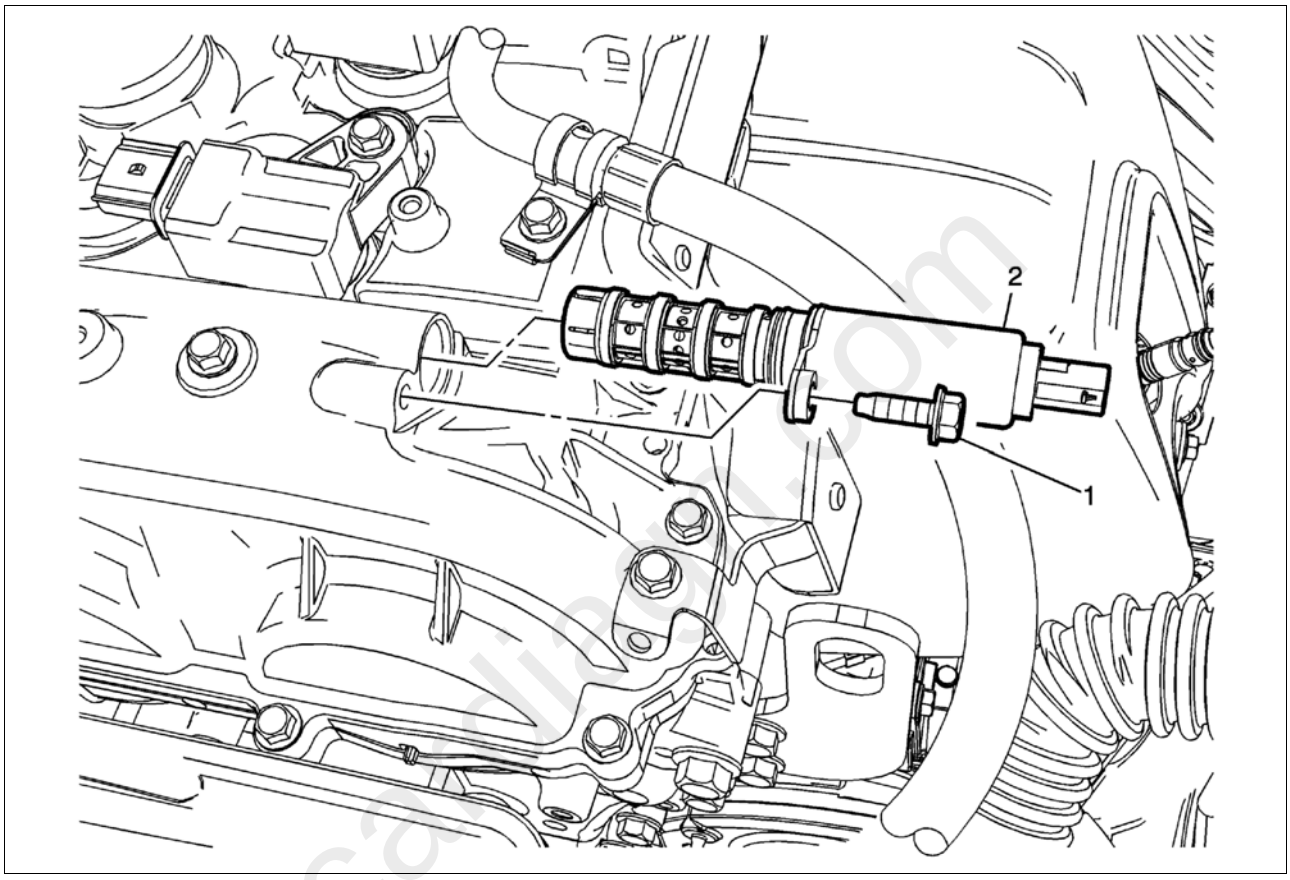
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Position Sensor Fastener *CAUTION:* *Refer to Fastener Caution .* **Tighten** 10 N.m (89 lb in)

2	Camshaft Position Sensor **Procedure** Disconnect the electrical wiring harness connector from the camshaft position sensor.

REPAIR INSTRUCTIONS > CAMSHAFT POSITION ACTUATOR EXHAUST SOLENOID VALVE REPLACEMENT

Fig 1: Camshaft Position Actuator Exhaust Solenoid Valve



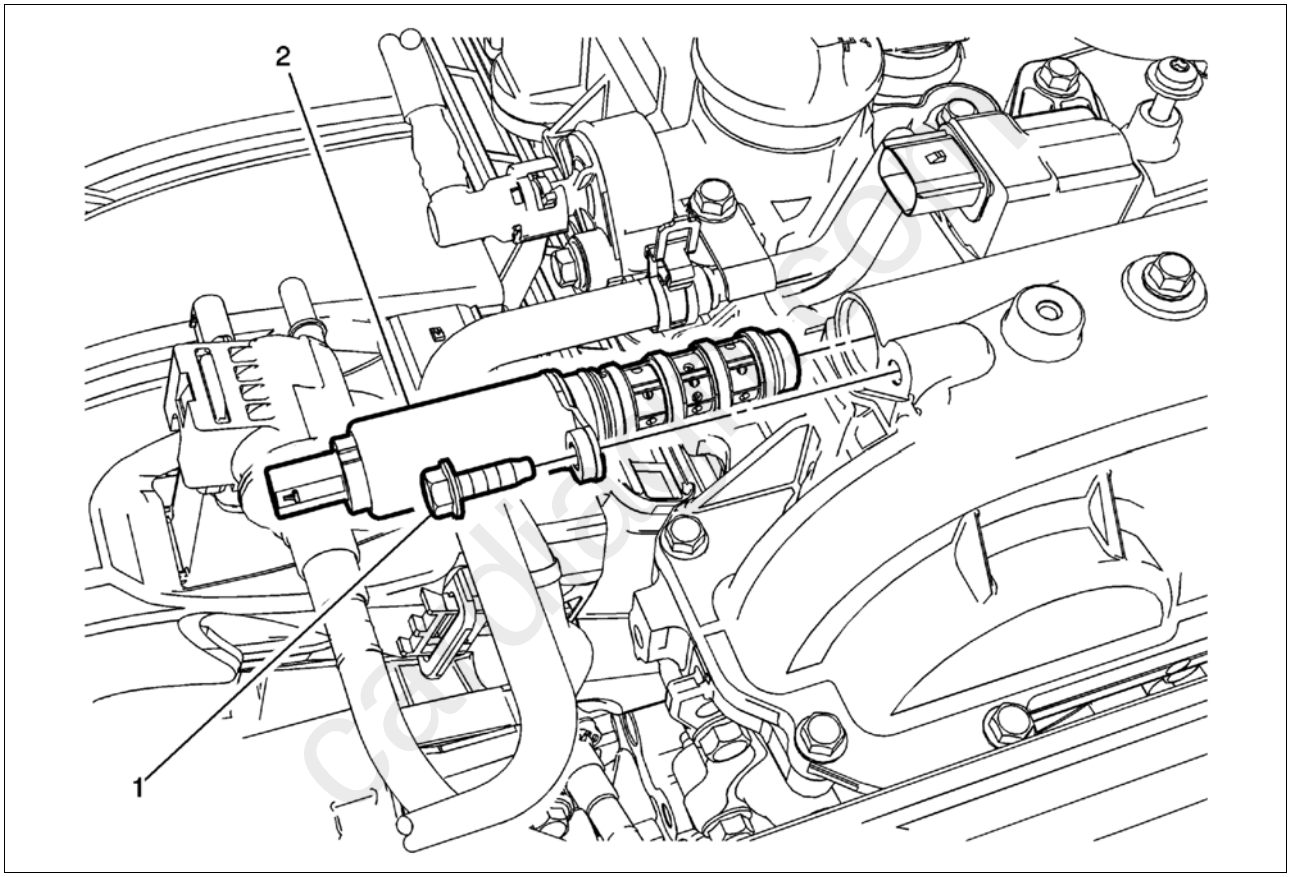
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the intake manifold cover. Refer to Intake Manifold Cover Replacement .	
1	Camshaft Position Actuator Exhaust Solenoid Valve Fastener *CAUTION:* *Refer to Fastener Caution .*

	Tighten 10 N.m (89 lb in)
2	Camshaft Position Actuator Exhaust Solenoid Valve **Procedure** Disconnect the electrical wiring harness connector from the camshaft position actuator exhaust solenoid valve.

REPAIR INSTRUCTIONS > CAMSHAFT POSITION ACTUATOR INTAKE SOLENOID VALVE REPLACEMENT

Fig 1: Camshaft Position Actuator Intake Solenoid Valve



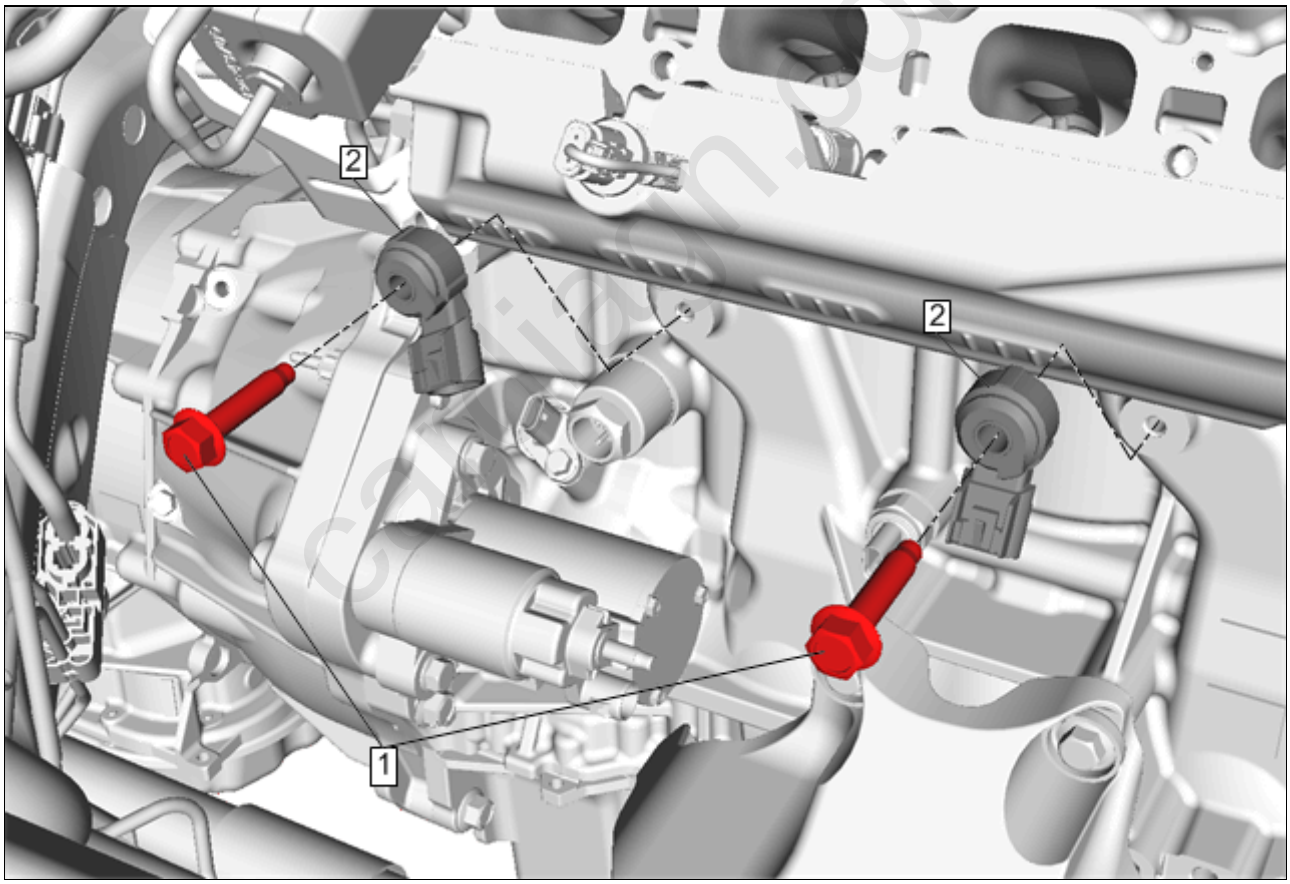
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the intake manifold cover. Refer to Intake Manifold Cover Replacement .	
1	Camshaft Position Actuator Intake Solenoid Valve Fastener

	CAUTION: *Refer to Fastener Caution .* **Tighten** 10 N.m (89 lb in)
2	Camshaft Position Actuator Intake Solenoid Valve **Procedure** Disconnect the electrical wiring harness connector from the camshaft position actuator intake solenoid valve.

REPAIR INSTRUCTIONS > KNOCK SENSOR REPLACEMENT

Fig 1: Knock Sensor



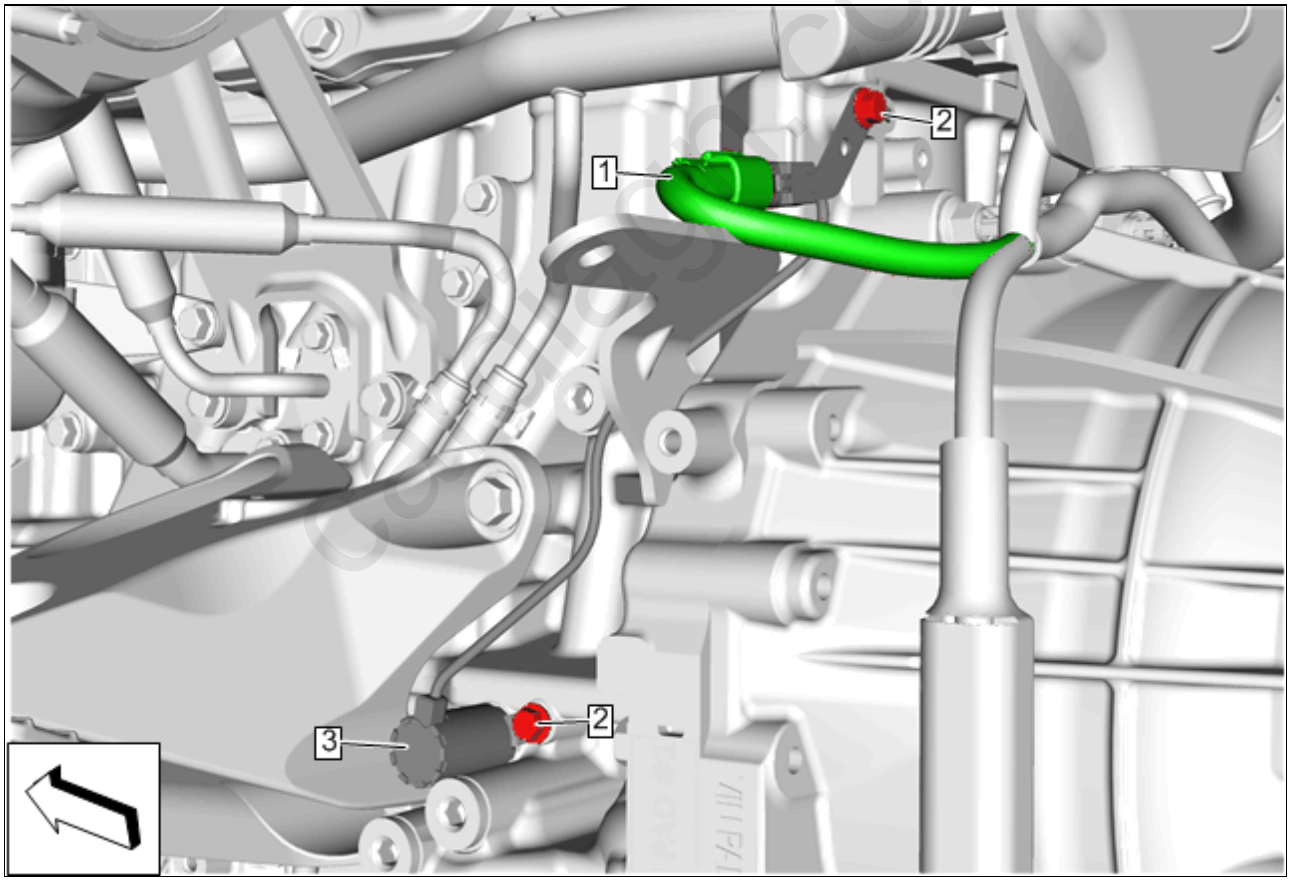
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the intake manifold. Refer to Intake Manifold Cover Replacement .	

1	Knock Sensor Fasteners (Qty: 2) *CAUTION:* *Refer to Fastener Caution .* **Tighten** 25 N.m (18 lb ft)
2	Knock Sensors (Qty: 2) **Procedure** Disconnect the electrical wiring harness connectors from the knock sensors.

REPAIR INSTRUCTIONS > OIL PUMP FLOW CONTROL VALVE REPLACEMENT

Fig 1: Oil Pump Flow Control Valve



Courtesy of GENERAL MOTORS COMPANY

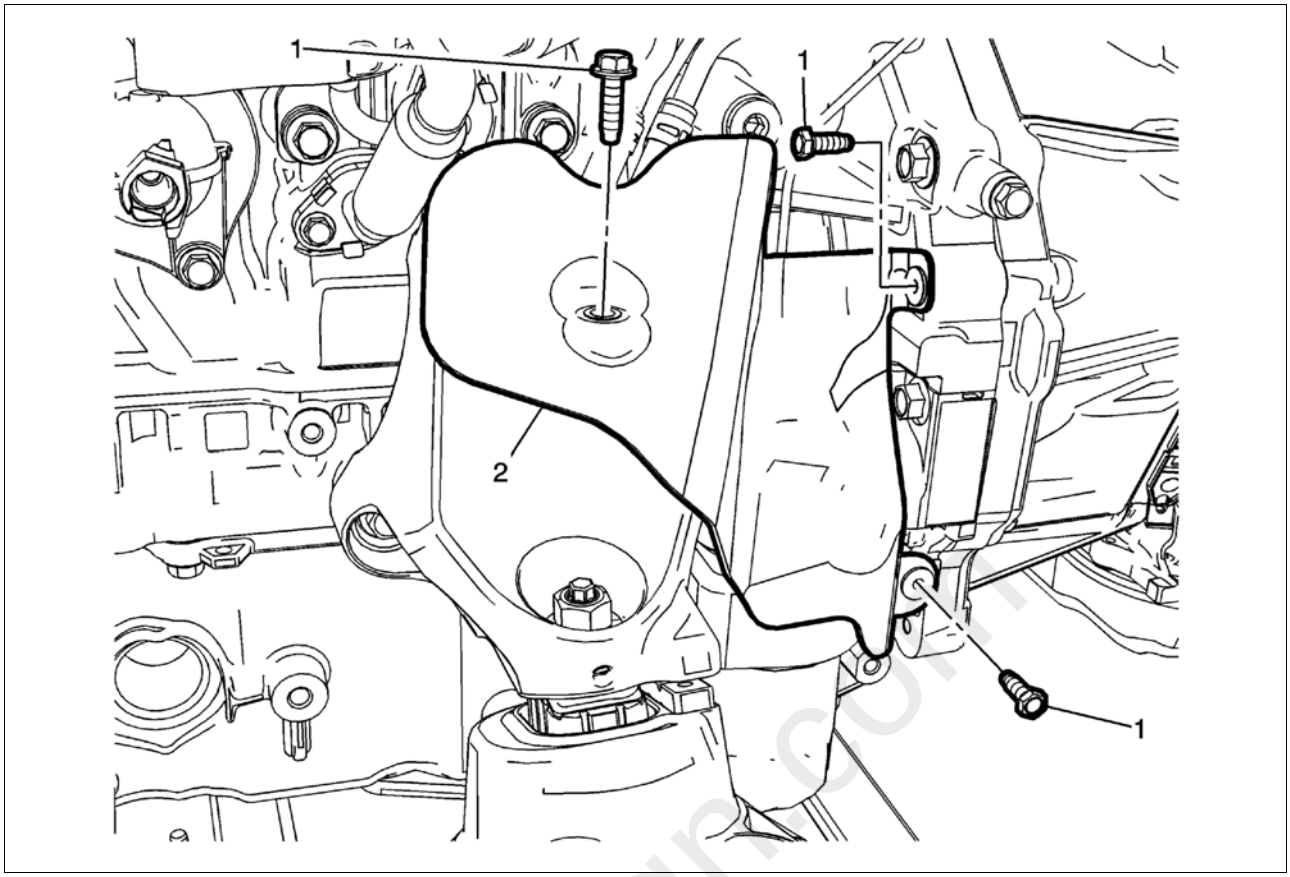
Callout	Component Name
Preliminary Procedures	

	1. Warm Up Three-Way Catalytic Converter Replacement (LTG) 2. Oil Pump Flow Control Valve Heat Shield Replacement
1	Electrical Connector
2	Oil Pump Flow Control Valve Bolt (Qty: 2) *CAUTION:* *Refer to Fastener Caution .* **Tighten** 10 N.m (89 lb in)
3	Oil Pump Flow Control Valve **Procedure** Install a NEW O-ring seal.

REPAIR INSTRUCTIONS > OIL PUMP FLOW CONTROL VALVE HEAT SHIELD REPLACEMENT

cardiagn.com

Fig 1: Oil Pump Flow Control Valve Heat Shield

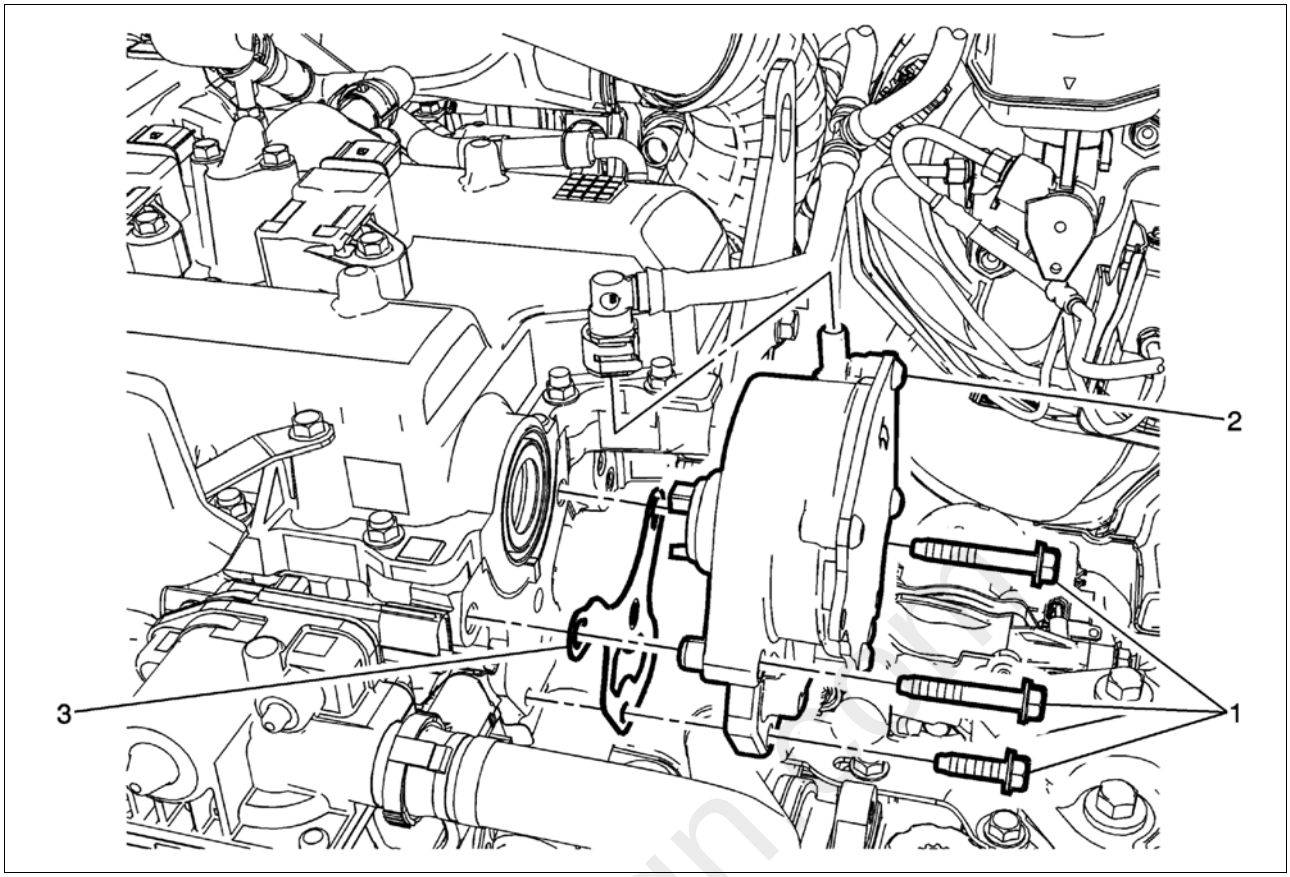


Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Warm Up Three-Way Catalytic Converter Replacement (LTG)	
1	Oil Pump Flow Control Valve Heat Shield Fastener (Qty: 3) *CAUTION:* *Refer to Fastener Caution .* **Tighten** 9 N.m (80 lb in)
2	Oil Pump Flow Control Valve Heat Shield

