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MS45 - E85 with M54 Engine

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Emissions Management - M54B2.5 Low Emission Vehicle (LEV) - M54B3.0 Ultra Low Emission Vehicle (ULEV)

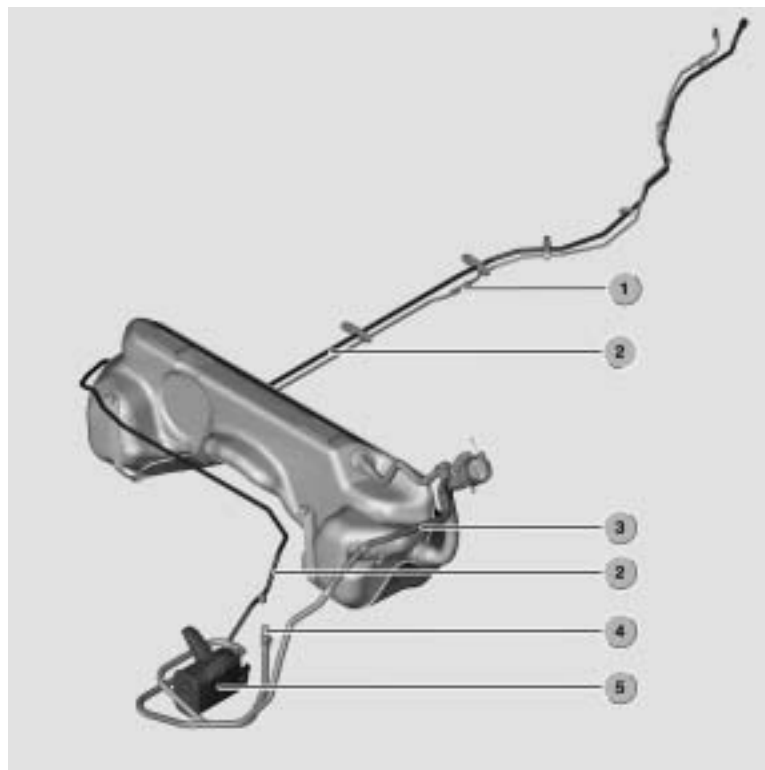
Evaporative Emissions: The control of the evaporative fuel vapors (Hydrocarbons) from the fuel tank is important for the overall reduction in vehicle emissions. The evaporative system has been combined with the ventilation of the fuel tank, which allows the tank to breath (equalization). The overall operation provides:

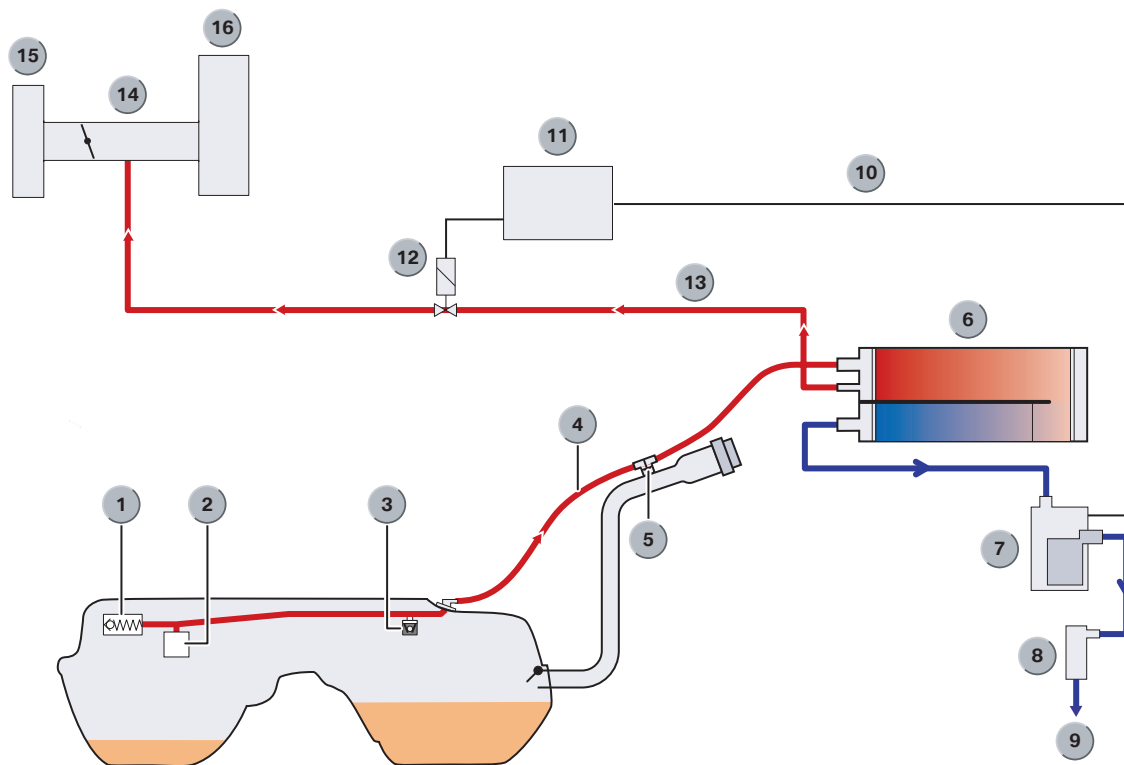
- An inlet vent, to an otherwise “sealed” fuel tank, for the the entry of air to replace the fuel consumed during engine operation.
- An outlet vent with a storage canister to “trap and hold” fuel vapors that are produced by the expansion/evaporation of the fuel in the tank, when the vehicle is stationary.

The canister is then "purged" using the engine vacuum to draw the fuel vapors into the combustion chamber. This "cleans" the canister allowing for additional storage. Like any other form of combustible fuel, the introduction of these vapors on a running engine must be controlled.

The ECM controls the Evaporative Emission Valve which regulates purging of evaporative vapors. The evaporative system must be monitored for correct purge operation and Leak Detection.

1. Fuel supply line
2. Evaporative purge line
3. Evaporative vent line (to carbon canister)
4. Atmospheric vent line with filter
5. Carbon canister with DM TL pump





- | | |
|--|--|
| 1. Overpressure protection valve | 9. Atmospheric vent line |
| 2. Filling vent valve (rollover valve) | 10. DM TL (electrical control circuit) |
| 3. Operating vent valve | 11. ECM (DME) |
| 4. Ventilation line | 12. Evaporative emission (purge) control valve |
| 5. Mushroom valve ("T" fitting) | 13. Evaporative emission (purge) line |
| 6. Carbon canister | 14. Intake manifold |
| 7. DM TL (leakage diagnosis pump) | 15. Engine air filter |
| 8. Filter | 16. M54 engine |

On-Board Refueling Vapor Recovery (ORVR - DM TL Equipped Vehicles): The ORVR system recovers and stores hydrocarbon fuel vapor that was previously released during refueling. Non ORVR vehicles vent fuel vapors from the tank venting line back to the filler neck and in many states reclaimed by a vacuum receiver on the filling station's fuel pump nozzle.

