

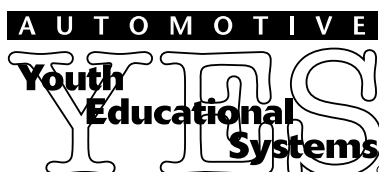


# **Technicians Reference Booklet**

**Basic Emission  
and  
Fuel Systems**

**Module 405**

MSA5P0160C



**Technical Training**

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# Basic Emission and Fuel Systems

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# Basic Emission and Fuel Systems

## Introduction



Today's automobile is the refinement of research, which through the years has led to a computer controlled machine sensitive to both internal and external influences. It is able to provide optimum performance throughout a broad range of atmospheric conditions, fuel quality, engine condition and driver demand. The information covered in this course will get you started with the knowledge base you must have to effectively analyze conditions, situations and problems associated with vehicle emissions. The majority of the course will be conducted in a lab/lecture format.

**You are required to be an active member of the class. Take notes and complete the lab structured work sheets. A completion test will be given at the end of the class based on information covered in lecture and hands on exercises.**

## Raw Materials For Combustion

To fully understand the emissions produced by a vehicle, a closer look at the raw materials used must be made. They include fuel and the atmosphere. The fuel or gasoline is a hydrocarbon made from a mixture of components which vary widely in their physical and chemical properties. Gasoline must cover a wide range of vehicle operating conditions, engine temperature, climates, altitudes and driving patterns.



There are many driveability conditions that can be caused from gasoline problems. One such problem is incorrect fuel volatility. Volatility is a fuel's ability to change from a liquid to a vapor. Gasoline refiners must chemically adjust their product seasonally, providing more volatile gasoline in the winter and less in the summer. There are many ways of measuring volatility however there is only one practical way you can check it in your shop. That is the vapor pressure test using the Reid Method.

# Basic Emission and Fuel Systems

Problems associated with incorrect Volatility:

## Low Volatility -

Cold Start

Warm up performance

Cool weather performance

Cool weather drive ability

Increased deposits of the combustion chamber

## High Volatility -

High evap emissions

Hot drive ability

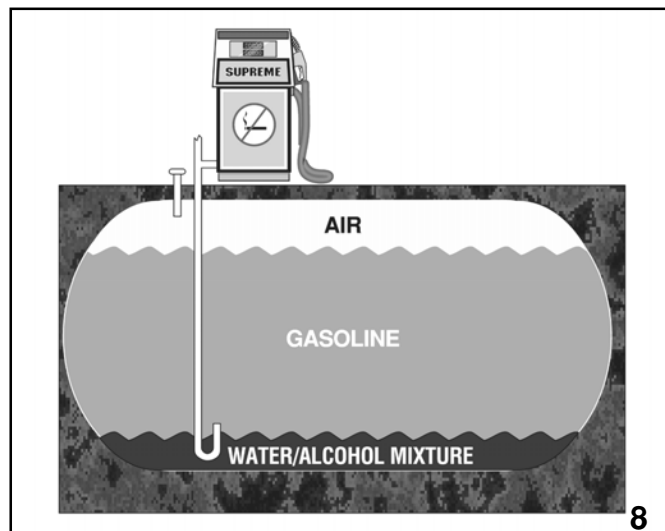
Vapor lock

Poor fuel mileage

There are six volatility classes of gasoline. Record their values on the spaces below.

AA \_\_\_\_\_  
A \_\_\_\_\_  
B \_\_\_\_\_  
C \_\_\_\_\_  
D \_\_\_\_\_  
E \_\_\_\_\_

Higher volatile fuels will evaporate easier than lower volatile fuels so higher pressure readings will be achieved.



*Storage Tank*

## Phase Separation

Another problem of today's gasoline can be created if the fuel is stored in a water contaminated tank. Referred to as Phase separation, this condition results because of the use of alcohols as octane boosters and oxygenates. The alcohol in the gasoline will absorb the water in the tank and separate from the gasoline. This new heavier mixture will settle in the bottom of the storage tank. Sooner or later someone will get a tank full or enough of it pumped into their vehicle to cause a drive ability problem. Oxygenates or alcohols are used in fuels where lower emission output is required by state or federal regulations. These fuels are called "Reformulated" or "Oxygenated" fuel. The difference between the two is the amount of additional oxygen they supply to the combustion process.



# Basic Emission and Fuel Systems

## Reformulated and Oxygenated Fuel

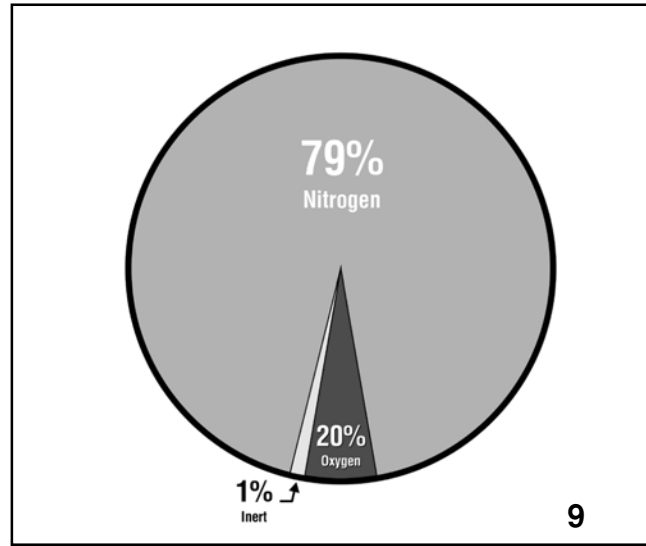
"Reformulated" fuel contains 2% oxygen by weight. "Oxygenated" fuel contains 3.5% oxygen by weight. There is a trade off with use of either of these fuels and that is a 2% fuel economy loss and less energy output per gallon. Gasoline normally creates 115,000 BTU's per gallon. Reformulated or Oxygenated fuel will produce only 76,000 BTU's per gallon. Ethanol and Methanol are the two alcohols used in oxygenated gasoline. Methanol is a wood alcohol and can be used up to 5% with most auto manufactures. However it is very corrosive and many cosolvents and rust inhibitors must be used with it to prevent damage to the fuel system. Ethanol or grain alcohol is not as corrosive and is allowed up to 10%.

## Octane

Octane is defined as a fuels ability to resist knock. Also known as the Anti Knock Index. (AKI) is the average of the Motor and Research Octane Number (RON).

$(R+M)/2$  Laboratory tests determine MON and RON. There is no advantage in using a higher octane than it takes to prevent engine knock. Engine knock is created by using a lower octane than is required. Heat and pressure will ignite the air fuel mixture before the spark, creating an uneven burn across the combustion chamber. Subaru ignition timing learning control logic memorizes when the engine knock occurs, and retards the timing away from optimum to compensate.

## Atmosphere

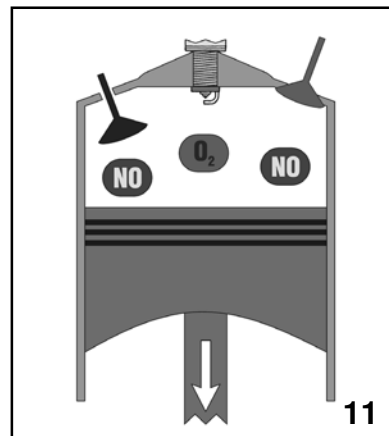


*Atmosphere*

The atmosphere is composed of 79% nitrogen, 20% oxygen and 1% inert gases.

Each intake stroke fills the cylinder with these gases. This action also produces vacuum.

## Vacuum

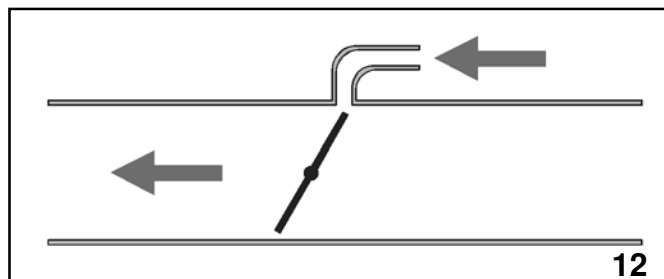


*Manifold Vacuum*

There are two types of vacuum or negative pressure produced by the engine. The first to be produced in a measurable amount is called Intake manifold vacuum. It is produced by the intake stroke of the engine.