REPAIR INSTRUCTIONS > VACUUM PUMP REPLACEMENT

Fig 1: Vacuum Pump & Mounting Components



Courtesy of GENERAL MOTORS COMPANY

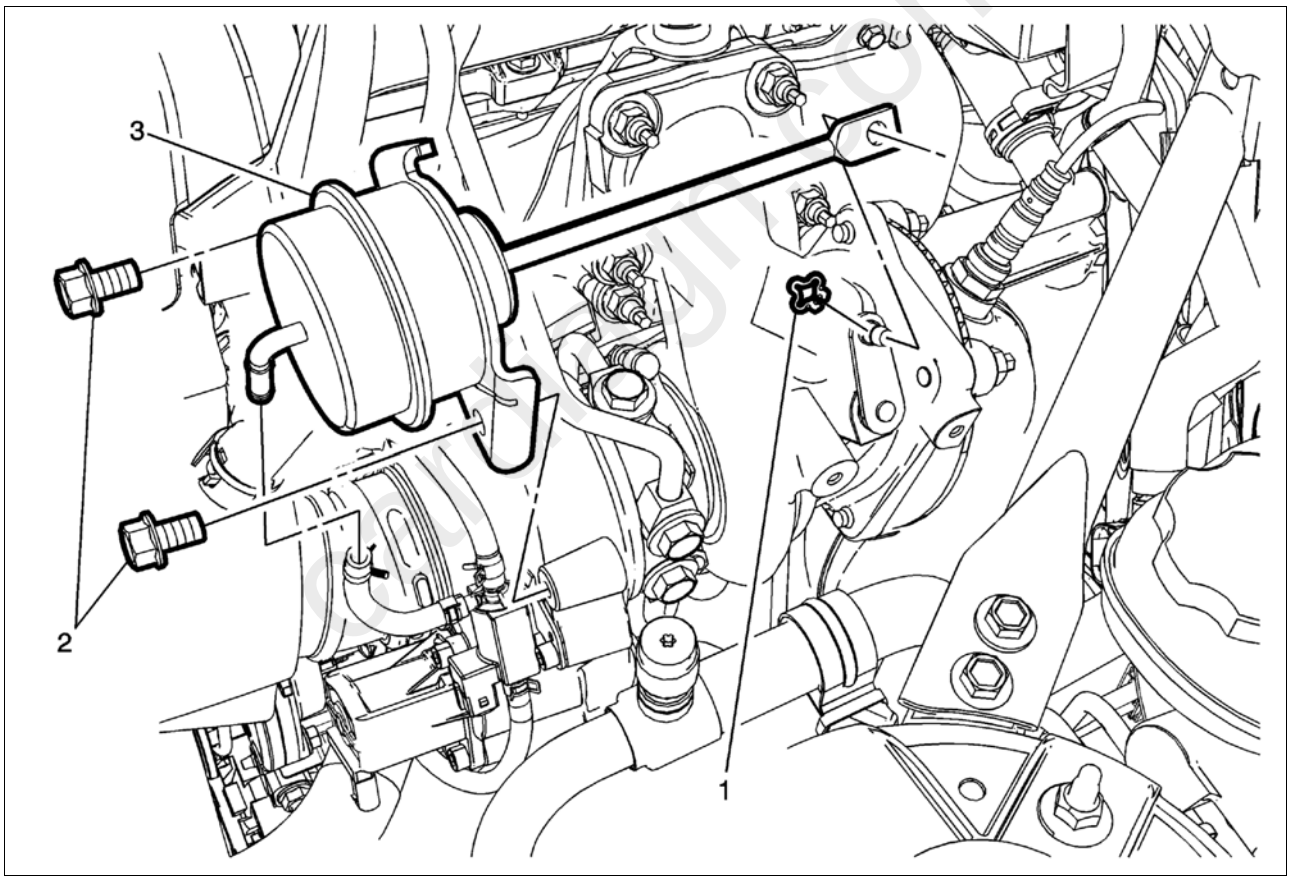
Callout	Component Name
Preliminary Procedure 1. Remove the intake manifold cover. Intake Manifold Cover Replacement 2. Remove the plenum front panel. Plenum Front Panel Replacement 3. Remove the outer fuel pump insulator. Fuel Pump Insulator Replacement (Outer) 4. Disconnect the vacuum hose from the vacuum pump. Plastic Collar Quick Connect Fitting Service	
1	Vacuum Pump Fasteners (Qty: 3) *CAUTION:* *Refer to Fastener Caution .* **Tighten**

cardiagn.com

	10 N.m (89 lb in)
2	Vacuum Pump
3	Vacuum Pump Gasket *NOTE:* *Inspect the gasket and replace if necessary.*

REPAIR INSTRUCTIONS > TURBOCHARGER WASTEGATE ACTUATOR REPLACEMENT

Fig 1: Turbocharger Wastegate Actuator



Courtesy of GENERAL MOTORS COMPANY

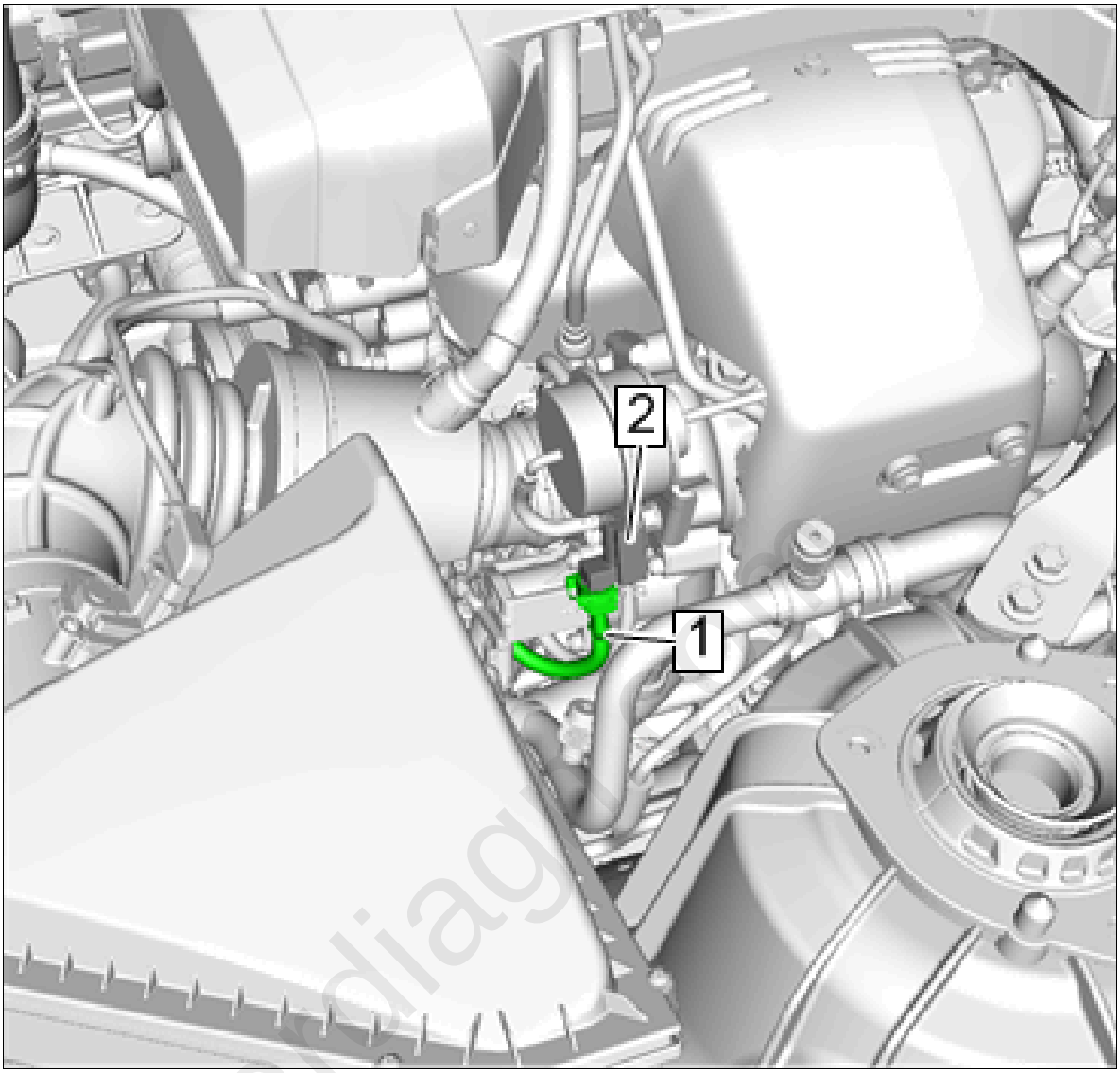
Callout	Component Name
Preliminary Procedure Turbocharger Heat Shield Replacement	
1	Turbocharger Wastegate Actuator Arm Retainer

2	Turbocharger Wastegate Actuator Fastener (Qty: 2) *CAUTION:* *Refer to Fastener Caution .* **Tighten** 20 N.m (15 lb ft)
3	Turbocharger Wastegate Actuator **Procedure** Disconnect the vacuum line from the turbocharger wastegate actuator.

REPAIR INSTRUCTIONS > TURBOCHARGER WASTEGATE REGULATOR SOLENOID VALVE REPLACEMENT > REMOVAL PROCEDURE

cardiagn.com

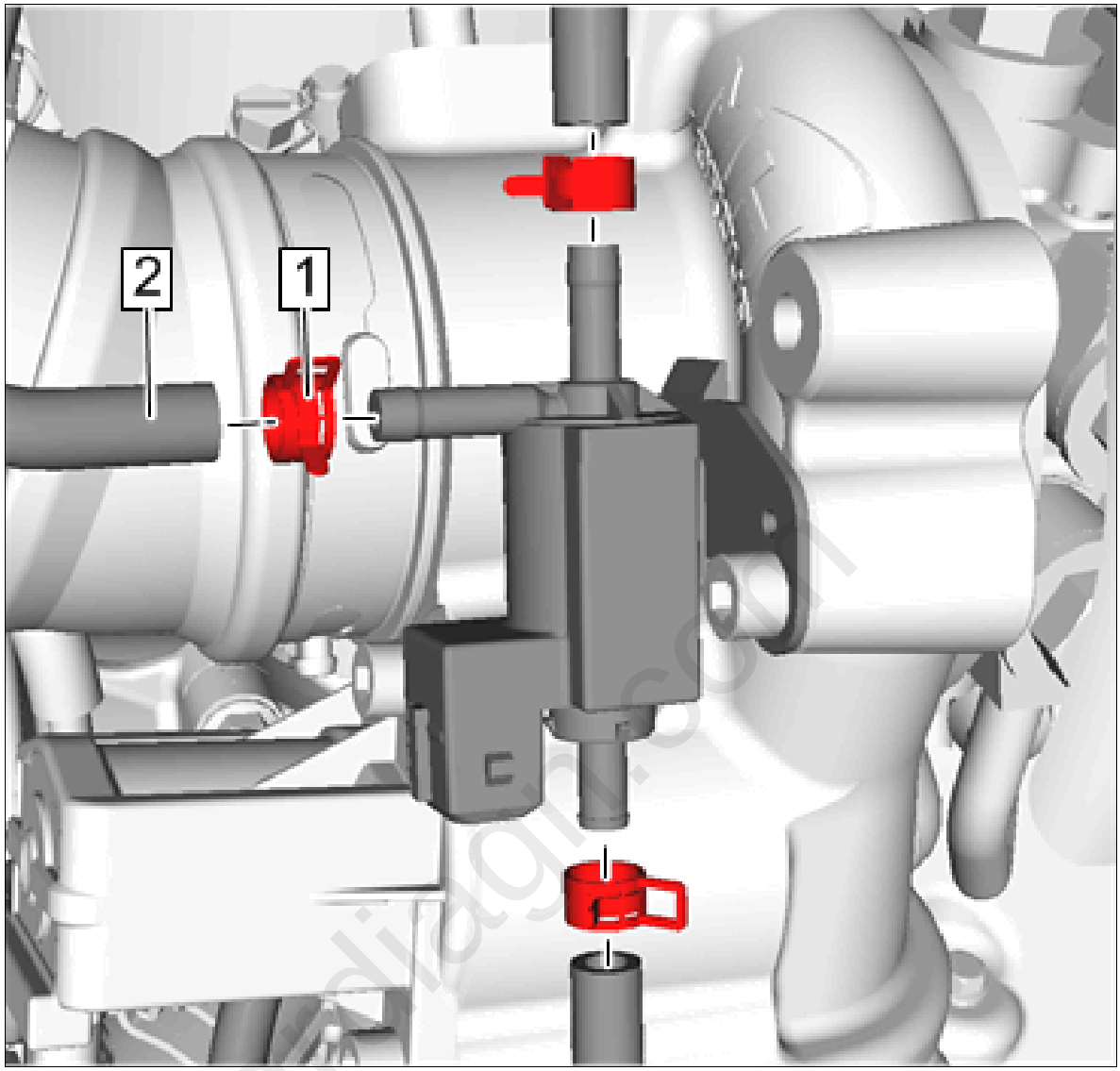
Fig 1: Turbocharger Wastegate Regulator Solenoid Valve Electrical Connector



Courtesy of GENERAL MOTORS COMPANY

1. Disconnect Electrical Connector (1) at Turbocharger Wastegate Regulator Solenoid Valve (2)

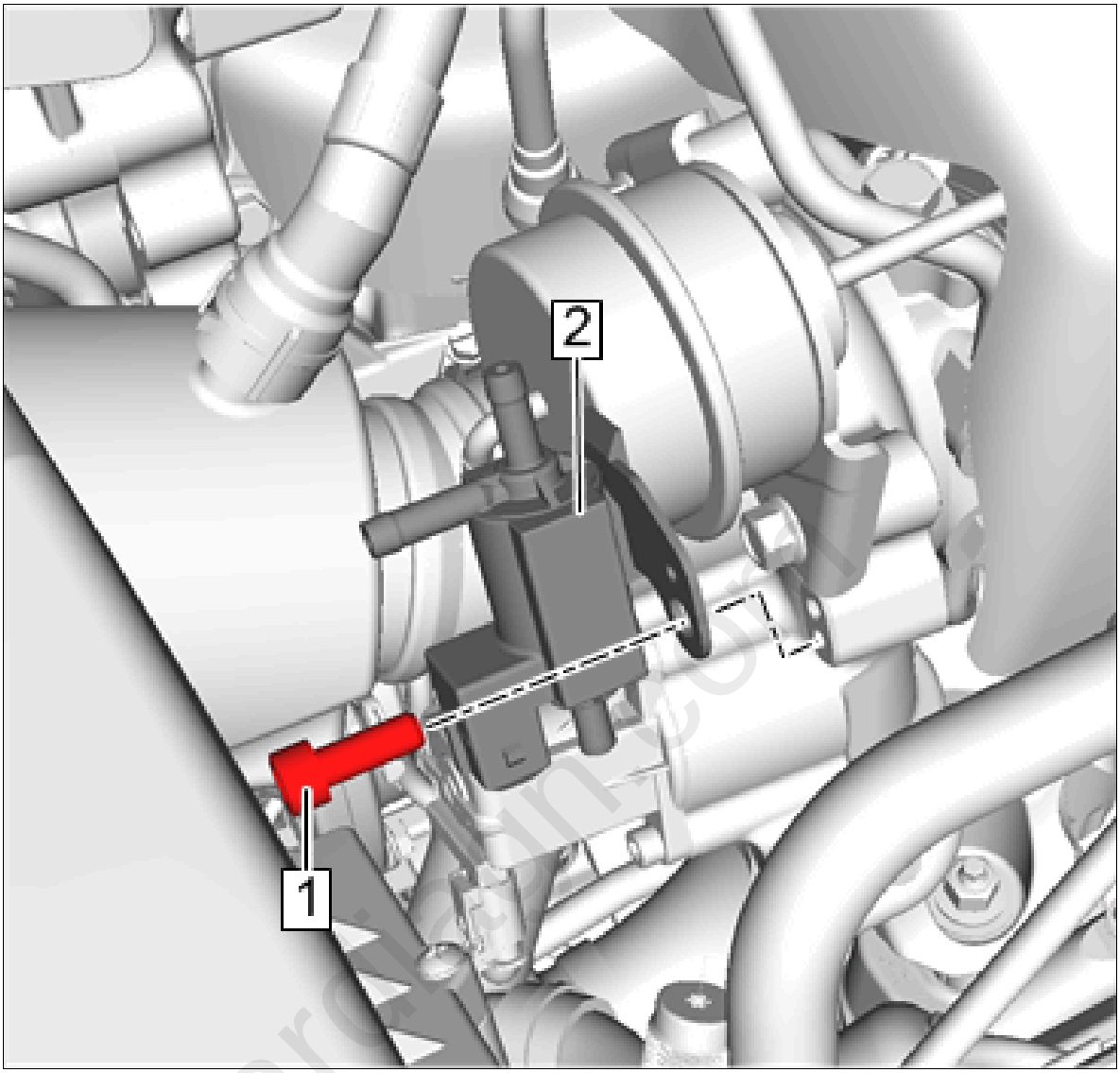
Fig 2: Hose Clamp



Courtesy of GENERAL MOTORS COMPANY

2. Disengage Hose Clamp (1) (Qty: 3) - Hose Clamp Replacement Guidelines - Spring Type
3. Disconnect Turbocharger Wastegate Regulator Solenoid Valve Hose (2)

Fig 3: Turbocharger Wastegate Regulator Solenoid Valve Fastener

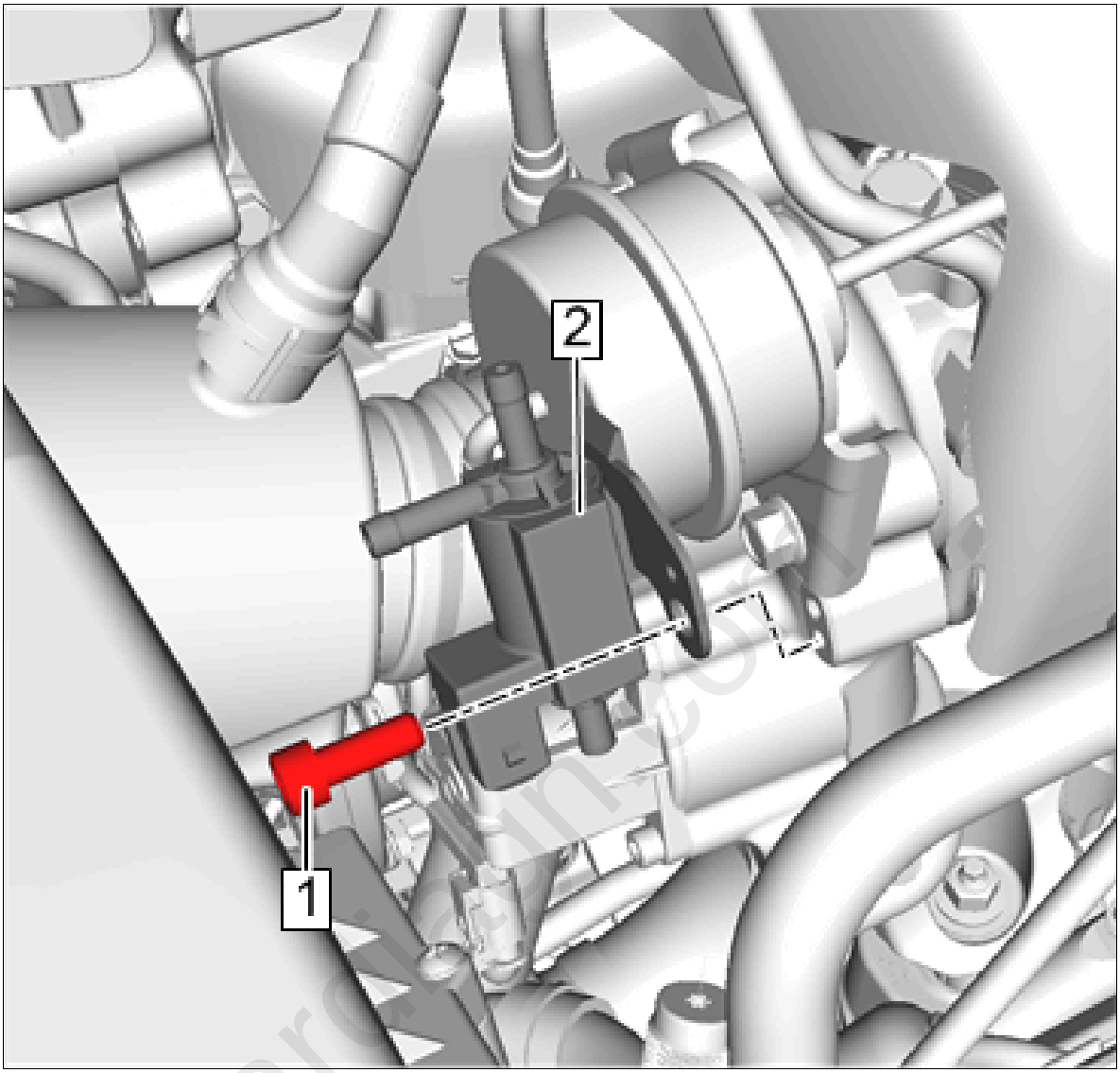


Courtesy of GENERAL MOTORS COMPANY

4. Remove Turbocharger Wastegate Regulator Solenoid Valve Fastener (1)
5. Remove Turbocharger Wastegate Regulator Solenoid Valve (2)

REPAIR INSTRUCTIONS > TURBOCHARGER WASTEGATE REGULATOR SOLENOID VALVE REPLACEMENT > INSTALLATION PROCEDURE

Fig 1: Turbocharger Wastegate Regulator Solenoid Valve Fastener



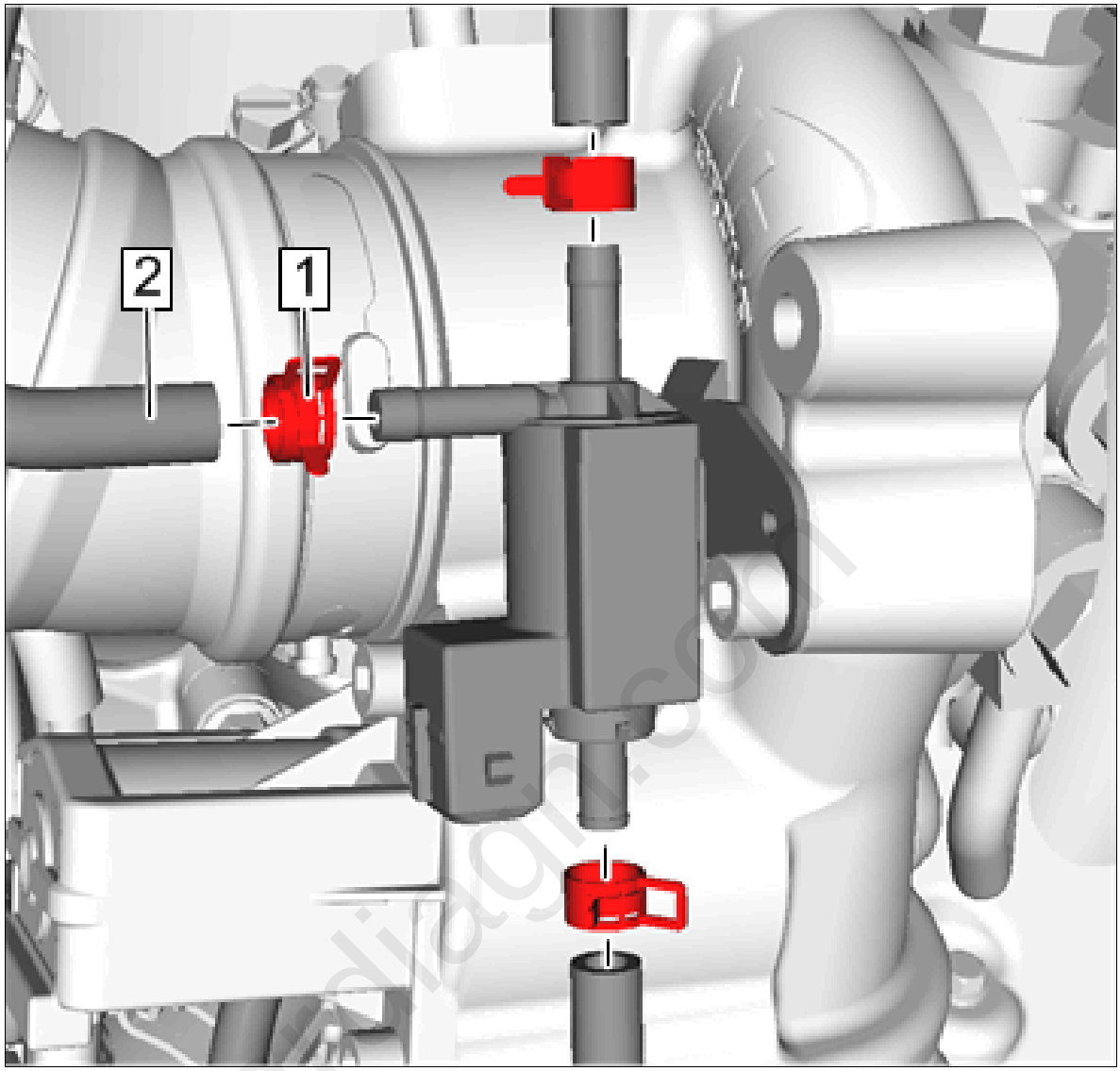
Courtesy of GENERAL MOTORS COMPANY

1. Install Turbocharger Wastegate Regulator Solenoid Valve (2)

> ⚠ *CAUTION:*
>
> *Refer to Fastener Caution .*

2. Install Turbocharger Wastegate Regulator Solenoid Valve Fastener (1) and tighten to 7.8 N.m (69 lb in)

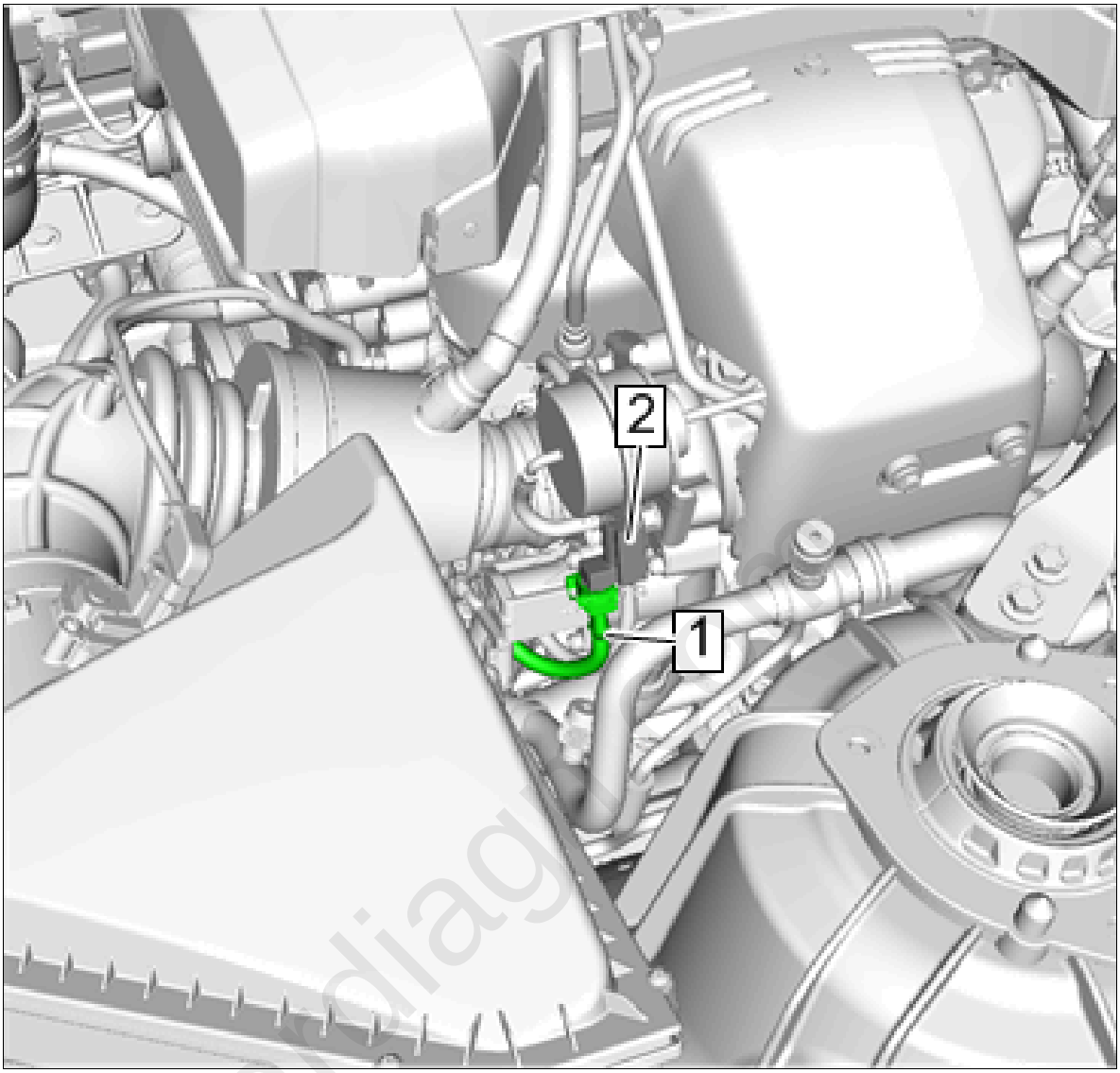
Fig 2: Turbocharger Wastegate Regulator Solenoid Valve Hose



Courtesy of GENERAL MOTORS COMPANY

3. Connect Turbocharger Wastegate Regulator Solenoid Valve Hose (2)
4. Engage Hose Clamp (1) (Qty: 3) - Hose Clamp Replacement Guidelines - Spring Type