When refueling an ORVR equipped vehicle, the pressure of the fuel entering the tank forces the hydrocarbon vapors through the Filling Vent Valve (2) and the large tank ventilation line (4) into the Carbon Canister (6). The HC is stored in the Carbon Canister and the system can then "breathe" through the DM TL (7) and the filter (8).

Note: A small diameter connection to the filler neck is provided by the Mushroom Valve "T fitting" (5). This is necessary for checking the filler cap/neck during Evaporative Leak Testing.

The ventilation continues until the rising fuel level lifts the float in the Filling Vent Valve (2) and closes the outlet. When the ventilation outlet is closed, a pressure cushion (vapor area) is created in the fuel tank. This creates a backup of fuel into the filler neck and the tank is full.

This leaves a vapor area of approximately 6 liters above the fuel level. This area provides integral liquid/vapor separation. The vapor condensates separate and drain back into the fuel. The remaining vapors exit the fuel tank (when sufficient pressure is present) through the Operating Vent Valve (3) to the Carbon Canister.

Note: The Operating Vent Valve is also equipped with a protection float in the event of an “overfill” situation.

Carbon Canister: As the hydrocarbon vapors enter the canister, they will be absorbed by the active carbon. The remaining air will be vented to the atmosphere through the end of the canister, DM TL and filter, allowing the fuel tank to “breathe”.

When the engine is running, the canister is “purged” using intake manifold vacuum to draw air through the canister which extracts the HC vapors into the combustion chamber.

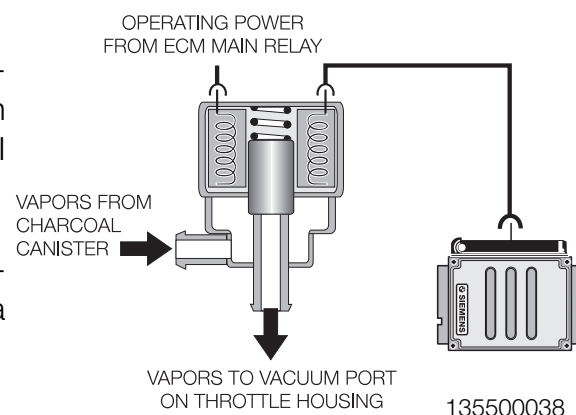
The Carbon Canister with DM TL and air filter are located at the right rear underside of the vehicle, below the luggage compartment floor.



Evaporative Emission Valve: This ECM controlled solenoid valve regulates the purge flow from the Carbon Canister into the intake manifold. The ECM Relay provides operating voltage, and the ECM controls the valve by regulating the ground circuit. The valve is powered open and closed by an internal spring.

If the Evaporative Emission Valve circuit is defective, a fault code will be set and the “Malfunction Indicator Light” will illuminate when the OBD II criteria is achieved.

If the valve is “mechanically” defective, a drivability complaint could be encountered and a mixture related fault code will be set.



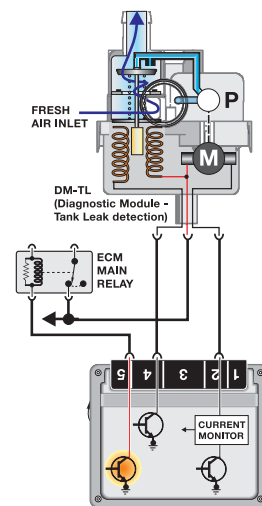
Evaporative Leakage Detection (DM TL): This component ensures accurate fuel system leak detection for leaks *as small as 0.5 mm* by slightly pressurizing the fuel tank and evaporative components. The DM TL pump contains an integral DC motor which is activated directly by the ECM. The ECM monitors the pump motor operating current as the measurement for detecting leaks.

The pump also contains an ECM controlled change over valve that is energized closed during a Leak Diagnosis test. The change over valve is open during all other periods of operation allowing the fuel system to “breathe” through the inlet filter. The DM TL is located under the luggage compartment floor with the Carbon Canister.

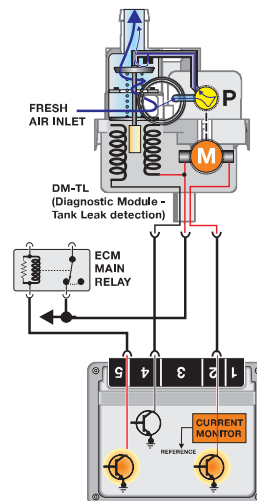
1. In its inactive state, filtered fresh air enters the evaporative system through the sprung open valve of the DM TL.
2. When the DME activates the DM TL for leak testing, it first activates only the pump motor. This pumps air through a restrictor orifice (0.5 mm) which causes the electric motor to draw a specific amperage value. This value is equivalent to the size of the restrictor.
3. The solenoid valve is then energized which seals the evaporative system and directs the pump output to pressurize the evaporative system.

- A large leak is detected in the evaporative system if the amperage value is not achieved.
- A small leak is detected if the same reference amperage is achieved.
- The system is sealed if the amperage value is higher than the reference amperage.

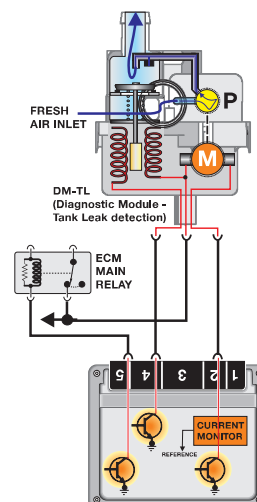
Since MY 2002, a heating element is integrated in the DM TL pump to eliminate condensation. The heater is provided battery voltage with “KL15” and the ECM provides the ground path.