# Basic Emission and Fuel Systems

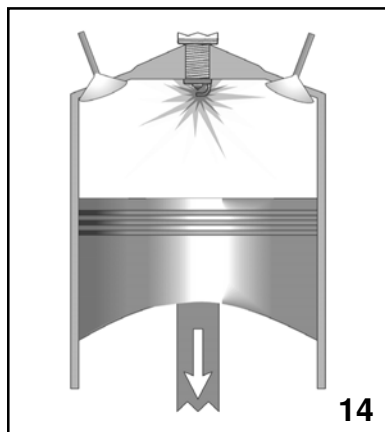
The second type is Ported vacuum. It is produced by the volume and speed of the air entering the engine. The positioning of the throttle plate determines the amount produced and at what spot in the throttle bore it is located. This effect enables the ported vacuum to be used as a working pressure and a controlling pressure.



*Ported Vacuum*

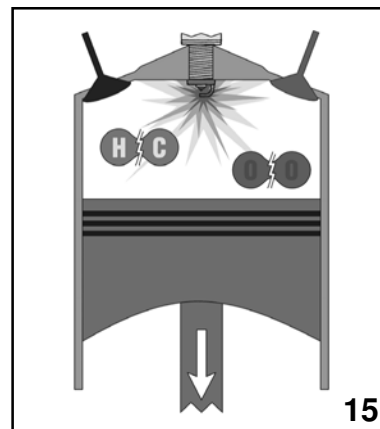
## Combustion Process

Combining fuel and atmosphere in the combustion chamber under pressure and supplying a spark changes chemical energy to heat energy. The resulting gas expansion pushes the piston down.



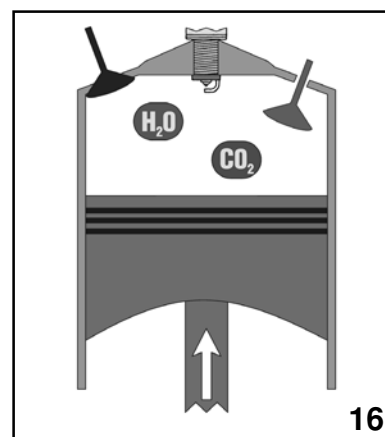
*Power Stroke*

Combustion splits gasoline or HC. Engine temperature, compression, fuel purity, ignition timing, and the mechanical condition of the engine determine the degree of complete combustion. This ultimately determines the amount and type of exhaust emissions produced. Near complete combustion will join oxygen with hydrogen and form water. The carbon will join with oxygen to form CO<sub>2</sub>, Carbon Dioxide.



*Combustion Process*

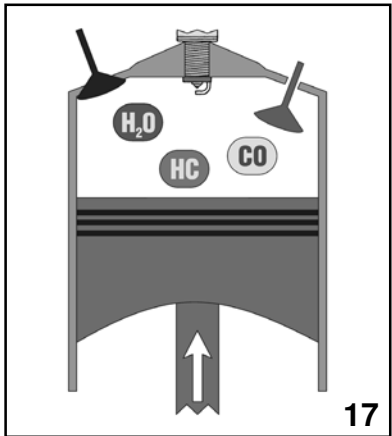
Complete combustion is very hard to achieve because of uneven engine temperatures, random fuel impurities and many other situations, however in theory if complete combustion did take place one gallon of gasoline would produce one gallon of water.



*Complete Combustion*

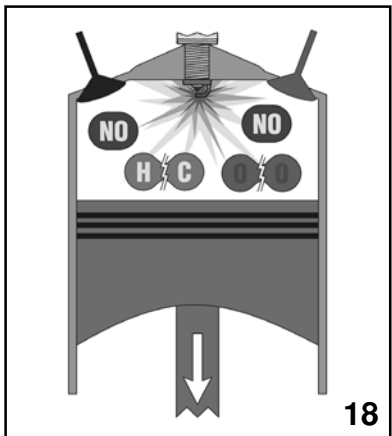
Incomplete combustion occurs when the entire fuel charge is not burned in the combustion chamber. Unburned HC will be exhausted to the atmosphere if the exhaust remains untreated Carbon will still join with oxygen but with only one part so the result is the production of Carbon Monoxide, CO. This gas is very unstable. If inhaled .3 of 1% in a 30 minute time frame will create Carbon Monoxide Poisoning which can be fatal. HC and CO are both harmful to the atmosphere.

## Basic Emission and Fuel Systems

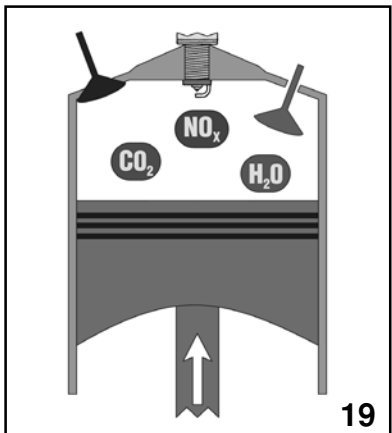


### *Incomplete Combustion*

Another harmful gas is oxides of nitrogen, NO<sub>x</sub>. The x is an indicator that the number of oxygen molecules is unknown. NO<sub>x</sub> is produced from high pressure and heat in excess of 2500° F (1371.1 C) in the combustion chamber.



### Nitrogen During Combustion



### *NO<sub>x</sub> Production*

<b>HYDROCARBONS (HC)</b> <i>Measured in PPM</i> Result of incomplete combustion (raw fuel)	<b>75 PPM</b>
<b>CARBON MONOXIDE (CO)</b> <i>Measured in (%)</i> Result of fuel burnt without enough air.	<b>0.5%</b>
<b>OXYGEN (O<sub>2</sub>)</b> <i>Measured in (%)</i> Result of a lean running engine.	<b>0.5%</b>
<b>CARBON DIOXIDE (CO<sub>2</sub>)</b> <i>Measured in (%)</i> Result of an efficient running engine.	<b>13.5%</b>
<b>OXIDES OF NITROGEN (NO<sub>x</sub>)</b> <i>Measured in PPM</i> Result of combustion chamber temperatures over 2500° F	<b>&lt;400 PPM</b>

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Notes:

[illegible]

# Basic Emission and Fuel Systems

Review the analyzer readings below and choose the correct answer that best describes the condition. (Write the corresponding letter on the space provided below).

- |                     |                             |
|---------------------|-----------------------------|
| A) Normal Condition | E) Loose Knock Sensor       |
| B) Rich             | F) Open Coolant Temp Sensor |
| C) Lean             | G) Clogged Injector         |
| D) Lean Misfire     | H) Open Plug Wire           |

<b>CONDITION 1</b>	<b>HC (hydrocarbons)</b>	<b>75 PPM</b>
	<b>CO (carbon monoxide)</b>	<b>0.1%</b>
	<b>O<sub>2</sub> (oxygen)</b>	<b>9.0%</b>
	<b>CO<sub>2</sub> (carbon dioxide)</b>	<b>5.0%</b>
	<b>NO<sub>x</sub> (oxides of nitrogen)</b>	<b>1000 PPM</b>
<b>CONDITION 2</b>	<b>HC (hydrocarbons)</b>	<b>20 PPM</b>
	<b>CO (carbon monoxide)</b>	<b>0.5%</b>
	<b>O<sub>2</sub> (oxygen)</b>	<b>13.0%</b>
	<b>CO<sub>2</sub> (carbon dioxide)</b>	<b>0.5%</b>
	<b>NO<sub>x</sub> (oxides of nitrogen)</b>	<b>&lt;400 PPM</b>

**21**

Condition 1: \_\_\_\_\_

Condition 2: \_\_\_\_\_

<b>CONDITION 3</b>	<b>HC (hydrocarbons)</b>	<b>20 PPM</b>
	<b>CO (carbon monoxide)</b>	<b>0.0%</b>
	<b>O<sub>2</sub> (oxygen)</b>	<b>9.0%</b>
	<b>CO<sub>2</sub> (carbon dioxide)</b>	<b>5.0%</b>
	<b>NO<sub>x</sub> (oxides of nitrogen)</b>	<b>800 PPM</b>
<b>CONDITION 4</b>	<b>HC (hydrocarbons)</b>	<b>350 PPM</b>
	<b>CO (carbon monoxide)</b>	<b>3.0%</b>
	<b>O<sub>2</sub> (oxygen)</b>	<b>9.0%</b>
	<b>CO<sub>2</sub> (carbon dioxide)</b>	<b>0.1%</b>
	<b>NO<sub>x</sub> (oxides of nitrogen)</b>	<b>11 PPM</b>