Fig 3: Turbocharger Wastegate Regulator Solenoid Valve Electrical Connector

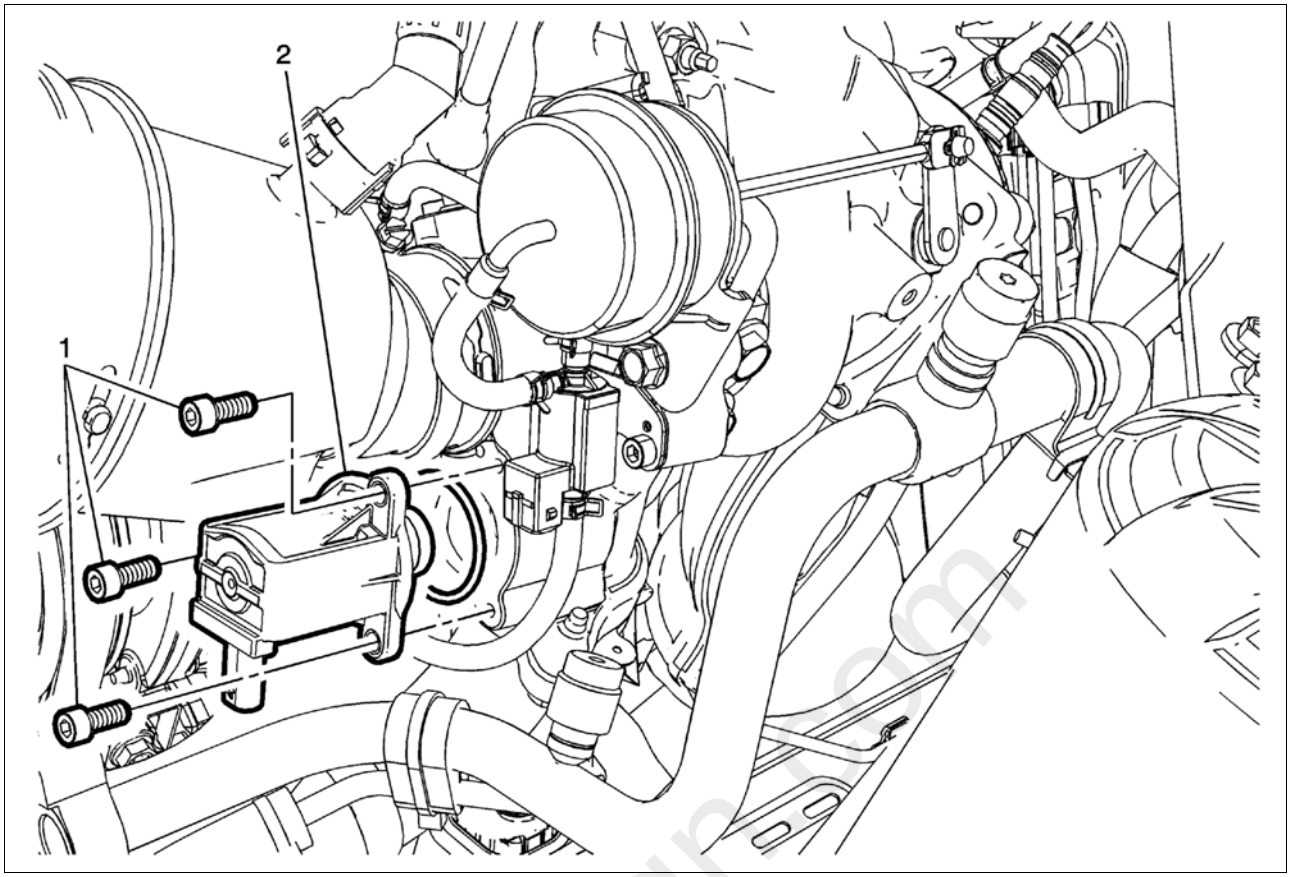


Courtesy of GENERAL MOTORS COMPANY

5. Connect Electrical Connector (1) at Turbocharger Wastegate Regulator Solenoid Valve (2)

REPAIR INSTRUCTIONS > TURBOCHARGER BYPASS VALVE SOLENOID REPLACEMENT

Fig 1: Turbocharger Bypass Valve Solenoid



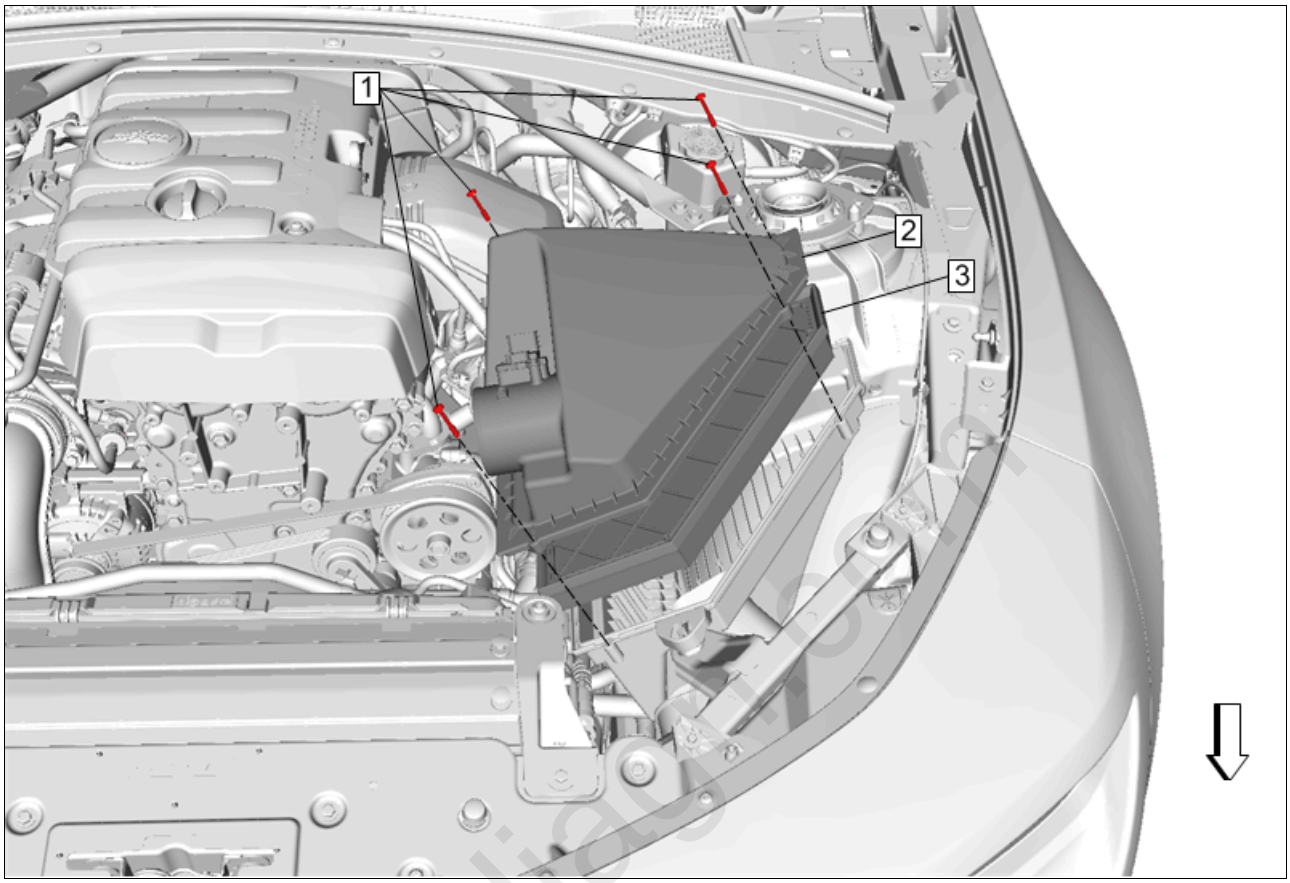
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Air Cleaner Outlet Duct Replacement	
1	Turbocharger Bypass Valve Solenoid Bolt (Qty: 3) *CAUTION:* *Refer to Fastener Caution .* **Tighten** 7.8 N.m (69 lb in)
2	Turbocharger Bypass Valve Solenoid Procedure 1. Disconnect the turbocharger bypass valve solenoid harness connector. 2. Inspect the turbocharger bypass valve solenoid seal and replace if necessary.

cardiagn.com

REPAIR INSTRUCTIONS > AIR CLEANER ELEMENT REPLACEMENT

Fig 1: Air Cleaner Element



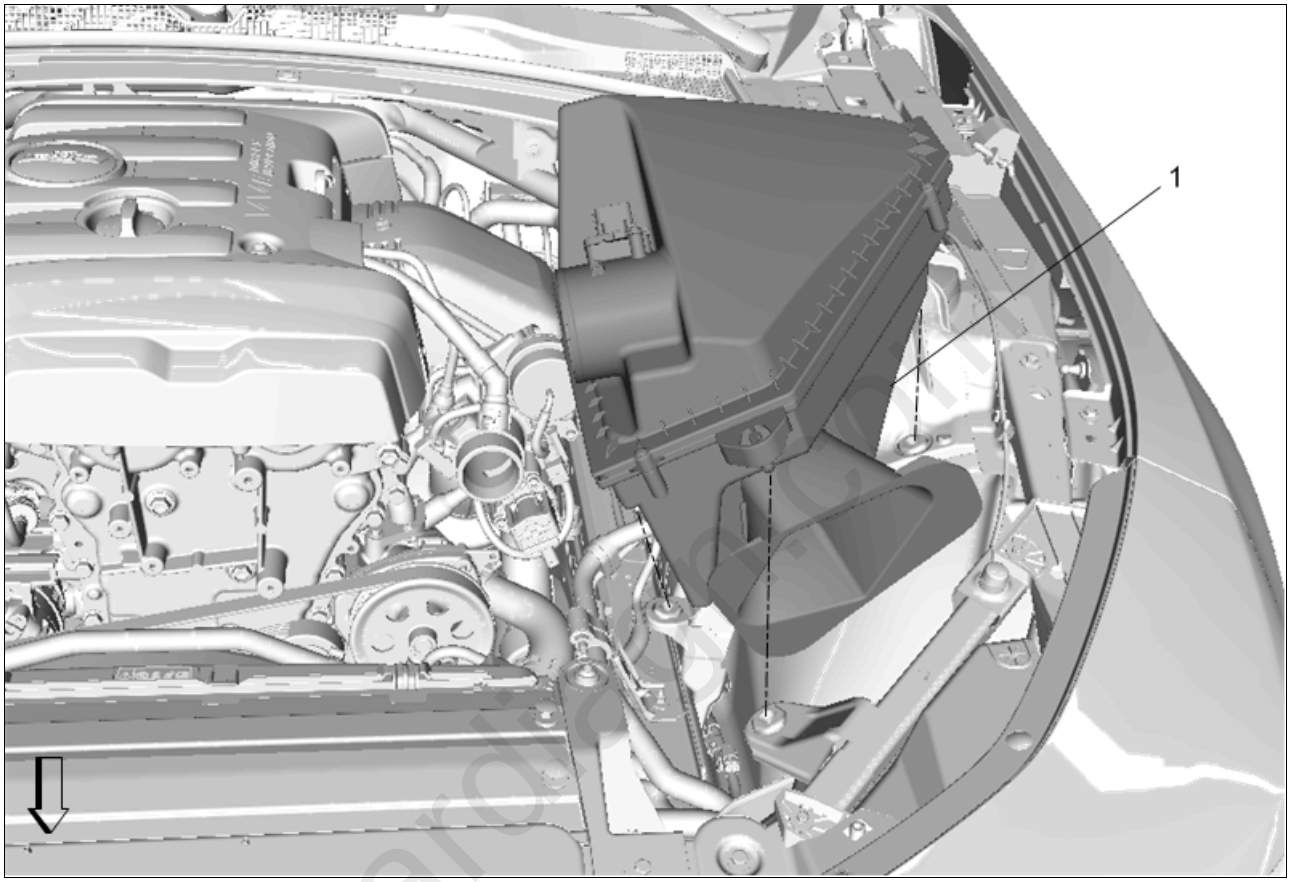
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Air Cleaner Outlet Duct Replacement 2. Disconnect the electrical connector.	
1	Air Cleaner Upper Housing Bolt (Qty: 4) *CAUTION:* *Refer to Fastener Caution .* **Tighten** 2 N.m (18 lb in)

2	Air Cleaner Upper Housing
3	Air Cleaner Element

REPAIR INSTRUCTIONS > AIR CLEANER ASSEMBLY REPLACEMENT

Fig 1: Air Cleaner Assembly

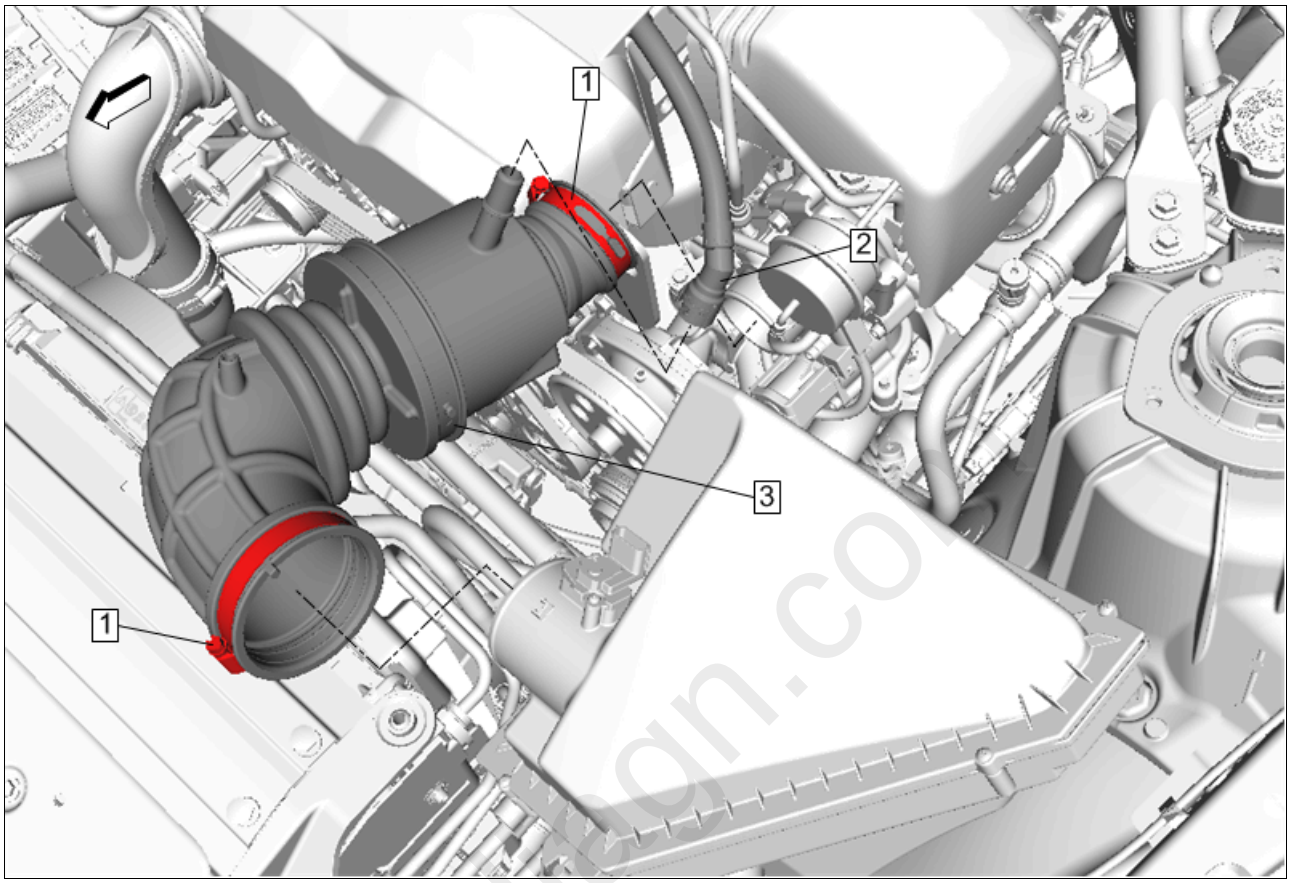


Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Air Cleaner Outlet Duct Replacement 2. Disconnect the electrical connector.	
1	Air Cleaner Assembly Procedure 1. Remove the air cleaner housing from the retainers. 2. Transfer parts as necessary.

REPAIR INSTRUCTIONS > AIR CLEANER OUTLET DUCT REPLACEMENT

Fig 1: Air Cleaner Outlet Duct

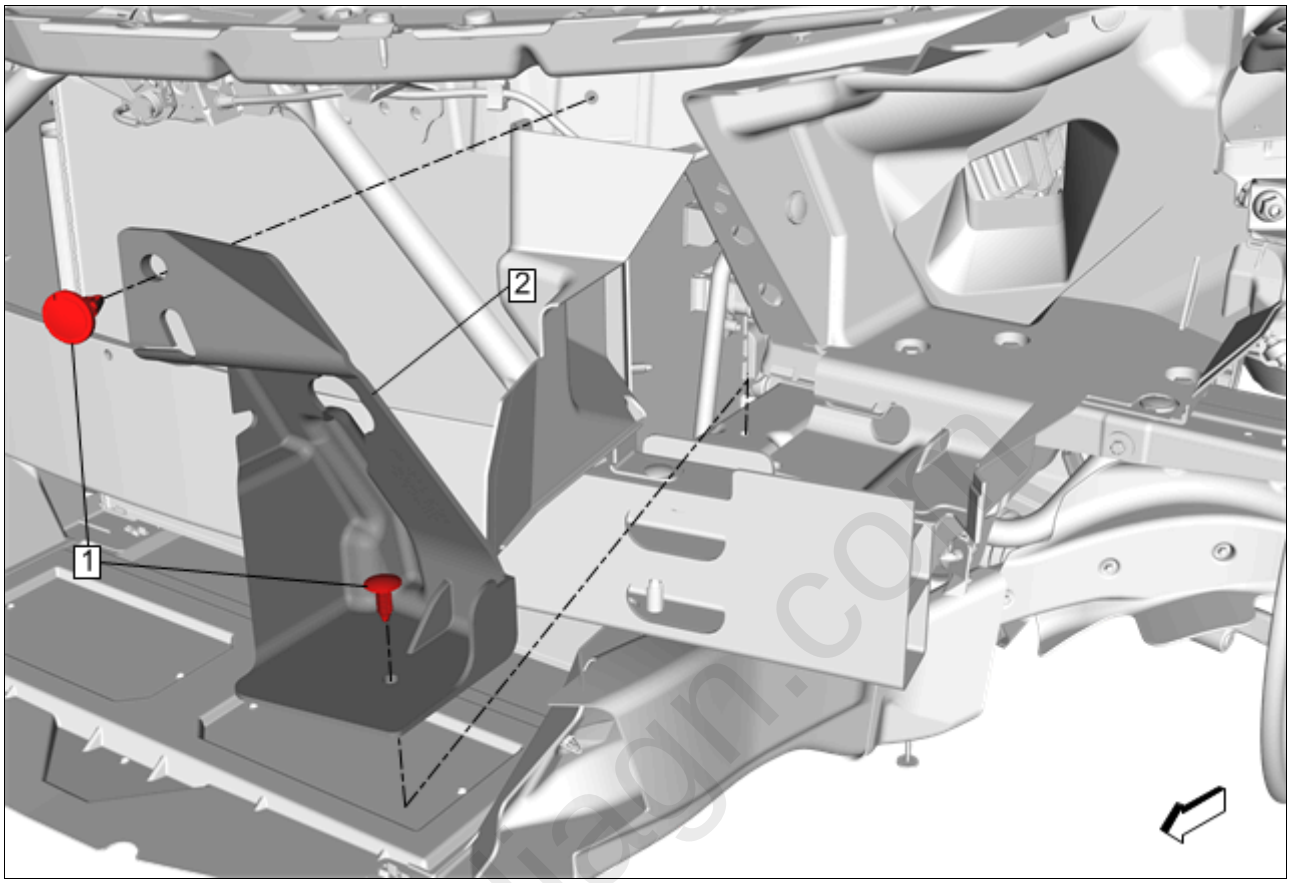


Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Air Cleaner Outlet Duct Clamp (Qty: 2) *CAUTION:* *Refer to Fastener Caution .* **Tighten** 4 N.m (35 lb in)
2	Positive Crankcase Ventilation Tube **Procedure** Disconnect PCV Tube at Air Cleaner Outlet Duct - Plastic Collar Quick Connect Fitting Service
3	Air Cleaner Outlet Duct

REPAIR INSTRUCTIONS > INTAKE AIR SPLASH SHIELD REPLACEMENT

Fig 1: Intake Air Splash Shield



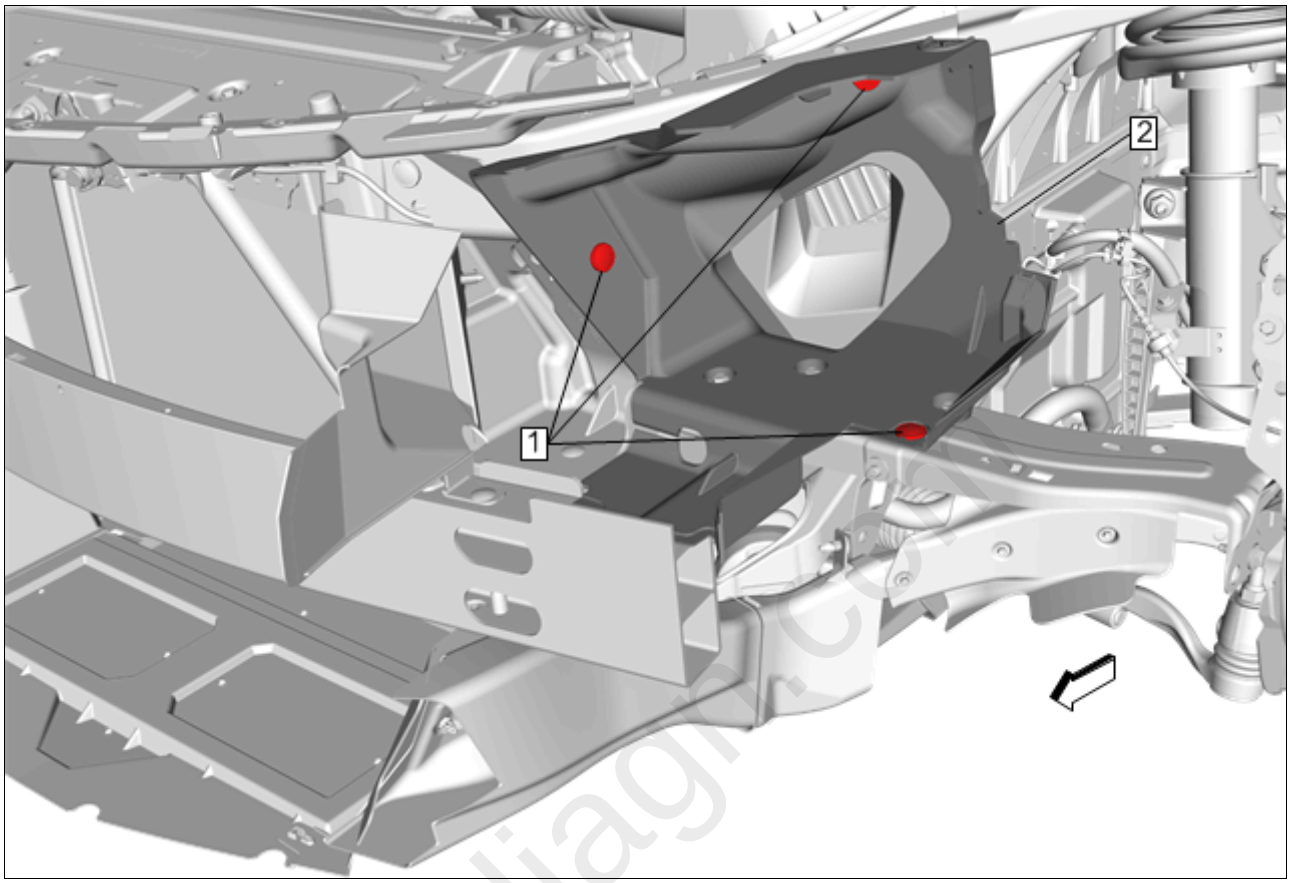
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Headlamp Replacement (HID) Headlamp Replacement (Halogen) 2. Remove ground wire bolt and reposition ground wire and harness.	
1	Intake Air Splash Shield Retainer (Qty: 2) *CAUTION:* *Refer to Fastener Caution .*
2	Intake Air Splash Shield

cardiagn.com

REPAIR INSTRUCTIONS > INTAKE AIR BAFFLE REPLACEMENT

Fig 1: Intake Air Baffle

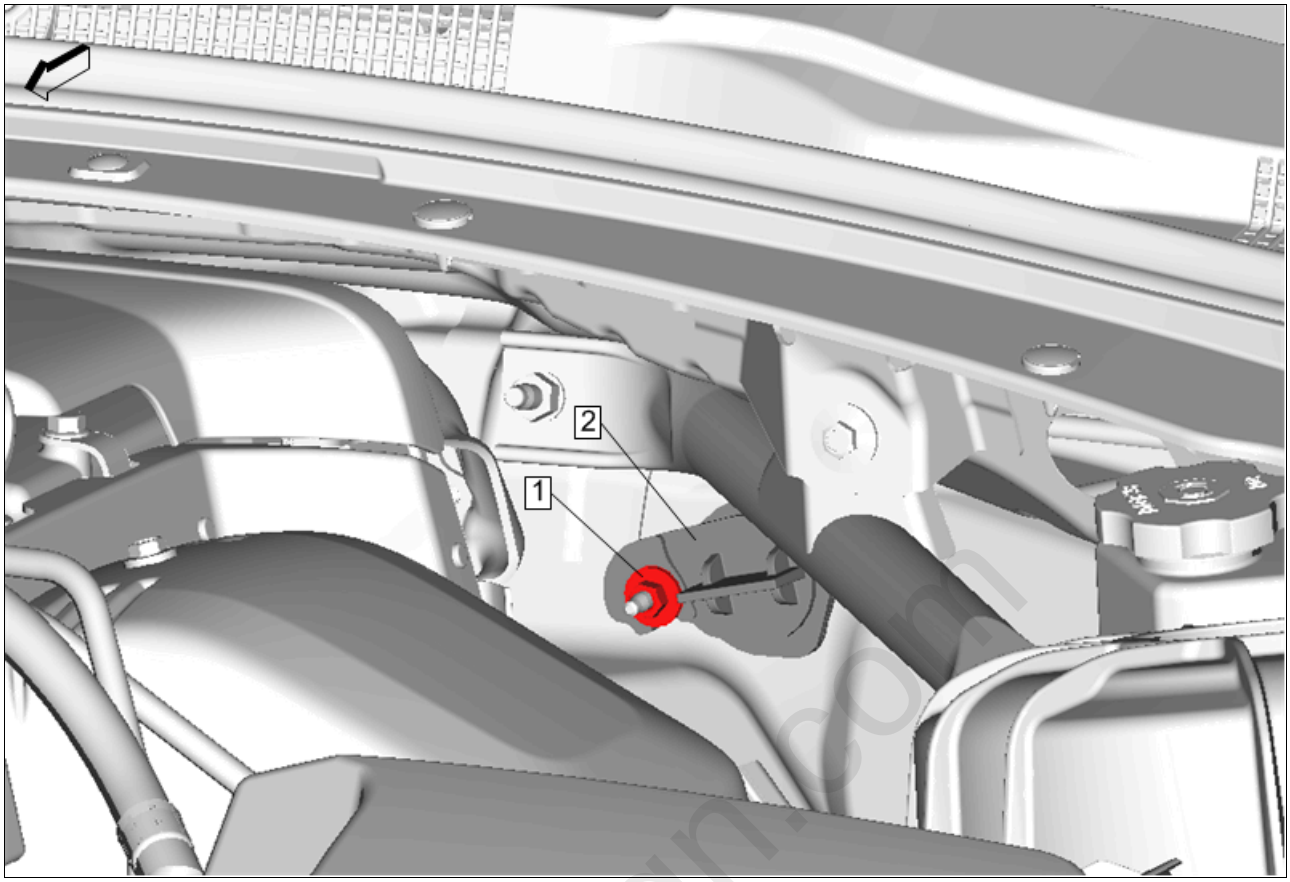


Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Headlamp Replacement (HID) Headlamp Replacement (Halogen)	
1	Intake Air Baffle Retainer (Qty: 3) *CAUTION:* *Refer to Fastener Caution .*
2	Intake Air Baffle

REPAIR INSTRUCTIONS > FRONT INTAKE AIR DUCT HOLE PLUG REPLACEMENT

Fig 1: Front Intake Air Duct Hole Plug



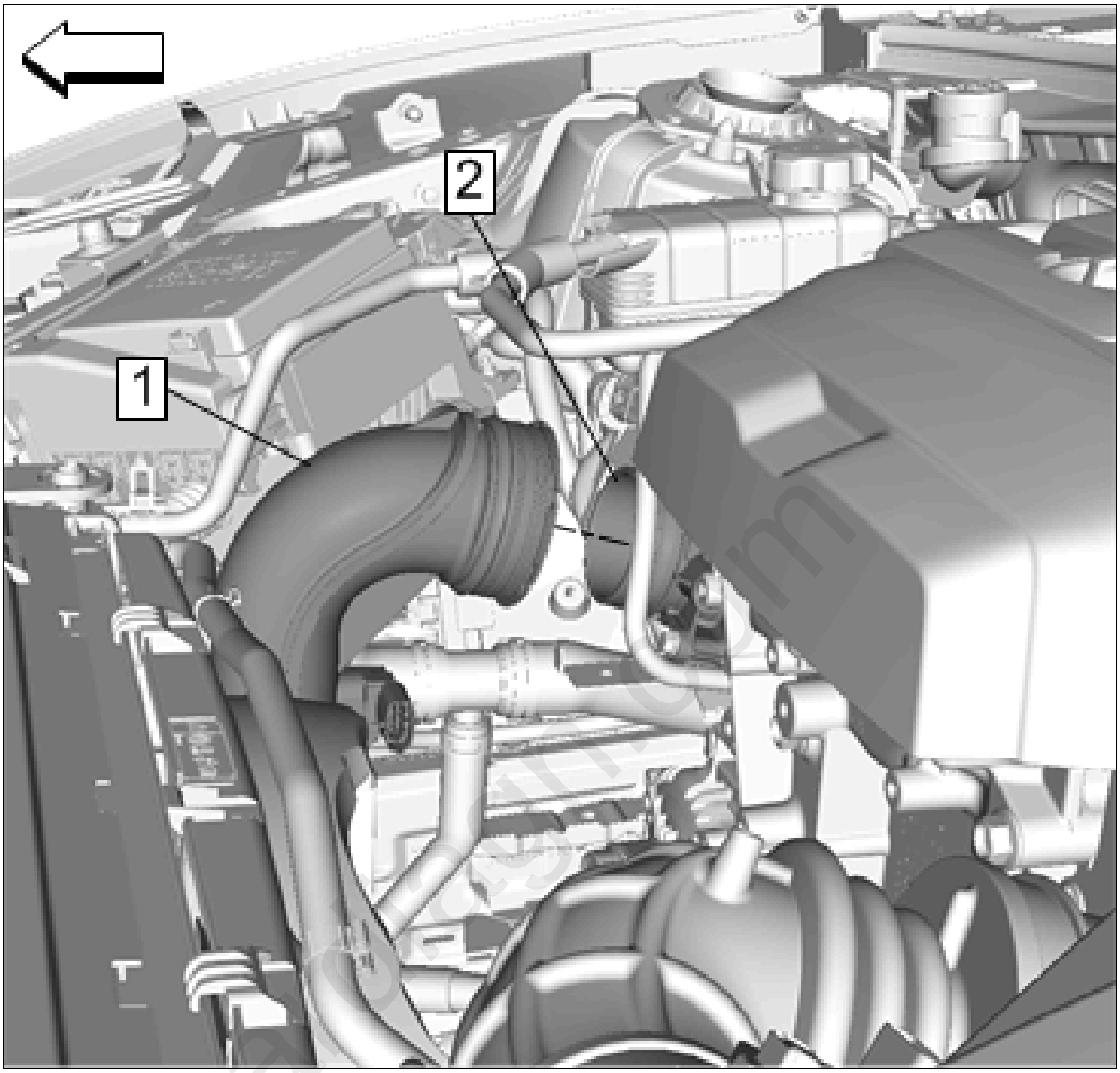
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Front Intake Air Duct Hole Plug Nut *CAUTION:* *Refer to Fastener Caution .* **Tighten** 9 N.m (80 lb in)
2	Front Intake Air Duct Hole Plug **Procedure** Install NEW seal.