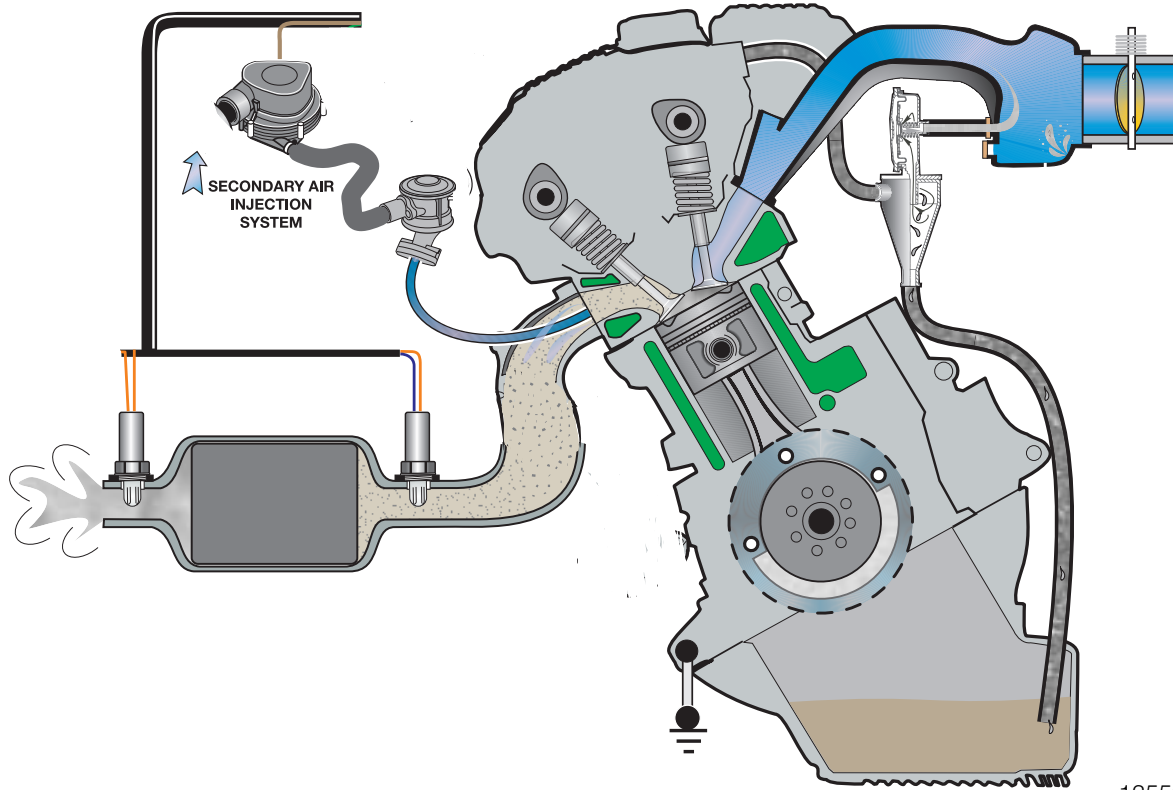
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Exhaust Emissions: The combustion process of a gasoline powered engine produces Carbon Monoxide (CO), Hydrocarbons (HC) and Oxides of Nitrogen (NOx).

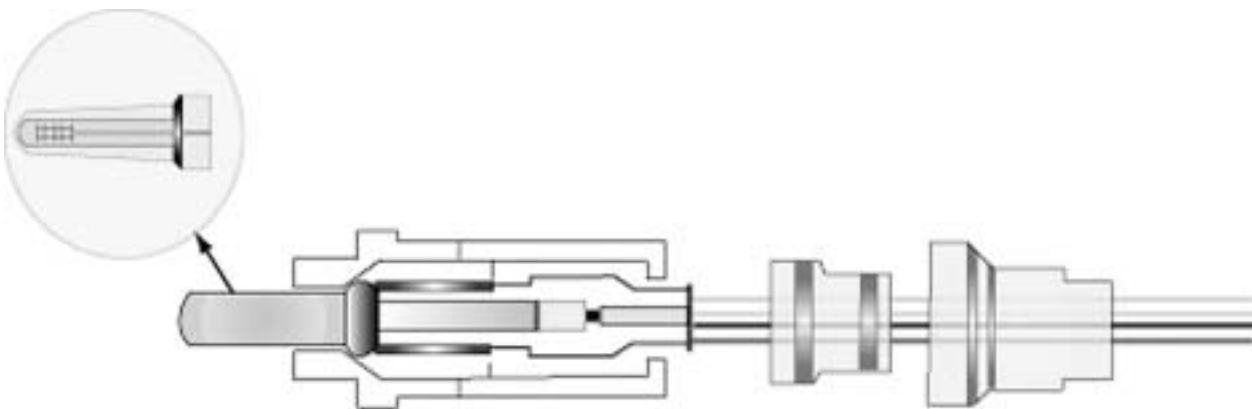
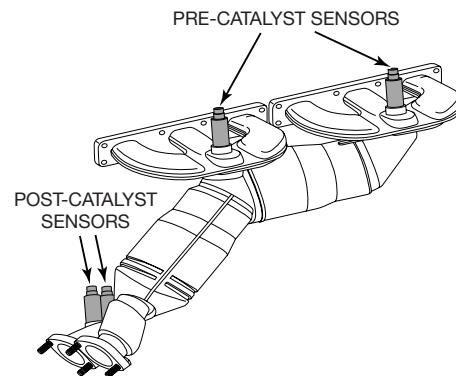
- Carbon Monoxide is a product of incomplete combustion under conditions of air deficiency. CO emissions are dependent on the air/fuel ratio.
- Hydrocarbon are also a product of incomplete combustion which results in unburned fuel. HC emissions are dependent on air/fuel ratio and the ignition of the mixture.
- Oxides of Nitrogen are a product of peak combustion temperature (and temperature duration). NOx emissions are dependent on internal cylinder temperature affected by the air/fuel ratio and ignition of the mixture.

Control of exhaust emissions is accomplished by the engine and engine management design as well as after-treatment.

- The ECM manages exhaust emissions by controlling the air/fuel ratio and ignition.
- The ECM controlled Secondary Air Injection further dilutes exhaust emissions leaving the engine and reduce the catalyst warm up time.
- The Catalytic Converter further reduces exhaust emissions leaving the engine.

Bosch LSH 25 Oxygen Sensors: The pre-cat oxygen sensors measure the residual oxygen content of the exhaust gas. The sensors produce a low voltage (0-1000 mV) proportional to the oxygen content that allows the ECM to monitor the air/fuel ratio.

The sensors are mounted in the hot exhaust stream directly in front of the catalytic converters.



