SPECIFICATIONS

TEMPERATURE VS RESISTANCE

Temperature vs Resistance

°C	°F	OHMS
Temperature vs Resistance Values (Approximate)		
150	302	47
140	284	60
130	266	77
120	248	100
110	230	132
100	212	177
90	194	241
80	176	332
70	158	467
60	140	667
50	122	973
45	113	1188
40	104	1459
35	95	1802
30	86	2238
25	77	2796
20	68	3520
15	59	4450
10	50	5670
5	41	7280
0	32	9420
-5	23	12300
-10	14	16180
-15	5	21450
-20	-4	28680
-30	-22	52700
-40	-40	100700

ALTITUDE VS BAROMETRIC PRESSURE

Altitude vs Barometric Pressure

Altitude Measured in Meters (m)	Altitude Measured in Feet (ft)	Barometric Pressure Measured in Kilopascals (kPa)
Determine your altitude by contacting a local weather station or by using another reference source.		
4 267	14,000	56-64
3 962	13,000	58-66
3 658	12,000	61-69
3 353	11,000	64-72
3 048	10,000	66-74
2 743	9,000	69-77
2 438	8,000	71-79
2 134	7,000	74-82
1 829	6,000	77-85
1 524	5,000	80-88
1 219	4,000	83-91
914	3,000	87-95
610	2,000	90-98
305	1,000	94-102
0	0 Sea Level	96-104
-305	-1,000	101-105

IGNITION SYSTEM SPECIFICATIONS

Ignition System Specifications

Application	Specification	
	Metric	English
Ignition Type	Waste Spark Cassette W/Compression Sense	
Firing Order	1-3-4-2	
Spark Plug Type	GM P/N 12569190 A/C/ DELCO P/N 41-981	
Spark Plug Torque	20 N.m	15 lb ft
Spark Plug Gap	1.08 mm	0.042 in
Primary Coil Current Output	8.5-9.5 Amps	

FASTENER TIGHTENING SPECIFICATIONS

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Accelerator Cable Bracket Nuts	10 N.m	89 lb in
Accelerator Pedal Retaining Nuts	10 N.m	89 lb in
Air Cleaner Assembly Attaching Bolt	10 N.m	89 lb in

Air Cleaner Assembly Bracket Bolt	10 N.m	89 lb in
Air Cleaner Intake Duct Assembly Bolt	10 N.m	89 lb in
Air Cleaner Intake Duct Clamp	5 N.m	44 lb in
Air Cleaner Outlet Resonator Clamp	4 N.m	36 lb in
Air Cleaner Outlet Resonator Duct Bolt	10 N.m	89 lb in
CKP Sensor Bolt	8 N.m	71 lb in
Engine Control Module (ECM) Bolts	8 N.m	71 lb in
Engine Coolant Temperature (ECT) Sensor	10 N.m	89 lb in
EVAP Canister Purge Valve Mounting Bracket Nut	8 N.m	71 lb in
EVAP Canister Retaining Bolt	10 N.m	89 lb in
Fuel Filler Hose Clamp	4.5 N.m	40 lb in
Fuel Filler Pipe Attaching Screw	10 N.m	89 lb in
Fuel Filler Pipe Lower Retaining Bolt	10 N.m	89 lb in
Fuel Supply Line Fitting	10 N.m	89 lb in
Fuel Tank Strap Bolts	25 N.m	18 lb ft
Heated Oxygen Sensor (HO2S) 1	45 N.m	33 lb ft
Heated Oxygen Sensor (HO2S) 2	45 N.m	33 lb ft
Heated Oxygen Sensor (HO2S) 2 Harness Clip	4 N.m	35 lb in
Idle Air Control (IAC) Valve Screw	3 N.m	27 lb in
Ignition Coil Housing Retaining Bolts	10 N.m	89 lb in
Ignition Control Module (ICM) Screws	1.5 N.m	13 lb in
Knock Sensor (KS)	25 N.m	18 lb ft
Spark Plugs	20 N.m	15 lb ft
Throttle Body Attaching Bolts	10 N.m	89 lb in
Throttle Position (TP) Sensor Mounting Screw	2 N.m	18 lb in

DIAGNOSTIC TROUBLE CODE (DTC) TYPE DEFINITIONS

Emissions Related DTCs

Action Taken When the DTC Sets - Type A

- The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Freeze Frame/Failure Records.

Action Taken When the DTC Sets - Type B

- The control module illuminates the MIL on the second consecutive ignition cycle that the diagnostic runs and fails.
- The control module records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the control module stores this information in the Failure Records. If the diagnostic

reports a failure on the second consecutive ignition cycle, the control module records the operating conditions at the time of the failure. The control module writes the operating conditions to the Freeze Frame and updates the Failure Records.

Conditions for Clearing the MIL/DTC - Type A or Type B

- The control module turns OFF the MIL after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC Last Test Failed clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other emission related diagnostic.
- Use a scan tool in order to clear the MIL and the DTC.

Non-Emissions Related DTCs

Action Taken When the DTC Sets - Type C

- The control module stores the DTC information into memory when the diagnostic runs and fails.
- The MIL will not illuminate.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Failure Records.
- The driver information center, if equipped, may display a message.

Action Taken When the DTC Sets - Type D

- The control module stores the DTC information into memory when the diagnostic runs and fails.
- The MIL will not illuminate.
- The control module records the operating conditions at the time the diagnostic fails. The control module stores this information in the Failure Records.

Conditions for Clearing the DTC - Type C or Type D

- A last test failed, or current DTC, clears when the diagnostic runs and passes.
- A history DTC clears after 40 consecutive warm-up cycles, if no failures are reported by this or any other non-emission related diagnostic.
- Use a scan tool in order to clear the DTC.

DIAGNOSTIC TROUBLE CODE (DTC) TYPE(S)

Diagnostic Trouble Code (DTC) Type(s)

Diagnostic Trouble Code (DTC)	Domestic	Export Unleaded Fuel
P0068	A	A
P0106	B	B

P0107	B	B
P0108	B	B
P0112	B	B
P0113	B	B
P0117	B	B
P0118	B	B
P0120	A	A
P0122	B	B
P0123	B	B
P0125	B	B
P0128	B	B
P0130	B	B
P0131	B	B
P0132	B	B
P0133	B	B
P0134	B	B
P0135	B	B
P0136	B	B
P0137	B	B
P0138	B	B
P0140	B	B
P0141	B	B
P0171	B	B
P0172	B	B
P0201-P0204	B	B
P0220	A	A
P0222	A	A
P0223	A	A
P0300	Type B EMISSION Type A CATALYST	B
P0301-P0304	Type B EMISSION Type A CATALYST	B
P0315	A	A
P0326	B	B
P0327	B	B
P0336	B	B
P0340	B	B
P0341	B	B
P0420	A	A
P0442	A	A
P0446	A	A

P0452	A	A
P0453	A	A
P0455	A	A
P0461	C	C
P0462	C	C
P0463	C	C
P0480	B	B
P0481	B	B
P0496	A	A
P0502	B	B
P0506	B	B
P0507	B	B
P0530	C	C
P0562	C	C
P0563	C	C
P0567	C	C
P0568	C	C
P0571	C	C
P0601	A	A
P0602	A	A
P0604	A	A
P0606	A	A
P0607	C	C
P0621	C	C
P0641	A	A
P0651	A	A
P0856	C	C
P1133	B	B
P1137	B	B
P1138	B	B
P1171	C	C
P1516	A	A
P1574	D	D
P1599	D	D
P1621	A	A
P1630	C	C
P1631	C	C
P1640	C	C
P1650		
P1670	B	B
P1680	A	A

P1681	A	A
P1682	A	A

SCHEMATIC AND ROUTING DIAGRAMS

EMISSION HOSE ROUTING DIAGRAM

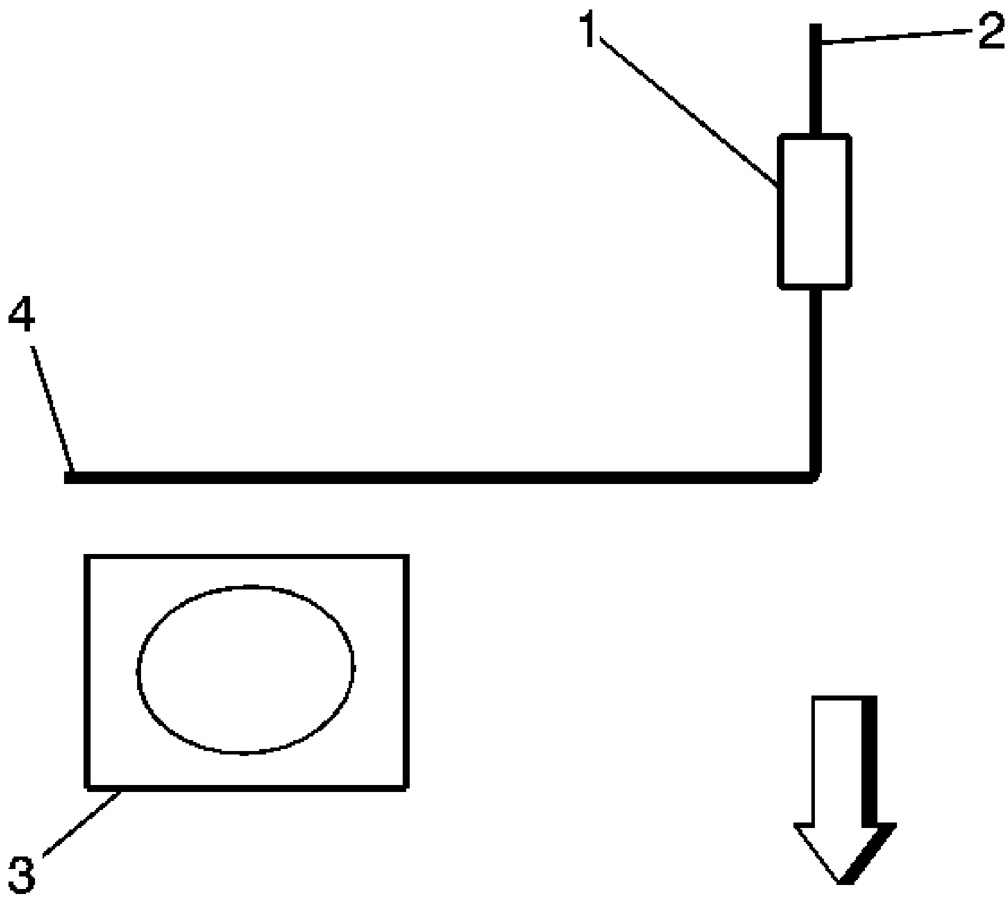


Fig. 1: View Of Emission Hose Routing Diagram
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 1

Callout	Component Name
1	EVAP Canister Purge Solenoid Valve

2	To EVAP Canister
3	Throttle Body
4	To Intake Manifold

EVAPORATIVE EMISSIONS (EVAP) HOSE ROUTING DIAGRAM

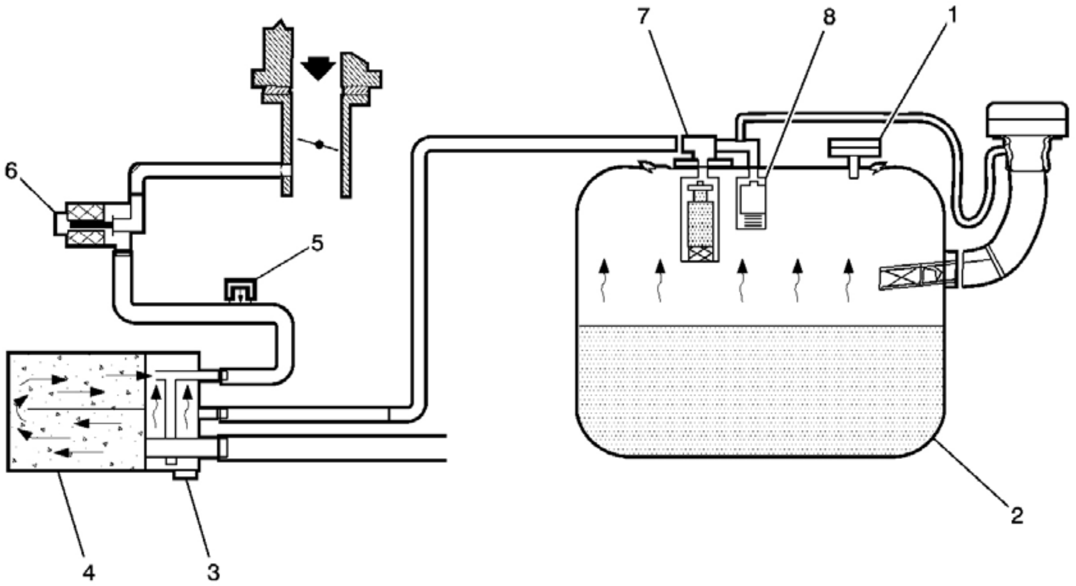


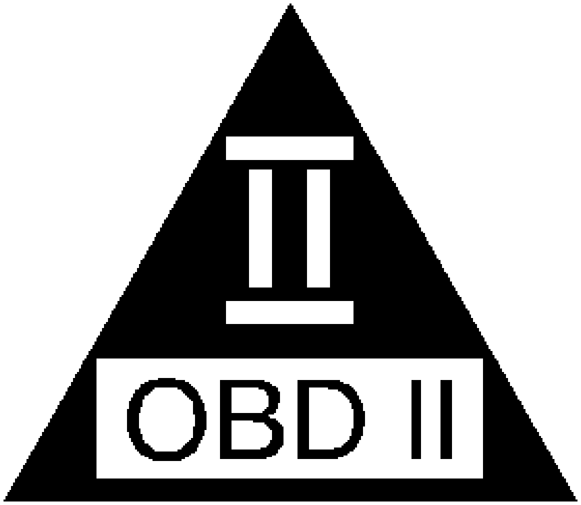
Fig. 2: Evaporative Emissions (EVAP) Hose Routing Diagram
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 2

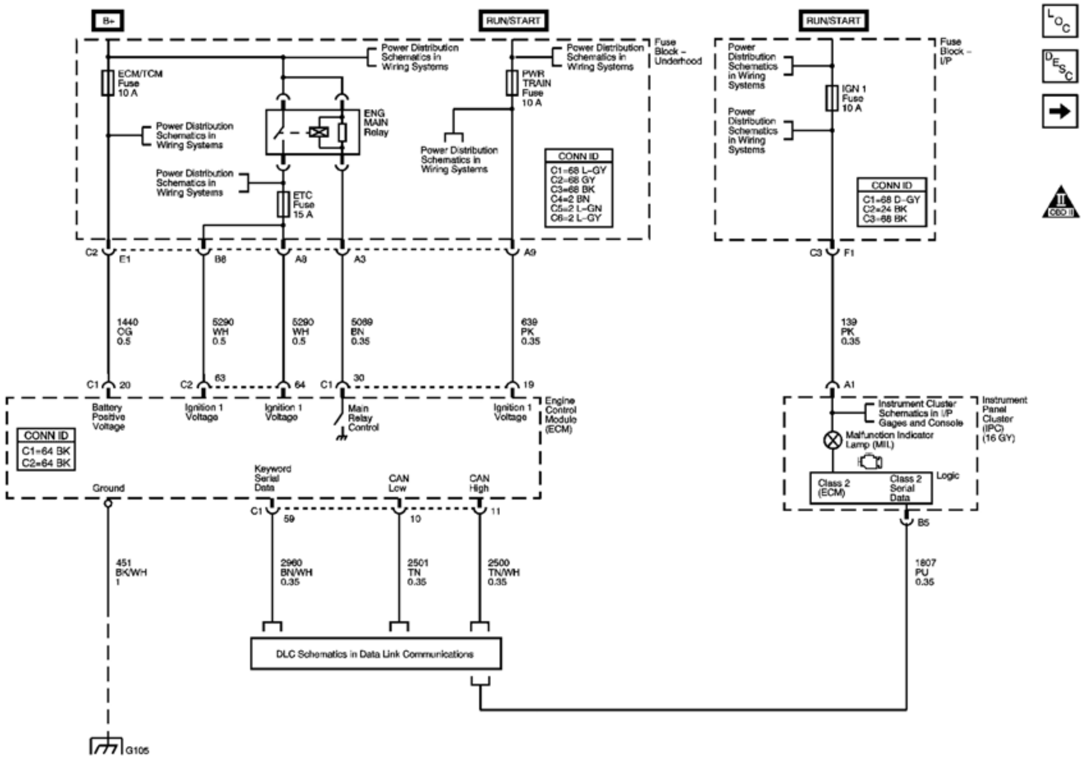
Callout	Component Name
1	Fuel Tank Pressure (FTP) Sensor
2	Fuel Tank
3	Evaporative Emission (EVAP) Vent Solenoid Valve
4	EVAP Canister
5	EVAP Service Port
6	EVAP Purge Solenoid Valve
7	Fill Limit Vent Valve (FLVV)
8	Grade Vent Valve

ENGINE CONTROLS SCHEMATIC ICONS

Engine Controls Schematic Icons

Icon	Icon Definition
	**NOTE:** **The OBD II symbol is used on the circuit diagrams in order to alert the technician that the circuit is essential for proper OBD II emission control circuit operation. Any circuit which fails and causes the malfunction indicator lamp (MIL) to turn ON, or causes emissions-related component damage, is identified as an OBD II circuit.**
	IMPORTANT: **Twisted-pair wires provide an effective shield that helps protect sensitive electronic components from electrical interference. If the wires were covered with shielding, install new shielding.** **In order to prevent electrical interference from degrading the performance of the connected components, you must maintain the proper specification when making any repairs to the twisted-pair wires shown :** • **The wires must be twisted a minimum of 9 turns per 31 cm (12 in) as measured anywhere along the length of the wires** • **The outside diameter of the twisted wires must not exceed 6.0 mm (0.25 in)**

ENGINE CONTROLS SCHEMATICS



<u>Fig. 3: ECM Power, Ground, MIL, and Communication Schematic</u>
Courtesy of GENERAL MOTORS CORP.

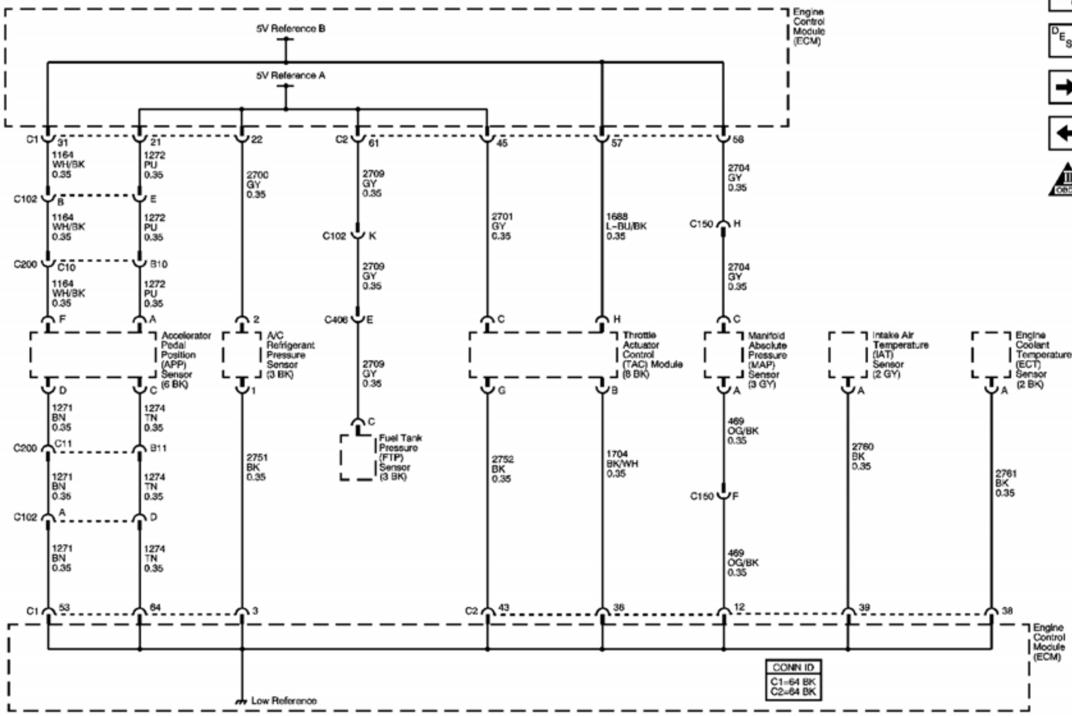


Fig. 4: Engine Data Sensors - Low and 5 Volt References Schematic
Courtesy of GENERAL MOTORS CORP.

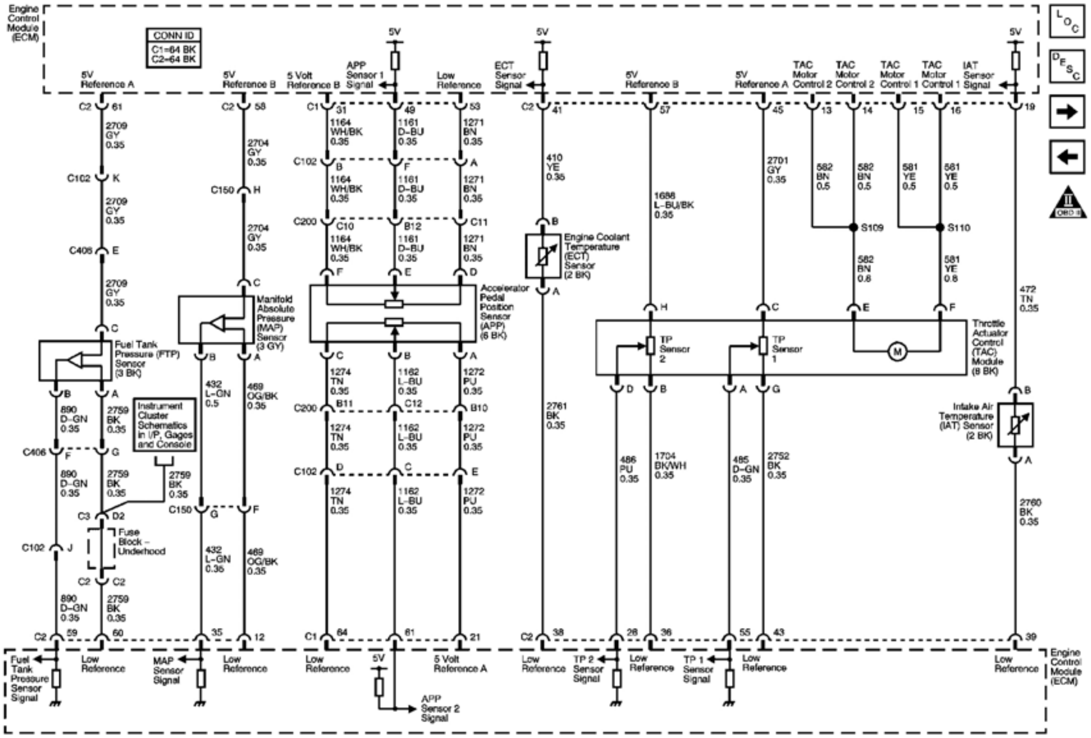
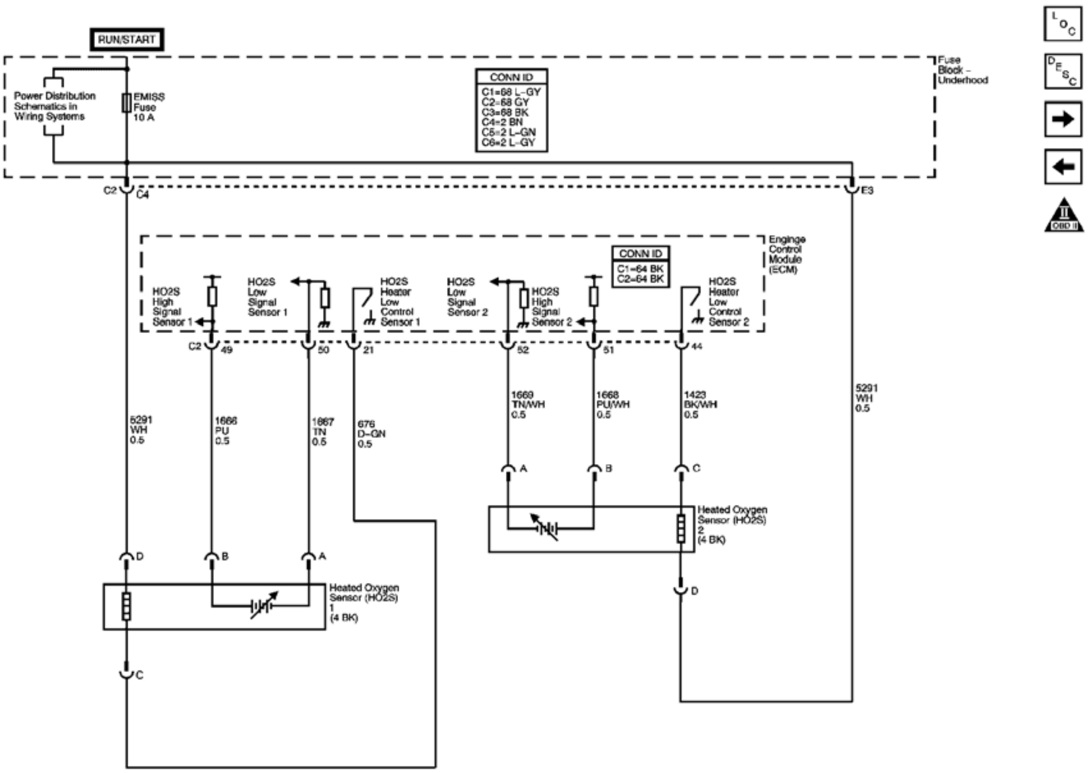


Fig. 5: Engine Data Sensors Schematic
Courtesy of GENERAL MOTORS CORP.



<u>Fig. 6: Oxygen Sensors Schematic</u>
Courtesy of GENERAL MOTORS CORP.

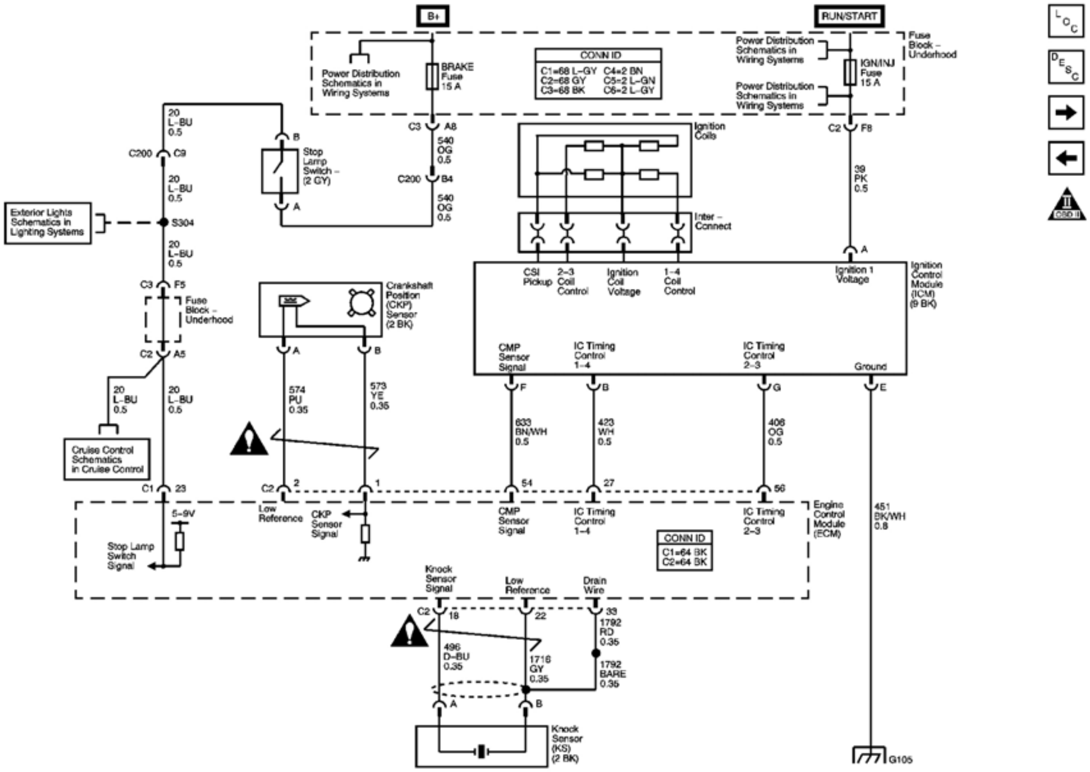
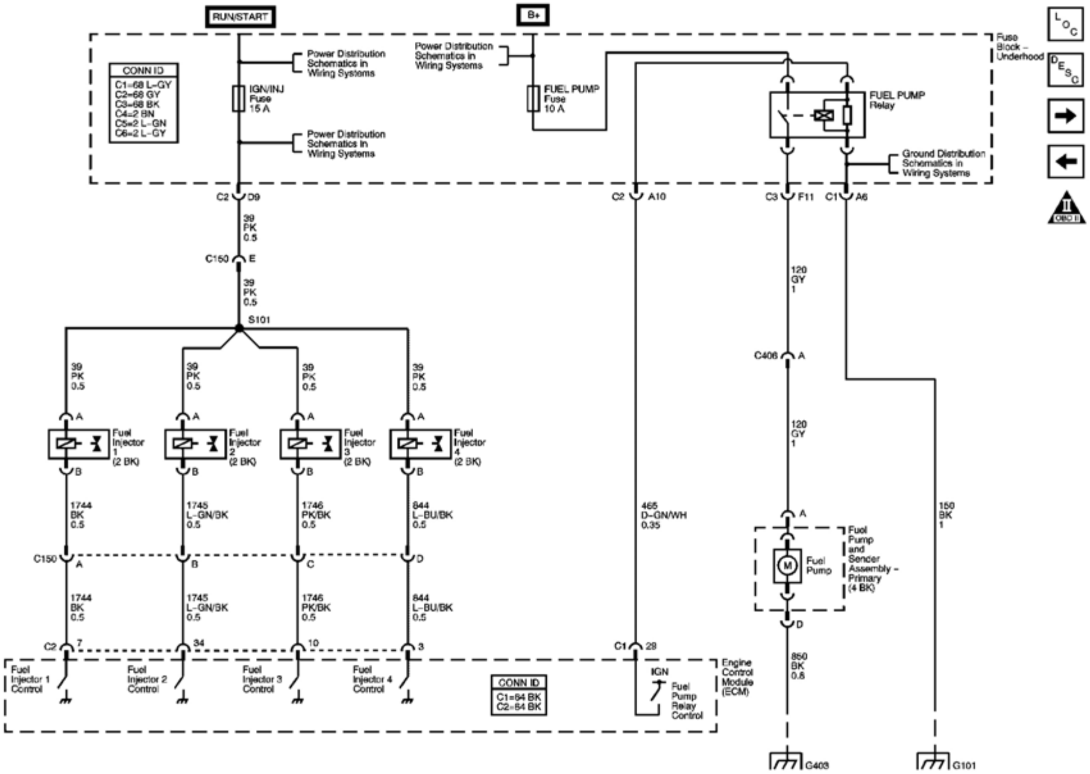


Fig. 7: Ignition Controls Schematic
Courtesy of GENERAL MOTORS CORP.



<u>Fig. 8: Fuel Controls Schematic</u>
Courtesy of GENERAL MOTORS CORP.

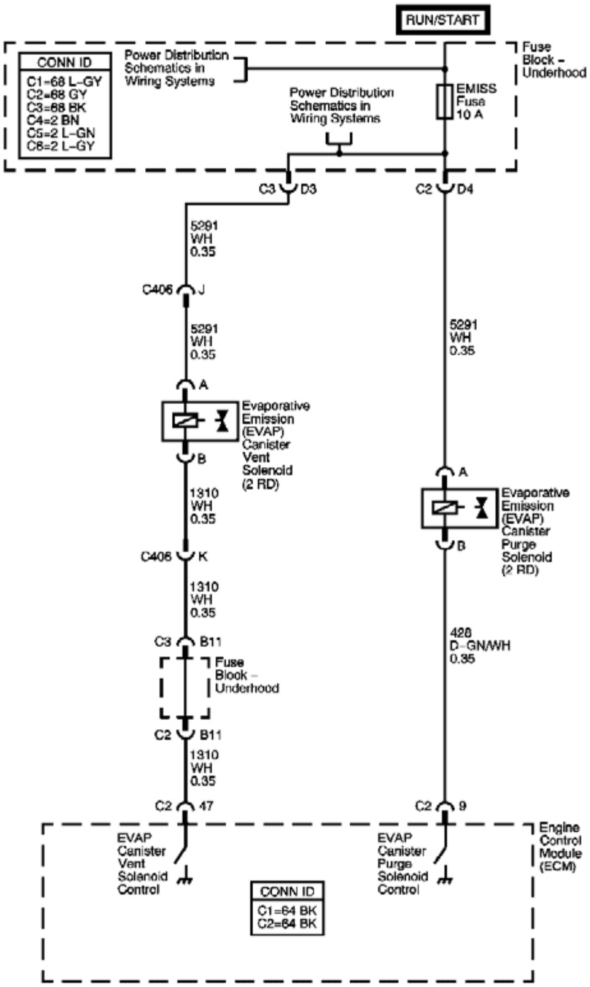
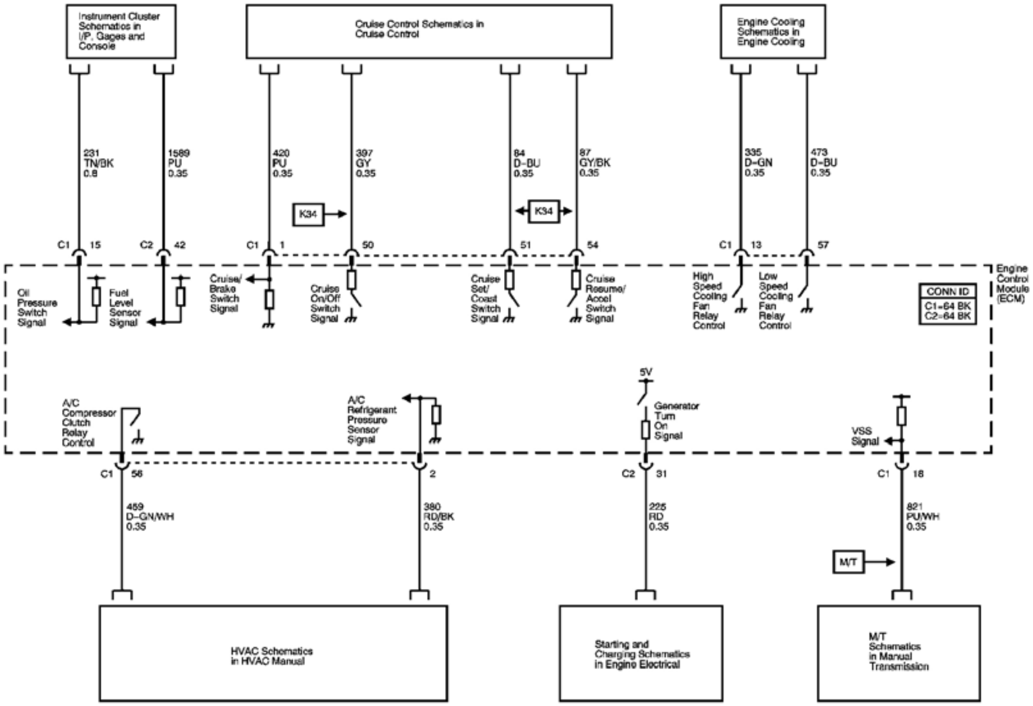


Fig. 9: EVAP Controls Schematic
Courtesy of GENERAL MOTORS CORP.



<u>**Fig. 10: Controlled/Monitored Subsystem References Schematic**</u>
Courtesy of GENERAL MOTORS CORP.

COMPONENT LOCATOR

ENGINE CONTROLS COMPONENT VIEWS

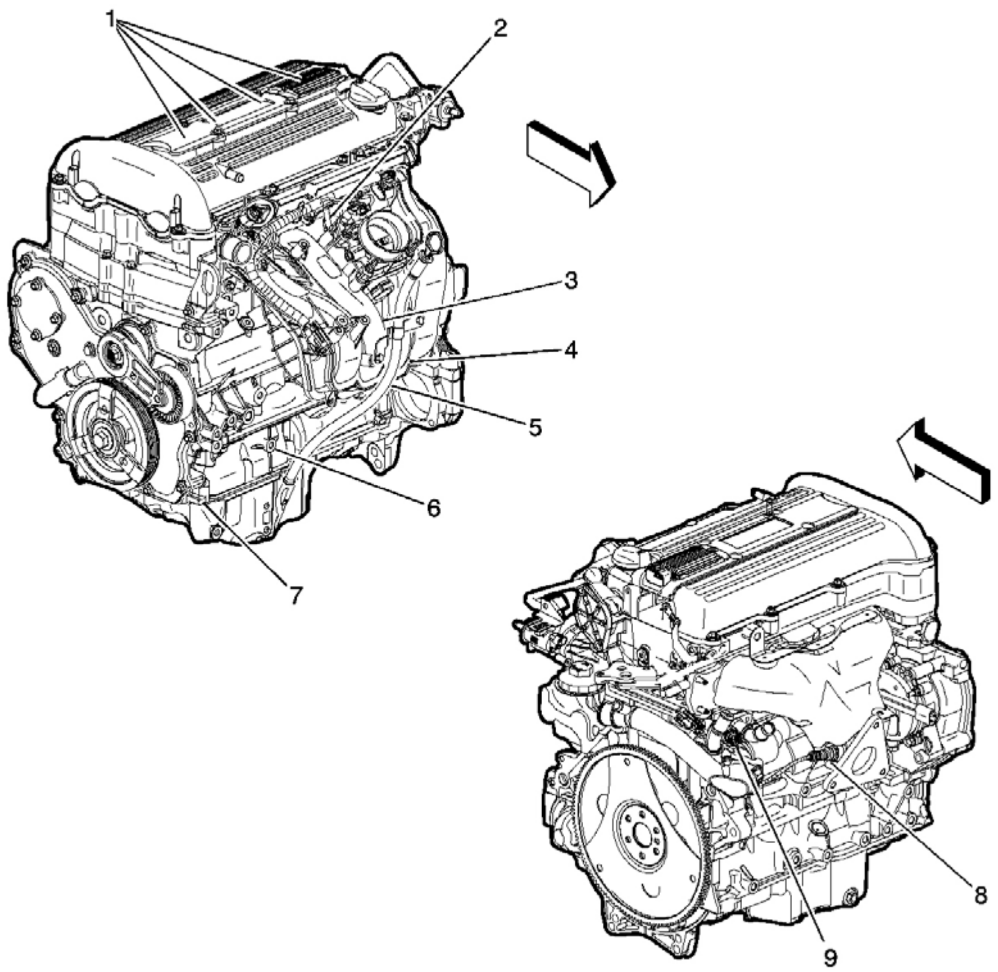


Fig. 11: Engine Controls Components View - Front and Rear
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 11

Callout	Component Name
1	Spark Plugs
2	Manifold Absolute Pressure (MAP) Sensor
3	Knock Sensor (KS)
4	Crankshaft Position (CKP) Sensor
5	Engine Oil Pressure (EOP) Switch
6	Generator Mounting Location
7	A/C Compressor Clutch Location
8	Heated Oxygen Sensor (HO2S) Sensor 1
9	Engine Coolant Temperature (ECT) Sensor

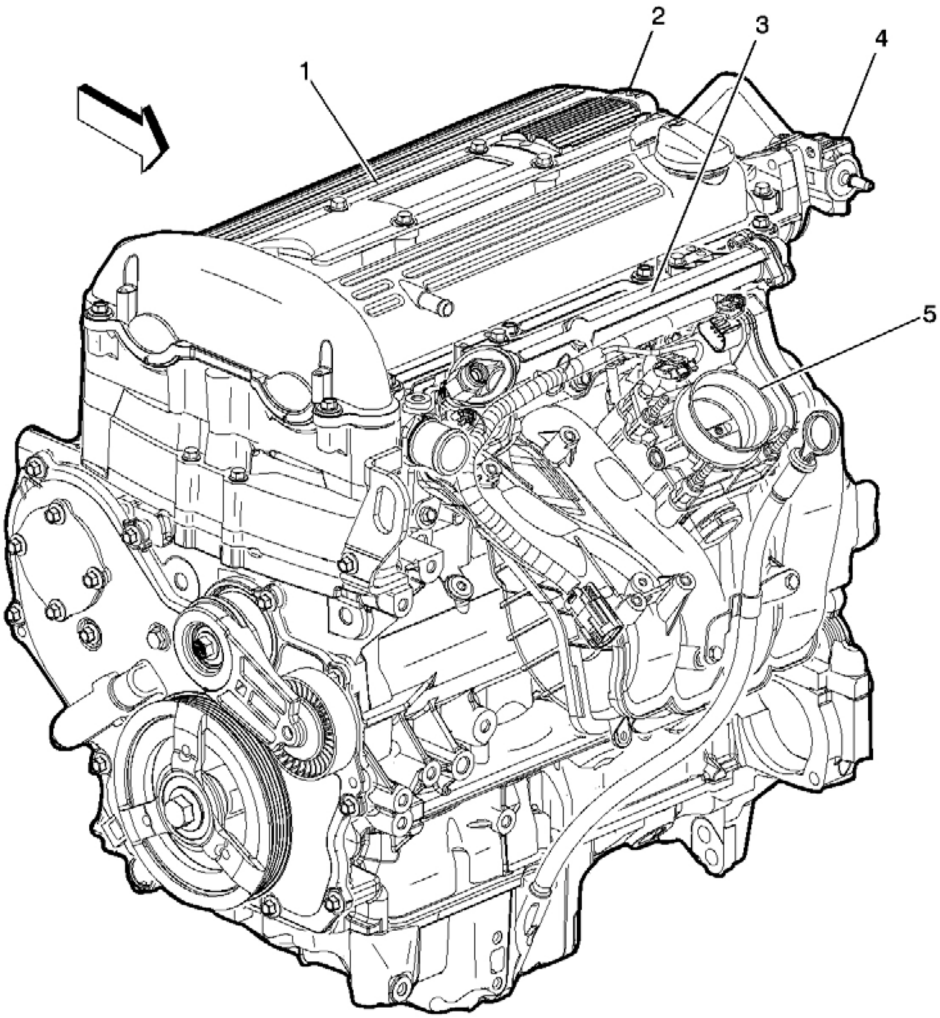


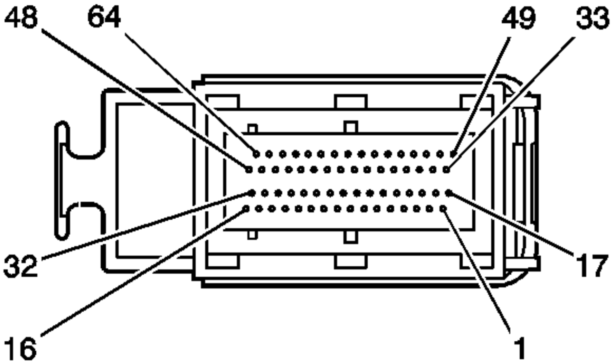
Fig. 12: Engine Controls Components View - Front
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 12

Callout	Component Name
1	Ignition Coil Housing
2	Ignition Control Module (ICM)
3	Fuel Rail and Injectors
4	Evaporative Emissions (EVAP) Canister Purge Solenoid
5	Throttle Body and Throttle Actuator Control (TAC) Module

ENGINE CONTROL MODULE (ECM) CONNECTOR END VIEWS

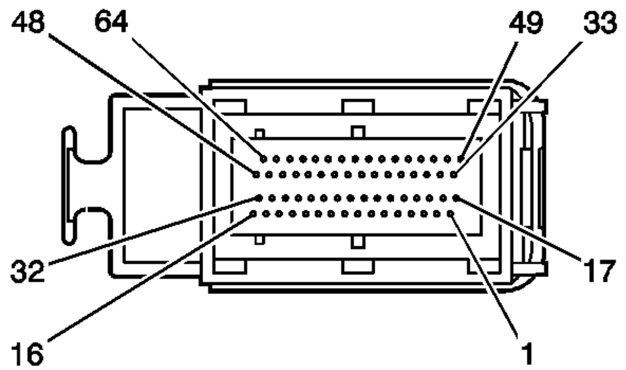
Engine Control Module (ECM) C1 Connector End View



Connector Part Information		• 1928403379 • 64-Way F Bosch Connector (BK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	PU	420	Cruise/Brake Switch Signal
2	RD/BK	380	A/C Refrigerant Pressure Sensor Signal
3	BK	2751	Low Reference
4-9	-	-	Not Used
10	TN	2501	CAN Low
11	TN/WH	2500	CAN High
12	-	-	Not Used
13	D-GN	335	High Speed Cooling Fan Relay Control
14	-	-	Not Used
15	TN/BK	231	Engine Oil Pressure Switch Signal
16-17	-	-	Not Used
18	-	-	Not Used (w/A/T)
18	PU/WH	821	VSS Signal (w/M/T)
19	PK	639	Ignition 1 Voltage
20	OG	1440	Battery Positive Voltage
21	PU	1272	5-Volt Reference - A
22	GY	2700	5-Volt Reference - A
23	L-BU	20	Stop Lamp Switch Signal
24-28	-	-	Not Used
29	D-GN/WH	465	Fuel Pump Relay Control
30	BN	5069	Main Relay Control
31	WH/BK	1164	5-Volt Reference - B
32-48	-	-	Not Used
49	D-BU	1161	APP Sensor 1 Signal
50	GY	397	Cruise On/Off Switch Signal (w/K34)

51	D-BU	84	Cruise Set/Coast Switch Signal (w/K34)
52	-	-	Not Used
53	BN	1271	Low Reference
54	GY/BK	87	Cruise Resume/Accel Switch Signal (w/K34)
55	-	-	Not Used
56	D-GN	459	Low Reference
57	D-BU	473	Low Speed Cooling Fan Relay Control
58	-	-	Not Used
59	BN/WH	2960	Keyword Serial Data
60	-	-	Not Used
61	L-BU	1162	APP Sensor 2 Signal
62-63	-	-	Not Used
64	TN	1274	Low Reference

Engine Control Module (ECM) C2 Connector End View



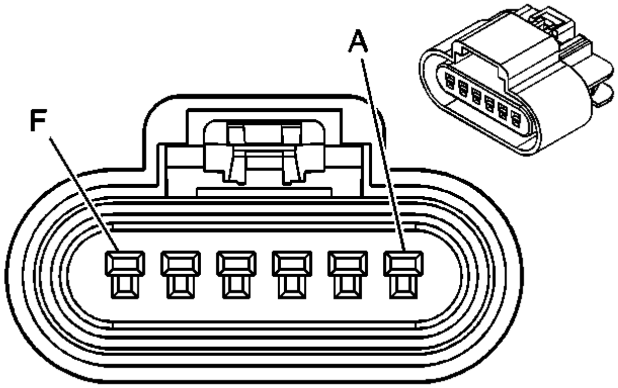
Connector Part Information		• **1928403386** • **64-Way F Bosch Connector (BK)**	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	YE	573	CKP Sensor Signal
2	PU	574	Low Reference
3	L-BU/BK	844	Fuel Injector 4 Control
4-6	-	-	Not Used
7	BK	1744	Fuel Injector 1 Control
8	-	-	Not Used
9	D-GN/WH	428	EVAP Canister Purge Solenoid Control
10	PK/BK	1746	Fuel Injector 3 Control
11	-	-	Not Used
12	OG/BK	469	Low Reference

13	BN	582	TAC Motor Control 2
14	BN	582	TAC Motor Control 2
15	YE	581	TAC Motor Control 1
16	YE	581	TAC Motor Control 1
17	-	-	Not Used
18	D-BU	496	Knock Sensor Signal
19	TN	472	IAT Sensor Signal
20	-	-	Not Used
21	D-GN	676	HO2S Heater Low Control - Sensor 1
22	GY	1716	Low Reference
23-25	-	-	Not Used
26	PU	486	TP Sensor 2 Signal
27	WH	423	IC Timing Control 1-4
28-30	-	-	Not Used
31	RD	225	Generator Turn On Signal
32	-	-	Not Used
33	BARE	1792	Drain Wire
34	L-GN/BK	1745	Fuel Injector 2 Control
35	L-GN	432	MAP Sensor Signal
36	BK/WH	1704	Low Reference
37	-	-	Not Used
38	BK	2761	Low Reference
39	BK	2760	Low Reference
40	-	-	Not Used
41	YE	410	ECT Sensor Signal
42	PU	1589	Fuel Level Sensor Signal
43	BK	2752	Low Reference
44	BK/WH	1423	HO2S Heater Low Control - Sensor 2
45	GY	2701	5-Volt Reference - A
46	-	-	Not Used
47	WH	1310	EVAP Canister Vent Solenoid Control
48	-	-	Not Used
49	PU	1666	HO2S High Signal - Sensor 1
50	TN	1667	HO2S Low Signal - Sensor 1
51	PU/WH	1668	HO2S High Signal - Sensor 2
52	TN/WH	1669	HO2S Low Signal - Sensor 2
53	-	-	Not Used
54	BN/WH	633	CMP Sensor Signal
55	D-GN	485	TP Sensor 1 Signal
56	OG	406	IC Timing Control 2-3
57	L-BU/BK	1688	5-Volt Reference - B

58	GY	2704	5-Volt Reference - B
59	D-GN	890	FTP Sensor Signal
60	BK	2759	Low Reference
61	GY	2709	5-Volt Reference - A
62	-	-	Not Used
63	WH	5290	Ignition 1 Voltage
64	WH	5290	Ignition 1 Voltage

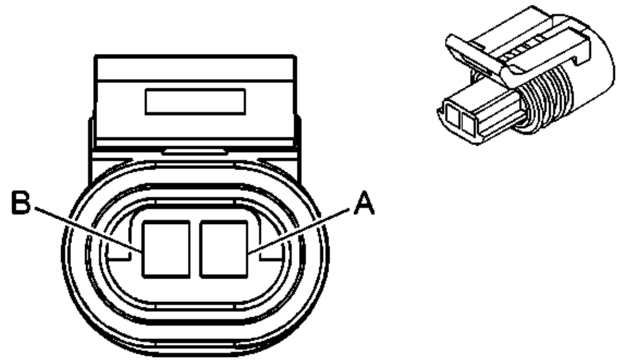
ENGINE CONTROLS CONNECTOR END VIEWS

Accelerator Pedal Position (APP) Sensor Connector End View



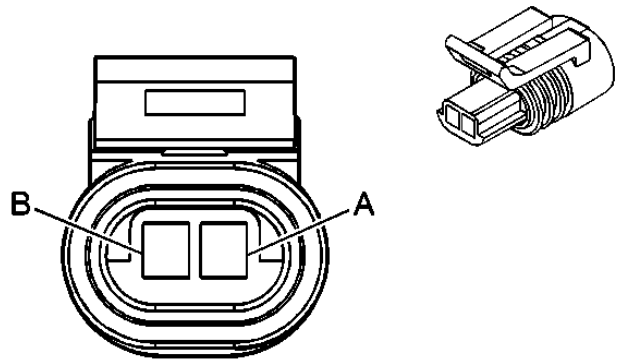
Connector Part Information		• **15317832 - CPA Assembly** • **15326829 - Connector** • **6-Way F 150 Series Sealed (BK)**	
Pin	**Wire Color**	**Circuit Number**	**Function**
A	PU	1272	5 Volt Reference - A
B	L-BU	1162	APP Sensor 2 Signal
C	TN	1274	Low Reference
D	BN	1271	Low Reference
E	D-BU	1161	APP Sensor 1 Signal
F	WH/BK	1164	5 Volt Reference - B

Crankshaft Position (CKP) Sensor Connector End View



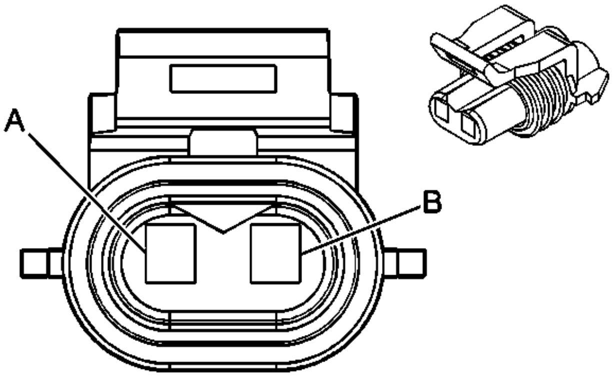
Connector Part Information		• 12162193 • 2-Way F Metri-Pack 150.2 Series Sealed (BK)	
Pin	**Wire Color**	**Circuit Number**	**Function**
A	PU	574	Low Reference
B	YE	573	CKP Sensor Signal

Engine Coolant Temperature (ECT) Sensor Connector End View



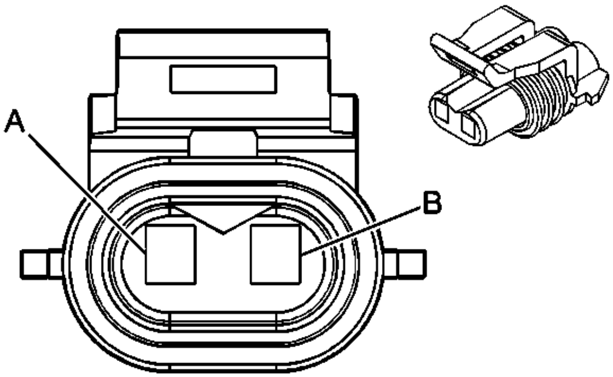
Connector Part Information		• 15336024 • 2-Way F GT 150 Series (BK)	
Pin	**Wire Color**	**Circuit Number**	**Function**
A	BK	2761	Low Reference
B	YE	410	ECT Sensor Signal

Evaporative Emission (EVAP) Canister Purge Solenoid Connector End View



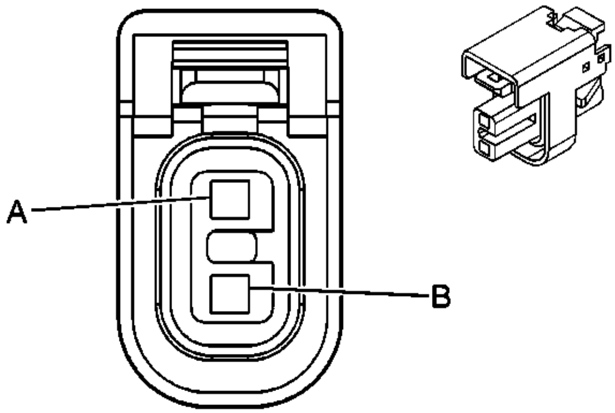
Connector Part Information	• 12052643 • 2-Way F Metri-Pack 150 Series Sealed (RD)		
Pin	**Wire Color**	**Circuit Number**	**Function**
A	WH	5291	Ignition 1 Voltage
B	D-GN/WH	428	EVAP Canister Purge Solenoid Control

Evaporative Emission (EVAP) Canister Vent Solenoid Connector End View



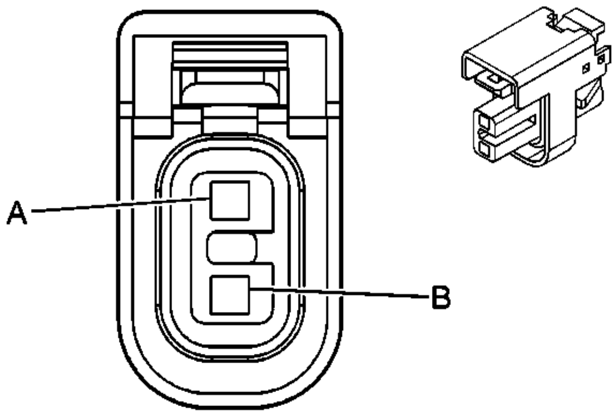
Connector Part Information	• 12052643 • 2-Way F Metri-Pack 150 Series Sealed (RD)		
Pin	**Wire Color**	**Circuit Number**	**Function**
A	WH	5291	Ignition 1 Voltage
B	WH	1310	EVAP Canister Vent Solenoid Control

Fuel Injector 1 Connector End View



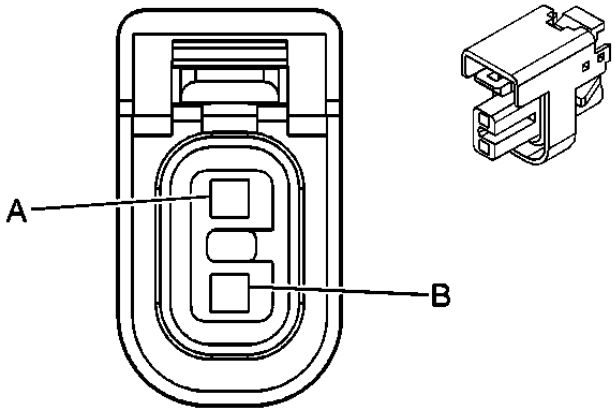
Connector Part Information		• **15236181** • **2-Way F (BK)**	
Pin	**Wire Color**	**Circuit Number**	**Function**
A	PK	39	Ignition 1 Voltage
B	BK	1744	Fuel Injector 1 Control

Fuel Injector 2 Connector End View



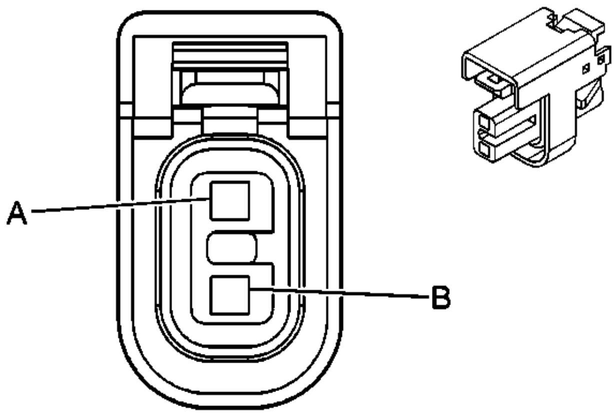
Connector Part Information		• **15236181** • **2-Way F (BK)**	
Pin	**Wire Color**	**Circuit Number**	**Function**
A	PK	39	Ignition 1 Voltage
B	L-GN/BK	1745	Fuel Injector 2 Control

Fuel Injector 3 Connector End View



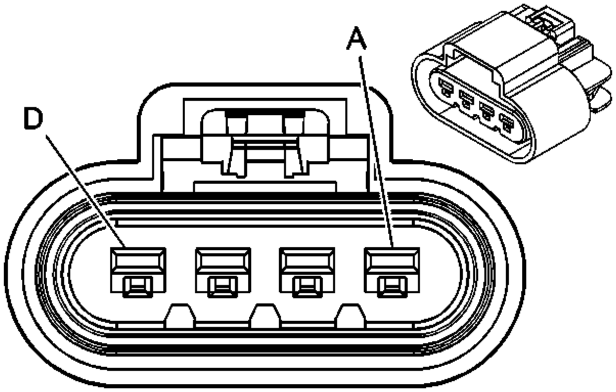
Connector Part Information		• **15236181** • **2-Way F (BK)**	
Pin	**Wire Color**	**Circuit Number**	**Function**
A	PK	39	Ignition 1 Voltage
B	PK/BK	1746	Fuel Injector 3 Control

Fuel Injector 4 Connector End View



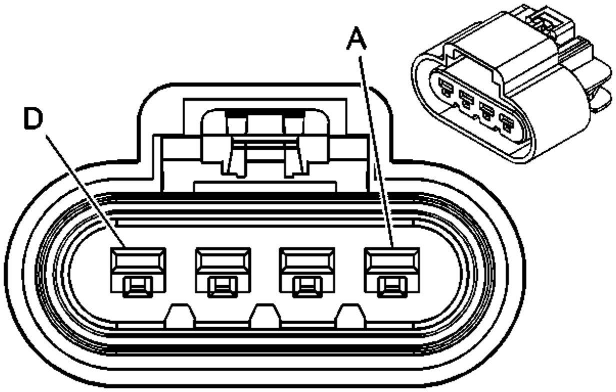
Connector Part Information		• **15236181** • **2-Way F (BK)**	
Pin	**Wire Color**	**Circuit Number**	**Function**
A	PK	39	Ignition 1 Voltage
B	L-BU/BK	844	Fuel Injector 4 Control

Fuel Pump and Sender Assembly - Primary Connector End View



Connector Part Information		• 15326631 • 4-Way F GT 280 Sealed 5.8 (BK)	
Pin	**Wire Color**	**Circuit Number**	**Function**
A	GY	120	Fuel Pump Supply Voltage
B	PU	1589	Fuel Level Sensor Signal
C	BU	930	Fuel Level Sensor Signal - Common
D	BK	850	Ground

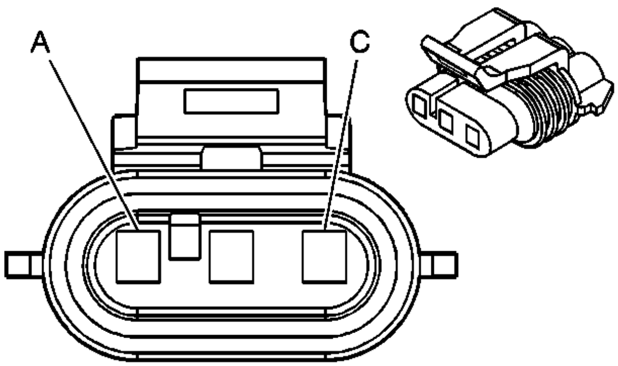
Fuel Pump and Sender Assembly - Secondary Connector End View



Connector Part Information		• 15326631 • 4-Way F GT 280 Sealed 5.8 (BK)	
Pin	**Wire Color**	**Circuit Number**	**Function**
A	-	-	Not Used

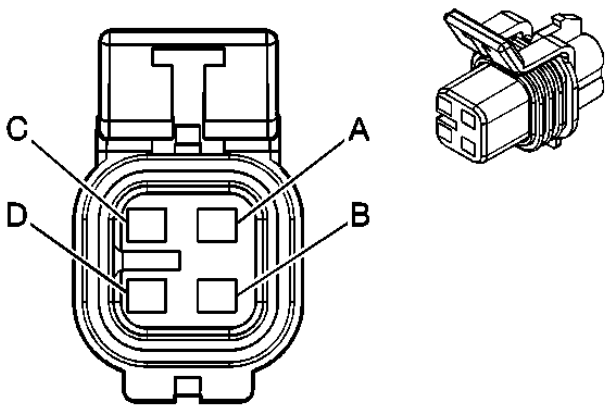
B	BU	930	Fuel Level Sensor Signal - Common
C	BK/WH	2759	Low Reference
D	-	-	Not Used

Fuel Tank Pressure (FTP) Sensor Connector End View



Connector Part Information	• **12059595** • **3-Way F Metri-Pack 150 Series Sealed (BK)**		
Pin	**Wire Color**	**Circuit Number**	**Function**
A	BK	2759	Low Reference
B	D-BN	890	FTP Sensor Signal
C	GY	2709	5 Volt Reference - A

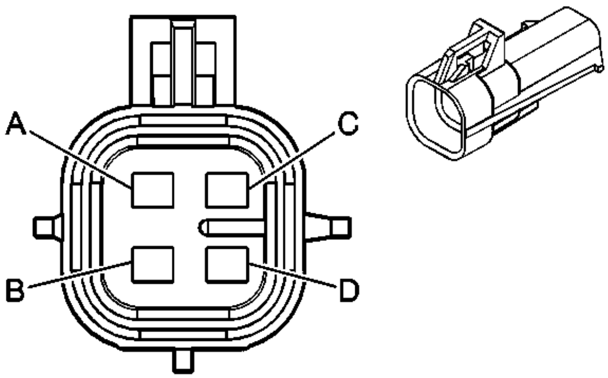
Heated Oxygen Sensor (HO2S) 1 Connector End View



Connector Part Information	• **12160482**

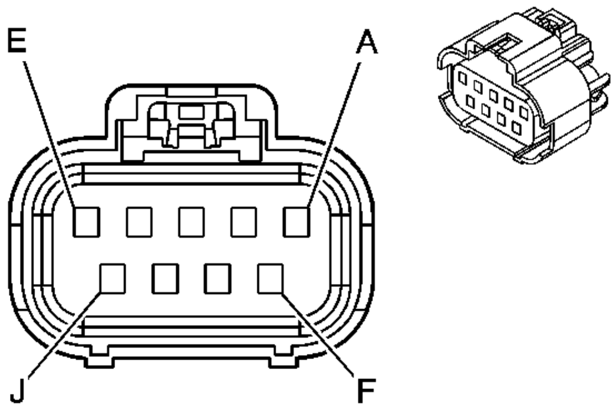
		• 4-Way F (BK)	
Pin	Wire Color	Circuit Number	Function
A	TN	1667	HO2S Low Signal Sensor 1
B	PU	1666	HO2S High Signal Sensor 1
C	D-GN	676	HO2S Heater Low Control Sensor 1
D	WH	5291	Ignition 1 Voltage

Heated Oxygen Sensor (HO2S) 2 Connector End View



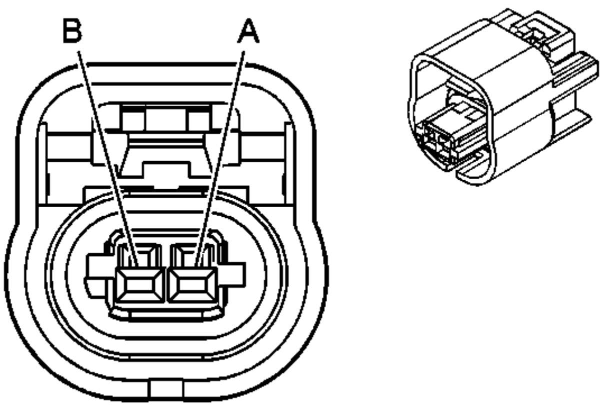
Connector Part Information		• 12160825 • 4-Way M Metri-Pack 150 Series (BK)	
Pin	Wire Color	Circuit Number	Function
A	TN/WH	1669	HO2S Low Signal Sensor 2
B	PU/WH	1668	HO2S High Signal Sensor 2
C	BK/WH	1423	HO2S Heater Low Control Sensor 2
D	WH	5291	Ignition 1 Voltage

Ignition Control Module (ICM) Connector End View



Connector Part Information		• **15356705** • **9-Way F (BK)**	
Pin	**Wire Color**	**Circuit Number**	**Function**
A	PK	39	Ignition 1 Voltage
B	WH	423	IC Timing Control 1-4
C-D	-	-	Not Used
E	BK/WH	451	Ground
F	BN/WH	633	Camshaft Position Sensor Signal
G	OG	406	IC Timing Control 2-3
H-J	-	-	Not Used

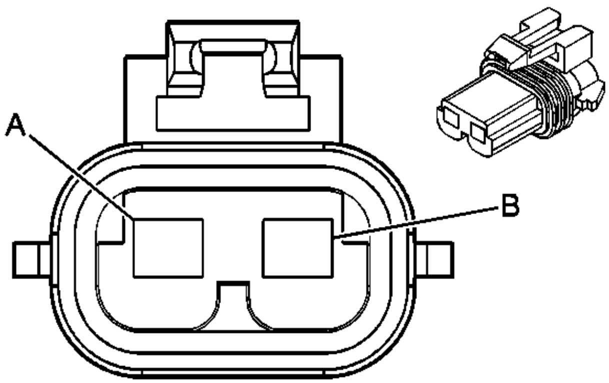
Intake Air Temperature (IAT) Sensor Connector End View



	• **Assembly - 15335987**

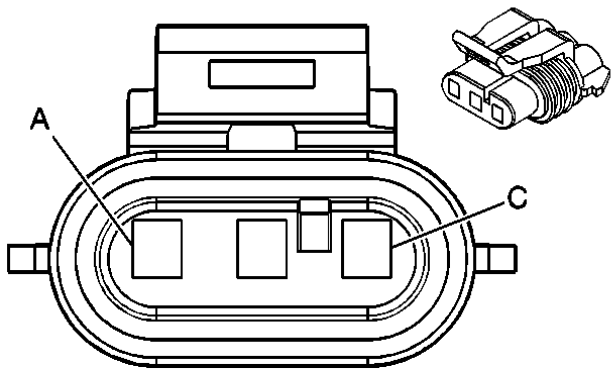
Connector Part Information		• Connector - 15335986 • 2-Way F GT 150 Sealed 3.2x4.0 (BK)	
Pin	**Wire Color**	**Circuit Number**	**Function**
A	BK	2760	Low Reference
B	TN	472	IAT Sensor Signal

Knock Sensor (KS) Connector End View



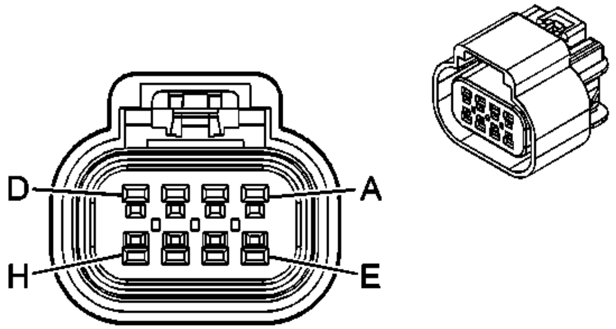
Connector Part Information		• 12077900 • 2-Way F Metri-Pack 280 Series Sealed (BK)	
Pin	**Wire Color**	**Circuit Number**	**Function**
A	D-BU	496	Knock Sensor Signal
B	GY	1716	Low Reference

Manifold Absolute Pressure (MAP) Sensor Connector End View



Connector Part Information		• 12129946 • 3-Way F Metri-Pack 150 Series Sealed (GY)	
Pin	**Wire Color**	**Circuit Number**	**Function**
A	OG/BK	469	Low Reference
B	L-GN	432	MAP Sensor Signal
C	GY	2704	5 Volt Reference - B

Throttle Actuator Control (TAC) Module Connector End View



Connector Part Information		• 15326835 • 8-Way F GT 150 Sealed 4.0 (BK)	
Pin	**Wire Color**	**Circuit Number**	**Function**
A	D-GN	485	TP Sensor 1 Signal
B	BK/WH	1704	Low Reference
C	GY	2701	5 Volt Reference A
D	PU	486	TP Sensor 2 Signal
E	BN	582	TAC Motor Control 2
F	YE	581	TAC Motor Control 1
G	BK	2752	Low Reference
H	L-BU/BK	1688	5 Volt Reference B

REPAIR INSTRUCTIONS

ENGINE CONTROL MODULE (ECM) REPLACEMENT

IMPORTANT: It is necessary to record the remaining engine oil life. If the replacement module is not programed with the remaining engine oil life, the engine oil life will default to 100%. If the replacement module is not programmed with the remaining engine oil life, the engine oil will need to be changed at 5000 km (3,000 mi) from the last engine oil change.

1. Using a scan tool, retrieve the percentage of remaining engine oil. Record the remaining engine oil life.

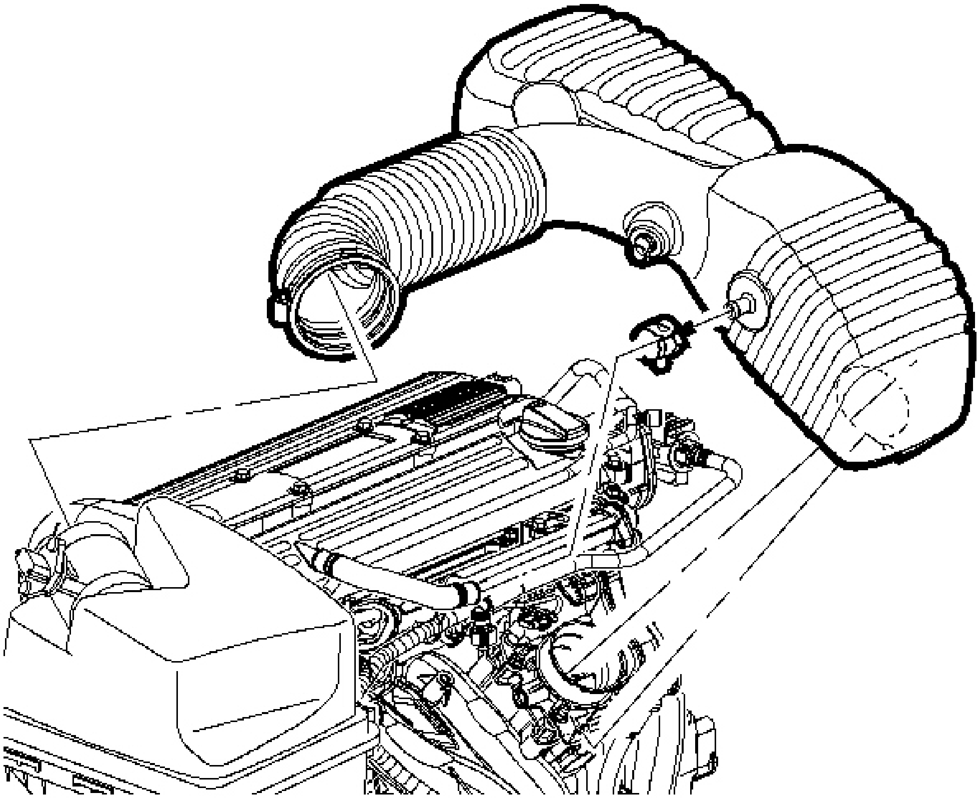


Fig. 13: View Of Engine Control Module
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
3. Disconnect the intake air temperature (IAT) sensor.
4. Loosen the clamp at the air cleaner assembly.
5. Remove the push pin attachment from the outlet resonator/duct assembly to support bracket.
6. Loosen the clamp at the throttle body assembly.
7. Disconnect the PCV fresh air hose at the cam cover.

8. Remove the outlet resonator/duct assembly.
9. Remove the J 1 and J 2 connectors at the ECM.
10. Remove the 4 ECM attachment bolts.

Installation Procedure

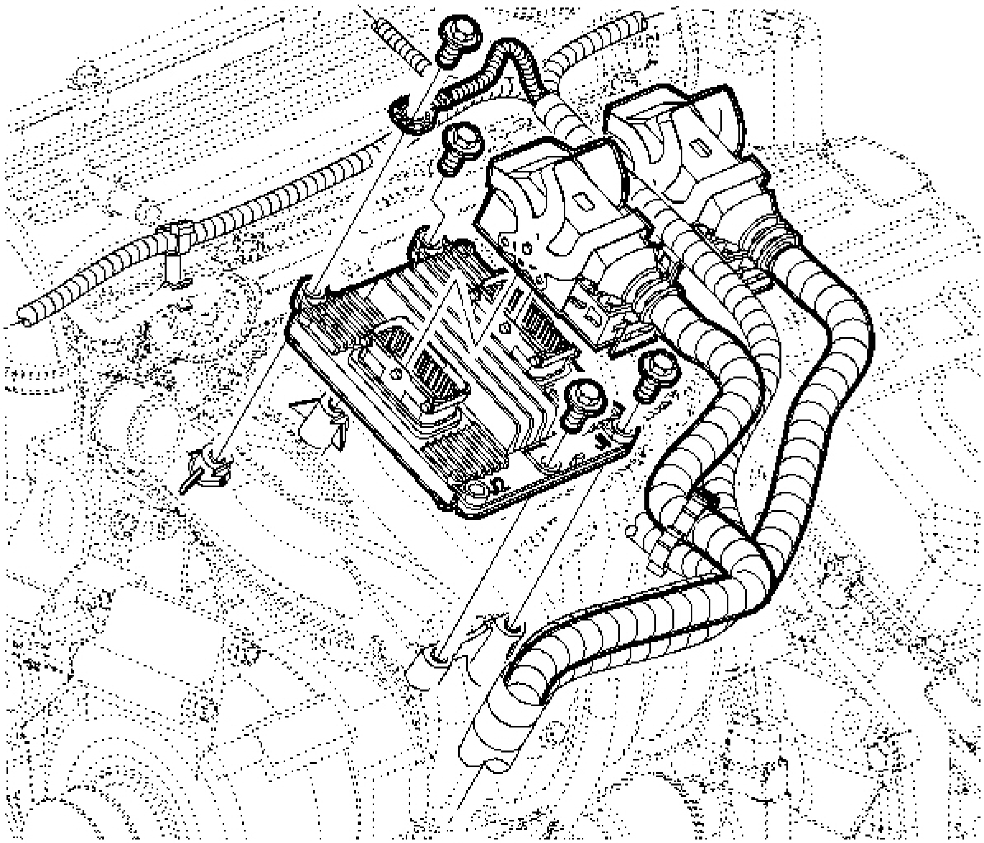


Fig. 14: View Of ECM Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the ECM.

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

2. Install the ECM bolts.

   Tighten: Tighten the engine control module bolts to 8 N.m (71 lb in).

3. Connect the J 1 and J 2 ECM electrical connectors.
4. Install the outlet resonator/duct assembly into position.
5. Connect the PCV fresh air vent hose assembly.
6. Tighten the clamp at the throttle body assembly.
7. Position the outlet resonator/duct assembly up with the support bracket and install the push-pin.
8. Tighten the clamp at the air cleaner assembly.
9. Connect the intake air temperature (IAT) sensor connector.
10. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.

    NOTE: If a new ECM is being installed, it must be reprogrammed with new software and calibrations. Refer to Service Stall System (SSS) User Guide for reprogramming procedures. The ECM may be damaged if the reprogramming process is interrupted. Make sure the scan tool is connected securely to the DLC and the vehicle battery has sufficient charge.

    IMPORTANT: Ensure the original ECM has the correct VIN and vehicle options.

11. Reprogram the ECM. Refer to **Service Programming System (SPS)** in Programming.

    IMPORTANT: The new ECM must learn the passlock password from the BCM. When the ECM reprogram is completed, use the SSS to perform the ECM Passlock Relearn Procedure.

12. Perform the Passlock Relearn Procedure using the Service Stall System (SSS).
13. Turn the ignition to OFF for 10 seconds.

    IMPORTANT: Following the ECM reprogramming, the ECM will have to learn the crankshaft notch variation for misfire diagnostics.

14. Perform the crankshaft relearn procedure. Refer to **CKP System Variation Learn Procedure** .
15. Verify no DTCs exist. If one exists, refer to the specific DTC diagnostic.

CKP SYSTEM VARIATION LEARN PROCEDURE

1. Install a scan tool.
2. Monitor the engine control module (ECM) for DTCs with a scan tool. If other DTCs are set, except DTC

P0315, refer to **Diagnostic Trouble Code (DTC) List** for the applicable DTC that set.

3. Select the crankshaft position variation learn procedure with a scan tool.
4. The scan tool instructs you to perform the following:
   - Accelerate to wide open throttle (WOT).
   - Release throttle when fuel cutoff occurs.
   - Observe fuel cutoff specifications for applicable engine.
   - Engine should not accelerate beyond calibrated RPM value.
   - Release throttle immediately if value is exceeded.
   - Block drive wheels.
   - Set parking brake.
   - DO NOT apply brake pedal.
   - Cycle ignition from OFF to ON.
   - Apply and hold brake pedal.
   - Start and idle engine.
   - Turn A/C OFF.
   - Vehicle must remain in Park or Neutral.
   - The scan tool monitors certain component signals to determine if all the conditions are met to continue with the procedure. The scan tool only displays the condition that inhibits the procedure. The scan tool monitors the following components:
     - Crankshaft position (CKP) sensors activity-If there is a CKP sensor condition, refer to the applicable DTC that set.
     - Camshaft position (CMP) signal activity-If there is a CMP signal condition, refer to the applicable DTC that 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.

IMPORTANT: While the learn procedure is in progress, release the throttle immediately when the engine starts to decelerate. The engine control is returned to the operator and the engine responds to throttle position after the learn procedure is complete.

5. Enable the crankshaft position system variation learn procedure with the scan tool and perform the following:
   - Accelerate to WOT.
   - Release when fuel cutoff occurs.
   - Test in progress
6. The scan tool displays Learn Status: Learned this ignition. If the scan tool indicates that DTC P0315 ran and passed, the CKP variation learn procedure is complete. If the scan tool indicates DTC P0315 failed or did not run, refer to **DTC P0315** . If any other DTCs set, refer to **Diagnostic Trouble Code (DTC) List** for the applicable DTC that set.

7. Turn OFF the ignition for 30 seconds after the learn procedure is completed successfully.
8. The CKP system variation learn procedure is also required when the following service procedures have been performed, regardless of whether DTC P0315 is set:
    - Engine replacement
    - ECM replacement
    - A harmonic balancer replacement
    - Crankshaft replacement
    - CKP sensor replacement
    - Any engine repairs which disturb the crankshaft to CKP sensor relationship

ENGINE COOLANT TEMPERATURE (ECT) SENSOR REPLACEMENT

Removal Procedure

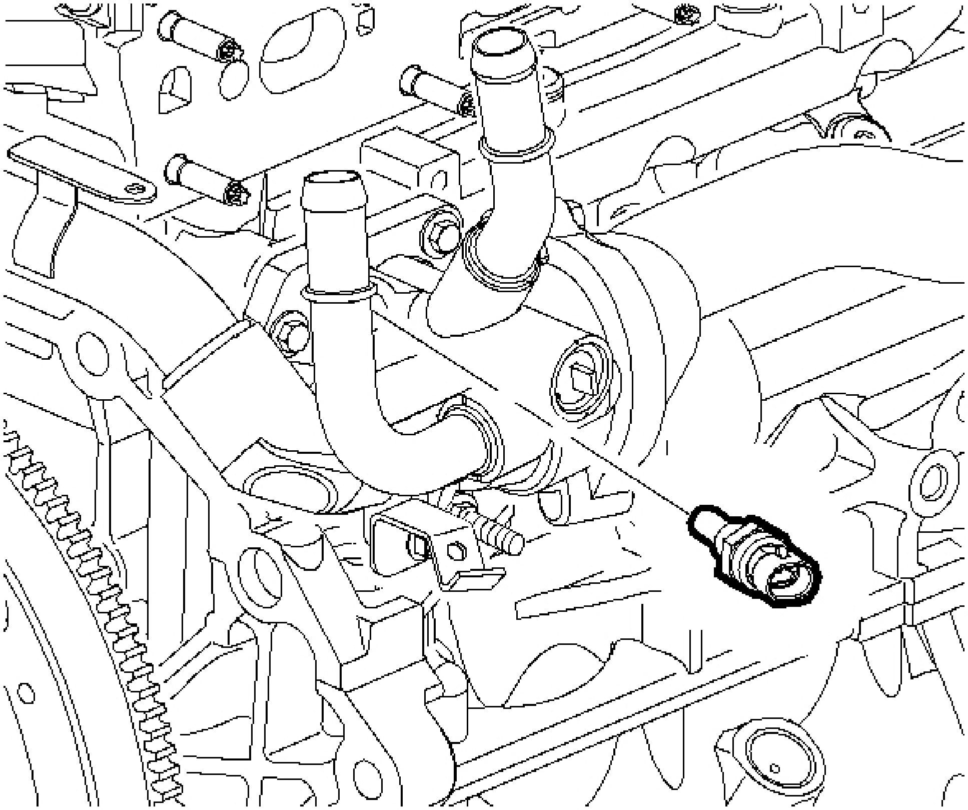


Fig. 15: View Of Engine Coolant Temperature (ECT) Sensor
Courtesy of GENERAL MOTORS CORP.

1. Turn the ignition OFF.

IMPORTANT: Engine coolant must be drained below the level of the engine coolant temperature sensor (ECT) sensor. Refer to Draining and Filling Cooling System in Engine Cooling.

2. Disconnect the ECT sensor harness connector.
3. Remove the ECT.

Installation Procedure

IMPORTANT: Tap out sensor mounting hole in engine head to remove any thread sealant residue. Clean any sealant residue from old sensor and apply RTV sealant to threads if old sensor is going to be reused.

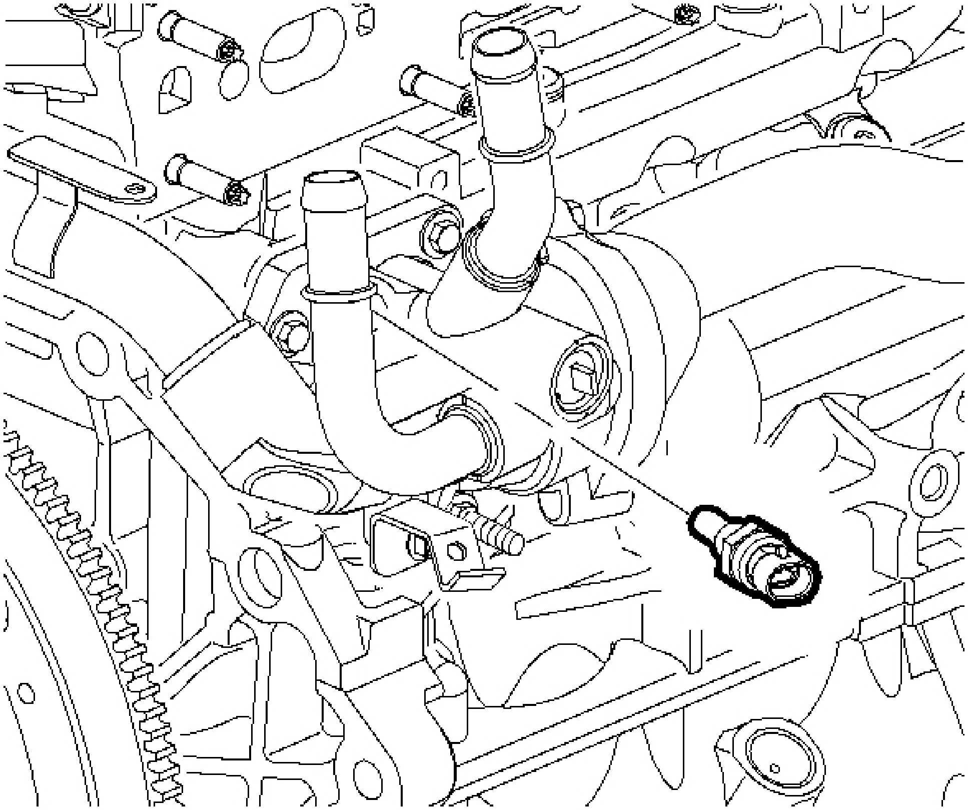


Fig. 16: View Of Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

1. Apply thread sealant Saturn P/N 21485277 Loctite 242(R) Threadlocker, or equivalent, to sensor threads.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the ECT sensor.

Tighten: Tighten the engine coolant temperature sensor to 10 N.m (89 lb in).

3. Connect the ECT sensor harness connector. Push in the connector until a click is heard, then pull back to confirm a positive engagement.
4. Fill engine coolant to proper level. Refer to **Draining and Filling Cooling System** in Engine Cooling.

INTAKE AIR TEMPERATURE (IAT) SENSOR REPLACEMENT

Removal Procedure

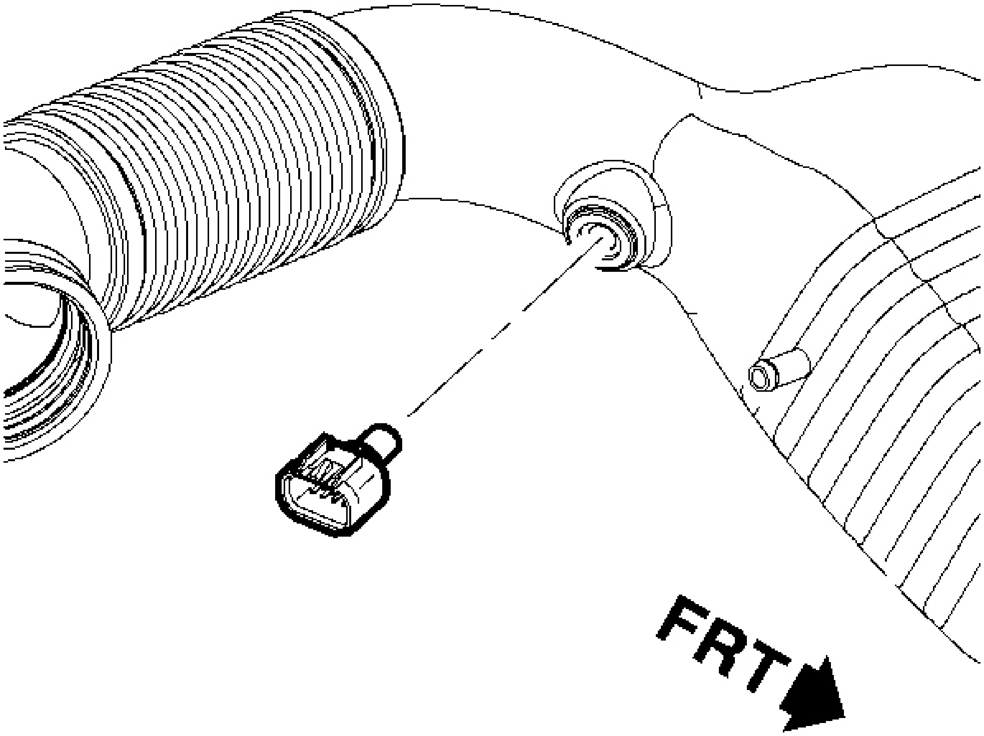


Fig. 17: View Of Intake Air Temperature (IAT) Sensor
Courtesy of GENERAL MOTORS CORP.

1. Turn the ignition OFF.
2. Disconnect the IAT sensor harness connector.
3. Remove the IAT sensor by pulling it out of the air induction tube.

Installation Procedure

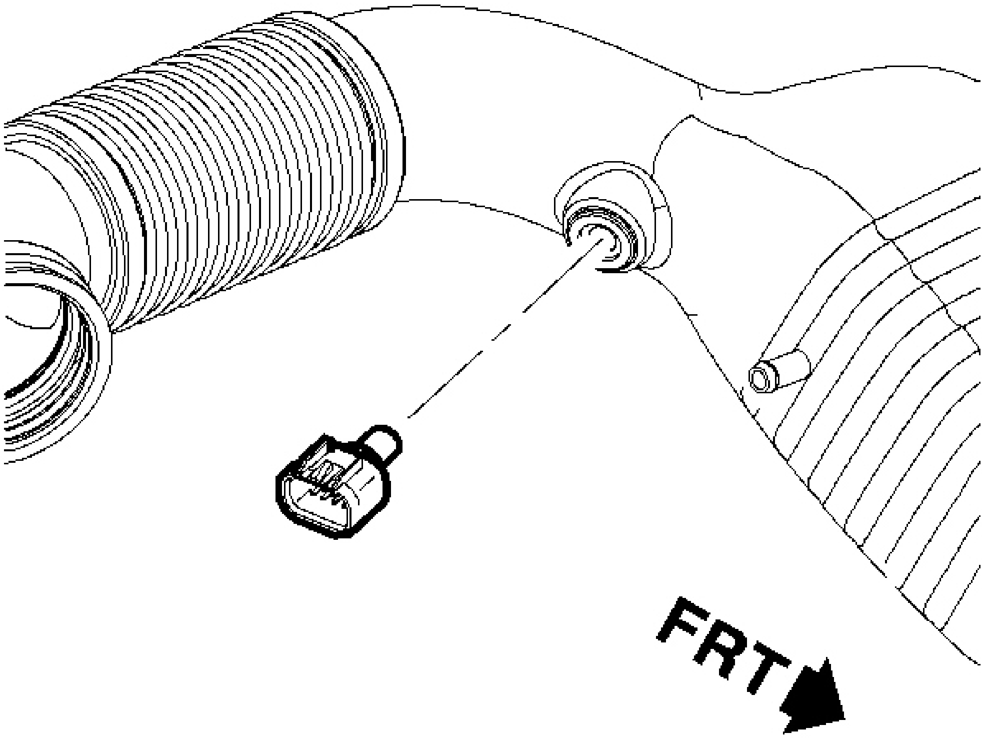


Fig. 18: View Of Intake Air Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

1. Install the IAT sensor.
2. Connect the IAT sensor harness connector. Push in the connector until a click is heard, then pull back to confirm a positive engagement.

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR REPLACEMENT

Removal Procedure

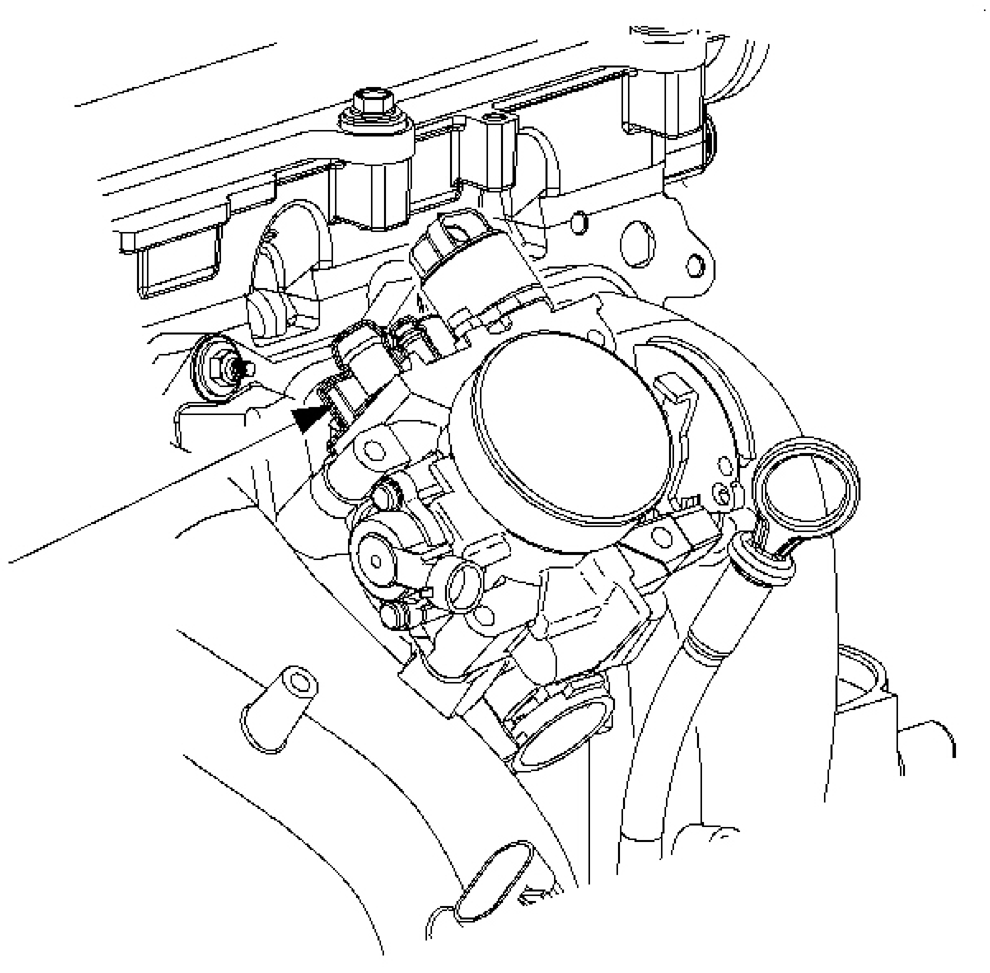


Fig. 19: View Of Manifold Absolute Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the intake air temperature (IAT) sensor connector.
2. Loosen the clamp at the air cleaner assembly.
3. Remove the push-pin attachment from the outlet resonator/duct assembly to support bracket.
4. Loosen the clamp at the throttle body assembly.
5. Disconnect the PCV fresh air vent hose at the cam cover.

6. Remove the outlet resonator/duct assembly.
7. Disconnect the MAP sensor electrical connector.
8. Remove the MAP sensor and the MAP sensor port seal if it is still retained in the intake manifold.

Installation Procedure

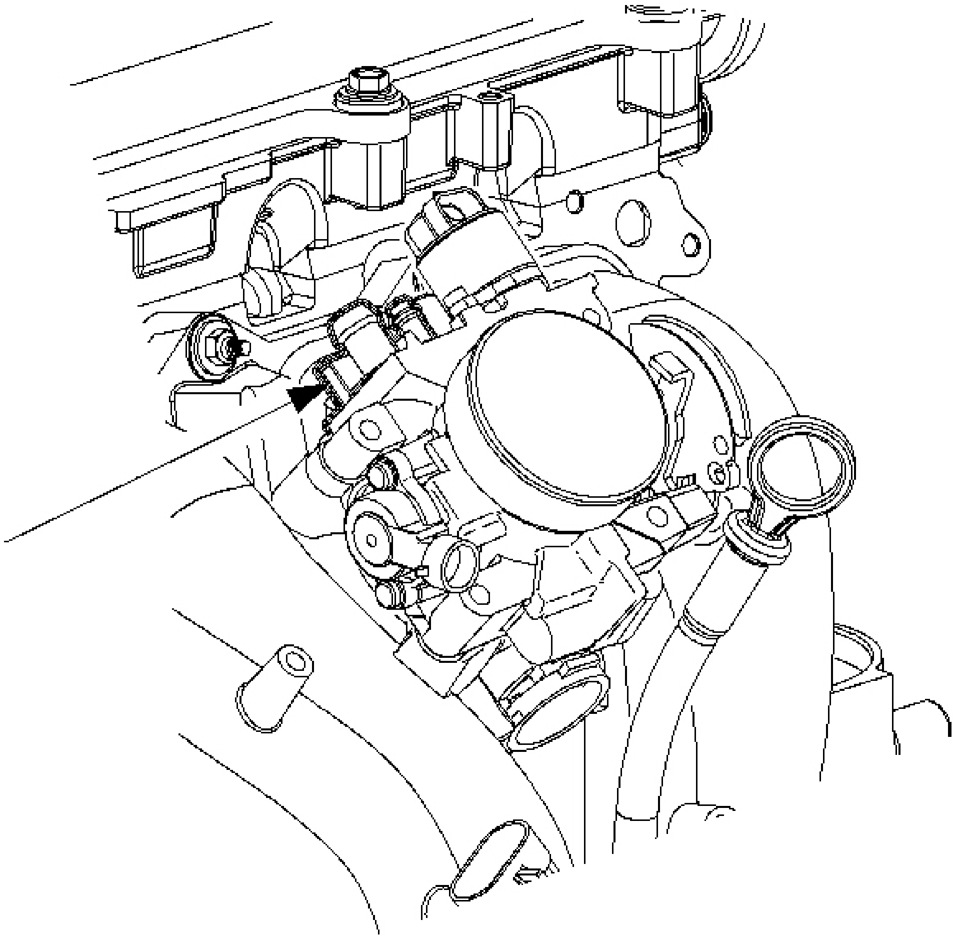


Fig. 20: View Of Manifold Absolute Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

1. Install the MAP sensor with port seal into the intake manifold.
2. Connect the MAP sensor electrical connector. Push in the connector until a click is heard and pull back to confirm a positive engagement.

3. Install the outlet resonator/duct assembly into position.
4. Connect the PCV fresh air vent hose assembly.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Tighten the clamp at the throttle body assembly.

   Tighten: Tighten the clamp to 4 N.m (36 lb in).

6. Position the outlet resonator/duct assembly up with the support bracket and install the push-pin.
7. Tighten the clamp at the air cleaner assembly.

   Tighten: Tighten the clamp to 4 N.m (36 lb in).

8. Connect the IAT sensor connector.

HEATED OXYGEN SENSOR REPLACEMENT - POSITION 1

Tools Required

J 39194-C O2 Sensor Wrench. See **Special Tools and Equipment** .

Removal Procedure

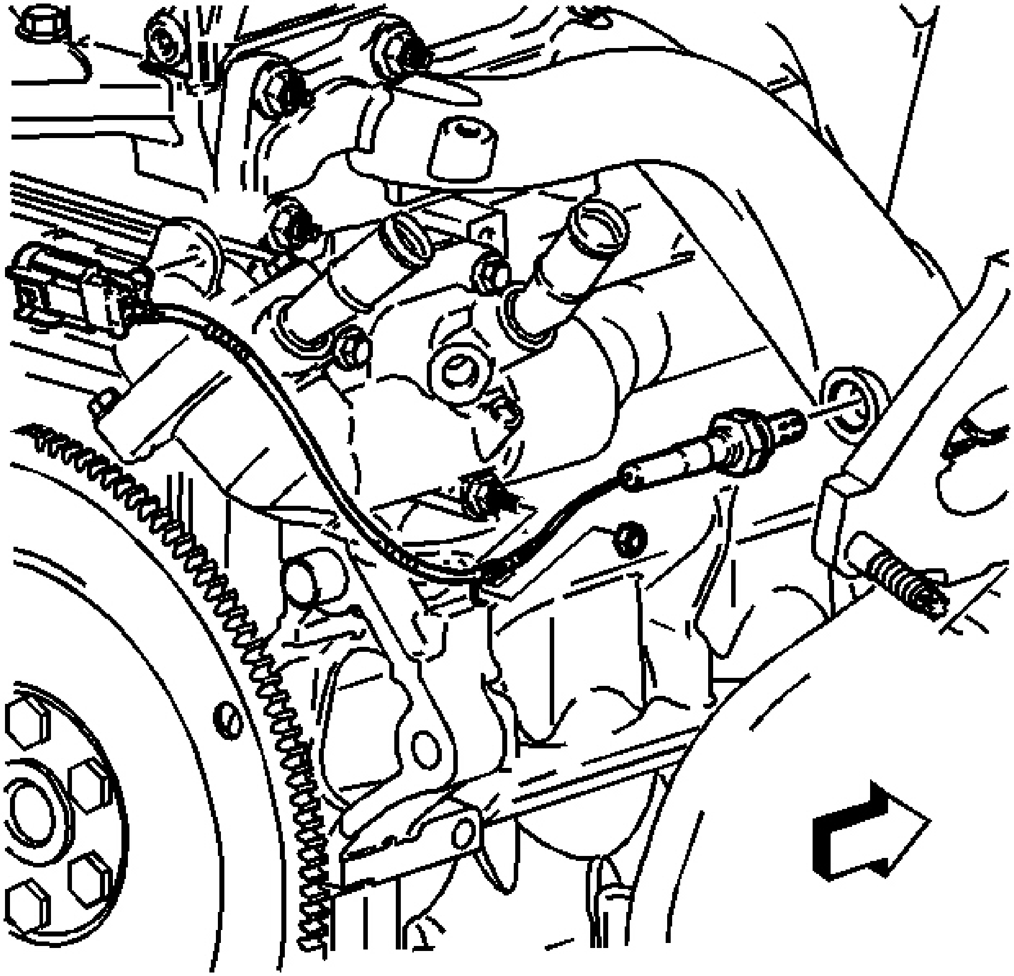


Fig. 21: View Of Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

NOTE: The HO2S uses a permanently attached pigtail and connector. This pigtail should not be removed from the HO2S. Damage or removal of the pigtail or connector could affect proper operation of the sensor.

1. Turn the ignition OFF.
2. Disconnect the HO2S-1 harness connector.
3. Remove the sensor harness and connector from the attachment clip.
4. Use a liquid penetrate before removing the sensor.

NOTE: **Removal of the sensor is easier if the exhaust system is slightly warmed up. Be careful that the exhaust is not hot to work on safely. Moving the sensor back and forth while applying penetrating oil to the threads will aid in removal and will decrease the chance of exhaust pipe thread damage.**

5. Remove the H02S-1 using the **J 39194-C** , or equivalent. See **Special Tools and Equipment** .

Installation Procedure

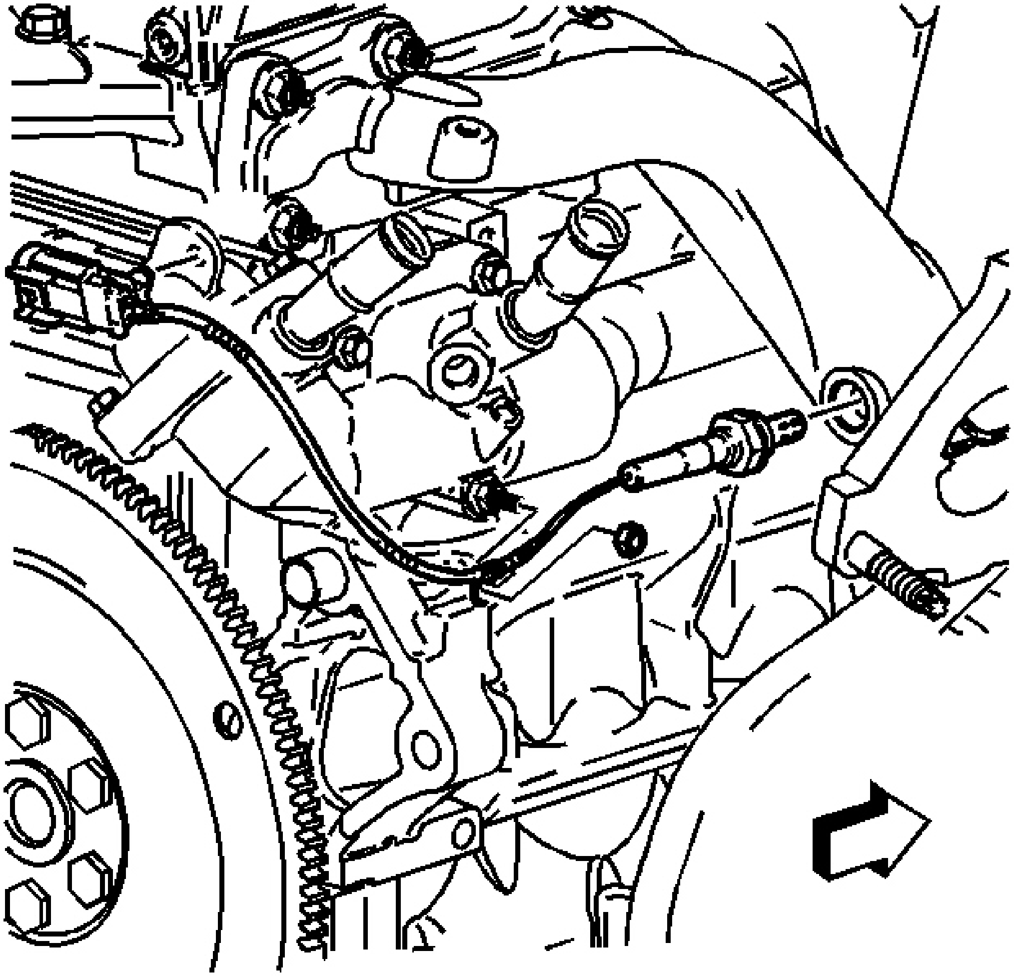


Fig. 22: View Of Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

NOTE: Silicone based products will contaminate the HO2S. Use only a nickel based anti-seize compound that does not contain silicone.

1. Apply a small amount of anti-seize compound Saturn P/N 21485279, or equivalent, to the threads of the HO2S-1.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the HO2S-1 using the **J 39194-C** , or equivalent. See **Special Tools and Equipment** .

   Tighten: Tighten the oxygen sensor-to-exhaust manifold pipe to 45 N.m (33 lb ft).

3. Install the sensor harness and connector to the attachment clip.
4. Connect the HO2S-1 harness connector. Push in the connector until a click is heard and pull back to confirm a positive engagement.

HEATED OXYGEN SENSOR REPLACEMENT - POSITION 2

Tools Required

J 39194-C O2 Sensor Wrench. See **Special Tools and Equipment** .

Removal Procedure

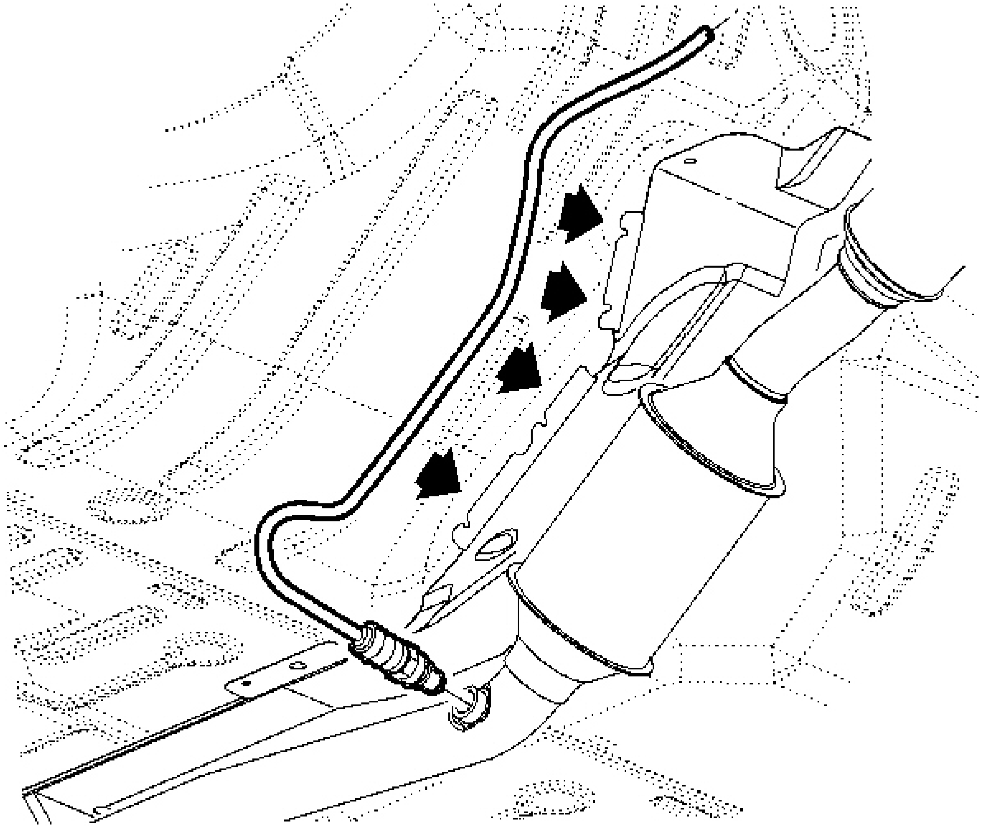


Fig. 23: View Of HO2S-2 Harness Connector
Courtesy of GENERAL MOTORS CORP.

NOTE: **The HO2S uses a permanently attached pigtail and connector. This pigtail should not be removed from the HO2S. Damage or removal of the pigtail or connector could affect proper operation of the sensor.**

1. Turn the ignition OFF.

CAUTION: **Ensure that the vehicle is properly supported and squarely positioned. To help avoid personal injury when a vehicle is on a hoist, provide additional support for the vehicle on the opposite end**

from which the components are being removed.

2. Raise the vehicle.
3. Disconnect the HO2S-2 harness connector.
4. Remove the HO2S-2 harness clip from the heat shield attachment.
5. Use a liquid penetrate before removing the sensor.

NOTE: **Refer to Heated Oxygen and Oxygen Sensor Notice in Cautions and Notices.**

6. Remove the HO2S-2 using the **J 39194-C** , or equivalent. See **Special Tools and Equipment** .

Installation Procedure

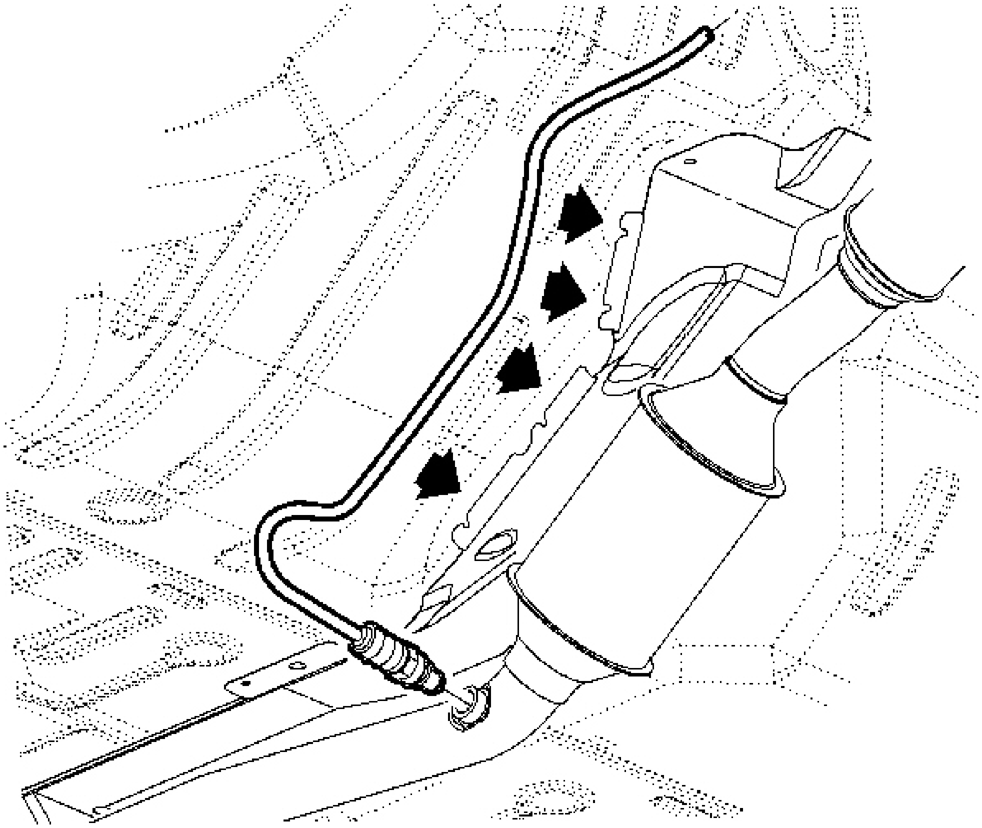


Fig. 24: View Of HO2S-2 Harness Connector
Courtesy of GENERAL MOTORS CORP.

NOTE: **Silicone based products will contaminate the HO2S. Use only a nickel based anti-seize compound that does not contain silicone.**

1. Apply a small amount of anti-seize compound Saturn P/N 21485279, or equivalent, to the threads of the HO2S-2.

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

2. Install the HO2S-2 using the **J 39194-C** , or equivalent. See **Special Tools and Equipment** .

Tighten: Tighten the HO2S-2 sensor-to-exhaust pipe to 45 N.m (33 lb ft).

NOTE: **Do Not apply any material in the HO2S-2 harness connector such as grease or dielectric compound. The wires carry air reference to the sensor in order for the sensor to operate properly.**

3. Install the HO2S-2 harness clip to the heat shield attachment bolt.

   Tighten: Tighten the bolt to 4 N.m (35 lb in).

4. Connect the HO2S-2 harness connector. Push in the connector until a click is heard, then pull back to confirm a positive engagement.
5. Ensure the HO2S-2 harness pigtail connector is secure to the chassis.

ACCELERATOR PEDAL POSITION ASSEMBLY REPLACEMENT

Removal Procedure

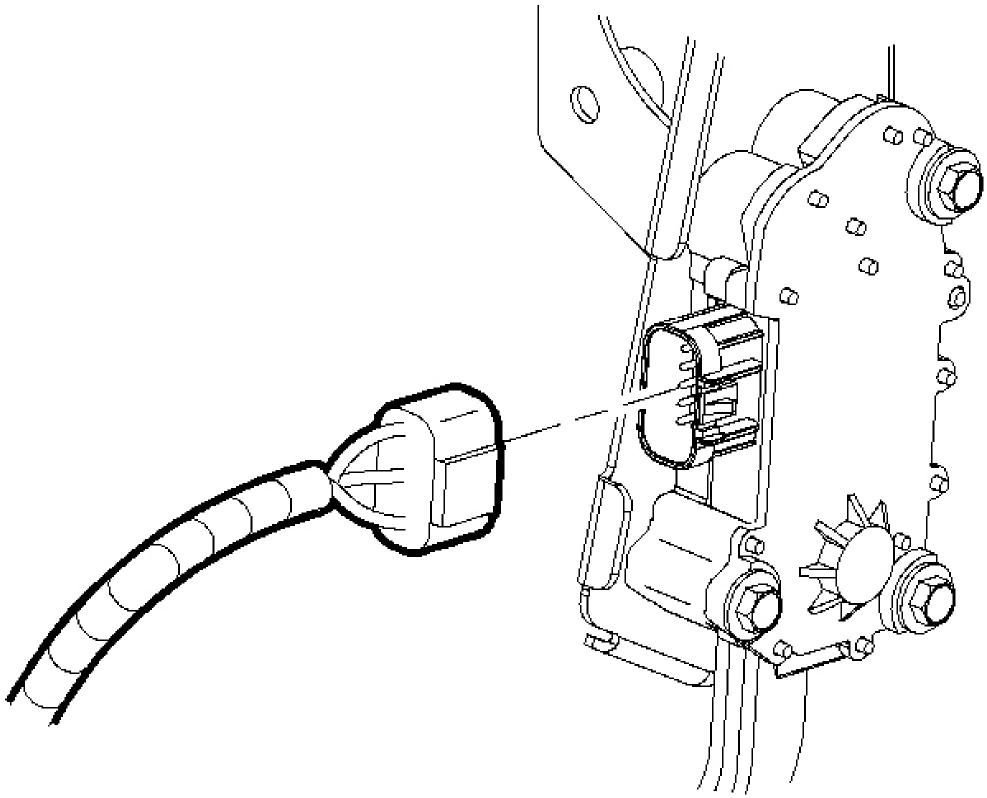


Fig. 25: View Of Accelerator Pedal Assembly
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the connector position assurance (CPS) from the accelerator pedal position (APP) sensor connector.
2. Disconnect the APP sensor harness connector.

IMPORTANT: Due to clearance issues, the upper attachment bolt cannot be removed from the accelerator pedal assembly. Loose then bolt completely and leave the bolt in the component until the assembly is removed from the vehicle.

IMPORTANT: A speed wrench may be used to aid in the removal and installation.

3. Remove the APP assembly attachment bolts to the brake pedal assembly.

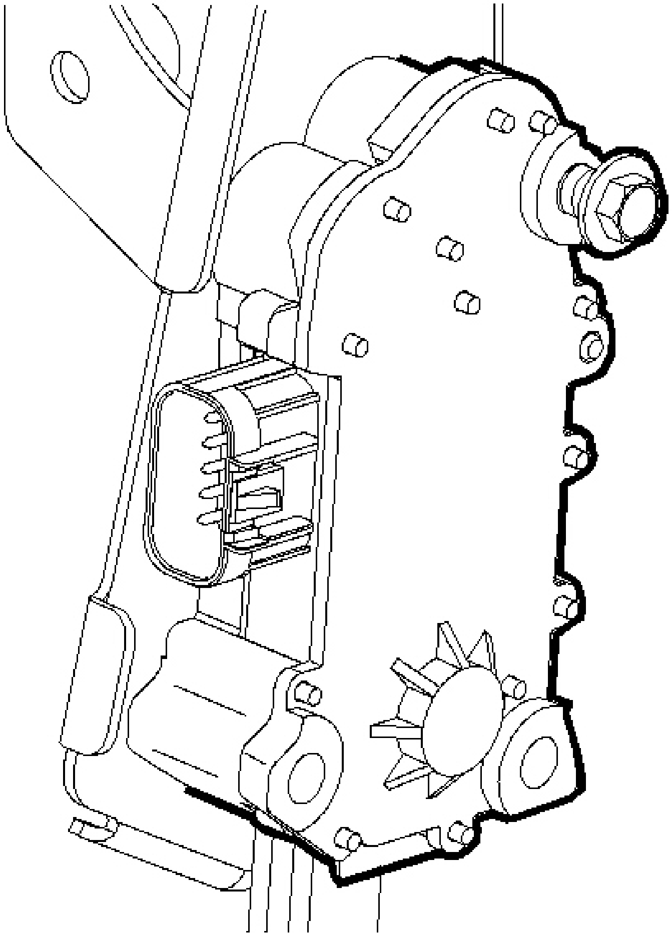


Fig. 26: View Of APP Assembly From The Vehicle
Courtesy of GENERAL MOTORS CORP.

4. Remove the APP assembly from the vehicle.

Installation Procedure

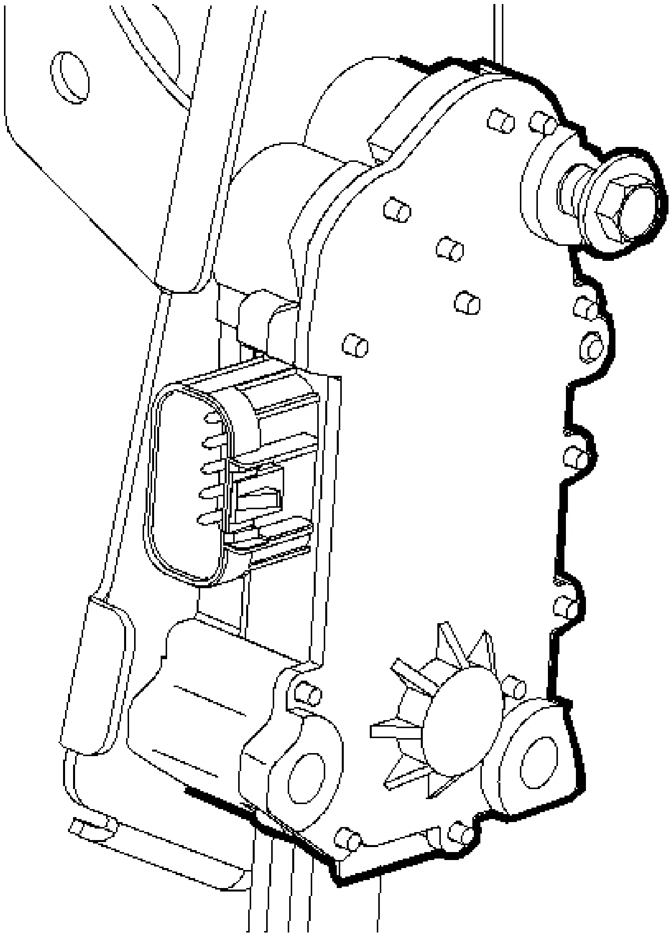


Fig. 27: View Of APP Assembly From The Vehicle
Courtesy of GENERAL MOTORS CORP.

1. Install the upper attachment bolt into the APP assembly.
2. Install the APP assembly into the vehicle.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the attachment bolts into the APP assembly.

Tighten: Tighten the accelerator pedal position assembly-to-brake bracket bolt to 25 N.m (18 lb ft).

4. Connect the APP sensor harness connector. Push the connector in until the lock position is felt, then pull back to confirm engagement.
5. Install the APP sensor connect CPA.

THROTTLE BODY ASSEMBLY REPLACEMENT

Removal Procedure

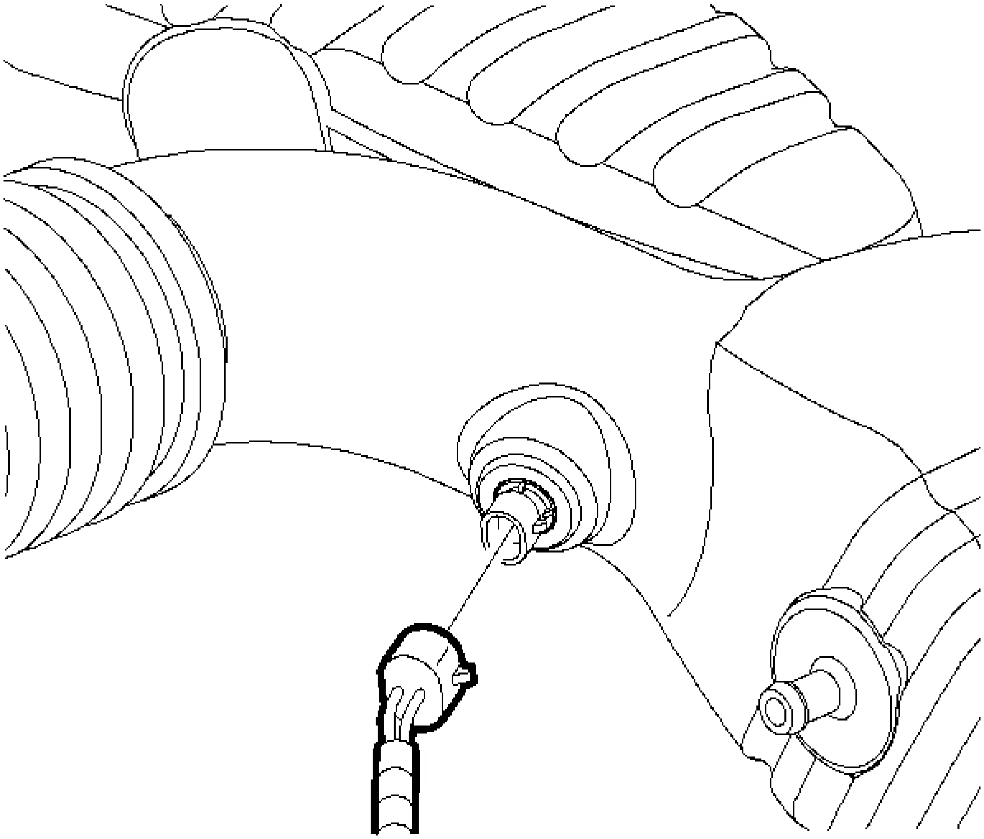
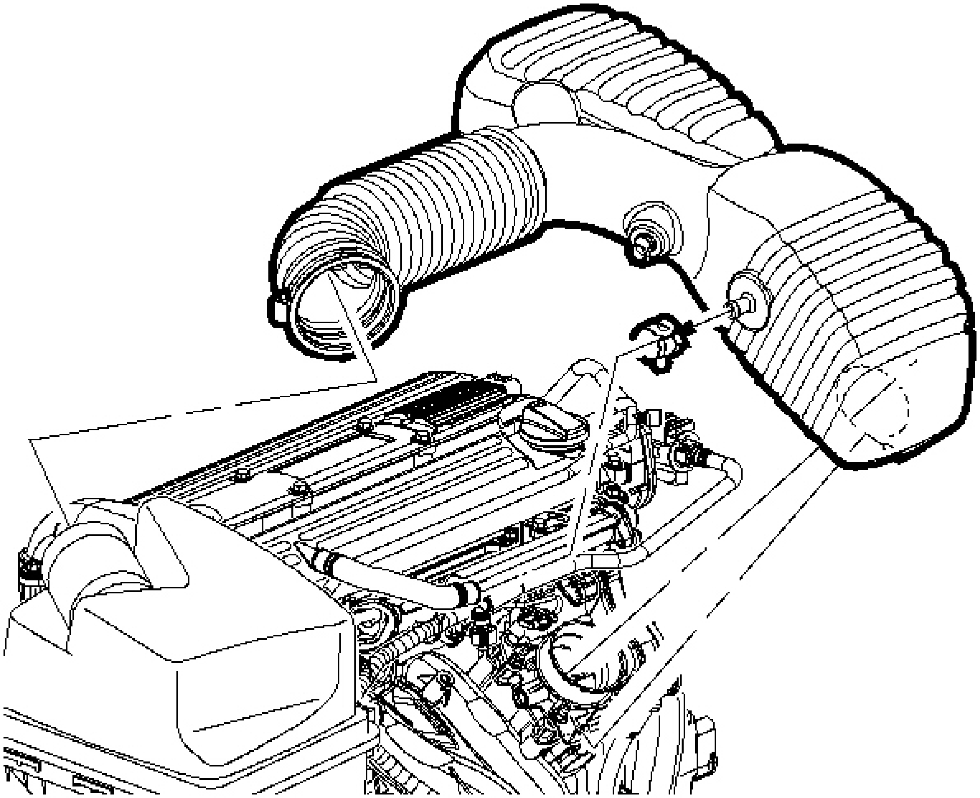


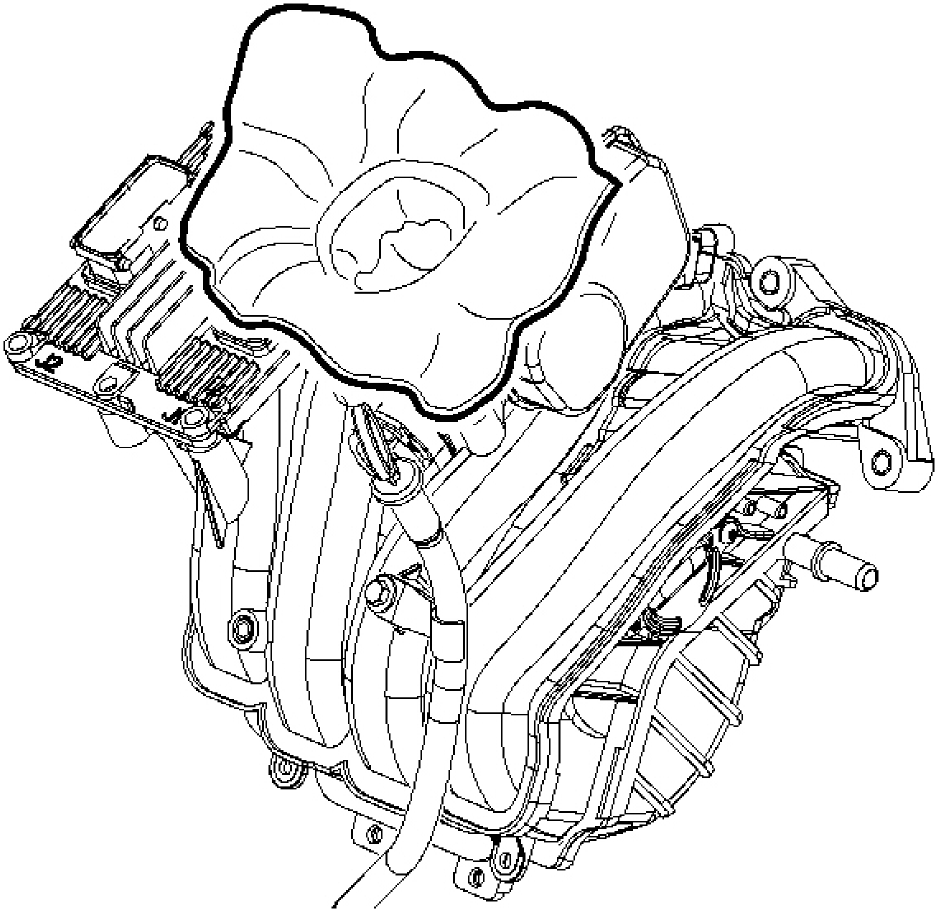
Fig. 28: View Of Throttle Body Assembly
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the intake air temperature (IAT) sensor connector.



<u>Fig. 29: Locating Air Intake Assembly</u>
Courtesy of GENERAL MOTORS CORP.

2. Loosen the clamp a the air cleaner assembly.
3. Remove the push pin attachment from the outlet resonator/duct assembly to support bracket.
4. Loosen the clamp at the throttle body assembly.
5. Disconnect the PCV fresh air vent hose at the cam cover.
6. Remove the outlet resonator/duct assembly.



<u>**Fig. 30: View Of Throttle Body Opening With A Shop Towel**</u>
Courtesy of GENERAL MOTORS CORP.

NOTE: **Cover the throttle body with a shop towel. Using air, clean the base of the throttle body to prevent debris from entering the manifold when the throttle body is removed.**

7. Cover the throttle body opening with a shop towel and use the shop air to remove any dirt at the base of the throttle body.

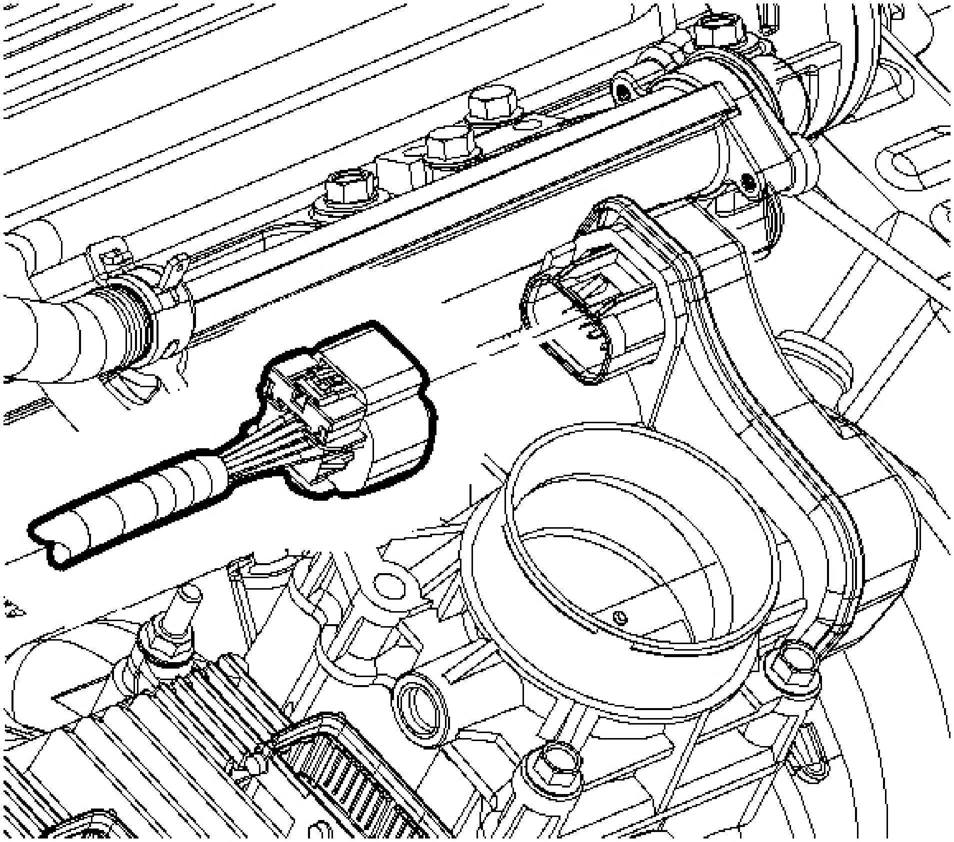


Fig. 31: View Of Throttle Body Electrical Connector
Courtesy of GENERAL MOTORS CORP.

8. Disconnect the electrical connector at throttle body.

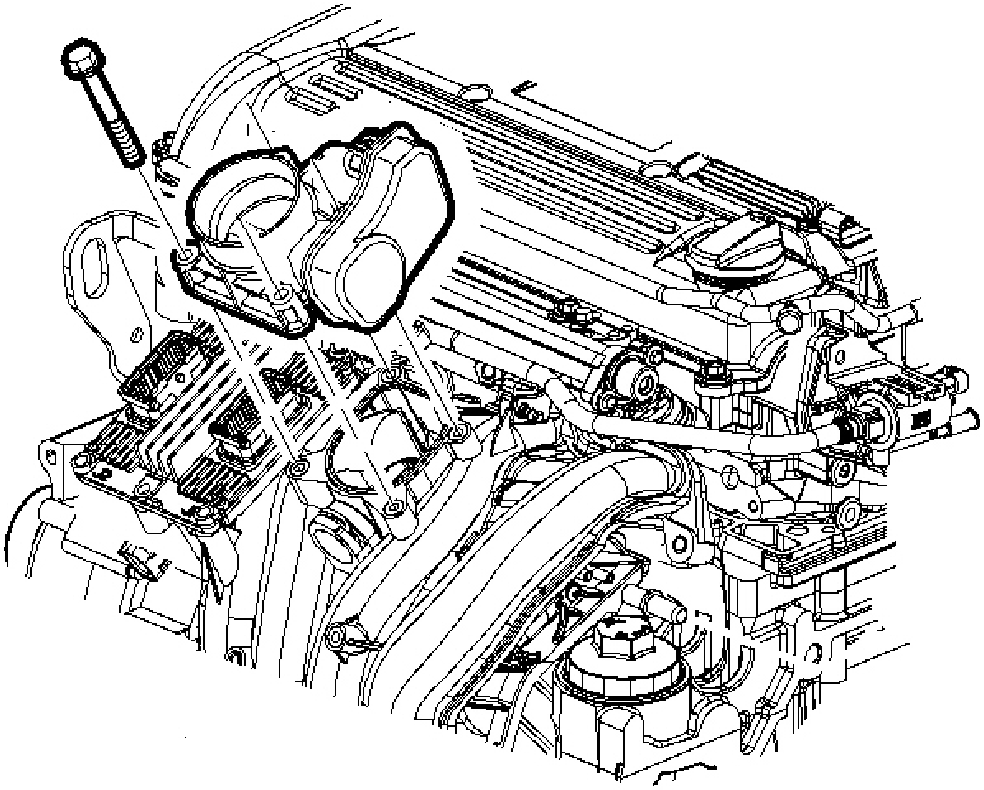


Fig. 32: View Of Throttle Body Assembly & Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the throttle body bolts.
10. Remove the throttle body.

IMPORTANT: The throttle body-to-manifold gasket is not reusable.

11. Remove the gasket and discard.

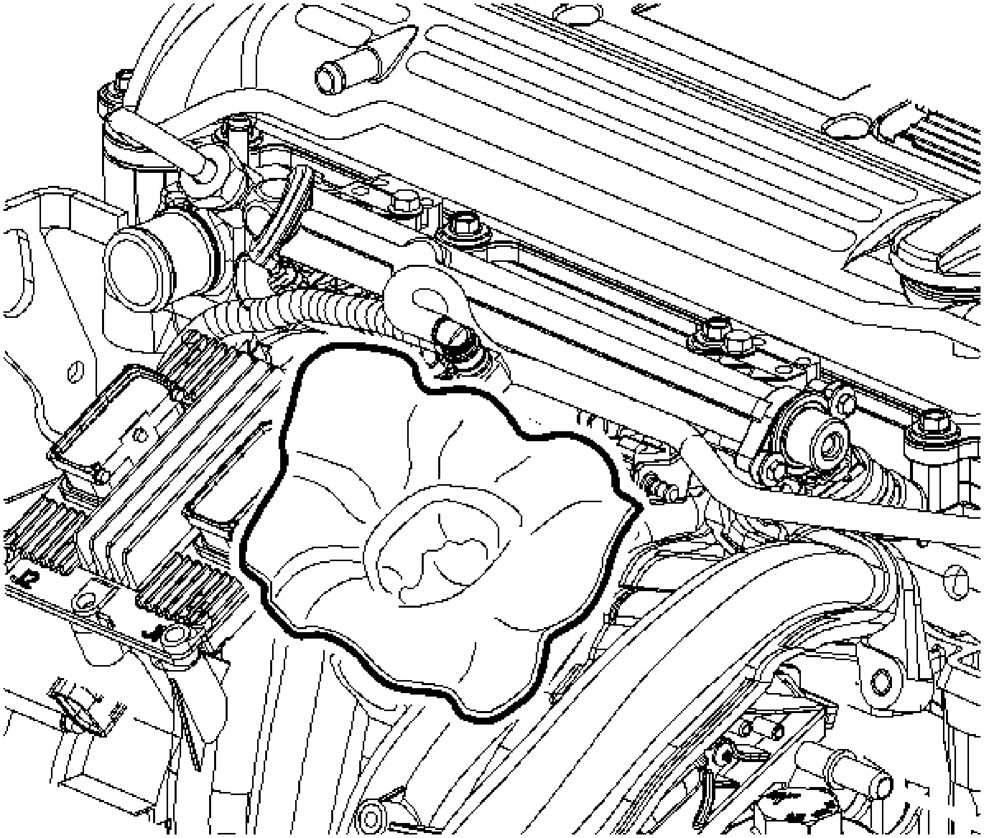


Fig. 33: View Of Intake Manifold Opening With A Clean Shop Towel
Courtesy of GENERAL MOTORS CORP.

NOTE: **Cover the intake manifold opening with a shop towel whenever the throttle body is removed to prevent foreign material entry.**

12. Block the intake manifold opening with a clean shop towel to prevent dirt from entering.

Installation Procedure

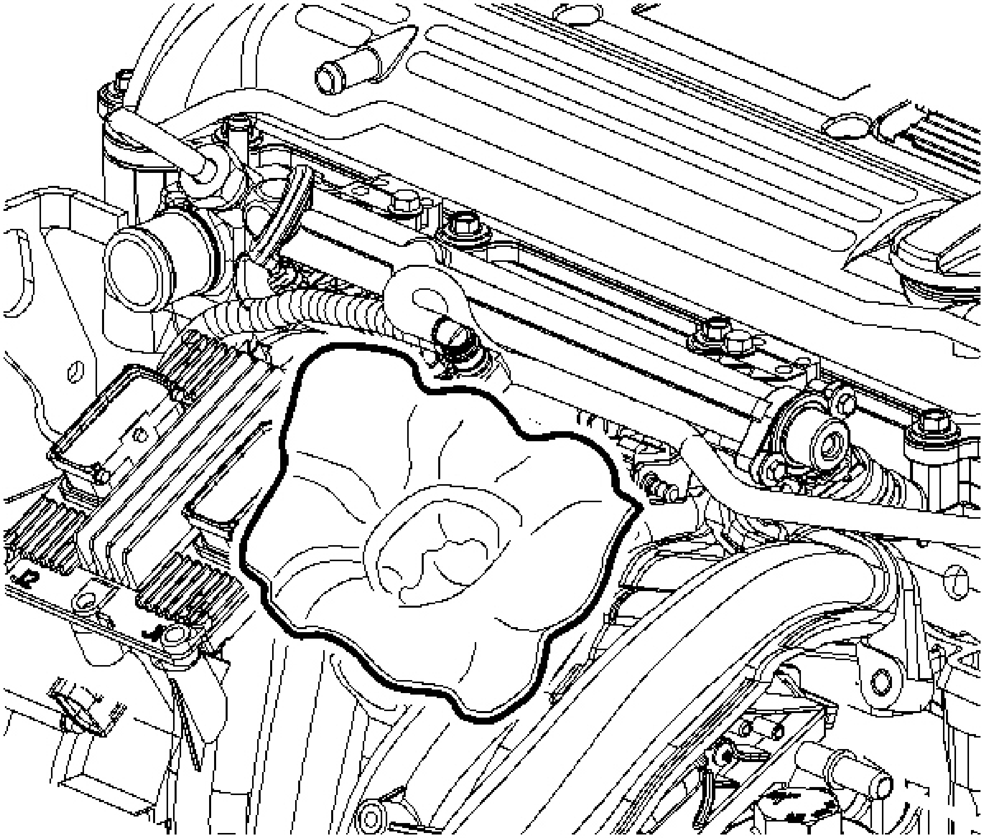


Fig. 34: View Of Intake Manifold Opening With A Clean Shop Towel
Courtesy of GENERAL MOTORS CORP.

1. Remove the shop towel from the throttle body opening.

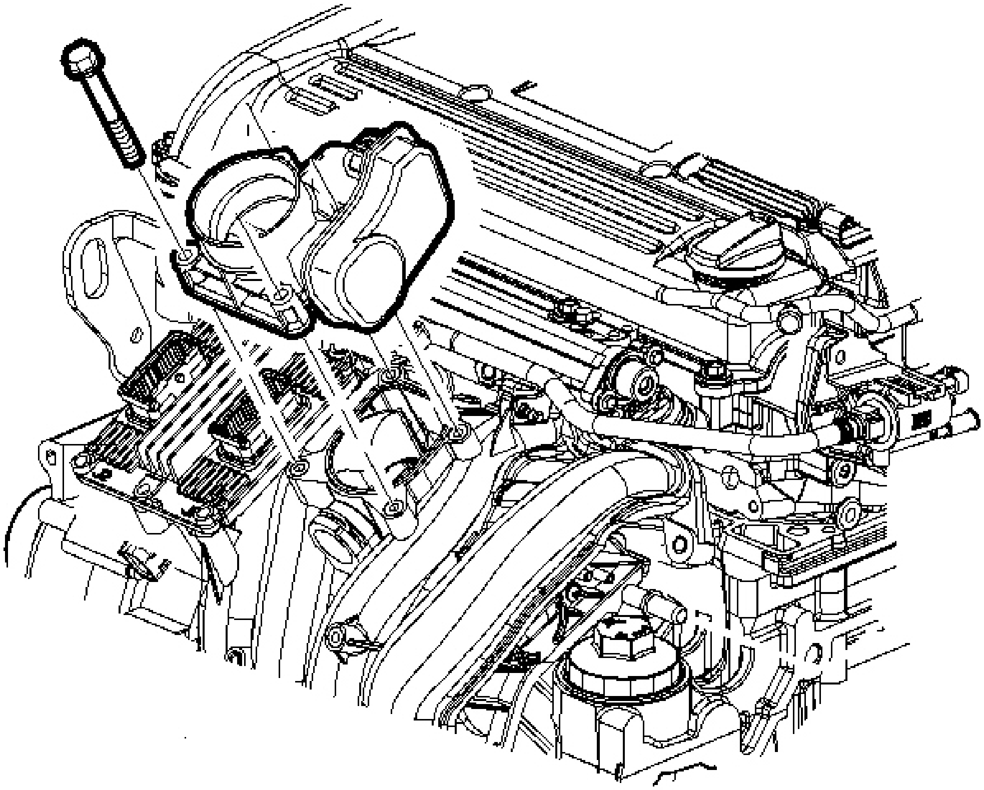


Fig. 35: View Of Throttle Body Assembly & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the throttle body gasket.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the throttle body assembly and bolts.

Tighten: Tighten the throttle body-to-intake manifold bolts - L61 to 10 N.m (89 lb in).

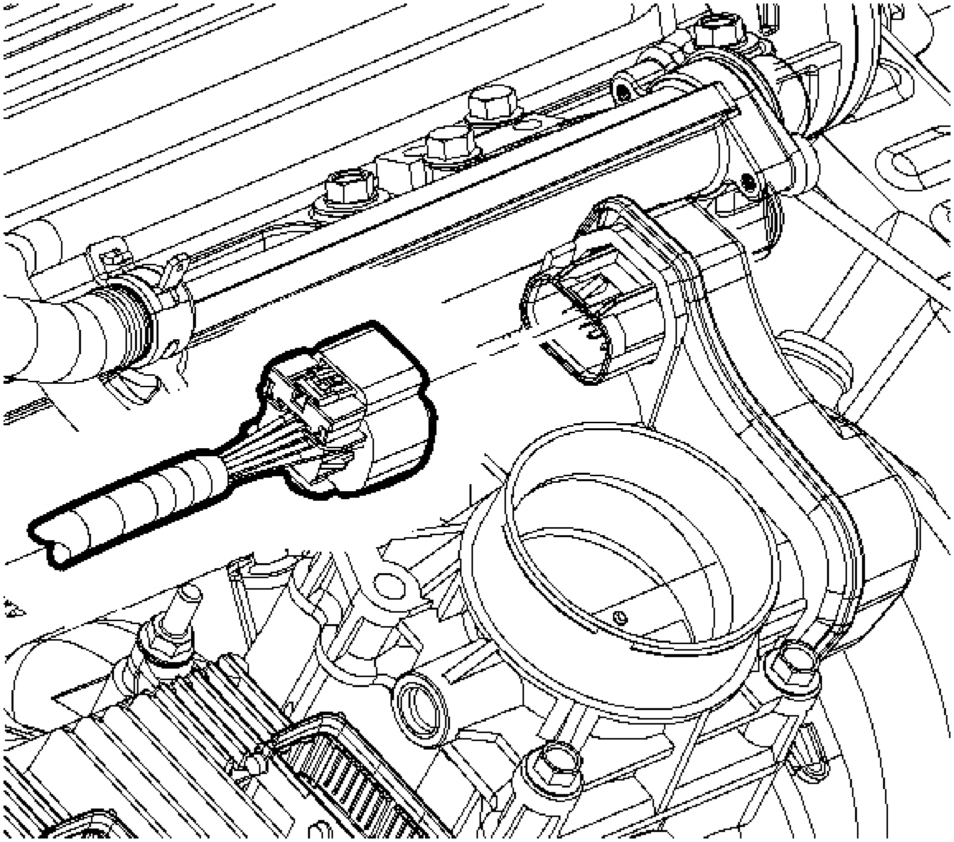


Fig. 36: View Of Throttle Body Electrical Connector
Courtesy of GENERAL MOTORS CORP.

4. Connect the throttle body electrical connector.

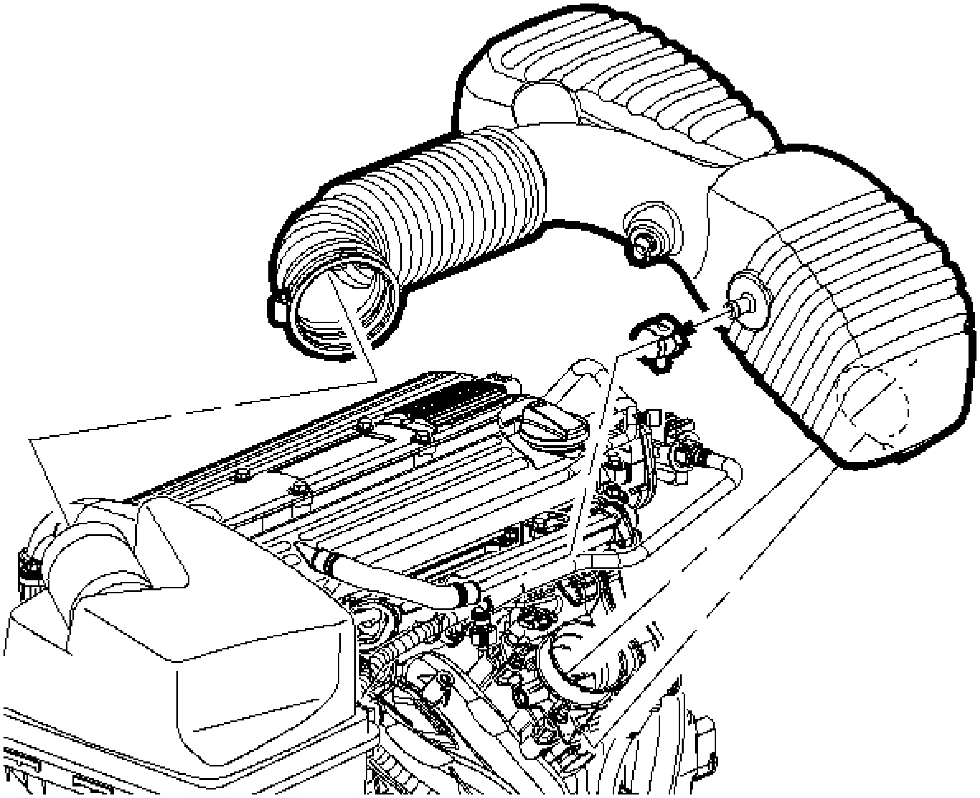


Fig. 37: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

5. Position the outlet resonator/duct assembly into position.
6. Connect PCV fresh air vent hose assembly.
7. Tighten the clamp at throttle body assembly.
8. Position the outlet resonator/duct assembly up with support bracket and install the push-pin.
9. Tighten the clamp at the air cleaner assembly.
10. Connect the intake air temperature (IAT) sensor connector.
11. Turn the ignition ON for one minute while the engine control module (ECM) automatically relearns throttle position.

FUEL PRESSURE RELIEF PROCEDURE

Tools Required

J 34730-1A Fuel Pressure Gage. See **Special Tools and Equipment** .

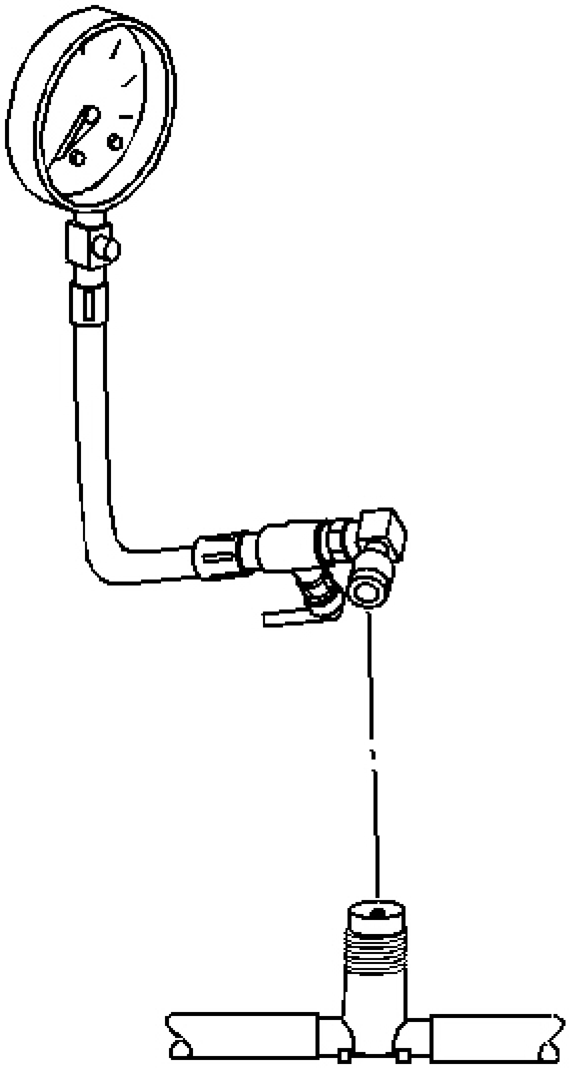


Fig. 38: Identifying Fuel Pressure Gauge J 34730-1A
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Connect the **J 34730-1A** to the fuel pressure connection. See **Special Tools and Equipment** . Refer to **Fuel Pressure Gage Installation and Removal** .
3. Install the bleed hose into an approved container and open the valve to bleed the system pressure. The fuel connections are now safe for servicing.
4. Disconnect the fuel pressure gage from the fuel pressure connection. Refer to **Fuel Pressure Gage Installation and Removal** .

FUEL PRESSURE GAGE INSTALLATION AND REMOVAL

Tools Required

J 34730-1A Fuel Pressure Gage. See **Special Tools and Equipment** .

Installation Procedure

CAUTION: 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.

CAUTION: 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 gage. Place the towel in an approved container when the connection of the fuel pressure gage is complete.

NOTE: 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**

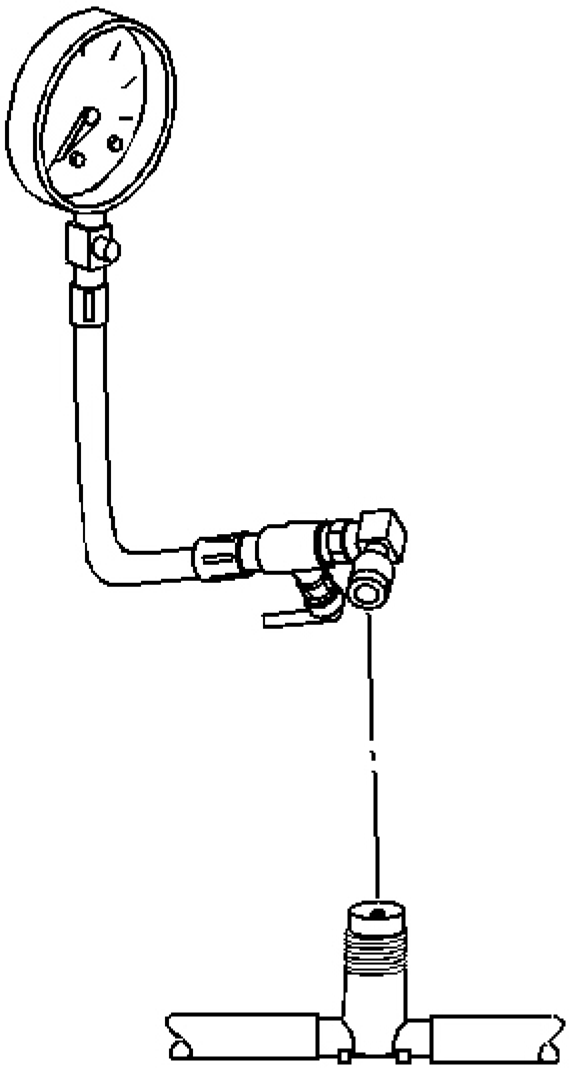


Fig. 39: Identifying Fuel Pressure Gauge J 34730-1A
Courtesy of GENERAL MOTORS CORP.

1. Install the **J 34730-1A** to the fuel pressure connection, located on the fuel rail. See **Special Tools and Equipment** .

CAUTION: Do not drain the fuel into an open container. Never store the fuel in an open container due to the possibility of a fire or an explosion.

2. Place the bleed hose of the fuel pressure gage into an approved gasoline container.
3. Open the bleed valve on the fuel pressure gage in order to bleed the air from the gage.
4. Turn ON the ignition, with the engine OFF.
5. Command the fuel pump ON with a scan tool until all of the air is bled out of the gage.
6. Close the bleed valve on the fuel pressure gage.
7. Command the fuel pump ON with a scan tool.
8. Inspect for fuel leaks.

Removal Procedure

1. Place the fuel pressure gage bleed hose into an approved container and open the bleed valve to bleed fuel system pressure.

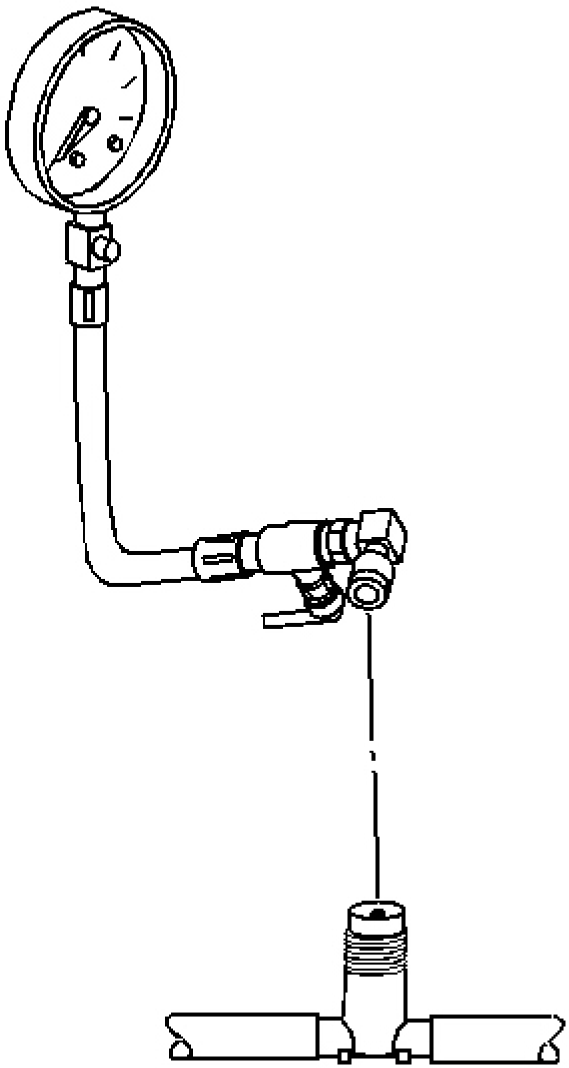


Fig. 40: Identifying Fuel Pressure Gauge J 34730-1A
Courtesy of GENERAL MOTORS CORP.

2. Place a shop towel under the fuel pressure gage to catch any remaining fuel spillage.
3. Remove the **J 34730-1A** from fuel pressure connection. See **Special Tools and Equipment** .
4. Drain any fuel remaining in the fuel pressure gage into an approved container.
5. Install the cap on the fuel pressure connection.
6. Place the shop towel in an approved container.

FUEL INJECTORS AND FUEL RAIL REPLACEMENT

Tools Required

- **SA9127E** Gage Bar Set
- **SA9805E** Fuel Line Separator

Removal Procedure

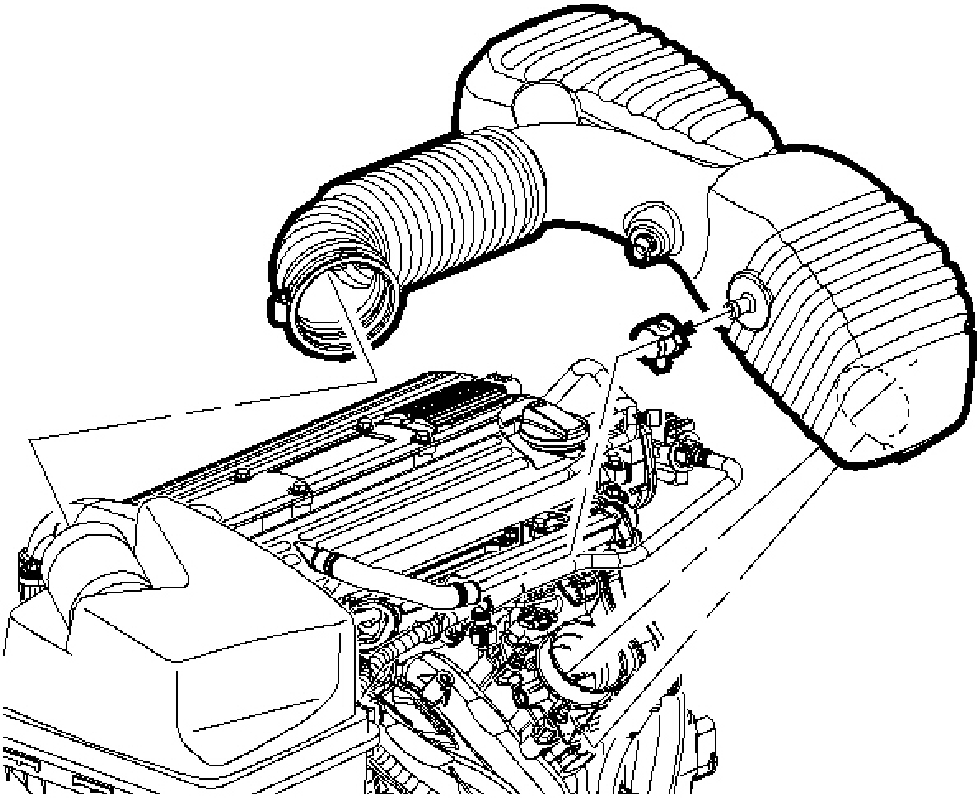


Fig. 41: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the negative battery cable.

2. Disconnect the intake air temperature (IAT) sensor connector.
3. Loosen the clamp at the air cleaner assembly.
4. Remove the push pin attachment from the outlet resonator/duct assembly to support bracket.
5. Loosen the clamp at the throttle body assembly.
6. Disconnect the PCV fresh air vent hose at the cam cover.
7. Remove the outlet resonator/duct assembly.
8. Place a shop rag over the throttle body assembly.
9. Using shop air, blow off the dirt and dust near the fuel injector ports.

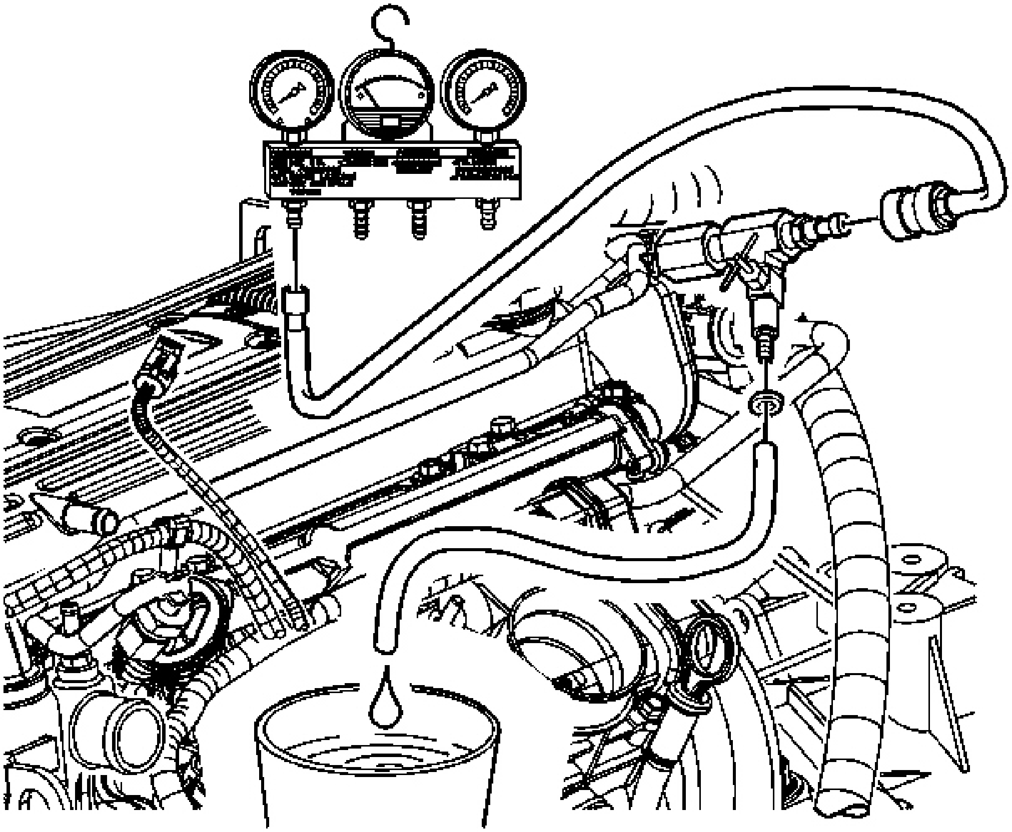


Fig. 42: View Of Fuel System Pressure
Courtesy of GENERAL MOTORS CORP.

CAUTION: Whenever fuel line fittings are loosened or disconnected, wrap a shop cloth around the fitting to collect fuel. Place the cloth in an

approved container.

10. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** .
11. Disconnect the **SA9127E** after the pressure has been relieved.
12. Position the engine harness away from the fuel rail assembly.

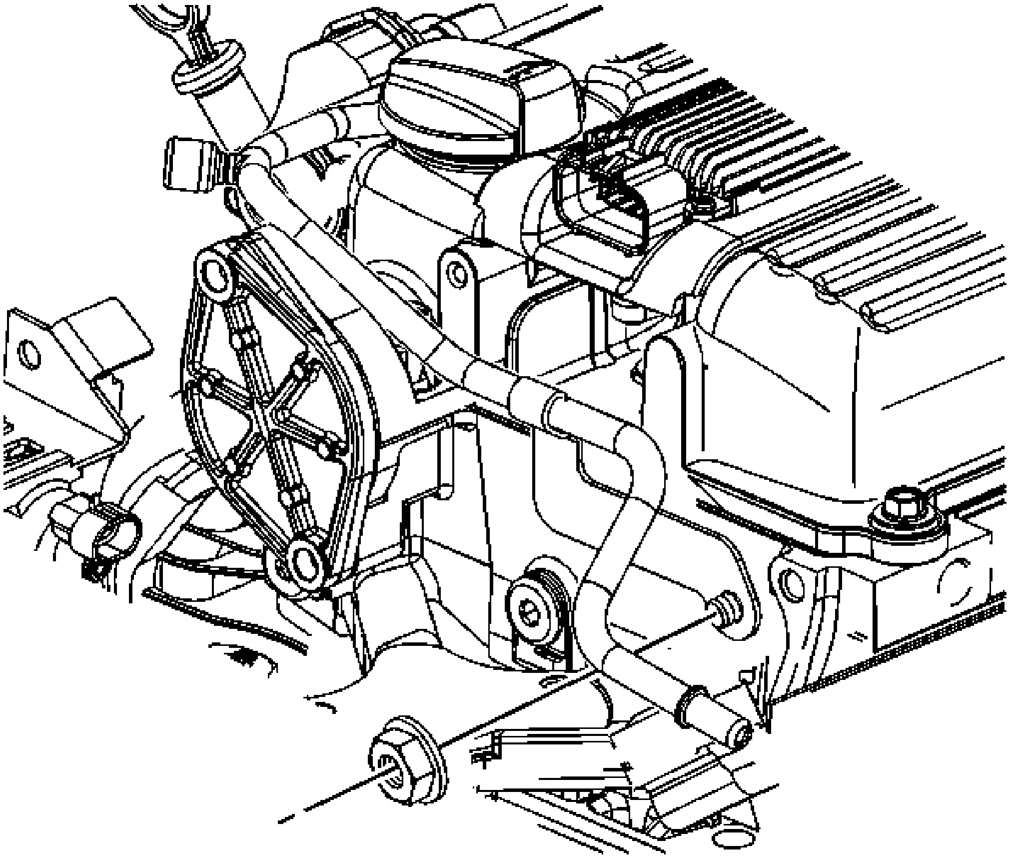


Fig. 43: View Of Fuel Rail Bracket
Courtesy of GENERAL MOTORS CORP.

13. Disconnect the fuel rail bracket and nut at the rear of the cam cover.

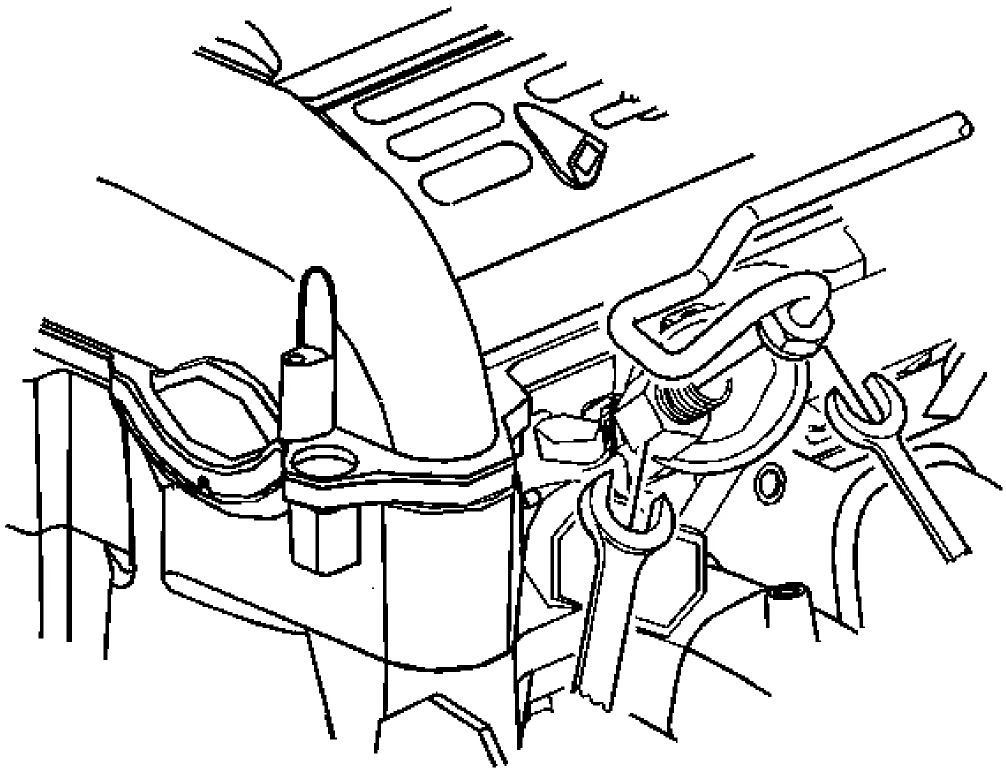


Fig. 44: View Of Fuel Line Bracket & Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: **An open-end wrench must be used to support the fuel line to rail connection during loosening/tightening to avoid damaging the fuel rail assembly.**

14. Disengage the fuel transfer lines at quick contract from the fuel line using the **SA9805E** .
15. While supporting the fuel rail assembly with an open-end wrench, loosen the transfer line fitting at the fuel rail.

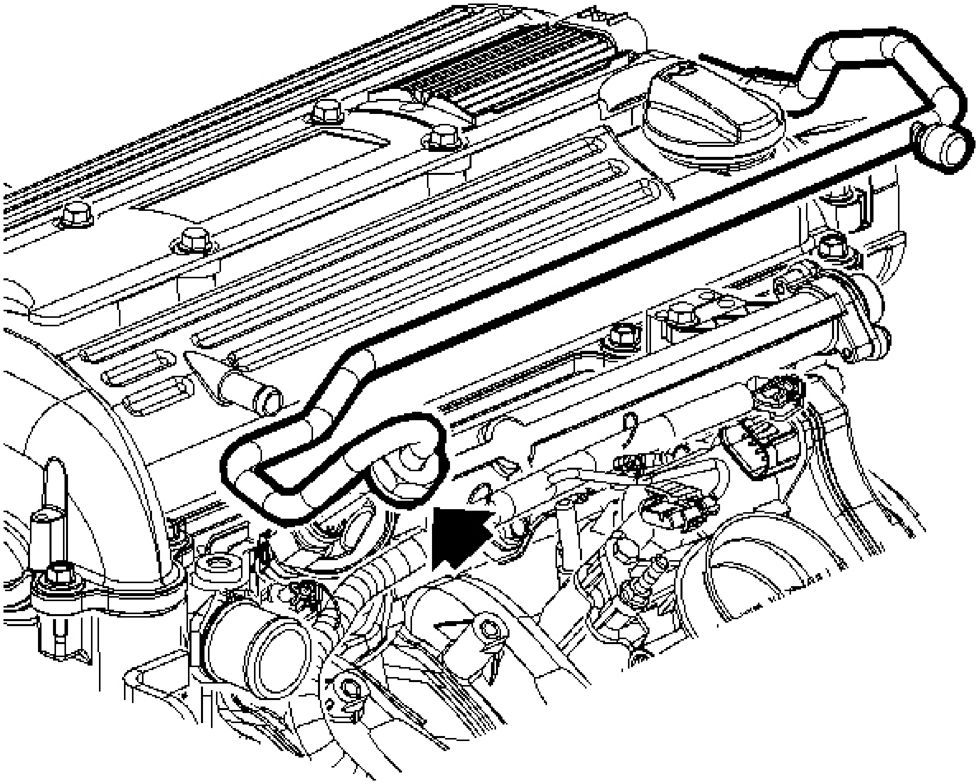


Fig. 45: Positioning The Fuel Transfer Line Assembly
Courtesy of GENERAL MOTORS CORP.

16. Position the fuel line away from the rail assembly without disconnecting the degas hose.

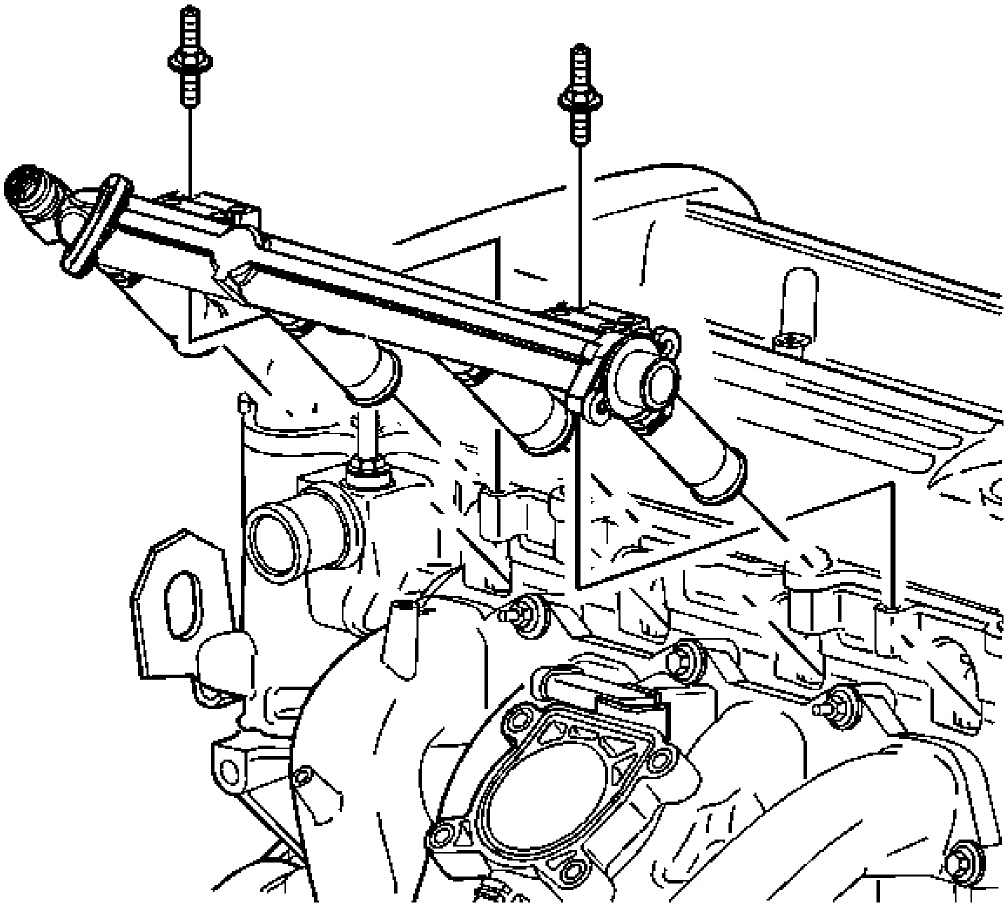


Fig. 46: View Of Fuel Rail Assembly Attachment Bolts
Courtesy of GENERAL MOTORS CORP.