REPAIR INSTRUCTIONS > CHARGE AIR COOLER OUTLET AIR TUBE REPLACEMENT > REMOVAL PROCEDURE

1. Remove Front Bumper Fascia Replacement

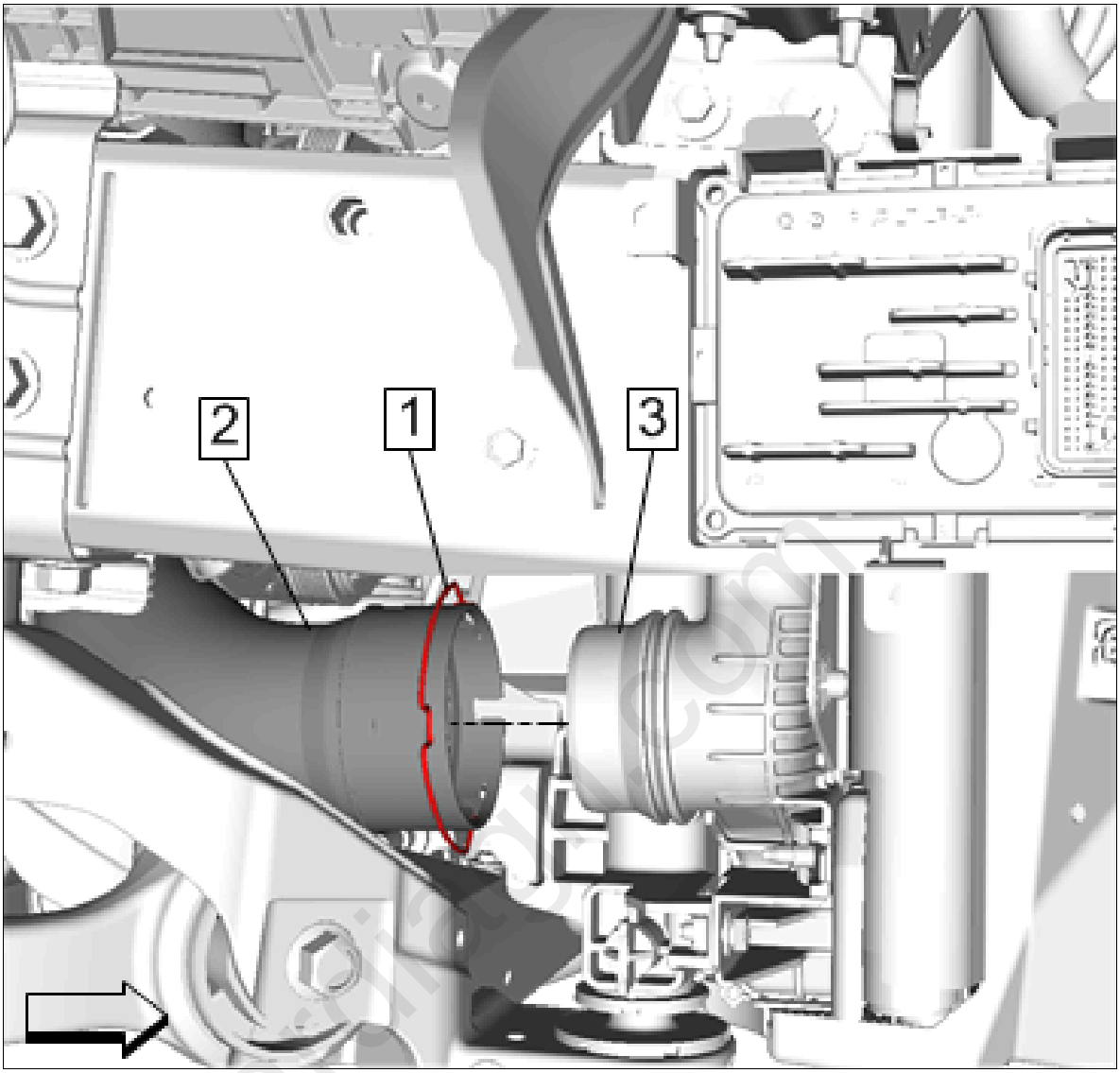
Fig 1: Charge Air Cooler Outlet Air Tube



Courtesy of GENERAL MOTORS COMPANY

2. Remove Charge Air Cooler Outlet Air Tube (1) at Throttle Body (2)

Fig 2: Retainer Spring

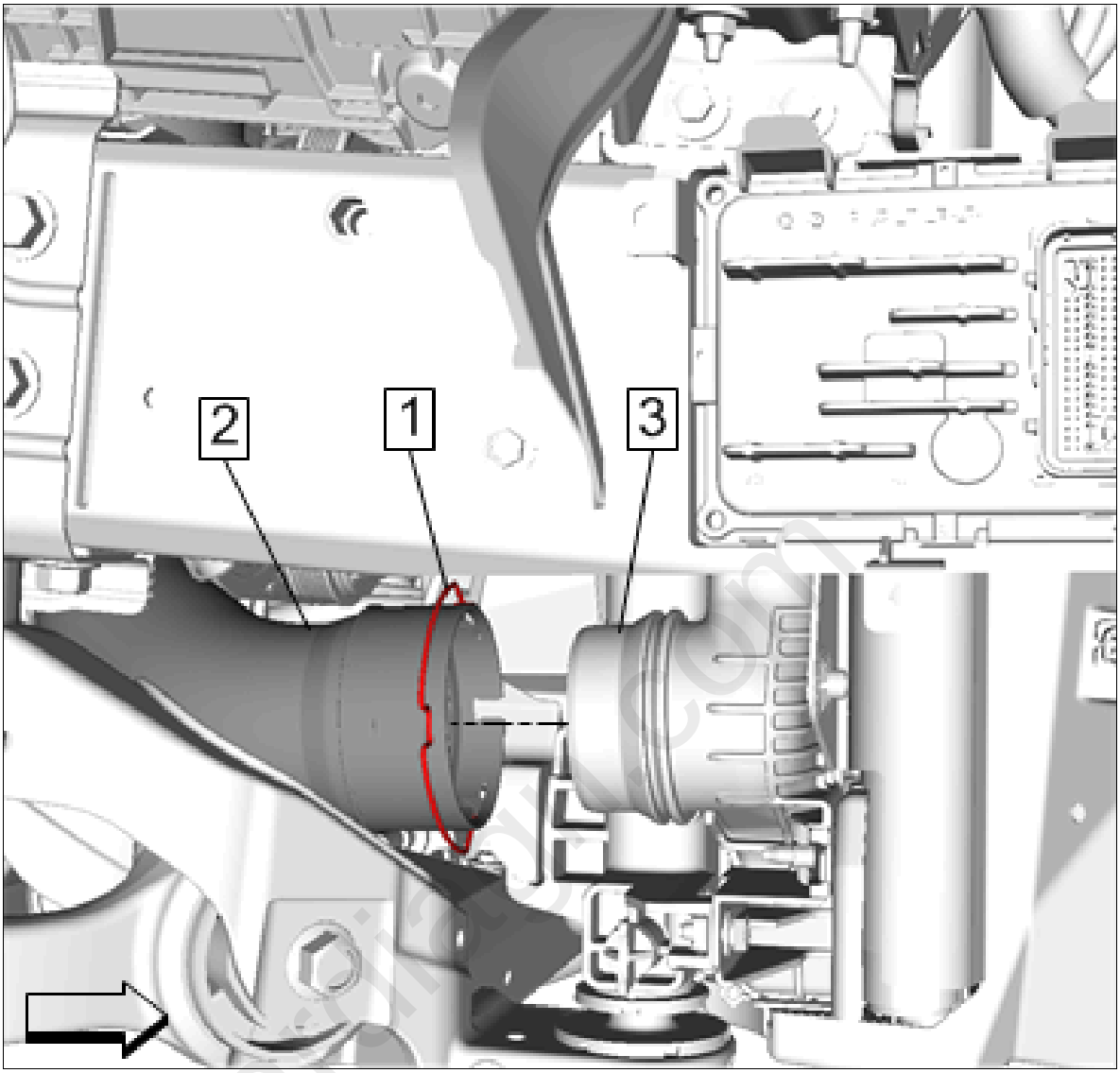


Courtesy of GENERAL MOTORS COMPANY

3. Release Retainer Spring (1)
4. Remove Charge Air Cooler Outlet Air Tube (2) at Charge Air Cooler (3)

REPAIR INSTRUCTIONS > CHARGE AIR COOLER OUTLET AIR TUBE REPLACEMENT > INSTALLATION PROCEDURE

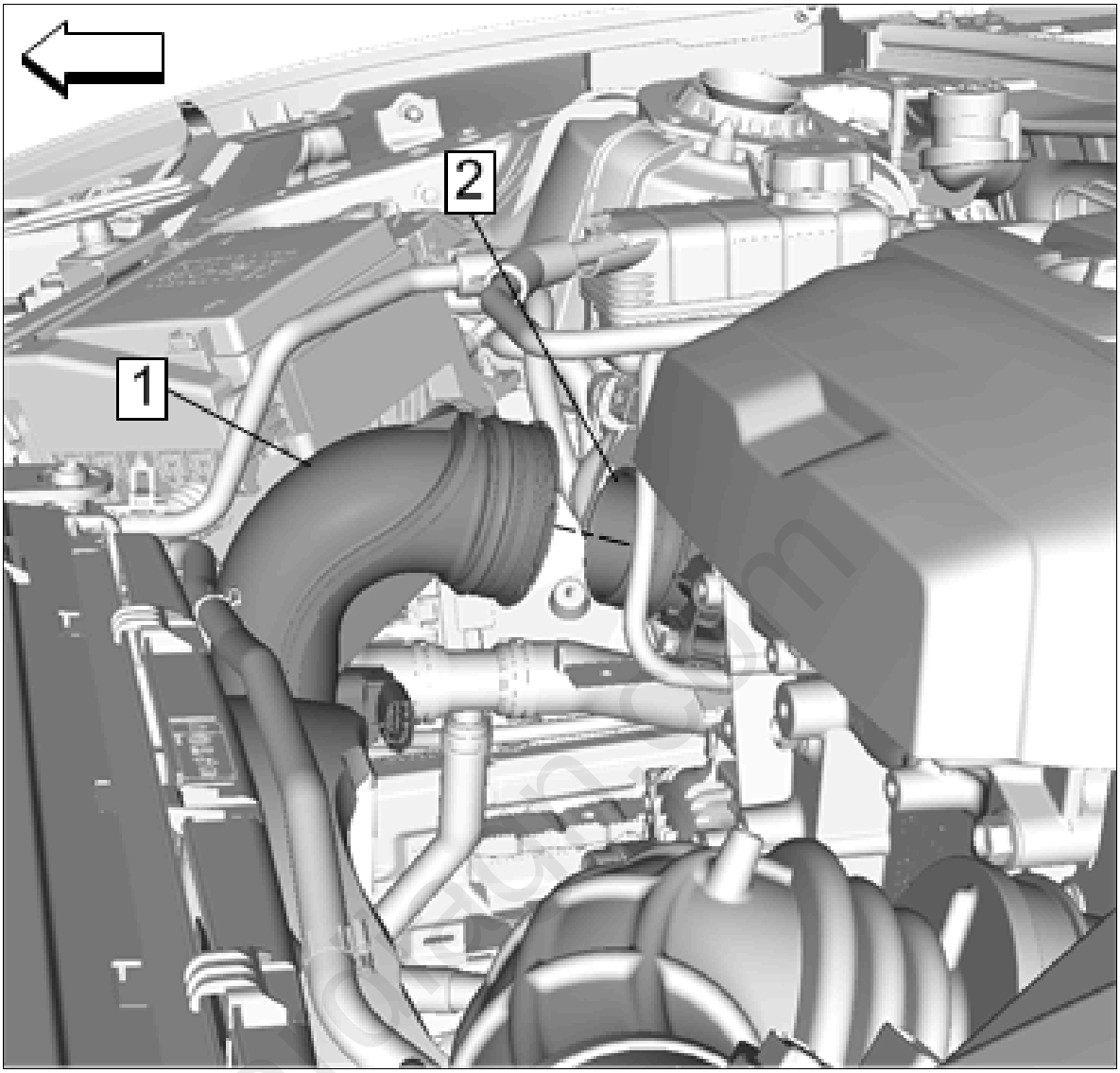
Fig 1: Charge Air Cooler Outlet Air Tube At Charge Air Cooler



Courtesy of GENERAL MOTORS COMPANY

1. Install Charge Air Cooler Outlet Air Tube (2) at Charge Air Cooler (3)
2. Engage Retainer Spring (1)

Fig 2: Charge Air Cooler Outlet Air Tube At Throttle Body



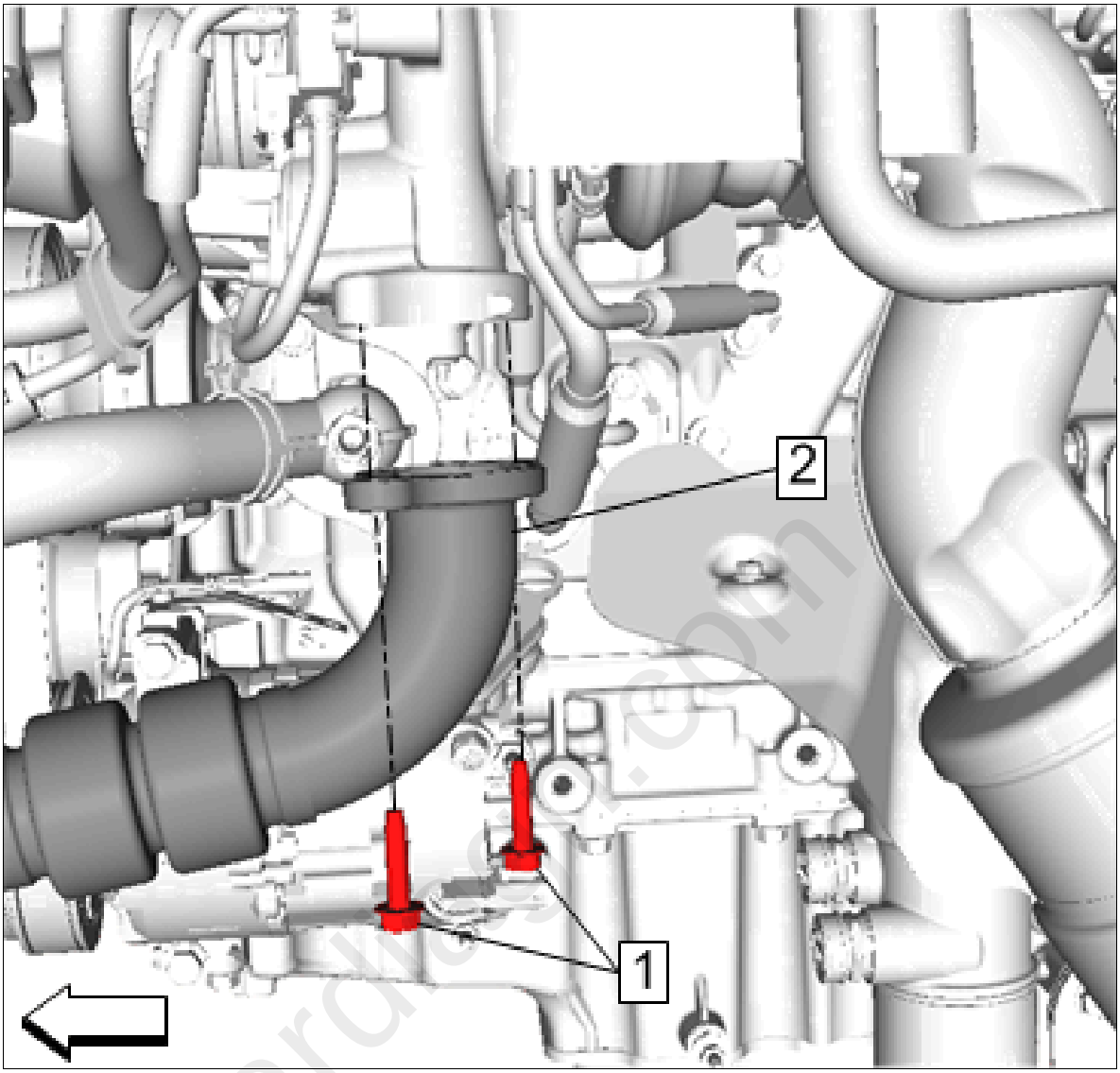
Courtesy of GENERAL MOTORS COMPANY

3. Install Charge Air Cooler Outlet Air Tube (1) at Throttle Body (2)
4. Install Front Bumper Fascia Replacement

REPAIR INSTRUCTIONS > CHARGE AIR COOLER INLET AIR TUBE REPLACEMENT > REMOVAL PROCEDURE

1. Remove Front Bumper Fascia Replacement

Fig 1: Charge Air Cooler Inlet Air Tube

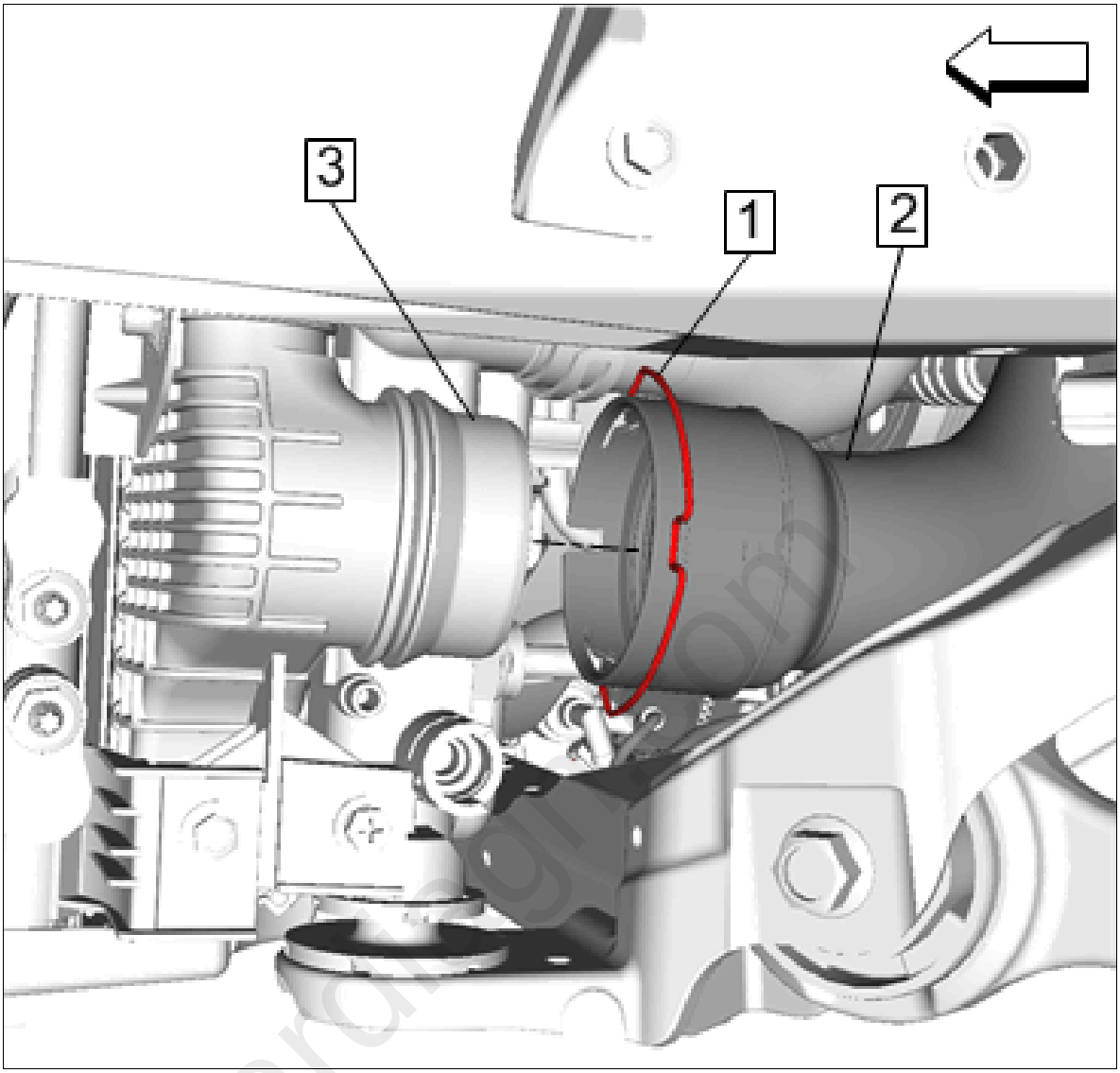


Courtesy of GENERAL MOTORS COMPANY

2. Remove Charge Air Cooler Inlet Air Tube Bolt (1) (Qty: 2)

3. Remove Charge Air Cooler Inlet Air Tube (2)

Fig 2: Retainer Spring

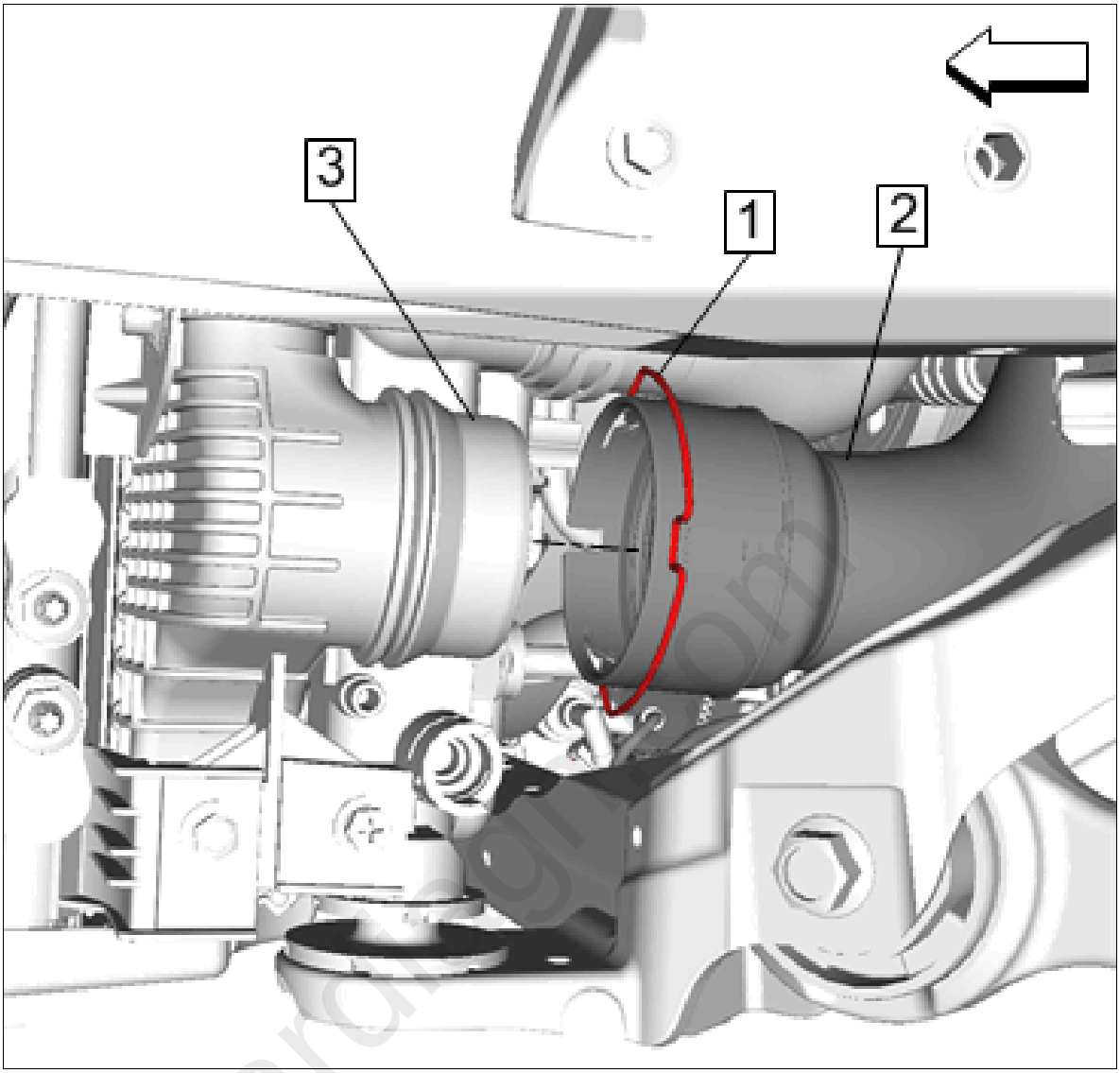


Courtesy of GENERAL MOTORS COMPANY

4. Release Retainer Spring (1)
5. Remove Charge Air Cooler Inlet Air Tube (2) at Charge Air Cooler (3)

REPAIR INSTRUCTIONS > CHARGE AIR COOLER INLET AIR TUBE REPLACEMENT > INSTALLATION PROCEDURE

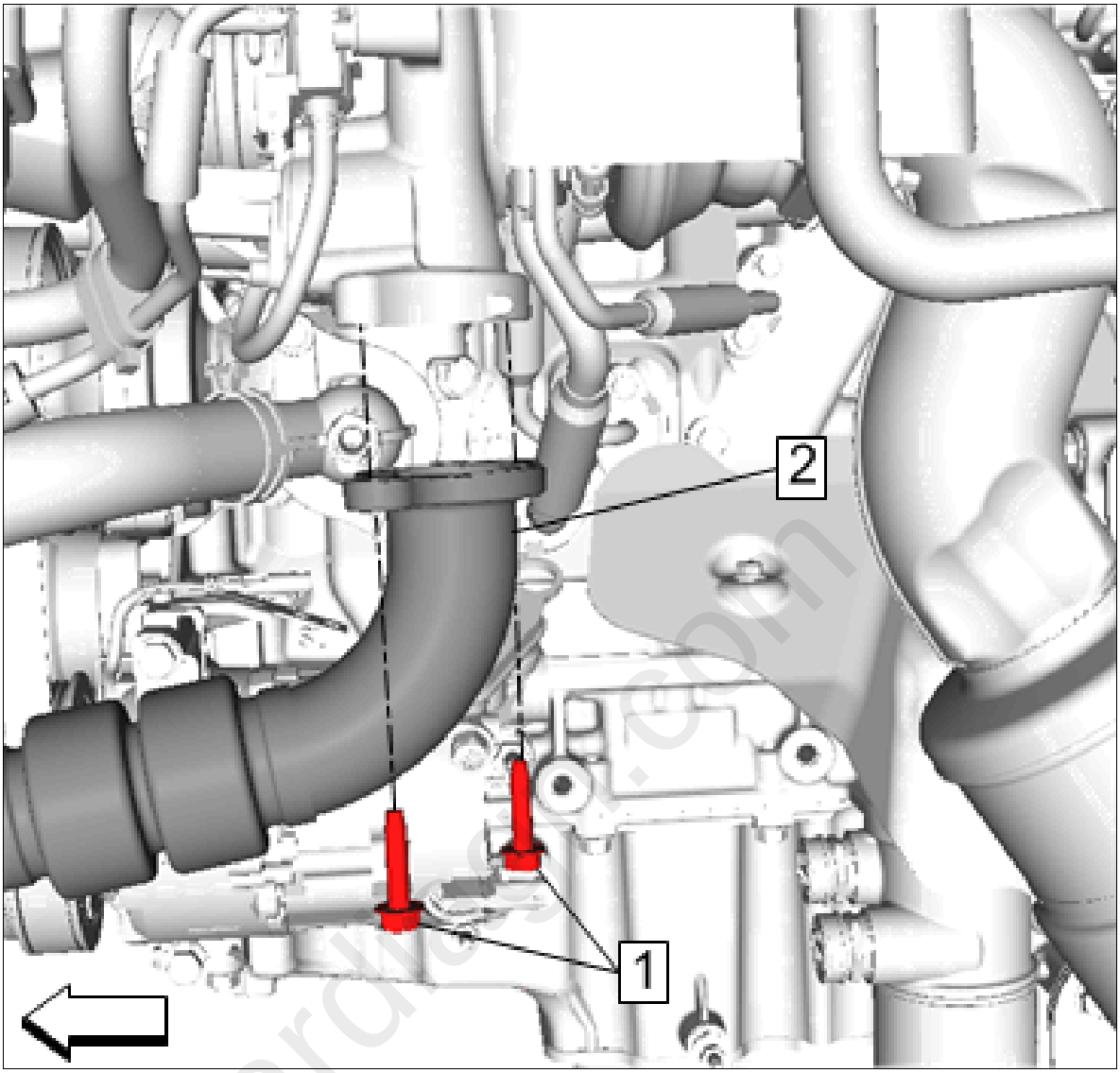
Fig 1: Charge Air Cooler Inlet Air Tube At Charge Air Cooler