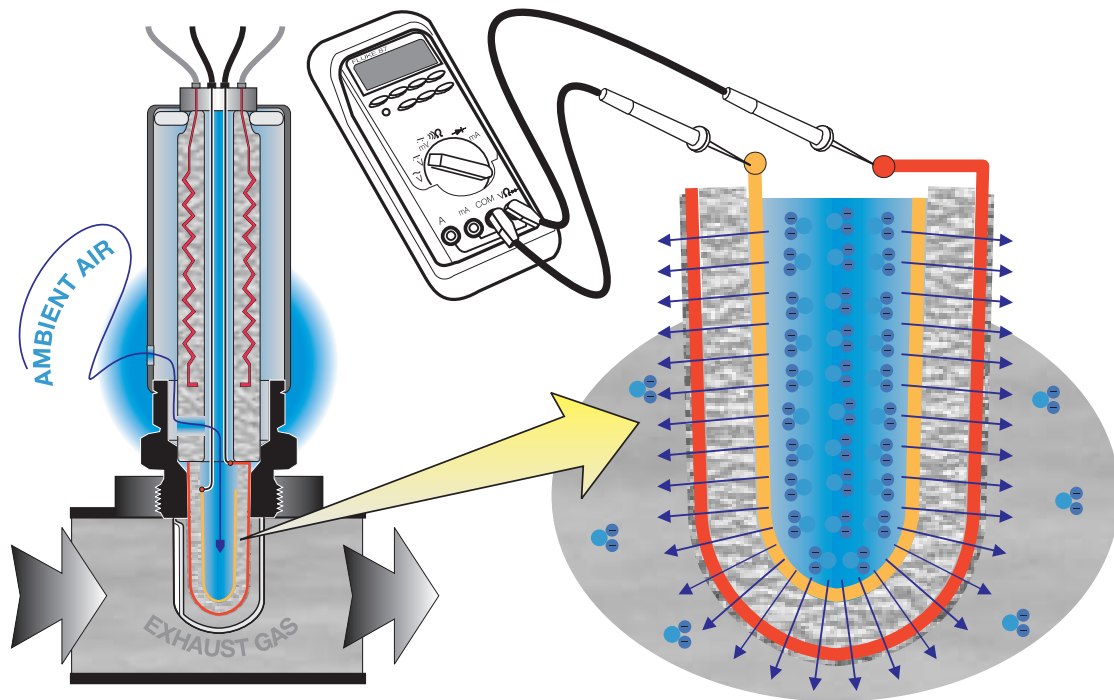
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The “tip” of the sensor contains a microporous platinum coating (electrodes) which conduct current. The platinum electrodes are separated by solid electrolyte which conducts oxygen ions. The platinum conductors are covered with a highly porous ceramic coating and the entire tip is encased in a ventilated metal “cage”.

This assembly is submersed in the exhaust stream. The sensor body (external) has a small vent opening in the housing that allows ambient air to enter the inside of the tip.

The ambient air contains a constant level of oxygen content (21%) and the exhaust stream has a much lower oxygen content. The oxygen ions (which contain small electrical charges) are “purged” through the solid electrolyte by the hot exhaust gas flow. The electrical charges (low voltage) are conducted by the platinum electrodes to the sensor signal wire that is monitored by the ECM.

Notes: _____



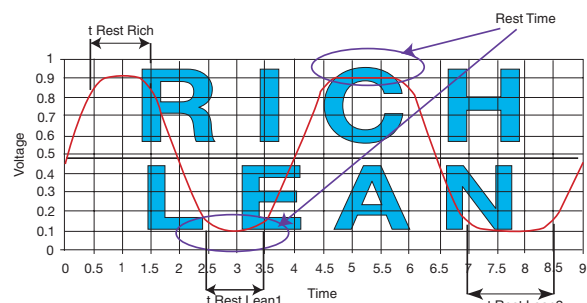
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If the exhaust has a lower oxygen content (rich mixture), there will be a large ion “migration” through the sensor generating a higher voltage (950 mV).

If the exhaust has a higher oxygen content (lean mixture), there will be a small ion “migration” through the sensor generating a lower voltage (080 mV).

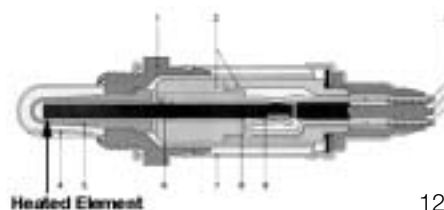
This voltage signal is constantly changing due to combustion variations and normal exhaust pulsations.

The ECM monitors the length of time the sensors are operating in the lean, rich (including the time of rise and fall) and rest conditions. The evaluation period of the sensors is over a pre-defined number of oscillation cycles.



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This conductivity is efficient when the oxygen sensor is hot (250° - 300° C). For this reason, the sensor contains a heating element. This “heated” sensor reduces warm up time, and retains the heat during low engine speed when the exhaust temperature is cooler.



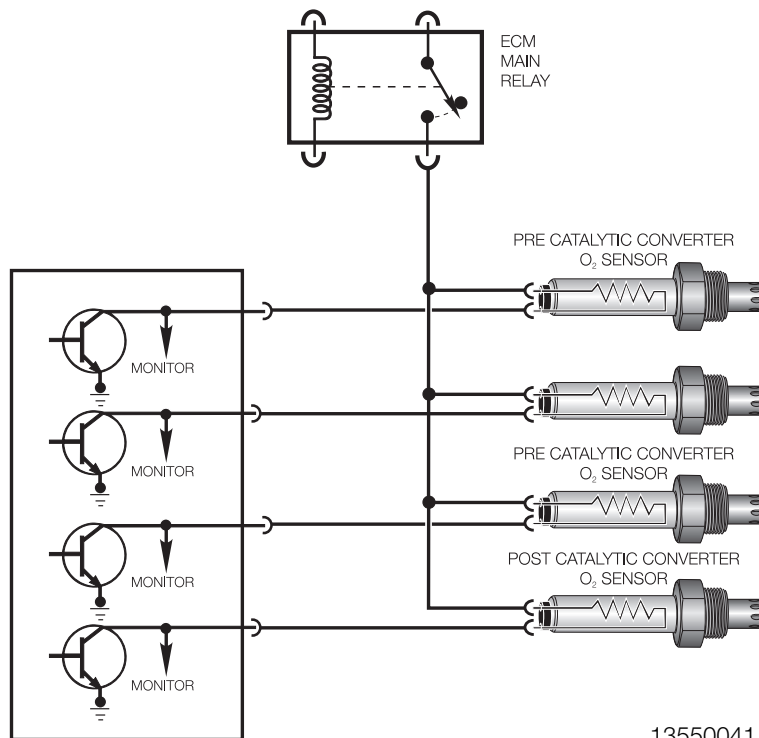
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Direct Oxygen Sensor Heating: The oxygen sensor conductivity is efficient when it is hot (600° - 700° C). For this reason, the sensors contain heating elements. These “heated” sensors reduce warm up time, and retain the heat during low engine speed when the exhaust temperature is cooler. OBD II requires monitoring of the oxygen sensor heating function and heating elements for operation.

The four oxygen sensor heating circuits receive operating voltage from the ECM Relay when KL15 is switched “ON”. Each of the sensors heaters are controlled through separate final stage transistors.

The sensor heaters are controlled with a pulse width modulated voltage during a cold start. This allows the sensors to be brought up to operating temperature without the possibility of thermal shock. The duty cycle is then varied to maintain the heating of the sensors.

When the engine is decelerating (closed throttle), the ECM increases the duty cycle of the heating elements to compensate for the decreased exhaust temperature.