**22**

Condition 3: \_\_\_\_\_

Condition 4: \_\_\_\_\_

<b>CONDITION 5</b>	<b>HC (hydrocarbons)</b>	<b>850 PPM</b>
	<b>CO (carbon monoxide)</b>	<b>0.3%</b>
	<b>O<sub>2</sub> (oxygen)</b>	<b>8.0%</b>
	<b>CO<sub>2</sub> (carbon dioxide)</b>	<b>5.0%</b>
	<b>NO<sub>x</sub> (oxides of nitrogen)</b>	<b>800 PPM</b>
<b>CONDITION 6</b>	<b>HC (hydrocarbons)</b>	<b>1200 PPM</b>
	<b>CO (carbon monoxide)</b>	<b>0.3%</b>
	<b>O<sub>2</sub> (oxygen)</b>	<b>8.0%</b>
	<b>CO<sub>2</sub> (carbon dioxide)</b>	<b>8.0%</b>
	<b>NO<sub>x</sub> (oxides of nitrogen)</b>	<b>800 PPM</b>

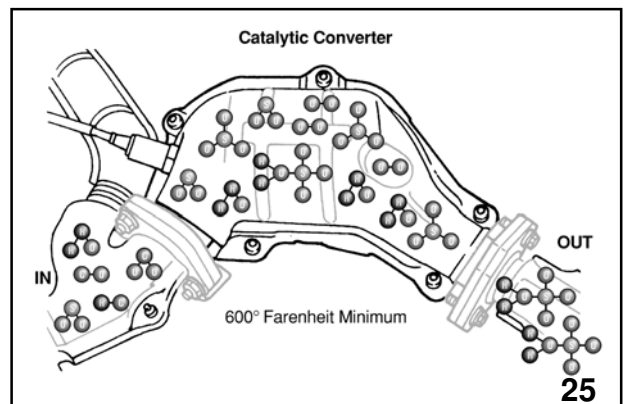
**23**

Condition 5: \_\_\_\_\_

Condition 6: \_\_\_\_\_

## Catalytic Converter

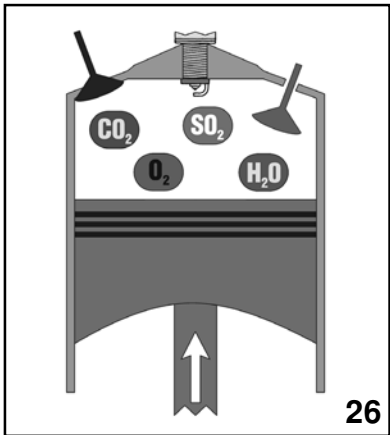
Reducing HC, CO and NO<sub>x</sub> is the objective of the catalytic converter. The converter is made of a honey comb ceramic structure held in place with a Nickel support shell all contained in a metal housing. Rare nobel metals, Platinum, Palladium and Rhodium, are adhered to the ceramic structure. These two metals give the catalytic converter a 3 way operating characteristic. When in operation the converter will change CO, HC and NO<sub>x</sub> to CO<sub>2</sub>, Nitrogen also enables it to store oxygen during times of a lean mixture and bring it into the conversion process during times of ric mixtures. An operating temperature of at least 600° F (315.55 C) is required for the catalytic converter to operate.



Normal Catalytic Operation

# Basic Emission and Fuel Systems

The Nickel content of Catalytic converts has been reduced in recent years because of its natural ability as a reducing agent.

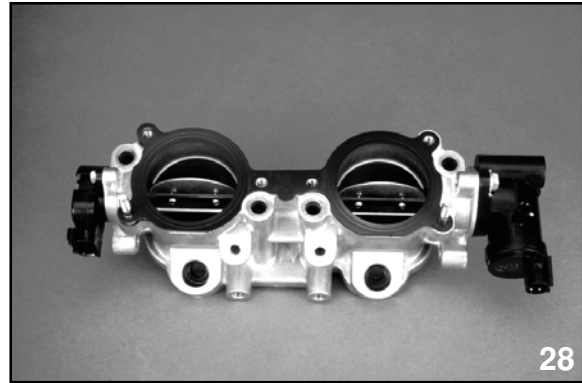


*$\text{SO}_2$  Production*

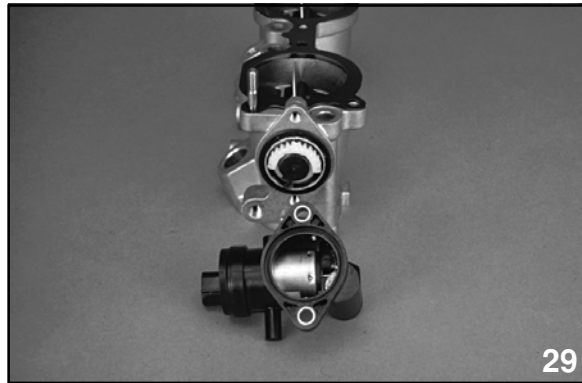
This characteristic normally is beneficial to the reduction of harmful emissions but if the fuel is sulfur contaminated the results is the production of Hydrogen Sulfide,  $\text{H}_2\text{S}$ . Federal regulations state that there can only be 1/10 of 1% sulfur content in fuel. Removing sulfur from crude oil is an expensive and difficult procedure sometimes yielding poor results. Sulfur content higher than the Federal specification creates the sulfur contaminated fuel. Initial combustion of the contaminated fuel produces  $\text{SO}_2$ .  $\text{SO}_2$  burned in the catalytic converter creates  $\text{SO}_3$ .  $\text{SO}_3$  absorbs water very easy and produces  $\text{H}_2\text{SO}_4$ .

Some of the  $\text{SO}_2$  created at combustion will flow across the Nickel which strips or reduces an oxygen molecule from it and a Hydrogen molecule will replace it. Yielding  $\text{H}_2\text{S}$  the aromatic that smells like rotten eggs.

## Tumble Generator Valve



*Runner Intake*



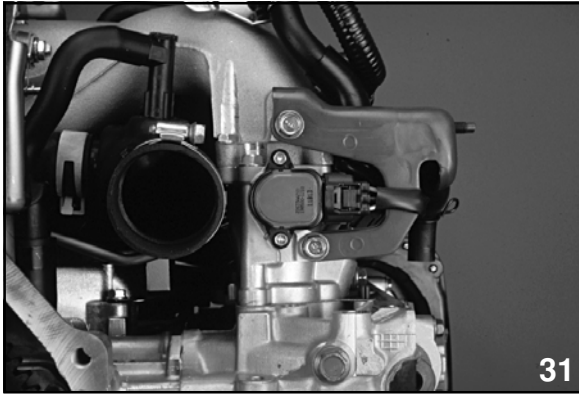
*Stepper Motor*

The EJ-2.0 is equipped with a tumble generator valve at each intake runner. This new system uses a shaft for each side of the engine that is driven by a stepper motor. The movement of the shaft is monitored by a sensor on the opposite end.



*Vent Hose*

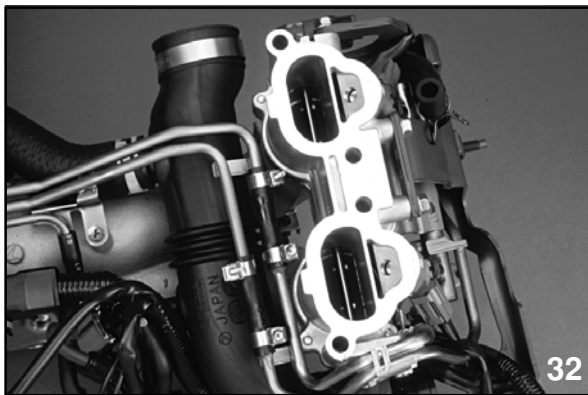
# Basic Emission and Fuel Systems



*TGV Sensor*

The shaft operates the tumble generator valve, which is a plate similar in design to the throttle plate. At idle the plate is closed (dependant on coolant temperature and time from engine start).