Courtesy of GENERAL MOTORS COMPANY

1. Install Charge Air Cooler Inlet Air Tube (2) at Charge Air Cooler (3)
2. Engage Retainer Spring (1)

Fig 2: Charge Air Cooler Inlet Air Tube



Courtesy of GENERAL MOTORS COMPANY

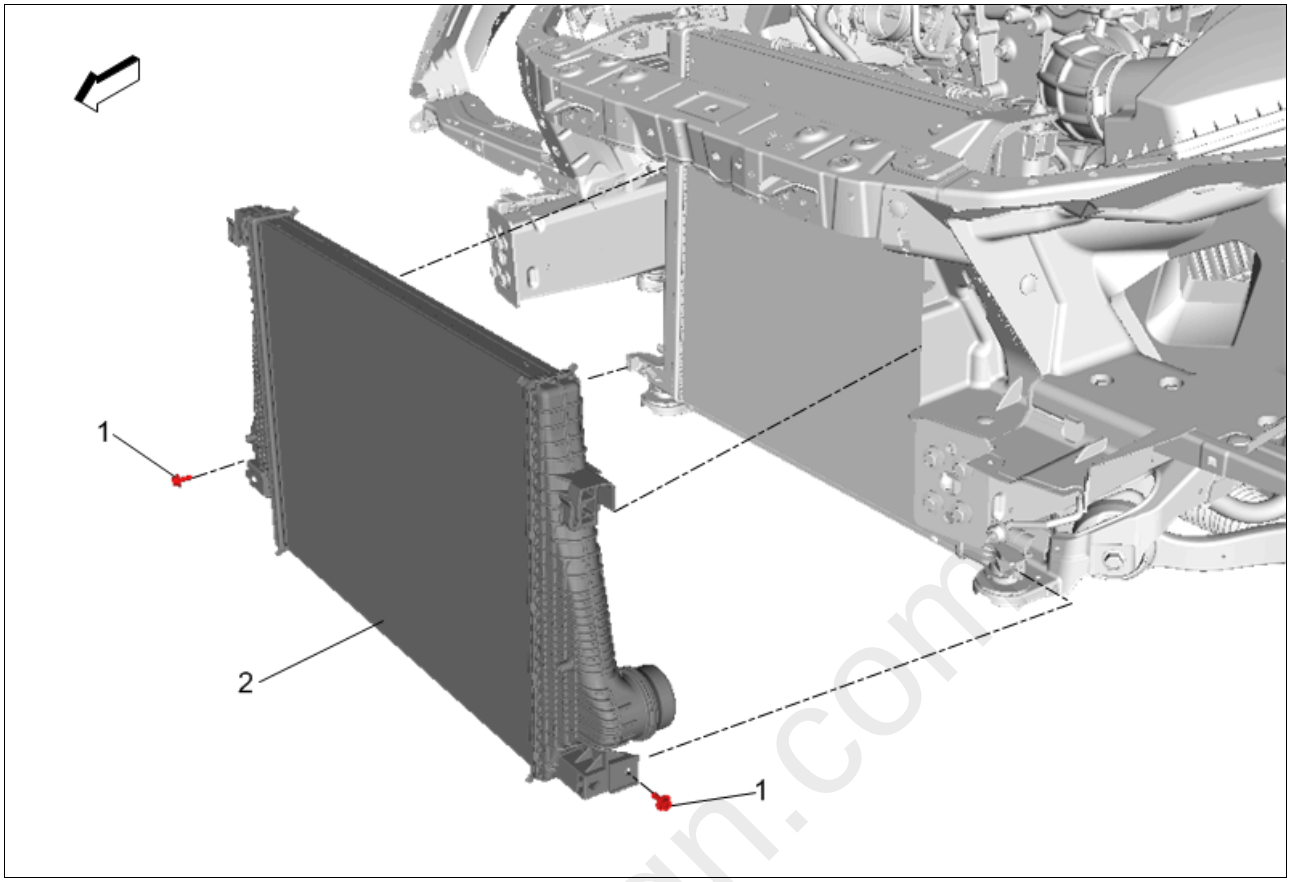
3. Install Charge Air Cooler Inlet Air Tube (2)

> ⚠ *CAUTION:*
>
> *Refer to Fastener Caution .*

4. Install Charge Air Cooler Inlet Air Tube Bolt (1) (Qty: 2) to 22 N.m (16 lb ft)
5. Install Front Bumper Fascia Replacement

REPAIR INSTRUCTIONS > CHARGE AIR COOLER RADIATOR REPLACEMENT

Fig 1: Charge Air Cooler Radiator



Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Air Conditioning Condenser Replacement (LTG with Y4Q) Air Conditioning Condenser Replacement (LTG without Y4Q) 2. Disconnect Charge Air Cooler Outlet Air Tube at Charge Air Cooler - Charge Air Cooler Outlet Air Tube Replacement 3. Disconnect Charge Air Cooler Inlet Air Tube at Charge Air Cooler - Charge Air Cooler Inlet Air Tube Replacement	
1	Charge Air Cooler Bolt (Qty: 2) *CAUTION:* *Refer to Fastener Caution .* **Tighten**

cardiagn.com

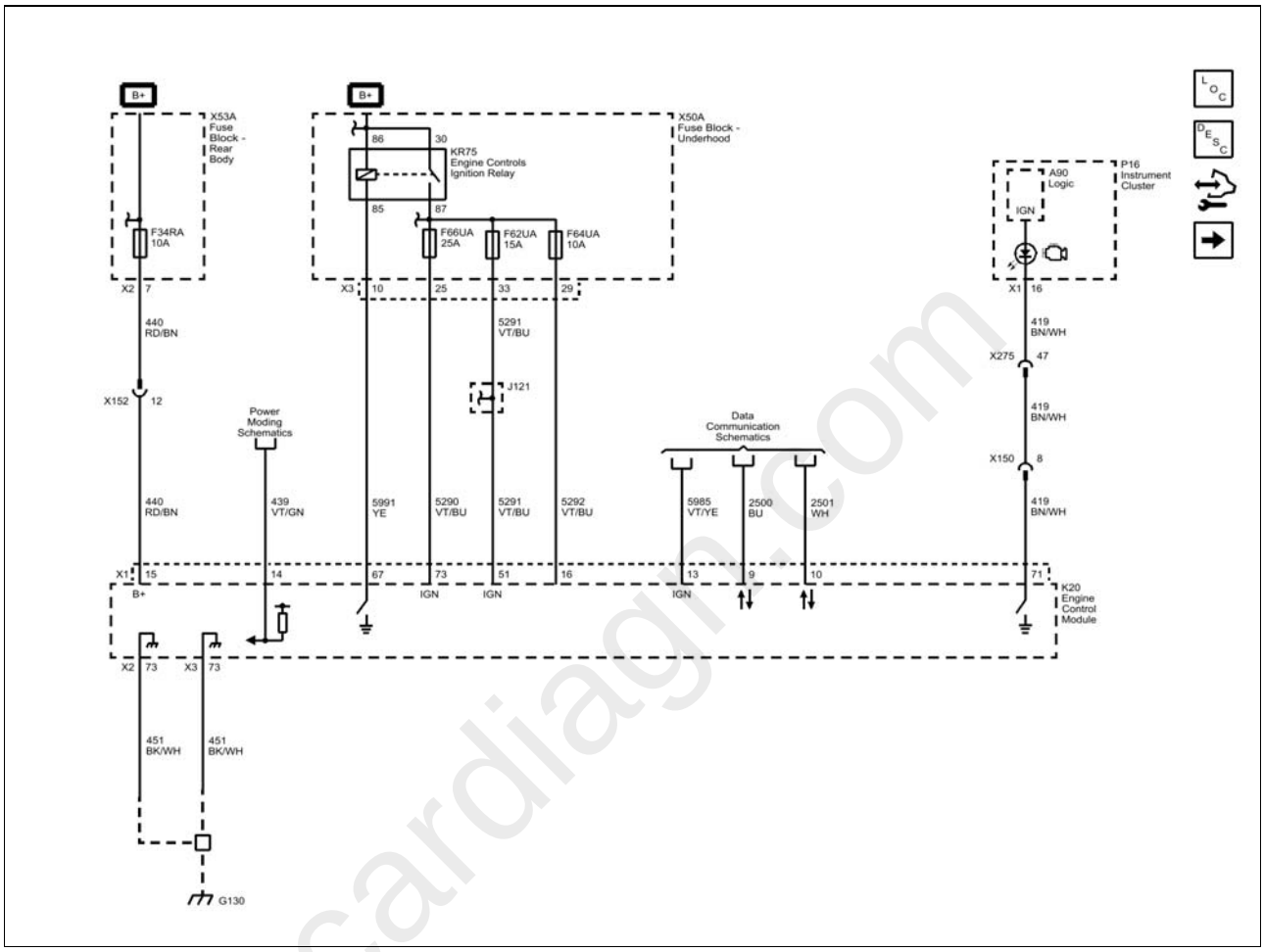
	9 N.m (80 lb in)
2	Charge Air Cooler

cardiagn.com

Service Manual: ENGINE CONTROLS AND FUEL - 2.0L (LTG)
- SCHEMATIC WIRING DIAGRAMS

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > POWER, GROUND, SERIAL DATA AND MIL

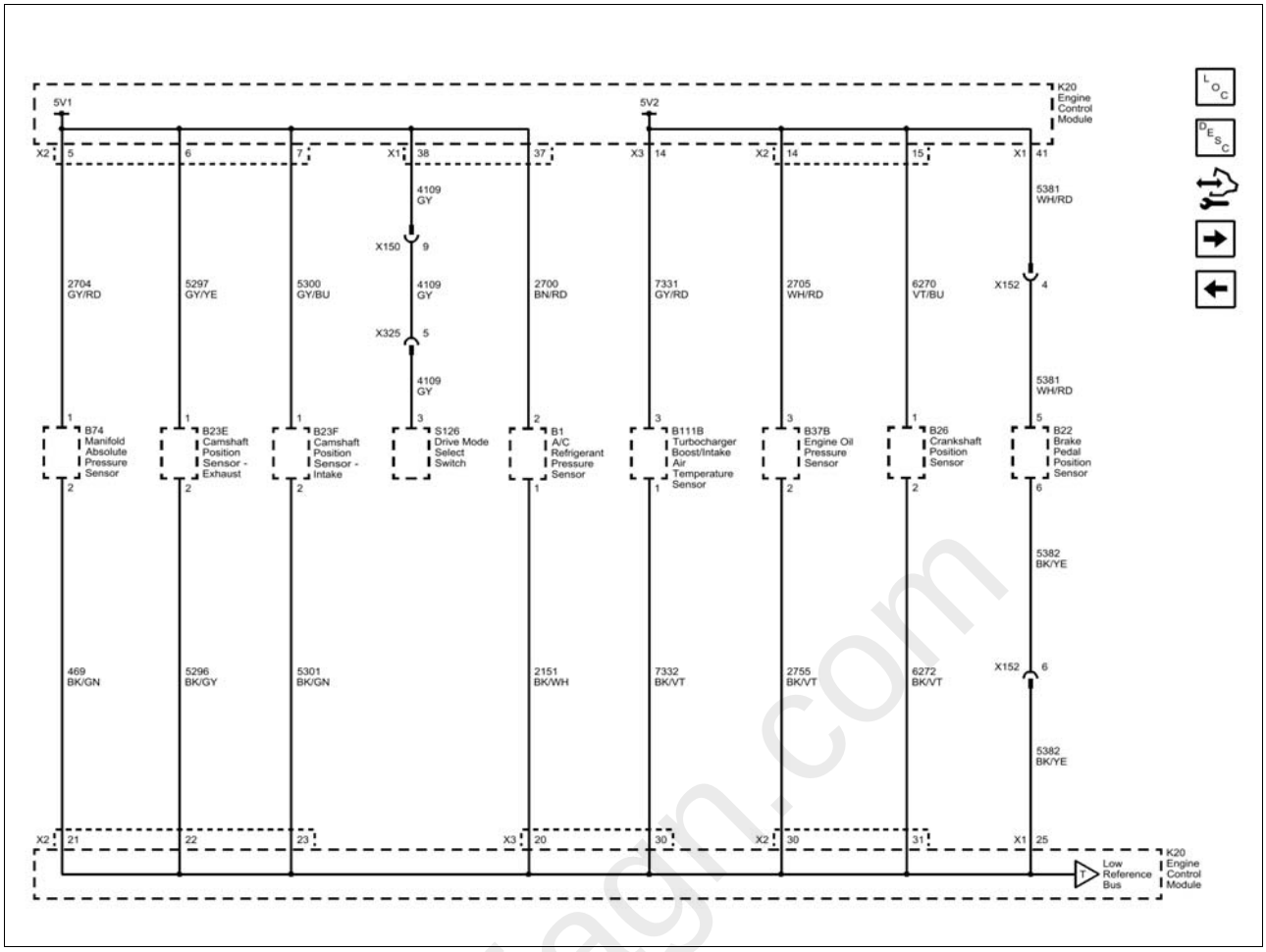
Fig 1: Power, Ground, Serial Data and MIL



Courtesy of GENERAL MOTORS COMPANY

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > 5V1 AND LOW REFERENCE BUS (1 OF 2)

Fig 1: 5V1 and Low Reference Bus (1 of 2)

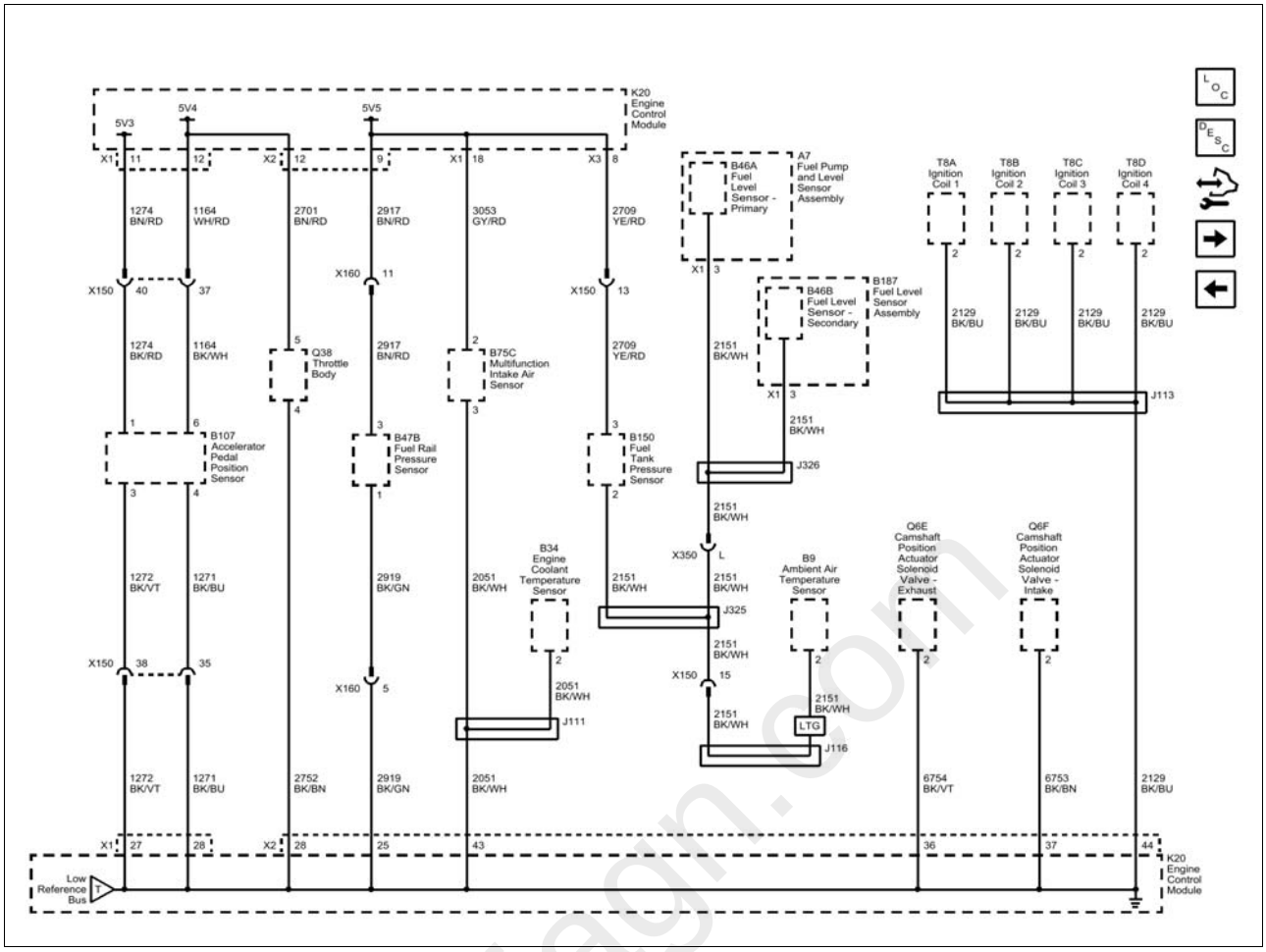


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > 5V2, 5V3, 5V4 AND LOW REFERENCE BUS (2 OF 2)

Fig 1: 5V2, 5V3, 5V4 and Low Reference Bus (2 of 2)

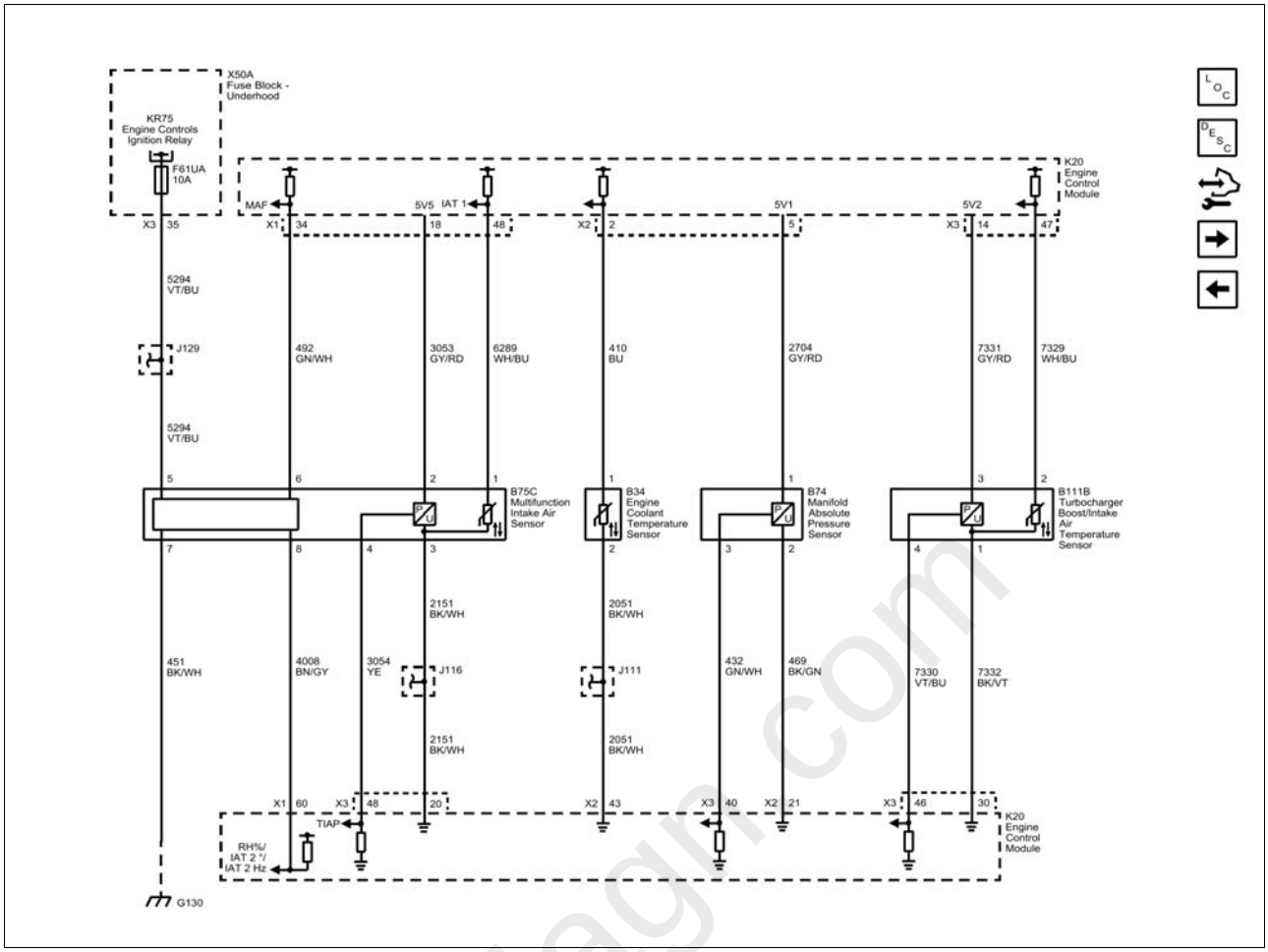


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > ENGINE DATA SENSORS - PRESSURE AND TEMPERATURE

Fig 1: Engine Data Sensors - Pressure and Temperature

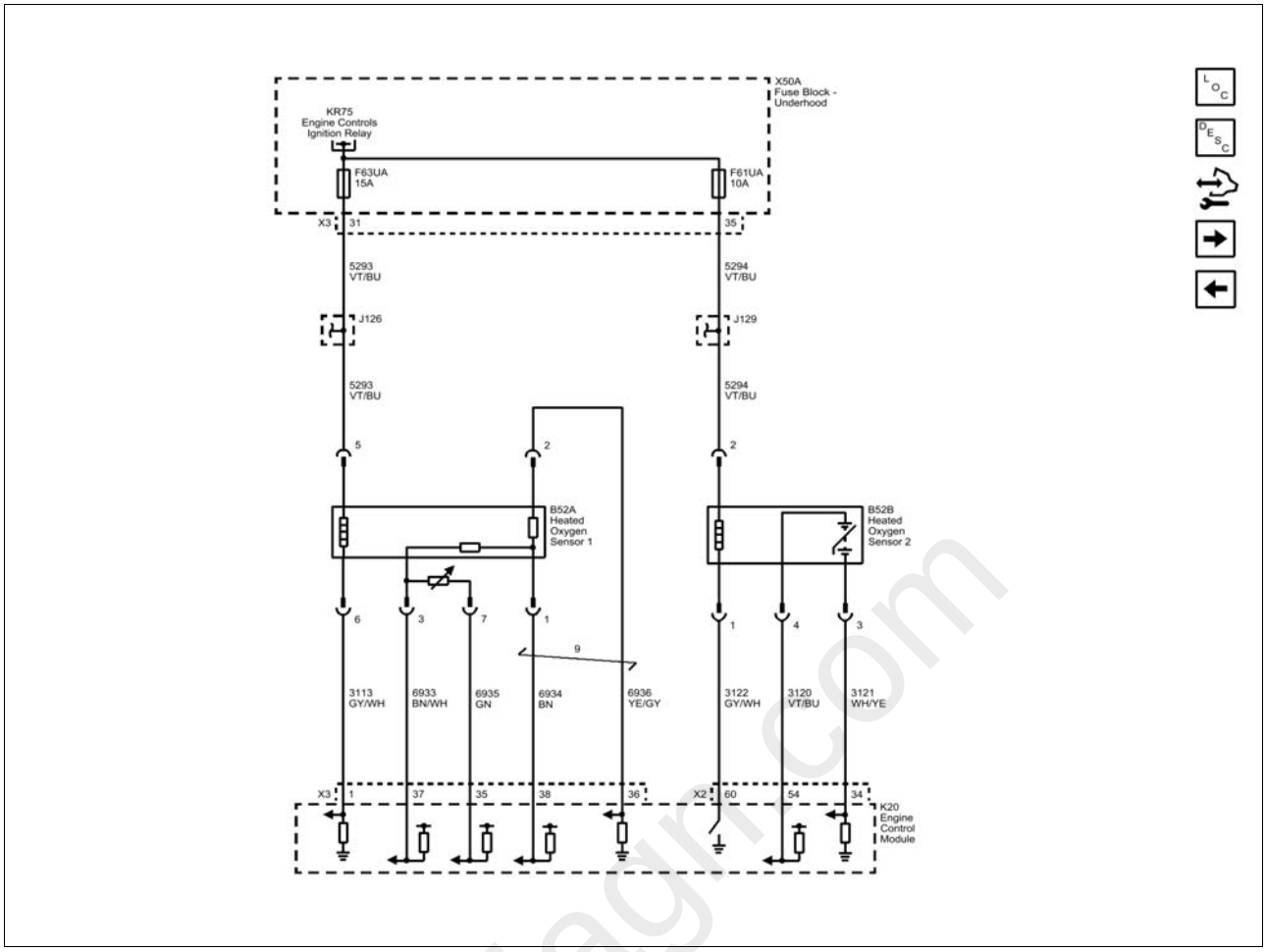


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > ENGINE DATA SENSORS - OXYGEN SENSORS