17. Disconnect the electrical connectors at the fuel injectors.
18. Remove the fuel rail assembly attachment bolts.

NOTE:	**Use care in removing the fuel rail assembly to prevent damage to the electrical connector terminals and spray tips. The fuel injector is serviced as a complete assembly only. Support fuel after fuel rail is removed in order to avoid damaging fuel rail components. Since it is electrical, it should not be immersed in any cleaner.**

19. Remove the fuel rail assembly by carefully pulling the rail backward and upward to remove injectors from the cylinder head.

20. Move the fuel rail assembly rearward while slightly rotating to remove the fuel rail assembly.

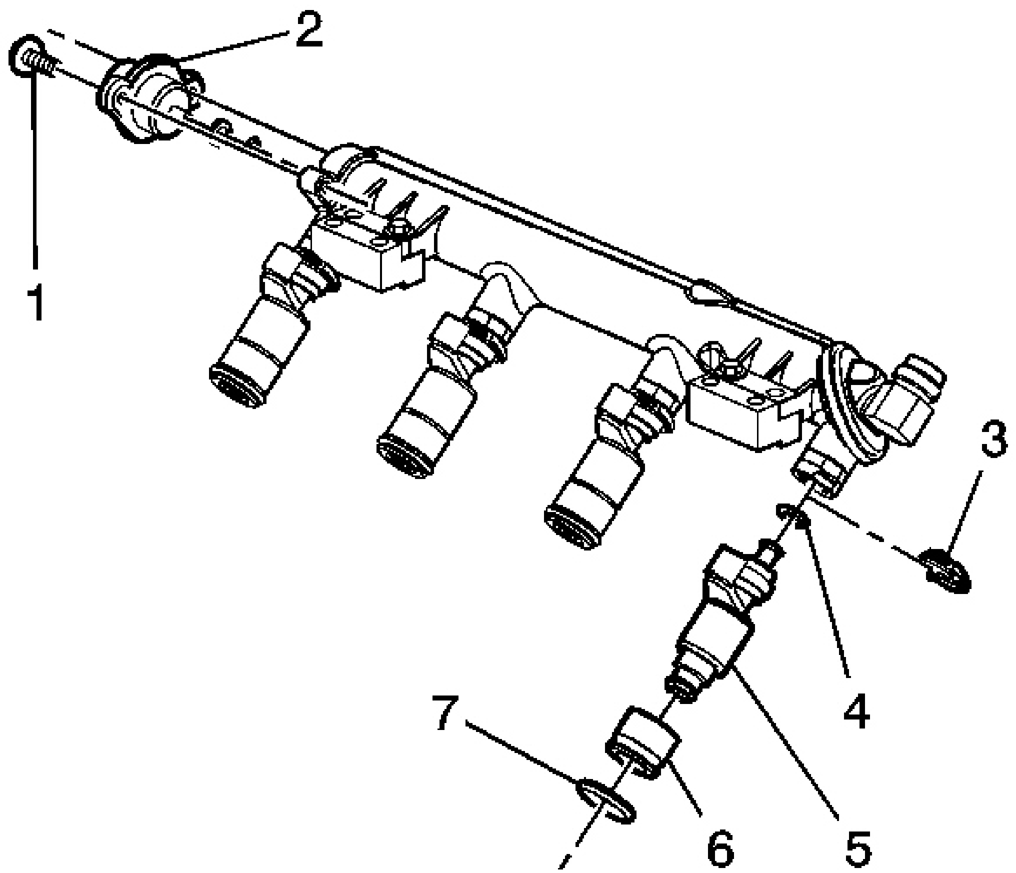


Fig. 47: View Of Fuel Rail Assembly
Courtesy of GENERAL MOTORS CORP.

NOTE: **When cleaning or servicing the fuel rail, care must be taken to assure that the plastic fuel rail surfaces that mate to the injector O-rings are not scratched.**

IMPORTANT: **Whenever the fuel rail is removed for service, upper and lower O-ring seals must be replaced. The injectors can be serviced individually if required.**

21. Remove the fuel injector retaining clips (3).

22. Remove the fuel injectors (5) from the fuel rail.
23. Remove and discard all injector O-ring seals (4, 7) by using a small pick.

Installation Procedure

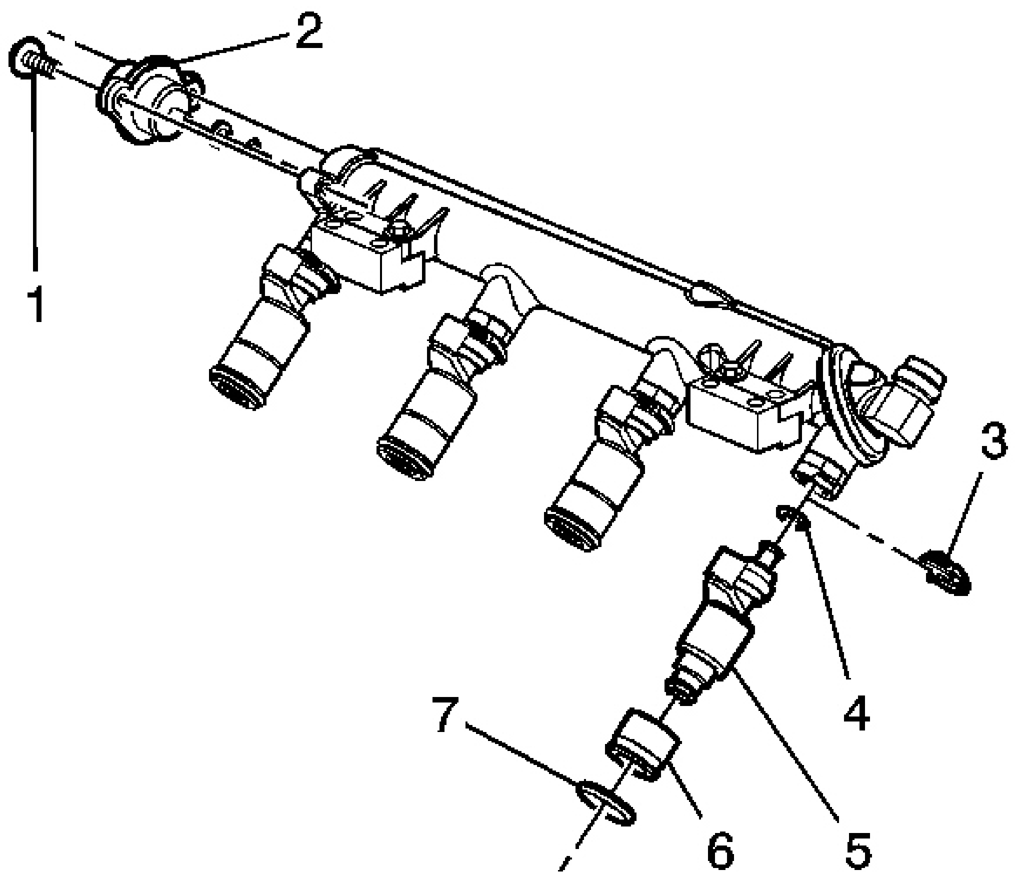


Fig. 48: View Of Fuel Rail Assembly
Courtesy of GENERAL MOTORS CORP.

1. Transfer components to the new fuel rail if the rail is being replaced.
2. Install the new upper and lower O-ring seals (4, 7) to injectors (5).
3. Install the injectors (5) to the fuel rail assembly.
4. Install the isolators (6) with new seals to injectors.
5. Install the injector retaining clip (3).

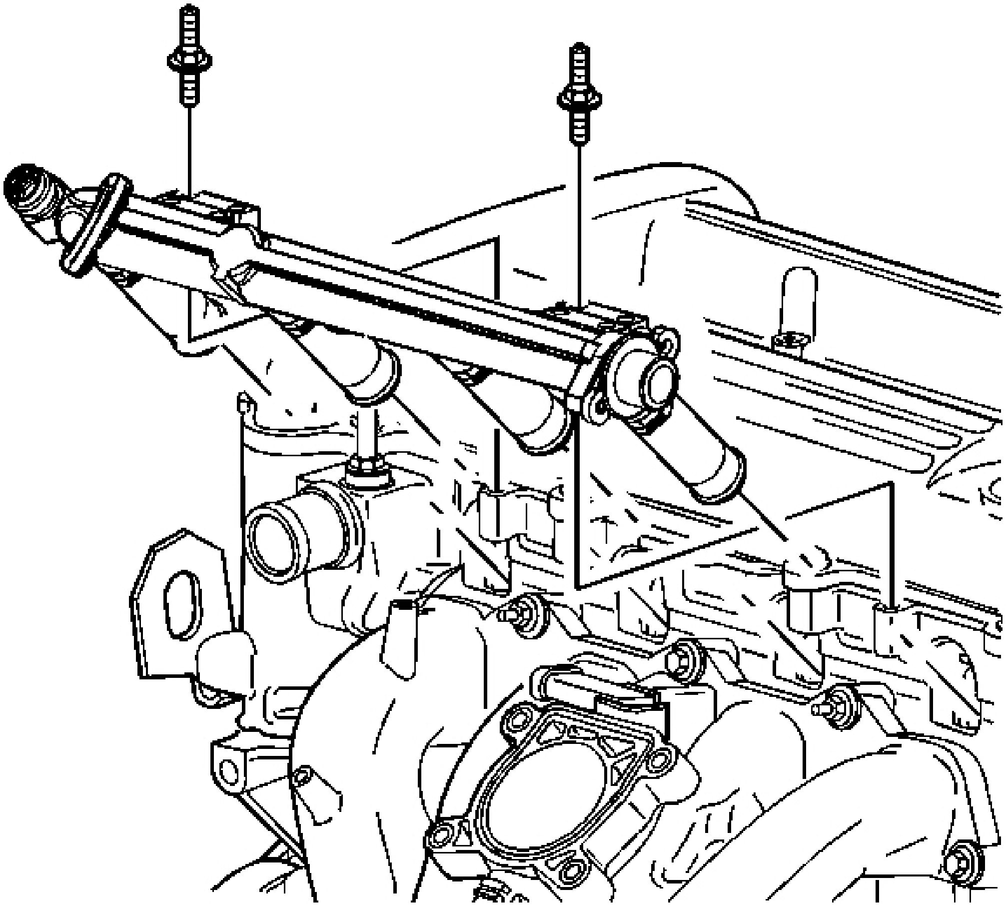


Fig. 49: View Of Fuel Rail Assembly Attachment Bolts
Courtesy of GENERAL MOTORS CORP.

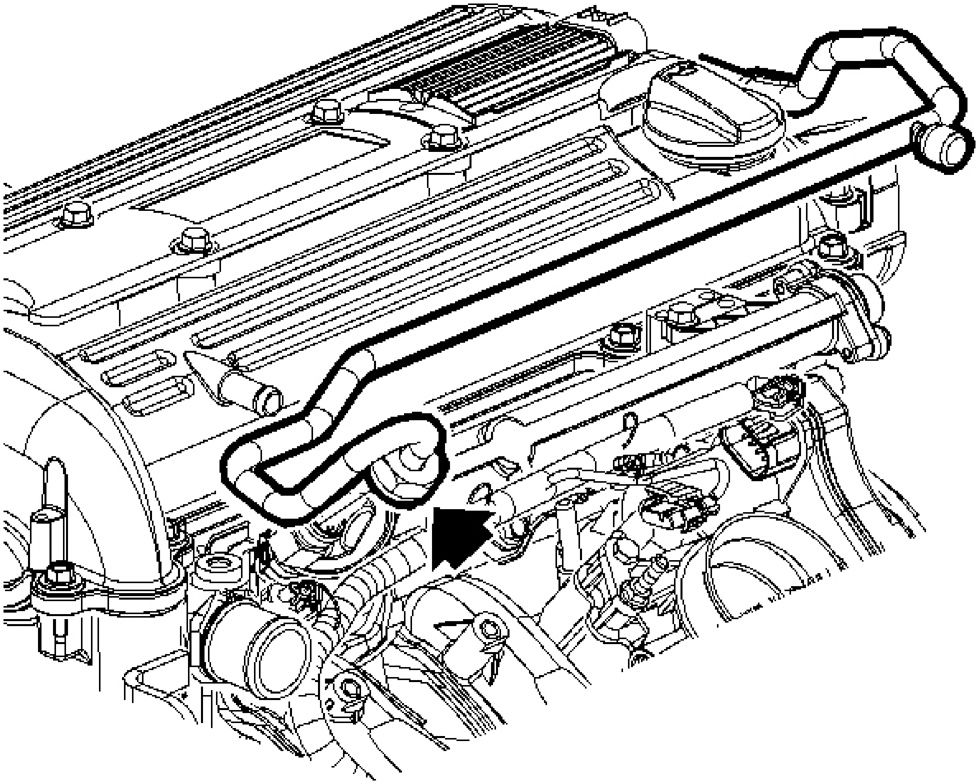
IMPORTANT: Lubricate the O-rings at injector isolators prior to installing injectors into the cylinder head.

6. Install the fuel rail to the cylinder head.

NOTE: Refer to Fastener Notice in Cautions and Notices.

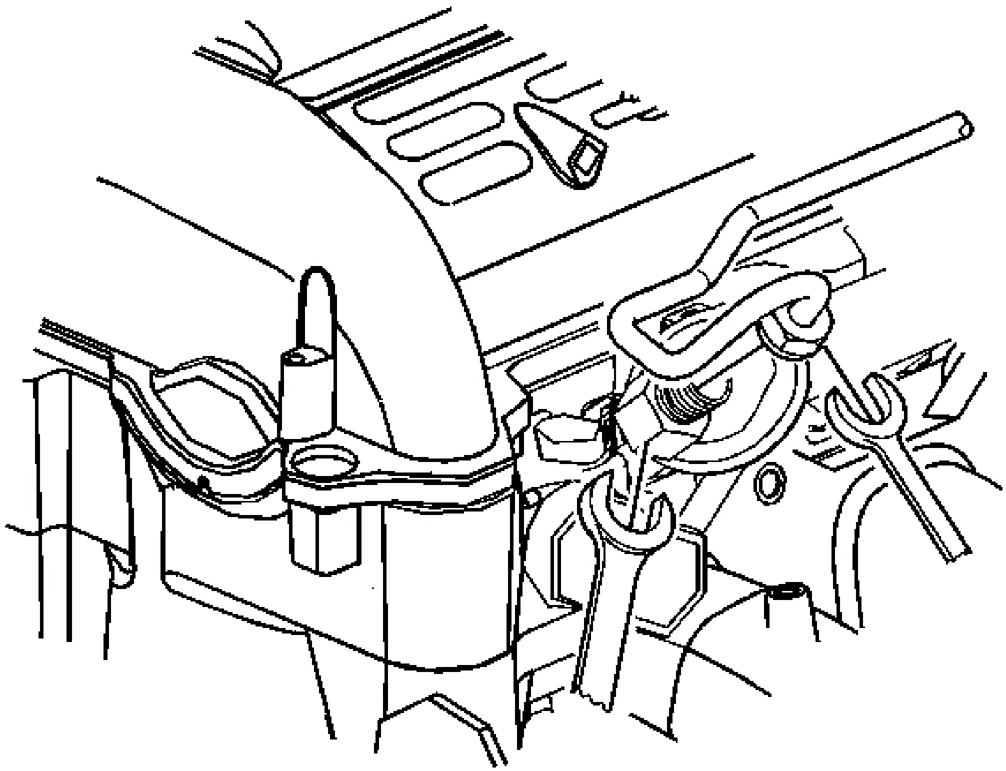
7. Install the fuel rail bolts.

Tighten: Tighten the fuel rail-to-cylinder head L61 to 10 N.m (89 lb in).



<u>Fig. 50: Positioning The Fuel Transfer Line Assembly</u>
Courtesy of GENERAL MOTORS CORP.

8. Position the fuel line assembly.



<u>**Fig. 51: View Of Fuel Line Bracket & Bracket Bolt**</u>
Courtesy of GENERAL MOTORS CORP.

NOTE: **An open-end wrench must be used to support the fuel line to rail connection during loosening/tightening to avoid damaging the fuel rail assembly.**

9. Install the fuel line bracket and bracket bolt.

Tighten: Tighten the transfer line fitting-to-fuel rail L61 to 10 N.m (89 lb in).

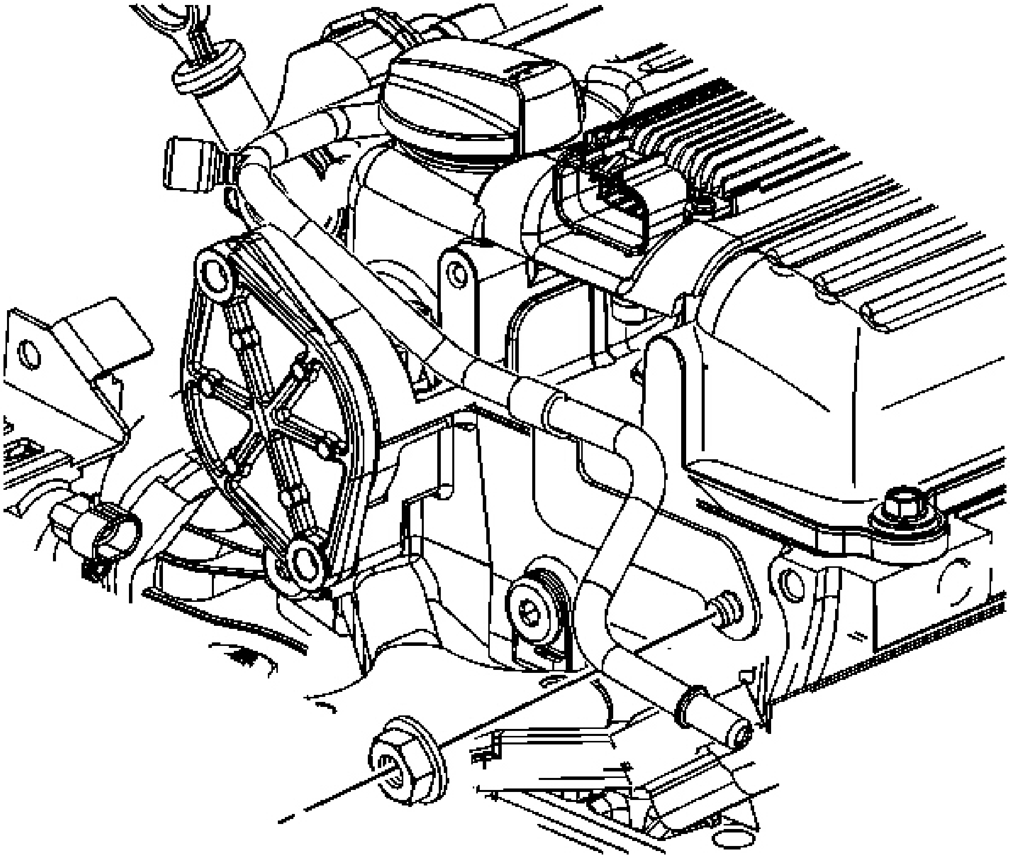


Fig. 52: View Of Fuel Rail Bracket
Courtesy of GENERAL MOTORS CORP.

10. Connect the fuel rail bracket and nut to the cylinder head.

    Tighten: Tighten the fuel line bracket bolt L61 to 10 N.m (89 lb in).

11. Connect the fuel line to transfer line.

    IMPORTANT: To assure proper connection and to fully seat the retaining tabs, lightly pull apart the connection.

12. Insert the fuel transfer line into the fuel line connection. An audible click should be heard.

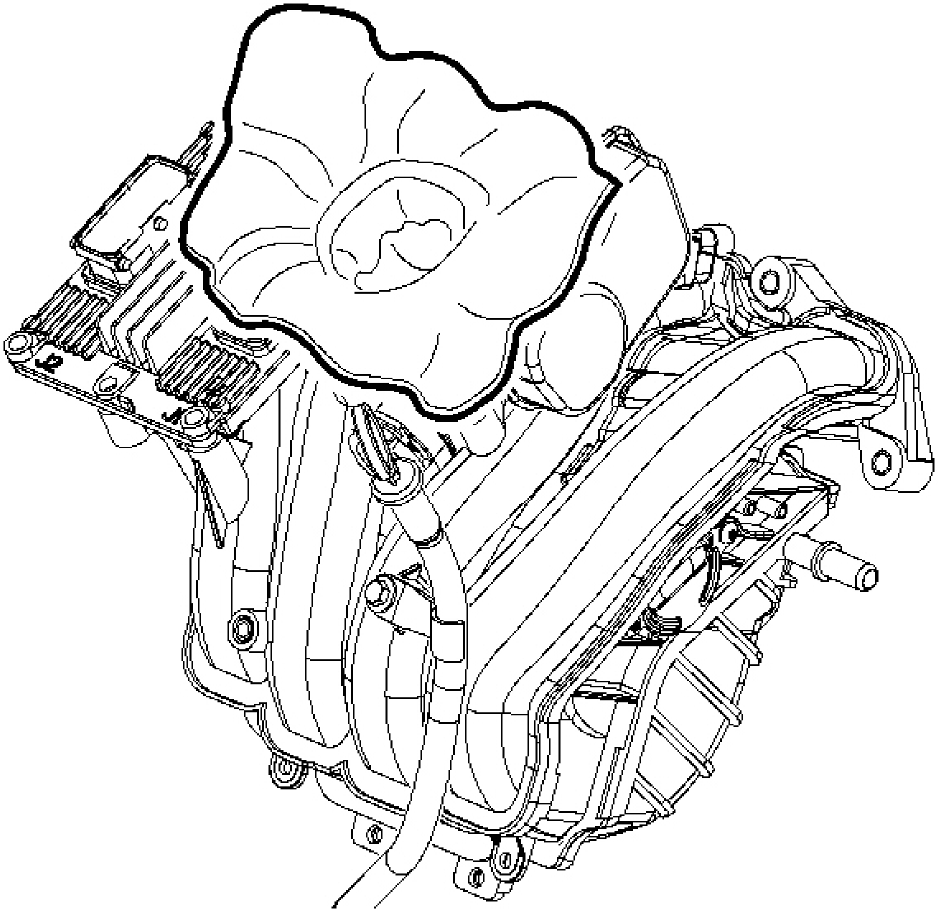


Fig. 53: View Of Throttle Body Opening With A Shop Towel
Courtesy of GENERAL MOTORS CORP.

13. Remove the shop towel from the throttle body.

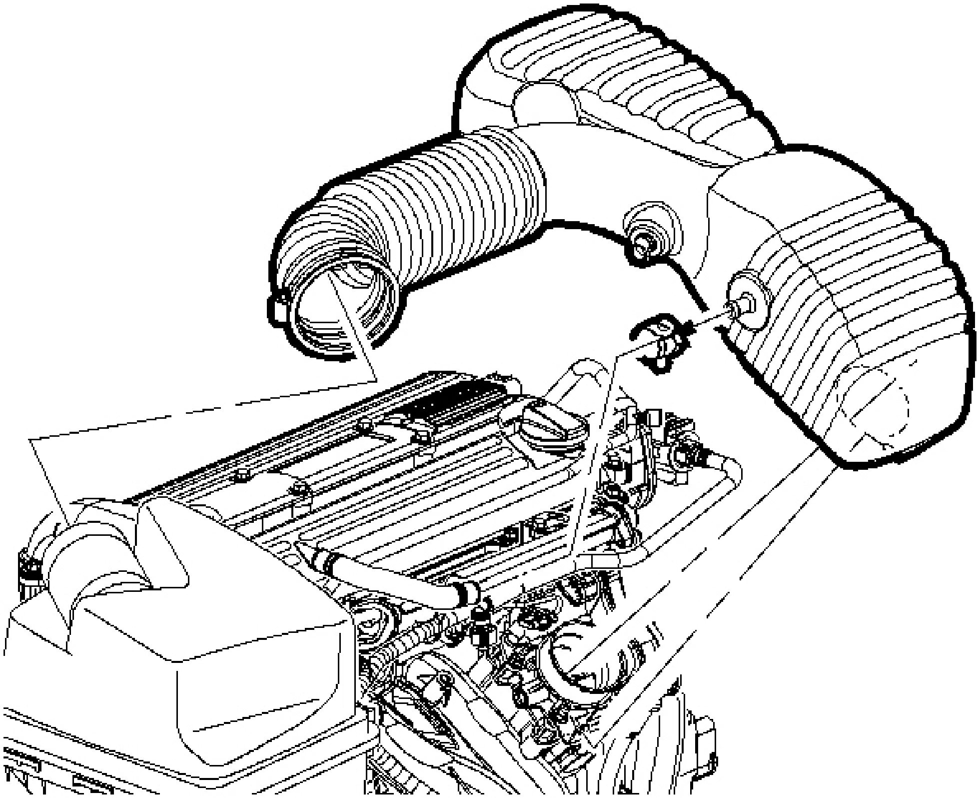


Fig. 54: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

14. Install the outlet resonator/duct assembly into position.
15. Connect the PCV fresh air bent hose assembly.
16. Tighten the clamp at the throttle body assembly.
17. Position the outlet resonator/duct assembly up with a support bracket and install the push pin.
18. Tighten the clamp at the air cleaner assembly.
19. Connect the intake air temperature (IAT) sensor connector.
20. Connect the negative battery cable.

Tighten: Tighten the battery terminal bolts to 17 N.m (13 lb ft).

FUEL TANK MODULE REPLACEMENT - SECONDARY

Tools Required

SA9156E Fuel Tank Lock Ring Remover. See **Special Tools and Equipment** .

Removal Procedure

> **CAUTION: Whenever fuel line fittings are loosened or removed, wrap a shop cloth around the fitting and have an approved container available to collect any fuel.**

> **NOTE: Clean all fuel pipe and hose connections and surrounding areas before disassembling to avoid possible contamination of the fuel system. Spray the fuel pump module cam-lock ring tang with penetrating oil prior to attempting removal.**

1. Remove the fuel tank. Refer to **Fuel Tank Replacement** .
2. Disconnect the evaporative emission (EVAP) vent line quick connect.

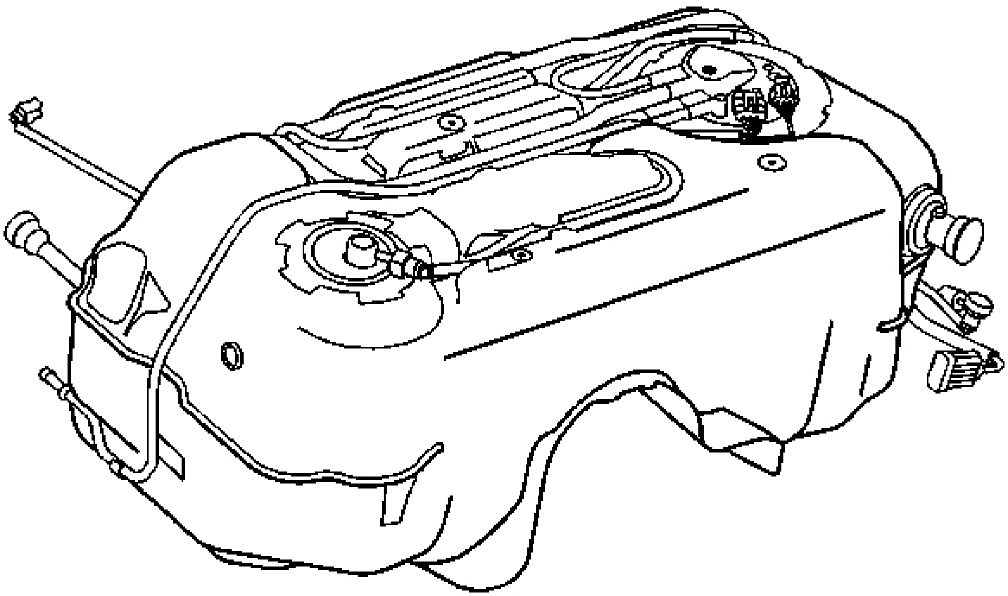


Fig. 55: View Of Fuel Tank Module
Courtesy of GENERAL MOTORS CORP.

NOTE: To prevent retainer damage, do not attempt to remove the retainer with a 12 in. or shorter ratchet/breaker bar.

3. Use the **SA9156E** and remove the fuel pump module retaining ring. See **Special Tools and Equipment** .

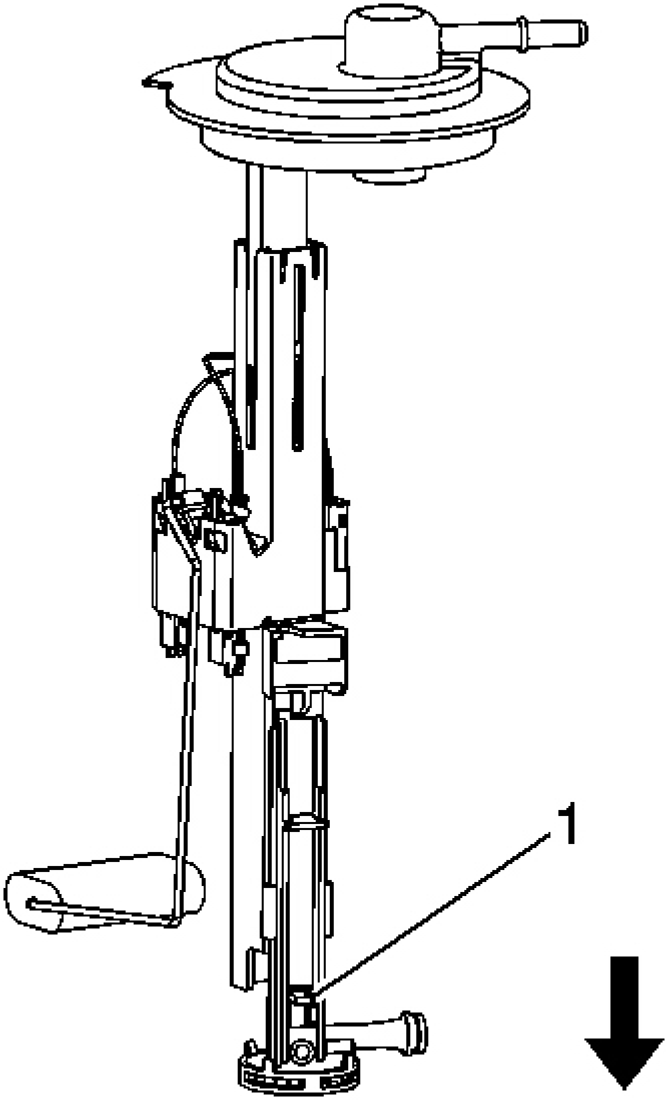


Fig. 56: View Of Suction Port
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the secondary level sensor electrical connector.
5. Disconnect the suction port attaching tube by pressing down on the tab (1).

NOTE: To prevent bending of the sending unit float arm during removal, lift the pump module up slightly to disengage the orientation tabs in the tank and rotate the module 45 degrees.

6. Remove the secondary fuel pump module.

IMPORTANT: Always replace the fuel pump module-to-tank seal, O-ring, when the fuel pump module is removed.

7. Discard the fuel pump module-to-tank seal.
8. If the fuel level sending unit is being replaced as well, remove the fuel level sender. Refer to **Fuel Level Sensor Replacement - Secondary** .

Installation Procedure

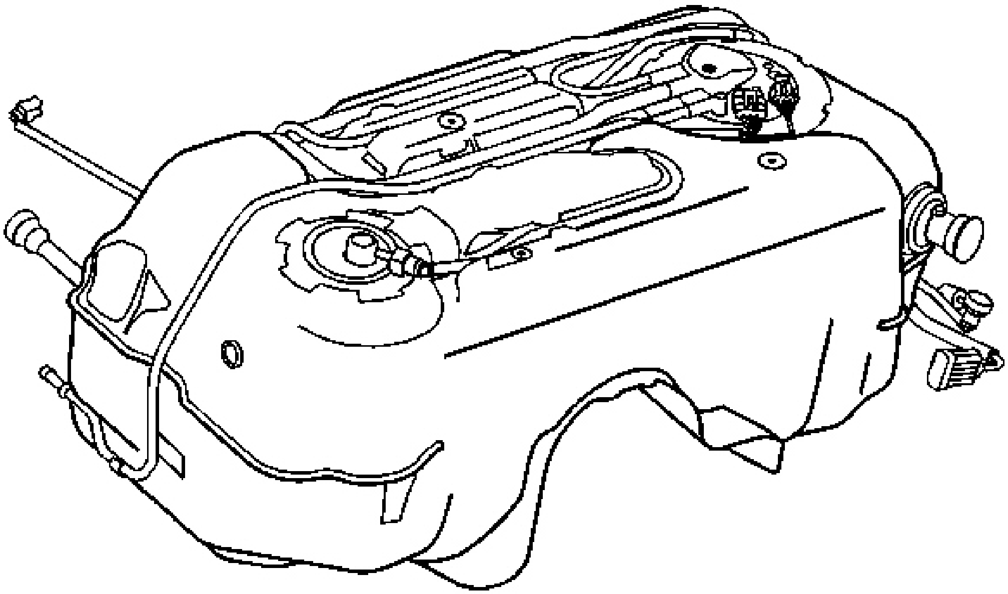


Fig. 57: View Of Electrical Connectors From The Primary Fuel Pump Module
Courtesy of GENERAL MOTORS CORP.

1. If the fuel level sending unit is being replaced, install the fuel level sending unit into the new fuel pump.

Refer to **Fuel Level Sensor Replacement - Secondary** .

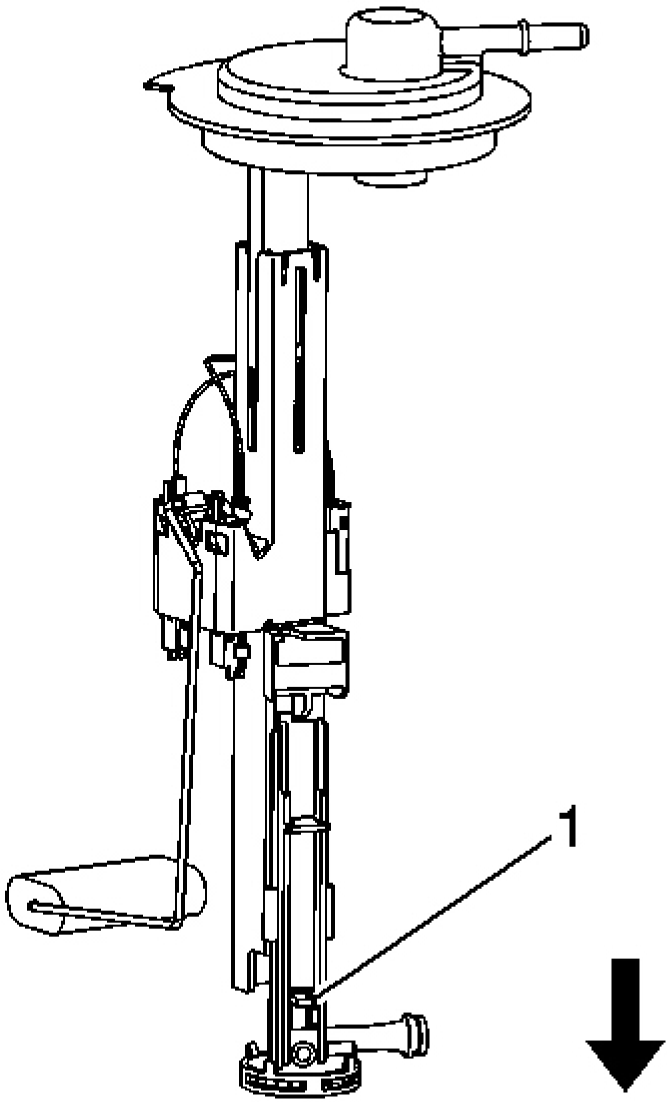


Fig. 58: View Of Suction Port
Courtesy of GENERAL MOTORS CORP.

2. Connect the suction port (1).
3. Insert the new secondary fuel pump module with the level sender and new fuel pump-to-tank seal. Ensure the orientation tabs are aligned.

4. Use the **SA9156E** to install the fuel pump lock ring. See **Special Tools and Equipment** .
5. Connect the EVAP line quick connect.
6. Install the fuel tank. Refer to **Fuel Tank Replacement** .

FUEL TANK MODULE REPLACEMENT - PRIMARY

Tools Required

J 45722 Fuel Tank Lock Ring Remover. See **Special Tools and Equipment** .

Removal Procedure

CAUTION: Whenever fuel line fittings are loosened or removed, wrap a shop cloth around the fitting and have an approved container available to collect any fuel.

NOTE: Clean all fuel pipe and hose connections and surrounding areas before disassembling to avoid possible contamination of the fuel system. Spray the fuel pump module cam-lock ring tang with penetrating oil prior to attempting removal.

1. Remove the fuel tank. Refer to **Fuel Tank Replacement** .
2. Remove the secondary fuel pump module. Refer to **Fuel Tank Module Replacement - Secondary** .

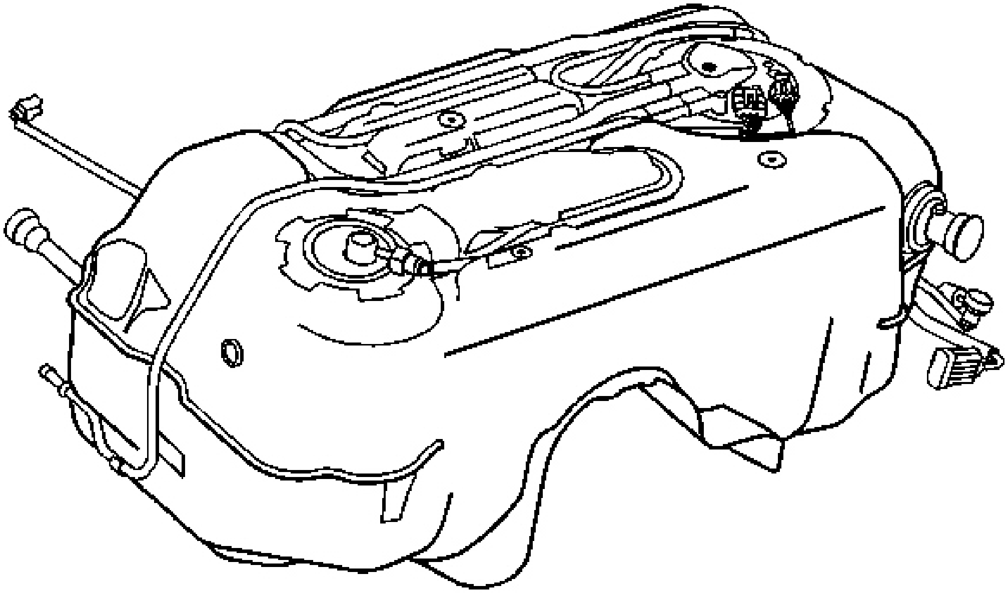


Fig. 59: View Of Fuel Tank Module
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the electrical connectors from the primary fuel pump module and fuel tank pressure sensor.

NOTE: To prevent retainer damage, do not attempt to remove the retainer with a 12 in. or shorter ratchet/breaker bar.

4. Use the **J 45722** and remove the fuel pump module retaining ring. See **Special Tools and Equipment** .
5. Disconnect the fuel feed and vent lines from the fuel tank.

NOTE: To prevent bending of the sending unit float arm during removal, lift the pump module up slightly to disengage the orientation tabs in the tank and rotate the module 45 degrees.

6. Remove the primary fuel pump module assembly.

IMPORTANT: Always replace the fuel pump module-to-tank seal, O-ring, when the fuel pump module is removed.

7. Discard the fuel pump module-to-tank seal.

8. If the fuel level sending unit is being replaced, remove the fuel level sender. Refer to **Fuel Level Sensor Replacement - Primary** .

Installation Procedure

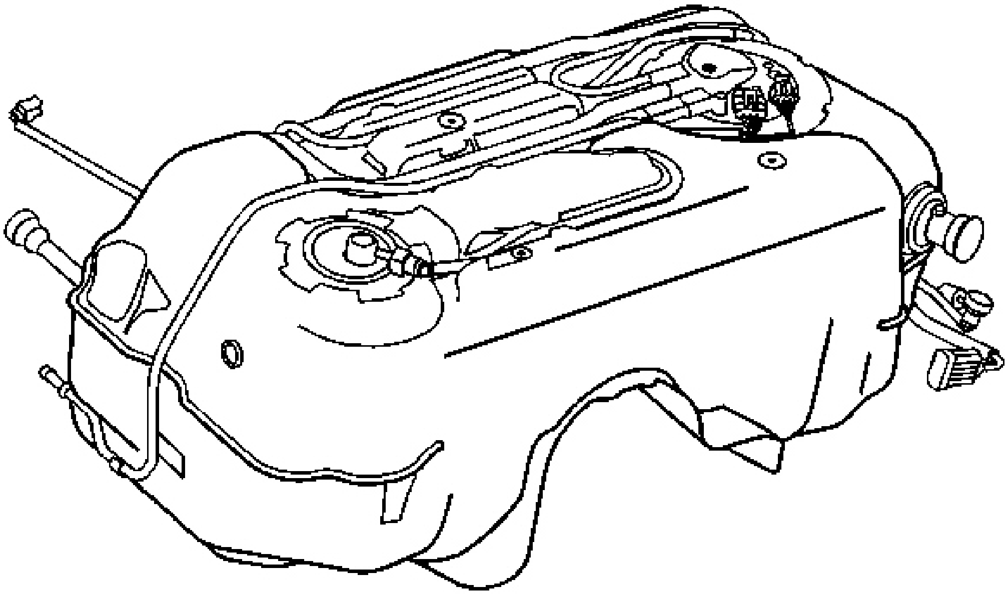


Fig. 60: View Of Electrical Connectors From The Primary Fuel Pump Module
Courtesy of GENERAL MOTORS CORP.

1. If the fuel level sending unit is being replaced, install the fuel level sending unit onto the new fuel pump. Refer to **Fuel Level Sensor Replacement - Primary** .
2. Insert the new primary fuel pump module assembly with the level sender and the new fuel pump-to-tank seal. Ensure the orientation tabs are aligned.
3. Use the **J 45722** to install the fuel pump lock ring. See **Special Tools and Equipment** .
4. Connect the wiring harness to the primary fuel pump module and fuel tank pressure sensor.
5. Install the secondary fuel pump module. Refer to **Fuel Tank Module Replacement - Secondary** .
6. Install the fuel tank. Refer to **Fuel Tank Replacement** .

FUEL RAIL TRANSFER LINE REPLACEMENT

Tools Required

- **SA9127E** Gage Bar Set

- **SA9805E** Fuel Line Separator

Removal Procedure

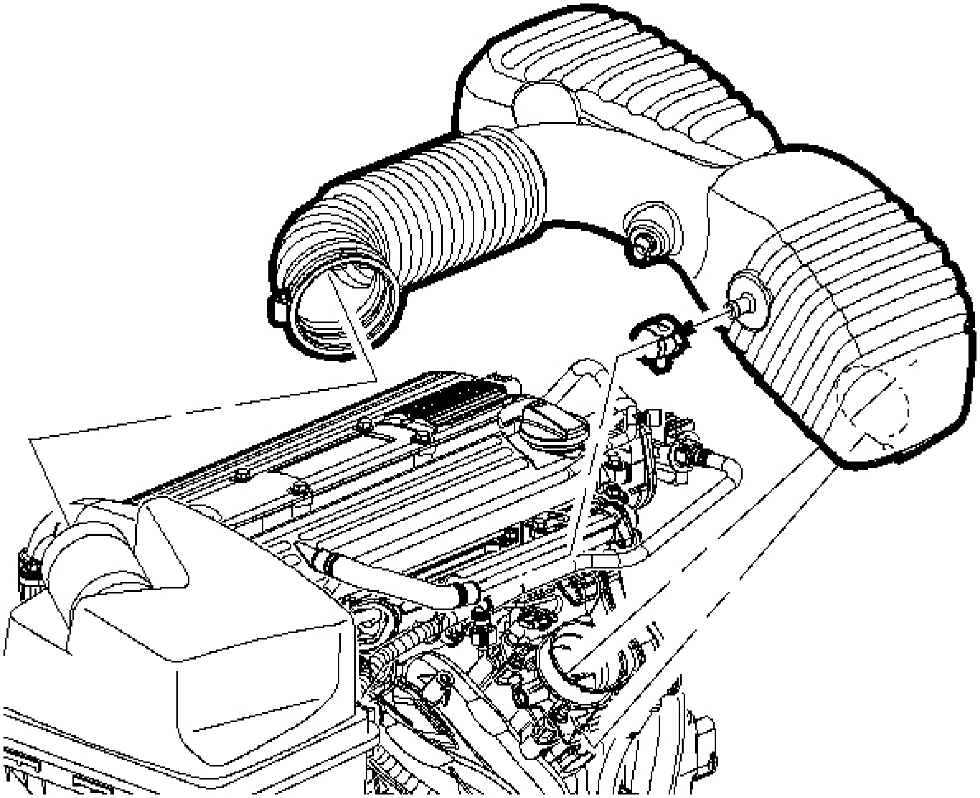


Fig. 61: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

CAUTION: Do not allow smoking or the use of open flames in the area where work on the fuel or EVAP system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

CAUTION: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Disconnect the intake air temperature (IAT) sensor connector.
3. Loosen the clamp at the air cleaner assembly.
4. Remove the push pin attachment from the outlet resonator/duct assembly to support bracket.
5. Loosen the clamp at the throttle body assembly.
6. Disconnect the PCV fresh air vent hose at cam cover.
7. Remove the outlet resonator/duct assembly.

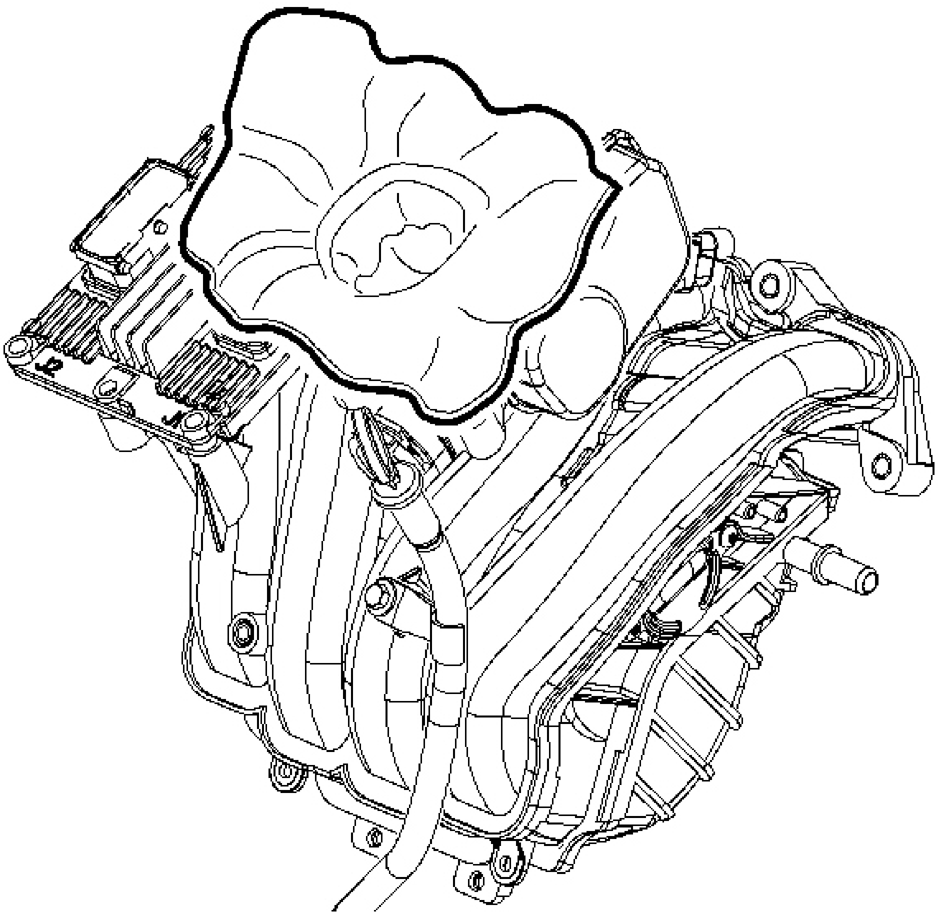


Fig. 62: View Of Throttle Body Opening With A Shop Towel
Courtesy of GENERAL MOTORS CORP.

8. Cover the throttle body opening with a shop towel. Use shop air to remove any dirt near the transfer line connection.
9. Remove any electrical harness or hoses that may be attached to the transfer line.

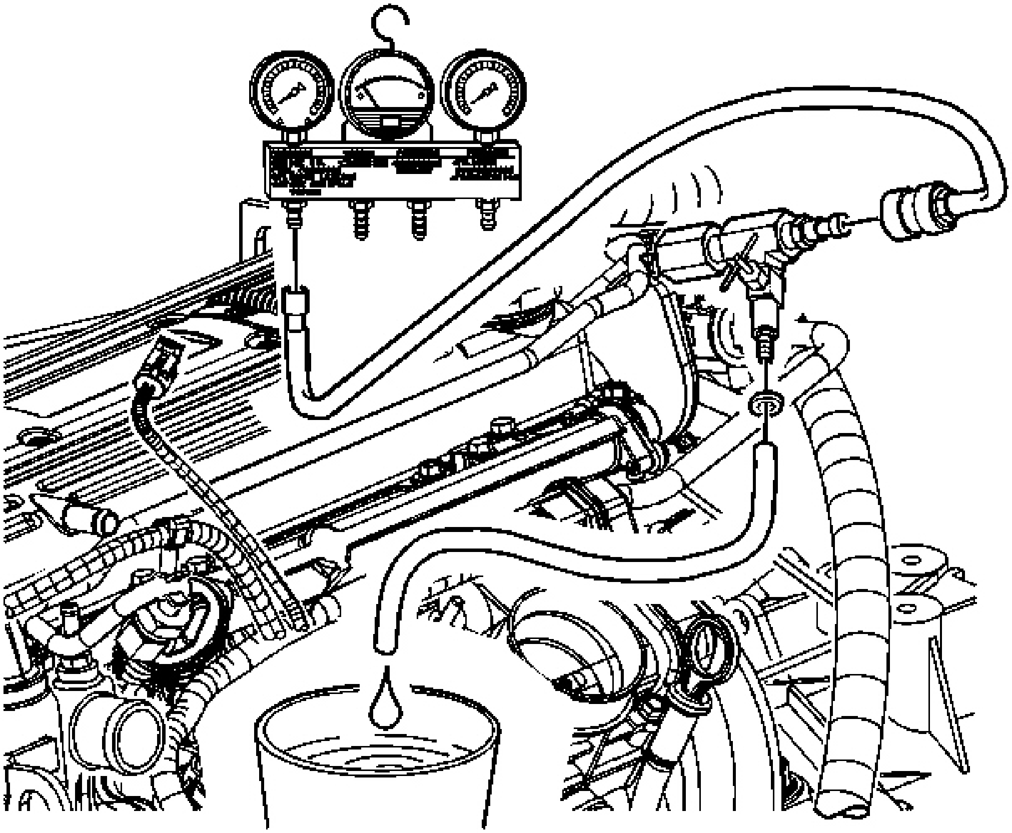


Fig. 63: View Of Fuel System Pressure
Courtesy of GENERAL MOTORS CORP.

CAUTION: Whenever fuel line fittings are loosened or disconnected, wrap a shop cloth around the fitting to collect fuel. Place the cloth in an approved container.

10. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** .
11. Disconnect the **SA9127E** after the pressure has been relieved.

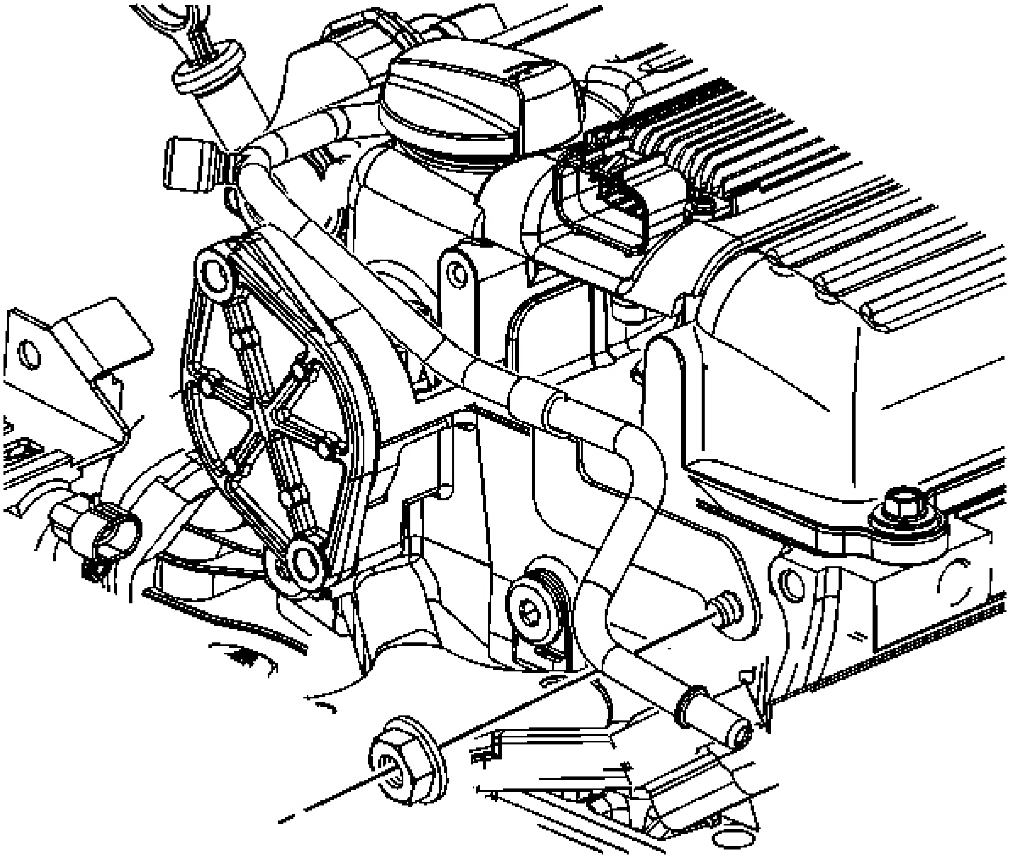


Fig. 64: View Of Fuel Rail Bracket
Courtesy of GENERAL MOTORS CORP.

12. Disconnect the fuel rail bracket and bolt at the rear of the camshaft cover.
13. Disconnect the fuel transfer at quick connect from the fuel line using the **SA9805E** .

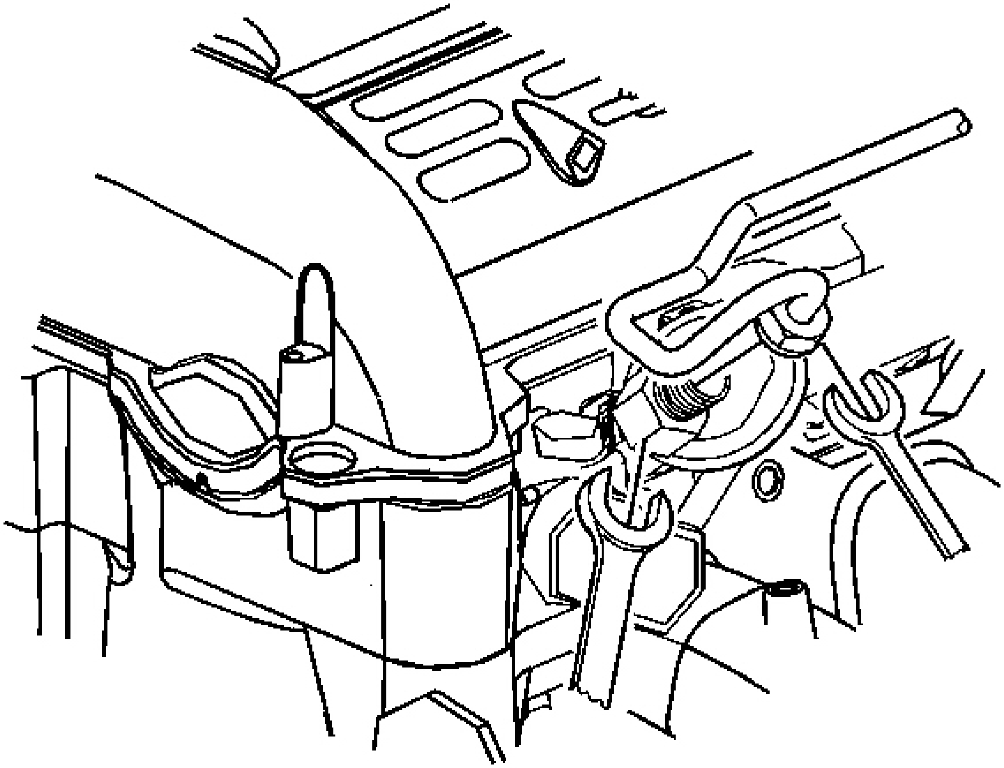


Fig. 65: View Of Fuel Line Bracket & Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: **An open-end wrench must be used to support the fuel line to rail connection during loosening/tightening to avoid damaging the fuel rail assembly.**

14. While supporting the fuel rail assembly with an open-end wrench, loosen the transfer line fitting at fuel rail.

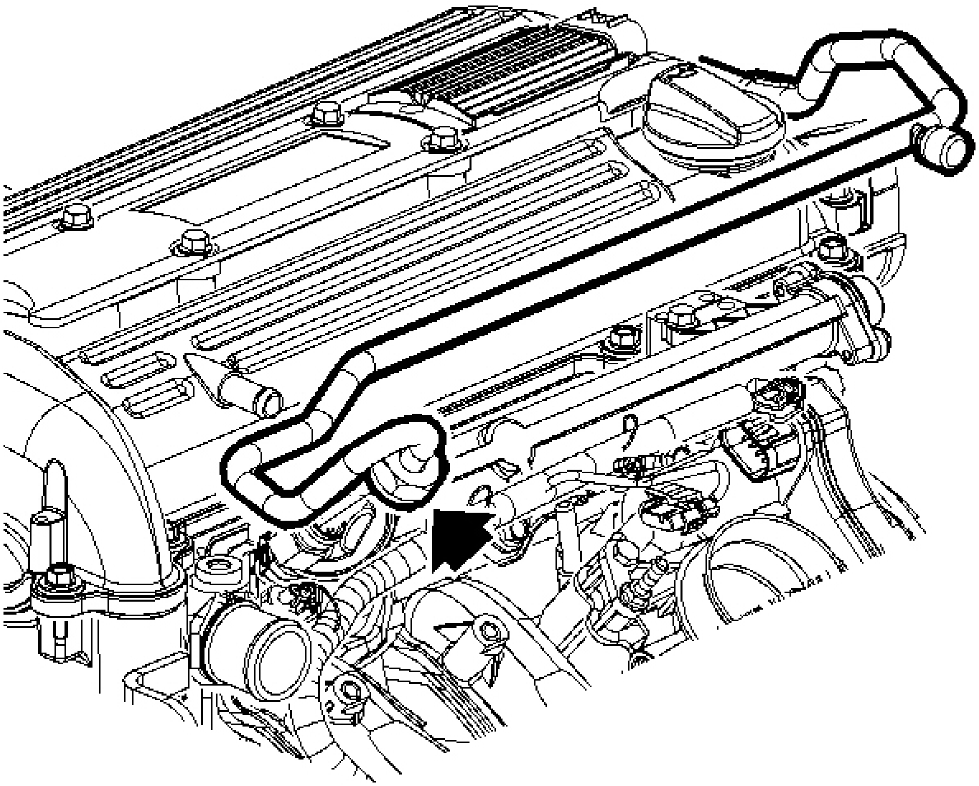


Fig. 66: Positioning The Fuel Transfer Line Assembly
Courtesy of GENERAL MOTORS CORP.

15. Remove the fuel transfer line.
16. Visually inspect the O-ring seals for cuts, nicks, or flatness. Replace as necessary.

Installation Procedure

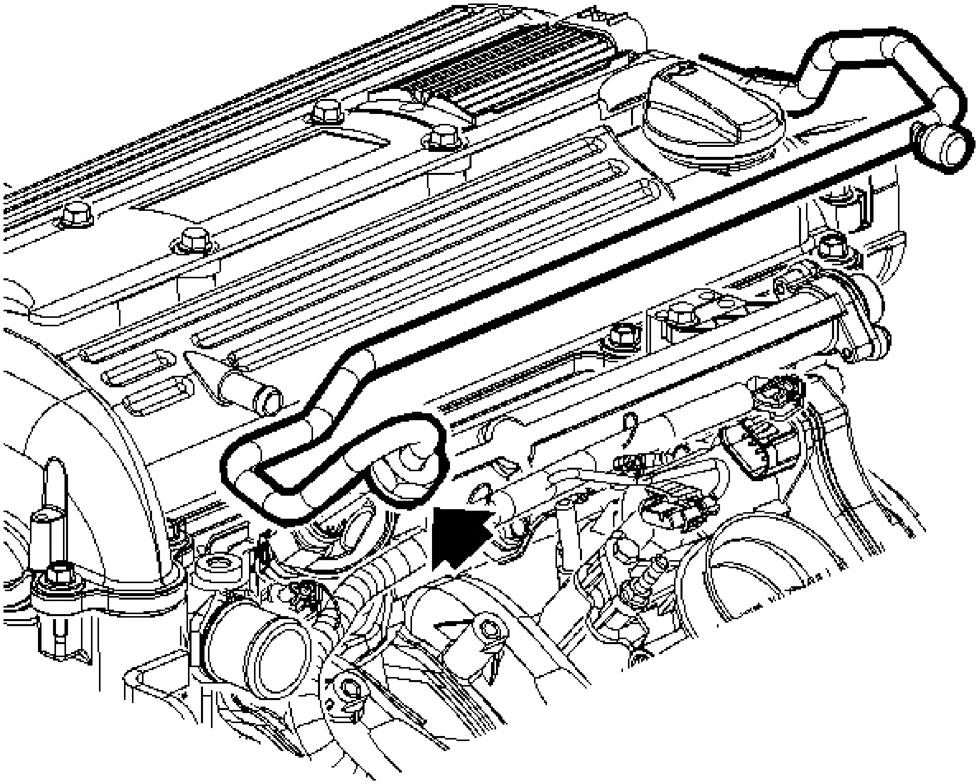


Fig. 67: Positioning The Fuel Transfer Line Assembly
Courtesy of GENERAL MOTORS CORP.

1. Properly position the fuel transfer line assembly.
2. Install the transfer line assembly with an O-seal to fuel rail assembly and hand tighten.

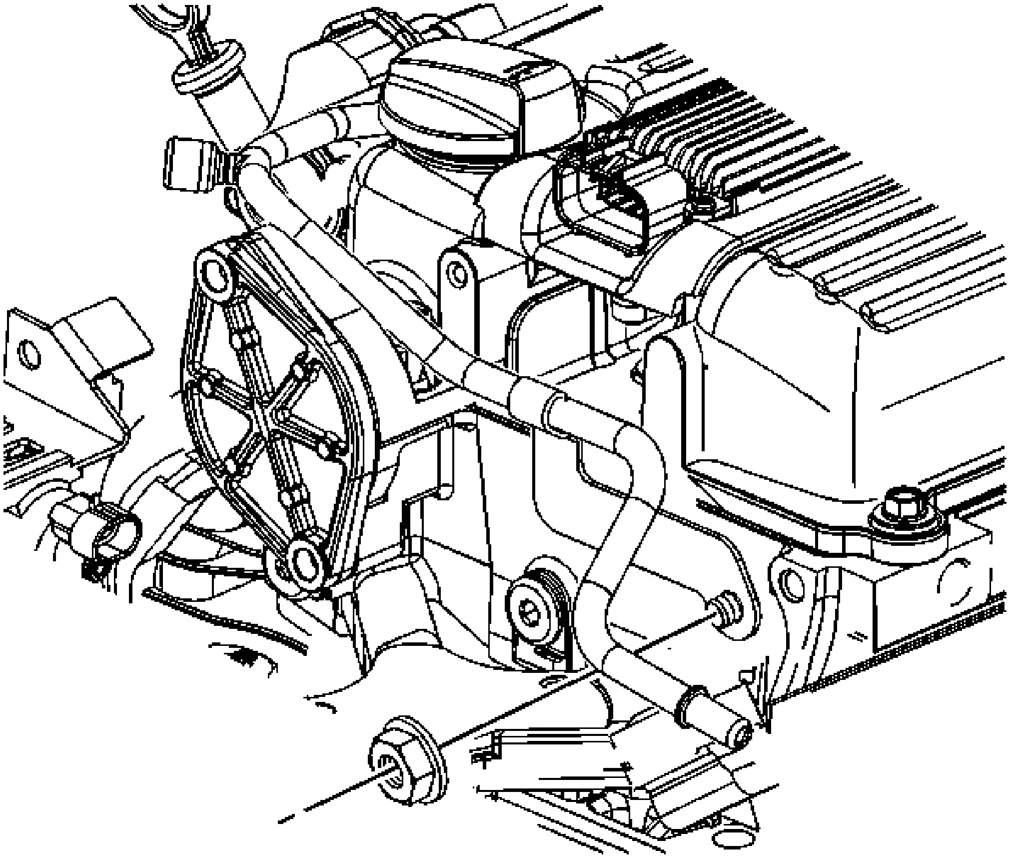


Fig. 68: View Of Fuel Rail Bracket
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

3. Connect the fuel rail bracket and nut to the cylinder head.

   Tighten: Tighten the fuel line bracket-to-cylinder head bolt to 10 N.m (89 lb in).

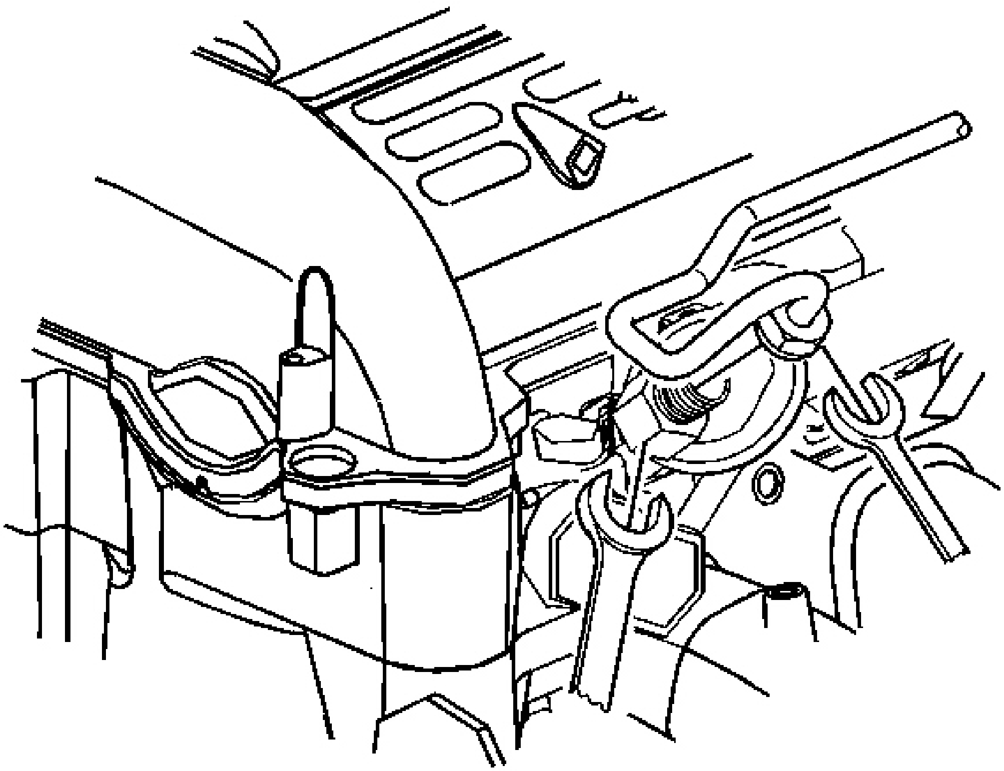


Fig. 69: View Of Fuel Line Bracket & Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

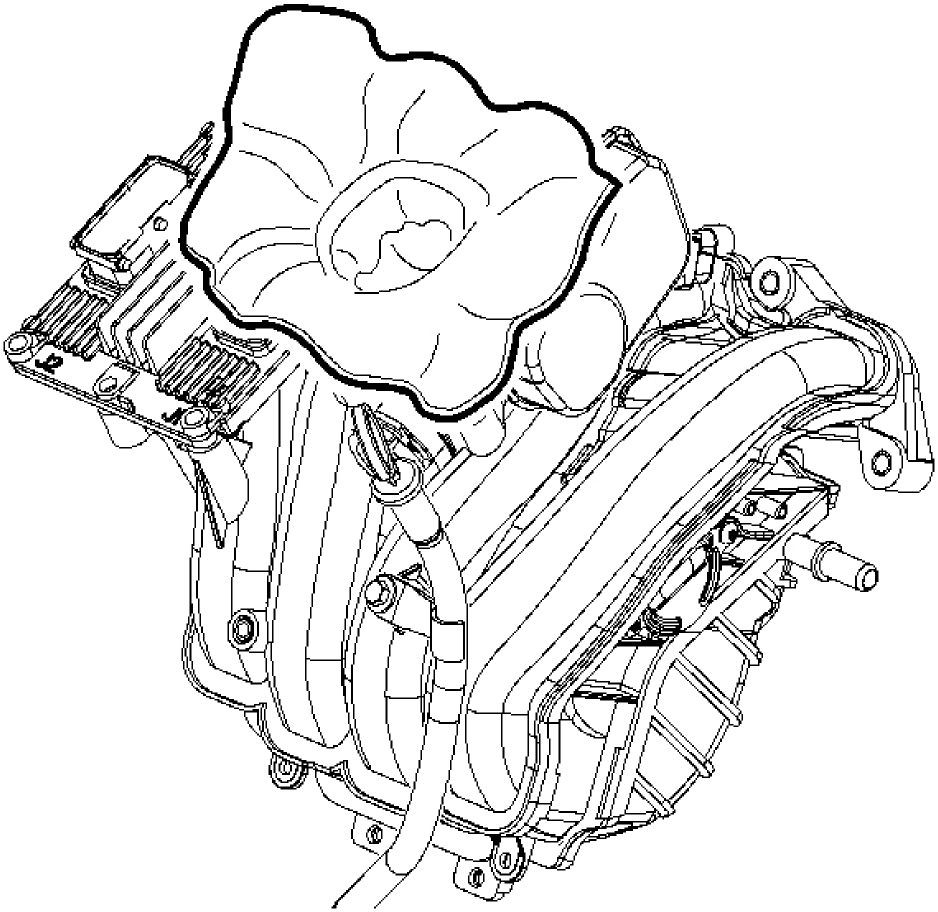
NOTE: **An open-end wrench must be used to support the fuel line to rail connection during loosening/tightening to avoid damaging the fuel rail assembly.**

4. Tighten the transfer line fitting at fuel rail.

   Tighten: Tighten the fuel transfer line fitting-to-fuel rail 4 cylinder to 10 N.m (89 lb in).

IMPORTANT: **To assure a proper connection and to fully seat the retaining tabs, lightly pull apart the connection.**

5. Insert the fuel transfer line into the fuel line connection. An audible click should be heard. Pull rearward to fully seat the connection.



<u>Fig. 70: View Of Throttle Body Opening With A Shop Towel</u>
Courtesy of GENERAL MOTORS CORP.

6. Remove the shop towel from the throttle body.
7. Connect any electrical harness or hoses that have been disconnected from the transfer line.

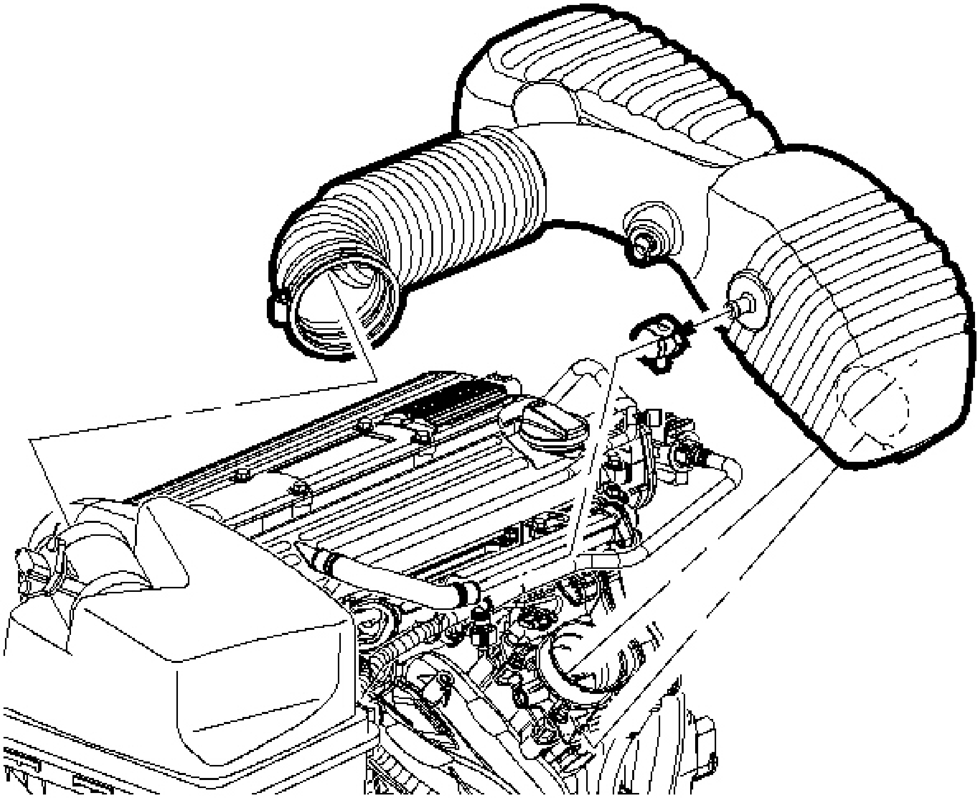


Fig. 71: View Of Outlet Resonator/Duct Assembly
Courtesy of GENERAL MOTORS CORP.

8. Install the outlet resonator/duct assembly into position.
9. Connect the PCV fresh air bent hose assembly.
10. Tighten the clamp at the throttle body assembly.
11. Position the outlet resonator/duct assembly up with a support bracket and install the push pin.
12. Tighten the clamp at the air cleaner assembly.
13. Connect the intake air temperature (IAT) sensor connector.
14. Connect the negative battery cable.

Tighten: Tighten the battery terminal bolts to 17 N.m (13 lb ft).

FUEL PRESSURE DAMPENER REPLACEMENT

Tools Required

SA9127E Gage Bar Set

Removal Procedure

CAUTION: Do not allow smoking or the use of open flames in the area where work on the fuel or EVAP system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

CAUTION: Refer to <u>Battery Disconnect Caution</u> in Cautions and Notices.

1. Disconnect the negative battery cable.

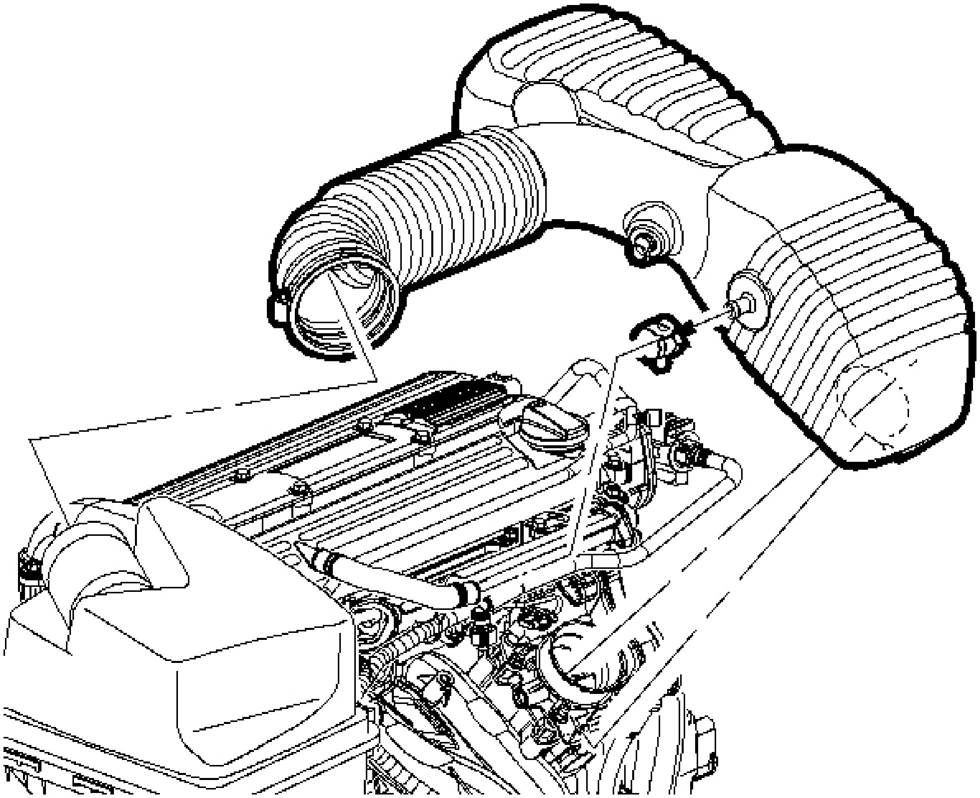


Fig. 72: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the intake air temperature (IAT) sensor connector.
3. Loosen the clamp at the air cleaner assembly.
4. Remove the push pin attachment from the outlet resonator/duct assembly to support bracket.
5. Loosen the clamp at the throttle body assembly.
6. Disconnect the PCV fresh air vent hose at the cam cover.
7. Remove the outlet resonator/duct assembly.

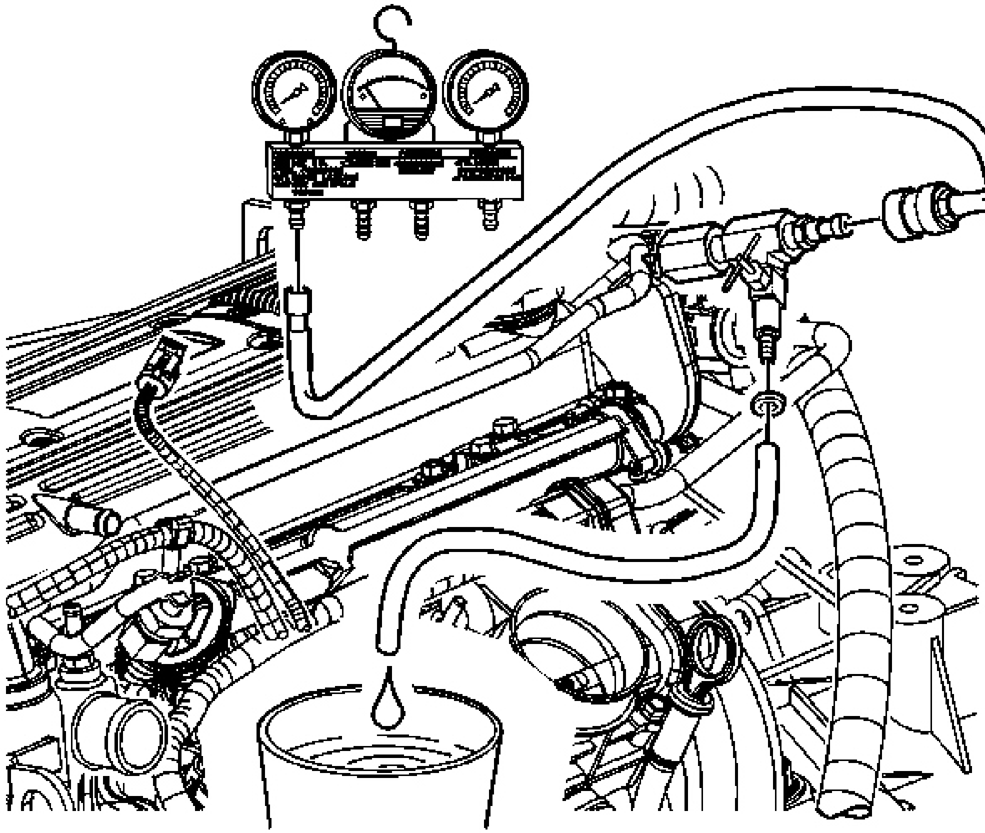


Fig. 73: View Of Fuel System Pressure
Courtesy of GENERAL MOTORS CORP.

CAUTION: Whenever fuel line fittings are loosened or disconnected, wrap a shop cloth around the fitting to collect fuel. Place the cloth in an approved container.

8. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** .
9. Disconnect the **SA9127E** after the pressure has been relieved.

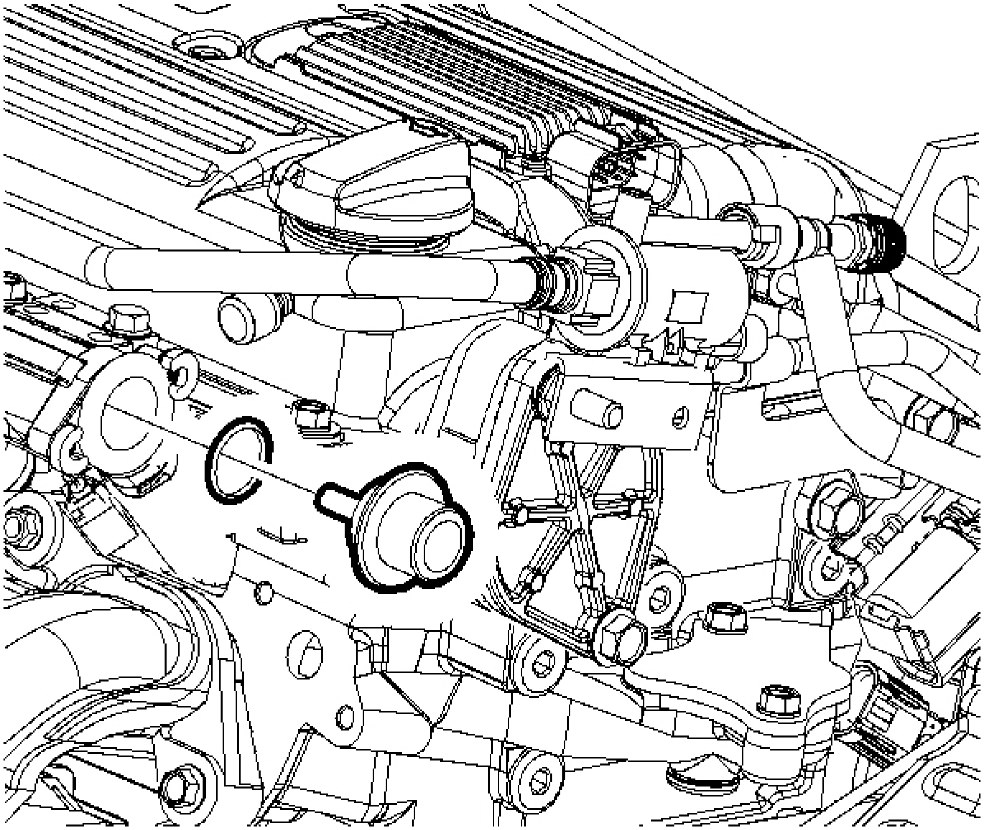


Fig. 74: View Of Fuel Pressure Regulator
Courtesy of GENERAL MOTORS CORP.

10. Remove the fuel dampener bolts.
11. Remove the fuel pressure dampener and O-ring seals.
12. Visually inspect the seals for cuts, nicks, or flatness. Replace as necessary.

Installation Procedure

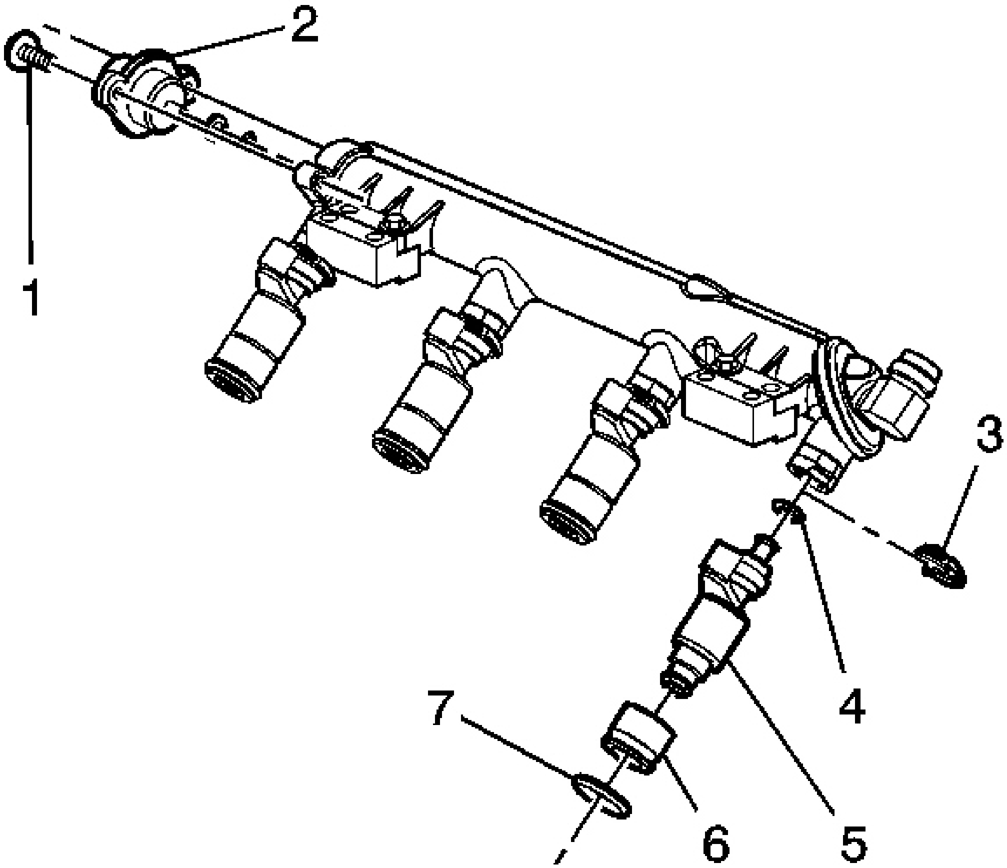


Fig. 75: View Of Fuel Rail Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: O-rings must be lubricated with clean engine oil and installed into the fuel rail before the fuel pressure regulator is installed.

1. Install the small oiled O-ring (4) into the fuel rail.
2. Install the large oiled O-ring (7) into the fuel rail.

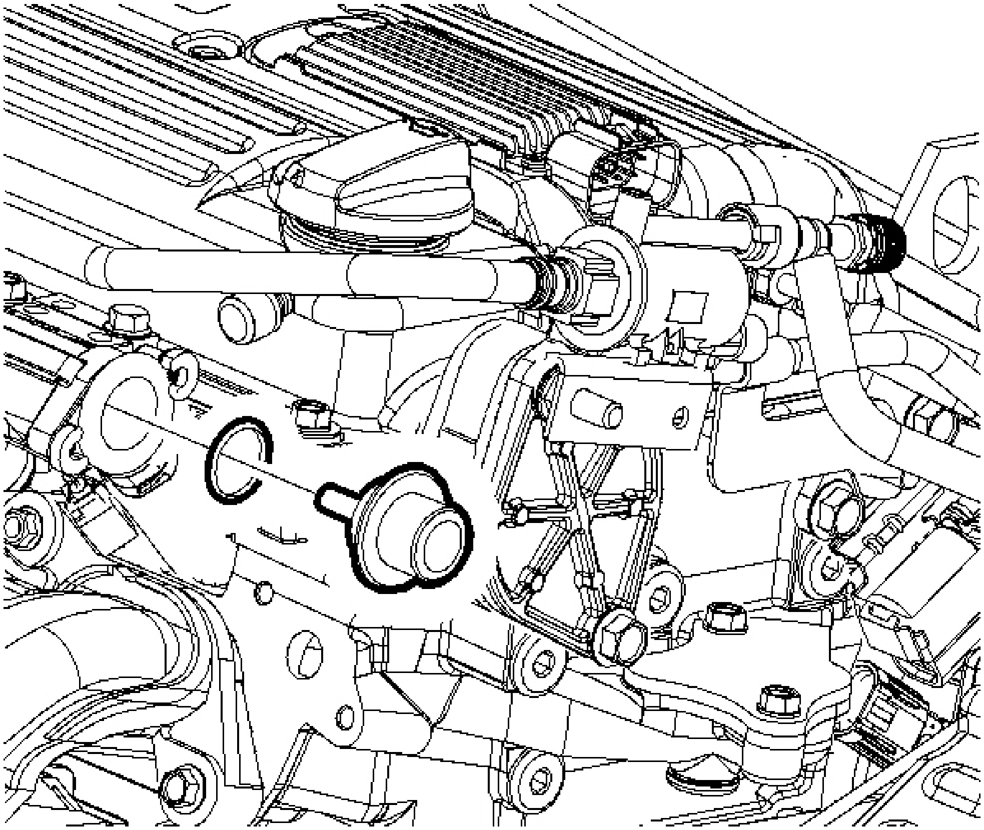


Fig. 76: View Of Fuel Pressure Regulator
Courtesy of GENERAL MOTORS CORP.

3. Install the fuel pressure regulator into the fuel rail.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the retaining bolts.

Tighten: Tighten the fuel pressure dampener bolts to 5 N.m (44 lb in).

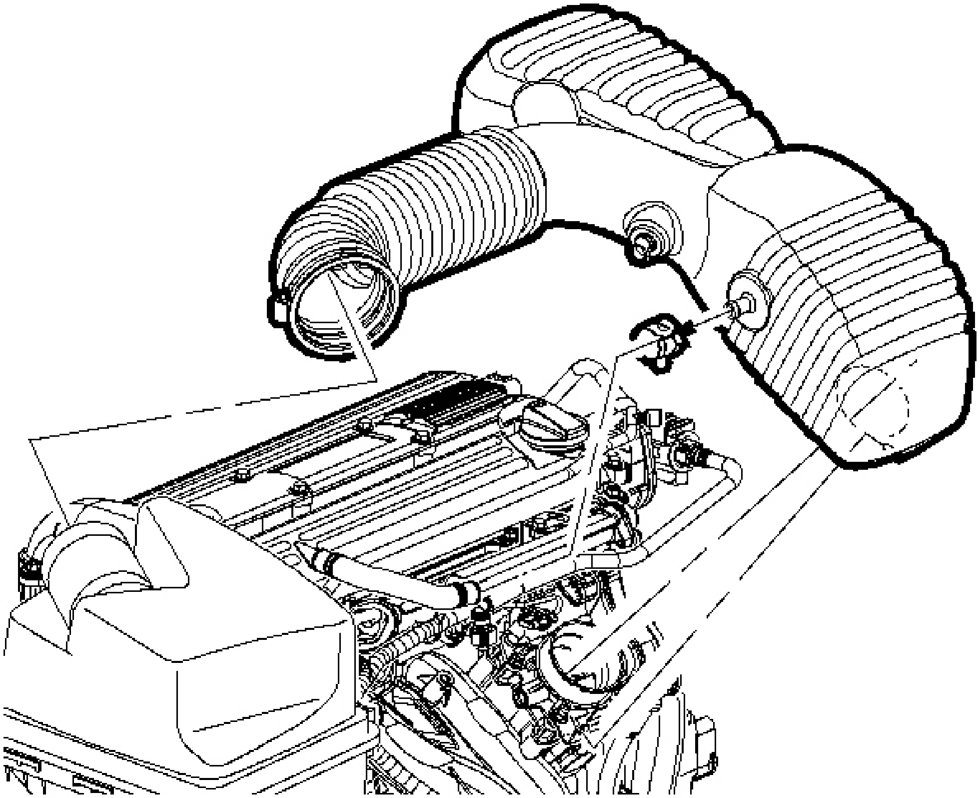


Fig. 77: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

5. Install the outlet resonator/duct assembly into position.
6. Connect the PCV fresh air vent hose assembly.
7. Tighten the clamp at the throttle body assembly.
8. Position the outlet resonator/duct assembly up with a support bracket and install the push pin.
9. Tighten the clamp at the air cleaner assembly.
10. Connect the air intake temperature (IAT) sensor connector.
11. Connect the negative battery cable.

Tighten: Tighten the battery terminal bolt to 17 N.m (13 lb ft).

12. Run the vehicle and inspect for leaks.

QUICK CONNECT FITTING(S) SERVICE (PLASTIC COLLAR)

Removal Procedure

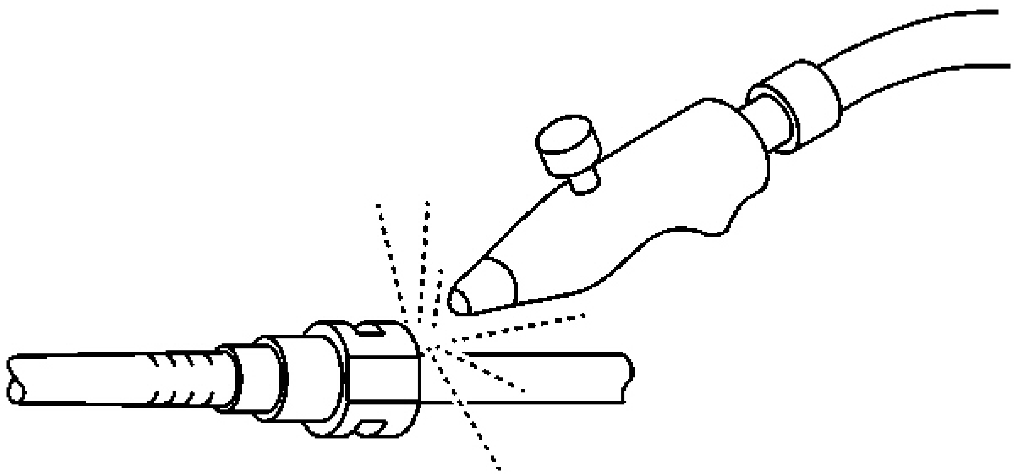


Fig. 78: Blowing Out Dirt (Plastic Collar)
Courtesy of GENERAL MOTORS CORP.

1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** .

CAUTION: Wear safety glasses when using compressed air in order to prevent eye injury.

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

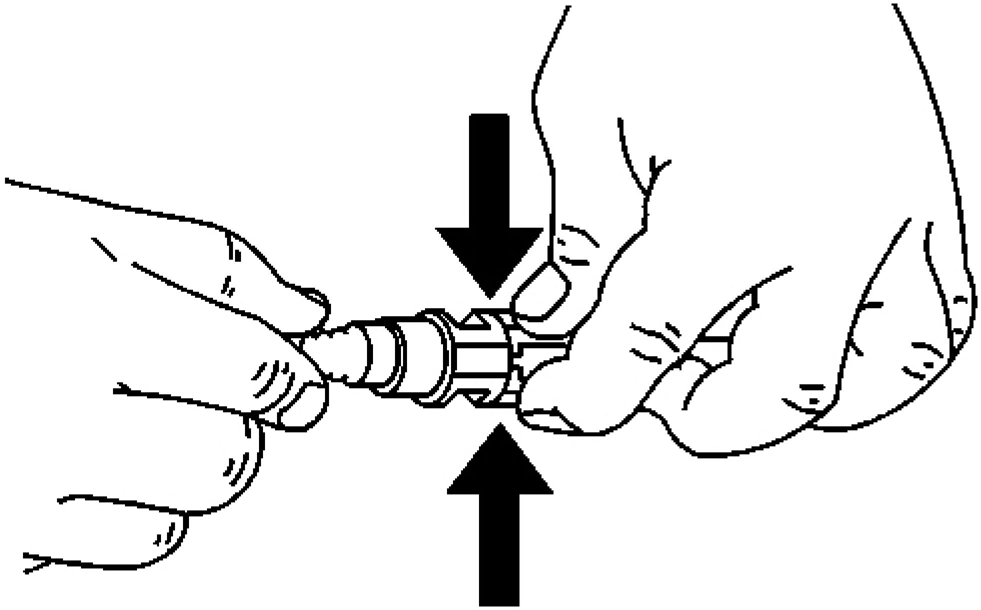


Fig. 79: Squeezing Plastic Tabs Of Male End Connector (Plastic Collar)
Courtesy of GENERAL MOTORS CORP.

3. Squeeze the plastic tabs of the male end connector.

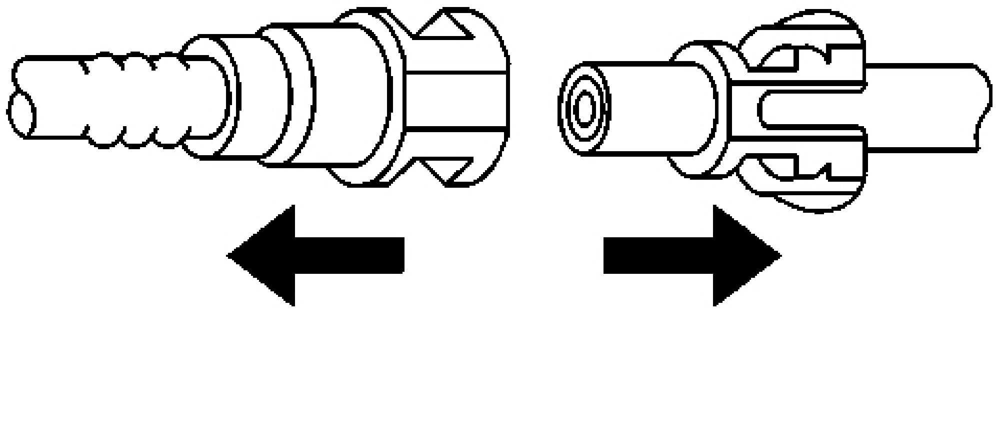


Fig. 80: Pulling Connection Apart (Plastic Collar)
Courtesy of GENERAL MOTORS CORP.

4. Pull the connection apart.

NOTE: **Use an emery cloth in order to remove rust or burrs from the fuel pipe. Use a radial motion with the fuel pipe end in order to prevent damage to the O-ring sealing surface.**

5. Wipe off the male pipe end using a clean shop towel.
6. Inspect both ends of the fitting for dirt and burrs.
7. Clean or replace the components as required.

Installation Procedure

CAUTION: **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.

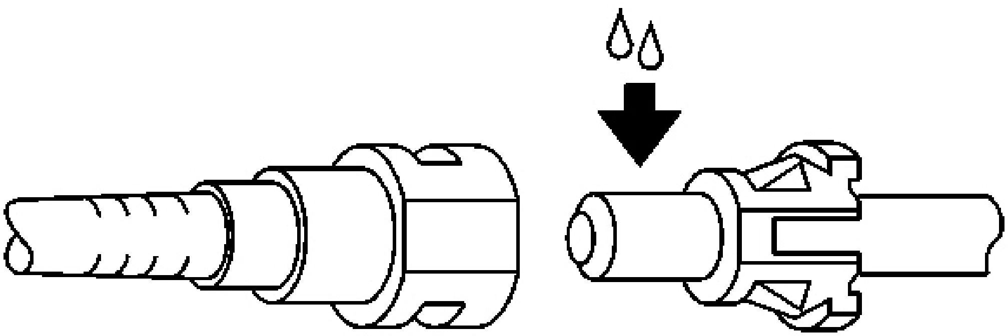


Fig. 81: Oiling Male Pipe End (Plastic Collar)
Courtesy of GENERAL MOTORS CORP.

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

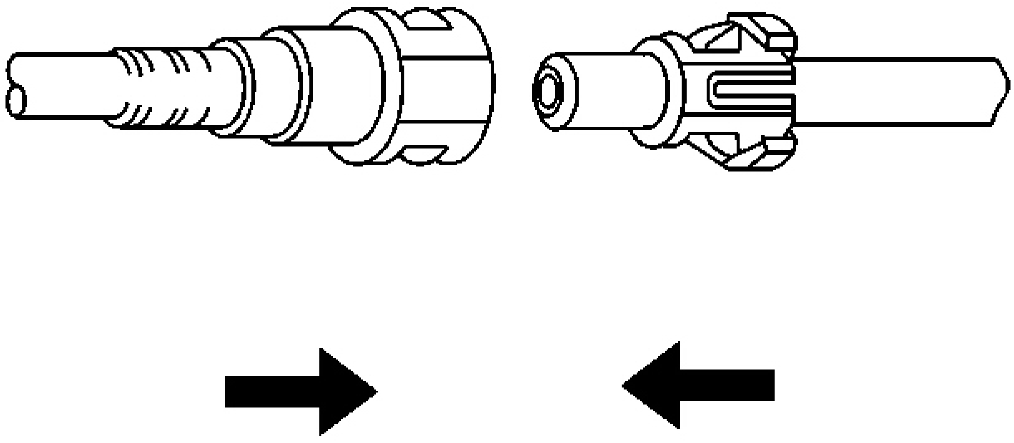


Fig. 82: Connecting Fittings (Plastic Collar)
Courtesy of GENERAL MOTORS CORP.

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

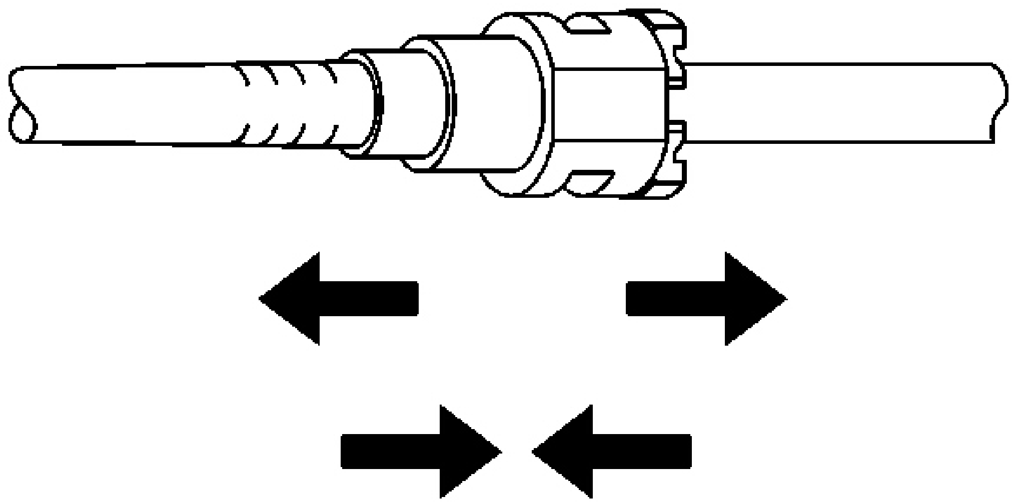


Fig. 83: Ensuring Secure Connection (Plastic Collar)
Courtesy of GENERAL MOTORS CORP.

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

FUEL TANK DRAINING PROCEDURE

Tools Required

- **SA9127E-7** Fuel Pressure/Flow Adapter
- **SA9804E** Fuel Tank Drain Hose

For any operation requiring removal of the fuel tank, there should be no more than 11.4 L (3 gal) of fuel remaining. This minimizes the weight of the assembly and eases handling. The fuel level can be determined by reading the fuel level gage. A reading below 1/4 full indicates that no more than 11.4 L (3 gal) are remaining.

Using The Fuel Pump

CAUTION: Do not allow smoking or the use of open flames in the area where work on the fuel or EVAP system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

CAUTION: Never drain or store fuel in an open container due to the possibility of fire or explosion.

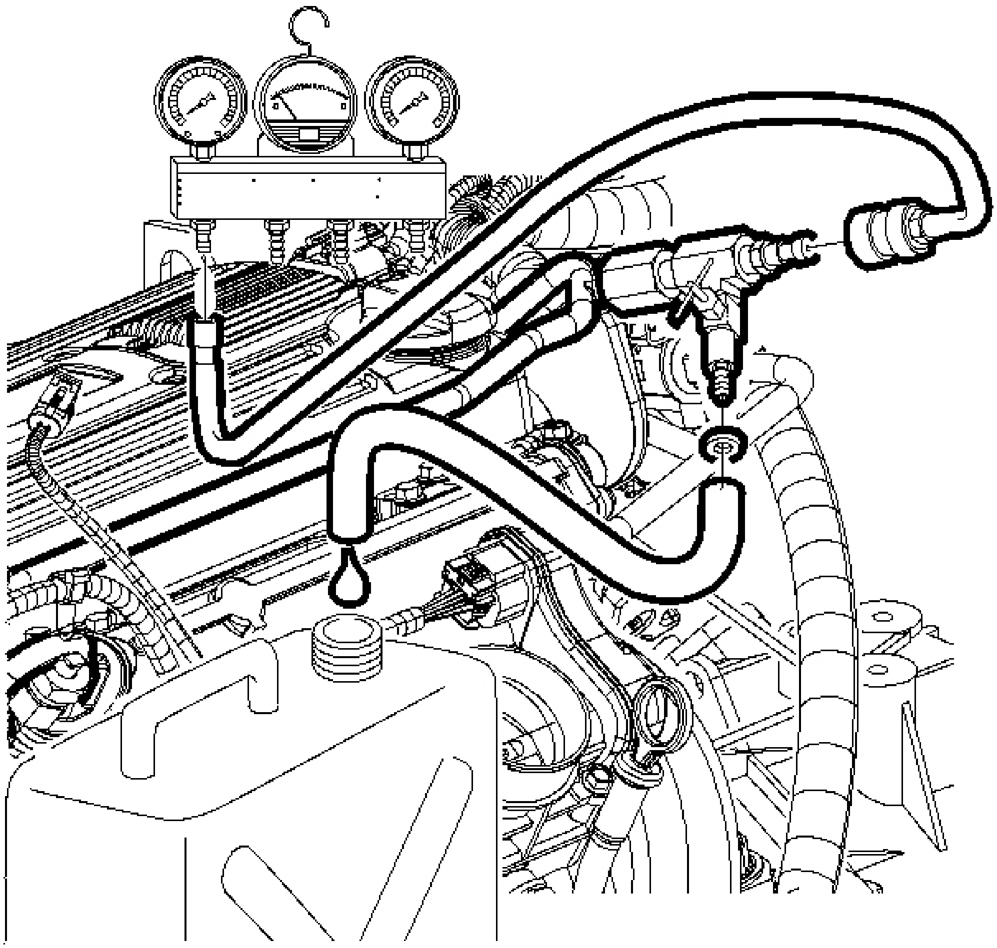


Fig. 84: View Of Fuel Tank Drain Hose
Courtesy of GENERAL MOTORS CORP.

Using the fuel pump to drain the tank is the easiest procedure if the pump is operable. The fuel can be pumped out with the vehicle on the ground or on the hoist.

On The Ground

> **CAUTION: Fuel supply lines will remain pressurized for long periods of time after the engine is shutdown. This pressure must be relieved before servicing the fuel system.**

1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** .

CAUTION: Whenever fuel line fittings are loosened or removed, wrap a shop cloth around the fitting and have an approved container available to collect any fuel.

2. Disconnect the fuel feed line at the fuel rail and install the 3/8 in. x 1/4 in. quick connect from the **SA9127E-7** into the fuel feed line.
3. Connect a suitable drain hose to the other end of the adapter and connect the drain hose into a certified fuel handling cart.
4. Connect the scan tool to the vehicle and turn the ignition ON.
5. Energize the fuel pump using the scan tool. Refer to **Fuel Injector Circuit Diagnosis** .
6. Pump out the fuel until no more than 1/4 tank remains.

On The Hoist

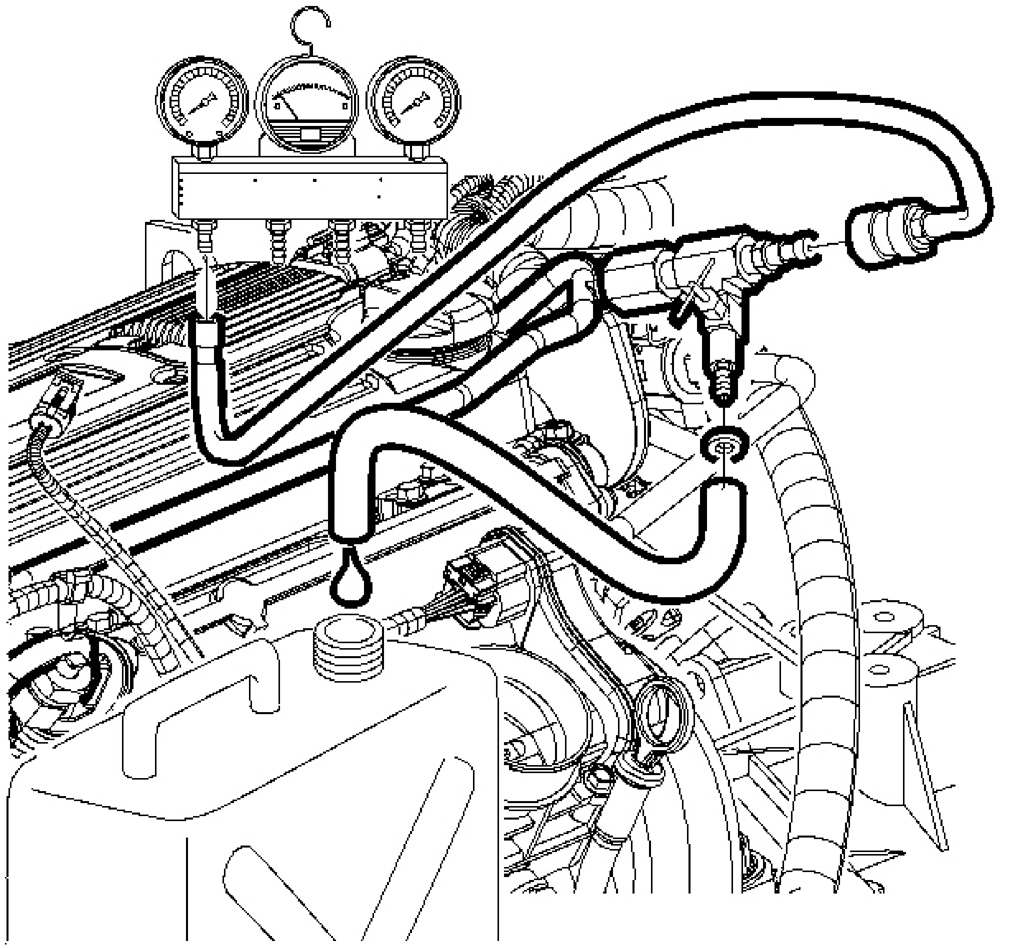


Fig. 85: View Of Fuel Tank Drain Hose
Courtesy of GENERAL MOTORS CORP.

> **CAUTION: Fuel supply lines will remain pressurized for long periods of time after the engine is shutdown. This pressure must be relieved before servicing the fuel system.**

1. Connect the scan tool to the vehicle diagnostic connector and turn the ignition ON.
2. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** .

> **CAUTION: Ensure that the vehicle is properly supported and squarely positioned. To help avoid personal injury when a vehicle is on a**

hoist, provide additional support for the vehicle on the opposite end from which the components are being removed.

3. Raise the vehicle on a hoist to a comfortable working height, keeping the scan tool outside of the vehicle and accessible from under the car.

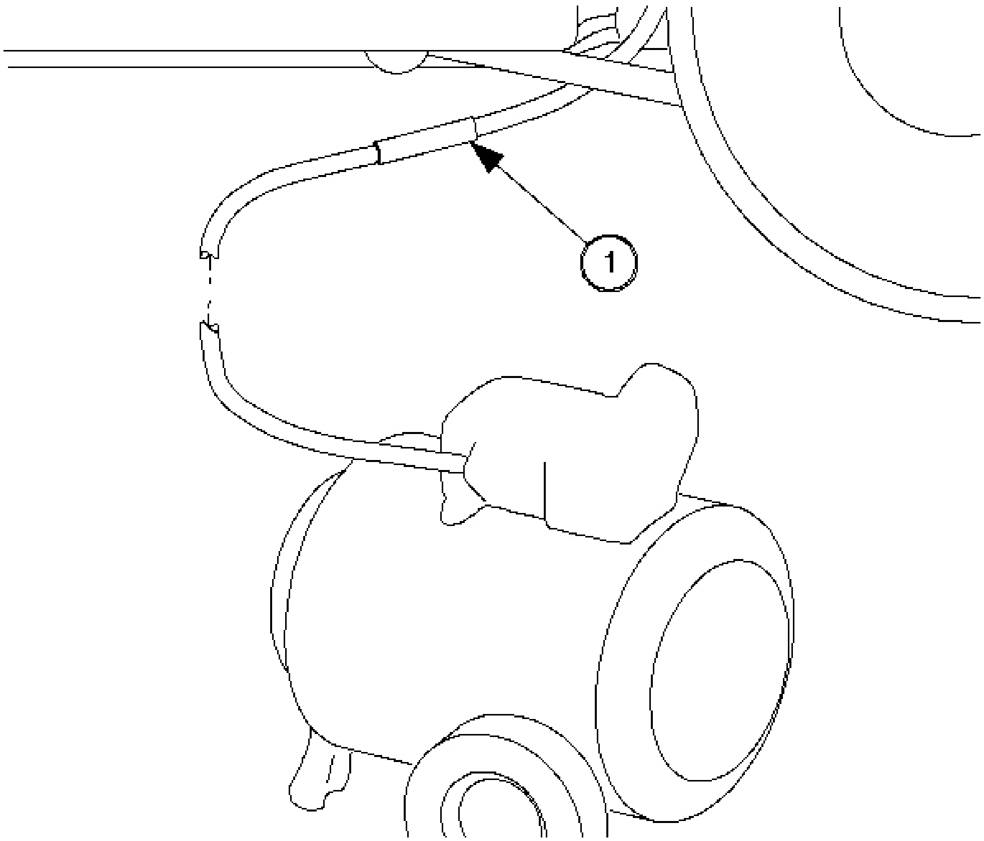


Fig. 86: View Of Adapter From SA9127E-7
Courtesy of GENERAL MOTORS CORP.

CAUTION: Whenever fuel line fittings are loosened or removed, wrap a shop cloth around the fitting and have an approved container available to collect any fuel.

4. Disconnect the chassis fuel feed line at the filter outlet, the 3/8 in. line.
5. Install the 3/8 in. x 1/4 in. quick connect (1) adapter from the **SA9127E-7** onto the fuel feed line.
6. Connect a suitable drain hose to the other end of the adapter, and connect the drain hose to a certified fuel handling cart.
7. Energize the fuel pump using the scan tool. Refer to **Fuel Injector Circuit Diagnosis** .
8. Pump out the fuel until no more than 1/4 tank remains.

Siphoning The Fuel Tank

CAUTION: Do not allow smoking or the use of open flames in the area where work on the fuel or EVAP system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

If the fuel pump is inoperative, the tank can be drained by siphoning from the tank. A suitable means is through the fuel filler pipe with the correct type and stiffness of tubing as used with the **SA9804E** .

CAUTION: Do not allow smoking or the use of open flames in the area where work on the fuel or EVAP system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

1. Disconnect the negative battery cable.
2. Open the fuel filler door and remove the gas cap.

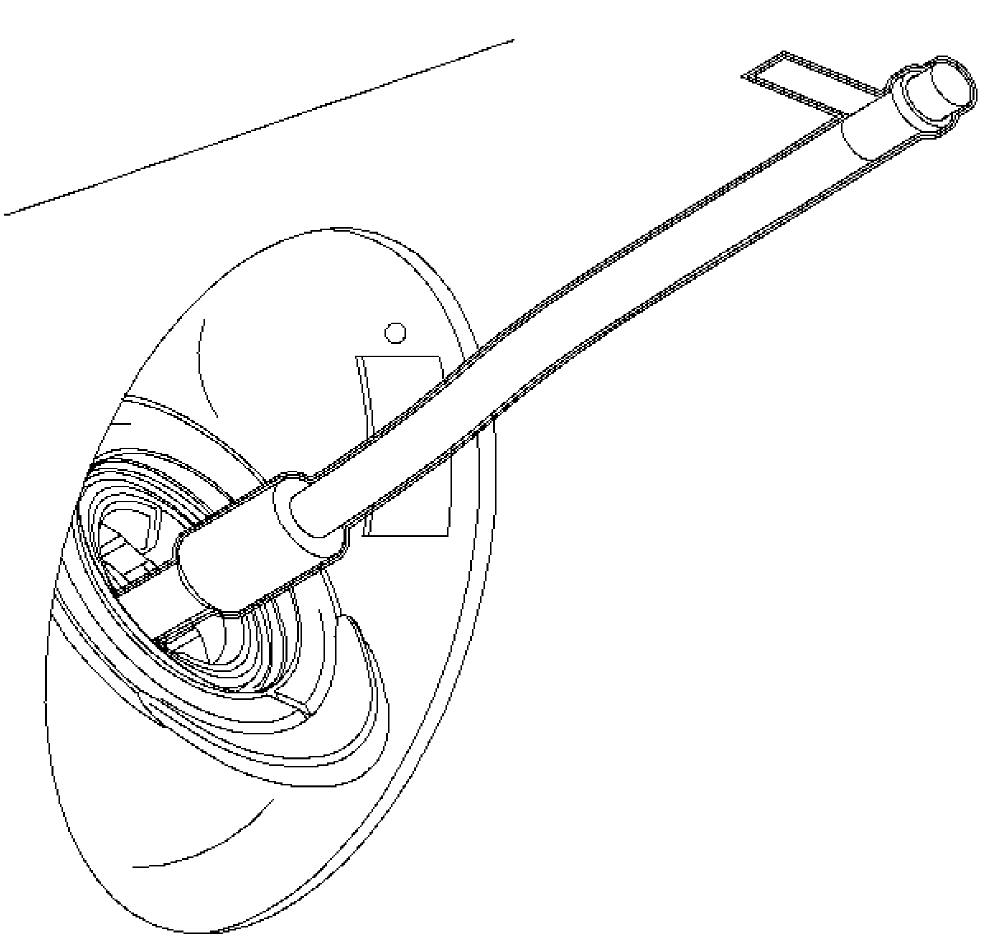


Fig. 87: View Of Siphon Hose or Tube Into The Fuel Filler Pipe
Courtesy of GENERAL MOTORS CORP.

NOTE: **Do not attempt to insert any other type of siphon hose or tube into the fuel filler pipe. The design of the inlet check valve at the end of the fuel filler tube restricts the insertion of a hose and, most importantly, prevents the removal of this hose. See Fuel Inlet Check Valve in this section. If the siphon hose becomes stuck in the check valve, the fuel filler pipe will not be able to be removed from the fuel tank without damage to the fill pipe or fuel tank.**

3. Insert the siphon hose guide/funnel into the fuel filler pipe.

IMPORTANT: The siphon hose will reach the bottom of the tank, on the primary side only, within about 25.4 cm (10 in) of the end fitting and tag. When connecting the siphon hose to another length of hose connected to the fuel drain tanker, DO NOT insert the siphon hose into the fill pipe funnel past the tag at the fitting end. If inserted too far, the upper portion of the siphon hose may pass through the check valve cage and then jam on attempted removal.

4. Insert the **SA9804E** into the guide funnel and into the fuel filler pipe. Some resistance may be encountered when the tip of the siphon hose reaches the inlet check valve. Repeated probing may be necessary to slide the hose tip through the check valve cage.

CAUTION: Whenever fuel lines are removed, catch fuel in an approved container. Container opening must be a minimum of 300 mm (12 in) diameter to adequately catch the fluid.

IMPORTANT: The fuel flow rate from the siphon hose will range from 1.1 L/min (0.3 gal/min) up to 3.8 L/min (1 gal/min), depending on whether it is gravity siphoned or with an air-powered pump.

5. Begin the fuel siphoning process. Place the fuel into an approved fuel container.
6. Remove the siphon hose from the fuel filler pipe after draining is complete.

FUEL TANK REPLACEMENT

Removal Procedure

CAUTION: Do not allow smoking or the use of open flames in the area where work on the fuel or EVAP system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

1. Ensure that the fuel level in the tank is less than 1/4 full. If necessary, drain the fuel tank to at least this level. Refer to **Fuel Tank Draining Procedure** .

CAUTION: Fuel supply lines will remain pressurized for long periods of time after the engine is shutdown. This pressure must be relieved before servicing the fuel system.

2. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** .
3. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
4. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.

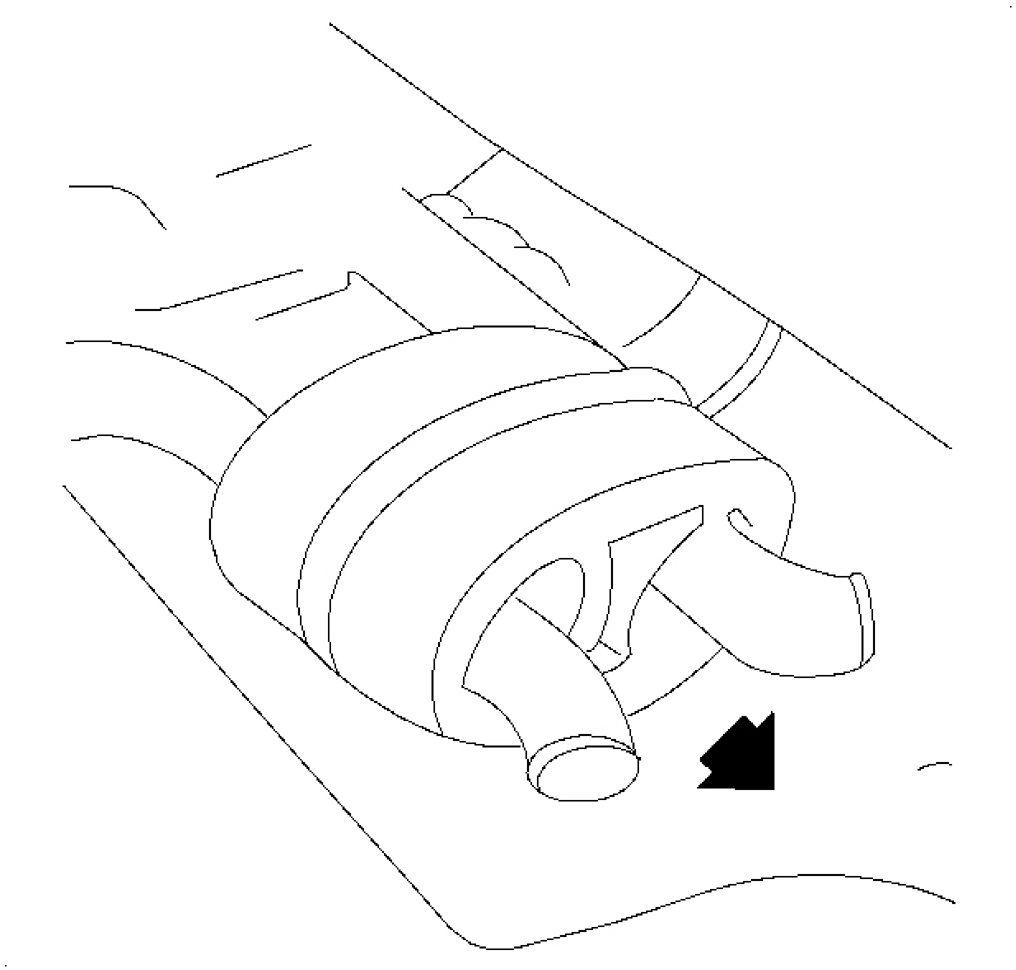


Fig. 88: View Of Rubber Exhaust Hangers
Courtesy of GENERAL MOTORS CORP.

5. Remove the rubber exhaust hangers on order to allow the exhaust system to drop slightly.
6. Remove the propeller shaft, if equipped. Refer to **Propeller Shaft Replacement** in Propeller Shaft.

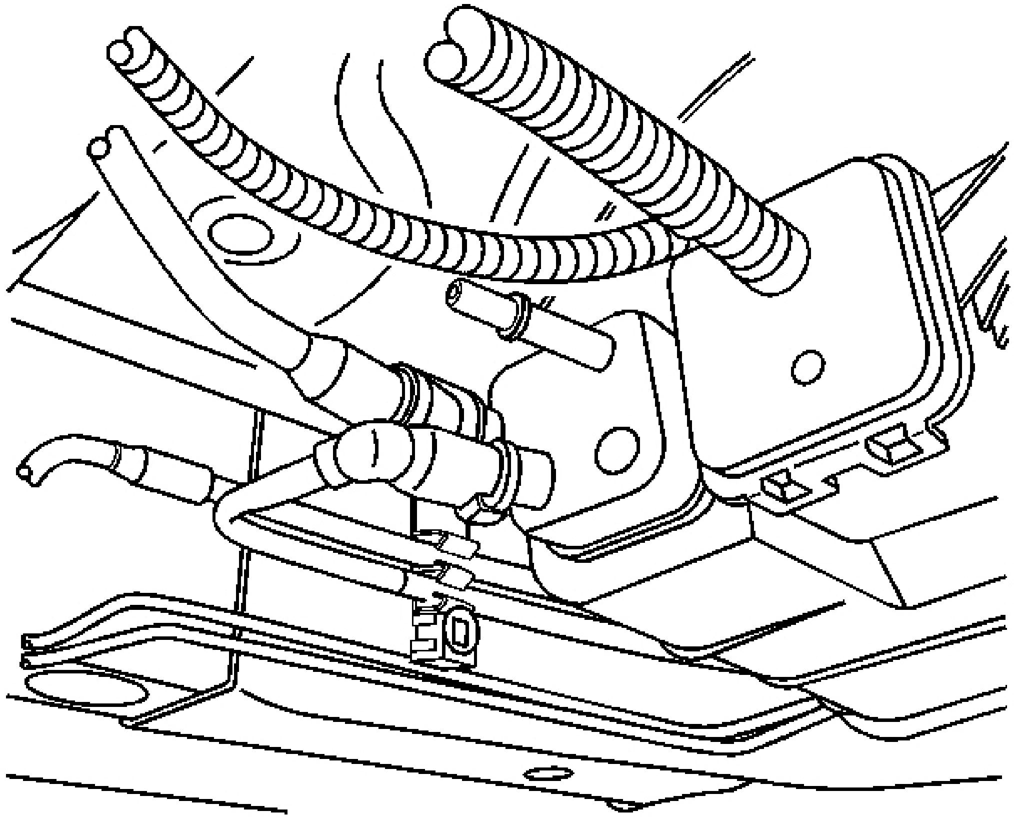


Fig. 89: View Of Evaporative Emission Canister
Courtesy of GENERAL MOTORS CORP.

NOTE: **Clean all fuel pipe connections and surrounding areas before disconnecting the fuel pipes to avoid contamination of the fuel system.**

7. Disconnect the evaporative emission (EVAP) canister vent and fresh air hoses:
    1. Grasping both sides of the quick-connect fitting, twist the female connector 1/4 turn in each direction in order to loosen dirt within the quick-connect fitting.
    2. Blow any dirt out of the quick-connect fitting using compressed air.
    3. Squeeze the plastic retainer release tabs.
    4. Pull the connection apart.
    5. Inspect both ends of the quick-connect fitting for dirt and burrs.

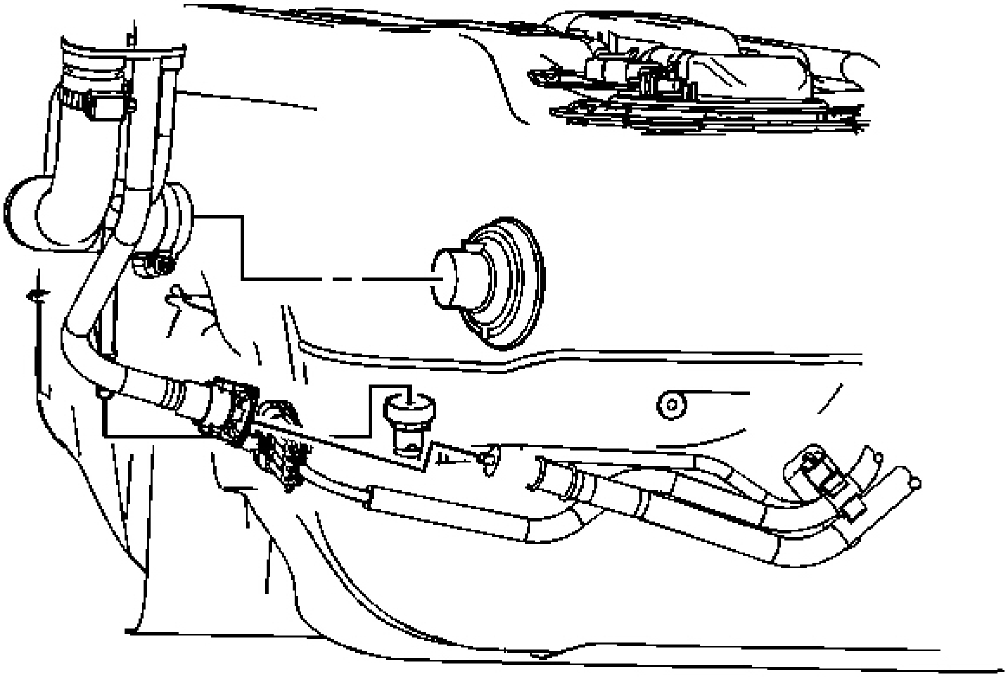


Fig. 90: View Of Fuel Filler Pipe, EVAP Vent & Fresh Air Hoses To The Fuel Tank
Courtesy of GENERAL MOTORS CORP.

8. Remove the fuel filler pipe, EVAP vent hose, and fresh air hose from the fuel tank.

CAUTION: Whenever fuel lines are removed, catch fuel in an approved container. Container opening must be a minimum of 300 mm (12 in) diameter to adequately catch the fluid.

9. Disconnect the chassis fuel supply line from the tank.
10. Disconnect the electrical connectors:
    1. Fuel tank electrical connectors
    2. EVAP solenoid electrical connector

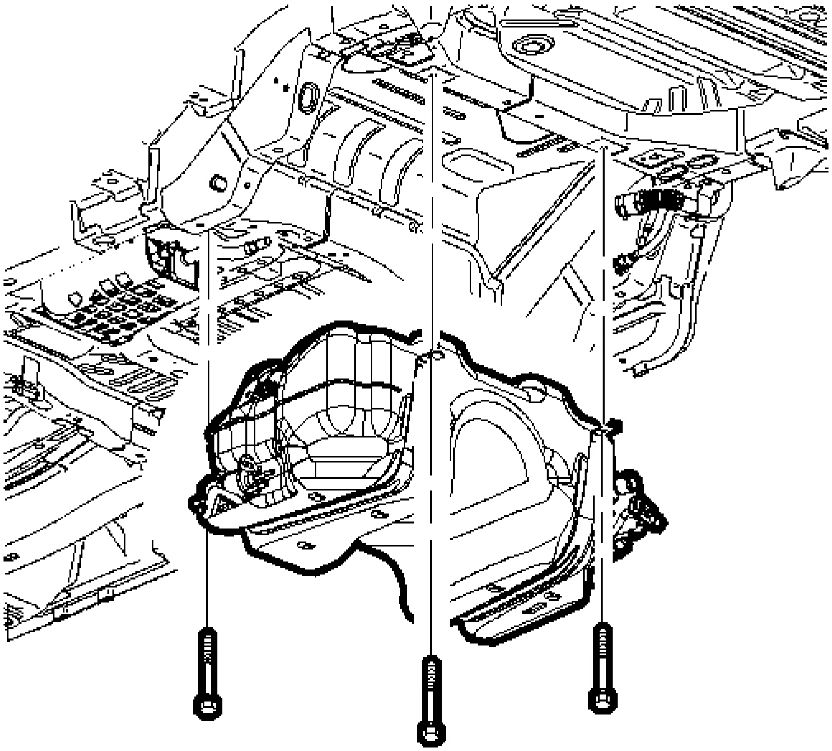


Fig. 91: View Of Fuel Tank Heat Shield & Fuel Tank Assembly Into The Vehicle
Courtesy of GENERAL MOTORS CORP.

NOTE: **Do not bend the fuel tank straps. Bending the fuel tank straps may cause damage to the straps.**

IMPORTANT: **Do not disassemble the rear drive module (RDM). It is not necessary to touch the RDM for fuel tank removal.**

11. Support the fuel tank.
12. Remove the fuel tank strap bolts and fuel tank straps.
13. Lower the fuel tank from the underbody of the vehicle.

14. Remove the fuel tank module assemblies. Refer to **Fuel Tank Module Replacement - Primary** and **Fuel Tank Module Replacement - Secondary** .

Installation Procedure

1. Install the fuel tank module assemblies. Refer to **Fuel Tank Module Replacement - Primary** and **Fuel Tank Module Replacement - Secondary** .

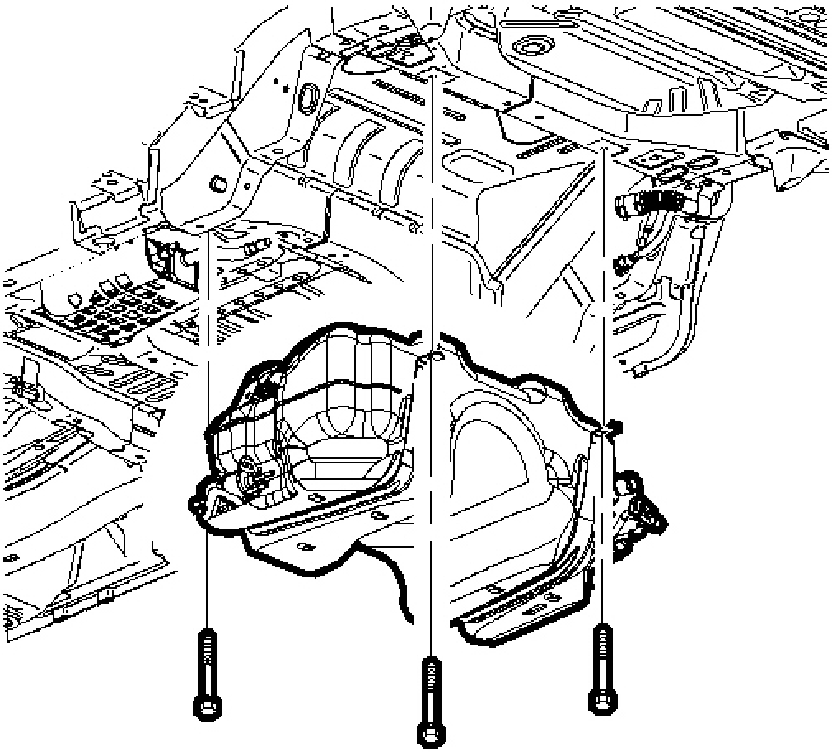


Fig. 92: View Of Fuel Tank Heat Shield & Fuel Tank Assembly Into The Vehicle
Courtesy of GENERAL MOTORS CORP.

2. Install the fuel tank heat shield and fuel tank assembly into the vehicle.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the fuel tank straps and tighten the bolts.

   Tighten: Tighten the fuel tank strap-to-body bolts to 25 N.m (18 lb ft).

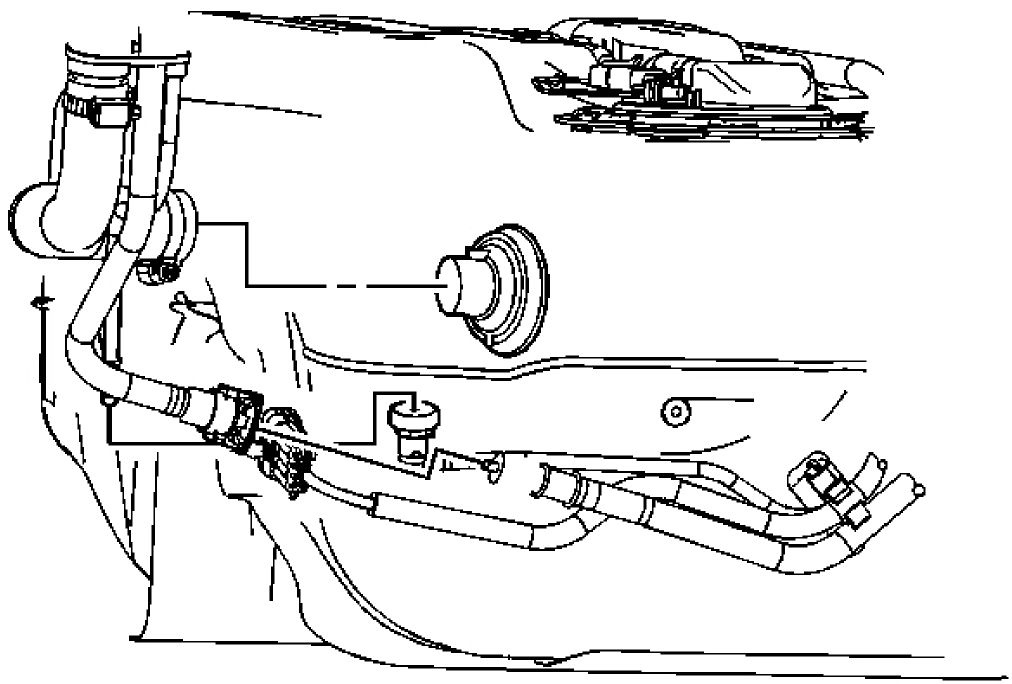


Fig. 93: View Of Fuel Filler Pipe, EVAP Vent & Fresh Air Hoses To The Fuel Tank
Courtesy of GENERAL MOTORS CORP.

4. Install the fuel filler pipe, EVAP vent, and fresh air hoses to the fuel tank.
5. Connect the electrical connectors:
   1. Fuel tank electrical connector
   2. EVAP solenoid electrical connectors
6. Tighten the hose clamp on the filler pipe-to-fuel tank connecting hose.

   Tighten: Tighten the fuel fill neck-to-fuel tank clamp to 5 N.m (44 lb in).

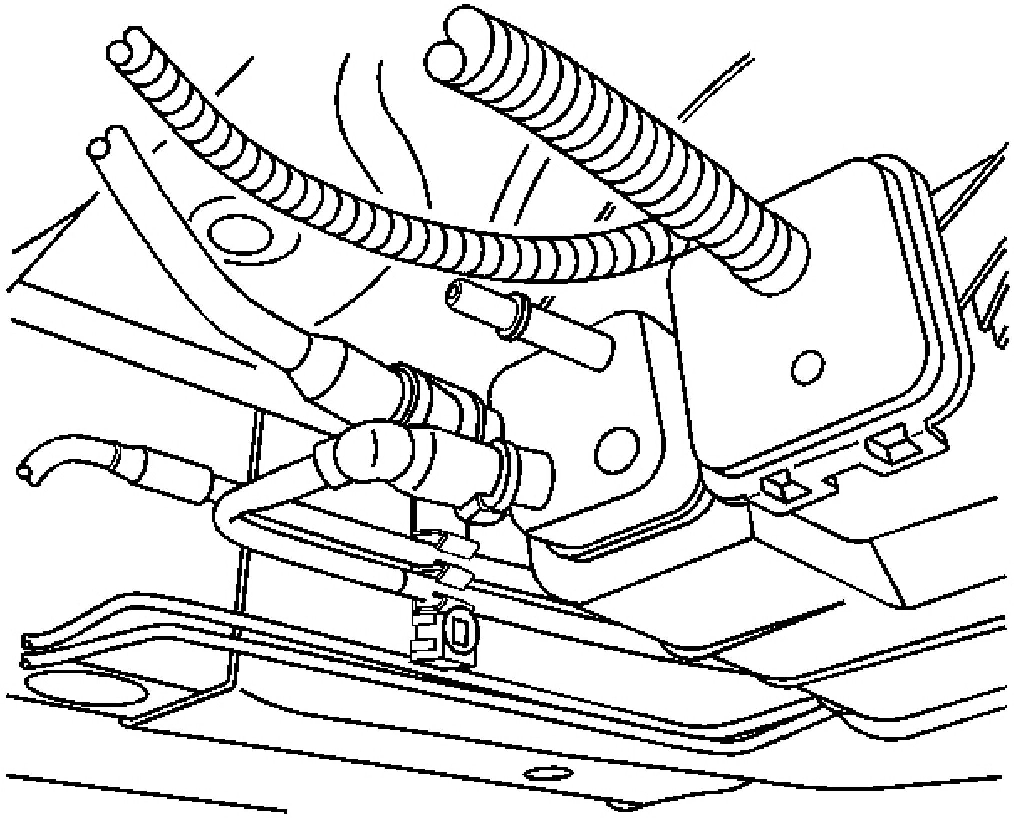


Fig. 94: View Of Evaporative Emission Canister
Courtesy of GENERAL MOTORS CORP.

7. Connect the EVAP canister vent and fresh air hoses to the fuel tank hoses.
8. If equipped, install the propeller shaft. Refer to **Propeller Shaft Replacement** in Propeller Shaft.

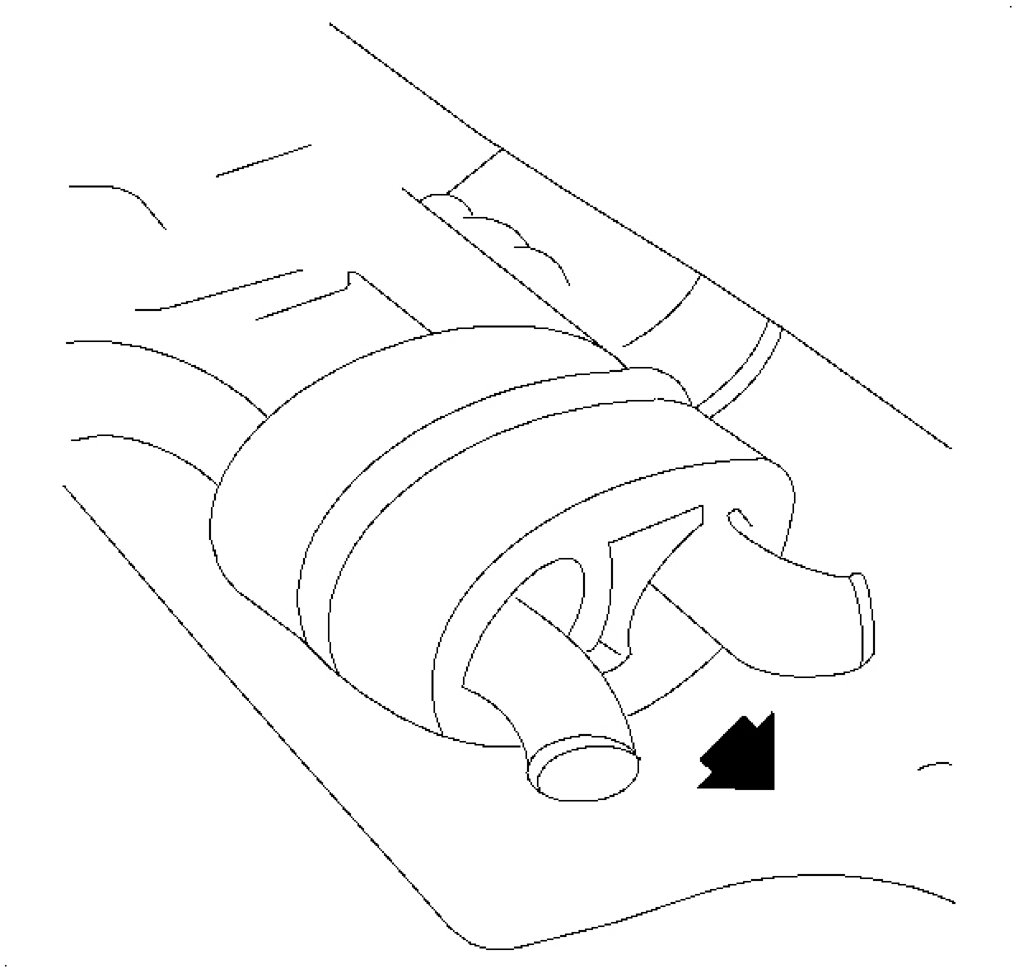


Fig. 95: View Of Rubber Exhaust Hangers
Courtesy of GENERAL MOTORS CORP.

9. Install the rubber exhaust hangers.
10. Lower the vehicle.
11. Fill the fuel tank with gasoline.
12. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
13. Prime the fuel system:
    1. Cycle the ignition ON for 5 seconds and then OFF for 10 seconds.
    2. Repeat the previous step twice.

3. Crank the engine until it starts. The maximum starter motor cranking time is 20 seconds.
4. If the engine does not start, repeat steps 13.1-13.3.

FUEL TANK PRESSURE SENSOR REPLACEMENT

Removal Procedure

1. Remove the fuel tank. Refer to **Fuel Tank Replacement** .

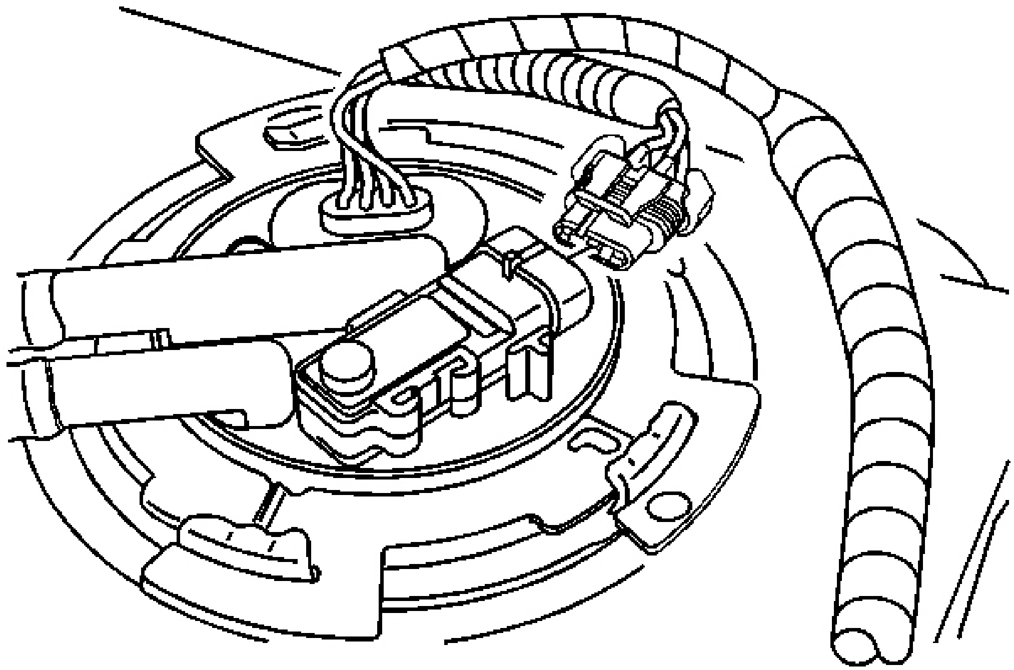


Fig. 96: View Of Fuel Tank Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the fuel pump module harness electrical connector from the fuel tank pressure sensor.

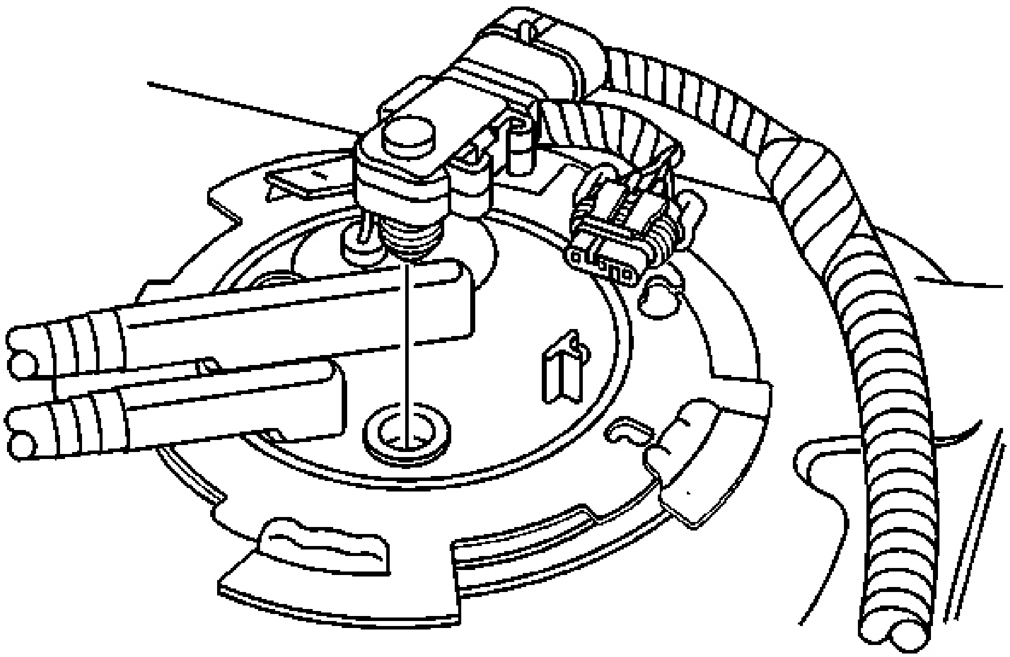


Fig. 97: View Of Fuel Tank Pressure Sensor To The Fuel Pump Module Assembly
Courtesy of GENERAL MOTORS CORP.

3. Position 2 flat-bladed screwdrivers, one on each side of the sensor, near the vacuum port.
4. Carefully use the screwdrivers to lift and release the sensor from the fuel pump module.

Installation Procedure

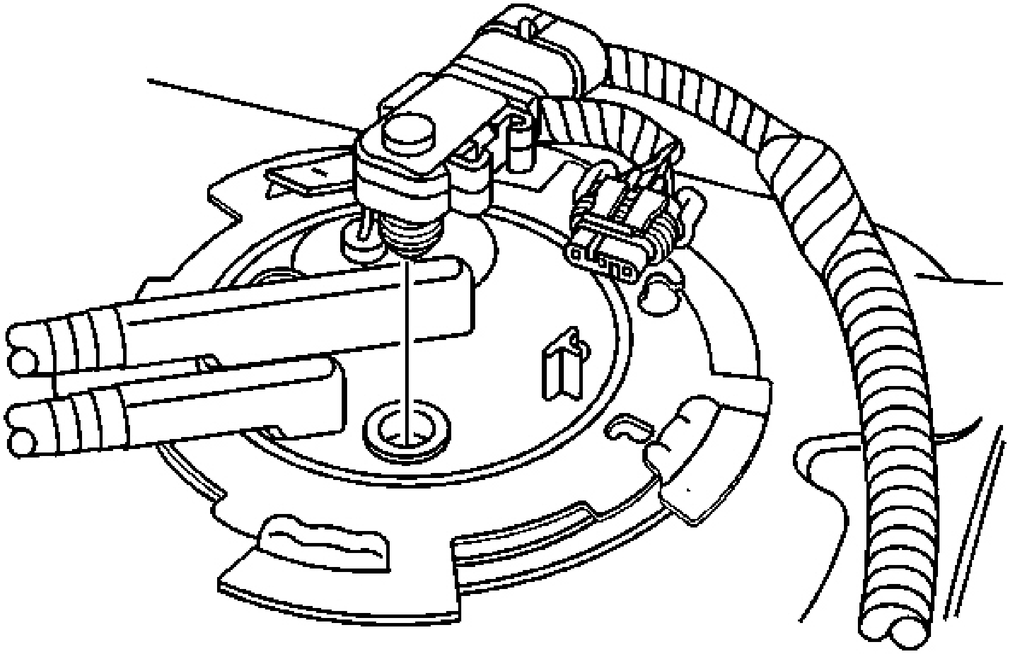


Fig. 98: View Of Fuel Tank Pressure Sensor To The Fuel Pump Module Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the fuel tank pressure sensor to the fuel pump module assembly. Ensure that the sensor grommet is fully seated to the pump module.

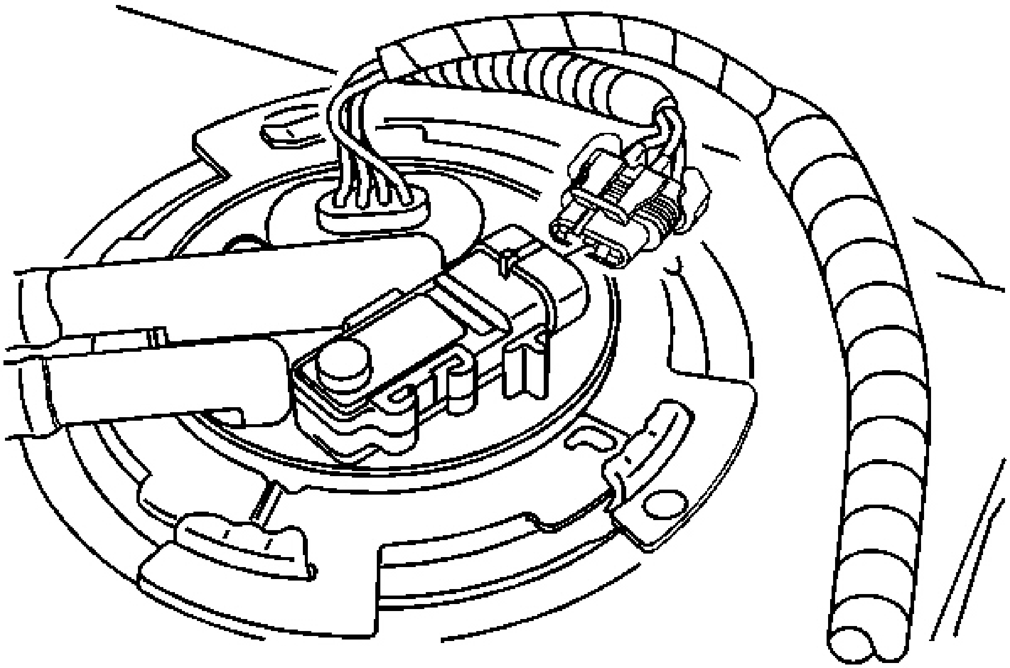


Fig. 99: View Of Fuel Tank Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

2. Connect the pump module electrical connector to the fuel tank pressure sensor.
3. Install the fuel tank. Refer to **Fuel Tank Replacement** .

FUEL LEVEL SENSOR REPLACEMENT (PRIMARY)

Removal Procedure

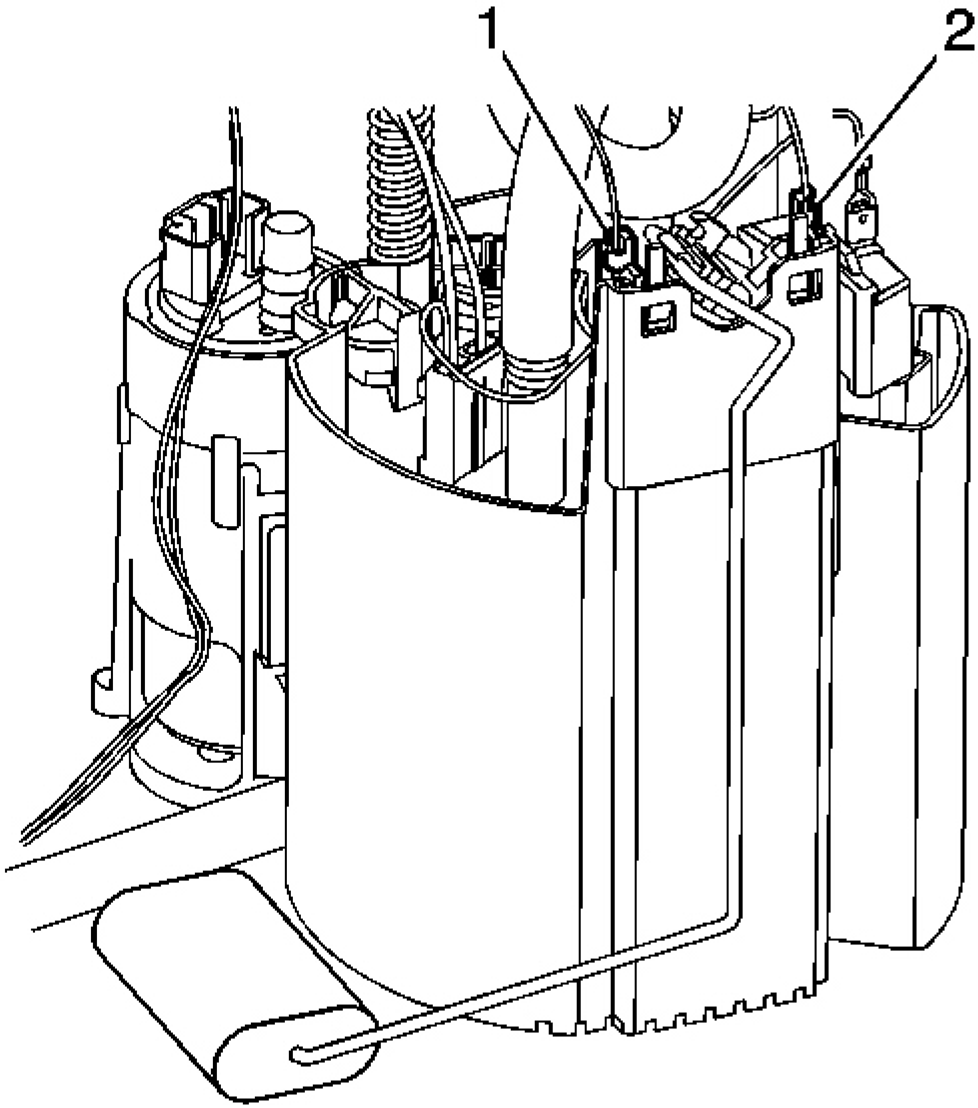


Fig. 100: View Of Fuel Level Sensor
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: There are 2 fuel level sender unit and float assemblies in the fuel tank. There is 1 located on each fuel pump module. The fuel level sender unit and float is NOT the same for each of the fuel pump modules.

1. Remove the fuel tank. Refer to **Fuel Tank Replacement** .

2. Remove the fuel pump module. Refer to **Fuel Tank Module Replacement - Primary** .
3. Disconnect the fuel level sender unit and float electrical connector from the underside of the top of the pump module.
4. Release the retaining tabs (1, 2) and remove the level sensor by sliding up.

Installation Procedure

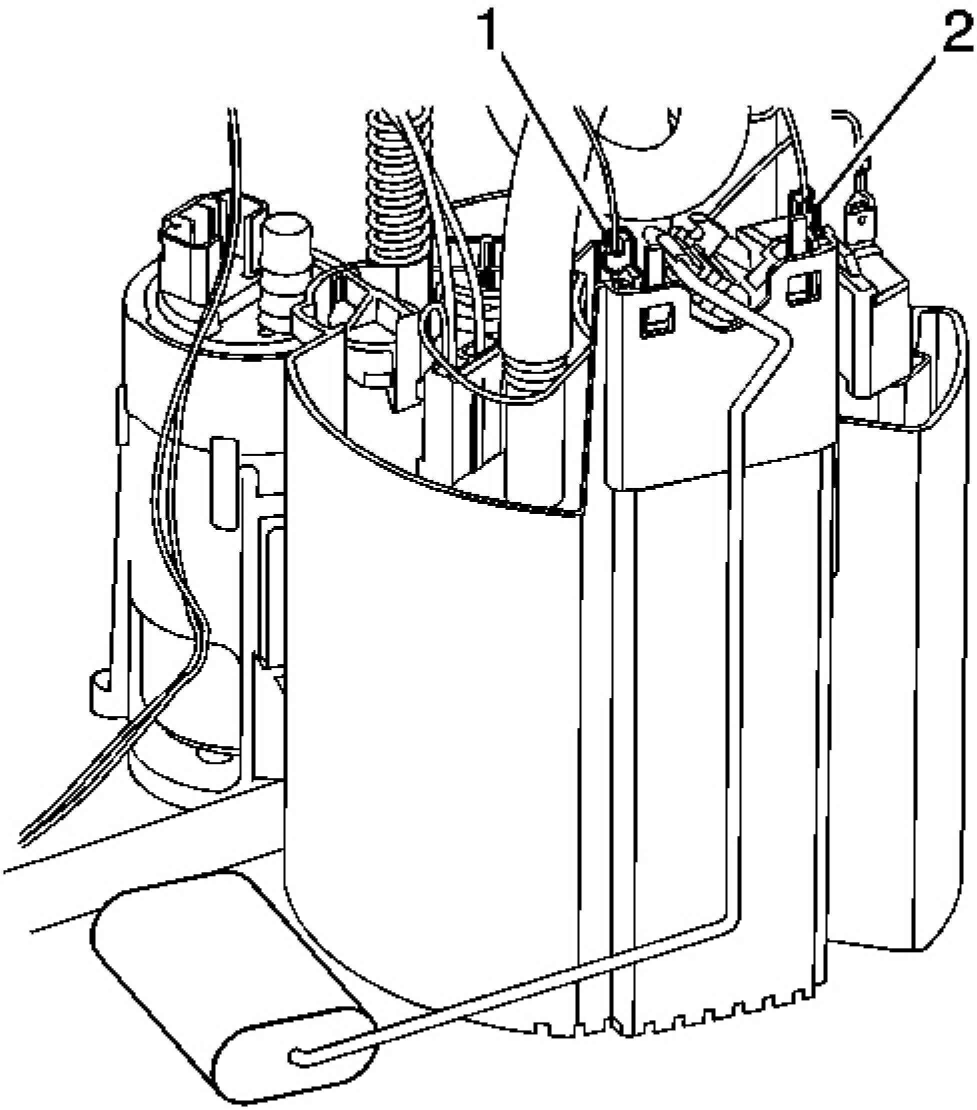


Fig. 101: View Of Fuel Level Sensor
Courtesy of GENERAL MOTORS CORP.

1. Install the fuel level sender unit and float onto the fuel pump module. Make sure that the sender cap snaps into place (1, 2).
2. Connect the fuel level sender unit and float electrical connector.
3. Install the fuel pump module into the fuel tank. Refer to **Fuel Tank Module Replacement - Primary** .
4. Install the fuel tank. Refer to **Fuel Tank Replacement** .

FUEL LEVEL SENSOR REPLACEMENT (SECONDARY)

Removal Procedure

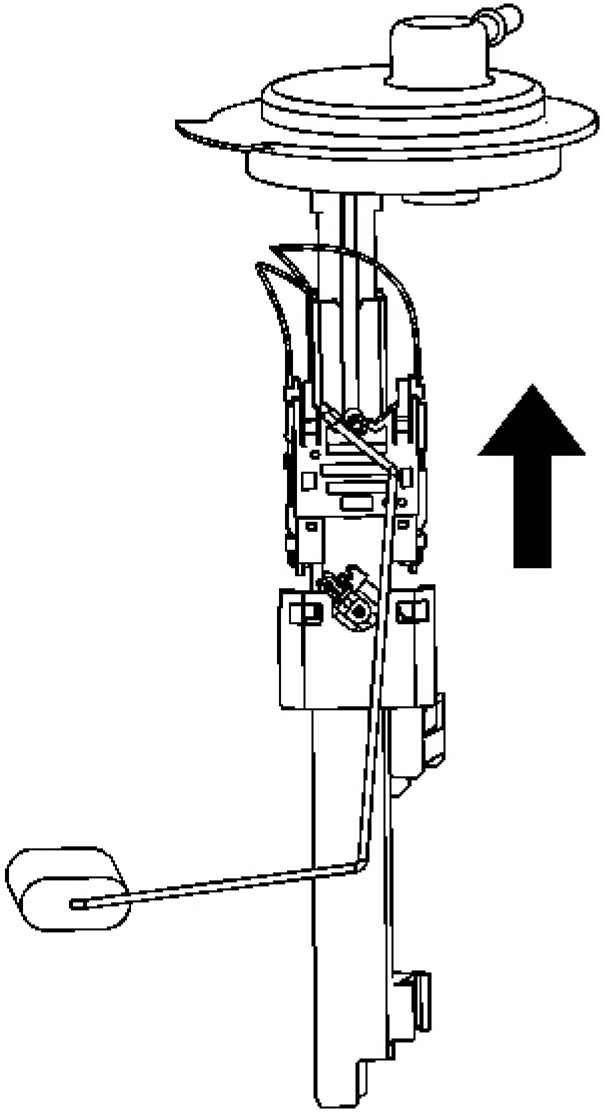


Fig. 102: View Of Fuel Level Sensor (Secondary)
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: **There are 2 fuel level sender unit and float assemblies in the fuel tank. There is 1 located on each fuel pump module. The fuel level sender unit and float is NOT the same for each of the fuel pump modules.**

1. Remove the fuel tank. Refer to **Fuel Tank Replacement** .
2. Remove the fuel pump module. Refer to **Fuel Tank Module Replacement - Secondary** .
3. Disconnect the fuel level sender unit and the float electrical connector.
4. Release the retaining tabs and remove the level sensor by sliding up.

Installation Procedure

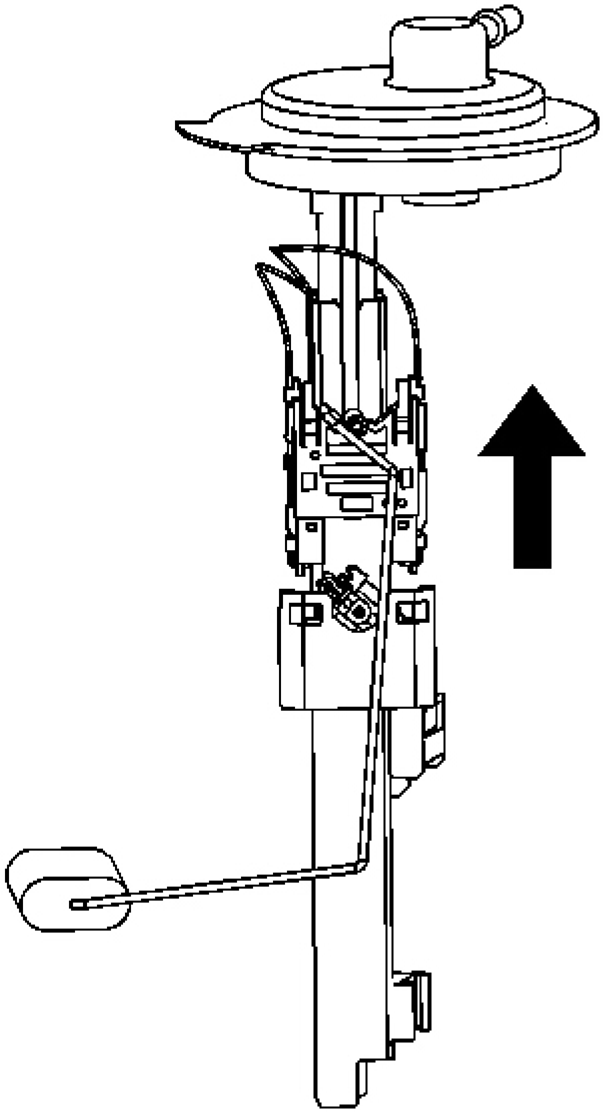


Fig. 103: View Of Fuel Level Sensor (Secondary)
Courtesy of GENERAL MOTORS CORP.

1. Install the fuel level sender unit and float onto the fuel pump module. Make sure that the sender cap snaps into place.
2. Connect the fuel level sender unit and the float electrical connector.
3. Install the fuel pump module into the fuel tank. Refer to **Fuel Tank Module Replacement - Secondary** .
4. Install the fuel tank. Refer to **Fuel Tank Replacement** .

FILLER TUBE REPLACEMENT

Removal Procedure

CAUTION: Do not allow smoking or the use of open flames in the area where work on the fuel or EVAP system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

1. Ensure that the fuel level in the tank is less than 1/4 full. If necessary, drain the fuel tank to at least this level. Refer to **Fuel Tank Draining Procedure** .

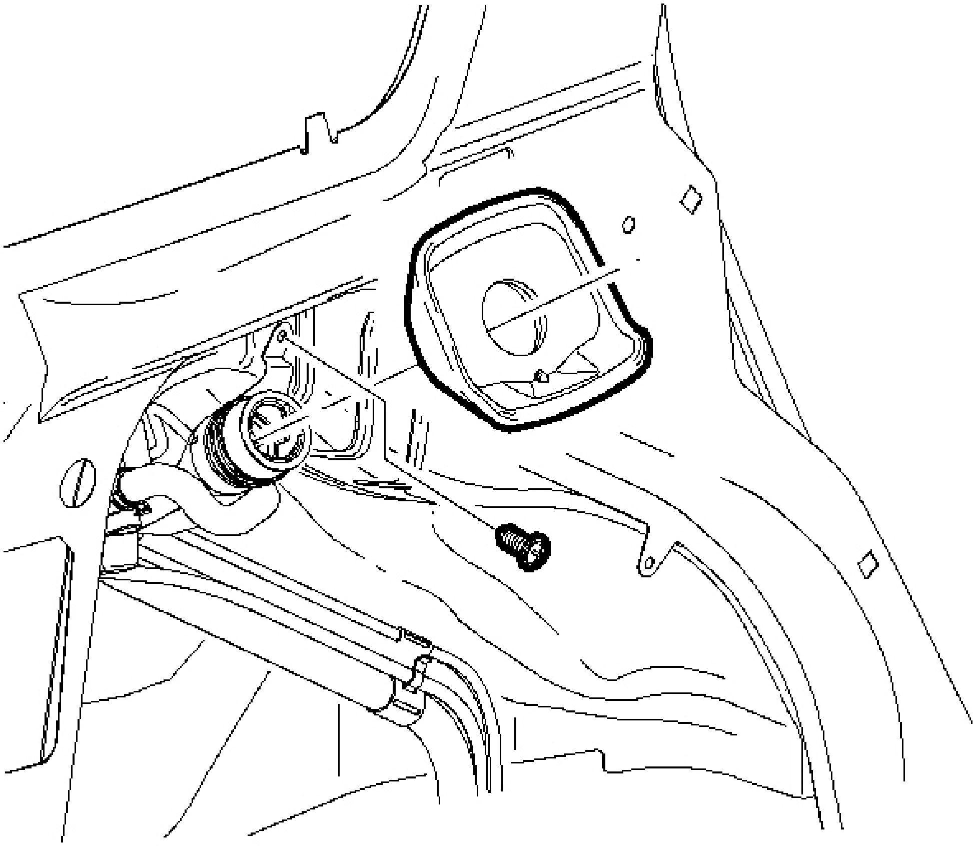


Fig. 104: View Of Filler Tube
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
3. Remove the fuel filler cap.
4. Push/pry the closeout grommet to expose the fuel fill neck attachment bolt. Remove the fill neck attachment bolt.
5. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
6. Remove the right rear wheel and tire. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
7. Remove the right rear wheelhouse inner liner. Refer to **Wheelhouse Liner Panel Replacement - Rear** in

Body Rear End.

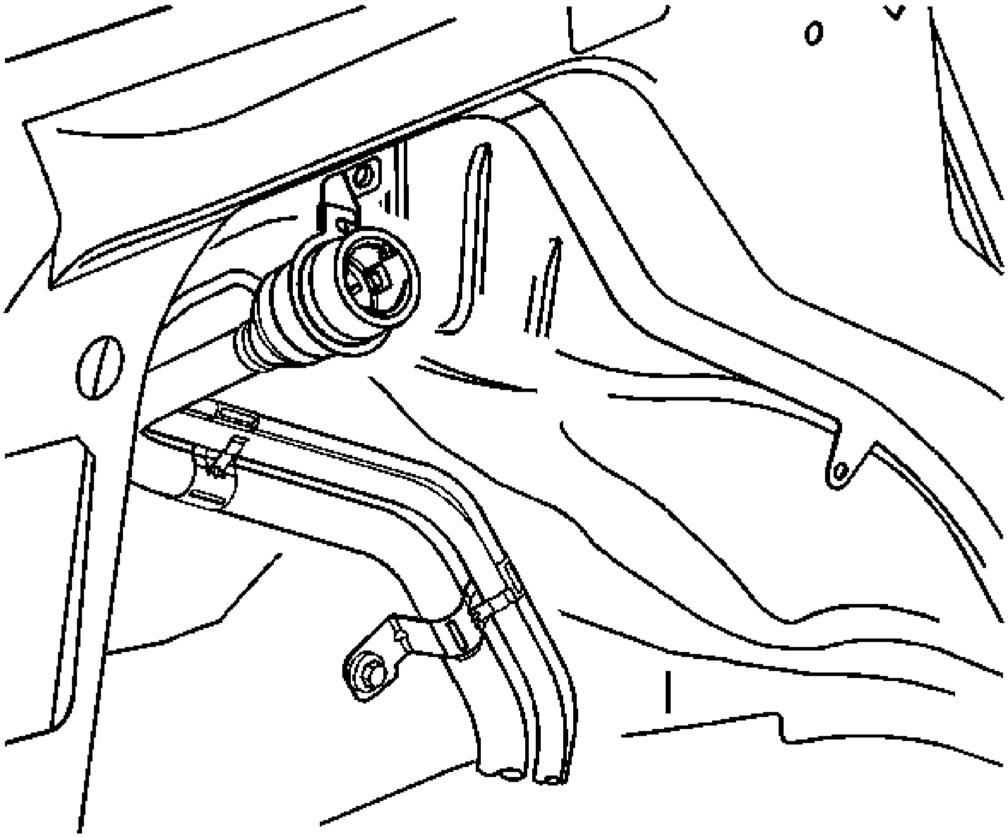


Fig. 105: View Of Fuel Pipe Intermediate Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

8. Remove the fuel filler pipe intermediate bracket bolt.
9. Disengage the fuel filler neck from the support bracket by moving the fuel filter neck up and to the left, toward the rear of the vehicle.

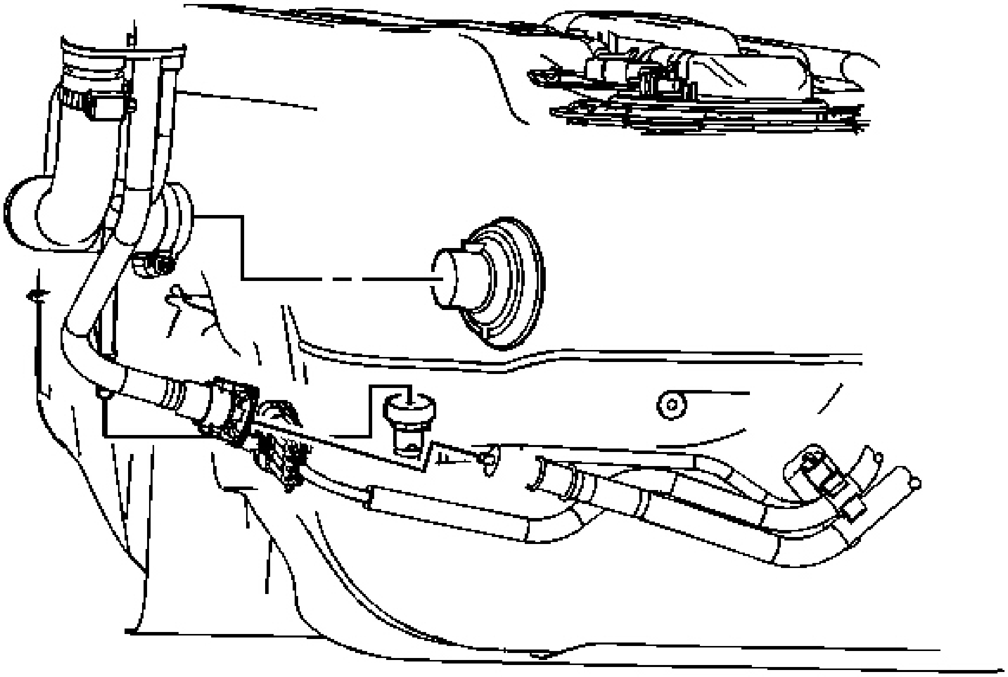


Fig. 106: View Of Fuel Filler Pipe, EVAP Vent & Fresh Air Hoses To The Fuel Tank
Courtesy of GENERAL MOTORS CORP.