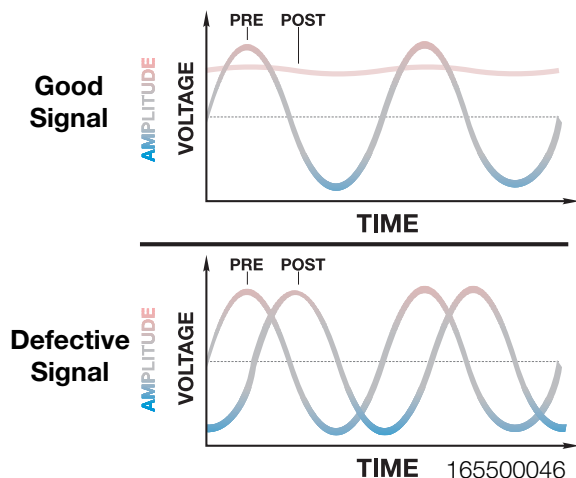


Catalytic Converter Monitoring: The efficiency of catalyst operation is determined by evaluating the oxygen consumption of the catalytic converters using the pre and post oxygen sensor signals. A properly operating catalyst consumes most of the O₂ (oxygen) that is present in the exhaust gas (input to catalyst). The gases that flow into the catalyst are converted from CO, HC and NO_x to CO₂, H₂O and N₂ respectively.

In order to determine if the catalysts are working correctly, post catalyst oxygen sensors are installed to monitor exhaust gas content exiting the catalysts. The signal of the post cat. O₂ sensor is evaluated over the course of several pre cat. O₂ sensor oscillations.

During the evaluation period, the signal of the post cat. sensor must remain within a relatively constant voltage range (700 - 800 mV). The post cat. O₂ voltage remains high with a very slight fluctuation. This indicates a further lack of oxygen when compared to the pre cat. sensor.

If this signal decreased in voltage and/or increased in fluctuation, a fault code will be set for Catalyst Efficiency and the “Malfunction Indicator Light” will illuminate when the OBD II criteria is achieved.



Secondary Air Injection: Injecting ambient air into the exhaust stream after a cold engine start reduces the warm up time of the catalyst and reduces HC and CO emissions. The ECM controls and monitors the Secondary Air Injection.

An Electric Secondary Air Pump and Air Injection Valve direct fresh air through an internal channel in the cylinder head into the exhaust ports. The Air Injection Valve is opened by air pressure (from the pump) and is closed by an internal spring.

The E85 uses a higher volume Secondary Air Pump (45 kg/hour). The pump contains an integral air filter element which is maintenance free.

1. Air filter
2. Secondary air pump (SLP)
3. Air injection valve (SLV)



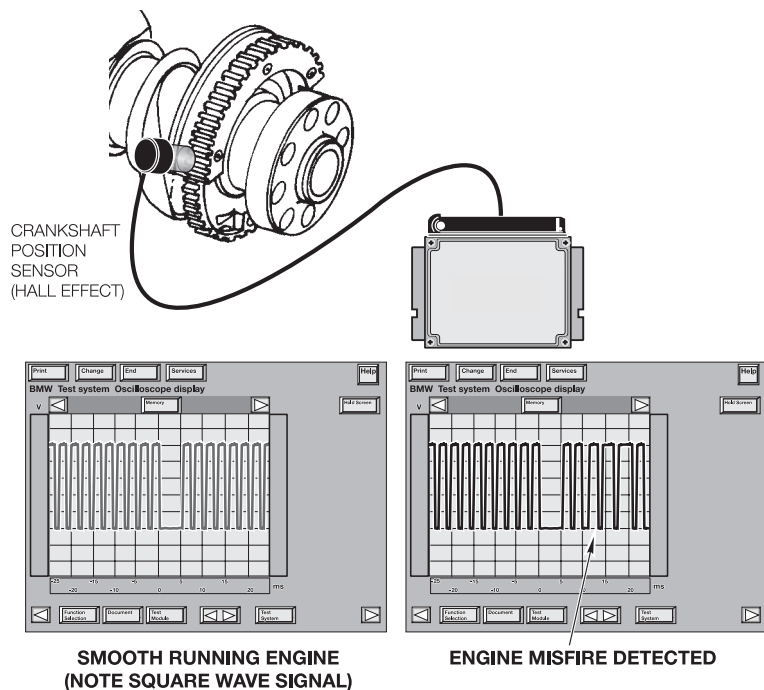
Misfire Detection: As part of the OBD II regulations the ECM must determine misfire and also identify the specific cylinder(s), the severity of the misfire and whether it is emissions relevant or catalyst damaging based on monitoring crankshaft acceleration.

In order to accomplish these tasks the ECM monitors the crankshaft for acceleration by the impulse wheel segments of cylinder specific firing order. The misfire/engine roughness calculation is derived from the differences in the period duration of individual increment gear segments.

Each segment period consist of an angular range of 90° crank angle that starts 54° before Top Dead Center.

If the expected period duration is greater than the permissible value a misfire fault for the particular cylinder is stored in the fault memory of the ECM.

Depending on the level of misfire rate measured the ECM will illuminate the "Malfunction Indicator Light", deactivate the specific fuel injector to the particular cylinder and switch oxygen sensor control to open-loop.



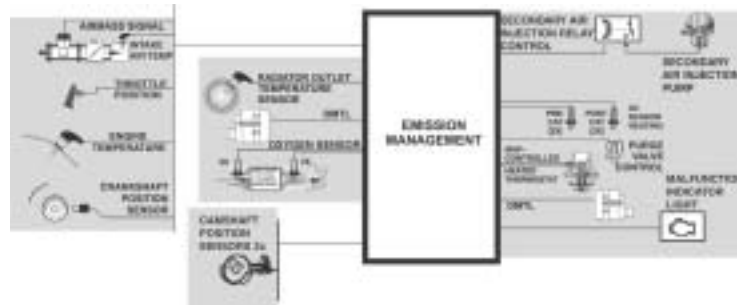
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In order to eliminate misfire faults that can occur as a result of varying flywheel tolerances (manufacturing process) an internal adaptation of the flywheel is made. The adaptation is made during periods of decel fuel cut-off in order to avoid any rotational irregularities which the engine can cause during combustion. This adaptation is used to correct segment duration periods prior to evaluation for a misfire event.

If the sensor wheel adaptation has not been completed the misfire thresholds are limited to engine speed dependent values only and misfire detection is less sensitive. The crankshaft sensor adaptation is stored internally and is not displayed via DISplus or GT1. If the adaptation limit is exceeded a fault will be set.