Off idle the plate is open.

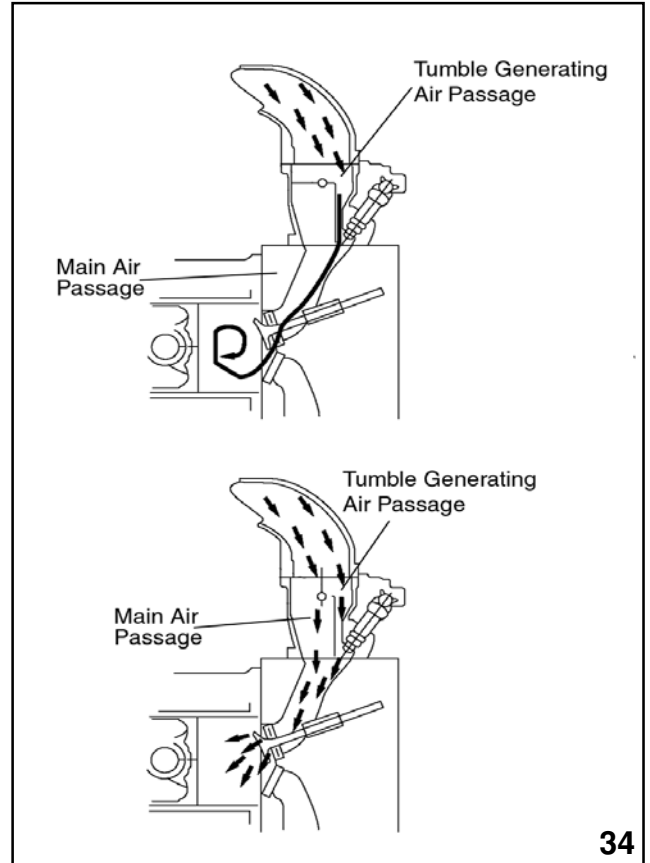


*Manifold Bottom View*



*TGV Passage*

When the plate is closed the main air passage through the intake runner is blocked. This will force all air necessary for engine operation during idle to flow through the bypass channel. This action helps to mix the air fuel mixture by producing a tumbling effect to the incoming air, resulting in a cleaner operating engine while idling.

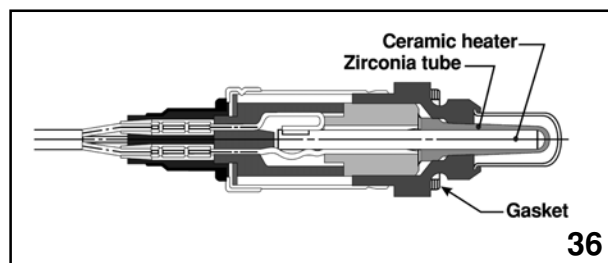


*TGV Close / Open*

# Basic Emission and Fuel Systems

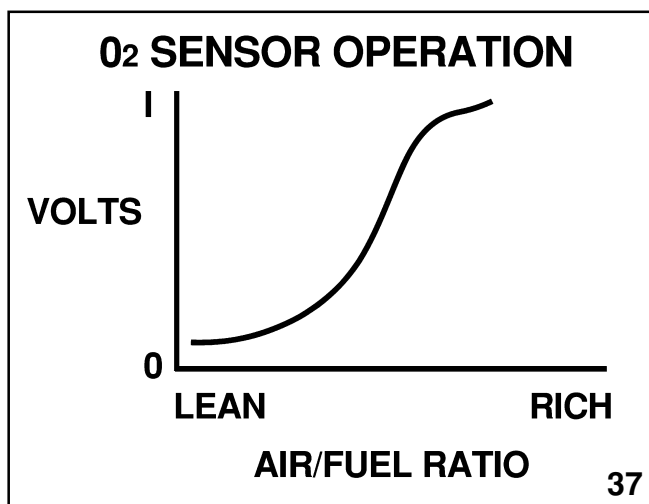
## Oxygen Sensors

Oxygen sensors function to determine the amount of oxygen in the exhaust. The sensor is located upstream of the catalytic converter and monitors the exhaust as it leaves the engine. Rich air fuel mixtures will have very little oxygen in the exhaust while lean mixtures have much more by comparison.



*O<sub>2</sub> Sensor*

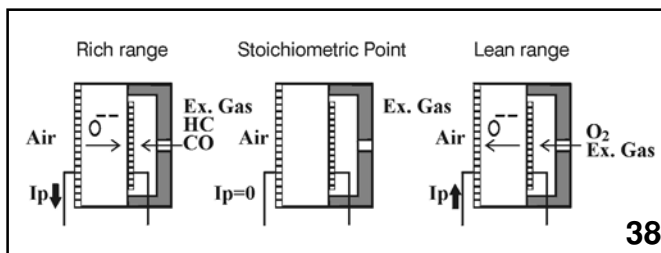
The oxygen sensor after reaching an operating temperature of 600° F (315.55 C) compares the oxygen content of the atmosphere to the oxygen content of the exhaust. Materials making up the oxygen sensor generate a small voltage that represents the air fuel mixture. This electrical signal is sent to the ECM so that adjustments can be made reducing harmful HC emissions. Rich air fuel mixtures generate higher voltages no higher than 1 volt and lean air fuel mixtures generate lower voltages closer to 300 millivolts.



*Voltage Chart  
(Oxygen Sensor Operation)*

The normal color of the oxygen sensor tip is gray. White indicates the sensor has been operating in a constant lean air fuel mixture. Black indicates a constant rich air fuel mixture. Diagnose the fuel and engine management system if the color of the sensor is other than grey, as the response time or sensitivity of the sensor has been affected.

The Air Fuel Ratio Sensor is used on 1999 California Models. Located in place of the front Oxygen Sensor, the AFR begins to operate and effect the Air Fuel Ratio faster than conventional Oxygen Sensors. Zirconia remains the key material in AFR construction. It's ability to absorb oxygen and new ECM circuitry work together to provide fast accurate data.

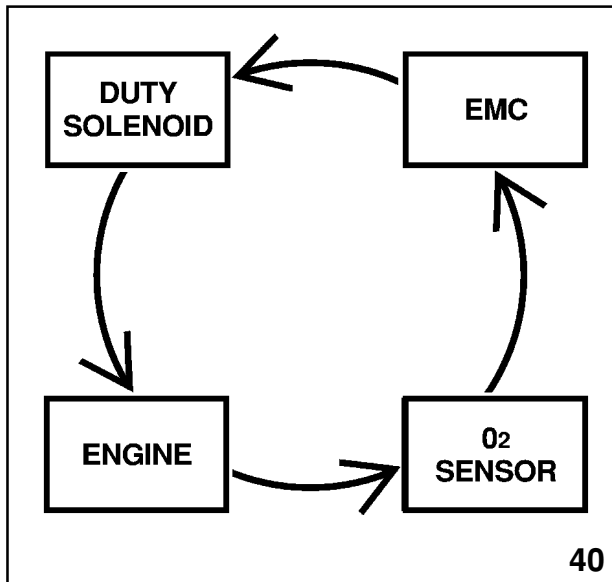


A contact plate is located on the top and bottom of a layer of Zirconia. These plates are connected to wires that lead to the ECM. The exhaust side of the AFR is covered by a porous chamber that allows the exhaust gas access to the Zirconia center while the outside of the AFR sensor is exposed to the atmosphere.

Oxygen ions pass from the exhaust side to the atmospheric side during lean engine operation and from the atmospheric side to the exhaust side during rich engine operation. Stoichiometric engine operation will result in no ion exchange.

# Basic Emission and Fuel Systems

## Closed Loop

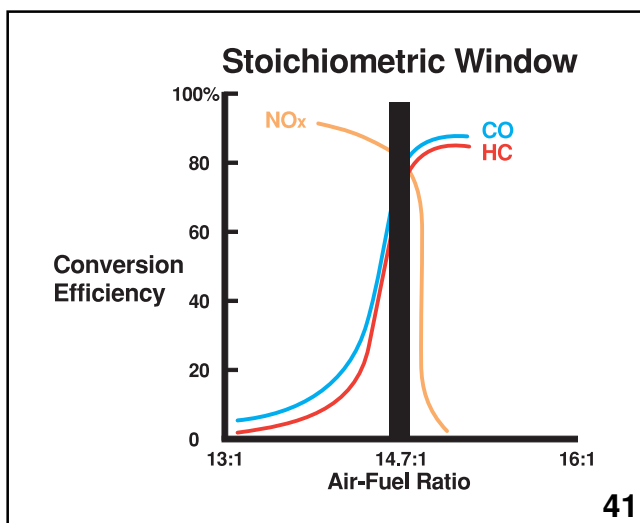


*Closed Loop*

Closed loop is a description of fuel injection and engine management operation where both systems are monitored and adjusted.