10. Disconnect the fuel fill pipe vent tube, fresh air hose, and fuel fill hose from the fuel tank.
11. Disengage the filler pipe hose from the fuel tank and remove the fuel filler pipe and rubber grommet from the vehicle.

Installation Procedure

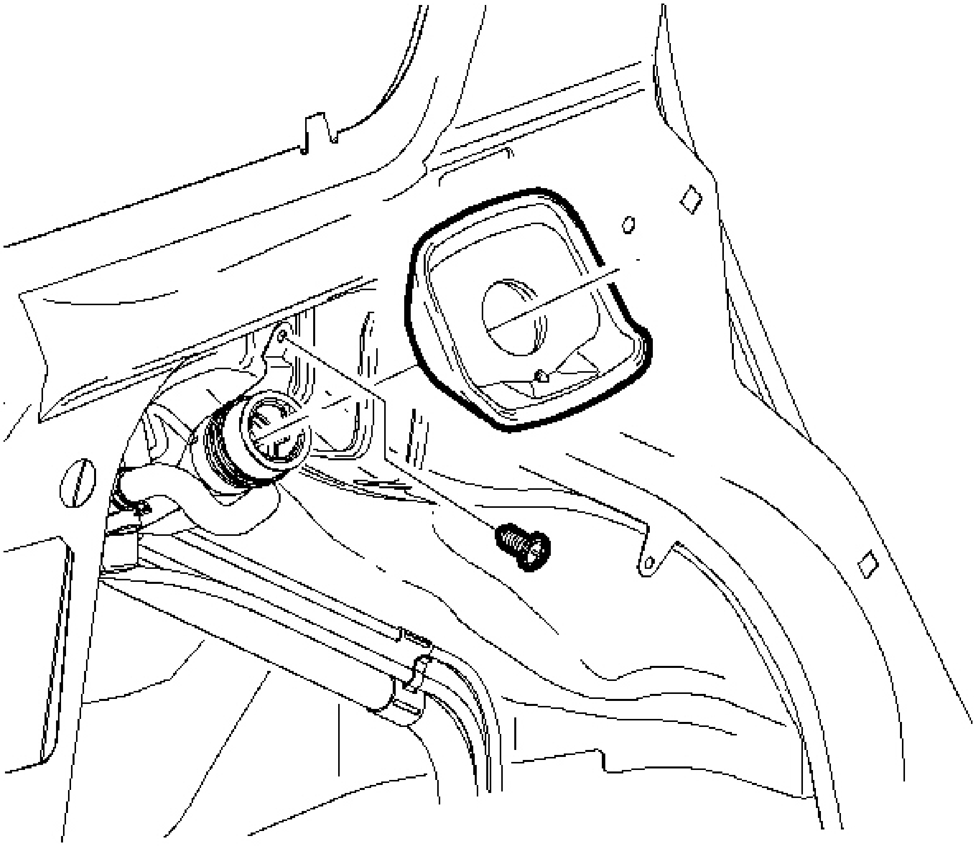


Fig. 107: View Of Rubber Grommet Onto The Fuel Filler Pipe
Courtesy of GENERAL MOTORS CORP.

1. Install the rubber grommet onto the fuel filler pipe.
2. Position the filler pipe into the wheel opening with the top of the pipe within the body panel opening.

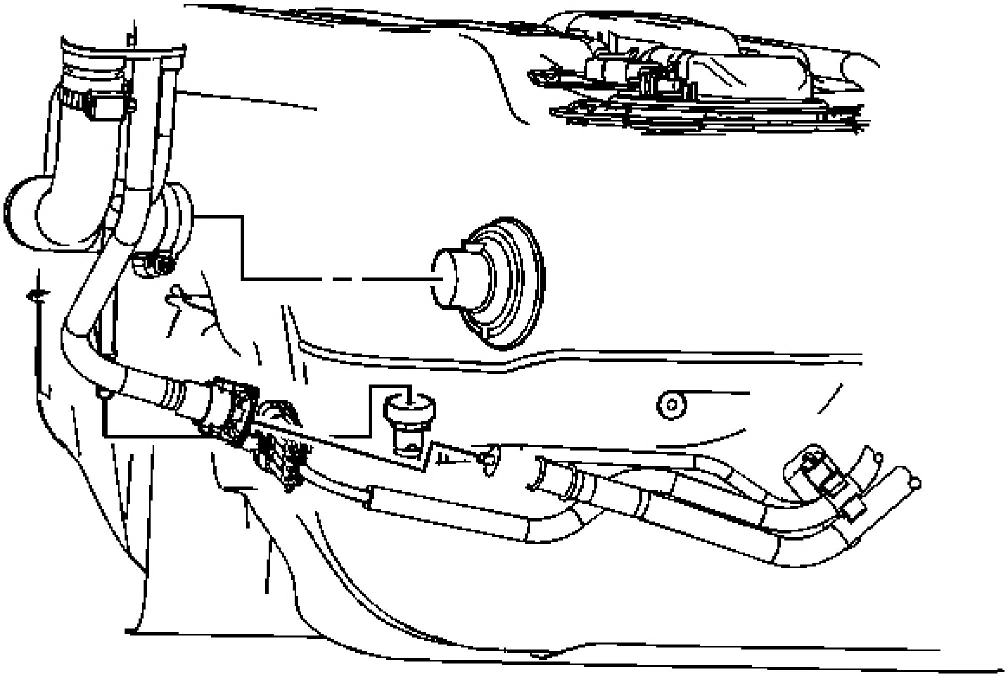


Fig. 108: View Of Fuel Filler Pipe, EVAP Vent & Fresh Air Hoses To The Fuel Tank
Courtesy of GENERAL MOTORS CORP.

3. Install the fuel filler hose onto the fuel tank inlet.

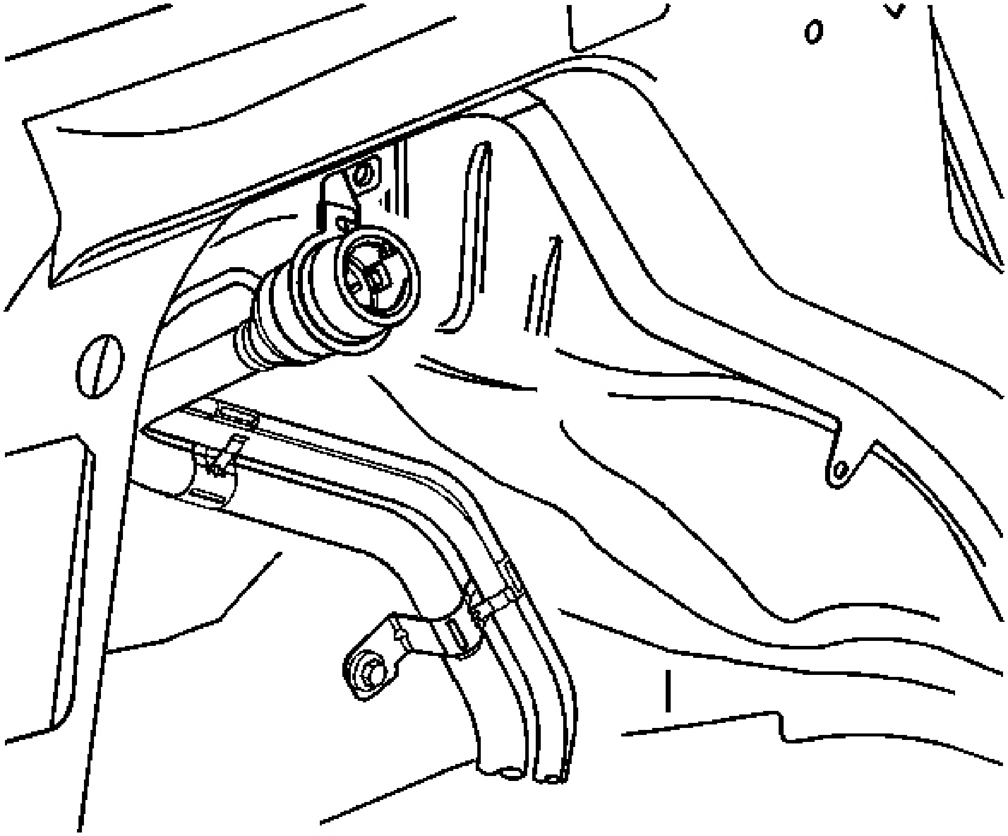


Fig. 109: View Of Fuel Pipe Intermediate Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

4. Install the fuel filler pipe intermediate bracket bolt. Do not tighten at this time.

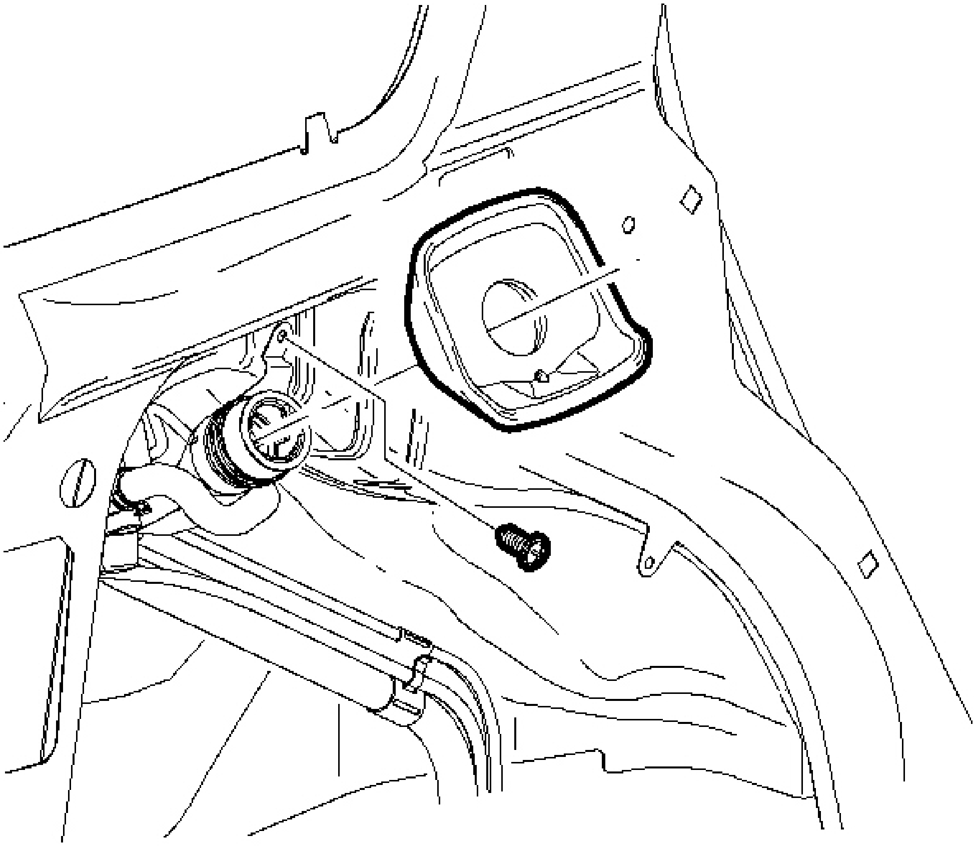


Fig. 110: View Of Rubber Grommet Onto The Fuel Filler Pipe
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Lower the vehicle and install the filler pipe to upper fuel fill pipe support bracket by moving the fuel filler neck up and to the right, toward the front of the vehicle. Tighten the fuel fill pipe-to-body bolt.

   Tighten: Tighten the bolt to 3 N.m (27 lb in).

6. Install the fuel cap.
7. Raise the vehicle to a comfortable working height.

IMPORTANT: Ensure that the fuel pipe connecting hose is installed until it touches the fuel tank body. The hose clamp should be located within 13 mm (1/2 in) of the end of the connecting hose.

8. Tighten the hose clamp on the filler pipe-to-fuel tank connecting hose.

   Tighten: Tighten the fuel fill neck-to-fuel tank clamp to 5 N.m (44 lb in).

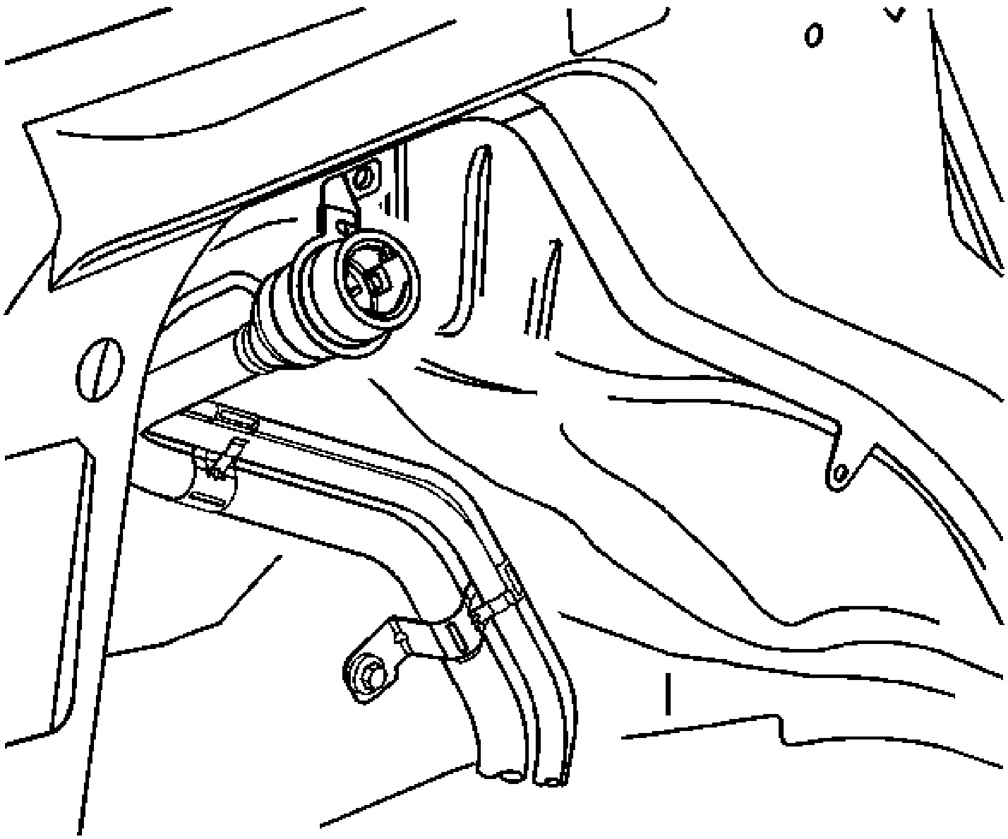


Fig. 111: View Of Fuel Pipe Intermediate Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

9. Connect the fuel fill pipe vent tube and fresh air hose.
10. Tighten the intermediate bracket bolt.

    Tighten: Tighten the bolt to 10 N.m (89 lb in).

11. Install the inner wheelhouse liner. Refer to **Wheelhouse Liner Panel Replacement - Rear** in Body Front End.
12. Install the wheel and tire. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
13. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
14. Lower the vehicle from the hoist.
15. Perform the Service Bay Diagnostic Test for the EVAP emission system using the scan tool. This test will verify the integrity of the vapor handling areas of the fuel system.

FUEL HOSE/PIPES REPLACEMENT - CHASSIS

Removal Procedure

CAUTION: Ensure that the vehicle is properly supported and squarely positioned. To help avoid personal injury when a vehicle is on a hoist, provide additional support for the vehicle on the opposite end from which the components are being removed.

CAUTION: Do not allow smoking or the use of open flames in the area where work on the fuel or EVAP system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

CAUTION: Whenever fuel lines are removed, catch fuel in an approved container. Container opening must be a minimum of 300 mm (12 in) diameter to adequately catch the fluid.

NOTE: Fuel/Vapor lines cannot be spliced or repaired. The line must be replaced (if damaged) with the same type of line.

1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** .
2. Disconnect the negative battery terminal. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.

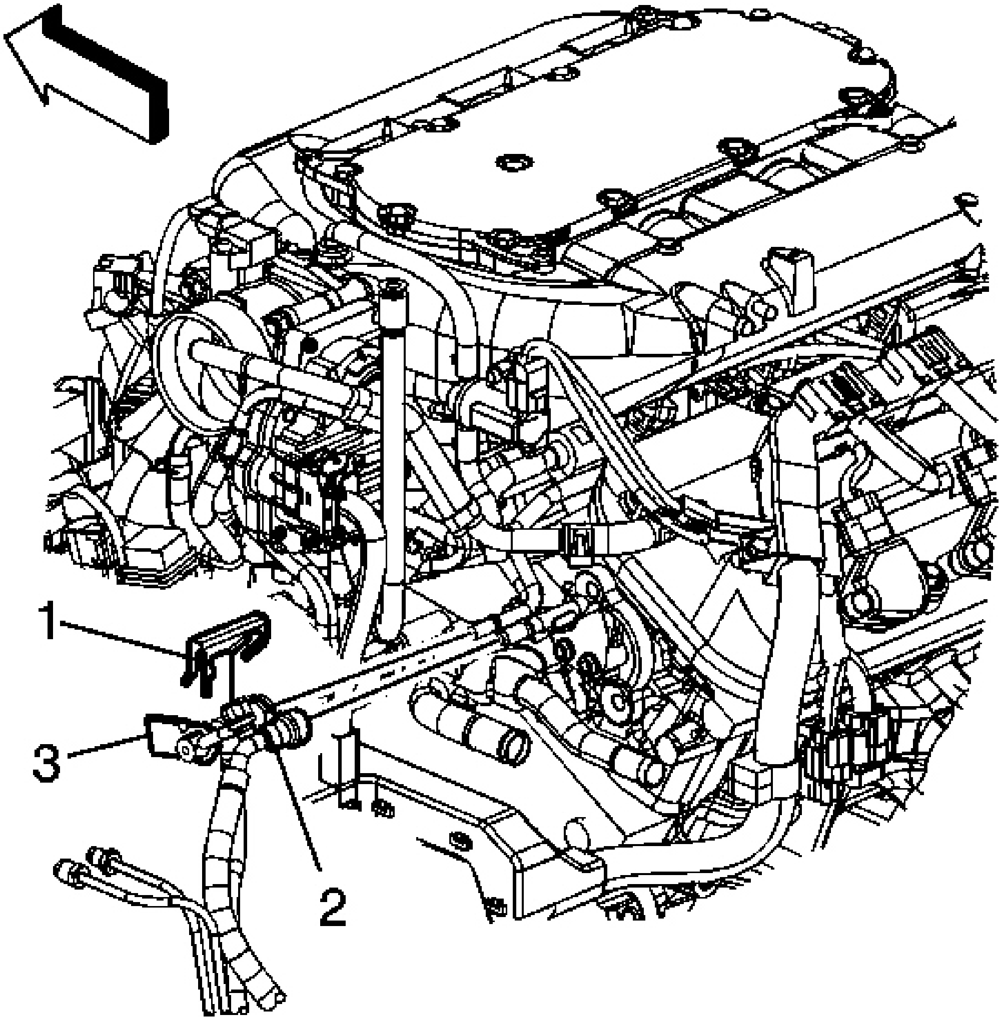


Fig. 112: View Of Fuel Hose/Pipes
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: To facilitate removal, it may be necessary to spray quick connect fittings with penetrating oil to remove debris.

3. From underhood, remove the fuel line clip and using the Snap-On(tm) tool YA 9457 or equivalent, disconnect the fuel feed line from the fuel rail.
4. Disconnect the evaporative emission (EVAP) purge line from the EVAP purge solenoid.
5. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.

6. Disconnect the chassis fuel feed line from the fuel tank.
7. Disconnect the EVAP purge line from the EVAP canister.
8. Release the fuel and EVAP purge lines from underbody retainers.

Installation Procedure

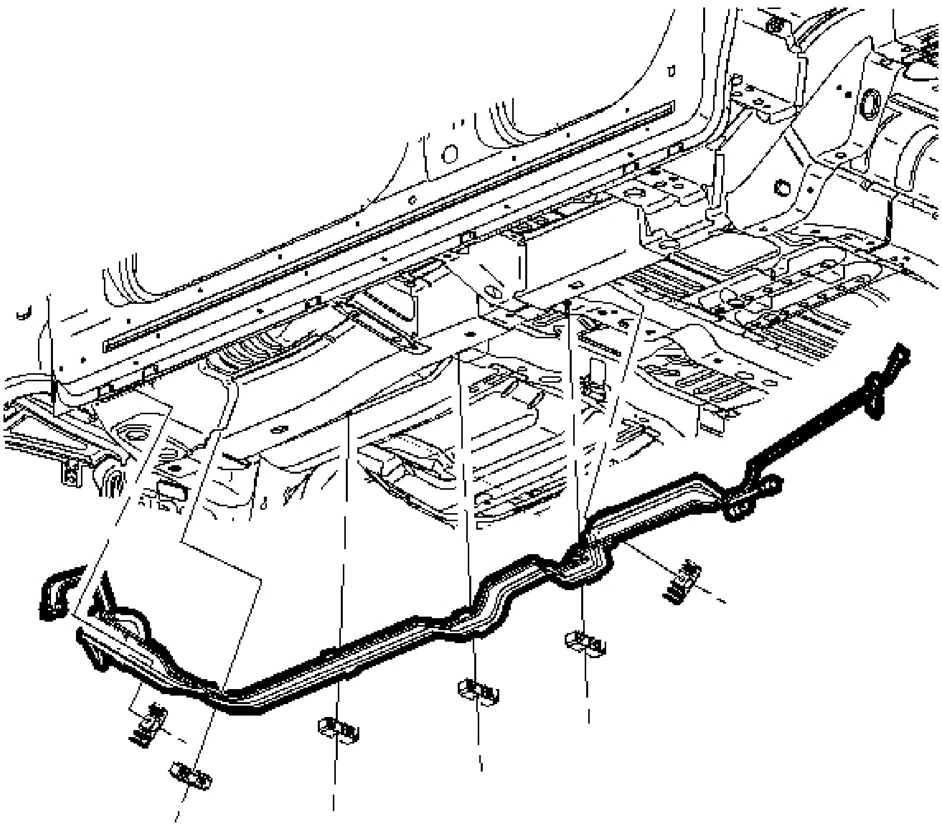


Fig. 113: View Of Fuel & EVAP Lines Onto Underbody Retainers
Courtesy of GENERAL MOTORS CORP.

NOTE: **Fuel/Vapor lines cannot be spliced or repaired. The line must be replaced (if damaged) with the same type of line.**

1. Make sure the lines are not kinked, bent, or damaged.
2. Install the fuel and EVAP lines into underbody retainers. Make sure the lines are properly routed and attach retainers to the vehicle.
3. Connect the EVAP purge line onto the EVAP canister.
4. Lower the vehicle from the hoist.

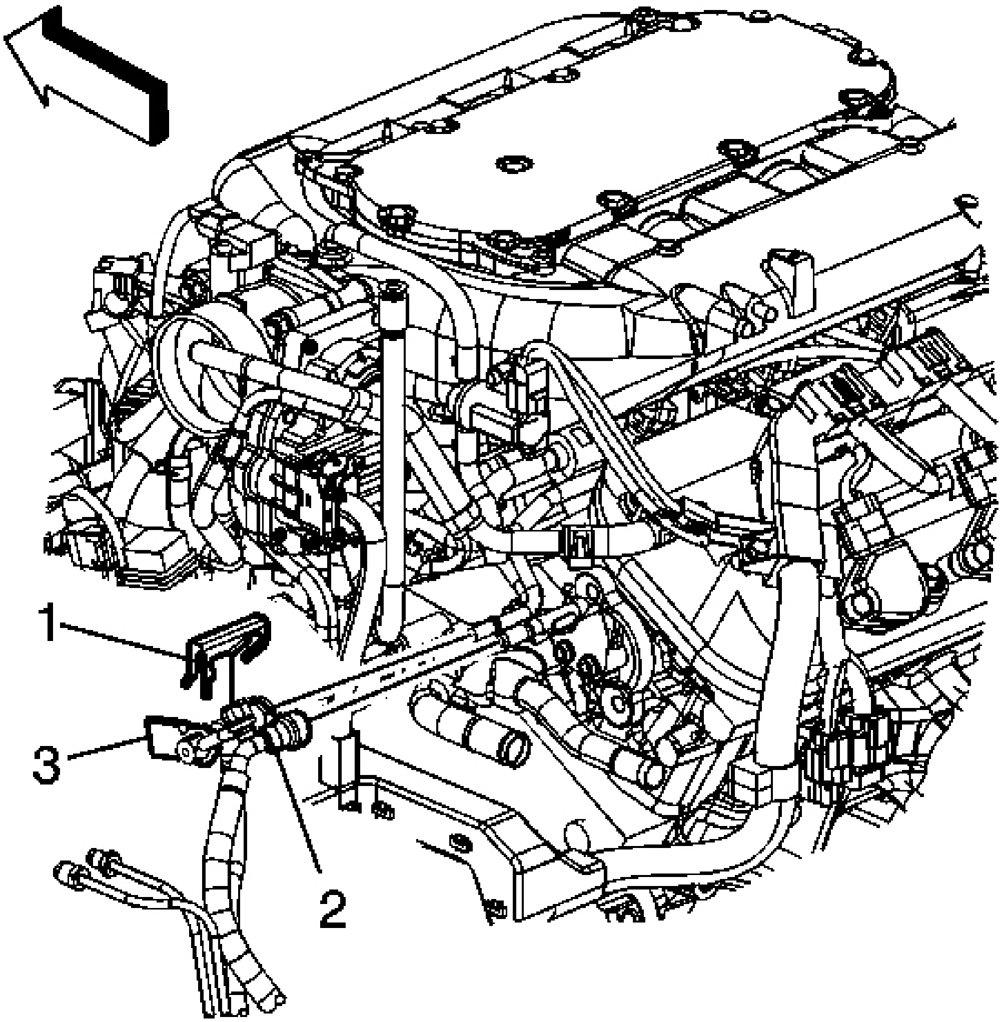


Fig. 114: View Of Fuel Feed Line
Courtesy of GENERAL MOTORS CORP.

5. Connect the fuel feed line to fuel rail and install the safety clip.

6. Connect the negative battery terminal. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
7. Prime the fuel system.
    1. Cycle the ignition ON for 5 seconds and then OFF for 10 seconds.
    2. Repeat step 7.1 twice.
    3. Crank the engine until it starts. The maximum starter motor cranking time is 20 seconds.
    4. If the engine does not start, repeat steps 7.1-7.4.
8. Run the engine and check the system for leaks.

FUEL SYSTEM CLEANING

Tools Required

SA9127E-7 Fuel Pressure/Flow Adapter

After it is determined that the fuel system is contaminated, the following procedure to clean it is recommended.

CAUTION: Ensure that the vehicle is properly supported and squarely positioned. To help avoid personal injury when a vehicle is on a hoist, provide additional support for the vehicle on the opposite end from which the components are being removed.

1. Place the vehicle on a hoist and open the hood.

CAUTION: Do not allow smoking or the use of open flames in the area where work on the fuel or EVAP system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

CAUTION: Refer to Battery Disconnect Caution in Cautions and Notices.

2. Disconnect the negative battery cable.

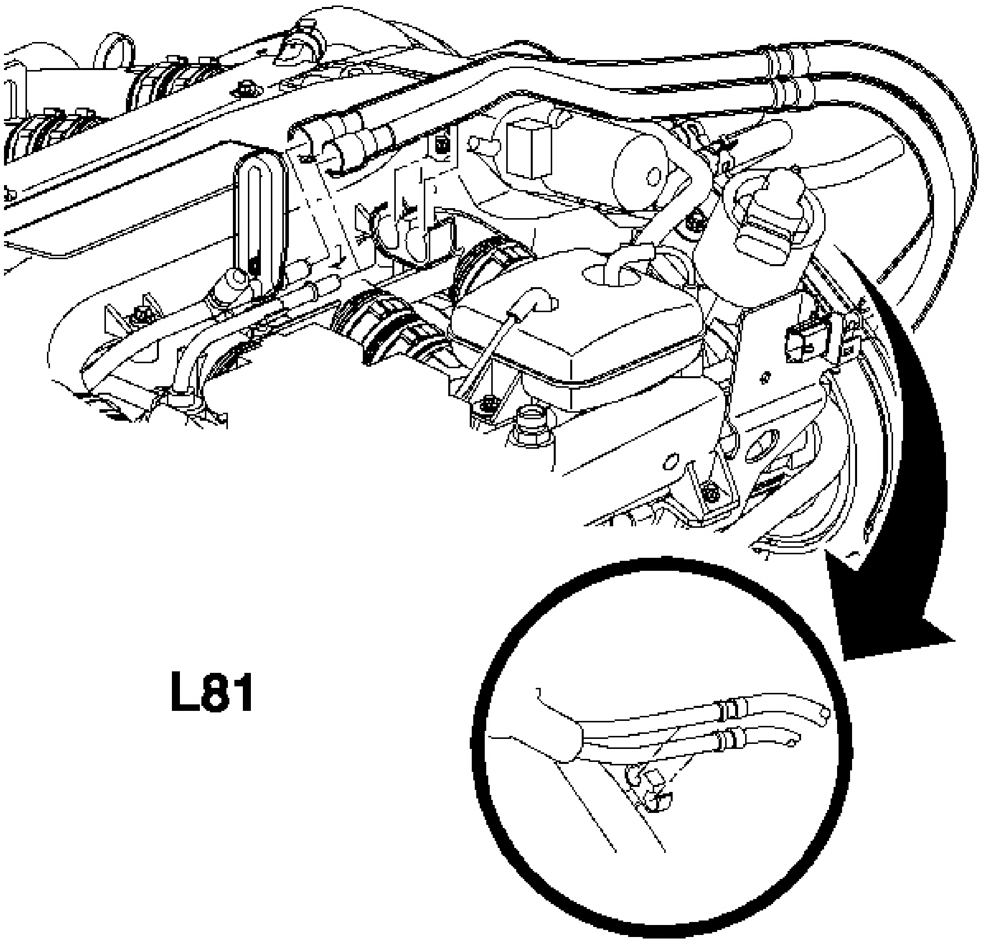


Fig. 115: View Of Fuel System
Courtesy of GENERAL MOTORS CORP.

3. Drain the fuel tank. Refer to **Fuel Tank Draining Procedure** .
4. Remove the fuel tank. Refer to **Fuel Tank Replacement** .
5. Disconnect the fuel feed line at the fuel rail.
6. With compressed air, blow out the fuel feed. Catch the fuel in a container at the opposite end of the line.

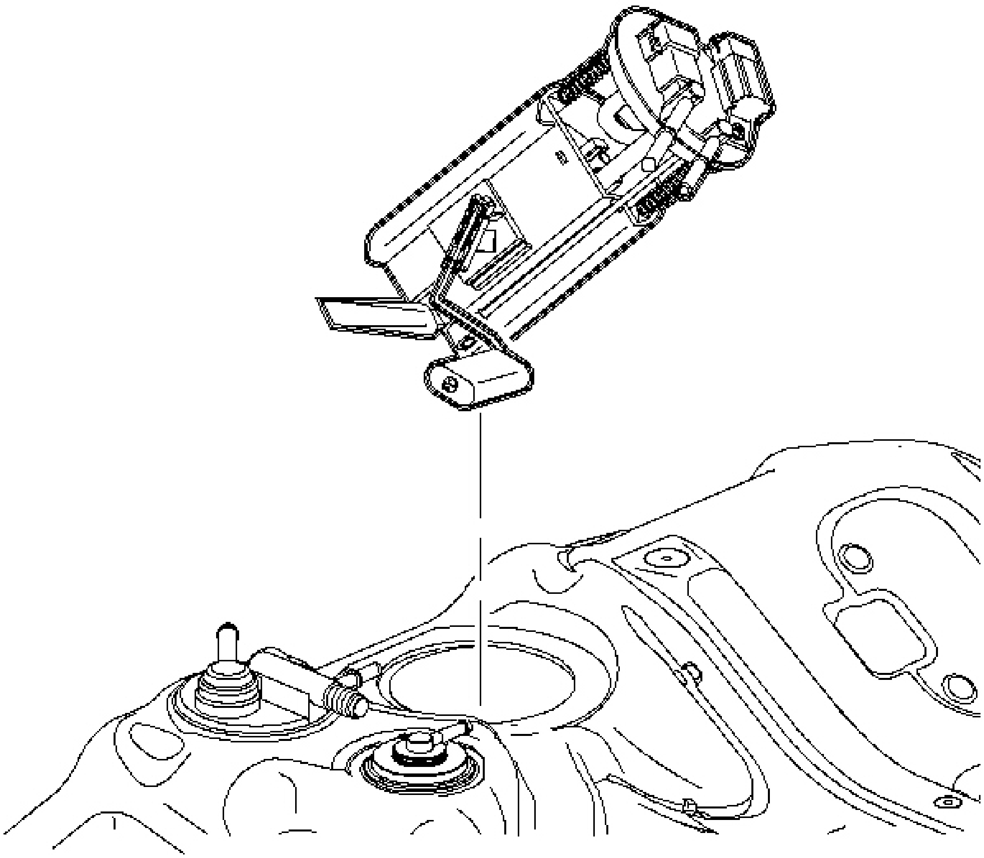


Fig. 116: View Of Fuel Pump Modules
Courtesy of GENERAL MOTORS CORP.

7. Remove the fuel pump modules. Refer to **Fuel Tank Module Replacement - Primary** and **Fuel Tank Module Replacement - Secondary** .
8. Inspect the inlet filter on the primary pump. If plugged or damaged, the fuel pump module must be replaced.
9. Flush the tank with hot water for at least 6 minutes. Invert and drain. All metal chips/debris must be removed from the tank prior to installation.
10. Install the fuel pump modules to the fuel tank using a new fuel pump seal. Do not connect the fuel feed line to the new filter.
11. Install the fuel tank to the vehicle.

NOTE: Replace plastic fuel line retainers whenever the fuel supply or return line is disconnected at the fuel rail. Install the new retainer into the female cavity of the connection. Care must be taken to ensure that the locking tab is centered in the window of the female cavity. Firmly press the female connection onto the male end until a click is heard, then pull back to confirm engagement. Pinched, kinked, or damaged fuel lines must be replaced.

12. Connect the fuel line to the fuel rail.
13. Put at least 22.7 liters (6 gallons) of clean fuel into the fuel tank.

NOTE: Refer to Fastener Notice in Cautions and Notices.

14. Connect the negative battery cable.

    Tighten: Tighten the battery terminal bolt to 17 N.m (13 lb ft).

15. Connect a scan tool to the vehicle and turn the ignition ON.

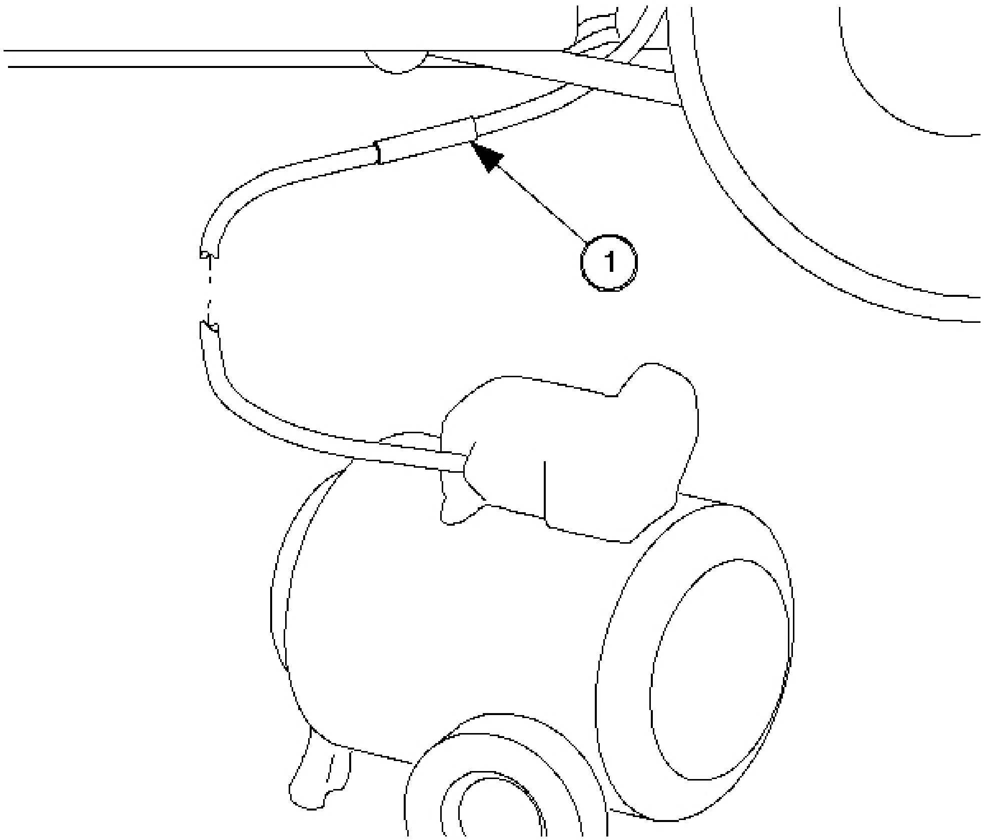


Fig. 117: View Of Adapter From SA9127E-7
Courtesy of GENERAL MOTORS CORP.

16. Raise the vehicle on a hoist and install the male quick connect adapter **SA9127E-7** into the fuel feed line.
17. Install the drain hose to the adapter and place the other end in an approved container.
18. Energize the fuel pump with the scan tool for 1-2 minutes. Refer to Energizing the Fuel Pump. This will pump about 1.9 liters (2 quarts) of fuel and purge any debris in the fuel pump.
19. Disconnect the fuel drain hose adapter at the fuel feed line and connect the fuel line to the fuel filter.
20. Energize the fuel pump and check all connections for leaks.
21. De-energize the pump, lower the vehicle, and start the engine.

EVAPORATIVE EMISSION (EVAP) CANISTER PURGE SOLENOID VALVE REPLACEMENT

Removal Procedure

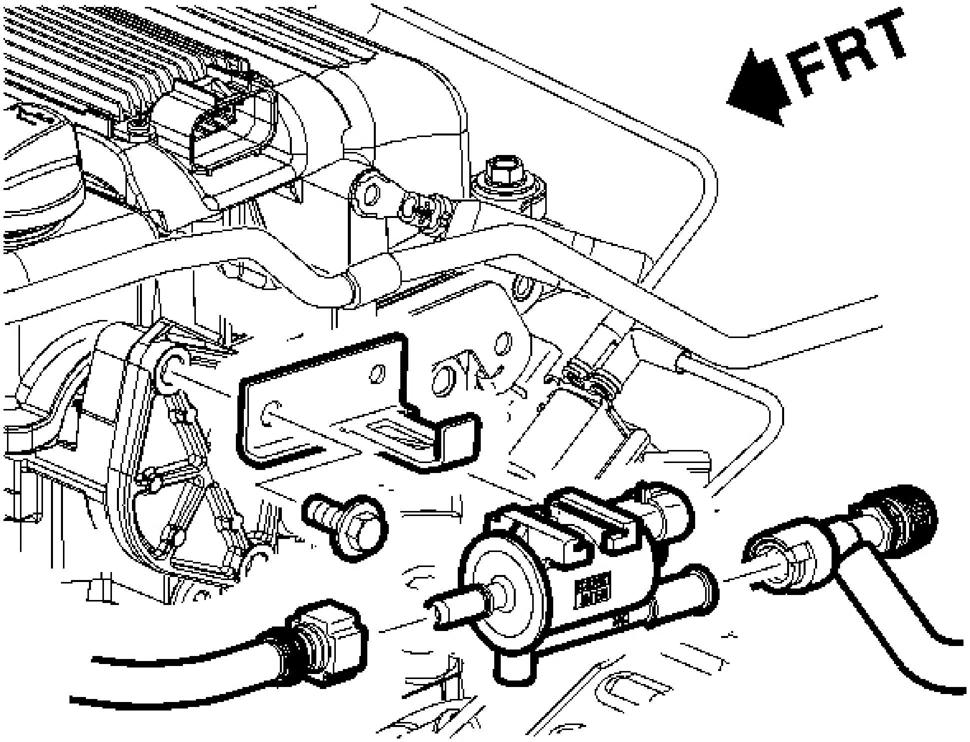


Fig. 118: View Of Evaporative Emission Purge Solenoid
Courtesy of GENERAL MOTORS CORP.

> **CAUTION: Do not allow smoking or the use of open flames in the area where work on the fuel or EVAP system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.**

1. Turn ignition OFF.
2. Disconnect both purge link quick connects from the evaporative emission (EVAP) purge solenoid.

3. Disconnect the EVAP purge solenoid harness connector.
4. Slide the EVAP purge solenoid from the retaining bracket.

Installation Procedure

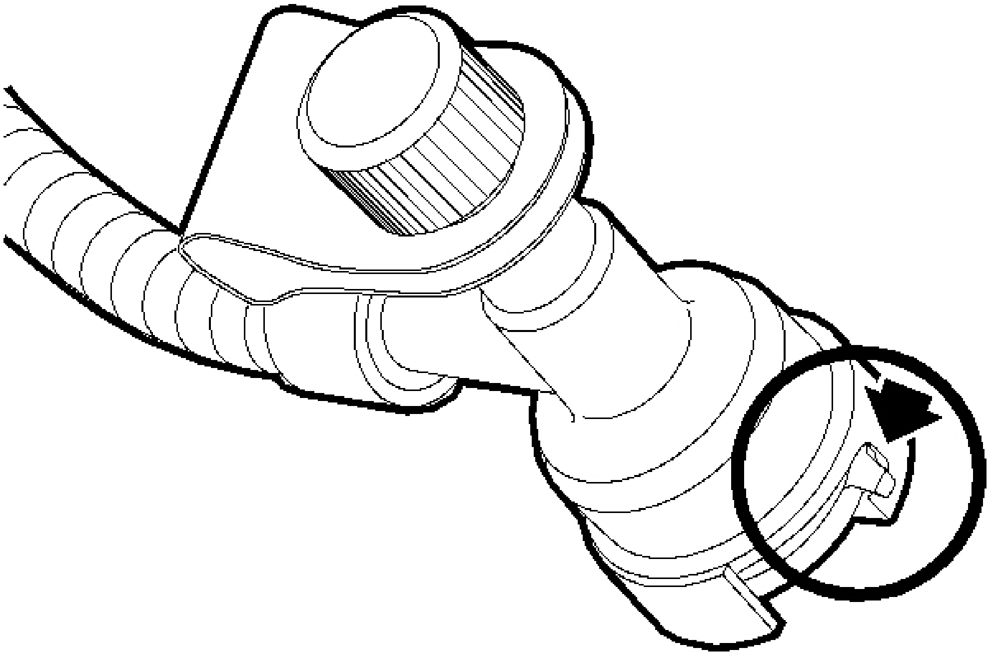


Fig. 119: View of EVAP Purge Solenoid Into The Retaining Bracket
Courtesy of GENERAL MOTORS CORP.

1. Slide the EVAP purge solenoid into the retaining bracket.
2. Connect the purge line quick connects to the EVAP purge solenoid. Push in the connector until a slick is heard, then pull back to confirm positive engagement.
3. Connect the EVAP purge solenoid harness connector.

EVAPORATIVE EMISSION (EVAP) CANISTER VENT SOLENOID VALVE REPLACEMENT

Removal Procedure

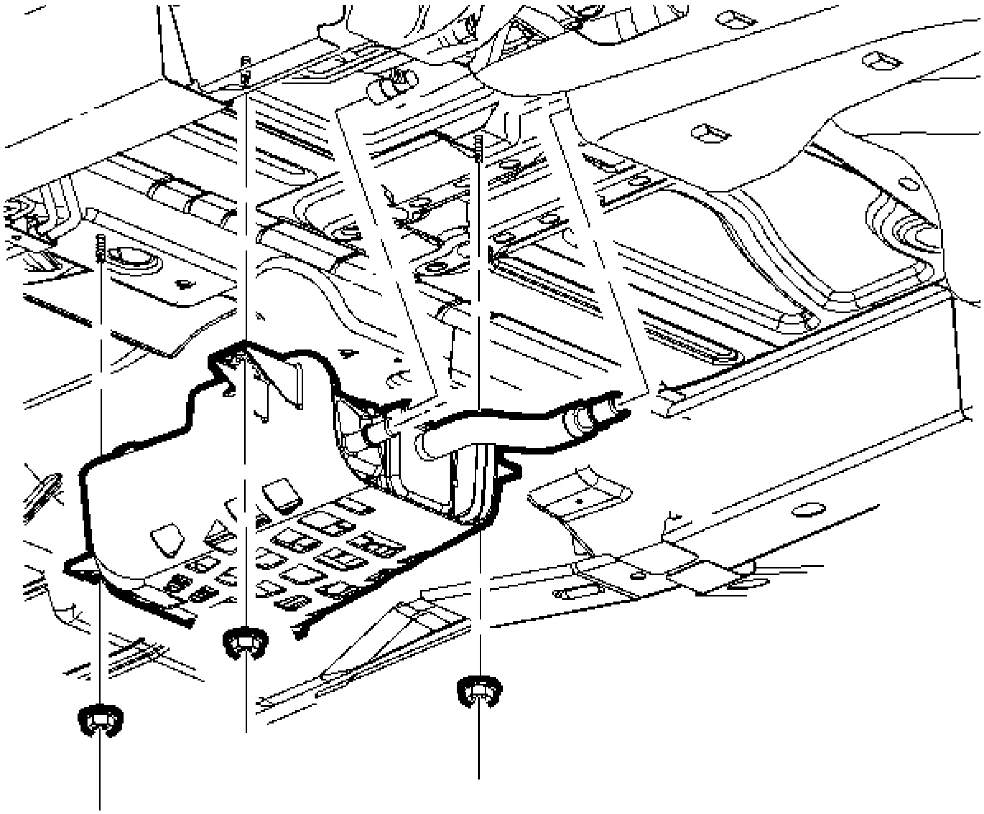


Fig. 120: View Of Evaporative Emission Vent Solenoid
Courtesy of GENERAL MOTORS CORP.

CAUTION: Ensure that the vehicle is properly supported and squarely positioned. To help avoid personal injury when a vehicle is on a hoist, provide additional support for the vehicle on the opposite end from which the components are being removed.

IMPORTANT: The evaporative emission (EVAP) vent solenoid is located on the top of

the EVAP canister.

1. Raise the vehicle on a hoist.

IMPORTANT: Take care when removing the EVAP vent solenoid from the EVAP canister. Fuel vapor lines are fragile.

2. Remove the 3 EVAP canister-to-underbody fasteners and slightly lower the EVAP canister enough to remove the EVAP vent solenoid.
3. Disconnect the EVAP vent solenoid electrical connector.

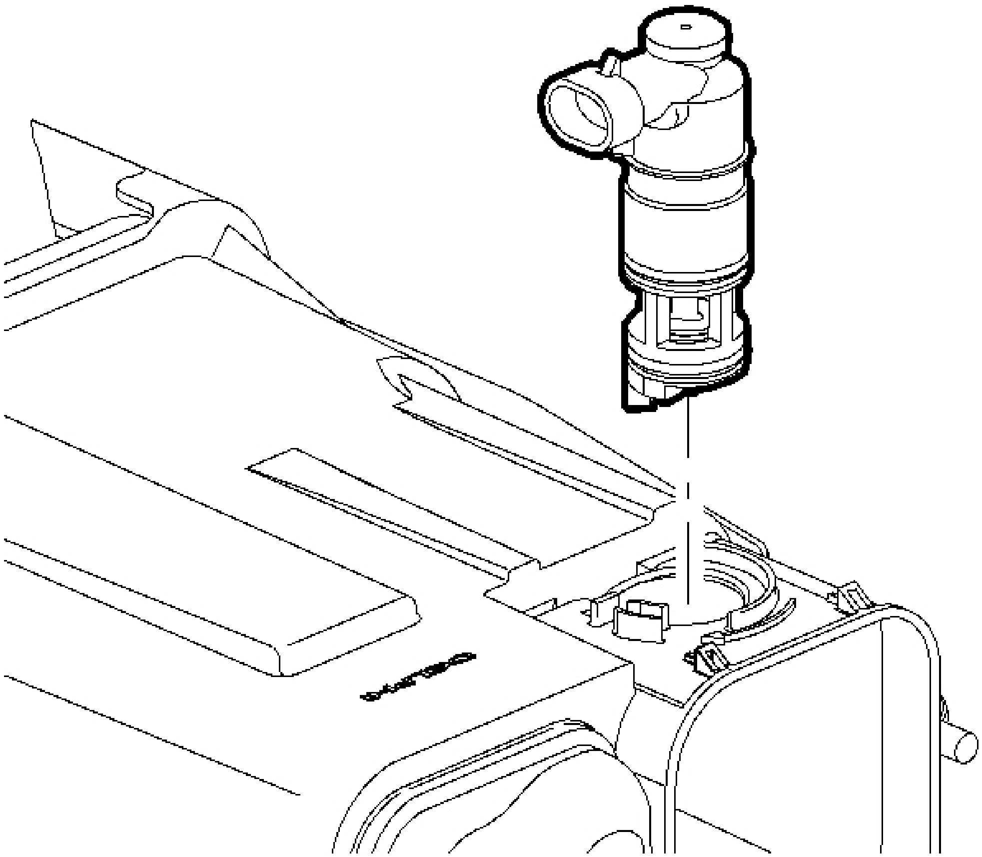


Fig. 121: View Of EVAP Vent Solenoid

Courtesy of GENERAL MOTORS CORP.

4. Turn the EVAP vent solenoid counter clockwise and remove from the EVAP canister.

Installation Procedure

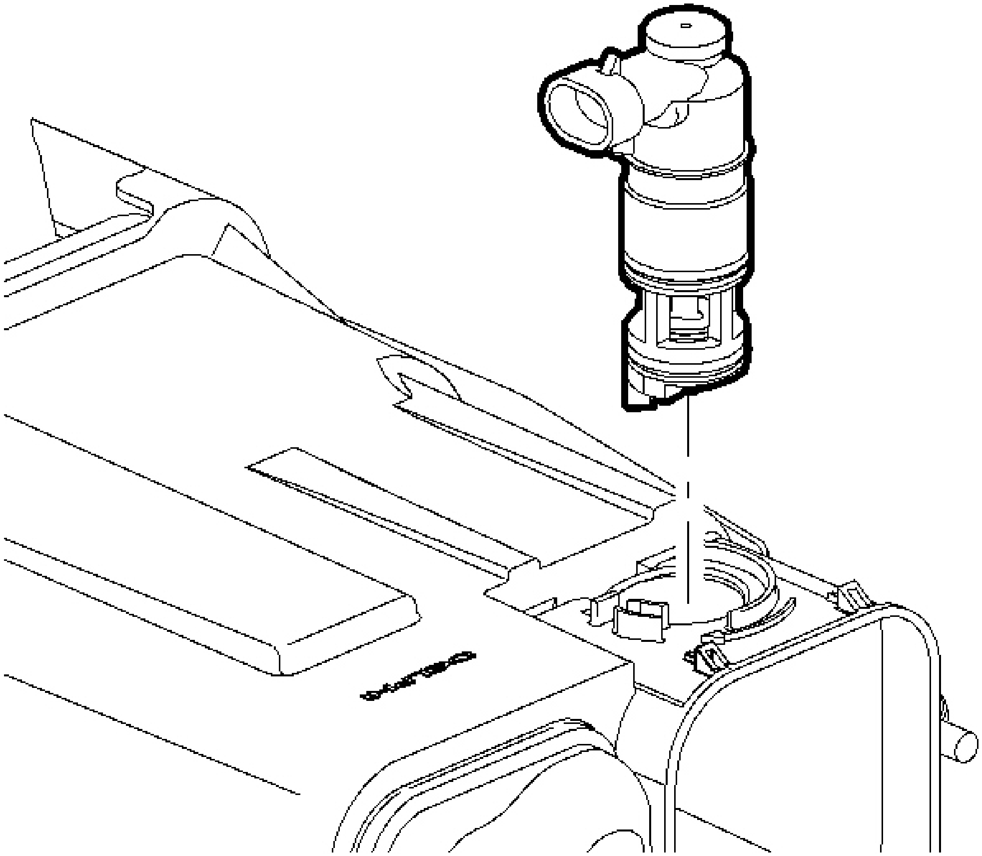


Fig. 122: View Of EVAP Vent Solenoid
Courtesy of GENERAL MOTORS CORP.

1. Install the EVAP vent solenoid by gently turning the solenoid clockwise until it clicks into position.
2. Connect the EVAP vent solenoid electrical connector.

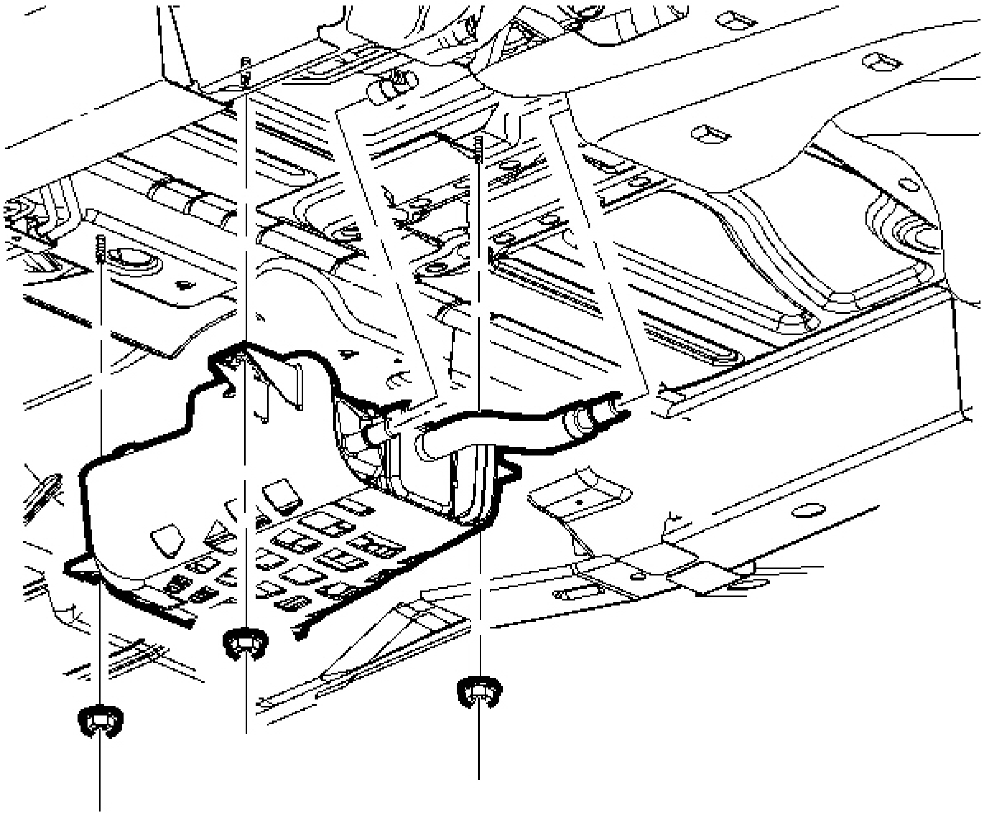


Fig. 123: View Of EVAP Canister Bracket-To-Underbody Fasteners
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the EVAP canister bracket-to-underbody fasteners.

   Tighten: Tighten the EVAP canister-to-body nuts to 8 N.m (71 lb in).

4. Lower the vehicle from the hoist.

EVAPORATIVE EMISSION (EVAP) CANISTER REPLACEMENT

Removal Procedure

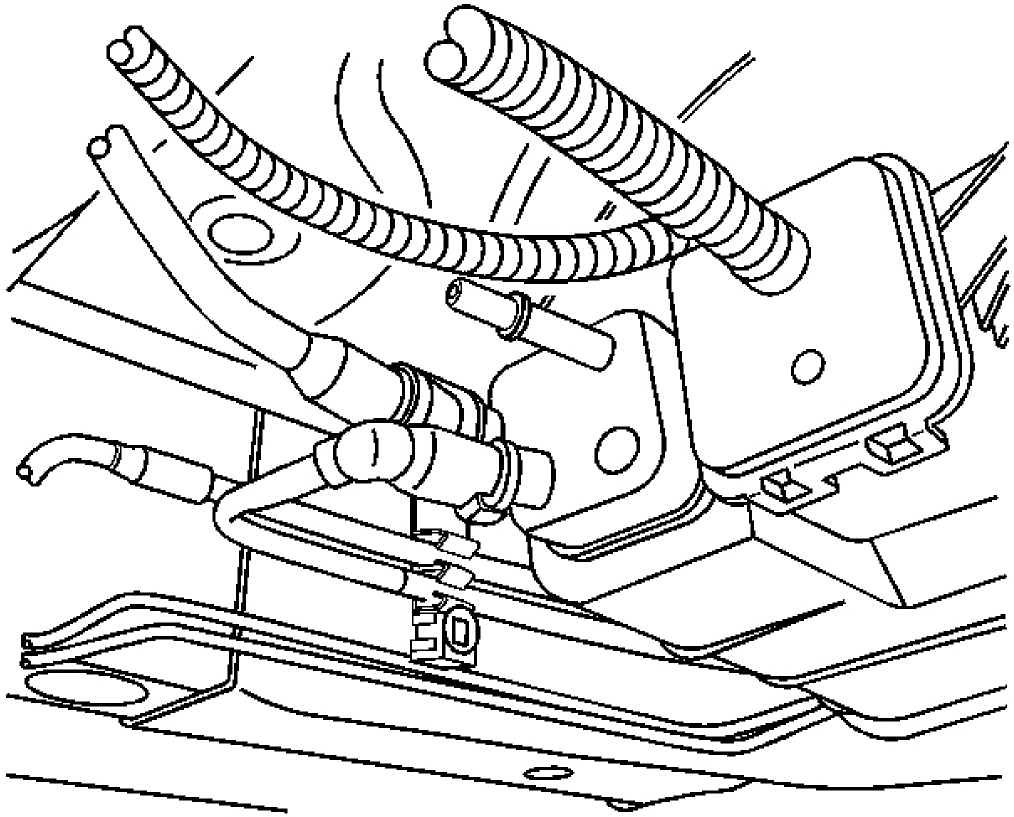


Fig. 124: View Of Evaporative Emission Canister
Courtesy of GENERAL MOTORS CORP.

CAUTION: **Ensure that the vehicle is properly supported and squarely positioned. To help avoid personal injury when a vehicle is on a hoist, provide additional support for the vehicle on the opposite end from which the components are being removed.**

IMPORTANT: **The EVAP emissions canister is located under the center of the vehicle. It has 3 EVAP line connections:**

- **The EVAP fresh air hose**
- **The EVAP purge connection**
- **The EVAP vent connection**

1. Raise the vehicle on a hoist. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Disconnect the EVAP canister fresh air line from the fuel tank fresh air line.
3. Disconnect the EVAP canister purge line and vent line from the EVAP canister.

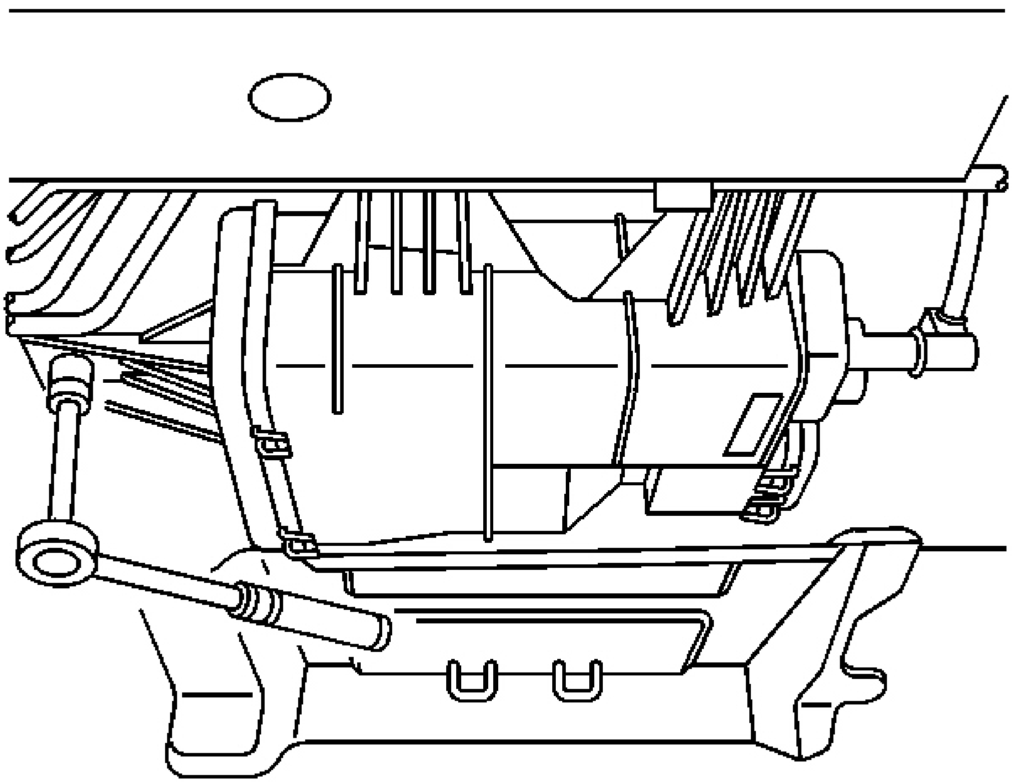


Fig. 125: View Of EVAP Canister-To-Body Underbody Fasteners
Courtesy of GENERAL MOTORS CORP.

4. Remove the EVAP canister-to-underbody fasteners.
5. Disconnect the EVAP vent solenoid electrical connector.
6. Remove the canister from the vehicle.

Installation Procedure

1. Connect the EVAP vent solenoid electrical connector.

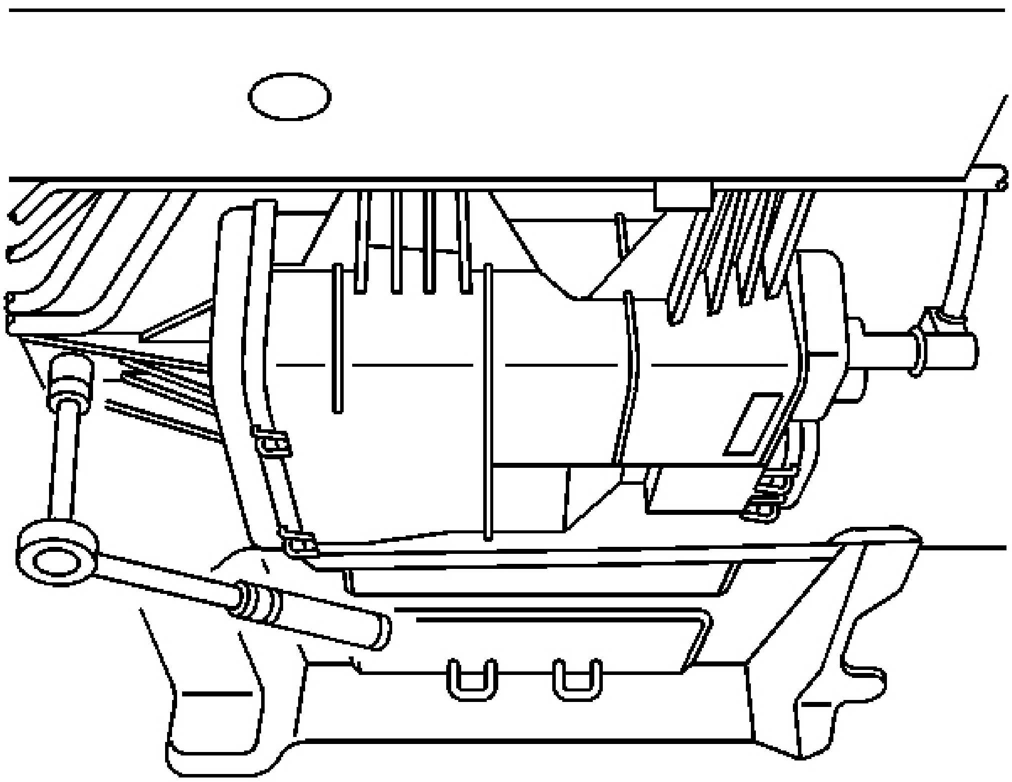


Fig. 126: View Of EVAP Canister-To-Body Underbody Fasteners
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the EVAP canister-to-body underbody fasteners.

   Tighten: Tighten the EVAP canister nuts to 8 N.m (71 lb in).

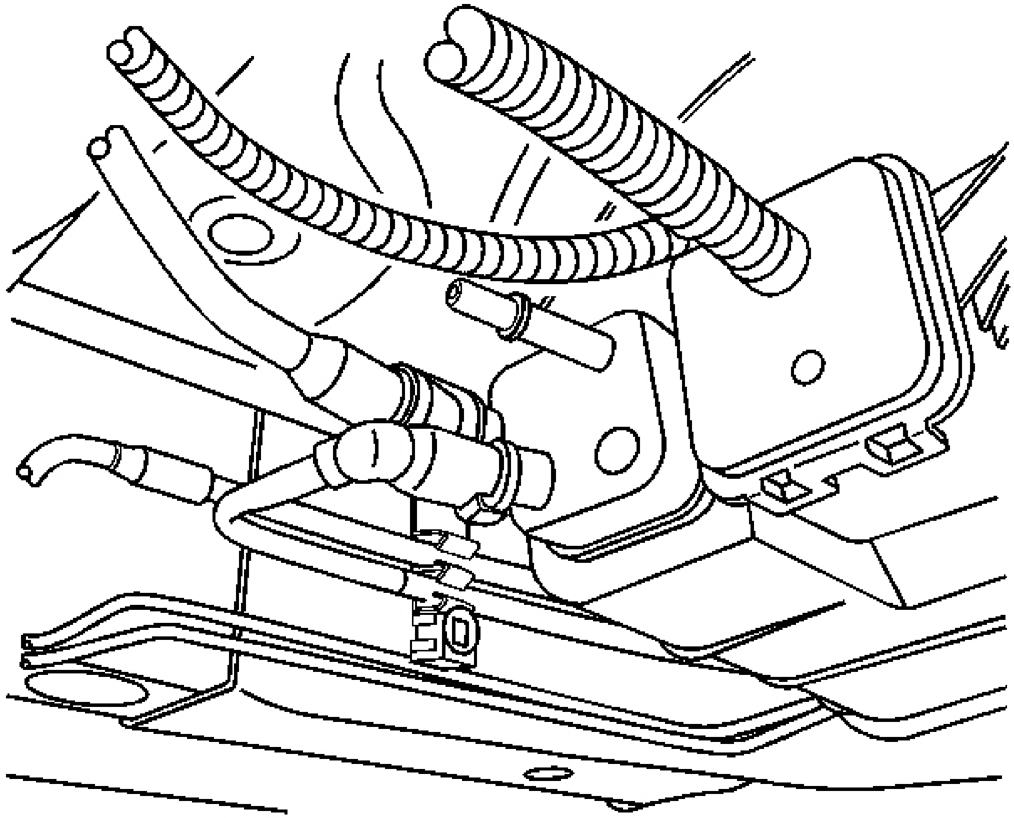


Fig. 127: View Of Evaporative Emission Canister
Courtesy of GENERAL MOTORS CORP.

3. Connect the EVAP canister purge and vent lines to the EVAP canister.

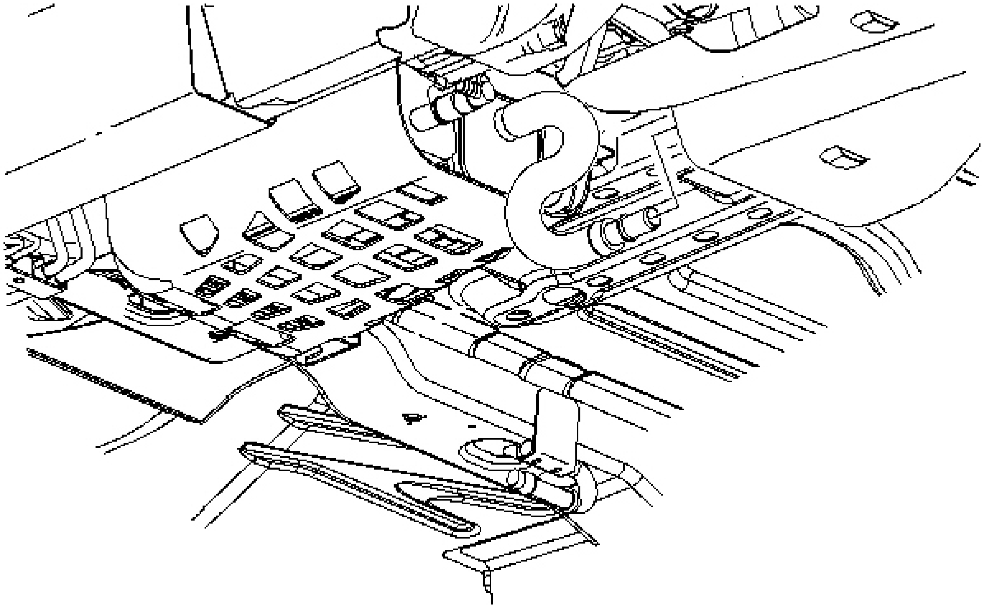


Fig. 128: View Of EVAP Canister Fresh Air Line
Courtesy of GENERAL MOTORS CORP.

4. Connect the EVAP canister fresh air line to the fuel tank fresh air line.
5. Lower the vehicle from the hoist.

EVAPORATIVE EMISSION (EVAP) CANISTER FILTER REPLACEMENT

Removal Procedure

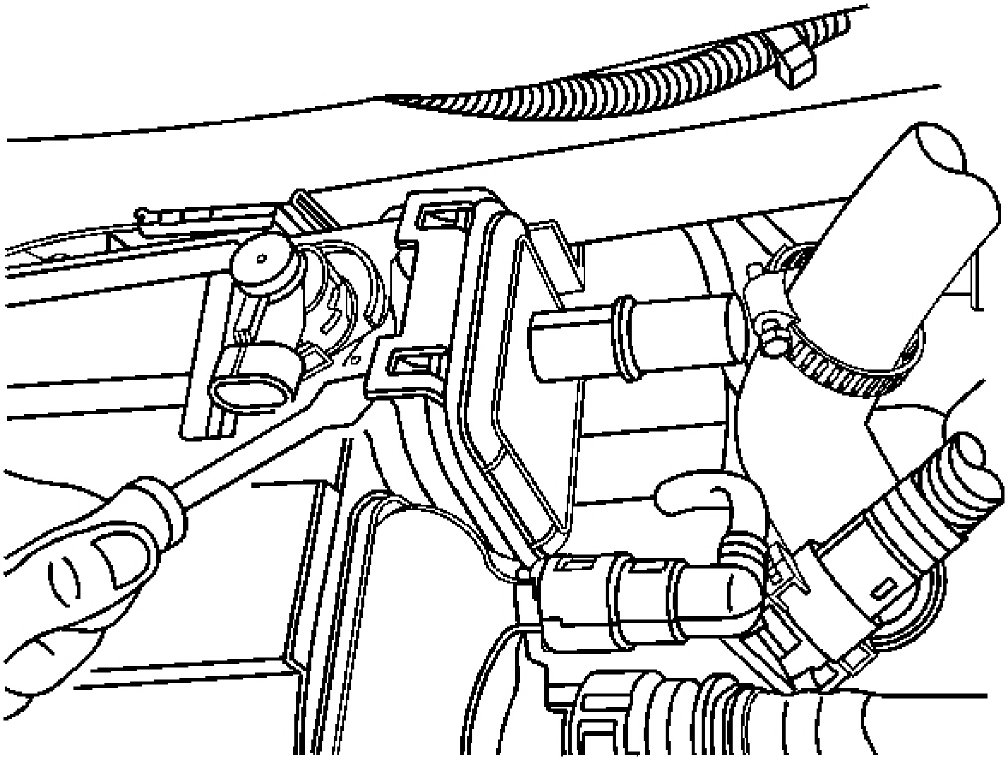


Fig. 129: View Of Evaporative Emission Canister Vent Filter Cover
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Clean away any debris that may be present around the evaporative emission (EVAP) canister vent filter cover.
3. Carefully release the canister filter cover rear retaining tabs.
4. Carefully release the canister filter cover forward retaining tabs and remove the cover from the EVAP canister.

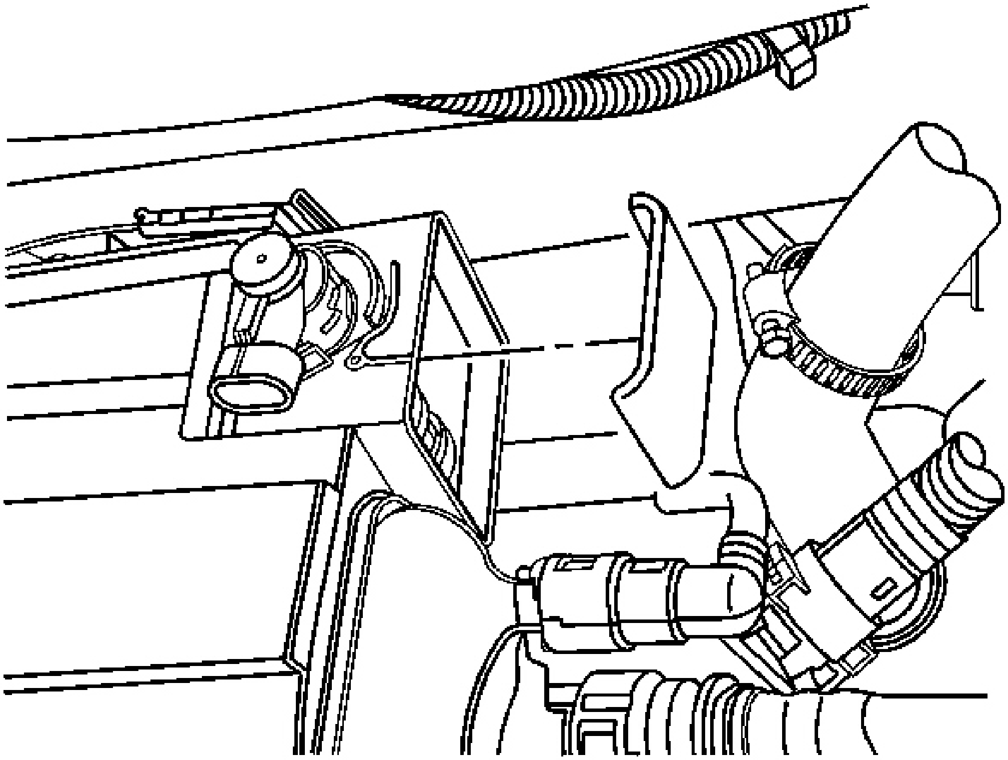


Fig. 130: View Of Cover To The Canister
Courtesy of GENERAL MOTORS CORP.

5. Remove the filter from the canister and discard the filter.
6. Remove the seal from the filter cover and discard the seal.
7. Clean the inside of the EVAP canister filter housing with a clean shop towel.

Installation Procedure

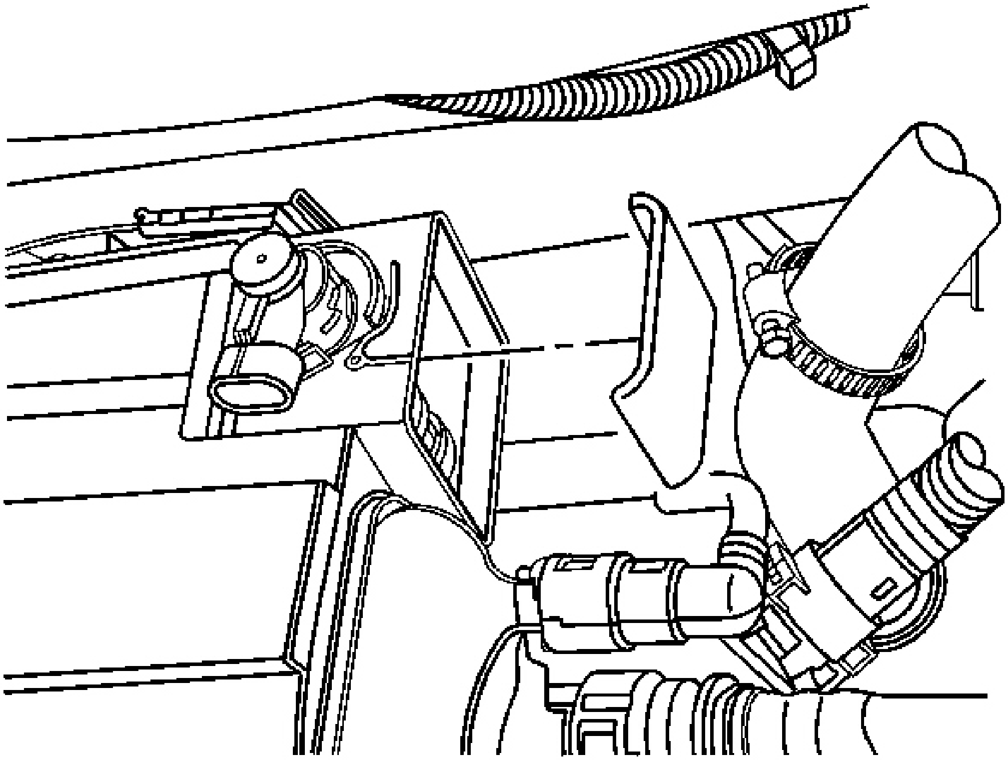


Fig. 131: View Of Cover To The Canister
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW cover to the canister. Ensure that the seal is properly seated to the cover.
2. Install a NEW filter to the canister filter housing.

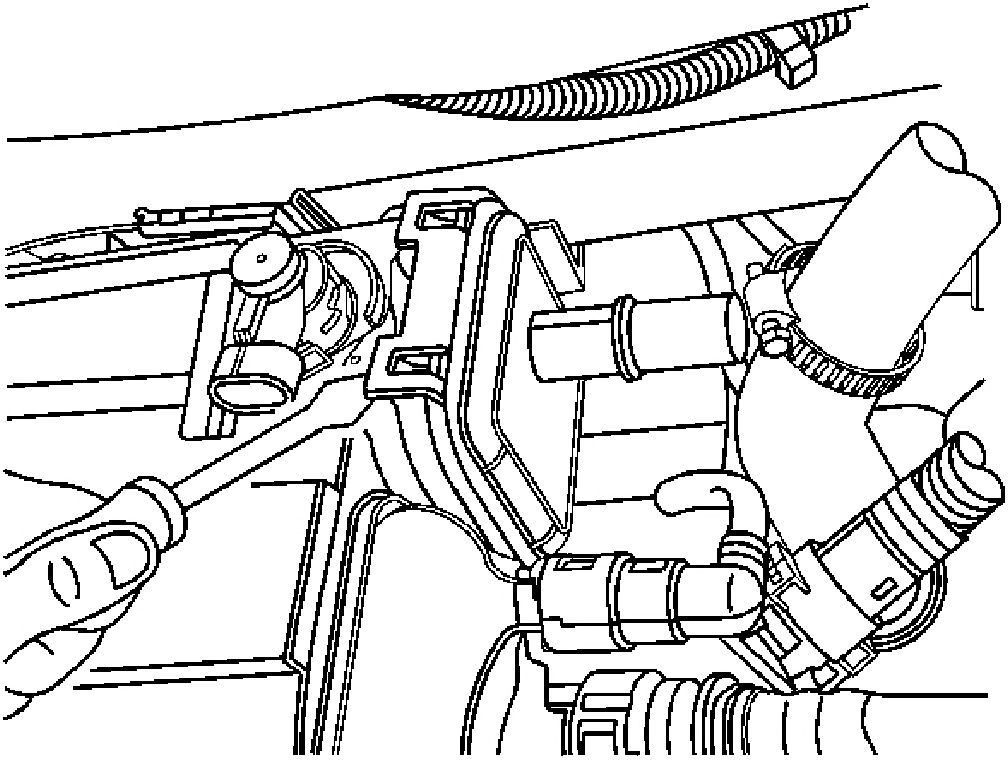


Fig. 132: View Of Evaporative Emission Canister Vent Filter Cover
Courtesy of GENERAL MOTORS CORP.

3. Install the filter cover to the EVAP canister.
4. Lower the vehicle.

IGNITION COIL HOUSING REPLACEMENT

Removal Procedure

1. Remove the accelerator and cruise control cables from the bracket, if equipped.
2. Remove the bracket.
3. Remove the ignition control module (ICM). Refer to **Ignition Control Module Replacement** .

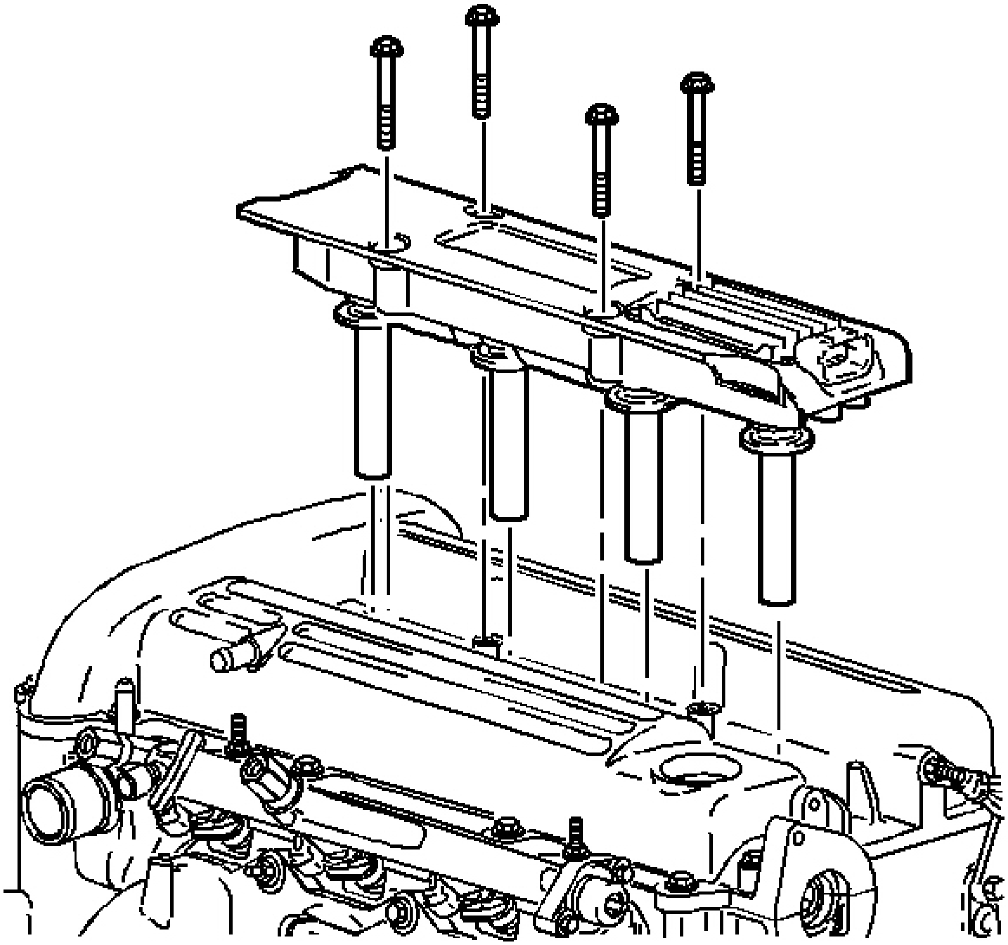


Fig. 133: View Of Ignition Coil & Module Assembly
Courtesy of GENERAL MOTORS CORP.

4. Remove the ignition coil housing retaining bolts.
5. Remove the ignition coil housing from the camshaft cover.

Installation Procedure

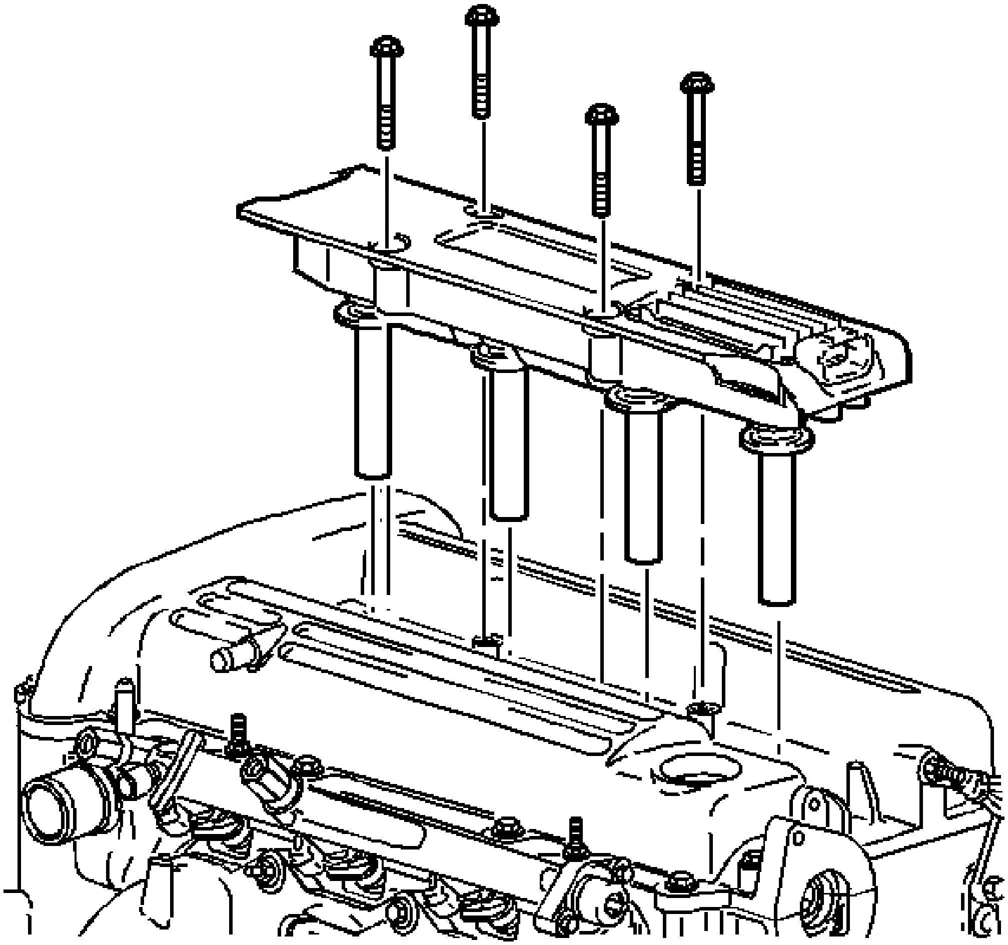


Fig. 134: View Of Ignition Coil & Module Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the ignition coil housing to the camshaft cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the ignition coil housing retaining bolts.

   Tighten: Tighten the retaining bolts to 10 N.m (89 lb in).

3. Install the ICM. Refer to **Ignition Control Module Replacement** .
4. Install the accelerator and cruise control cables bracket.

5. Install the accelerator and cruise control cables bracket bolts.

   Tighten: Tighten the retaining bolts to 10 N.m (89 lb in).

6. Install the accelerator and cruise control cables to the bracket.

IGNITION CONTROL MODULE REPLACEMENT

Removal Procedure

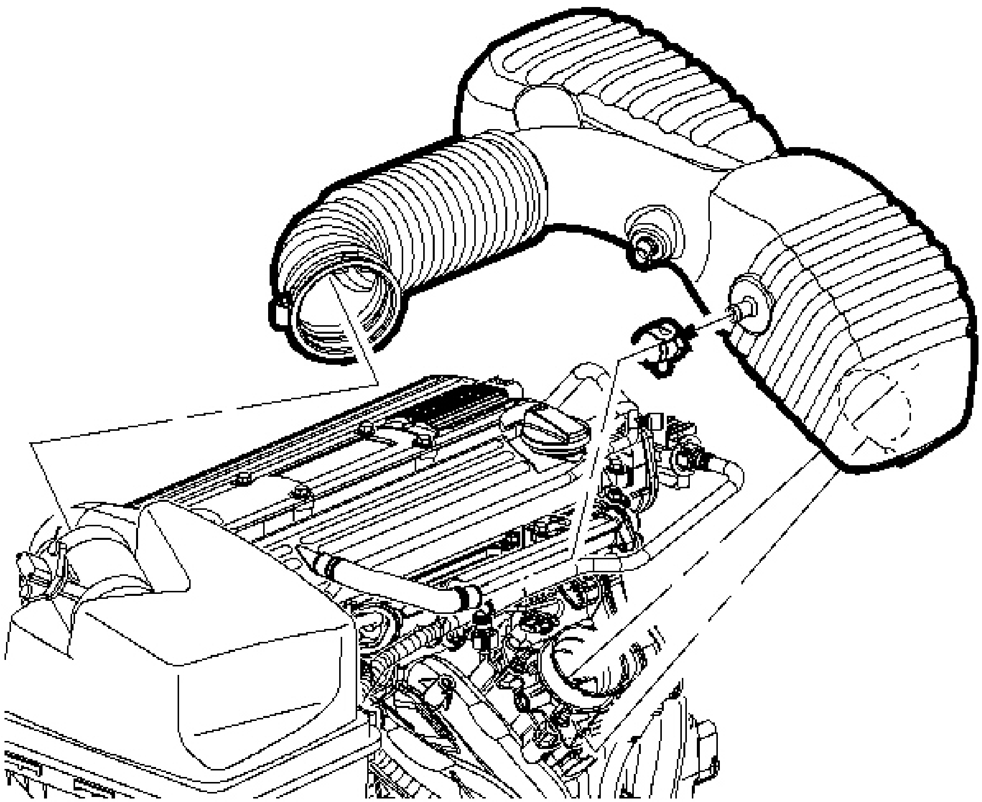


Fig. 135: View Of Ignition Control Module
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the intake air temperature (IAT) sensor connector.
2. Loosen the clamp at the air cleaner assembly.
3. Remove the push-push attachment from the outlet resonator/duct assembly to support bracket.
4. Loosen the clamp at the throttle body assembly.
5. Disconnect the PCV fresh air bent hose at the cam cover.
6. Remove the outlet resonator/duct assembly.
7. Disconnect the EI module electrical connector.

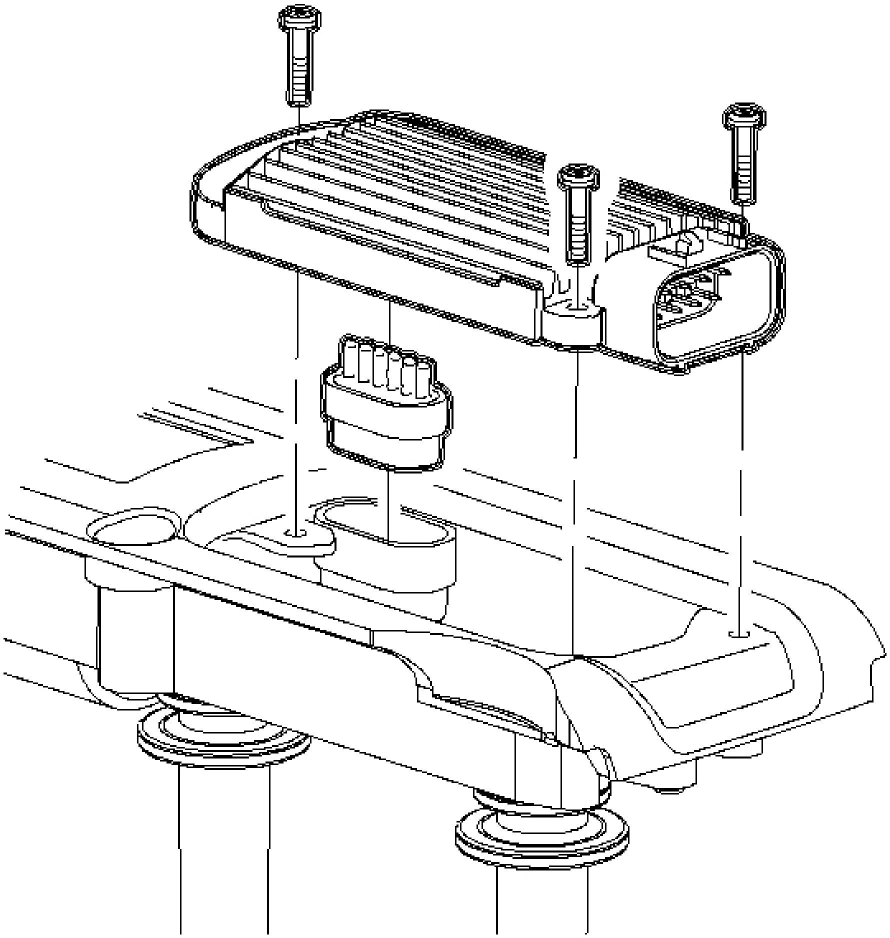


Fig. 136: View Of El Module & Attachment Screws
Courtesy of GENERAL MOTORS CORP.

8. If the module only is being replaced, remove the EI module attachment screws.
9. Remove the ignition module attachment bolts.

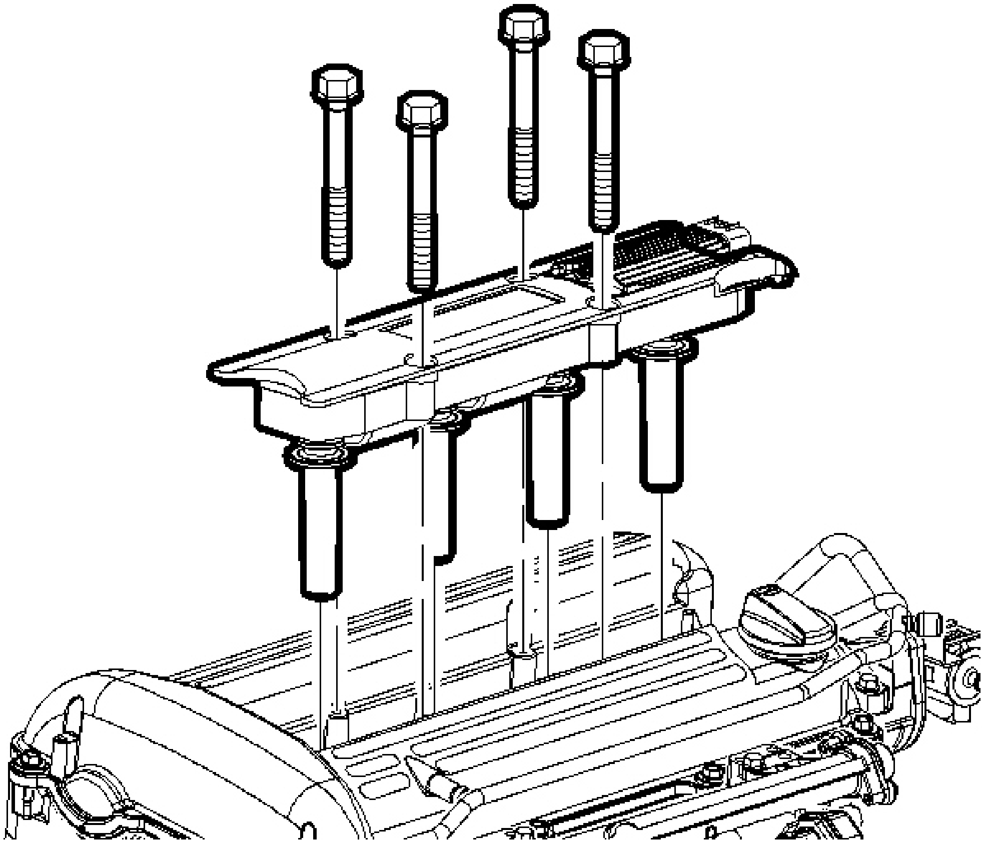


Fig. 137: View of Ignition Module Housing Assembly With Spark Plug Boots
Courtesy of GENERAL MOTORS CORP.

10. Remove the ignition module housing assembly with spark plug boots.

Installation Procedure

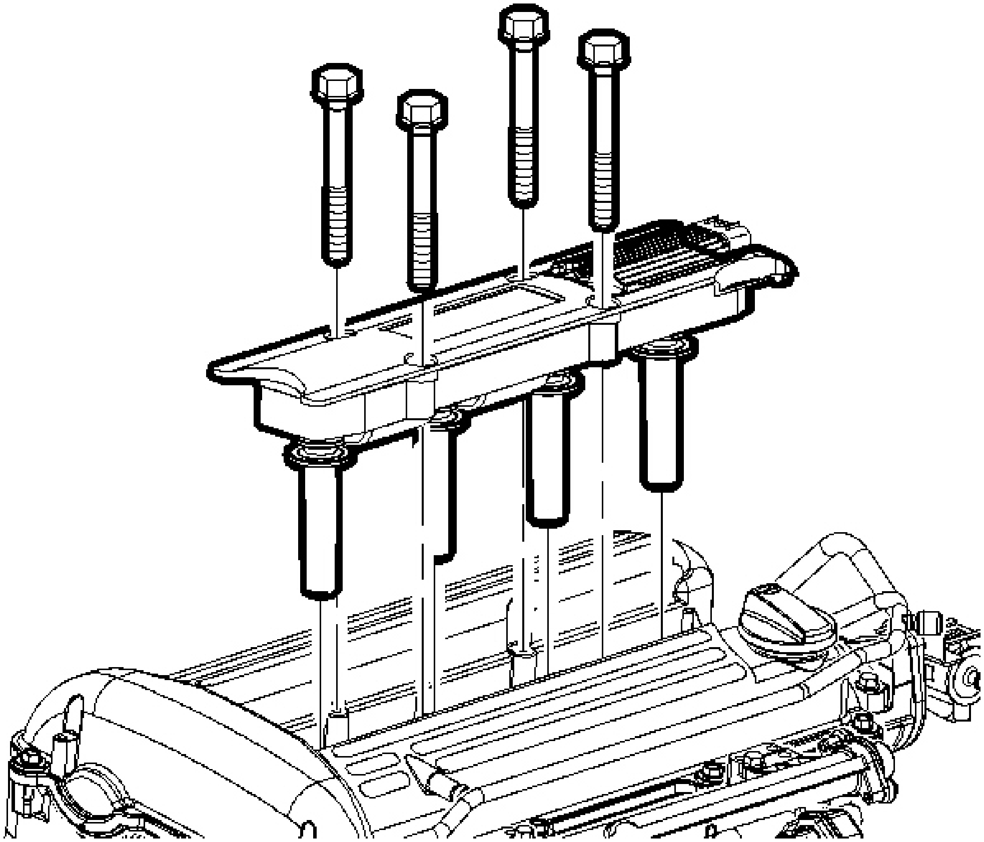


Fig. 138: View of Ignition Module Housing Assembly With Spark Plug Boots
Courtesy of GENERAL MOTORS CORP.

1. Apply dialectic compound to the spark plug boots and ensure no corrosion is present.

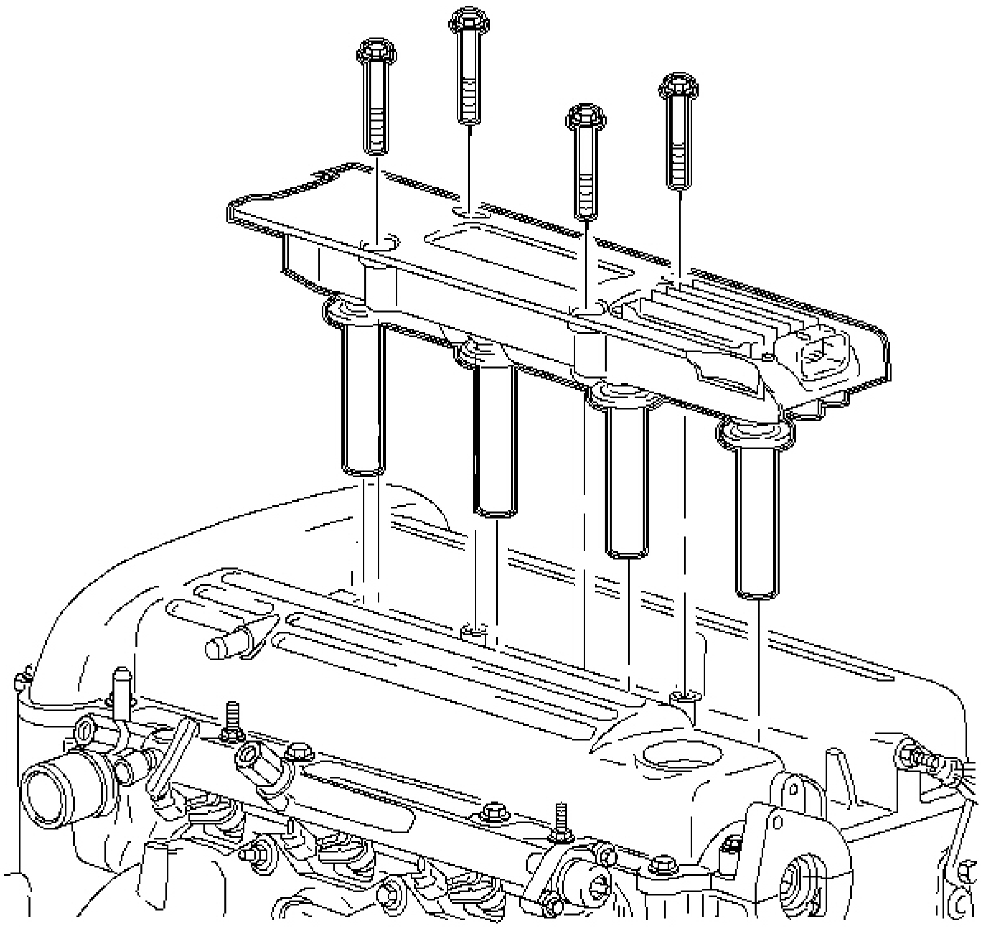


Fig. 139: View Of Ignition Module Assembly With Spark Plug Boots
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the ignition module housing assembly with spark plug boots into position.

   Tighten: Tighten the ignition module-to-camshaft cover bolts to 10 N.m (89 lb in).

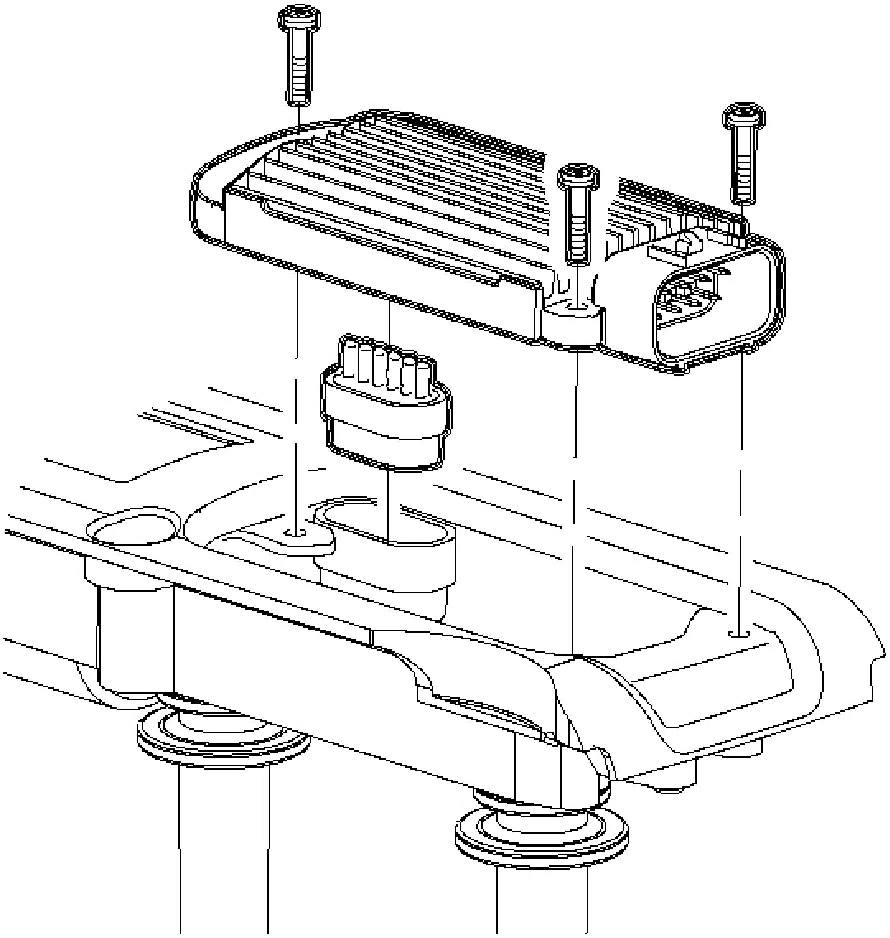


Fig. 140: View Of El Module & Attachment Screws
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure the interconnect is line up and the interconnect seal is in place before installing the attachment screws.

3. Install the EI module and attachment screws (if removed).

   Tighten: Tighten the module screws to 1.5 N.m (13 lb in).

4. Connect the EI module harness connector. Push in the connector until a slick is heard, then pull back to confirm a positive engagement.

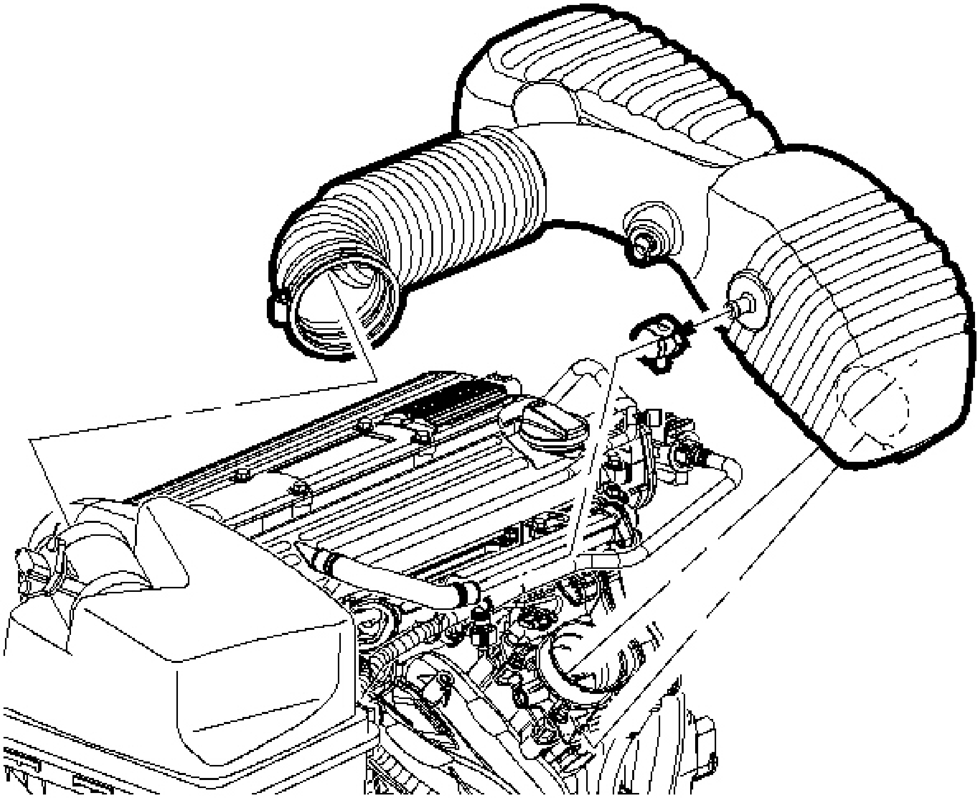


Fig. 141: View Of Outlet Resonator/Duct Assembly
Courtesy of GENERAL MOTORS CORP.

5. Position the outlet resonator/duct assembly into position.
6. Connect the PCV fresh air bent hose assembly.
7. Tighten the clamp at the throttle body assembly.
8. Position the outlet resonator/duct assembly up with the support bracket and install the push-pin.
9. Tighten the clamp at the air cleaner assembly.
10. Connect the intake air temperature (IAT) sensor connector.

SPARK PLUG INSPECTION

Spark Plug Usage

- Ensure that the correct spark plug is installed. An incorrect spark plug causes driveability conditions. Refer to **Ignition System Specifications** for the correct spark plug.
- Ensure that the spark plug has the correct heat range. An incorrect heat range causes the following conditions:
  - Spark plug fouling - colder plug
  - Pre-ignition causing spark plug and/or engine damage - hotter plug

Spark Plug Inspection

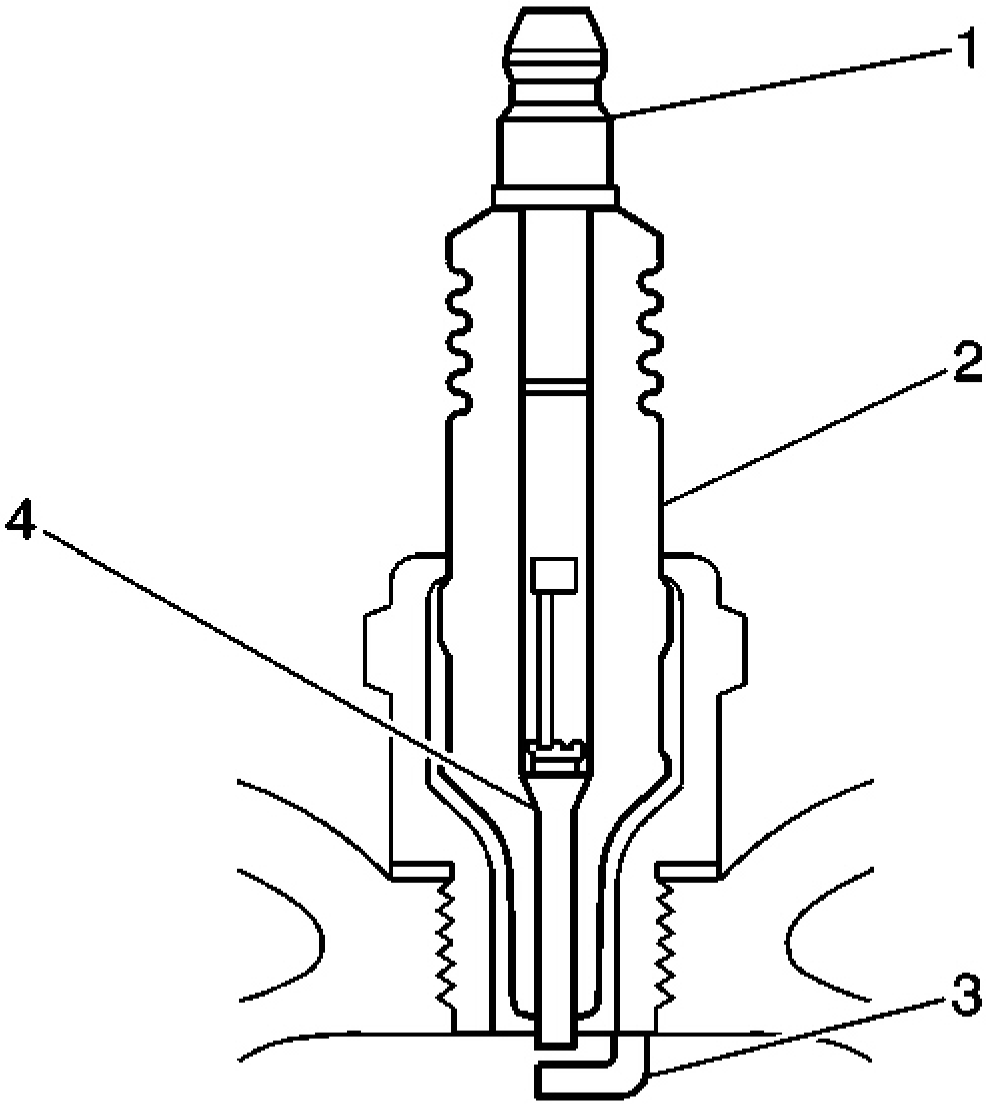


Fig. 142: Inspecting Spark Plug Components
Courtesy of GENERAL MOTORS CORP.

- 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.

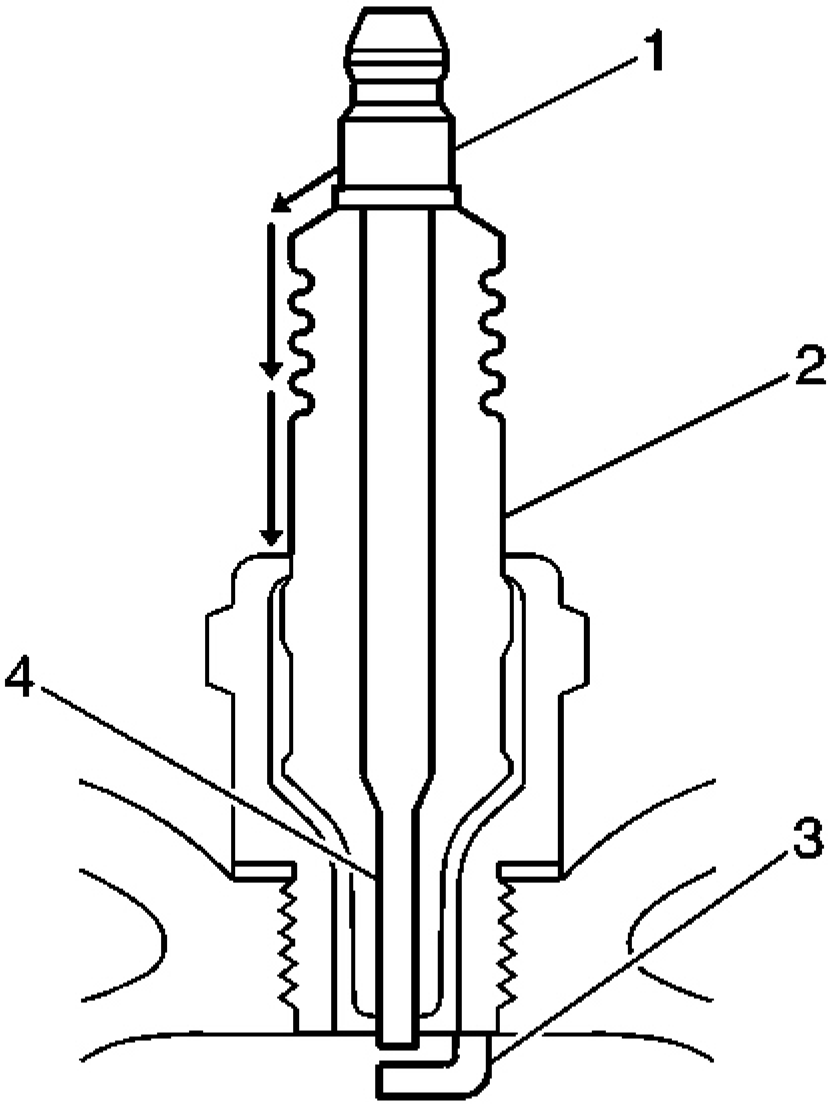


Fig. 143: Inspecting Spark Plug Insulator For Soot
Courtesy of GENERAL MOTORS CORP.

- Inspect the insulator (2) for flashover or carbon tracking, soot. 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.

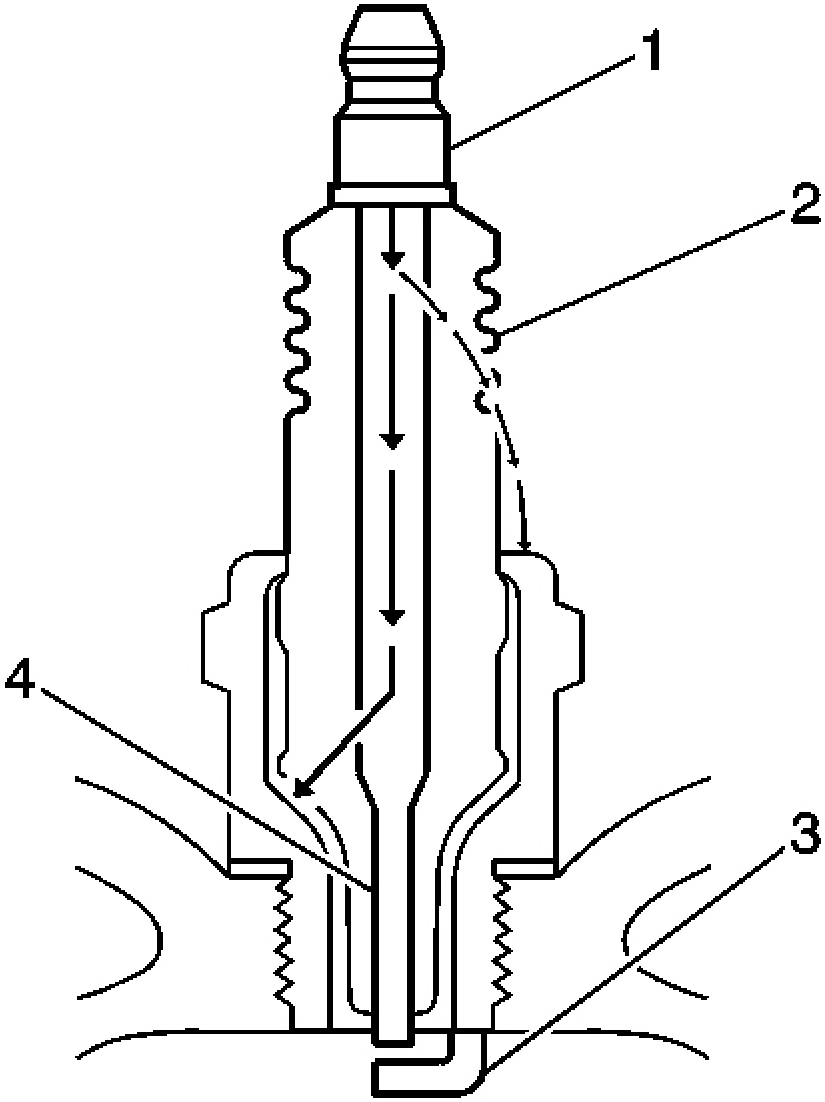


Fig. 144: Inspecting Spark Plug Insulator
Courtesy of GENERAL MOTORS CORP.

- Inspect the insulator (2) for cracks. All or part of the electrical charge may arc through the crack instead of the electrodes (3, 4).

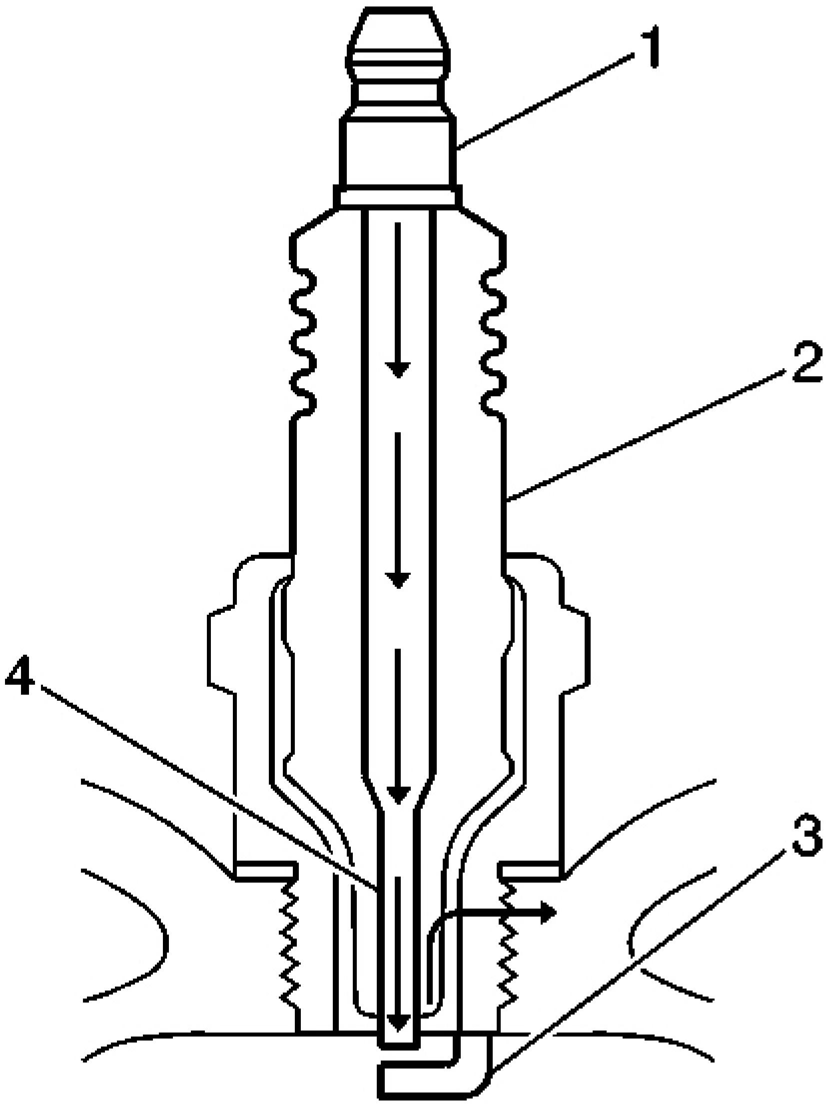


Fig. 145: Inspecting Spark Plug For Improper Arcing
Courtesy of GENERAL MOTORS CORP.

- Inspect for evidence of improper arcing.
    - Measure the gap between the center electrode (4) and the side electrode (3) terminals. 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.

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.
- 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.

SPARK PLUG REPLACEMENT

Removal Procedure

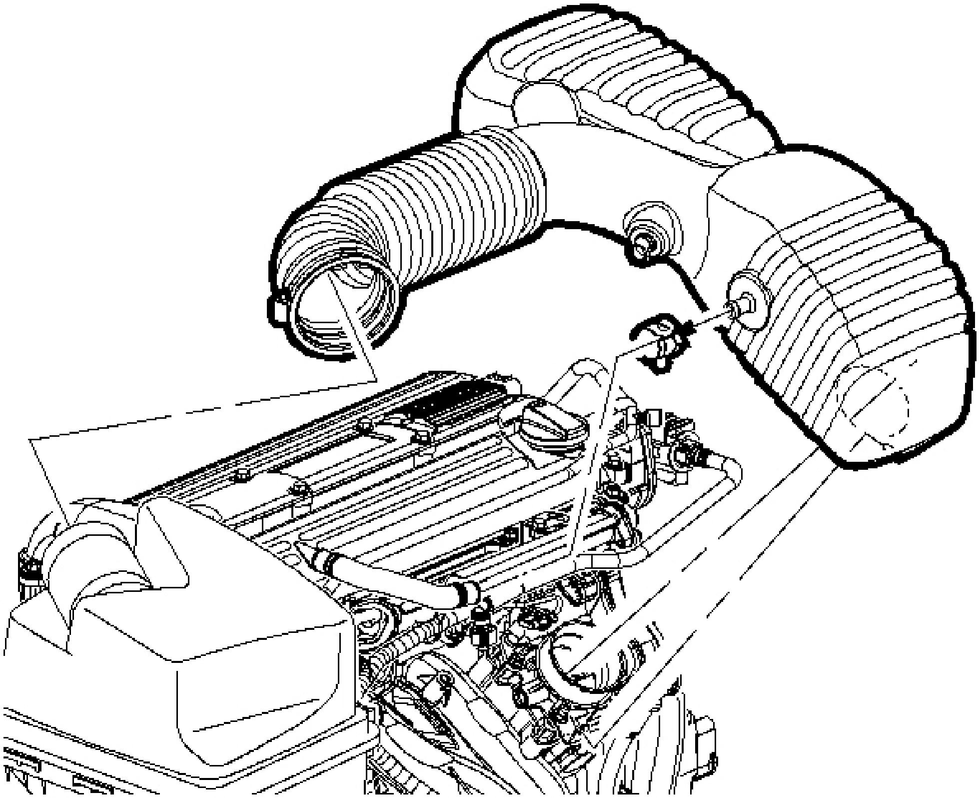


Fig. 146: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the intake air temperature (IAT) sensor connector.
2. Loosen the clamp at the air cleaner assembly.
3. Remove the push-pin attachment from the outlet resonator/duct assembly to support bracket.
4. Loosen the clamp at the throttle body assembly.
5. Disconnect the PCV fresh air bent hose at the cam cover.
6. Remove the outlet resonator/duct assembly.
7. Disconnect the EI module electrical connector.

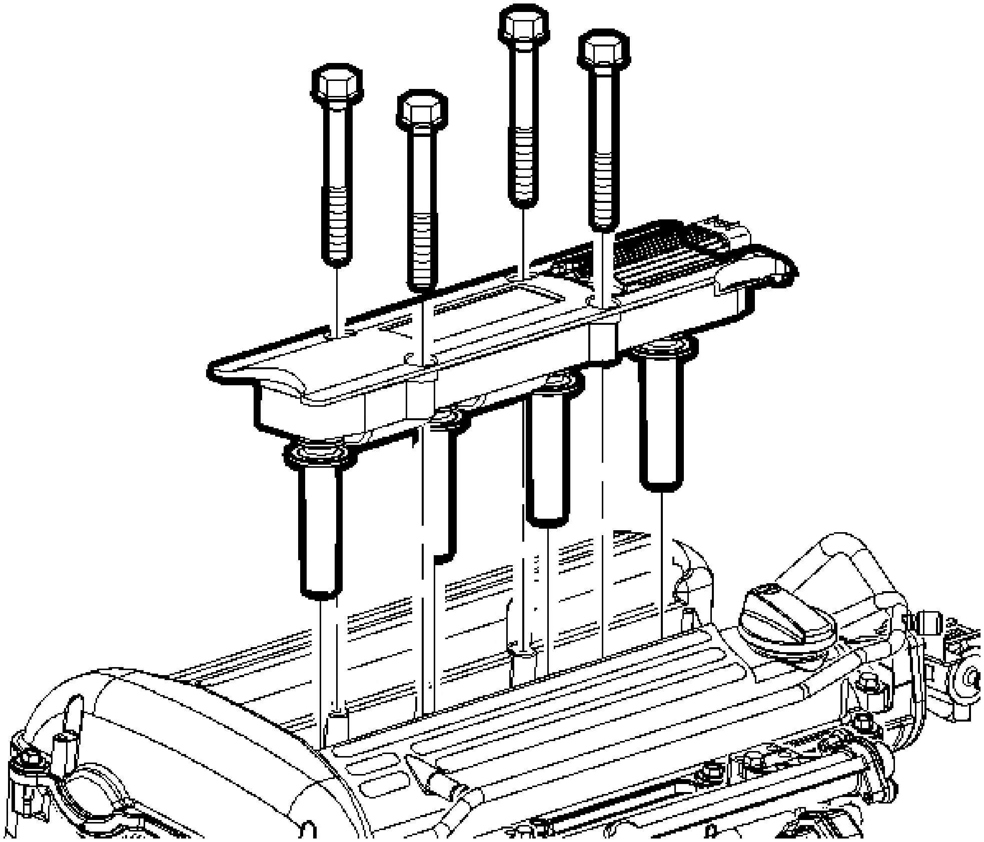


Fig. 147: View of Ignition Module Housing Assembly With Spark Plug Boots
Courtesy of GENERAL MOTORS CORP.

8. Remove the ignition module attachment bolts.
9. Remove the ignition module housing assembly with the spark plug boots from the spark plugs.

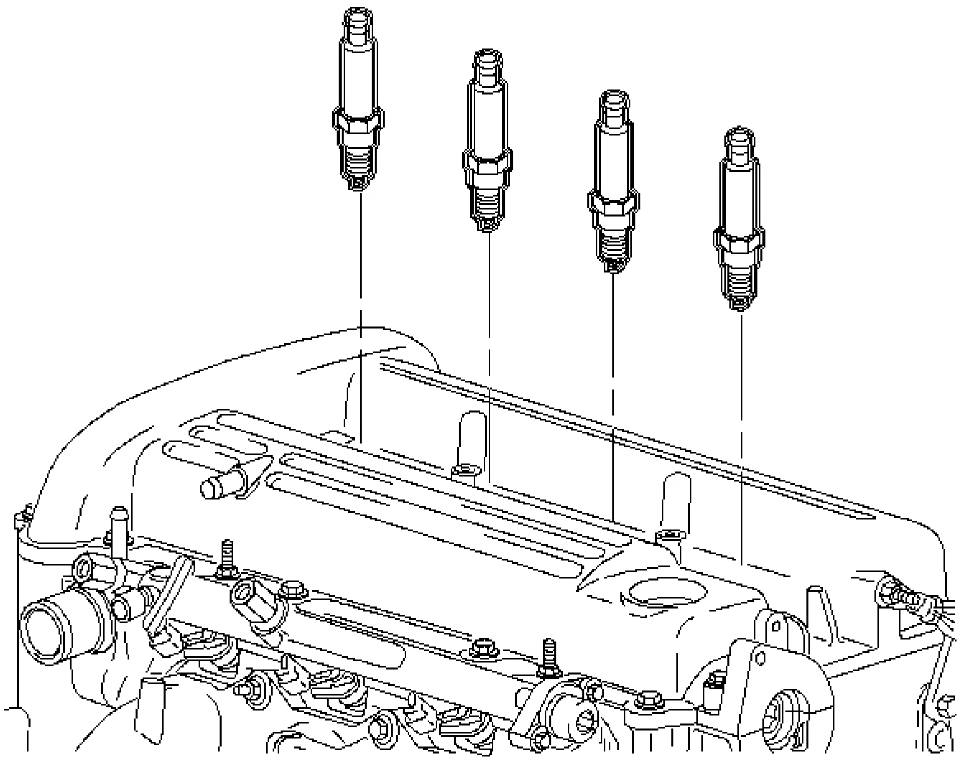


Fig. 148: View Of Spark Plugs
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: To avoid getting water and debris into the spark plug holes, used compressed air and a shop rag to blow out each spark plug hole before plus are removed.

10. Remove the spark plugs using a spark plug socket.

Installation Procedure

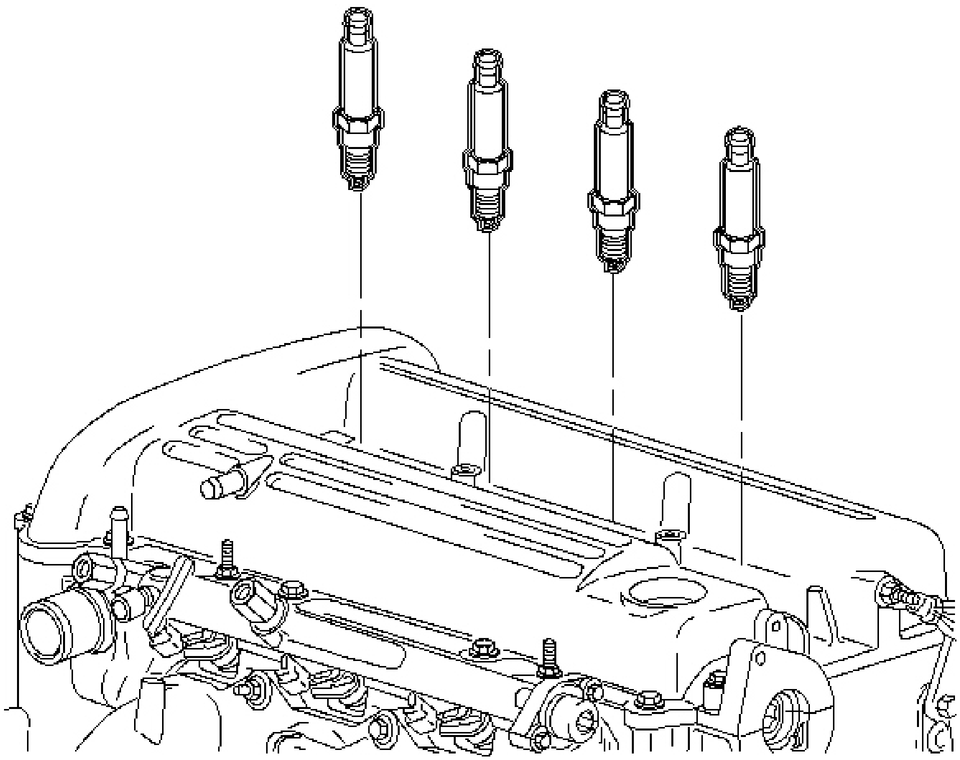


Fig. 149: View Of Spark Plugs
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not coat spark plug threads with anti-seize compound. If anti-seize compound is used and spark plugs are over-torqued, damage to the cylinder head threads may result.

1. Gap the spark plugs.

Specification: Spark Plug Gap: 1.14 mm

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the spark plugs.

   Tighten: Tighten the spark plugs to 20 N.m (15 lb ft).

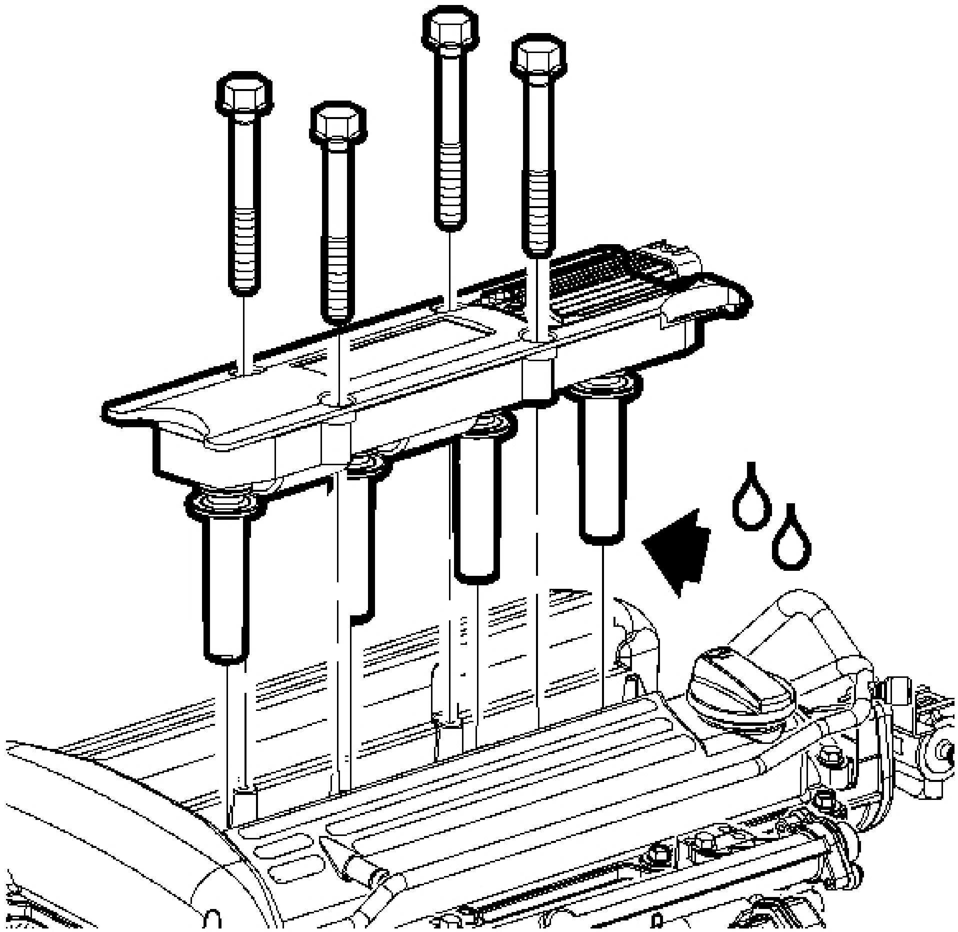


Fig. 150: Applying Dielectric Compound To The Spark Plug Boots
Courtesy of GENERAL MOTORS CORP.

3. Apply dielectric compound to the spark plug boots and ensure no corrosion is present.

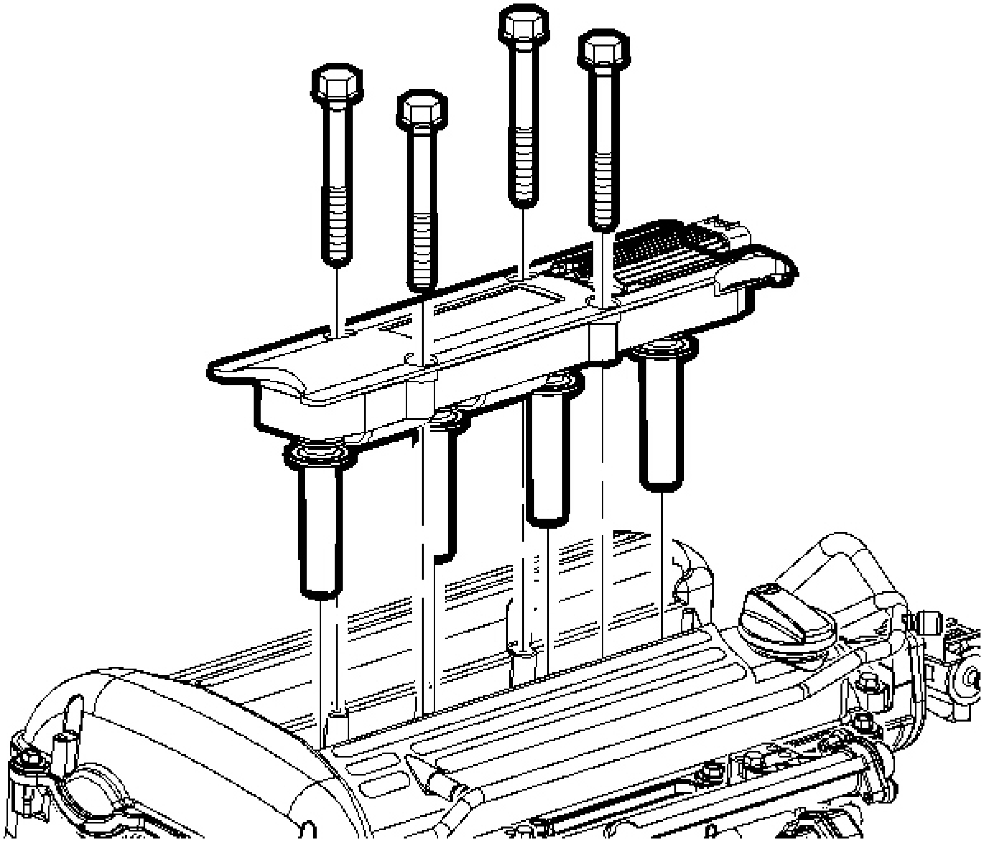


Fig. 151: View of Ignition Module Housing Assembly With Spark Plug Boots
Courtesy of GENERAL MOTORS CORP.

4. Install the ignition module housing assembly with spark plug boots into position.

   Tighten: Tighten the ignition module-to-camshaft cover bolts to 10 N.m (89 lb in).

5. Connect the EI module harness connector. Push in until a click is heard and pull back to confirm a positive engagement.

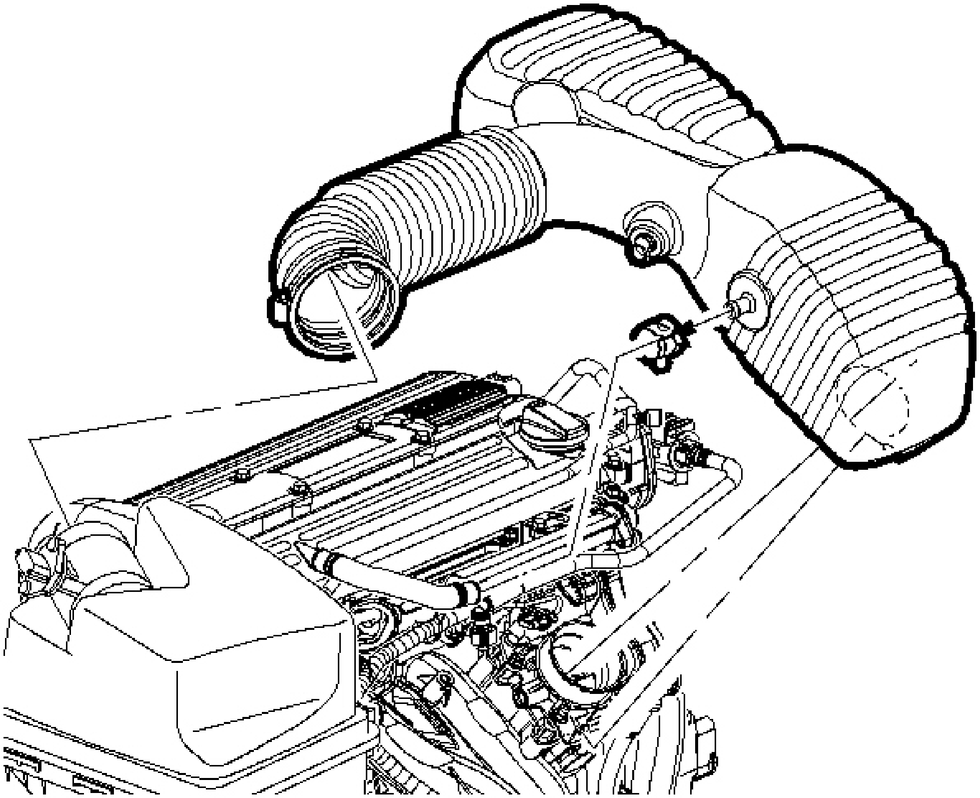


Fig. 152: View Of Outlet Resonator/Duct Assembly
Courtesy of GENERAL MOTORS CORP.

6. Position the outlet resonator/duct assembly into position.
7. Connect the PCV fresh air vent hose assembly.
8. Tighten the clamp at the throttle body assembly.
9. Position the outlet resonator/duct assembly up with support bracket and install the push-pin.
10. Tighten the clamp at the air cleaner assembly.
11. Connect the intake air temperature (IAT) sensor connector.

CRANKSHAFT POSITION (CKP) SENSOR REPLACEMENT

Removal Procedure

1. Remove the starter. Refer to **Starter Motor Replacement (L61)** or **Starter Motor Replacement (L66)** in Engine Electrical.

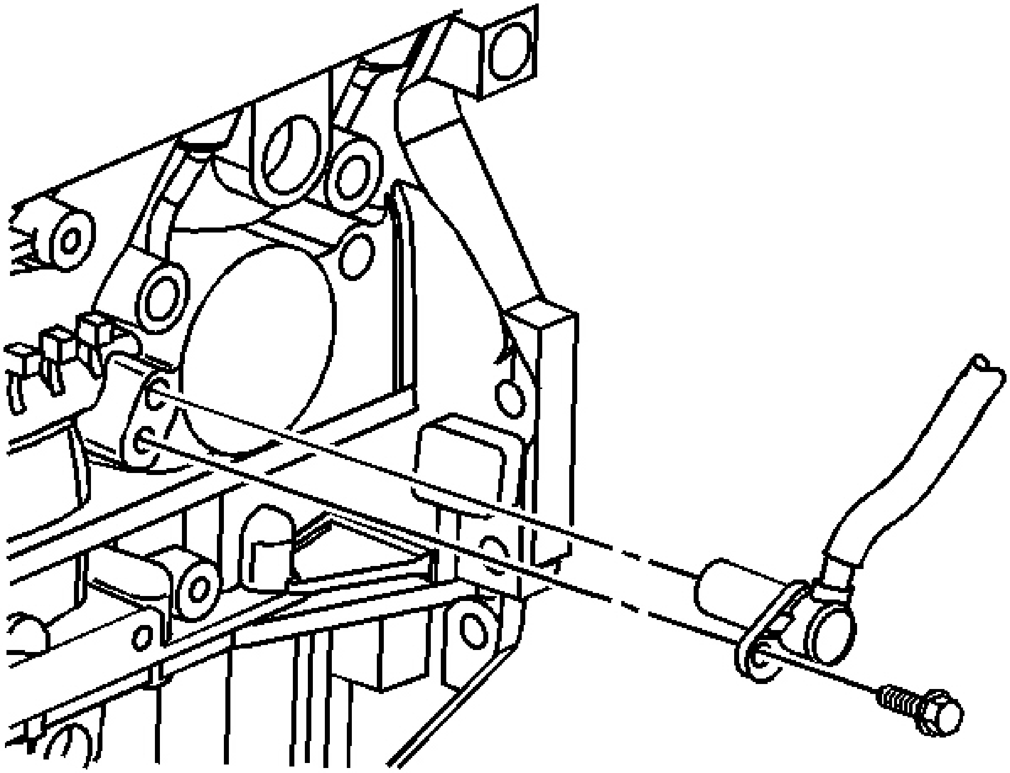


Fig. 153: View Of Crankshaft Position (CKP) Sensor
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the Crankshaft Position (CKP) sensor electrical connector.
3. Remove the CKP sensor bolt.
4. Remove the CKP sensor.

Installation Procedure

1. Inspect the CKP sensor O-ring and lubricate with a mineral based grease.

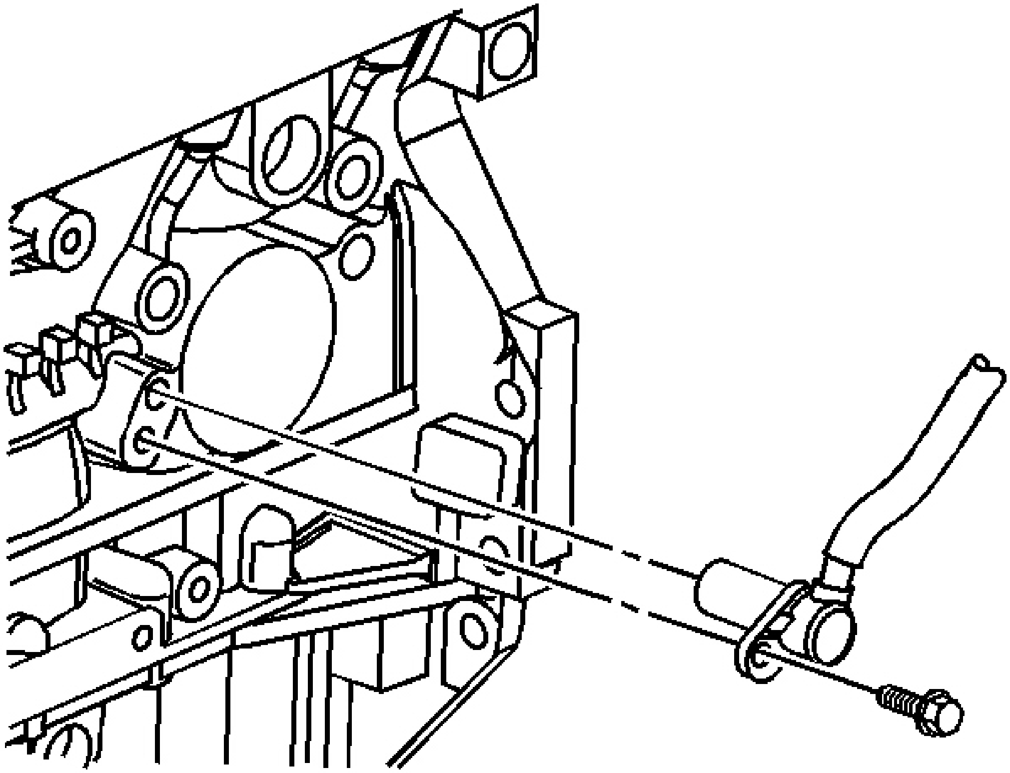


Fig. 154: View Of Crankshaft Position (CKP) Sensor
Courtesy of GENERAL MOTORS CORP.

2. Gently insert the CKP sensor into the block.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the CKP sensor bolt.

   Tighten: Tighten the CKP sensor bolt to 8 N.m (71 lb in).

4. Reconnect the CKP sensor electrical connector.
5. Install the starter. Refer to **Starter Motor Replacement (L61)** or **Starter Motor Replacement (L66)** in Engine Electrical.
6. Perform the CKP system Variation Learn Procedure. Refer to **CKP System Variation Learn Procedure** .

KNOCK SENSOR (KS) REPLACEMENT

Removal Procedure

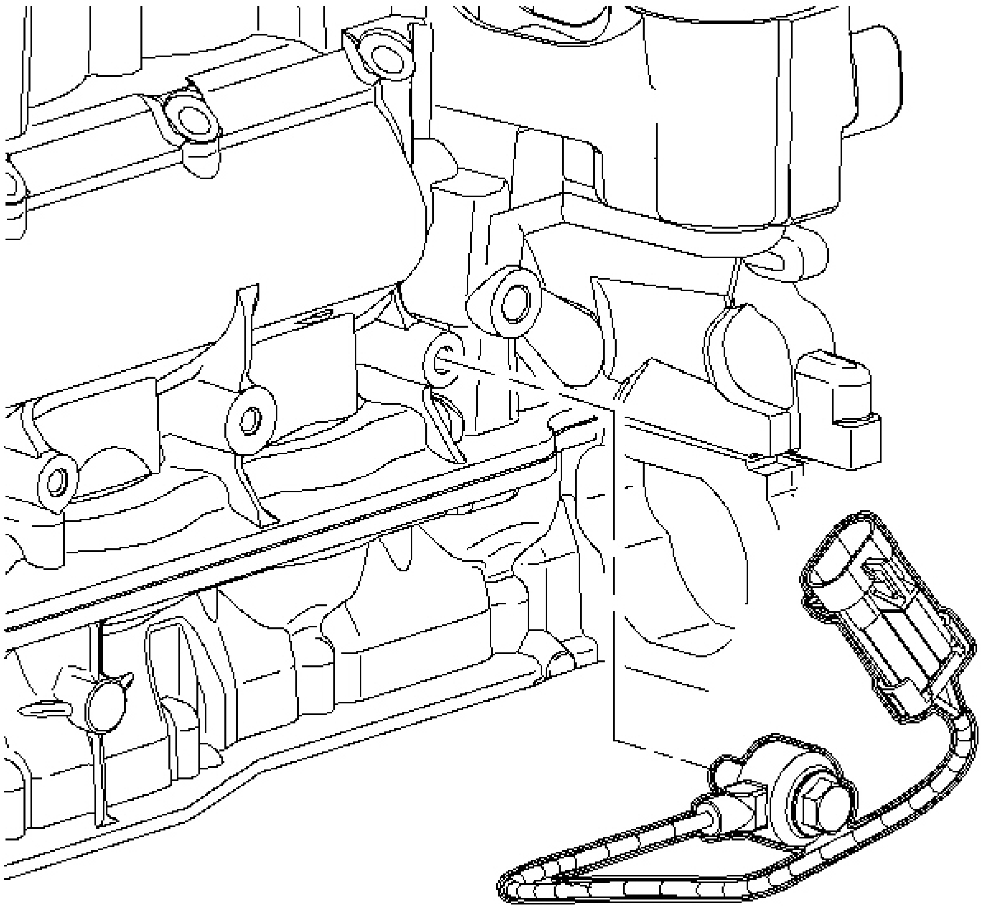


Fig. 155: View Of Know Sensor (KS)
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Remove the knock sensor harness connector.
3. Remove the knock sensor connector from the retaining clip by inserting a flat-bladed screwdriver between the connector and clip while sliding the connector upward.

4. Remove the knock sensor.

Installation Procedure

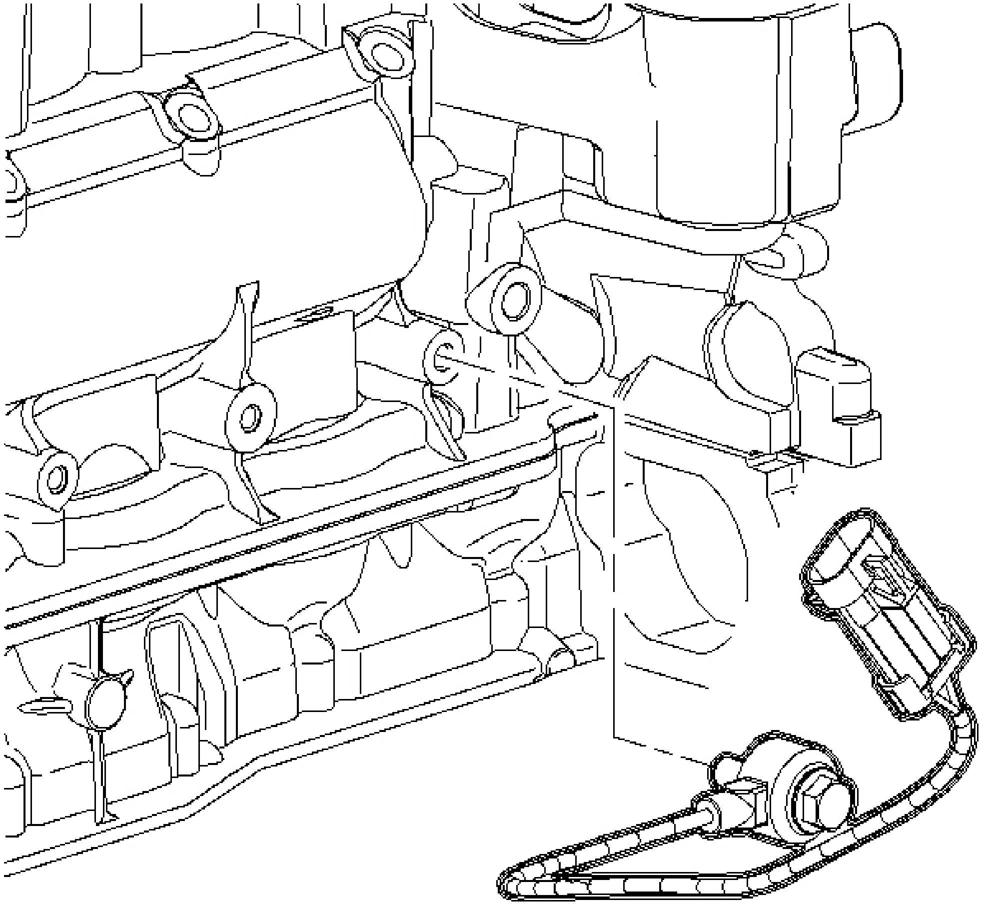


Fig. 156: View Of Know Sensor (KS) Harness Connector
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If a new knock sensor pigtail connector retaining clip is going to be used, the old one must be removed from the intake manifold. Use a push pin removal tool to remove the clip from the intake manifold.

1. Insert the knock sensor pigtail connector with retaining clip into the intake manifold hole or slide the knock sensor pigtail connector over the retaining clip from the top.

2. Connect the knock sensor harness connector. Push in the connector until a click is heard, then pull back to confirm a positive engagement.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: The larger metal contact area of the knock sensor MUST be toward the engine block. A DTC P0327 may result if the sensor is installed backwards.

3. Install the knock sensor at the 9 o'clock position and attachment bolt.

   Tighten: Tighten the knock-sensor-engine block bolt to 25 N.m (18 lb ft).

4. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.

AIR CLEANER ELEMENT REPLACEMENT

Removal Procedure

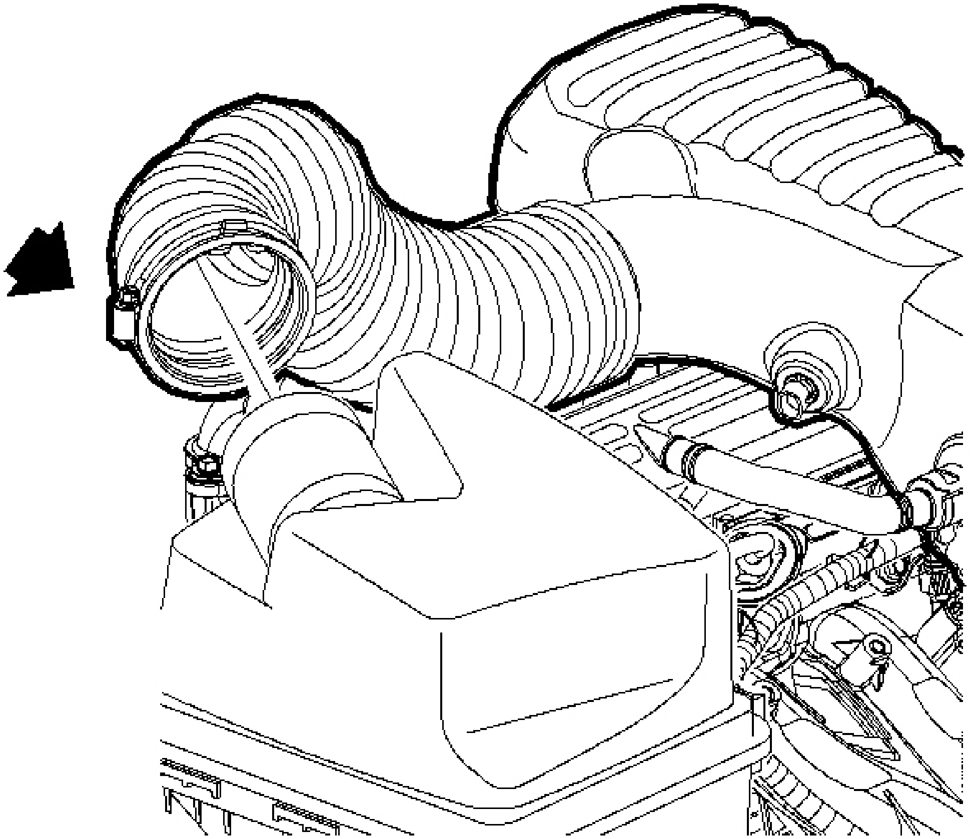


Fig. 157: Locating Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

1. Loosen the clamp at the air cleaner assembly.
2. Unclamp the air cleaner lid
3. Remove the air filter assembly.

Installation Procedure

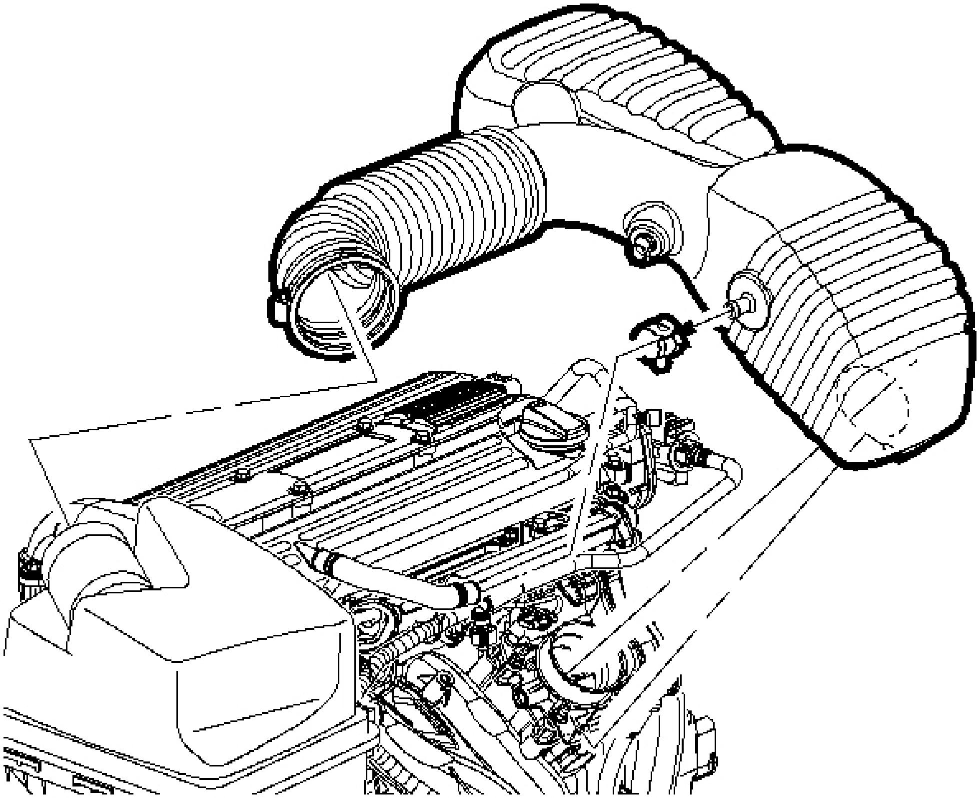


Fig. 158: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the air filter into the box.
2. Install the air cleaner lid and snap clips onto the lid.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Connect the outlet resonator duct assembly to the air cleaner lid. Tighten the clamp.

   Tighten: Tighten the outlet resonator clamps to 4 N.m (36 lb in).

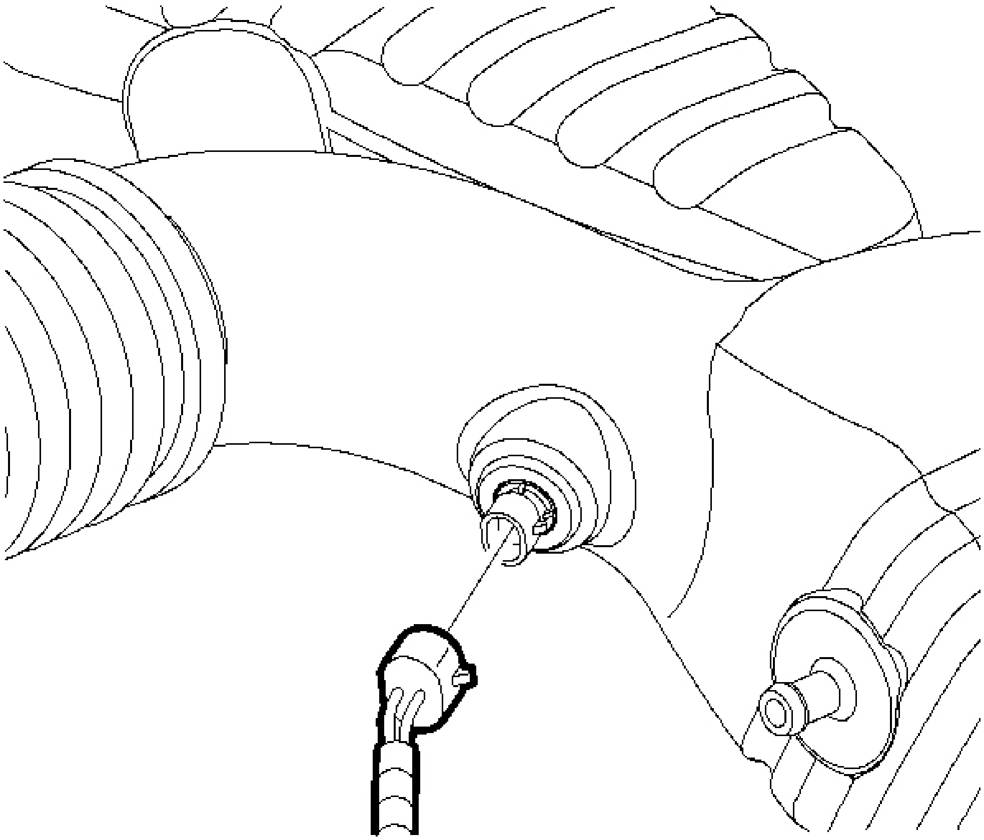


Fig. 159: View Of Intake Air Temperature Sensor Connector
Courtesy of GENERAL MOTORS CORP.

4. Connect the intake air temperature (IAT) sensor connector.

AIR CLEANER ASSEMBLY REPLACEMENT

Removal Procedure

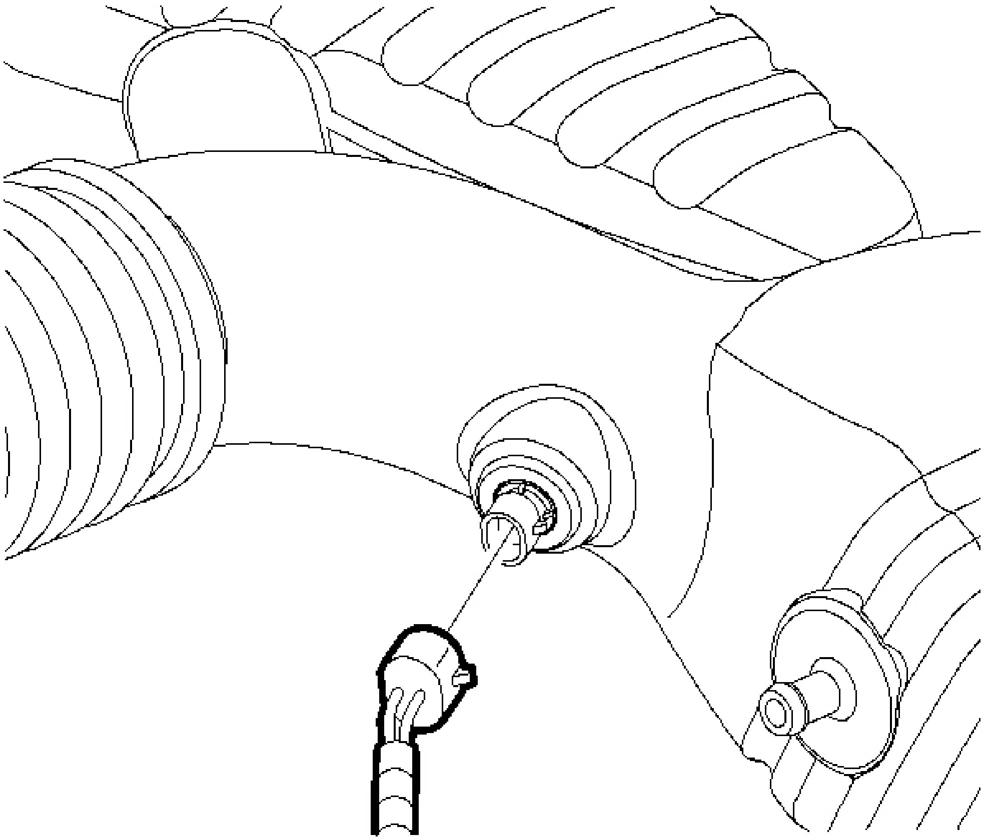


Fig. 160: View Of Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the intake air temperature (IAT) sensor connector.

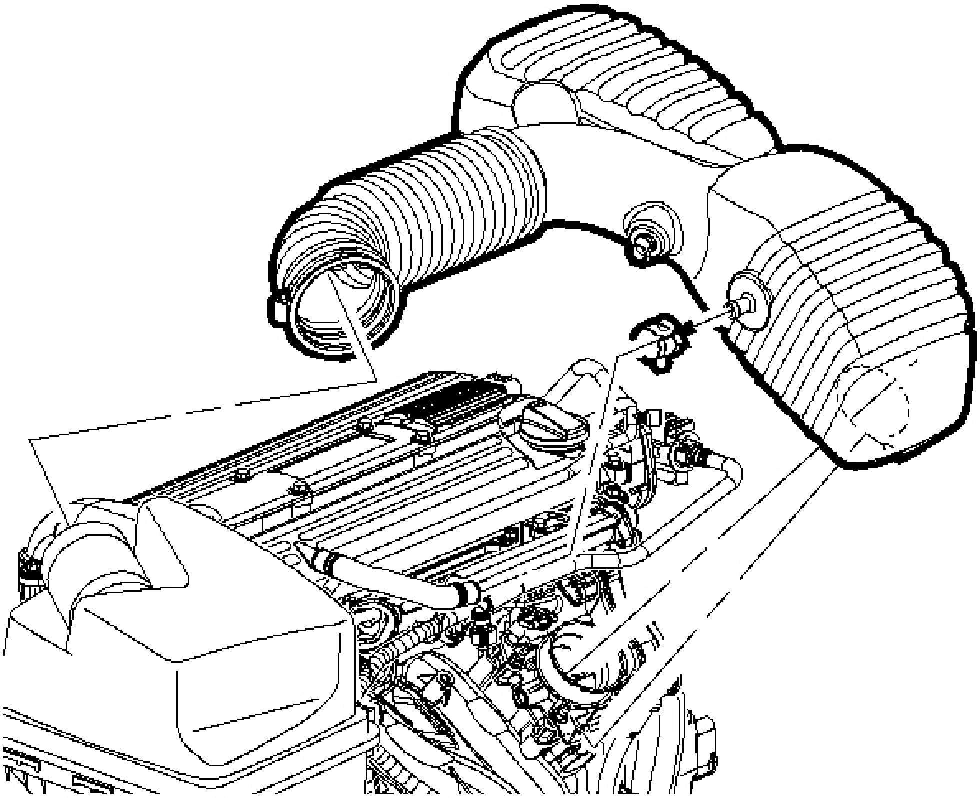


Fig. 161: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

2. Loosen the clamp at the air cleaner assembly.
3. Remove the outlet resonator duct from the air cleaner.
4. Loosen the clamp at throttle body assembly.
5. Disconnect PCV fresh air vent hose at cam cover.
6. Remove the air outlet resonator/bolt.

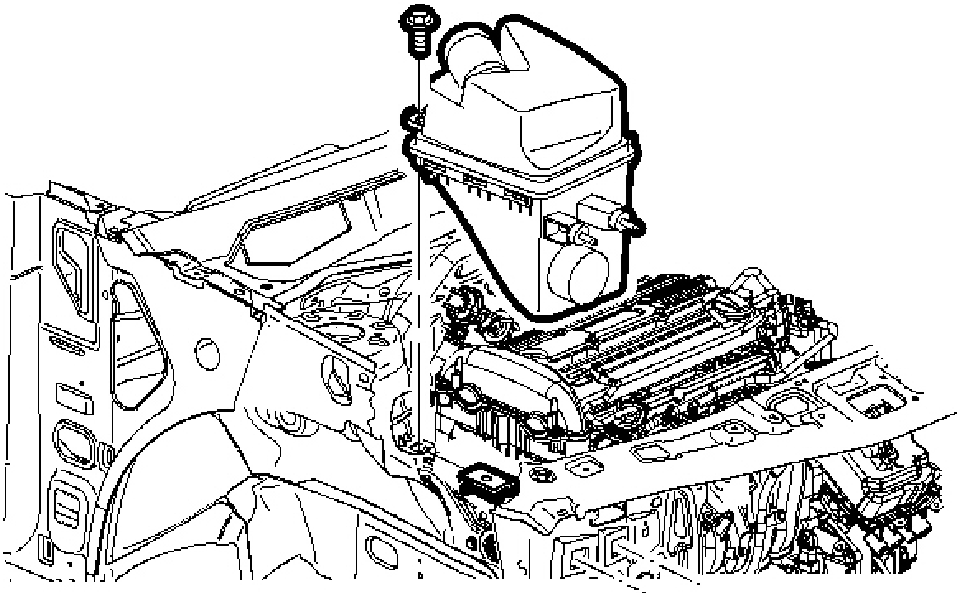


Fig. 162: View Of Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

7. Remove the air cleaner attachment bolt.
8. Remove the air cleaner assembly.

Installation Procedure

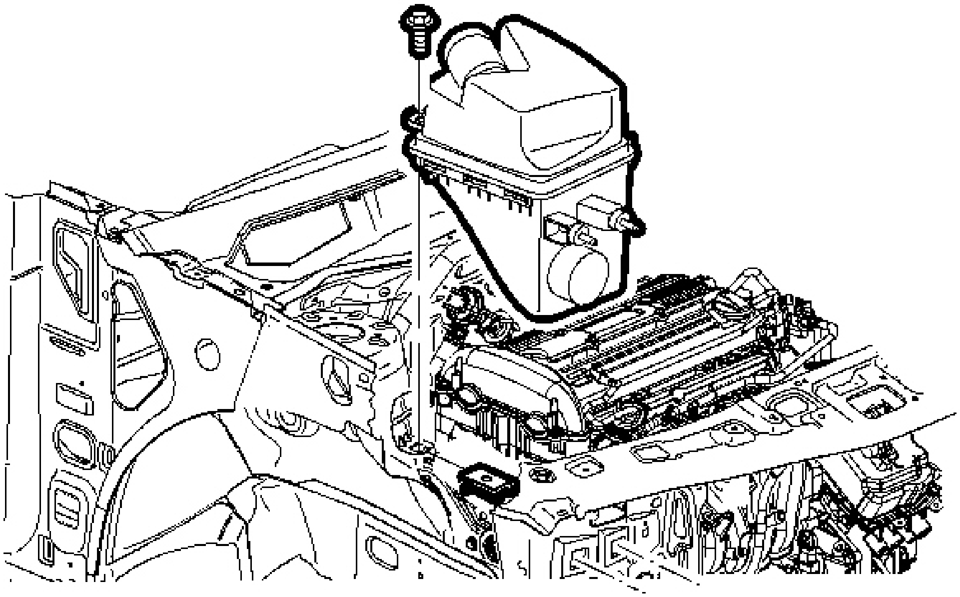


Fig. 163: View Of Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the air cleaner assembly into position.
2. Install the air cleaner attachment bolt.

Tighten: Tighten the air cleaner-to-support bracket bolt 4 cylinder to 10 N.m (89 lb in).

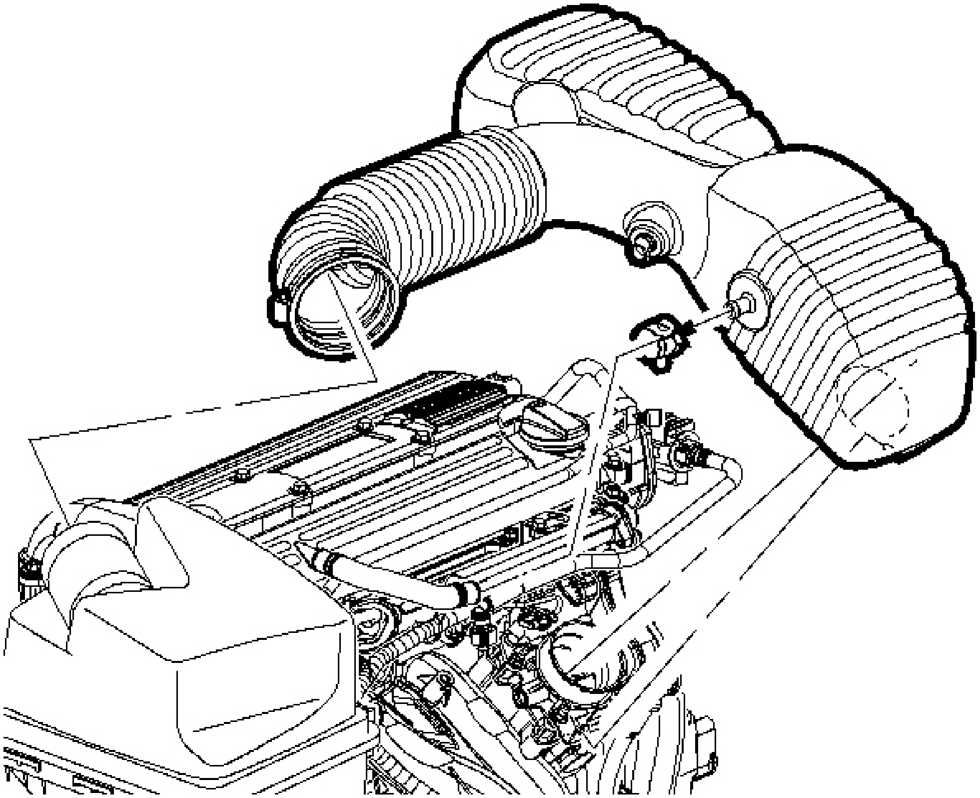


Fig. 164: Locating Air Intake Assembly
Courtesy of GENERAL MOTORS CORP.