Fig 1: Engine Data Sensors - Oxygen Sensors

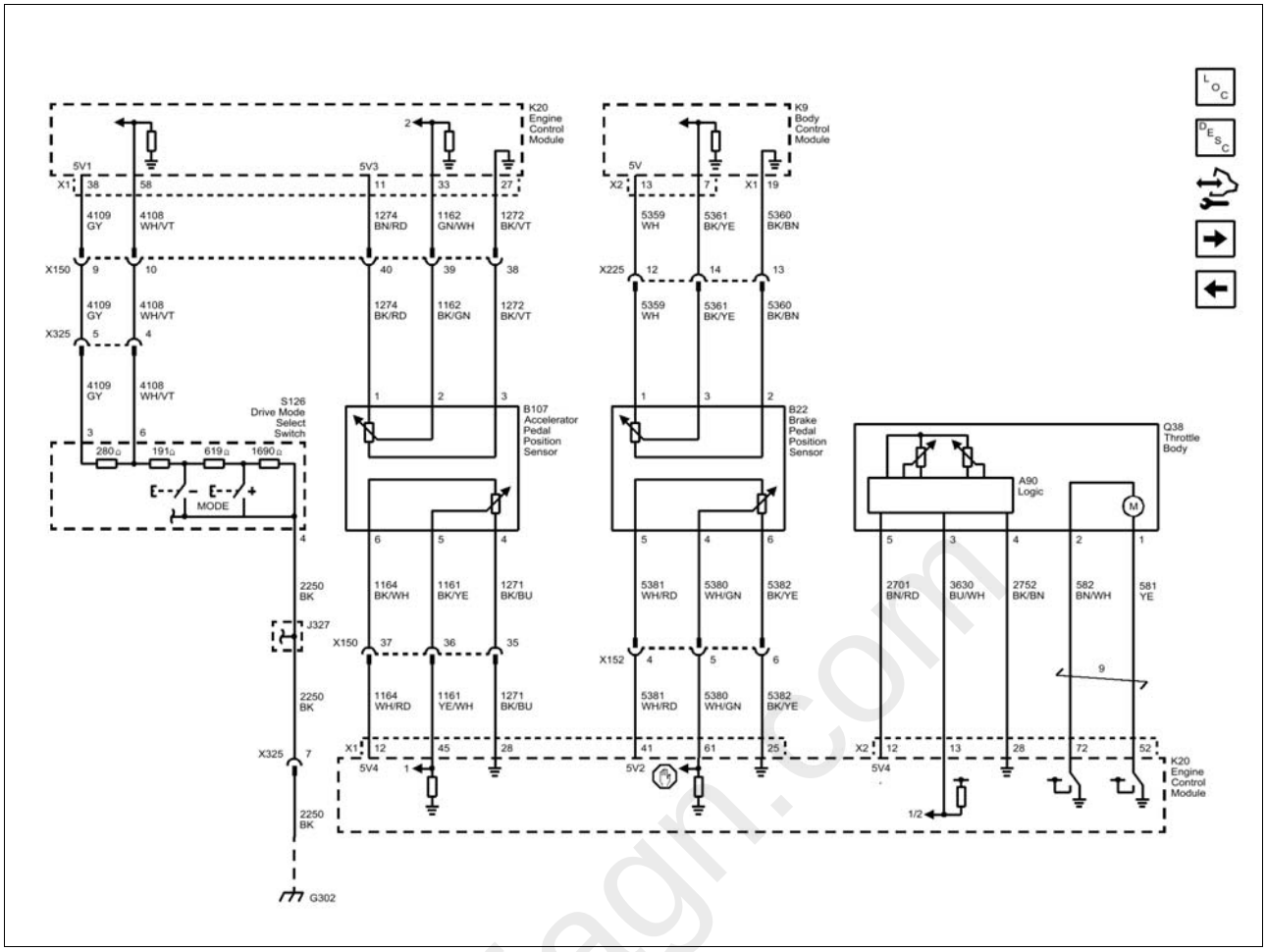


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > ENGINE DATA SENSORS - THROTTLE CONTROLS AND OVERRIDE

Fig 1: Engine Data Sensors - Throttle Controls and Override

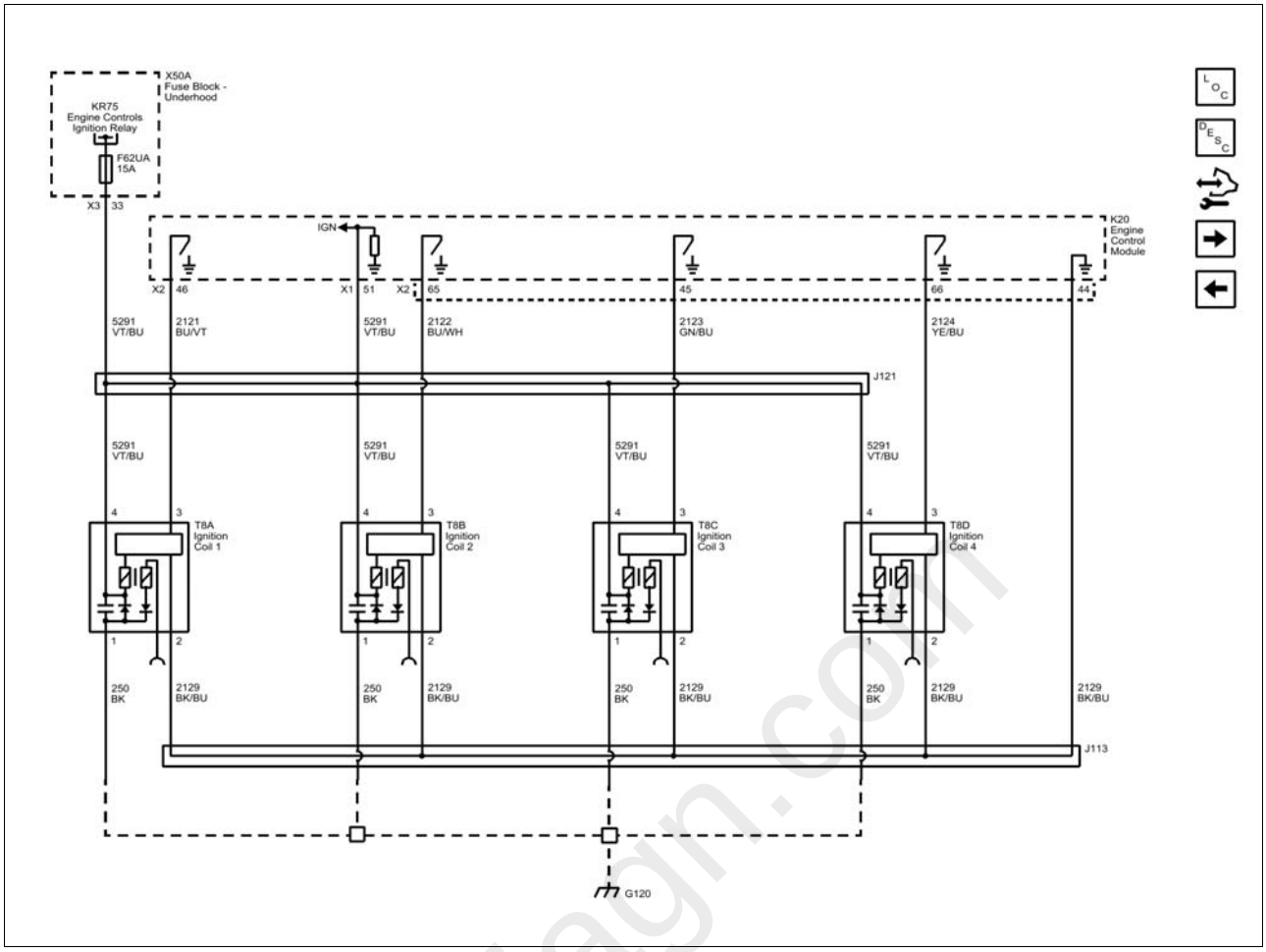


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > IGNITION CONTROLS - IGNITION SYSTEM

Fig 1: Ignition Controls - Ignition System

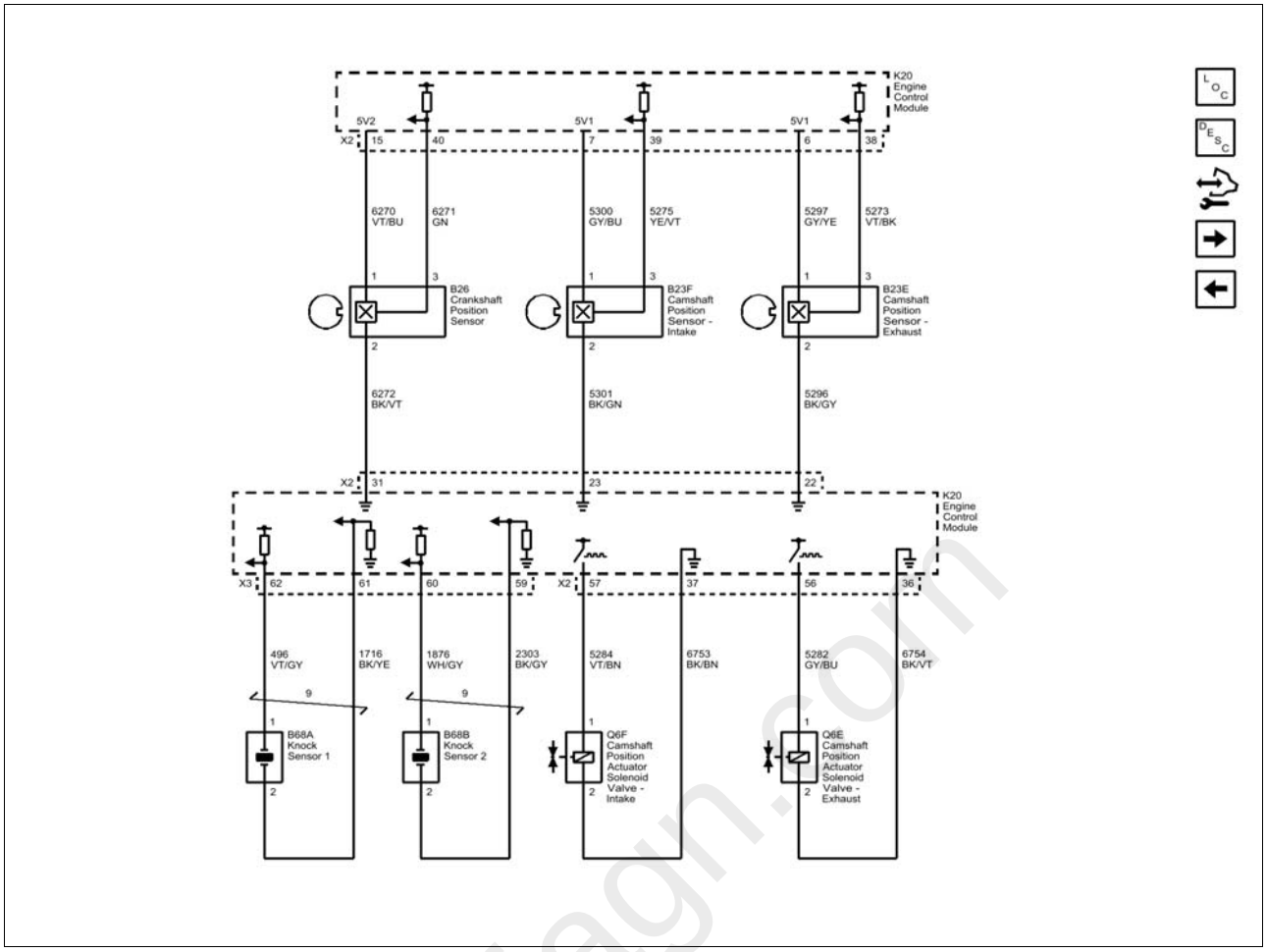


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > IGNITION CONTROLS - CAMSHAFT SOLENOIDS AND IGNITION SENSORS

Fig 1: Ignition Controls - Camshaft Solenoids and Ignition Sensors

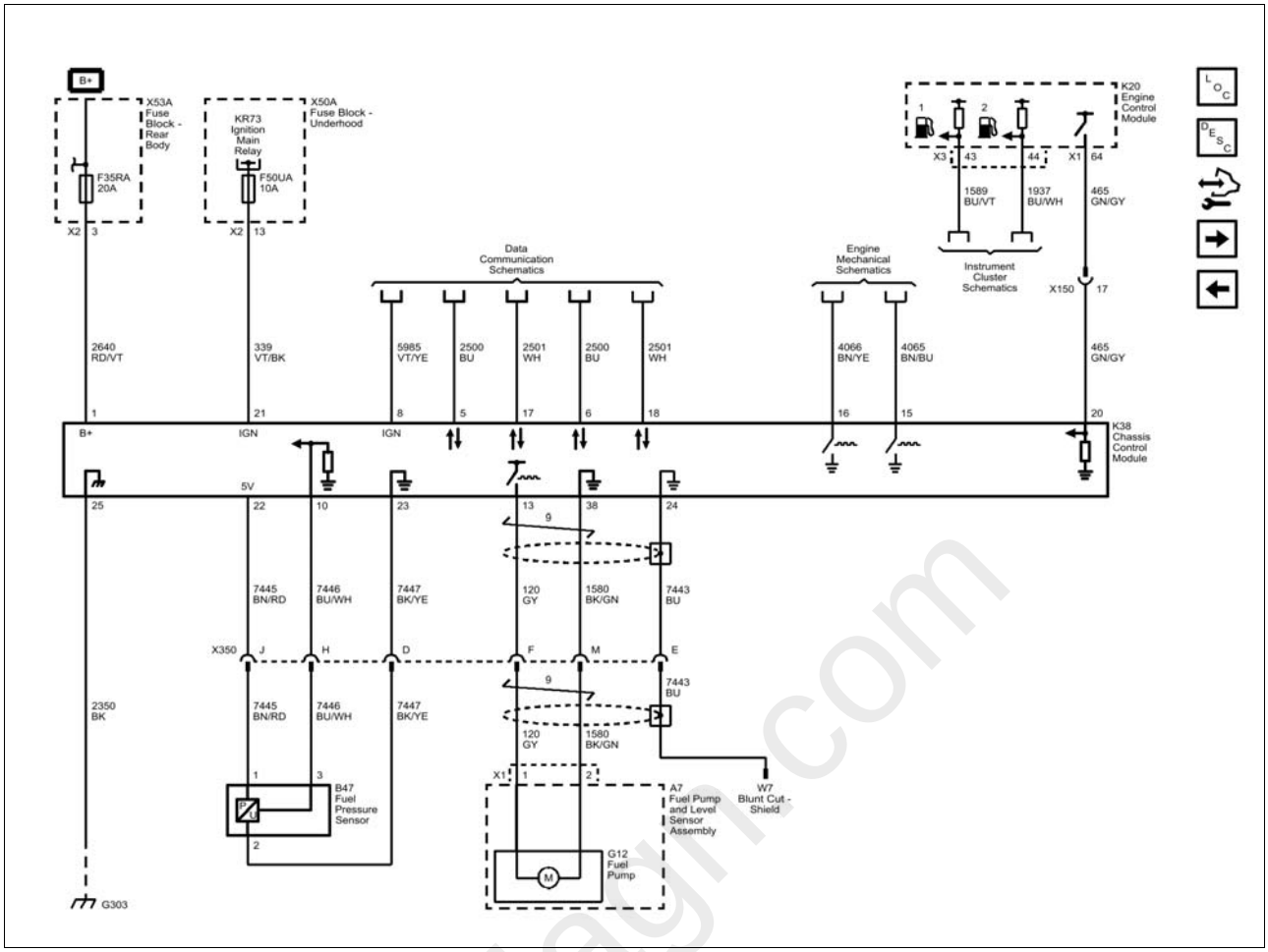


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > FUEL CONTROLS - FUEL PUMP CONTROLS

Fig 1: Fuel Controls - Fuel Pump Controls

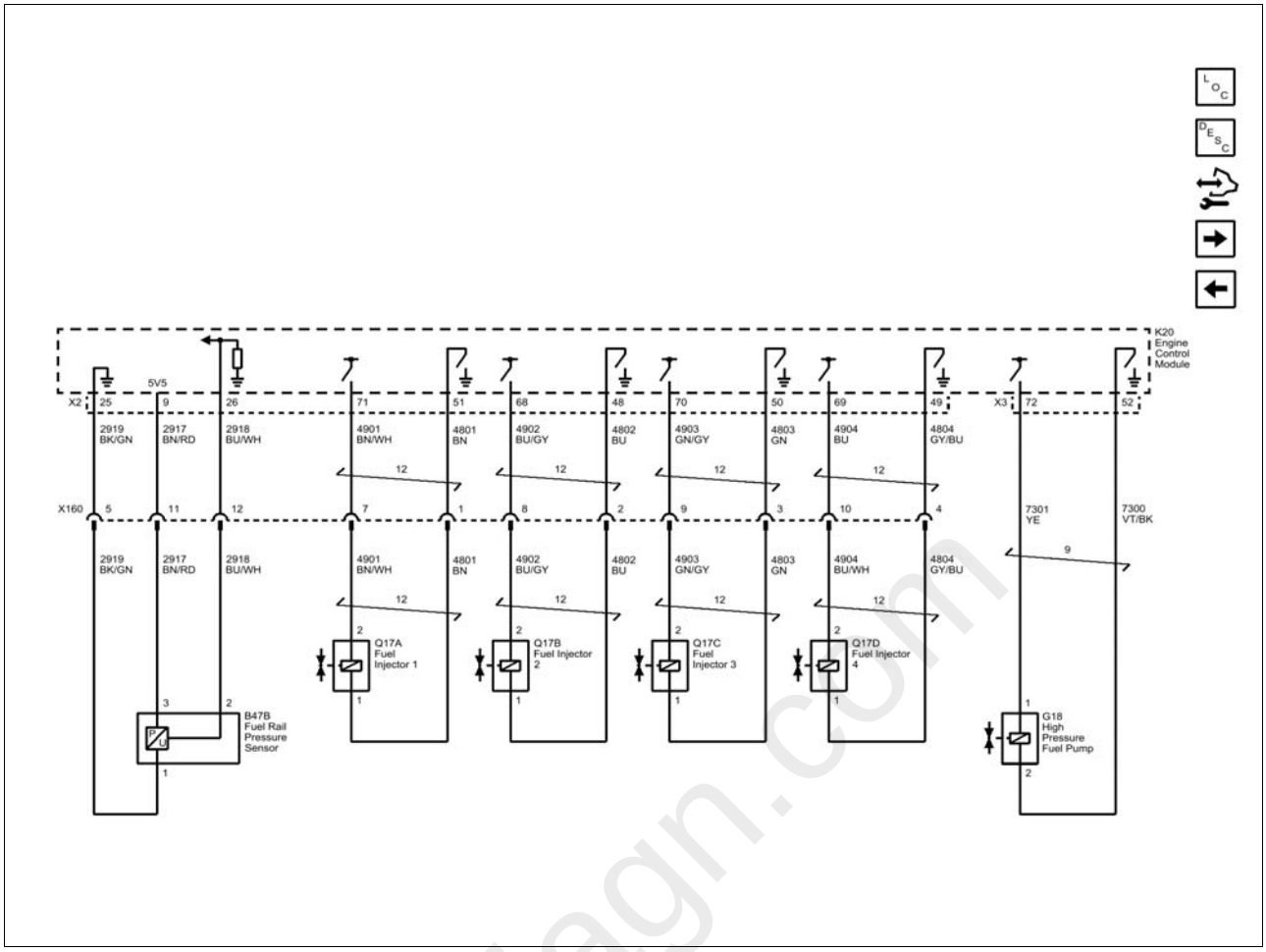


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > FUEL CONTROLS - FUEL INJECTORS AND HIGH PRESSURE CONTROL

Fig 1: Fuel Controls - Fuel Injectors and High Pressure Control

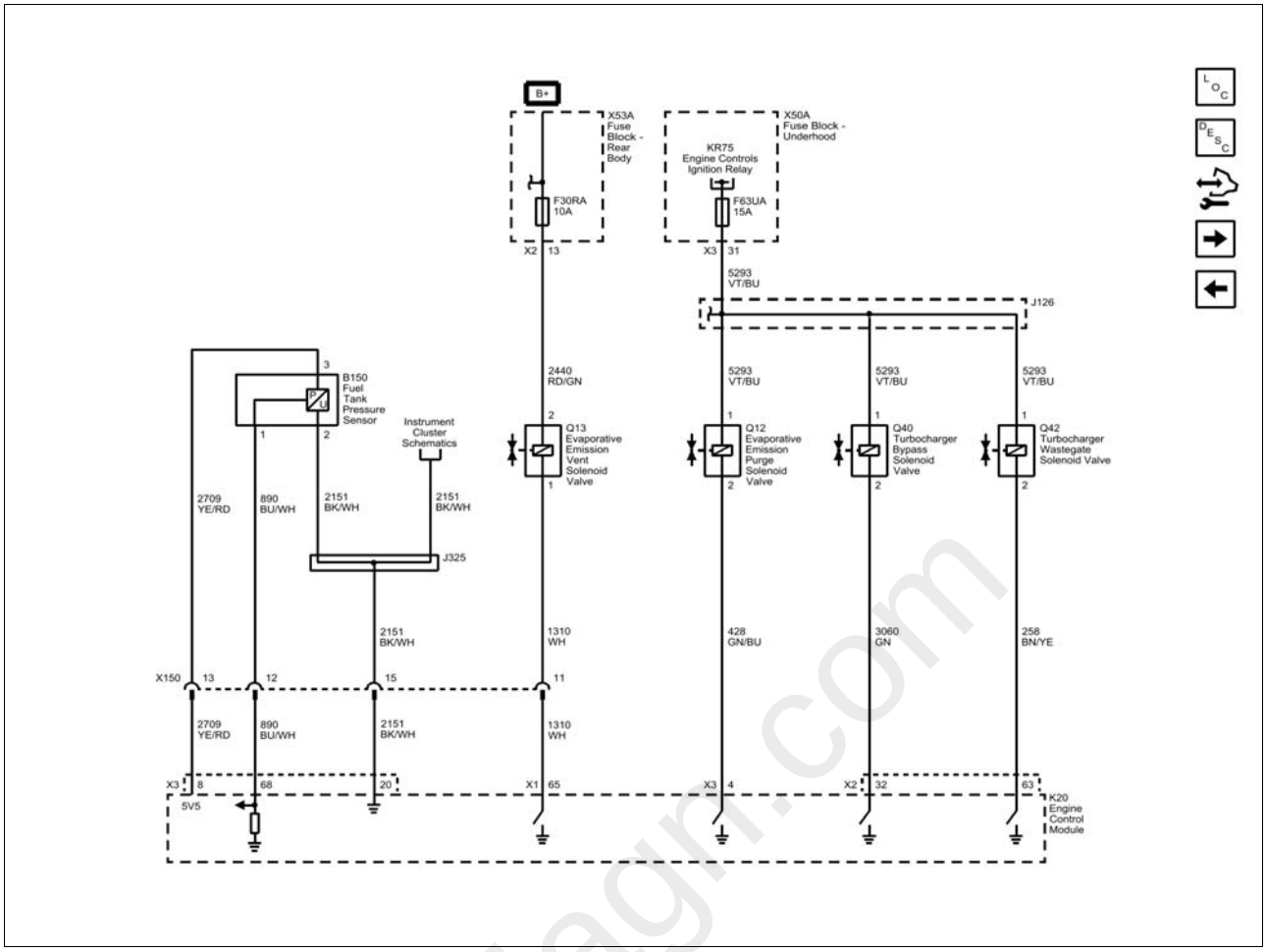


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > FUEL CONTROLS - EVAPORATIVE EMISSION AND TURBOCHARGER CONTROLS

Fig 1: Fuel Controls - Evaporative Emission and Turbocharger Controls

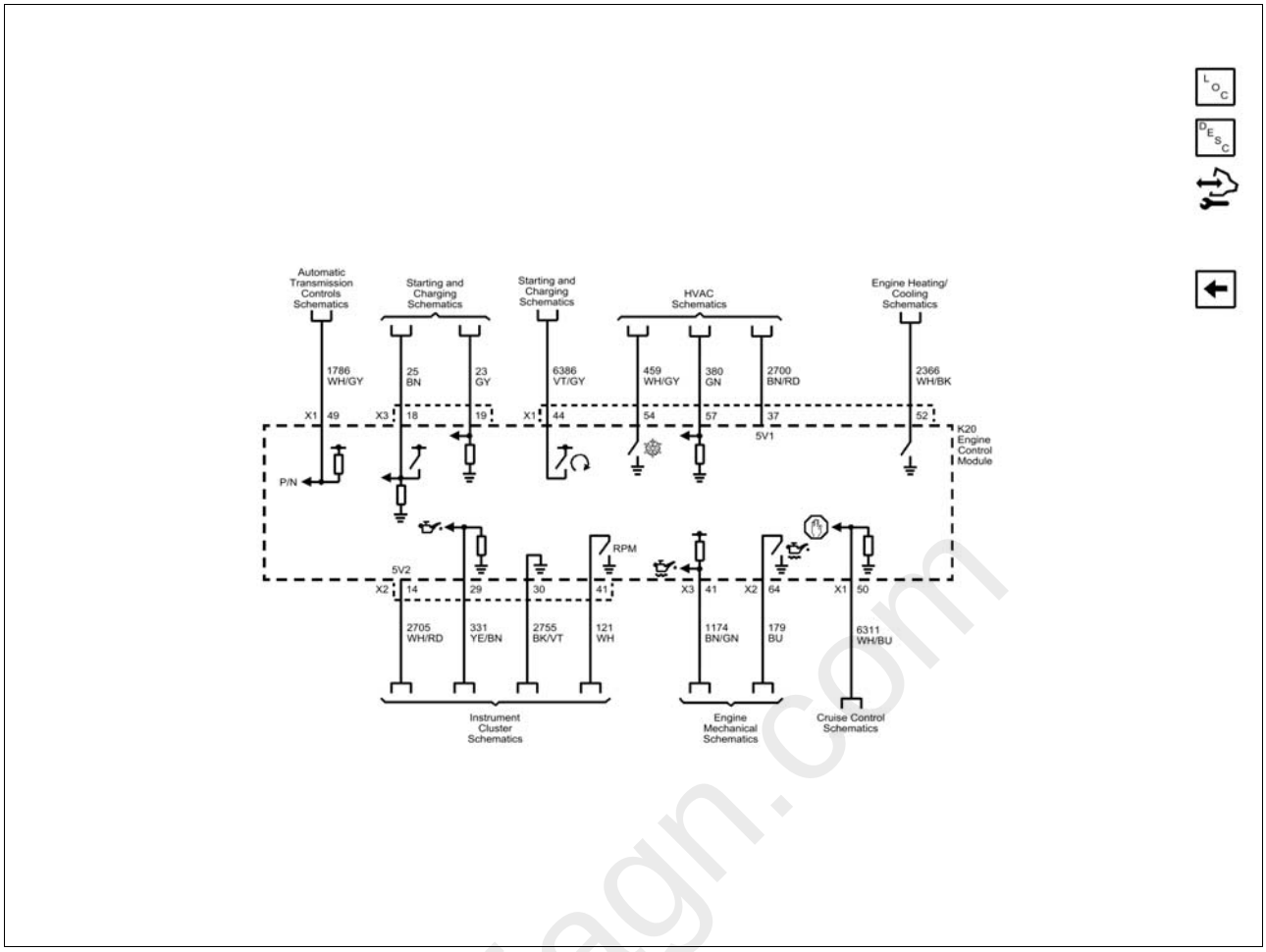


Courtesy of GENERAL MOTORS COMPANY

cardiagn.com

SCHEMATIC WIRING DIAGRAMS > ENGINE CONTROLS WIRING SCHEMATICS > CONTROLLED/MONITORED SUBSYSTEM REFERENCES

Fig 1: Controlled/Monitored Subsystem References

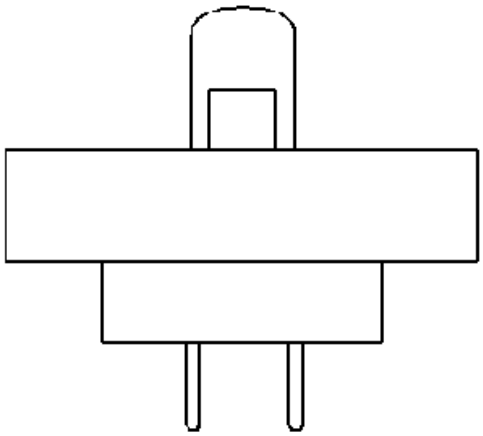
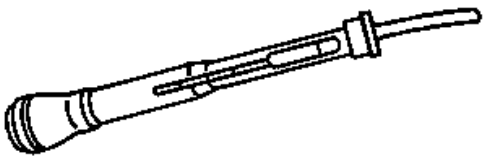


Courtesy of GENERAL MOTORS COMPANY

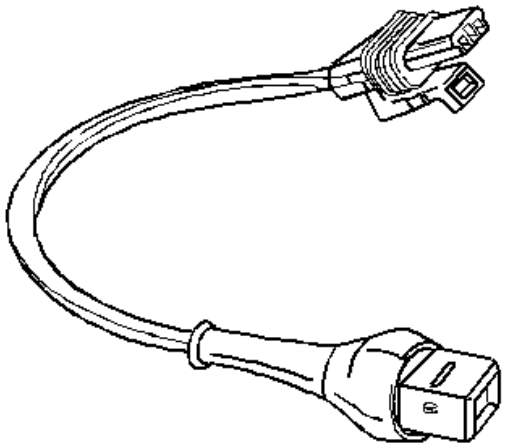
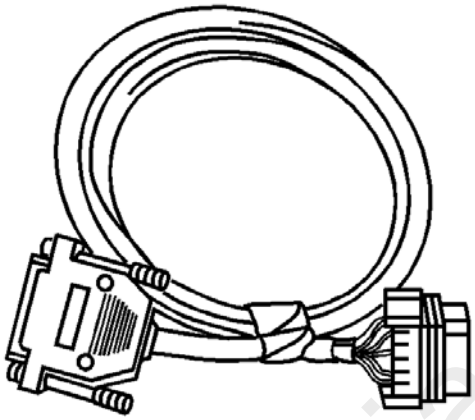
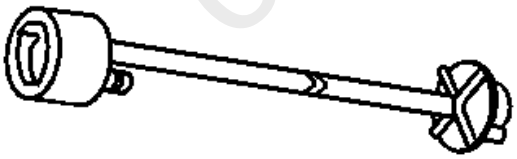
cardiagn.com