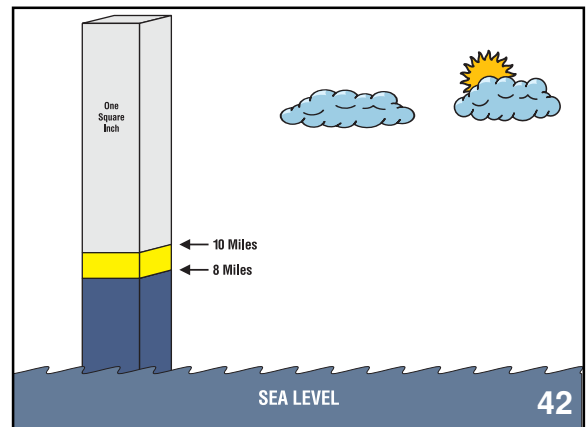
Closed loop relies on input from sensors that monitor engine operation. Providing precise control to increase power and reduce emissions.

Open loop is a description of the fuel injection and engine management systems that provide the best operating conditions during: Cold engine operation, near full throttle, and fail-safe.



*Stoichiometric Window*

Maintaining the ideal air fuel mixture that creates the most power and lowest emissions is referred to as Stoichiometric. At sea level the weight of the atmosphere is 14.7 pounds per square inch. This column of air extends from the ground to approx. 110 miles straight up. This 14.7 psi burned with 1 pound of fuel is stoichiometric. Higher altitudes have less dense air, it weighs less because its closer to the beginning of the 110 mile high column.



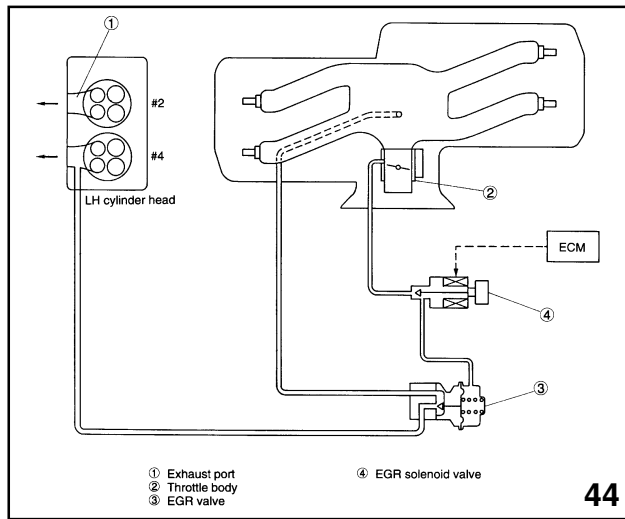
*Sea Level  
(Atmospheric Pressure)*

Maintaining stoichiometric air fuel mixture in this condition becomes more difficult. The atmospheric pressure can be increased in the engine with turbo chargers and super chargers. The introduction of additional air to the air fuel mixture will compensate for the less dense air.



# Basic Emission and Fuel Systems

## Exhaust Gas Recirculation



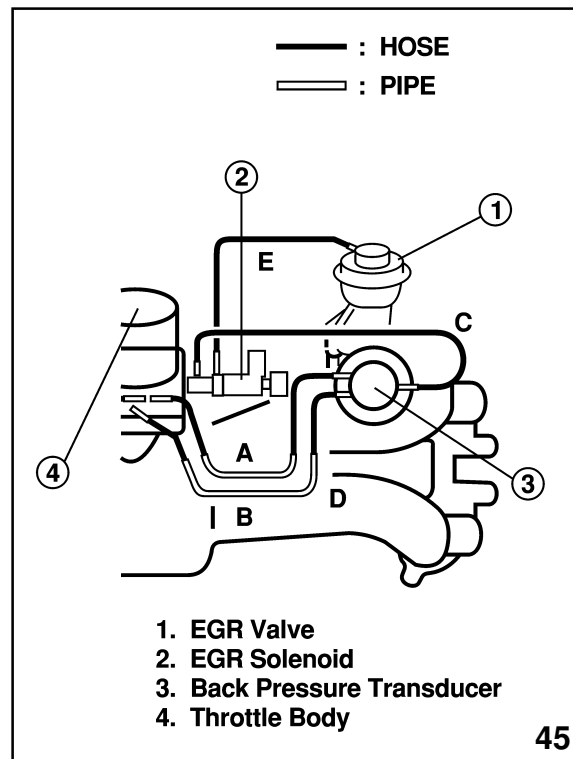
*Exhaust Gas Recirculation*

Preventing the production of harmful emissions is the best way to keep them from the atmosphere. NO<sub>x</sub> emissions control is performed by the Exhaust Gas Recirculation (EGR) system. The EGR system when activated displaces 6 to 13 % of the normal air in the intake manifold. Part of the exhaust is routed through the EGR valve to the intake manifold. This EGR gas has already burned, containing little oxygen and fuel. Mixed in the combustion chamber with normal air and fuel, the EGR gas reduces the heat because the EGR gas will not effectively burn. The heat generated with normal air surrounding the EGR gas is absorbed by the EGR gas and exits the engine as exhaust. This action lowers the overall combustion chamber temperature controlling the production of NO<sub>x</sub> emissions.

The EGR valve is operated with a ported vacuum signal that is controlled by the EGR solenoid. Solenoid activation is dependent on ECM logic.

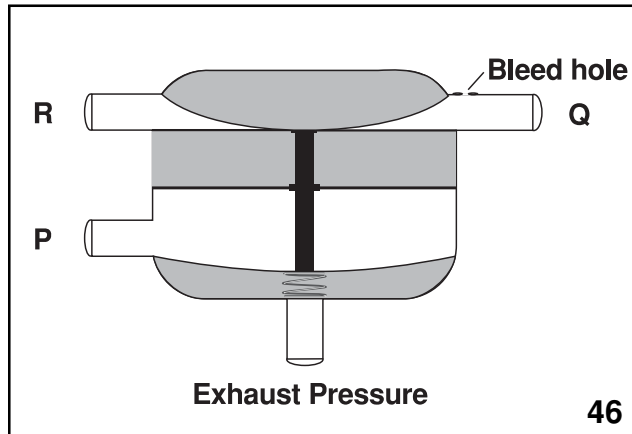
EGR systems used on later model Subaru vehicles are controlled with a solenoid and a Back Pressure Transducer (BPT). Ported vacuum enters the BPT at line R, this will be used as working pressure. Ported vacuum enters the BPT at line P, this will be used as control pressure, throttling vacuum in line R to line Q. Exhaust enters the bottom of the BPT pushing the diaphragm assisting the pressure at line P.

This action continues during all engine operation, however the EGR valve will not operate until the ECM grounds the EGR solenoid.