3. Position the outlet resonator/duct assembly.
4. Connect the PCV fresh air vent hose assembly.
5. Tighten the clamp at throttle body assembly.
6. Position outlet resonator/duct assembly up with support bracket and install push-pin.
7. Tighten the clamp at the air cleaner assembly.

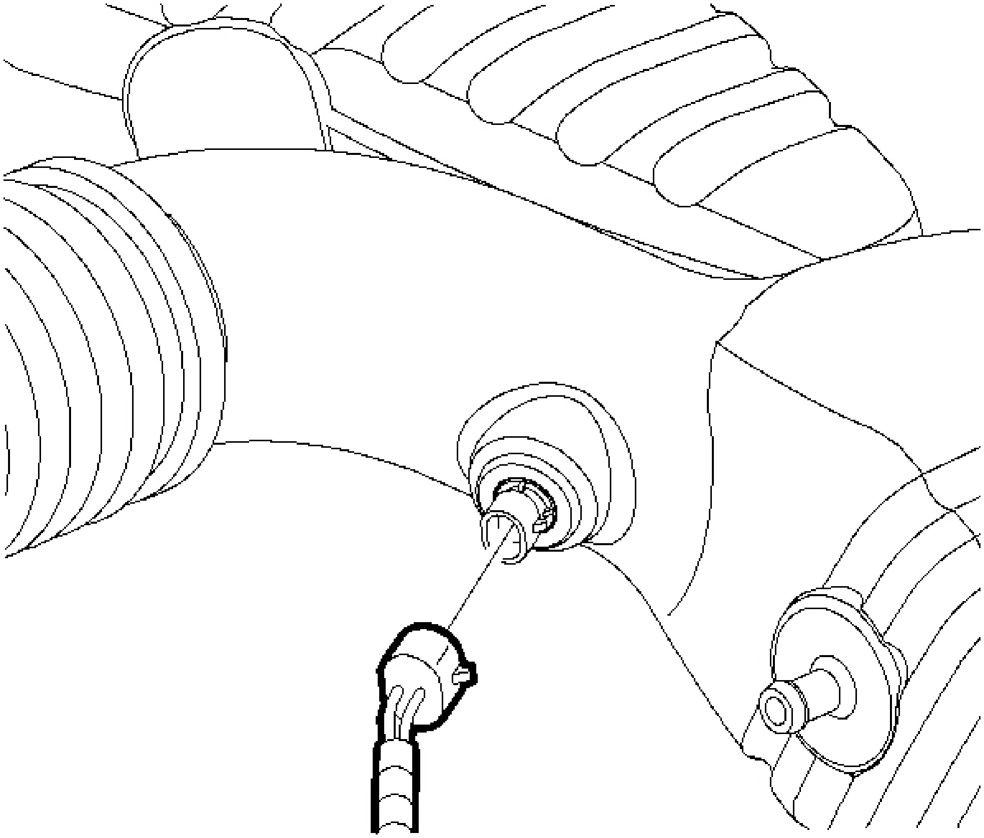


Fig. 165: View Of Intake Air Temperature Sensor Connector
Courtesy of GENERAL MOTORS CORP.

8. Connect the intake air temperature (IAT) sensor connector.

AIR CLEANER OUTLET RESONATOR REPLACEMENT

Removal Procedure

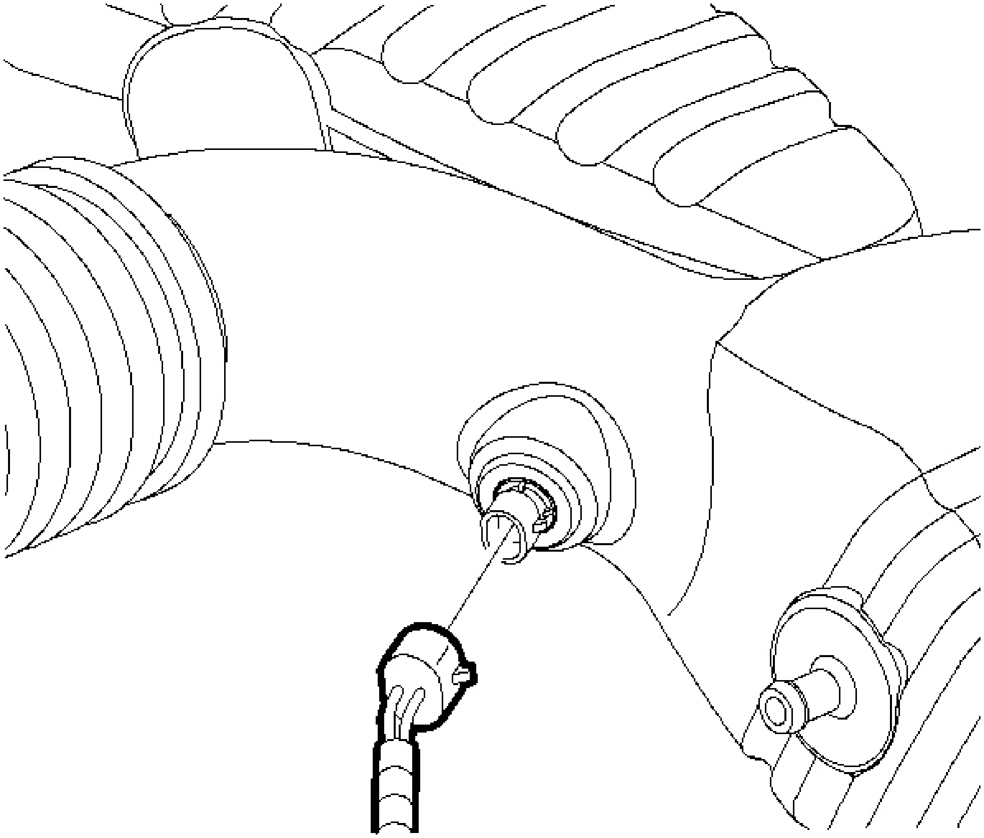


Fig. 166: View Of Air Cleaner Outlet Resonator
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the intake air temperature (IAT) sensor connector

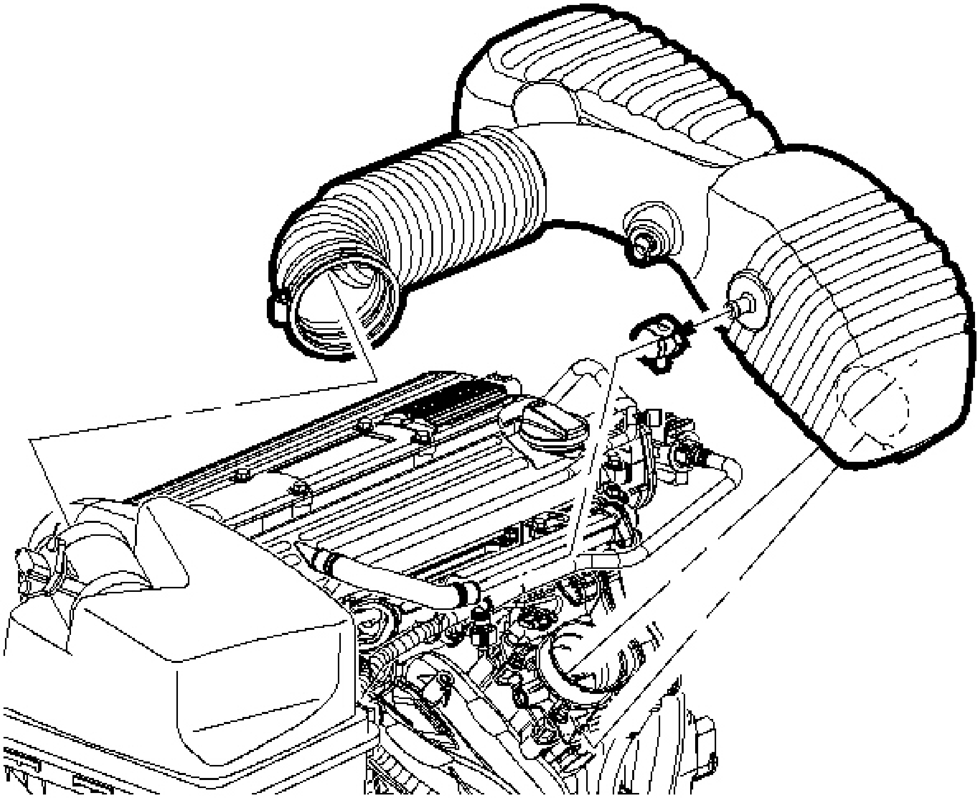


Fig. 167: View Of Outlet Resonator/Duct Assembly
Courtesy of GENERAL MOTORS CORP.

2. Loosen the clamp at the air cleaner assembly.
3. Remove the push pin attachment from the outlet resonator/duct assembly to support bracket.
4. Loosen the clamp at throttle body assembly.
5. Disconnect the PCV fresh air vent hose at cam cover.
6. Remove the outlet resonator/duct assembly.

Installation Procedure

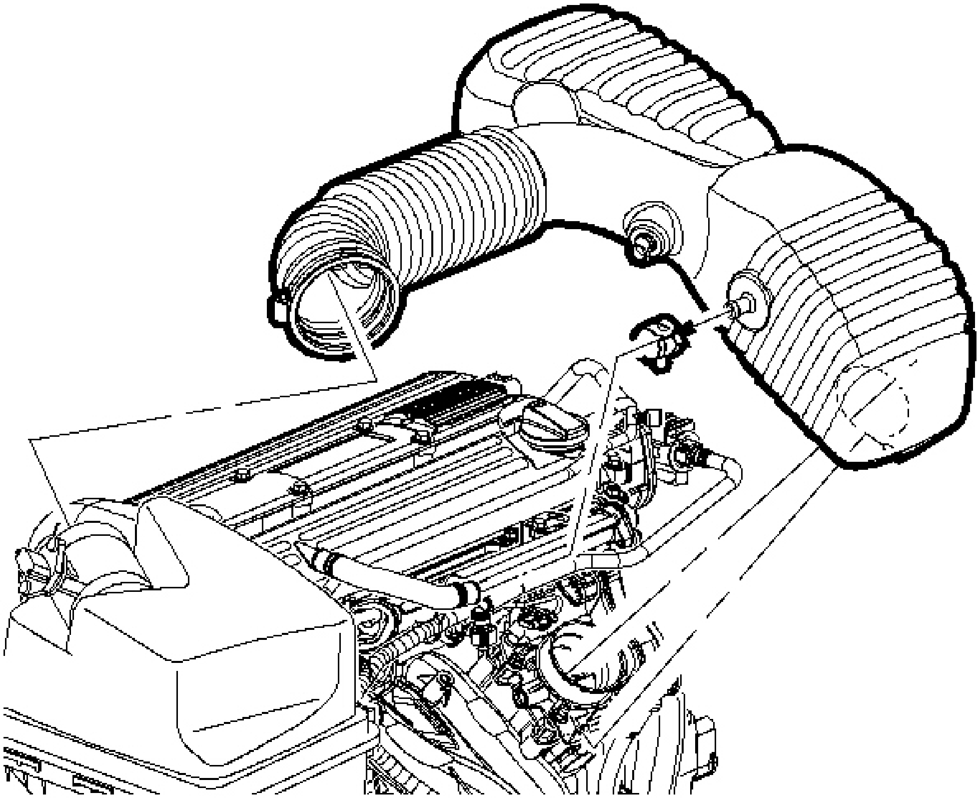


Fig. 168: View Of Outlet Resonator/Duct Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the outlet resonator/duct assembly into position at the throttle body and air cleaner.
2. Connect the PCV fresh air vent hose assembly.
3. Tighten the clamp at the throttle body assembly.
4. Position the outlet resonator/duct assembly up with the support bracket and install the push-pin.
5. Tighten the clamp at the air cleaner assembly.

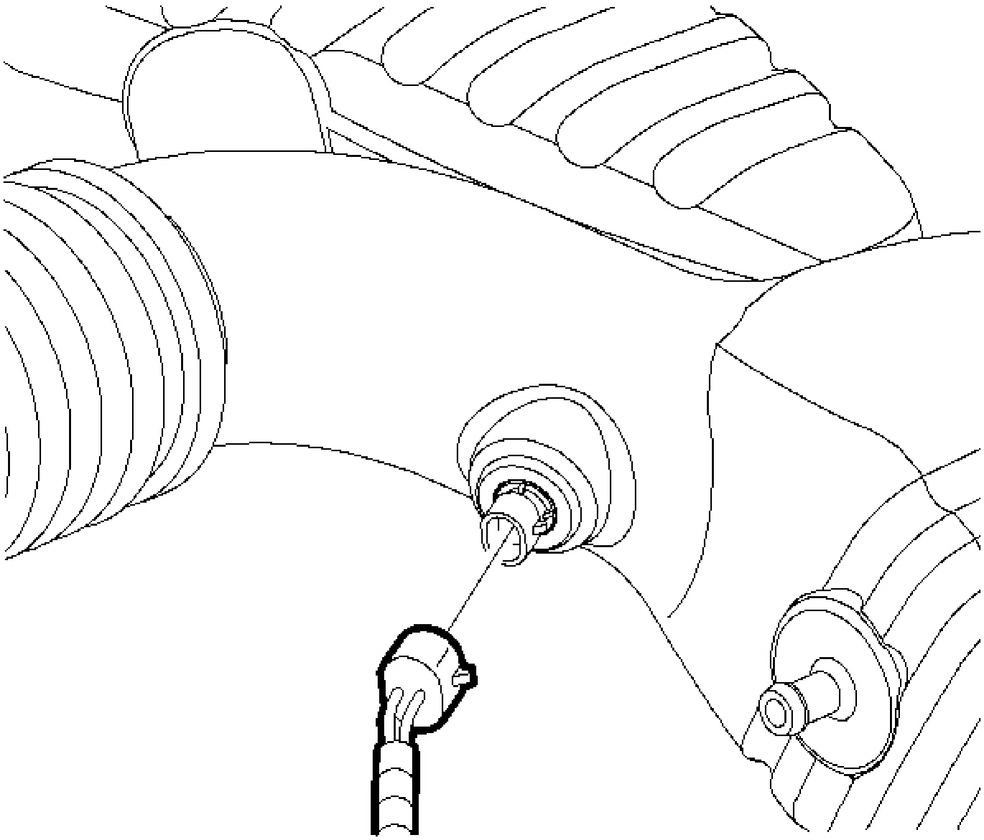


Fig. 169: View Of Intake Air Temperature Sensor Connector
Courtesy of GENERAL MOTORS CORP.

6. Connect the intake air temperature (IAT) sensor connector.

AIR CLEANER INTAKE DUCT REPLACEMENT

Removal Procedure

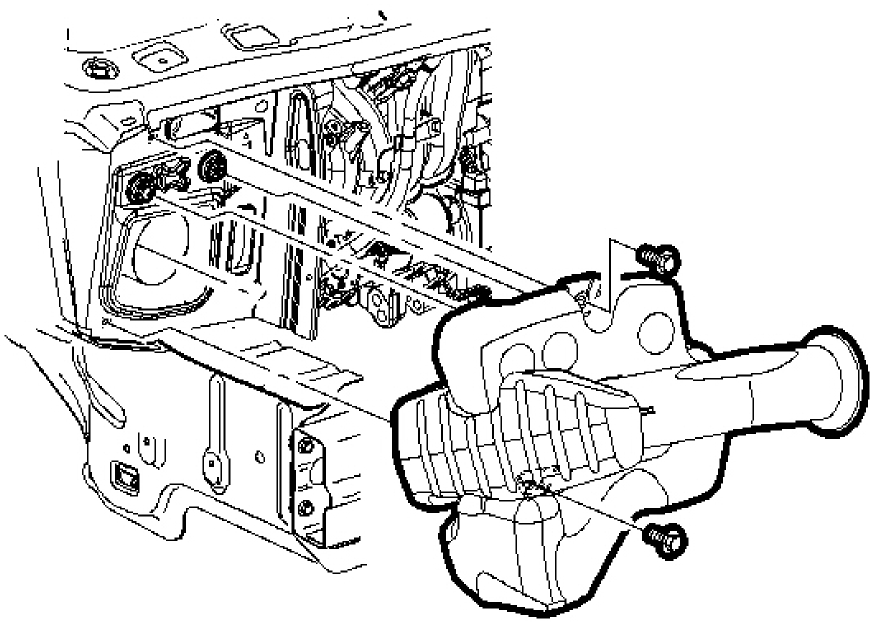


Fig. 170: View Of Intake Duct Assembly
Courtesy of GENERAL MOTORS CORP.

1. Remove the front fascia. Refer to **Fascia Replacement - Front Bumper** in Bumpers.
2. Remove the inlet duct assembly attachment bolts.

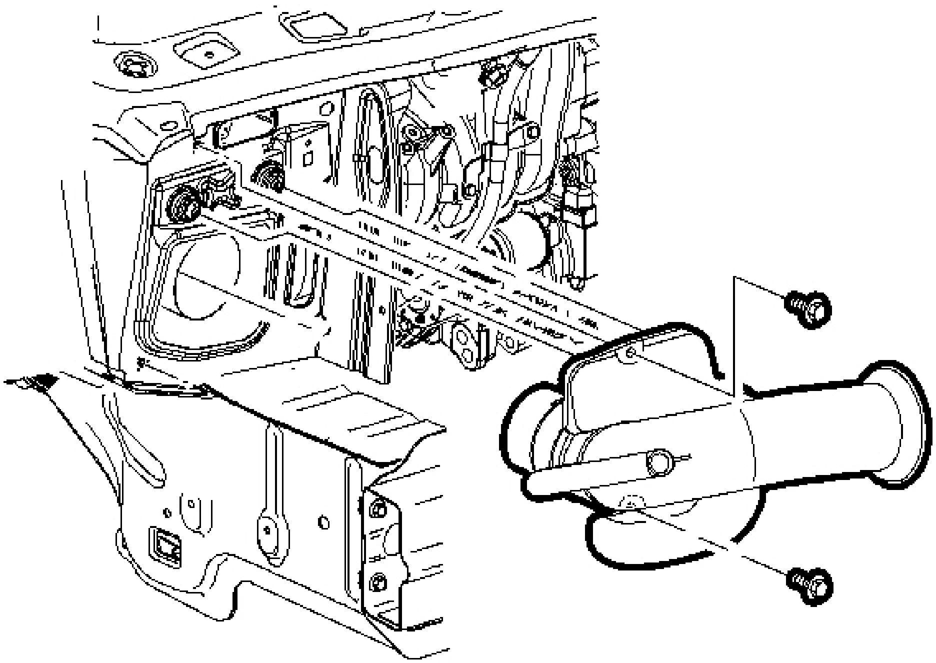


Fig. 171: View Of Air Resonator/Duct Assembly
Courtesy of GENERAL MOTORS CORP.

3. Remove the inlet duct assembly.

Installation Procedure

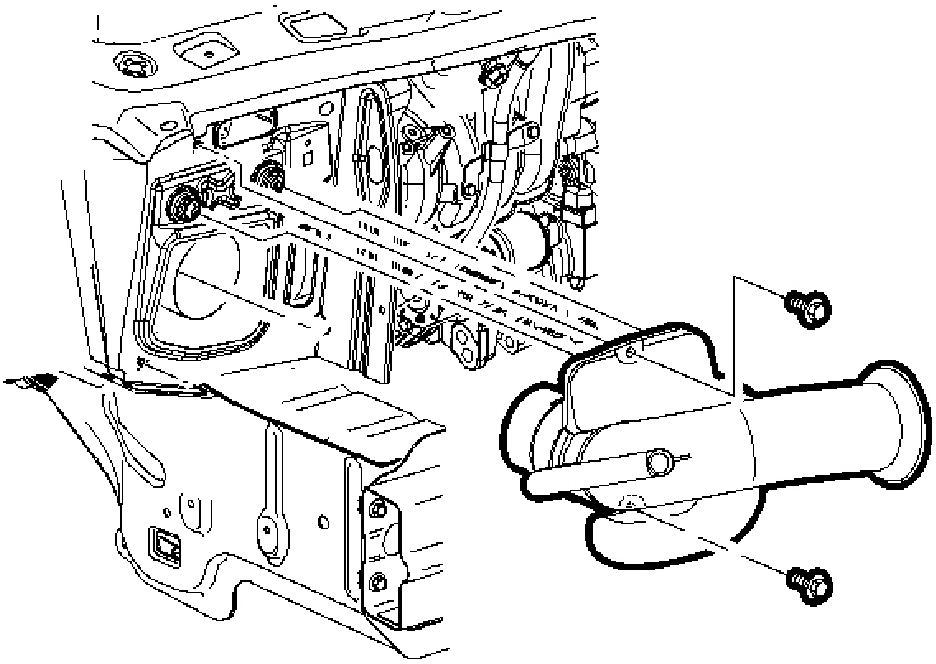


Fig. 172: View Of Air Resonator/Duct Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the air resonator/duct assembly.

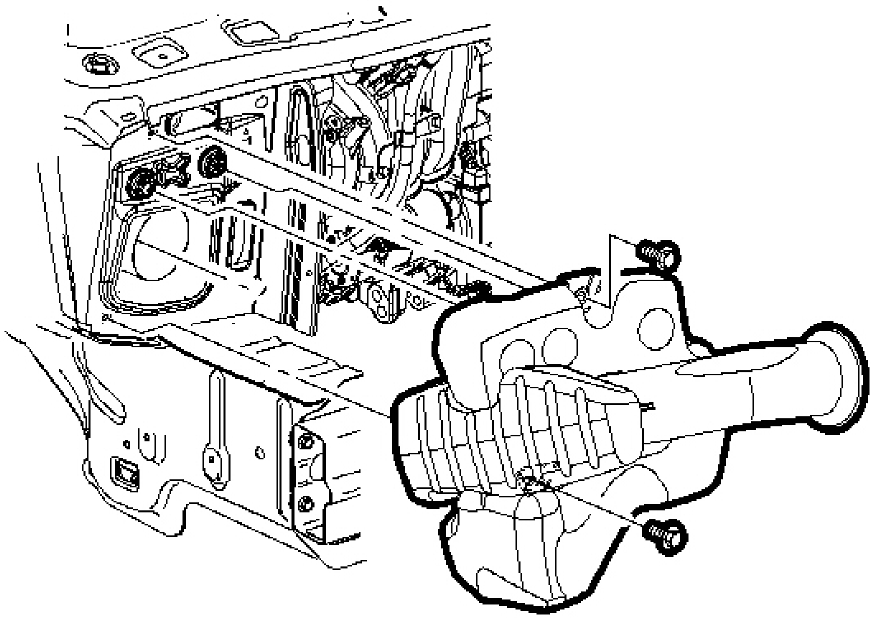


Fig. 173: View Of Intake Duct Assembly
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the air resonator/duct assembly bolts.

   Tighten: Tighten the air resonator/duct assembly-to-body to 10 N.m (89 lb in).

3. Install the front fascia. Refer to **Fascia Replacement - Front Bumper** in Bumpers.

DESCRIPTION AND OPERATION

ENGINE CONTROL MODULE (ECM) DESCRIPTION

Powertrain

The powertrain has electronic controls to reduce exhaust emissions while maintaining excellent driveability and fuel economy. The engine control module (ECM) is the control center of this system. The ECM monitors numerous engine and vehicle functions. The ECM constantly looks at the information from various sensors and other inputs, and controls the systems that affect vehicle performance and emissions. The ECM also performs the diagnostic tests on various parts of the system. The ECM can recognize operational problems and alert the driver with the malfunction indicator lamp (MIL). When the ECM detects a malfunction, the ECM stores a diagnostic trouble code (DTC). The problem area is identified by the particular DTC that is set. Review the components and wiring diagrams in order to determine which systems are controlled by the ECM.

The following are some of the functions that the ECM controls:

- The engine fueling
- The ignition control (IC)
- The knock sensor (KS) system
- The evaporative emissions (EVAP) system
- The generator
- The A/C clutch control
- The cooling fan control

Engine Control Module Function

The ECM constantly looks at the information from various sensors and other inputs and controls systems that affect vehicle performance and emissions. The ECM also performs diagnostic tests on various parts of the system. The ECM can recognize operational problems and alert the driver with the malfunction indicator lamp (MIL). When the ECM detects a malfunction, the ECM stores a diagnostic trouble code (DTC). The problem area is identified by the particular DTC that is set. The input and output devices in the ECM include analog-to-digital converters, signal buffers, counters, and output drivers. The output drivers are electronic switches that complete a ground or voltage circuit when turned on. Most ECM controlled components are operated by output drivers. The ECM monitors these driver circuits for proper operation and, in most cases, can set a DTC corresponding to the controlled device if a problem is detected.

Malfunction Indicator Lamp (MIL) Operation

The malfunction indicator lamp (MIL) is located in the instrument panel cluster. The MIL will display as either SERVICE ENGINE SOON or one of the following symbols when commanded ON:

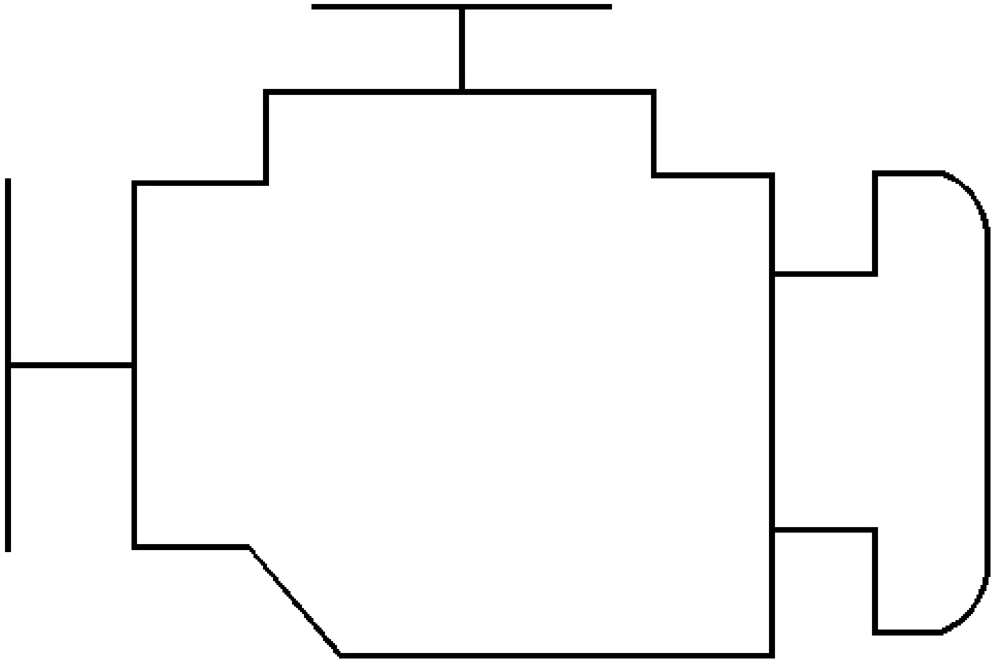


Fig. 174: Identifying MIL Symbol
Courtesy of GENERAL MOTORS CORP.

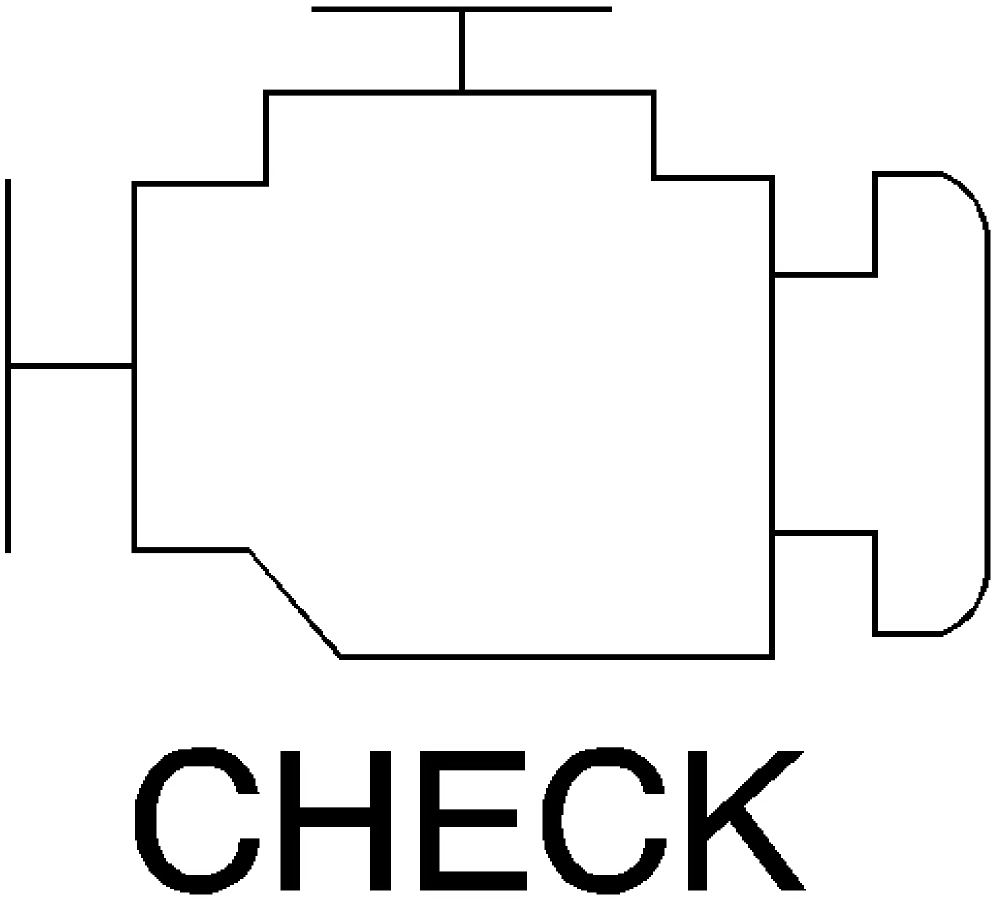


Fig. 175: MIL ON (Check)
Courtesy of GENERAL MOTORS CORP.

The MIL indicates that an emissions related fault has occurred and vehicle service is required.

The following is a list of the modes of operation for the MIL:

- The MIL illuminates when the ignition is turned ON, with the engine OFF. This is a bulb test to ensure the MIL is able to illuminate.
- The MIL turns OFF after the engine is started if a diagnostic fault is not present.
- The MIL remains illuminated after the engine is started if the control module detects a fault. A diagnostic trouble code (DTC) is stored any time the control module illuminates the MIL due to an emissions related fault. The MIL turns OFF after three consecutive ignition cycles in which a Test Passed has been reported

for the diagnostic test that originally caused the MIL to illuminate.

- The MIL flashes if the control module detects a misfire condition which could damage the catalytic converter.
- When the MIL is illuminated and the engine stalls, the MIL will remain illuminated as long as the ignition is ON.
- When the MIL is not illuminated and the engine stalls, the MIL will not illuminate until the ignition is cycled OFF and then ON.

Warm-up Cycle

The ECM uses warm-up cycles to run some diagnostics and to clear any diagnostic trouble codes (DTCs). A warm-up cycle occurs when the engine coolant temperature increases 22°C (40°F) from the start-up temperature. The engine coolant must also achieve a minimum temperature of 71°C (160°F). The ECM counts the number of warm-up cycles in order to clear the malfunction indicator lamp (MIL). The ECM will clear the DTCs when 40 consecutive warm-up cycles occur without a malfunction.

Diagnostic Trouble Codes (DTCs)

The ECM is programmed with test routines that test the operation of the various systems the ECM controls. Some tests monitor internal ECM functions. Many tests are run continuously. Other tests run only under specific conditions, referred to as Conditions for Running the DTC. When the vehicle is operating within the conditions for running a particular test, the ECM monitors certain parameters and determines if the values are within an expected range. The parameters and values considered outside the range of normal operation are listed as Conditions for Setting the DTC. When the Conditions for Setting the DTC occur, the ECM executes the Action Taken When the DTC Sets. Some DTCs alert the driver via the MIL or a message. Other DTCs do not trigger a driver warning, but are stored in memory. The ECM also saves data and input parameters when most DTCs are set. This data is stored in the Freeze Frame and/or Failure Records.

The DTCs are categorized by type. The DTC type is determined by the MIL operation and the manner in which the fault data is stored when a particular DTC fails. In some cases there may be exceptions to this structure. Therefore, when diagnosing the system it is important to read the Action Taken When the DTC Sets and the Conditions for Clearing the DTC in the supporting text.

There are different types of DTCs and different actions taken when the DTCs set. Refer to Diagnostic Trouble Code (DTC) Type Definitions for a description of the general characteristics of each DTC type.

FUEL SYSTEM DESCRIPTION

Fuel System Overview

The fuel system is a returnless on-demand design. The fuel pressure regulator is a part of the primary fuel tank module, eliminating the need for a return pipe from the engine. 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 module inside the fuel tank. The fuel pump supplies high pressure fuel through the fuel filter, past the fuel pressure regulator, and through the fuel feed pipe to the fuel injection system. The fuel pressure regulator has a T-joint that diverts the needed fuel to the fuel rail with the unused fuel dropping back into the reservoir of the primary fuel tank module. The primary fuel tank module contains a reverse flow check valve. The check valve and the fuel pressure regulator maintain fuel pressure in the fuel feed pipe and the fuel rail in order to prevent long cranking times.

The primary fuel tank 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 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.

Fuel Tank

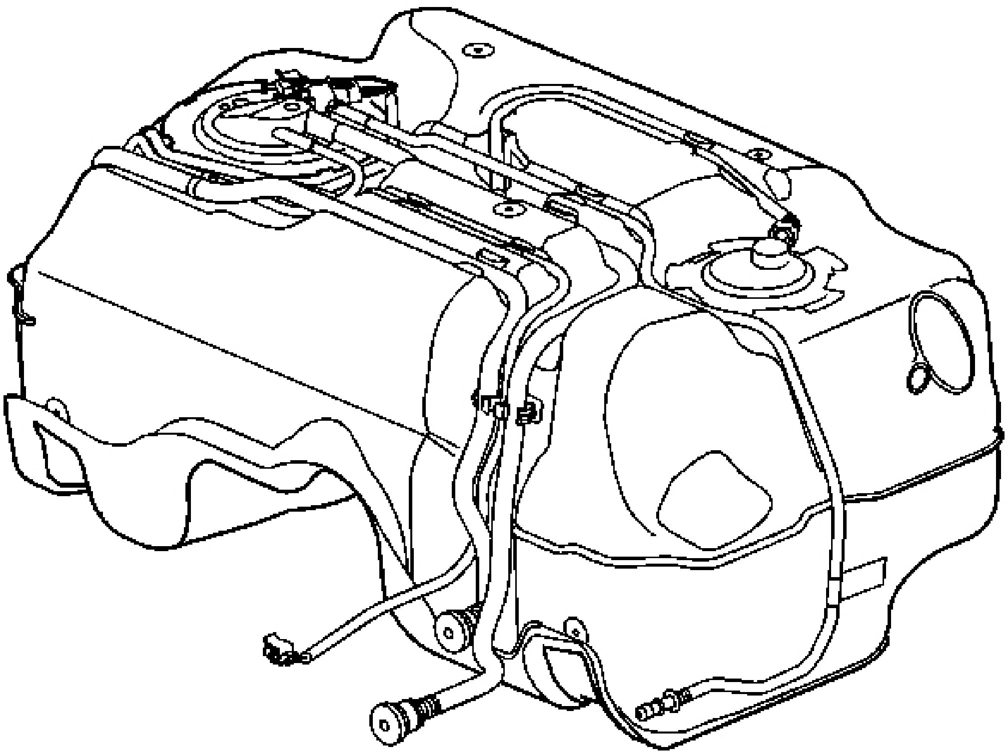


Fig. 176: View Of Fuel Tank
Courtesy of GENERAL MOTORS CORP.

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 under body of the vehicle. The fuel tank is molded from high-density polyethylene.

In order to provide space for a driveshaft though the center area of the tank, the fuel tank is a saddle configuration. Because of the saddle shape of the tank two fuel tank modules are required. The primary fuel tank module is located on the right side of the tank. The secondary fuel tank module is located on the left side of the tank.

Fuel Fill Pipe

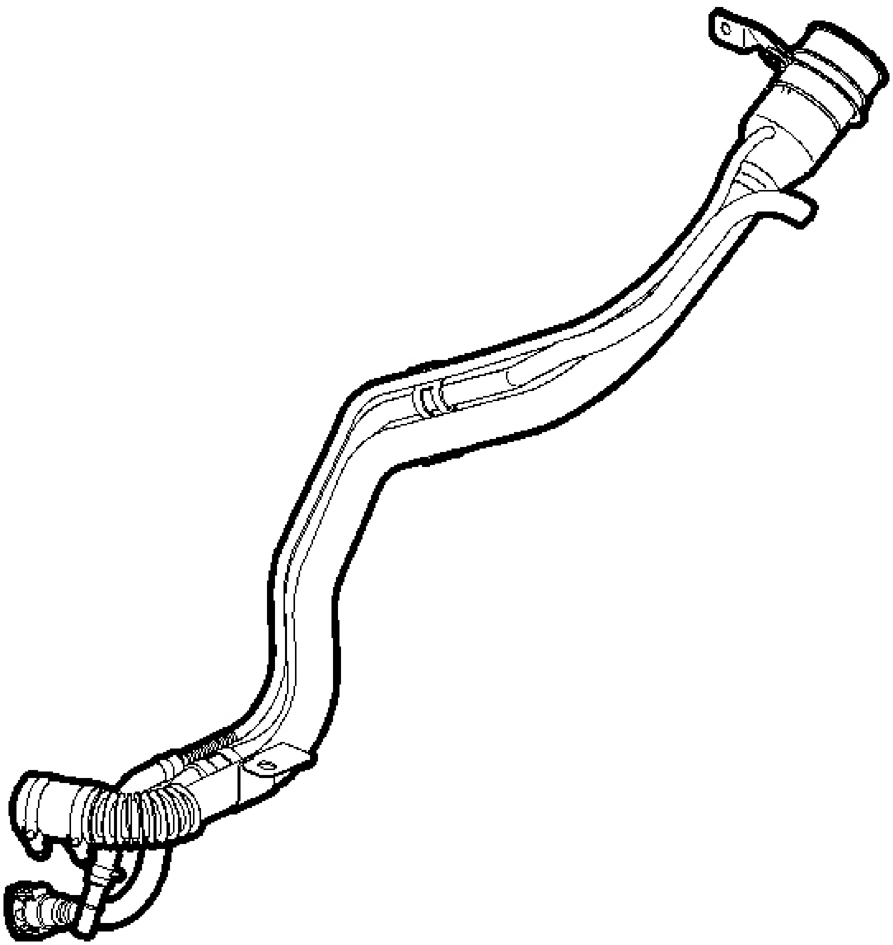


Fig. 177: View Of Fuel Fill Pipe
Courtesy of GENERAL MOTORS CORP.

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

Fuel Filler Cap

NOTE:	**If a fuel tank filler cap requires replacement, use only a fuel tank filler cap with the same features. Failure to use the correct fuel tank filler cap can result in a serious malfunction of the fuel and EVAP system.**

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

Primary Fuel Tank Module

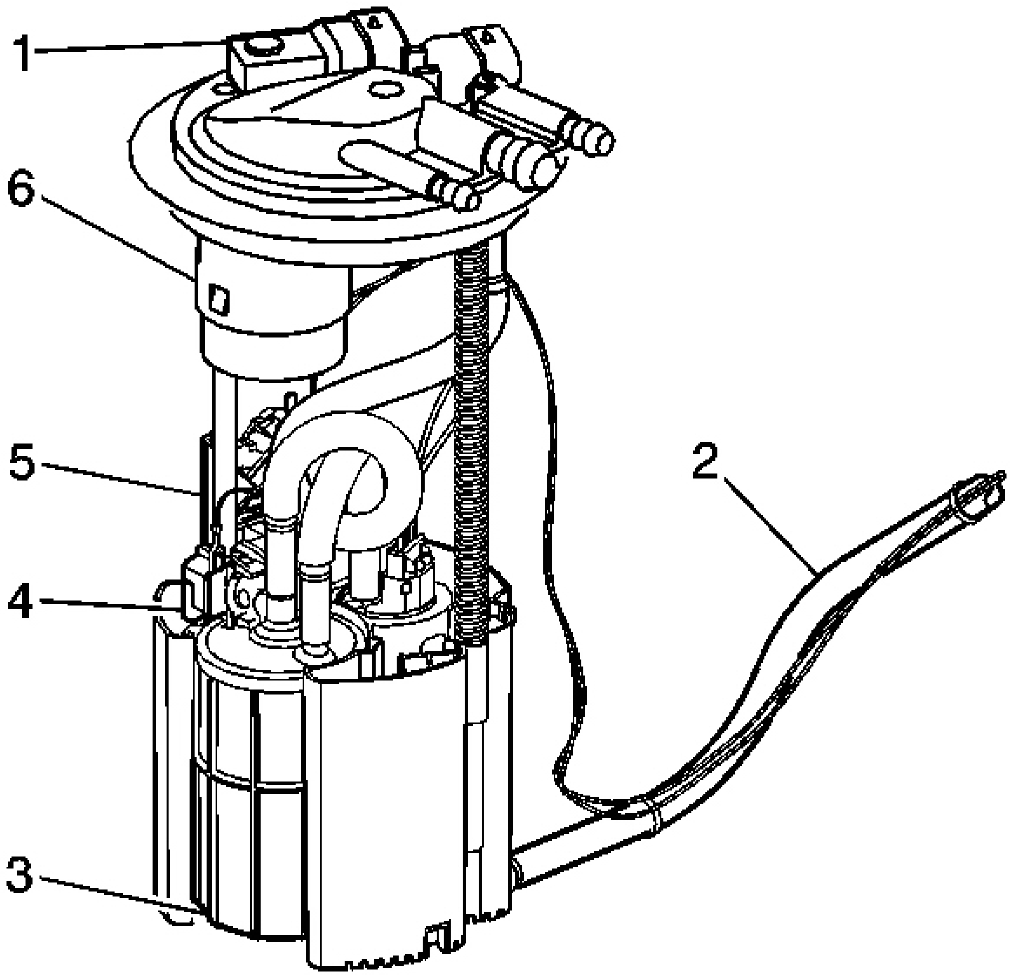


Fig. 178: View Of Primary Fuel Tank Module
Courtesy of GENERAL MOTORS CORP.

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

- The fuel level sensor (4)
- The fuel pump and reservoir assembly
- The fuel strainer
- The primary jet pump
- The secondary jet pump
- The fill limiter vent valve (6)
- The fuel pressure sensor (1)
- The fuel filter (3)
- The fuel pressure regulator (5)
- The fuel transfer pipe (2)

Secondary Fuel Tank Module

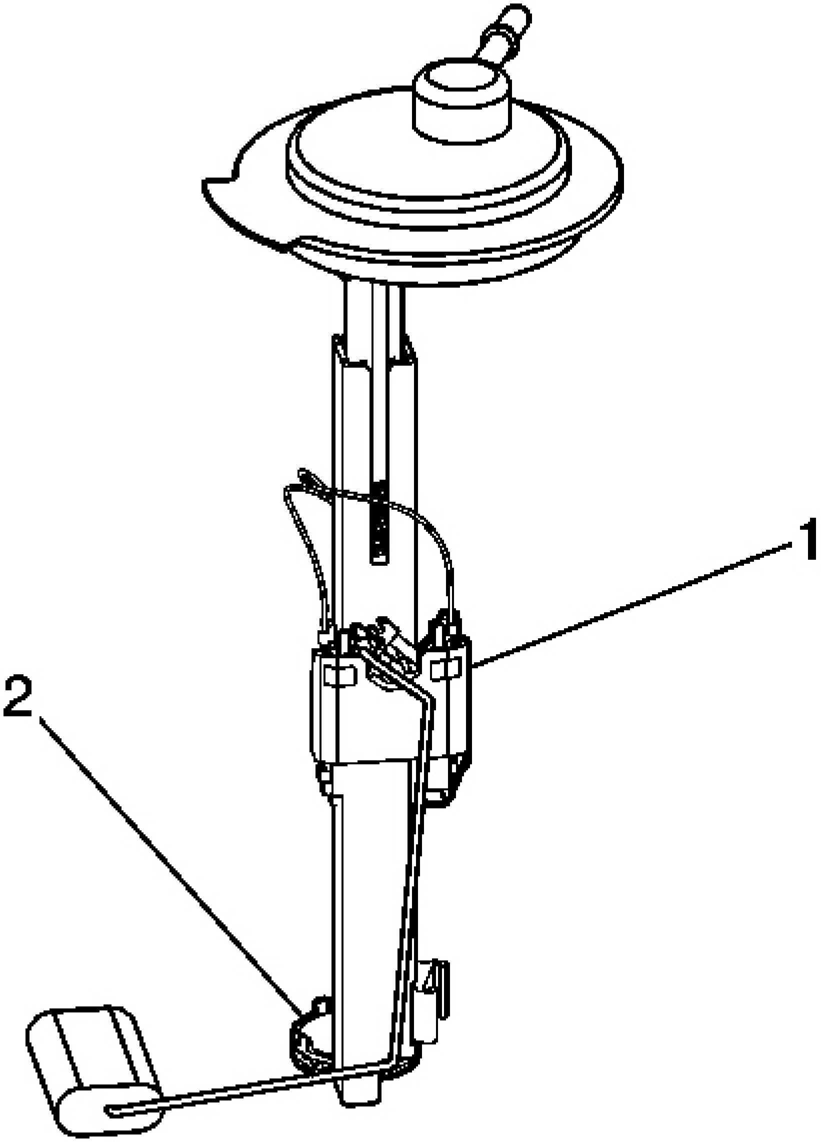


Fig. 179: View Of Secondary Fuel Tank Module
Courtesy of GENERAL MOTORS CORP.

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

- The fuel level sensor (1)

- The fuel pick-up (2)

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 control module sends the fuel level information via the CAN serial data to the body control module (BCM). The instrument panel cluster (IPC) displays the fuel level as determined by the BCM. This information is used for the IPC fuel gage and the low fuel warning indicator, if applicable. The control module also monitors the fuel level input for various diagnostics.

Fuel Pump

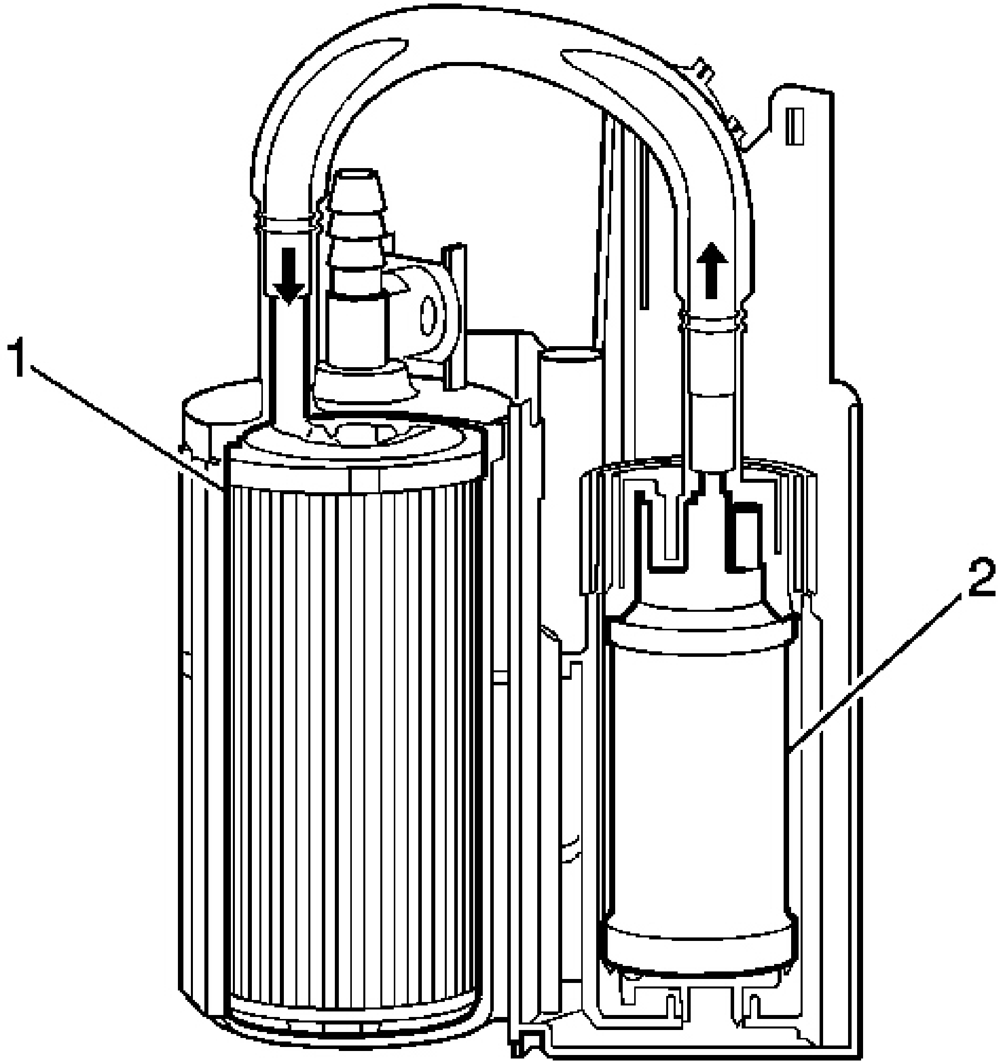


Fig. 180: View Of Fuel Pump
Courtesy of GENERAL MOTORS CORP.

The fuel pump (2) is mounted in the primary fuel tank module reservoir. The fuel pump is an electric high-pressure pump. Fuel is pumped to the fuel injection system at a specified flow and pressure. The fuel pump delivers a constant flow of fuel to the engine even during low fuel conditions and aggressive vehicle maneuvers. The control module controls the electric fuel pump operation through a fuel pump relay.

Primary and Secondary Jet Pumps

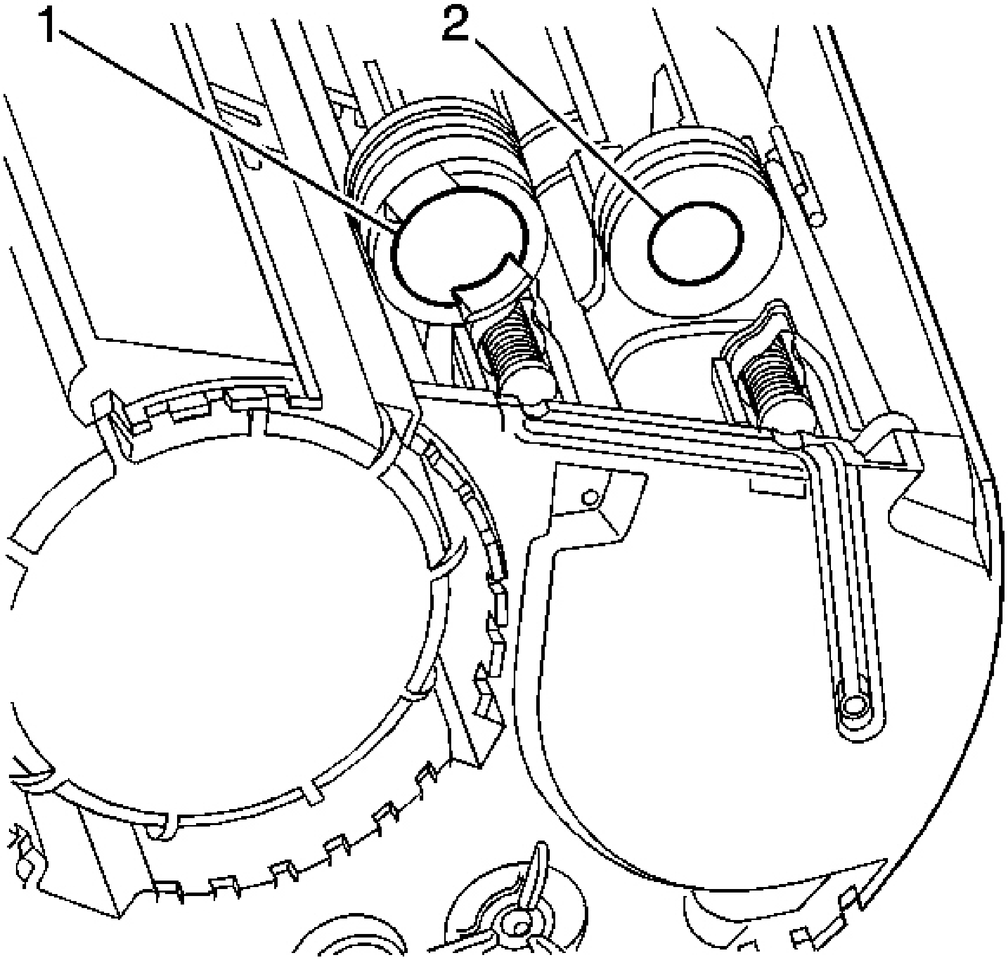


Fig. 181: View Of Primary & Secondary Jet Pumps
Courtesy of GENERAL MOTORS CORP.

The primary jet pump (1) is located in the primary fuel tank 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 (2) through a restrictive orifice located on the pump cover. The primary jet pump fills the reservoir of the primary fuel tank module.

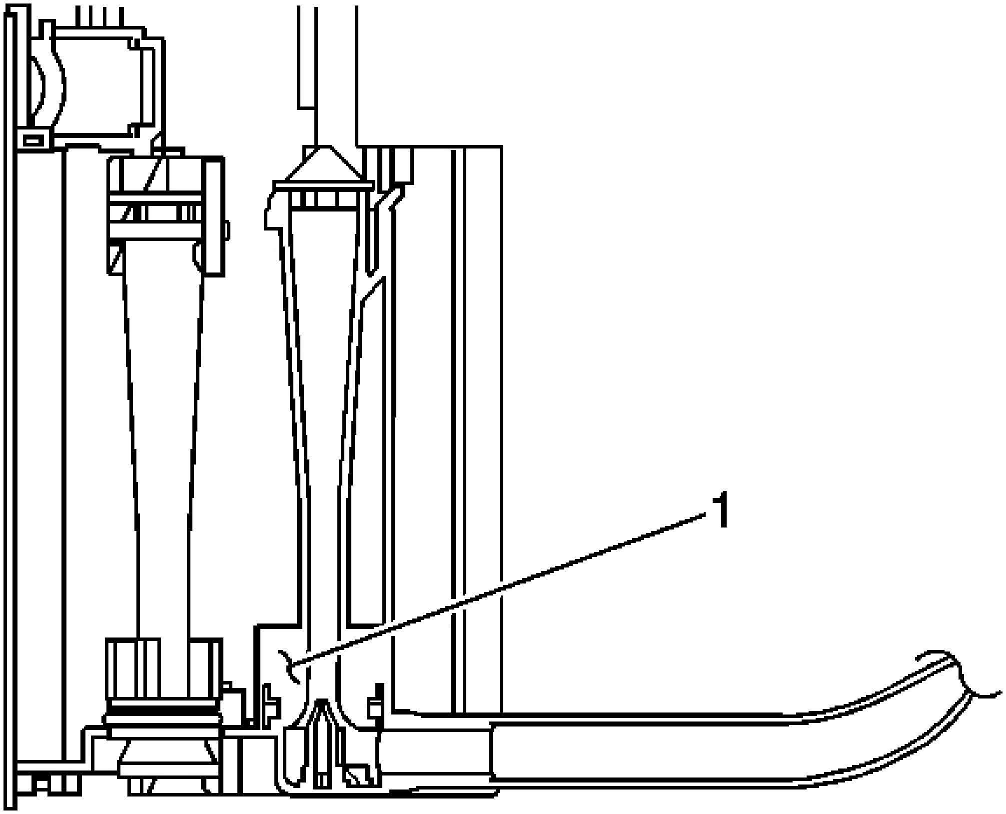


Fig. 182: View Of Secondary Jet Pump
Courtesy of GENERAL MOTORS CORP.

The secondary jet pump (1) 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.

Fuel Strainer

The fuel strainer attaches to the lower end of the primary fuel tank 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.

Fuel Filter

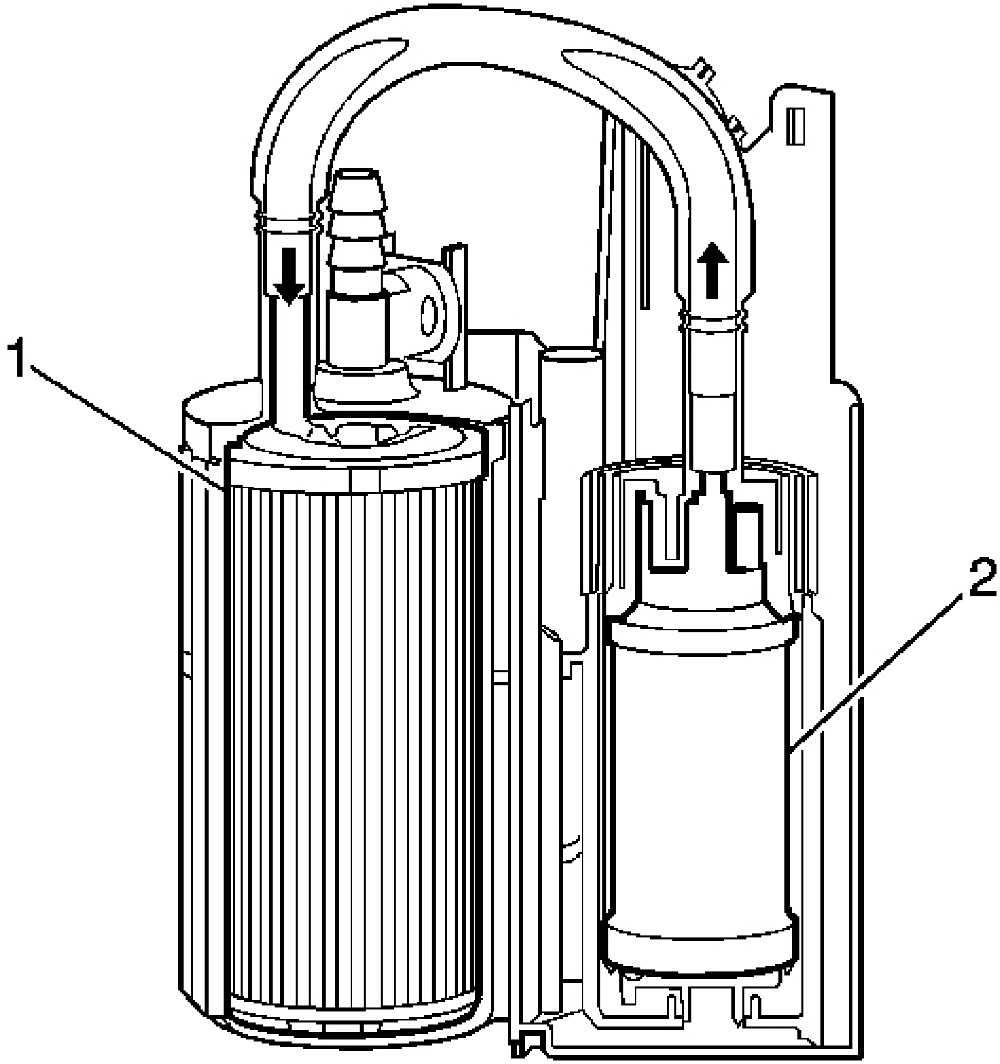


Fig. 183: View Of Fuel Filter
Courtesy of GENERAL MOTORS CORP.

The fuel filter (1) is located in the primary fuel tank module. The paper filter element traps particles in the fuel that may damage the fuel injection system. The filter housing is made to withstand maximum fuel system pressure, exposure to fuel additives, and changes in temperature.

Fuel Pressure Regulator

The fuel pressure regulator is integrated into the fuel filter cover on the primary fuel tank module. The fuel pressure regulator uses a spring with a preset tension and a stainless steel ball inserted into a precision ground seat in order to regulate fuel pressure. This type of fuel pressure regulator is not serviceable.

Fuel Feed Pipes

The fuel feed pipe carries fuel from the fuel tank to the fuel injection system. The fuel pipe consists of 3 sections:

- The rear fuel pipe is located from the top of the fuel tank to the chassis fuel pipe. The rear fuel pipe is constructed of nylon.
- The chassis fuel pipe is located under the vehicle and connects the rear fuel pipe to the engine compartment fuel pipe. The chassis fuel pipe is constructed of steel with a section of rubber hose.
- The engine compartment fuel pipe connects the chassis fuel feed pipe to the fuel rail. The engine compartment fuel pipe is constructed of steel.

Nylon Fuel Pipes

CAUTION: 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.**
- **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. The following 2 sizes of nylon pipes are used:

- 9.53 mm (3/8 in) ID for the fuel feed
- 12.7 mm (1/2 in) ID for the vent

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.

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.

Fuel Pipe O-rings

O-rings seal the threaded connections in the fuel system. The fuel system O-ring seals are made of special material. Service the O-ring seals with the correct service part.

Fuel Rail Assembly

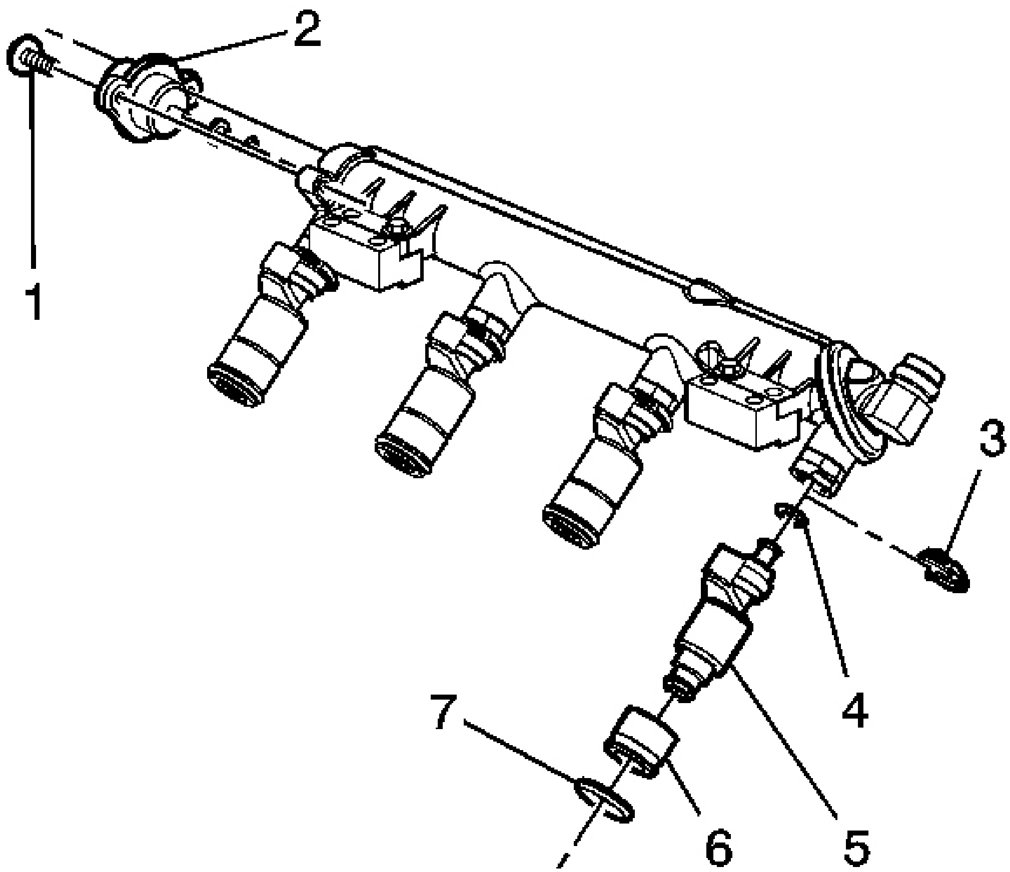


Fig. 184: View Of Fuel Rail Assembly
Courtesy of GENERAL MOTORS CORP.

The fuel rail assembly attaches to the engine intake manifold. The fuel rail assembly performs the following functions:

- Positions the injectors (5) in the intake manifold
- Distributes fuel evenly to the injectors
- Integrates the fuel pulse dampener (2) into the fuel metering system

Fuel Injectors

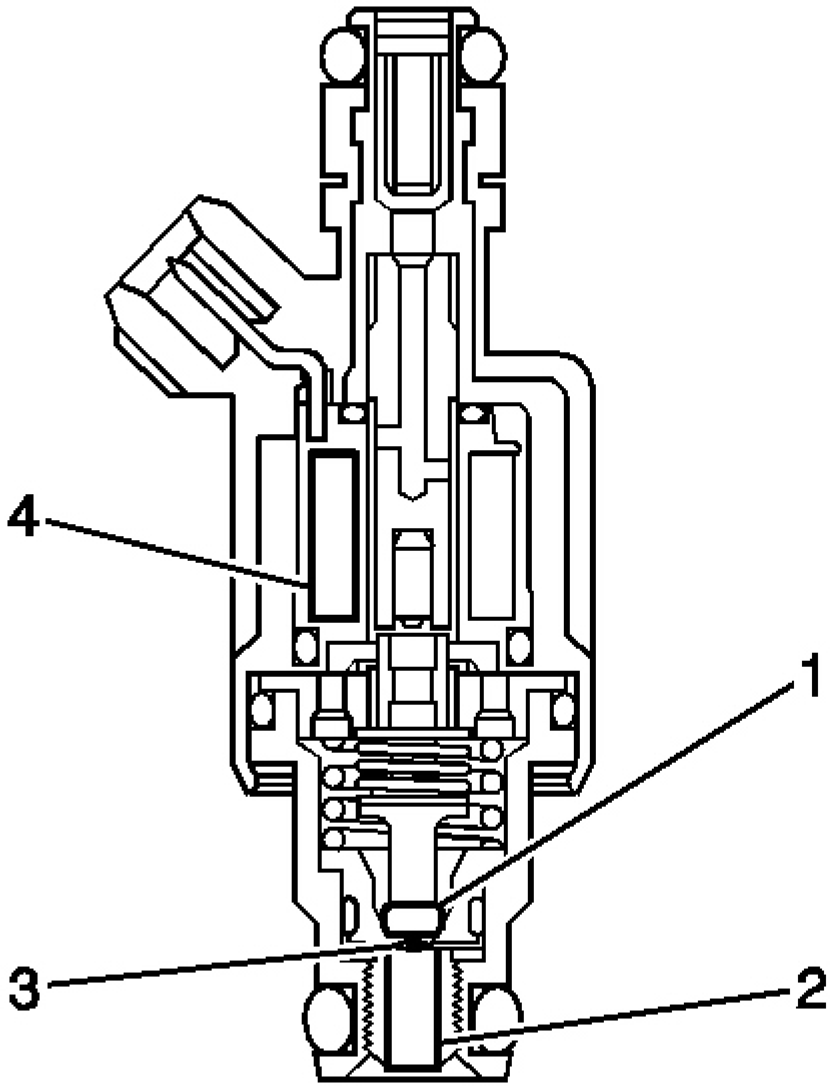


Fig. 185: Fuel Injector Assembly Cross Sectional View
Courtesy of GENERAL MOTORS CORP.

The fuel injector assembly is a solenoid device controlled by the control module that meters pressurized fuel to a single engine cylinder. The control module energizes the high-impedance, 12 ohm, injector solenoid (4) to open a normally closed ball valve (1). This allows fuel to flow into the top of the injector, past the ball valve, and through a director plate (3) at the injector outlet. The director plate has machined holes that control the fuel flow, generating a spray of finely atomized fuel at the injector tip. Fuel from the injector tip is directed at the intake valve, causing the fuel to become further atomized and vaporized before entering the combustion chamber. This fine atomization improves fuel economy and emissions.

Fuel Pulse Dampener

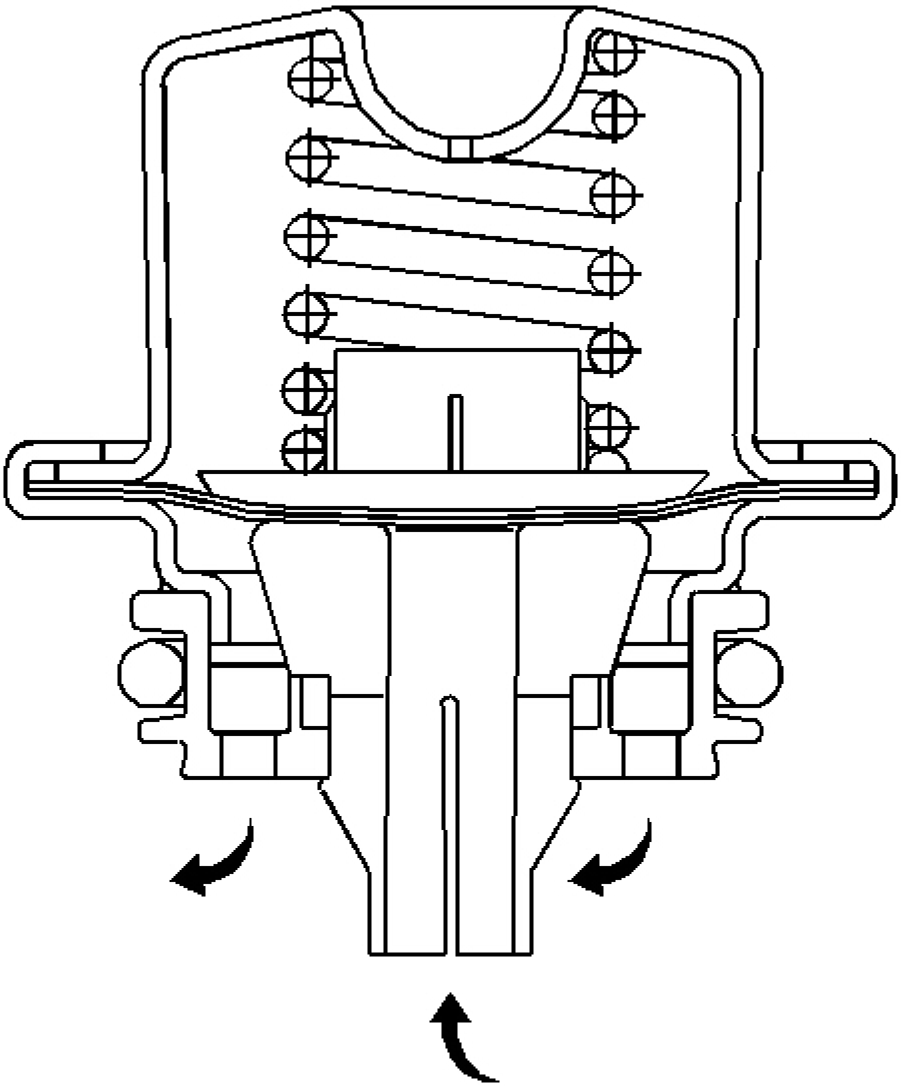


Fig. 186: View Of Fuel Pulse Dampener
Courtesy of GENERAL MOTORS CORP.

The rapid opening and closing of the fuel injectors cause pressure fluctuation in the fuel rail. The result is that the amount of injected fuel will be more or less than the desired amount. Mounted on the fuel rail, the pulsation damper reduces these pressure fluctuations. When pressure suddenly begins to drop, the spring-loaded diaphragm extends slightly decreasing fuel rail volume. This will momentarily prevent fuel pressure from becoming too low.

Fuel Metering Modes of Operation

The control module monitors voltages from several sensors in order to determine how much fuel to give the engine. The control module 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.

Starting Mode

When the ignition is first turned ON, the control module energizes the fuel pump relay for 2 seconds. This allows the fuel pump to build pressure in the fuel system. The control module calculates the air/fuel ratio based on inputs from the engine coolant temperature (ECT), manifold absolute pressure (MAP), and throttle position (TP) sensors. The system stays in starting mode until the engine speed reaches a predetermined RPM.

Clear Flood Mode

If the engine floods, clear the engine by pressing the accelerator pedal down to the floor and then crank the engine. When the TP sensor is at wide open throttle (WOT), the control module reduces the fuel injector pulse width in order to increase the air to fuel ratio. The control module 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 control module returns to the starting mode.

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 control module ignores the signal from the heated oxygen sensor (HO2S). The control module calculates the air/fuel ratio based on inputs from the ECT, MAP, and TP 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 this 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 control module 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.

Acceleration Mode

When the driver pushes on the accelerator pedal, air flow into the cylinders increases rapidly. To prevent possible hesitation, the control module increases the pulse width to the injectors to provide extra fuel during acceleration. This is also known as power enrichment. The control module determines the amount of fuel required based upon the TP, the ECT, the MAP, and the engine speed.

Deceleration Mode

When the driver releases the accelerator pedal, air flow into the engine is reduced. The control module monitors the corresponding changes in the TP and the MAP. The control module 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.

Battery Voltage Correction Mode

When the battery voltage is low, the control module 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

Fuel Cutoff Mode

The control module 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

Fuel Trim

The control module controls the air/fuel metering system in order to provide the best possible combination of driveability, fuel economy, and emission control. The control module monitors the HO2S 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 (FT) values are around 0 percent for both short and long term FT. A positive FT value indicates the control module is adding fuel in order to compensate for a lean condition by increasing the pulse width. A negative FT value indicates that the control module 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 FT values. The short term FT values change rapidly in response to the HO2S signal voltage. These changes fine tune the engine fueling. The long term FT makes coarse adjustments to fueling in order to re-center and restore control to short term FT. A scan tool can be used to monitor the short and long term FT values. The long term FT diagnostic is based on an average of several of the long term speed load learn cells. The control module selects the cells based on the engine speed and engine load. If the control module detects an excessively lean or rich condition, the control module will set a FT DTC.

EVAPORATIVE EMISSION (EVAP) CONTROL SYSTEM DESCRIPTION

EVAP System Operation

The evaporative emission (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 vapor pipe, into the EVAP canister. Carbon in the canister absorbs and stores the fuel vapors. Excess pressure is vented through the vent line and EVAP vent valve to atmosphere. The EVAP canister stores the fuel vapors until the engine is able to use them. At an appropriate time, the control module will command the EVAP purge valve ON, open, allowing engine vacuum to be applied to the EVAP canister. With the EVAP vent valve OFF, open, fresh air will be drawn through the valve and vent line 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 pipe and EVAP purge valve into the intake manifold to be consumed during normal combustion. The control module uses several tests to determine if the EVAP system is leaking.

Large Leak Test

This tests for large leaks and blockages in the EVAP system. The control module will command the EVAP vent valve ON, closed, and command the EVAP purge valve ON, open, with the engine running, allowing engine vacuum into the EVAP system. The control module monitors the fuel tank pressure (FTP) sensor to verify that the system is able to reach a predetermined level of vacuum within a set amount of time. The control module then commands the EVAP purge valve OFF, closed, sealing the system and monitors the vacuum level for decay. If the control module does not detect that the predetermined vacuum level was achieved, or the vacuum decay is more than a calibrated level on 2 consecutive tests, a DTC P0440 will set.

Small Leak Test

If the large leak test passes, the control module will test for small leaks by continuing to monitor the FTP sensor for a change in voltage over a period of time. If the decay rate is more than a calibrated value, the control module will rerun the test. If the test fails again, a DTC P0442 will set.

Canister Vent Restriction Test

If the EVAP vent system is restricted, fuel vapors will not be properly purged from the EVAP canister. The control module tests this by commanding the EVAP purge valve ON, open, and commanding the EVAP vent valve OFF, open, and monitoring the FTP sensor for an increase in vacuum. If vacuum increases more than a calibrated value, DTC P0446 will set.

Purge Valve Leak Test

If the EVAP purge valve does not seal properly, fuel vapors could enter the engine at an undesired time causing driveability concerns. The control module tests for this by commanding the EVAP purge valve OFF, closed, and vent valve OFF, open, sealing the system, and monitoring the FTP for an increase in vacuum. If the control module detects that EVAP system vacuum increases above a calibrated value, DTC P1441 will set.

EVAP System Components

The EVAP system consists of the following components:

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 control module determines that the vapor can be consumed in the normal combustion process.

EVAP Purge Valve

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

EVAP Vent Valve

The EVAP vent valve controls fresh airflow into the EVAP canister. The valve is normally open. The control module will command the valve closed during some EVAP tests, allowing the system to be tested for leaks.

Fuel Tank Pressure Sensor

The FTP sensor measures the difference between the pressure or vacuum in the fuel tank and outside air pressure. The control module provides a 5-volt reference and a ground to the FTP sensor. The FTP sensor provides a signal voltage back to the control module that can vary between 0.1-4.9 volts. As FTP increases, FTP sensor voltage decreases, high pressure = low voltage. As FTP decreases, FTP voltage increases, low pressure or vacuum = high voltage.

EVAP Service Port

The EVAP service port is located in the EVAP purge pipe between the EVAP purge valve and the EVAP canister. The service port is identified by a green colored cap.

ELECTRONIC IGNITION (EI) SYSTEM DESCRIPTION

The electronic ignition (EI) 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 one coil for each pair of cylinders. Each pair of cylinders that are at top dead center (TDC) at the same time are known as companion cylinders. The cylinder that is at TDC of its compression stroke is called the event cylinder. The cylinder that is at TDC of its exhaust stroke is called the waste cylinder. When the ignition coil is triggered, both companion cylinder spark plugs fire at the same time, completing a series circuit. Because the lower pressure inside the waste cylinder offers very little resistance, the event cylinder uses most of the available voltage to produce a very high energy spark. This is known as waste spark ignition. The ignition coils and ignition control module (ICM) are contained within one assembly. The ignition coil/ICM assembly is mounted in the center of the engine camshaft cover, with short boots connecting the ignition coils to the spark plugs. The ignition coil driver modules within the ICM are commanded ON/OFF by the engine control module (ECM). The EI system consists of the following components:

Crankshaft Reluctor Wheel

The crankshaft reluctor wheel is part of the crankshaft. The reluctor wheel has seven machined notches, six of which are equally spaced 60 degrees apart. The seventh notch is spaced 10 degrees after one of the 60-degree notches. The 10-degree notch is used to synchronize the engine position, while the other notches are used to provide cylinder location during a revolution.

Crankshaft Position (CKP) Sensor

The crankshaft position (CKP) sensor is a permanent magnet generator, known as a variable reluctance sensor. The CKP sensor produces an AC voltage of different amplitude and frequency. The frequency depends on the velocity of the crankshaft. The AC voltage output depends on the crankshaft position and the battery voltage. The CKP sensor works in conjunction with a 7X reluctor wheel attached to the crankshaft. The CKP sensor produces seven pulses for each revolution of the crankshaft. The pulse from the 10-degree notch is known as the sync pulse. The sync pulse is used to synchronize the coil firing sequence with the crankshaft position. The CKP sensor is used for ignition timing, the fuel injector timing, misfire diagnostics and tachometer display. The CKP sensor is connected tot he ECM by a signal circuit and a low reference circuit.

Ignition Control Module (ICM) and Ignition Coils

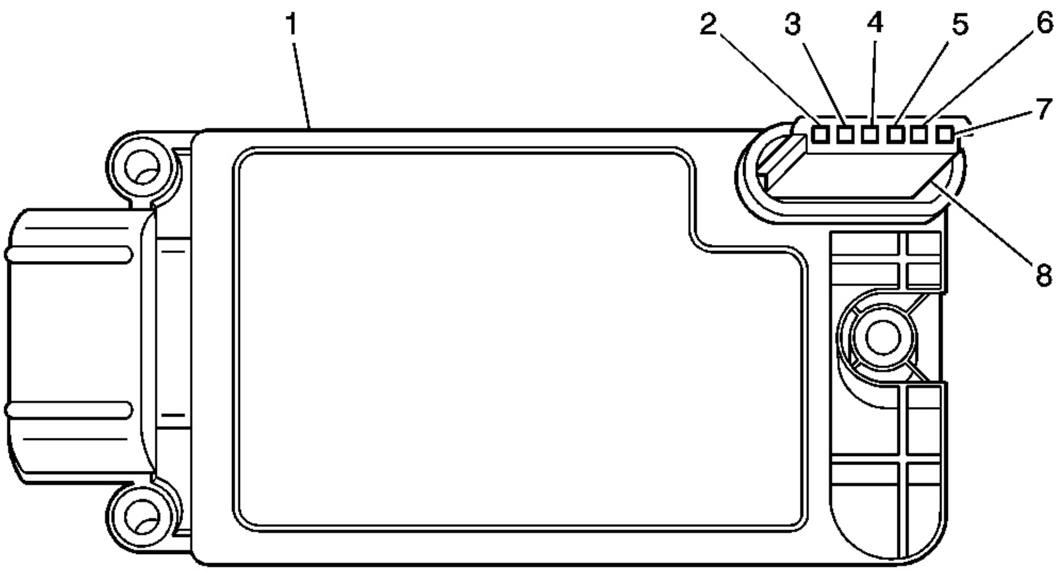


Fig. 187: View Of Ignition Control Module (ICM) & Ignition Coils
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 187

Callout	Component Name
1	Ignition Control Module (ICM)
2	Compression Sense Ignition (CSI) Pickup

3	Not Used
4	2-3 Coil Control
5	Ignition Voltage
6	1-4 Coil Control
7	Not Used
8	Interconnect

The powertrain control module (PCM) supplies a signal on each of the ignition control (IC) timing control circuits to the ignition control module (ICM). The ICM fires the correct ignition coil at the correct time based on the signals. The ICM detects if cylinder 1 or cylinder 3 is on the compression stroke by sensing the secondary voltage and polarity of each side of the ignition coil. The ICM detects this voltage with sensing circuitry integrated into each ignition coil. The higher voltage is on the compressing cylinder. This is called compression sense ignition. The ICM provides a synthesized cam signal to the PCM based on these inputs. The PCM uses the cam signal to synchronize fuel injection. This system consists of the following circuits:

- An ignition voltage circuit
- A ground circuit
- A camshaft position (CMP) sensor signal circuit
- An IC timing control circuit for cylinders #1 and #4
- An IC timing control B circuit for cylinders #2 and #3

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 include the following:

- The throttle position (TP) sensor
- The engine coolant temperature (ECT) sensor
- The intake air temperature (IAT) sensor
- The vehicle speed sensor (VSS)
- The transmission gear position or range information sensors
- The engine knock sensors (KS)

Modes of Operation

There is one normal mode of operation during which the ECM controls spark. If the CKP pulses are lost the engine will not run. The loss of a CMP signal may result in a longer crank time since the ECM cannot determine which stroke the pistons are on. Diagnostic trouble codes are available to accurately diagnose the ignition system with a scan tool.

THROTTLE ACTUATOR CONTROL (TAC) SYSTEM DESCRIPTION

Purpose

The throttle actuator control (TAC) system delivers improved throttle response and greater reliability and eliminates the need for mechanical cable. The TAC system performs the following functions:

- Accelerator pedal position sensing
- Throttle positioning to meet driver and engine demands
- Throttle position sensing
- Internal diagnostics
- Cruise control functions
- Manage TAC electrical power consumption

The TAC system includes the following components:

- The accelerator pedal position (APP) sensors
- The throttle body assembly
- The engine control module (ECM)

Accelerator Pedal Position (APP) Sensor

The accelerator pedal contains 2 individual APP sensors within the assembly. The APP sensors 1 and 2 are potentiometer type sensors each with 3 circuits:

- A 5-volt reference circuit
- A low reference circuit
- A signal circuit

The APP sensors are used to determine the pedal angle. The ECM provides each APP sensor a 5-volt reference circuit and a low reference circuit. The APP sensors provide the ECM with signal voltage proportional to the pedal movement. The APP sensor 1 signal voltage at rest position is near the low reference and increases as the pedal is actuated. The APP sensor 2 signal voltage at rest position is near the 5-volt reference and decreases as the pedal is actuated.

Throttle Body Assembly

The throttle assembly contains the following components:

- The throttle blade
- The throttle actuator motor
- The throttle position (TP) sensor 1 and 2

The throttle body functions similar to a conventional throttle body with the following exceptions:

- An electric motor opens and closes the throttle valve.
- The throttle blade is spring loaded in both directions and the default position is slightly open.

- There are 2 individual TP sensors within the throttle body assembly.

The TP sensors are used to determine the throttle plate angle. The TP sensors provide the ECM with a signal voltage proportional to throttle plate movement. The TP sensor 1 signal voltage at closed throttle is near the 5-volt reference and decreases as the throttle plate is opened. The TP sensor 2 signal voltage at closed throttle is near the low reference and increases as the throttle plate is opened.

Engine Control Module

The ECM is the control center for the TAC system. The ECM determines the drivers intent and then calculates the appropriate throttle response. The ECM achieves throttle positioning by providing a pulse width modulated voltage to the TAC motor.

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 operation:

- Minimum pedal value-At key-up the ECM updates the learned minimum pedal value.
- Minimum TP values-At key-up the ECM updates the learned minimum TP value. In order to learn the minimum TP value, the throttle blade is moved to the closed position.
- Ice break mode-If the throttle 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 RPM, 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 idle by positioning the throttle position, or by controlling the fuel and spark if the throttle is turned off.

    - Ignore the accelerator pedal input.
- Engine shutdown mode-The ECM will disable fuel and de-energize the throttle actuator.

KNOCK SENSOR (KS) SYSTEM DESCRIPTION

Purpose

The knock sensor (KS) system enables the control module to control the ignition timing for the best possible performance while protecting the engine from potentially damaging levels of detonation. The control module uses the KS system to test for abnormal engine noise that may indicate detonation, also known as spark knock.

Sensor Description

This KS system uses one or two flat response two-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 are dependant upon the level of knock that the KS detects. The control module receives the KS signal through a signal circuit. The KS ground is supplied by the control module through a low reference circuit.

The control module learns a minimum noise level, or background noise, at idle from the KS and uses calibrated values for the rest of the RPM range. The control module uses the minimum noise level to calculate a noise channel. A normal KS 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 KS signal, keeping the signal within the channel. In order to determine which cylinders are knocking, the control module only uses KS 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 control module has determined that knock is present, it will retard the ignition timing to attempt to eliminate the knock. The control module will always try to work back to a zero compensation level, or no spark retard. An abnormal KS signal will stay outside of the noise channel or will not be present. KS diagnostics are calibrated to detect faults with the KS circuitry inside the control module, the KS wiring, or the KS 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.

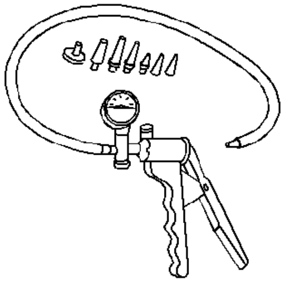
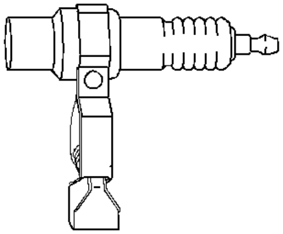
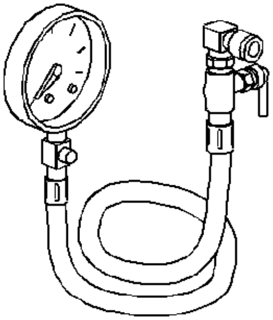
AIR INTAKE SYSTEM DESCRIPTION

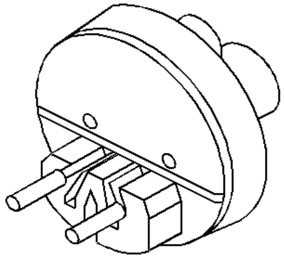
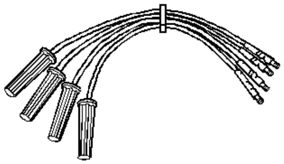
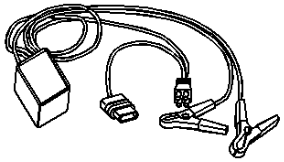
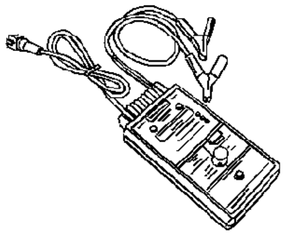
The primary function of the air intake system is to provide filtered air to the engine. The system uses a cleaner element mounted in a housing. The cleaner element housing is remotely mounted. Intake ducts route the incoming air into the throttle body. The secondary function of the air intake system is to muffle air induction noise. This is achieved through the use of resonators attached to the air intake ducts. The resonators are tuned to the specific powertrain.

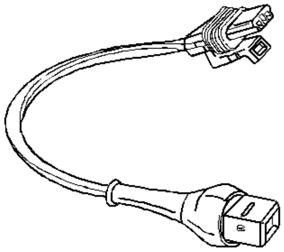
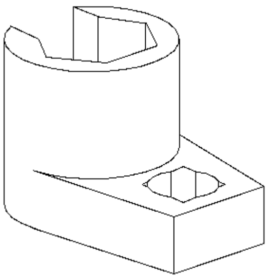
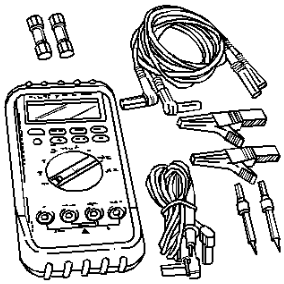
SPECIAL TOOLS AND EQUIPMENT

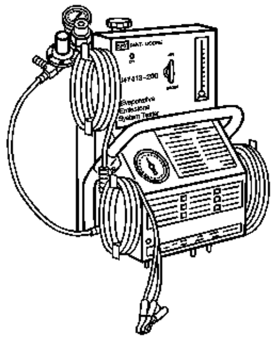
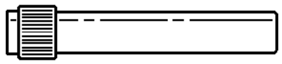
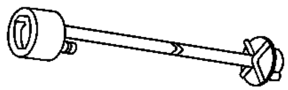
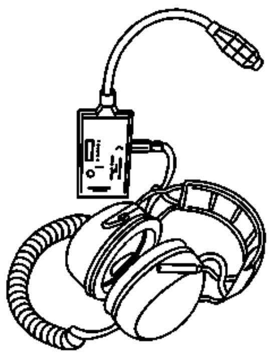
SPECIAL TOOLS

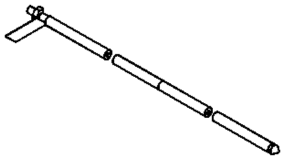
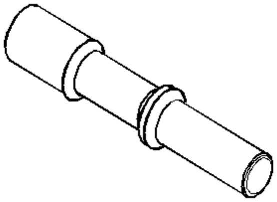
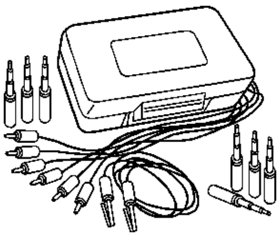
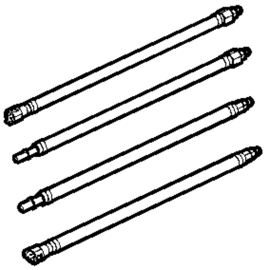
Special Tools

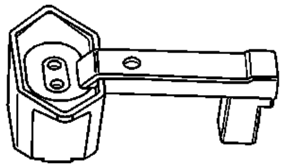
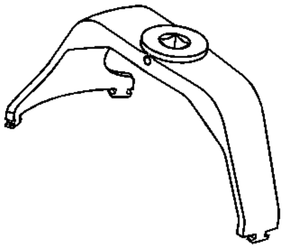
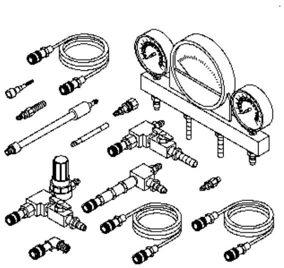
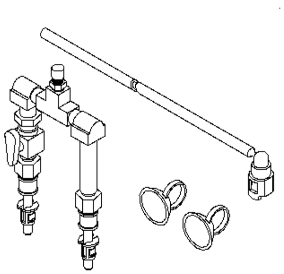
Illustration	Tool Number/ Description
	J 23738-A (SA9180NE) Mityvac (Vacuum Tester)
	J 26792 (SA9199Z) Spark Tester
	J 34730-1A Fuel Pressure Gage
	J 34730-405 Injector Test Lamp (Noid Light)

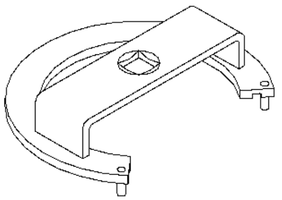
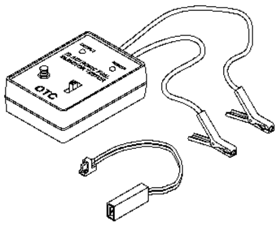
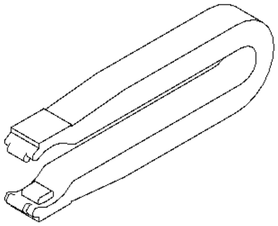
	
	J 36012-A (J 43883) Ignition System Diagnostic Harness
	J 37027-1A (SA9195E) IAC Motor Driver You may also use an IAC Motor Driver from one of the following approved manufactures listed below: • OTC • Thexton • CTI • Snap On • MAC Tools • NAPA/Balkamp
	J 39021 Fuel Injector Coil and Balance Tester

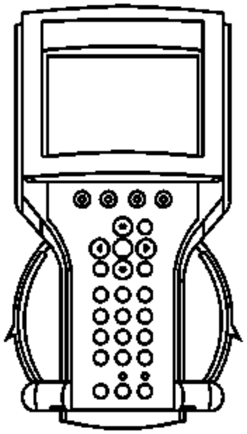
	J 39021-380 Injector Test Adapter
	J 39194-C Oxygen Sensor Wrench
	J 39200 (SA91114NE) High Impedance Multimeter (Digital Multimeter-DMM)
	J 41413-200 (J 41413-100) Evaporative Emissions System Tester (EEST)

	
	J 41413-VLV EVAP Service Port Vent Fitting
	GE 41415-50 Interrupted Thread Fuel Tank Cap Adapter
	J 41416 Ultrasonic Leak Detector
	J 42960-1 (SA9804E) Fuel Tank Siphoning Hose

	
	J 42960-2 (SA9804E) Fuel Flapper Door Holder
	J 43907 Connector Test Adapter Kit
	J 43937 Fuel Pressure Adapter Lines
	J 44175 Fuel Composition Tester

	
	J 45722 Fuel Tank Lock Ring Remover
	SA9127E Gage Bar Set
	SA9127E-7 Fuel Pressure/Flow Adapter
	SA9156E

	Fuel Tank Lock Ring Remover
	SA9182E Electronic Fuel Injector Tester
	SA9805E Fuel Line Separator
	7000061 (7000081-SAT4-32MG) Tech II Diagnostic Scan Tool



SPECIFICATIONS

TEMPERATURE VS RESISTANCE - ENGINE COOLANT TEMPERATURE (ECT) SENSOR

Temperature vs Resistance - Engine Coolant Temperature (ECT) Sensor

°C	°F	OHMS
Temperature vs Resistance Values (Approximate)		
80	176	315
70	158	435
60	140	580
50	122	810
45	113	940
40	104	1,150
35	95	1,360
30	86	1,600
25	77	2,000
20	68	2,400
15	59	3,000
10	50	3,600
5	41	4,600
0	32	5,700
-5	23	7,400
-10	14	9,800
-15	5	12,700
-20	-4	16,000

TEMPERATURE VS RESISTANCE - INTAKE AIR TEMPERATURE (IAT) SENSOR

Temperature vs Resistance - Intake Air Temperature (IAT) Sensor

°C	°F	OHMS
Temperature vs Resistance Values (Approximate)		
80	176	315
70	158	435
60	140	580
50	122	810
45	113	940
40	104	1,150
35	95	1,360

30	86	1,600
25	77	2,000
20	68	2,400
15	59	3,000
10	50	3,600
5	41	4,600
0	32	5,700
-5	23	7,400
-10	14	9,800
-15	5	12,700
-20	-4	16,000

IGNITION SYSTEM SPECIFICATIONS

Ignition System Specifications

Application	Specification	
	Metric	English
Firing Order	1-4-2-5-3-6	
Spark Plug Torque	18 N.m	13 lb ft
Spark Plug Gap	1.0-1.1 mm	0.039-0.043 in
Spark Plug Type	IZFR5K-11 NGK SKJ16DR-M11 DENSO	

FASTENER TIGHTENING SPECIFICATIONS

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Accelerator Pedal Position (APP) Assembly Bracket Fastener	25 N.m	18 lb ft
Air Cleaner Assembly Fastener	10 N.m	89 lb in
Air Cleaner Inlet Duct Fastener	10 N.m	89 lb in
Air Cleaner Outlet Resonator Duct Clamp	4 N.m	35 lb in
Air Cleaner Outlet Resonator Duct Fastener	10 N.m	89 lb in
Camshaft Position (CMP) Sensor Fastener	4 N.m	35 lb ft
Crankshaft Position (CKP) Sensor Fastener	9.8 N.m	88 lb in
Engine Coolant Temperature (ECT) Sensor	18 N.m	13 lb ft
Evaporative Emission (EVAP) Canister Purge Valve Fastener	9.8 N.m	88 lb in
EVAP Canister Support Cover Fastener	8 N.m	71 lb in
Exhaust Gas Recirculation (EGR) Valve	22 N.m	16 lb ft
Fuel Filler Pipe Bracket Fastener-Lower	10 N.m	89 lb in
Fuel Filler Pipe Bracket Fastener-Upper	2.5 N.m	17 lb in

Fuel Rail Fastener	9.8 N.m	87 lb in
Fuel Rail Inlet Pipe Fastener	9.8 N.m	87 lb in
Fuel Tank Retaining Strap Fastener	25 N.m	18 lb ft
Heated Oxygen Sensor (HO2S) 1	44 N.m	32 lb ft
Heated Oxygen Sensor (HO2S) 2	44 N.m	32 lb ft
Ignition Coil Fastener	12 N.m	8.8 lb ft
Intake Air Temperature (IAT) Sensor 2	18 N.m	13 lb ft
Intake Manifold Cover Fasteners	12 N.m	8.8 lb ft
Knock Sensor (KS) Nut	31 N.m	16 lb ft
Manifold Absolute Pressure (MAP) Sensor Fastener	4 N.m	35 lb in
Negative Battery Cable Terminal Retainer Fastener	17 N.m	13 lb ft
Positive Crankcase Ventilation (PCV) Valve Bolt	12 N.m	8.8 lb ft
Powertrain Control Module (PCM) Mounting Fastener	12 N.m	8.8 lb ft
Rocker Arm Oil Control Solenoid Valve Bolt	12 N.m	8.8 lb ft
Rocker Arm Oil Pressure Switch	22 N.m	16 lb ft
Spark Plug	18 N.m	13 lb ft
Throttle Body Fasteners	22 N.m	16 lb ft

DIAGNOSTIC TROUBLE CODE (DTC) TYPE DEFINITIONS

Emissions Related DTCs

Action Taken When the DTC Sets - Type A

The control module illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.

Action Taken When the DTC Sets - Type B

The control module illuminates the MIL on the second consecutive ignition cycle that the diagnostic runs and fails.

Conditions for Clearing the MIL/DTC - Type A or Type B

- The control module turns OFF the MIL after 3 consecutive ignition cycles that the diagnostic runs and does not fail.
- A current DTC Last Test Failed clears when the diagnostic runs and passes.
- Use a scan tool in order to clear the MIL and the DTC.

Non-Emissions Related DTCs

Action Taken When the DTC Sets - Type C

- The control module stores the DTC information into memory when the diagnostic runs and fails.
- The MIL will not illuminate.

- The Service Vehicle Soon indicator on the instrument panel may illuminate.

Action Taken When the DTC Sets - Type D

- The control module stores the DTC information into memory when the diagnostic runs and fails.
- The MIL will not illuminate.

Conditions for Clearing the DTC - Type C or Type D

- A last test failed, or current DTC, clears when the diagnostic runs and passes.
- Use a scan tool in order to clear the DTC.

DIAGNOSTIC TROUBLE CODE (DTC) TYPE(S)

Diagnostic Trouble Code (DTC) Type(s)

Diagnostic Trouble Code (DTC)	Type
P0030 HO2S Heater Control Circuit Bank 1 Sensor 1	A
P0036 HO2S Heater Control Circuit Bank 1 Sensor 2	A
P0050 HO2S Heater Control Circuit Bank 2 Sensor 1	A
P0056 HO2S Heater Control Circuit Bank 2 Sensor 2	A
P0097 Intake Air Temperature (IAT) Sensor 2 Circuit Low Voltage	A
P0098 Intake Air Temperature (IAT) Sensor 2 Circuit High Voltage	A
P0107 Manifold Absolute Pressure (MAP) Sensor Circuit Low Voltage	A
P0108 Manifold Absolute Pressure (MAP) Sensor Circuit High Voltage	A
P0112 Intake Air Temperature (IAT) Sensor 1 Circuit Low Voltage	A
P0113 Intake Air Temperature (IAT) Sensor 1 Circuit High Voltage	A
P0116 Engine Coolant Temperature (ECT) Sensor Performance	B
P0117 Engine Coolant Temperature (ECT) Sensor Circuit Low Voltage	A
P0118 Engine Coolant Temperature (ECT) Sensor Circuit High Voltage	A
P0122 Throttle Position (TP) Sensor Circuit Low Voltage	A
P0123 Throttle Position (TP) Sensor Circuit High Voltage	A
P0125 Engine Coolant Temperature (ECT) Excessive Time to Closed Loop Fuel Control	B
P0128 Engine Coolant Temperature (ECT) Below Thermostat Regulating Temperature	B
P0133 Heated Oxygen Sensor (HO2S) Slow Response Bank 1 Sensor 1	B
P0135 Heated Oxygen Sensor (HO2S) Heater Performance Bank 1 Sensor 1	A
P0137 Heated Oxygen Sensor (HO2S) Circuit Low Voltage Bank 1 Sensor 2	B
P0138 Heated Oxygen Sensor (HO2S) Circuit High Voltage Bank 1 Sensor 2	B
P0139 HO2S Slow Response Bank 1 Sensor 2	B
P0141 Heated Oxygen Sensor (HO2S) Heater Performance Bank 1 Sensor 2	A
P0153 Heated Oxygen Sensor (HO2S) Slow Response Bank 2 Sensor 1	B
P0155 Heated Oxygen Sensor (HO2S) Heater Performance Bank 2 Sensor 1	A
P0157 Heated Oxygen Sensor (HO2S) Circuit Low Voltage Bank 2 Sensor 2	B

P0158 Heated Oxygen Sensor (HO2S) Circuit High Voltage Bank 2 Sensor 2	B
P0159 Slow Response Bank 2 Sensor 2	B
P0161 Heated Oxygen Sensor (HO2S) Heater Performance Bank 2 Sensor 2	A
P0171 Fuel Trim System Lean Bank 1	B
P0172 Fuel Trim System Rich Bank 1	B
P0174 Fuel Trim System Lean Bank 2	B
P0175 Fuel Trim System Rich Bank 2	B
P0201 Injector 1 Control Circuit	A
P0202 Injector 2 Control Circuit	A
P0203 Injector 3 Control Circuit	A
P0204 Injector 4 Control Circuit	A
P0205 Injector 5 Control Circuit	A
P0206 Injector 6 Control Circuit	A
P0218 Transmission Fluid Overtemperature	C
P0222 Throttle Position (TP) Sensor 2 Circuit Low Voltage	A
P0223 Throttle Position (TP) Sensor 2 Circuit High Voltage	A
P0300 Engine Misfire Detected	B
P0301 Cylinder 1 Misfire Detected	B
P0302 Cylinder 2 Misfire Detected	B
P0303 Cylinder 3 Misfire Detected	B
P0304 Cylinder 4 Misfire Detected	B
P0305 Cylinder 5 Misfire Detected	B
P0306 Cylinder 6 Misfire Detected	B
P0325 Knock Sensor (KS) Circuit	A
P0335 Crankshaft Position (CKP) Sensor A Circuit	A
P0336 Crankshaft Position (CKP) Sensor A Performance	A
P0340 Camshaft Position (CMP) Sensor Circuit	A
P0341 Camshaft Position (CMP) Sensor Performance	A
P0385 Crankshaft Position (CKP) Sensor B Circuit	A
P0386 Crankshaft Position (CKP) Sensor B Performance	A
P0401 Exhaust Gas Recirculation (EGR) Flow Insufficient	B
P0403 Exhaust Gas Recirculation (EGR) Solenoid Control Circuit	A
P0404 Exhaust Gas Recirculation (EGR) Open Position Performance	B
P0406 Exhaust Gas Recirculation (EGR) Position Sensor Circuit High Voltage	A
P0420 Three Way Catalyst (TWC) System Low Efficiency Bank 1	B
P0430 Three Way Catalyst (TWC) System Low Efficiency Bank 2	B
P0442 Evaporative Emission (EVAP) System Small Leak Detected	B
P0443 Evaporative Emission (EVAP) Purge Solenoid Control Circuit	A
P0446 Evaporative Emission (EVAP) Vent System Performance	B
P0452 Fuel Tank Pressure (FTP) Sensor Circuit Low Voltage	B
P0453 Fuel Tank Pressure (FTP) Sensor Circuit High Voltage	B

P0455 Evaporative Emission (EVAP) System Large Leak Detected	B
P0461 Fuel Level Sensor Performance	B
P0462 Fuel Level Sensor Circuit Low Voltage	B
P0463 Fuel Level Sensor Circuit High Voltage	B
P0496 Evaporative Emission (EVAP) System Flow During Non-Purge	B
P0498 Evaporative Emission (EVAP) Vent Solenoid Control Circuit Low Voltage	A
P0499 Evaporative Emission (EVAP) Vent Solenoid Control Circuit High Voltage	A
P0501 Vehicle Speed Sensor (VSS) Performance	A
P0502 Vehicle Speed Sensor (VSS) Circuit Low Voltage	A
P0503 Vehicle Speed Sensor (VSS) Circuit Intermittent	B
P0506 Idle Speed Low	B
P0507 Idle Speed High	B
P0520 Engine Oil Pressure (EOP) Switch Control	C
P0530 Air Conditioning (A/C) Refrigerant Pressure Sensor Circuit	B
P0562 System Voltage Low	D
P0563 System Voltage High	D
P0567 Cruise Control Resume Switch Circuit	C
P0568 Cruise Control Set Switch Circuit	C
P0571 Cruise Control Brake Switch Circuit	C
P0602 Control Module Not Programmed	A
P0621 Generator L-Terminal Circuit	C
P0622 Generator F-Terminal Circuit	C
P0628 Fuel Pump Relay Control Circuit Low Voltage	A
P0629 Fuel Pump Relay Control Circuit High Voltage	A
P0641 5 Volt Reference 1 Circuit	A
P0646 Air Conditioning (A/C) Clutch Relay Control Circuit Low Voltage	D
P0647 Air Conditioning (A/C) Clutch Relay Control Circuit High Voltage	D
P0651 5 Volt Reference 2 Circuit	A
P0685 Engine Controls Ignition Relay Control Circuit	A
P0688 Engine Controls Ignition Relay Feedback Circuit	C
P0691 Cooling Fan Relay 1 Control Circuit Low Voltage	C
P0692 Cooling Fan Relay 1 Control Circuit High Voltage	C
P0693 Cooling Fan Relay 2 Control Circuit Low Voltage	C
P0694 Cooling Fan Relay 2 Control Circuit High Voltage	C
P0705 Transmission Range (TR) Sensor Circuit	A
P0706 Transmission Range (TR) Switch Performance	B
P0711 Transmission Fluid Temperature (TFT) Sensor Performance	C
P0712 Transmission Fluid Temperature (TFT) Sensor Circuit Low Voltage	C
P0713 Transmission Fluid Temperature (TFT) Sensor Circuit High Voltage	C
P0716 Input Speed Sensor Performance	A
P0717 Input/Turbine Speed Sensor Circuit Low Voltage	A

P0718 Input Speed Sensor Circuit Intermittent	B
P0731 Incorrect 1st Gear Ratio	C
P0732 Incorrect 2nd Gear Ratio	C
P0733 Incorrect 3rd Gear Ratio	C
P0734 Incorrect 4th Gear Ratio	C
P0735 Incorrect 5th Gear Ratio	C
P0741 Torque Converter Clutch (TCC) Circuit Performance or Stuck Off	B
P0746 Clutch Pressure Control (PC) Solenoid 1- Stuck Off	B
P0747 Clutch Pressure Control (PC) Solenoid 1-Stuck On	B
P0751 Shift Solenoid (SS) 1 Valve Performance or Stuck Off	B
P0752 Shift Solenoid (SS) 1 Valve Performance or Stuck On	B
P0756 Shift Solenoid (SS) 2 Valve Performance or Stuck Off	B
P0757 Shift Solenoid (SS) 2 Valve Performance or Stuck On	B
P0761 Shift Solenoid (SS) 3 Valve Performance or Stuck Off	B
P0762 Shift Solenoid (SS) 3 Valve Performance or Stuck On	B
P0776 Clutch Pressure Control (PC) Solenoid 2 Stuck Off	B
P0777 Clutch Pressure Control (PC) Solenoid 2 Stuck On	B
P0780 Incorrect Shift Pattern	B
P0847 Transmission Fluid Pressure (TFP) Switch 2 Circuit Low Voltage	C
P0848 Transmission Fluid Pressure (TFP) Switch 2 Circuit High Voltage	C
P0872 Transmission Fluid Pressure (TFP) Switch 3 Circuit Low Voltage	C
P0873 Transmission Fluid Pressure (TFP) Switch 3 High Voltage	C
P0962 Clutch Pressure Control (PC) Solenoid 1 Control Circuit Low Voltage	A
P0963 Clutch Pressure Control (PC) Solenoid 1 Control Circuit High Voltage	A
P0966 Clutch Pressure Control (PC) Solenoid 2 Control Circuit Low Voltage	A
P0967 Clutch Pressure Control (PC) Solenoid 2 Control Circuit High Voltage	A
P0973 Shift Solenoid (SS) 1 Control Circuit Low Voltage	A
P0974 Shift Solenoid (SS) 1 Control Circuit High Voltage	A
P0976 Shift Solenoid (SS) 2 Control Circuit Low Voltage	A
P0977 Shift Solenoid (SS) 2 Control Circuit High Voltage	A
P0979 Shift Solenoid (SS) 3 Control Circuit Low Voltage	A
P0980 Shift Solenoid (SS) 3 Control Circuit High Voltage	A
P1128 Manifold Absolute Pressure (MAP) Sensor Low Pressure	B
P1129 Manifold Absolute Pressure (MAP) Sensor High Pressure	B
P1574 Stoplamp Switch Circuit	C
P1621 Control Module Long Term Memory Performance	A
P1630 Theft Deterrent Learn Mode Active	C
P1631 Theft Deterrent Start Enable Signal Not Correct	C
P2100 Throttle Actuator Control (TAC) Motor Control Circuit	A
P2101 Throttle Actuator Position Performance	A
P2108 Throttle Actuator Control (TAC) Module Performance	A

P2111 Throttle Actuator Control (TAC) Throttle Valve Stuck Open	A
P2112 Throttle Actuator Control (TAC) Throttle Valve Stuck Closed	A
P2122 Accelerator Pedal Position (APP) Sensor 1 Circuit Low Voltage	A
P2123 Accelerator Pedal Position (APP) Sensor 1 Circuit High Voltage	A
P2127 Accelerator Pedal Position (APP) Sensor 2 Circuit Low Voltage	A
P2128 Accelerator Pedal Position (APP) Sensor 2 Circuit High Voltage	A
P2135 Throttle Position (TP) Sensor 1-2 Correlation	A
P2138 Accelerator Pedal Position (APP) Sensor 1-2 Correlation	A
P2176 Minimum Throttle Position Not Learned	A
P2199 Intake Air Temperature (IAT) Sensor 1-2 Correlation	B
P2227 Barometric Pressure (BARO) Sensor Performance	B
P2228 Barometric Pressure (BARO) Sensor Circuit Low Voltage	A
P2229 Barometric Pressure (BARO) Sensor Circuit High Voltage	A
P2238 HO2S Pumping Current Control Circuit Low Voltage Bank 1 Sensor 1	A
P2239 HO2S Pumping Current Control Circuit High Voltage Bank 1 Sensor 1	A
P2241 HO2S Pumping Current Control Circuit Low Voltage Bank 2 Sensor 1	A
P2242 HO2S Pumping Current Control Circuit High Voltage Bank 2 Sensor1	A
P2243 HO2S Reference Voltage Circuit Bank 1 Sensor 1	A
P2245 HO2S Reference Voltage Circuit Low Voltage Bank 1 Sensor 1	A
P2247 HO2S Reference Voltage Circuit Bank 2 Sensor 1	A
P2249 HO2S Reference Voltage Circuit Low Voltage Bank 2 Sensor 1	A
P2252 HO2S Reference Ground Circuit Low Voltage Bank 1 Sensor 1	A
P2253 HO2S Reference Ground Circuit High Voltage Bank 1 Sensor 1	A
P2255 HO2S Reference Ground Circuit Low Voltage Bank 2 Sensor 1	A
P2256 HO2S Reference Ground Circuit High Voltage Bank 2 Sensor 1	A
P2282 Intake Manifold Air Leak	B
P2297 HO2S Performance During Decel Fuel Cut-Off (DFCO) Bank 1 Sensor 1	B
P2298 HO2S Performance During Decel Fuel Cut-Off (DFCO) Bank 2 Sensor 1	B
P2413 Exhaust Gas Recirculation (EGR) System Performance	B
P2414 HO2S Exhaust Sample Bank 1 Sensor 1	A
P2415 HO2S Exhaust Sample Bank 2 Sensor 1	A
P2553 Throttle Actuator Control (TAC) Inhibit Control Performance	A
P2554 Throttle Actuator Control (TAC) Inhibit Circuit Low Voltage	A
P2555 Throttle Actuator Control (TAC) Inhibit Circuit High Voltage	A
P2610 Control Module Ignition Off Timer Performance	A
P2627 HO2S Pumping Current Trim Circuit Low Voltage Bank 1 Sensor 1	A
P2628 HO2S Pumping Current Trim Circuit High Voltage Bank 1 Sensor 1	A
P2630 HO2S Pumping Current Trim Circuit Low Voltage Bank 2 Sensor 1	A
P2631 HO2S Pumping Current Trim Circuit High Voltage Bank 2 Sensor 1	A
P2646 Intake Rocker Arm Actuator System Stuck Off	A
P2647 Intake Rocker Arm Actuator System Stuck On	A

P2648 Intake Rocker Arm Actuator Solenoid Control Circuit Low Voltage	A
P2649 Intake Rocker Arm Actuator Solenoid Control Circuit High Voltage	A
P2763 Torque Convertor Clutch (TCC) Pressure Control (PC) Solenoid Control Circuit High Voltage	A
P2764 Torque Convertor Clutch (TCC) Pressure Control (PC) Solenoid Control Circuit Low Voltage	A
P2769 Torque Converter Clutch (TCC) Enable Solenoid Control Circuit Low Voltage	A
P2770 Torque Converter Clutch (TCC) Enable Solenoid Control Circuit High Voltage	A
U0107 Lost Communication With Throttle Actuator Control (TAC) Module	A

SCHEMATIC AND ROUTING DIAGRAMS

EMISSION HOSE ROUTING DIAGRAM

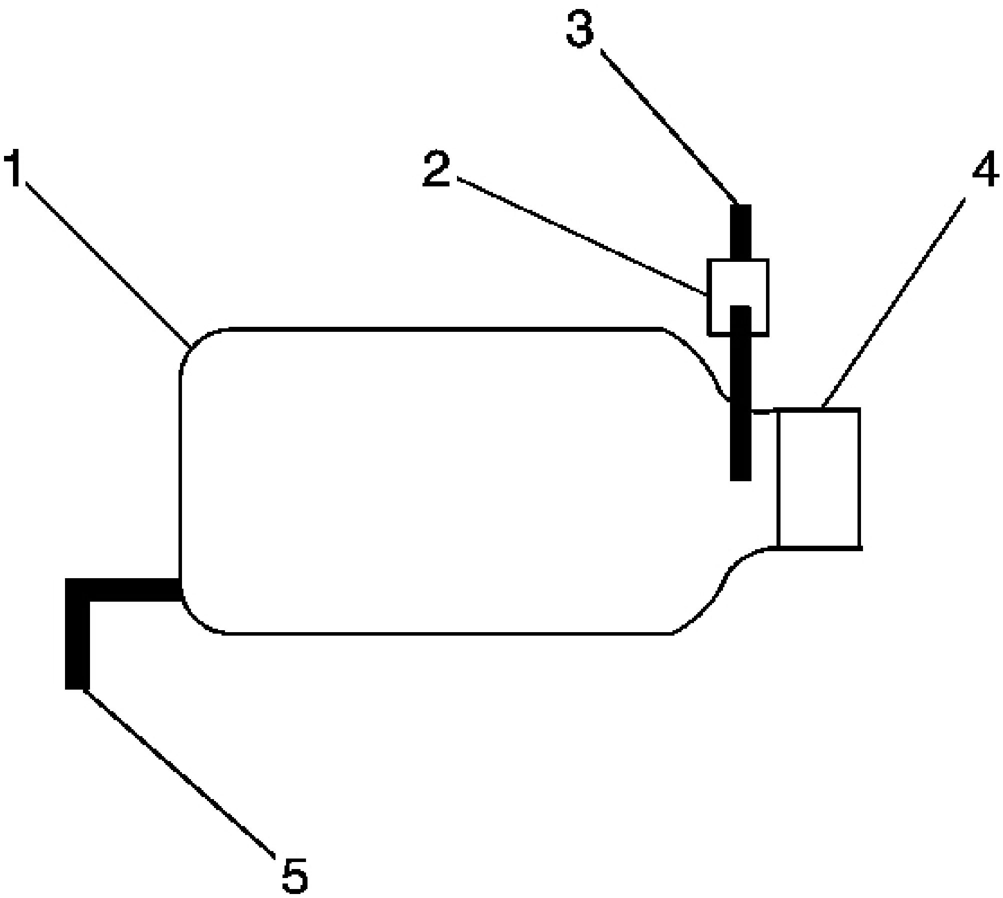


Fig. 1: View Of Emission Hose Routing Diagram
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 1

Callout	Component Name
1	Intake Manifold
2	Evaporative Emissions (EVAP) Canister Purge Solenoid
3	Emissions Hose to EVAP Canister
4	Throttle Body Assembly
5	PCV Hose to Cylinder Head Cover

EVAPORATIVE EMISSIONS (EVAP) HOSE ROUTING DIAGRAM

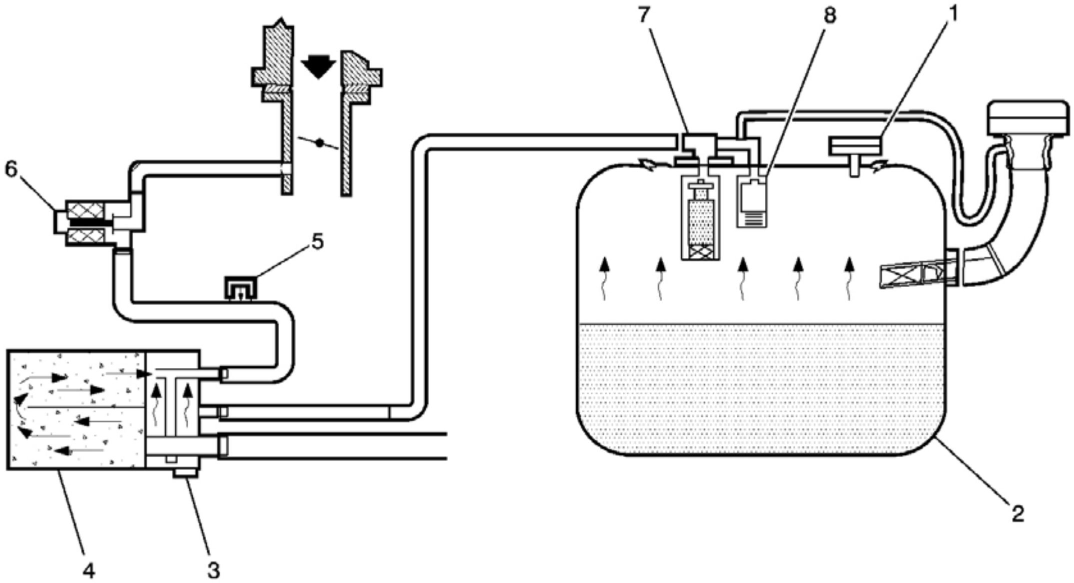


Fig. 2: View Of Evaporative Emission (EVAP) Hose Routing Diagram
Courtesy of GENERAL MOTORS CORP.

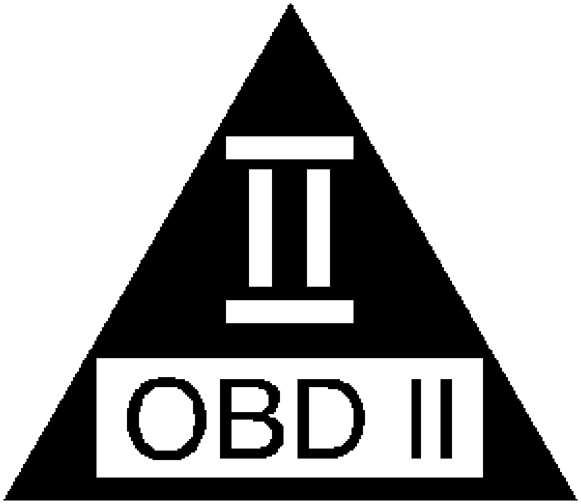
Callouts For Fig. 2

Callout	Component Name
1	Fuel Tank Pressure (FTP) Sensor
2	Fuel Tank
3	Evaporative Emission (EVAP) Vent Solenoid Valve
4	EVAP Canister
5	EVAP Service Port
6	EVAP Purge Solenoid Valve
7	Fill Limit Vent Valve (FLVV)
8	Grade Vent Valve

ENGINE CONTROLS SCHEMATIC ICONS

Engine Controls Schematic Icons

Icon	Icon Definition
	NOTE: **The OBD II symbol is used on the circuit diagrams in order to alert the technician that the circuit is essential for proper OBD II emission control circuit operation. Any circuit**

	which fails and causes the malfunction indicator lamp (MIL) to turn ON, or causes emissions-related component damage, is identified as an OBD II circuit.

ENGINE CONTROLS SCHEMATICS

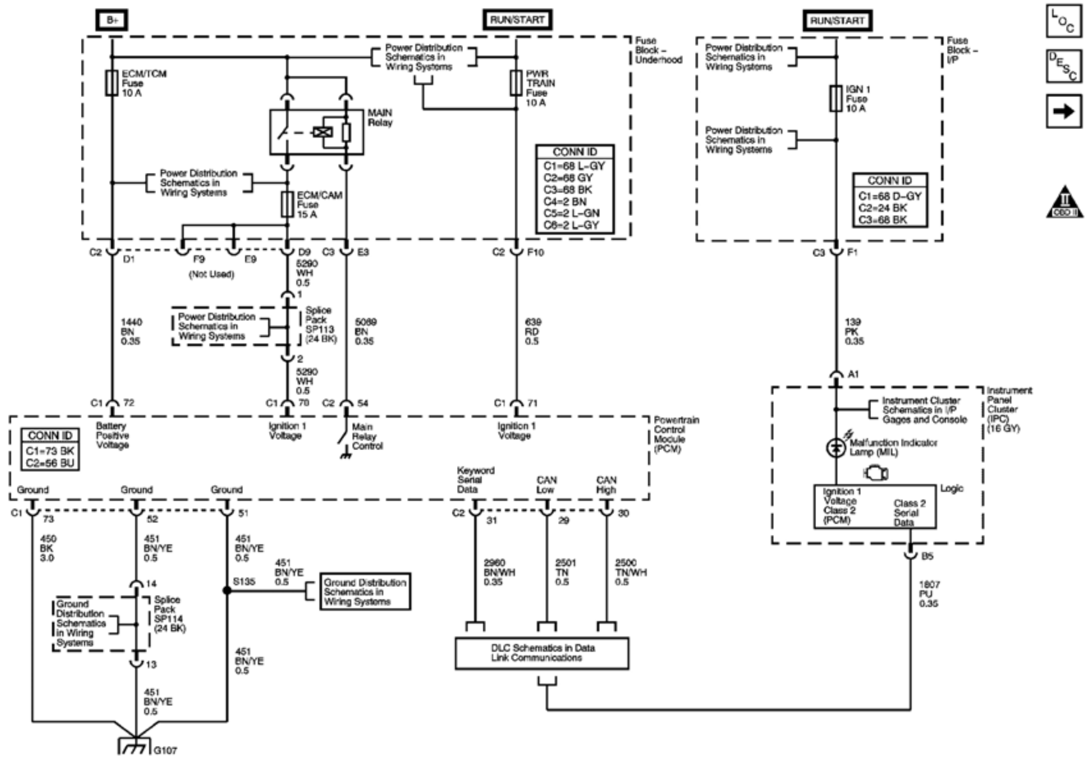


Fig. 3: Power, Ground, MIL, and PCM Communication Schematics
Courtesy of GENERAL MOTORS CORP.

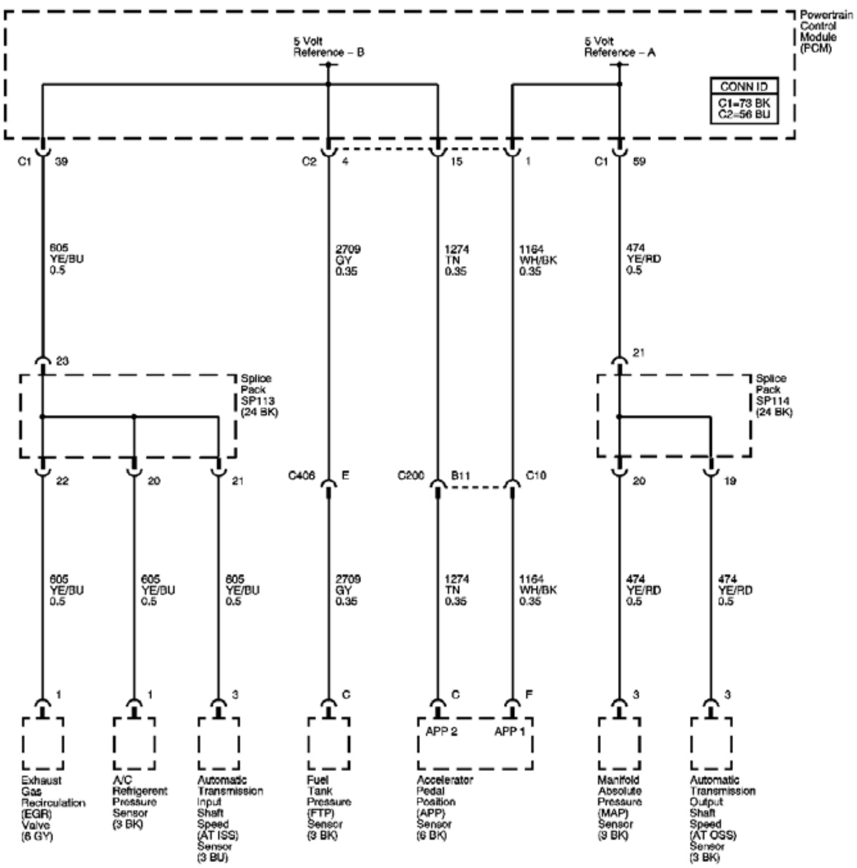
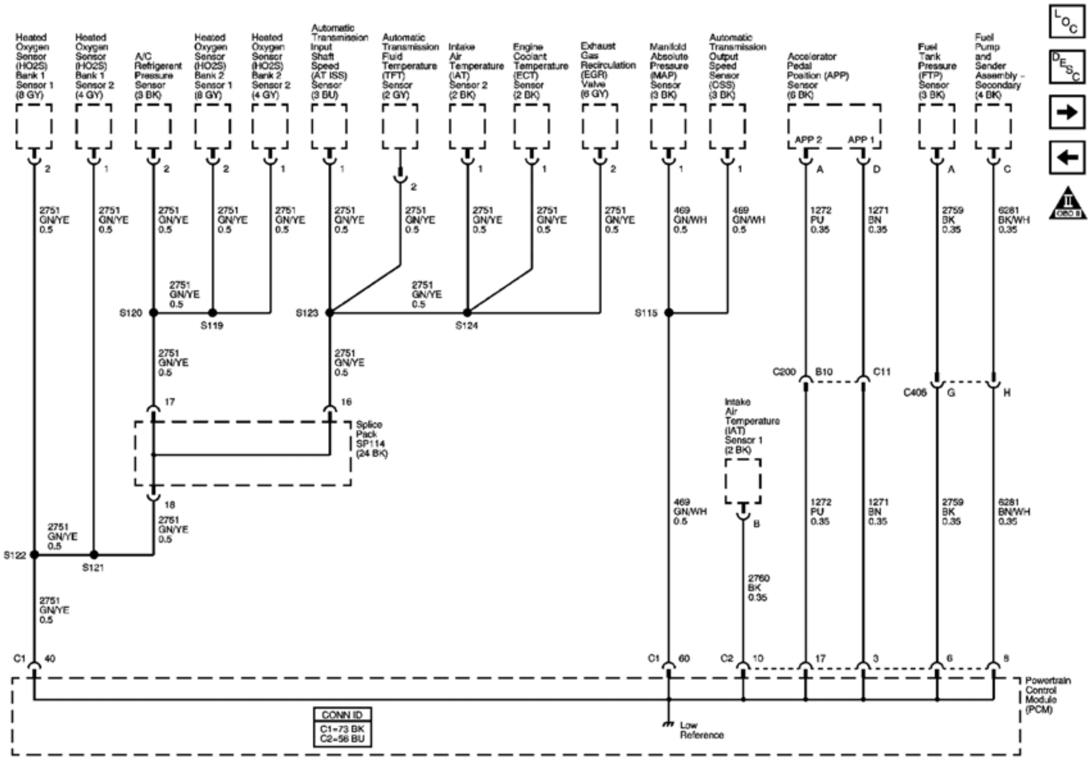


Fig. 4: Engine Data Sensors - 5-Volt References Shematics
Courtesy of GENERAL MOTORS CORP.



<u>Fig. 5: Engine Data Sensors - Low References Schematics</u>
Courtesy of GENERAL MOTORS CORP.

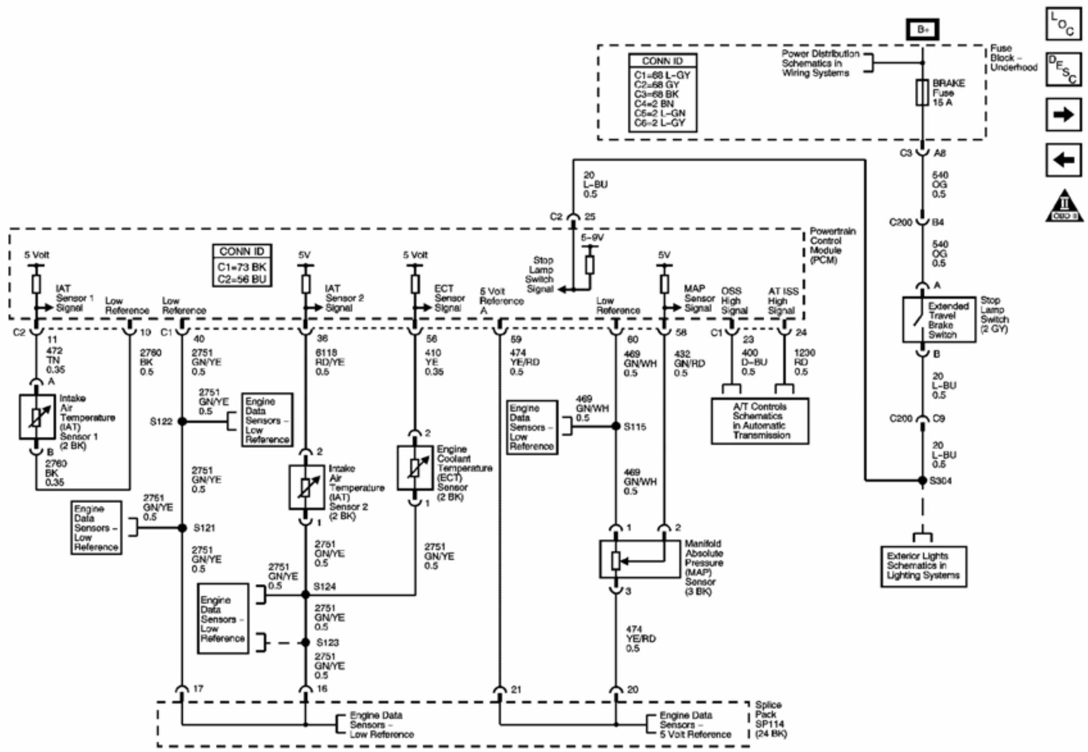


Fig. 6: IAT, ECT, and MAP Sensors, and Stop Lamp Switch Signal Schematics
Courtesy of GENERAL MOTORS CORP.

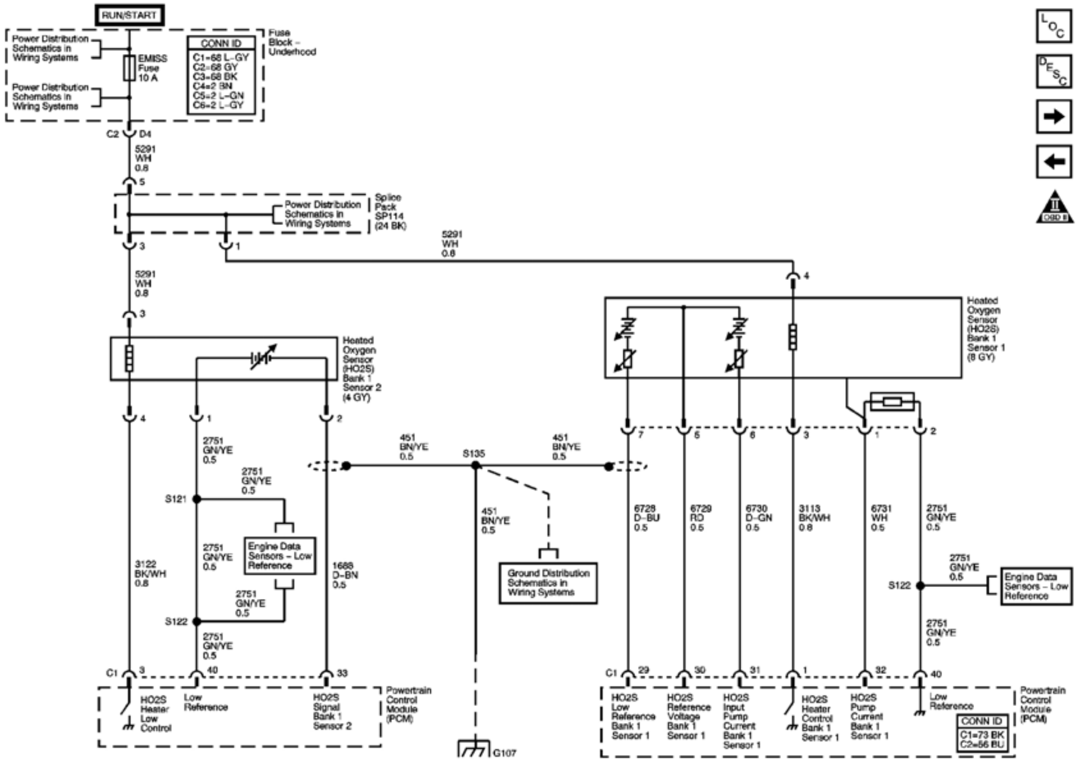


Fig. 7: Bank 1 Oxygen Sensors Shematics
Courtesy of GENERAL MOTORS CORP.

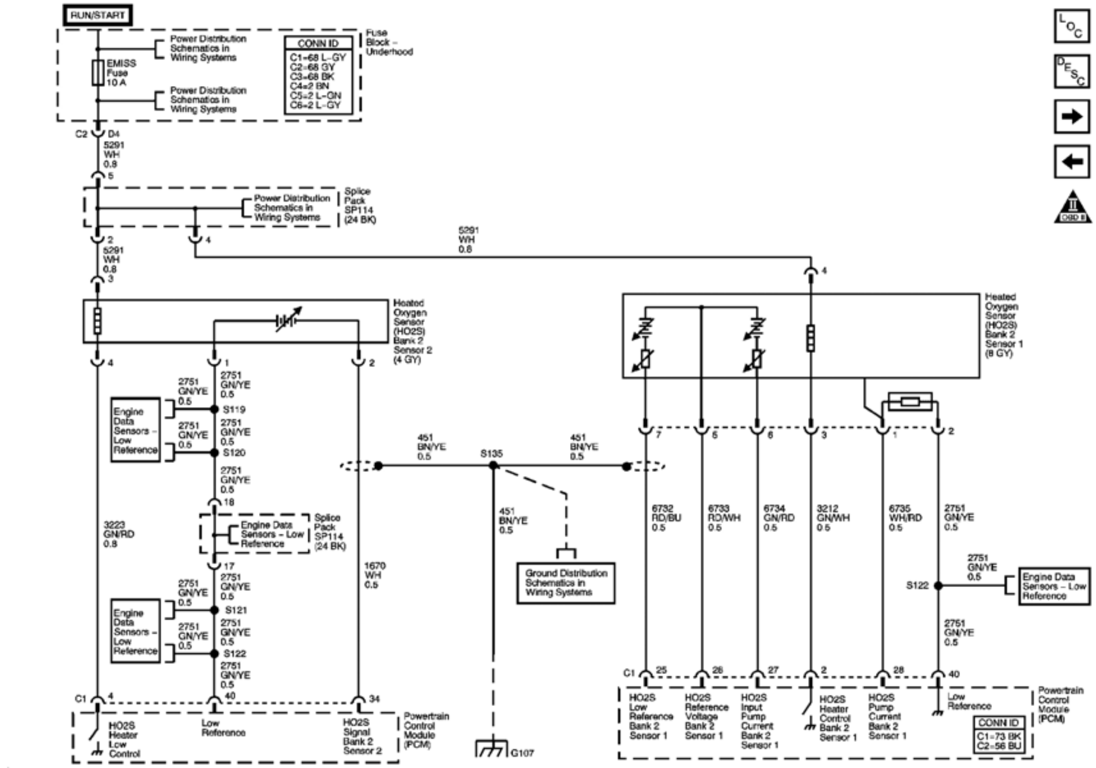


Fig. 8: Bank 2 Oxygen Sensors Schematics
Courtesy of GENERAL MOTORS CORP.

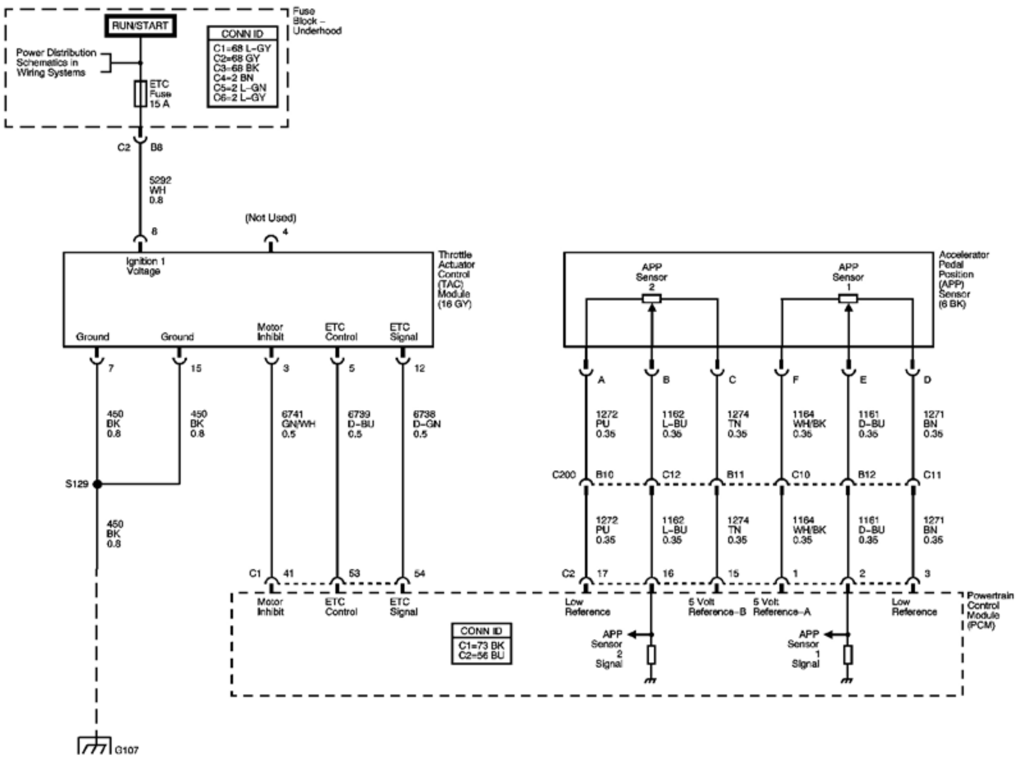


Fig. 9: Throttle Controls Schematics
Courtesy of GENERAL MOTORS CORP.

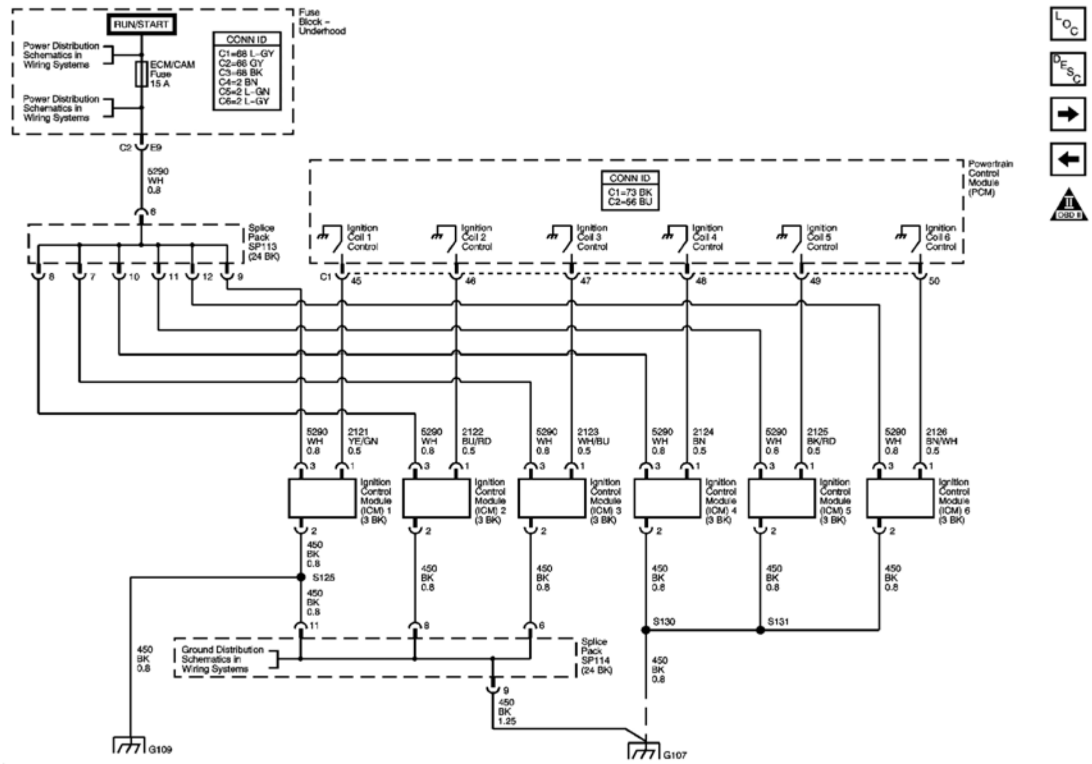
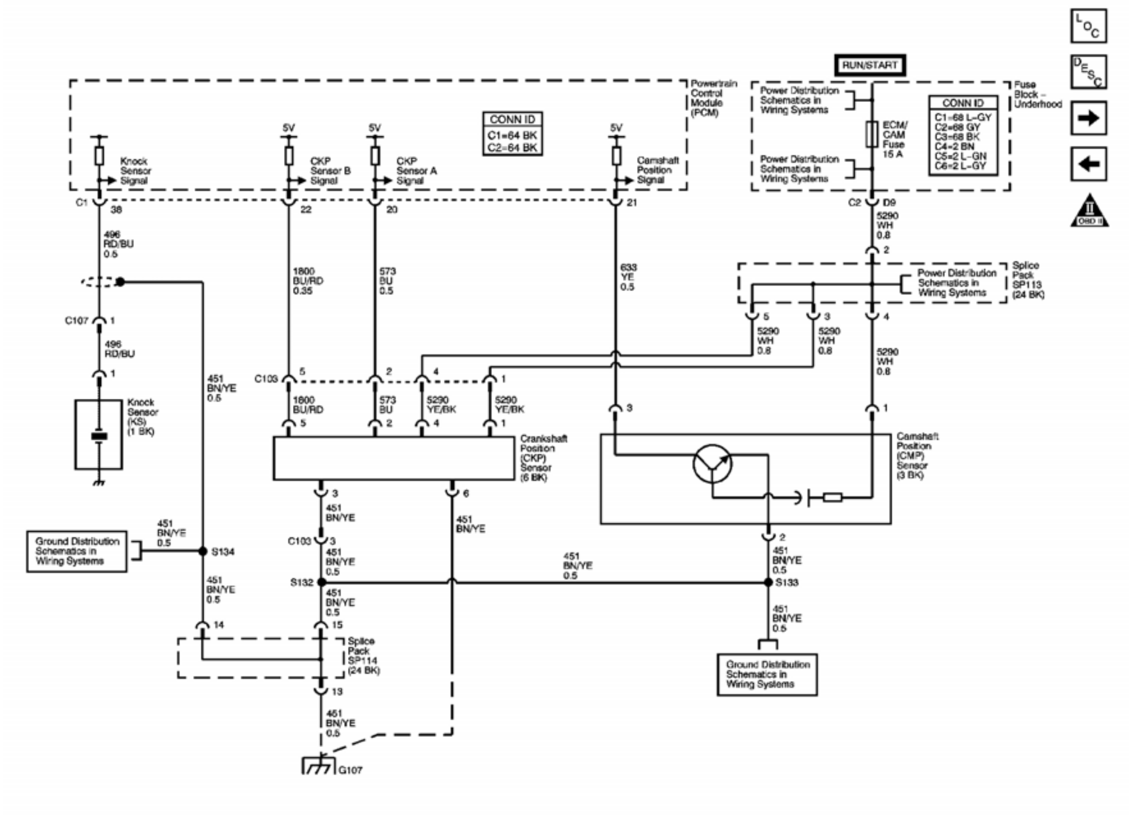


Fig. 10: Ignition Controls Schematics
Courtesy of GENERAL MOTORS CORP.



<u>Fig. 11: Ignition Controls - Sensors Schematics</u>
Courtesy of GENERAL MOTORS CORP.

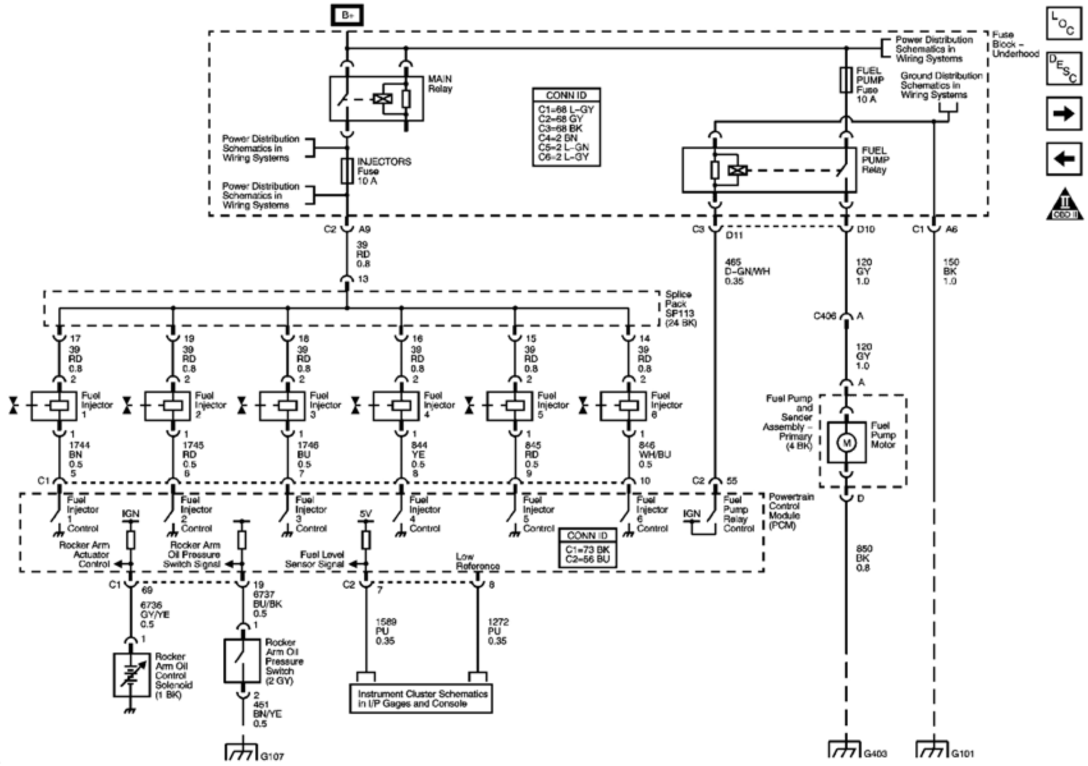
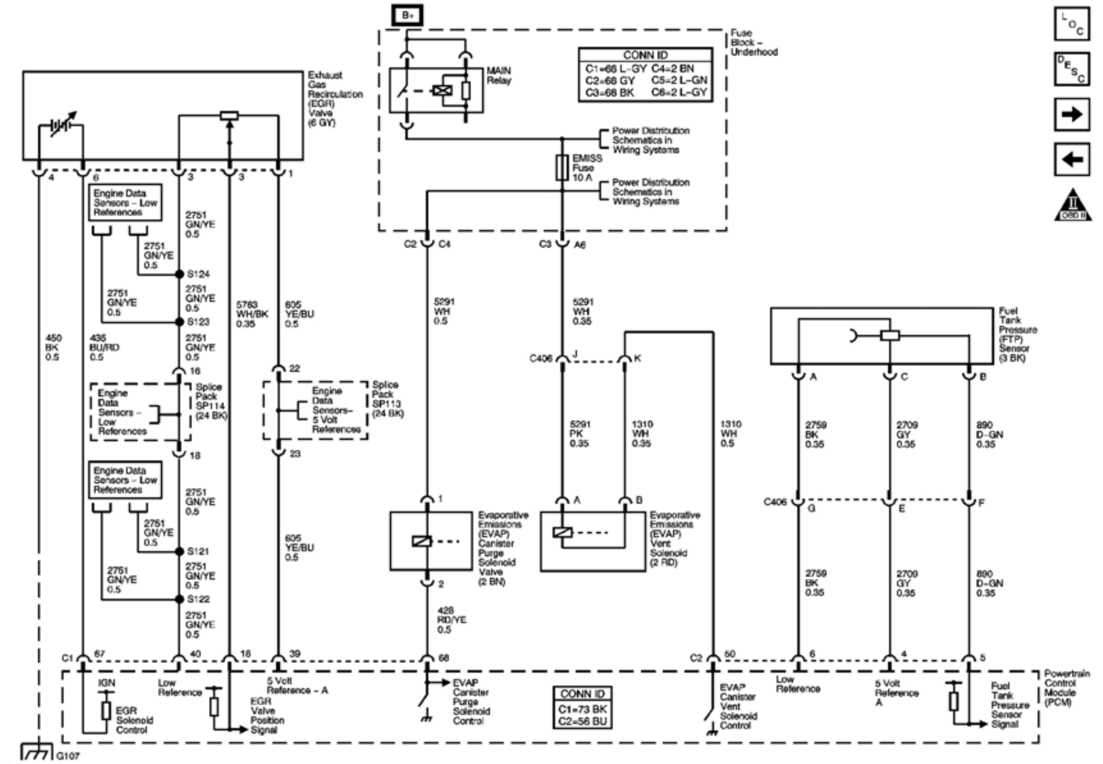


Fig. 12: Fuel Controls and Rocker Arm Oil Switch and Solenoid Controls Schematics
Courtesy of GENERAL MOTORS CORP.



<u>**Fig. 13: EVAP Controls, EGR Valve, and FTP Sensor Signals Schematics**</u>
Courtesy of GENERAL MOTORS CORP.

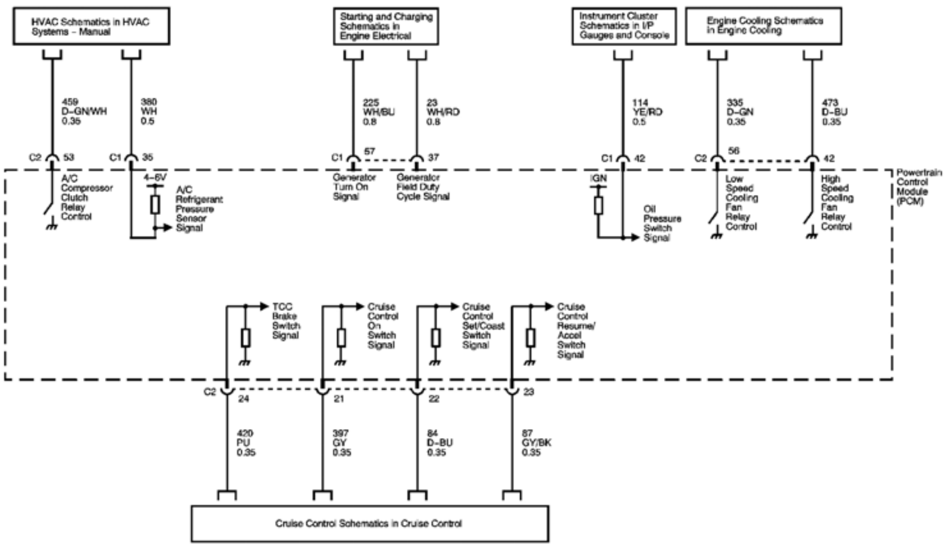


Fig. 14: Controlled/Monitored Subsystem References Schematics
Courtesy of GENERAL MOTORS CORP.

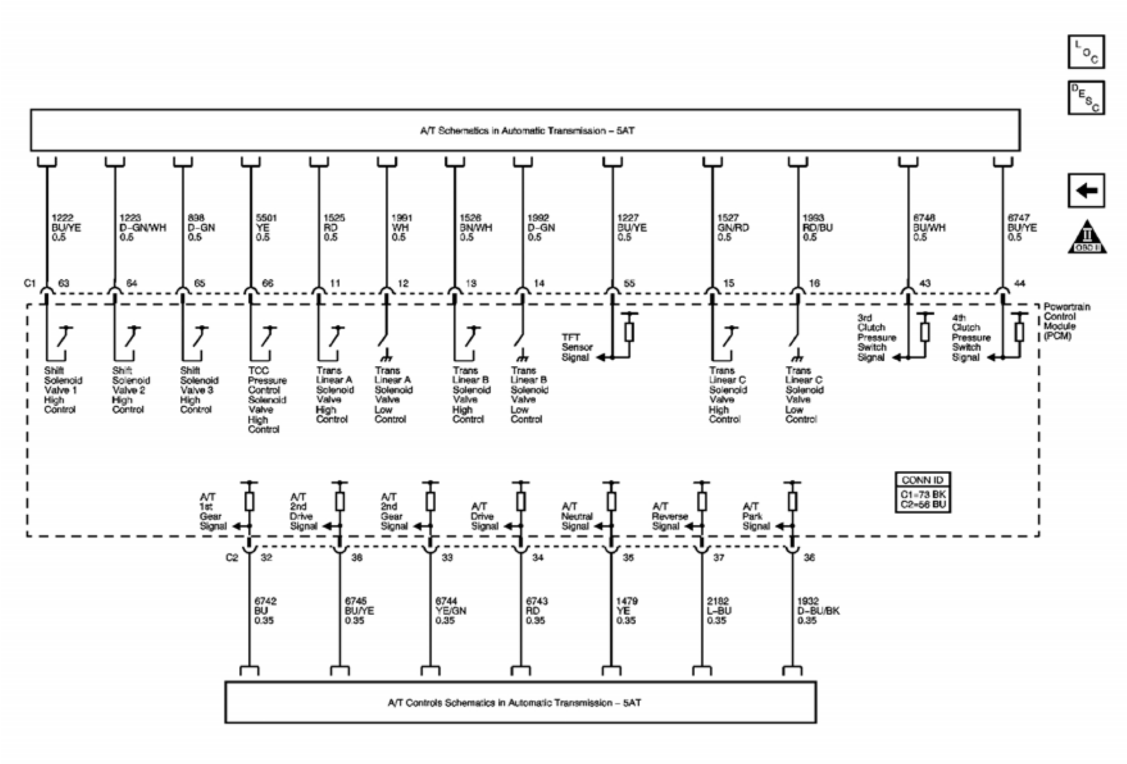


Fig. 15: Transmission Controls References Schematics
Courtesy of GENERAL MOTORS CORP.

COMPONENT LOCATOR

ENGINE CONTROLS COMPONENT VIEWS

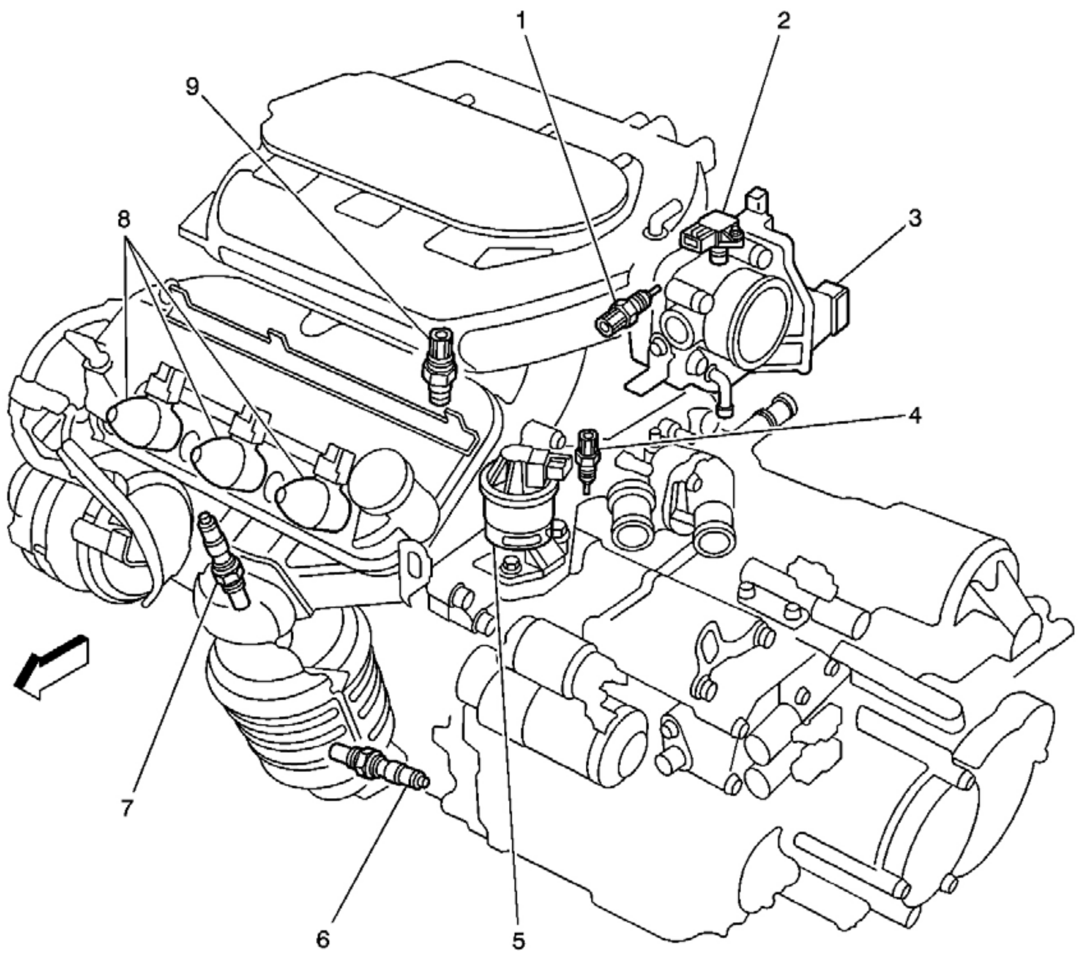


Fig. 16: Engine Components - Front View
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 16

Callout	Component Name
1	Intake Air Temperature (IAT) Sensor 2 (Sensor 1 in the Air Cleaner Housing)
2	Manifold Absolute Pressure (MAP) Sensor
3	Throttle Actuator Control (TAC) Module
4	Engine Coolant Temperature (ECT) Sensor
5	Exhaust Gas Recirculation (EGR) Valve
6	Heated Oxygen Sensor (HO2S) Bank 2 Sensor 2
7	Heated Oxygen Sensor (HO2S) Bank 2 Sensor 1
8	Ignition Control Modules (ICM) 4, 5, and 6
9	Knock Sensor (KS)

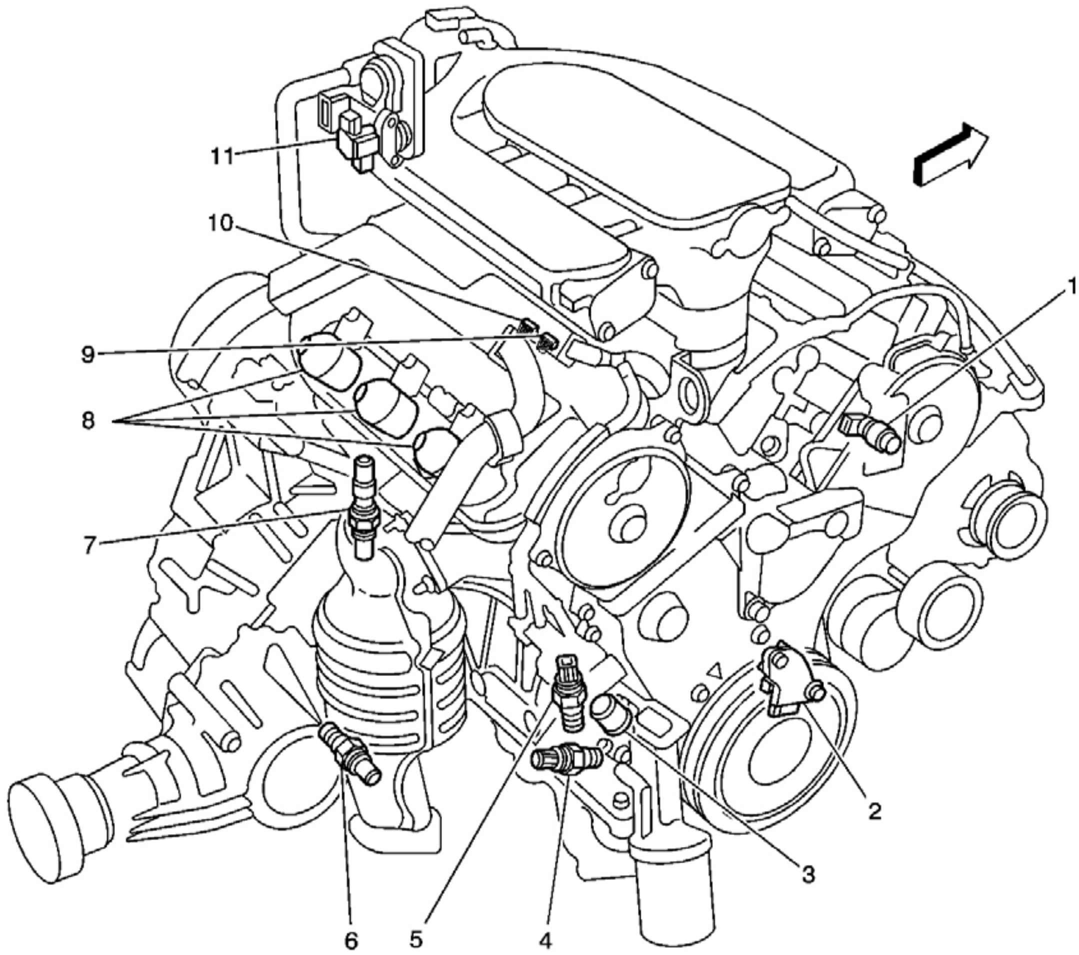


Fig. 17: Engine Components - Rear View
Courtesy of GENERAL MOTORS CORP.