Service Manual: ENGINE CONTROLS AND FUEL - 2.0L (LTG)
- SPECIAL TOOLS AND EQUIPMENT

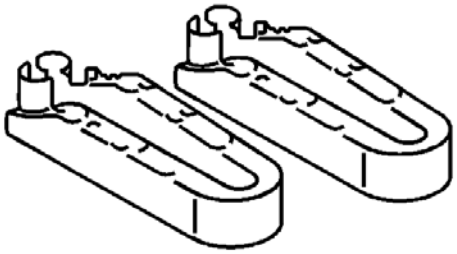
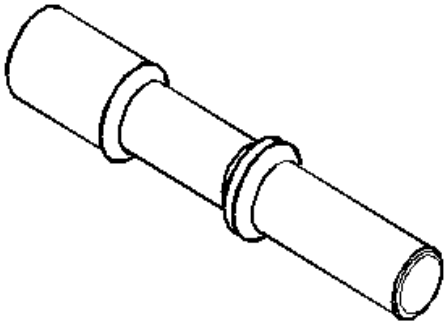
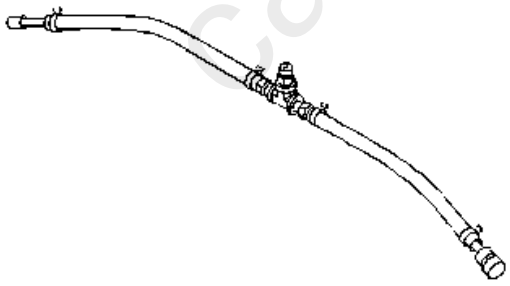
SPECIAL TOOLS AND EQUIPMENT > SPECIAL TOOLS (DIAGNOSTIC TOOLS)

Illustration	Tool Number/Description
	CH-34730-2C J-34730-2C Injector Test Lamp
	CH-37287-1A Fuel Pressure Gauge Adapter 3/8"
	CH-38641-B J-38641-B Diesel Fuel Quality Tester

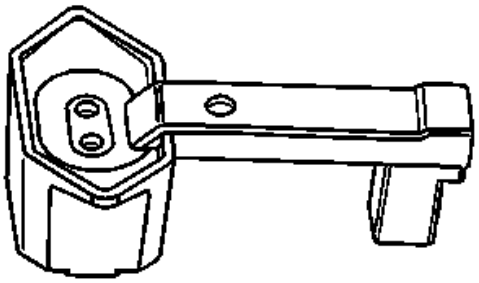
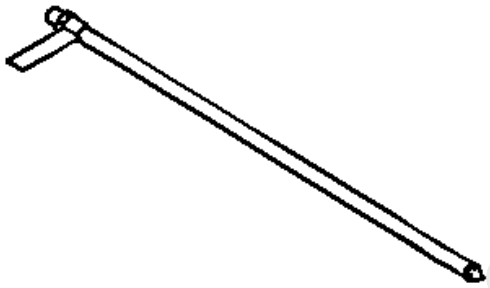
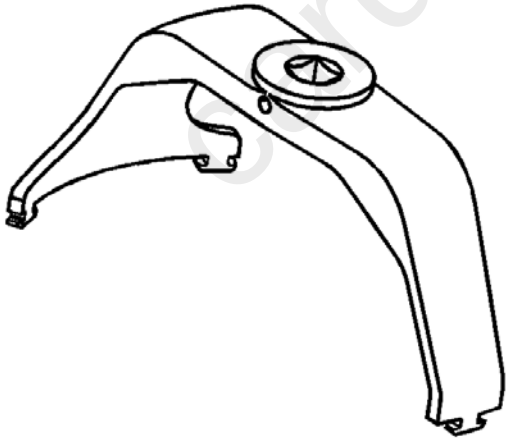
cardiagn.com

	CH-39021-301 J-39021-301 Fuel Injector Harness Adapter
	CH-39021-460 J-39021-460 Fuel Injector Test Adapter
	CH-41415-30 GE-41415-30 J-41415-30 Fuel Tank Cap Adapter

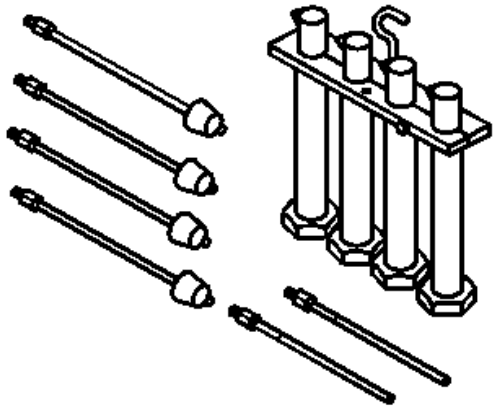
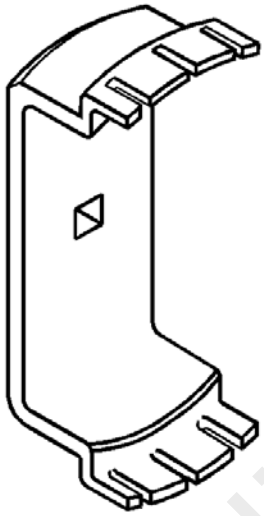
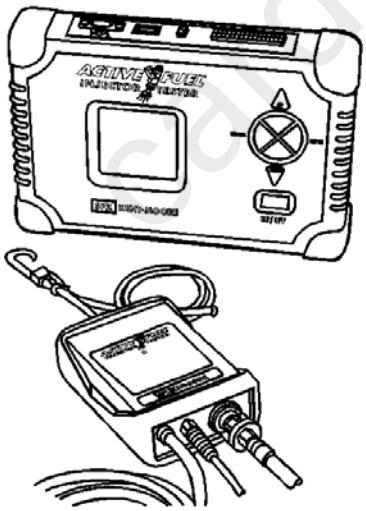
cardiagn.com

	CH-41769 J-41769 Fuel Line Quick Disconnect Tool
	CH-42960-2 J-42960-2 Fuel Flapper Door Holder
	CH-42982 J-42982 Fuel Pressure Gauge Adapter

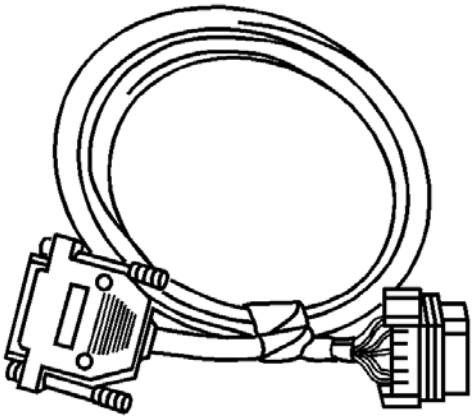
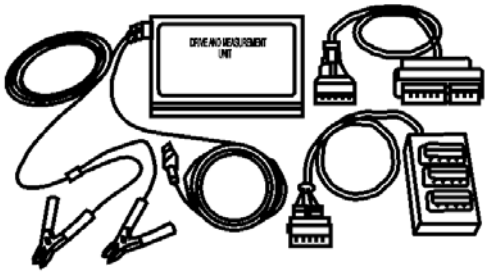
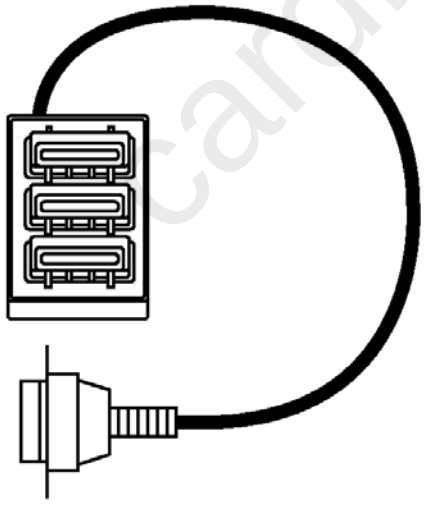
cardiagn.com

	CH-44175-A J-44175-A Fuel Composition Tester
	CH-45004 J-45004 Fuel Tank Drain Hose
	CH-45722 J-45722 Fuel Sender Lock Ring Wrench

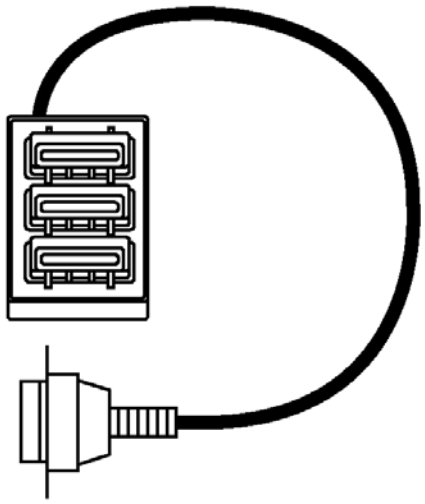
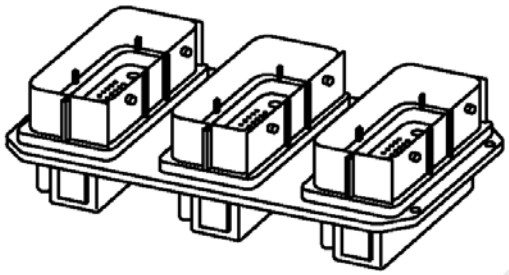
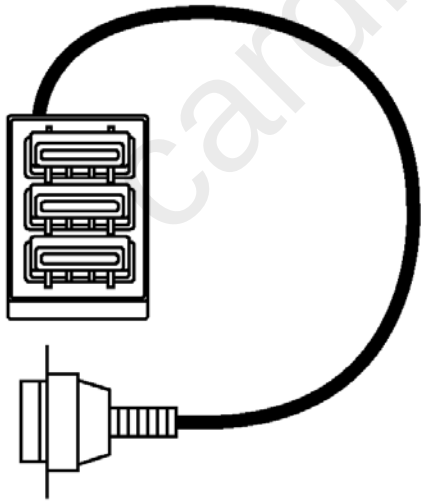
cardiagn.com

	CH-45873 J-45873 Fuel Return Volume Test Kit
	CH-47717 Lock Ring Wrench
	CH-47976 Active Fuel Injector Tester (AFIT)

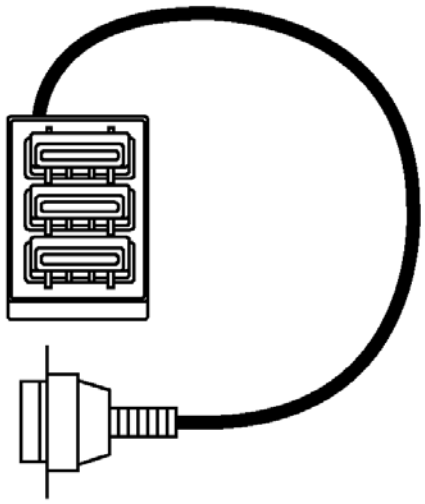
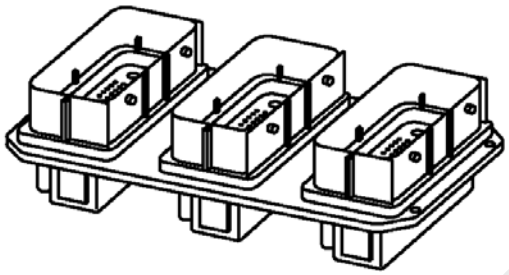
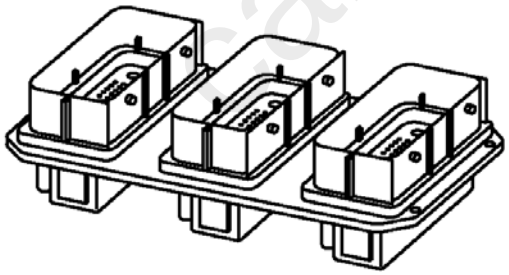
sadiagn.com

	CH-47976-75 Fuel Injector Harness Adapter
	CH-47976-500A Active Fuel Injection Tester (AFIT) SIDI Adapter Kit
	CH-47976-502A AFIT SIDI E92 G2A Adapter Cable

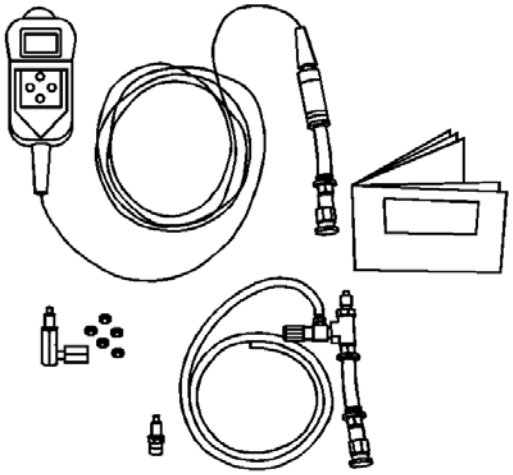
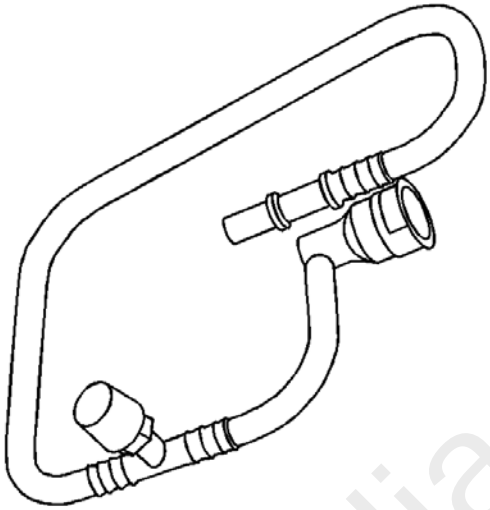
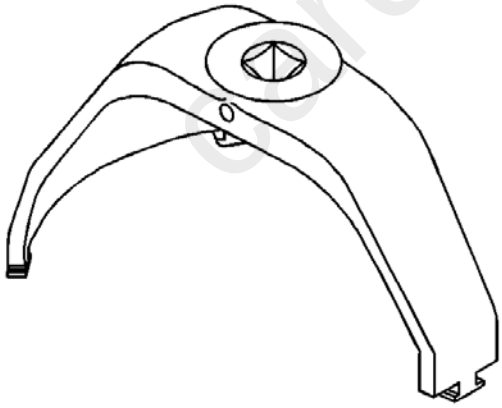
cardiagn.com

	CH-47976-503 AFIT SIDI E80 G3 Adapter Cable
	CH-47976-504 E92/E39A G2B Start/Stop Adapter
	CH-47976-509 AFIT SIDI E81 G4 Adapter Cable

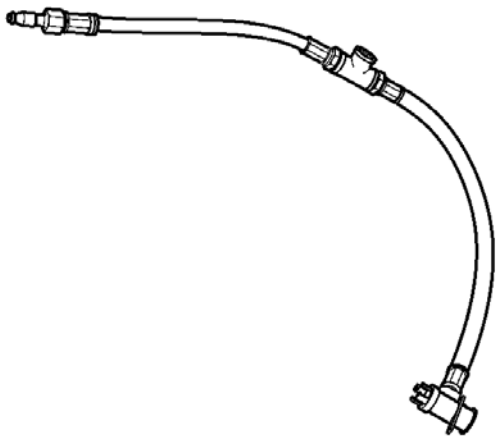
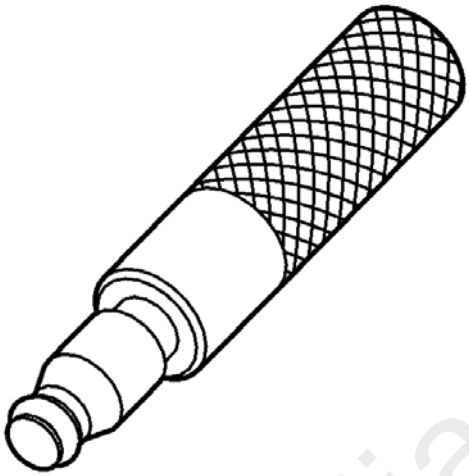
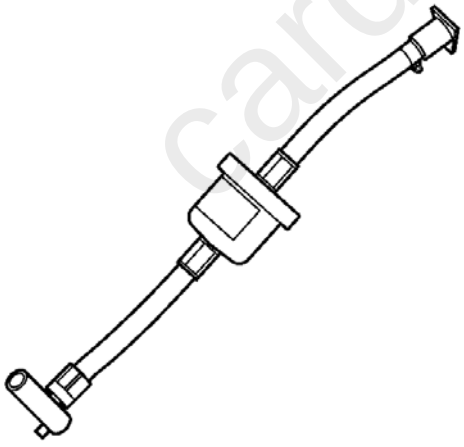
cardiagn.com

	CH-47976-511 AFIT SIDI E82 G5 Adapter Cable
	CH-47976-512 E80 G3B Stop/Start Adapter
	CH-47976-513 E92 G2C Stop/Start and SENT Adapter

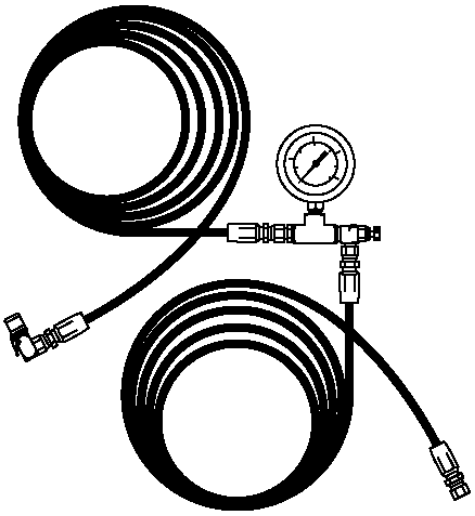
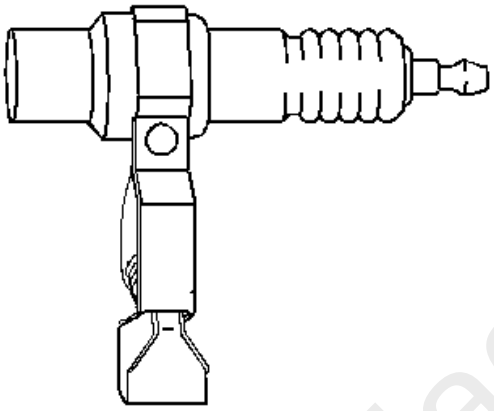
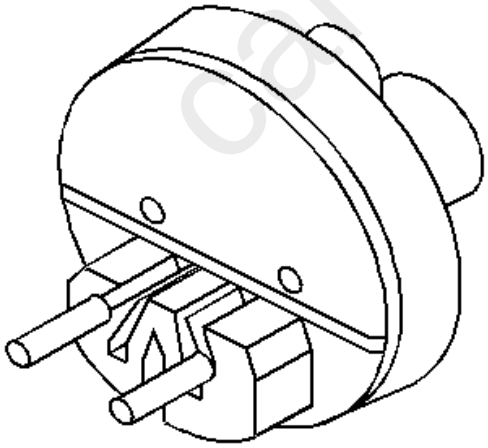
cardiagn.com

	CH-48027 Fuel Pressure Gauge
	CH-48096 EVAP Service Access Port Tool
	CH-48482 Fuel Sender Lock Ring Wrench

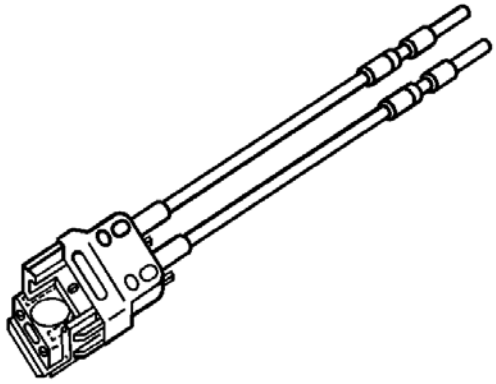
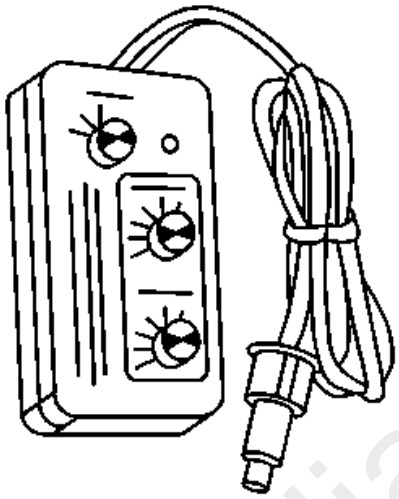
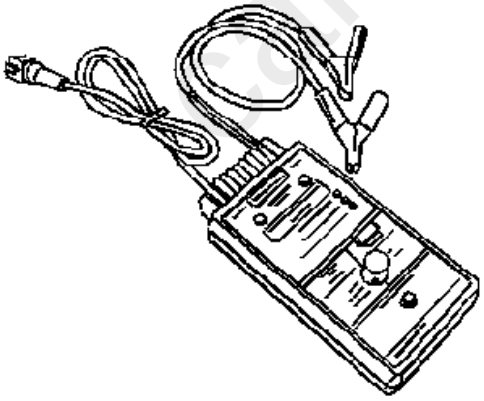
cardiagn.com

	CH-50375 Diesel Injector Return Line Pressure Adapter
	CH-50377-A Injector Return Line Cap
	CH-50378 Injector Return Leakage Test Adapter

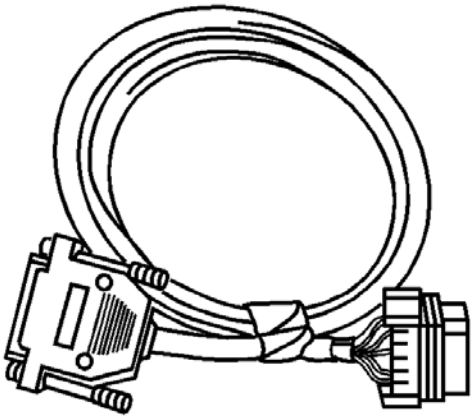
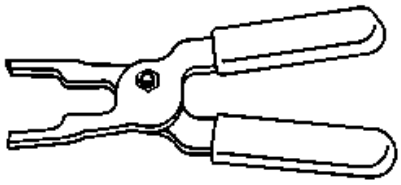
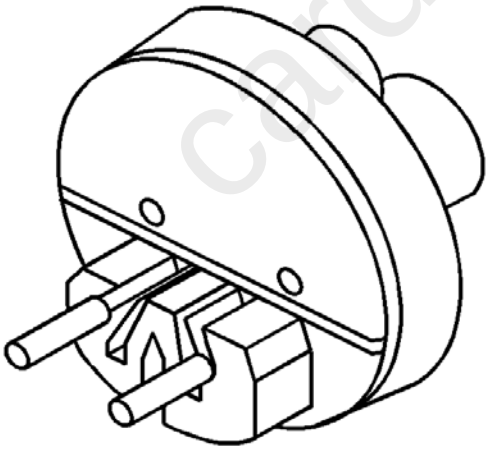
cardiagn.com

	CH-50933 Gauge Assembly, Liquid Propane Gas (LPG)
	EL-26792 J-26792 HEI Spark Tester
	EL-34730-405 J-34730-405 Injector Test Lamp

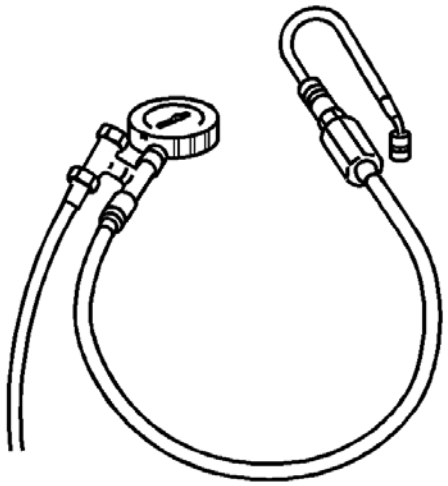
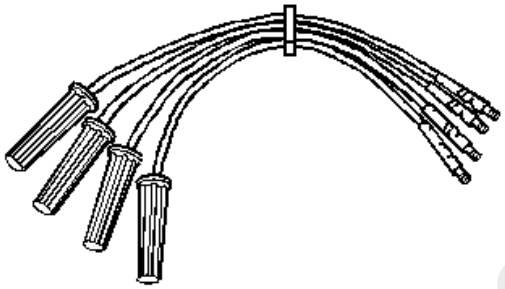
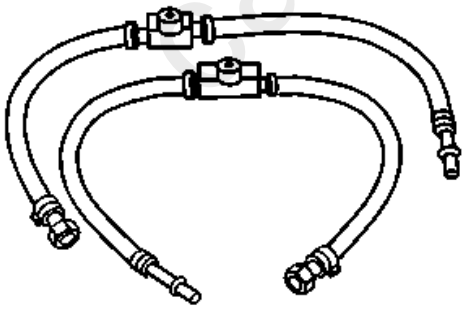
cardiagn.com

	EL-36169-HD Heavy Duty Fused Jumper
	EL-38522-A J-38522-A Variable Signal Generator
	EL-39021 J-39021 Fuel Injector Coil Balance Tester

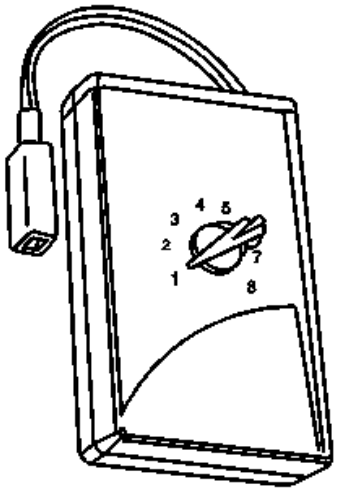
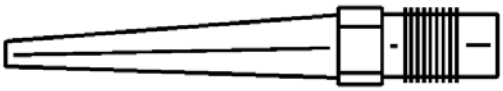
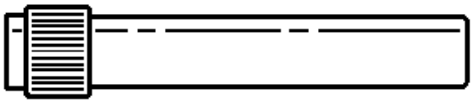
ardiagn.com

	EL-39021-460 J-39021-460 Fuel Injector Test Adapter
	EL-43244 J-43244 Relay Puller Pliers
	EL-44603 J-44603 Injector Test Lamp

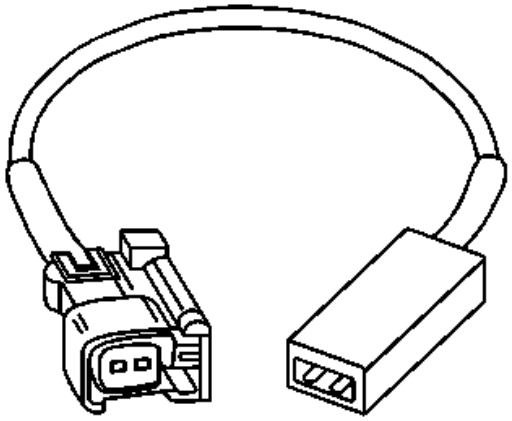
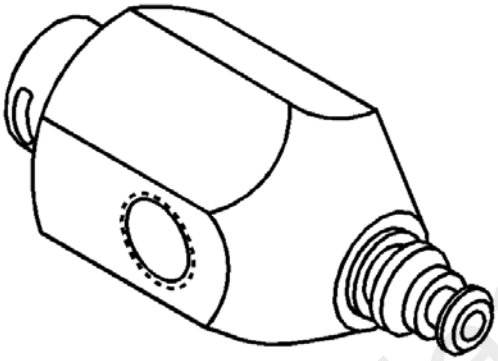
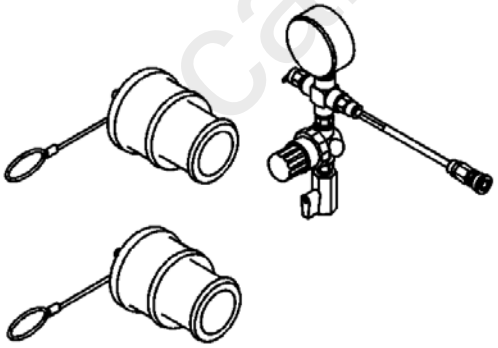
cardiagn.com

	EN-34730-91 J-34730-91 KM-J-34730-91 Pressure Tester
	EN-36012-A J-36012-A Ignition System Diagnosis Harness
	EN-37287 J-37287 Fuel Line Shut-off Adapters