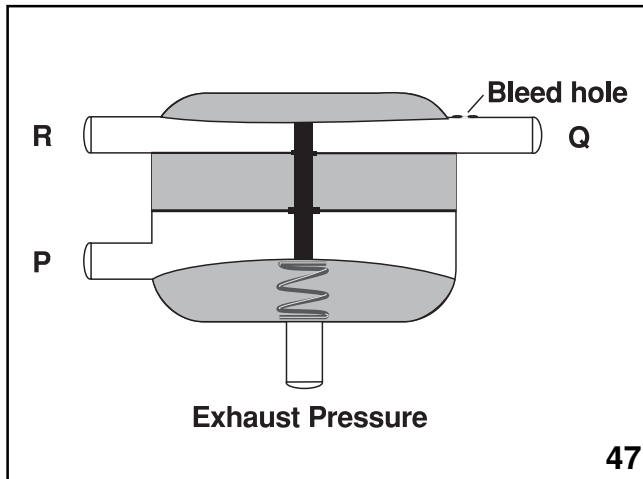


*Vacuum Diagram  
Most 95 and Newer EGR*

# Basic Emission and Fuel Systems



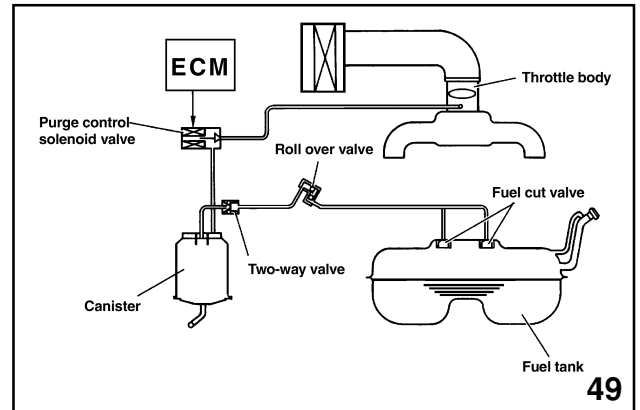
*BPT Operation  
EGR Off*



*BPT Operation  
EGR On*

## Evaporative Emissions Control

Subaru vehicles are equipped with either a Conventional or Enhanced Evaporative Emissions Control System. Both systems function to prevent unburned Hydrocarbons from escaping to the atmosphere.



*Conventional Evaporative System*

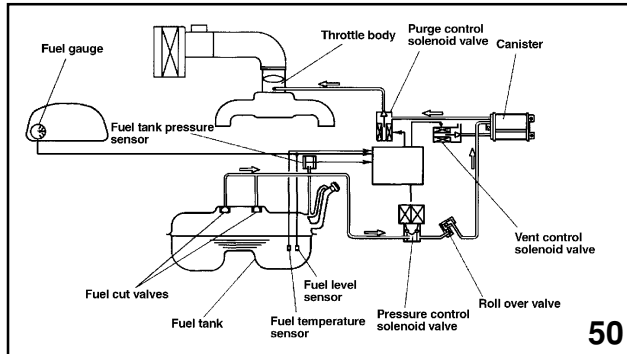
Conventional Evaporative components include the following:

1. Fuel Cap - Construction incorporates a relief valve that allows air to enter the tank in the event a vacuum develops.
2. Canister - Temporarily stores evaporative gas from the fuel tank.
3. Purge control Solenoid valve - Controls the flow of stored evaporative gas from the canister to the intake manifold.
4. Two way valve - Controls air flow to the fuel tank. High tank pressure opens the valve allowing the pressure and evaporative gas to the canister. Low tank pressure closes the valve allowing atmosphere to the fuel tank through a pinhole in the valve.
5. Fuel cut valve - Used on AWD models. Prevents liquid fuel from entering the evaporative line.

Fuel separator allows fuel vapor to condense and return to the tank as liquid. Some models use a plastic tank mounted in the trunk or cargo areas. Other models use an air space designed into the fuel tank to condense fuel vapors.

# Basic Emission and Fuel Systems

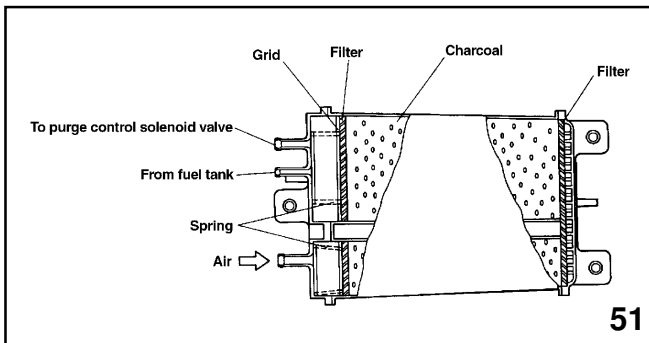
System operation - The ECM grounds the purge control solenoid turning it on. Ported vacuum then removes the stored evaporative gas from the canister. System activation is controlled using coolant temperature engine load and vehicle speed input.



*Enhanced Evaporative System*

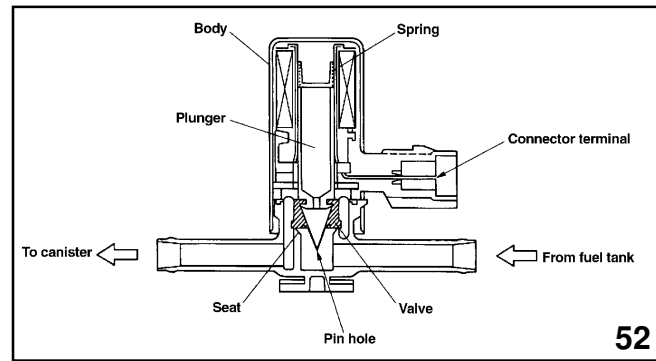
Enhanced Evaporative components include:

1. Canister - Function is unchanged, however the shape is more boxy and is located under the right rear of the vehicle.



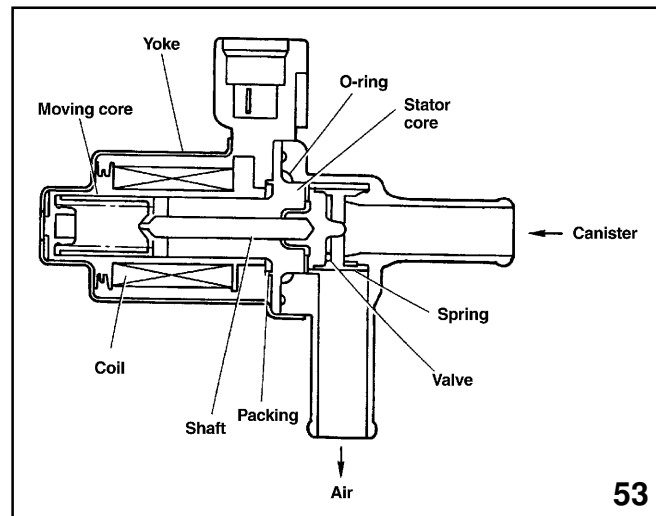
*Canister*

2. Pressure control duty solenoid - Adjusts the pressure inside the fuel tank from a signal from the ECM. It also controls the flow of evaporative gas from the fuel tank to the canister.



*Pressure Control Duty Solenoid*

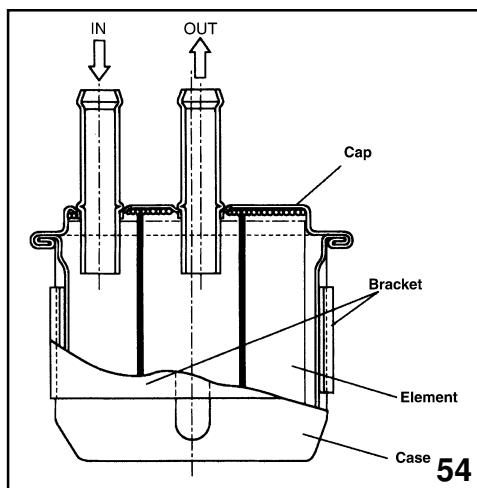
3. Vent Control Solenoid Valve - Controls the flow of atmospheric pressure to the canister. During normal operation the valve is open allowing atmospheric pressure to the canister. During the time the ECM is checking the integrity of the evaporative system the valve is closed to isolate the system from atmosphere.



*Vent Control Solenoid Valve*

4. Air Filter - Filters air as it enters the vent control solenoid valve.

# Basic Emission and Fuel Systems



*Air Filter*

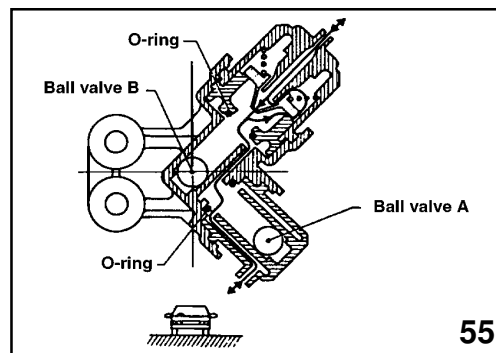
5. Fuel Tank Pressure Sensor - Monitors fuel tank pressure and sends an input signal to the ECM.

System operation - Optimum purge control is programmed in the ECM and is influenced by engine load, coolant temperature and vehicle speed.