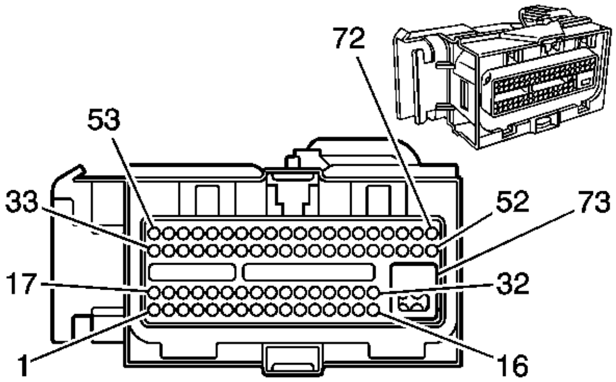
Callouts For Fig. 17

Callout	Component Name
1	Camshaft Position (CMP) Sensor
2	Crankshaft Position (CKP) Sensor
3	Rocker Arm Oil Control Solenoid
4	Rocker Arm Oil Pressure Switch
5	Engine Oil Pressure (EOP) Switch
6	Heated Oxygen Sensor (HO2S) Bank 1 Sensor 2
7	Heated Oxygen Sensor (HO2S) Bank 1 Sensor 1
8	Ignition Control Modules (ICM) 1, 2, and 3
9	Splice Pack SP113
10	Splice Pack SP114

11	Evaporative (EVAP) Emissions Purge Control Solenoid Valve

POWERTRAIN CONTROL MODULE (PCM) CONNECTOR END VIEWS

Powertrain Control Module (PCM) C1 Connector End View



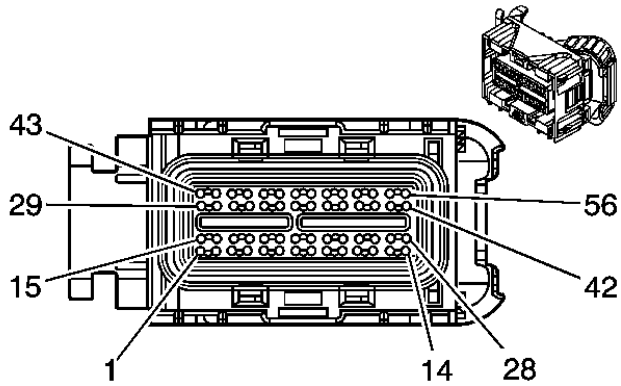
Connector Part Information	• **Assembly-15357131** • **Connector-15357133/13007928** • **73-Way F Micro 64 Series (BK)**

Pin	Wire Color	Circuit Number	Function
1	BK/WH	3113	HO2S Heater Control - Bank 1 Sensor 1
2	GN/WH	3212	HO2S Heater Control - Bank 2 Sensor 1
3	BK/WH	3122	HO2S Heater Low Control - Bank 1 Sensor 2
4	GN/RD	3223	HO2S Heater Low Control - Bank 2 Sensor 2
5	BN	1744	Fuel Injector 1 Control
6	RD	1745	Fuel Injector 2 Control
7	BU	1746	Fuel Injector 3 Control
8	YE	844	Fuel Injector 4 Control
9	BK/RD	845	Fuel Injector 5 Control
10	WH/BU	846	Fuel Injector 6 Control
11	RD	1525	Transmission Linear A Solenoid Valve High Control
12	WH	1991	Transmission Linear A Solenoid Valve Low Control
13	BN/WH	1526	Transmission Linear B Solenoid Valve High Control
14	D-GN	1992	Transmission Linear B Solenoid Valve Low Control
15	GN/RD	1527	Transmission Linear C Solenoid Valve High Control
16	RD/BU	1993	Transmission Linear C Solenoid Valve Low Control
17	-	-	Not Used
18	WH/BK	5763	EGR Valve Position Signal
19	BU/BK	6737	Rocker Arm Oil Pressure Switch Signal

20	BU	573	CKP Sensor A Signal
21	YE	633	CMP Sensor Signal
22	BU/RD	1800	CKP Sensor B Signal
23	D-BU	400	OSS High Signal
24	RD	1230	AT ISS High Signal
25	RD/BU	6732	HO2S Low Reference Bank 2 Sensor 1
26	RD/WH	6733	HO2S Reference Voltage - Bank 2 Sensor 1
27	GN/RD	6734	HO2S Input Pump Current - Bank 2 Sensor 1
28	WH/RD	6735	HO2S Pump Current - Bank 2 Sensor 1
29	D-BU	6728	HO2S Low Reference - Bank 1 Sensor 1
30	RD	6729	HO2S Reference Voltage - Bank 1 Sensor 1
31	D-GN	6730	HO2S Input Pump Current - Bank 1 Sensor 1
32	WH	6731	HO2S Pump Current - Bank 1 Sensor 1
33	D-GN	1688	HO2S Signal - Bank 1 Sensor 2
34	WH	1670	HO2S Signal - Bank 2 Sensor 2
35	WH	380	A/C Refrigerant Pressure Sensor Signal
36	RD/YE	6118	IAT Sensor 2 Signal
37	WH/RD	23	Generator Field Duty Cycle
38	RD/BU	496	KS Signal
39	YE/BU	605	5 Volt Reference B
40	GN/YE	2751	Low Reference
41	GN/WH	6741	ETC Motor Inhibit
42	YE/RD	114	Oil Pressure Switch Signal
43	BU/WH	6746	3rd Clutch Pressure Switch Signal
44	BU/YE	6747	4th Clutch Pressure Switch Signal
45	YE/GN	2121	Ignition Coil 1 Control
46	BU/RD	2122	Ignition Coil 2 Control
47	WH/BU	2123	Ignition Coil 3 Control
48	BN	2124	Ignition Coil 4 Control
49	BK/RD	2125	Ignition Coil 5 Control
50	BN/WH	2126	Ignition Coil 6 Control
51	BN/YE	451	Ground
52	BN/YE	451	Ground
53	D-BU	6739	ECT Control
54	D-GN	6738	ECT Signal
55	BU/YE	1227	TFT Sensor Signal
56	YE	410	ECT Sensor Signal
57	WH/BU	225	Generator Turn On Signal
58	GN/RD	432	MAP Sensor Signal
59	YE/RD	474	5 Volt Reference B
60	GN/WH	469	Low Reference

61-62	-	-	Not Used
63	BU/YE	1222	Shift Solenoid Valve 1 High Control
64	D-GN/WH	1223	Shift Solenoid Valve 2 High Control
65	D-GN	898	Shift Solenoid Valve 3 High Control
66	YE	5501	TCC Pressure Control Solenoid Valve High Control
67	BU/RD	435	EGR Solenoid Control
68	RD/YE	428	EVAP Canister Purge Solenoid Control
69	GY/YE	6736	Rocker Arm Oil Actuator Control
70	WH	5290	Ignition 1 Voltage
71	RD	639	Ignition 1 Voltage
72	BN	1440	Battery Positive Voltage
73	BK	450	Ground

Powertrain Control Module (PCM) C2 Connector End View

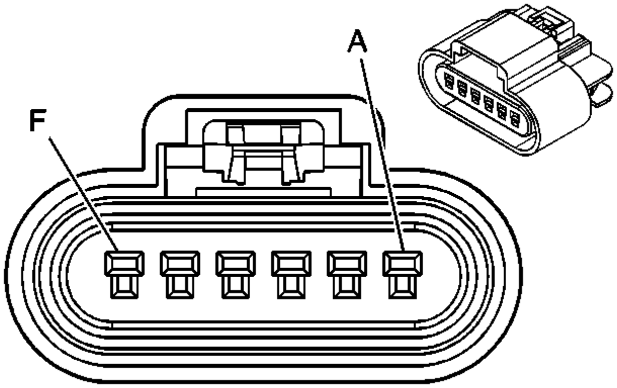


Connector Part Information	• 15357147 - Assembly • 15357150 - Connector • 56-Way F Micro 64 Series (BU)		
Pin	**Wire Color**	**Circuit Number**	**Function**
1	WH/BK	1164	5 Volt Reference A
2	D-BU	1161	APP Sensor 1 Signal
3	BN	1271	Low Reference
4	GY	2709	5 Volt Reference A
5	D-GN	890	Fuel Tank Pressure Sensor Signal
6	BK	2759	Low Reference
7	PU	1589	Fuel Level Sensor Signal
8	BN/WH	6281	Low Reference
9	-	-	Not Used

10	BK	2760	5 Volt Reference A
11	TN	472	IAT Sensor 1 Signal
12-14	-	-	Not Used
15	TN	1274	5 Volt Reference B
16	L-BU	1162	APP Sensor 2 Signal
17	PU	1272	Low Reference
18-20	-	-	Not Used
21	GY	397	Cruise Control On Switch Signal
22	D-BU	84	Cruise Control Set/Coast Switch Signal
23	GY/BK	87	Cruise Control Resume/Accel Switch Signal
24	PU	420	TCC/Cruise /Brake Switch Signal
25	L-BU	20	Stop Lamp Switch Signal
26-28	-	-	Not Used
29	TN	2501	CAN Low
30	TN/WH	2500	CAN High
31	BN/WH	2960	Keyword Serial Data
32	BU	6742	A/T 1st Gear Signal
33	YE/GN	6744	A/T 2nd Gear Signal
34	RD	6743	A/T Drive Signal
35	RD/BK	1479	A/T Neutral Signal
36	D-BU/BK	1932	A/T Park Signal
37	D-BU/WH	2182	A/T Reverse Signal
38	BU/YE	6745	A/T 2nd Drive Signal
39-41	-	-	Not Used
42	D-BU	473	Low Speed Cooling Fan Relay Control
43-49	-	-	Not Used
50	WH	1310	EVAP Canister Vent Solenoid Control
51-52	-	-	Not Used
53	D-GN/WH	459	A/C Compressor Clutch Relay Control
54	BN	5069	Main Relay Control
55	D-GN/WH	465	Fuel Pump Relay Control
56	D-GN	335	Low Speed Cooling Fan Relay Control

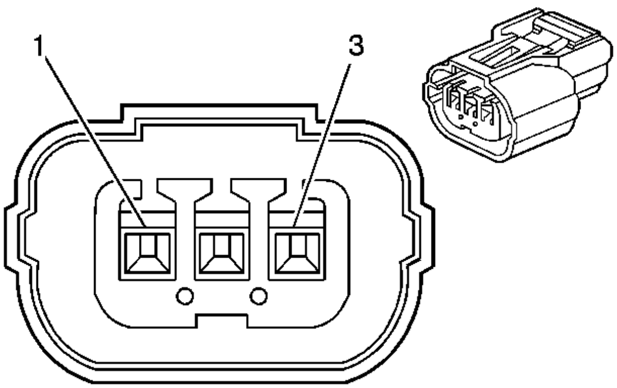
ENGINE CONTROLS CONNECTOR END VIEWS

Accelerator Pedal Position (APP) Sensor Connector End View



Connector Part Information		• **15317832 - CPA Assembly** • **15326829 - Connector** • **6-Way F 150 Series Sealed (BK)**	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	PU	1272	Low Reference
B	L-BU	1162	APP Sensor 2 Signal
C	TN	1274	5-Volt Reference - B
D	BN	1271	Low Reference
E	D-BU	1161	APP Sensor 1 Signal
F	WH/BK	1164	5-Volt Reference - A

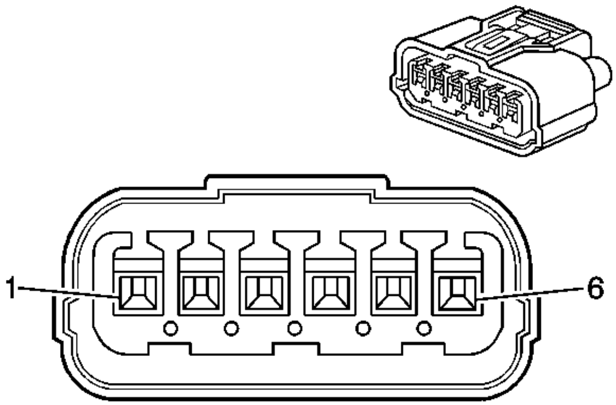
Camshaft Position (CMP) Sensor Connector End View



Connector Part Information	• **6189-0887** • **3-Way F HX Series (BK)**

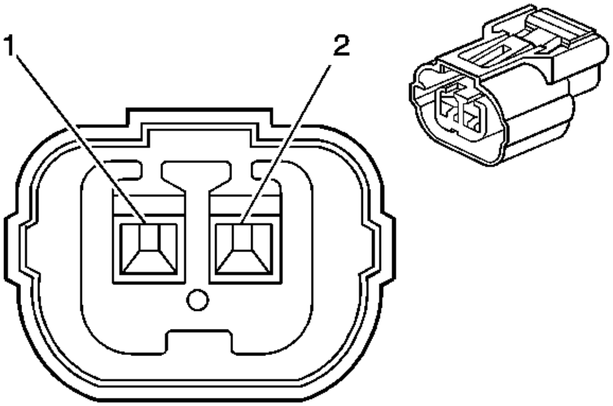
Pin	Wire Color	Circuit No.	Function
1	WH	5290	Ignition 1 Voltage
2	BN/YE	451	Ground
3	YE	633	CMP Sensor Signal

Crankshaft Position (CKP) Sensor Connector End View



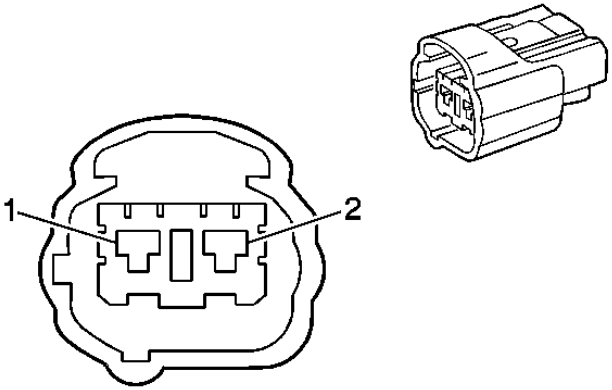
Connector Part Information		• 91703-RCA-A010-Y1 • 6-Way M (BK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	YE/BK	5290	Ignition 1 Voltage
2	BU	573	CKP Sensor A Signal
3	BN/YE	451	Ground
4	YE/BK	5290	Ignition 1 Voltage
5	BU/RD	1800	CKP Sensor B Signal
6	BN/YE	451	Ground

Engine Coolant Temperature (ECT) Sensor Connector End View



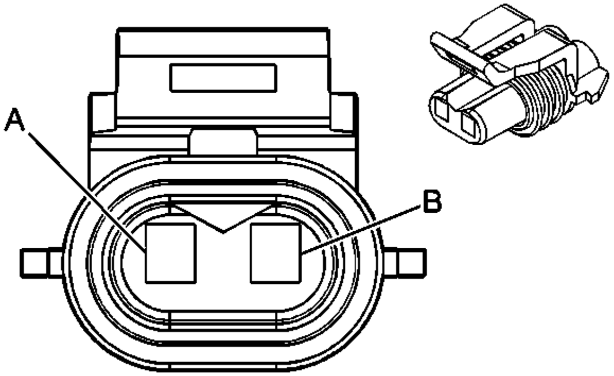
Connector Part Information		• 6189-0890 • 2-Way F HX Series (BK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	GN/YE	2751	Low Reference
2	YE	410	ECT Sensor Signal

Evaporative Emissions (EVAP) Canister Purge Solenoid Valve Connector End View



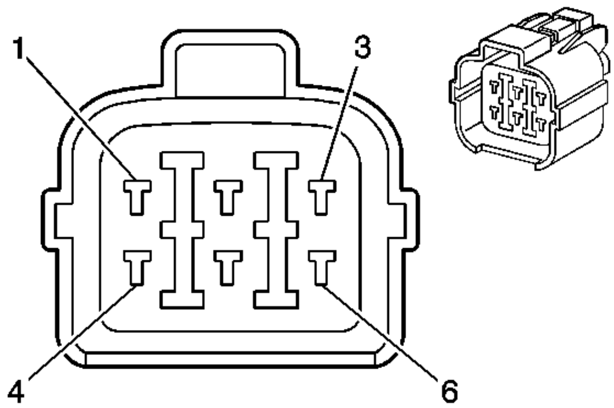
Connector Part Information		• 6189-0593 • 2-Way F HX Series (BN)	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	WH	5291	Ignition 1 Voltage
2	RD/YE	428	EVAP Canister Purge Solenoid Control

Evaporative Emissions (EVAP) Vent Solenoid Connector End View



Connector Part Information		• 12052643 • 2-Way F Metri-Pack 150 Series, Sealed (RD)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	WH	5291	Ignition 1 Voltage
B	WH	1310	EVAP Canister Vent Solenoid Control

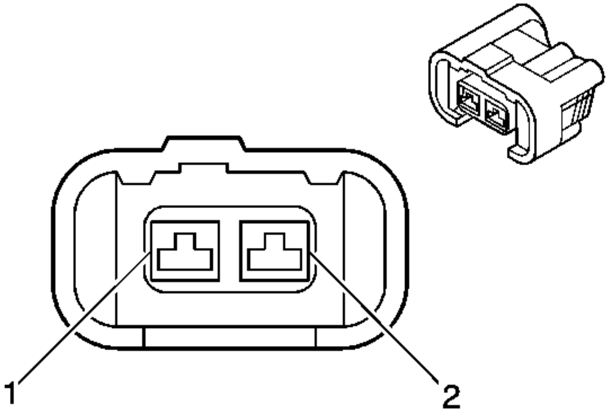
Exhaust Gas Recirculation (EGR) Valve Connector End View



Connector Part Information		• 6189-0133 • 6-Way F HX Series (GY)	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	YE/BU	605	5-Volt Reference
2	GN/YE	2751	Low Reference
3	WH/BK	5763	EGR Valve Position Signal

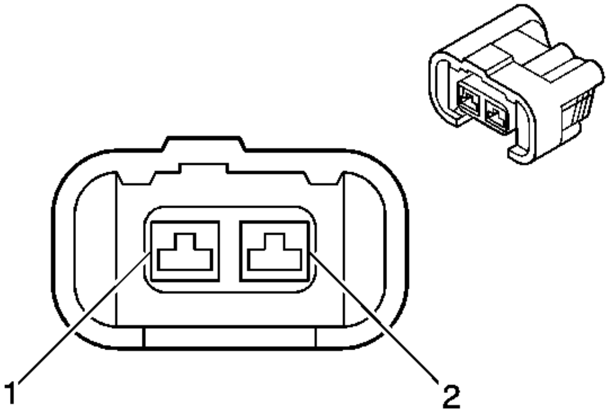
4	BK	450	Ground
5	-	-	Not Used
6	BU/RD	435	EGR Solenoid Control

Fuel Injector 1 Connector End View



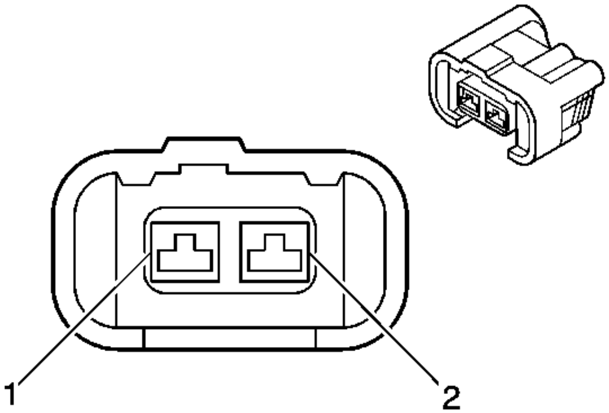
Connector Part Information		• **6189-0553** • **2-Way F HX Series (BK)**	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	BN	1744	Fuel Injector 1 Control
2	RD	39	Ignition 1 Voltage

Fuel Injector 2 Connector End View



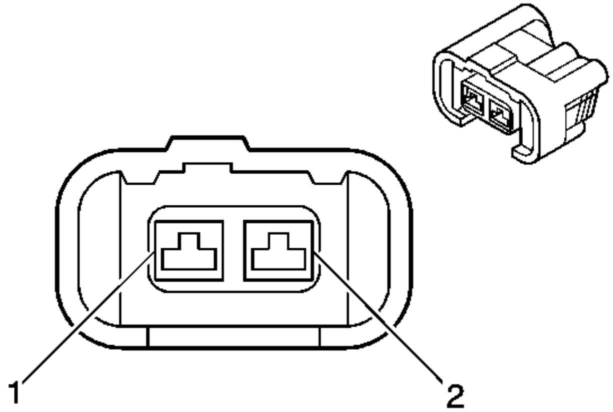
Connector Part Information		• 6189-0553 • 2-Way F HX Series (BK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	RD	1745	Fuel Injector 2 Control
2	RD	39	Ignition 1 Voltage

Fuel Injector 3 Connector End View



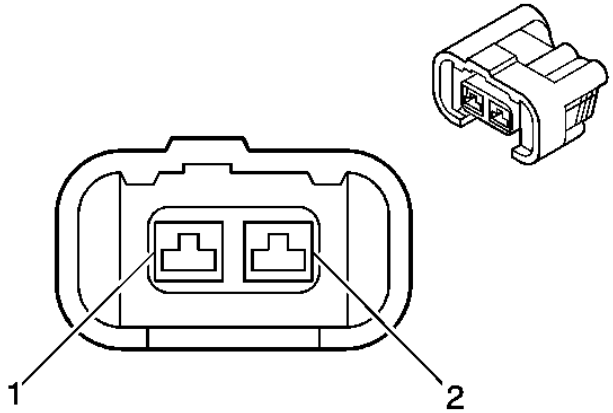
Connector Part Information		• 6189-0553 • 2-Way F HX Series (BK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	BU	1746	Fuel Injector 3 Control
2	RD	39	Ignition 1 Voltage

Fuel Injector 4 Connector End View



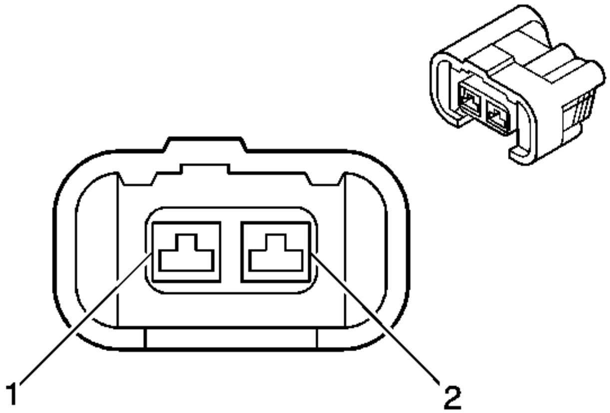
Connector Part Information		• 6189-0553 • 2-Way F HX Series (BK)	
Pin	Wire Color	Circuit No.	Function
1	YE	844	Fuel Injector 4 Control
2	RD	39	Ignition 1 Voltage

Fuel Injector 5 Connector End View



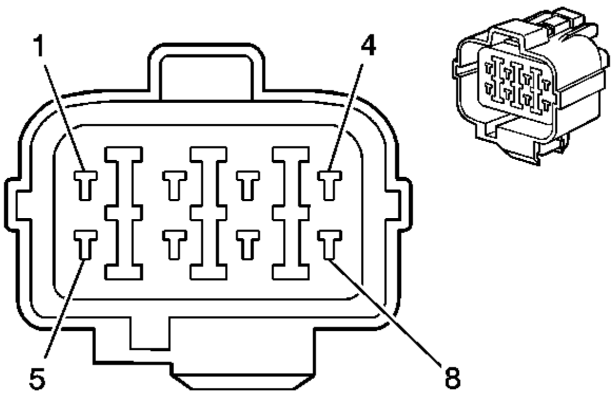
Connector Part Information		• 6189-0553 • 2-Way F HX Series (BK)	
Pin	Wire Color	Circuit No.	Function
1	BK/RD	845	Fuel Injector 5 Control
2	RD	39	Ignition 1 Voltage

Fuel Injector 6 Connector End View



Connector Part Information		6189-0553 2-Way F HX Series (BK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	WH/BU	846	Fuel Injector 6 Control
2	RD	39	Ignition 1 Voltage

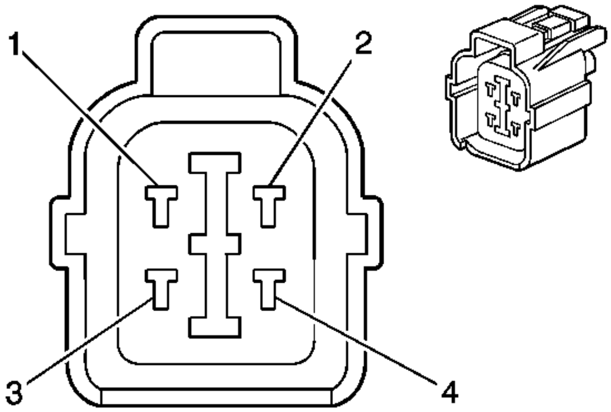
Heated Oxygen Sensor (HO2S) Bank 1 Sensor 1 Connector End View



Connector Part Information		6189-0134 8-Way F HW Series (GY)	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	WH/RD	6731	HO2S Pump Current - Bank 1 Sensor 1
2	GN/YE	2751	Low Reference

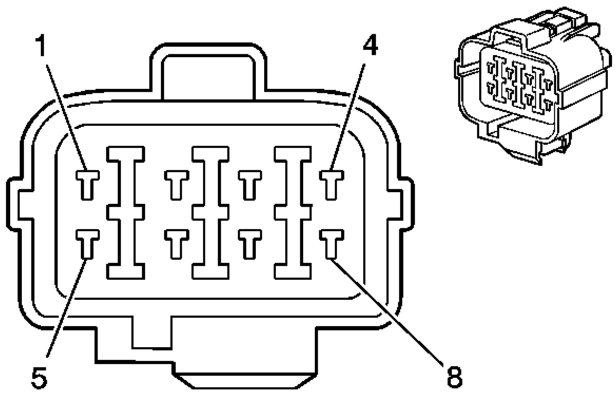
3	BK/WH	3113	HO2S Heater Control - Bank 1 Sensor 1
4	WH	5291	Ignition 1 Voltage
5	RD	6729	HO2S Reference Voltage - Bank 1 Sensor 1
6	D-GN	6730	HO2S Input Pump Current - Bank 1 Sensor 1
7	D-BU	6728	HO2S Low Reference - Bank 1 Sensor 1
8	-	-	Not Used

Heated Oxygen Sensor (HO2S) Bank 1 Sensor 2 Connector End View



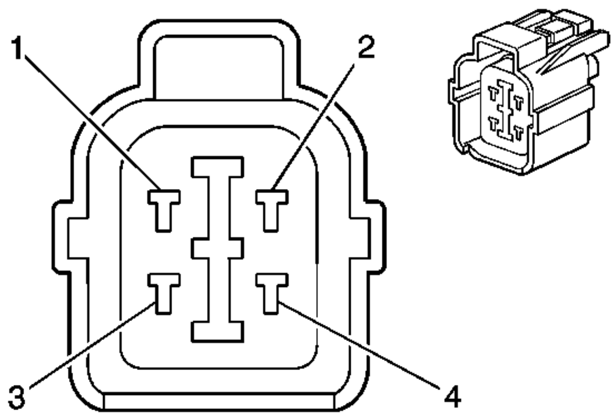
Connector Part Information		• **6189-0132** • **4-Way F HW Series (GY)**	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	GN/YE	2751	Low Reference
2	D-GN	1688	HO2S Signal - Bank 1 Sensor 2
3	WH	5291	Ignition 1 Voltage
4	BK/WH	3122	HO2S Heater Low Control

Heated Oxygen Sensor (HO2S) Bank 2 Sensor 1 Connector End View



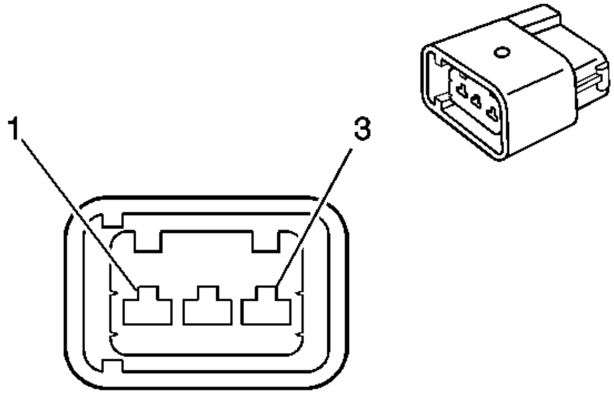
Connector Part Information	• 6189-0134 • 8-Way F HW Series (GY)		
Pin	**Wire Color**	**Circuit No.**	**Function**
1	WH/RD	6735	HO2S Pump Current - Bank 2 Sensor 1
2	GN/YE	2751	Low Reference
3	GN/WH	3212	HO2S Heater Control - Bank 2 Sensor 1
4	WH	5291	Ignition 1 Voltage
5	RD/WH	6733	HO2S Reference Voltage - Bank 2 Sensor 1
6	GN/RD	6734	HO2S Input Pump Current- Bank 2 Sensor 1
7	RD/BU	6732	HO2S Low Reference - Bank 2 Sensor 1
8	-	-	Not Used

Heated Oxygen Sensor (HO2S) Bank 2 Sensor 2 Connector End View



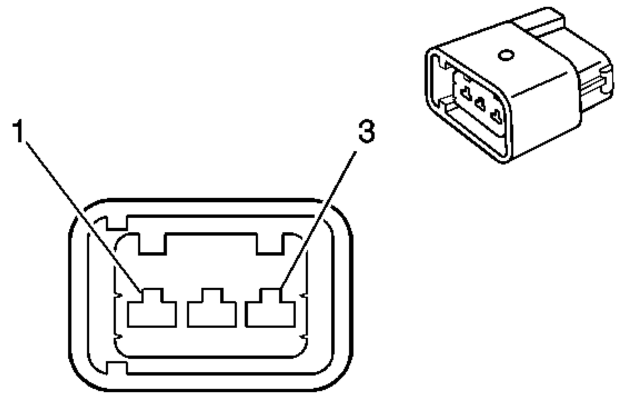
Connector Part Information		• 6189-0132 • 4-Way F HW Series (GY)	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	GN/YE	2751	Low Reference
2	WH	1670	HO2S Signal - Bank 2 Sensor 2
3	WH	5291	Ignition 1 Voltage
4	BK/WH	3122	HO2S Heater Low Control

Ignition Control Module (ICM) 1 Connector End View



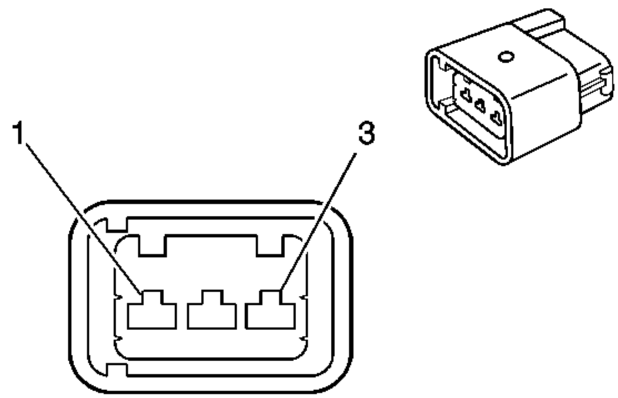
Connector Part Information		• 6189-0728 • 3-Way F HX Series (BK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	YE/GN	2121	Ignition Coil 1 Control
2	BK	450	Ground
3	WH	5290	Ignition 1 Voltage

Ignition Control Module (ICM) 2 Connector End View



Connector Part Information		• 6189-0728 • 3-Way F HX Series (BK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	BU/RD	2122	Ignition Coil 2 Control
2	BK	450	Ground
3	WH	5290	Ignition 1 Voltage

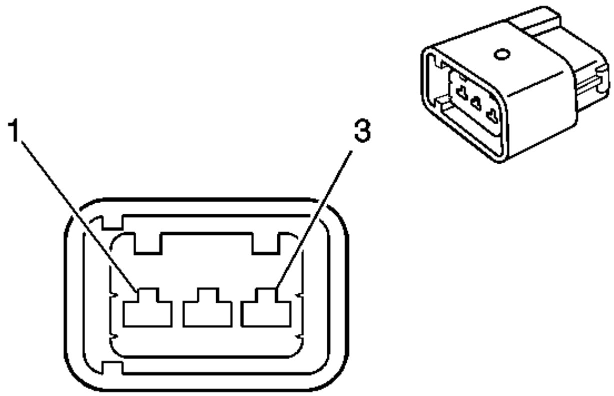
Ignition Control Module (ICM) 3 Connector End View



Connector Part Information		• 6189-0728 • 3-Way F HX Series (BK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	WH/BU	2123	Ignition Coil 3 Control
2	BK	450	Ground

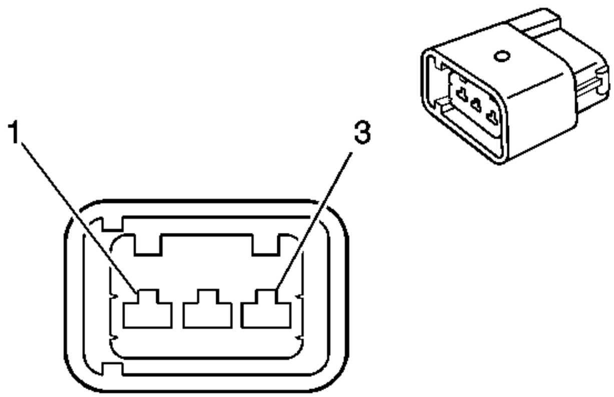
3	WH	5290	Ignition 1 Voltage

Ignition Control Module (ICM) 4 Connector End View



Connector Part Information	• **6189-0728** • **3-Way F HX Series (BK)**		
Pin	**Wire Color**	**Circuit No.**	**Function**
1	BN	2124	Ignition Coil 4 Control
2	BK	450	Ground
3	WH	5290	Ignition 1 Voltage

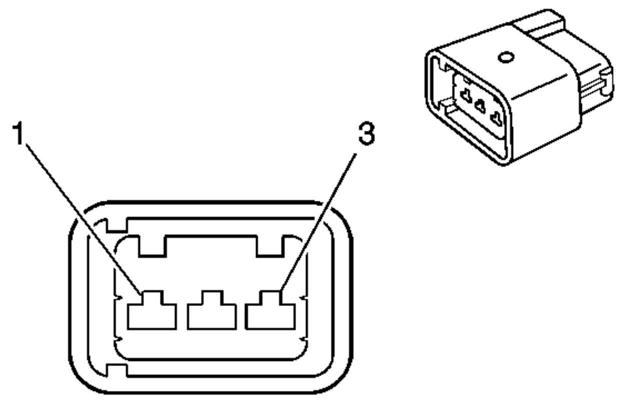
Ignition Control Module (ICM) 5 Connector End View



Connector Part Information	• **6189-0728** • **3-Way F HX Series (BK)**

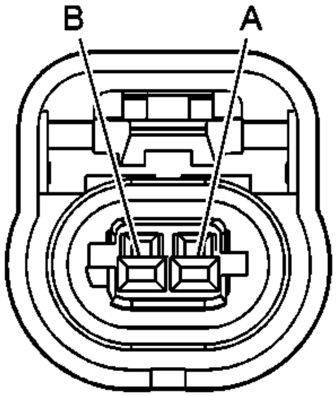
Pin	Wire Color	Circuit No.	Function
1	BK/RD	2125	Ignition Coil 5 Control
2	BK	450	Ground
3	WH	5290	Ignition 1 Voltage

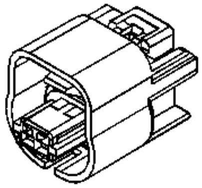
Ignition Control Module (ICM) 6 Connector End View



Connector Part Information		• 6189-0728 • 3-Way F HX Series (BK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	BN/WH	2126	Ignition Coil 6 Control
2	BK	450	Ground
3	WH	5290	Ignition 1 Voltage

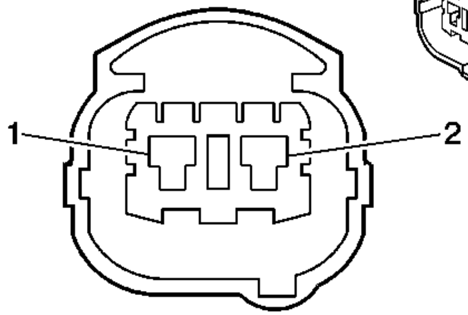
Intake Air Temperature (IAT) Sensor 1 Connector End View

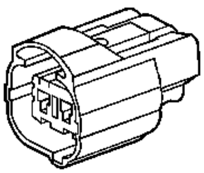




Connector Part Information		• 15335987 • 2-Way F GT 150 Series Sealed (BK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
A	TN	472	IAT Sensor 1 Signal
B	BK	2760	Low Reference

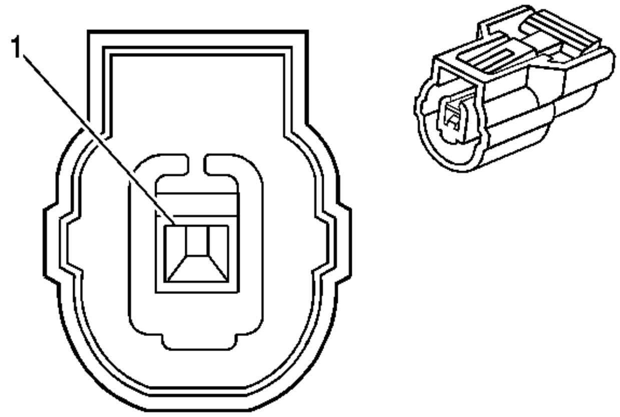
Intake Air Temperature (IAT) Sensor 2 Connector End View





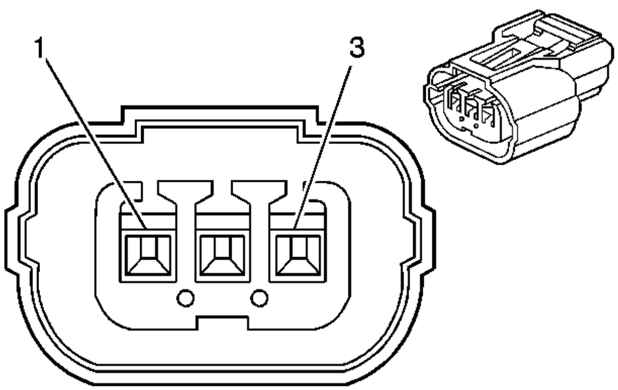
Connector Part Information		• 6189-0552 • 2-Way F HX Series (BK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	GN/YE	2751	Low Reference
2	RD/YE	6118	IAT Sensor 2 Signal

Knock Sensor (KS) Connector End View



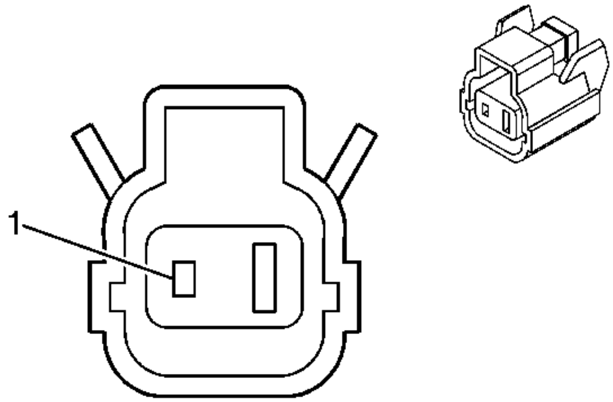
Connector Part Information		• 6189-0940 • 1-Way F HX Series (BK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	RD/BU	496	KS Signal

Manifold Absolute Pressure (MAP) Sensor Connector End View



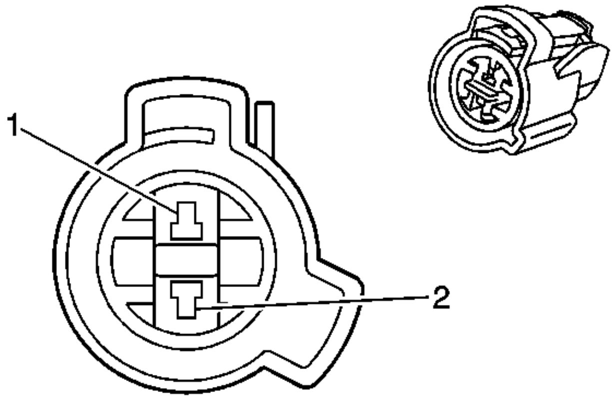
Connector Part Information		• 6189-0887 • 3-Way F HX Series (BK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	GN/WH	469	Low Reference
2	GN/RD	432	MAP Sensor Signal
3	YE/RD	474	5-Volt Reference B

Rocker Arm Oil Control Solenoid Connector End View



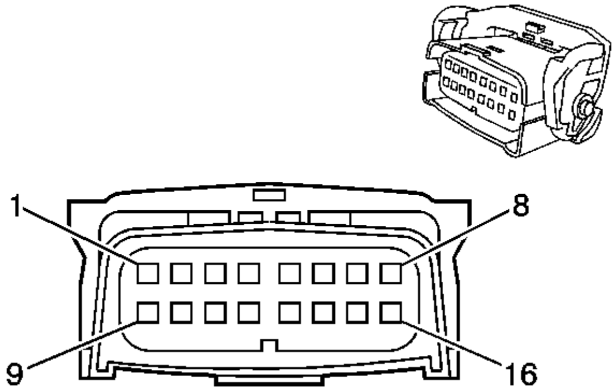
Connector Part Information		• 6189-0724 • 1-Way F HW Series (BK)	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	GY/YE	6736	Rocker Arm Oil Actuator Control Signal

Rocker Arm Oil Pressure Switch Connector End View



Connector Part Information		• 6189-0156 • 2-Way F (GY)	
Pin	**Wire Color**	**Circuit No.**	**Function**
1	BU/BK	6737	Rocker Arm Oil Pressure Switch Signal
2	BN/YE	451	Ground

Throttle Actuator Control (TAC) Module Connector End View



Connector Part Information		• 6610-5412 • 16-Way F (GY)	
Pin	**Wire Color**	**Circuit No.**	**Function**
1-2	-	-	Not Used
3	GN/WH	6741	Motor Inhibit
4	-	-	Not Used
5	D-BU	6739	ETC Control
6	-	-	Not Used
7	BK	450	Ground
8	WH	5292	Ignition 1 Voltage
9-11	-	-	Not Used
12	D-GN	6738	ETC Signal
13-14	-	-	Not Used
15	BK	450	Ground
16	-	-	Not Used

REPAIR INSTRUCTIONS

POWERTRAIN CONTROL MODULE (PCM) REPLACEMENT

Removal Procedure

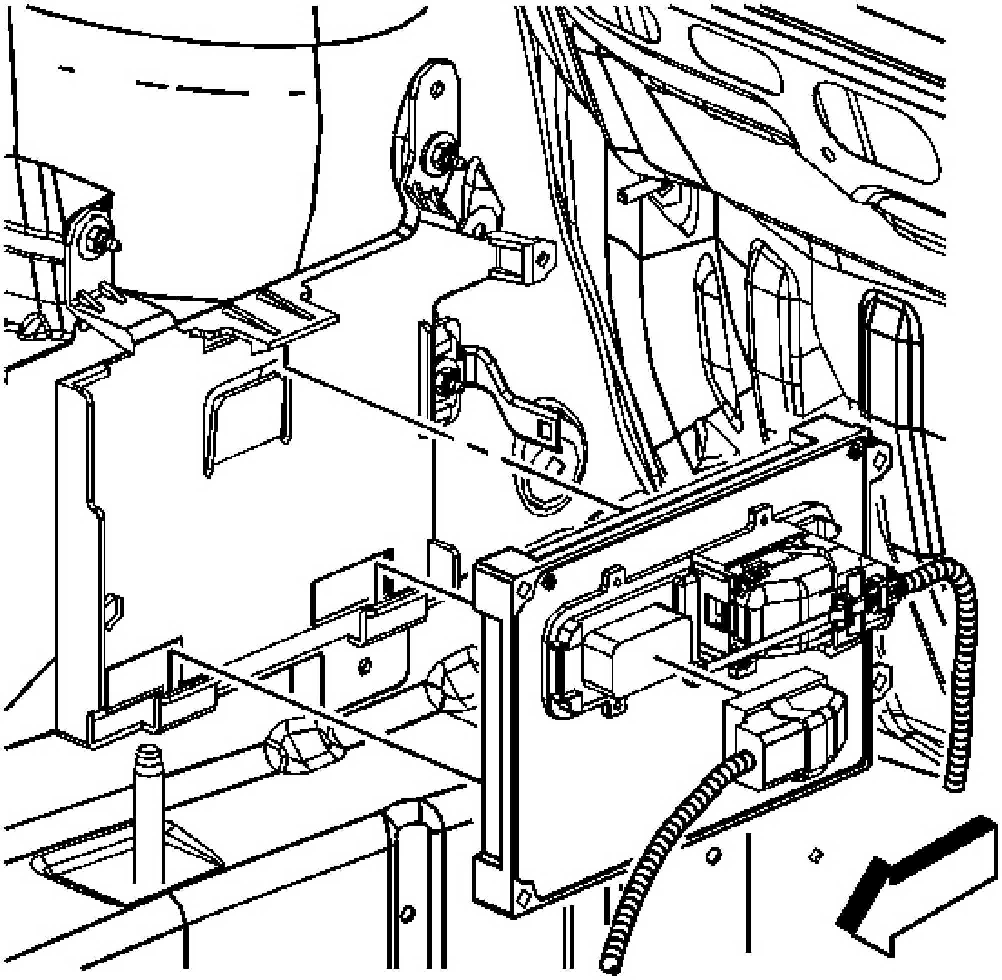


Fig. 18: View Of Powertrain Control Module (PCM)
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the battery negative cable. Refer to**Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Disconnect the wiring harness.
3. Depress the retaining tab and remove the powertrain control module (PCM).
4. Remove the PCM from the housing.

Installation Procedure

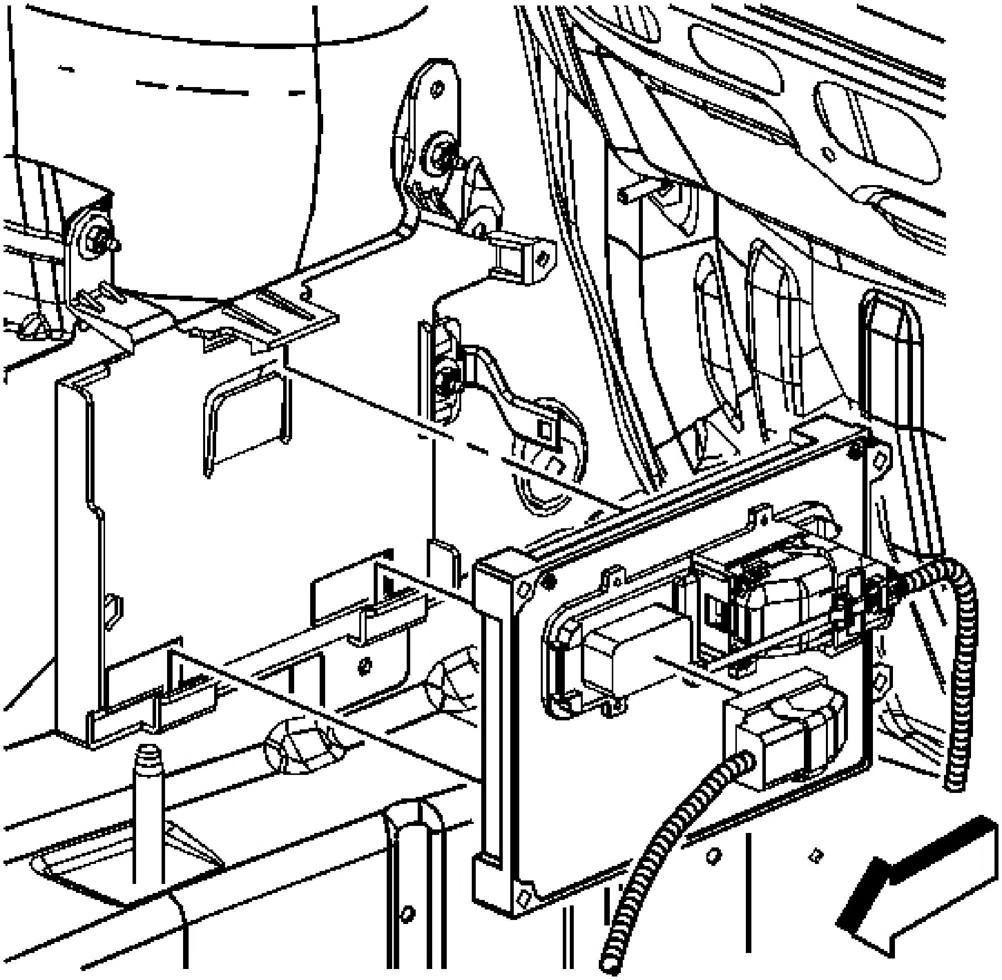


Fig. 19: View Of Powertrain Control Module (PCM)
Courtesy of GENERAL MOTORS CORP.

1. Install the PCM into the housing bracket.
2. Connect the wiring harness.
3. Connect the battery negative cable. Refer to**Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
4. Program the PCM. Refer to**Service Programming System (SPS)** in Programming.
5. Perform the Idle Learn procedure. Refer to**Idle Learn Procedure** .

IDLE LEARN PROCEDURE

1. Install a scan tool.
2. Diagnose and repair any DTCs before proceeding with this procedure. Refer to **Diagnostic Trouble Code (DTC) List** for the applicable DTC that set.
3. Ensure that all electrical loads and accessories are OFF.
4. Turn OFF the air conditioning.
5. Ensure that the vehicle is in PARK or NEUTRAL.
6. Turn ON the ignition.
7. Clear the DTC information with the scan tool.
8. Wait 5 seconds and start the engine.
9. Operate the engine with no load at 3,000 RPM until the ECT reaches 90°C (194°F).

IMPORTANT: If the engine cooling fan turns ON during the idle portion of this procedure, do not include the fan run time in the total idle time.

10. Let the engine idle with the THROTTLE CLOSED and the engine cooling fan OFF, for a total of 5 minutes.
11. The PCM has a new learned idle position.
12. The idle learn procedure is required when the following service procedures have been performed:
    - The throttle body assembly is replaced
    - The throttle valve is cleaned-Deposits can build up in the throttle body requiring periodic cleaning of the throttle valve and throttle bore area. Refer to **Throttle Body Service** .
    - The Clear DTCs function has been performed
    - The PCM has been programmed.
    - The PCM is replaced

Idle Speed Inspection

1. Install a scan tool.
2. Ensure that all electrical loads and accessories are OFF.
3. Turn OFF the air conditioning.
4. Ensure that the vehicle is in PARK or NEUTRAL.
5. Start and run the engine until the ECT is at least 80°C (176°F).
6. Ensure that the scan tool data parameter Engine at Operating Temperature says YES.
7. Observe that the engine speed is 730 RPM +/-50 RPM with the scan tool.
8. Idle the engine for 1 minute with the AC ON and the blower motor operating on HIGH.
9. Observe that the engine speed is 730 RPM +/-50 RPM with the scan tool.
10. Compare the engine speed at idle with the scan tool to the following specifications:
    - All engine accessories OFF-730 RPM +/-50 RPM
    - Turn the AC ON and the heater fan on HIGH-730 RPM +/-50 RPM

11. If the scan tool indicated that the engine idle was within the specified values, the idle speed is normal.
12. If the scan tool indicated that the engine idle was more than or less than specified values, refer to **Rough, Unstable, or Incorrect Idle and Stalling** .

POSITIVE CRANKCASE VENTILATION VALVE REPLACEMENT

Removal Procedure

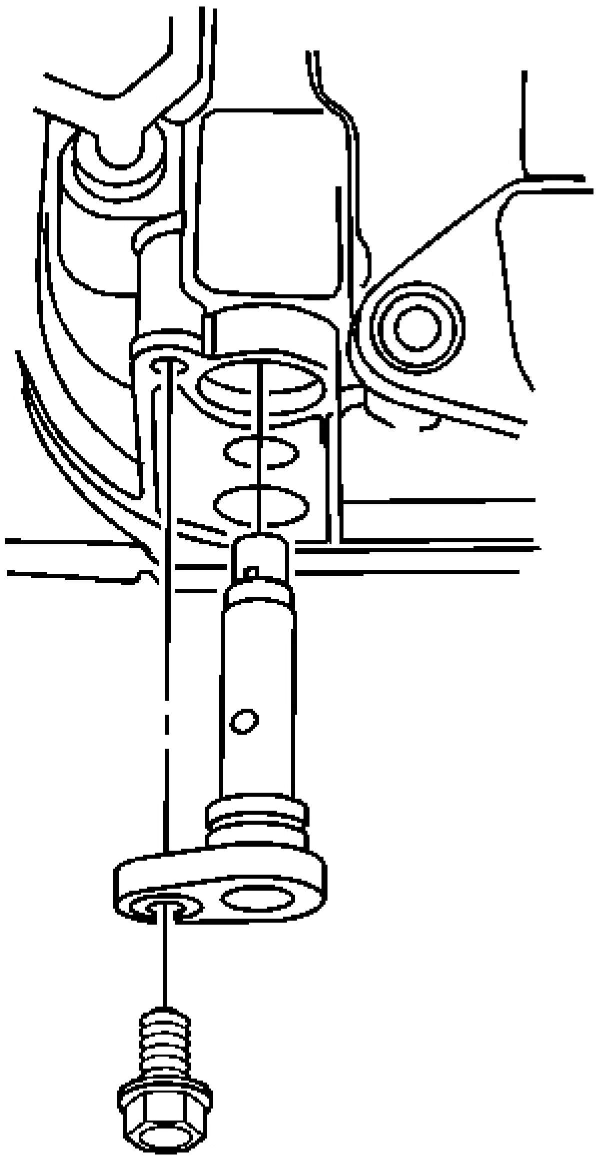


Fig. 20: View Of Positive Crankcase Ventilation (PCV) Valve
Courtesy of GENERAL MOTORS CORP.

1. Remove the positive crankcase ventilation (PCV) valve bolt.
2. Remove the PCV valve.

Installation Procedure

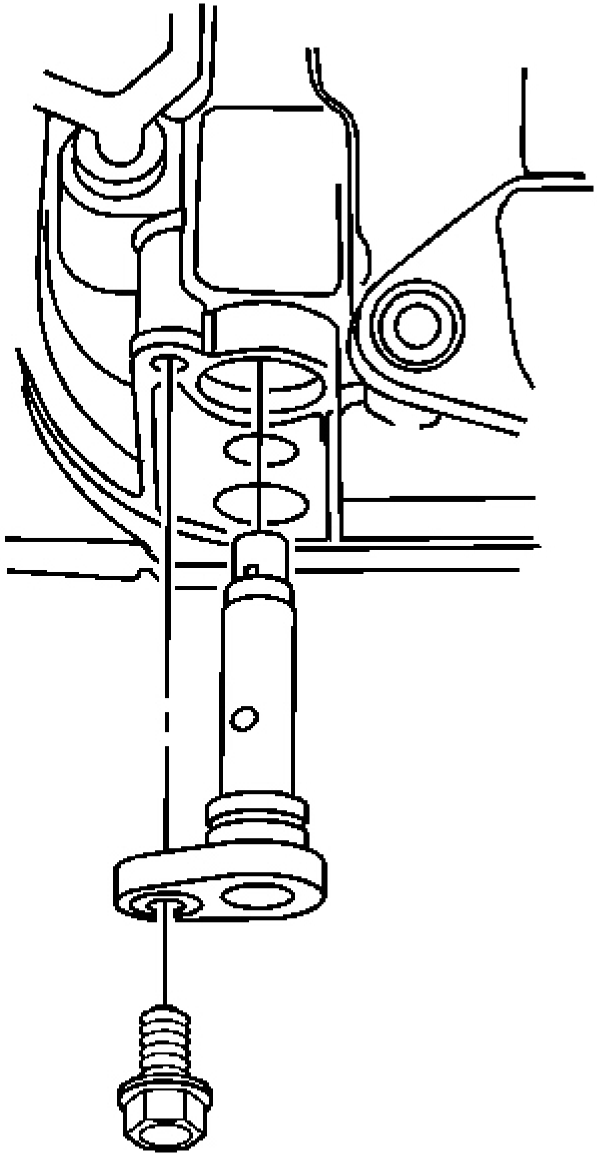


Fig. 21: View Of Positive Crankcase Ventilation (PCV) Valve
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When installing a new PCV valve, make sure the O-rings are in place.

When installing a used PCV valve, use NEW 0-rings.

1. Install the PCV valve.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the PCV bolt.

Tighten: Tighten the bolt to 12 N.m (106 lb in).

ENGINE COOLANT TEMPERATURE (ECT) SENSOR REPLACEMENT

Removal Procedure

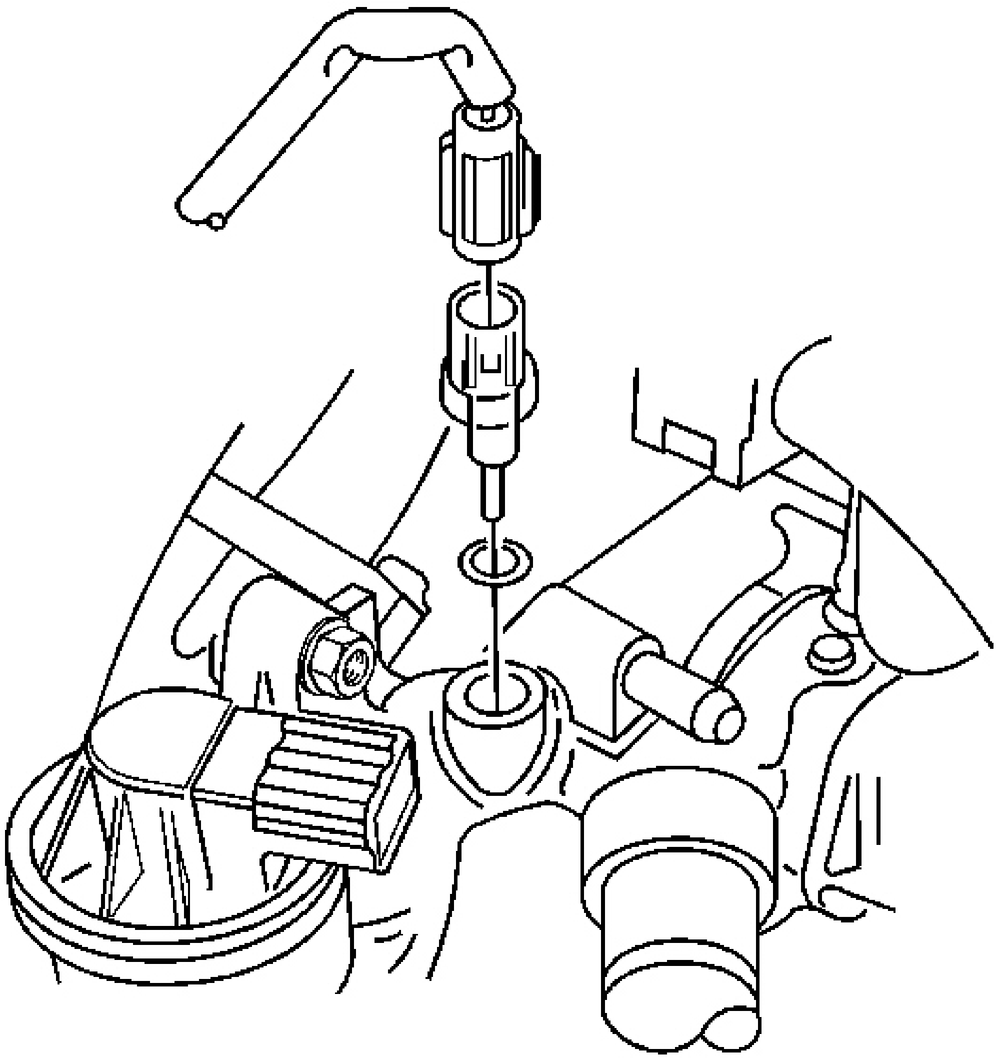


Fig. 22: View Of Engine Coolant Temperature(ECT) Sensor
Courtesy of GENERAL MOTORS CORP.

1. Turn ignition OFF.

IMPORTANT: Engine coolant must be drained below the level of the engine coolant temperature sensor (ECT) sensor. Refer to Draining and Filling Cooling System in Engine Cooling.

2. Disconnect the ECT sensor harness connector.
3. Remove the ECT.

Installation Procedure

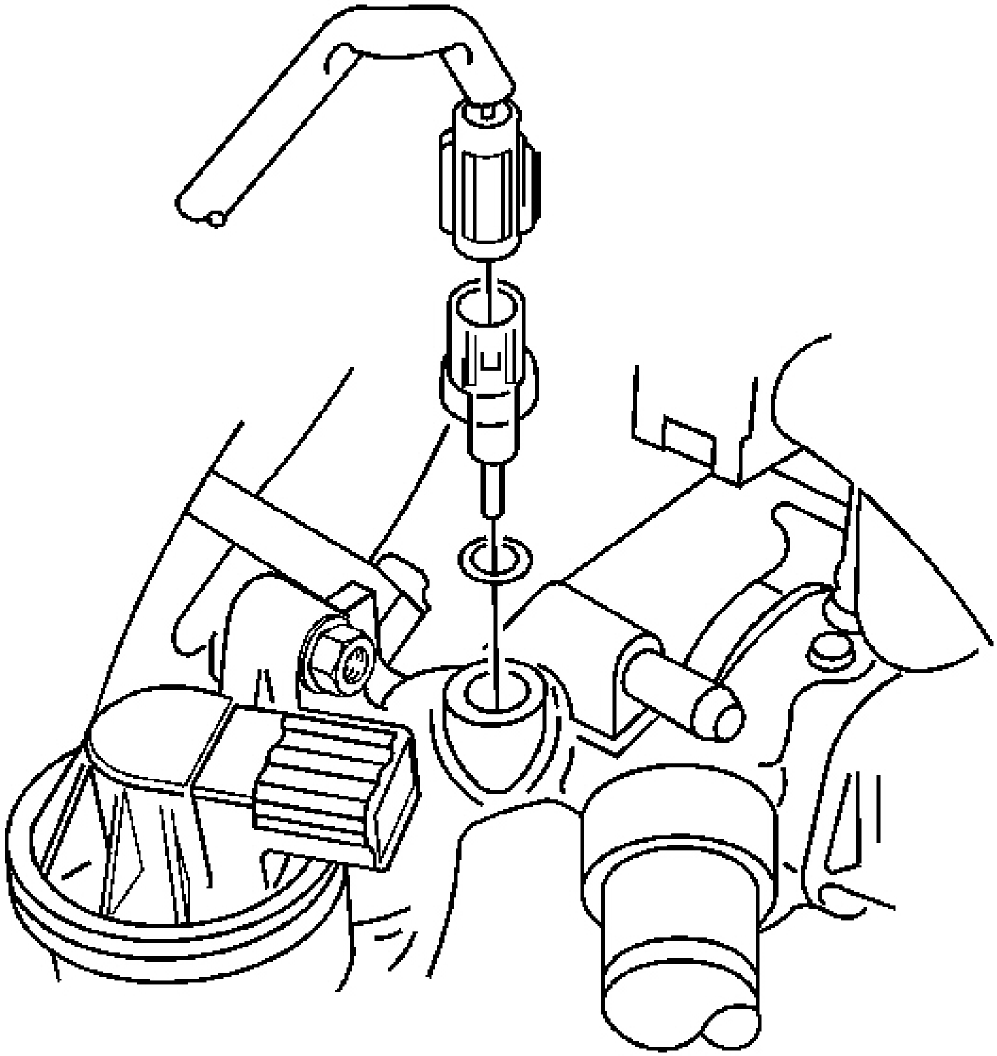


Fig. 23: View Of Engine Coolant Temperature (ECT) Sensor
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: **Tap out sensor mounting hole in engine head to remove any thread**

sealant residue. Clean any sealant residue from old sensor and apply RTV sealant to threads if old sensor is going to be reused.

1. Apply thread sealant SA P/N 21485277 Loctite 242(R) Threadlocker (or equivalent) to sensor threads.

   NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the ECT sensor with a new O-ring.

   Tighten: Tighten the engine coolant temperature sensor to 18 N.m (13 lb ft).

3. Connect the ECT sensor harness connector. Push in the connector until a click is heard, then pull back to confirm a positive engagement.
4. Fill engine coolant to proper level. Refer to **Draining and Filling Cooling System** in Engine Cooling.

INTAKE AIR TEMPERATURE (IAT) SENSOR 1 REPLACEMENT

Removal Procedure

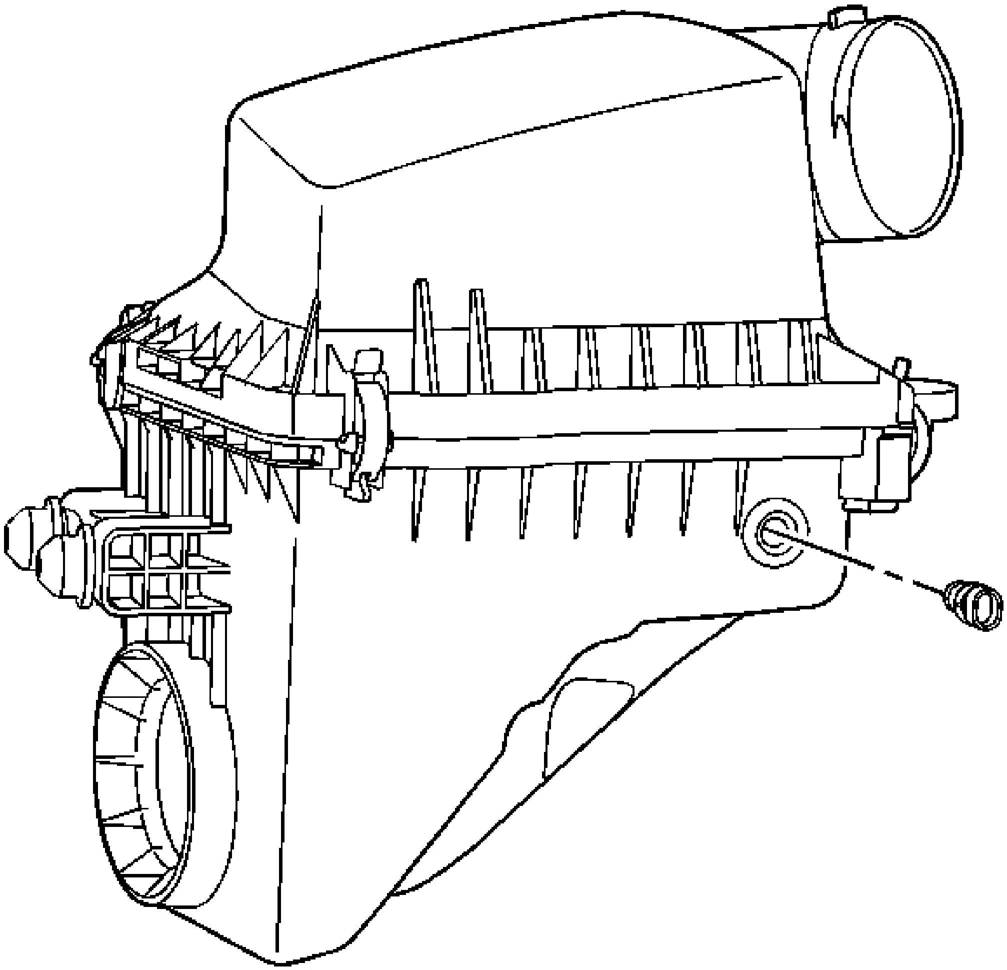


Fig. 24: View Of Intake Air Temperature (IAT) Sensor
Courtesy of GENERAL MOTORS CORP.

1. Turn the ignition OFF.
2. Disconnect the IAT sensor harness connector.
3. Remove the IAT sensor by pulling it out of the air cleaner housing.

Installation Procedure

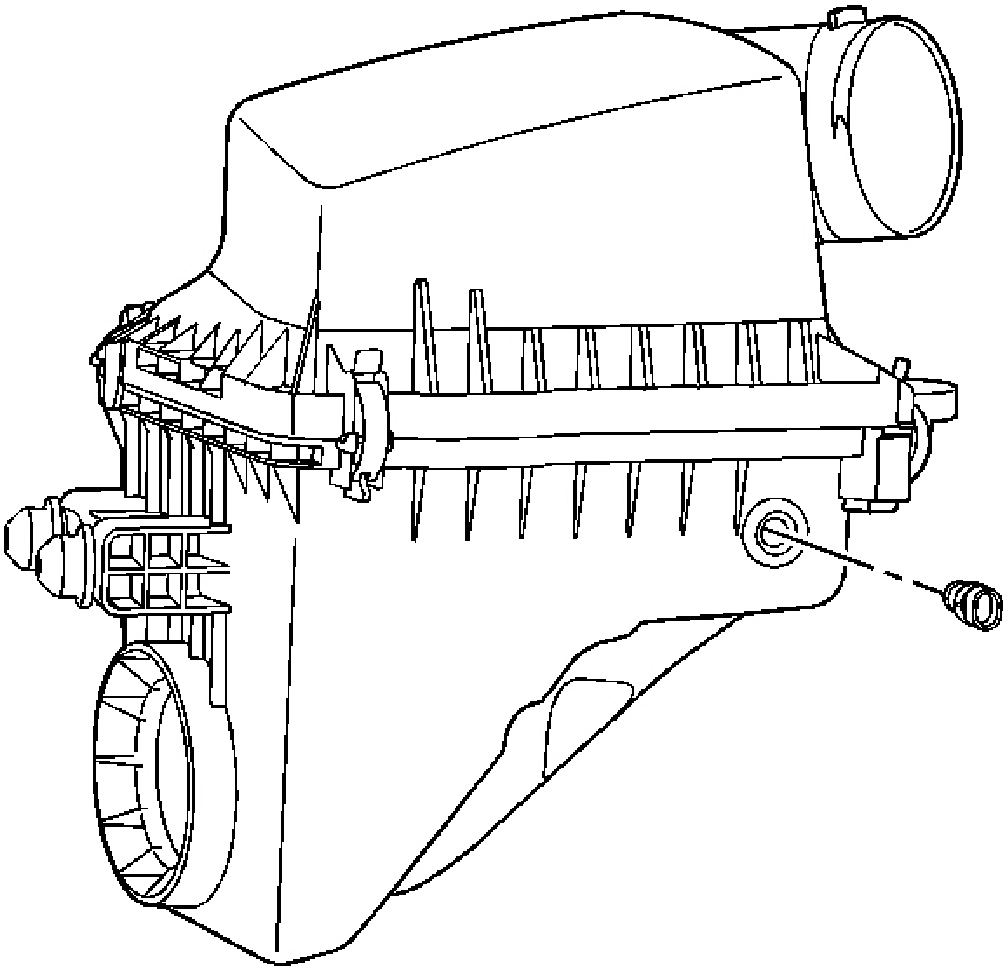


Fig. 25: View Of Intake Air Temperature (IAT) Sensor
Courtesy of GENERAL MOTORS CORP.

1. Install the IAT sensor with a new O-ring.
2. Connect the IAT sensor harness connector. Push in the connector until a click is heard, then pull back to confirm a positive engagement.

INTAKE AIR TEMPERATURE (IAT) SENSOR 2 REPLACEMENT

Removal Procedure

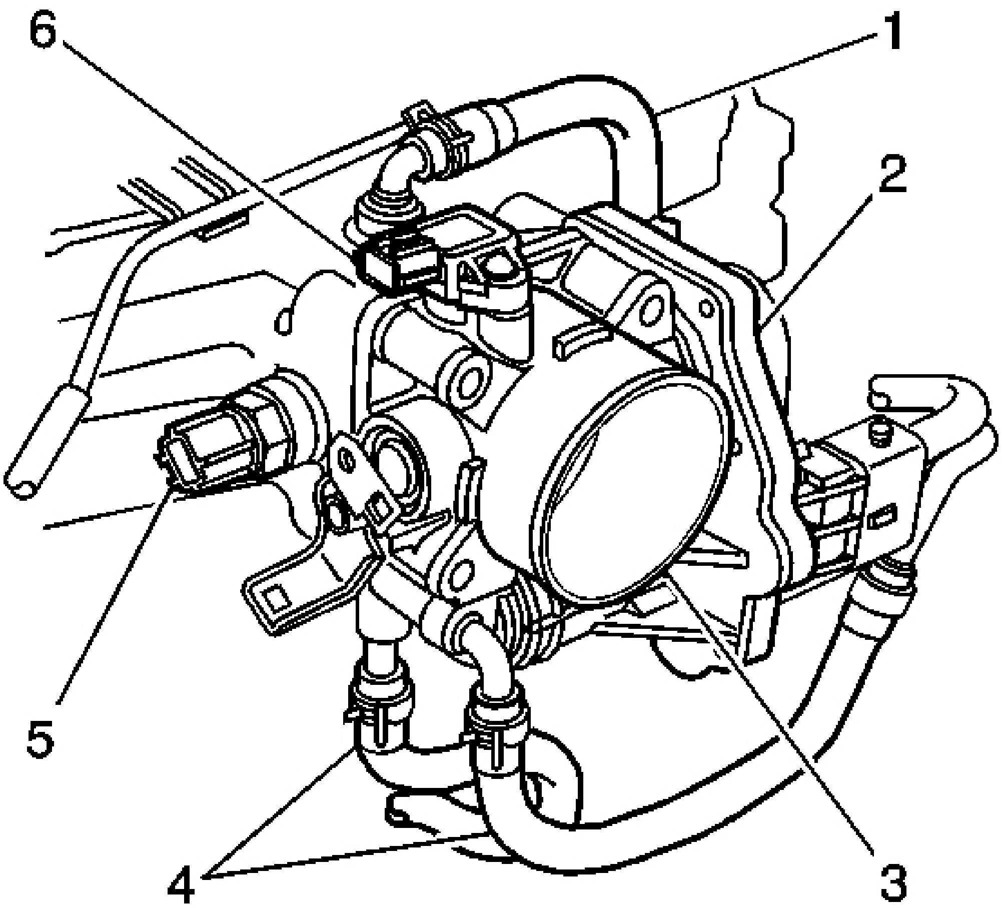


Fig. 26: View Of Intake Air Temperature (IAT) Sensor 2
Courtesy of GENERAL MOTORS CORP.

1. Turn the ignition OFF.
2. Disconnect the IAT sensor harness connector.
3. Remove the IAT sensor from the side of the intake manifold (5).

Installation Procedure

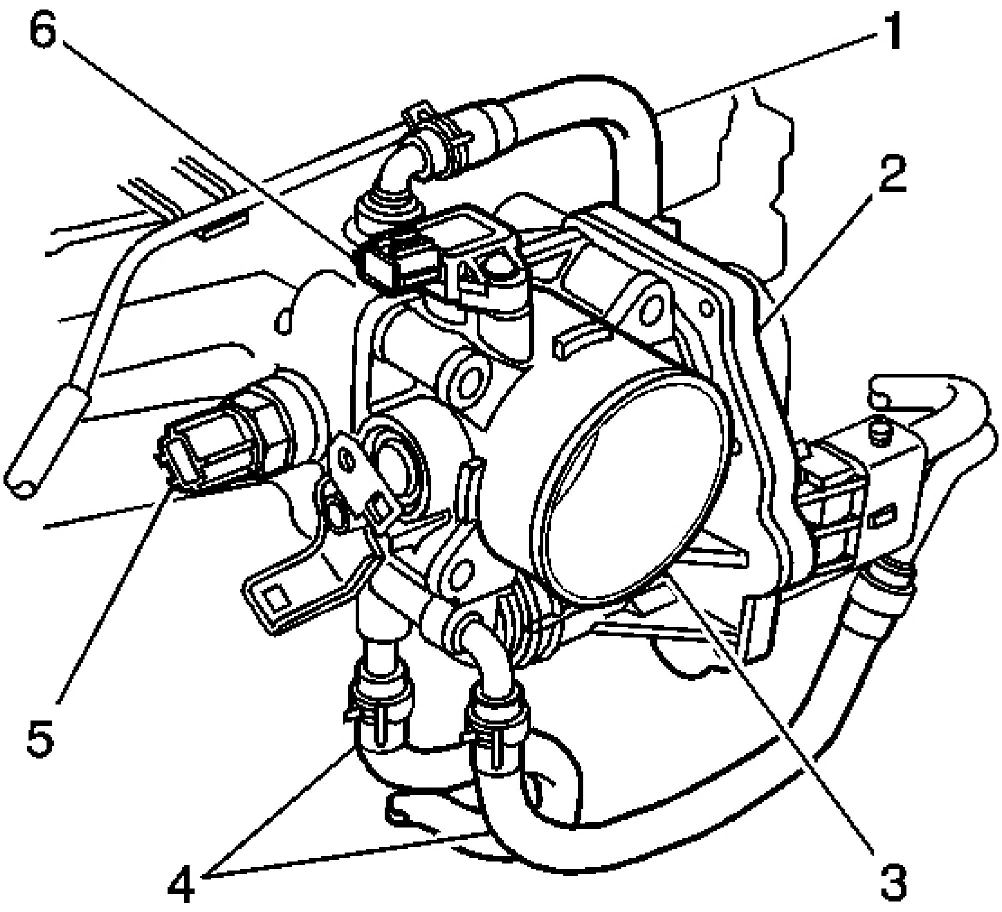


Fig. 27: View Of Intake Air Temperature (IAT) Sensor 2
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the IAT sensor to the side of the intake manifold (5).

   Tighten: Tighten the IAT sensor to 18 N.m (13 lb ft).

2. Connect the IAT sensor harness connector. Push in the connector until a click is heard, then pull back to confirm a positive engagement.

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR REPLACEMENT

Removal Procedure

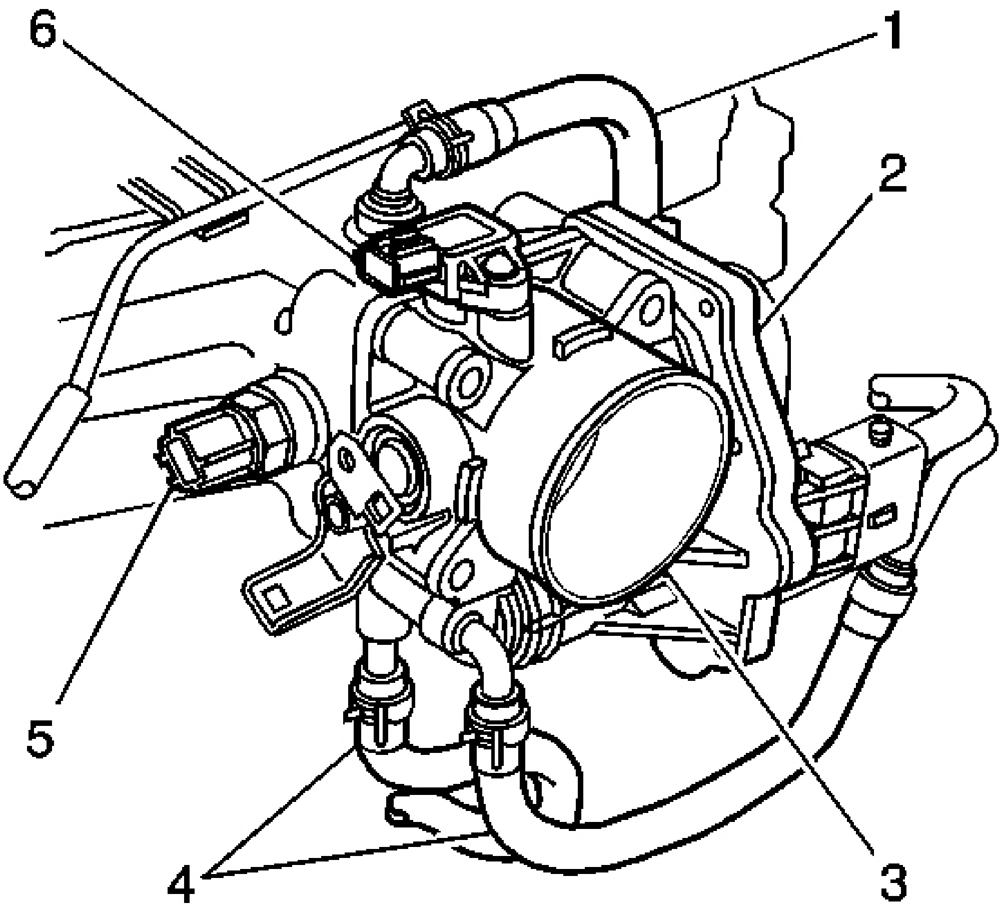


Fig. 28: View Of Manifold Absolute Pressure (MAP) Sensor
Courtesy of GENERAL MOTORS CORP.

1. Turn the ignition OFF.
2. Disconnect the manifold absolute pressure (MAP) sensor harness connector.
3. Remove the MAP sensor attachment screw and remove the MAP sensor and O-ring (6).

Installation Procedure

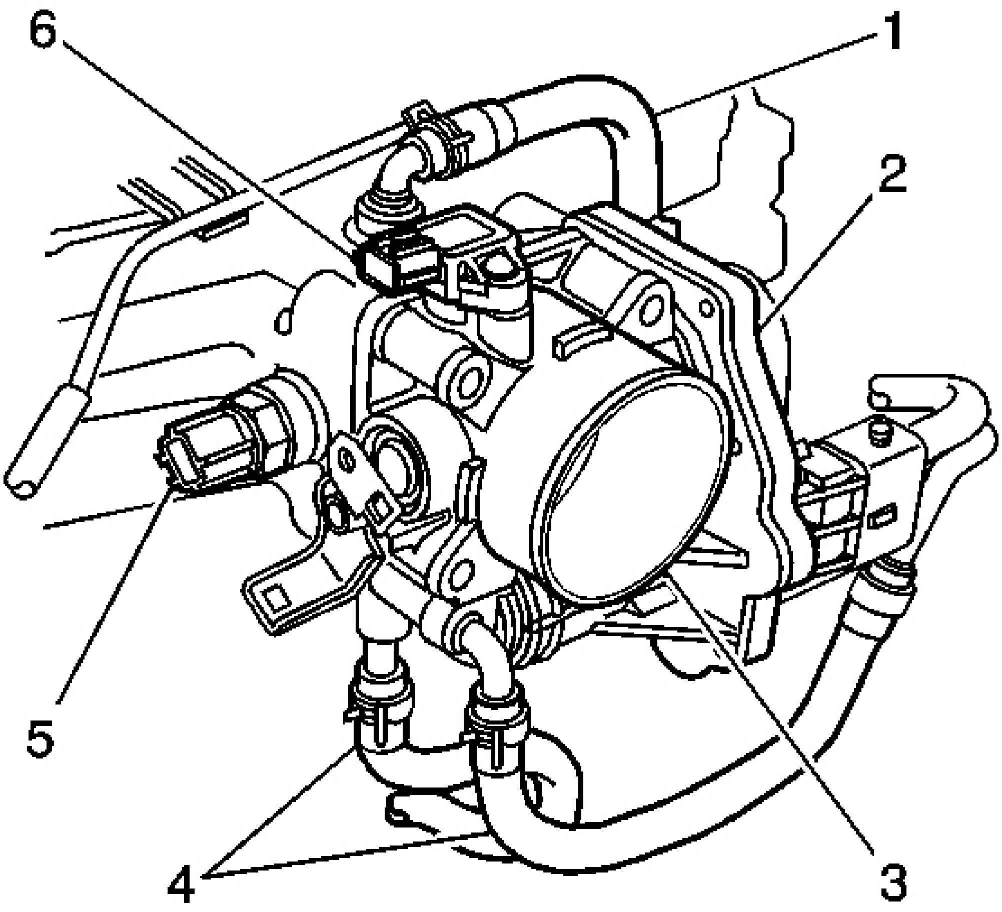


Fig. 29: View Of Intake Air Temperature (IAT) Sensor 2
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Make sure the MAP sensor mounting surface is clean. Install the MAP sensor with the new O-ring and attachment bolt (6).

   Tighten: Tighten the manifold absolute pressure sensor screw to 4 N.m (35 lb in).

2. Connect the MAP sensor harness connector. Push the connector in until the lock position is felt, then pull back to confirm engagement.

HEATED OXYGEN SENSOR (HO2S) REPLACEMENT BANK 1 SENSOR 1

Tools Required

J 39194-C Oxygen Sensor Wrench

Removal Procedure

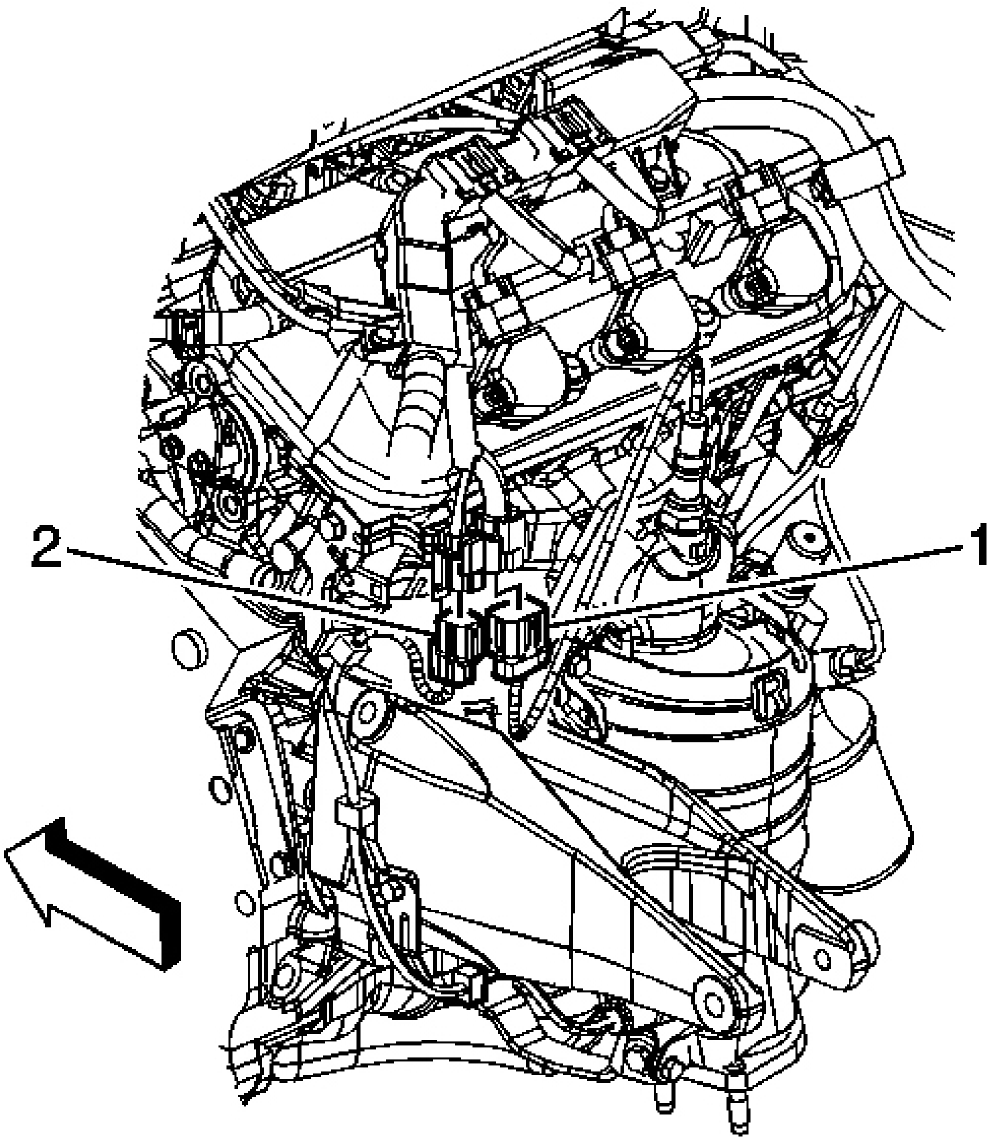


Fig. 30: View Of Heated Oxygen Sensor (HO2S)

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Bank 1 are cylinders 1, 3, and 5 which are closest to the front of the dash.

1. Turn the ignition OFF.
2. Disconnect the bank 1 heated oxygen sensor 1 harness connector (1).

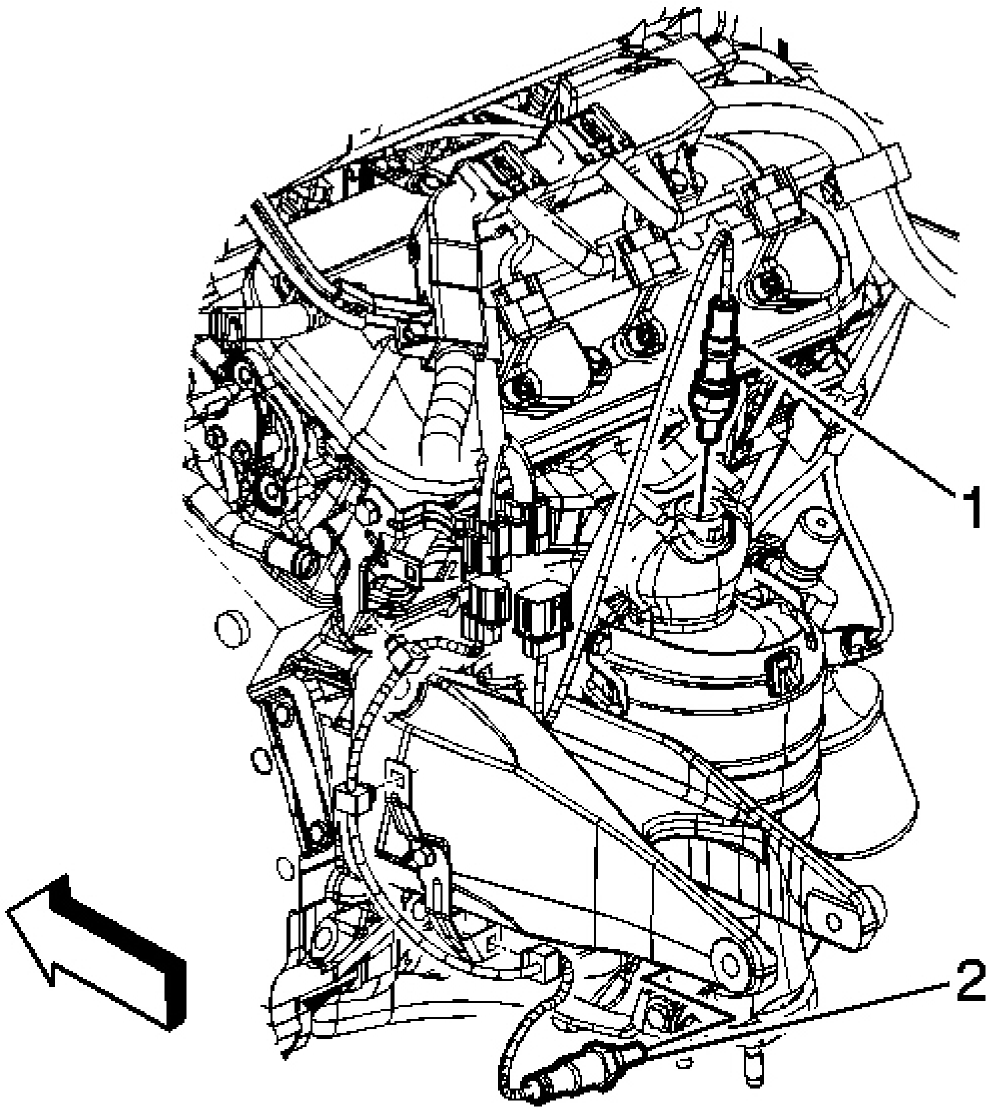


Fig. 31: View Of Heated Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

CAUTION: Removal of the sensor is easier if the exhaust system is warmed up slightly. Be careful that it is not too hot to work on safely. Applying penetrating oil to the threads while moving the sensor back and forth will also aid in removal and will decrease the chance of exhaust pipe thread damage.

3. Remove the oxygen sensor using the **J 39194-C** .

Installation Procedure

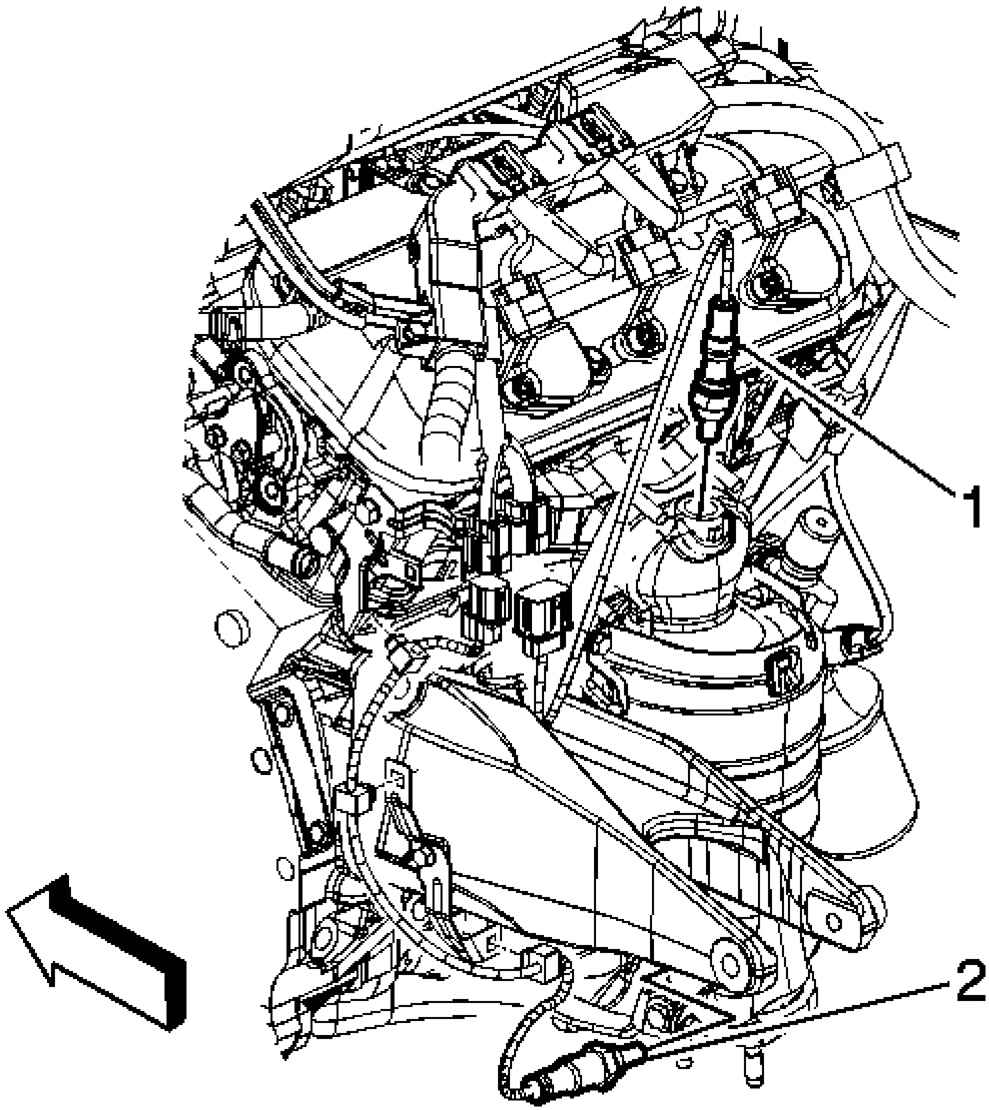


Fig. 32: View Of Heated Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

1. Apply a small amount of the anti-seize compound SA P/N 21485279, or equivalent, to the threads of the heated oxygen sensor 1.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the heated oxygen sensor 1 using the **J 39194-C** .

Tighten: Tighten the oxygen sensor to 44 N.m (33 lb ft).

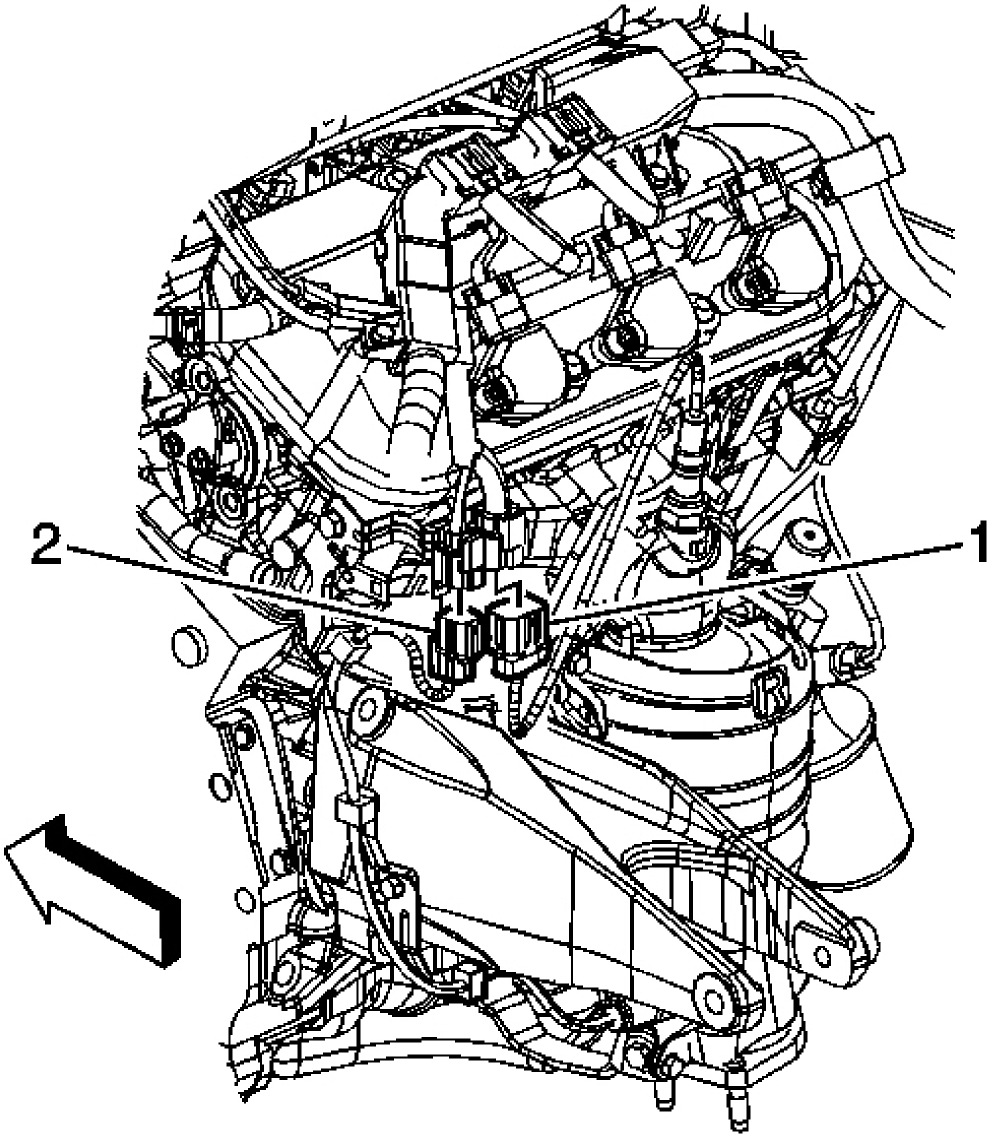


Fig. 33: View Of Heated Oxygen Sensor (HO2S)
Courtesy of GENERAL MOTORS CORP.

3. Connect the bank 1 heated oxygen sensor 1 harness connector (1). Make sure the locking tab is in the full closed position.
4. Start the engine and make sure no exhaust leaks exist.

HEATED OXYGEN SENSOR (HO2S) REPLACEMENT BANK 1 SENSOR 2

Tools Required

J 39194-C Oxygen Sensor Wrench

Removal Procedure

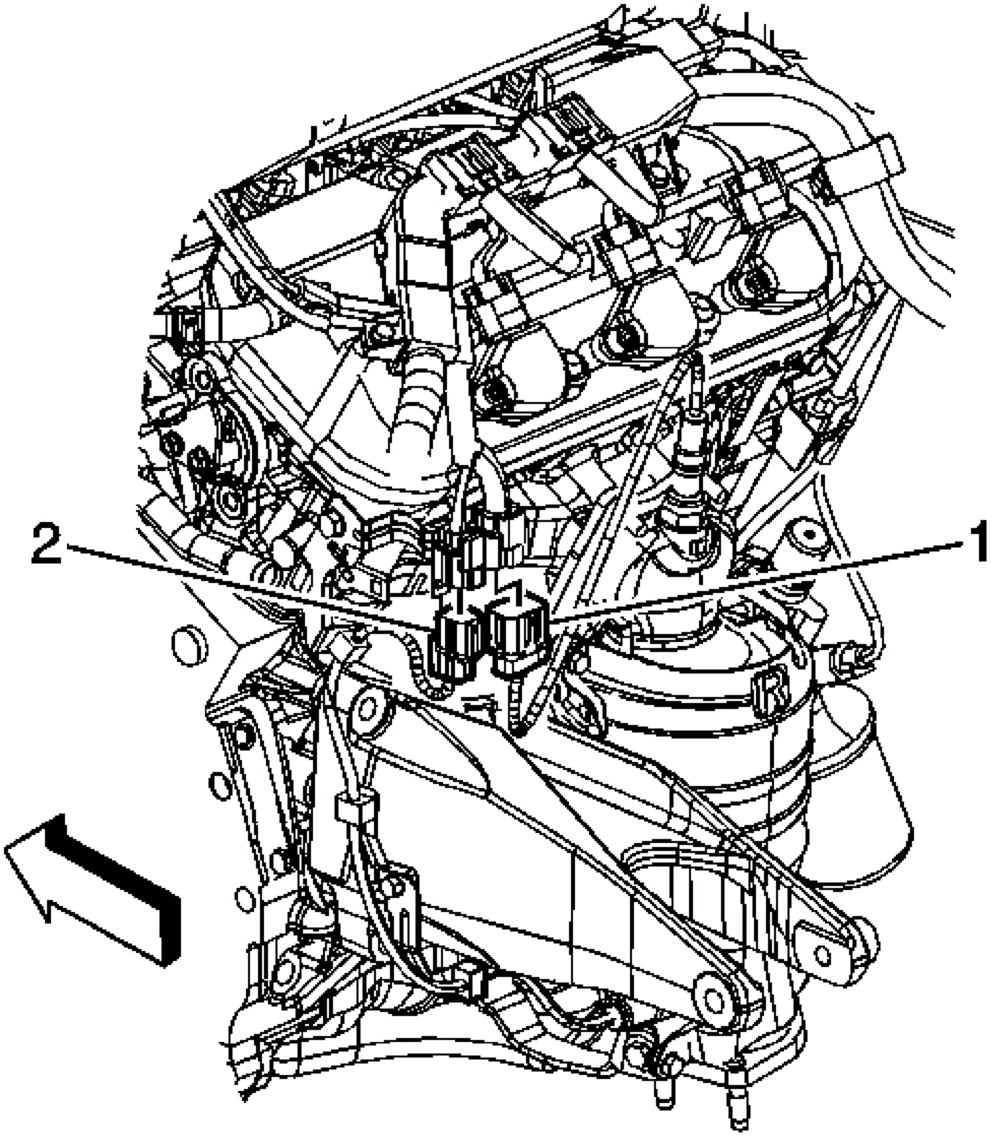


Fig. 34: View Of Heated Oxygen Sensor (HO2S)
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: **Bank 1 are cylinders 1, 3, and 5 which are the closest to the front of the dash.**

1. Turn the ignition OFF.

2. Disconnect the bank 1 heated oxygen sensor 2 harness connector (2).
3. Disconnect the connectors from the retaining bracket.
4. Remove the heated oxygen sensor connector retaining bracket and bolt.
5. Raise and support the vehicle. Refer to**Lifting and Jacking the Vehicle** in General Information.
6. Remove the heated oxygen sensor wiring harness bracket and bolt.

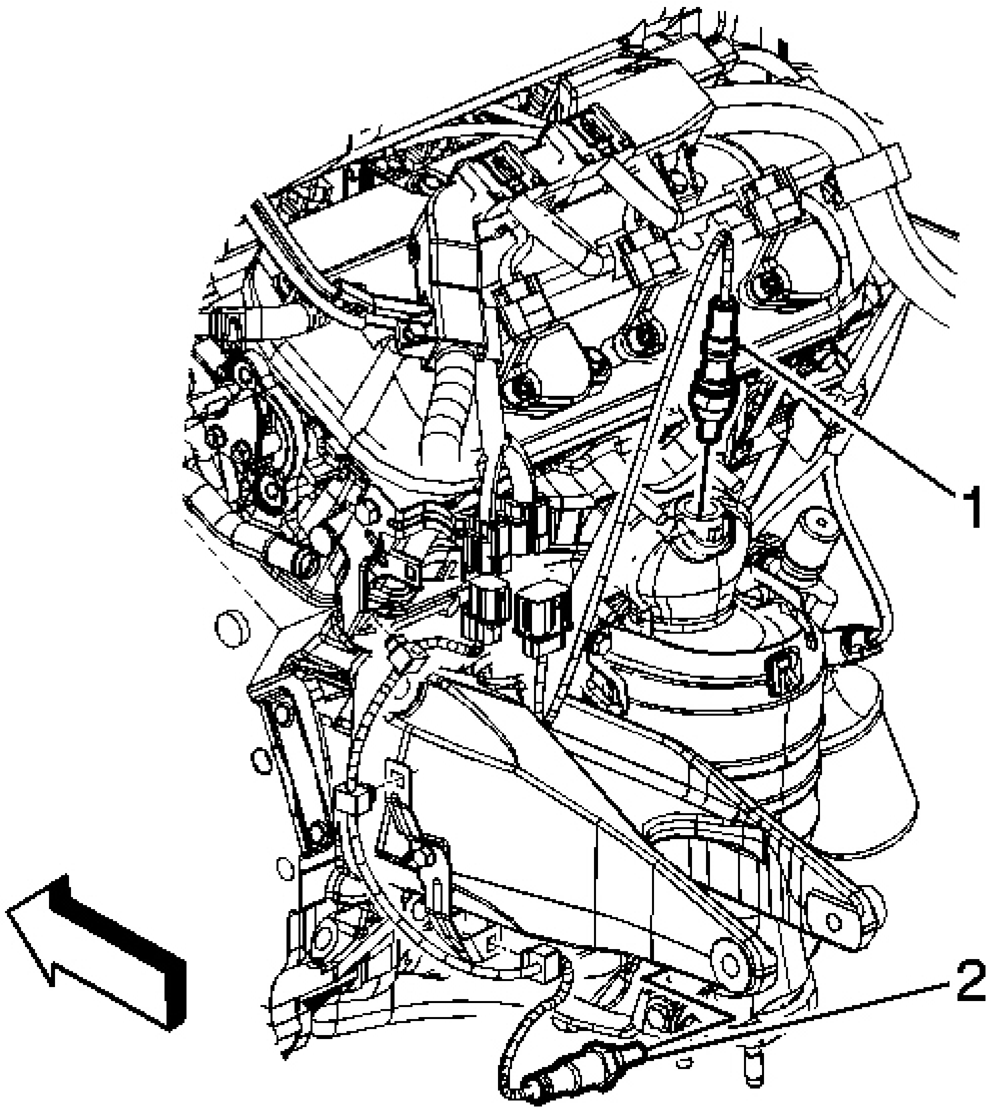


Fig. 35: View Of Heated Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

CAUTION: Removal of the sensor is easier if the exhaust system is warmed up slightly. Be careful that it is not too hot to work on safely. Applying penetrating oil to the threads while moving the sensor back and forth will also aid in removal and will decrease the chance of exhaust pipe thread damage.

7. Remove the bank 1 heated oxygen sensor 2 using the **J 39194-C** .

Installation Procedure

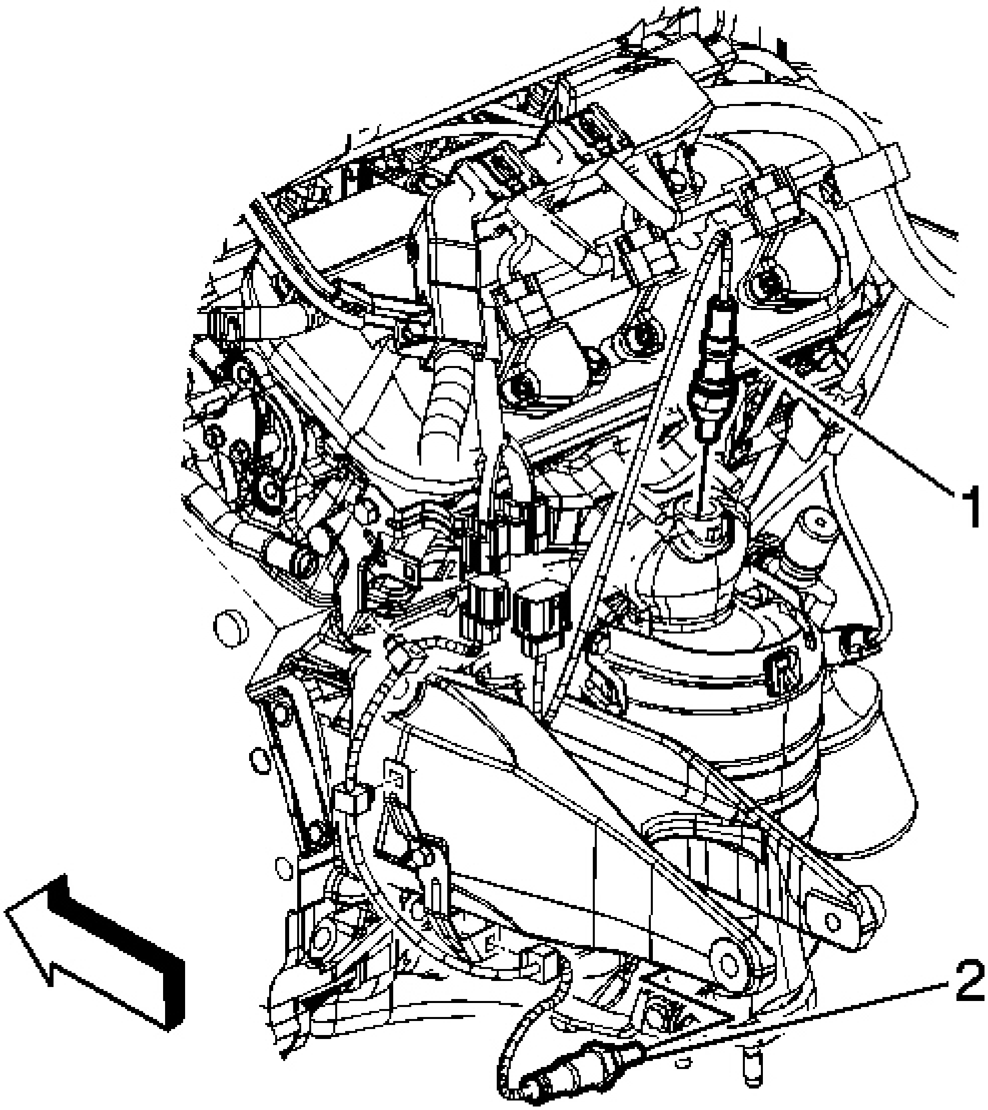


Fig. 36: View Of Heated Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

1. Apply a small amount of anti-seize compound SA P/N 21485279, or equivalent, to the threads of the heated sensor 2.

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

2. Install the bank 1 heated oxygen sensor 2 using the **J 39194-C** .

Tighten: Tighten the oxygen sensor to 44 N.m (33 lb ft).

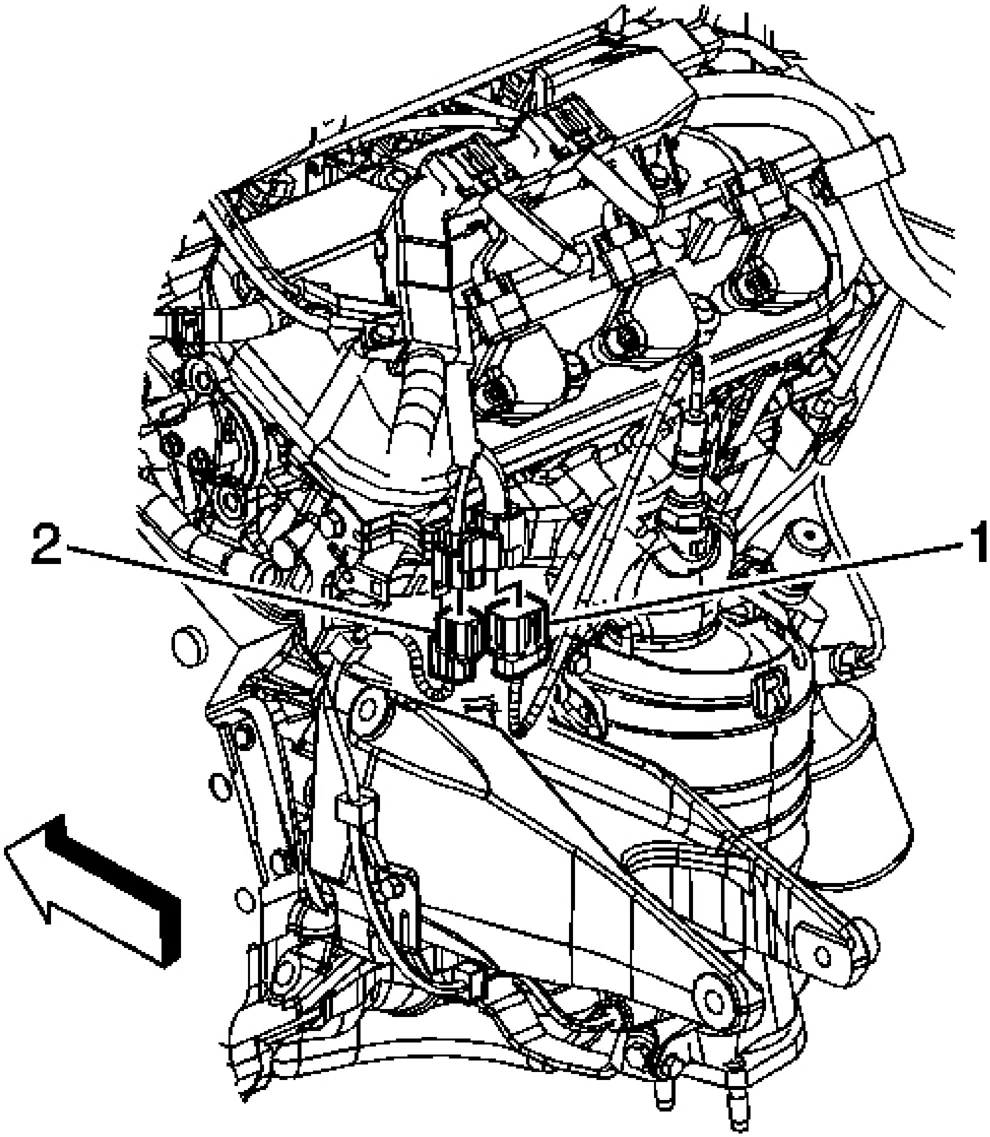


Fig. 37: View of Heated Oxygen Sensor Wiring Harness Bracket & Bolt
Courtesy of GENERAL MOTORS CORP.

3. Install the heated oxygen sensor wiring harness bracket and bolt.

   Tighten: Tighten the bolt to 10 N.m (89 lb in).

4. Lower the vehicle.
5. Install the heated oxygen sensor connector retaining bracket and bolt.

   Tighten: Tighten the bolt to 10 N.m (89 lb in).

6. Connect the bank 1 heated oxygen sensor 2 harness connector (2). Make sure the locking tab is in the full closed position.
7. Connect the connectors to the retaining bracket.
8. Start the engine and make sure no exhaust leaks exist.

HEATED OXYGEN SENSOR (HO2S) REPLACEMENT BANK 2 SENSOR 1

Tools Required

J 39194-C Oxygen Sensor Wrench

Removal Procedure

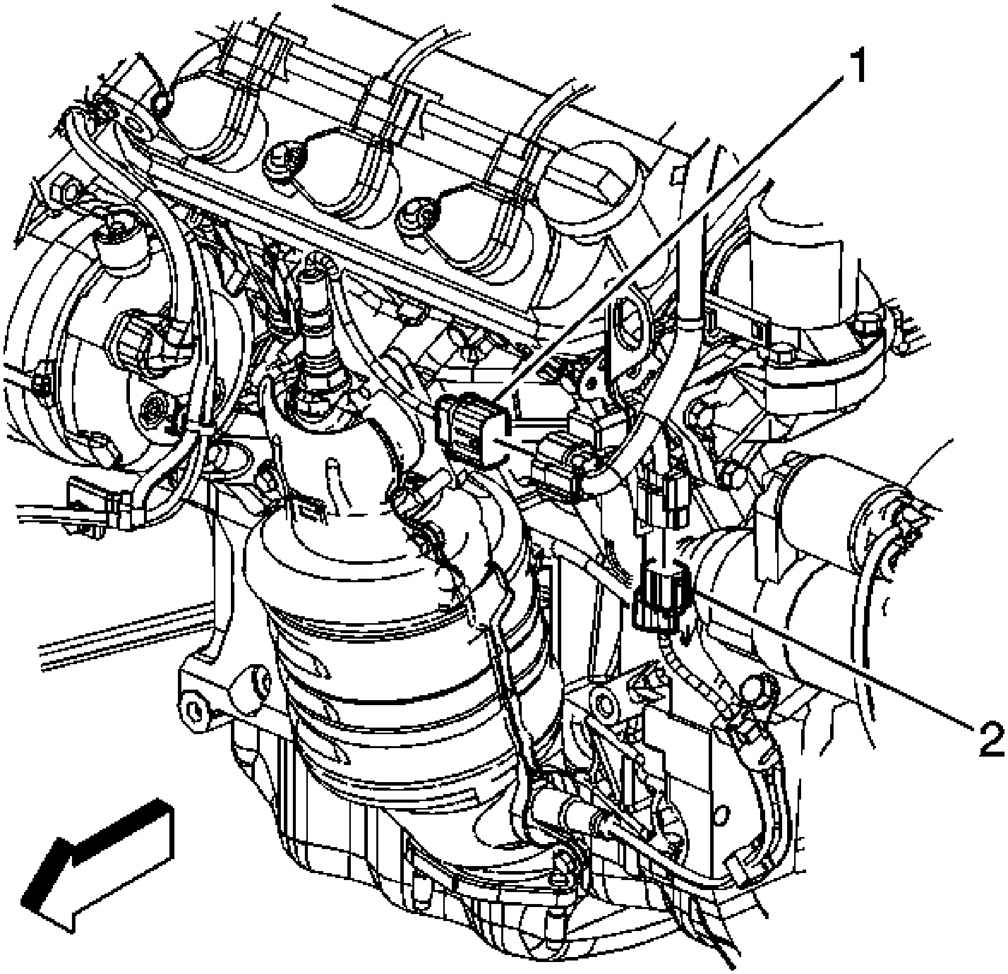


Fig. 38: View of Heated Oxygen Sensor (HO2S) Bank 2 Sensor 1
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Bank 2 are cylinders 2, 4, and 6 which are closest to the front of the vehicle.

1. Turn the ignition OFF.
2. Disconnect the bank 2 heated oxygen sensor 1 harness connector (1).

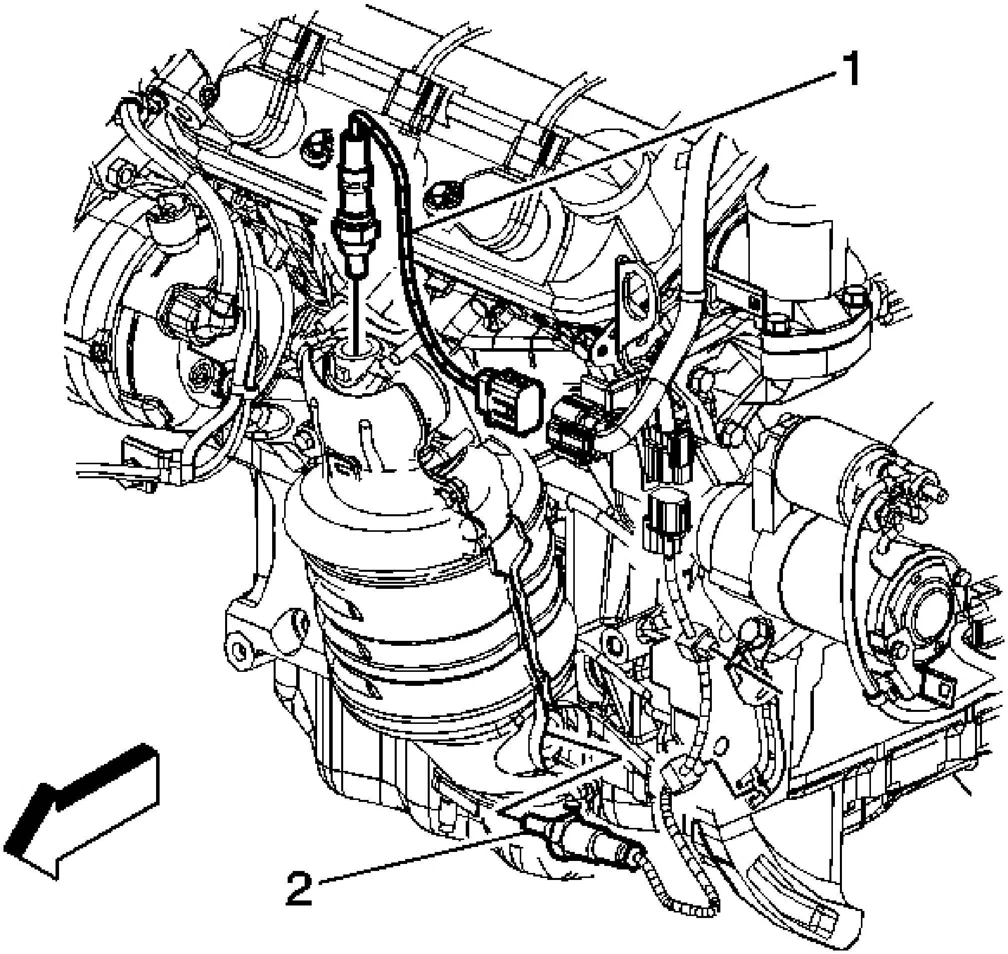


Fig. 39: View Of Bank 2 Heated Oxygen Sensor 1 Using The J39194-C
Courtesy of GENERAL MOTORS CORP.

CAUTION: Removal of the sensor is easier if the exhaust system is warmed up slightly. Be careful that it is not too hot to work on safely. Applying penetrating oil to the threads while moving the sensor back and forth will also aid in removal and will decrease the chance of exhaust pipe thread damage.

3. Remove the bank 2 heated oxygen sensor 1 using the **J 39194-C** .

Installation Procedure

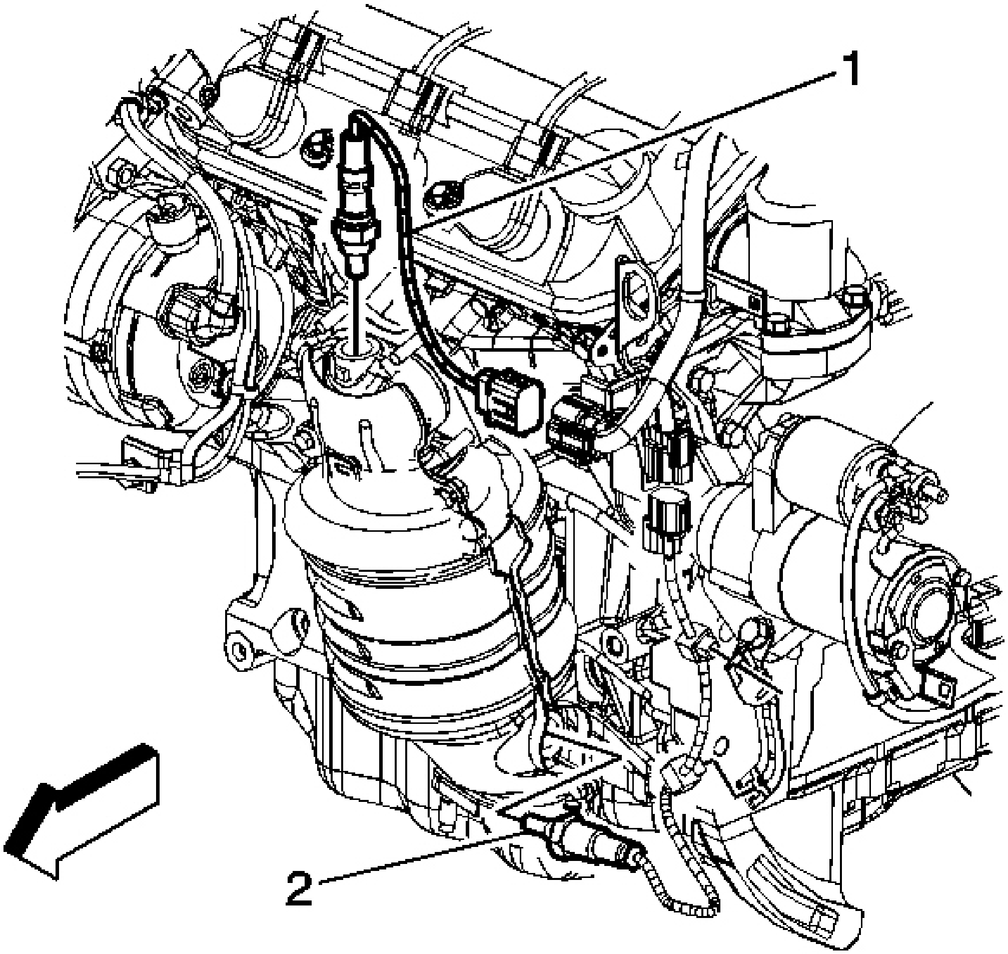


Fig. 40: View Of Bank 2 Heated Oxygen Sensor 1 Using The J39194-C
Courtesy of GENERAL MOTORS CORP.

1. Apply a small amount of the anti-seize compound SA P/N 21485279, or equivalent, to the threads of the heated oxygen sensor.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the bank 2 heated oxygen sensor 1 using the **J 39194-C** .

Tighten: Tighten the oxygen sensors (exhaust manifold) to 44 N.m (33 lb ft).

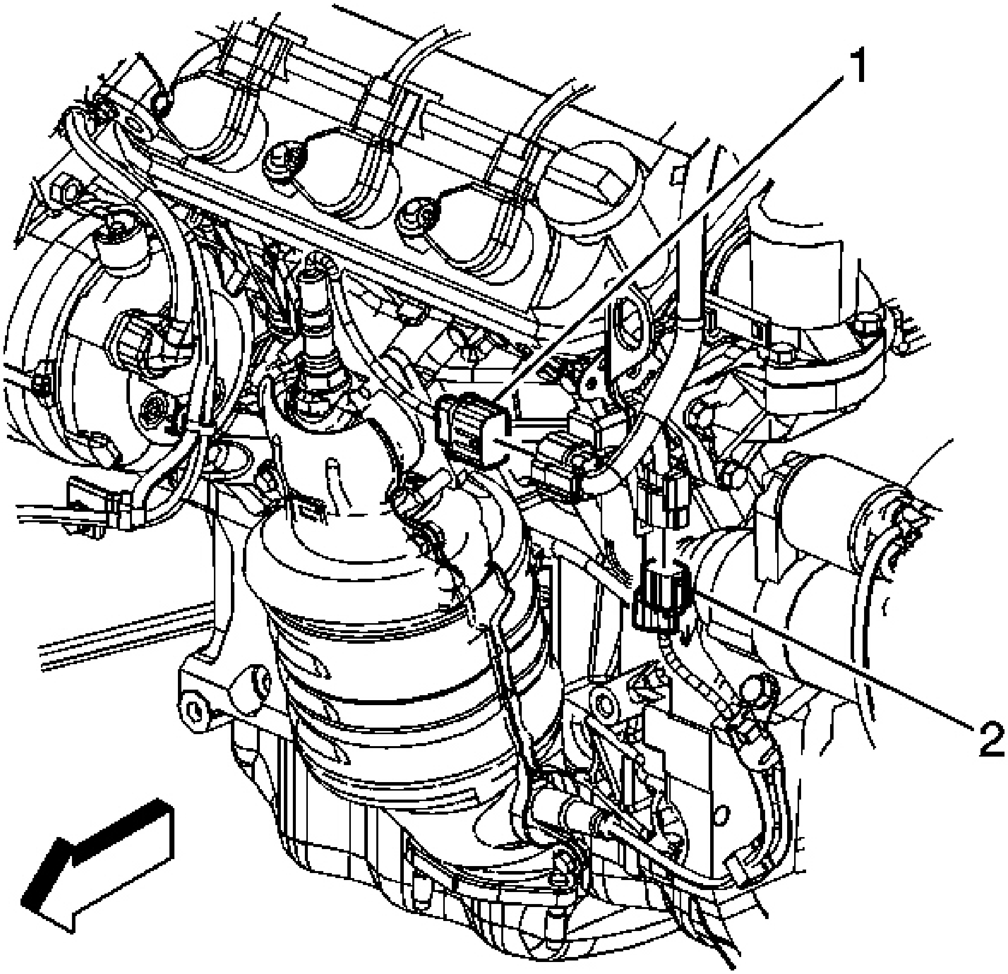


Fig. 41: View of Heated Oxygen Sensor (HO2S) Bank 2 Sensor 1
Courtesy of GENERAL MOTORS CORP.

3. Connect the heated oxygen sensor harness connector (1). Make sure the locking tab is in the full closed position.
4. Start the engine and make sure no exhaust leaks exist.

HEATED OXYGEN SENSOR (HO2S) REPLACEMENT BANK 2 SENSOR 2

Tools Required

J 39194-C Oxygen Sensor Wrench

Removal Procedure

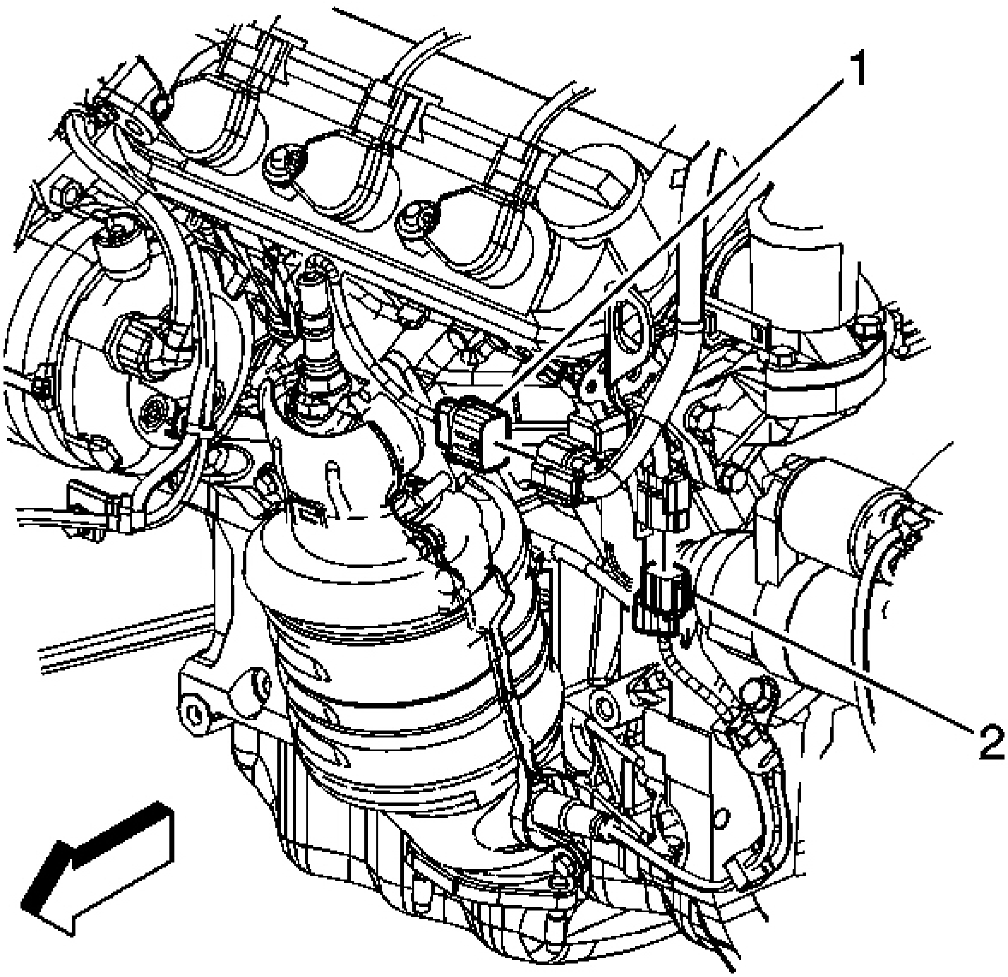


Fig. 42: View of Heated Oxygen Sensor (HO2S) Bank 2 Sensor 2
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: **Bank 2 are cylinders 2, 4, and 6 which are closest to the front of the vehicle.**

1. Turn the ignition OFF.
2. Disconnect the bank 2 heated oxygen sensor 2 harness connector (2) and disconnect from the retaining bracket.
3. Raise and support the vehicle. Refer to**Lifting and Jacking the Vehicle** in General Information.

4. Remove the left transmission mount just enough to gain access to the heated oxygen sensor. Refer to**Automatic Transmission Mount Replacement - Rear** in Automatic Transmission.
5. Remove the heated oxygen sensor wiring harness bracket and bolt.

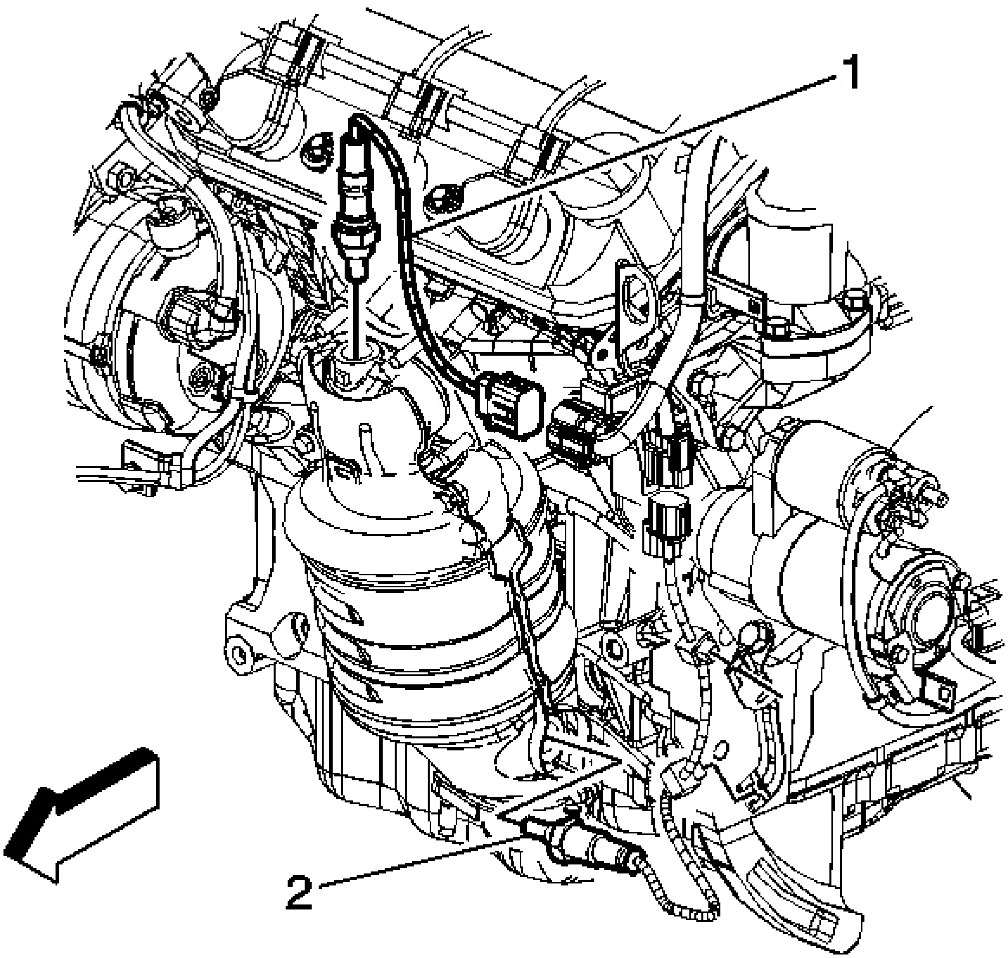


Fig. 43: View Of Bank 2 Heated Oxygen Sensor 1 Using The J39194-C
Courtesy of GENERAL MOTORS CORP.

CAUTION: Removal of the sensor is easier if the exhaust system is warmed up slightly. Be careful that it is not too hot to work on safely. Applying penetrating oil to the threads while moving the sensor back and forth will also aid in removal and will decrease the chance of exhaust pipe thread damage.

6. Remove the bank 2 heated oxygen sensor 2 using the **J 39194-C** .

Installation Procedure

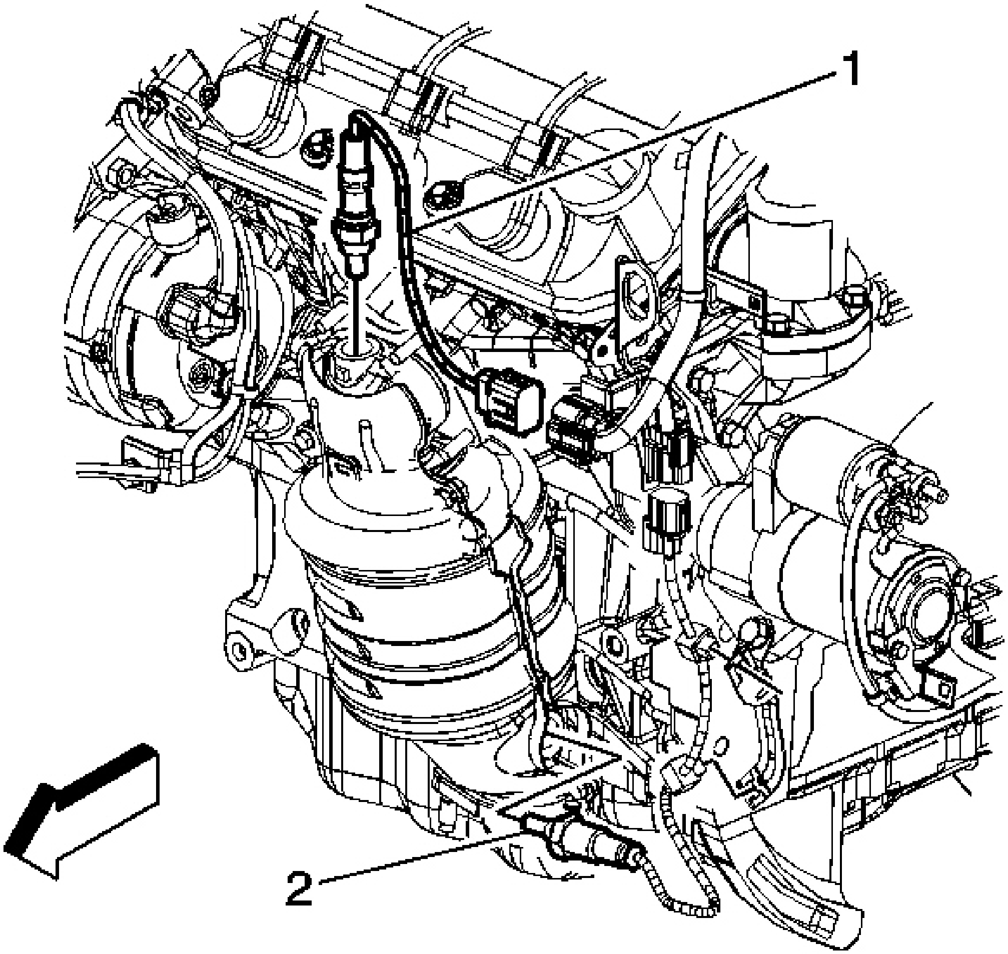


Fig. 44: View Of Bank 2 Heated Oxygen Sensor 1 Using The J39194-C
Courtesy of GENERAL MOTORS CORP.

1. Apply a small amount of the anti-seize compound SA P/N 21485279, or equivalent, to the threads of the heated oxygen sensor.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the bank 2 heated oxygen sensor 2 using the **J 39194-C** .

Tighten: Tighten the oxygen sensors (exhaust manifold) to 44 N.m (33 lb ft).

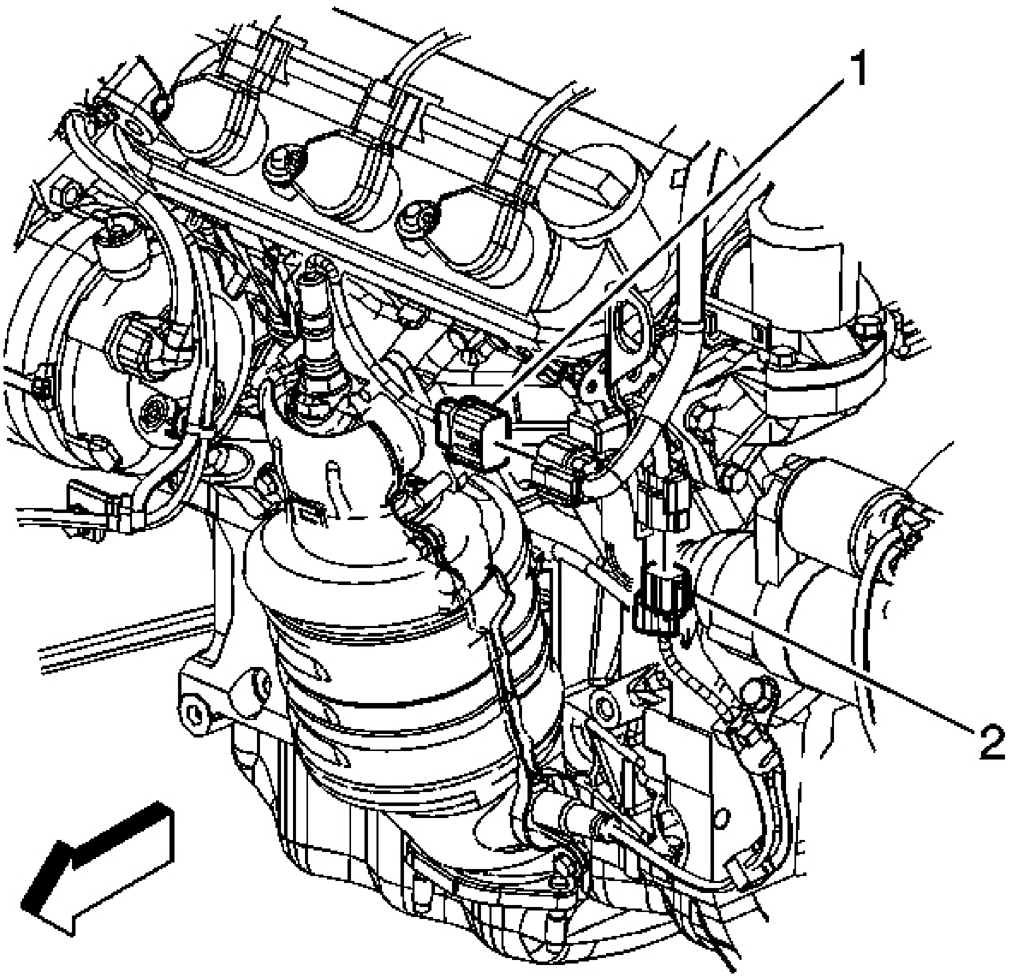


Fig. 45: View of Heated Oxygen Sensor (HO2S) Bank 2 Sensor 2
Courtesy of GENERAL MOTORS CORP.

3. Install the heated oxygen sensor wiring harness bracket and bolt.

   Tighten: Tighten the bolt to 40 N.m (30 lb ft).

4. Install the left transmission mount. Refer to**Automatic Transmission Mount Replacement - Rear** in Automatic Transmission.
5. Lower the vehicle. Refer to**Lifting and Jacking the Vehicle** in General Information.

6. Connect the heated oxygen sensor harness connector (2). Make sure the locking tab is in the full closed position.
7. Start the engine and make sure no exhaust leaks exist.

ACCELERATOR PEDAL POSITION (APP) SENSOR REPLACEMENT

Removal Procedure

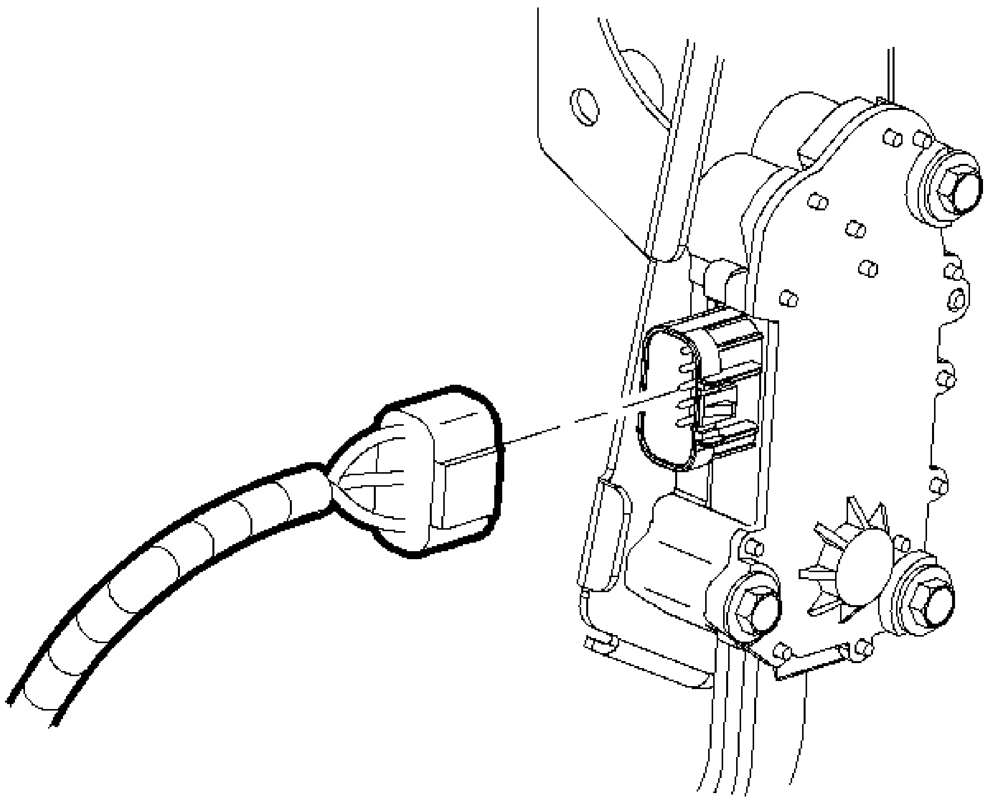


Fig. 46: View Of Accelerator Pedal Position (APP) Sensor
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the connector position assurance (CPS) from the accelerator pedal position (APP) sensor connector.

2. Disconnect the APP sensor harness connector.

IMPORTANT: Due to clearance issues, the upper attachment bolt cannot be removed from the accelerator pedal assembly. Loosen the bolt completely and leave the bolt in the component until the assembly is removed from the vehicle.

IMPORTANT: A speed wrench may be used to aid in the removal and installation.

3. Remove the APP assembly attachment bolts to the brake pedal assembly.

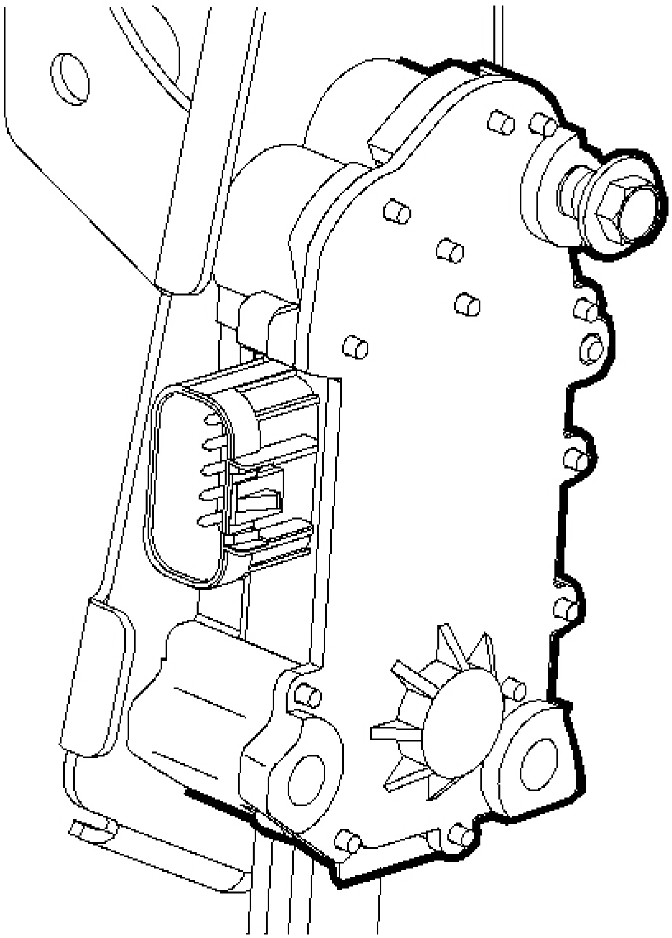


Fig. 47: View Of APP Assembly From The Vehicle

Courtesy of GENERAL MOTORS CORP.

4. Remove the APP assembly from the vehicle.

Installation Procedure

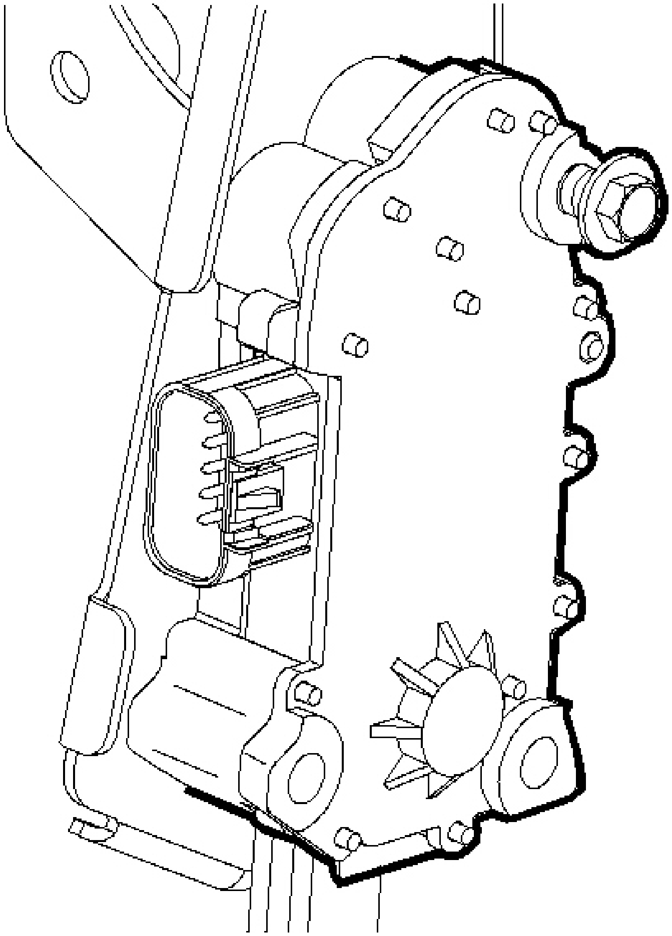


Fig. 48: View Of APP Assembly From The Vehicle
Courtesy of GENERAL MOTORS CORP.

1. Install the upper attachment bolt into the APP assembly.
2. Install the APP assembly into the vehicle.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the attachment bolts into the APP assembly.

   Tighten: Tighten the accelerator pedal position assembly-to-brake bracket bolt to 25 N.m (18 lb ft).

4. Connect the APP sensor harness connector. Push the connector in until the lock position is felt, then pull back to confirm engagement.
5. Install the APP sensor connect CPA.

THROTTLE BODY ASSEMBLY REPLACEMENT

Removal Procedure

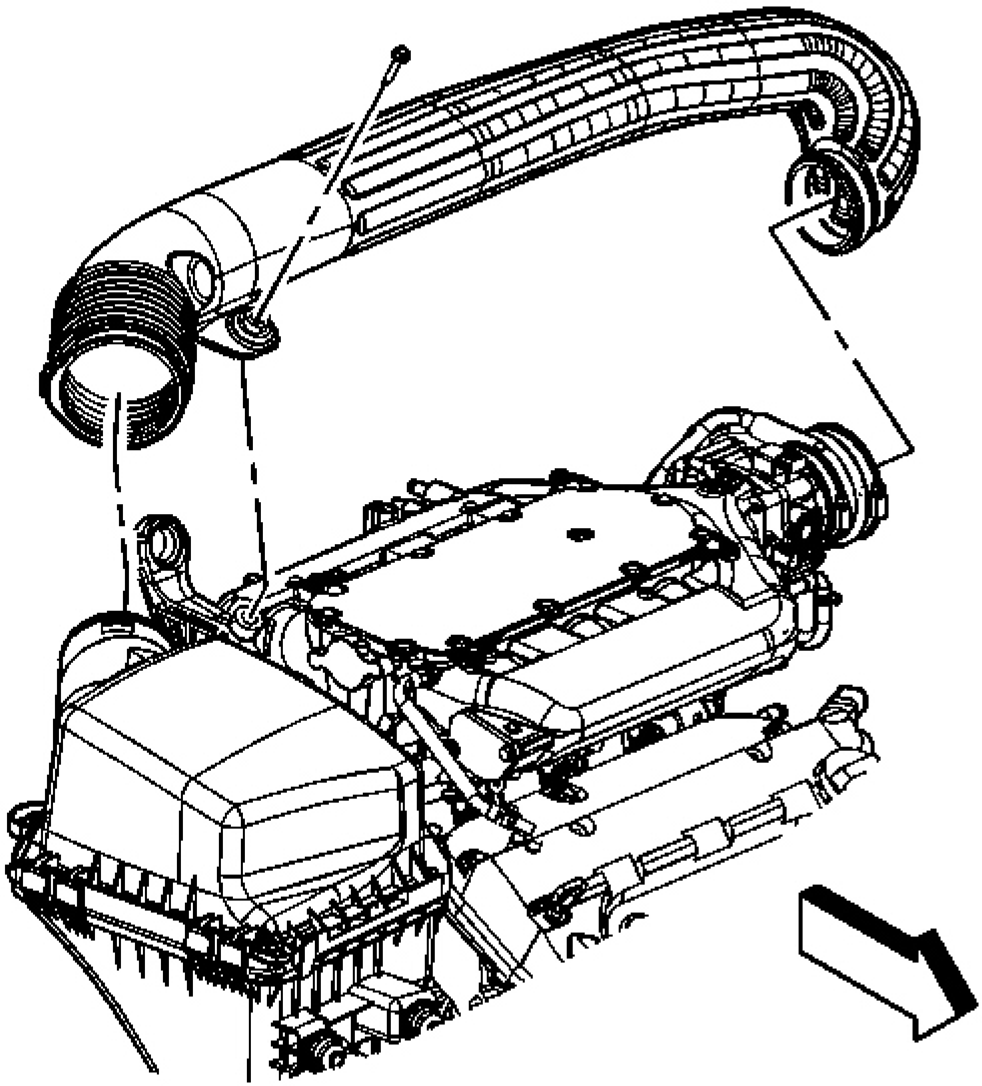


Fig. 49: View Of Throttle Body Assembly
Courtesy of GENERAL MOTORS CORP.

1. Remove the outlet resonator/duct assembly. Refer to **Air Cleaner Resonator Outlet Duct Replacement** .
2. Cover the throttle body opening with a shop towel and use shop air to remove any dirt at the base of the throttle body.

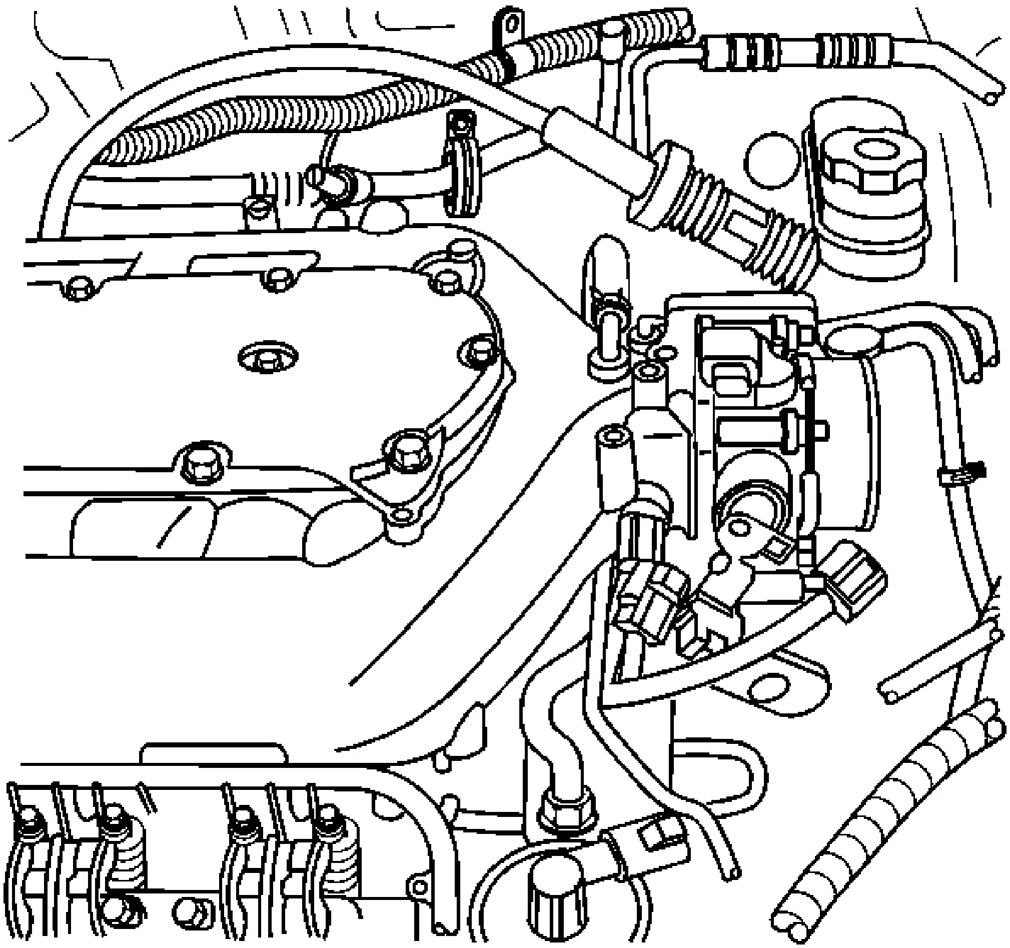


Fig. 50: View Of MAP Sensor Connector
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the MAP sensor connector.
4. Disconnect the throttle control connector at throttle body.

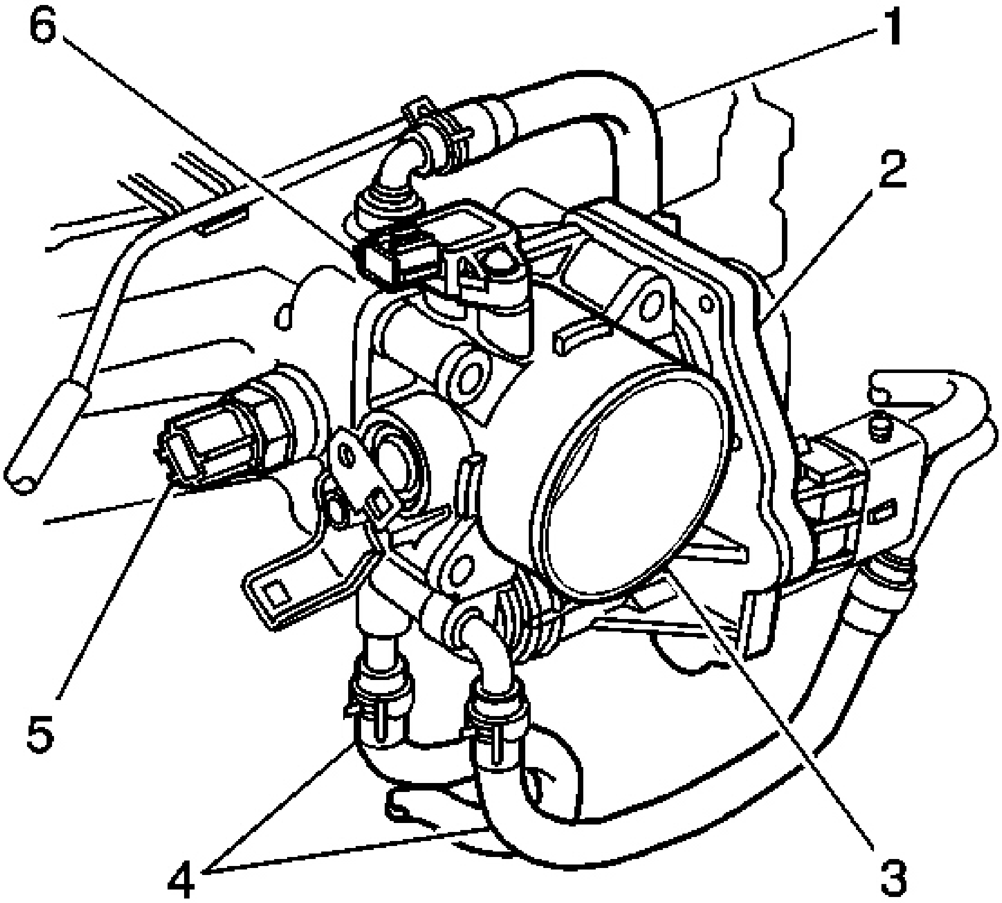


Fig. 51: View Of Intake Air Temperature (IAT) Sensor 2
Courtesy of GENERAL MOTORS CORP.

5. Clamp off the hoses to avoid leaking coolant on engine.
6. Remove the wiring harness bracket bolt from the throttle body.
7. Remove the coolant hoses at throttle body (4).

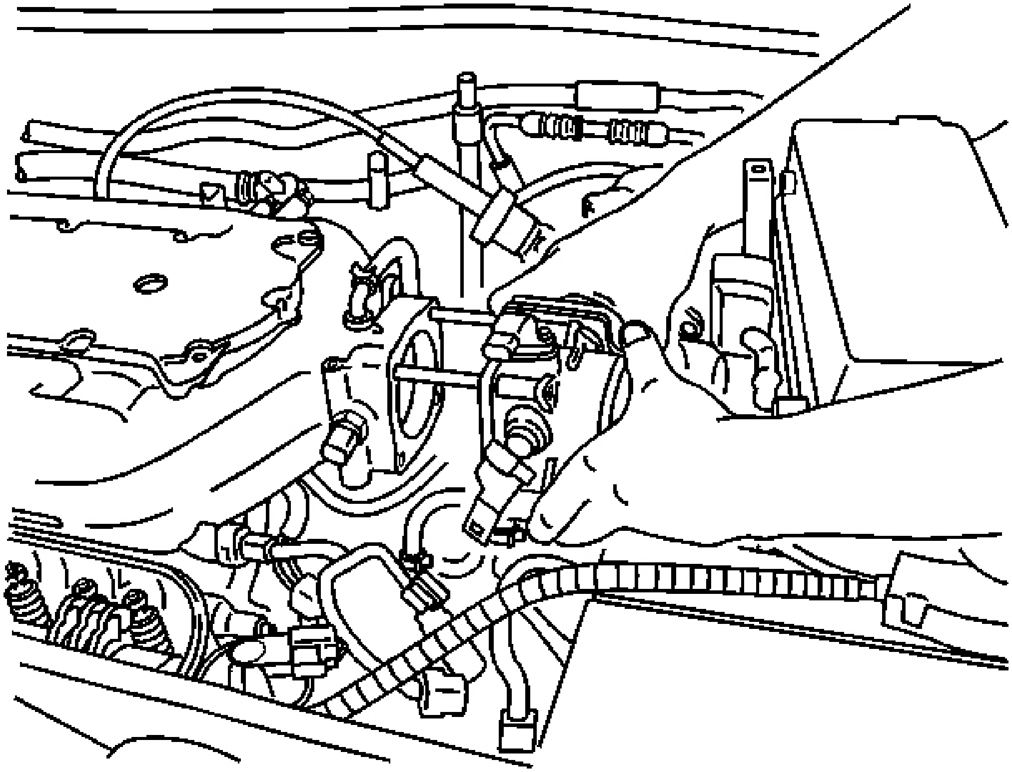


Fig. 52: View Of Throttle Body Gasket
Courtesy of GENERAL MOTORS CORP.

8. Remove the throttle body fasteners.
9. Remove the throttle body.

NOTE: Cover the intake manifold opening with a shop towel whenever the throttle body is removed to prevent foreign material entry.

10. Block the intake manifold opening with a clean shop towel to prevent dirt from entering.

Installation Procedure

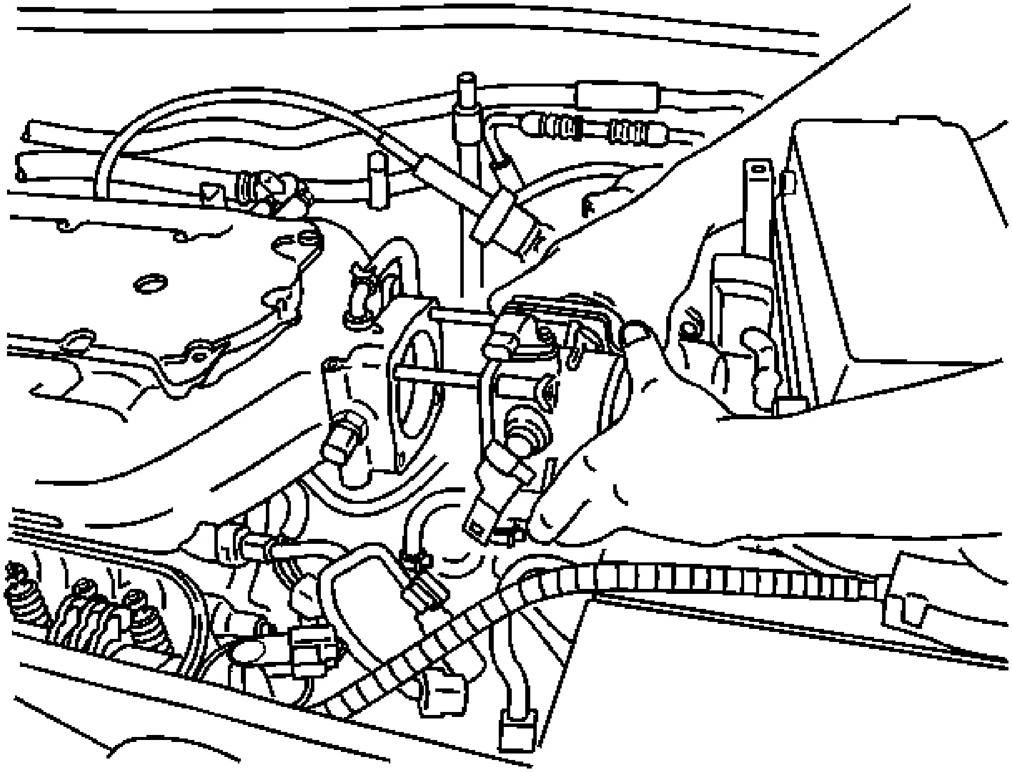


Fig. 53: View Of Throttle Body Gasket
Courtesy of GENERAL MOTORS CORP.

1. Remove the shop towel from the throttle body opening.
2. Install a new throttle body gasket.

NOTE: Use care when tightening the throttle body bolts. Manifold damage will result if over torqued.

3. Install the throttle body assembly and fasteners.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the throttle body fasteners.

Tighten: Tighten the fasteners to 22 N.m (16 lb in).

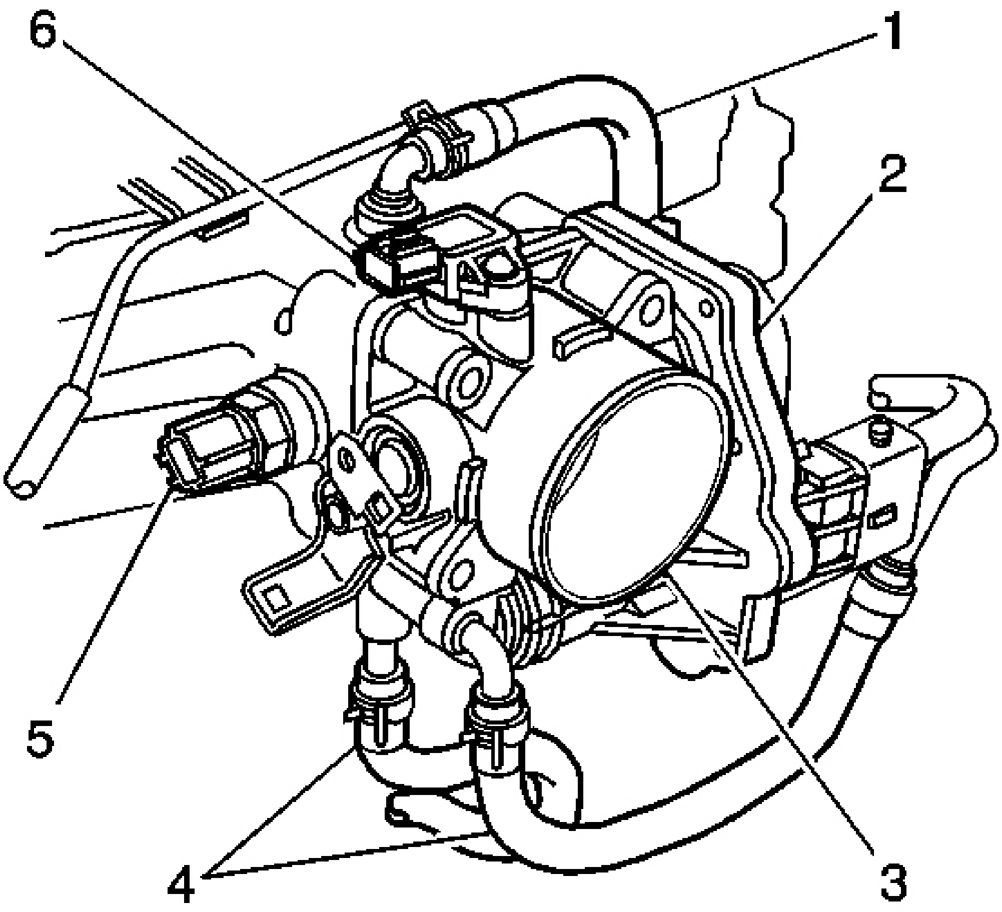


Fig. 54: View Of Intake Air Temperature (IAT) Sensor 2
Courtesy of GENERAL MOTORS CORP.

5. Attach the coolant hoses (4) to the throttle body assembly and unclamp.
6. Install the wiring harness bracket bolt.

   Tighten: Tighten the bolt to 10 N.m (89 lb in).

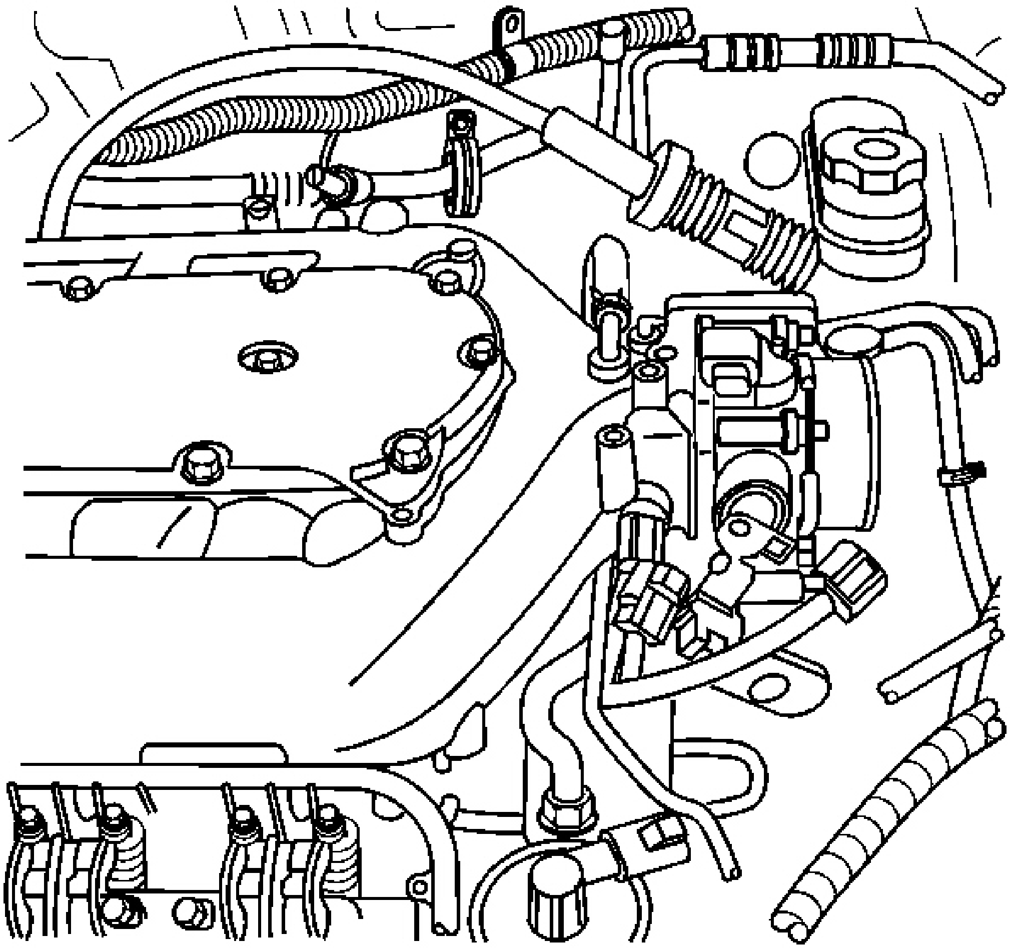


Fig. 55: View Of MAP Sensor Connector
Courtesy of GENERAL MOTORS CORP.

7. Connect the MAP sensor connectors.
8. Connect throttle body electrical connector.

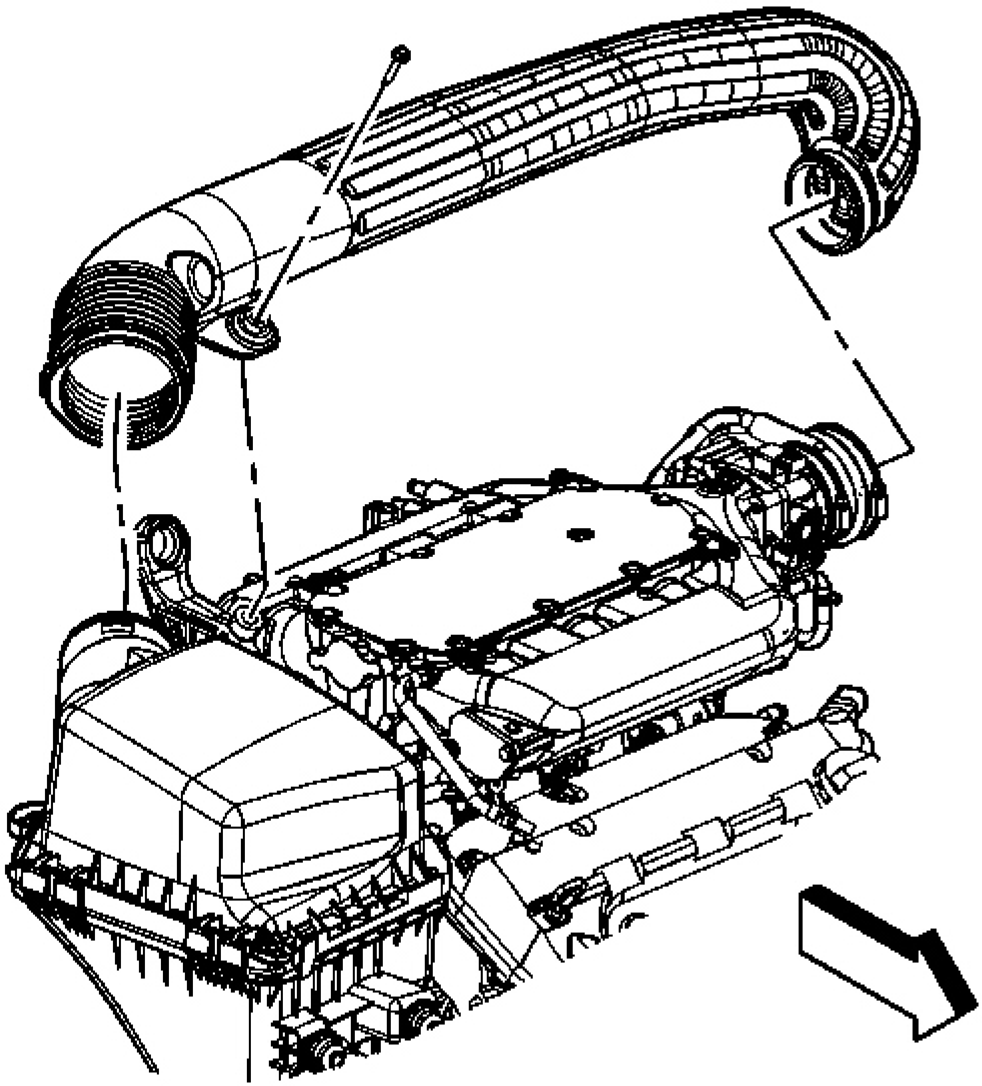


Fig. 56: View Of Outlet Resonator/Duct Assembly
Courtesy of GENERAL MOTORS CORP.

9. Install the outlet resonator/duct assembly into position. Refer to **Air Cleaner Resonator Outlet Duct Replacement** .
10. If the throttle body assembly has been replaced, perform the idle learn procedure. Refer to **Idle Learn Procedure** .

THROTTLE BODY SERVICE

CAUTION: Wear safety glasses when using compressed air in order to prevent eye injury.

1. Remove the throttle body from the vehicle. Refer to **Throttle Body Assembly Replacement** .

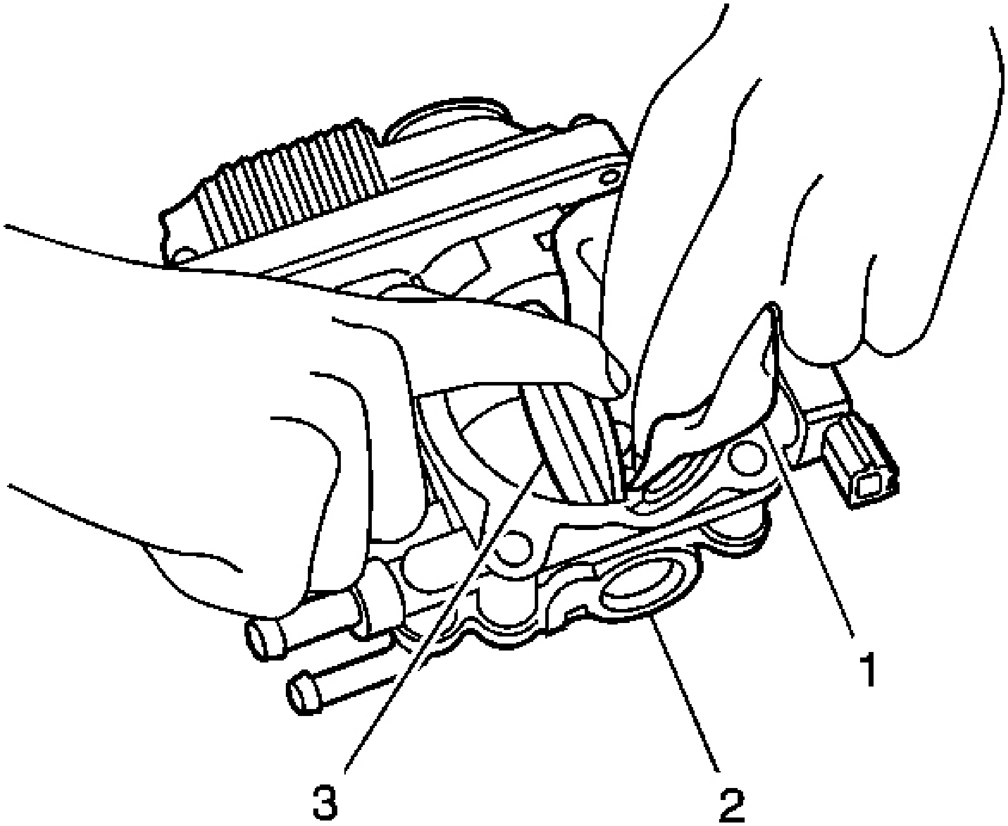


Fig. 57: View Of Throttle Body Assembly
Courtesy of GENERAL MOTORS CORP.

2. Open the throttle valve (3) of the throttle body (2).
3. Use a solvent soaked cloth (1) to remove dirt or carbon deposits/buildup from the throttle valve and the throttle bore.
4. Ensure that the throttle valve and throttle bore are clean and dry.
5. Inspect that the throttle valve operates smoothly and freely.

Install the throttle body to the vehicle. Refer to **Throttle Body Assembly Replacement** .

6. Reset the TP Learned Value. Refer to **Scan Tool Output Controls** .
7. Perform the Idle Learn Procedure. Refer to **Idle Learn Procedure** .

FUEL PRESSURE RELIEF PROCEDURE

Tools Required

SA9127E Gage Bar Set

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Connect the **SA9127E** to the fuel pressure connection. Refer to**Fuel Pressure Gage Installation and Removal** .
3. Install the bleed hose (3) into an approved container and open the valve (5) to bleed the system pressure. The fuel connections are now safe for servicing.
4. Disconnect the fuel pressure gage from the fuel pressure connection. Refer to **Fuel Pressure Gage Installation and Removal** .

FUEL PRESSURE GAGE INSTALLATION AND REMOVAL

Tools Required

SA9127E Gage Bar Set

Installation Procedure

1. Remove the intake air duct with resonator from the engine. Refer to **Air Cleaner Resonator Outlet Duct Replacement** .

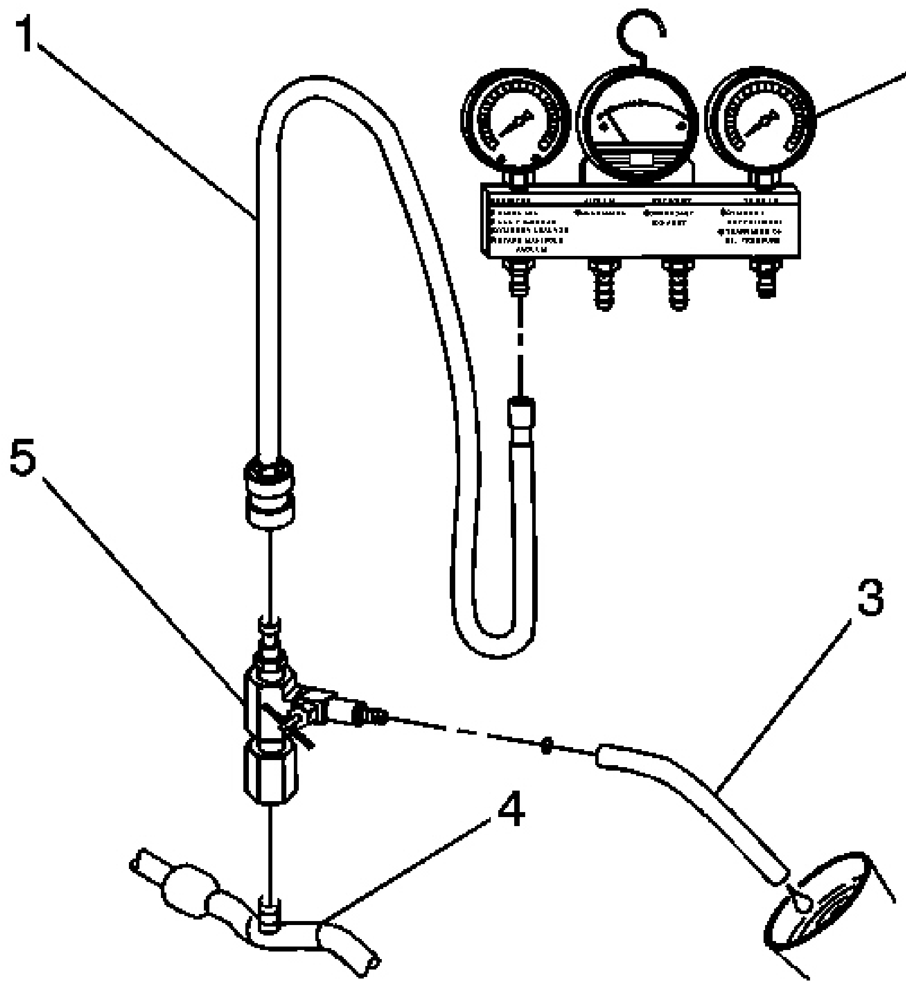


Fig. 58: View Of Fuel Pressure Gage
Courtesy of GENERAL MOTORS CORP.

2. Connect one end of the gage hose (1) from the **SA9127E** , to the fuel shut off and bleed assembly (5).
3. Connect the other end of the gage hose (1) to the fuel pressure gage side of the gage bar set (2).
4. Remove the schrader valve cap.
5. Connect the fuel shut off and bleed assembly (5) to the schrader valve on the fuel feed pipe (4) near the fuel rail. Use a shop towel in order to catch any remaining fuel that may leak.
6. Use the scan tool, in order to pressurize the fuel system. Refer to **Scan Tool Output Controls** .
7. Use the drain hose (3) of the fuel shut off and bleed assembly (5) to bleed any trapped air from the lines and hoses.