Principle of Operation

Emissions Management controls evaporative and exhaust emissions. The ECM monitors the fuel storage system for **evaporative leakage** and controls the **purging** of evaporative vapors. The ECM monitors and controls the exhaust emissions by regulating the **combustible mixture** and after treating by injecting **fresh air** into the exhaust system. The catalytic converter further breaks down remaining combustible exhaust gases and is monitored by the ECM for **catalyst efficiency**.



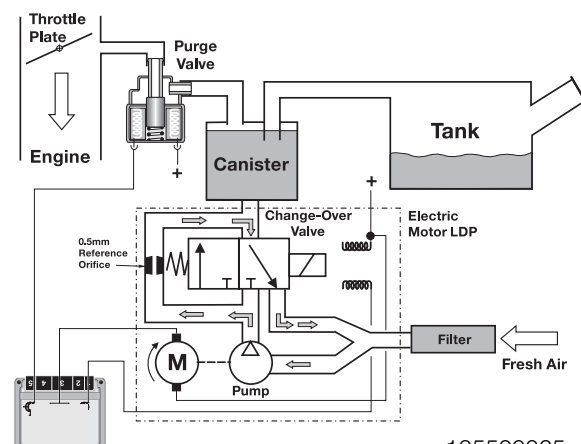
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The MS45 Evaporative Leakage Detection is performed on the fuel storage system by the DM TL pump which contains an integral DC motor that is activated by the ECM. The ECM monitors the pump motor operating current as the measurement for detecting leaks. The pump also contains an ECM controlled change over valve that is energized closed during a Leak Diagnosis test. The ECM initiates a leak diagnosis test every time the criteria are met. The criteria is as follows:

- Engine **OFF** with ignition switched **OFF**.
- ECM still in active state or what is known as “follow up mode” (ECM Relay energized, ECM and components online for extended period after key off).
- Prior to Engine/Ignition switch OFF condition, vehicle must have been driven for a minimum of 20 minutes.
- Prior to minimum 20 minute drive, the vehicle must have been OFF for a minimum of 5 hours.
- Fuel Tank Capacity must be between **15 and 85%** (safe approximation between 1/4 - 3/4 of a tank).
- Ambient Air Temperature between **4°C & 35°C** (40°F & 95°F)
- Altitude < **2500m** (8,202 feet).
- Battery Voltage - **between 10.95 and 14.5 Volts**

PHASE 1 - Reference Measurement

The ECM activates the pump motor. The pump pulls air from the filtered air inlet and passes it through a precise 0.5 mm reference orifice in the pump assembly. The ECM simultaneously monitors the pump motor current flow. The motor current raises quickly and levels off (stabilizes) due to the orifice restriction. The ECM stores the stabilized amperage value in memory. The stored amperage value is the electrical equivalent of a 0.5 mm (0.020”) leak.



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PHASE 2 - Leak Detection

The ECM energizes the Change Over Valve allowing the pressurized air to enter the fuel system through the Charcoal Canister. The ECM monitors the current flow and compares it with the stored reference measurement over a duration of time.

Once the test is concluded, the ECM stops the pump motor and immediately de-energizes the change over valve. This allows the stored pressure to vent thorough the charcoal canister trapping hydrocarbon vapor and venting air to atmosphere through the filter.

Test Results

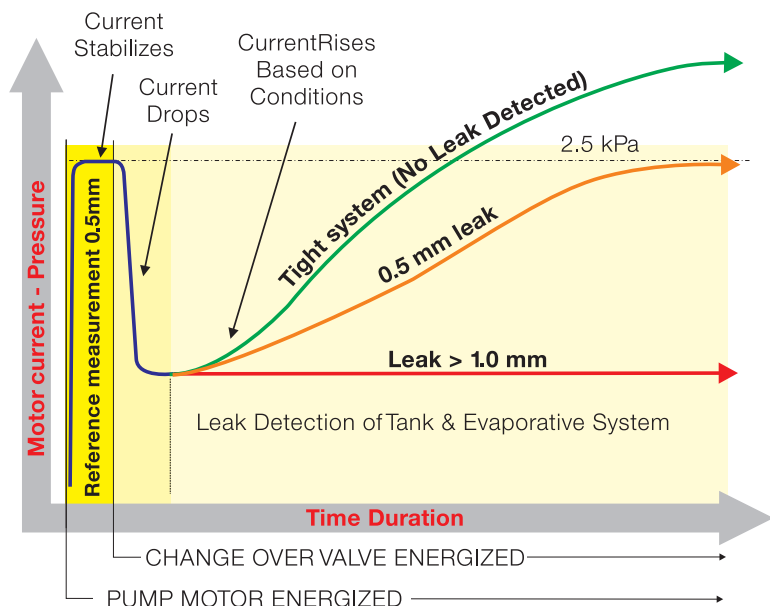
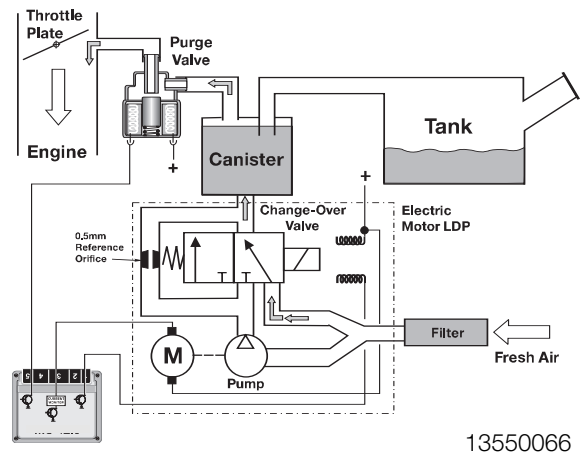
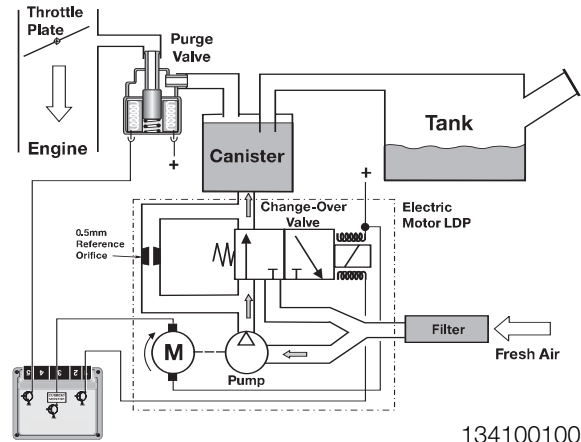
The time duration varies between 45 & 270 seconds depending on the resulting leak diagnosis test results (developed tank pressure “amperage”/within a specific time period). However the chart depicts the logic used to determine fuel system leaks.

If the ECM detects a leak, a fault will be stored and the “Malfunction Indicator Light” will be illuminated. Depending on the amperage measurement detected by the ECM, the fault code displayed will be *small leak* or *large leak*.