Low fuel tank pressure - Pressure control solenoid valve closed. Vent control solenoid open. Purge Control Duty Solenoid active.

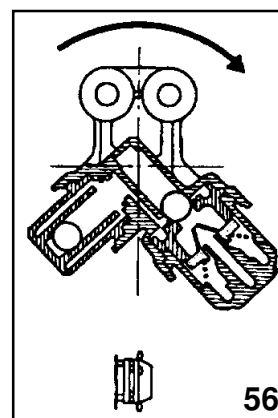
High fuel tank pressure - Pressure control solenoid valve open.

Fuel caps of both systems have a vacuum relief valve that allows atmospheric pressure to enter the fuel tank. This prevents vacuum from forming as the fuel is used, and acts as a back up for the two way valve.

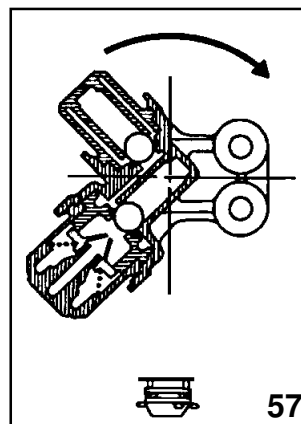


*Roll Over Valve In Normal Vehicle Position*

Both systems use a rollover valve located under the center rear of the vehicle. Rollover valve operation prevents fuel from flowing through the evaporative line in event of vehicle rollover. Valve operation is performed by gravity and the position of two "Ball Valves".



*Roll Over Valve With Vehicle On Its Side*



*Roll Over Valve With Vehicle On Its Roof*

# Basic Emission and Fuel Systems

## On Board Refueling Vapor Recovery

This system will be used on all 2.2 liter Legacy and Impreza vehicles. Forester will be equipped with ORVR beginning approximately with October production.

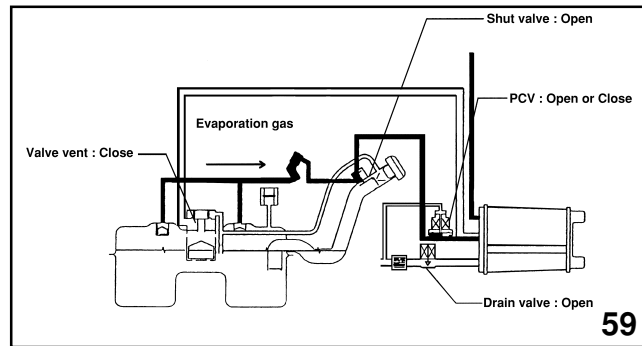
ORVR controls the pressure inside the fuel tank and collects fuels vapors during all vehicle operating conditions and during the time the vehicle is being refueled.

### Components include:

- Fuel cut valve (FCV) - Prevents liquid fuel from entering into the evaporative line.
- Valve vent - Controls the flow of fuel vapors during the time the vehicle is being refueled.
- Pressure difference detecting line-Directs atmospheric pressure
- to the back side of the valve vent diaphragm.
- Orifice chamber - Drains fuel from the pressure difference detecting line into the tank.
- Shut valve - Closes the evaporation line when a filler gun is inserted into the filler neck. Prevents fuel vapors from escaping to atmosphere while refueling.
- Tank pressure sensor - Monitors fuel tank pressure for diagnosis.
- Vent line - Directs fuel vapors from the valve vent to the cannister during the time the vehicle is being refueled.
- PCV (Pressure Control Valve)-Controls the flow of fuel vapors from the tank to the cannister except during the time the vehicle is being refueled. And controls the flow of atmospheric pressure to the tank when a negative pressure develops.
- Drain Valve - Provides a pathway to atmosphere for air after the fuel vapors have been removed by the charcoal element of the cannister. (Only during the time the vehicle is being refueled.)

## System Operation

### While driving



ORVR System

The fuel tank pressure is applied to one side of diaphragm inside the Pressure Control Valve.

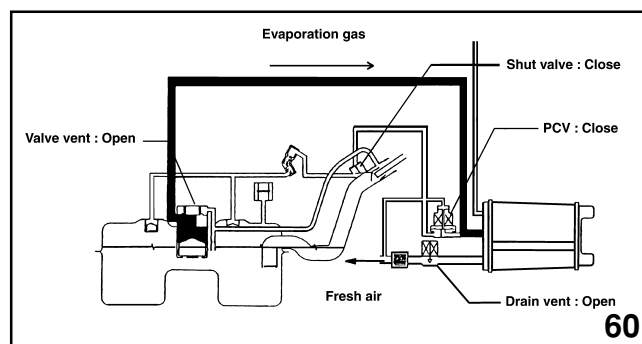
When the pressure is greater than atmospheric a port inside the PCV opens allowing fuel vapors to the cannister.

If negative pressure exists the PCV opens allowing atmospheric pressure to the fuel tank.

### While refueling

As fuel fills the tank the air inside the tank is displaced caring fuel vapors with it. This large increase in pressure opens the valve vent allowing the fuel vapors to the cannister.

The continued filling of the tank pushes the remaining air and fuel vapors through the cannister. The charcoal element of the cannister absorbs the fuel vapors an directs fuel vapor free air to the atmosphere though the Drain valve and air filter.

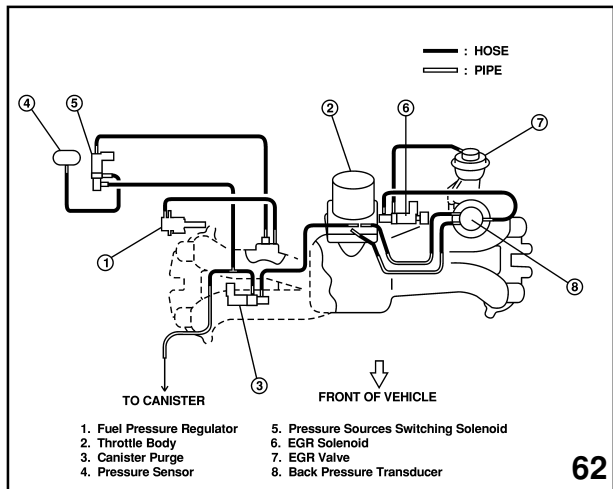


While Refueling

The PCV is checked for circuit malfunction. Drain valve checks include circuit and performance checks.

# Basic Emission and Fuel Systems

## Pressure Sources Switching Operation



1995 and Newer Manifold

Pressure sources switching solenoid (PSSS) Used on 1995 and newer vehicles equipped with OBDII. Functions from an ECM ground signal and Switches to allow atmospheric pressure to the pressure sensor during engine start and every 30 minutes, or 3.1 miles (5 kilometers). Switches to allow manifold pressure sensor when not switched to atmosphere.

The passage way to atmosphere on Conventional evaporative systems access atmosphere through the evaporative canister. Enhanced evaporative systems access atmosphere through an extension of the PSSS.

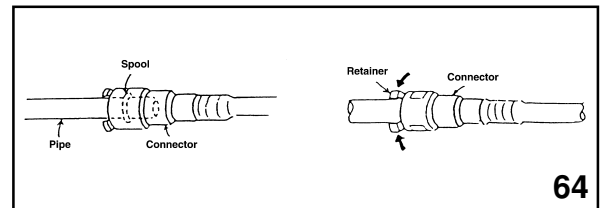
The Pressure sensor Functions to monitor manifold and atmospheric pressure. PSSS position determines pressure source. Changes in pressure positive or negative produce a changing reference voltage signal. Reference voltage signal changes are used to influence ignition timing and injection duration.

Canister purge flow is also monitored with the Pressure Sensor. (PSSS switches to atmosphere while the purge control solenoid is on)

## Fuel Delivery Quick Connector

The fuel system of the forester is very similar to past models with enhancements to tank capacity, clamps, and delivery line. The resin delivery line between the fuel pump and the 60 liter fuel tank are connected by a one time use only "Quick Connector".

This "Quick Connector" must be released when removing the fuel pump or fuel tank. C the directions in the appropriate service manual before removing any fuel lines.