8. After bleeding the lines and hoses, pressurize the fuel system.
9. Inspect for any fuel leaks.

Removal Procedure

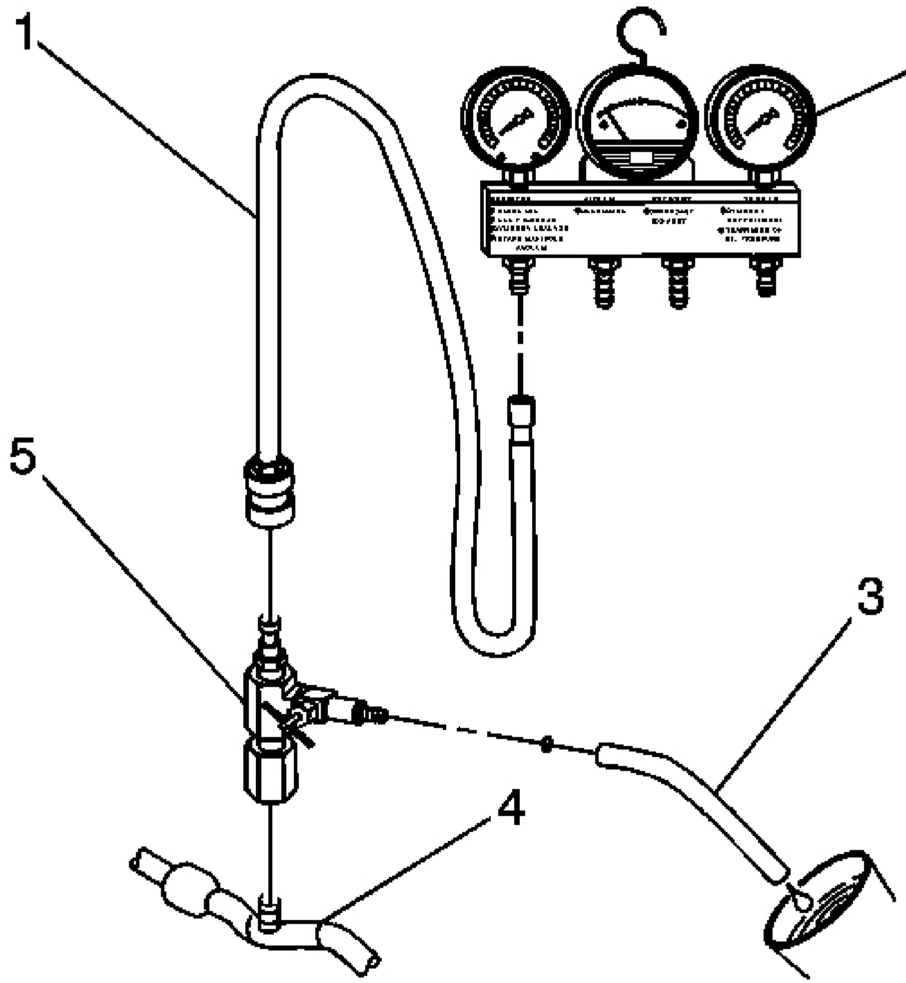


Fig. 59: View Of Fuel Pressure Gage
Courtesy of GENERAL MOTORS CORP.

1. Start the engine and command the fuel pump OFF with the scan tool. Refer to **Scan Tool Output Controls** .
2. Run the engine until the engine stalls.

3. Use the drain hose (3) of the fuel shut off and bleed assembly (5) in order to drain any remaining fuel from the gage, the lines, and the hoses.
4. Disconnect the gage hose (1) from the fuel shut off and bleed assembly (5).
5. Remove the fuel shut off and bleed assembly (5) from the fuel feed pipe (4). Use a shop towel in order to catch any remaining fuel that may leak.
6. Install the schrader valve cap in order to protect the fitting from dirt and contaminants.
7. Install the intake air duct to the engine. Refer to **Air Cleaner Resonator Outlet Duct Replacement** .
8. Perform the idle learn procedure. Refer to **Idle Learn Procedure** .

QUICK CONNECT FITTING(S) SERVICE (METAL COLLAR)

Tools Required

J 37088-A Fuel Line Disconnect Tool Set. See **Special Tools and Equipment** .

Removal Procedure

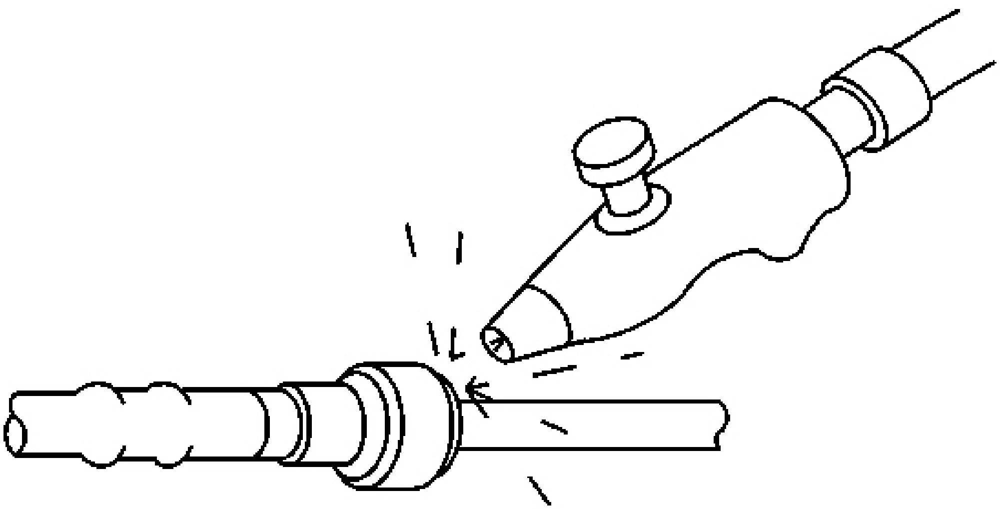


Fig. 60: Blowing Dirt Out Of Fitting (Metal Collar)
Courtesy of GENERAL MOTORS CORP.

1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** .
2. Remove the retainer from the quick-connect fitting, if applicable.

CAUTION: 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.

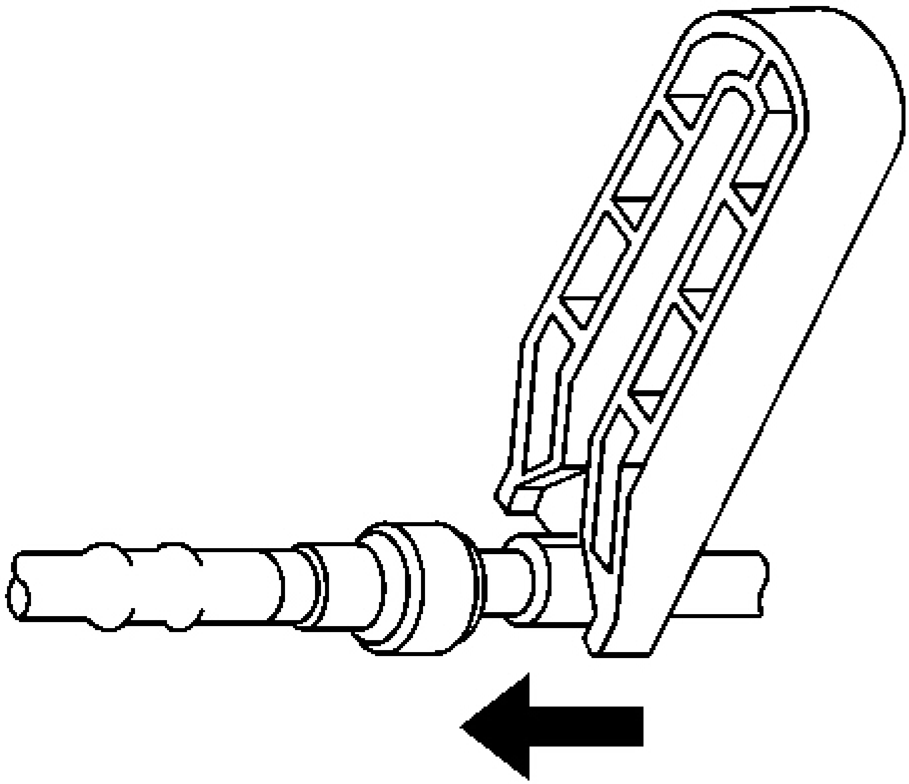


Fig. 61: Releasing Locking Tabs (Metal Collar)
Courtesy of GENERAL MOTORS CORP.

4. Choose the correct tool from J 37088-A tool set for the size of the fitting. Insert the tool into the female connector, then push inward to release the locking tabs.

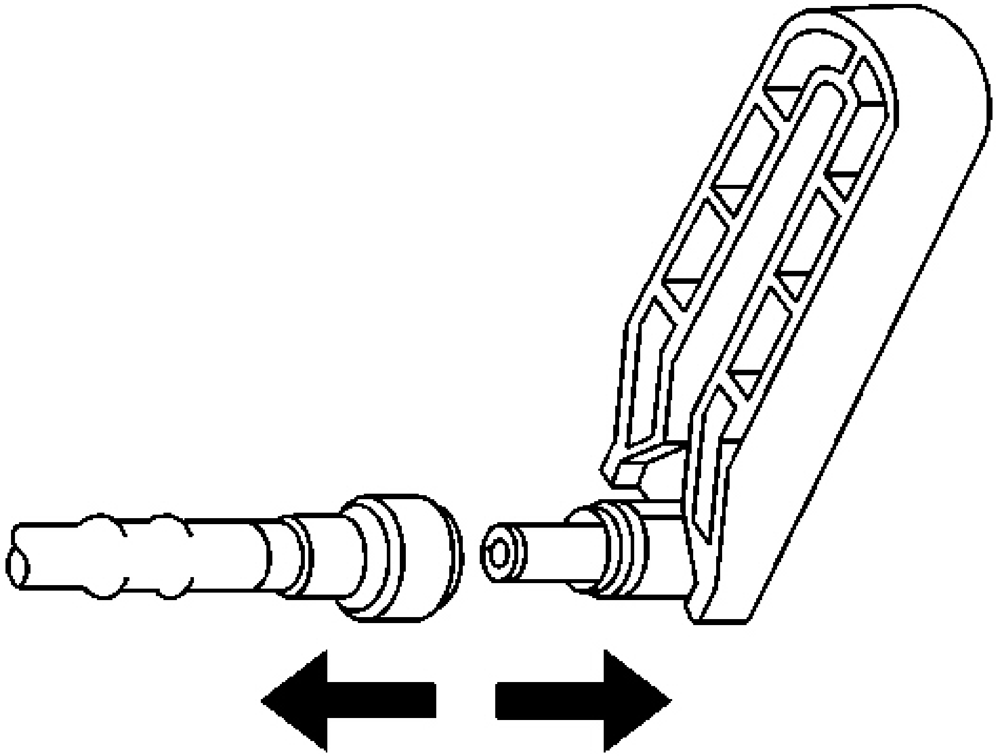


Fig. 62: Pulling Connection Apart (Metal Collar)
Courtesy of GENERAL MOTORS CORP.

5. Pull the connection apart.

NOTE: **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. Clean or replace the components as required.

Installation Procedure

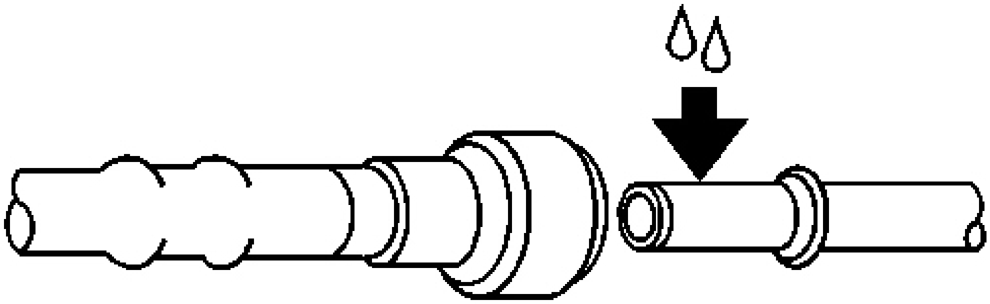


Fig. 63: Oiling Male Pipe Ends (Metal Collar)
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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.

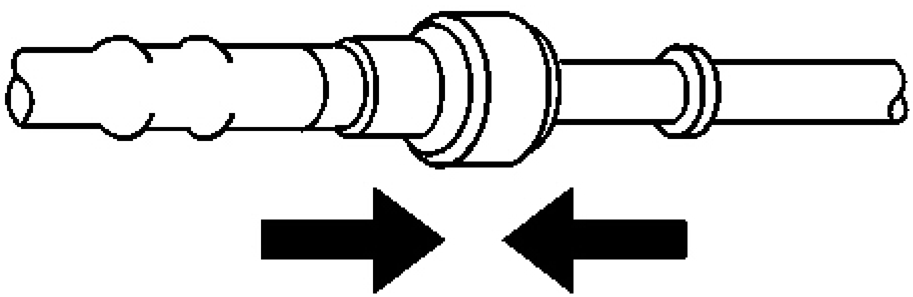


Fig. 64: Connecting Fittings (Metal Collar)

Courtesy of GENERAL MOTORS CORP.

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

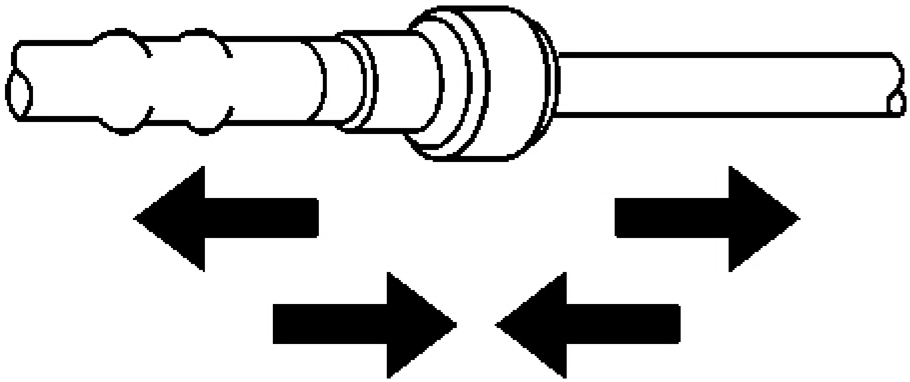


Fig. 65: Ensuring Secure Connection (Metal Collar)
Courtesy of GENERAL MOTORS CORP.

3. Once installed, pull on both sides of the fitting to make sure the connection is secure.
4. Install the retainer to the quick-connect fitting, if applicable.

QUICK CONNECT FITTING(S) SERVICE (PLASTIC COLLAR) (PLASTIC COLLAR)

Removal Procedure

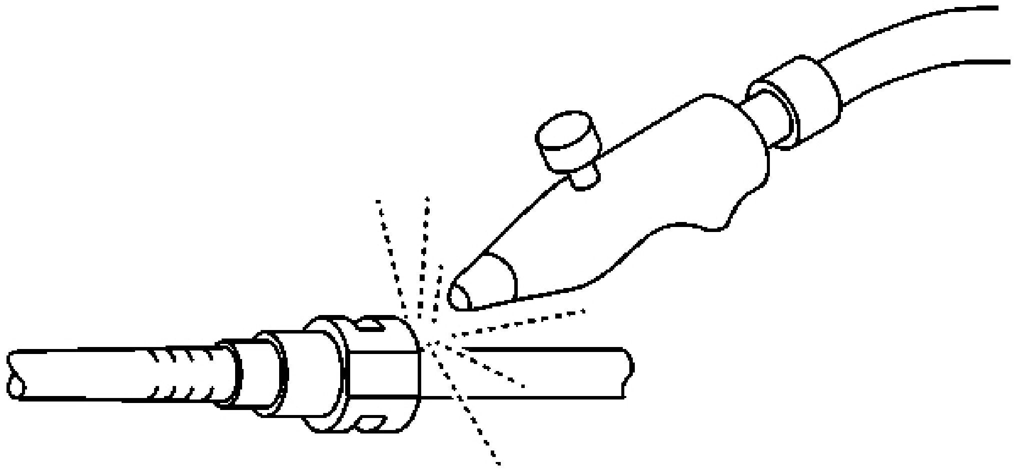


Fig. 66: Blowing Out Dirt (Plastic Collar)
Courtesy of GENERAL MOTORS CORP.

1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** .

CAUTION: Wear safety glasses when using compressed air in order to prevent eye injury.

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

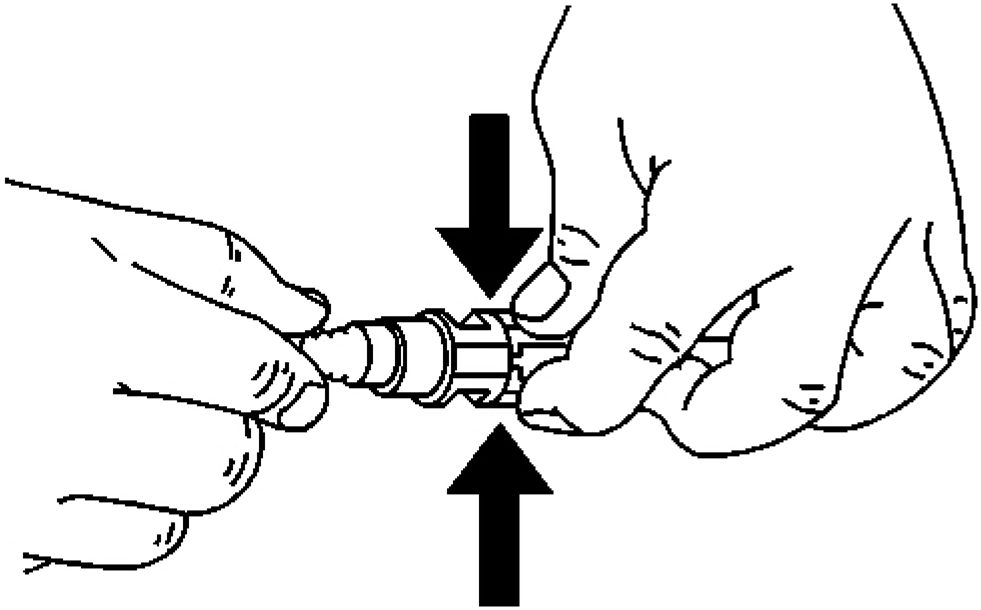


Fig. 67: Squeezing Plastic Tabs Of Male End Connector (Plastic Collar)
Courtesy of GENERAL MOTORS CORP.

3. Squeeze the plastic tabs of the male end connector.

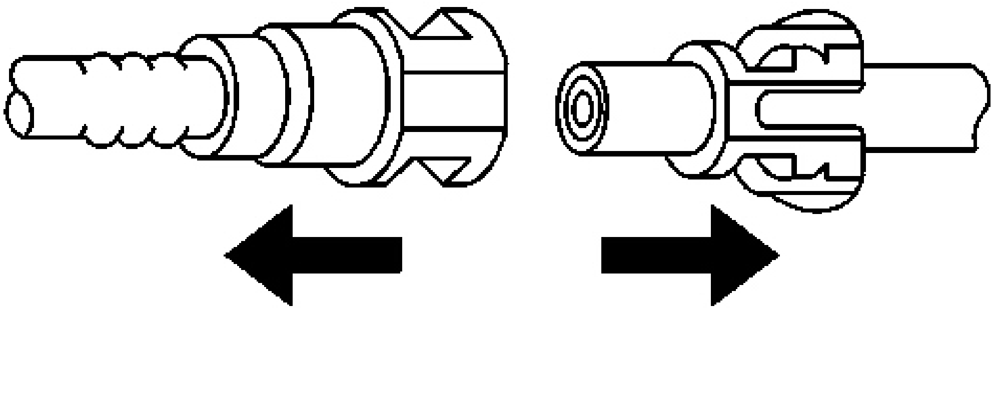


Fig. 68: Pulling Connection Apart (Plastic Collar)
Courtesy of GENERAL MOTORS CORP.

4. Pull the connection apart.

NOTE: Use an emery cloth in order to remove rust or burrs from the fuel pipe. Use a radial motion with the fuel pipe end in order to prevent damage to the O-ring sealing surface.

5. Wipe off the male pipe end using a clean shop towel.
6. Inspect both ends of the fitting for dirt and burrs.
7. Clean or replace the components as required.

Installation Procedure

CAUTION: 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.

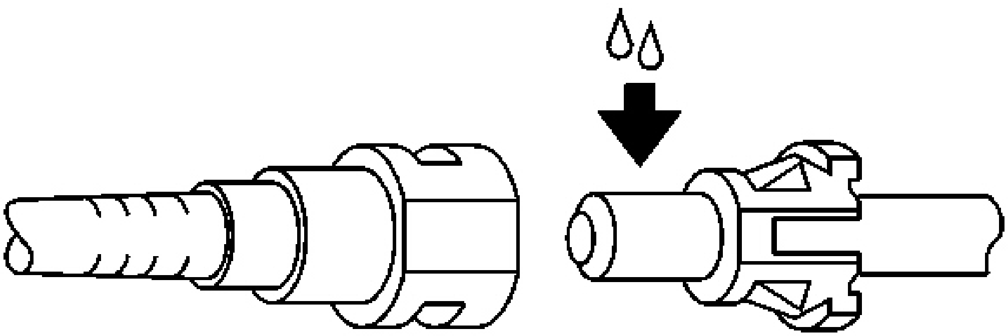


Fig. 69: Oiling Male Pipe End (Plastic Collar)
Courtesy of GENERAL MOTORS CORP.

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

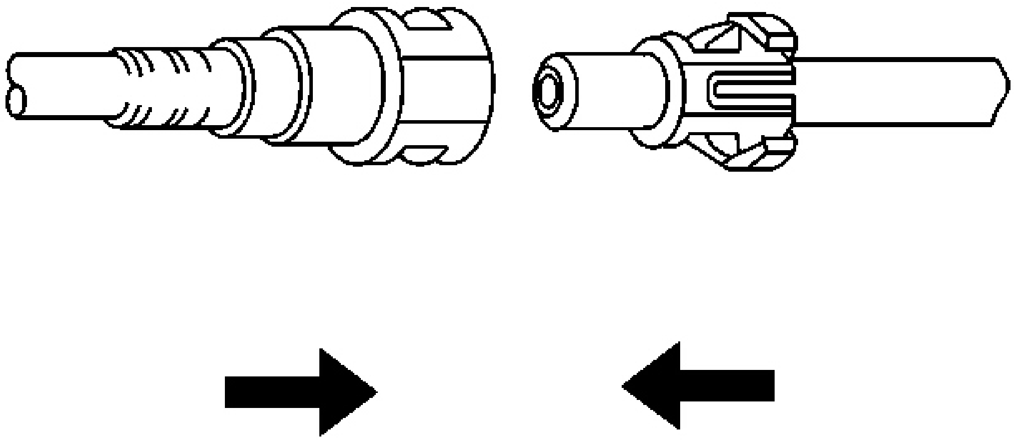


Fig. 70: Connecting Fittings (Plastic Collar)
Courtesy of GENERAL MOTORS CORP.

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

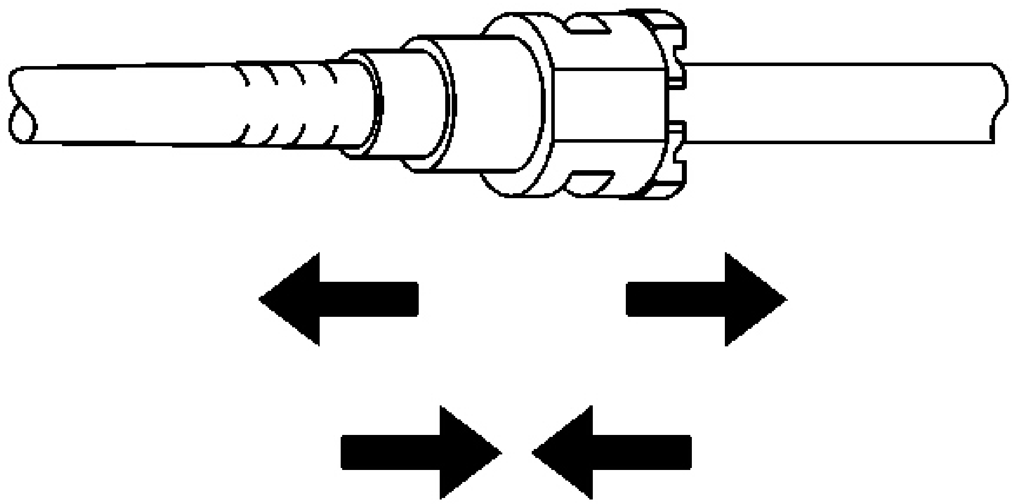


Fig. 71: Ensuring Secure Connection (Plastic Collar)
Courtesy of GENERAL MOTORS CORP.

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

QUICK CONNECT FITTING(S) SERVICE (PLASTIC COLLAR) (PLASTIC COLLAR PRESS RELEASE)

Removal Procedure

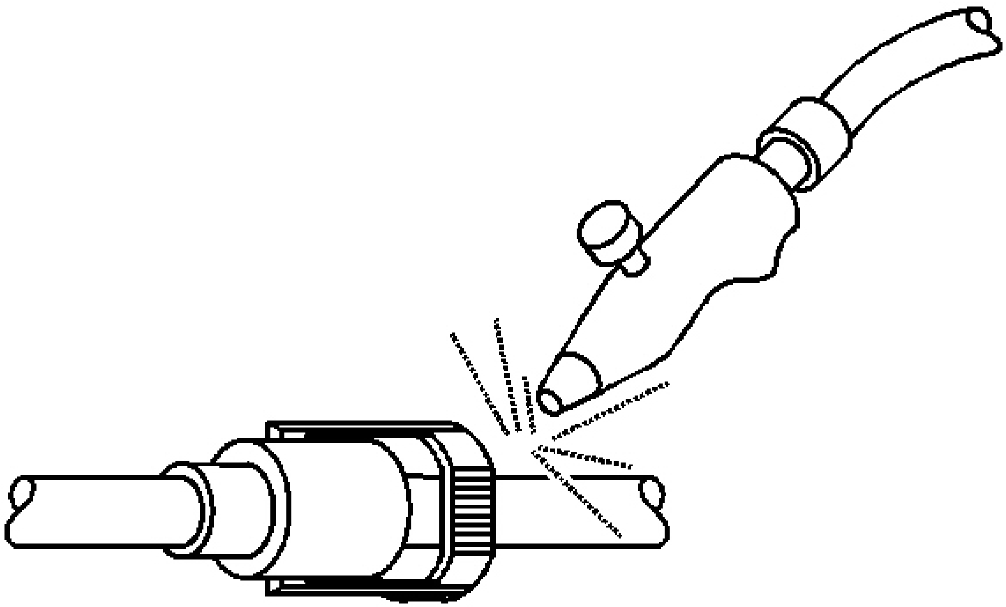


Fig. 72: View Of Quick Connect Fitting Service (Plastic Collar)
Courtesy of GENERAL MOTORS CORP.

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

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

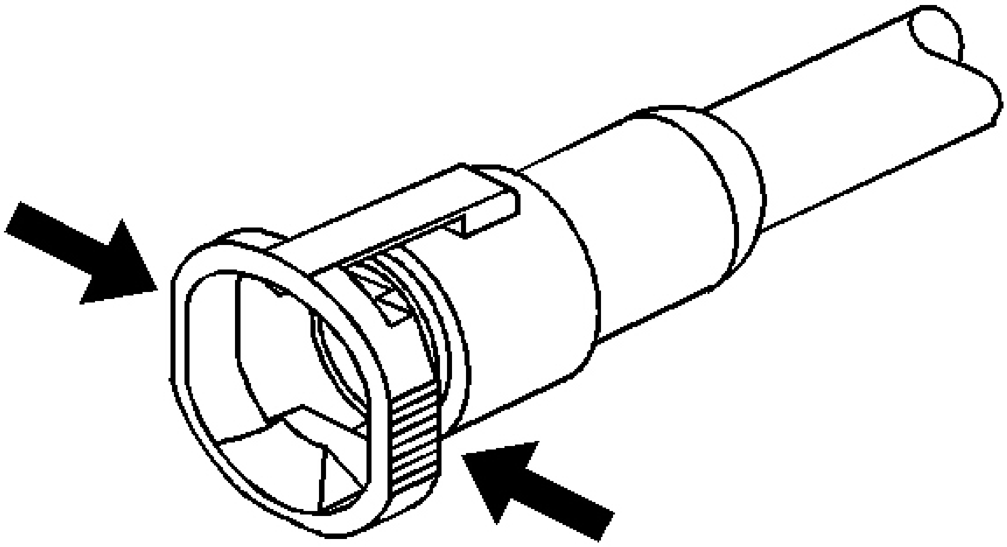


Fig. 73: Releasing Connector
Courtesy of GENERAL MOTORS CORP.

2. Depress the tabs on the connector housing in order to release the connector.

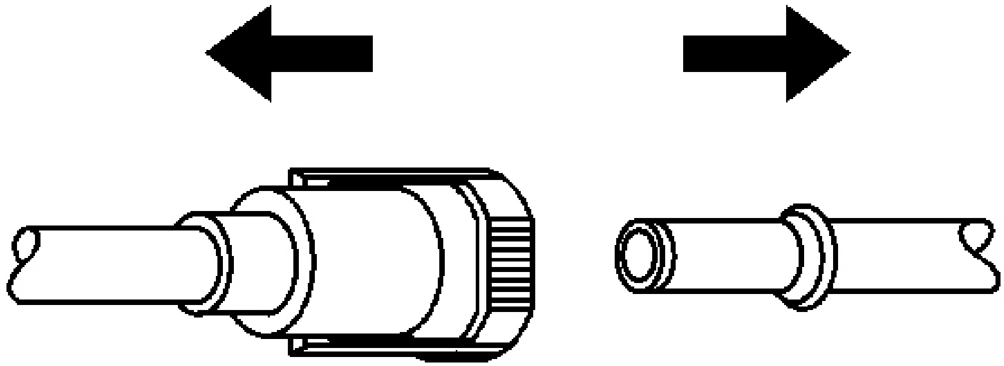


Fig. 74: Pulling The Connector Apart
Courtesy of GENERAL MOTORS CORP.

3. Continue to depress the tabs while pulling the connector apart.

NOTE: 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.

4. Wipe off the male end using a clean shop towel.
5. Inspect both ends of the fitting for dirt and burrs.
6. Clean or replace the components as required.

Installation Procedure

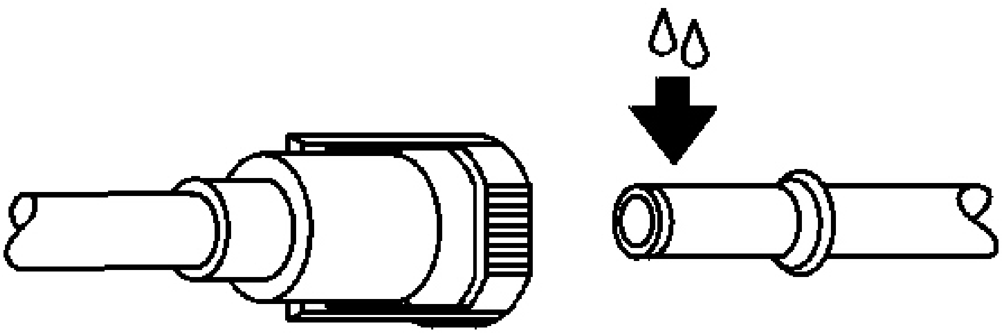


Fig. 75: Oiling Male Pipe Ends
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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.

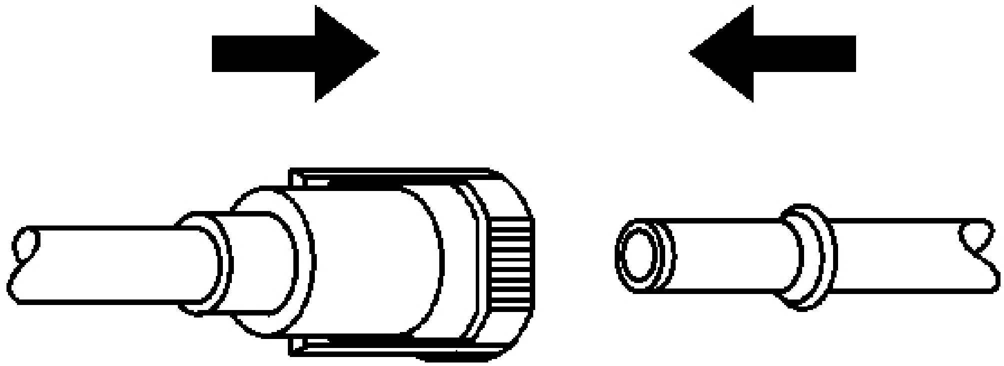


Fig. 76: Connecting Fitting Of Retainer
Courtesy of GENERAL MOTORS CORP.

2. Push both sides of the quick-connect fittings together in order to snap the retainer in place.

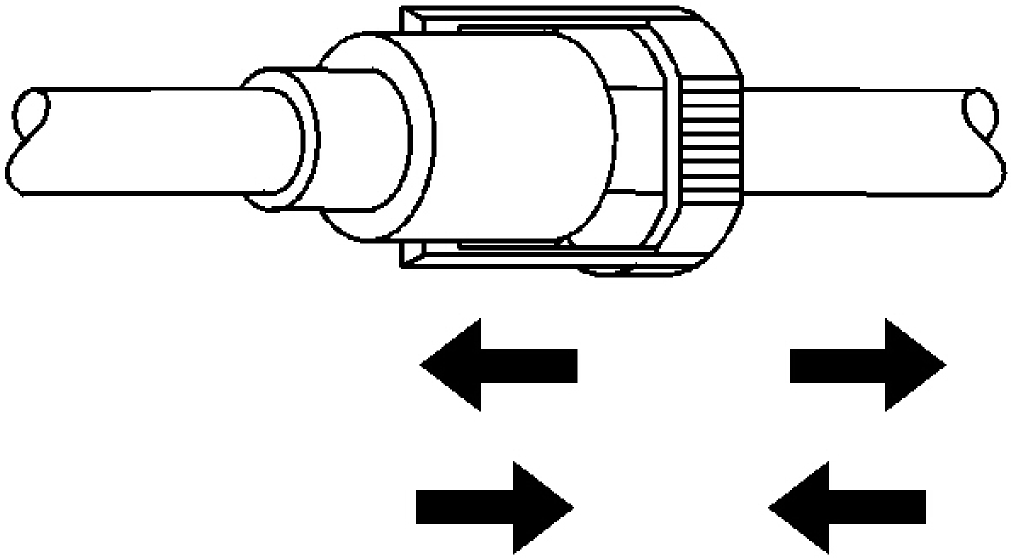


Fig. 77: Securing The Connection
Courtesy of GENERAL MOTORS CORP.

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

QUICK CONNECT FITTING(S) SERVICE (PLASTIC COLLAR) (PLASTIC COLLAR LEVER RELEASE)

Removal Procedure

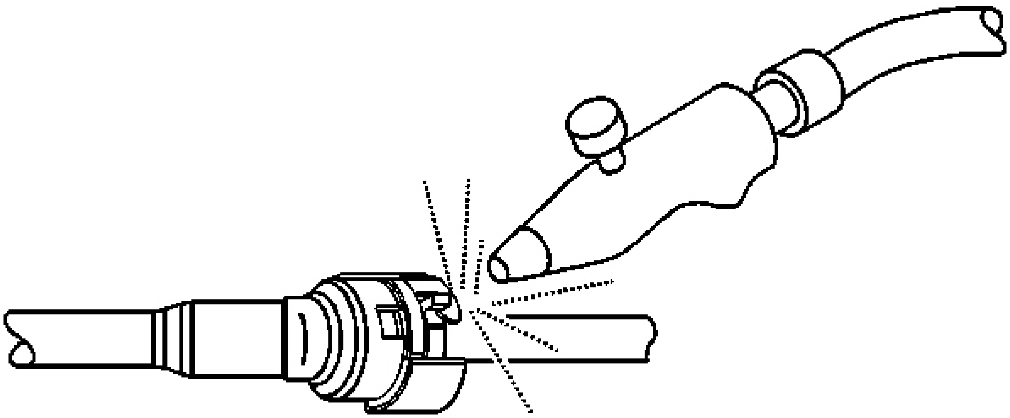


Fig. 78: View Of Quick Connect Fitting Service (Plastic Collar) (Plastic Collar Level)
Courtesy of GENERAL MOTORS CORP.

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

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

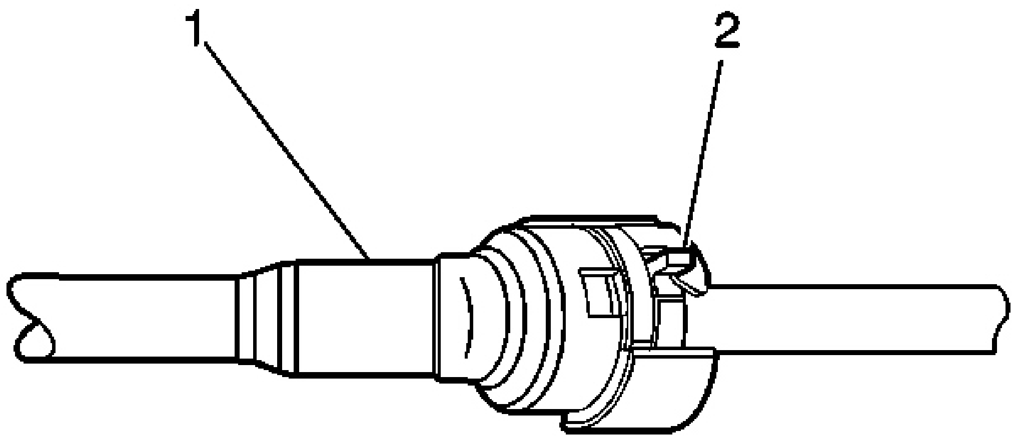


Fig. 79: View Of Retaining Tab While Holding The Connertor Housing
Courtesy of GENERAL MOTORS CORP.

2. Depress the retaining tab (2) while holding the connector housing (1).

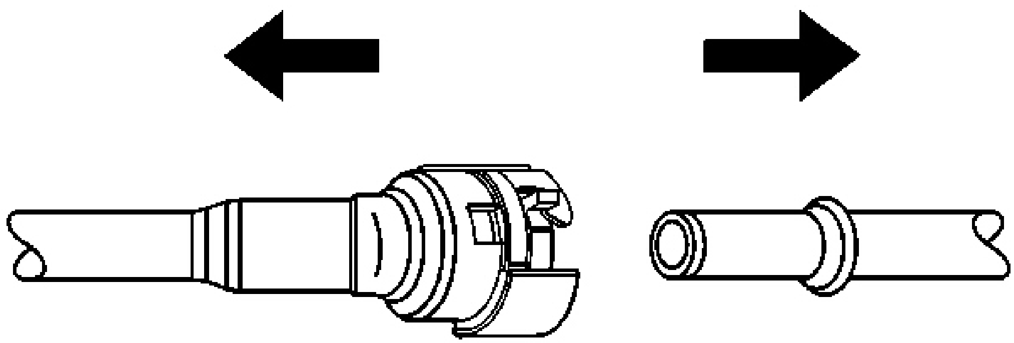


Fig. 80: Pulling The Connector Apart
Courtesy of GENERAL MOTORS CORP.

3. Continue to depress the retaining tab while pulling the connector apart.

NOTE: 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.

4. Wipe off the male end using a clean shop towel.
5. Inspect both ends of the fitting for dirt and burrs.
6. Clean or replace the components as required.

Installation Procedure

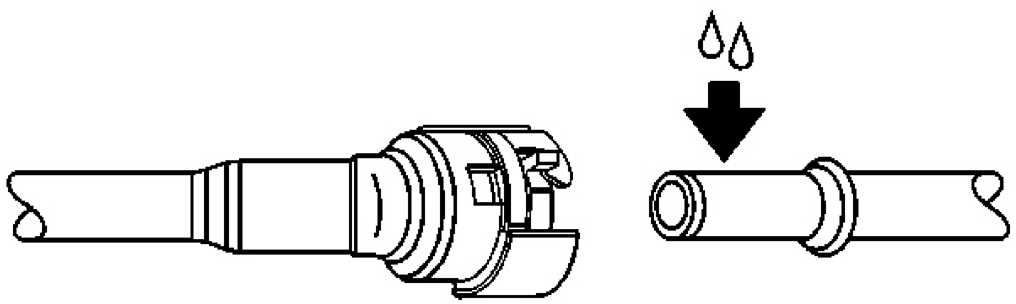


Fig. 81: Oiling Male Pipe Ends
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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.

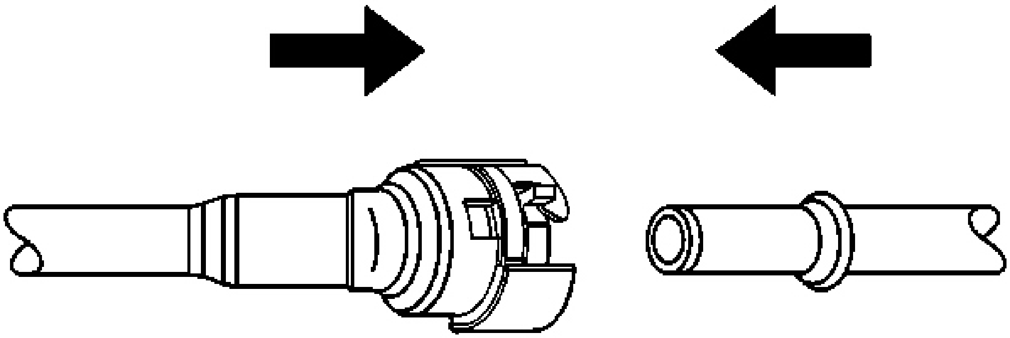


Fig. 82: Connecting Fitting Of Retainer
Courtesy of GENERAL MOTORS CORP.

2. Push both sides of the quick-connect fittings together in order to snap the retainer in place.

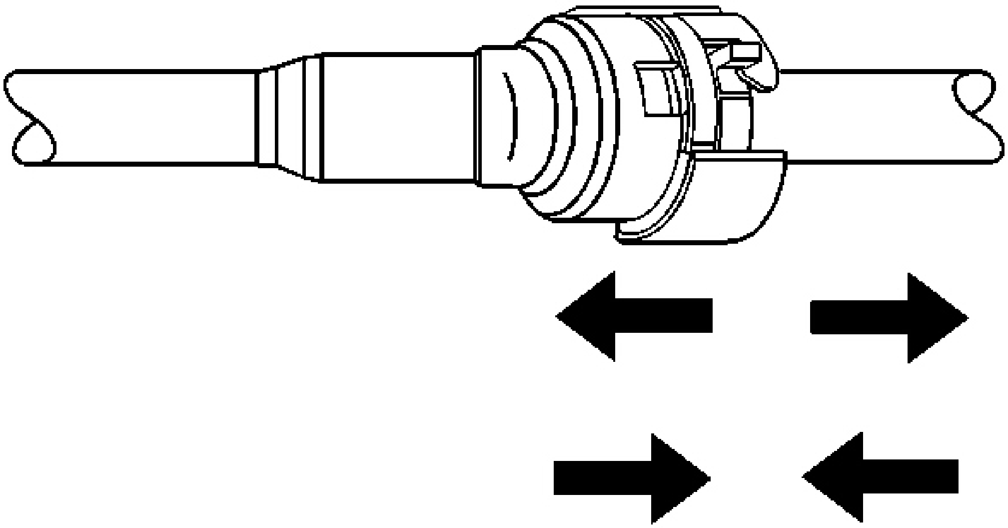


Fig. 83: Ensuring Secure Connection
Courtesy of GENERAL MOTORS CORP.

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

FUEL TANK DRAINING PROCEDURE

Tools Required

- **SA9127E** Gage Bar Set
- **SA9804E** Fuel Tank Drain Hose. See **Special Tools and Equipment** .

Using The Fuel Pump

CAUTION: Do not allow smoking or the use of open flames in the area where work on the fuel or EVAP system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

CAUTION: Never drain or store fuel in an open container due to the possibility of fire or explosion.

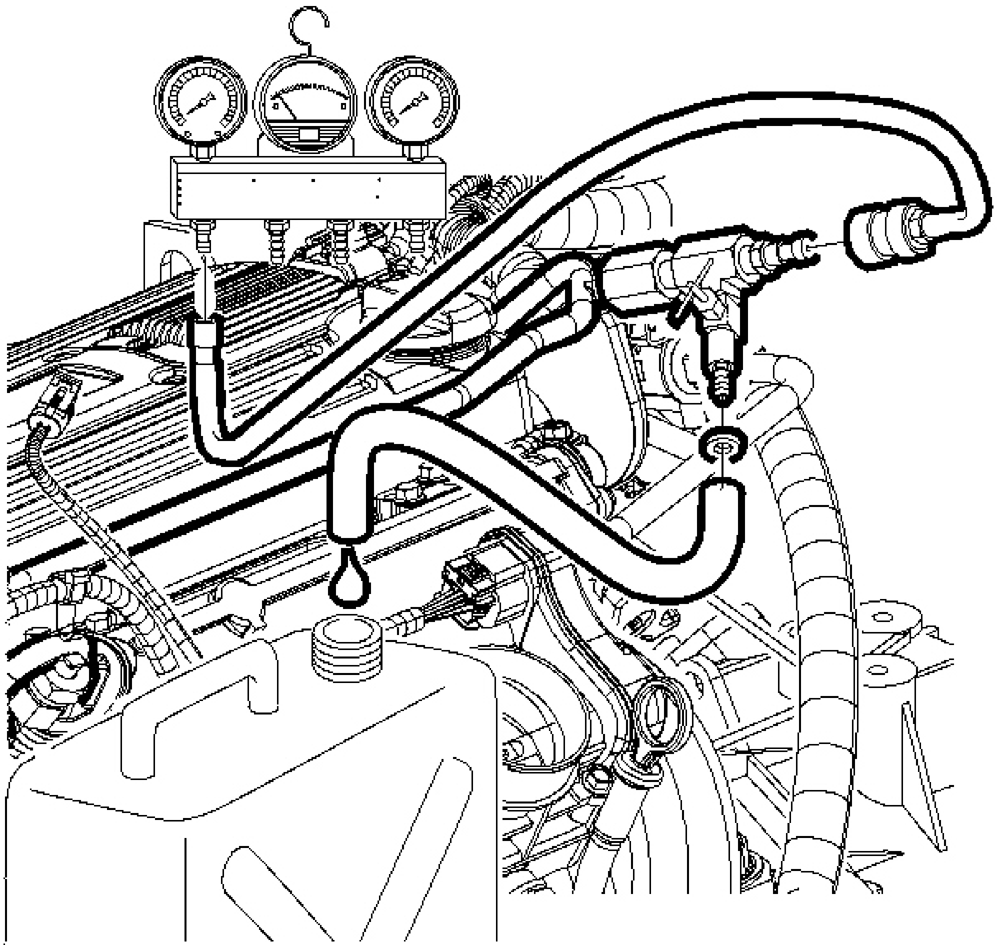


Fig. 84: View Of Fuel Tank Drain Hose
Courtesy of GENERAL MOTORS CORP.

Using the fuel pump to drain the tank is the easiest procedure if the pump is operable. The fuel can be pumped out with the vehicle on the ground or on the hoist.

On The Ground

CAUTION: Fuel supply lines will remain pressurized for long periods of time after the engine is shutdown. This pressure must be relieved before servicing the fuel system.

1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** .

CAUTION: Whenever fuel line fittings are loosened or removed, wrap a shop cloth around the fitting and have an approved container available to collect any fuel.

2. Disconnect the fuel feed line at the fuel rail and install the 3/8 inch x 1/4 inch quick connect from the **SA9127E** into the fuel feed line.
3. Connect a suitable drain hose to the other end of the adapter and connect the drain hose into a certified fuel handling cart.
4. Connect the scan tool to the vehicle and turn the ignition ON.
5. Energize the fuel pump using the scan tool. Refer to**Fuel System Diagnosis** .
6. Pump out the fuel until no more than 1/4 tank remains.

On The Hoist

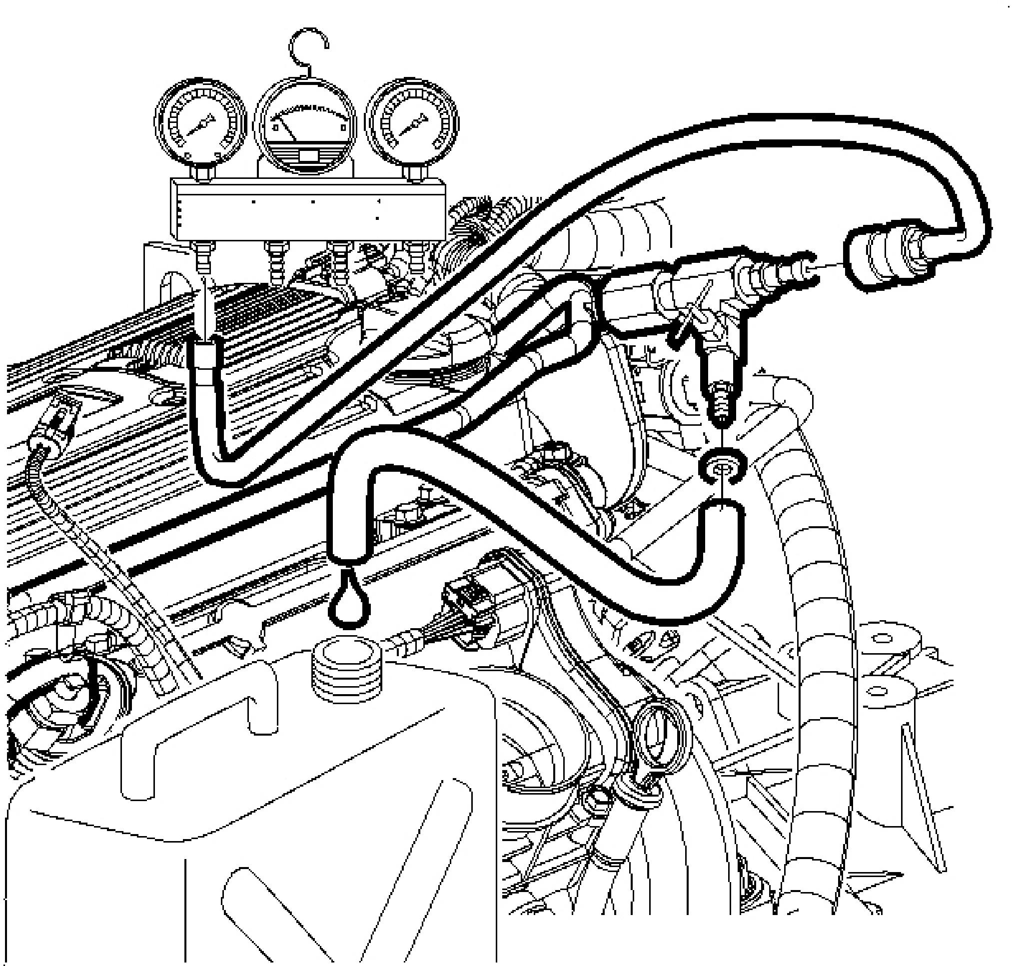


Fig. 85: View Of Fuel Tank Drain Hose
Courtesy of GENERAL MOTORS CORP.

CAUTION: Fuel supply lines will remain pressurized for long periods of time after the engine is shutdown. This pressure must be relieved before servicing the fuel system.

1. Connect the scan tool to the vehicle diagnostic connector and turn the ignition ON.
2. Relieve the fuel system pressure. Refer to**Fuel Pressure Relief Procedure** .

CAUTION: Ensure that the vehicle is properly supported and squarely positioned. To help avoid personal injury when a vehicle is on a

hoist, provide additional support for the vehicle on the opposite end from which the components are being removed.

3. Raise the vehicle on a hoist to a comfortable working height, keeping the scan tool outside of the vehicle and accessible from under the car.

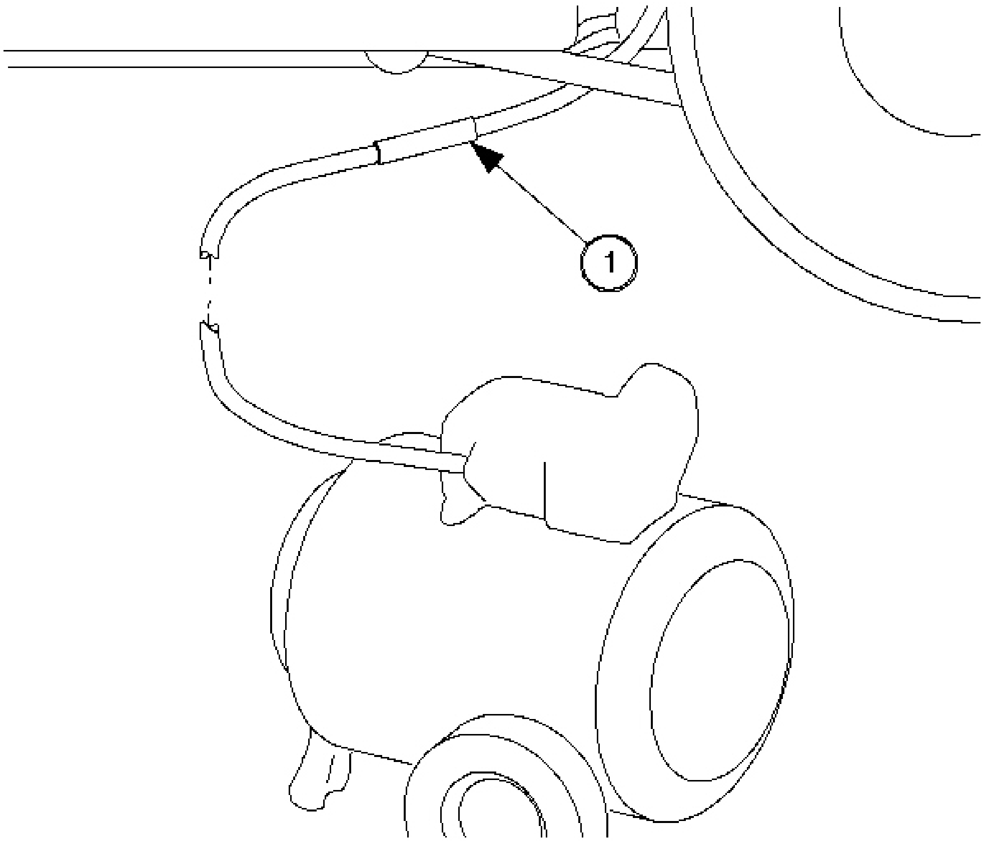


Fig. 86: Connecting Adapter From The SA9127E
Courtesy of GENERAL MOTORS CORP.

CAUTION: Whenever fuel line fittings are loosened or removed, wrap a shop cloth around the fitting and have an approved container available to collect any fuel.

4. Disconnect the chassis fuel feed line at fuel tank.
5. Install the 3/8 inch x 1/4 inch quick connect (1) adapter from the **SA9127E** onto the fuel feed line.
6. Connect a suitable drain hose to the other end of the adapter, and connect the drain hose to a certified fuel handling cart.
7. Energize the fuel pump using the scan tool. Refer to**Fuel System Diagnosis** .
8. Pump out the fuel until no more than 1/4 tank remains.

Siphoning The Fuel Tank

CAUTION: Do not allow smoking or the use of open flames in the area where work on the fuel or EVAP system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

If the fuel pump is inoperative, the tank can be drained by siphoning from the tank. A suitable means is through the fuel filler pipe with the correct type and stiffness of tubing as used with the **SA9804E** . See **Special Tools and Equipment** .

CAUTION: Do not allow smoking or the use of open flames in the area where work on the fuel or EVAP system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Open the fuel filler door and remove the gas cap.

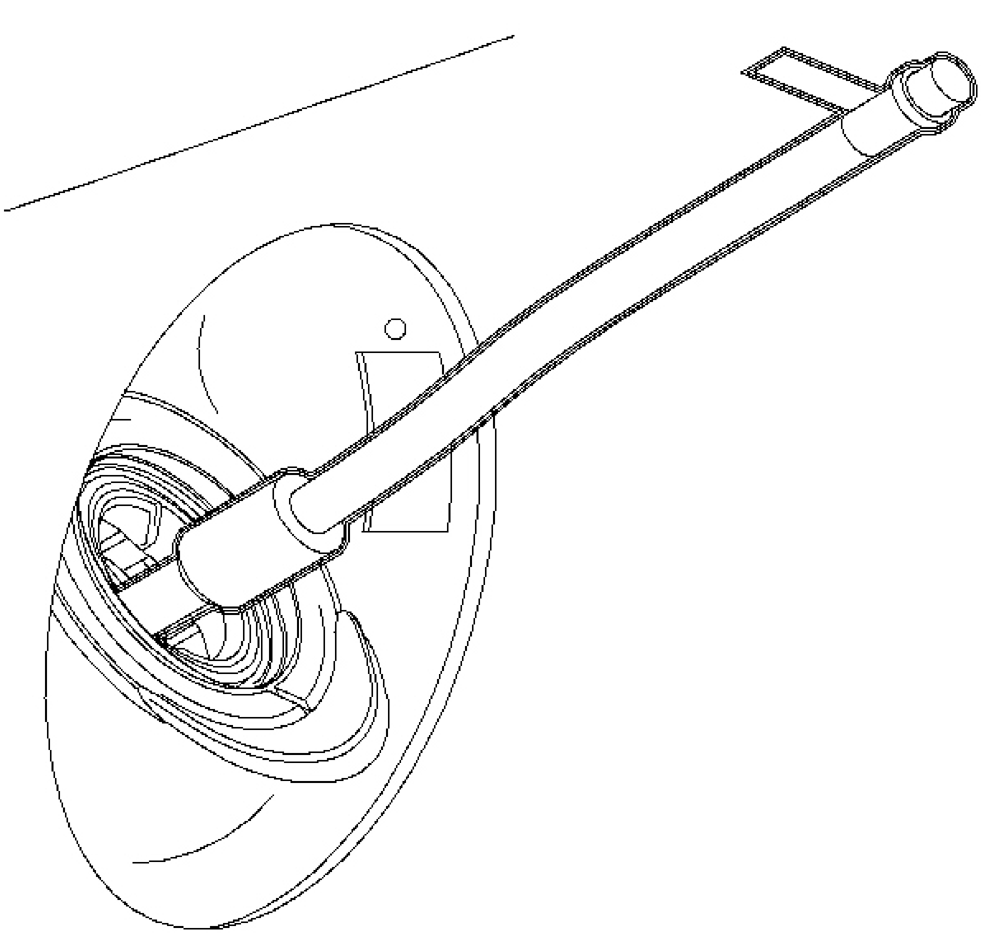


Fig. 87: View Of Siphon Hose Guide/Funnel
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not attempt to insert any other type of siphon hose or tube into the fuel filler pipe. The design of the inlet check valve at the end of the fuel filler tube restricts the insertion of a hose and, most importantly, prevents the removal of this hose. See Fuel Inlet Check Valve in this section. If the siphon hose becomes stuck in the check valve, the fuel filler pipe will not be able to be removed from the fuel tank without damage to the fill pipe or fuel tank.

3. Insert the siphon hose guide/funnel into the fuel filler pipe.

IMPORTANT: When inserting the drain hose, take care to prevent damaging the fuel level sensor assembly.

IMPORTANT: The siphon hose will reach the bottom of the tank, on the primary side only, within about 25.4 cm (10 in) of the end fitting and tag. When connecting the siphon hose to another length of hose connected to the fuel drain tanker, DO NOT insert the siphon hose into the fill pipe funnel past the tag at the fitting end. If inserted too far, the upper portion of the siphon hose may pass through the check valve cage and then jam on attempted removal.

4. Insert the **SA9804E** into the guide funnel and into the fuel filler pipe. See **Special Tools and Equipment** . Some resistance may be encountered when the tip of the siphon hose reaches the inlet check valve. Repeated probing may be necessary to slide the hose tip through the check valve cage.

CAUTION: Whenever fuel lines are removed, catch fuel in an approved container. Container opening must be a minimum of 300 mm (12 in) diameter to adequately catch the fluid.

IMPORTANT: The fuel flow rate from the siphon hose will range from 1.1 L/min (0.3 gal/min) up to 3.8 L/min (1 gal/min), depending on whether it is gravity siphoned or with an air-powered pump.

5. Begin the fuel siphoning process. Place the fuel into an approved fuel container.
6. Remove the siphon hose from the fuel filler pipe after draining is complete.

FUEL TANK REPLACEMENT

Removal Procedure

CAUTION: Do not allow smoking or the use of open flames in the area where work on the fuel or EVAP system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

1. Ensure that the fuel level in the tank is less than 1/4 full. If necessary, drain the fuel tank to at least this level. Refer to **Fuel Tank Draining Procedure** .

CAUTION: Fuel supply lines will remain pressurized for long periods of time after the engine is shutdown. This pressure must be relieved before servicing the fuel system.

2. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** .
3. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure**

in Engine Electrical.

4. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.

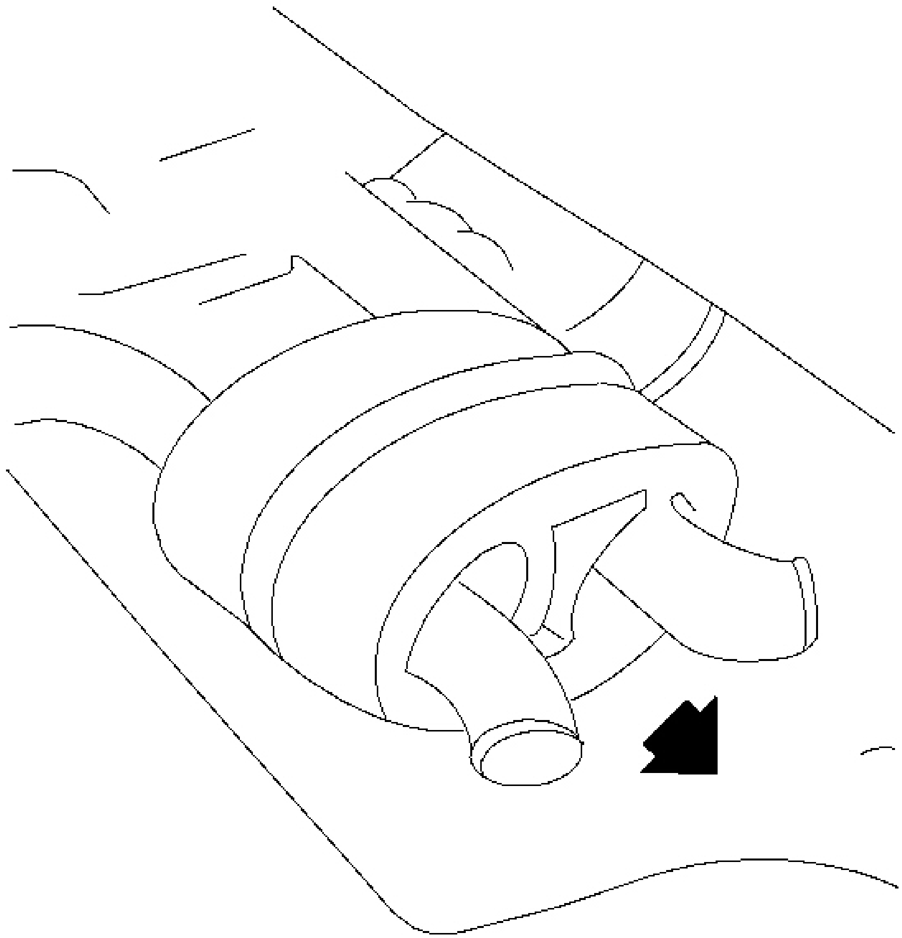


Fig. 88: View Of Fuel Tank
Courtesy of GENERAL MOTORS CORP.

5. Remove the rubber exhaust hangers on order to allow the exhaust system to drop slightly.
6. Remove the propeller shaft, if equipped. Refer to **Propeller Shaft Replacement** in Propeller Shaft.

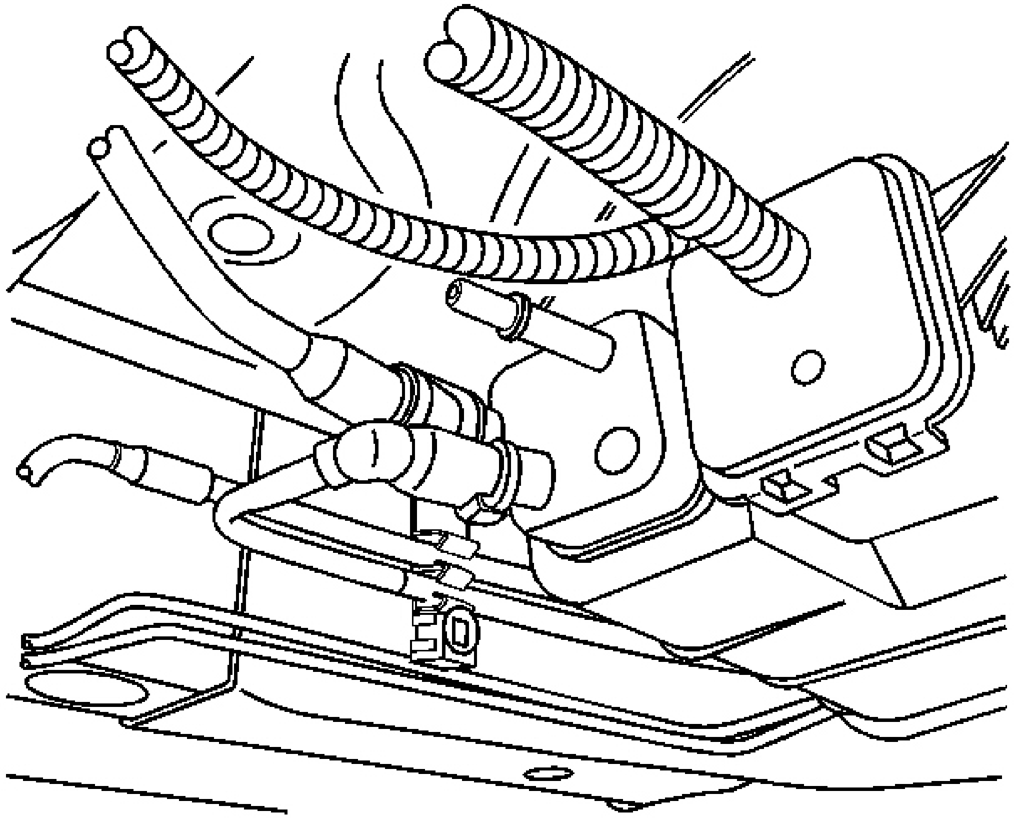


Fig. 89: View Of EVAP Vent & Fresh Air Hoses
Courtesy of GENERAL MOTORS CORP.

NOTE: Clean all fuel pipe connections and surrounding areas before disconnecting the fuel pipes to avoid contamination of the fuel system.

7. Disconnect the EVAP canister vent and fresh air hoses:
    1. Grasping both sides of the quick-connect fitting, twist the female connector 1/4 turn in each direction in order to loosen dirt within the quick-connect fitting.
    2. Blow any dirt out of the quick-connect fitting using compressed air.
    3. Squeeze the plastic retainer release tabs.
    4. Pull the connection apart.
    5. Inspect both ends of the quick-connect fitting for dirt and burrs.

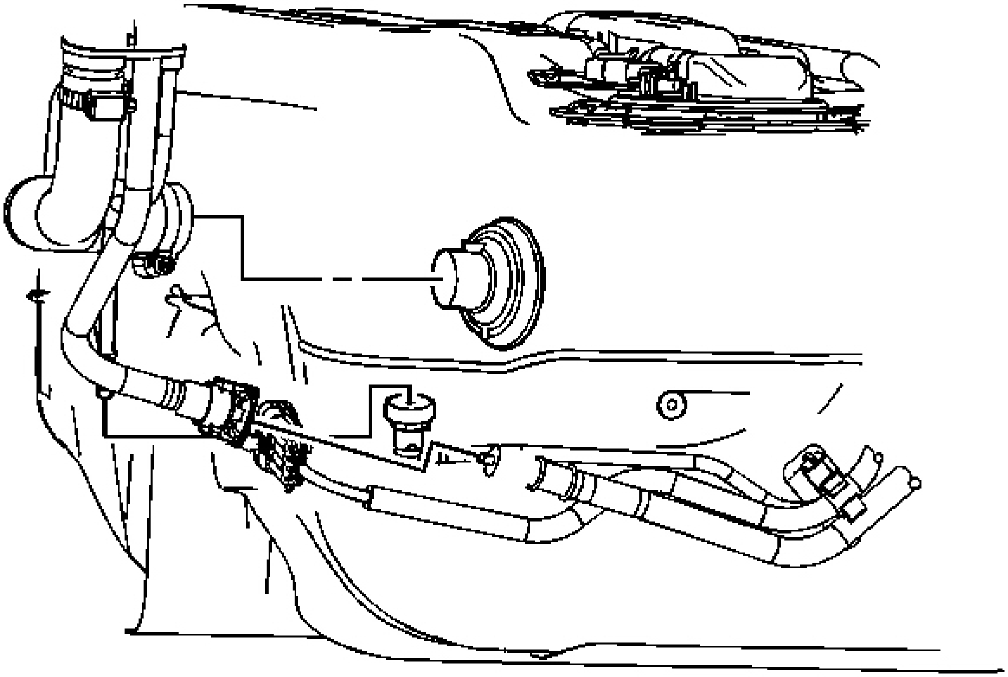


Fig. 90: View Of Fuel Filler Pipe, EVAP Vent & Fresh Air Hose From The Fuel Tank
Courtesy of GENERAL MOTORS CORP.

8. Remove the fuel filler pipe, EVAP vent hose, and fresh air hose from the fuel tank.

> **CAUTION: Whenever fuel lines are removed, catch fuel in an approved container. Container opening must be a minimum of 300 mm (12 in) diameter to adequately catch the fluid.**

9. Disconnect the chassis fuel supply line from the tank.
10. Disconnect the electrical connectors:
    1. Fuel tank electrical connectors
    2. EVAP solenoid electrical connector

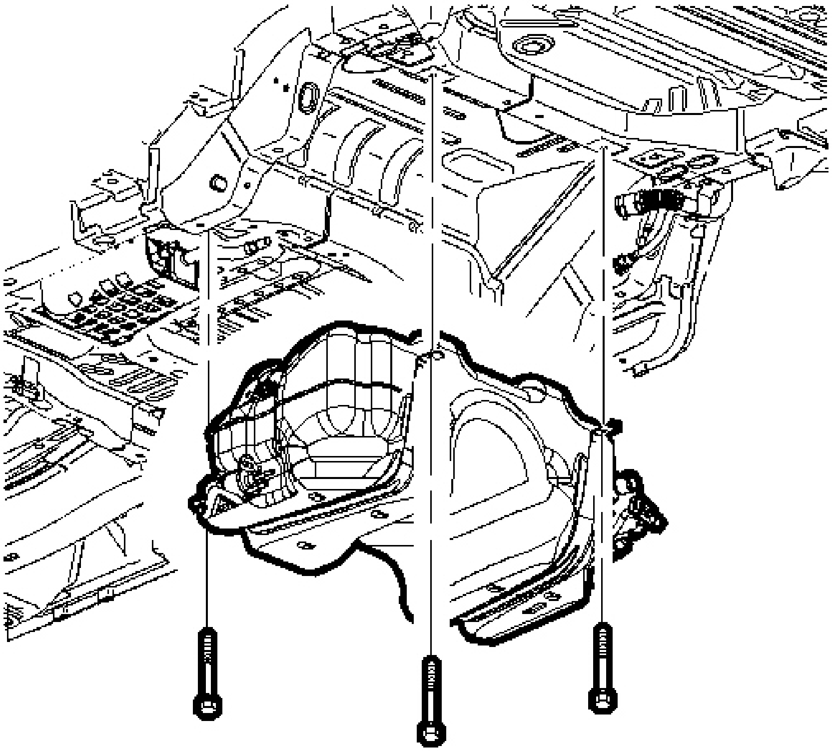


Fig. 91: View Of Fuel Tank Heat Shield & Fuel Tank Assembly
Courtesy of GENERAL MOTORS CORP.

NOTE: **Do not bend the fuel tank straps. Bending the fuel tank straps may cause damage to the straps.**

IMPORTANT: **Do not disassemble the RDM. It is not necessary to touch the RDM for fuel tank removal.**

11. Support the fuel tank.
12. Remove the fuel tank strap bolts and fuel tank straps.
13. Lower the fuel tank from the underbody of the vehicle.

14. Remove the fuel tank module assemblies. Refer to **Fuel Tank Module Replacement - Primary** and **Fuel Tank Module Replacement - Secondary** .

Installation Procedure

1. Install the fuel tank module assemblies. Refer to **Fuel Tank Module Replacement - Primary** and **Fuel Tank Module Replacement - Secondary** .

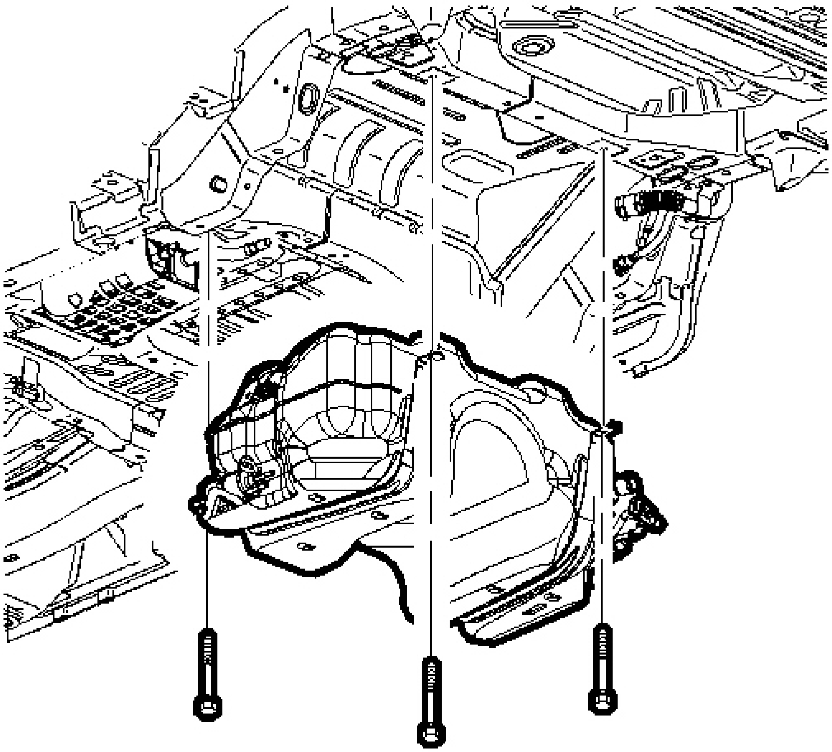


Fig. 92: View Of Fuel Tank Heat Shield & Fuel Tank Assembly
Courtesy of GENERAL MOTORS CORP.

2. Install the fuel tank heat shield and fuel tank assembly into the vehicle.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the fuel tank straps and tighten the bolts.

   Tighten: Tighten the fuel tank strap-to-body bolts to 25 N.m (18 lb ft).

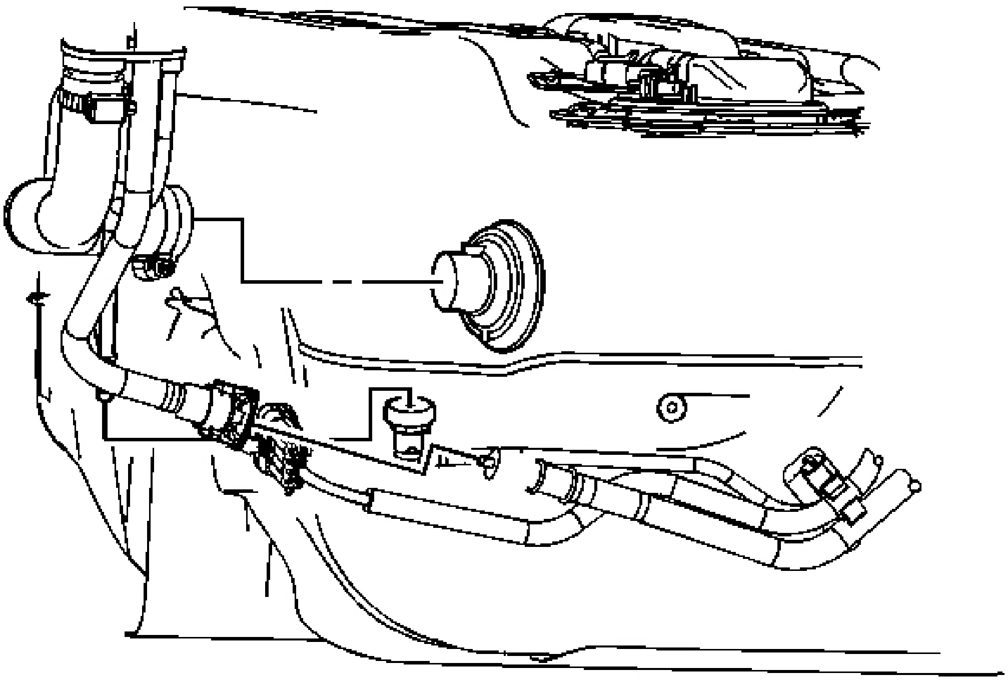


Fig. 93: View Of Fuel Filler Pipe, EVAP Vent & Fresh Air Hose From The Fuel Tank
Courtesy of GENERAL MOTORS CORP.

4. Install the fuel filler pipe, EVAP vent, and fresh air hoses to the fuel tank.
5. Connect the electrical connectors:
   1. Fuel tank electrical connector
   2. EVAP solenoid electrical connectors
6. Tighten the hose clamp on the filler pipe-to-fuel tank connecting hose.

   Tighten: Tighten the fuel fill neck-to-fuel tank clamp to 5 N.m (44 lb in).

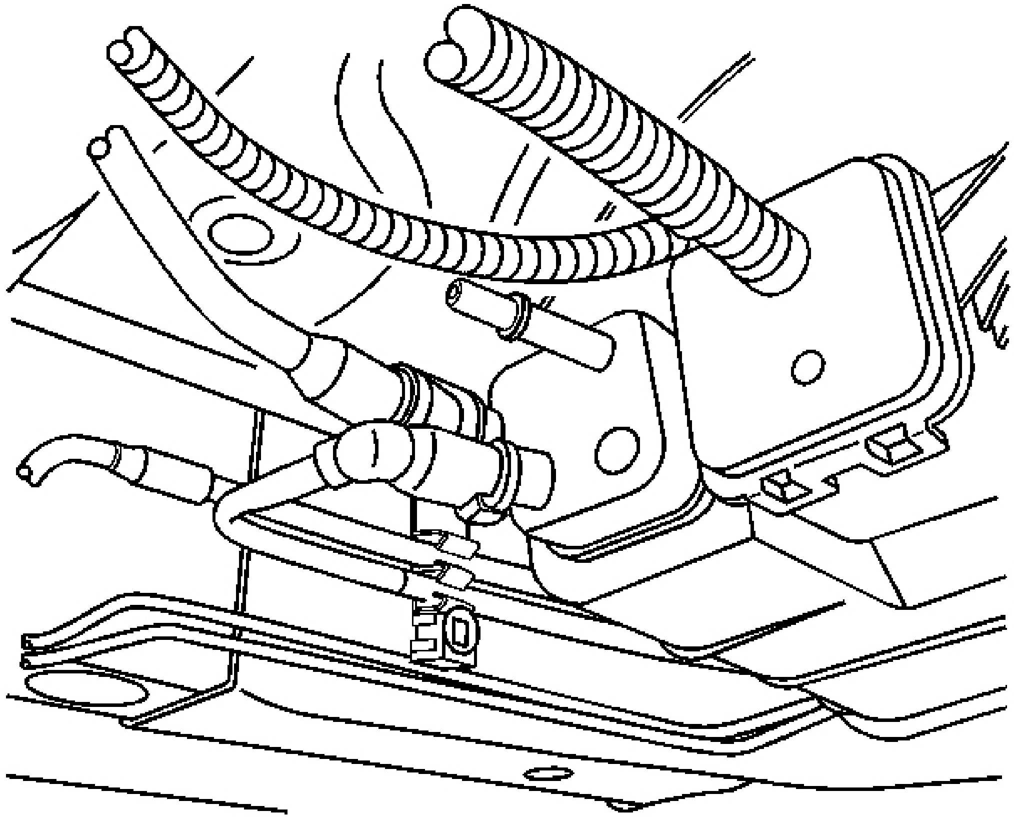


Fig. 94: View Of EVAP Vent & Fresh Air Hoses
Courtesy of GENERAL MOTORS CORP.

7. Connect the EVAP canister vent and fresh air hoses to the fuel tank hoses.
8. If equipped, install the propeller shaft. Refer to **Propeller Shaft Replacement** in Propeller Shaft.

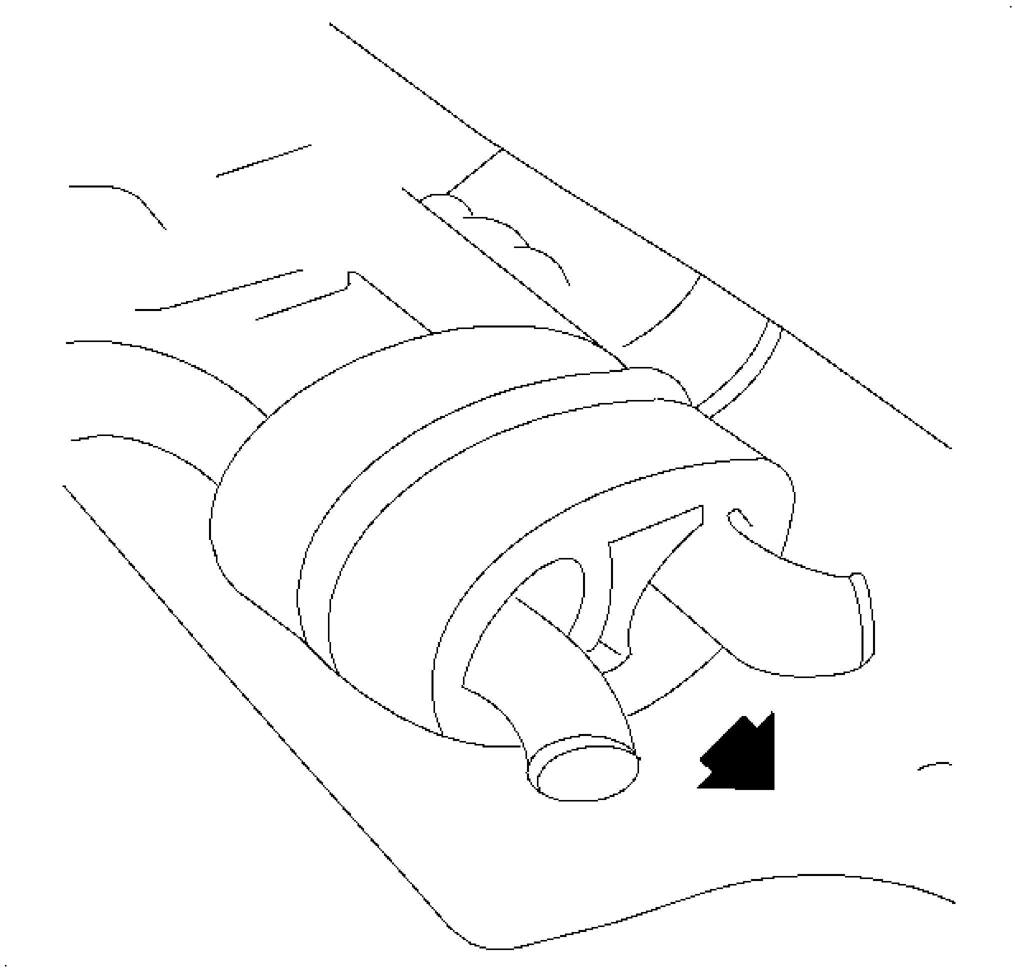


Fig. 95: View Of Rubber Exhaust Hangers
Courtesy of GENERAL MOTORS CORP.

9. Install the rubber exhaust hangers.
10. Lower the vehicle.
11. Fill the fuel tank with gasoline.
12. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
13. Prime the fuel system:
    1. Cycle the ignition ON for 5 seconds and then OFF for 10 seconds.
    2. Repeat the previous step twice.

3. Crank the engine until it starts. The maximum starter motor cranking time is 20 seconds.
4. If the engine does not start, repeat steps 13.1-13.3.

FUEL TANK PRESSURE SENSOR REPLACEMENT

Removal Procedure

1. Remove the fuel tank. Refer to **Fuel Tank Replacement** .

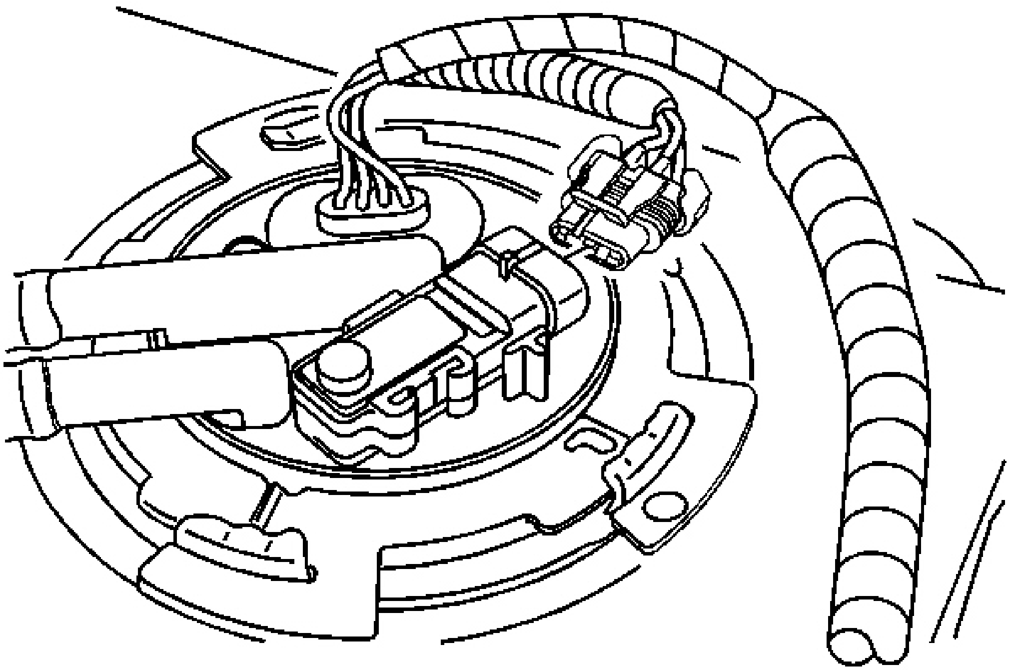


Fig. 96: View Of Fuel Tank Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the fuel pump module harness electrical connector from the fuel tank pressure sensor.

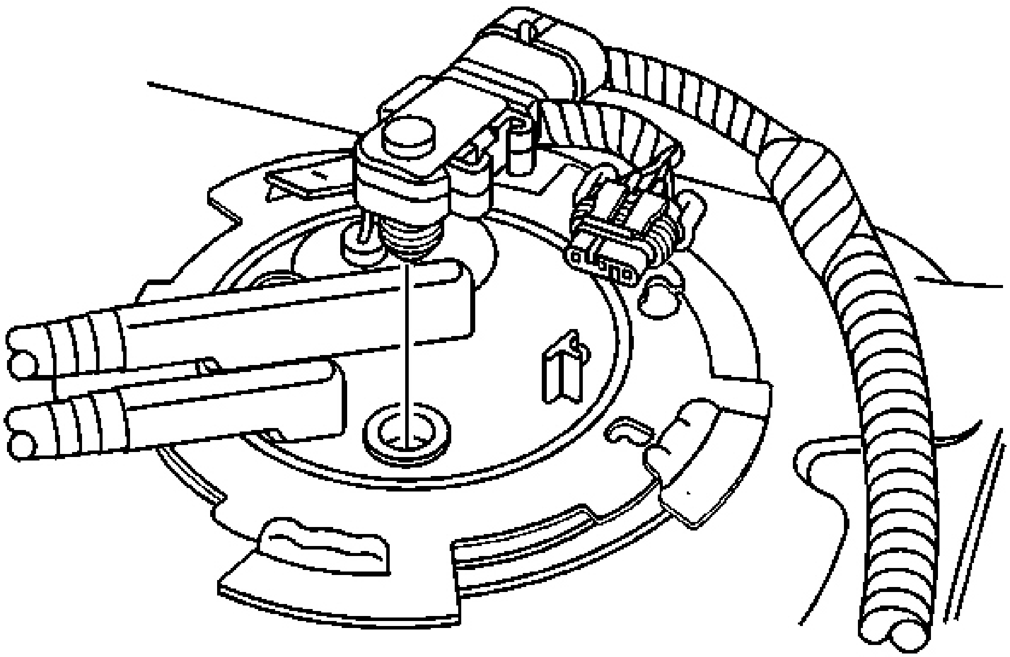


Fig. 97: View Of Fuel Tank Pressure Sensor To The Fuel Pump Module Assembly
Courtesy of GENERAL MOTORS CORP.

3. Position 2 flat-bladed screwdrivers, one on each side of the sensor, near the vacuum port.
4. Carefully use the screwdrivers to lift and release the sensor from the fuel pump module.

Installation Procedure

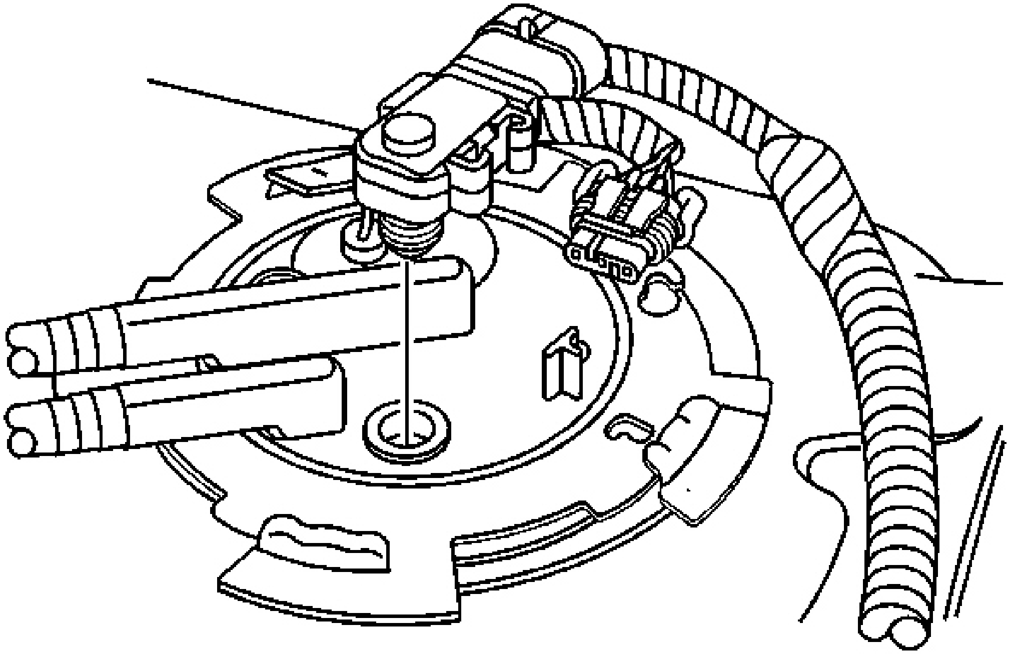


Fig. 98: View Of Fuel Tank Pressure Sensor To The Fuel Pump Module Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the fuel tank pressure sensor to the fuel pump module assembly. Ensure that the sensor grommet is fully seated to the pump module.

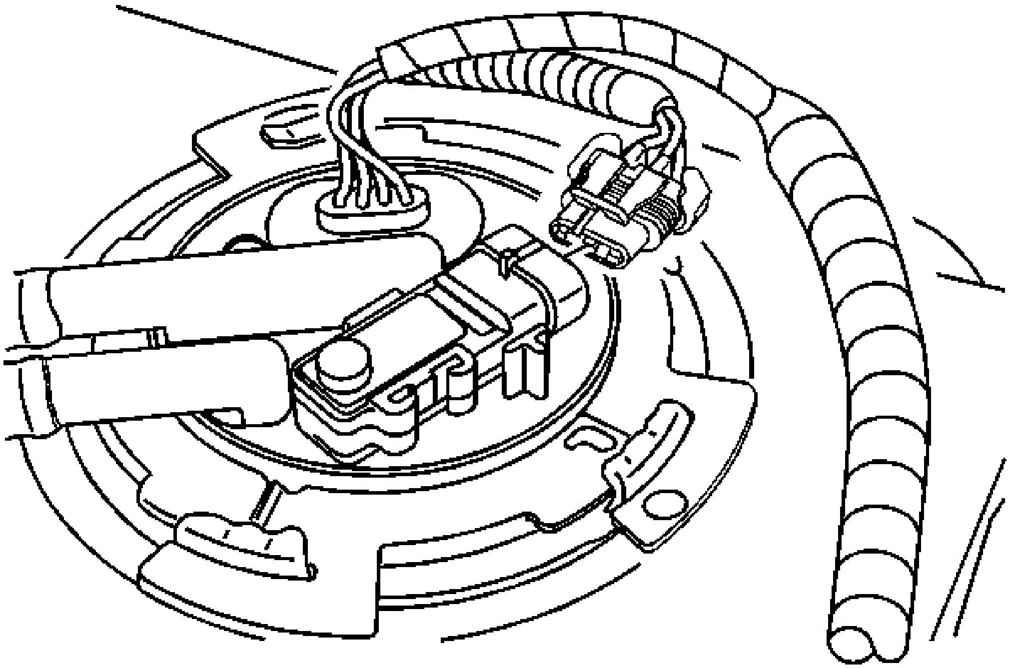


Fig. 99: View Of Fuel Tank Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

2. Connect the pump module electrical connector to the fuel tank pressure sensor.
3. Install the fuel tank. Refer to **Fuel Tank Replacement** .

FILLER TUBE REPLACEMENT

Removal Procedure

CAUTION: Do not allow smoking or the use of open flames in the area where work on the fuel or EVAP system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

1. Ensure that the fuel level in the tank is less than 1/4 full. If necessary, drain the fuel tank to at least this level. Refer to **Fuel Tank Draining Procedure** .

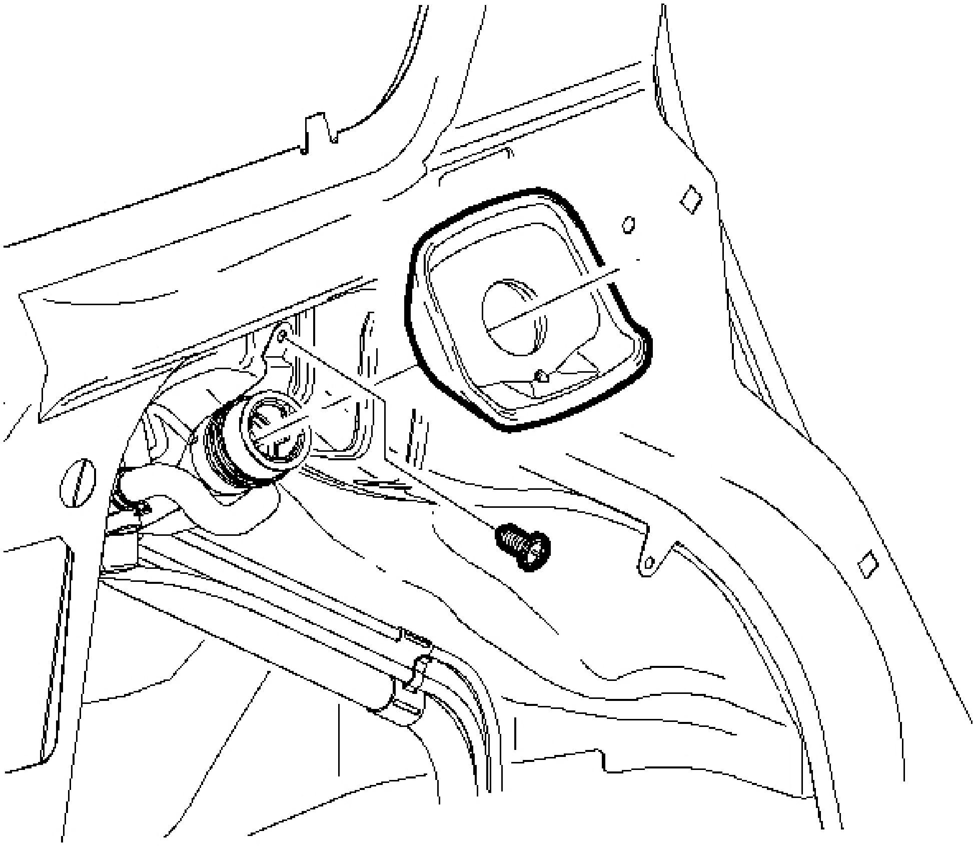


Fig. 100: View Of Filler Tube
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
3. Remove the fuel filler cap.
4. Push/pry the closeout grommet to expose the fuel fill neck attachment bolt. Remove the fill neck attachment bolt.
5. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
6. Remove the right rear wheel and tire. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
7. Remove the right rear wheelhouse inner liner. Refer to **Wheelhouse Liner Panel Replacement - Rear** in

Body Rear End.

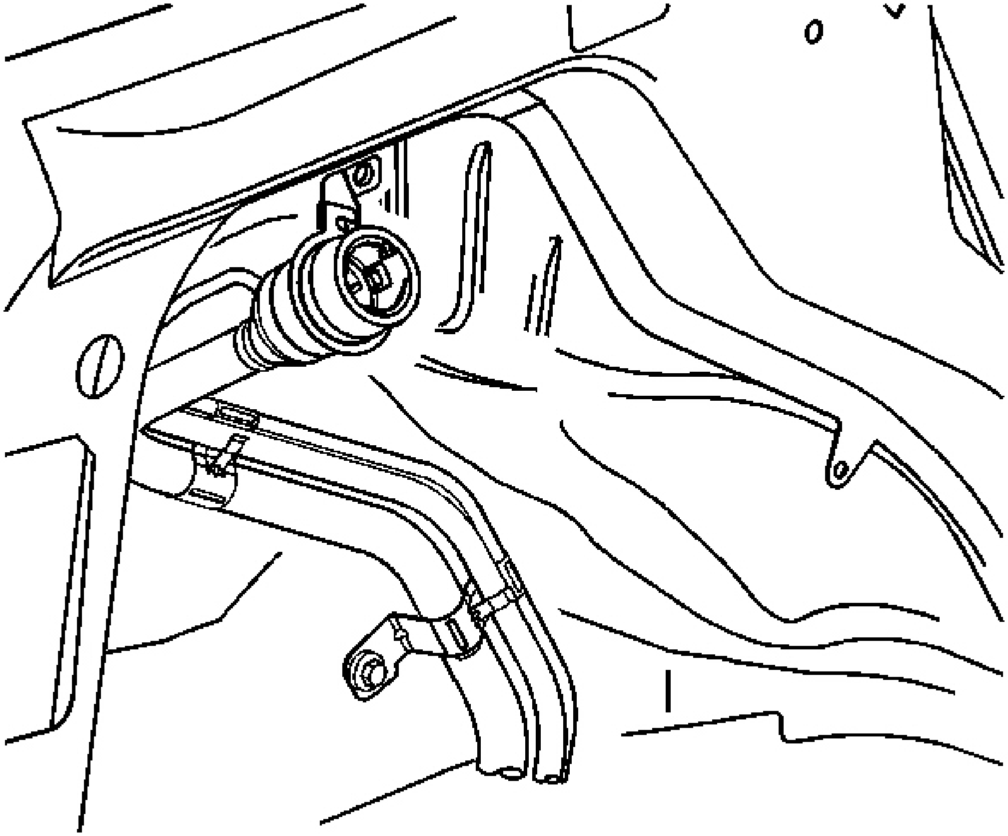


Fig. 101: View Of Fuel Filler Pipe Intermediate Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

8. Remove the fuel filler pipe intermediate bracket bolt.
9. Disengage the fuel filler neck from the support bracket by moving the fuel filter neck up and to the left, toward the rear of the vehicle.

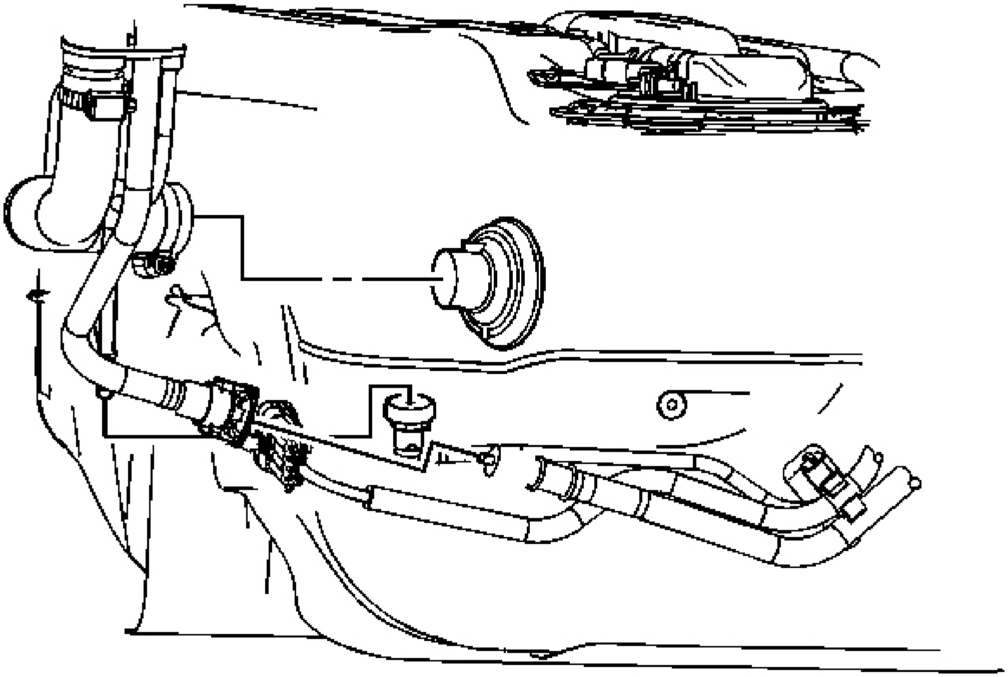


Fig. 102: View Of Fuel Filler Pipe, EVAP Vent & Fresh Air Hose From The Fuel Tank
Courtesy of GENERAL MOTORS CORP.

10. Disconnect the fuel fill pipe vent tube, fresh air hose, and fuel fill hose from the fuel tank.
11. Disengage the filler pipe hose from the fuel tank and remove the fuel filler pipe and rubber grommet from the vehicle.

Installation Procedure

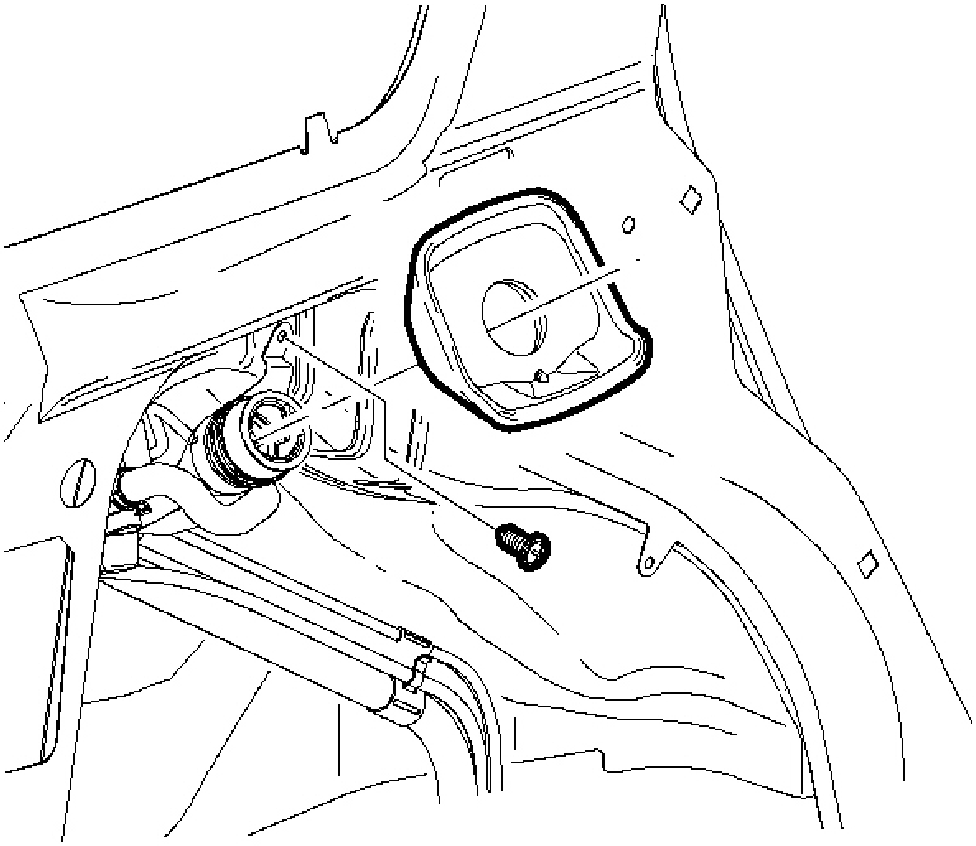


Fig. 103: View Of Rubber Grommet Onto The Fuel Filler Pipe
Courtesy of GENERAL MOTORS CORP.

1. Install the rubber grommet onto the fuel filler pipe.
2. Position the filler pipe into the wheel opening with the top of the pipe within the body panel opening.

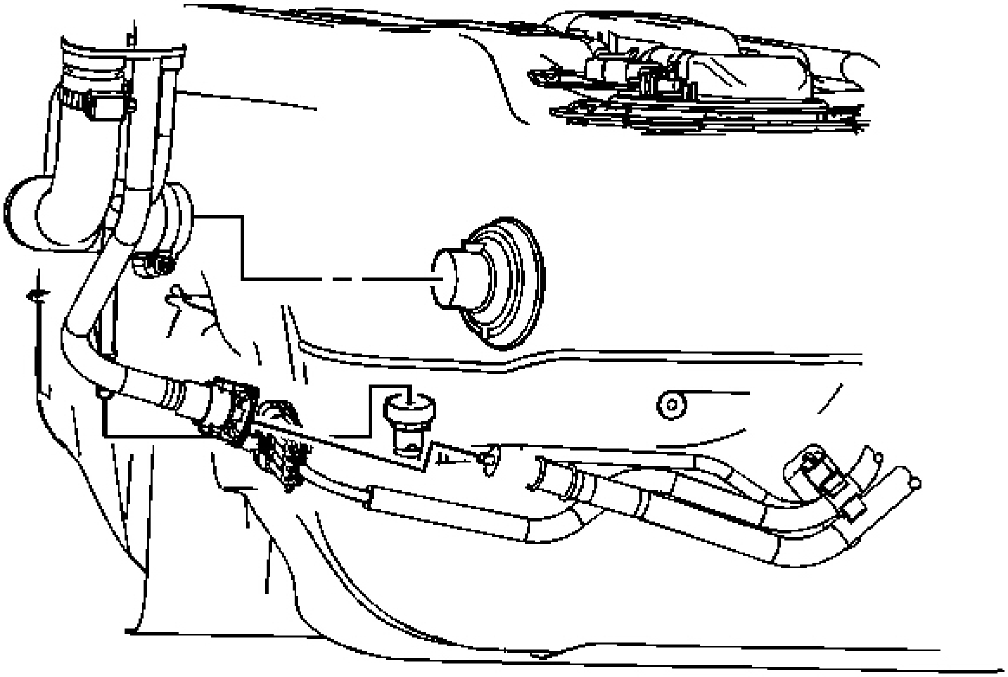


Fig. 104: View Of Fuel Filler Pipe, EVAP Vent & Fresh Air Hose From The Fuel Tank
Courtesy of GENERAL MOTORS CORP.

3. Install the fuel filler hose onto the fuel tank inlet.

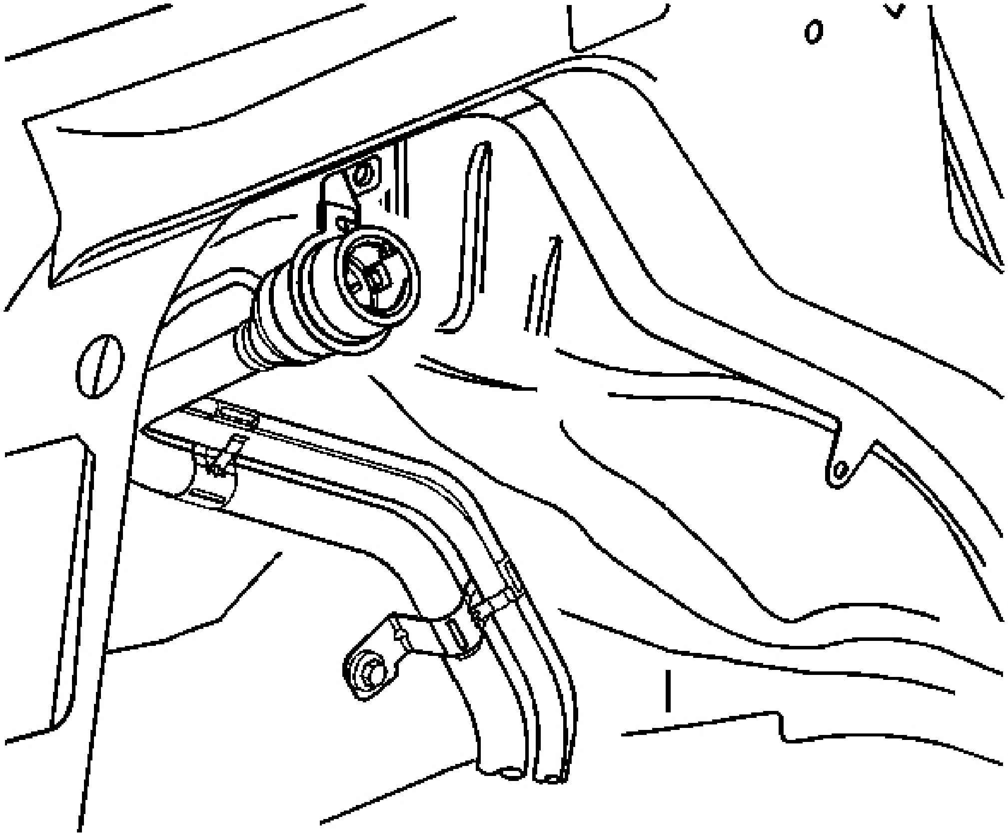


Fig. 105: View Of Fuel Filler Pipe Intermediate Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

4. Install the fuel filler pipe intermediate bracket bolt. Do not tighten at this time.

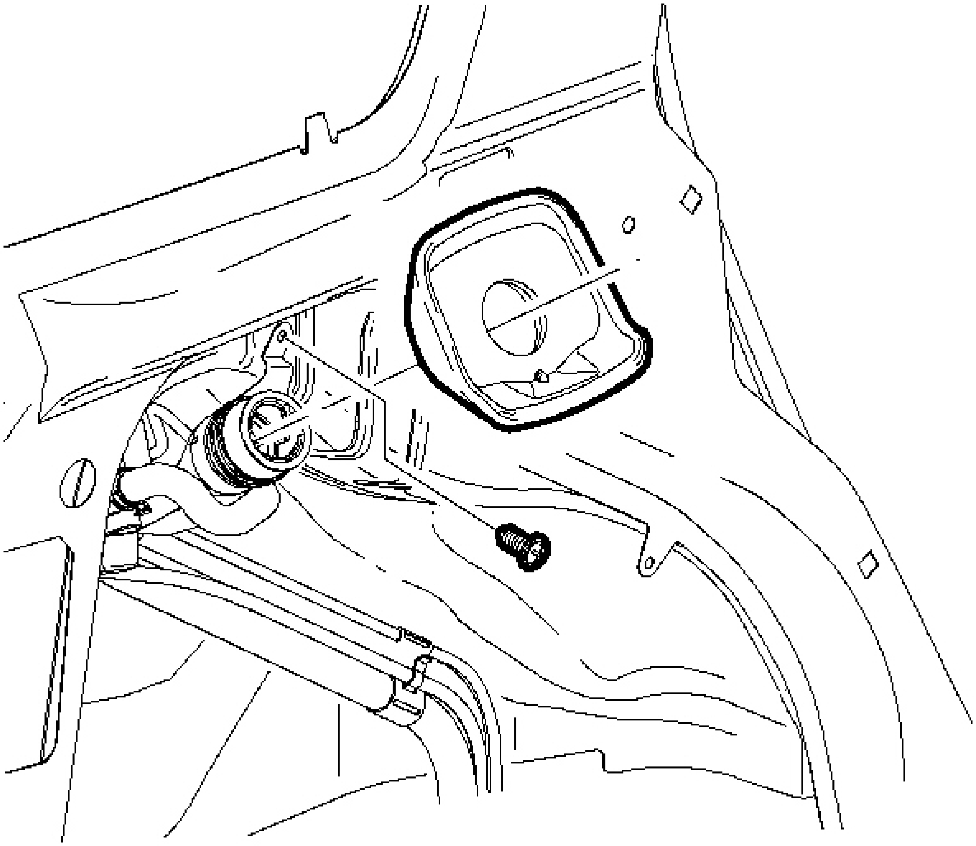


Fig. 106: View Of Rubber Grommet Onto The Fuel Filler Pipe
Courtesy of GENERAL MOTORS CORP.

5. Lower the vehicle and install the filler pipe to upper fuel fill pipe support bracket by moving the fuel filler neck up and to the right, toward the front of the vehicle.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Tighten the fuel fill pipe-to-body bolt.

   Tighten: Tighten the bolt to 3 N.m (27 lb in).

7. Install the fuel cap.

8. Raise the vehicle to a comfortable working height.

IMPORTANT: Ensure that the fuel pipe connecting hose is installed until it touches the fuel tank body. The hose clamp should be located within 13 mm (1/2 in) of the end of the connecting hose.

9. Tighten the hose clamp on the filler pipe-to-fuel tank connecting hose.

   Tighten: Tighten the fuel fill neck-to-fuel tank clamp to 5 N.m (44 lb in).

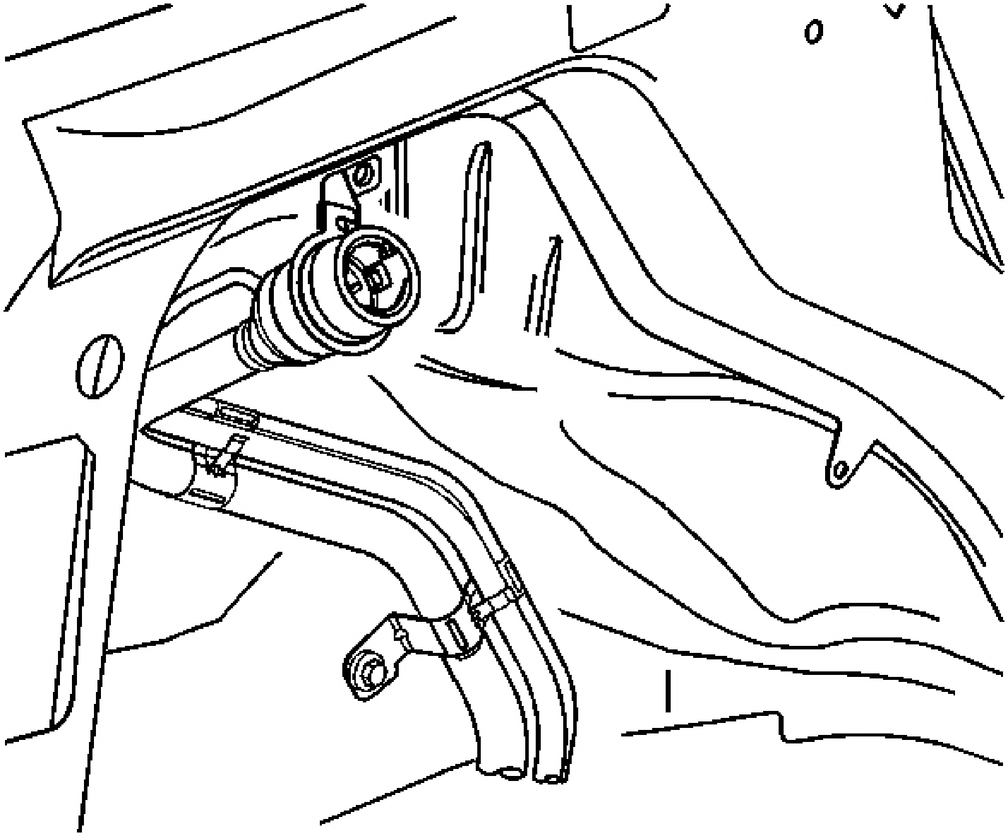


Fig. 107: View Of Fuel Filler Pipe Intermediate Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

10. Connect the fuel fill pipe vent tube and fresh air hose.
11. Tighten the intermediate bracket bolt.

Tighten: Tighten the bolt to 10 N.m (89 lb in).

12. Install the inner wheelhouse liner. Refer to **Wheelhouse Liner Panel Replacement - Rear** in Body Front End.
13. Install the wheel and tire. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
14. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
15. Lower the vehicle from the hoist.
16. Perform the Service Bay Diagnostic Test for the EVAP emission system using the scan tool. This test will verify the integrity of the vapor handling areas of the fuel system.

FUEL TANK MODULE REPLACEMENT - PRIMARY

Tools Required

J 45722 Fuel Tank Lock Ring Remover

Removal Procedure

CAUTION: Whenever fuel line fittings are loosened or removed, wrap a shop cloth around the fitting and have an approved container available to collect any fuel.

NOTE: Clean all fuel pipe and hose connections and surrounding areas before disassembling to avoid possible contamination of the fuel system. Spray the fuel pump module cam-lock ring tang with penetrating oil prior to attempting removal.

1. Remove the fuel tank. Refer to **Fuel Tank Replacement** .
2. Remove the secondary fuel pump module. Refer to **Fuel Tank Module Replacement - Secondary** .

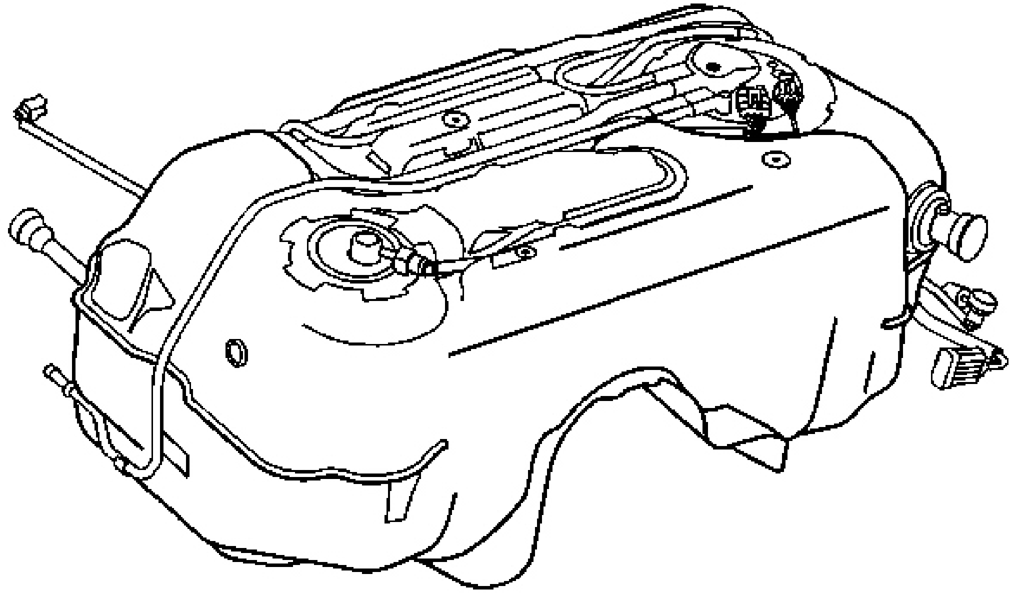


Fig. 108: View Of Fuel Tank Module
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the electrical connectors from the primary fuel pump module and fuel tank pressure sensor.

NOTE: To prevent retainer damage, do not attempt to remove the retainer with a 12 in. or shorter ratchet/breaker bar.

4. Use the **J 45722** and remove the fuel pump module retaining ring.
5. Disconnect the fuel feed and vent lines from the fuel tank.

NOTE: To prevent bending of the sending unit float arm during removal, lift the pump module up slightly to disengage the orientation tabs in the tank and rotate the module 45 degrees.

6. Remove the primary fuel pump module assembly.

IMPORTANT: Always replace the fuel pump module-to-tank seal, O-ring, when the fuel pump module is removed.

7. Discard the fuel pump module-to-tank seal.

8. If the fuel level sending unit is being replaced, remove the fuel level sender. Refer to **Fuel Level Sensor Replacement - Primary** .

Installation Procedure

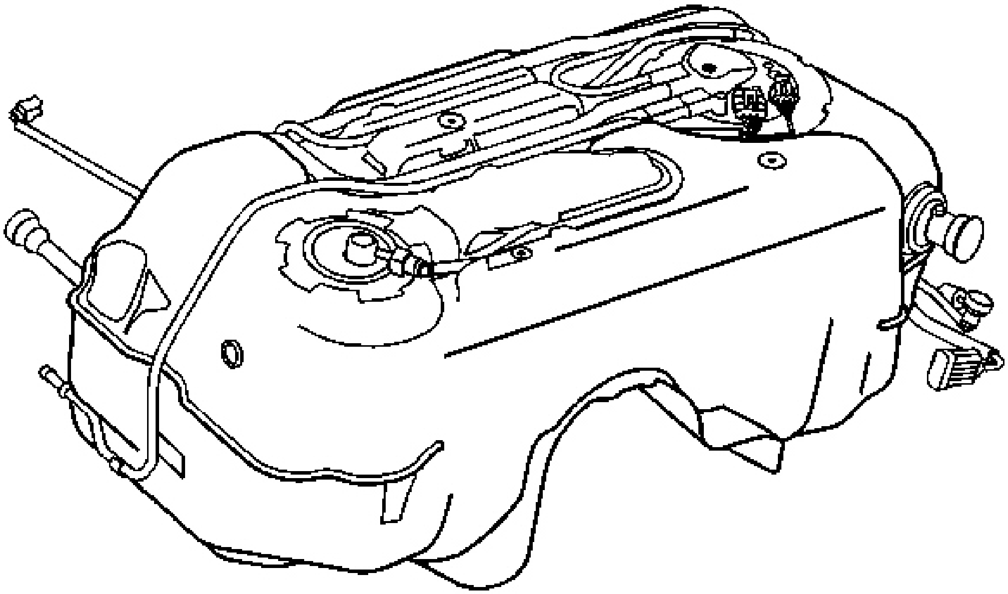


Fig. 109: View Of Fuel Tank Module
Courtesy of GENERAL MOTORS CORP.

1. If the fuel level sending unit is being replaced, install the fuel level sending unit onto the new fuel pump. Refer to **Fuel Level Sensor Replacement - Primary** .
2. Insert the new primary fuel pump module assembly with the level sender and the new fuel pump-to-tank seal. Ensure the orientation tabs are aligned.
3. Use the **J 45722** to install the fuel pump lock ring.
4. Connect the wiring harness to the primary fuel pump module and fuel tank pressure sensor.
5. Install the secondary fuel pump module. Refer to **Fuel Tank Module Replacement - Secondary** .
6. Install the fuel tank. Refer to **Fuel Tank Replacement** .

FUEL TANK MODULE REPLACEMENT - SECONDARY

Tools Required

SA9156E Fuel Tank Lock Ring Remover

Removal Procedure

CAUTION: Whenever fuel line fittings are loosened or removed, wrap a shop cloth around the fitting and have an approved container available to collect any fuel.

NOTE: Clean all fuel pipe and hose connections and surrounding areas before disassembling to avoid possible contamination of the fuel system. Spray the fuel pump module cam-lock ring tang with penetrating oil prior to attempting removal.

1. Remove the fuel tank. Refer to **Fuel Tank Replacement** .
2. Disconnect the EVAP vent line quick connect.

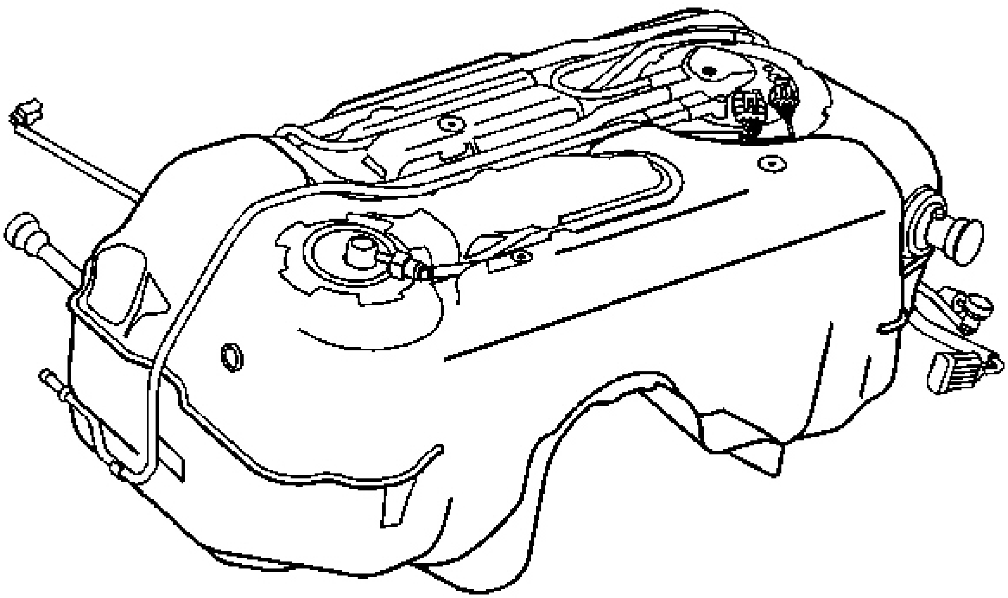


Fig. 110: View Of Fuel Tank Module
Courtesy of GENERAL MOTORS CORP.

NOTE: To prevent retainer damage, do not attempt to remove the retainer with a 12 in. or shorter ratchet/breaker bar.

3. Use the **SA9156E** and remove the fuel pump module retaining ring.

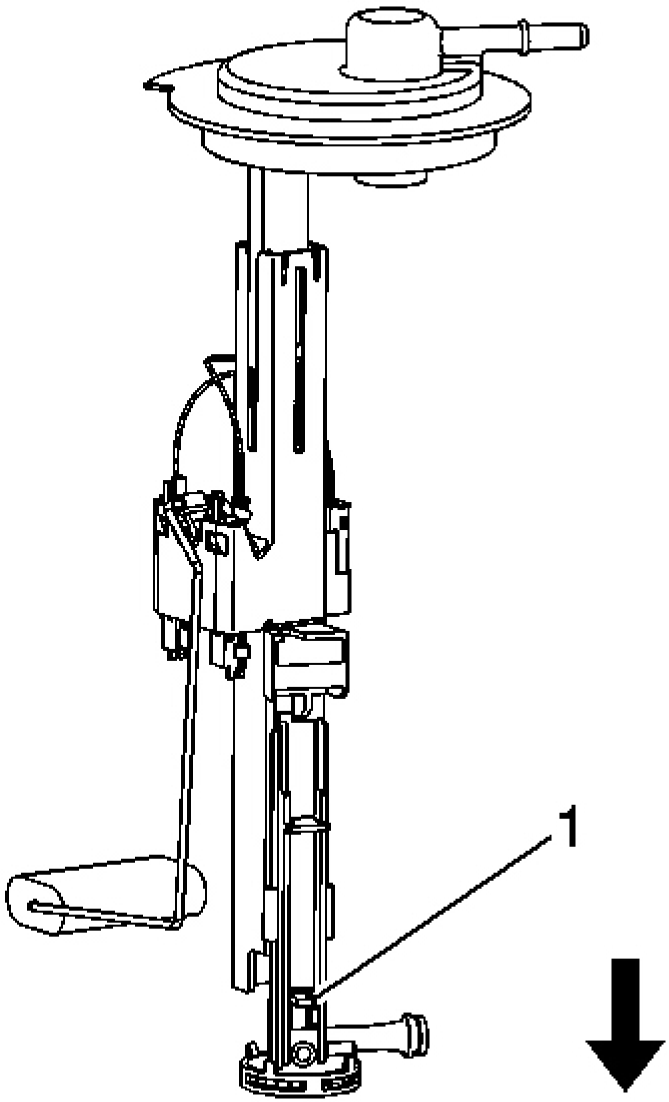


Fig. 111: View Of The Suction Port
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the secondary level sensor electrical connector.
5. Disconnect the suction port attaching tube by pressing down on the tab (1).

NOTE: **To prevent bending of the sending unit float arm during removal, lift the**

pump module up slightly to disengage the orientation tabs in the tank and rotate the module 45 degrees.

6. Remove the secondary fuel pump module.

IMPORTANT: Always replace the fuel pump module-to-tank seal, O-ring, when the fuel pump module is removed.

7. Discard the fuel pump module-to-tank seal.
8. If the fuel level sending unit is not being replaced as well, remove the fuel level sender. Refer to **Fuel Level Sensor Replacement - Secondary** .

Installation Procedure

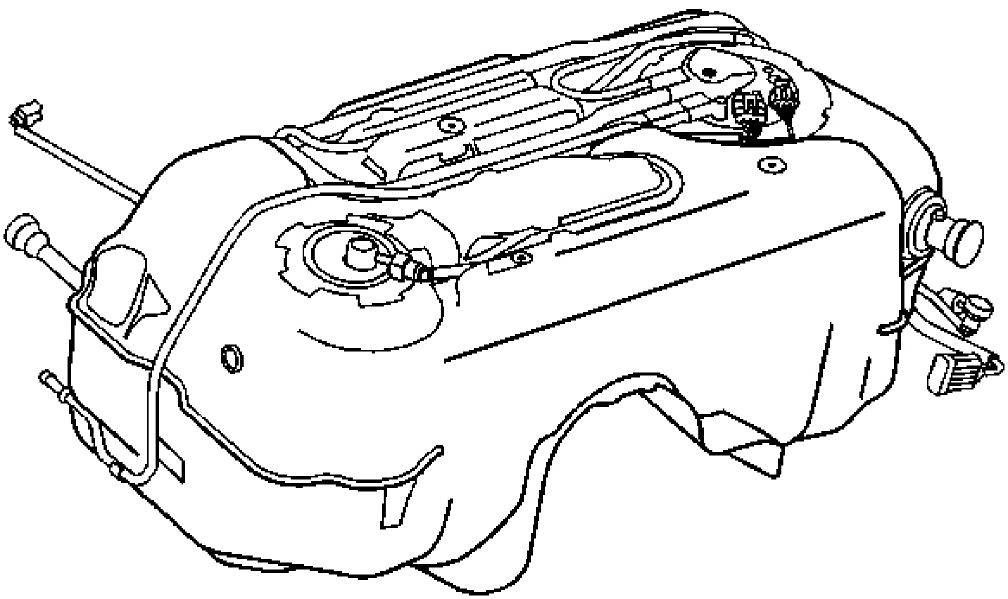


Fig. 112: View Of Fuel Tank Module
Courtesy of GENERAL MOTORS CORP.

1. If the fuel level sending unit is being replaced, install the fuel level sending unit into the new fuel pump. Refer to **Fuel Level Sensor Replacement - Secondary** .

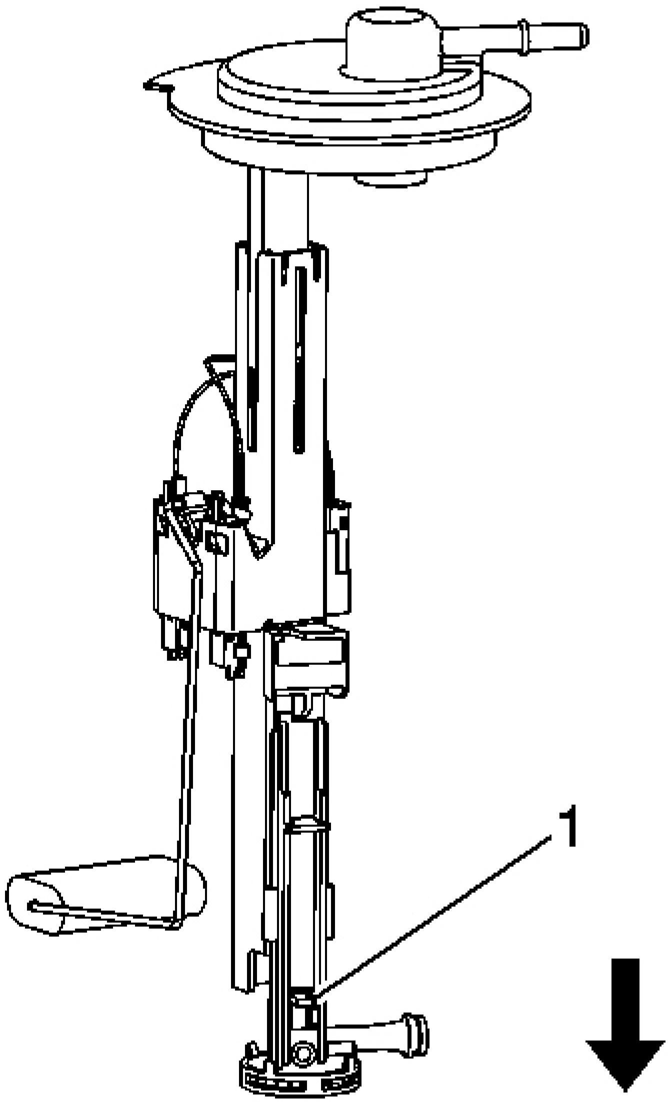


Fig. 113: View Of The Suction Port
Courtesy of GENERAL MOTORS CORP.

2. Connect the suction port.
3. Insert the new secondary fuel pump module with the level sender and new fuel pump-to-tank seal. Ensure the orientation tabs are aligned.
4. Use the **SA9156E** to install the fuel pump lock ring.

5. Connect the EVAP line quick connect.
6. Install the fuel tank. Refer to **Fuel Tank Replacement** .

FUEL LEVEL SENSOR REPLACEMENT - PRIMARY

Removal Procedure

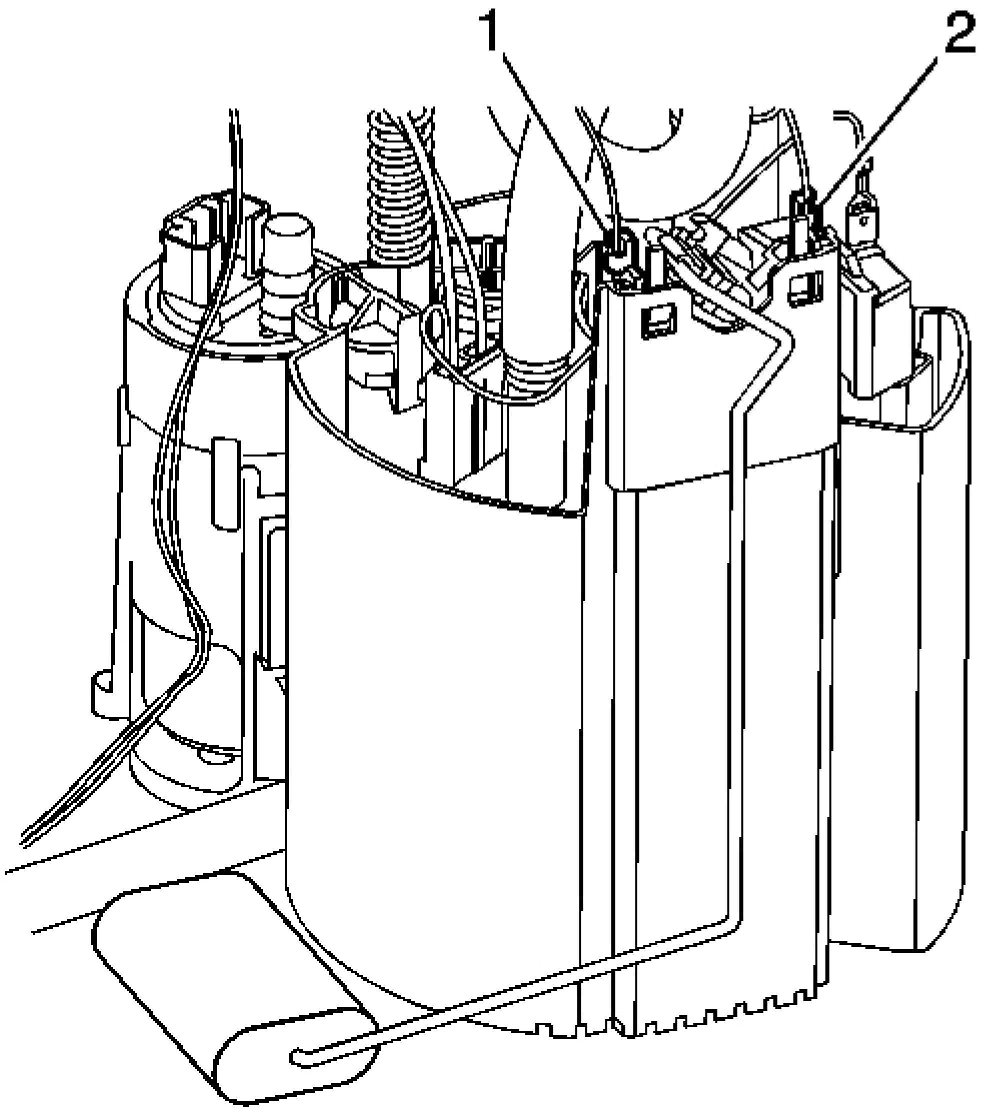


Fig. 114: View Of Fuel Level Sensor
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: There are 2 fuel level sender unit and float assemblies in the fuel tank. There is 1 located on each fuel pump module. The fuel level sender unit and float is NOT the same for each of the fuel pump modules.

1. Remove the fuel tank. Refer to **Fuel Tank Replacement** .
2. Remove the fuel pump module. Refer to**Fuel Tank Module Replacement - Primary** .
3. Disconnect the fuel level sender unit and float electrical connector from the underside of the top of the pump module.
4. Release the retaining tabs (1, 2) and remove the level sensor by sliding up.

Installation Procedure

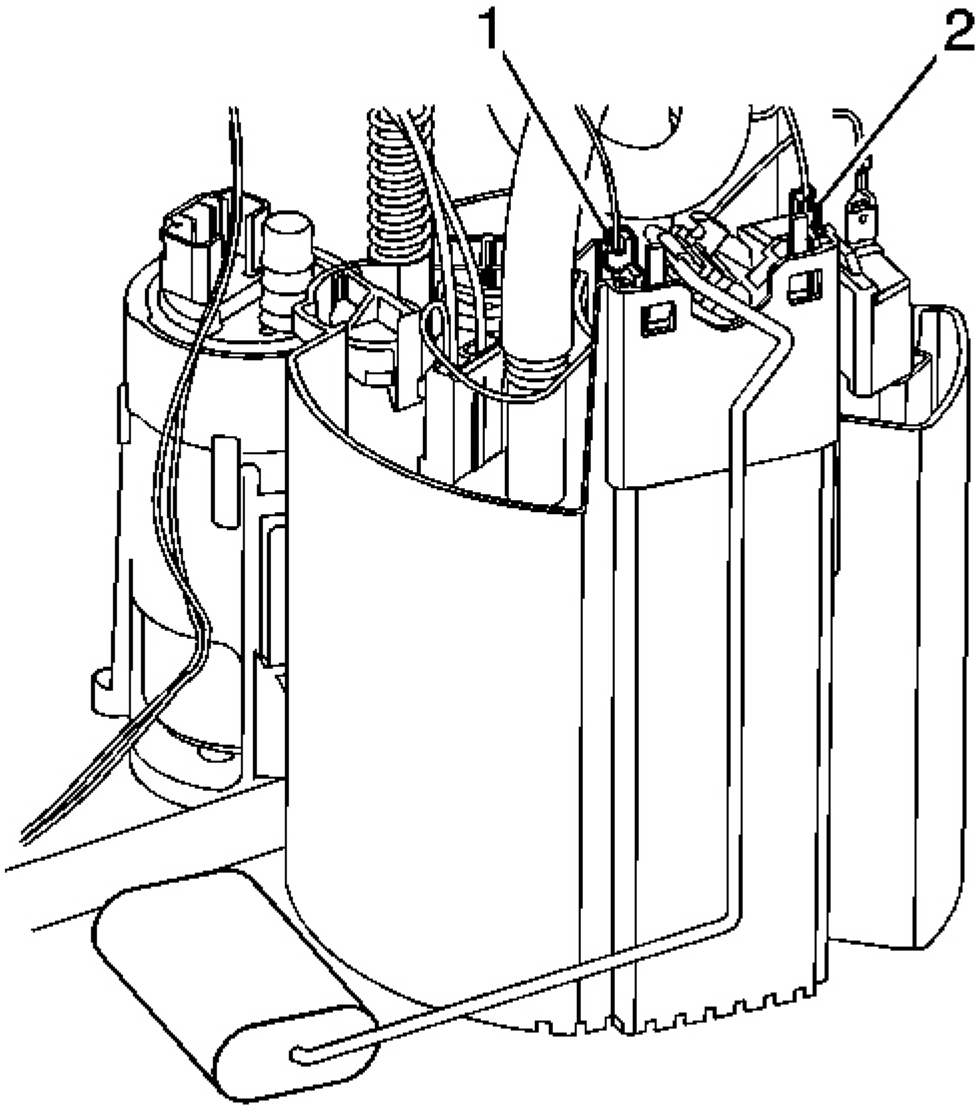


Fig. 115: Ensuring Sender Caps Snaps Onto Place
Courtesy of GENERAL MOTORS CORP.

1. Install the fuel level sender unit and float onto the fuel pump module. Make sure that the sender cap snaps into place (1, 2).
2. Connect the fuel level sender unit and float electrical connector.
3. Install the fuel pump module into the fuel tank. Refer to **Fuel Tank Module Replacement - Primary** .

4. Install the fuel tank. Refer to **Fuel Tank Replacement** .

FUEL LEVEL SENSOR REPLACEMENT - SECONDARY

Removal Procedure

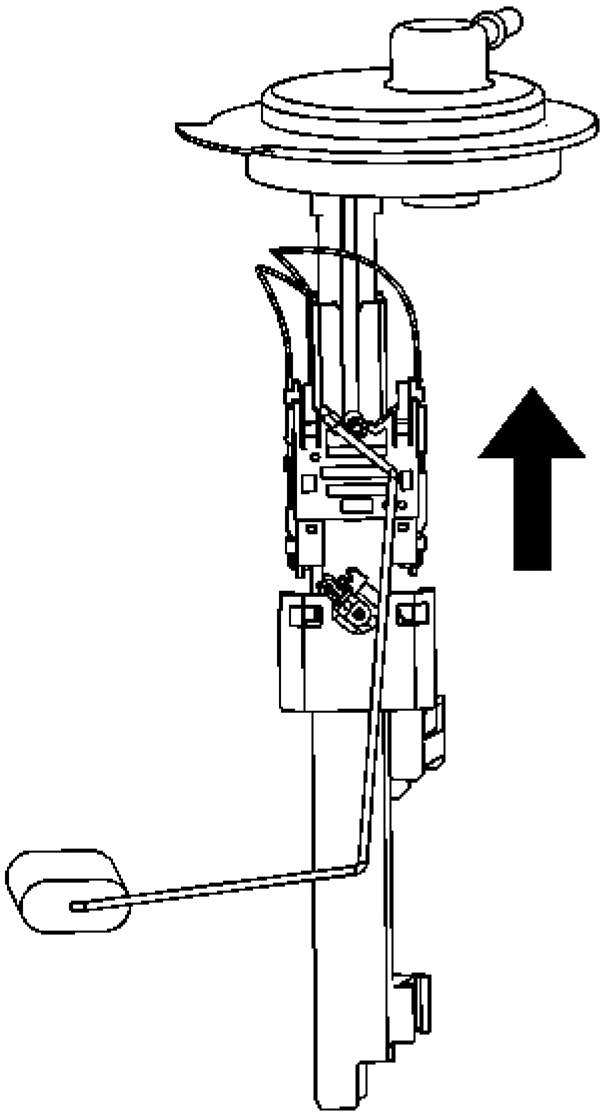


Fig. 116: View Of Fuel Level Sensor (Secondary)

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: There are 2 fuel level sender unit and float assemblies in the fuel tank. There is 1 located on each fuel pump module. The fuel level sender unit and float is NOT the same for each of the fuel pump modules.

1. Remove the fuel tank. Refer to **Fuel Tank Replacement** .
2. Remove the fuel pump module. Refer to**Fuel Tank Module Replacement - Secondary** .
3. Disconnect the fuel level sender unit and the float electrical connector.
4. Release the retaining tabs and remove the level sensor by sliding up.

Installation Procedure

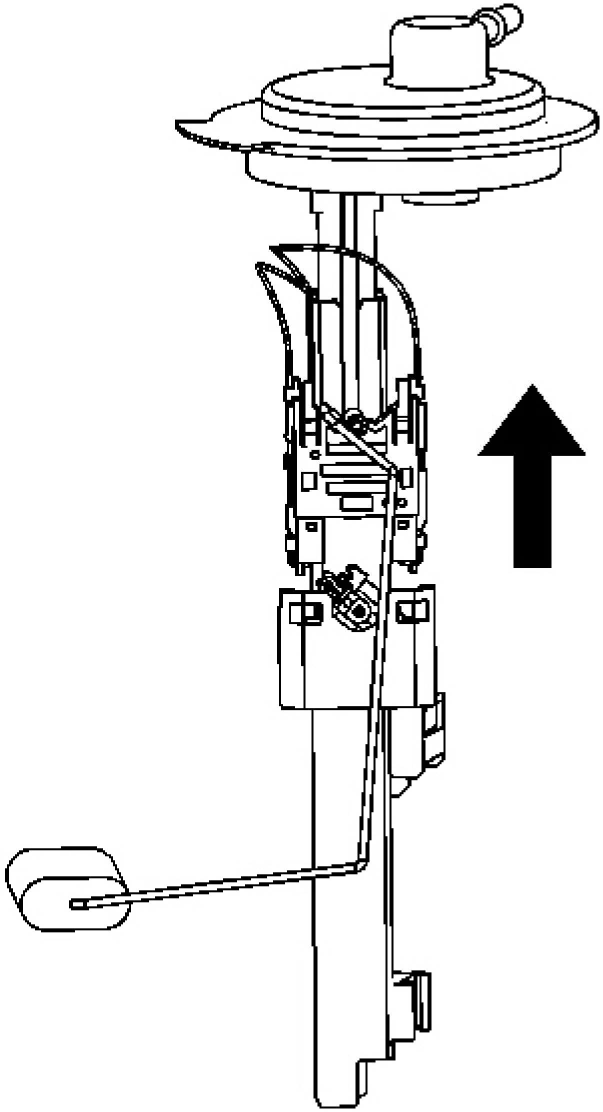


Fig. 117: View Of Fuel Level Sender Unit & Float Onto The fuel Pump Module
Courtesy of GENERAL MOTORS CORP.

1. Install the fuel level sender unit and float onto the fuel pump module. Make sure that the sender cap snaps into place.
2. Connect the fuel level sender unit and the float electrical connector.
3. Install the fuel pump module into the fuel tank. Refer to **Fuel Tank Module Replacement - Secondary** .

4. Install the fuel tank. Refer to **Fuel Tank Replacement** .

FUEL HOSE/PIPES REPLACEMENT - CHASSIS

Removal Procedure

CAUTION: Ensure that the vehicle is properly supported and squarely positioned. To help avoid personal injury when a vehicle is on a hoist, provide additional support for the vehicle on the opposite end from which the components are being removed.

CAUTION: Do not allow smoking or the use of open flames in the area where work on the fuel or EVAP system is taking place. Anytime work is being done on the fuel system, disconnect the negative battery cable, except for those tests where battery voltage is required.

CAUTION: Whenever fuel lines are removed, catch fuel in an approved container. Container opening must be a minimum of 300 mm (12 in) diameter to adequately catch the fluid.

NOTE: Fuel/Vapor lines cannot be spliced or repaired. The line must be replaced (if damaged) with the same type of line.

1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** .
2. Disconnect the negative battery terminal. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.

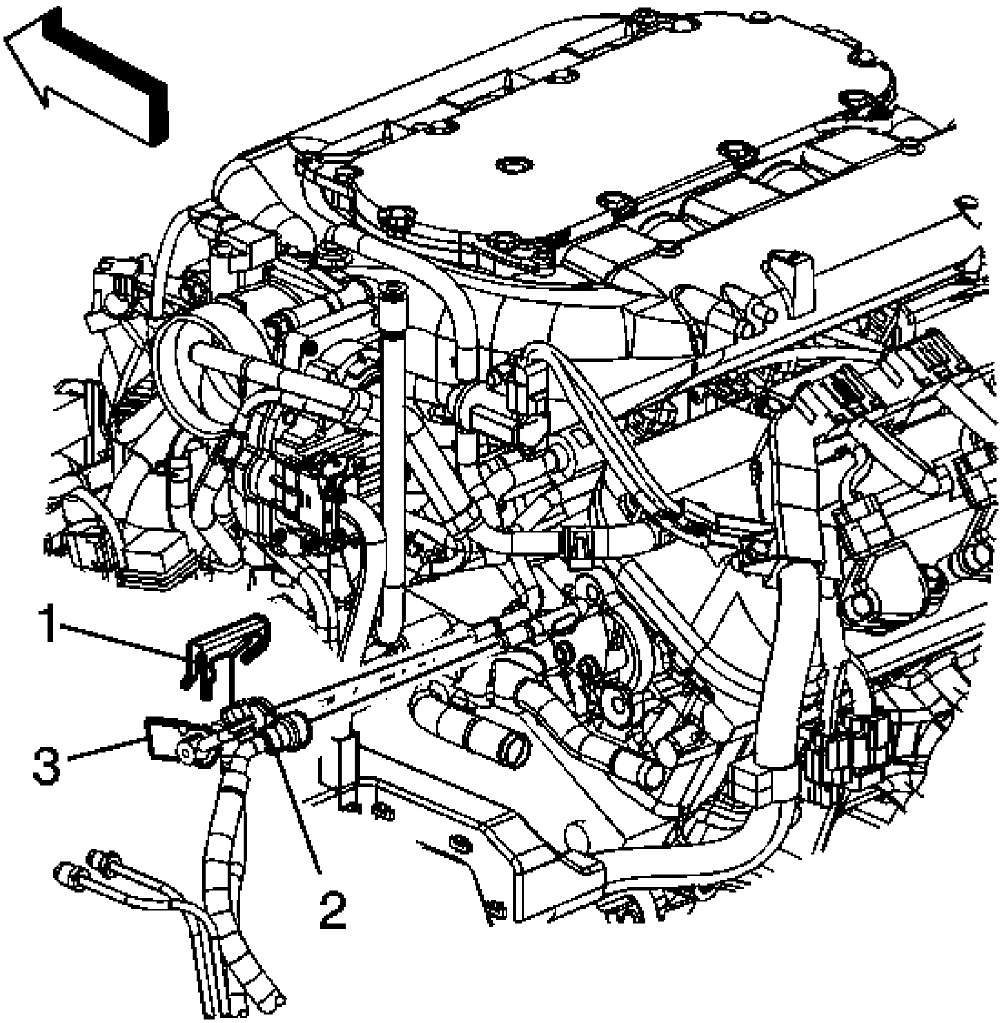


Fig. 118: View Of Fuel Hose/Pipes
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: To facilitate removal, it may be necessary to spray quick connect fittings with penetrating oil to remove debris.

3. From underhood, remove the fuel line clip and using the Snap-On(tm) tool YA 9457 or equivalent, disconnect the fuel feed line from the fuel rail.
4. Disconnect the evaporative emission (EVAP) purge line from the EVAP purge solenoid.
5. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.

6. Disconnect the chassis fuel feed line from the fuel tank.
7. Disconnect the EVAP purge line from the EVAP canister.
8. Release the fuel and EVAP purge lines from underbody retainers.

Installation Procedure

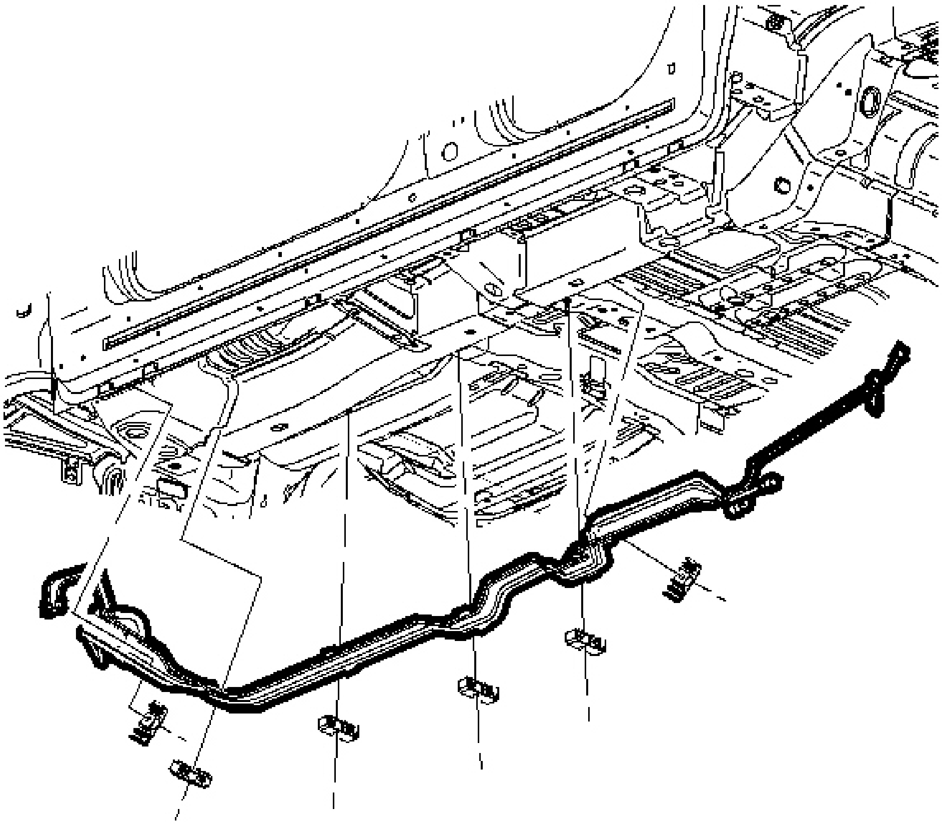


Fig. 119: View Of Fuel & EVAP Lines Into Underbody Retainers
Courtesy of GENERAL MOTORS CORP.

NOTE:	Fuel/Vapor lines cannot be spliced or repaired. The line must be replaced (if damaged) with the same type of line.

1. Make sure the lines are not kinked, bent, or damaged.
2. Install the fuel and EVAP lines into underbody retainers. Make sure the lines are properly routed and attach retainers to the vehicle.
3. Connect the EVAP purge line onto the EVAP canister.
4. Lower the vehicle from the hoist.

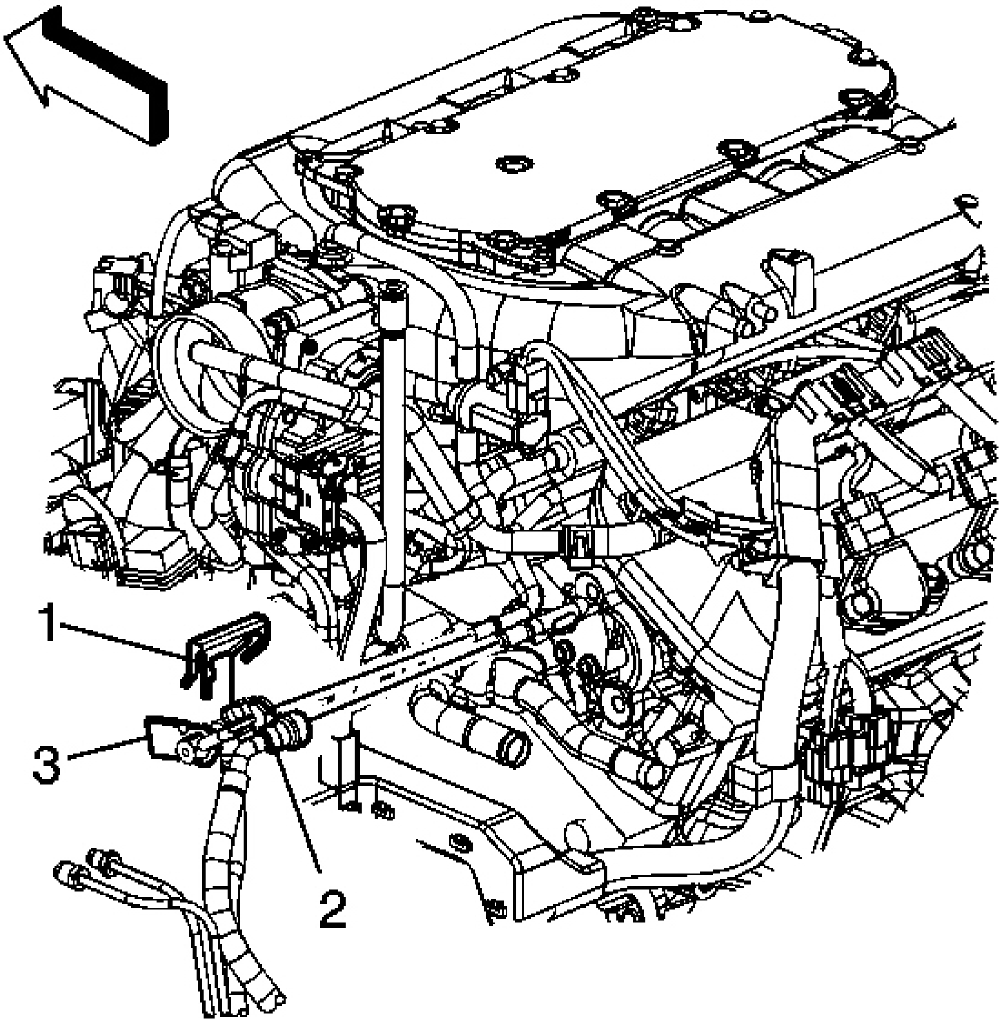


Fig. 120: View Of Fuel Feed Line To Fuel Rail & Install The Safety Clip
Courtesy of GENERAL MOTORS CORP.

5. Connect the fuel feed line to fuel rail and install the safety clip.

6. Connect the negative battery terminal. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
7. Prime the fuel system.
    1. Cycle the ignition ON for 5 seconds and then OFF for 10 seconds.
    2. Repeat step 7.1 twice.
    3. Crank the engine until it starts. The maximum starter motor cranking time is 20 seconds.
    4. If the engine does not start, repeat steps 7.1-7.4.
8. Run the engine and check the system for leaks.

FUEL SYSTEM CLEANING

IMPORTANT: If the fuel filter is plugged, the fuel tank should be inspected internally and cleaned if necessary.

1. Remove the fuel tank. Refer to **Fuel Tank Replacement** .
2. Remove the fuel pump module assemblies. Refer to **Fuel Tank Module Replacement - Primary** and**Fuel Tank Module Replacement - Secondary** .
3. Inspect the fuel pump module strainer. Replace the pump module assembly if the fuel strainer is contaminated.

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

4. Flush the fuel tank with hot water.
5. Pour the water out of the fuel sender assembly opening in the fuel tank. Rock the fuel tank in order to be sure that the removal of the water from the fuel tank is complete.
6. Allow the tank to dry completely before reassembly.
7. Disconnect the fuel feed pipe at the engine fuel rail. Refer to **Quick Connect Fitting(s) Service (Metal Collar)** .

    IMPORTANT: Only use oil-free compressed air to blow out the fuel pipes.

8. Clean the fuel pipes by applying air pressure in the opposite direction of the fuel flow.
9. Connect the fuel feed pipe to the engine fuel rail. Refer to **Quick Connect Fitting(s) Service (Metal Collar)** .
10. Install the fuel pump module assemblies. Refer to **Fuel Tank Module Replacement - Primary** and**Fuel Tank Module Replacement - Secondary** .
11. Install the fuel tank. Refer to **Fuel Tank Replacement** .

FUEL RAIL ASSEMBLY REPLACEMENT

Removal Procedure

1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** .
2. Remove the intake manifold. Refer to **Intake Manifold Replacement** in Engine Mechanical.
3. Disconnect the fuel injector electrical connectors.

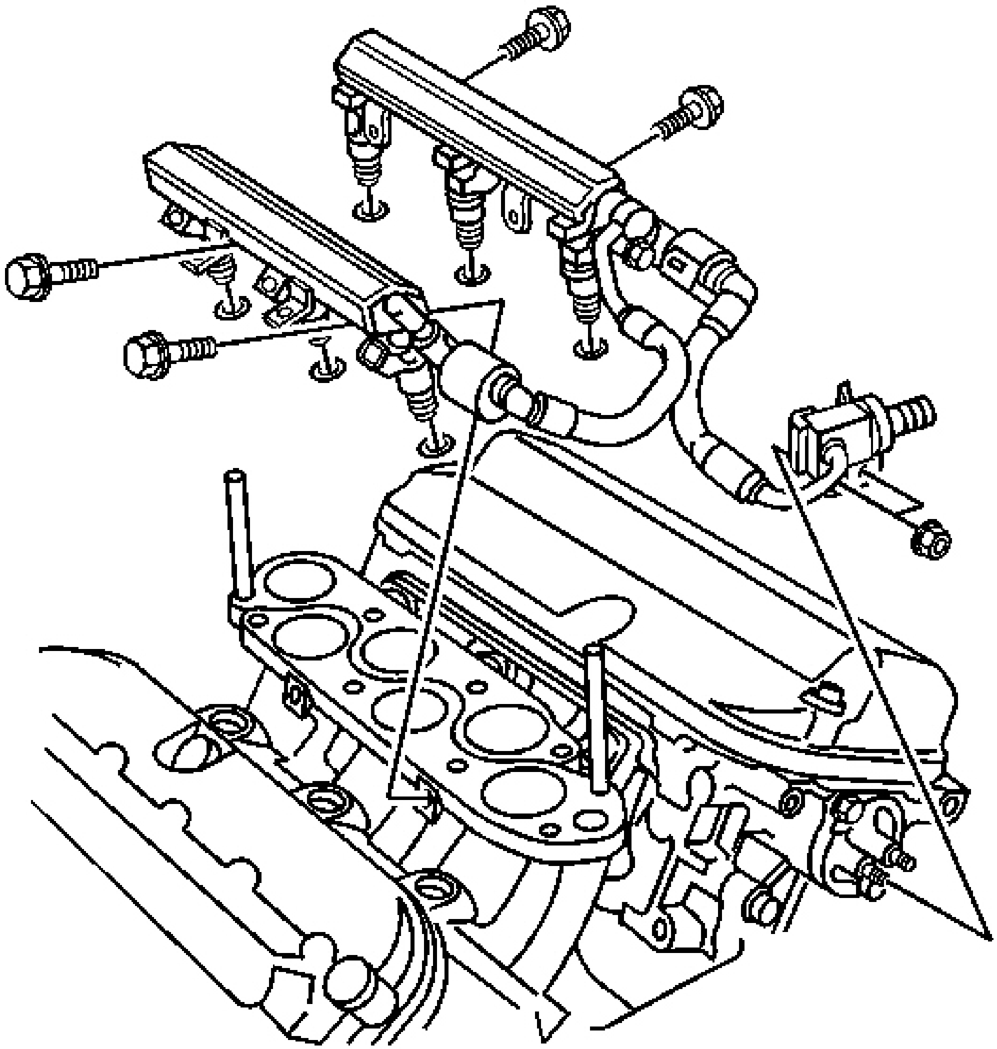


Fig. 121: Exploded View Of Fuel Rail Assembly
Courtesy of GENERAL MOTORS CORP.

4. Remove the bolts.

5. Remove the fuel rail and injectors from the manifold as an assembly.

Installation Procedure

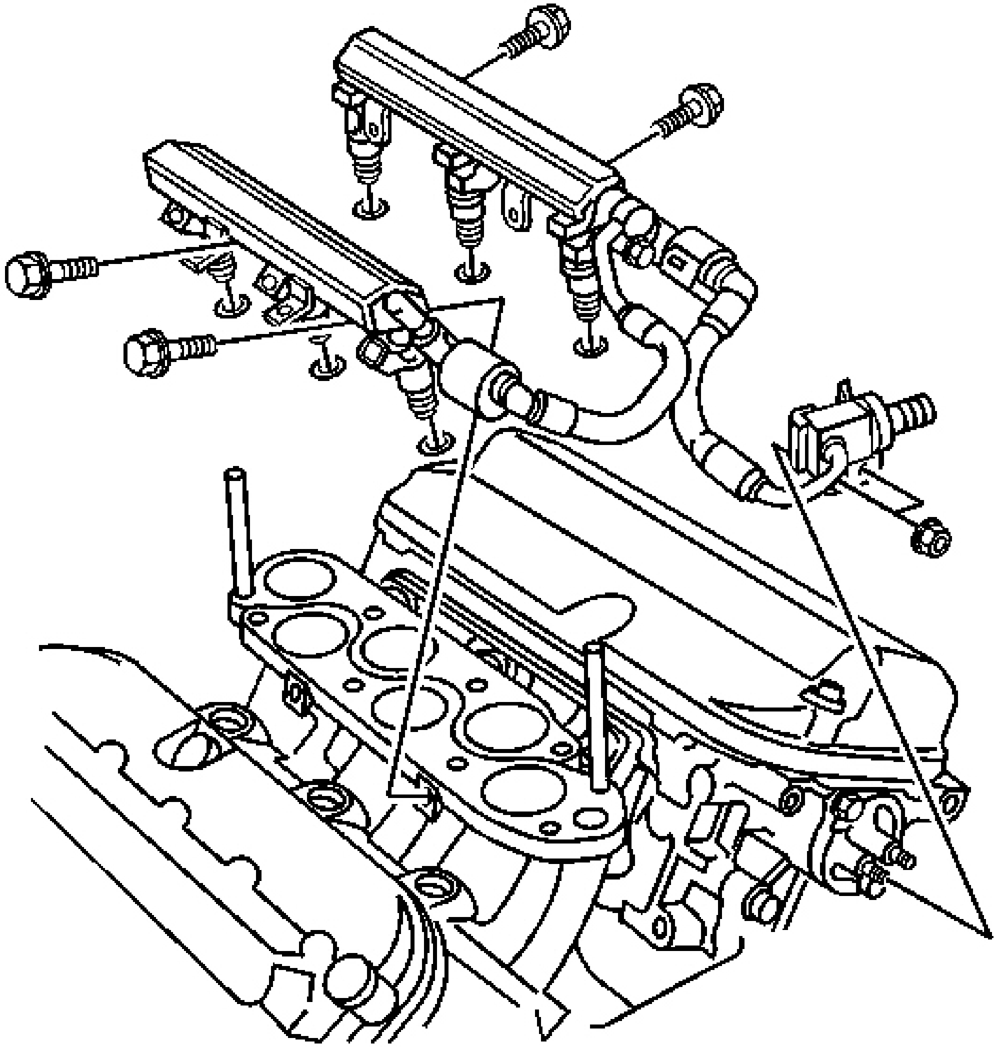


Fig. 122: View Of Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install new O-rings to the injectors.
2. Install the fuel rail and injectors as an assembly to the manifold.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the bolts.

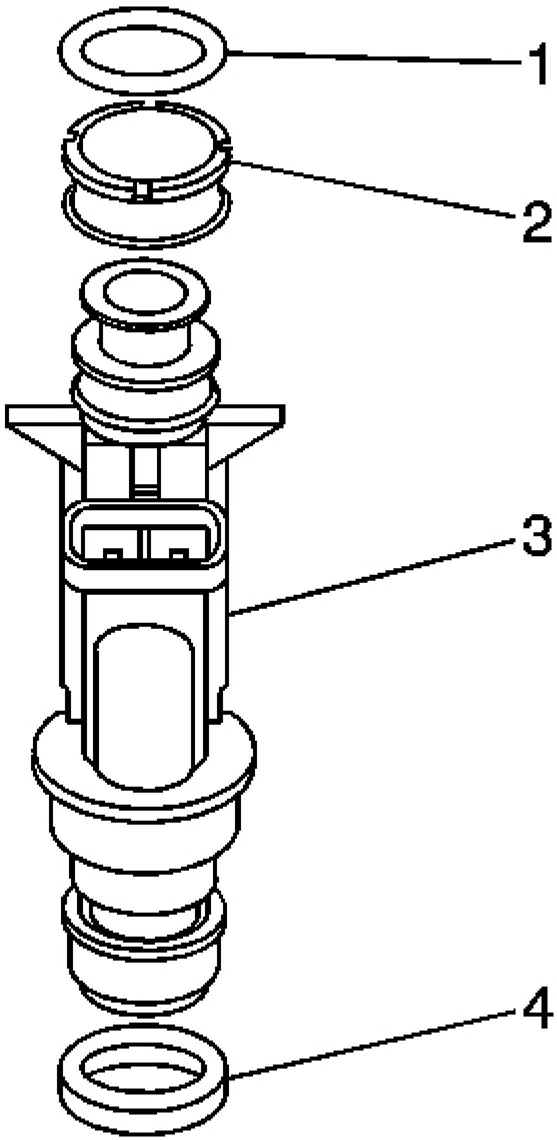
   Tighten: Tighten the bolts to 9.8 N.m (87 lb in).

4. Connect the fuel injector electrical connectors.
5. Install the intake manifold. Refer to **Intake Manifold Replacement** in Engine Mechanical.
6. Inspect for fuel leaks using the following procedure:
   1. With the engine OFF, turn ON the ignition for 2 seconds.
   2. Inspect for fuel leaks.
   3. Turn the ignition OFF for at least 10 seconds.
   4. With the engine OFF, turn ON the ignition for 2 seconds.
   5. Inspect for fuel leaks.
   6. Turn the ignition OFF.

FUEL INJECTOR REPLACEMENT

Removal Procedure

1. Remove the fuel rail. Refer to **Fuel Rail Assembly Replacement** .



<u>Fig. 123: Exploded View of Fuel Injector</u>
Courtesy of GENERAL MOTORS CORP.

2. Remove the fuel injectors from the fuel rail.

IMPORTANT: Visually inspect the fuel injector in order to determine if the upper O-ring was also removed. If the upper O-ring (1) is not removed, remove the O-

ring from the fuel rail assembly.

3. Remove and discard the fuel injector O-rings.

Installation Procedure

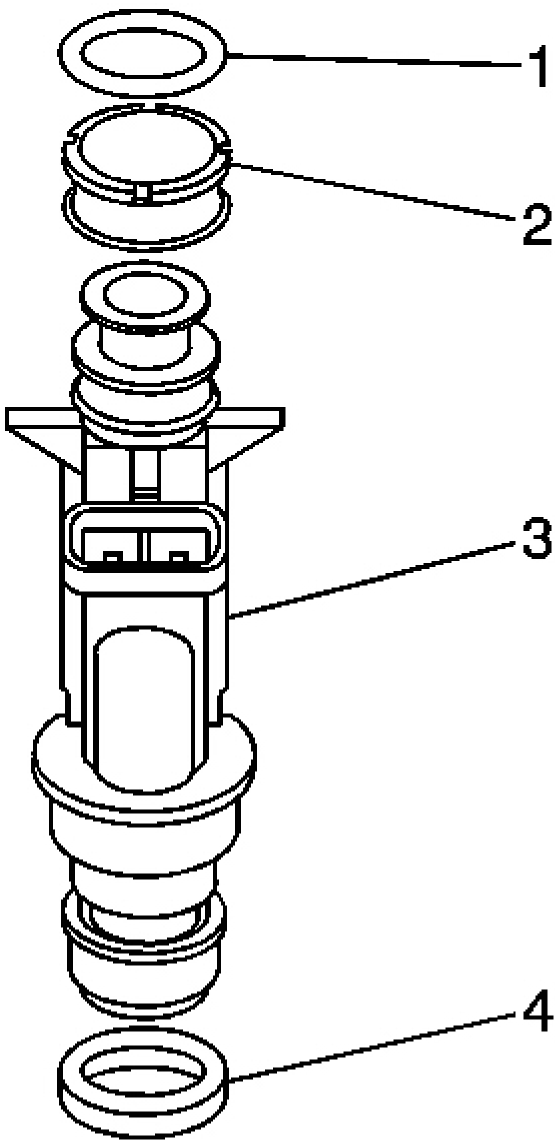


Fig. 124: Exploded View of Fuel Injector

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Always install new injector O-rings when servicing the fuel injectors. Lubricate the new injector O-rings with clean engine oil

1. Install the O-rings on the fuel injector (1).
2. Install the fuel injector in the fuel rail with the connector facing upward.
3. Install the fuel rail. Refer to **Fuel Rail Assembly Replacement** .

EVAPORATIVE EMISSION (EVAP) CANISTER PURGE SOLENOID VALVE REPLACEMENT

Removal Procedure

1. Disconnect the evaporative emission (EVAP) canister purge valve harness connector (1).
2. Disconnect the vacuum pipe (2) from the EVAP canister purge valve.
3. Disconnect the purge pipe (3) from the EVAP canister purge valve.

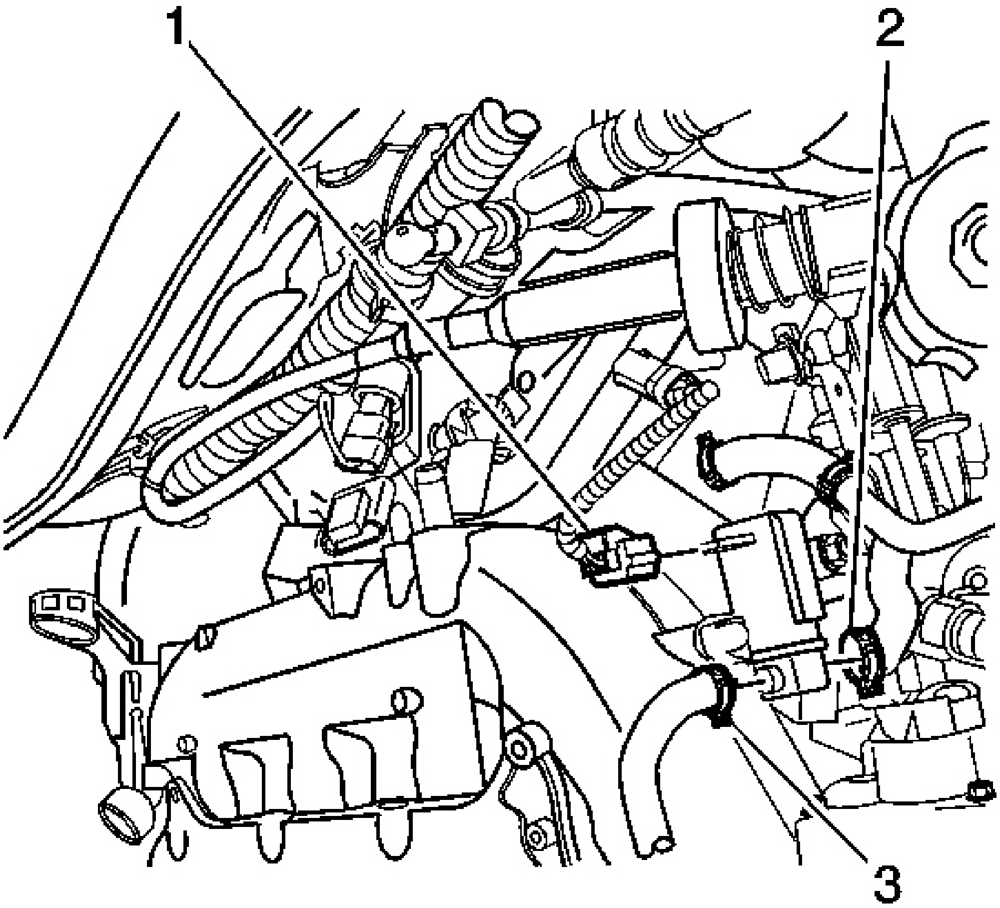


Fig. 125: View Of Evaporative Emission (EVAP) Canister Purge Valve
Courtesy of GENERAL MOTORS CORP.