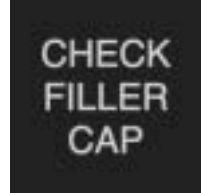
Refuelling during the test will interrupt the diagnosis and the DM TL will be denergized. The ECM detects this by:

- Pressure drop when filler cap is removed
- Rise in pressure due to refuelling

If refuelling does not take place immediately after opening the filler cap (pressure rise missing), a *large leak* is detected.



If the vehicle was refueled and the filler cap was not properly installed, the **“Check Filler Cap”** message will be displayed in the instrument cluster for 20 seconds.

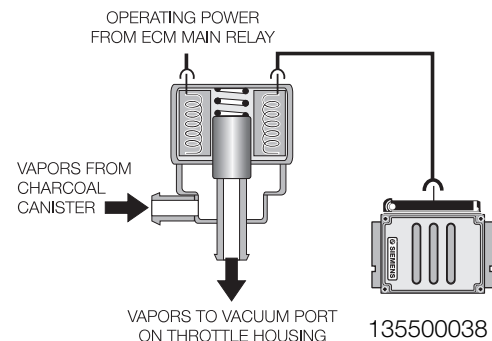


If the filler cap is installed and there is no leakage present the next time the leakage test is performed, the “Malfunction Indicator Light” will not be illuminated.

Evaporative Emission Purging is regulated by the ECM controlling the Evaporative Emission Valve. The Evaporative Emission Valve is a solenoid that regulates purge flow from the Active Carbon Canister into the intake manifold. The ECM Relay provides operating voltage, and the ECM controls the valve by regulating the ground circuit. The valve is powered open and closed by an internal spring.

The “purging” process takes place when:

- Oxygen Sensor Control is active
- Engine Coolant Temperature is $>67^{\circ}\text{C}$
- Engine Load is present



The Evaporative Emission Valve is opened in stages to moderate the purging.

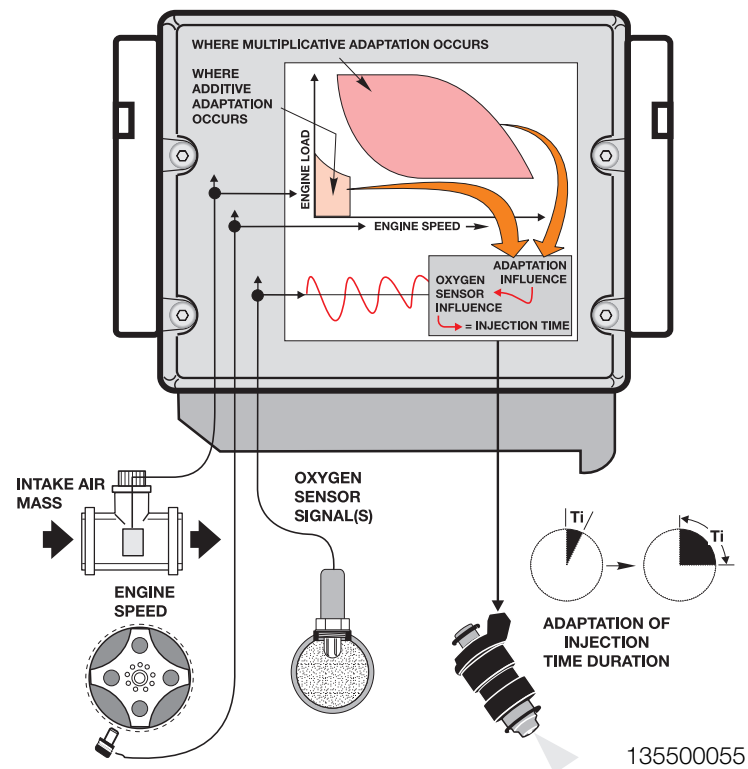
- Stage 1 opens the valve for 10 ms (milli-seconds) and then closes for 150 ms.
- The stages continue with increasing opening times (up to 16 stages) until the valve is completely open.
- The valve now starts to close in 16 stages in reverse order
- This staged process takes 6 minutes to complete. The function is inactive for 1 minute then starts the process all over again.
- During the purging process the valve is completely opened during full throttle operation and is completely closed during deceleration fuel cutoff.

Evaporative Purge System Flow Check is performed by the ECM when the oxygen sensor control and purging is active. When the Evaporative Emission Valve is open the ECM detects a rich/lean shift as monitored by the oxygen sensors indicating the valve is functioning properly.

If the ECM does not detect a rich/lean shift, a second step is performed when the vehicle is stationary and the engine is at idle speed. The ECM opens and close the valve (abruptly) several times and monitors the engine rpm for changes. If there are no changes, a fault code will be set.

Fuel System Monitoring is performed by the ECM which verifies the calculated injection time (t_i) in relation to engine speed, load and the oxygen sensor signal as a result of the residual oxygen in the exhaust stream.

The ECM uses the oxygen sensor signal as a correction factor for adjusting and optimizing the mixture pilot control under all engine operating conditions.



Adaptation Values are stored by the ECM in order to maintain an "ideal" air/fuel ratio. The ECM is capable of adapting to various environmental conditions encountered while the vehicle is in operation (changes in altitude, humidity, ambient temperature, fuel quality, etc.).

The adaptation can only make slight corrections and can not compensate for large changes which may be encountered as a result of incorrect airflow or incorrect fuel supply to the engine.

Within the areas of adjustable adaptation, the ECM modifies the injection rate under two areas of engine operation:

- During idle and low load mid range engine speeds (Additive Adaptation).
- During operation under a normal to higher load when at higher engine speeds (Multiplicative Adaptation).

These values indicate how the ECM is compensating for a less than ideal initial air/fuel ratio.

NOTE: If the adaptation value is greater than "0.0" Additive (% Multiplicative), the ECM is trying to richen the mixture. If the adaptation value is less than "0.0" Additive (% Multiplicative), the ECM is trying to lean-out the mixture.