Quick Connector

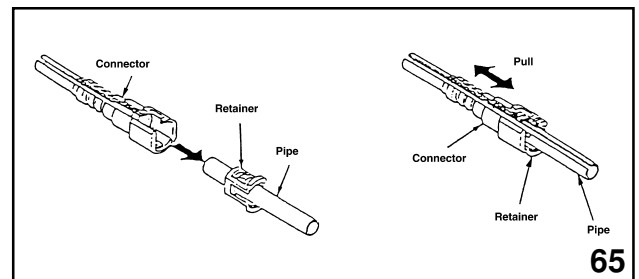
### Quick connector service procedure.

1. Separation - Pushing the retainer with a finger in the arrow direction, pull the connector to separate it. After separation, the retainer will remain attached to the pipe.
2. Connecting- Check the connecting portion of the pipe visually. If a scratch or foreign particle exists on it wipe them off.

Align the pipe and the connector, insert the end of the pipe into the connector until an audible click is heard.

Confirm connection by pulling the connector backward. Also check that the two pawls of the retainer are engaged to the connector.

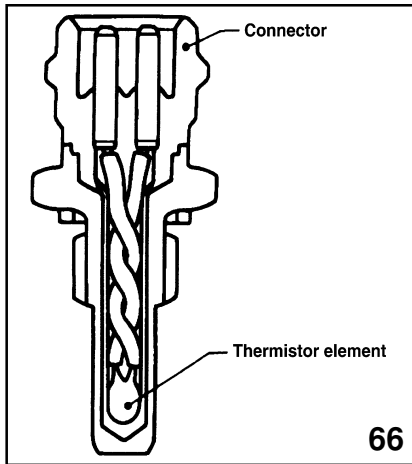
Replacement part is the retainer only.



Quick Connector Service

# Basic Emission and Fuel Systems

## Engine Coolant Temperature Sensor

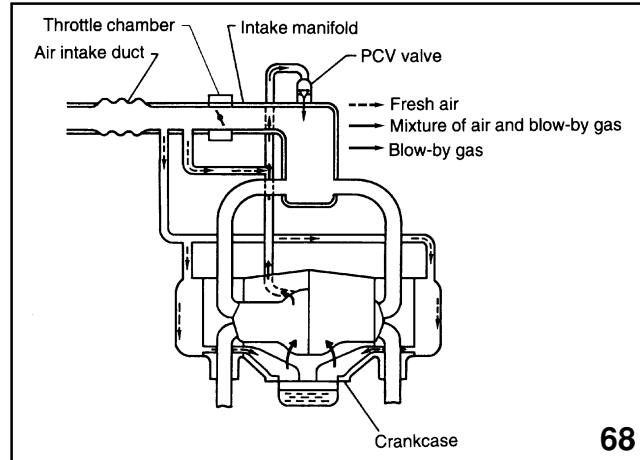


ECT

Engine Coolant Temperature Sensor (ECT) functions to monitor coolant temperature. Resistance of the sensor with cold coolant is high. Reference voltage from the sensor will be low. Resistance of the sensor with warmer coolant is low. Reference voltage will be higher. Reference voltage signal changes are used to influence ignition timing, injection duration, and idle speed. Some models use ECT signal to control radiator fan motor relays. Fail-safe on these models will result in constant radiator fan operation.

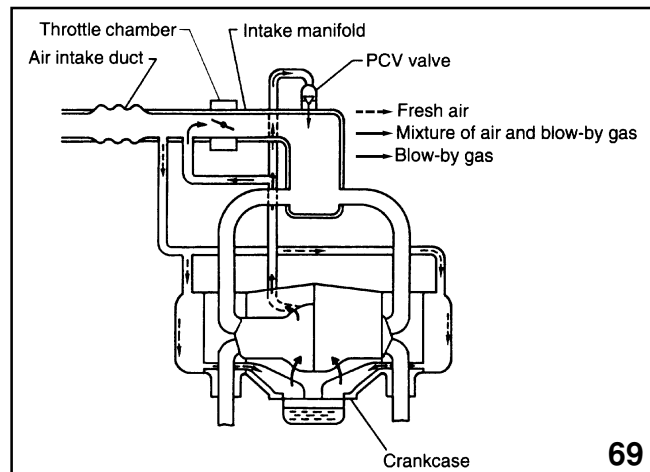
## Crankcase Emission Control

Crankcase Emission Control System Functions to prevent blow-by gases from entering the atmosphere. Components include: Sealed rocker covers, hoses, PCV valve and Air intake duct.



Operation is performed in two modes:

Mode one - (Light engine load) Air flows in to the air duct, and part of the air is routed to the rocker covers. Vapors and air enter the PCV because of the negative pressure at the valve.



Mode two - (Heavy engine load) Air flows in to the air duct, and produces a negative pressure at the rocker covers. This action carries the vapors from the crankcase into the throttle body.

Notes:

[illegible]



## Basic Emission and Fuel Systems

[illegible]

Notes:

[illegible]

# Basic Emission and Fuel Systems

## State I/M Program Advisories Bulletins and Service Bulletins

No.	Date	Title	Subject
11-50-97	12/05/97	All Subaru Full-Time AWD Models	State Emission Testing
11-51-97	12/05/97	All Subaru Full-Time AWD Models	Diagnostic Service Cautions
11-52-98	05/22/98	All 1999 Model Subaru AWD Models	State Emission Testing
11-49-97R	09/02/98	1996 MY Legacy, Impreza & SVX	OBD Check During State I/M Program
11-53-98	01/05/99	97-98 Legacy, Impreza and Forester Manual Transmission vehicles with 2.5L & 2.2L engines	Hesitation On Acceleration
11-54-99	03/01/99	All 1996-1999MY	On-Board Diagnostic System Diagnostic Link Connector (DLC) Location
11-55-99	03/17/99	All 1996-2000MY	On-Board Diagnostic System Check During State Emission Test
11-56-99	09/08/99	All 2000MY	State Emission Testing
11-57-99	09/29/99	All 2000 MY	On-Board Diagnostic System Diagnostic Link Connector (DLC) Location
11-59-00	02/25/00	1999 Legacy, Impreza, Forester	Air Intake Chamber Box Breakage
11-61-00	06/01/00	All Subaru Vehicles	State Emission Test / Fuel Filter or Gas Cap Test
11-62-00	05/08/00	All 2001 Models Subaru Vehicles	On-Board Diagnostic System Check During State Emission Test
11-63-00	11/01/00	1980-1989 MY Subaru Vehicles	Pressure Testing of Fuel Tank System During State Emission Test
11-64-01	02/01/01	All 1996-1999 Legacy Postal Vehicles	On-Board Diagnostic System Diagnostic Link Connector (DLC) Location

## Basic Emission and Fuel Systems

## 405 Module Service Help-Line Updates

Date	Subject
03/95	Legacy and Impreza engines with no injection pulse #1 cylinder
03/95	Impreza air suction valve noise
06/95	1995 Subaru Legacy DTC P0505 - Idle control system malfunction
06/95	1995 Subaru Legacy DTC P0325 - Knock sensor circuit malfunction
06/95	1995 Subaru Legacy DTC P0130 - Front O2 sensor circuit malfunction
07/95	Rough idle on MPFI vehicles
07/95	94 Impreza ROM sockets
09/95	DTC P0505 idle control system when solenoid measures 5Ω or less
12/95	Extreme cold weather engine warm up and OBD II
07/96	Loose fuel caps and trouble code P0440
09/96	1997 Legacy warranty claims for loose fuel caps
09/96	Legacy (Non Turbo), SVX, and Impreza ISC valves
11/96	P0440 and Legacy fuel caps
11/96	Blue vs. Gray connectors during diagnosis
11/96	Extreme cold weather engine warm-up and OBDII
03/97	DTC P1500 radiator fan relay one circuit
03/97	1997 Subaru Impreza Outback Sport
04/97	Understanding P0440
05/97	DTC P0507-Idle control system RPM higher than expected
07/97	Code P0500
07/97	Additional information regarding code P0440
08/97	OBD II cylinder misfire codes
10/97	More P0440 information
01/98	Exhaust smell during cold start
01/98 & 05/98	Model Year 1998 changes in P0440 Evap operation
05/98	DTC P0440 Revisited
11/98	P0440 TIP
11/98	DTC P1507
05/99	DTC P0705 diagnostics
08/99	Freeze frame data
09/99	Evaporative system diagnosis
11/99	OBD readiness codes
11/99	P0440 1998/1999 Forester
11/00	WXV-79 engine control module service program



Subaru of America, Inc.