4. Remove the EVAP canister purge valve and bracket.
5. Remove the EVAP canister purge valve from the purge bracket.
6. Inspect for carbon release in the EVAP canister purge valve ports. Refer to **Evaporative Emission (EVAP) System Cleaning** .

Installation Procedure

1. Install the EVAP canister purge valve on to the purge bracket.

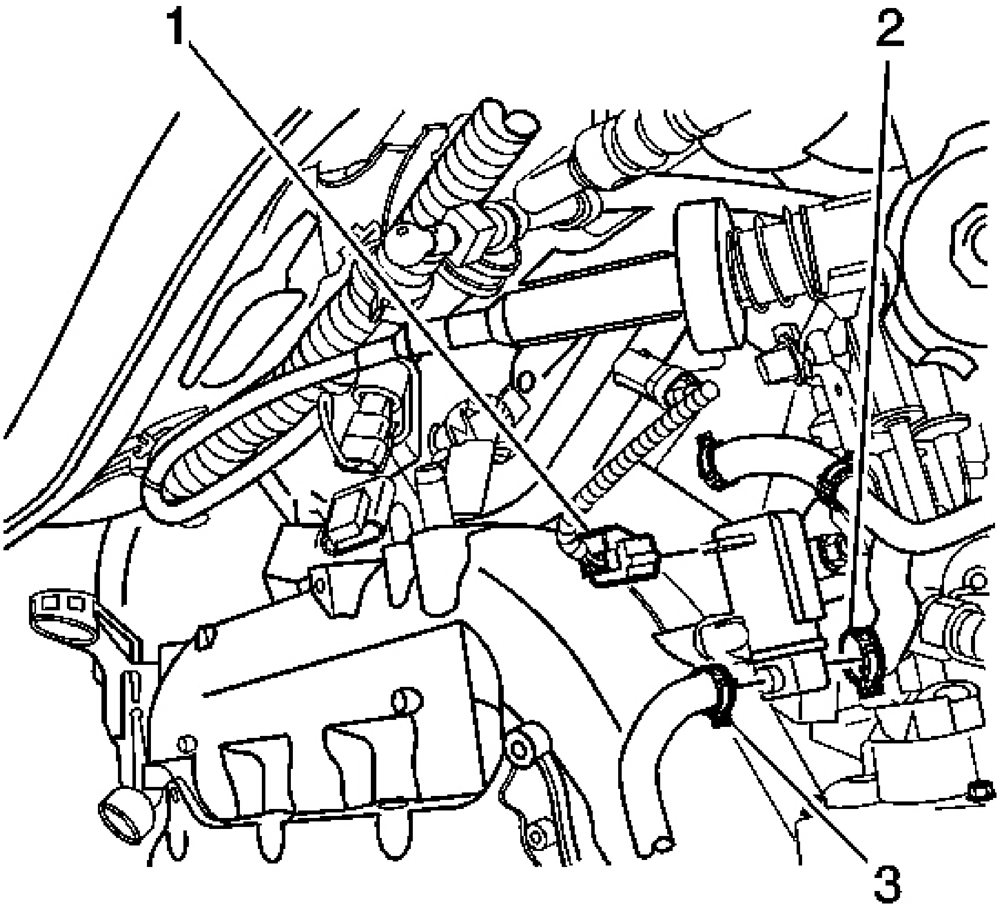


Fig. 126: View Of Evaporative Emission (EVAP) Canister Purge Valve
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

2. Install the EVAP canister purge valve and bracket.

   Tighten: Tighten the purge bracket nut to 8 N.m (71 lb in).

3. Connect the purge pipe (2) to the EVAP canister purge valve.
4. Connect the vacuum pipe (3) to the EVAP canister purge valve.
5. Connect the EVAP canister purge valve harness connector (1).

EVAPORATIVE EMISSION (EVAP) CANISTER VENT SOLENOID VALVE REPLACEMENT

Removal Procedure

> **CAUTION: 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.**

> **IMPORTANT: The EVAP vent solenoid is located on the top of the EVAP canister.**

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.

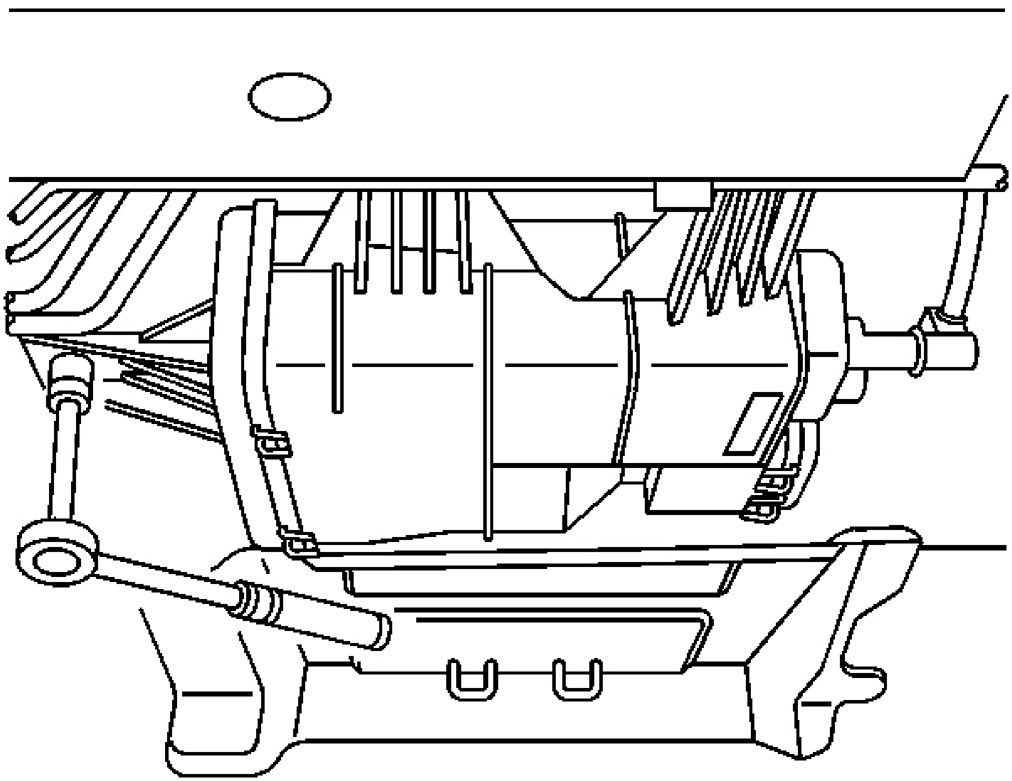


Fig. 127: View Of Evaporative Emission (EVAP) Canister Vent Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

2. Remove the EVAP canister bolts.

3. Disconnect the electrical connector from the evaporative emission EVAP canister vent solenoid valve.
4. Disconnect the EVAP canister lines.
5. Remove the EVAP canister from the vehicle.

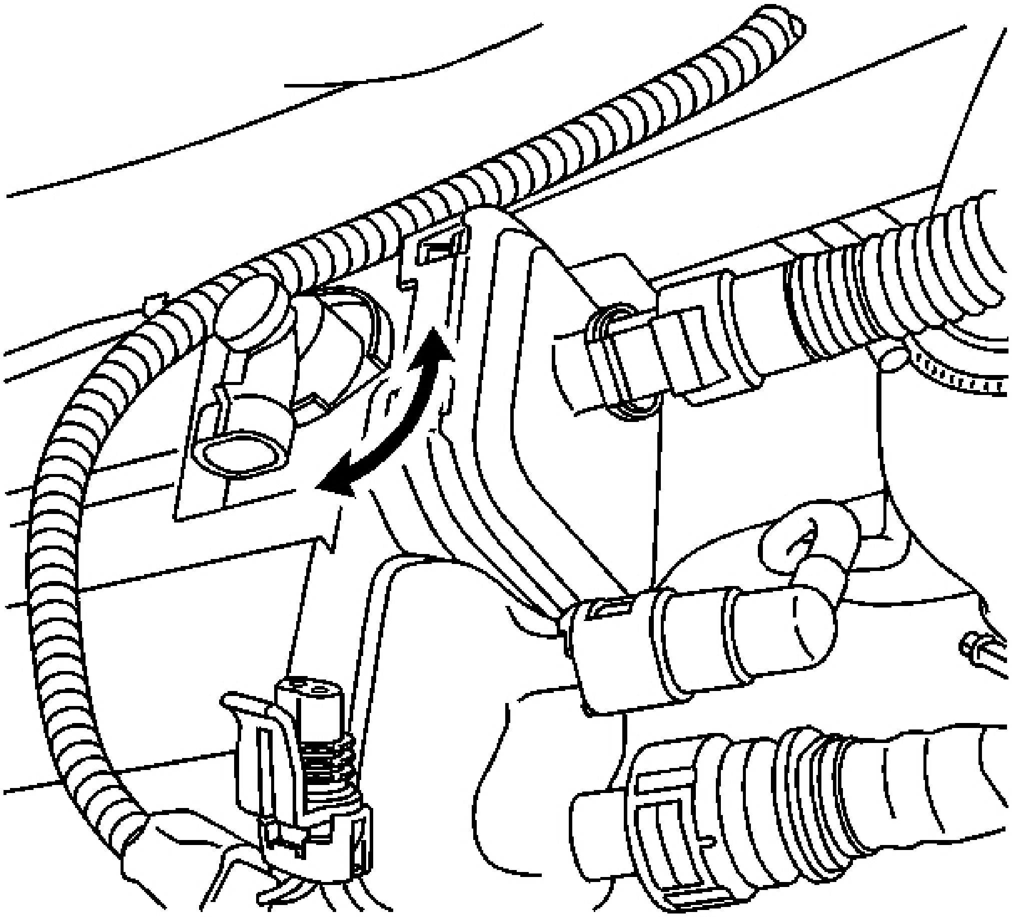


Fig. 128: Releasing Locking Position Of (EVAP) Canister Vent Valve
Courtesy of GENERAL MOTORS CORP.

6. Rotate the EVAP canister vent valve counterclockwise to release from the locked position.

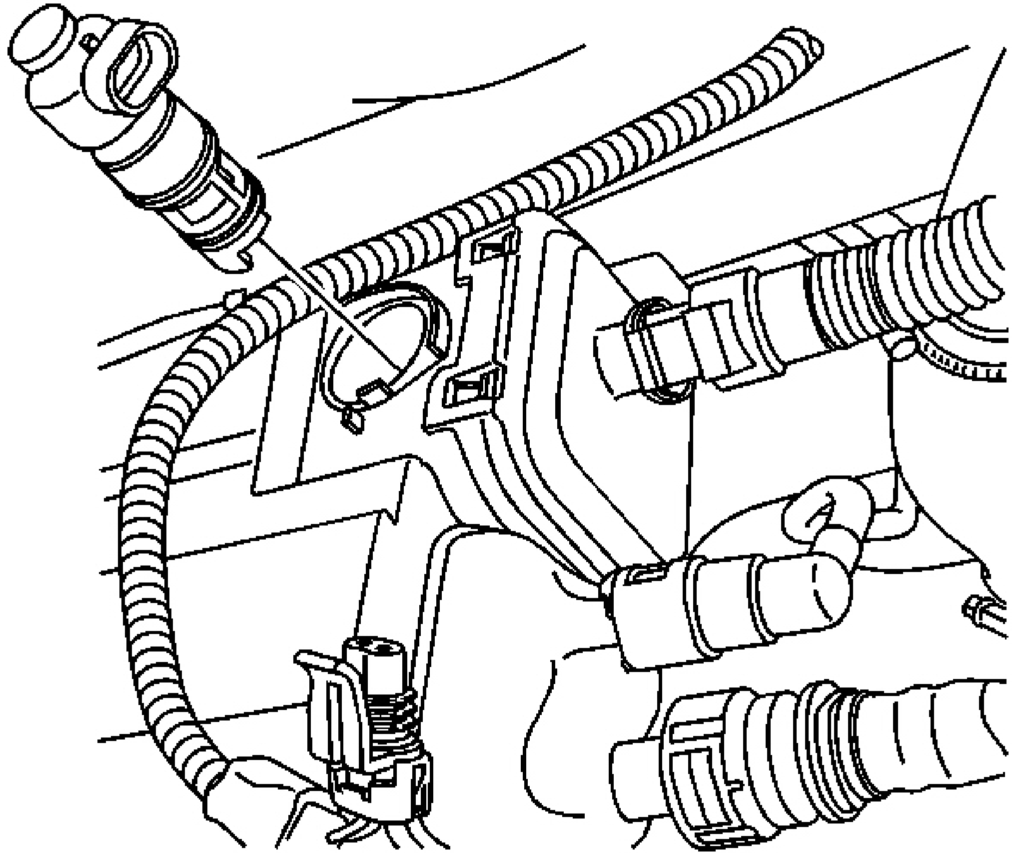


Fig. 129: View Of Vent Valve From The EVAP Canister
Courtesy of GENERAL MOTORS CORP.

7. Remove the vent valve from the EVAP canister.

Installation Procedure

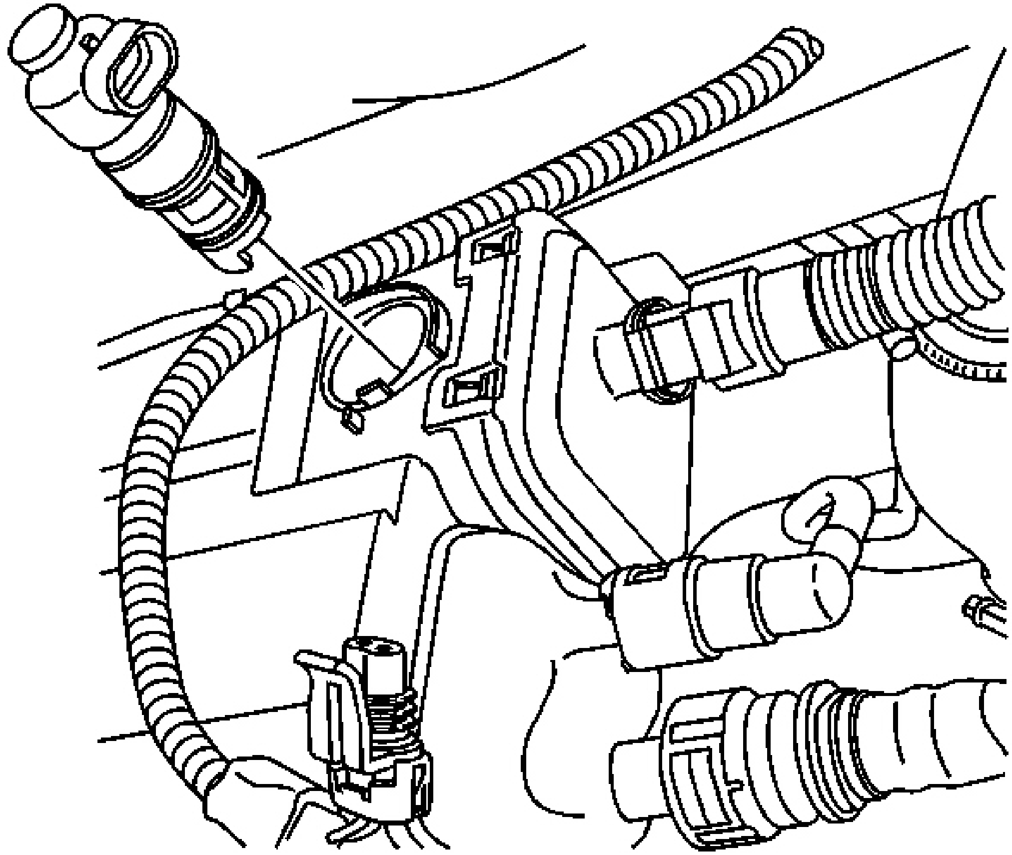


Fig. 130: View Of Vent Valve From The EVAP Canister
Courtesy of GENERAL MOTORS CORP.

1. Insert the EVAP canister vent solenoid valve into the EVAP canister, with the valve aligned to the released position.

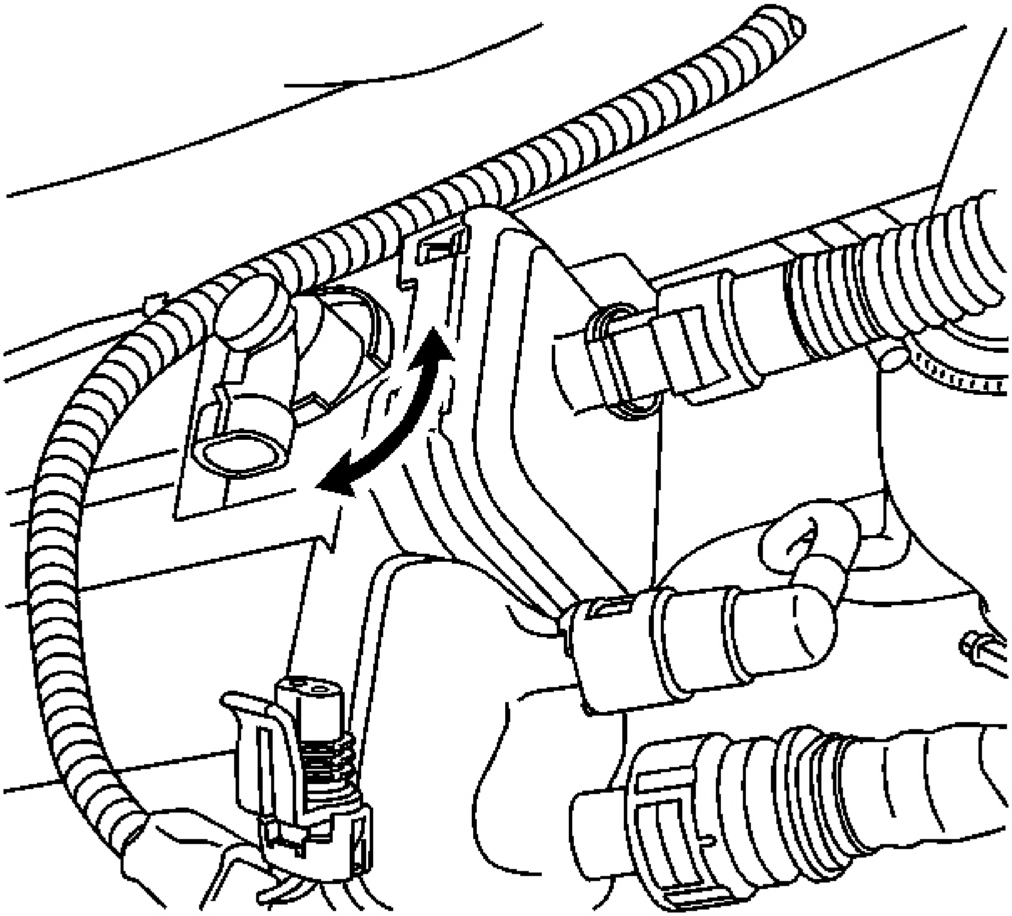


Fig. 131: Releasing Locking Position Of (EVAP) Canister Vent Valve
Courtesy of GENERAL MOTORS CORP.

2. Rotate vent valve clockwise to secure into the locked position.

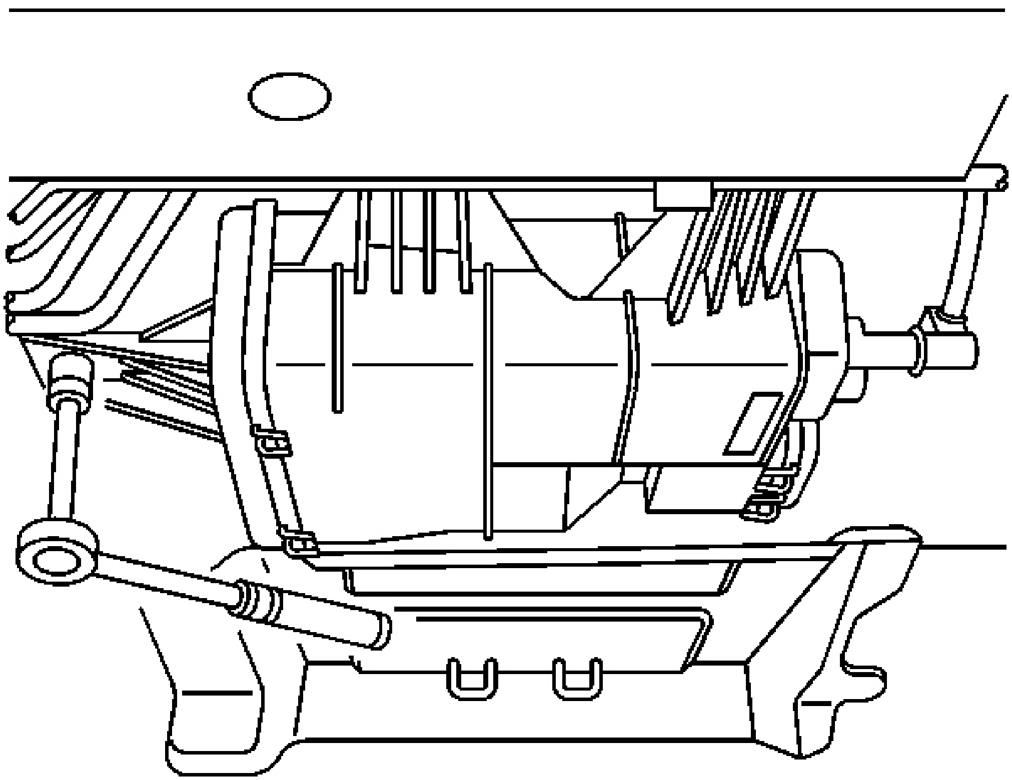


Fig. 132: View Of Evaporative Emission (EVAP) Canister Vent Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

3. Connect the electrical connector to the EVAP canister vent valve.
4. Connect the EVAP lines.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the EVAP canister and bolts.

   Tighten: Tighten the bolts to 8 N.m (71 lb in).

6. Lower the vehicle.

EVAPORATIVE EMISSION (EVAP) HOSES/PIPES REPLACEMENT - CHASSIS/CANISTER

Removal Procedure

1. Disconnect the EVAP purge pipe from the engine purge hose. Refer to **Quick Connect Fitting(s) Service (Plastic Collar) (Plastic Collar)** or **Quick Connect Fitting(s) Service (Plastic Collar) (Plastic Collar Press Release)** or **Quick Connect Fitting(s) Service (Plastic Collar) (Plastic Collar Lever Release)** .
2. Cap or plug the purge pipe and the engine purge hose to prevent contamination.

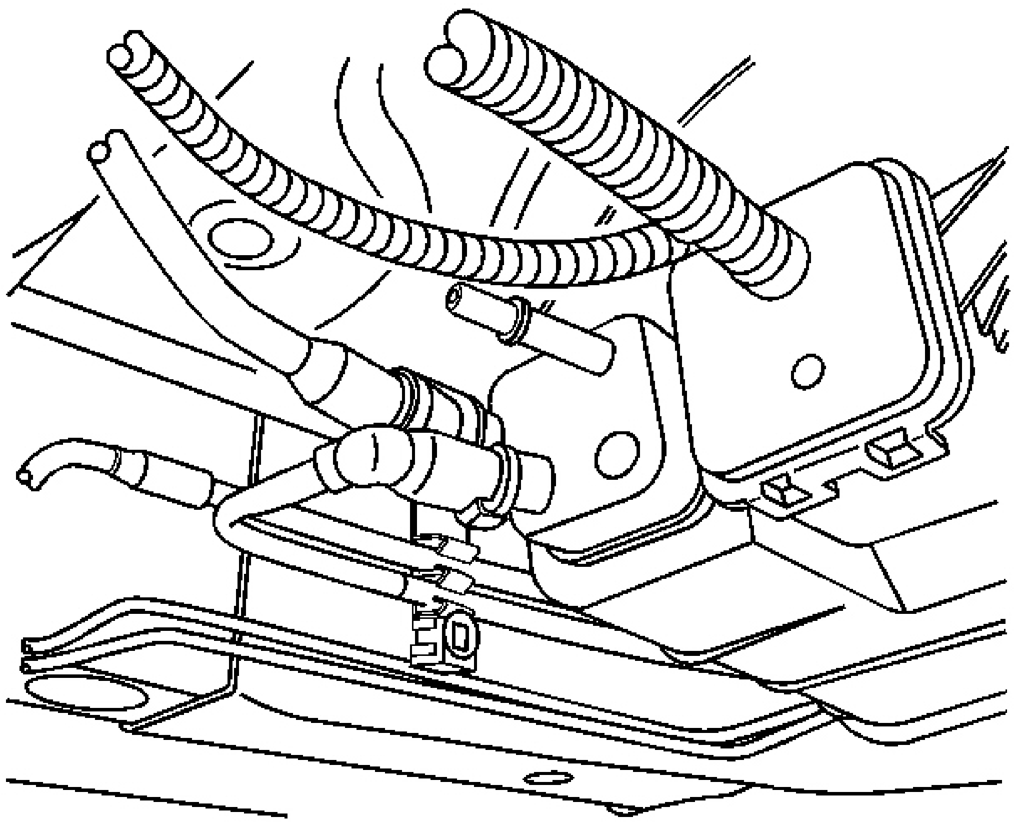


Fig. 133: View Of Evaporative Emission (EVAP) Hoses/Pipes
Courtesy of GENERAL MOTORS CORP.

3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
4. Disconnect the EVAP pipe from the EVAP canister.
5. Remove the rear brake pipe bracket retaining nuts and release the brackets from the body studs.

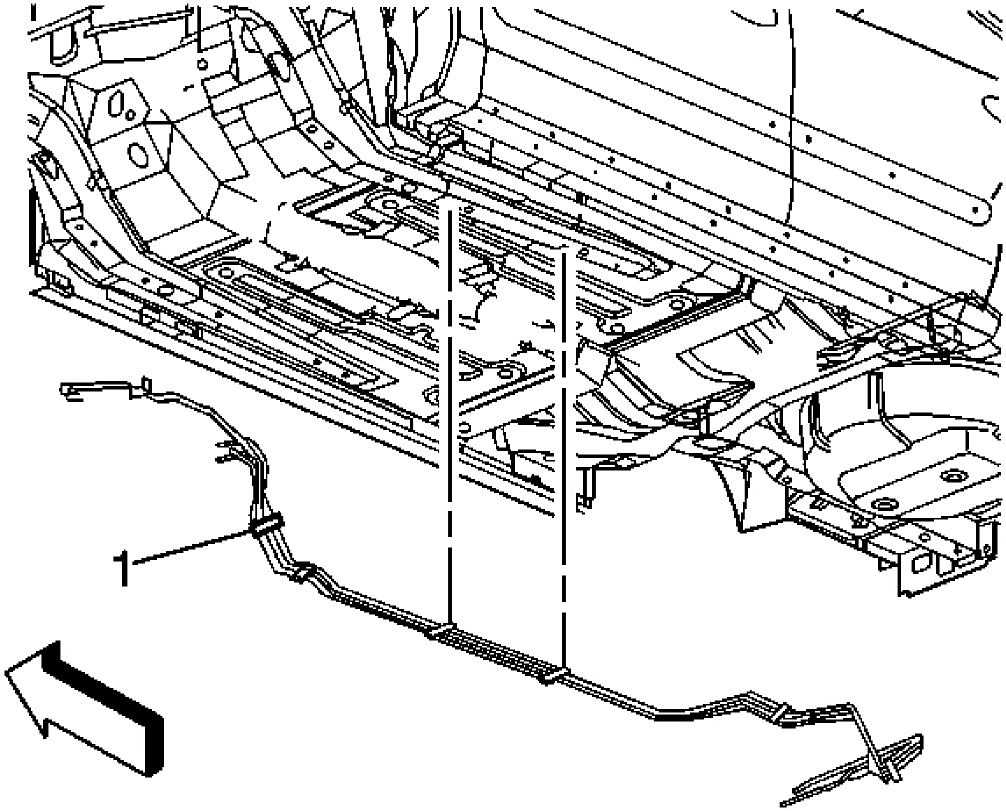


Fig. 134: Fuel Pipe Assembly View
Courtesy of GENERAL MOTORS CORP.

6. Release the pipe retainers (1) from the vehicle underbody.
7. Remove the purge pipe from the pipe retainers.
8. Lower the rear of the pipe while moving the pipe rearward slightly, then lower the front of the pipe.
9. Remove the purge pipe from the vehicle.

Installation Procedure

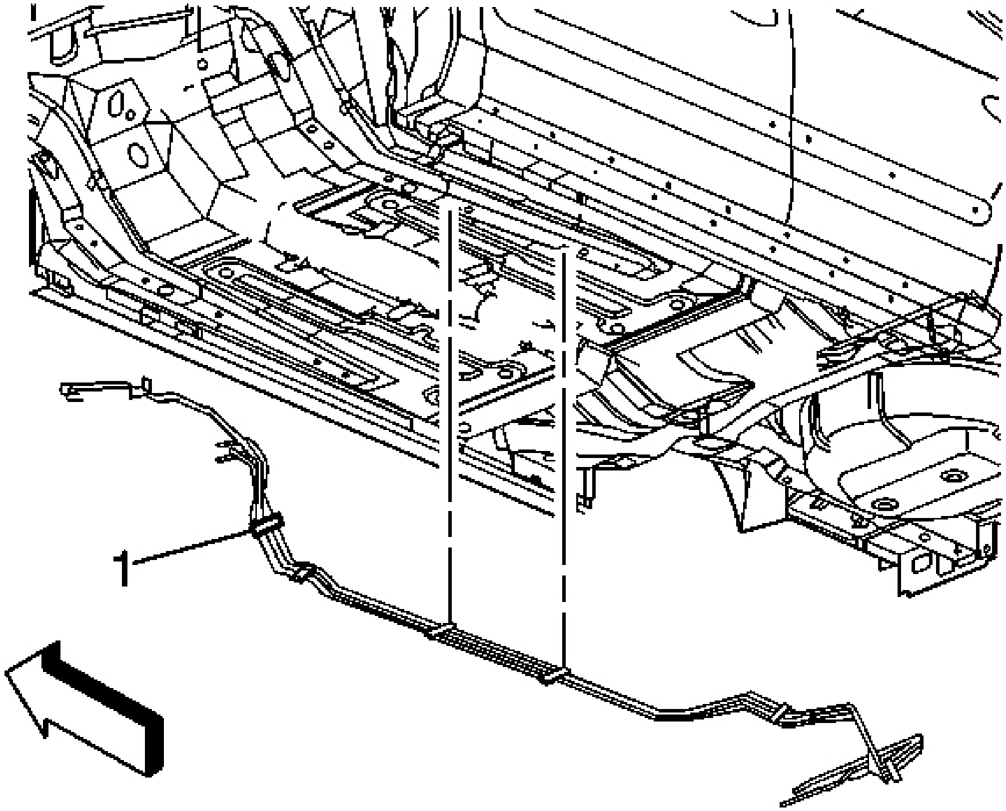
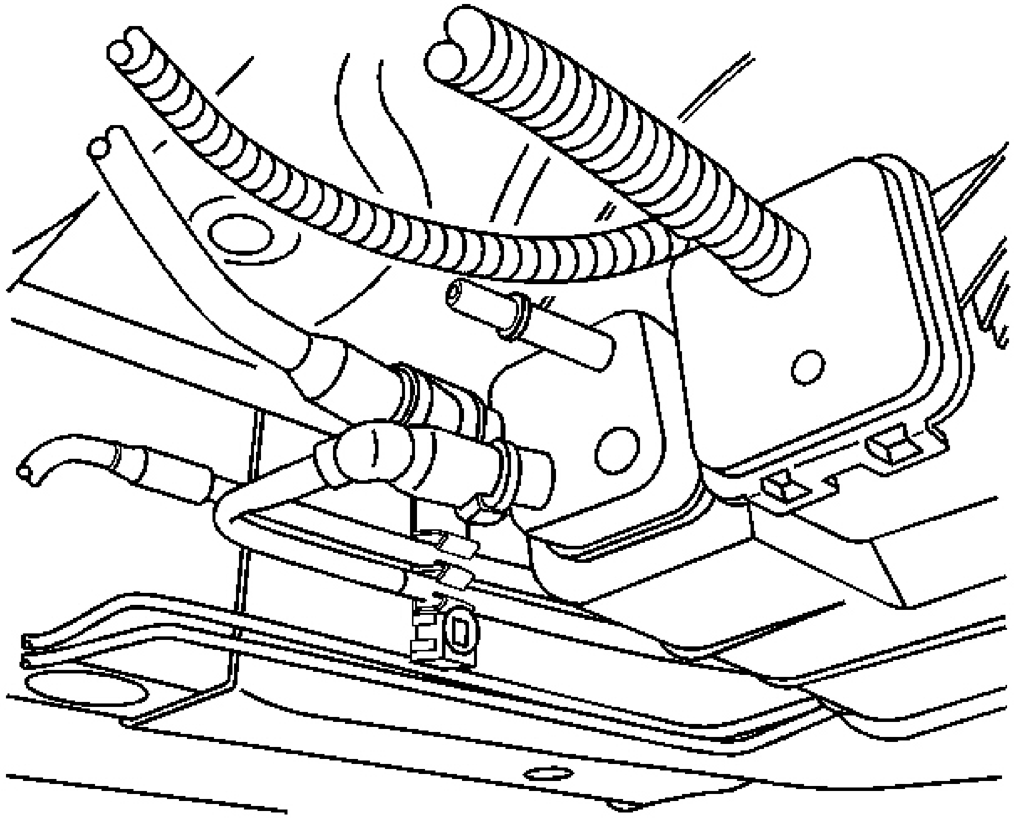


Fig. 135: Fuel Pipe Assembly View
Courtesy of GENERAL MOTORS CORP.

1. Position the purge pipe to the vehicle.
2. With the rear of the pipe positioned slightly rearward and down, raise the front of the pipe into position.
3. Install the remainder of the pipe into position.
4. Install the purge pipe to the pipe retainers.
5. Secure the pipe retainers (1) to the vehicle underbody.



<u>**Fig. 136: View Of EVAP Vent & Fresh Air Hoses**</u>
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to <u>Fastener Notice</u> in Cautions and Notices.

6. Install the rear brake hose brackets to the body studs and install the rear brake hose bracket retaining nuts.

   Tighten: Tighten the nuts to 10 N.m (89 lb in).

7. Connect the EVAP pipe to the EVAP canister.
8. Lower the vehicle.

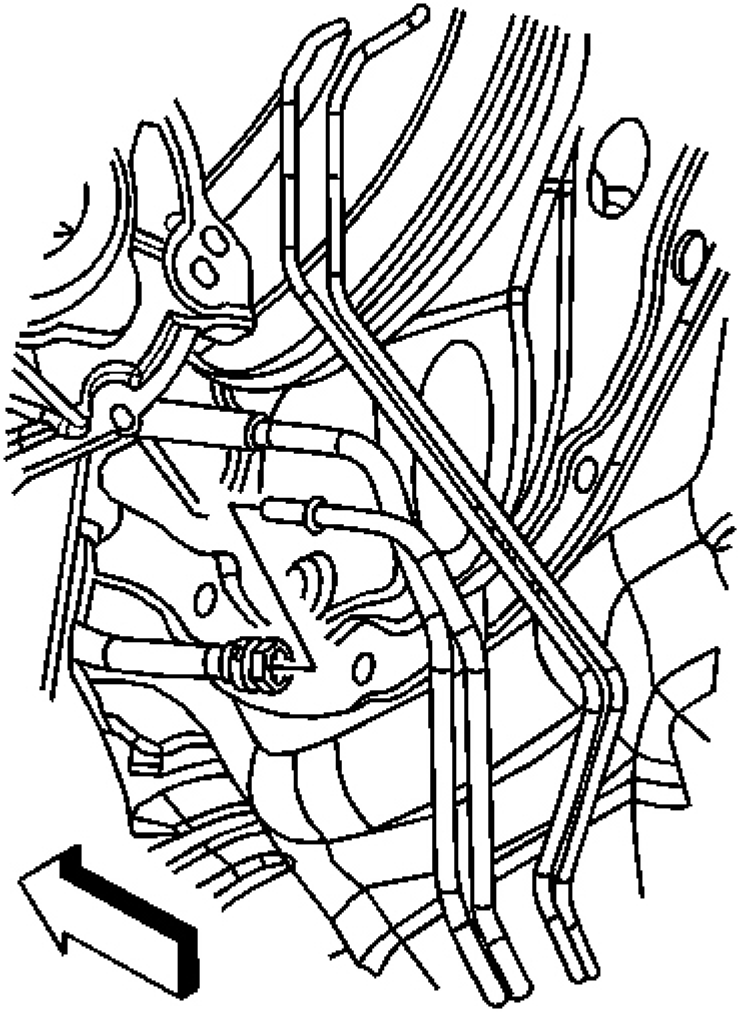


Fig. 137: View Of Caps or Plugs From The Purge Pipe
Courtesy of GENERAL MOTORS CORP.

9. Remove the caps or plugs from the purge pipe and the engine purge hose.
10. Connect the purge pipe to the engine purge hose. Refer to **Quick Connect Fitting(s) Service (Plastic Collar) (Plastic Collar)** or **Quick Connect Fitting(s) Service (Plastic Collar) (Plastic Collar Press Release)** or **Quick Connect Fitting(s) Service (Plastic Collar) (Plastic Collar Lever Release)** .

EVAPORATIVE EMISSION (EVAP) CANISTER REPLACEMENT

Removal Procedure

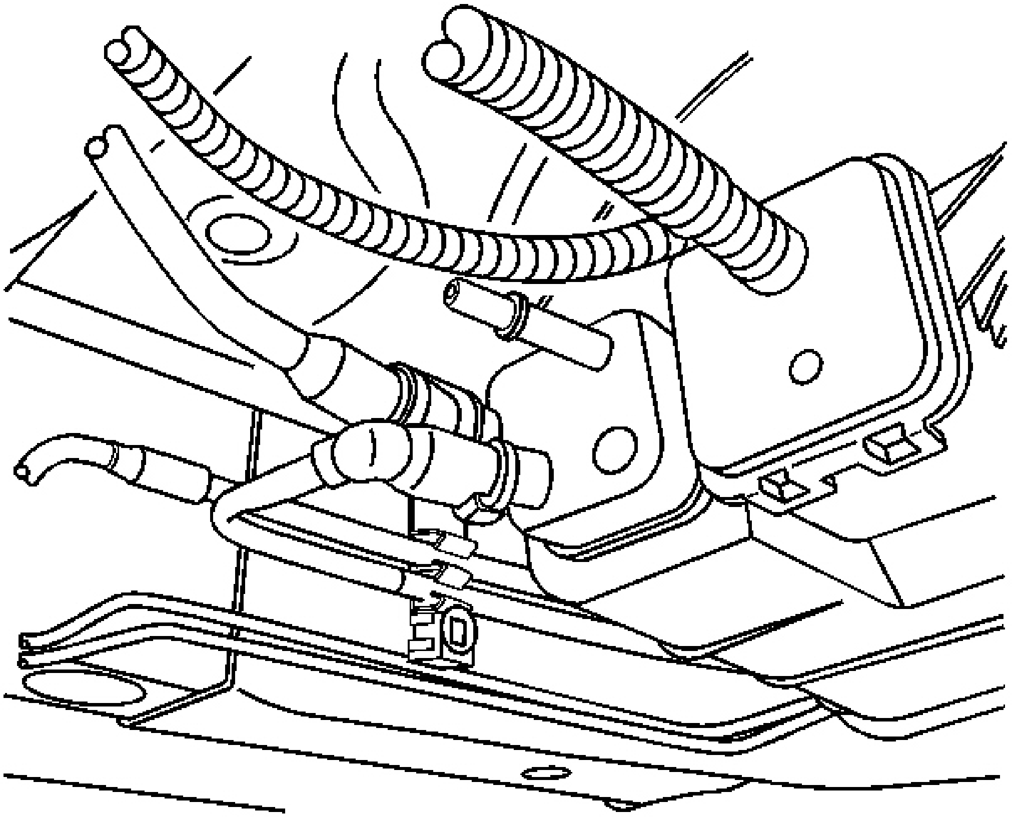


Fig. 138: View Of Evaporative Emission (EVAP) Canister
Courtesy of GENERAL MOTORS CORP.

CAUTION: Ensure that the vehicle is properly supported and squarely positioned. To help avoid personal injury when a vehicle is on a hoist, provide additional support for the vehicle on the opposite end from which the components are being removed.

IMPORTANT: The EVAP emissions canister is located under the center of the vehicle. It has 3 EVAP line connections:

- **The EVAP fresh air hose**
- **The EVAP purge connection**
- **The EVAP vent connection**

1. Raise the vehicle on a hoist. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Disconnect the EVAP canister fresh air line from the fuel tank fresh air line.
3. Disconnect the EVAP canister purge line and vent line from the EVAP canister.

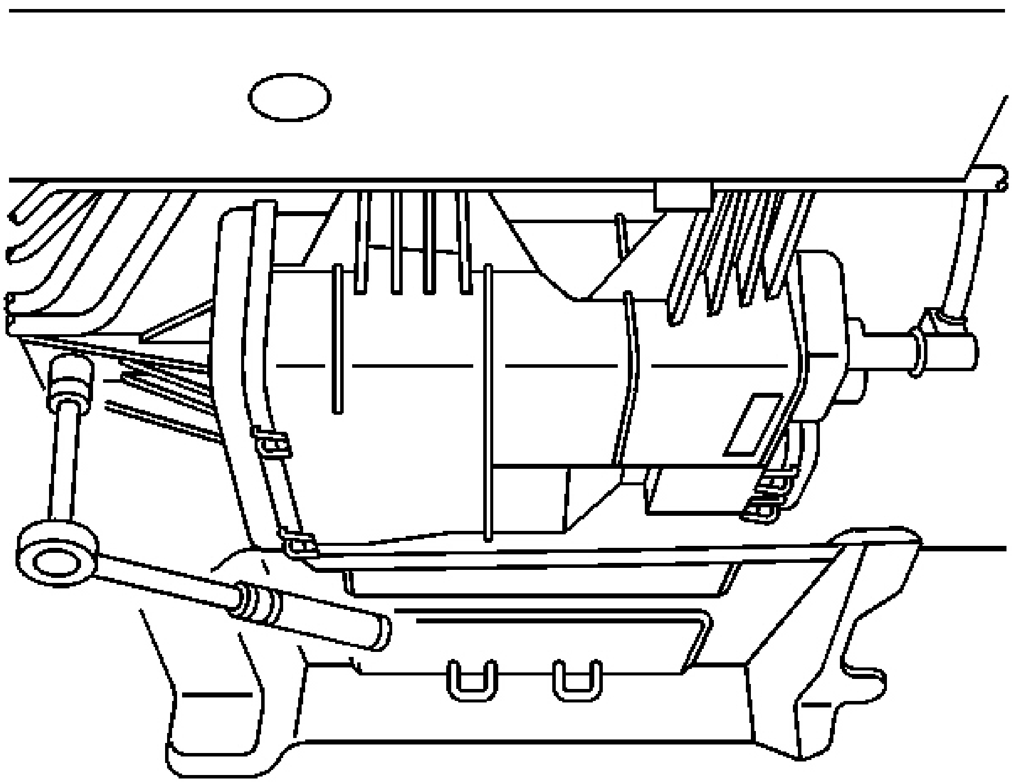


Fig. 139: View Of Evaporative Emission (EVAP) Canister Vent Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

4. Remove the EVAP canister-to-underbody fasteners.
5. Disconnect the EVAP vent solenoid electrical connector.
6. Remove the canister from the vehicle.

Installation Procedure

1. Connect the EVAP vent solenoid electrical connector.

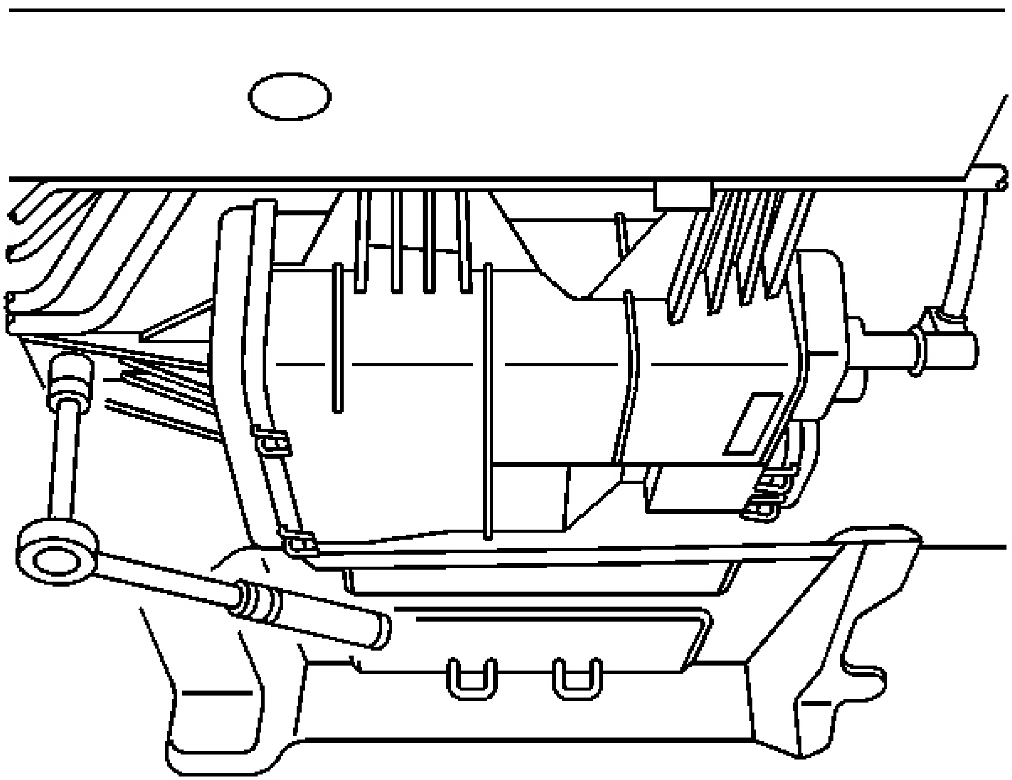


Fig. 140: View Of Evaporative Emission (EVAP) Canister Vent Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the EVAP canister-to-body underbody fasteners.

   Tighten: Tighten the EVAP canister nuts to 8 N.m (71 lb in).

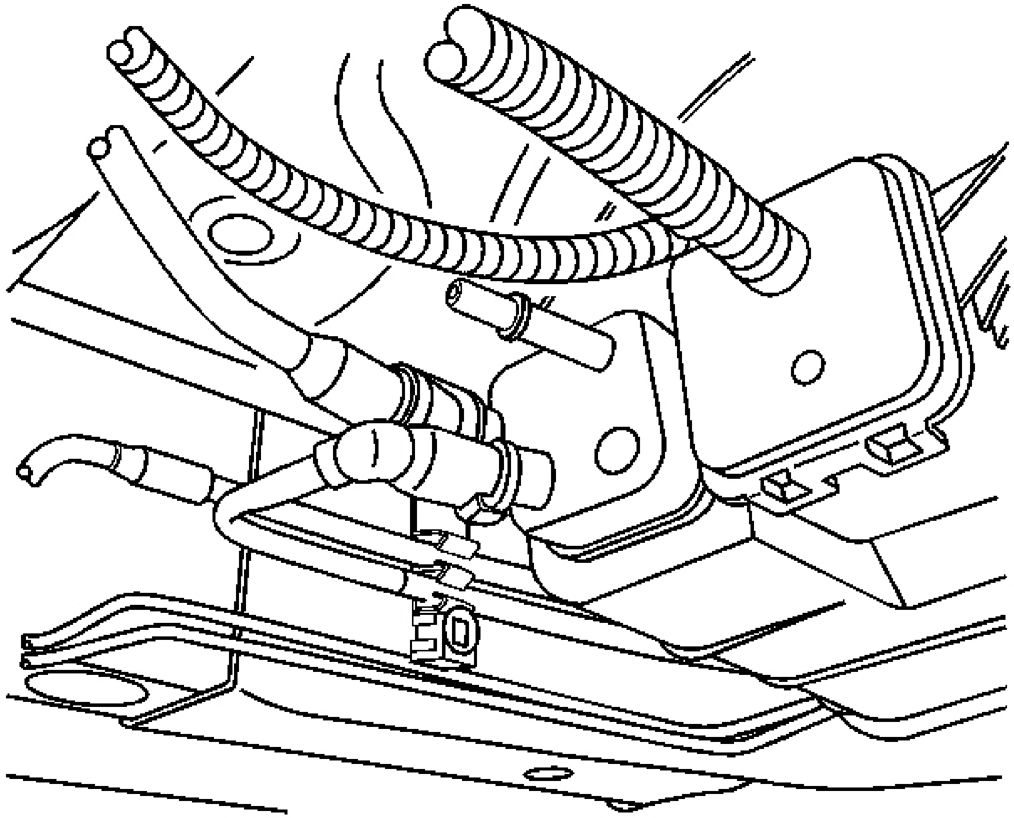


Fig. 141: View Of EVAP Vent & Fresh Air Hoses
Courtesy of GENERAL MOTORS CORP.

3. Connect the EVAP canister purge and vent lines to the EVAP canister.

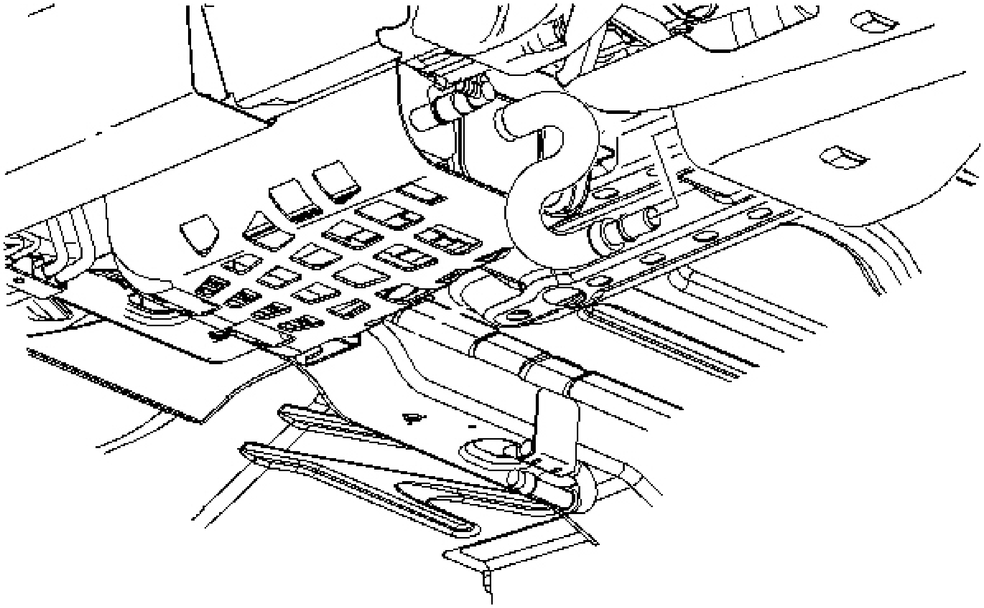


Fig. 142: View Of EVAP Canister Fresh Air Line
Courtesy of GENERAL MOTORS CORP.

4. Connect the EVAP canister fresh air line to the fuel tank fresh air line.
5. Lower the vehicle from the hoist.

EVAPORATIVE EMISSION (EVAP) CANISTER FILTER REPLACEMENT

Removal Procedure

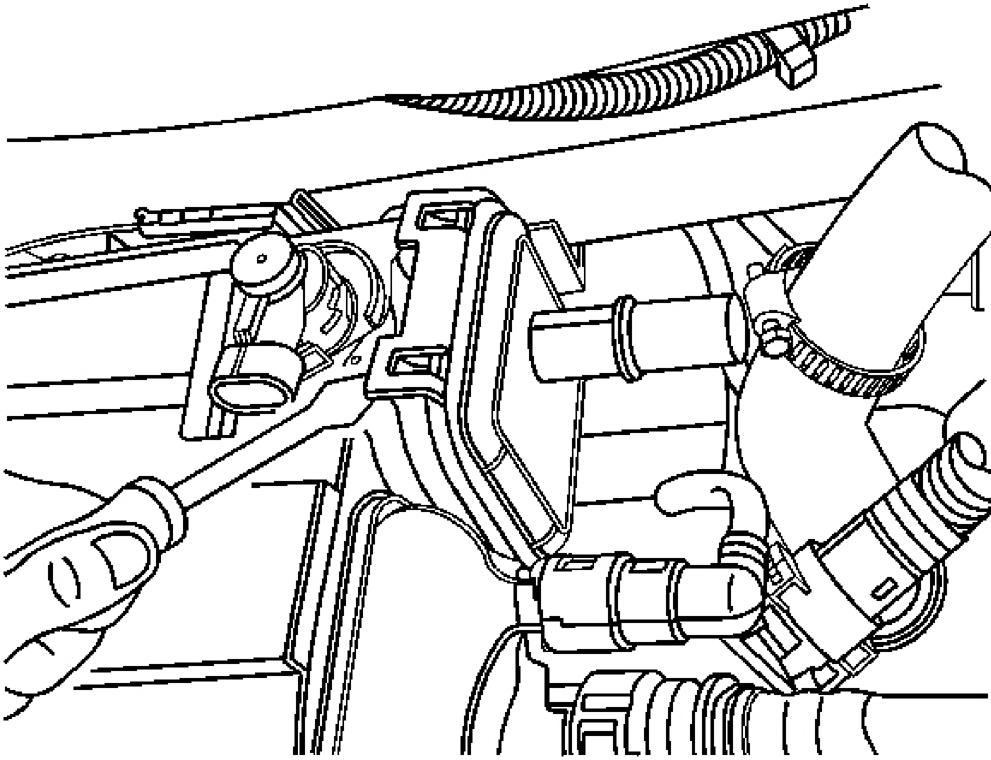


Fig. 143: View Of Evaporative Emission (EVAP) Canister Filter
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Clean away any debris that may be present around the evaporative emission (EVAP) canister vent filter cover.
3. Carefully release the canister filter cover rear retaining tabs.
4. Carefully release the canister filter cover forward retaining tabs and remove the cover from the EVAP canister.

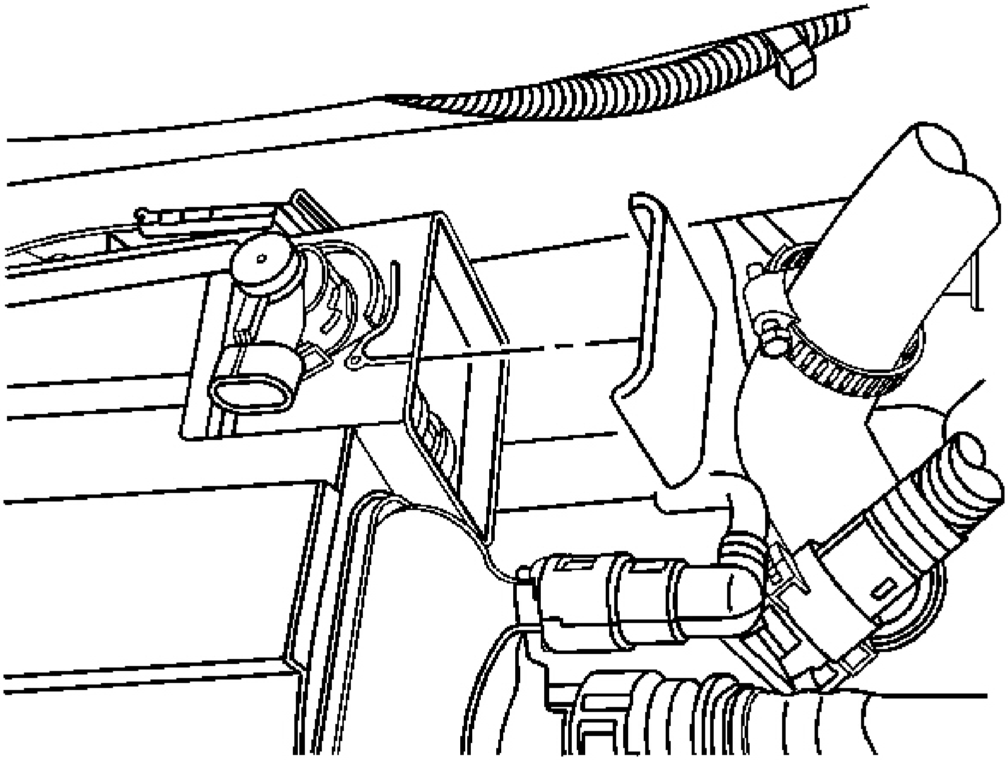


Fig. 144: View Of Cover To The Canister
Courtesy of GENERAL MOTORS CORP.

5. Remove the filter from the canister and discard the filter.
6. Remove the seal from the filter cover and discard the seal.
7. Clean the inside of the EVAP canister filter housing with a clean shop towel.

Installation Procedure

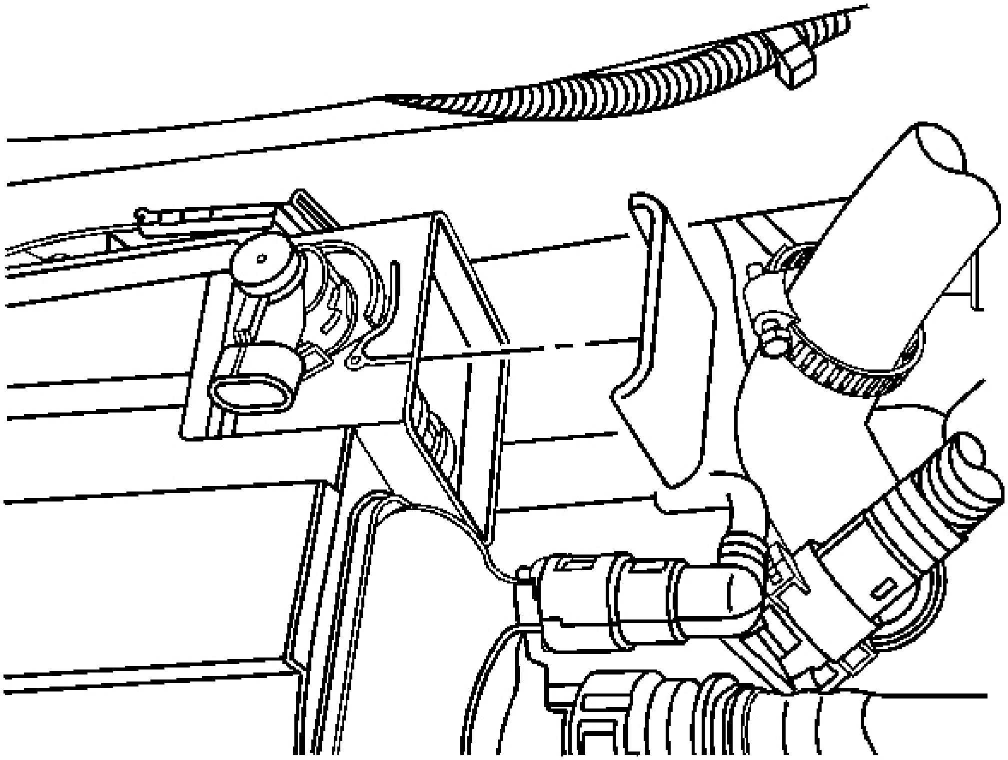


Fig. 145: View Of Cover To The Canister
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW cover to the canister. Ensure that the seal is properly seated to the cover.
2. Install a NEW filter to the canister filter housing.

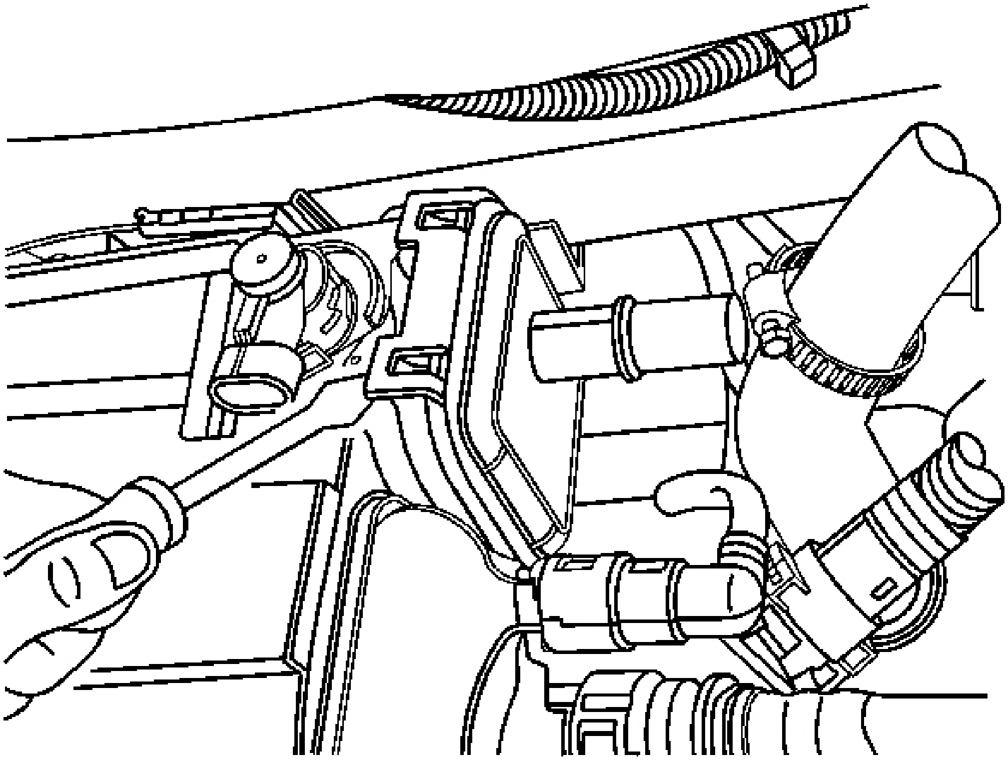


Fig. 146: View Of Evaporative Emission (EVAP) Canister Filter
Courtesy of GENERAL MOTORS CORP.

3. Install the filter cover to the EVAP canister.
4. Lower the vehicle.

EVAPORATIVE EMISSION (EVAP) SYSTEM CLEANING

Tools Required

J 41413 EVAP Pressure and Purge Station. See **Special Tools and Equipment** .

Inspection Procedure

NOTE: Refer to Clean, Dry, Low Pressure Gas Source Notice in Cautions and Notices.

IMPORTANT: Proceed with the following procedure only if referenced by an EVAP diagnostic or repair procedure.

1. Turn OFF the ignition.
2. Remove the EVAP canister purge valve. Refer to **Evaporative Emission (EVAP) 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.
    - 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.
    - If carbon particles are found during the inspection procedure, continue with the cleaning procedure.
    - 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.

Cleaning Procedure

1. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Remove the EVAP canister. Refer to **Evaporative Emission (EVAP) Canister Replacement** .
3. Turn OFF the main valve on the **J 41413** . See **Special Tools and Equipment** .
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. Refer to **Evaporative Emission (EVAP) Canister Replacement** .
11. Lower the vehicle.
12. Install a new EVAP canister purge valve. Refer to **Evaporative Emission (EVAP) Canister Purge Solenoid Valve Replacement** .
13. Return to the diagnostic table that sent you here.

IGNITION COIL(S) REPLACEMENT - BANK 1

Removal Procedure

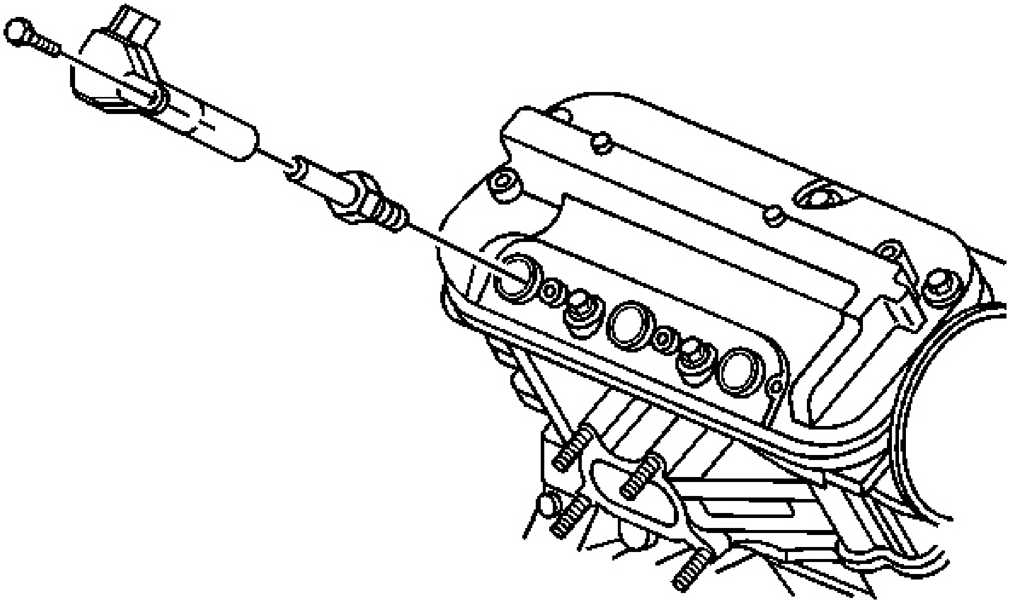


Fig. 147: View Of Ignition Coils
Courtesy of GENERAL MOTORS CORP.

1. Remove the air cleaner outlet duct assembly. Refer to**Air Cleaner Resonator Outlet Duct Replacement** .
2. Disconnect the electrical connectors.
3. Remove the engine coil bolts.
4. Remove the engine coils.

Installation Procedure

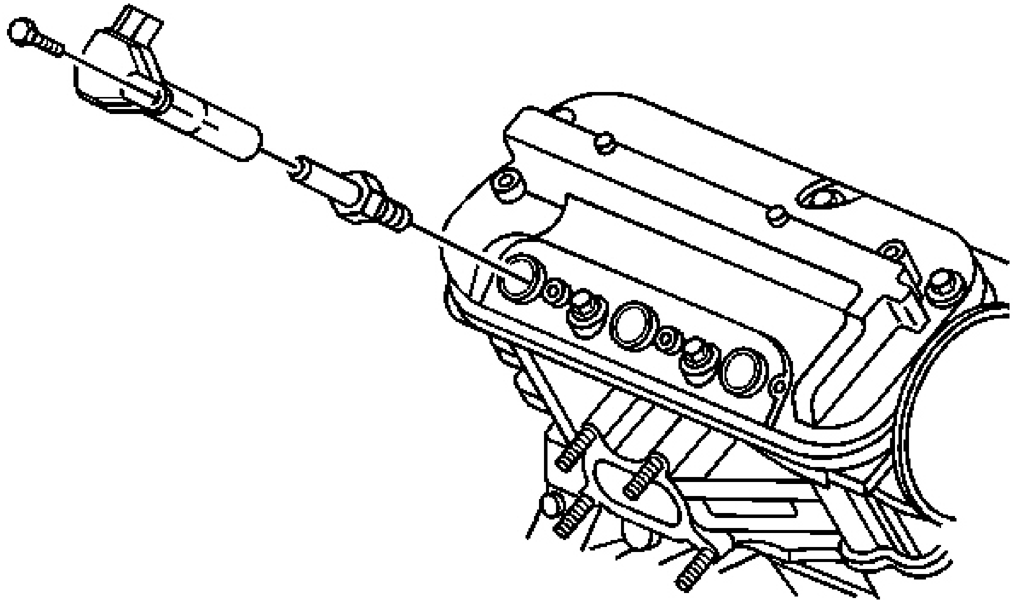


Fig. 148: View Of Ignition Coils
Courtesy of GENERAL MOTORS CORP.

1. Install the engine coils.

   NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine coil bolts.

   Tighten: Tighten the bolts to 12 N.m (106 lb in).

3. Connect the electrical connectors.
4. Install the air cleaner outlet duct assembly. Refer to**Air Cleaner Resonator Outlet Duct Replacement** .

IGNITION COIL(S) REPLACEMENT - BANK 2

Removal Procedure

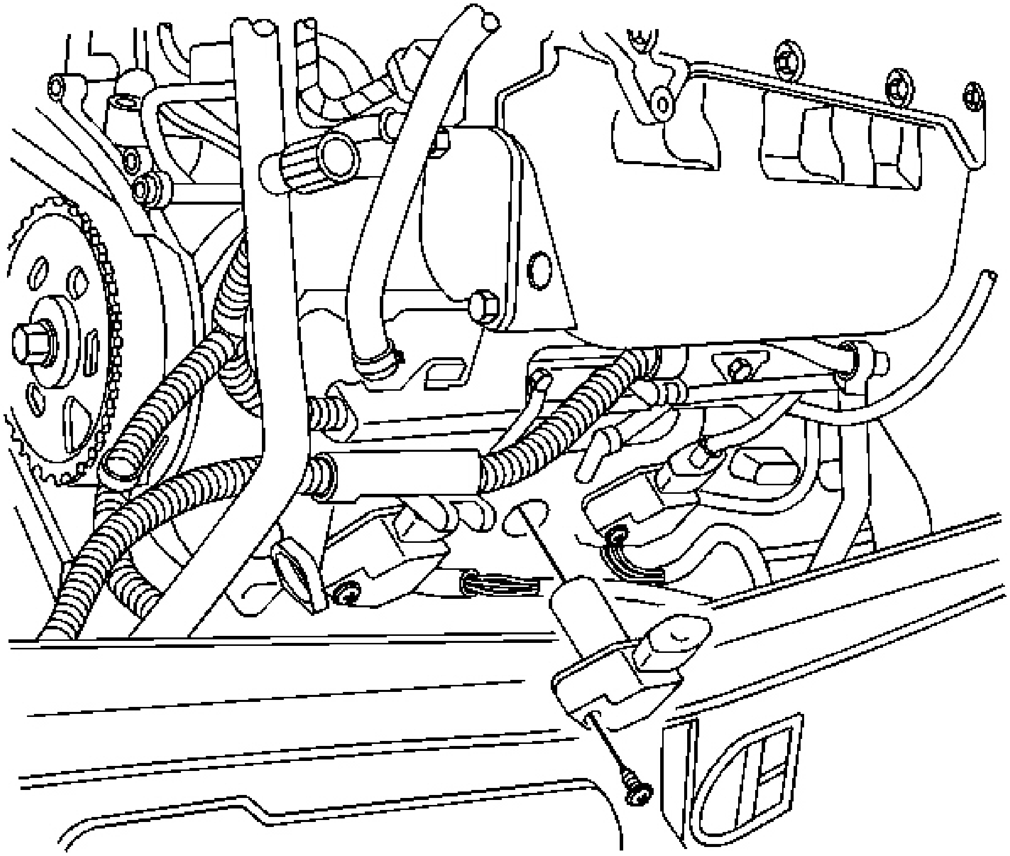


Fig. 149: View Of Engine Coils
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the electrical connectors.
2. Remove the engine coil bolts.
3. Remove the engine coils.

Installation Procedure

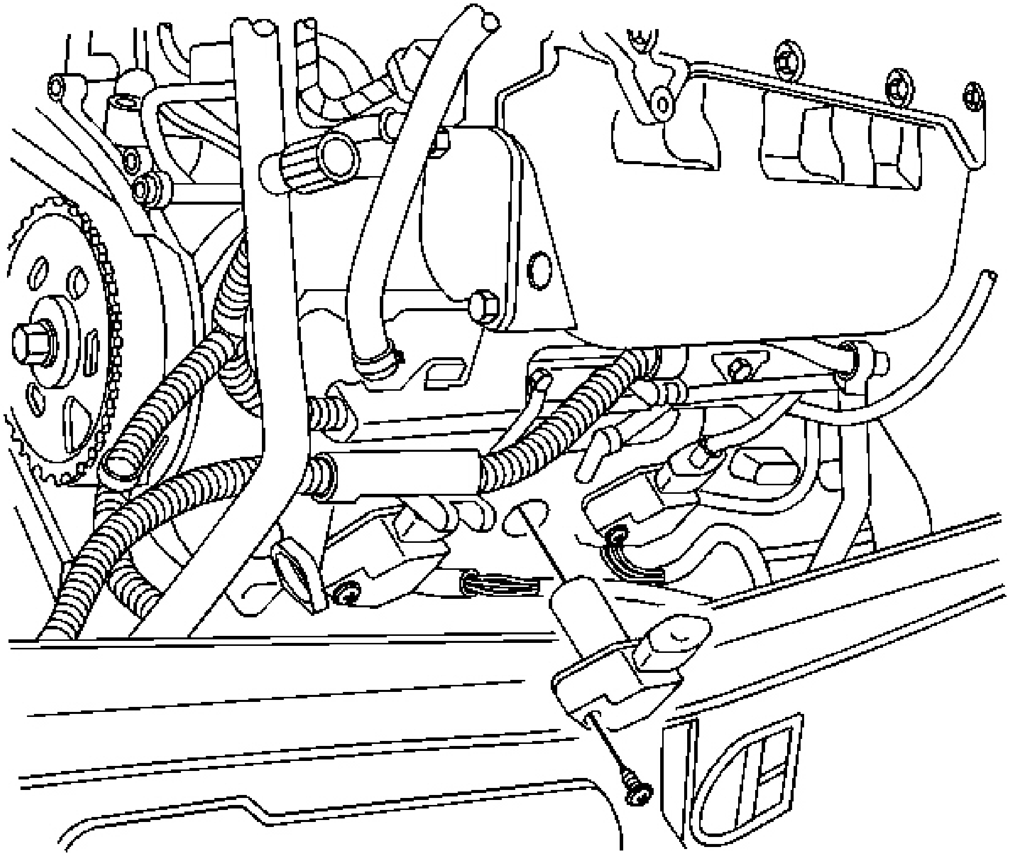


Fig. 150: View Of Engine Coils
Courtesy of GENERAL MOTORS CORP.

1. Install the engine coils.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine coil bolts.

   Tighten: Tighten the bolts to 12 N.m (106 lb in).

3. Connect the electrical connectors.

SPARK PLUG INSPECTION

Spark Plug Usage

- Ensure that the correct spark plug is installed. An incorrect spark plug causes driveability conditions. Refer to **Ignition System Specifications** for the correct spark plug.
- Ensure that the spark plug has the correct heat range. An incorrect heat range causes the following conditions:
  - Spark plug fouling - colder plug
  - Pre-ignition causing spark plug and/or engine damage - hotter plug

Spark Plug Inspection

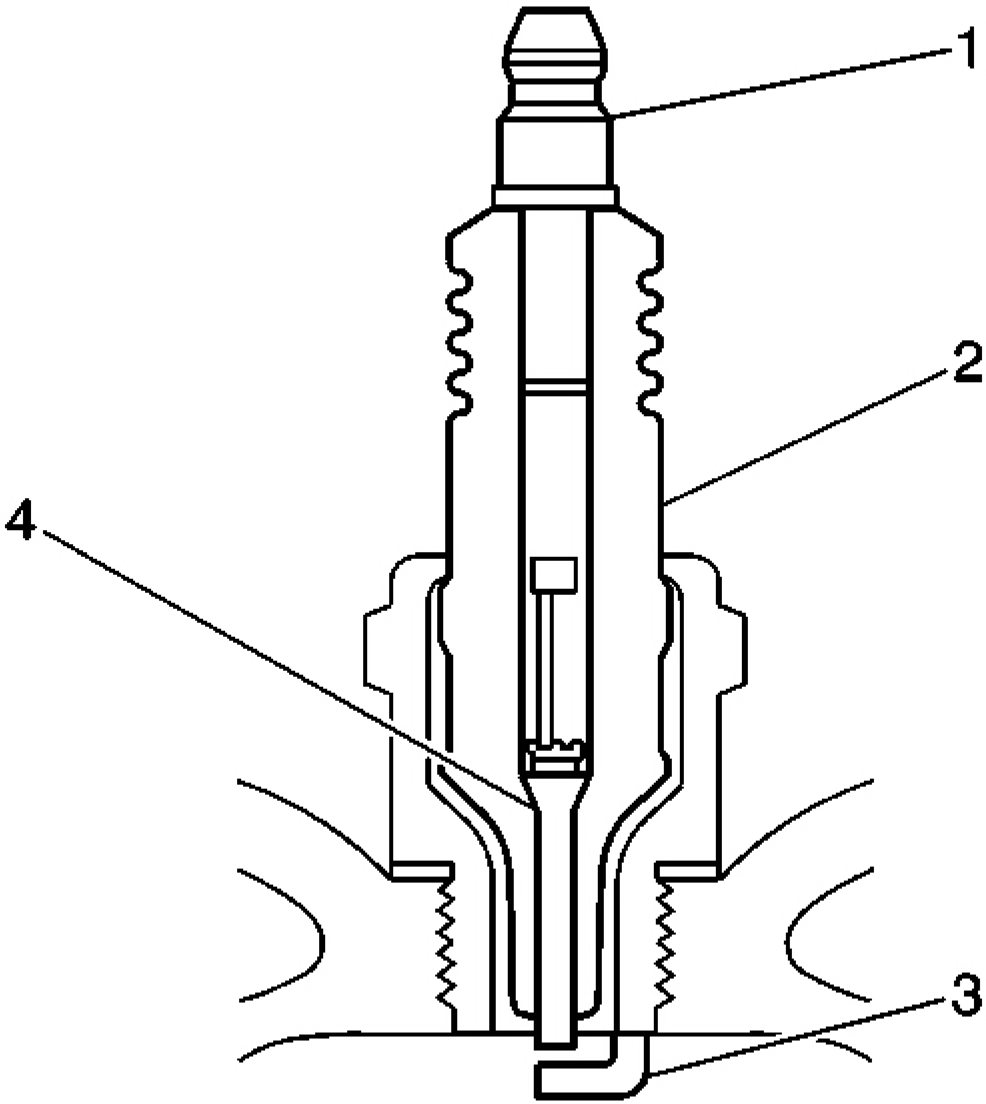


Fig. 151: Inspecting Spark Plug Components
Courtesy of GENERAL MOTORS CORP.

- 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.

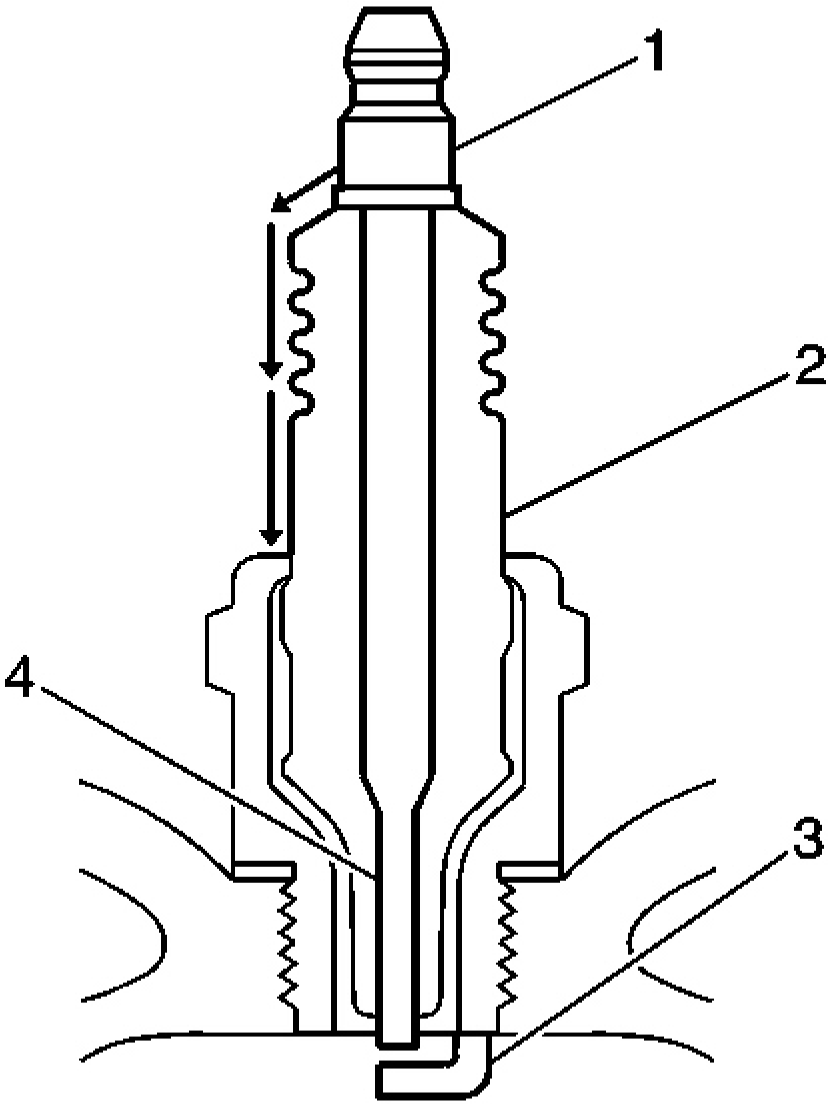


Fig. 152: Inspecting Spark Plug Insulator For Soot
Courtesy of GENERAL MOTORS CORP.

- Inspect the insulator (2) for flashover or carbon tracking, soot. 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.

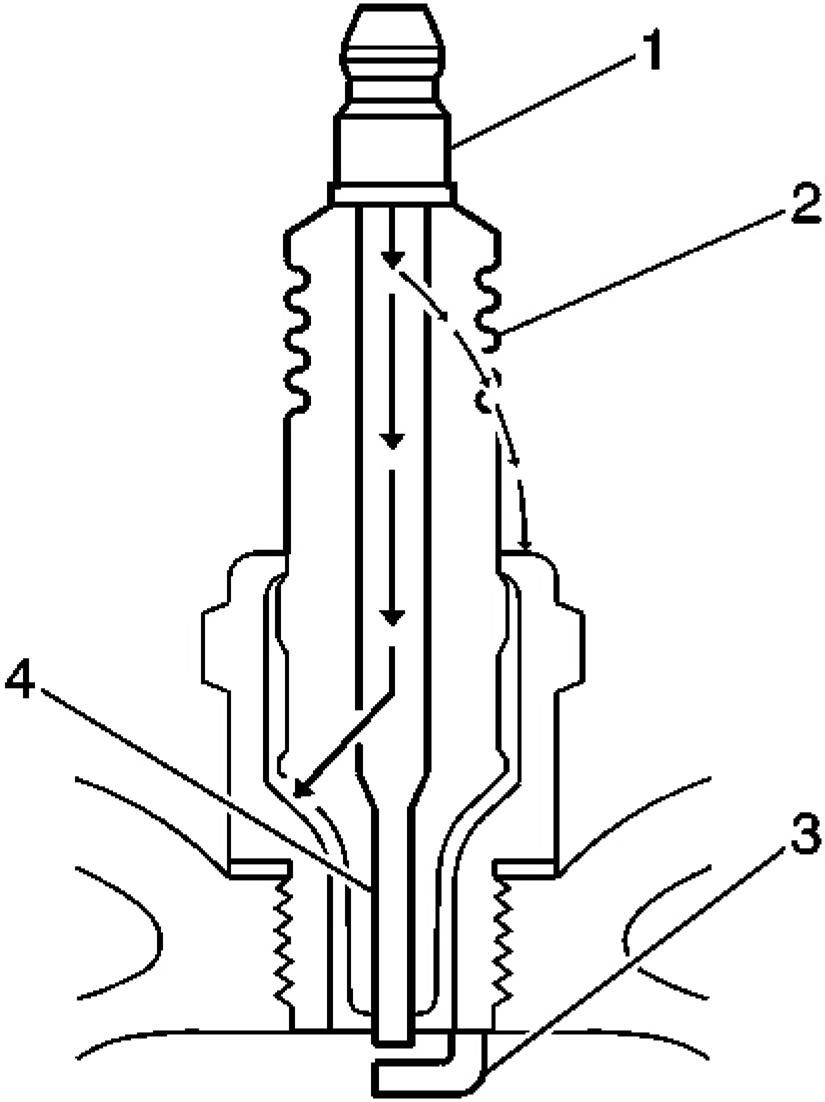


Fig. 153: Inspecting Spark Plug Insulator
Courtesy of GENERAL MOTORS CORP.

- Inspect the insulator (2) for cracks. All or part of the electrical charge may arc through the crack instead of the electrodes (3, 4).

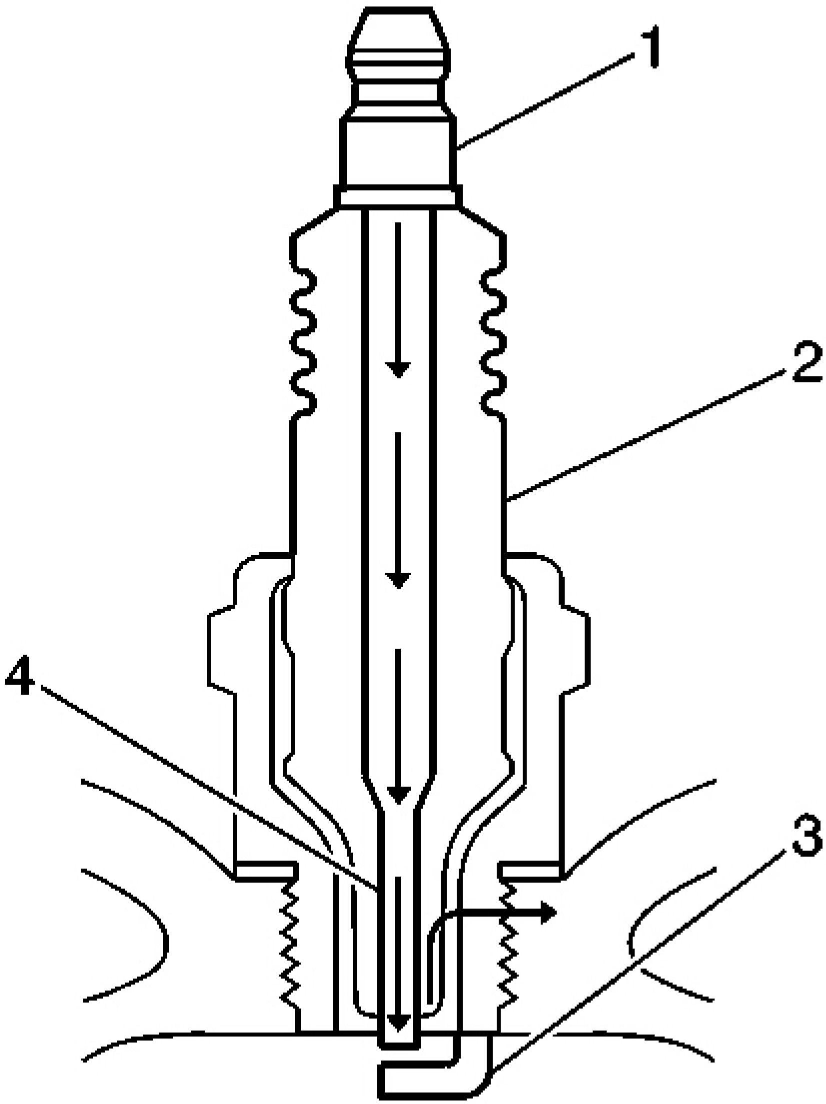


Fig. 154: Inspecting Spark Plug For Improper Arcing
Courtesy of GENERAL MOTORS CORP.

- Inspect for evidence of improper arcing.
    - Measure the gap between the center electrode (4) and the side electrode (3) terminals. 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.

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.
- 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.

SPARK PLUG REPLACEMENT

Removal Procedure

NOTE:	**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.**

1. Remove the ignition coils. Refer to **Ignition Coil(s) Replacement - Bank 1** and **Ignition Coil(s) Replacement - Bank 2** .

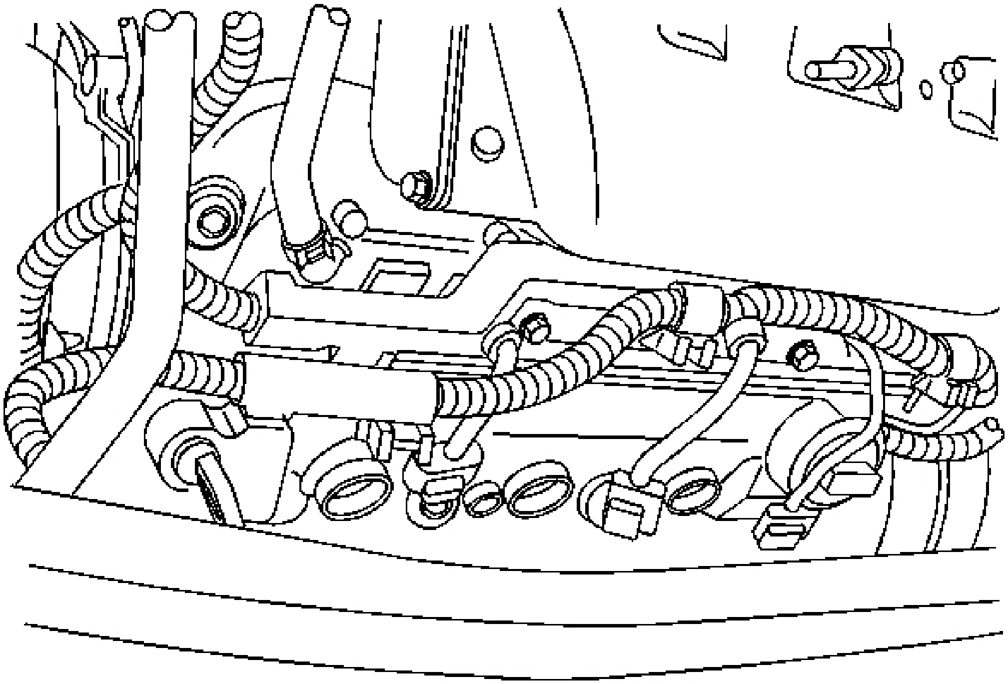


Fig. 155: View Of Spark Plugs
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Remove any water and debris from the spark plug holes before spark plug removal with compressed air.

2. Remove the spark plugs with a spark plug socket.
3. Inspect the spark plugs. Refer to **Spark Plug Inspection** .

Installation Procedure

1. Gap the spark plug, using round wire type spark plug gap gage.

   Gap: Adjust the spark plug gap to 1.1 mm (0.043 in).

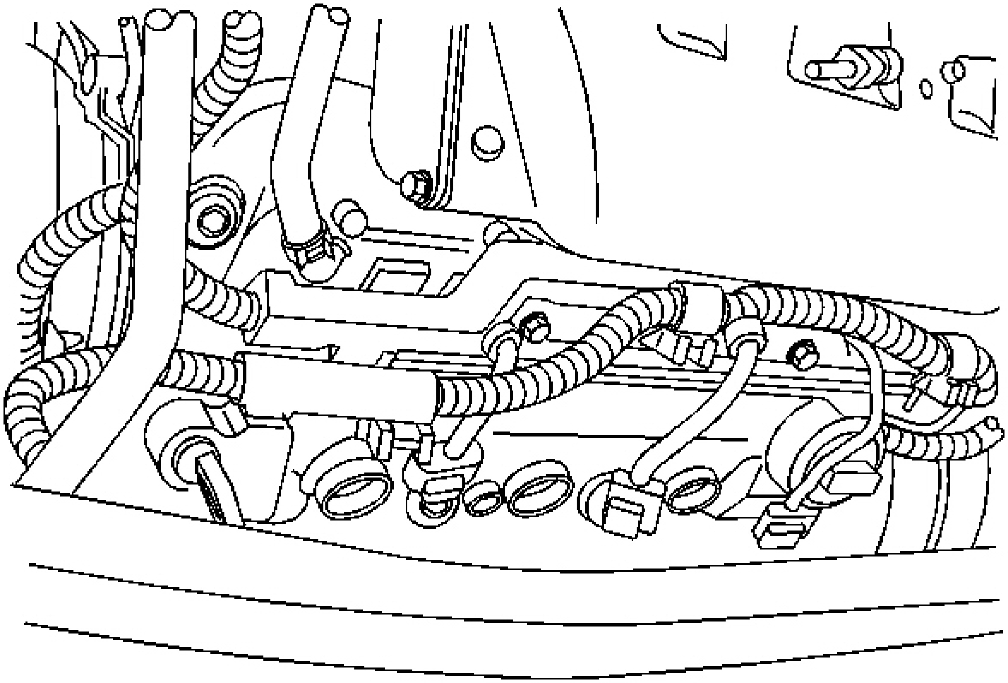


Fig. 156: View Of Spark Plugs With A Spark Plug Socket
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

IMPORTANT: **DO NOT coat the spark plugs with anti-seize compound. Over torquing could occur and damage to the cylinder head threads may result.**

2. Install the spark plugs with a spark plug socket.

   Tighten: Tighten the spark plugs to 18 N.m (13 lb in).

3. Install the ignition coils. Refer to **Ignition Coil(s) Replacement - Bank 1** and **Ignition Coil(s) Replacement - Bank 2** .

CRANKSHAFT POSITION (CKP) SENSOR REPLACEMENT

Removal Procedure

1. Remove the engine front cover. Refer to **Timing Belt Cover Replacement** in Engine Mechanical - 3.5L.

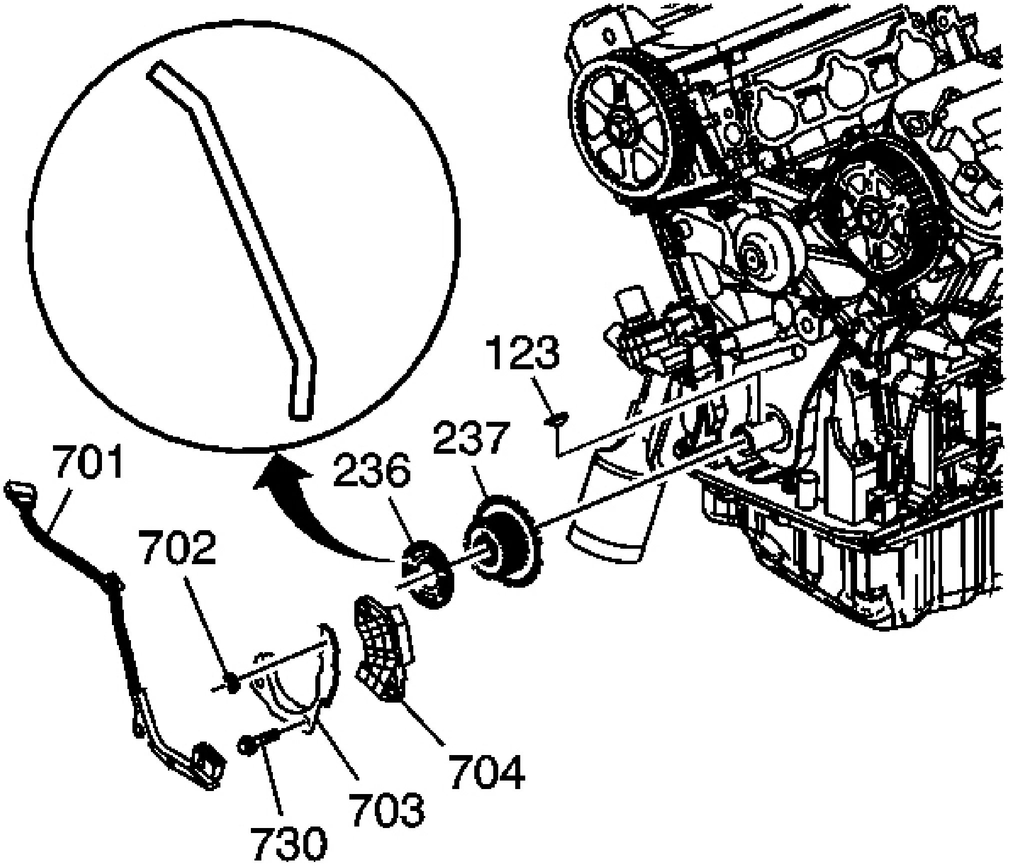


Fig. 157: View Of Crankshaft (CKP) Sensor
Courtesy of GENERAL MOTORS CORP.

2. Remove the timing belt guide (703).
3. Remove the crank sensor and harness.

Installation Procedure

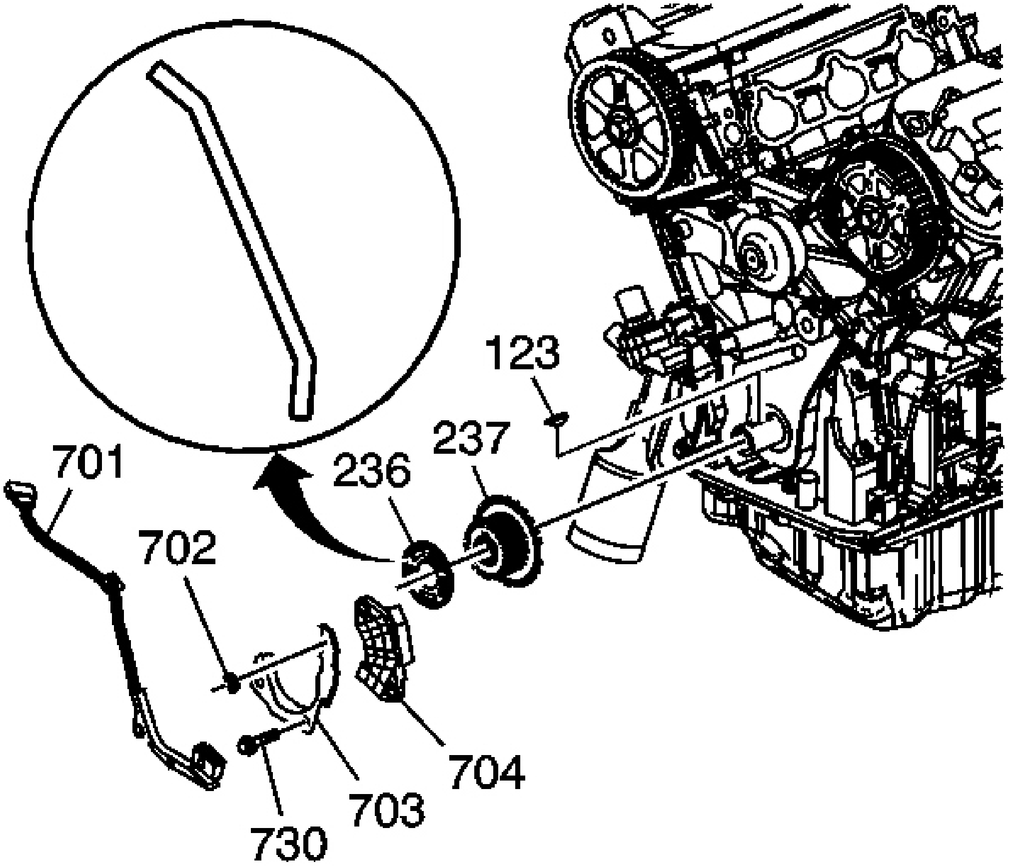


Fig. 158: View Of Crankshaft (CKP) Sensor & Harness
Courtesy of GENERAL MOTORS CORP.

1. Install the crank sensor and harness.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the timing belt guide (703).

   Tighten: Tighten the timing belt fasteners to 10 N.m (88 lb in).

3. Install the front cover. Refer to **Timing Belt Cover Replacement** in Engine Mechanical - 3.5L.
4. Perform the idle learn procedure. Refer to**Idle Learn Procedure** in Engine Controls - 3.5L (L66).

CAMSHAFT POSITION (CMP) SENSOR REPLACEMENT

Removal Procedure

1. Remove the left camshaft sprocket. Refer to **Camshaft Drive Sprocket Replacement - Left** in Engine Mechanical - 3.5L (L66).

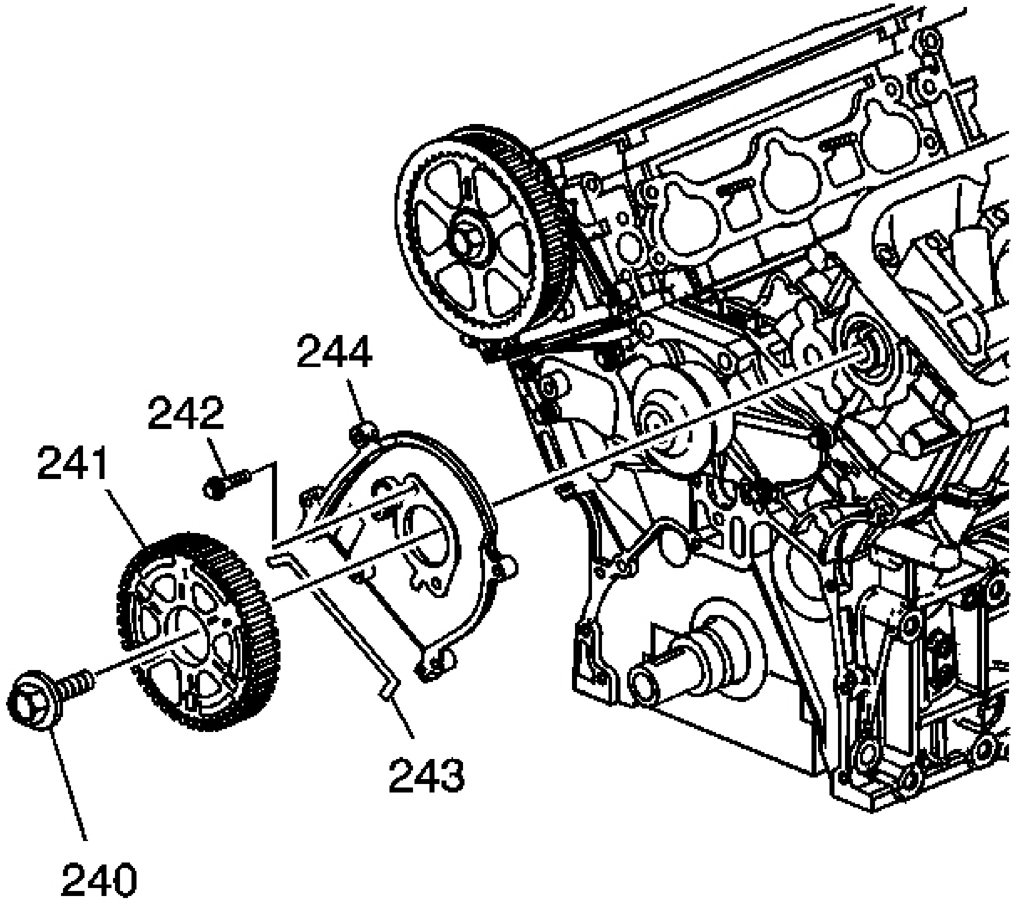


Fig. 159: View Of Camshaft (CMP) Sensor
Courtesy of GENERAL MOTORS CORP.

2. Remove the bolt (240), sprocket (241), bolts (242), cover (244) and seal (243).

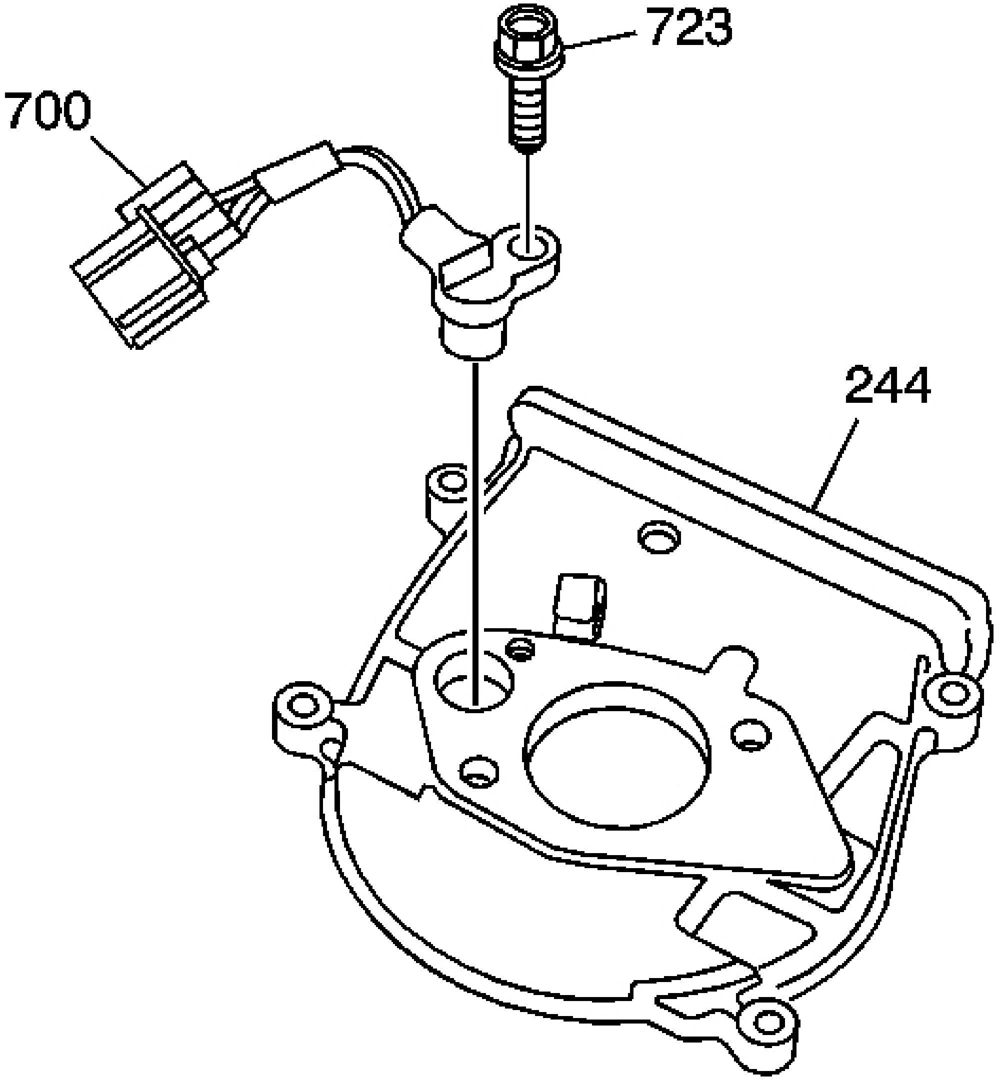


Fig. 160: View Of Bolt & Camshaft Position (CMP) Sensor
Courtesy of GENERAL MOTORS CORP.

3. Remove the bolt (723) and camshaft position (CMP) sensor (700).

Installation Procedure

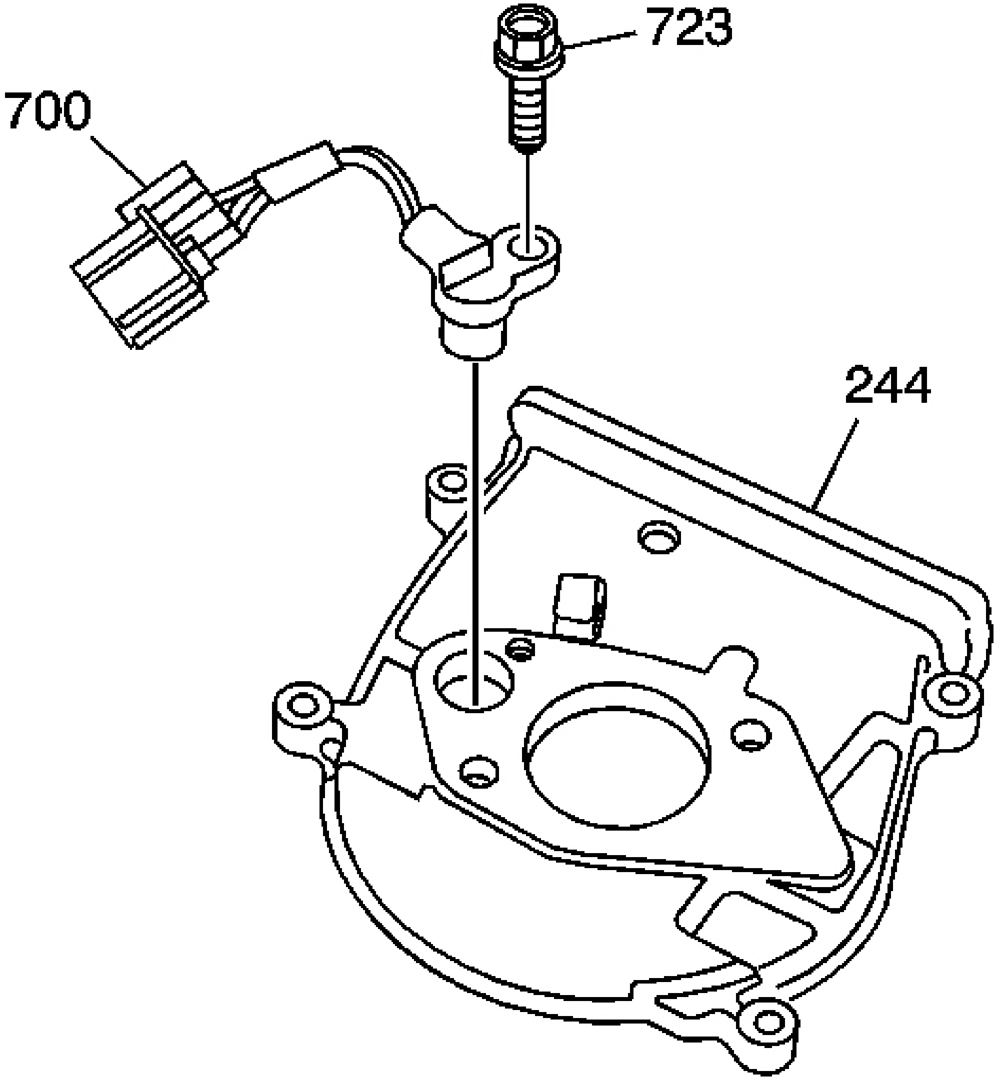


Fig. 161: View Of Bolt & Camshaft Position (CMP) Sensor
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the camshaft position (CMP) sensor (700) and bolt (723).

   Tighten: Tighten the bolt to 4 N.m (35 lb in).

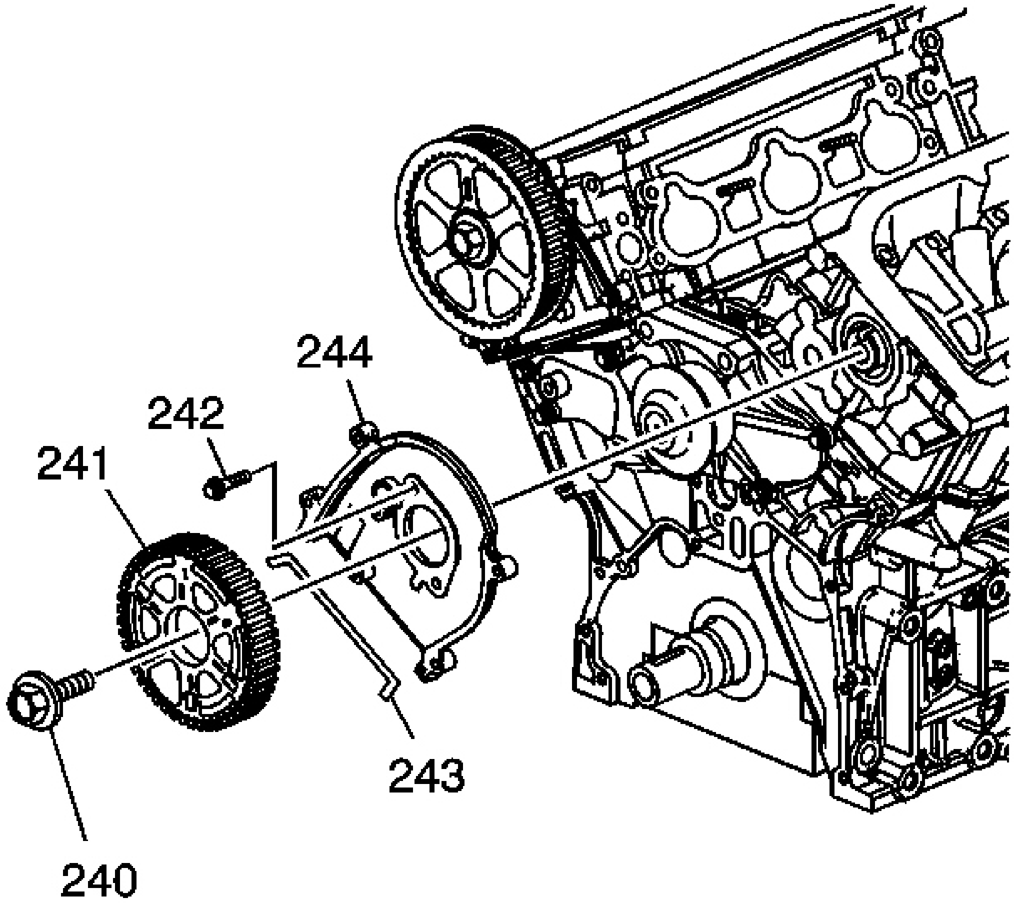


Fig. 162: View Of Camshaft (CMP) Sensor
Courtesy of GENERAL MOTORS CORP.

2. Install the cover (244), NEW seal (243) and bolts (242).

   Tighten: Tighten the bolts to 22 N.m (16 lb ft).

3. Install the left camshaft sprocket. Refer to **Camshaft Drive Sprocket Replacement - Left** in Engine Mechanical - 3.5L (L66).

ROCKER ARM OIL CONTROL SOLENOID VALVE REPLACEMENT

Removal Procedure

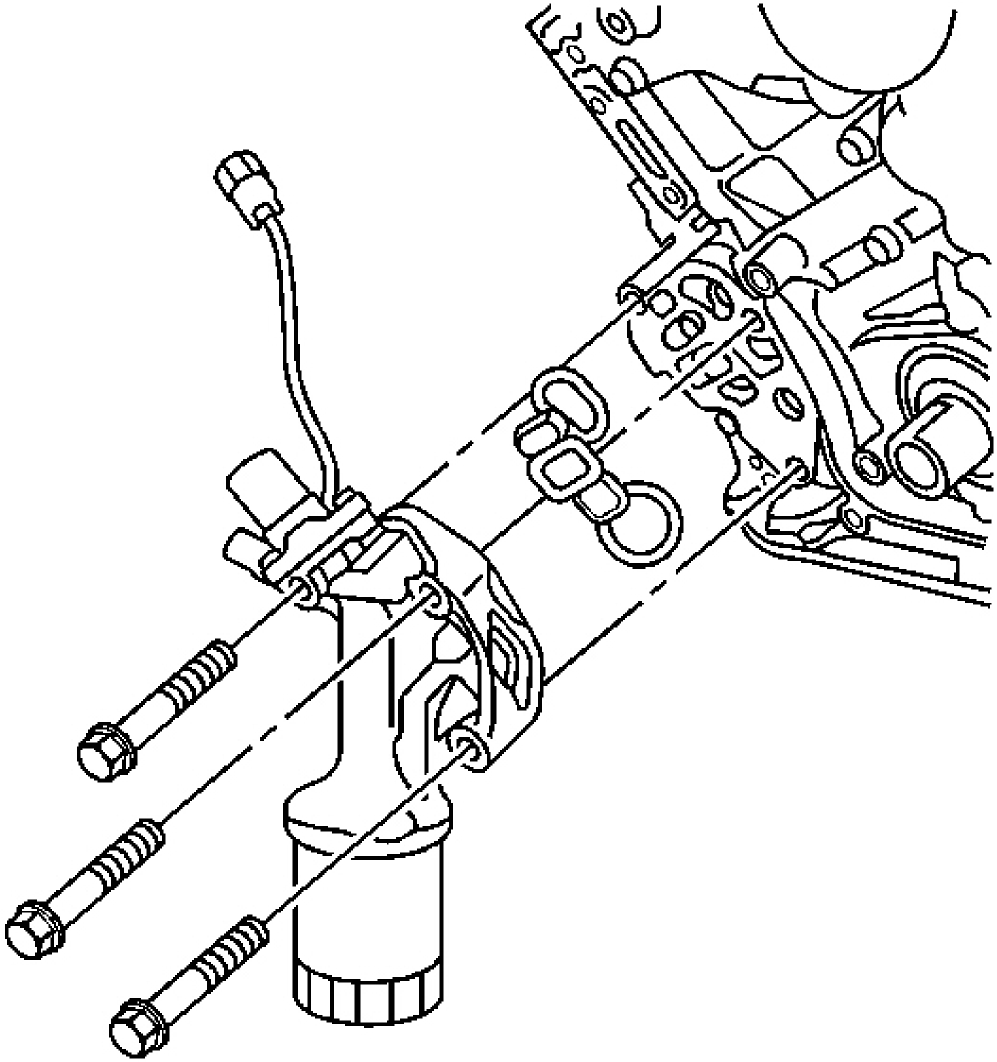


Fig. 163: View Of Rocker Arm Oil Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to**Lifting and Jacking the Vehicle** in General Information.
2. Remove the right front wheel. Refer to**Tire and Wheel Removal and Installation** in Tires and Wheels.
3. Remove the splash shield. Refer to**Splash Shield Replacement - Engine** in Body Front End.
4. Remove the solenoid and bolts.
5. Discard the O-ring.

Installation Procedure

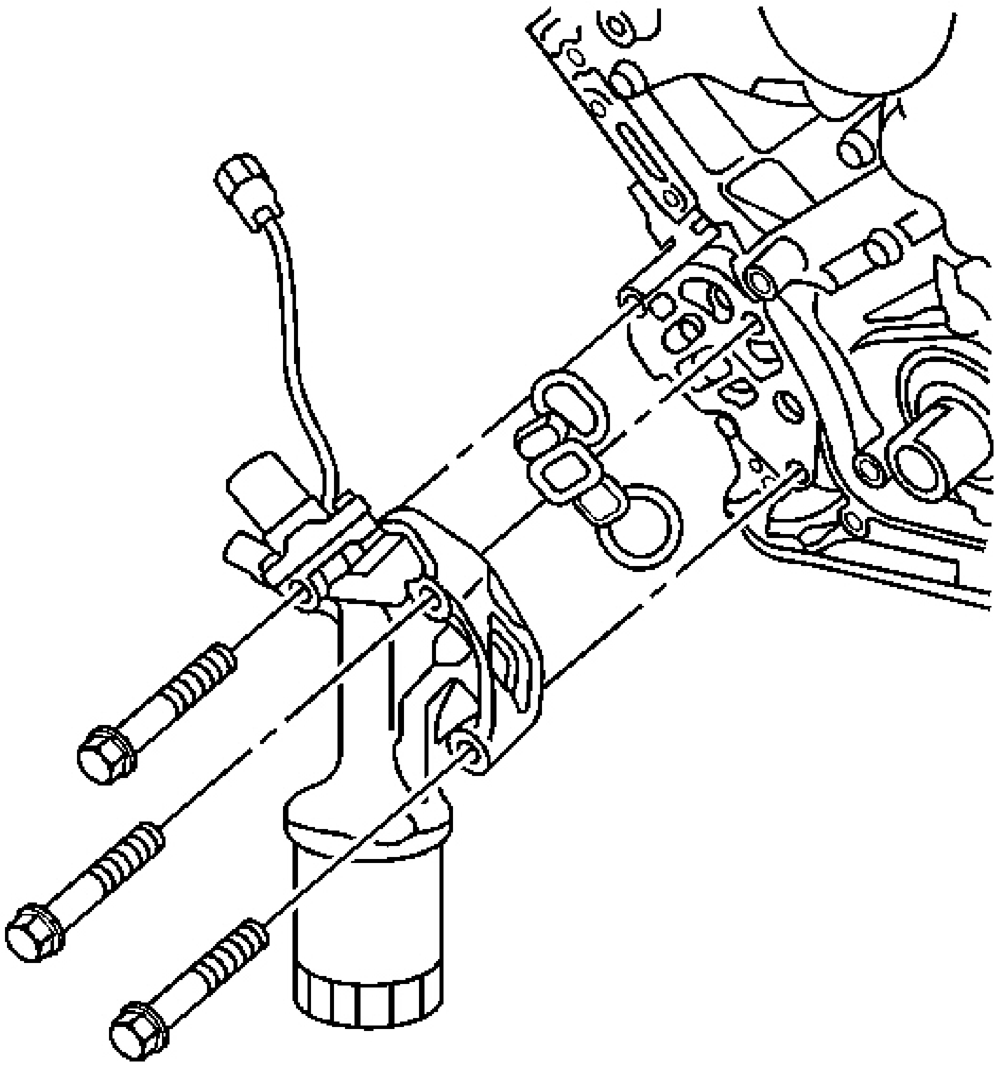


Fig. 164: View Of Rocker Arm Oil Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the NEW O-ring (415), solenoid (416) and bolts (417).

Tighten: Tighten the switch to 12 N.m (106 lb in).

2. Install the splash shield. Refer to**Splash Shield Replacement - Engine** in Body Front End.
3. Install the wheel. Refer to**Tire and Wheel Removal and Installation** in Tires and Wheels.
4. Lower the vehicle.

ROCKER ARM OIL PRESSURE SWITCH REPLACEMENT

Removal Procedure

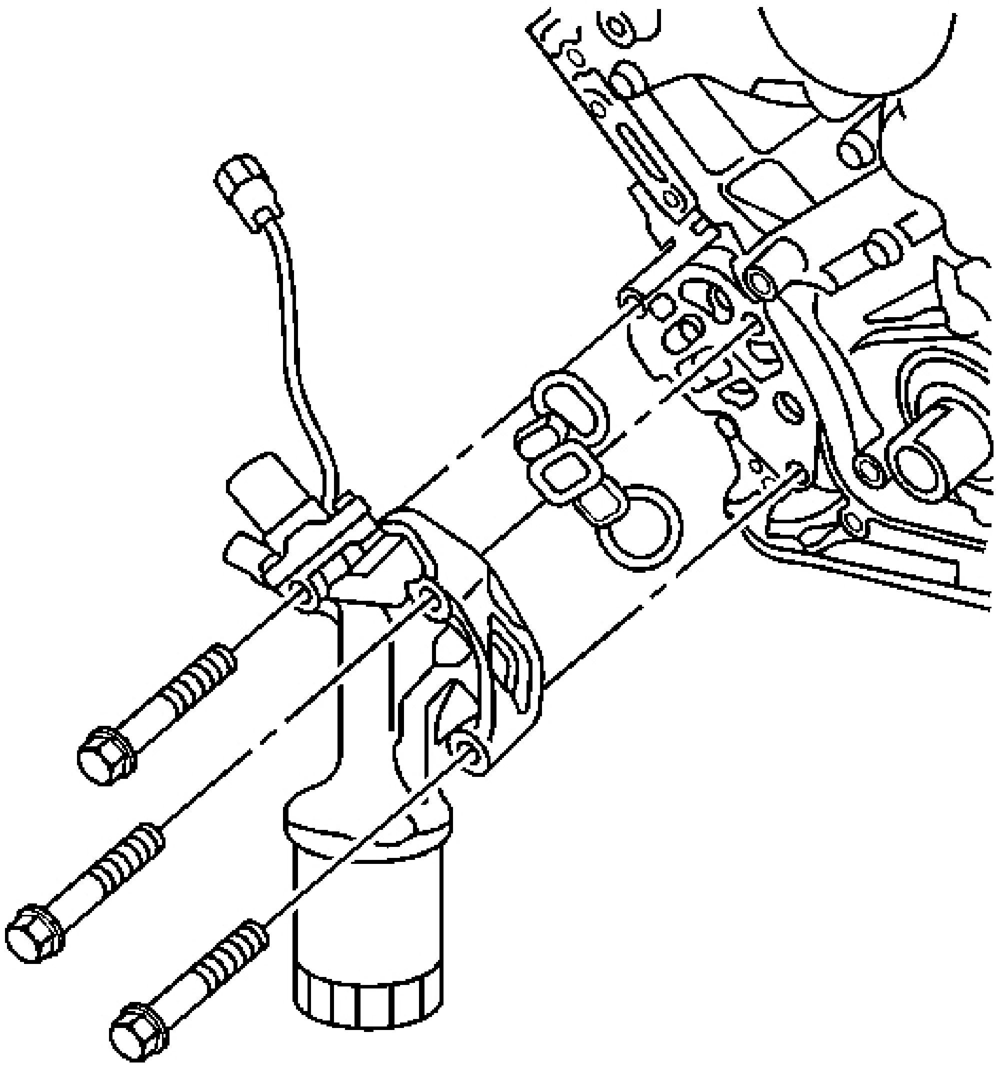


Fig. 165: View Of Rocker Arm Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to**Lifting and Jacking the Vehicle** in General Information.
2. Remove the right front wheel. Refer to**Tire and Wheel Removal and Installation** in Tires and Wheels.
3. Remove the splash shield. Refer to**Splash Shield Replacement - Engine** in Body Front End.
4. Remove the switch and O-ring.
5. Discard the O-ring.

Installation Procedure

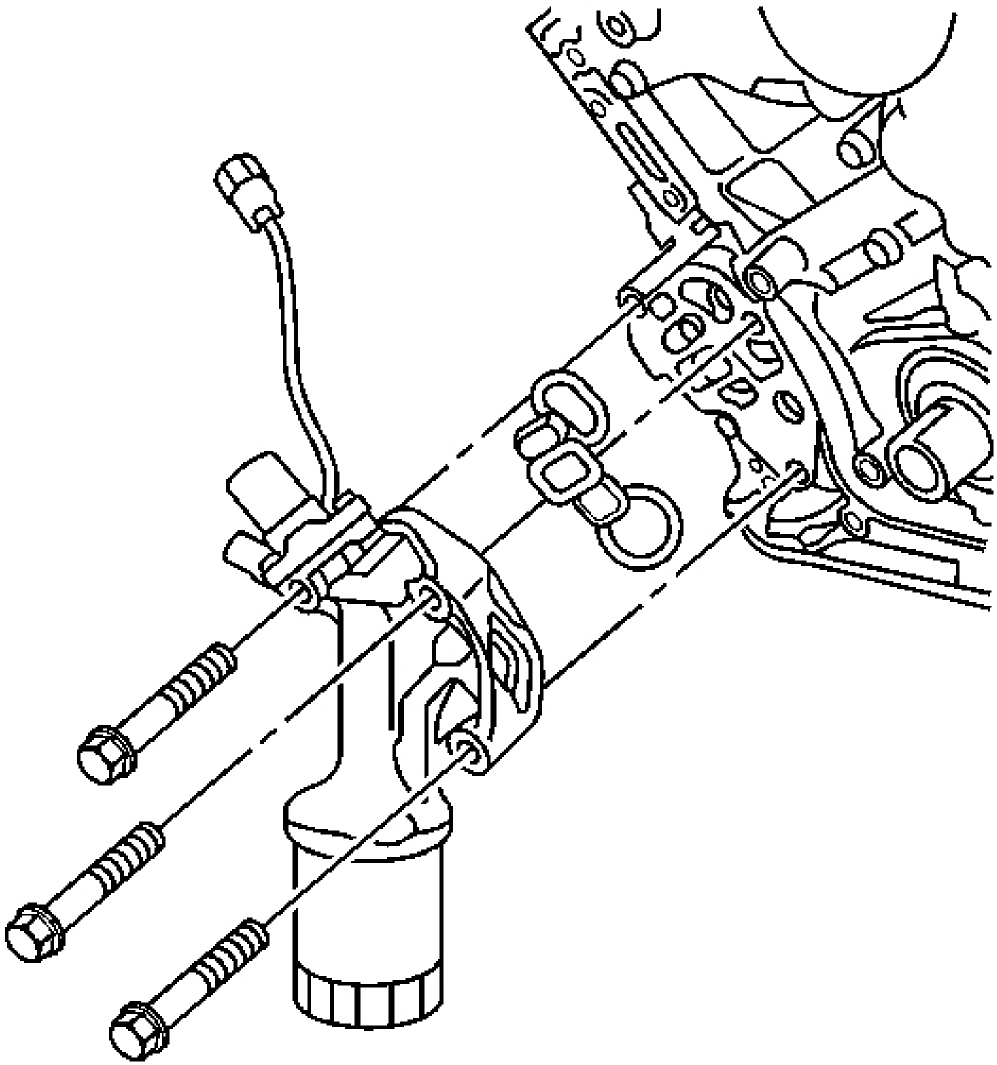


Fig. 166: View Of Rocker Arm Oil Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the NEW O-ring and switch.

Tighten: Tighten the switch to 22 N.m (16 lb ft).

2. Install the splash shield. Refer to**Splash Shield Replacement - Engine** in Body Front End.
3. Install the wheel. Refer to**Tire and Wheel Removal and Installation** in Tires and Wheels.
4. Lower the vehicle.

KNOCK SENSOR (KS) REPLACEMENT

Removal Procedure

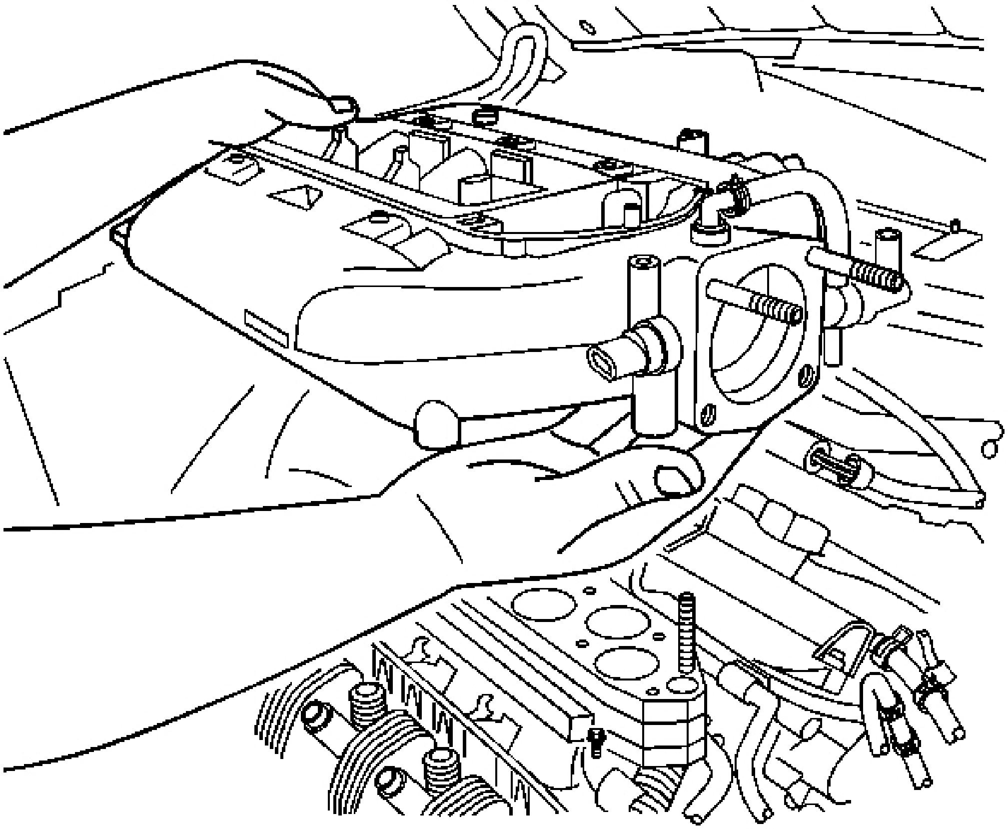


Fig. 167: View Of Knock Sensor (KS)
Courtesy of GENERAL MOTORS CORP.

1. Remove the lower left intake manifold. Refer to **Intake Manifold Spacer Replacement** and **Intake Manifold Replacement - Lower Left** in Engine Mechanical - 3.5L (L66).
2. Disconnect the wiring harness connector from the knock sensor (KS).

3. Remove the KS from the engine block.

Installation Procedure

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: DO NOT apply thread sealant to the sensor threads. The sensor threads are coated at the factory and applying additional sealant affects the sensors ability to detect detonation.

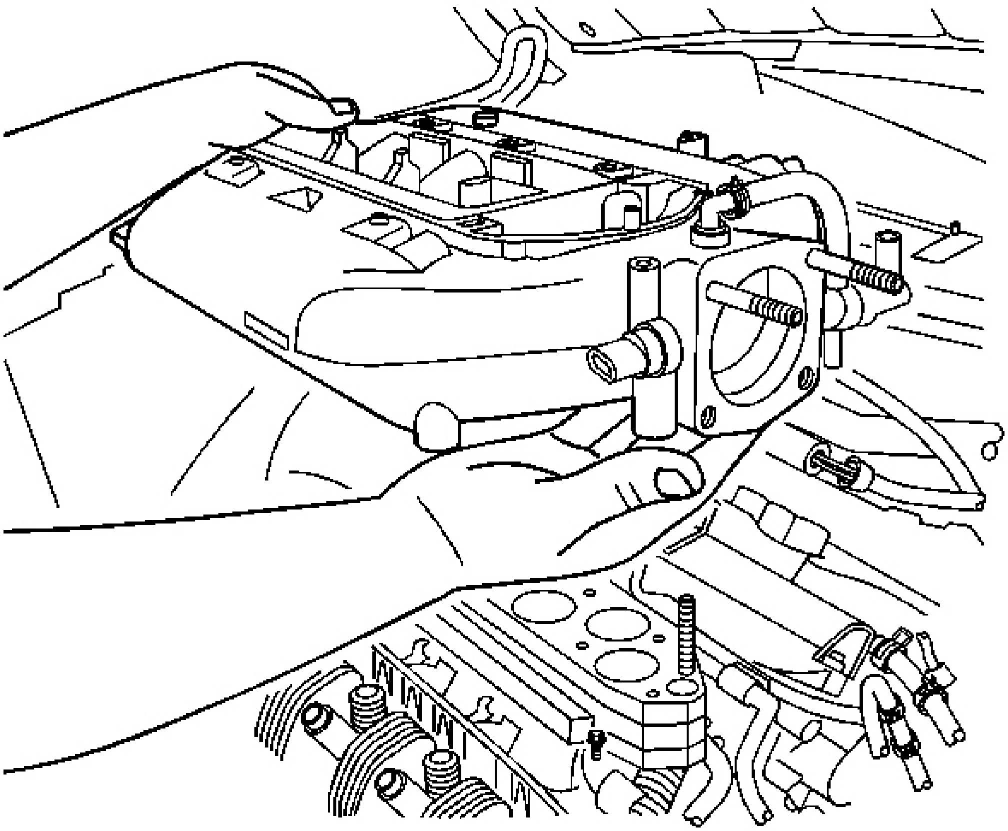


Fig. 168: View Of Knock Sensor (KS)
Courtesy of GENERAL MOTORS CORP.

1. Install the KS into engine block.

Tighten: Tighten the KS to 31 N.m (23 lb ft).

2. Connect the KS wiring harness connector to the knock sensor.
3. Install the lower left intake manifold. Refer to **Intake Manifold Spacer Replacement** and **Intake Manifold Replacement - Lower Left** in Engine Mechanical - 3.5L (L66).

EXHAUST GAS RECIRCULATION (EGR) VALVE REPLACEMENT

Removal Procedure

1. Turn OFF the ignition.

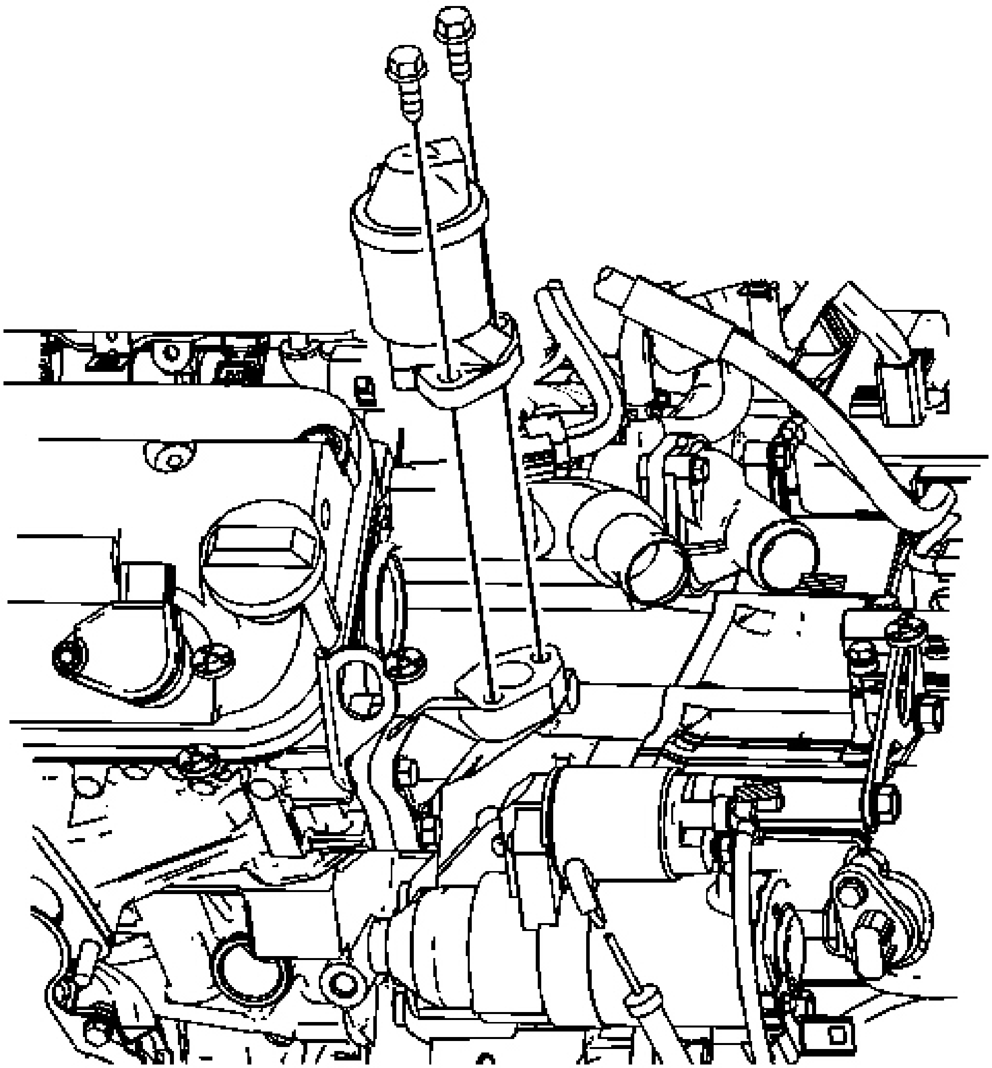


Fig. 169: View Of Exhaust Gas Recirculation (EGR) Valve
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the exhaust gas recirculation (EGR) valve electrical connector.
3. Remove the EGR valve retaining nuts.
4. Remove the EGR valve assembly.
5. Remove the gasket.
6. Clean the EGR valve mating surface.

Installation Procedure

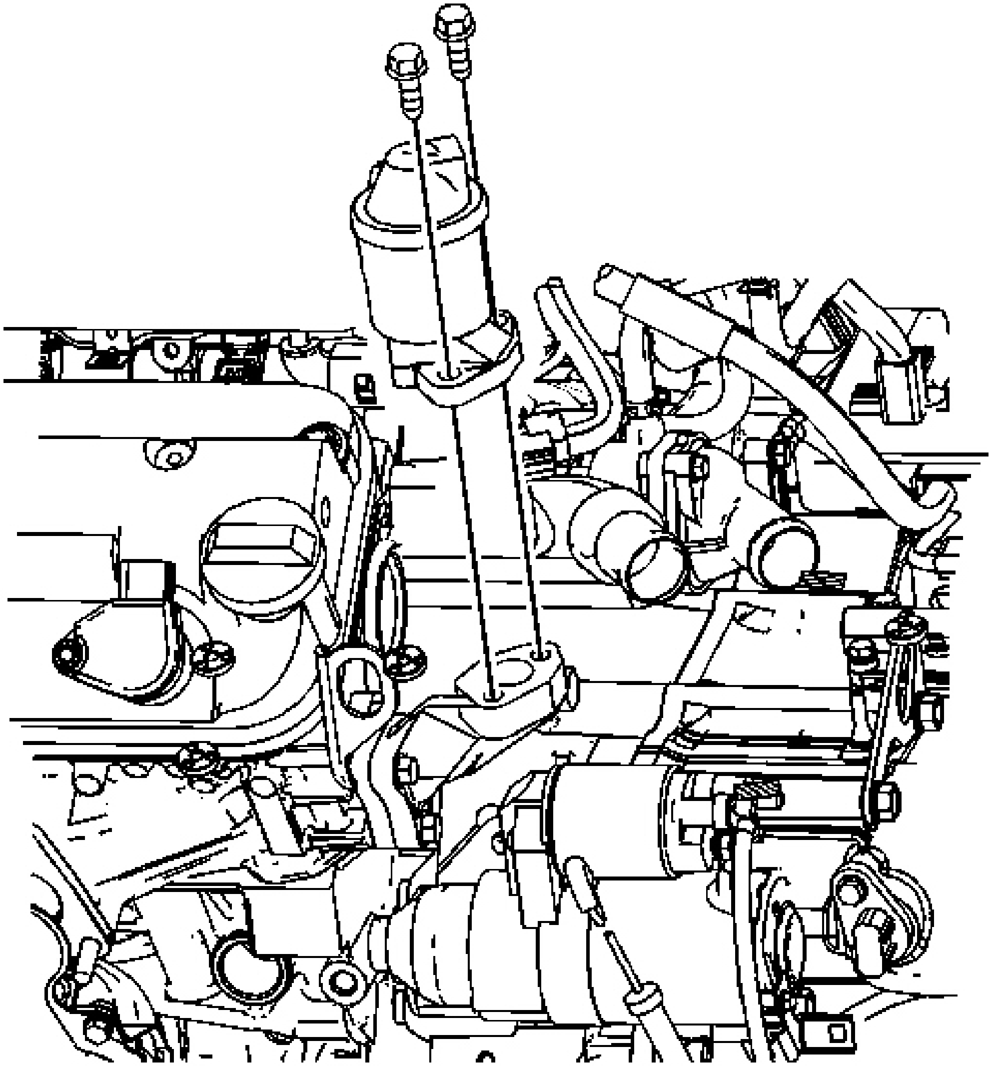


Fig. 170: View Of Exhaust Gas Recirculation (EGR) Valve With A New Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the EGR valve with a new gasket to the engine.

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

2. Install the EGR valve nuts.

   Tighten: Tighten the nuts to 22 N.m (16 lb ft).

3. Connect the EGR valve electrical connector.

AIR CLEANER ELEMENT REPLACEMENT

Removal Procedure

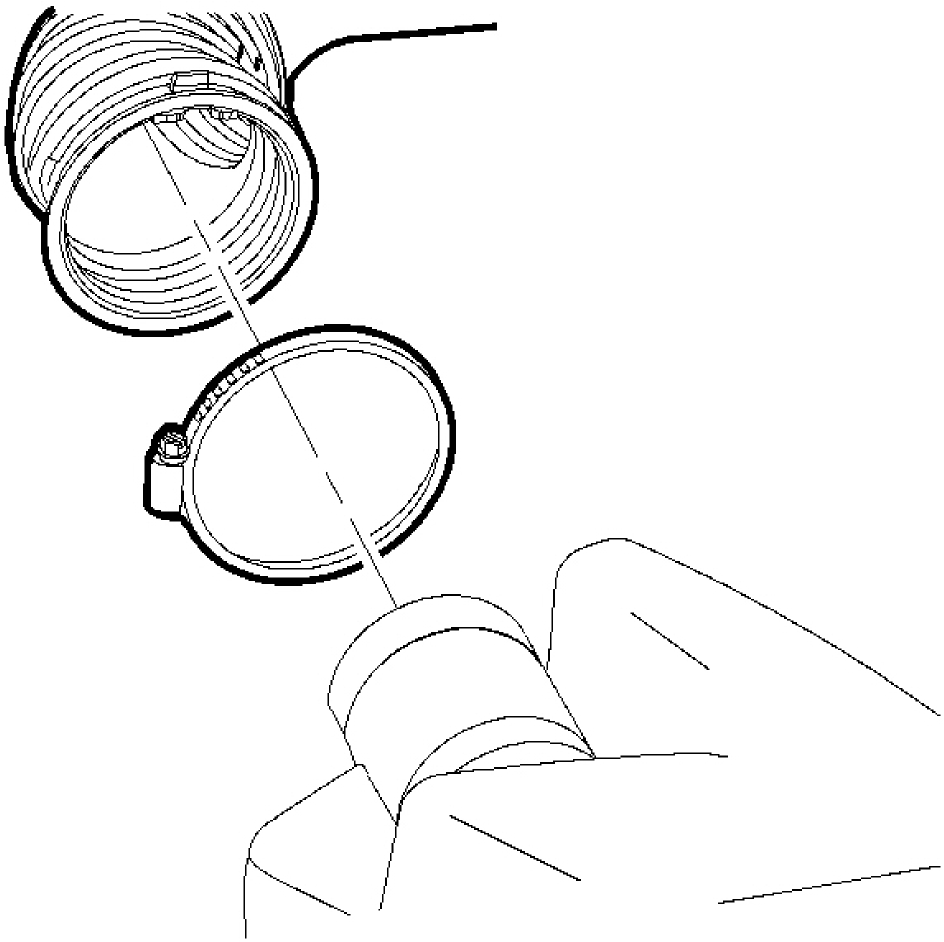


Fig. 171: View Of Air Cleaner Element
Courtesy of GENERAL MOTORS CORP.

1. Loosen the clamp at the air cleaner assembly.
2. Remove the outlet resonator/duct assembly from the air cleaner. Refer to**Air Cleaner Resonator Outlet Duct Replacement** .

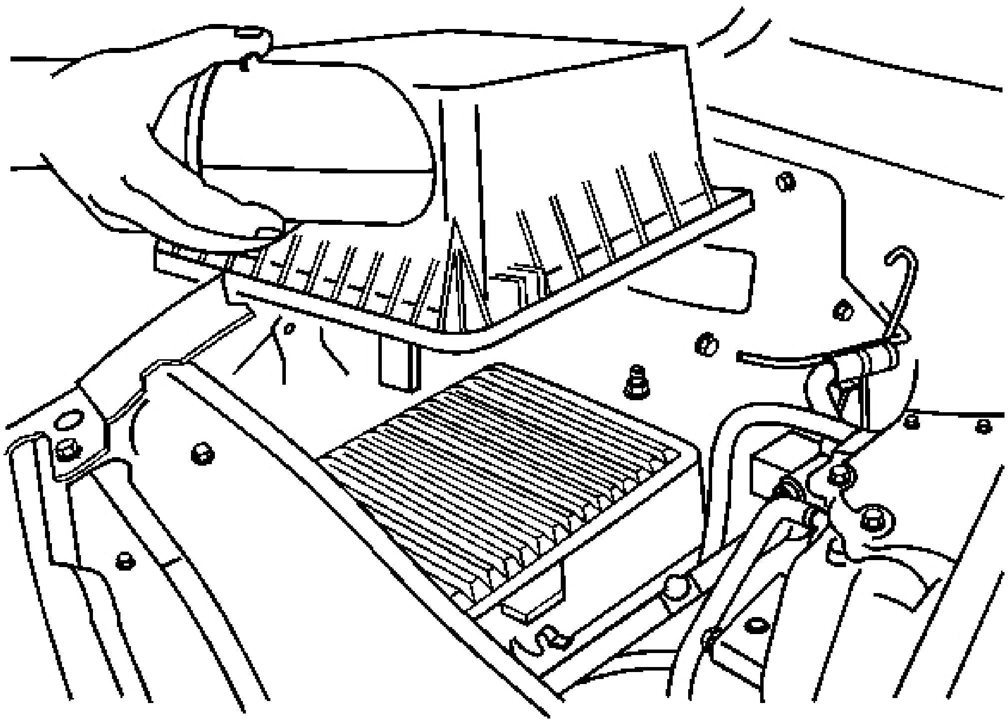


Fig. 172: View Of Filter Element & Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

3. Release the clamps on the side of the air cleaner assembly.
4. Remove the upper air cleaner lid.

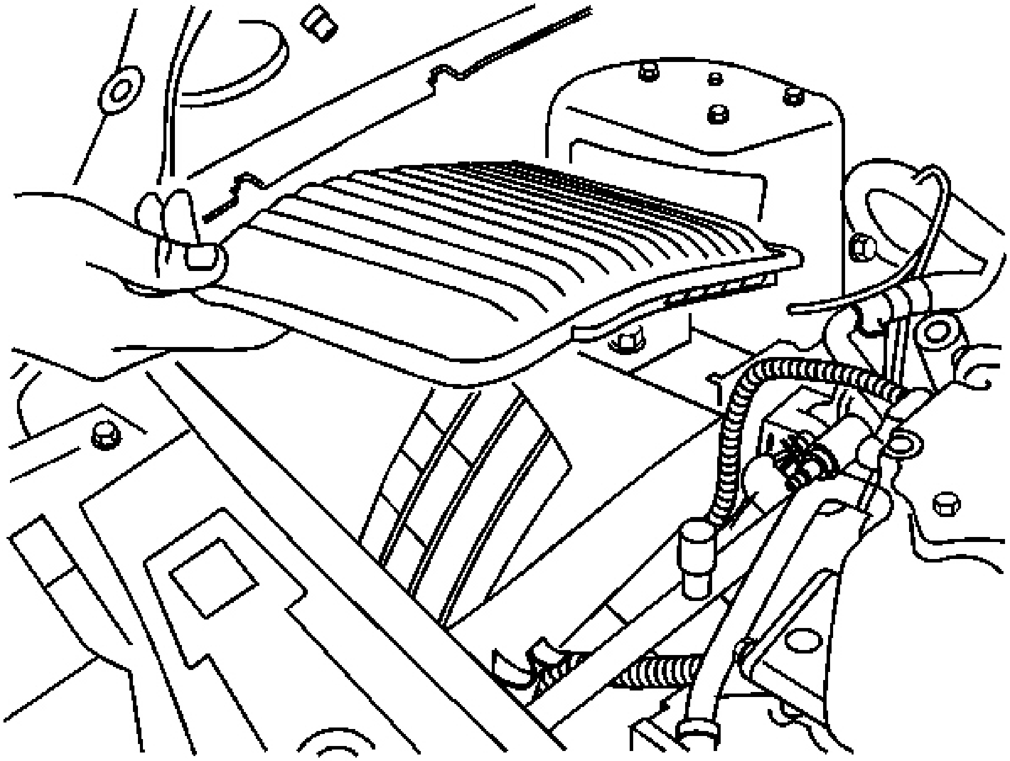


Fig. 173: View Of Air Filter Assembly
Courtesy of GENERAL MOTORS CORP.

5. Remove the air filter assembly.

Installation Procedure

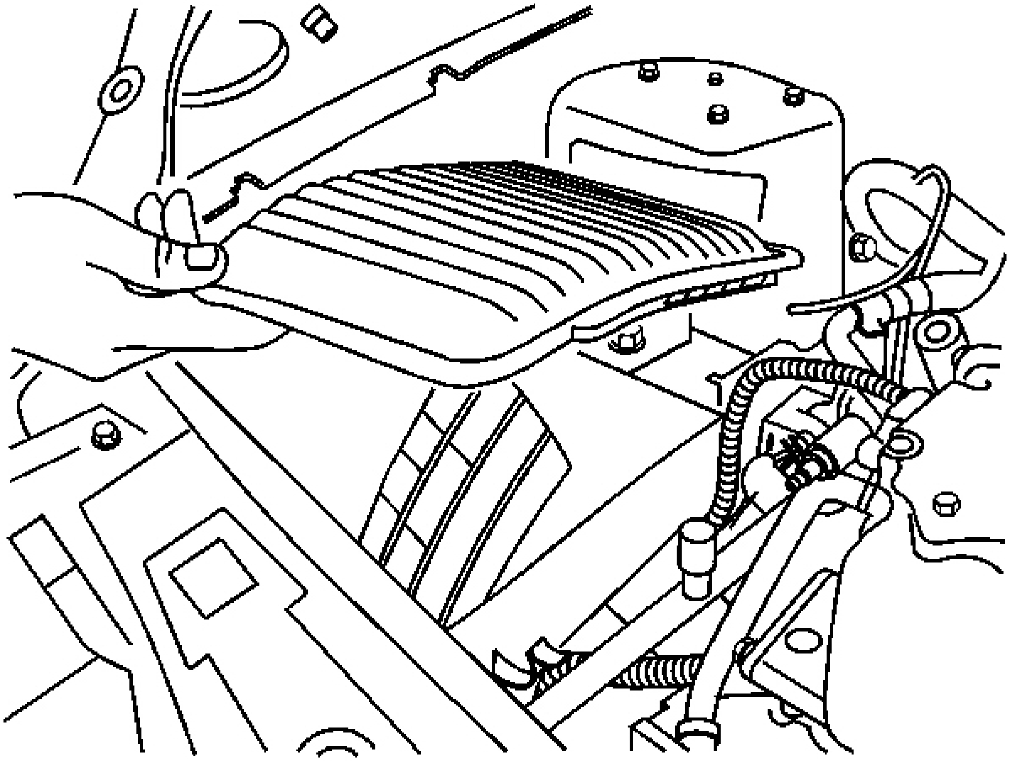


Fig. 174: View Of Air Filter Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the air filter assembly.

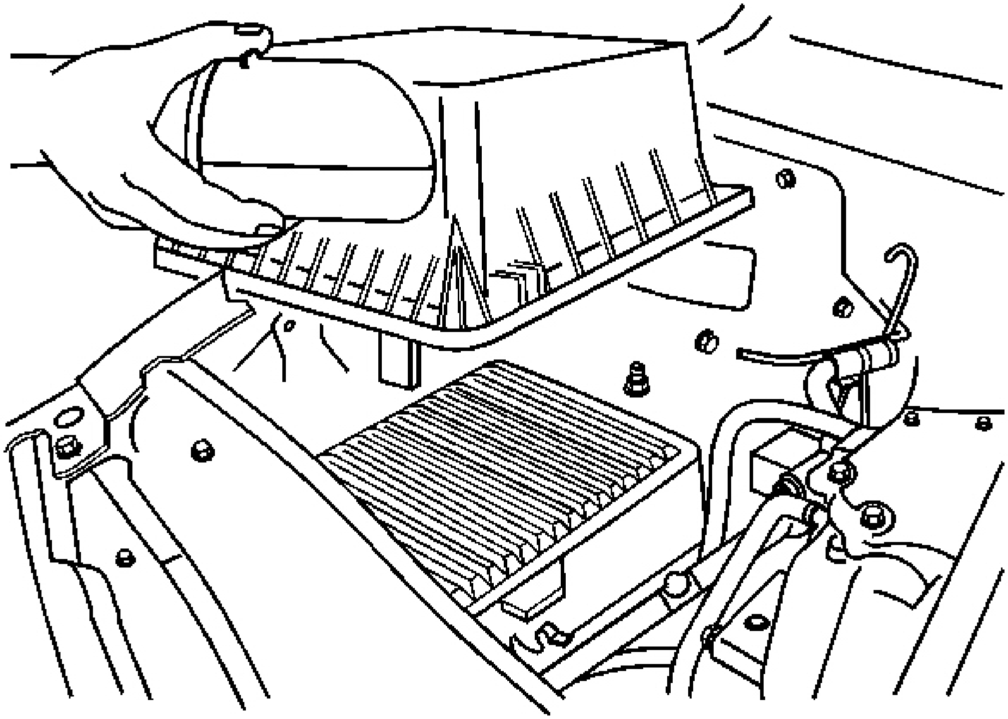


Fig. 175: View Of Filter Element & Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

2. Install the air cleaner assembly lid into position.
3. Fasten the clips into position inside of the air cleaner.
4. Install the outlet resonator/duct assembly into position. Refer to**Air Cleaner Resonator Outlet Duct Replacement** .

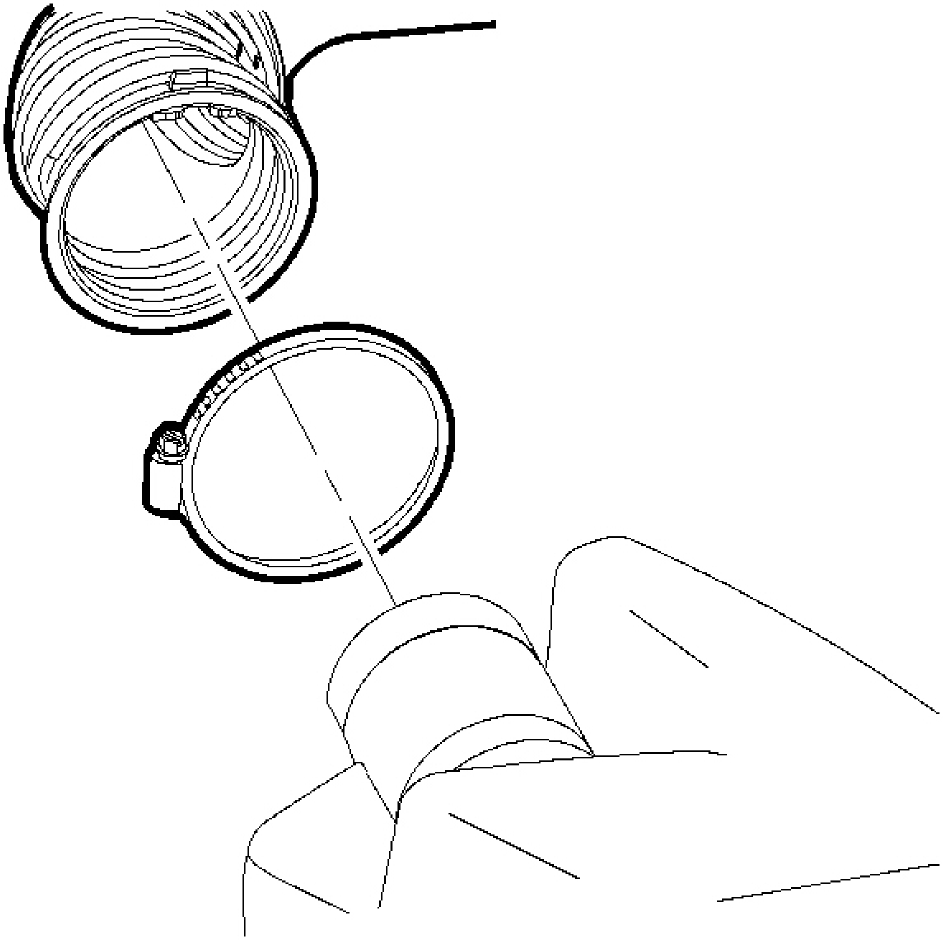


Fig. 176: View Of Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Tighten the clamp at the air cleaner assembly.

   Tighten: Tighten the clamp to 4 N.m (35 lb in).

AIR CLEANER ASSEMBLY REPLACEMENT

Removal Procedure

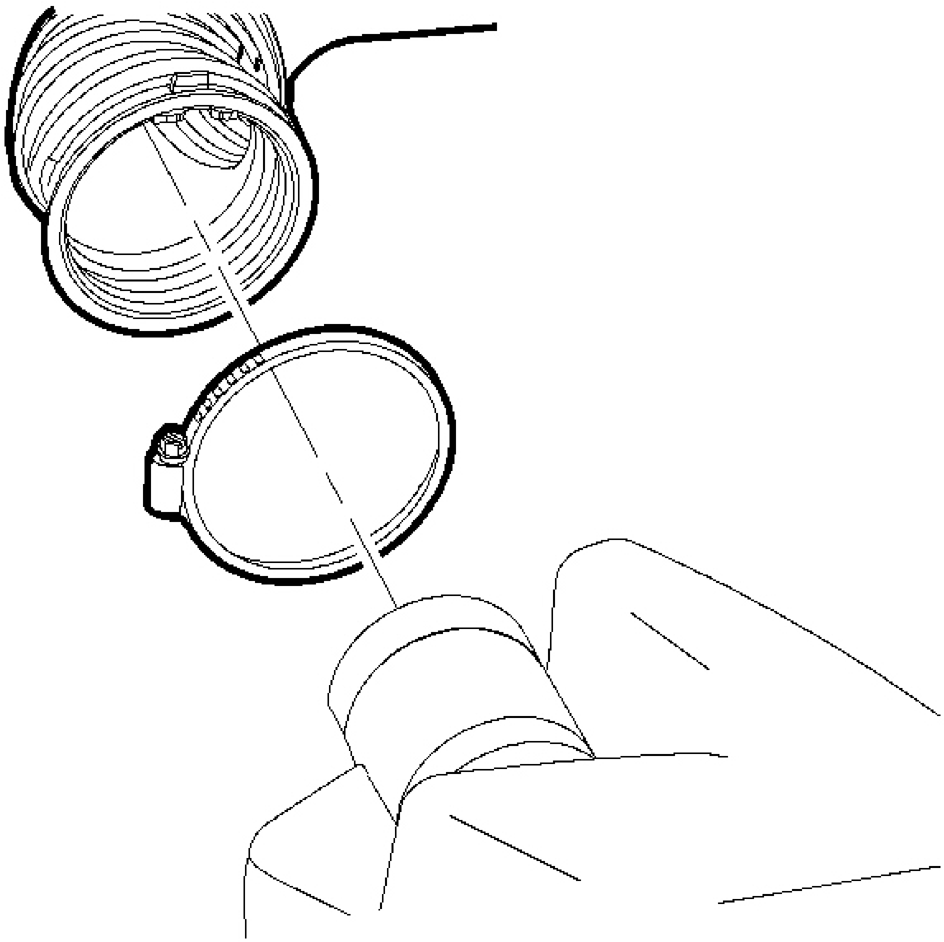


Fig. 177: View Of Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

1. Loosen the clamp at the air cleaner assembly.
2. Disconnect the IAT 1 sensor connector.

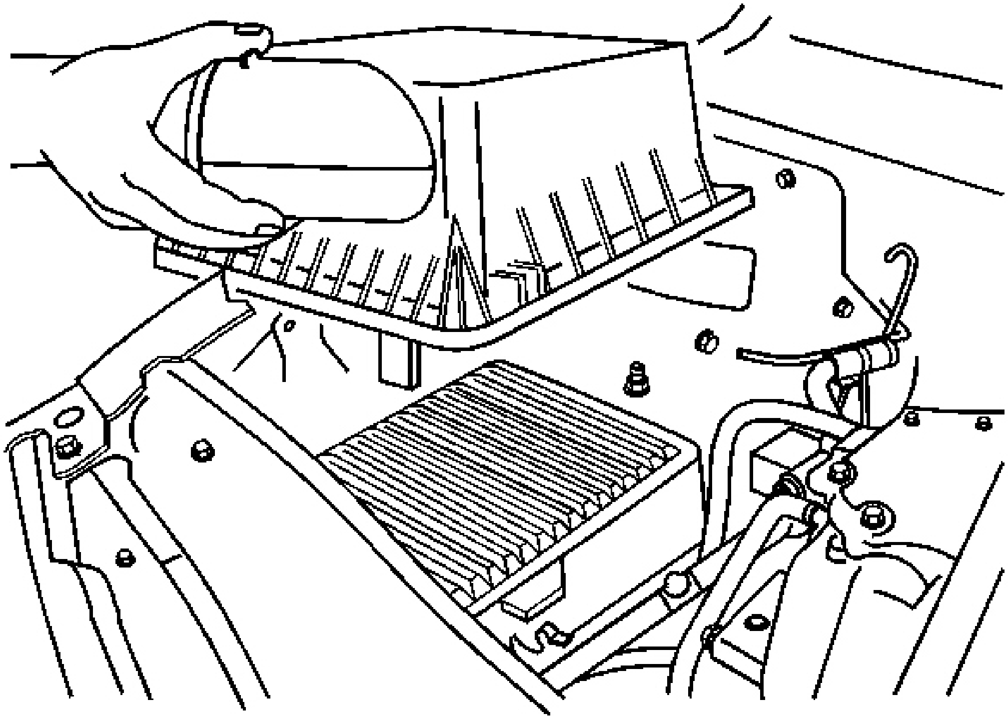


Fig. 178: View Of Filter Element & Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

3. Remove the air cleaner assembly top cover and filter element.

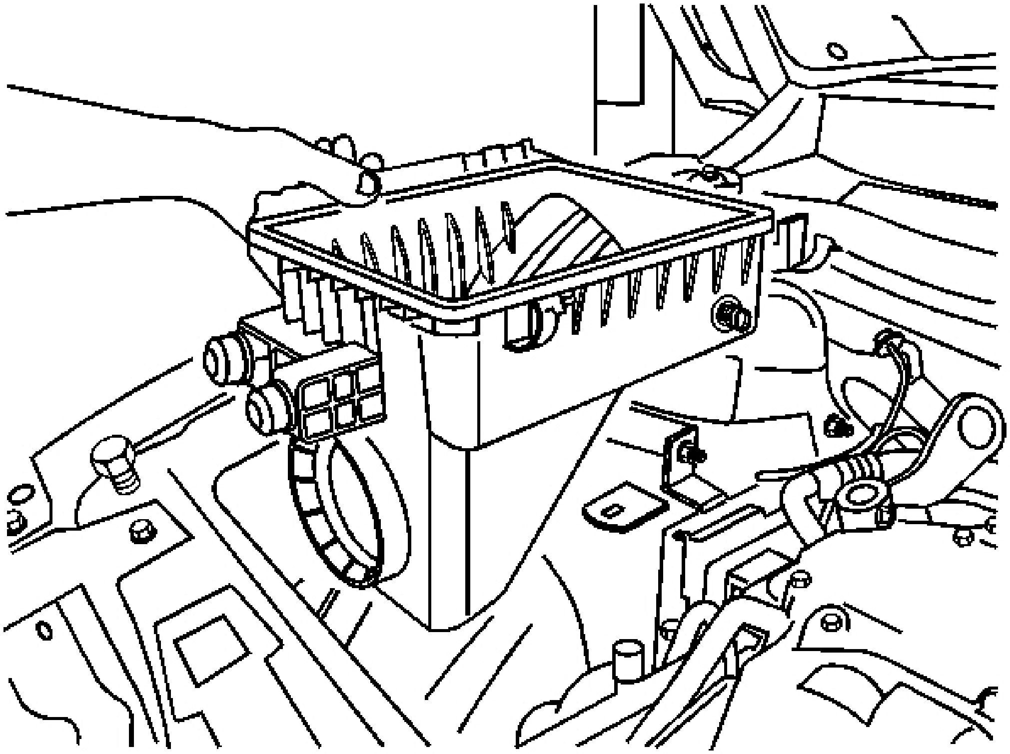


Fig. 179: View Of Air Cleaner Assembly & Aligning Locking Pins Into The Front Panel
Courtesy of GENERAL MOTORS CORP.

4. Remove the air cleaner assembly bolt.
5. Remove the air cleaner assembly.

Installation Procedure

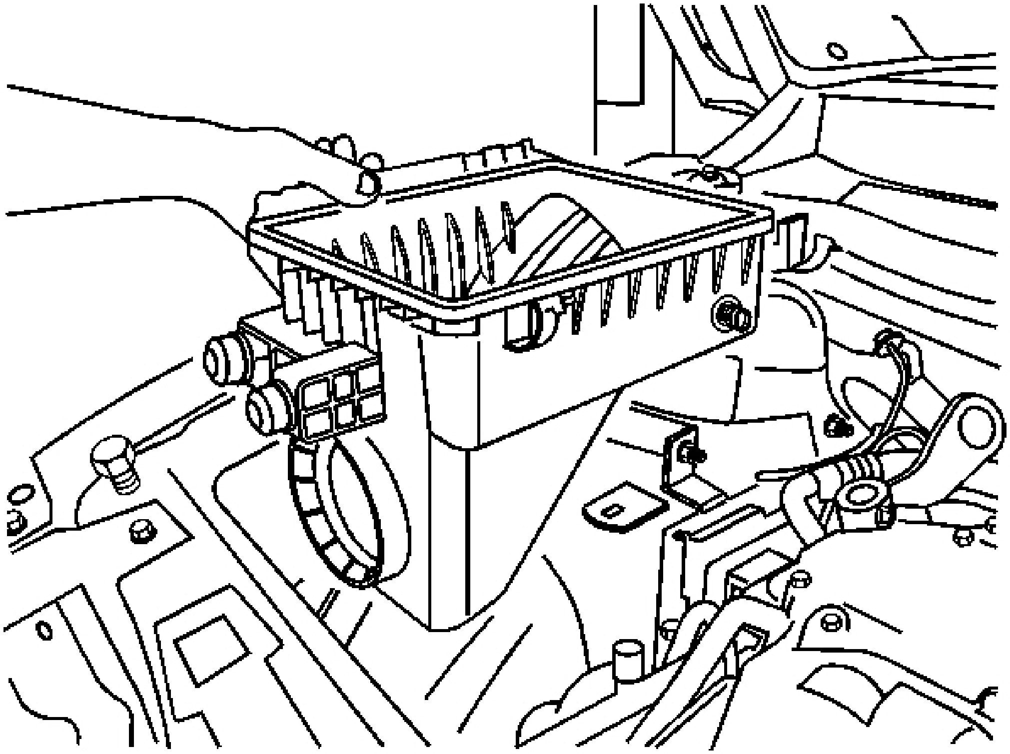


Fig. 180: View Of Air Cleaner Assembly & Aligning Locking Pins Into The Front Panel
Courtesy of GENERAL MOTORS CORP.

1. Install the air cleaner assembly into position, aligning locking pins into the front panel.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the air cleaner attachment bolt.

   Tighten: Tighten the bolt to 10 N.m (89 lb in).

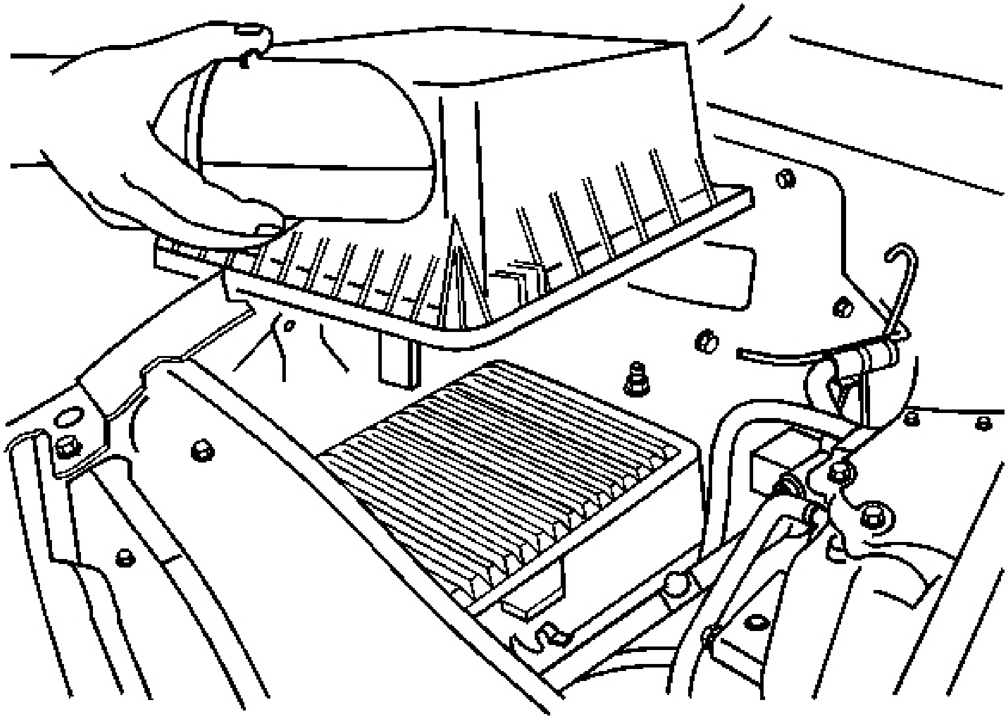


Fig. 181: View Of Filter Element & Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

3. Install the filter element and air cleaner assembly top cover.

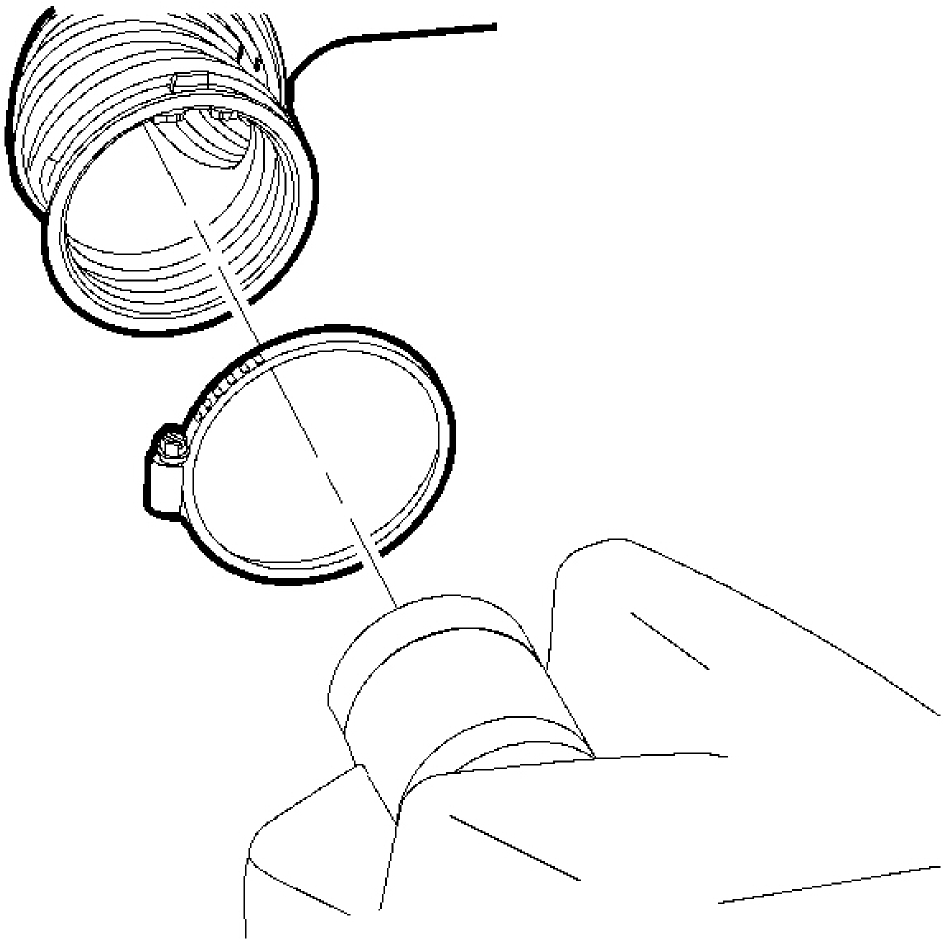


Fig. 182: View Of Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

4. Tighten the clamp at the air cleaner assembly.

   Tighten: Tighten the clamp to 4 N.m (35 lb in).