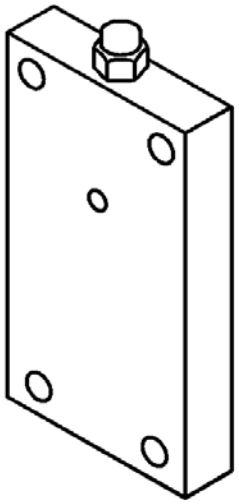
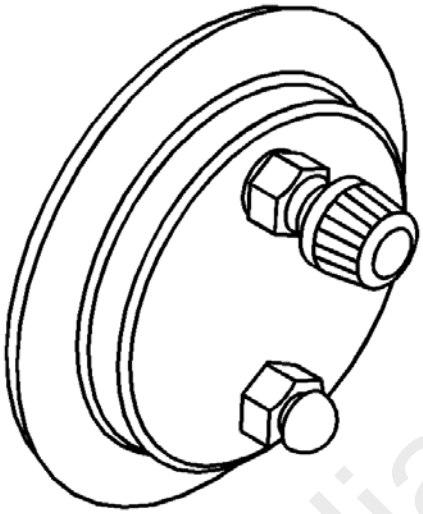
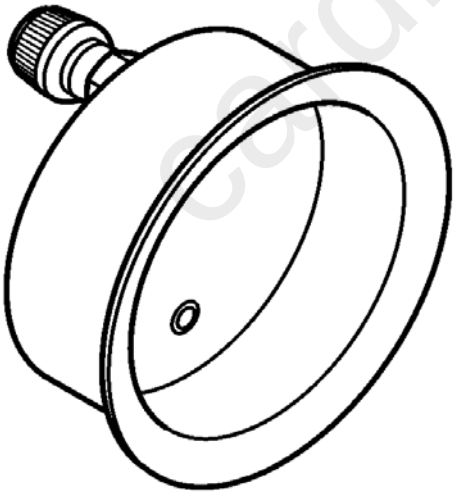
cardiagn.com

	EN-39021-210 J-39021-210 Injector Tester Adapter Box
	EN-41413-311 J-41413-311 EVAP Plug
	EN-41413-VLV J-41413-VLV EVAP Service Port Vent Fitting

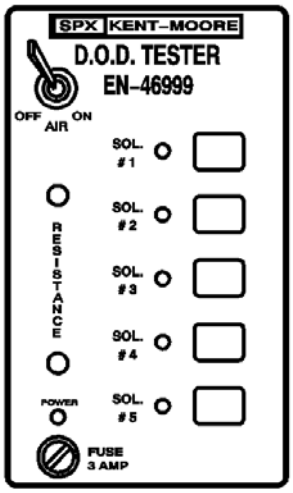
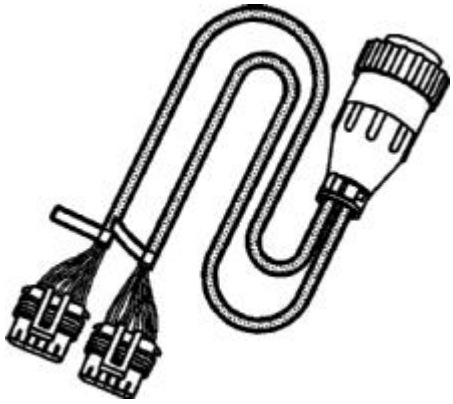
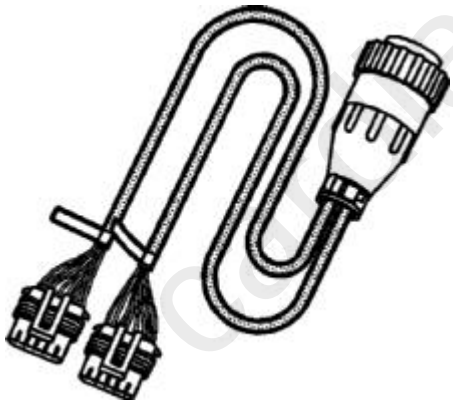
cardiagn.com

	EN-44602 J-44602 Injector Test Adapter
	EN-45873-30 J-45873-30 Injector Flow Test Adapter
	EN-46091 J-46091 Charge Air Cooler Tester

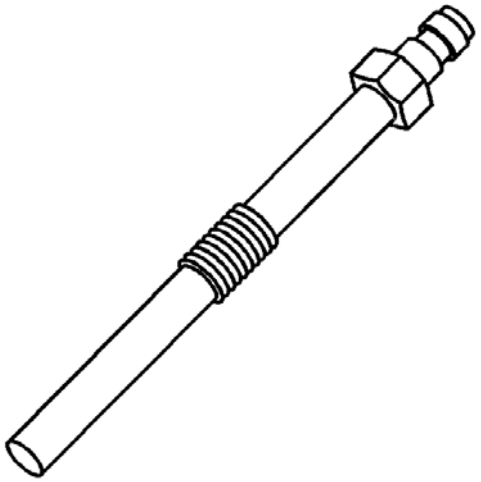
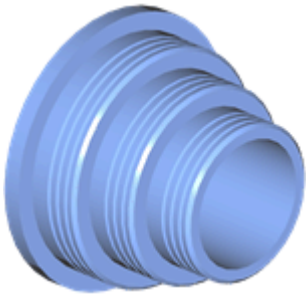
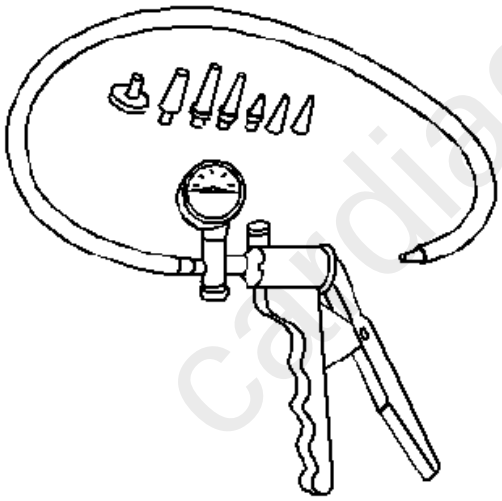
cardiagn.com

	EN-46091-5 J-46091-5 Charge Air Cooler Tester Adapter
	EN-46091-15 J-46091-15 Engine Pressure Test Adapter
	EN-46091-15A J-46091-15A Diesel Engine Pressure Test Adapter

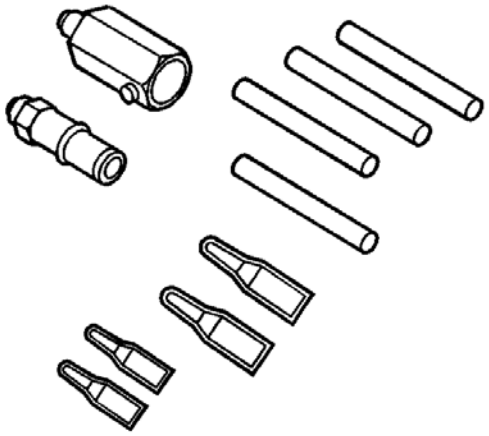
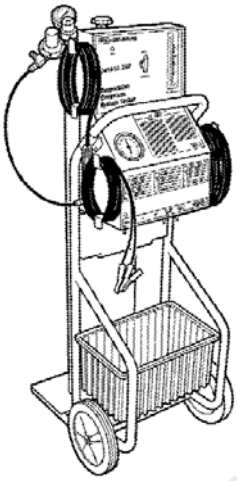
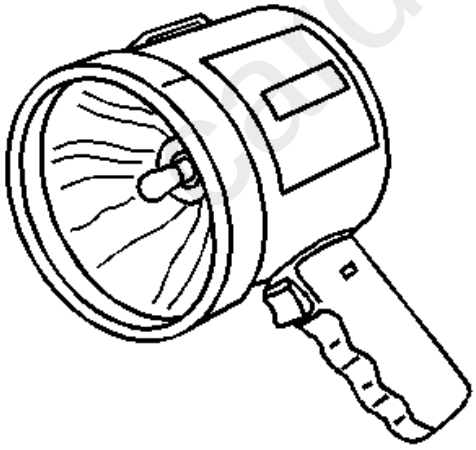
cardiagn.com

	EN-46999 Displacement On Demand Electric Tool
	EN-46999-15 Active Fuel Management Tester Harness - V6
	EN-46999-20 Active Fuel Management Tester Harness - Small Block V8

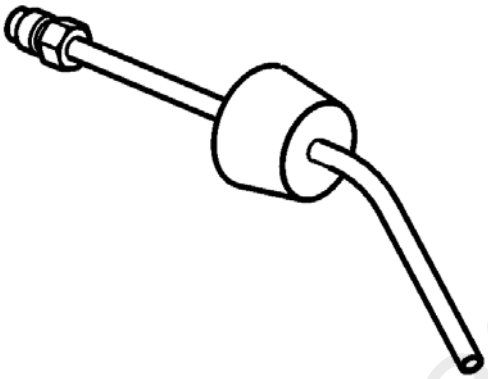
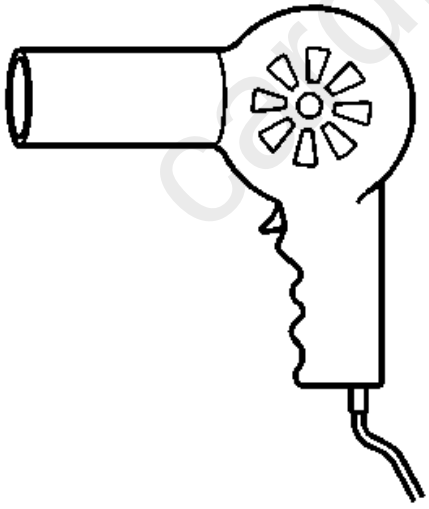
carlagn.com

	EN-47603 Compression Gauge Adapter
	EN-47656-NA Pressure Test Plugs
	GE-23738-A J-23738-A Vacuum Pump

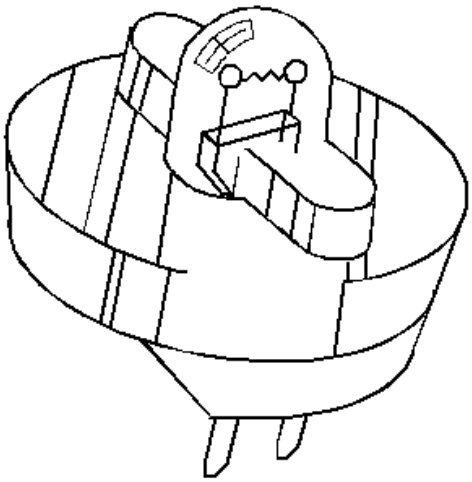
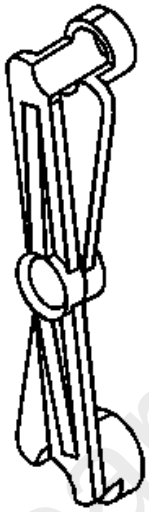
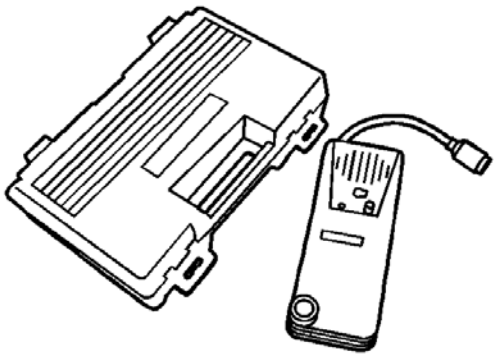
cardiagn.com

	GE-41413-300 EN-41413-300 J-41413-300 EVAP Cap and Plug Kit
	GE-41413-A EN-41413-A J-41413-A Evaporative Emissions System Tester (EEST)
	GE-41413-SPT J-41413-SPT High Intensity White Light

obdiagn.com

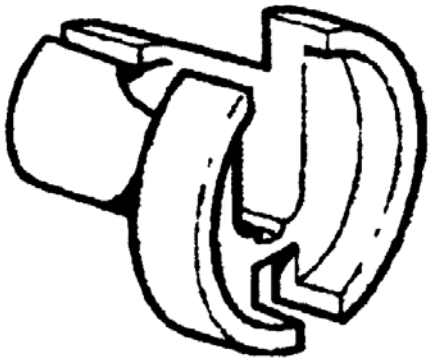
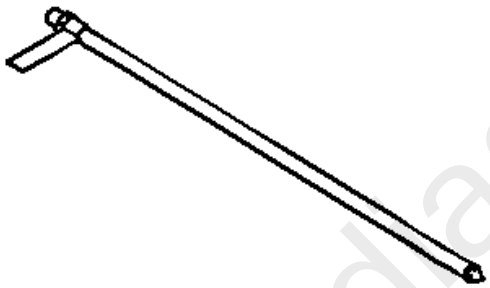
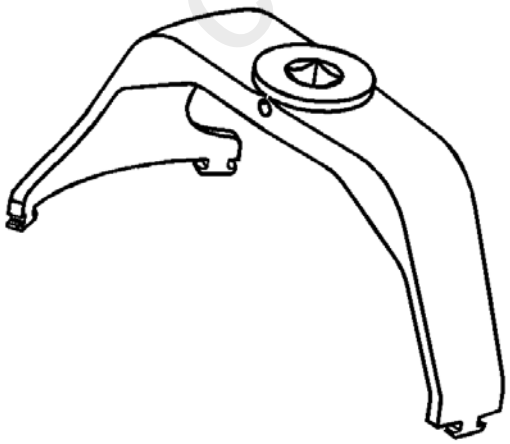
	GE-41415-50 J-41415-50 Fuel Tank Cap Adapter
	GE-41415-60 Engine Induction System Leak Test Adapter/Capless Fuel Fill Adapter
	J-25070 Heat Gun 260-399°C (500-750°F)

cardiagn.com

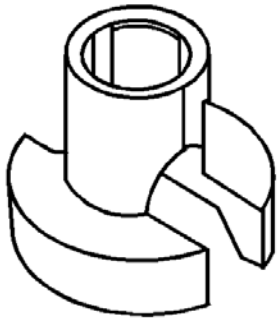
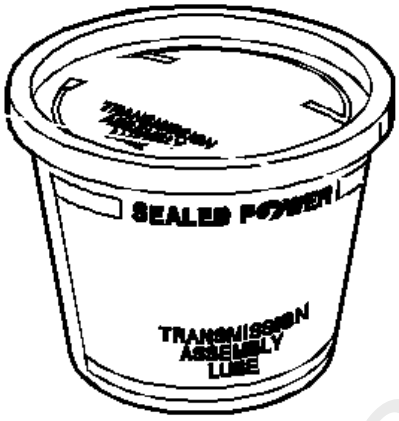
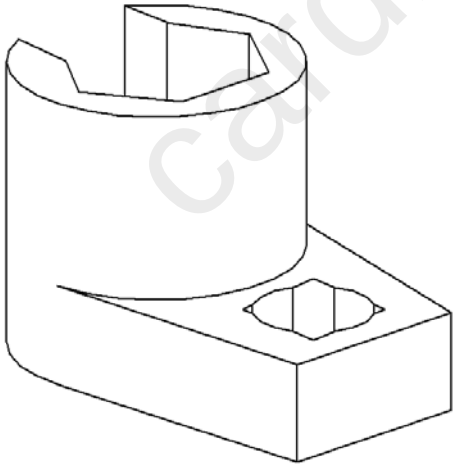
	J-34730-375 Injector Test Lamp
	J-44581 Fuel Line Disconnect Tool
	J-45878 Combustible Gas Detector

cardiagn.com

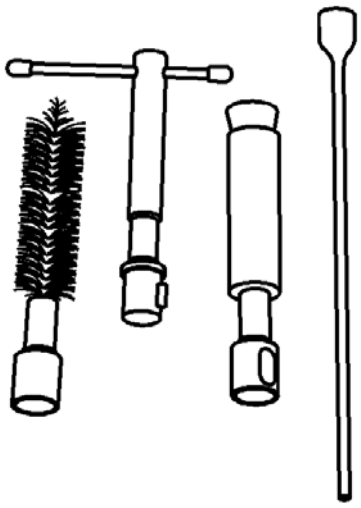
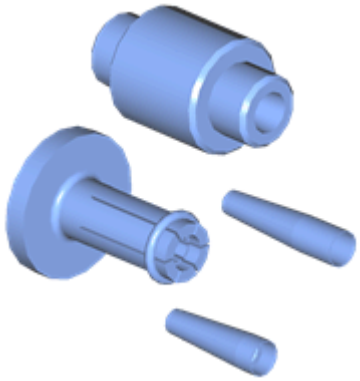
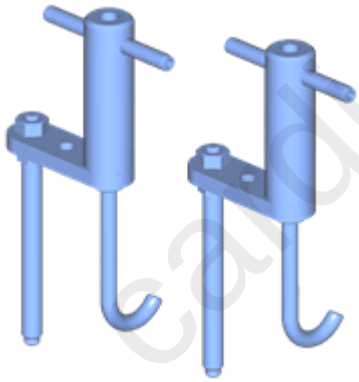
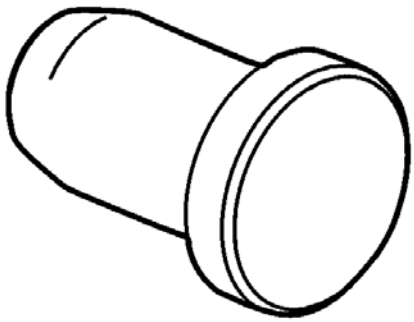
SPECIAL TOOLS AND EQUIPMENT > SPECIAL TOOLS (MECHANICAL TOOLS)

Illustration	Tool Number/Description
	CH-41769 Fuel Line Disconnect Tool Set
	CH-45004 Fuel Tank Drain Hose
	CH-45722 Fuel Sender Lock Ring Wrench

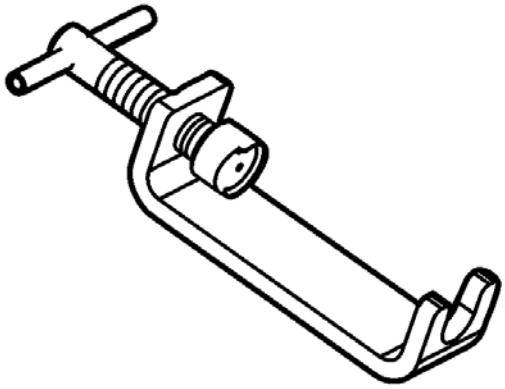
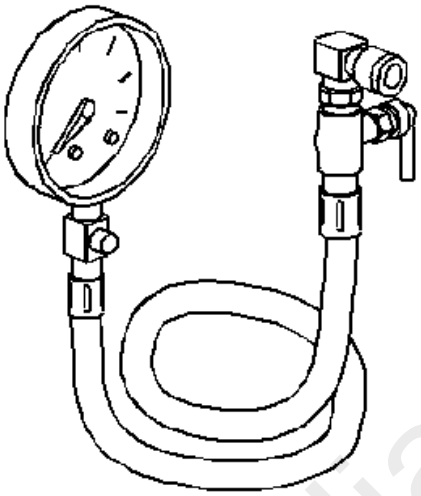
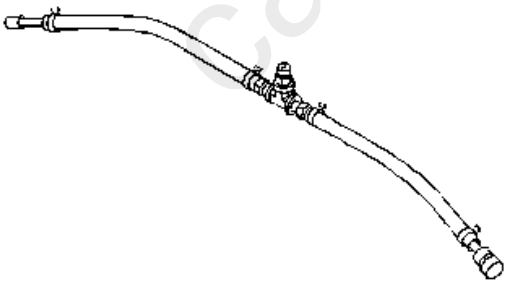
cardiagn.com

	CH-47831 Fuel Line Disconnect Tool
	DT-36850 Transjel Lubricant
	EN-39194-C J-39194-C Oxygen Sensor Wrench

cardiagn.com

	EN-47909 Injector Bore and Sleeve Cleaning Kit
	EN-49245 Fuel Injector Seal Installer and Sizer
	EN-49248 Fuel Rail Assembly Remover
	EN-50790 HP Fuel Pump Installation Alignment Gauge

cardiagn.com

	EN-50791 Fuel Injector Nozzle Installer
	J-34730-1A Fuel Pressure Gauge
	J-42982 Fuel Pressure Gauge Adapter

cardiagn.com

Service Manual: ENGINE CONTROLS AND FUEL - 2.0L (LTG)
- SPECIFICATIONS

SPECIFICATIONS > TEMPERATURE VERSUS RESISTANCE - INTAKE AIR TEMPERATURE SENSOR (HITACHI SENSOR)

Temperature C°/F°	Resistance Minimum Ohms	Resistance Maximum Ohms
Hitachi Intake Air Temperature (IAT) Sensor		
-40/-40	37, 527	49, 882
-20/-4	13, 110	16, 329
-10/14	8, 145	9, 851
0/32	5, 205	6, 122
20/68	2, 298	2, 570
25/77	1, 900	2, 100
40/104	1, 073	1, 226
60/140	537	639
80/176	289	356
100/212	165	210
120/248	99	129
140/284	62	83
150/302	49	67

cardiagn.com

SPECIFICATIONS > TEMPERATURE VERSUS RESISTANCE - INTAKE AIR TEMPERATURE SENSOR (DELCO SENSOR)

Temperature C°/F°	Resistance Minimum Ohms	Resistance Maximum Ohms
Delco Intake Air Temperature (IAT) Sensor		
-40/-40	42, 661	54, 224
-20/-4	14, 039	17, 333
-10/14	8, 529	10, 399
0/32	5, 358	6, 458
20/68	2, 308	2, 727

25/77	1, 904	2, 236
40/104	1, 113	1, 292
60/140	571	655
80/176	309	351
100/212	175	197
120/248	103	116
140/284	67	73
150/302	54	59

SPECIFICATIONS > TEMPERATURE VERSUS RESISTANCE - ENGINE COOLANT TEMPERATURE SENSOR

Temperature	Resistance
150°C (302°F)	42 to 44 Ω
140°C (284°F)	53 to 57 Ω
130°C (266°F)	68 to 72 Ω
120°C (248°F)	88 to 92 Ω
110°C (230°F)	114 to 120 Ω
100°C (212°F)	151 to 159 Ω
90°C (194°F)	203 to 215 Ω
80°C (176°F)	275 to 293 Ω
70°C (158°F)	379 to 405 Ω
60°C (140°F)	532 to 572 Ω
50°C (122°F)	762 to 824 Ω
45°C (113°F)	921 to 997 Ω
40°C (104°F)	1118 to 1212 Ω
35°C (95°F)	1366 to 1484 Ω
30°C (86°F)	1683 to 1829 Ω
25°C (77°F)	2088 to 2266 Ω
20°C (68°F)	2608 to 2828 Ω
15°C (59°F)	3289 to 3567 Ω
10°C (50°F)	4182 to 4532 Ω
5°C (41°F)	5356 to 5800 Ω

cardiagn.com

0°C (32°F)	6914 to 7484 Ω
-5°C (23°F)	8994 to 9732 Ω
-10°C (14°F)	11796 to 12762 Ω
-15°C (5°F)	15589 to 16871 Ω
-20°C (-4°F)	20791 to 22517 Ω
-30°C (-22°F)	37991 to 41273 Ω
-40°C (-40°F)	72230 to 78834 Ω

SPECIFICATIONS > ALTITUDE VERSUS BAROMETRIC PRESSURE

Altitude Measured in Meters (m)	Altitude Measured in Feet (ft)	Barometric Pressure Measured in Kilopascals (kPa)	Barometric Pressure Measured in Pounds Per Square Inch (PSI)
Determine your altitude by contacting a local weather station or by using another reference source.			
4, 267	14, 000	56-64	8.1-9.3
3, 962	13, 000	58-66	8.4-9.6
3, 658	12, 000	61-69	8.8-10.0
3, 353	11, 000	64-72	9.3-10.4
3, 048	10, 000	66-74	9.6-10.7
2, 743	9, 000	69-77	10.0-11.2
2, 438	8, 000	71-79	10.3-11.5
2, 134	7, 000	74-82	10.7-11.9
1, 829	6, 000	77-85	11.2-12.3
1, 524	5, 000	80-88	11.6-12.8
1, 219	4, 000	83-91	12.0-13.2
914	3, 000	87-95	12.6-13.8
610	2, 000	90-98	13.1-14.2
305	1, 000	94-102	13.6-14.8
0	0 Sea Level	96-104	13.9-15.1
-305	-1, 000	101-105	14.6-15.2

SPECIFICATIONS > IGNITION SYSTEM SPECIFICATIONS

cardiagn.com

Application	Specification
Ignition Type	Individual Ignition Coils
Firing Order	1-3-4-2
Spark Plug Torque	Refer to Fastener Specifications
Spark Plug Gap	Refer to Engine Mechanical Specifications
Spark Plug Type	Refer to Electronic Parts Catalog

SPECIFICATIONS > FASTENER SPECIFICATIONS

Application	Specification	
	Metric	English
Accelerator Pedal Bolt	9 N.m	80 lb in
Air Cleaner Resonator and Outlet Duct Bolt	9 N.m	80 lb in
Camshaft Position (CMP) Actuator Solenoid Valve Bolt	10 N.m	89 lb in
Camshaft Position (CMP) Sensor Bolt	10 N.m	89 lb in
Charge Air Cooler Inlet Air Tube Fasteners (LTG)	10 N.m	89 lb in
Charge Air Cooler Radiator Fasteners	10 N.m	89 lb in
Crankshaft Position (CKP) Sensor Bolt	10 N.m	89 lb in
Engine Control Module Bracket Fastener	7 N.m	62 lb in
Engine Oil Pressure Sensor	35 N.m	26 lb ft
Fuel Feed Intermediate Pipe Nut		
• First Pass - Fuel Feed Intermediate Pipe Nut to Fuel Rail	15 N.m	11 lb ft
• Second Pass - Fuel Feed Intermediate Pipe Nut to Fuel Pump	15 N.m	11 lb ft
• Third Pass - Fuel Feed Intermediate Pipe Nut to Fuel Rail	30 N.m	22 lb ft
• Final Pass - Fuel Feed Intermediate Pipe Nut to Fuel Pump	30 N.m	22 lb ft
Fuel Injection Fuel Rail Assembly Fasteners	25 N.m	18 lb ft

cardiagn.com

Fuel Injection Fuel Rail Fuel Pressure Sensor	33 N.m	24 lb ft
Fuel Pump Cover Fasteners	10 N.m	89 lb in
Fuel Pump Fasteners	15 N.m	11 lb ft
Fuel Pump Flow Control Module Fastener	7 N.m	62 lb in
Fuel Tank Fill Pipe Bracket Bolt	9 N.m	80 lb in
Fuel Tank Strap Bolt	20 N.m	15 lb ft
Heated Oxygen Sensor (HO2S)	42 N.m	31 lb ft
Ignition Coil Bolt	10 N.m	89 lb in
Knock Sensor (KS)	25 N.m	18 lb ft
Manifold Absolute Pressure Sensor Fastener	10 N.m	89 lb in
Oil Pump Flow Control Valve Bracket Fastener	9 N.m	80 lb in
Oil Pump Flow Control Valve Fastener	10 N.m	89 lb in
Oil Pump Flow Control Valve Heat Shield Fastener	9 N.m	80 lb in
Spark Plug	20 N.m	15 lb ft
Throttle Body Bolt	10 N.m	89 lb in
Turbocharger Bypass Valve Solenoid Fastener	7.8 N.m	69 lb in
Turbocharger Wastegate Actuator Fastener	20 N.m	15 lb ft
Turbocharger Wastegate Regulator Fastener	7.8 N.m	69 lb in
Vacuum Pump Fastener	10 N.m	89 lb in

cardiagn.com

SPECIFICATIONS > APPROXIMATE FLUID CAPACITIES

Application	Specification	
	Metric	English
Fuel Tank Capacity	71.0 liters	18.8 gallons

SPECIFICATIONS > ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS

Application	Type of Material	GM Part Number
Anti-Seize Compound	Lubricant	GM P/N 88862477 (Canadian P/N 88862478)
Camshaft Gear Access Hole Plug	Sealant	GM P/N 12346004 (Canadian P/N 10953480)

Coolant Temperature Sensor Threads	Sealant	GM P/N 12346004 (Canadian P/N 10953480)
Dielectric Grease for Spark Plug Wires	Lubricant	GM P/N 19260901 (Canadian P/N 19260902)
Fuel Injection Fuel Rail Bolt	Threadlocker	GM P/N 12345382 (Canadian P/N 10953489)
High Pressure Fuel Pump Bolt	Threadlocker	GM P/N 12345382 (Canadian P/N 10953489)
Silicon Free Engine Oil	5W-30	GM P/N 19293000 (Canadian P/N 19386321)
Top Engine Cleaner	Cleaner	GM P/N 1052626 (Canadian P/N 993026)

cardiagn.com