5. Connect the IAT 1sensor connector.

AIR CLEANER INTAKE DUCT AND RESONATOR REPLACEMENT

Removal Procedure

1. Remove the front fascia. Refer to **Fascia Replacement - Front Bumper** in Bumpers.

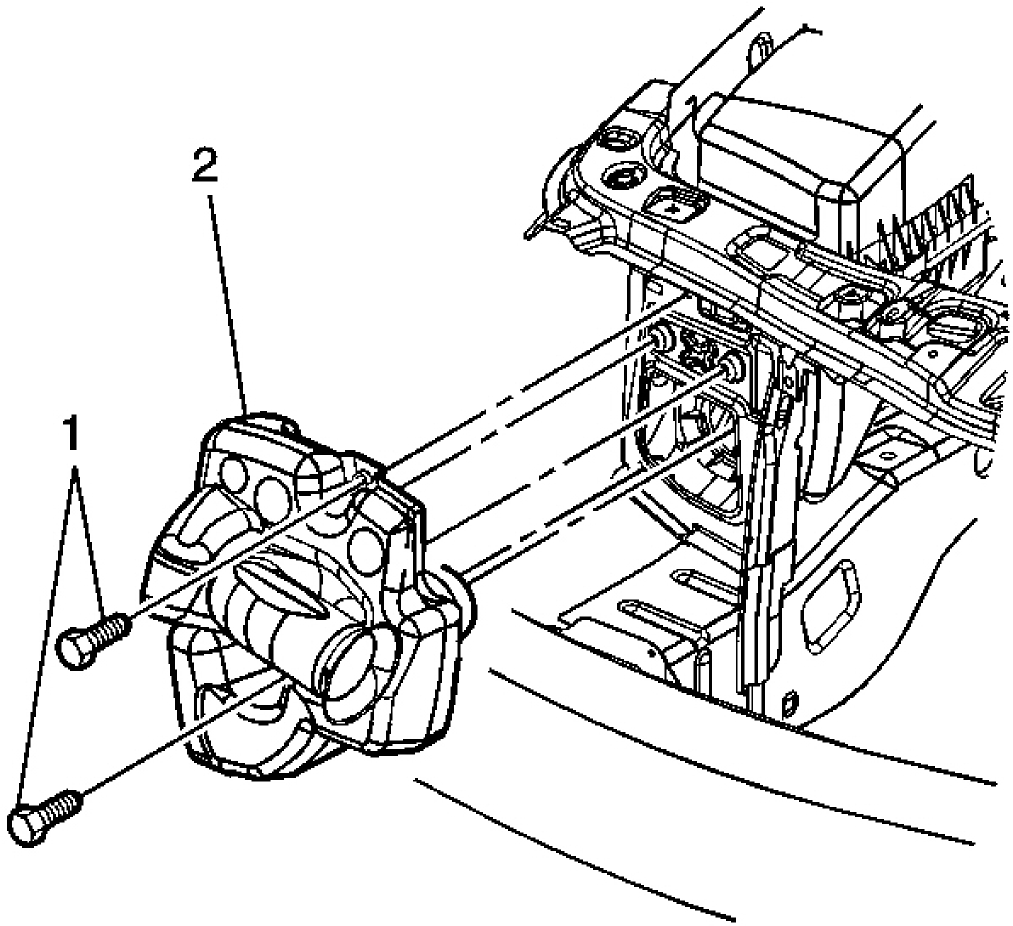


Fig. 183: View Of Inlet Duct Assembly
Courtesy of GENERAL MOTORS CORP.

2. Remove the inlet duct assembly attachment bolts (1).
3. Remove the inlet duct assembly (2).

Installation Procedure

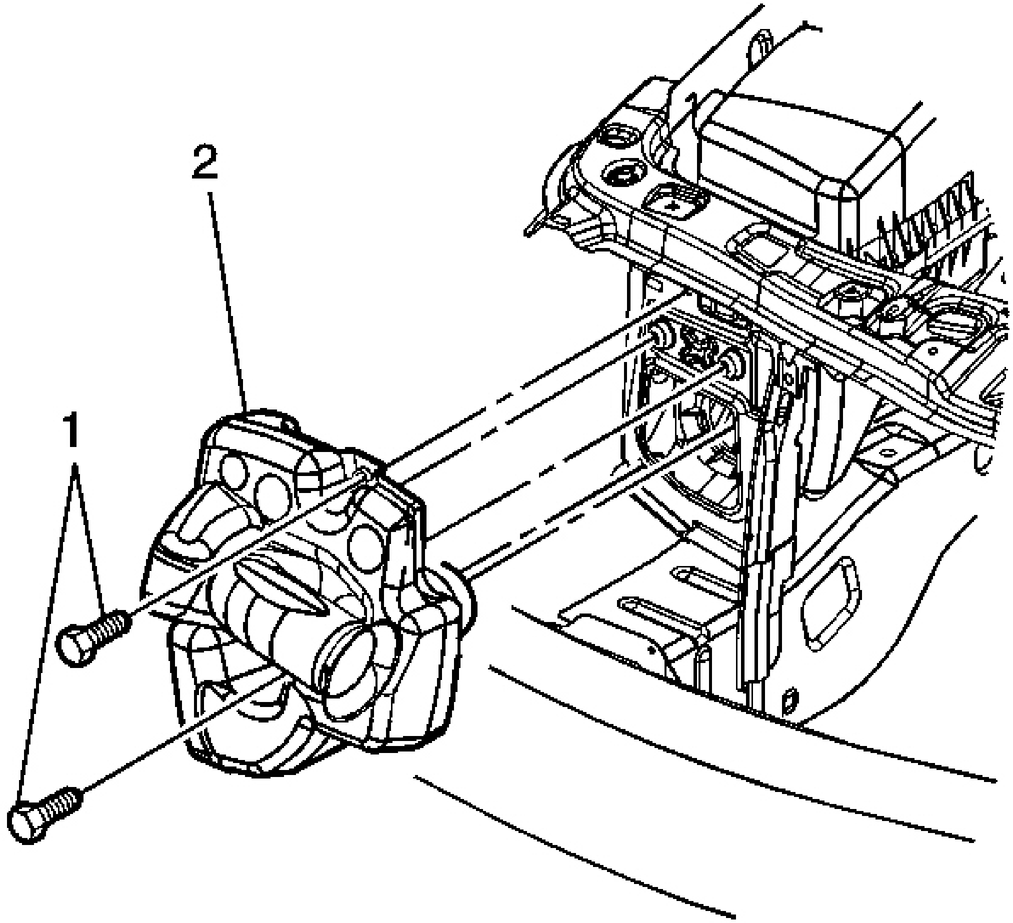


Fig. 184: View Of Inlet Duct Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the inlet duct assembly.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the inlet duct assembly bolts.

   Tighten: Tighten the bolts to 10 N.m (89 lb in).

3. Install the front fascia. Refer to **Fascia Replacement - Front Bumper** in Bumpers.

AIR CLEANER RESONATOR OUTLET DUCT REPLACEMENT

Removal Procedure

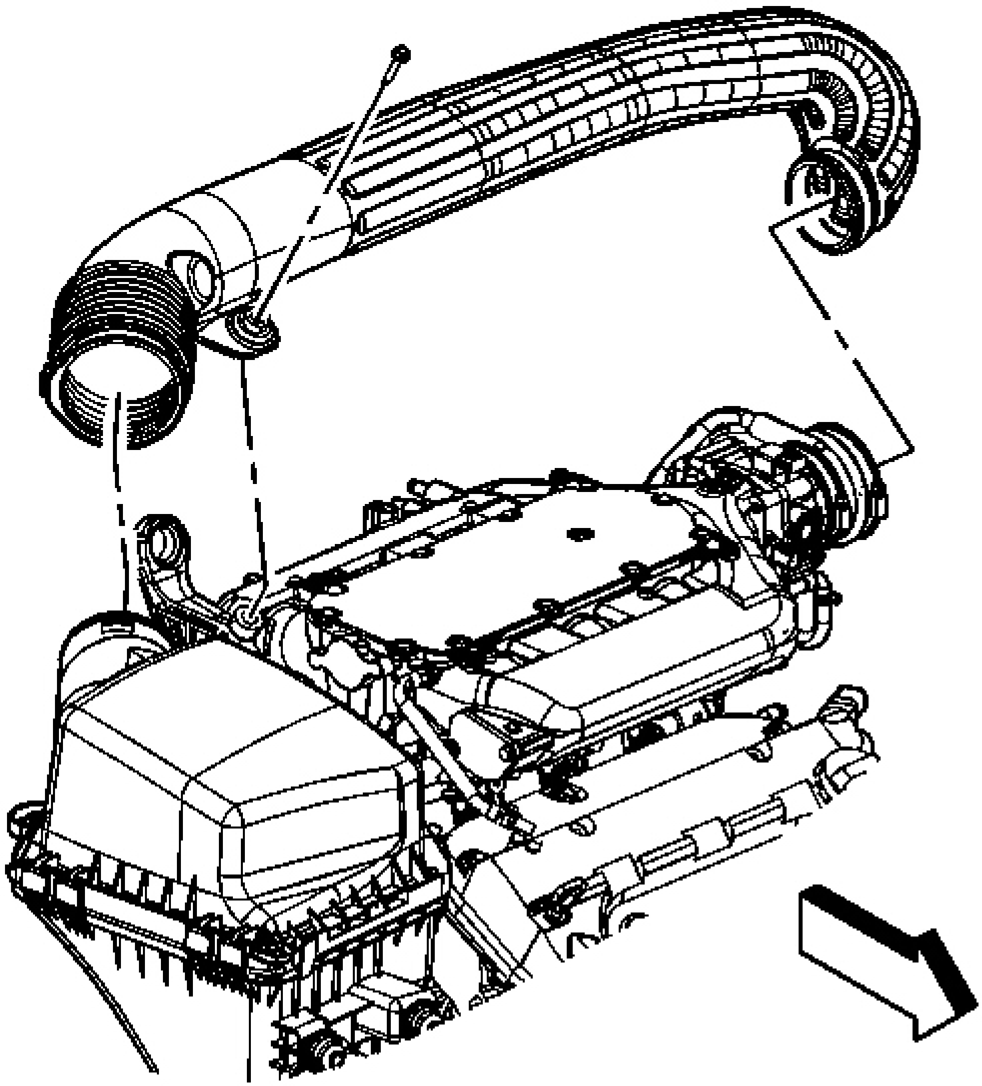


Fig. 185: View Of Air Cleaner Outlet Resonator Duct Assembly
Courtesy of GENERAL MOTORS CORP.

1. Loosen clamp at the air cleaner assembly and the front outlet duct seal assembly.
2. Remove the attachment bolt from the support bracket.
3. Remove the outlet resonator/duct assembly.

Installation Procedure

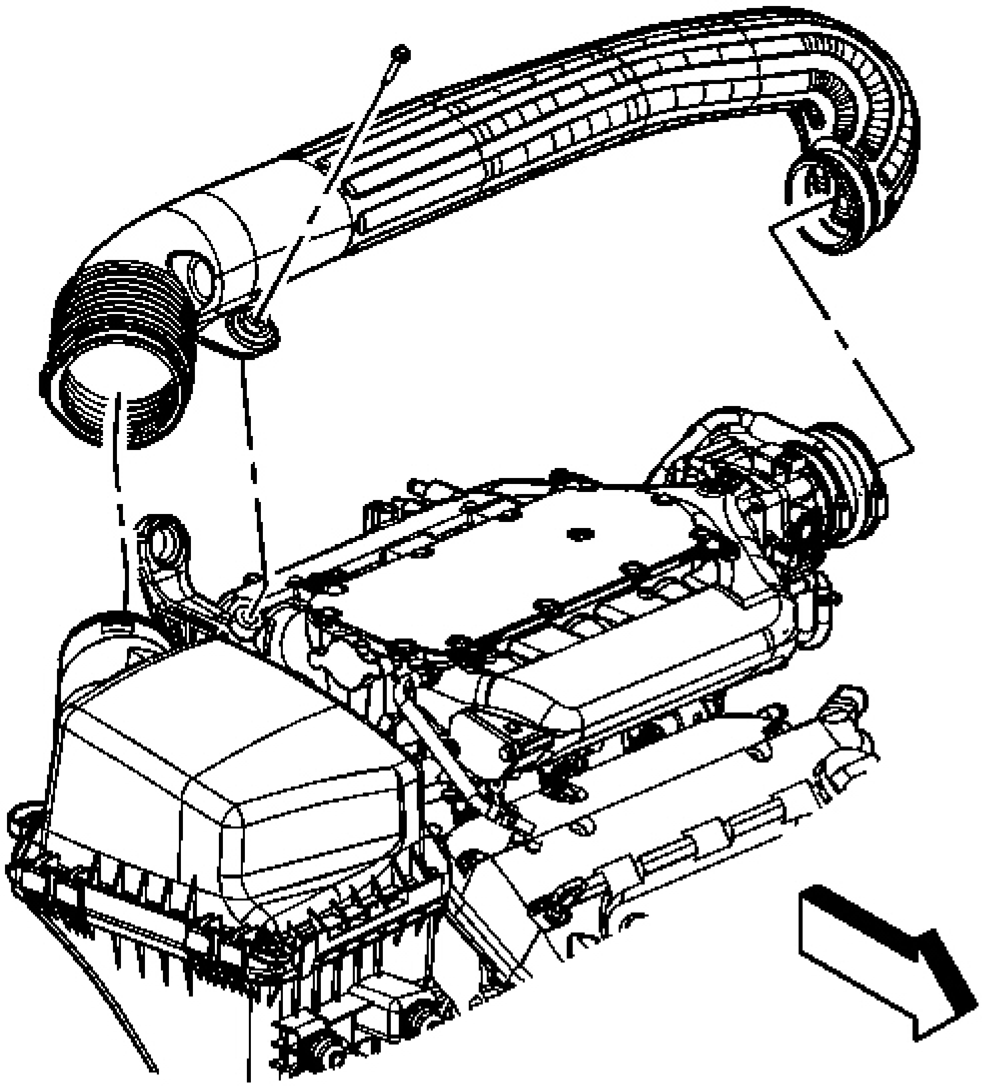


Fig. 186: View Of Outlet Resonator/Duct Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the outlet resonator/duct assembly into position.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Position the outlet resonator/duct assembly to support bracket and install the bolt.

   Tighten: Tighten the bolt to 10 N.m (89 lb in).

3. Tighten the clamps at the air cleaner assembly and the front outlet duct seal assembly.

   Tighten: Tighten the clamps to 4 N.m (35 lb in).

DESCRIPTION AND OPERATION

POWERTRAIN CONTROL MODULE (PCM) DESCRIPTION

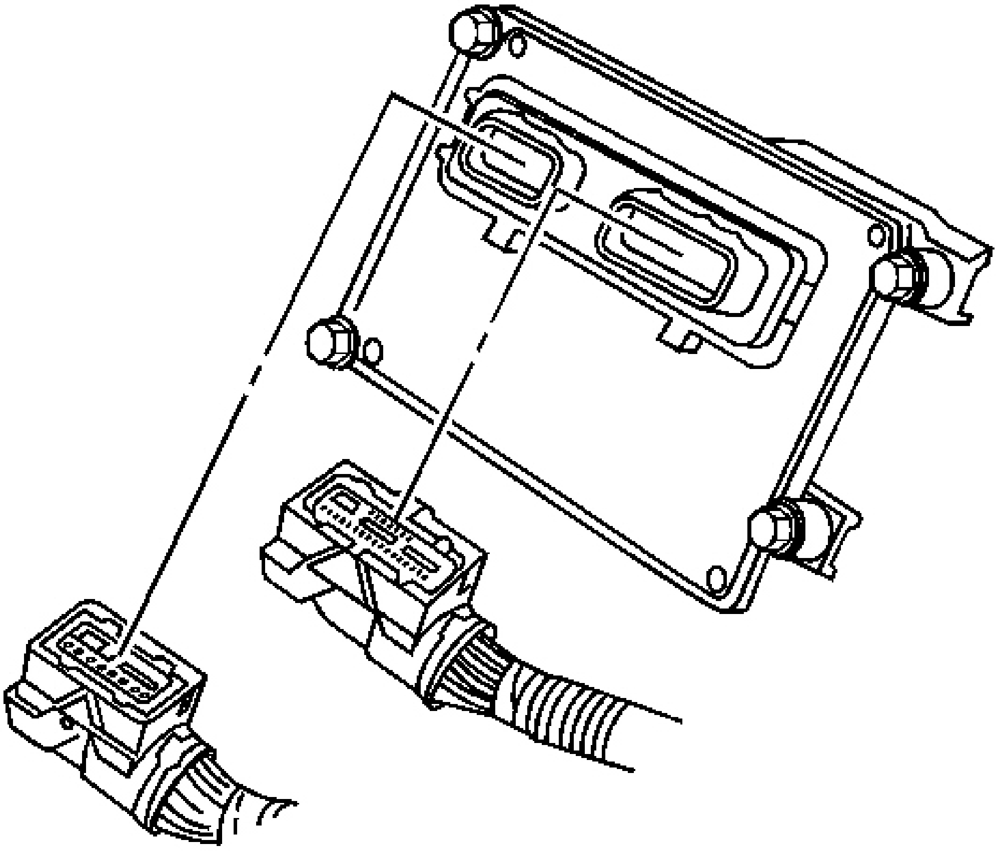


Fig. 187: View Of Powertrain Control Module (PCM)
Courtesy of GENERAL MOTORS CORP.

The powertrain control module (PCM) is a precision 32-bit microprocessor and is an essential part of the electronic control system. The PCM is located underhood on the right side of the engine compartment. The PCM uses a KW2000 communication protocol. Communication with the PCM is through the data link connector located on the left side of the passenger compartment below the IP.

The PCM performs the OBD II diagnostic tests of the emission related systems. The PCM supplies a buffered voltage, called reference voltage, to the various information sensors and switches. The PCM controls most components with an electronic switch that completes a ground circuit when turned ON. The electronic switch is commonly referred to as an output driver. The PCM is also responsible for a self-diagnosis function and a fail-safe function.

Self-Diagnosis Function

The powertrain control module (PCM) diagnoses any troubles which may occur in the engine control system when the ignition switch is in the ON position with the engine running. The PCM indicates a malfunction by illuminating the malfunction indicator lamp (MIL) when a fault occurs in any of the following systems:

- The heated oxygen sensor 1 (HO2S 1)
- The heated oxygen sensor 2 (HO2S 2)
- The engine coolant temperature (ECT) sensor
- The accelerator pedal position (APP) sensors
- The intake air temperature (IAT) sensors
- The camshaft position (CMP) sensor
- The crankshaft position (CKP) sensors
- The knock sensor (KS) system
- The evaporative emission (EVAP) control system
- The throttle actuator control (TAC) system
- The rocker arm oil control system
- The vehicle speed sensor (VSS)
- The misfire detection
- The fuel-trim
- The catalyst monitor
- The central processing unit (CPU) of the PCM

When the PCM detects a malfunction in one of the above areas, the PCM will illuminate or flash the MIL in order to notify the driver of the occurrence of a fault.

Malfunction Indicator Lamp (MIL) Operation

The malfunction indicator lamp (MIL) is located in the instrument panel cluster. The MIL will display as either SERVICE ENGINE SOON or one of the following symbols when commanded ON:

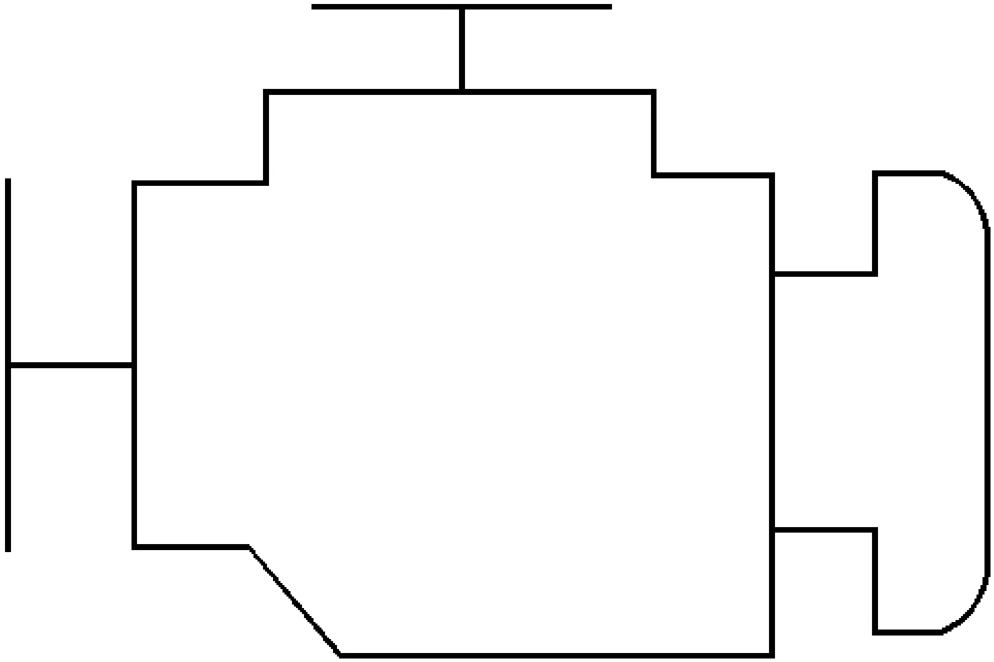


Fig. 188: Identifying MIL Symbol
Courtesy of GENERAL MOTORS CORP.

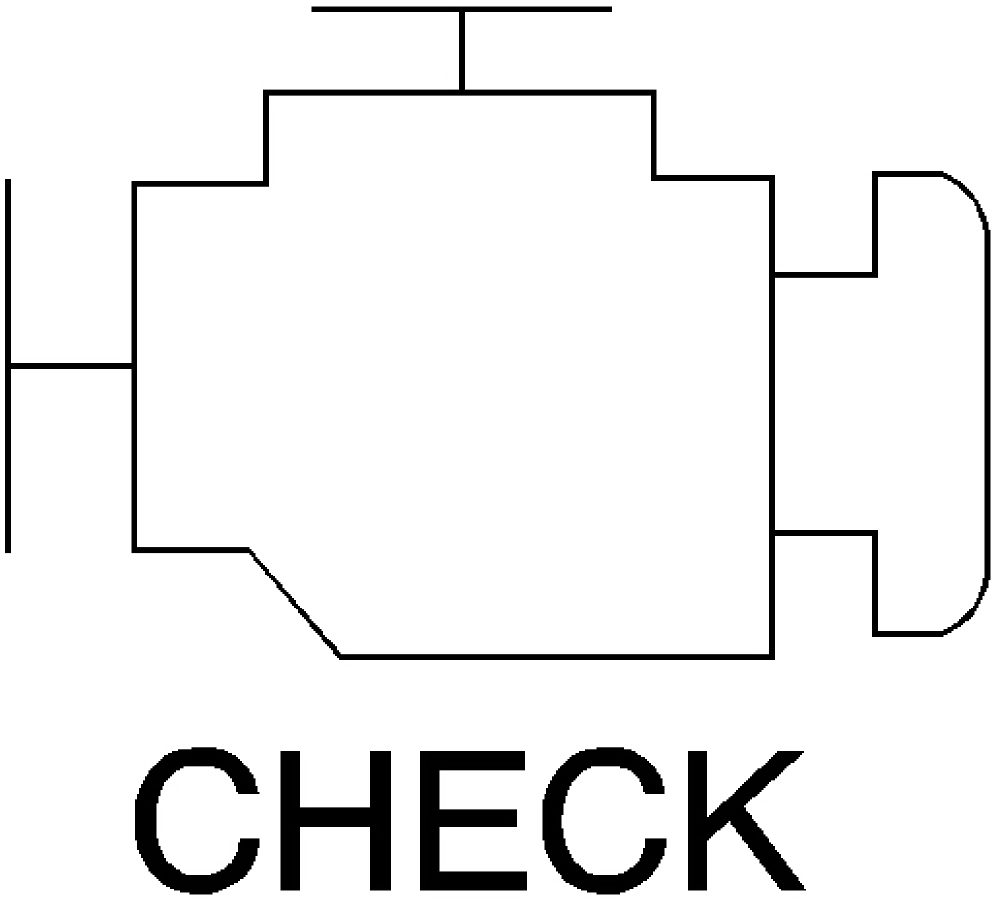


Fig. 189: MIL ON (Check)
Courtesy of GENERAL MOTORS CORP.

The MIL indicates that an emissions related fault has occurred and vehicle service is required.

The following is a list of the modes of operation for the MIL:

- The MIL illuminates when the ignition is turned ON, with the engine OFF. This is a bulb test to ensure the MIL is able to illuminate.
- The MIL turns OFF after the engine is started if a diagnostic fault is not present.
- The MIL remains illuminated after the engine is started if the control module detects a fault. A diagnostic trouble code (DTC) is stored any time the control module illuminates the MIL due to an emissions related fault. The MIL turns OFF after three consecutive ignition cycles in which a Test Passed has been reported

for the diagnostic test that originally caused the MIL to illuminate.

- The MIL flashes if the control module detects a misfire condition which could damage the catalytic converter.
- When the MIL is illuminated and the engine stalls, the MIL will remain illuminated as long as the ignition is ON.
- When the MIL is not illuminated and the engine stalls, the MIL will not illuminate until the ignition is cycled OFF and then ON.

Fail-Safe Function

When a malfunction occurs within the engine control system, the PCM maintains control over the fuel injection system, the idle speed control system, etc. The PCM controls these systems by using calculated values and/or backup programs stored within the PCM.

This function is called the fail-safe function. With the fail-safe function, a certain level of engine performance is available even when a malfunction occurs. The fail-safe function prevents a complete loss of engine performance.

The systems covered by the fail-safe function are as follows:

- The IAT sensor
- The TAC system
- The HO2S heater circuits
- The KS system
- The CPU in the PCM
- The fuel cut-off for certain system failures

Control Module Learning Ability

The powertrain control module has a "learning" ability which enables the control module to make corrections for minor variations in the fuel system. These "learned values" can improve driveability. Disconnecting the battery resets the learning process. A change in the vehicle's performance may be noticed when a reset from a PCM power down occurs. Operating the vehicle under varying conditions will enable the control module to regain any lost vehicle performance.

In order to initiate the control module learning ability, warm the engine to operating temperature and drive the vehicle at part throttle with moderate acceleration. Continue to drive the vehicle while including steady cruise and idle speed operation. For the best idle speed quality several key cycles with a short drive and long idle periods is recommended.

PCM Long Term Memory and Engine Off Diagnostics

Several ignition positive voltage circuits supply battery power to the PCM even when the ignition switch is turned OFF. The continuous battery power enables the PCM to support a long term memory. The long term memory provides storage of diagnostic trouble codes, diagnostic test status, and the aforementioned "learned values" that improve driveability.

Another use of continuous battery power is the PCM can run certain system diagnostics with the engine off. One of these diagnostics is the engine off natural vacuum (EONV) EVAP system leak test. With the engine OFF, the PCM can turn on the main relay and provide power to operate the EVAP solenoids while monitoring the fuel tank pressure. During the running of the EONV diagnostic routine, the PCM can be fully powered up for as long as 30 minutes.

PCM Output Controls

The powertrain control module (PCM) can be directed by a scan tool to operate certain solenoids, valves, motors, and switches. This scan tool function is generally referred to as Output Controls. The Output Controls can be found under Special Functions selection of the scan tool. Some Output Controls may be disabled by the PCM during certain types of vehicle operation. Operating a PCM controlled device with the scan tool should be limited to a maximum of ten seconds per test period.

Data Link Connector (DLC)

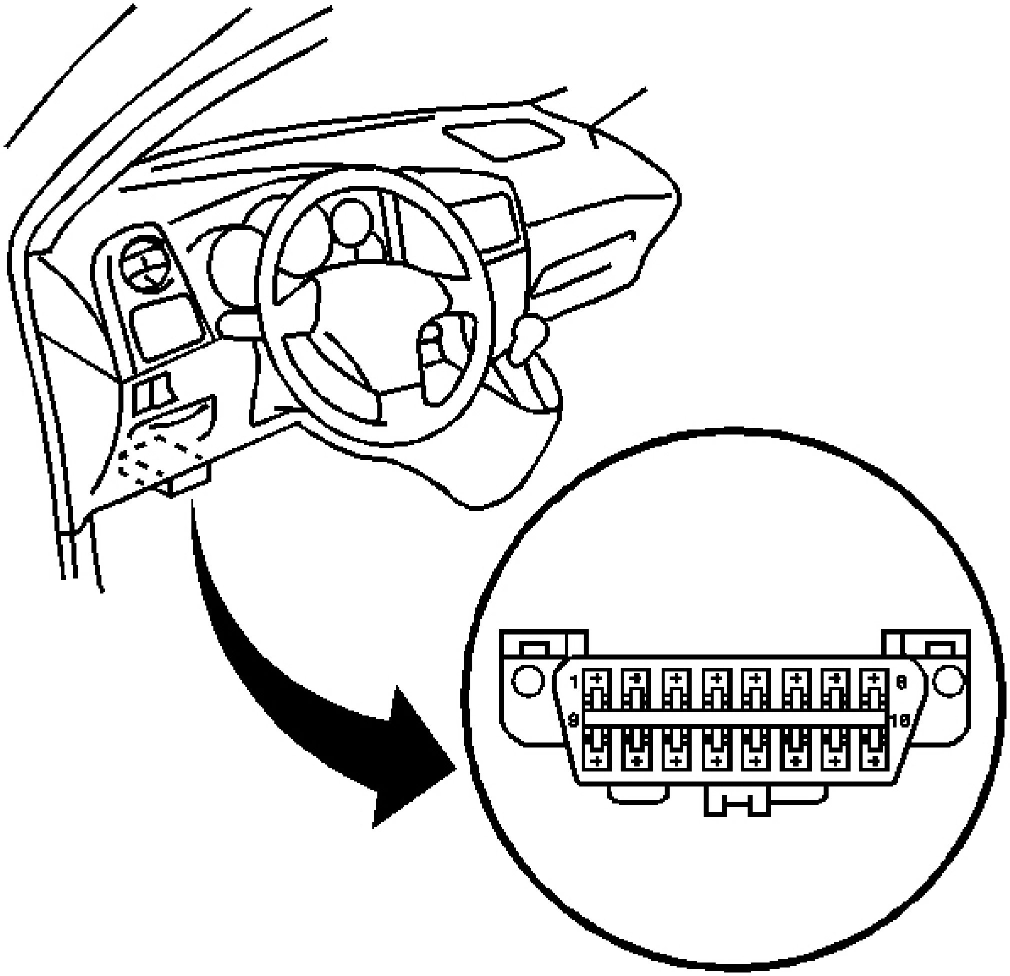


Fig. 190: View Of Data Link Connector (DLC)
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use a scan tool that displays faulty data. Report the scan tool problem to the manufacturer. Use of a faulty scan tool can result in misdiagnosis and unnecessary parts replacement.

The provision for communicating with the control module is the data link connector (DLC). The DLC is located under the instrument panel to the left of the steering column. The DLC is used to connect to a scan tool. Some common uses of the scan tool are listed below:

- Identifying stored diagnostic trouble codes (DTCs)

- Clearing the DTCs
- Performing output control tests
- Reading the serial data

Reading Diagnostic Trouble Codes

The procedure for reading diagnostic trouble codes is to use a diagnostic scan tool. Follow the instructions supplied by the scan tool manufacturer in order to read DTCs accurately.

Clearing Diagnostic Trouble Codes

IMPORTANT: Do not clear the DTCs unless directed to do so by the service information provided for each diagnostic procedure. The Freeze Frame data which may help diagnose an intermittent fault will be erased from the memory when the DTCs are cleared.

The PCM will begin to count the warm-up cycles when the fault that caused the DTC to be stored into memory has been corrected. The DTC will automatically be cleared from the PCM memory when the PCM has counted 40 consecutive warm-up cycles with no further faults detected.

Diagnostic trouble codes (DTCs) can be cleared using a scan tool. In order to clear DTCs, use the scan tools Clear DTC Information function. Follow the instructions supplied by the scan tool manufacturer.

Aftermarket (Add-On) Electrical and Vacuum Equipment

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

NOTE: 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.

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

Add-on electrical equipment may cause the engine control system to malfunction even when the add-on electrical equipment is installed properly. Portable telephones and radios may also cause engine control system malfunctions even when not connected to the vehicles electrical system. The first step in diagnosing any engine control system problem is to remove all aftermarket electrical equipment from the vehicle. Diagnosis may proceed in the normal manner after eliminating aftermarket equipment as a cause of the engine control system malfunction.

Electrostatic Discharge (ESD) Damage

NOTE: In order to prevent possible Electrostatic Discharge damage to the PCM, Do Not touch the connector pins or the soldered components on the circuit board.

Electronic components used in the engine control system are often designed to operate at very low voltages. Electronic components are susceptible to damage caused by electrostatic discharge. Less than 100 volts of static electricity can cause damage to some of the electronic components. 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. Therefore, use care when handling and testing electronic components in order to avoid electrostatic charges that can cause electronic component damage.

Input Components

The PCM supplies a buffered (reference) voltage to the various information sensors and switches. The PCM monitors the input components for circuit continuity and out-of-range values. The PCM also provides performance checking. Performance checking refers to the PCM indicating a fault when the signal from an input does not seem reasonable, i.e., a throttle position (TP) sensor that indicates a high throttle position at low engine loads or low manifold absolute pressure sensor voltage. The input components may include, but are not limited to the following sensors and switches:

- The crankshaft position (CKP) sensor
- The camshaft position (CMP) sensor
- The accelerator pedal position (APP) sensors
- The serial data from the throttle actuator control (TAC) module
- The engine coolant temperature (ECT) sensor
- The intake air temperature (IAT) sensors
- The heated oxygen sensors (HO2S)
- The fuel tank pressure (FTP) sensor
- The exhaust gas recirculation (EGR) valve position sensor
- The vehicle speed sensor (VSS)
- The rocker arm oil pressure switch
- The power steering pressure (PSP) switch, if equipped
- Transmission sensors and switches
- A/C system sensors

Output Components

The PCM is responsible for the control and operation of many output components. The PCM controls many components with an electronic switch called an output driver that completes a ground circuit when turned ON. The PCM monitors the output components for the proper response to the PCM commands. Components where functional monitoring is not feasible will be monitored for circuit continuity and out-of-range values if applicable.

Output components to be monitored include, but are not limited to the following circuits:

- The throttle actuator control (TAC) motor
- The rocker arm oil control solenoid valve
- The exhaust gas recirculation (EGR) valve
- The fuel pump relay
- The evaporative emission (EVAP) system solenoids
- The malfunction indicator lamp (MIL) control
- The A/C compressor controls
- The electronic transaxle controls

Catalyst Monitor Diagnostic Operation

The powertrain control module (PCM) uses certain diagnostic strategies known as primary system based diagnostics that evaluate the various primary system operations. The primary system based diagnostics also evaluate the various primary system operations affect on vehicle emissions. Some of the primary system based diagnostics are listed here with a brief functional description of the diagnostics involved.

The OBD 2 catalyst monitor diagnostic measures the oxygen storage capacity of the 3-way catalytic converter (TWC). Heated oxygen sensors (HO2S) are installed before (pre-catalyst) and after (post-catalyst) the TWC. Voltage variations between the sensors allow the PCM to determine the performance of the TWC catalyst. When the TWC catalyst becomes less effective in promoting chemical reactions, the catalyst's capacity to store and release oxygen is generally degraded. The OBD 2 catalyst monitor diagnostic is based on a correlation between the conversion efficiency of the TWC catalyst and the oxygen storage capacity of the catalyst. A good catalyst, e.g., 95 percent hydrocarbon conversion efficiency, will show a relatively flat output voltage on the post-catalyst sensor, HO2S 2. A degraded catalyst, 65 percent hydrocarbon conversion, will show greatly increased activity in the output voltage from the post catalyst HO2S.

The post-catalyst HO2S is used to measure the oxygen storage and release capacity of the catalyst in the TWC. A high oxygen storage capacity indicates a good catalyst. A low oxygen storage capacity indicates a failing catalyst. The TWC and the HO2S 2 must be at operating temperature in order to achieve the correct oxygen sensor voltages, like those shown in the post-catalyst HO2S Outputs graphic.

The catalyst monitor diagnostic is sensitive to the following conditions:

- Exhaust leaks
- HO2S contamination
- Alternative fuels

Exhaust system leaks may cause any of the following results:

- A false failure for a normally functioning, good catalyst.

- Prevent a degraded catalyst from failing the catalyst monitor diagnostic.
- Prevent the catalyst monitor diagnostic from running.

The presence of HO2S contaminants may prevent the catalyst monitor diagnostic from functioning properly.

Three-Way Catalyst Oxygen Storage Capacity

The TWC catalyst must be monitored for efficiency. In order to accomplish this, the control module monitors the pre-catalyst (HO2S 1) and post-catalyst (HO2S 2) oxygen sensors. When the TWC is operating properly, the post-catalyst oxygen sensor will have significantly less activity than the pre-catalyst oxygen sensor. The TWC stores and releases oxygen as needed during the normal reduction and oxidation process. The control module will calculate the oxygen storage capacity using the difference between the pre-catalyst and post-catalyst oxygen sensor voltage levels. If the activity of the post-catalyst oxygen sensor approaches that of the pre-catalyst oxygen sensor, the catalyst's efficiency is degraded.

Stepped or staged testing levels allow the PCM to statistically filter test information. This prevents falsely passing or falsely failing the catalyst monitor oxygen storage capacity test. The calculations performed by the on-board diagnostic system are very complex. Post-catalyst oxygen sensor activity should not be used to determine the oxygen storage capacity unless directed by the service manual.

A 2-stage test is used to monitor the catalyst efficiency. Failure of the first stage of the test will indicate that the catalyst requires further testing in order to determine the catalyst efficiency. The second stage test looks at the inputs from the pre-catalyst and post-catalyst HO2S sensors more closely in order to determine if the catalyst is actually degraded. This two stage test further increases the accuracy of the oxygen storage capacity monitor. Failing the first stage test DOES NOT indicate a failed catalyst. The catalyst may be marginal or the fuels sulfur content could be very high.

Aftermarket HO2S characteristics may be significantly different from the original equipment manufacturer HO2S. An inferior HO2S may lead to a false pass or a false fail of the catalyst monitor diagnostic. An aftermarket catalytic converter that does not contain the same amount of cerium as the original catalytic converter can cause a false DTC to set. An incorrect amount of cerium in the catalyst can alter the correlation between the oxygen storage and the conversion efficiency of the TWC.

Catalyst Monitor (Good Catalyst)

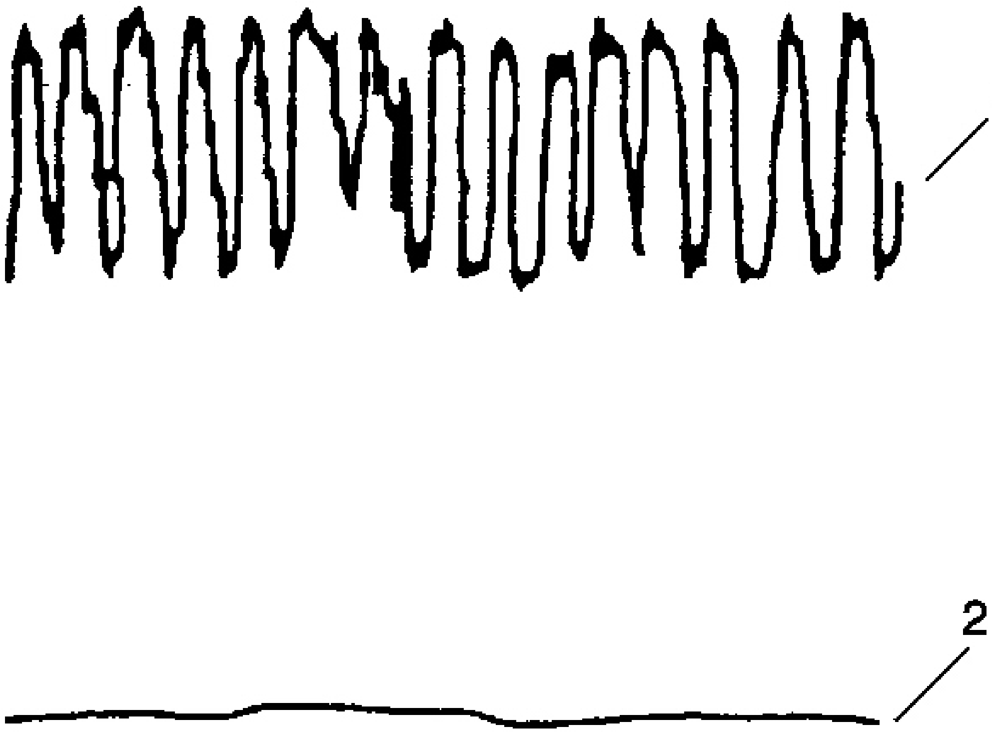


Fig. 191: View Of Catalyst Monitor (Good Catalyst)
Courtesy of GENERAL MOTORS CORP.

A good TWC catalyst will show a very active output voltage on the pre-catalyst heated oxygen sensor (1). A good catalyst, 95 percent hydrocarbon conversion, will show a relatively flat output voltage on the post-catalyst heated oxygen sensor (2).

Catalyst Monitor (Bad Catalyst)

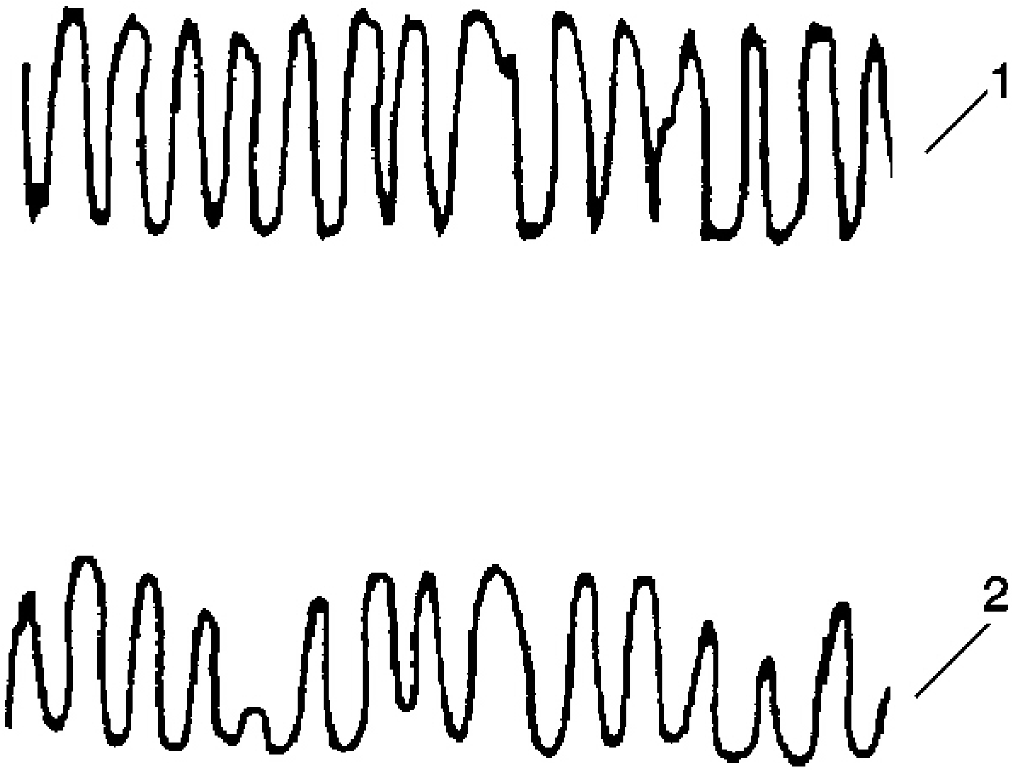


Fig. 192: View Of Catalyst Monitor (Bad Catalyst)
Courtesy of GENERAL MOTORS CORP.

A degraded TWC catalyst, 65 percent hydrocarbon conversion, will show greatly increased activity in the output voltage from the post-catalyst heated oxygen sensor (2). The degraded catalyst post-catalyst HO2S output voltage will therefore appear similar to the typically active output voltage of the pre-catalyst heated oxygen sensor (1).

Misfire Monitor Diagnostic Operation

The misfire monitor diagnostic is based on crankshaft rotational velocity, reference period, variations. The powertrain control module determines the crankshaft rotational velocity using the crankshaft position sensor and the camshaft position sensor. When a cylinder misfires the crankshaft actually slows down momentarily. By monitoring the crankshaft and the camshaft position sensor signals, the control module can calculate when a misfire occurs.

For a non-catalyst damaging misfire, the diagnostic will be required to report a misfire that is present within 1000-3200 engine revolutions.

For a catalyst damaging misfire, the diagnostic will respond to a misfire that is within 200 engine revolutions.

Rough roads may cause a false misfire detection. A rough road will cause torque to be applied to the drive wheels and the drive train. This torque can intermittently decrease the crankshaft rotational velocity and cause a false misfire detection.

On automatic transaxle equipped vehicles, the torque converter clutch (TCC) will be disabled whenever a misfire is detected. Disabling the TCC isolates the engine from the rest of the drive line and minimizes the effect of the drive wheel inputs (torque) on the crankshaft rotation.

When the TCC has been disabled as a result of a misfire detection, the TCC will be re-enabled after approximately 3200 engine revolutions with no misfire is detected. The TCC will remain disabled whenever a misfire is detected. This allows the misfire diagnostic to evaluate the system.

Fuel Trim System Monitor Diagnostic Operation

The fuel system monitor diagnostic averages of short-term and long-term fuel trim values. If these fuel trim values stay at the fuel trim limits for a calibrated period of time, a malfunction is indicated. The fuel trim diagnostic compares the averages of the short-term fuel trim values and the long-term fuel trim values to the rich and lean thresholds. If either value is within the thresholds, a pass is recorded. If both values are outside the acceptable thresholds, a rich or lean DTC will be recorded.

In order to meet OBD ll requirements, the control module uses weighted fuel trim cells in order to determine the need to set a fuel trim DTC. A fuel trim DTC can only be set if the fuel trim counts in the weighted fuel trim cells exceed the specifications. A vehicle that has a fuel trim problem that is causing a concern under certain conditions but operates fine under other conditions may not set a fuel trim DTC. For example an engine that is idling high due to a small vacuum leak or an engine that is running rough due to a large vacuum leak may set an idle speed DTC or an HO2S DTC but not a fuel trim DTC.

A fuel trim DTC may be triggered by many different vehicle faults. Use all of the diagnostic information available when diagnosing a fuel trim fault.

THROTTLE ACTUATOR CONTROL (TAC) SYSTEM DESCRIPTION

Purpose

The throttle actuator control (TAC) system delivers improved throttle response and greater reliability and eliminates the need for mechanical cable. The TAC system performs the following functions:

- Accelerator pedal position sensing
- Throttle positioning to meet driver and engine demands
- Throttle position sensing
- Internal diagnostics
- Cruise control functions

The TAC system includes the following components:

- The accelerator pedal position (APP) sensors
- The throttle body assembly
- The powertrain control module (PCM)

Accelerator Pedal Position (APP) Sensor

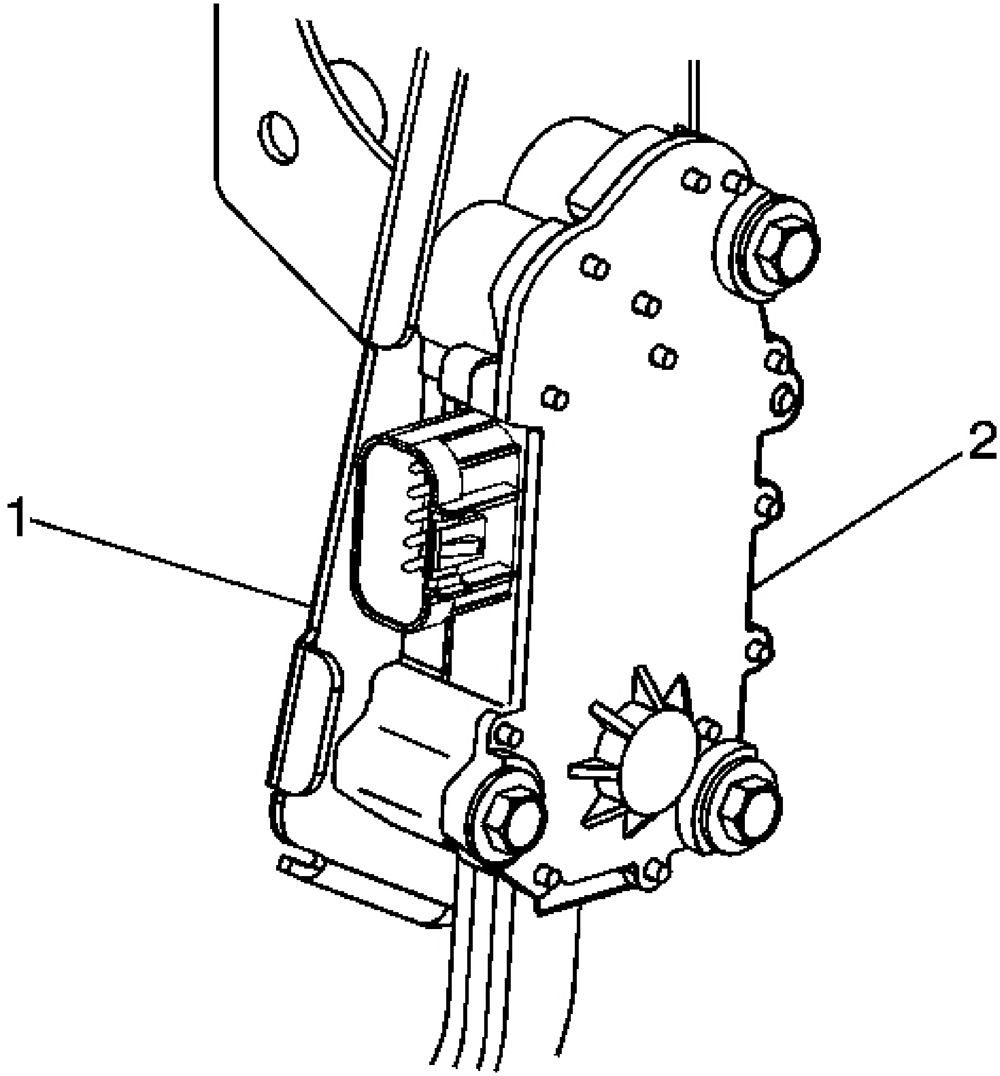


Fig. 193: View Of Accelerator Pedal Position (APP) Sensor
Courtesy of GENERAL MOTORS CORP.

The accelerator pedal position (APP) sensor assembly (2) is fastened to the accelerator pedal assembly and attached to the brake pedal bracket (1). The APP sensor assembly contains two APP sensors that are operated by the accelerator pedal movement. The APP sensors 1 and 2 are potentiometer type sensors each with 3 circuits:

- A 5-volt reference circuit
- A low reference circuit
- A signal circuit

The APP sensors are used to determine the pedal angle. The powertrain control module (PCM) provides each APP sensor a 5-volt reference circuit and a low reference circuit. The APP sensors provide the PCM with signal voltage proportional to the pedal movement. APP sensor 1 signal voltage is low at the rest position and increases to near the 5-volt reference as the pedal is applied. APP sensor 2 signal is low at rest and also increases as the accelerator pedal is applied. APP sensor 2 increases at a different rate to approximately half the reference voltage. The APP sensor 1 is responsible for providing the actual pedal position to the PCM. The PCM then sends a throttle position target value to the TAC control module. APP sensor 2 provides a backup value to the APP sensor 1.

Throttle Body Assembly

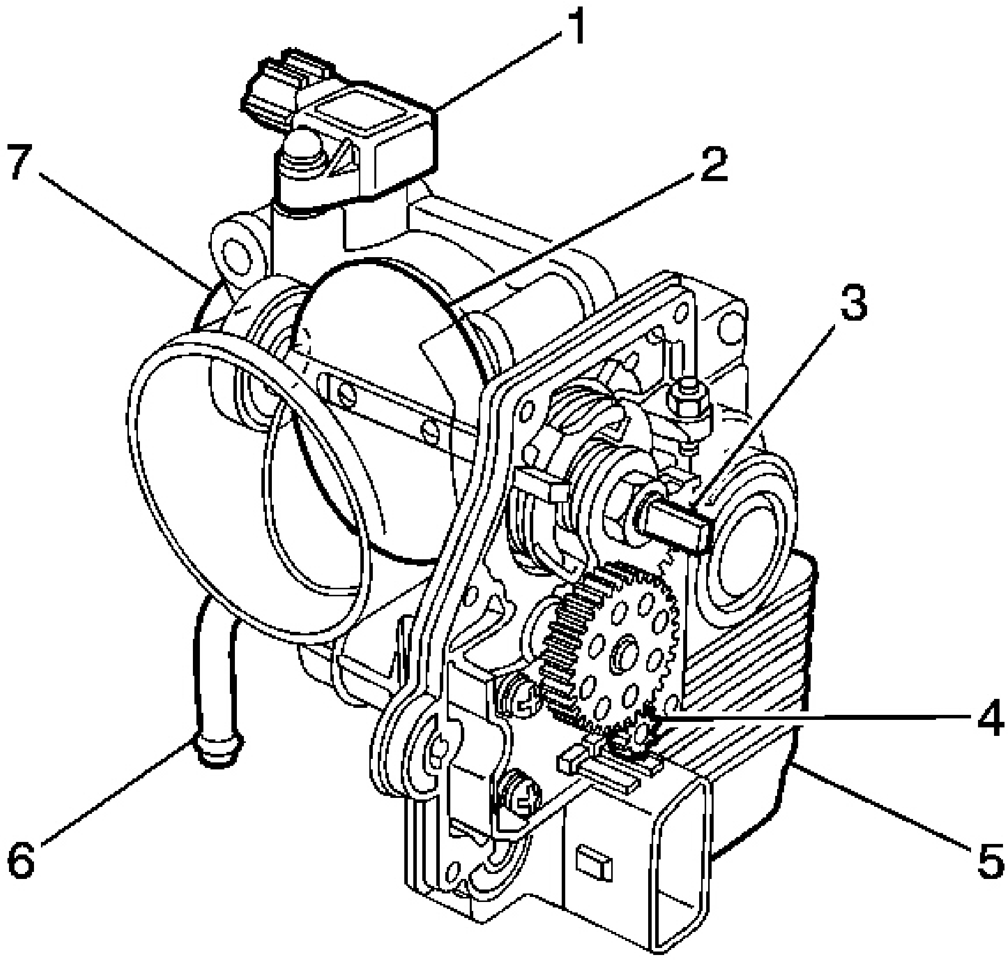


Fig. 194: View Of Throttle Body Assembly
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 194

Callout	Component Name
1	Manifold Absolute Pressure (MAP) Sensor
2	Throttle Valve, Plate
3	Throttle Shaft
4	Throttle Control Motor Drive Gear
5	Throttle Actuator Control (TAC) Module Cover
6	Engine Coolant Pipe
7	Throttle Body Housing

The throttle body functions similar to a conventional throttle body with the following exceptions:

- An electric motor opens and closes the throttle valve.
- The TAC module is an integral part of the throttle body assembly.
- The throttle valve is spring loaded and the default position is slightly open.
- There are 2 individual throttle position (TP) sensors integral to the TAC module cover.

The TP sensors are used to determine the throttle plate angle. The TP sensors provide the TAC module with a signal voltage proportional to throttle plate movement. Both TP sensor signal voltages are low at closed throttle and increase as the throttle opens. TP sensor 1 determines the actual throttle valve position. TP sensor 2 provides a backup value for TP sensor 1.

Throttle Actuator Control (TAC) Module

The throttle actuator control (TAC) module is the control center for the TAC system. The TAC module uses Read Only Memory (ROM) and Random Access Memory (RAM) along with an analog/digital (A/D) converter to control engine speed. The TAC module is self-diagnosing and communicates to the powertrain control module (PCM) with a dedicated serial data line. The TAC module receives accelerator pedal position (APP) sensor information from the PCM and provides diagnostic information to the PCM.

The APP sensor 1 enables the PCM to provide a target value to the TAC module in response to accelerator pedal movement. The TAC module achieves the correct throttle position by commanding the throttle control motor to position the throttle valve at the target value. The TAC module then compares the throttle position (TP) sensor 1 value to the target value. If necessary, the throttle control motor is moved slightly to obtain the exact desired position. The TAC module is not serviced separately and must be replaced with the throttle body assembly.

Powertrain Control Module

The powertrain control module (PCM) determines the drivers intent and then calculates the appropriate throttle response. This information is sent to the throttle actuator control (TAC) module through a dedicated serial data line.

Modes of Operation

Normal Mode

During the operation of the throttle actuator control (TAC) system, several modes or functions are considered normal. The following modes may be entered during normal operation:

- Learned idle mode-When ever the powertrain control module (PCM) recognizes the learned idle throttle position (TP) value, the engine operates in the learned idle mode. In the learned idle mode, the PCM uses stored engine performance settings in order to provide the best quality idle for all idle speed situations.
- Learned idle TP values-The TAC module relies on a stored TP sensor value for optimum idle speed operation. After PCM replacement or PCM reset, a new TP sensor value is learned and stored in the PCM memory. Refer to the Idle Learn Procedure below.

- Cold engine start mode-The throttle valve has a default start position that ensures improved cold engine starting and cold engine operation. In the cold engine start mode the TAC module commands the throttle control motor to the default position. In case of a TAC system malfunction, the default position spring opens the throttle valve to the default position.

Reduced Engine Power Mode

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

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

Idle Learn Procedure

When performing certain maintenance procedures, or when performing certain vehicle repairs, the idle learn procedure must be initiated. On a new or reset powertrain control module (PCM), the learned idle position is determined by the throttle position (TP) sensor value that is recognized when the ignition is first turned ON. The value is then retained in memory. A new value is automatically calculated by the PCM whenever there no idle learn value stored in memory. The idle learn procedure begins the learning of a new idle position when there is no old idle position value in the PCM memory. Performing the idle learn procedure is required for the following conditions:

- The throttle body assembly is replaced
- The throttle valve is cleaned-Deposits can build up in the throttle body requiring periodic cleaning of the throttle valve and throttle bore area. Refer to **Throttle Body Service** .
- The Clear DTCs function has been performed
- The PCM has been programmed.
- The PCM is replaced

If the PCM was replaced, proceed directly to the idle learn procedure. For the other actions above, the old learned idle position will be erased when the scan tool clear DTCs function is performed. Once the old learned idle position is erased, the idle learn procedure must be performed. Refer to **Idle Learn Procedure** .

TP Sensor Learned Value

On a new powertrain control module (PCM), the throttle position (TP) learned value is determined by the TP sensor value that is recognized when the ignition is first turned ON. The value is then retained in memory. This value is used as a baseline for a correlation between the TP input and the volume of intake air flow at idle. After many operating hours, deposits collect on the throttle plate and the bore of the throttle body. These deposits cause a restriction in the air flow at idle and can reduce engine performance at idle. In order to maintain engine idle quality, the PCM commands the throttle plate open slightly, correcting for the decreased air flow. Whenever this occurs, a new relationship is created between the TP sensor input and the actual throttle plate position. This relationship is the TP learned value.

When the throttle body is replaced, or the carbon deposits are removed, the TP learned value must be reset. If the value is not reset, the engine operates using stored values that are incorrect, resulting in a poor idle or hard starting. Resetting the TP learned value is required for the following conditions:

- The throttle body assembly is replaced
- The throttle valve is cleaned-Deposits can build up in the throttle body requiring periodic cleaning of the throttle valve and throttle bore area. Refer to **Throttle Body Service** .
- The PCM has been programmed.
- The PCM memory has been lost-as could happen with a long term power loss.

The TP learned value can be reset using the scan tool. Refer to **Scan Tool Output Controls** .

ROCKER ARM OIL CONTROL SYSTEM DESCRIPTION

The 3.5L RPO-L66 engine has a high speed cam system that increases engine output above 4,400 RPM. The increase in power is possible because valve lift is significantly increased between 4,400 and 6,500 RPM. A second camshaft lobe with a high lift profile is ground into each camshaft, alongside the low-medium speed lobes. In order to use the high speed cam only when desired, the engine utilizes a rocker arm oil control system. The system uses unique rocker arms that are hydraulically operated and electronically controlled.

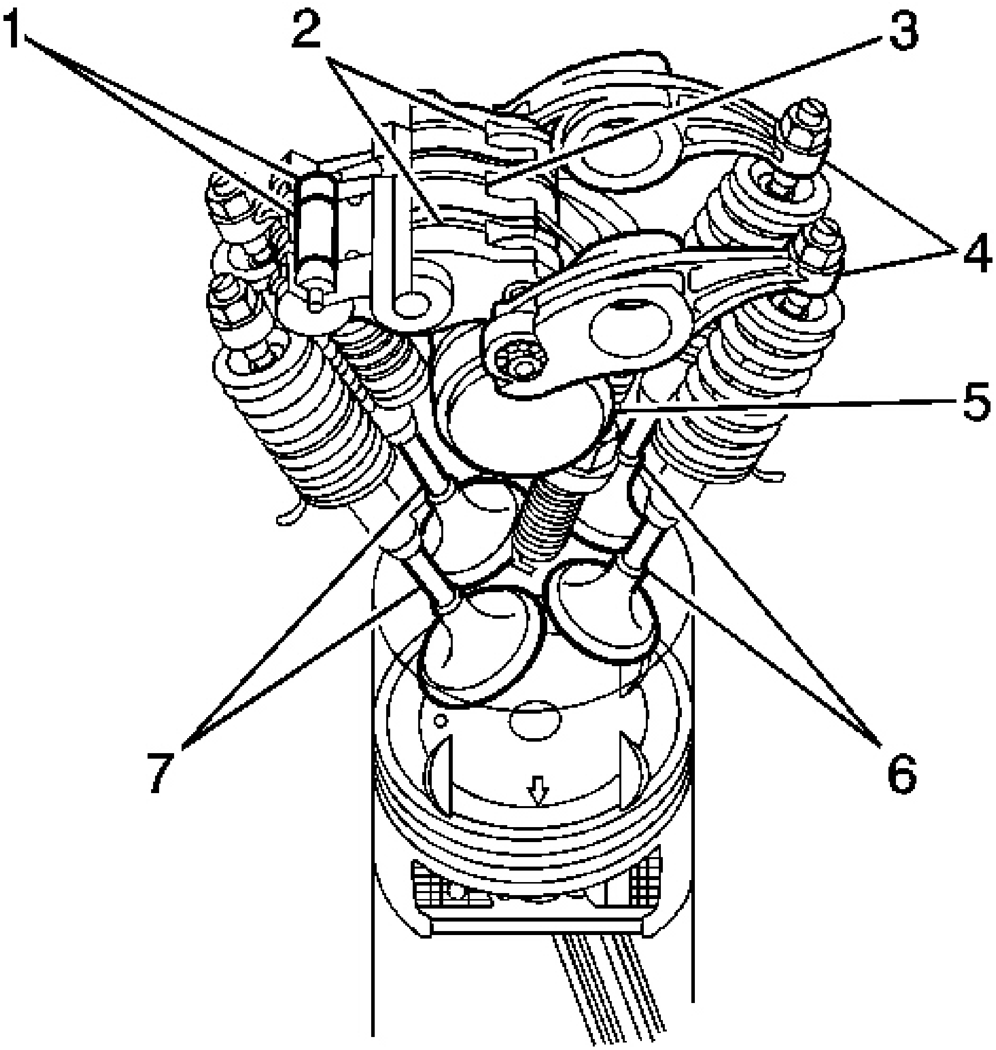


Fig. 195: View Of Rocker Arm Oil Control System
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 195

Callout	Component Name
1	Synchronizing Pistons
2	Low-Medium Speed Intake Rocker Arms
3	High Speed Intake Rocker Arm
4	Exhaust Rocker Arms

5	Camshaft
6	Exhaust Valves
7	Intake Valves

The three intake rocker arms (2 and 3) ride on rocker arm shafts as do the two exhaust rocker arms (4). The rocker arm shafts supply engine oil to the rocker arms. When the flow of oil to the rocker arms increases, the synchronizing pistons (1) move and lock the three rocker arms together. With all three rocker arms locked together, the high speed cam lobe opens and closes the intake valves (7).

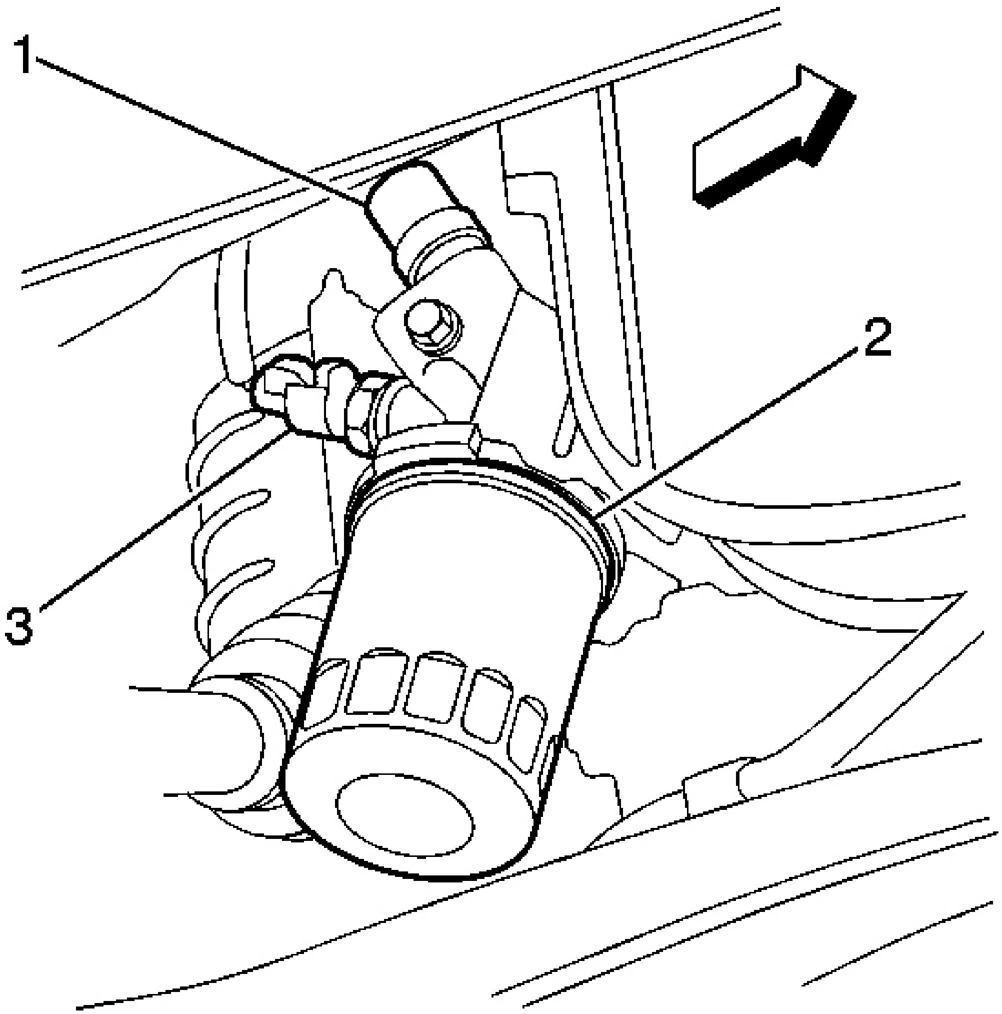


Fig. 196: View Of Rocker Arm Oil Control System
Courtesy of GENERAL MOTORS CORP.

The flow of oil thru the rocker shafts to the rocker arms is controlled by the rocker arm oil control solenoid. A rocker arm oil pressure switch monitors the operation of the oil control solenoid. The rocker arm oil control solenoid (1) and the oil pressure switch (3) are located near the engine oil filter (2) on the lower right rear corner of the engine.

System Operation

The rocker arm oil control system is an electronically controlled, hydraulically operated system that provides good low speed torque and high speed horsepower. The engine control module uses an electronic solenoid to control the flow of oil to the rocker arms. In order to determine when to transition from low to high speed operation, the control module relies on the following information:

- Engine speed
- Engine load
- Engine operating temperature
- Vehicle speed

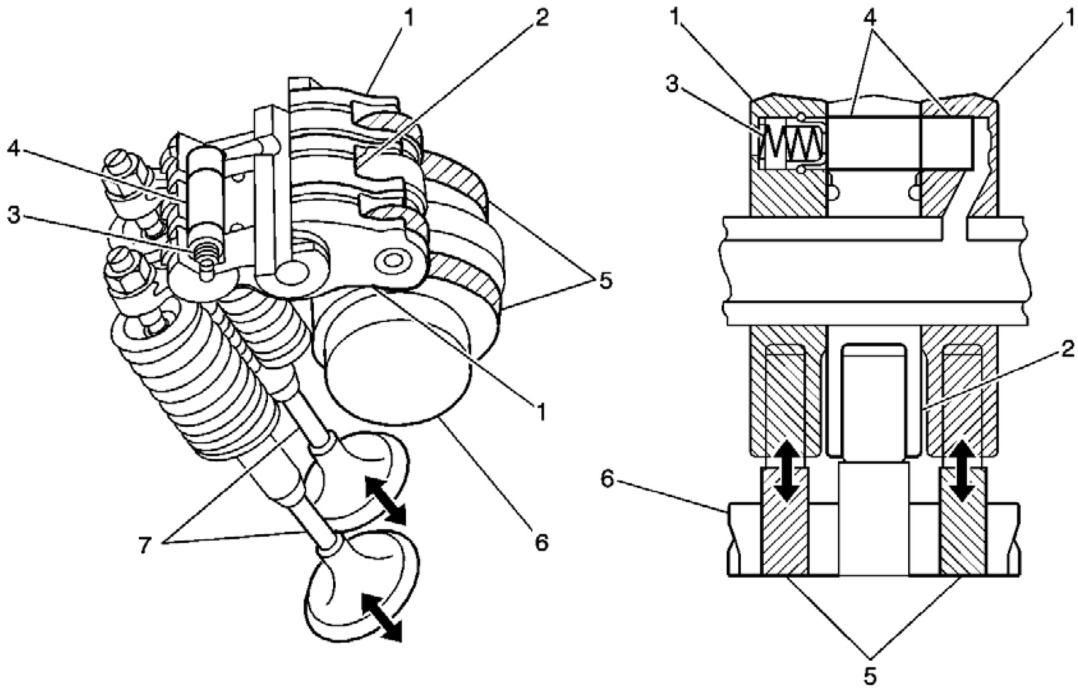


Fig. 197: Low-Medium Speed Cam Operation
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 197

Callout	Component Name
1	Low-Medium Speed Intake Rocker Arms

2	High Speed Intake Rocker Arm
3	Piston Spring
4	Synchronizing Pistons
5	Low-Medium Speed Cam Lobes
6	Camshaft
7	Intake Valves

At engine speeds below 4,400 RPM, the low-medium speed cam lobes (5) open and close the intake valves (7) thru the low-medium speed rocker arms (1). During low-medium speed operation, the rocker arm oil control solenoid is OFF and there is no oil flow to the rocker arms. Without oil flow there is no oil pressure, and the piston spring (3) keeps the synchronizing pistons (4) at rest in their bores within the three rocker arms (1 and 2). This allows the high speed rocker arm (2) to move independently of the two low-medium speed rocker arms (1) while following the high speed cam lobe.

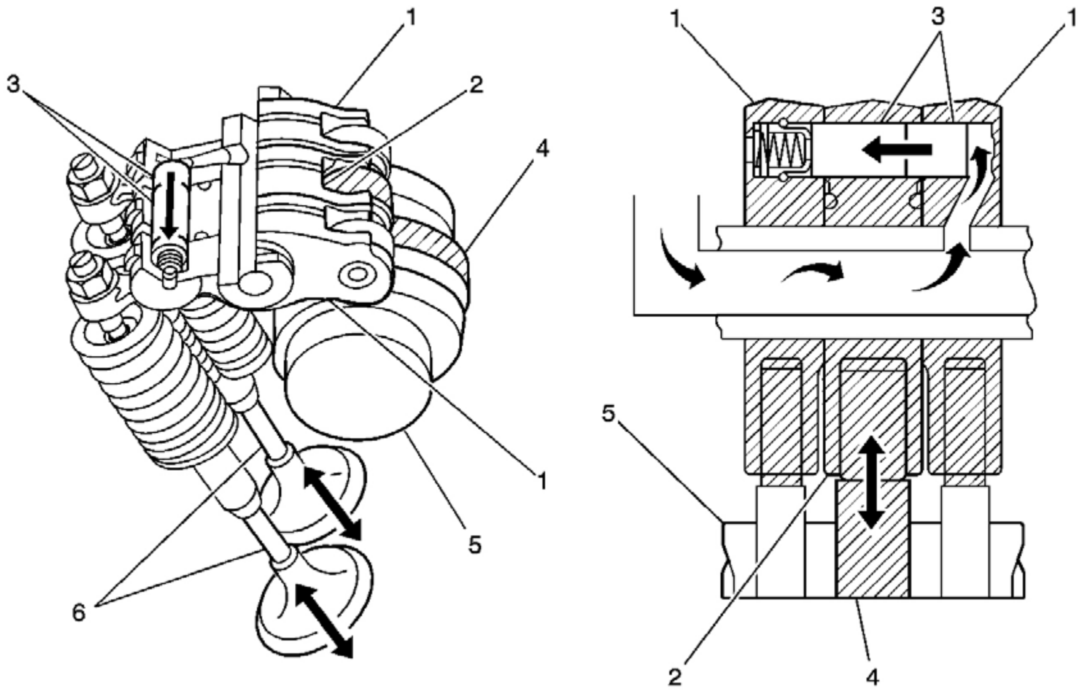


Fig. 198: High Speed Cam Operation
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 198

Callout	Component Name
1	Low-Medium Speed Intake Rocker Arms
2	High Speed Intake Rocker Arm
3	Synchronizing Pistons

4	High Speed Cam Lobe
5	Camshaft
6	Intake Valves

When engine speed exceeds 4,400 RPM engine oil is allowed to flow unobstructed to the rocker arms. This flow of oil into the rocker arm oil passages creates an increase in oil pressure. The increase in oil pressure moves the synchronizing pistons (3) further into their bores, compressing the piston spring. As the spring is compressed, the shifted pistons lock all three rocker arms together (1 and 2). When locked together, the low-medium speed rocker arms (1) follow the movement of the high speed rocker arm (2). Because the high speed rocker arm (2) is following the high speed cam lobe (4), the intake valves (6) open with more lift.

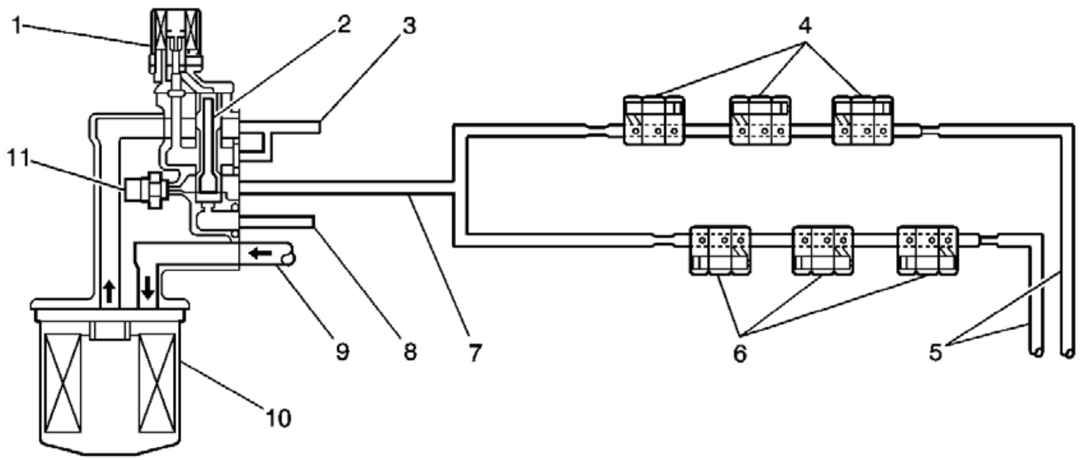


Fig. 199: System Oil Flow
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig.199

Callout	Component Name
1	Rocker Arm Oil Control Solenoid
2	Spool Valve
3	Oil Supply to Engine Block
4	Right Bank Intake Rocker Arm Assemblies
5	Oil Return Passages
6	Left Bank Intake Rocker Arm Assemblies
7	Oil Supply to Rocker Arms
8	Oil Return Passage
9	Oil Supply From Sump
10	Oil Filter
11	Rocker Arm Oil Pressure Switch

The flow of engine oil thru the rocker shafts to the intake rocker arms (4 and 6) is controlled by the rocker arm oil control solenoid (1). The oil control solenoid (1) has a plunger that moves a spool valve (2) located in the path of the rocker arm oil supply (7). When the oil control solenoid is energized, the spool valve is positioned to allow maximum oil flow to the intake rocker arms. Because of the restriction to full oil flow in the rocker arm oil passages, oil pressure increases. Excess oil is returned to the oil pan thru the oil return passages (5). The rocker arm oil pressure switch (11) detects oil pressure when the rocker arm oil control solenoid (1) is ON. The oil pressure switch input enables the engine control module to monitor the operation of the rocker arm oil control solenoid.

Rocker Arm Actuator System Operation

Rocker Arm Oil Control Solenoid	Oil Pressure/Flow	Rocker Arm Oil Pressure Switch
On	High	Open
Off	Low	Closed

If there is an open or short in the rocker arm oil control solenoid or the solenoid electrical circuit, DTC P2648 or DTC P2649 sets. If the rocker arm oil pressure switch detects oil pressure when there should be no pressure, DTC P2647 sets. If the rocker arm oil pressure switch detects no oil pressure when there should be pressure, DTC P2646 sets.

FUEL SYSTEM DESCRIPTION

Fuel System Overview

The fuel system is a returnless on-demand design. The fuel pressure regulator is a part of the primary fuel tank module, eliminating the need for a return pipe from the engine. 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 module inside the fuel tank. The fuel pump supplies high pressure fuel through the fuel filter, past the fuel pressure regulator, and through the fuel feed pipe to the fuel injection system. The fuel pressure regulator has a T-joint that diverts the needed fuel to the fuel rail with the unused fuel dropping back into the reservoir of the primary fuel tank module. The primary fuel tank module contains a reverse flow check valve. The check valve and the fuel pressure regulator maintain fuel pressure in the fuel feed pipe and the fuel rail in order to prevent long cranking times.

The primary fuel tank 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 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.

Fuel Tank

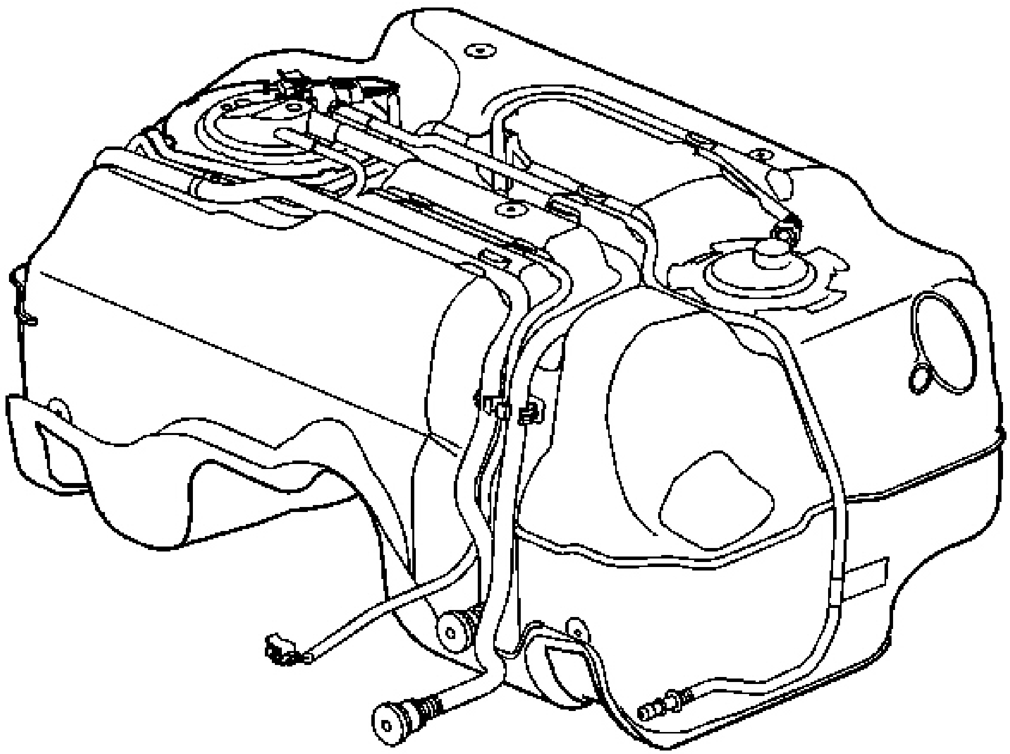


Fig. 200: View Of Fuel Tank
Courtesy of GENERAL MOTORS CORP.

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 under body of the vehicle. The fuel tank is molded from high-density polyethylene.

In order to provide space for a driveshaft though the center area of the tank, the fuel tank is a saddle configuration. Because of the saddle shape of the tank two fuel tank modules are required. The primary fuel tank module is located on the right side of the tank. The secondary fuel tank module is located on the left side of the tank.

Fuel Fill Pipe

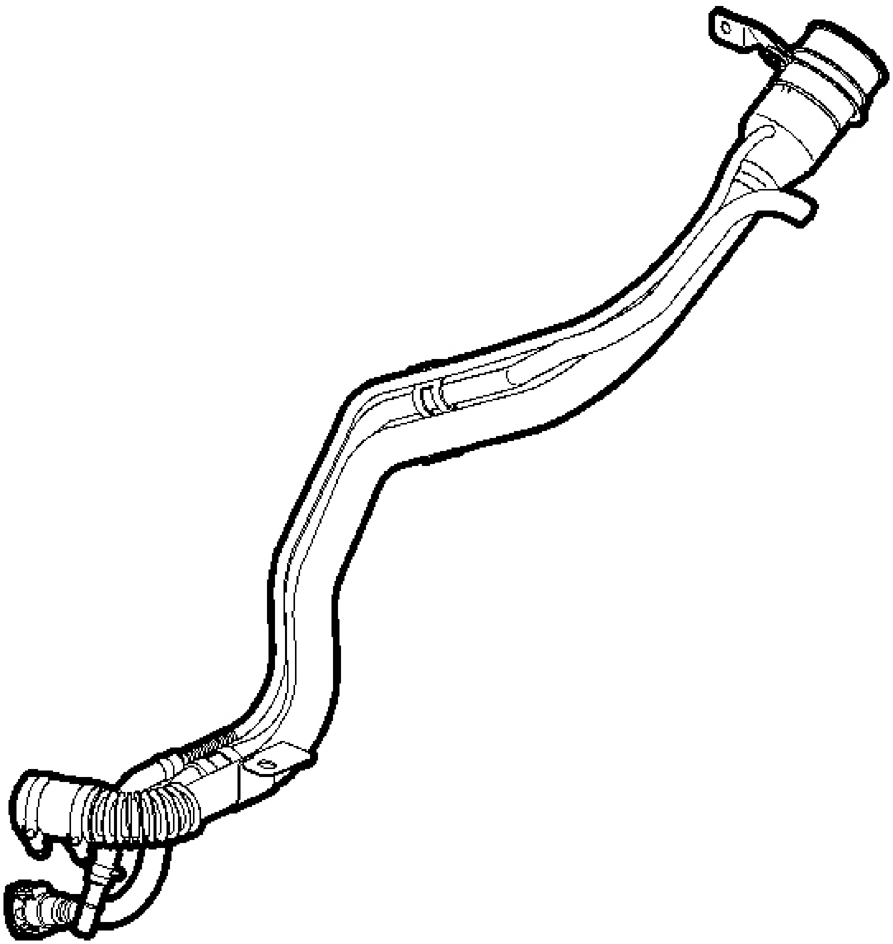


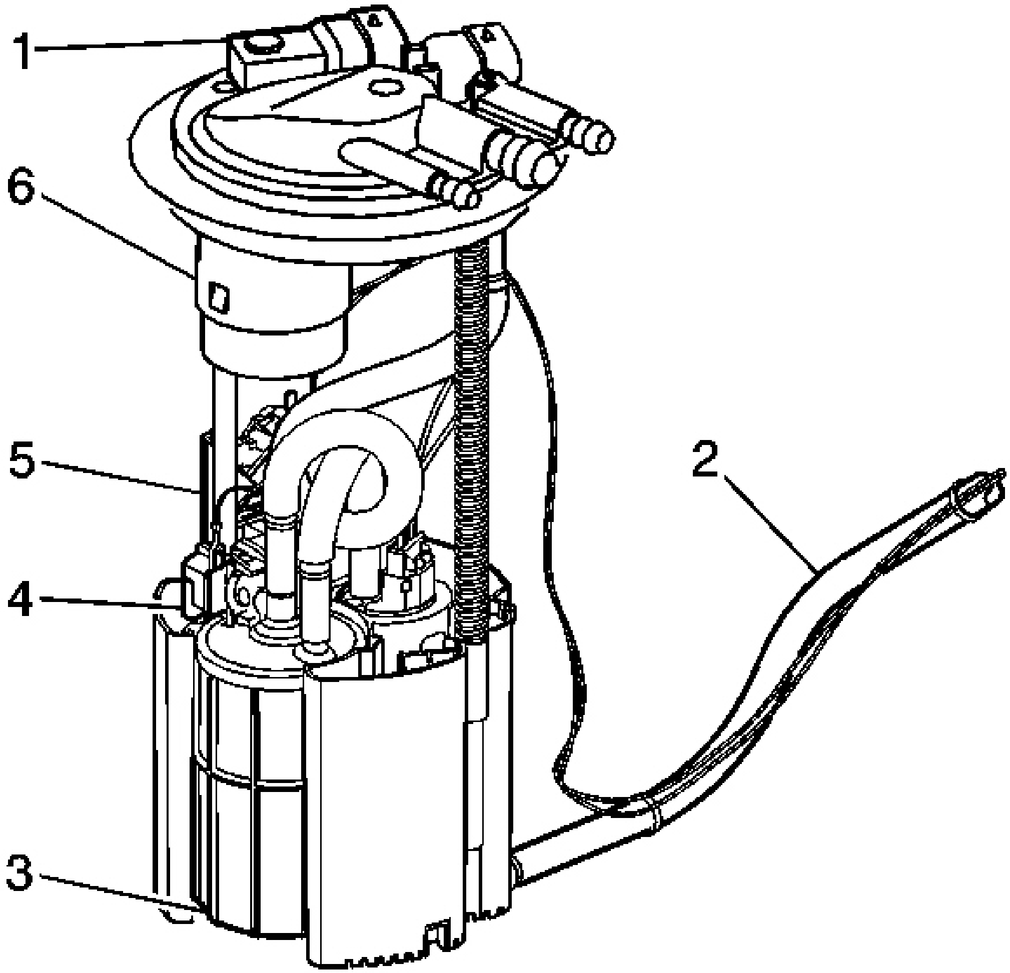
Fig. 201: View Of Fuel Fill Pipe
Courtesy of GENERAL MOTORS CORP.

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

Fuel Filler Cap

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

Primary Fuel Tank Module



<u>Fig. 202: View Of Primary Fuel Tank Module</u>
Courtesy of GENERAL MOTORS CORP.

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

- The fuel level sensor (4)
- The fuel pump and reservoir assembly
- The fuel strainer
- The primary jet pump
- The secondary jet pump

- The fill limiter vent valve (6)
- The fuel pressure sensor (1)
- The fuel filter (3)
- The fuel pressure regulator (5)
- The fuel transfer pipe (2)

Secondary Fuel Tank Module

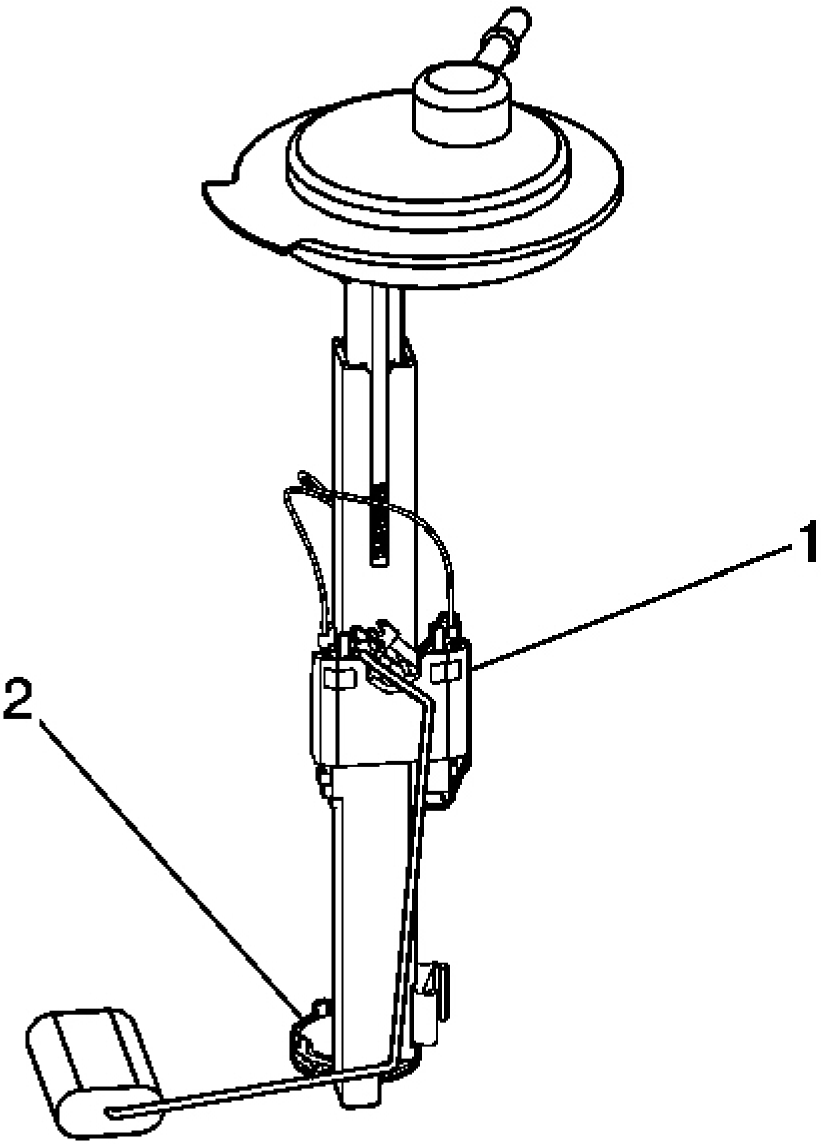


Fig. 203: View Of Secondary Fuel Tank Module
Courtesy of GENERAL MOTORS CORP.

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

- The fuel level sensor (1)

- The fuel pick-up (2)

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 control module sends the fuel level information via the CAN serial data to the body control module (BCM). The instrument panel cluster (IPC) displays the fuel level as determined by the BCM. This information is used for the IPC fuel gage and the low fuel warning indicator, if applicable. The control module also monitors the fuel level input for various diagnostics.

Fuel Pump

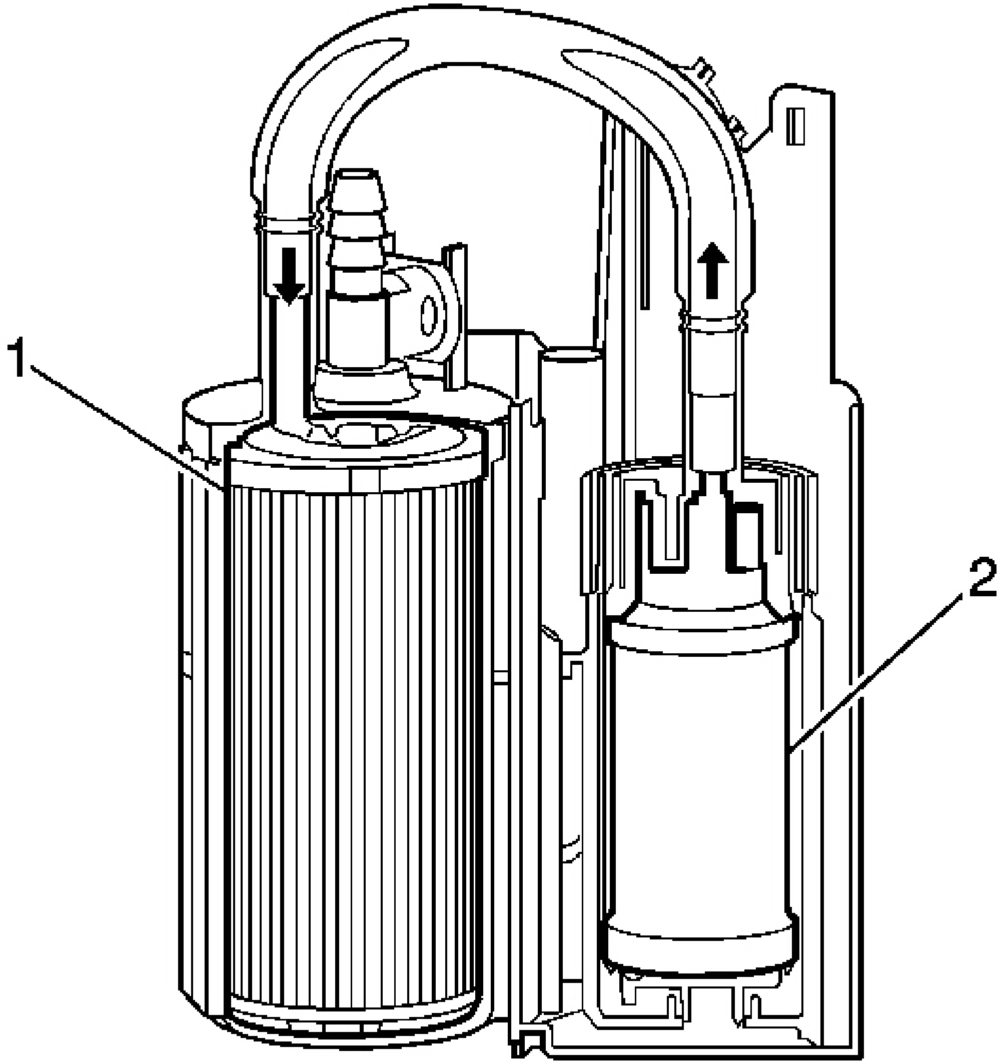


Fig. 204: View Of Fuel Pump
Courtesy of GENERAL MOTORS CORP.

The fuel pump (2) is mounted in the primary fuel tank module reservoir. The fuel pump is an electric high-pressure pump. Fuel is pumped to the fuel injection system at a specified flow and pressure. The fuel pump delivers a constant flow of fuel to the engine even during low fuel conditions and aggressive vehicle maneuvers. The control module controls the electric fuel pump operation through a fuel pump relay.

Primary and Secondary Jet Pumps

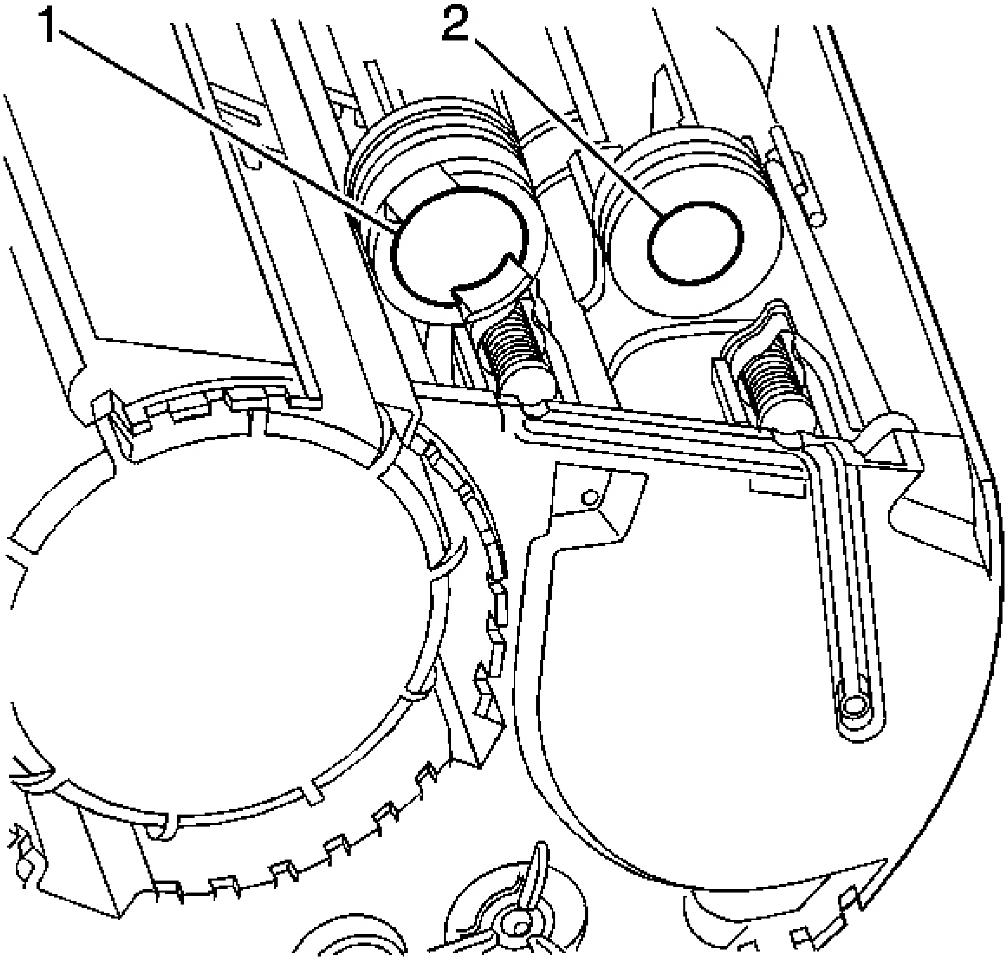


Fig. 205: View Of Primary & Secondary Jet Pumps
Courtesy of GENERAL MOTORS CORP.

The primary jet pump (1) is located in the primary fuel tank 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 (2) through a restrictive orifice located on the pump cover. The primary jet pump fills the reservoir of the primary fuel tank module.

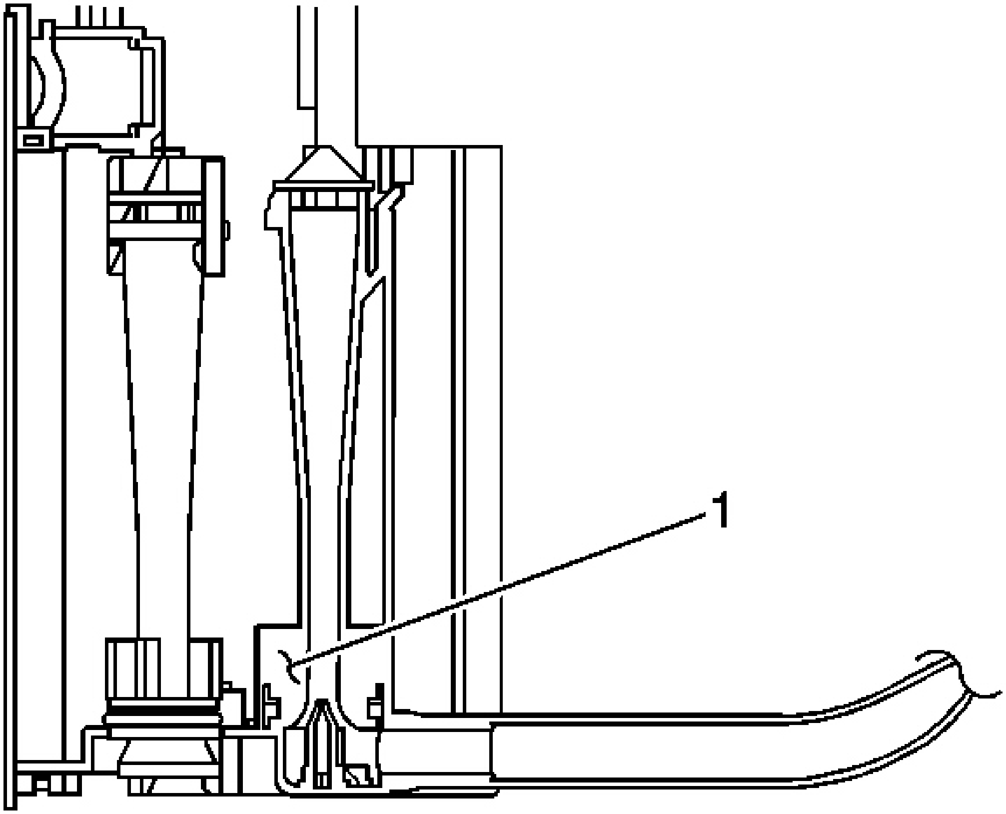


Fig. 206: View Of Secondary Jet Pump
Courtesy of GENERAL MOTORS CORP.

The secondary jet pump (1) 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.

Fuel Strainer

The fuel strainer attaches to the lower end of the primary fuel tank 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.

Fuel Filter

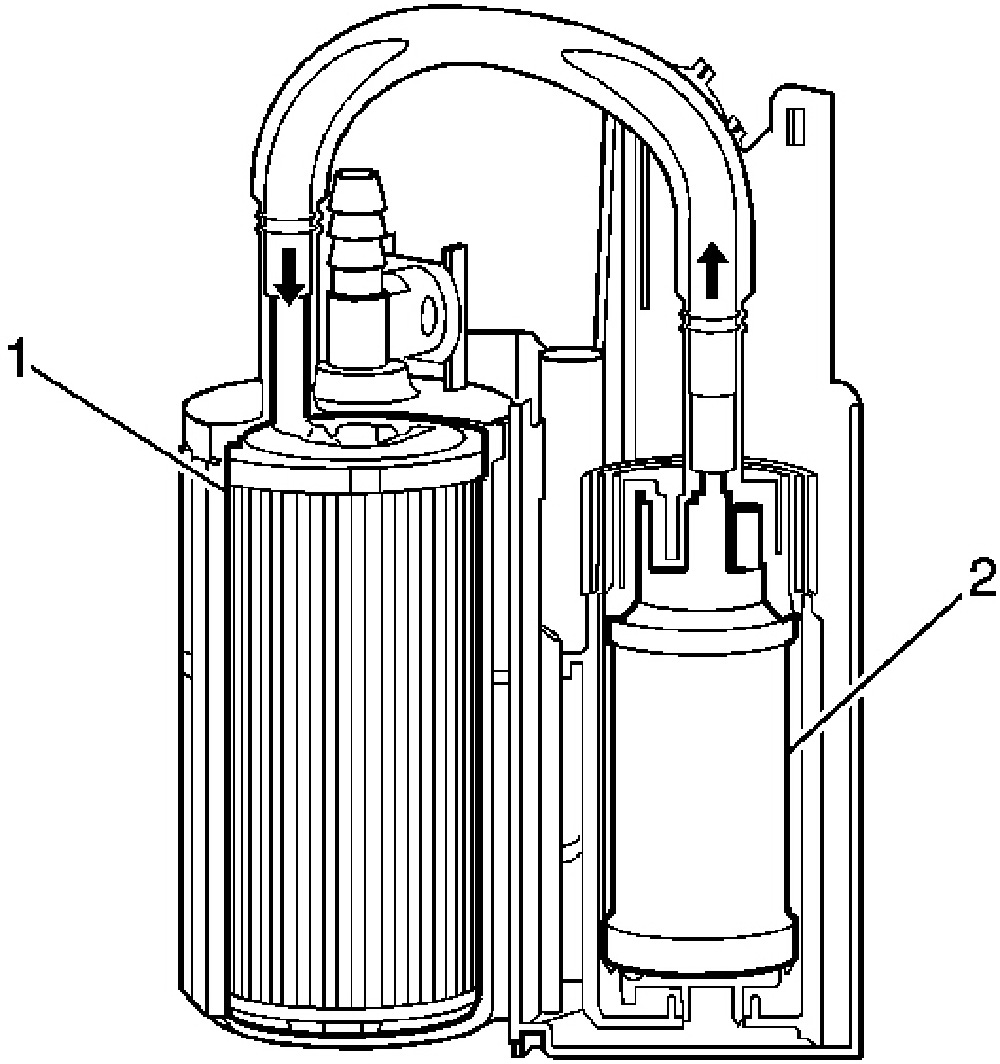


Fig. 207: View Of Fuel Filter
Courtesy of GENERAL MOTORS CORP.

The fuel filter (1) is located in the primary fuel tank module. The paper filter element traps particles in the fuel that may damage the fuel injection system. The filter housing is made to withstand maximum fuel system pressure, exposure to fuel additives, and changes in temperature.

Fuel Pressure Regulator

The fuel pressure regulator is integrated into the fuel filter cover on the primary fuel tank module. The fuel pressure regulator uses a spring with a preset tension and a stainless steel ball inserted into a precision ground seat in order to regulate fuel pressure. This type of fuel pressure regulator is not serviceable.

Fuel Feed Pipes

The fuel feed pipe carries fuel from the fuel tank to the fuel injection system. The fuel pipe consists of 3 sections:

- The rear fuel pipe is located from the top of the fuel tank to the chassis fuel pipe. The rear fuel pipe is constructed of nylon.
- The chassis fuel pipe is located under the vehicle and connects the rear fuel pipe to the engine compartment fuel pipe. The chassis fuel pipe is constructed of steel with a section of rubber hose.
- The engine compartment fuel pipe connects the chassis fuel feed pipe to the fuel rail. The engine compartment fuel pipe is constructed of steel.

Nylon Fuel Pipes

Nylon pipes are constructed to withstand maximum fuel system pressure, exposure to fuel additives, and changes in temperature. The following 2 sizes of nylon pipes are used:

- 9.53 mm (3/8 in) ID for the fuel feed
- 12.7 mm (1/2 in) ID for the vent

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.

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.

Fuel Pipe O-rings

O-rings seal the threaded connections in the fuel system. The fuel system O-ring seals are made of special material. Service the O-ring seals with the correct service part.

On-Board Refueling Vapor Recovery System (ORVR)

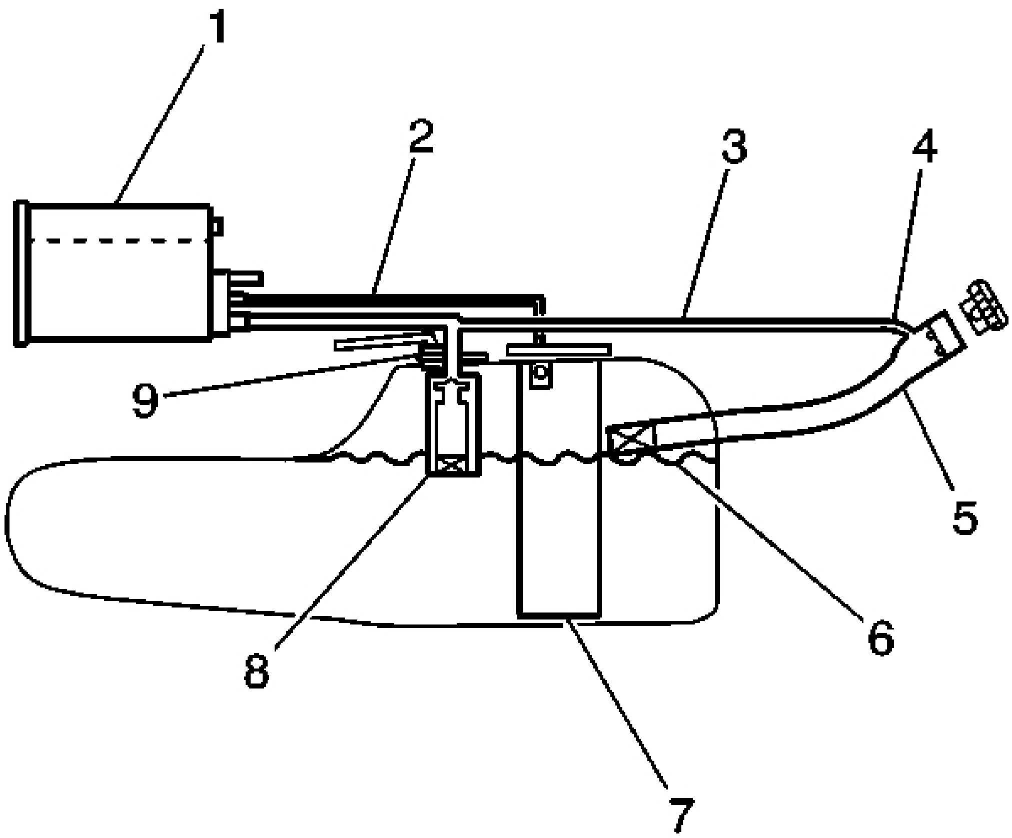


Fig. 208: View Of On-Board Refueling Vapor Recovery System (ORVR)
Courtesy of GENERAL MOTORS CORP.

The on-board refueling vapor recovery (ORVR) system is an on-board vehicle system designed to recover fuel vapors during the vehicle refueling operation. Instead of allowing fuel vapors to escape to the atmosphere the ORVR system transports the vapor to the EVAP canister for use by the engine. The flow of liquid fuel down the fuel filler neck provides a liquid seal that prevents fuel vapor from leaving the fuel system. The ORVR system architecture varies from platform to platform. Some of the items listed below are optional depending on the platform application. The following is a list of all the ORVR system components with a brief description of their operation:

- The EVAP canister (1). The EVAP canister receives and stores refueling vapor from the fuel system. The EVAP canister releases the fuel vapor to the engine through the EVAP control system.
- The vapor lines (2). The vapor lines transport fuel vapor from the fuel tank assembly to the EVAP canister.
- The vapor recirculation line (3), if equipped. The vapor recirculation line transports fuel vapor from the

fuel tank to the top of the fuel filler pipe during refueling in order to reduce the fuel vapor at the canister. The vapor recirculation line can be located inside the fuel filler pipe or outside of the fuel filler pipe.

- The variable orifice valve (4), if equipped. The variable orifice valve regulates the amount of vapor allowed to enter the vapor recirculation line.
- The fuel filler pipe (5). The fuel filler pipe carries fuel from the fuel dispensing nozzle to the fuel tank.
- The check valve (6). The check valve limits fuel spitback from the fuel tank during the refueling operation by allowing fuel flow only into the fuel tank. The check valve is located at the bottom of the fuel filler pipe or in the fuel tank filler neck.
- The fuel sender assembly (7). The fuel sender assembly pumps fuel to the engine from the fuel tank.
- The fill limiter vent valve (8). The fill limiter vent valve is located in the fuel tank and acts as a shut-off valve. The fill limiter vent valve performs the following functions:
    - Controls the fuel tank fill level by closing the primary vent of the fuel tank.
    - Prevents liquid fuel from exiting the fuel tank through the vapor line and entering the EVAP canister.
    - Provides fuel-spillage protection in the event of a vehicle rollover by closing the vapor path from the tank to the EVAP canister.
- The pressure/vacuum relief valve (9), if equipped. The pressure/vacuum relief valve provides venting of excessive fuel tank pressure or vacuum. The pressure/vacuum relief valve is located in the fuel filler neck on a plastic fuel tank and in the fill limiter vent valve on a steel fuel tank.

Fuel Metering System

The function of the fuel metering system is deliver the correct amount of fuel to the engine under all operating conditions. Fuel is delivered to each cylinder by the fuel injectors. The fuel injectors are controlled sequentially by the powertrain control module (PCM). The PCM bases the control of the fuel injectors on several important engine parameters. These engine parameters include the following:

- Engine speed (RPM)
- Accelerator pedal position (APP)
- Engine coolant temperature (ECT)
- Intake air temperature (IAT)
- Manifold absolute pressure (MAP)
- Fuel control oxygen sensor input (HO2S 1)

Fuel Rail

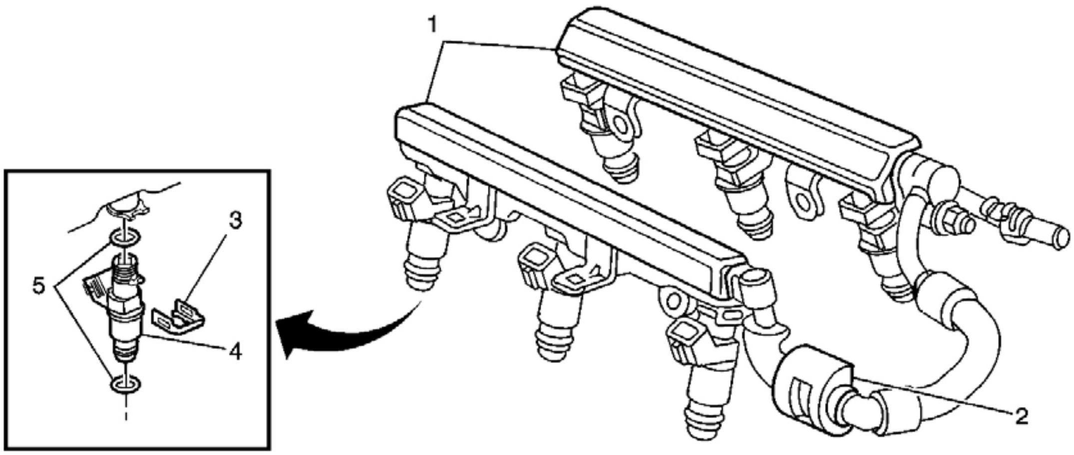


Fig. 209: View Of Fuel Rail
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 209

Callout	Component Name
1	Fuel Rails
2	Quick Connect Coupling
3	Retaining Clip
4	Fuel Injector
5	O-rings

The fuel rail is mounted on the intake manifold and distributes the fuel to each cylinder through the individual injectors. The fuel is delivered from the pump through the fuel supply line to the inlet pipe of the fuel rail. The fuel inlet pipe directs fuel to both the front and the rear fuel rails (1) suppling the individual fuel injector (4).

Fuel Injectors

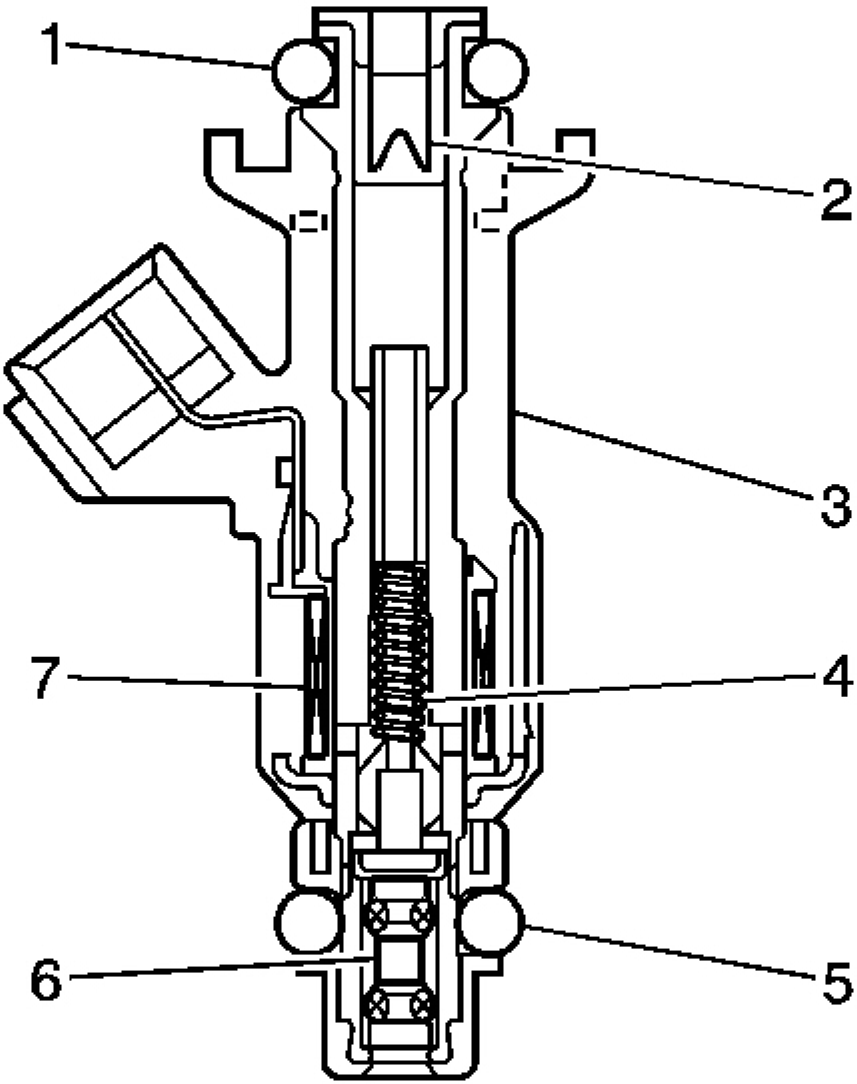


Fig. 210: View Of Fuel Injectors
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 210

Callout	Component Name
1	Upper O-ring Seal
2	Inlet Fuel Filter Screen
3	Injector Housing

4	Plunger Spring
5	Lower O-ring Seal
6	Needle Valve
7	Coil

The fuel injector is an electromagnetic (solenoid) type injection nozzle which injects fuel into the intake port of the cylinder head according to the signals from the powertrain control module (PCM). There are 6 fuel injectors, one for each cylinder, located between the intake manifold and the fuel rail.

The PCM energizes the solenoid coil of the fuel injector, generating an electromagnet field that attracts the solenoid plunger. The needle valve, which is incorporated with the solenoid plunger, is opened by the movement of the solenoid plunger. The opening of the needle valve allows fuel that is under pressure to disperse into a cone shaped pattern. Because the stroke of the needle valve in the fuel injector is set constant, the amount of fuel injected at one time is determined by the pulse width injection time-the length of time the solenoid coil is energized.

The fuel injectors may cause various driveability concerns if the following conditions occur:

- If the injectors will not open
- If the injectors are stuck open
- If the injectors are leaking
- If the injectors have a low or high coil resistance

Engine Fueling

The engine is fueled by 6 individual fuel injectors, one for each cylinder, that are controlled by the PCM. Each fuel injector is fired individually in the engine firing order, which is called a sequential multiport fuel injection. The PCM controls each fuel injector by energizing the fuel injector coil for a brief period once every other engine revolution. The length of this brief period, or pulse, is carefully calculated by the control module in order to deliver the correct amount of fuel for proper driveability and emissions control. The period of time when the fuel injector is energized is called the pulse width and is measured in milliseconds, thousandths of a second.

While the engine is running, the PCM is constantly monitoring the inputs and recalculating the appropriate pulse width for each fuel injector. The pulse width calculation is based on the fuel injector flow rate, mass of fuel the energized fuel injector will pass per unit of time, the desired air/fuel ratio, and actual air mass in each cylinder and is adjusted for battery voltage, short term, and long term fuel trim. The calculated pulse is timed to occur as each cylinders intake valves are closing to attain largest duration and most vaporization.

Fueling during an engine crank is slightly different than fueling during an engine run. As the engine begins to turn, a prime pulse may be injected to speed starting. As soon as the PCM can determine where in the firing order the engine is, the PCM begins pulsing the fuel injectors. The pulse width during the crank is based on the coolant temperature and the engine load.

The fueling system has several automatic adjustments in order to compensate for the differences in the fuel system hardware, the driving conditions, the fuel used, and the vehicle aging. The basis for the fuel control is the pulse width calculation that is described above. Included in this calculation are an adjustment for the battery voltage, the short term fuel trim, and the long term fuel trim. The battery voltage adjustment is necessary since the changes in the voltage across the fuel injector affect the fuel injector flow rate. The short term and the long term fuel trims are fine and gross adjustments to the pulse width that are designed in order to maximize the driveability and emissions control. These fuel trims are based on the feedback from the oxygen sensors in the exhaust stream and are only used when the fuel control system is in a Closed Loop operation.

Fuel Trim Operation

Fuel System Operation	Short Term Fuel Trim Indication	Long Term Fuel Trim Action	Short Term Fuel Trim Response
Lean Condition	1% or More	Increase (1% or more)	Return to 0%
Desired Condition	0%	0%	0%
Rich Condition	-1% or Less	Decrease (-1% or less)	Return to 0%

Air/Fuel Ratio Feedback Compensation - Closed Loop Operation

The wide band heated oxygen sensor (HO2S) measures the amount of oxygen in the exhaust system and provides more information than the switching style HO2S. The wide band sensor consists of an oxygen sensing cell, an oxygen pumping cell, and a heater. The exhaust gas sample passes through a diffusion gap between the sensing cell and the pumping cell. The engine control module (ECM) supplies a voltage to the HO2S and uses this voltage as a reference to the amount of oxygen in the exhaust system. An electronic circuit within the ECM controls the pump current through the oxygen pumping cell in order to maintain a constant voltage in the oxygen sensing cell. The ECM monitors the voltage variation in the sensing cell and attempts to keep the voltage constant by increasing or decreasing the amount of current flow to the pumping cell. By measuring the amount of current required to maintain the voltage in the sensing cell, the ECM can determine the concentration of oxygen in the exhaust. The HO2S voltage is displayed as a lambda value. A lambda value of 1 is equal to a stoichiometric air fuel ratio of 14.7:1. Under normal operating conditions, the lambda value will remain around 1. When the system is lean, the oxygen level will be high and the lambda signal will be high or more than 1. When the oxygen level is low, the lambda signal will be low or less than 1. The ECM uses this information to maintain the proper air/fuel ratio.

In order to obtain efficient performance of the 3-way catalytic converter (TWC) and a high clarification rate of CO, HC and NOx in the exhaust gas stream, the air/fuel mixture must be kept as close to the theoretical air/fuel ratio of 14.7:1 as possible. In order to accomplish this the PCM first compares the actual lambda value of the heated oxygen sensor 1 (HO2S 1) with the reference value of 1. If the HO2S 1 lambda value is less than the 1, the PCM determines that the air/fuel ratio is richer than the theoretical air/fuel ratio and reduces the fuel. If the lambda value of the HO2S 1 is more than 1, the PCM determines that the air/fuel ratio is lean and increases the fuel. By repeating these operations, the PCM can adjust the air/fuel ratio in order to be closer to the theoretical air/fuel ratio. Control of the fuel delivery system as just described is known as CLOSED LOOP operation.

Closed Loop Fuel Control Operation

Air/Fuel Mixture	Exhaust O2 Content	HO2S 1 Output	Fuel System Response
Lean Mixture	High Oxygen	More than One	Rich Command
Rich Mixture	Low Oxygen	Less than One	Lean Command

The Closed Loop fuel control operation will not take place under any of the following conditions:

- At engine start up
- When the fuel injection is increased just after engine start up.
- When the engine coolant temperature (ECT) sensor is indicating a low coolant temperature.
- When the engine is operating under a high demand, such as at wide open throttle (WOT).
- During fuel cutoff
- When the HO2S 1 is cold-Open Loop operation.

Control of the air supply that is mixed with the metered fuel is detailed in the description of the air intake system. Refer to **Air Intake System Description** .

Synchronous Injection

There are two types of injection timing. One is synchronous injection, when fuel injection is synchronous with the ignition signal or the signal from the camshaft position (CMP) sensor. The other is asynchronous injection, when fuel injection takes place independently of the ignition signal or the signal from the CMP sensor.

When starting the engine, the fuel injectors inject the fuel simultaneously and synchronously at every camshaft position (CMP) sensor signal. When the engine is starting at a cold state, the amount of fuel is determined by the engine coolant temperature (ECT) sensor and is divided and injected.

Once the engine is running, the fuel injection occurs in a cylinder only when the cylinder is in the exhaust stroke. The PCM detects the compression stroke of cylinder 1 through the CMP sensor signal.

Asynchronous Injection

Whenever a change in the throttle valve opening exceeds a specified value, as determined by the PCM, additional fuel is injected simultaneously into the cylinders which are in the intake and exhaust strokes. This is in addition to the above synchronous injection and is not based on the ignition signal.

Engine Starting Enrichment

In order to improve starting performance, fuel enrichment during start up is carried out. For a certain time after the engine is started, the air/fuel mixture is enriched slightly in order to stabilize the engine speed. The amount of compensation varies depending on the engine coolant temperature as measured by the ECT sensor.

Engine Warm-Up Enrichment

When the engine is cold, additional fuel is added in order to ensure good driveability. The level of initial enrichment is determined by the engine coolant temperature (ECT) sensor and intake air temperature (IAT) sensor input. The air/fuel mixture enrichment is gradually decreased until the ECT sensor reaches a specified value.

Acceleration Enrichment

During acceleration, the pulse width of the fuel injectors is lengthened in order to deliver more fuel. The additional fuel that is required is relative to throttle position (TP) sensor and manifold absolute pressure (MAP) sensor input. Acceleration Enrichment ensures smooth and reliable engine acceleration.

High Engine Load Enrichment

In order to provide maximum power during high engine load driving conditions, the air/fuel mixture is enriched when the MAP senor input within a specified PCM calibrated value.

System Voltage Compensation

A power supply system voltage drop will delay the mechanical operation of the fuel injector. The actual injector ON time becomes shorter when the system voltage decreases. In order to compensate for this, the fuel injector pulse width signal is lengthened.

Base Air/Fuel Ratio Compensation

The base air/fuel ratio may vary due to differences in individual engines and mileage. In order to compensate for such variations, feedback information is used to adjust the base air/fuel mixture to maintain the optimum air/fuel ratio.

Fuel Cutoff

Fuel cutoff occurs when the PCM stops fuel injection or turns off the fuel pump. Fuel cutoff is used during the following conditions:

- During deceleration, when the throttle valve is closed and engine speed is high, fuel injection is stopped so that unburned gas will not be exhausted. Fuel injection starts again when the above conditions are no longer present.
- When engine speed exceeds 5,000 RPM with no load.
- When a throttle actuator control (TAC) system malfunction is detected, the engine speed is limited to a maximum of 2,600 RPM.
- When a accelerator pedal position (APP) malfunction is detected, the engine speed is limited to a maximum of 3,200 RPM.
- In order to minimize any possible fuel spillage during an airbag deployment event, the fuel pump is de-energized,. The PCM receives a signal from the supplemental inflatable restraint (SIR) system and turns off the fuel pump relay. The relay is re-energized once the ignition switch is cycled off and then on again.

EVAPORATIVE EMISSION (EVAP) CONTROL SYSTEM DESCRIPTION

EVAP System Operation

The evaporative emission (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 vapor pipe, into the EVAP canister. Carbon in the canister absorbs and stores the fuel vapors. Excess pressure is vented through the vent line and EVAP vent valve to atmosphere. The EVAP canister stores the fuel vapors until the engine is able to use them. At an appropriate time, the control module will command the EVAP purge valve ON, open, allowing engine vacuum to be applied to the EVAP canister. With the EVAP vent valve OFF, open, fresh air will be drawn through the valve and vent line 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 pipe and EVAP purge valve into the intake manifold to be consumed during normal combustion. The control module uses several tests to determine if the EVAP system is leaking.

Large Leak Test

This tests for large leaks and blockages in the evaporative emission (EVAP) system. The control module will command the EVAP vent valve ON, closed, and command the EVAP purge valve ON, open, with the engine running, allowing engine vacuum into the EVAP system. The control module monitors the fuel tank pressure (FTP) sensor voltage to verify that the system is able to reach a predetermined level of vacuum within a set amount of time. The control module then commands the EVAP purge valve OFF, closed, sealing the system and monitors the vacuum level for decay. If the control module does not detect that the predetermined vacuum level was achieved, or the vacuum decay rate is more than a calibrated level on 2 consecutive tests, DTC P0455 sets.

Small Leak Test

The engine off natural vacuum, (EONV), diagnostic is the small leak detection diagnostic for the evaporative emission (EVAP) system. The EONV diagnostic monitors the EVAP system pressure or vacuum with the key OFF. The EONV utilizes the temperature changes and the resulting naturally occurring vacuum or pressure in the fuel tank immediately following a drive cycle. When the vehicle is driven, the temperature in the fuel tank rises. When the vehicle is parked with the engine OFF and key OFF, the temperature in the fuel tank will continue to rise for a period of time, and then begin to decrease. The EONV diagnostic relies on this temperature change, and the corresponding pressure change to determine if an EVAP system leak is present. The EONV diagnostic is designed to detect leaks as small as 0.51 mm (0.020 in). The diagnostic can determine if a small leak is present based on vacuum or pressure readings in the EVAP system. When the EVAP system is sealed a finite amount of pressure or vacuum will be observed. When a 0.51 mm (0.020 in) leak is present, little or no pressure or vacuum is observed. If the test reports a failing value, DTC P0442 will set.

Canister Vent Restriction Test

If the evaporative emission (EVAP) vent system is restricted, fuel vapors will not be properly purged from the EVAP canister. The control module tests this by commanding the EVAP purge valve ON, open; and commanding the EVAP vent valve OFF, open; and monitoring the fuel tank pressure (FTP) sensor for an increase in vacuum. If vacuum increases more than a calibrated value, DTC P0446 sets.

Purge Valve Leak Test

If the evaporative emission (EVAP) purge valve does not seal properly, fuel vapors could enter the engine at an undesired time, causing driveability concerns. The control module tests for this by commanding the EVAP purge valve OFF, closed; and vent valve ON, closed; sealing the system, and monitoring the fuel tank pressure (FTP) for an increase in vacuum. If the control module detects that EVAP system vacuum increases above a calibrated value, DTC P0496 sets.

EVAP System Components

The evaporative emission (EVAP) system consists of the following components:

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 control module determines that the vapor can be consumed in the normal combustion process.

EVAP Purge Valve

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

EVAP Vent Valve

The EVAP vent valve controls fresh airflow into the EVAP canister. The valve is normally open. The control module will command the valve closed during some EVAP tests, allowing the system to be tested for leaks.

Fuel Tank Pressure Sensor

The fuel tank pressure (FTP) sensor measures the difference between the pressure or vacuum in the fuel tank and outside air pressure. The control module provides a 5-volt reference and a ground to the FTP sensor. The FTP sensor provides a signal voltage back to the control module that can vary between 0.1-4.9 volts. As FTP increases, FTP sensor voltage decreases, high pressure, = low voltage. As FTP decreases, FTP sensor voltage increases low pressure or vacuum = high voltage.

EVAP Service Port

The EVAP service port is located in the EVAP purge pipe between the EVAP purge valve and the EVAP canister. The service port is identified by a green colored cap.

ELECTRONIC IGNITION (EI) SYSTEM DESCRIPTION

The electronic ignition system is of the direct ignition system (DIS) type and is controlled by the powertrain control module (PCM). The electronic ignition system is composed of the following components:

- The powertrain control module (PCM)
- The 6 ignition coil assemblies
- The crankshaft position (CKP) sensor
- The camshaft position (CMP) sensor
- The spark plugs

The electronic ignition system provides the following benefits:

- Improved ignition timing accuracy
- Reduced high-voltage losses
- Enhanced overall ignition system reliability

The electronic ignition system components cannot be disassembled or repaired. A component that is correctly diagnosed as faulty must be replaced as a complete unit.

Operation

The powertrain control module (PCM) uses reference pulses from the crankshaft position (CKP) sensor in order to determine the engine speed. The PCM cannot operate the ignition system or the fuel injectors without the engine speed signal from the CKP sensor. The PCM controls the ignition timing by controlling the ignition coils.

Each ignition coil has a built-in ignition module that controls the current flow in the primary coil winding. When the current flow is interrupted, the electrical field around the primary coil collapses and a high voltage is induced in the secondary coil. The secondary coil voltage travels from the coil output terminal, through the spark plug boot, and across the spark plug gap to the engine block. As a fail-safe function the ignition control module sends an ignition confirmation signal back to the PCM whenever the primary field collapses.

The camshaft position (CMP) sensor input is used to detect an engine misfire. The PCM also uses the CMP sensor signal as an input for modifying the fuel injection timing and for modifying the ignition timing.

The PCM receives information on the engine status from various engine sensors and then selects the most appropriate ignition timing settings from within the PCM's programming. The following are the most important inputs for determining ignition timing requirements:

- The engine speed
- The accelerator pedal position (APP)
- The intake air volume
- The engine coolant temperature (ECT)
- The knock sensor (KS) input

Crankshaft Position (CKP) Sensor

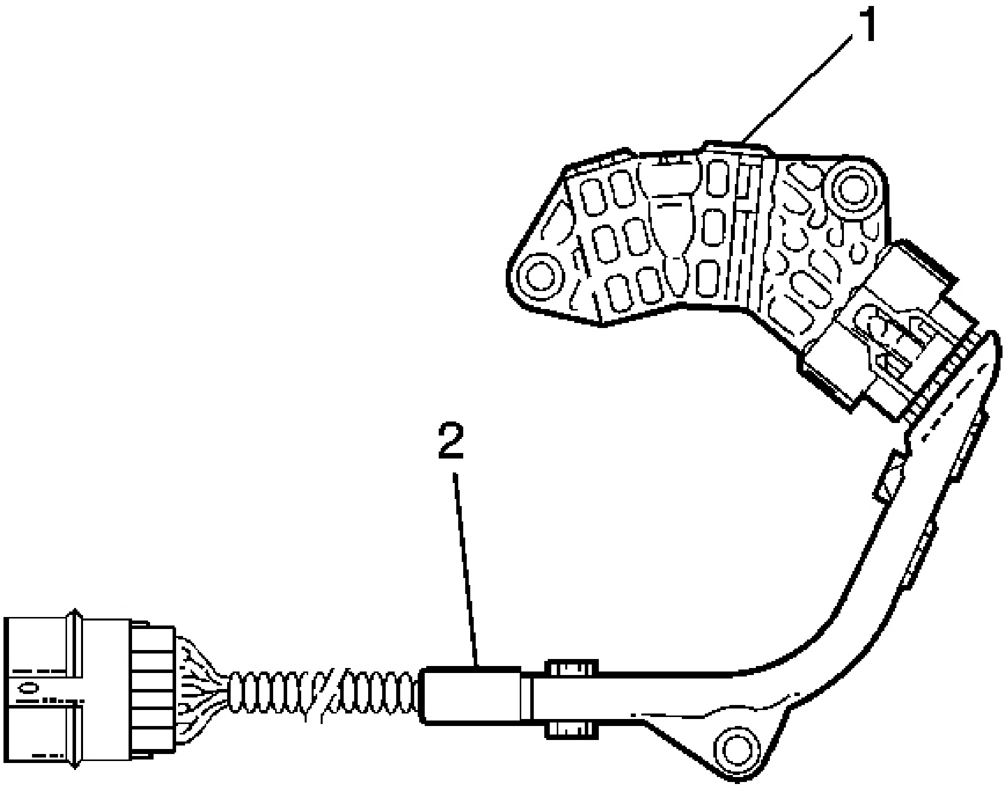


Fig. 211: View Of Crankshaft Position (CKP) Sensor
Courtesy of GENERAL MOTORS CORP.

The crankshaft position (CKP) sensor (1) is located in the front cover of the cylinder block near the crankshaft pulley. The CKP sensor is actually two separate sensors, located 22.5 degrees apart, within the same housing. Both CKP sensor A and CKP sensor B function the same and provide an AC signal that increases in both frequency and amplitude as the engine speed increases. The CKP sensor signal is sent to the PCM in order to indicate the RPM and the crankshaft position. The PCM uses the information from both CKP sensors in order to perform the following functions:

- Determine engine speed
- Determine accurate crankshaft position
- Calculate ignition system and fuel injection timing
- Provide continued engine operation even when one sensor fails
- Report engine misfire-when used with CMP sensor input

Operation

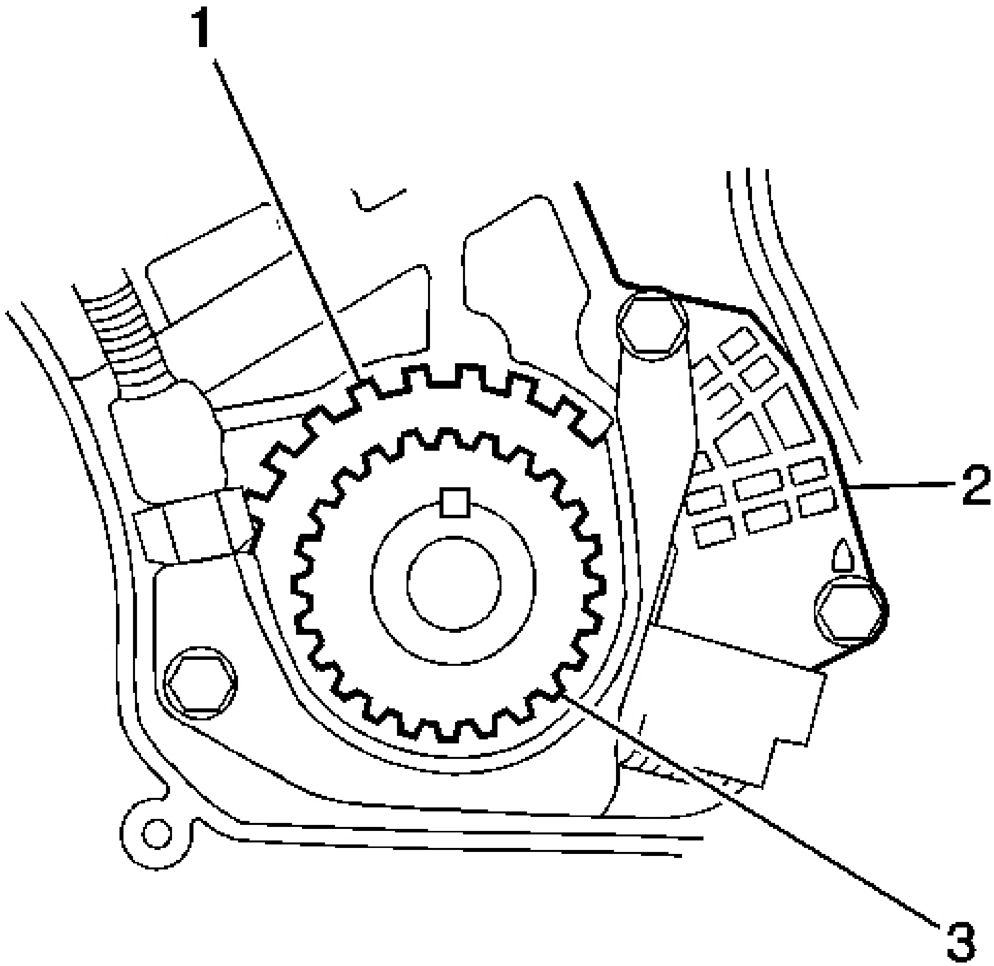


Fig. 212: View Of CKP Sensor Signal Rotor
Courtesy of GENERAL MOTORS CORP.

The CKP sensor signal rotor (1) is an integral part of the crankshaft pulley (3) and is located behind the timing belt cover. When the crankshaft rotates, the CKP sensor signal rotor teeth pass by the CKP sensor (2) causing a fluctuation in the sensors magnetic field. The fluctuation in the magnetic field induces a voltage in the CKP sensor circuitry that corresponds to every tooth on the crankshaft signal rotor. The rotor has 24 evenly spaced teeth, with two teeth missing, indicating top dead center (TDC) and producing 22 electrical pulse per revolution. CKP sensor A and CKP sensor B each provide position signals to the PCM. The PCM relies on the signal from CKP sensor A first, and uses the signal from sensor B only when sensor A is missing or unintelligible.

Camshaft Position (CMP) Sensor

The CMP sensor is a signal generator that is composed of a magnet and a coil with an iron core. The PCM relies on the AC signal provided by the CMP sensor in order perform the following:

- To optimize the ignition timing
- To optimize the fuel delivery
- To detect any engine misfire

Operation

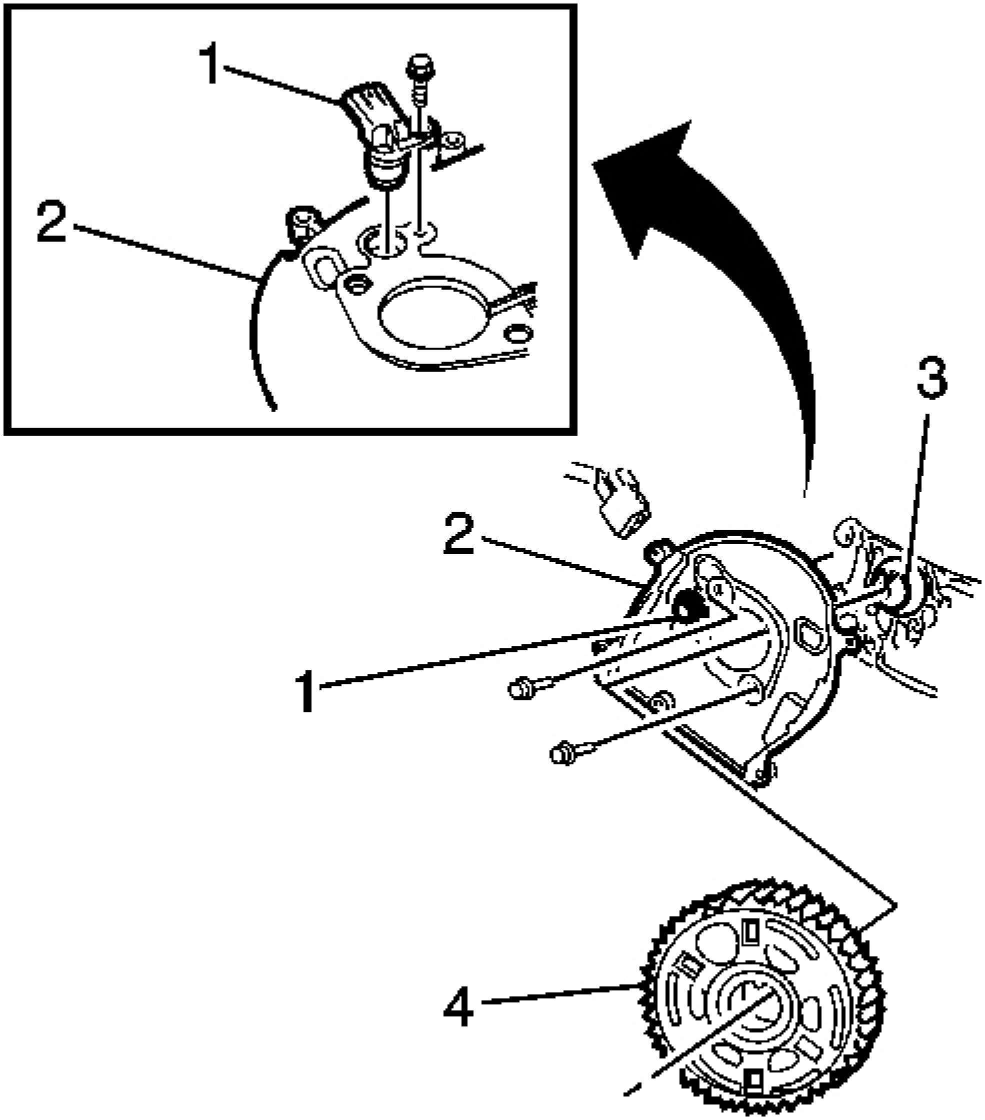


Fig. 213: View Of Camshaft Position (CPM) Sensor
Courtesy of GENERAL MOTORS CORP.

The camshaft position (CMP) sensor (1) is fastened to the backside of the timing belt cover (2) of the left bank cylinder head. The cam gear (4) is attached to the left bank camshaft (3) inside the timing belt cover (2). The CMP sensor signal rotor is integral to the cam gear (4). The signal rotor has three unevenly spaced teeth. When each tooth of the signal rotor moves past the CMP sensor (1), an electrical signal is generated. These AC signals, three per camshaft revolution, are sent to the PCM.

Knock Sensor (KS)

The knock sensor (KS) is located below the intake manifold, on the engine block between the left and right side engine cylinders. The KS detects engine detonation and sends a signal to the PCM. The PCM uses the input from the KS to adjust the ignition timing in order to control detonation. For detailed information on the operation of the KS refer to **Knock Sensor (KS) System Description** .

Noteworthy Ignition Information

Consider the following important information when servicing the ignition system:

- The ignition coils secondary output voltage is more than 40,000 volts. Avoid body contact with the ignition high voltage secondary components when the engine is running or personal injury may result.
- The ignition timing is not adjustable. A timing indicator and timing marks are still visible at the crankshaft pulley but are not used to set or adjust the ignition timing. The PCM provides all ignition timing adjustments electronically.
- Be careful not to damage the secondary ignition coil boots when servicing the ignition system. Rotate each ignition coil in order to loosen the boot from the spark plug before removing. Never pierce a secondary ignition boot for any testing purposes. Future ignition system problems are guaranteed if pinpoints or test lights are pushed through the secondary ignition component insulation during testing.
- Do not use a conventional tachometer in order to check the engine speed on this ignition system. An inductive type pick-up will not provide reliable engine speed information. Use a scan tool in order to monitor the engine RPM.

KNOCK SENSOR (KS) SYSTEM DESCRIPTION

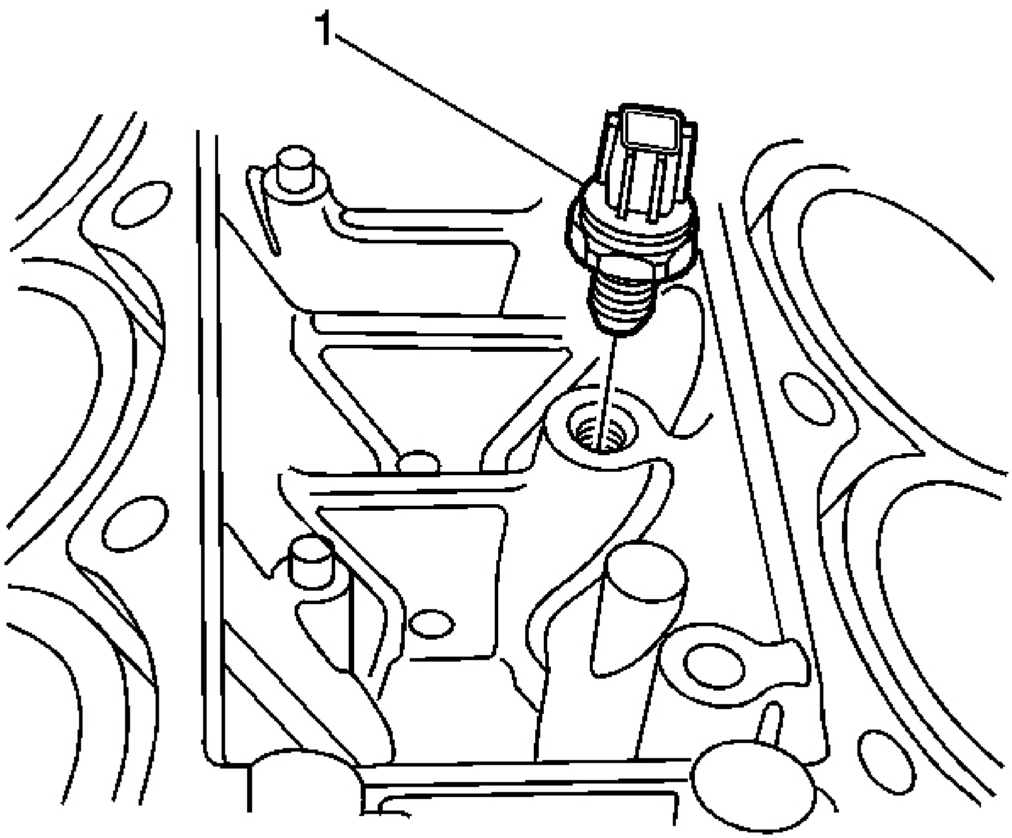


Fig. 214: View Of Knock Sensor (KS) System
Courtesy of GENERAL MOTORS CORP.

The 3.5L engine is equipped with a knock sensor (KS) (1) that is located on the engine block underneath the intake manifold. Ignition timing determines the relationship between the time the spark plug is fired and the time that the piston reaches top dead center (TDC). TDC is the point in time when the piston achieves maximum upward travel in the cylinder. If the spark plug ignites the compressed air/fuel mixture too late, not all of the air/fuel mixture has time to burn while the fuel is highly compressed. Late ignition causes a decrease in fuel efficiency, decreased power, and increased exhaust emissions. If the spark plug fires too soon, too much of the air/fuel mixture starts burning before the piston reaches the top of the compression stroke. Early ignition of the air/fuel mixture causes detonation, commonly referred to as spark knock. Constant spark knock in the motor is undesirable. Excessive spark knock can reduce engine performance. If severe enough, detonation can cause engine damage.

Every engine has an optimum ignition timing value. The optimum ignition timing is usually the earliest or most advanced firing of the spark plug that is possible without causing detonation. An engines optimum ignition timing is designed to be the most advanced ignition timing possible during the most demanding conditions. The optimum ignition timing is affected by all of the following variables:

- The engine load
- The engine temperature
- The atmospheric pressure
- The fuel quality
- The fuel's octane rating

Ignition systems equipped with a knock sensor (KS) can be engineered for optimum ignition timing. A KS detects when the engine is experiencing detonation and then signals the PCM to reduce the spark advance until detonation is no longer detected.

Operation

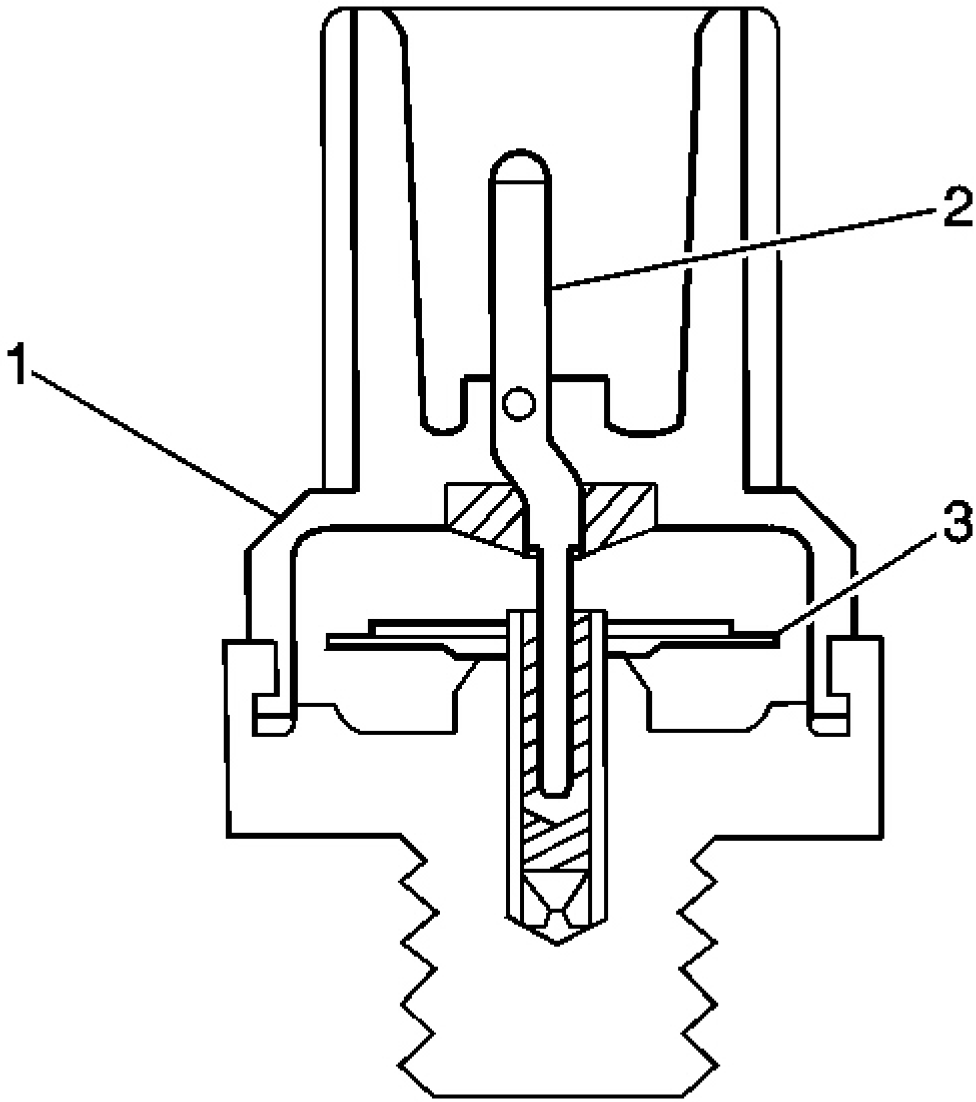


Fig. 215: Identifying Knock Sensor Components
Courtesy of GENERAL MOTORS CORP.

The KS detects when the engine is experiencing detonation. The KS (1) has a Piezo ceramic element (3) that generates a signal at the same resonance point as the expected knocking frequency of the engine. When engine detonation is detected, the sensor signals the PCM to reduce the spark advance until detonation is no longer detected.

In response to the KS signal the PCM retards the spark advance in order to reduce the detonation. The amount of timing retard that the PCM applies is based on the engine speed and the length of time that the engine detonation is detected. Once the spark timing is retarded, the KS circuitry in the PCM performs calculations in order to determine how much spark advance should be re-introduced. Normally the ignition timing advance is increased until zero retard, or normal ignition timing, is re-established. If detonation occurs again, the whole cycle will repeat. The alteration of the ignition timing by the KS often occurs continuously while the engine is running, even though no detonation is heard by the vehicle's operator.

Results of Faulty Knock Sensor Operation

A KS that falsely indicates detonation can cause the PCM to retard the ignition timing unnecessarily. Reduced spark advance can cause any of the following conditions:

- Poor fuel economy
- Sluggish engine performance
- Higher exhaust emissions

A KS that fails to detect detonation can cause the PCM to control the ignition timing as if no detonation were occurring. Failure of the PCM to retard the ignition timing when necessary could cause any of the following concerns:

- An excessive engine detonation
- Engine damage during heavy engine loads
- Higher exhaust emissions

EXHAUST GAS RECIRCULATION (EGR) SYSTEM DESCRIPTION

The exhaust gas recirculation (EGR) system controls the formation of oxides of nitrogen (NOx) emissions by recirculating the exhaust gases into the combustion chamber. NOx emissions increase with combustion chamber temperatures. Controlling the high combustion chamber temperatures will help limit the formation of NOx emissions. The EGR system accomplishes this by admitting controlled amounts of exhaust gas into the intake manifold to mix with the incoming air. Mixing exhaust gases with incoming air/fuel mixture modifies the combustion process resulting in lower combustion chamber temperatures.

EGR Valve

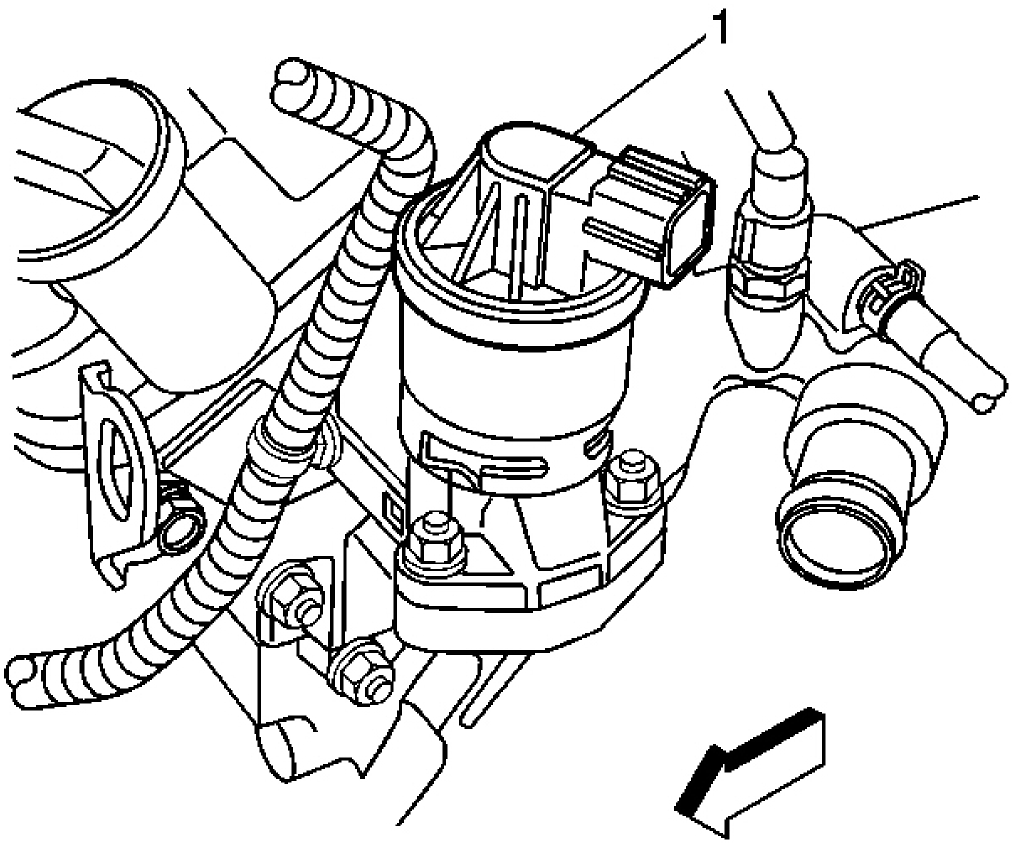


Fig. 216: View Of Exhaust Gas Recirculation (EGR) System
Courtesy of GENERAL MOTORS CORP.

The EGR valve (1) is located on the left corner of the front engine bank. The valve uses a stepper motor to drive a worm gear. The worm gear is in mesh with a plunger that controls the exhaust gas passage opening. Plunger movement is monitored by a position sensor. The powertrain control module (PCM) uses a pulse width modulated (PWM) signal to operate the stepper motor. By rotating the stepper motor in different directions, the PCM controls the opening of the exhaust gas passage to the intake manifold.

Operation

The PCM uses the inputs from various sensors in order to control the operation of the EGR valve. Information from the engine coolant temperature (ECT) sensor, the throttle position (TP) sensor, the vehicle speed sensor (VSS), and the manifold absolute pressure (MAP) sensor are critical for proper EGR valve operation. Under heavy engine loads, when the demand for power is high, the EGR valve is closed. In order to insure a smooth idle and stable engine operation, the EGR valve is also closed at closed throttle engine operation. The EGR valve is usually open during low and medium engine loads and speeds. Combining pre-programmed engine calibrations with various sensor inputs, the PCM calculates the optimum opening of the EGR valve.

The EGR valve position sensor enables the PCM to know if the valve plunger is actually in the desired position. Information from the sensor is used to increase or decrease the plunger opening, in order to achieve the correct flow. If the position sensor signal indicates that the plunger position is incorrect and cannot be adjusted, a diagnostic trouble code (DTC) will set.

Results Of Incorrect Operation of the EGR System

Excessive EGR valve flow may cause any of the following conditions:

- The engine stalling
- Rough idle, surging, or engine hesitation
- Lower fuel economy
- Incomplete combustion and high exhaust emissions

Inadequate EGR valve flow may cause any of the following conditions:

- Engine detonation
- Excessive exhaust emissions

AIR INTAKE SYSTEM DESCRIPTION

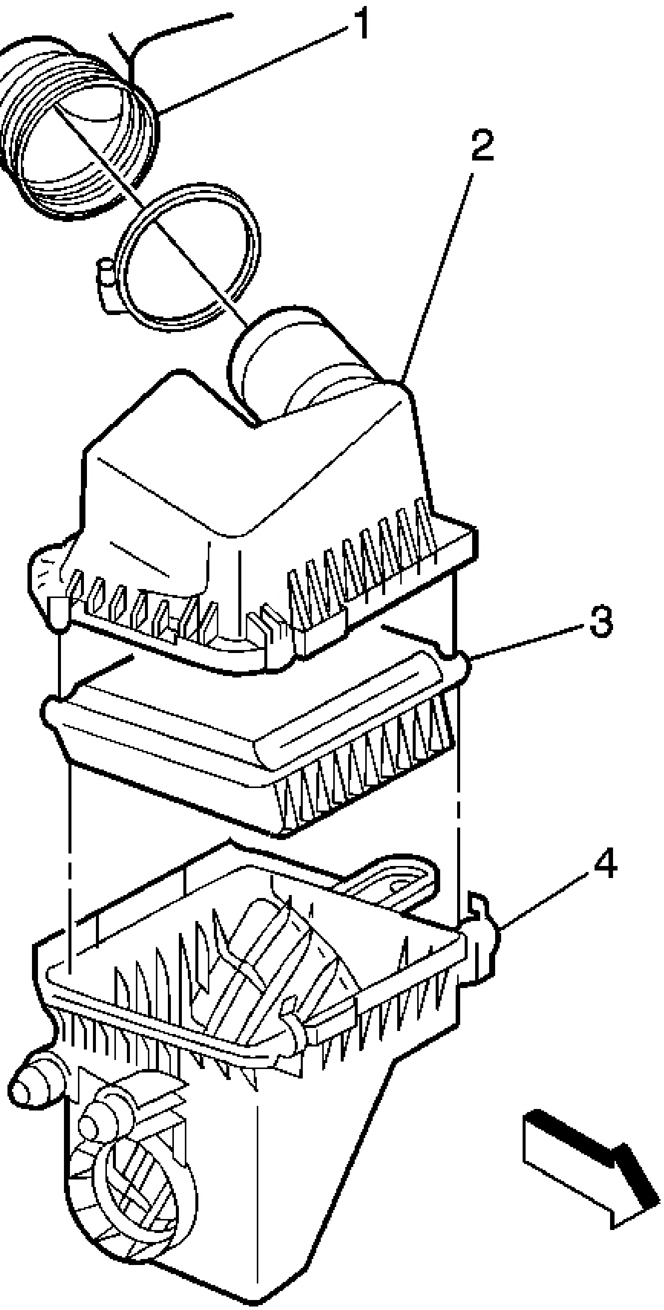


Fig. 217: View Of Air Intake System
Courtesy of GENERAL MOTORS CORP.

The air induction system provides air with oxygen for the combustion process. The air cleaner keeps dirt from entering the engine. Outside air is drawn into the air cleaner lower assembly (4) and passes through the air cleaner element (3). Next the air enters the air cleaner upper assembly (2) and flows through the inlet air duct (1), to the throttle body, and into the intake manifold. Finally the air travels into the cylinder head and through the intake port, ending in the combustion chamber. The inlet air duct contains the intake air temperature (IAT) sensor 1.

The following components are directly or indirectly a part of the air supply system.

Throttle Body Assembly

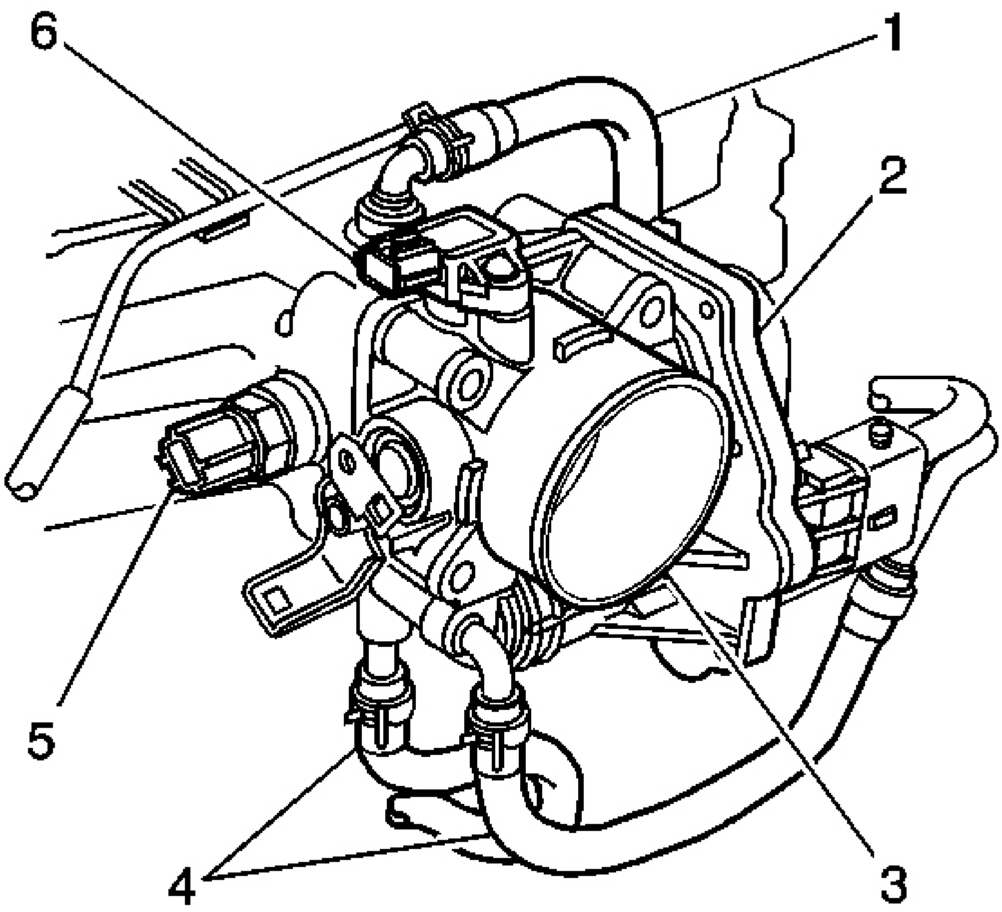


Fig. 218: View Of Throttle Body Assembly
Courtesy of GENERAL MOTORS CORP.

Callouts For Fig. 218

Callout	Component Name
1	Positive Crankcase Ventilation (PCV) Hose
2	Throttle Actuator Control (TAC) Module
3	Throttle Body
4	Engine Coolant Hoses
5	Intake Air Temperature (IAT) Sensor 2
6	Manifold Absolute Pressure (MAP) Sensor

The throttle body contains a throttle valve that controls the amount of air entering the engine. The throttle valve is opened and closed by the throttle actuator control (TAC) motor. The TAC motor is an integral part of the TAC module assembly (2) mounted on the side of the throttle body. The TAC motor is controlled by commands from the powertrain control module (PCM), passed to the module circuitry through a dedicated serial data line. The TAC module also contains two throttle position (TP) sensors, TP sensor 1 and TP sensor 2. For detailed information on the operation of the TAC system refer to **Throttle Actuator Control (TAC) System Description** .

In order to prevent cold weather icing and stabilize cold weather performance, the throttle body is warmed by engine coolant (4). The manifold absolute pressure (MAP) sensor (6) is located on top of throttle body.

Engine Idle Speed Control

The engine idle speed is controlled by the powertrain control module (PCM) through the throttle actuator control (TAC) motor located in the TAC module assembly. There are several reasons for idle speed control:

1. In order to maintain the engine idle speed at the specified RPM at all times. The engine idle speed can vary due to any of the following reasons:
    - A change in the load applied to engine such as when the rear defogger is operating, the automatic transaxle is shifted to R, D, 2 or L ranges, the A/C is turned ON, the headlights or stop lights are turned ON, etc.
    - A change in the atmospheric pressure.
    - A change in the engine's condition over time.
2. In order to improve the starting performance of the engine.
3. In order to improve the driveability of the engine during warm up.
4. In order to compensate for the change in the air/fuel mixture ratio when decelerating.

Intake Air Temperature (IAT) Sensors

The intake air temperature (IAT) sensor 1 is located in the inlet air duct between the air cleaner and the throttle body. The intake air temperature (IAT) sensor 2 is mounted in the front of the intake manifold just behind the throttle body. The IAT sensors measure the temperature of the air at their respective locations in the intake system. The IAT sensors provide useful air temperature information to the powertrain control module (PCM).

Each IAT sensor is a thermistor-a resistor whose resistance changes as a function of temperature. When the temperature is low, the resistance is high. The resistance decreases as the temperature increases. The IAT sensor is a 2-wire circuit with a reference or signal voltage and a ground coming from the PCM.

IAT Sensor Operation

Temperature	Resistance	Voltage
Low	High	High
High	Low	Low

Throttle Position (TP) Sensors

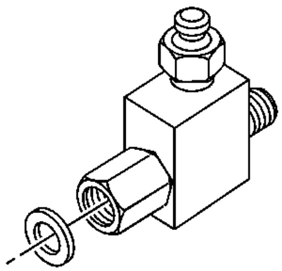
There are 2 throttle position (TP) sensors, both located in the molded side cover of the TAC module assembly. Each is a potentiometer connected to the throttle shaft of the throttle body. By monitoring the voltage on the signal line, the logic circuits in the throttle actuator control (TAC) module calculate the throttle position. When the TAC motor changes the throttle valve angle in response to accelerator pedal movement, the two TP sensor signal voltage outputs also change. Both TP sensor signal voltages are low at closed throttle and increase as the throttle opens. TP sensor 1 determines the actual throttle valve position. TP sensor 2 provides a backup value for TP sensor 1. For detailed information on the operation of the TAC system refer to **Throttle Actuator Control (TAC) System Description** .

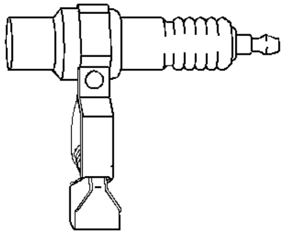
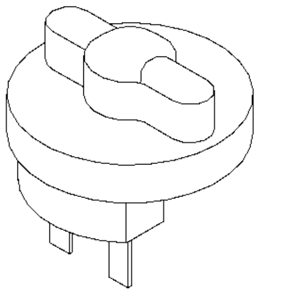
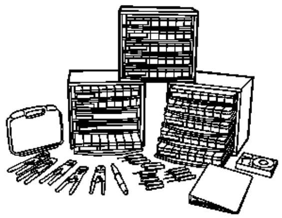
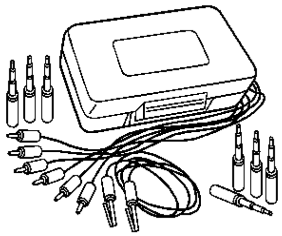
Because the position of the throttle valve controls the air supply to the engine, the powertrain control module (PCM) will modify the fuel delivery based on the throttle angle. For example, power enrichment occurs when the throttle angle approaches wide-open throttle. The PCM looks primarily for changes in the manifold absolute pressure (MAP) sensor and TP sensor outputs in order to control fuel delivery.

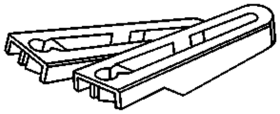
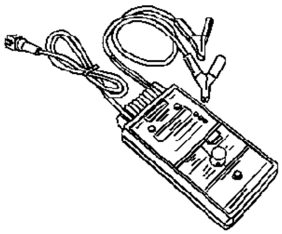
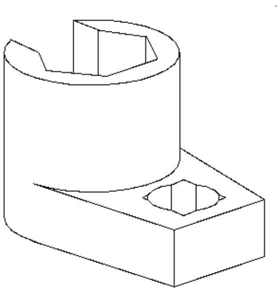
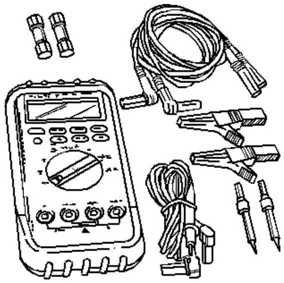
SPECIAL TOOLS AND EQUIPMENT

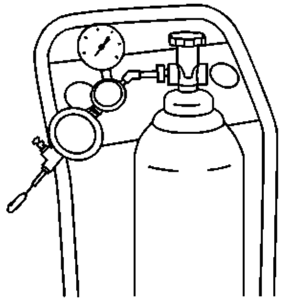
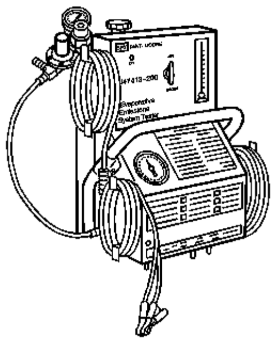
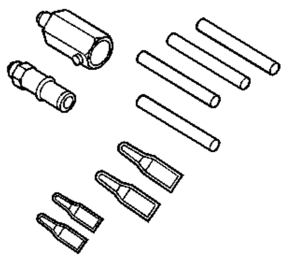
SPECIAL TOOLS

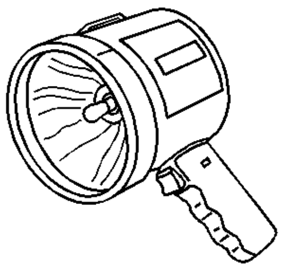
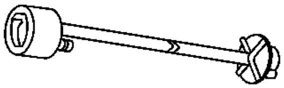
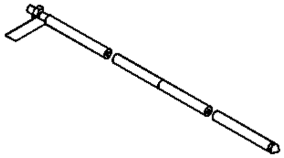
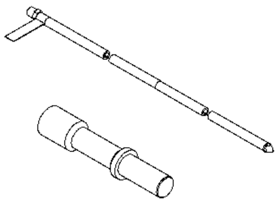
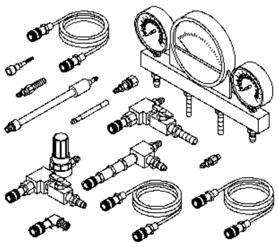
Special Tools

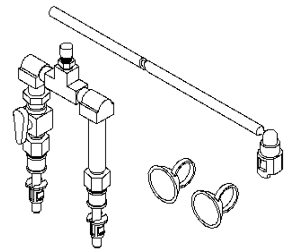
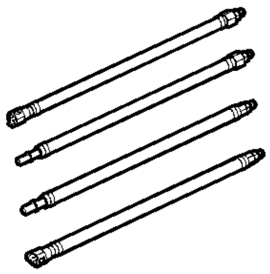
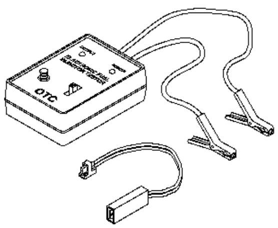
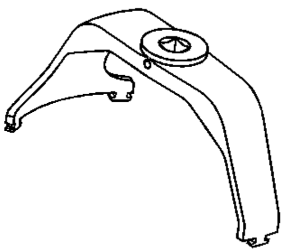
Illustration	Tool Number/ Description
	EN 46332 Rocker Arm Oil Pressure Gage Adapter
	J 26792 (SA9199Z)

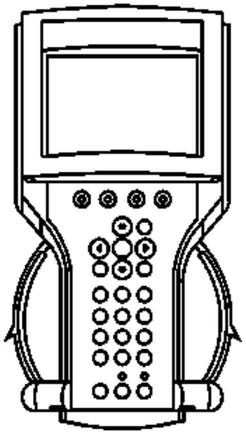
	Spark Tester
	J 34730-2B/2C (SA9194E) Injector Test Lamp
	J 38125-1 Terminal Repair Kit
	J 43907 Connector Test Adapter Kit
	J 37088-A (SA9157E) Fuel Line Disconnect Tool Set

	
	J 39021 (SA9182E) Fuel Injector Coil and Balance Tester
	J 39194-C Oxygen Sensor Wrench
	J 39200 (SA91114NE) High Impedance Multimeter (Digital Multimeter -DMM)
	J 41413

	Evaporative Pressure and Purge Station
	J 41413-100 (J 41413-200) Evaporative Emissions System Tester (EEST)
	J 41413-300 (J 45724) EVAP Cap and Plug Kit
	J 41413-SPT High Intensity White Light

	
	GE 41415-50 Fuel Tank Cap Adapter
	J 42960-1 (SA9804E) Fuel Tank Siphoning Hose
	SA9804E Fuel Tank Drain Hose
	SA9127E Gage Bar Set

	SA9127E-7 Fuel Pressure/Flow Adapter
	J 43937 3/8 Inch Male/Female Fuel Pressure Adapter Lines
	SA9156E Fuel Tank Lock Ring Remover
	J 45722 Fuel Tank Lock Ring Remover

	7000081-SAT4-32MG (7000061) Tech II Diagnostic Scan Tool