Catalyst Monitoring is performed by the ECM under oxygen sensor closed loop operation. The changing air/fuel ratio in the exhaust gas results in lambda oscillations at the pre-catalyst sensors. These oscillations are dampened by the oxygen storage activity of the catalysts and are reflected at the post catalyst sensors as a fairly stable signal (indicating oxygen has been consumed). Conditions for Catalyst Monitoring:

Requirements

- Closed loop operation
- Engine coolant temperature
- Vehicle road speed
- Catalyst temperature (calculated)
- Throttle angle deviation
- Engine speed deviation
- Average lambda value deviation

Status/Condition

YES
 Operating Temp.
 3 - 50 MPH (5 to 80 km/h)
 350°C to 650°C
 Steady throttle
 Steady/stable engine speed
 Steady/stable load

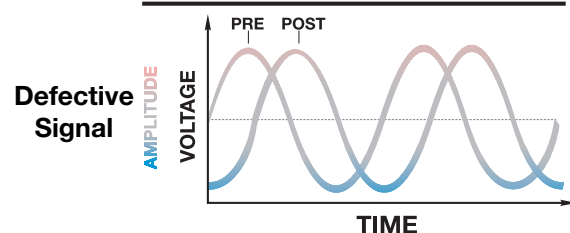
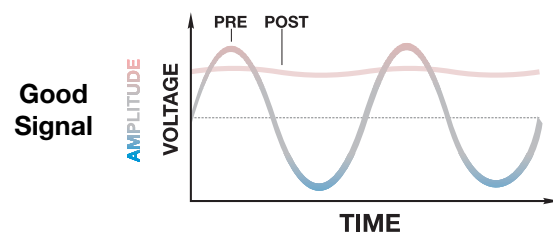
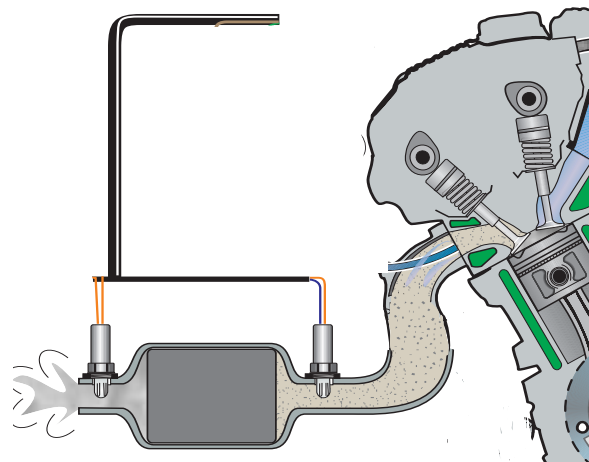
* Catalyst temperature is an internally calculated value that is a function of load/air mass and time.

As part of the monitoring process, the pre and post O₂ sensor signals are evaluated by the ECM to determine the length of time each sensor is operating in the rich and lean range.

If the catalyst is defective the post O₂ sensor signal will reflect the pre O₂ sensor signal (minus a phase shift/time delay), since the catalyst is no longer able to store oxygen.

The catalyst monitoring process is stopped once the predetermined number of cycles are completed, until the engine is shut-off and started again. After completing the next "customer driving cycle" whereby the specific conditions are met and a fault is again set, the "Malfunction Indicator Light" will be illuminated.

Note: The catalyst efficiency is monitored once per trip while the vehicle is in closed loop operation.



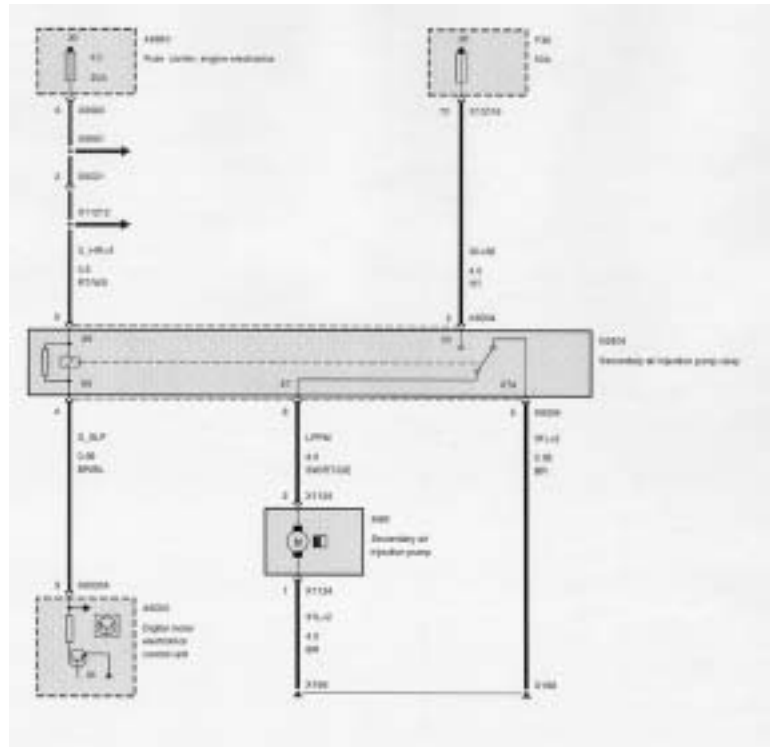
Secondary Air Injection is required to reduce HC and CO emissions while the engine is warming up. Immediately following a cold engine start (-10 to 60°C) fresh air/oxygen is injected directly into the exhaust stream.

The temperature signal is provided to the ECM by the Air Temperature Sensor in the HFM*.

The ECM provides a ground circuit to activate the Secondary Air Injection Pump Relay. The relay supplies voltage to the Secondary Air Injection Pump.

The single speed pump runs for approximately 90 seconds after engine start up.

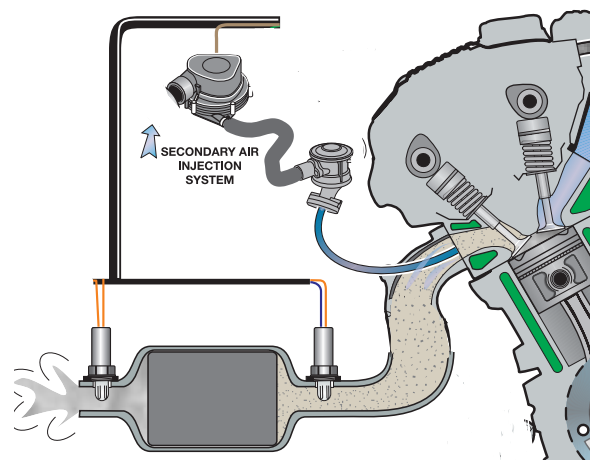
* Below -10° C the pump is activated briefly to “blow out” any accumulated moisture.



Secondary Air Injection Monitoring is performed by the ECM via the use of the pre-catalyst oxygen sensors. Once the air pump is active and is air injected into the exhaust system the oxygen sensor signals will indicate a lean condition (up to 16 seconds).

If the oxygen sensor signals do not change within a predefined time a fault will be set and identify the faulty bank.

If the additional oxygen is not detected for two consecutive cold starts, the ECM determines a general fault with the function of the secondary air injection system. After completing the next cold start and a fault is again present the "Malfunction Indicator Light" will be illuminated when the OBD II criteria is achieved.



Misfire Detection is part of the OBD II regulations the ECM must determine misfire and also identify the specific cylinder(s). The ECM must also determine the severity of the misfire and whether it is emissions relevant or catalyst damaging based on monitoring crankshaft acceleration.

Emission Increase:

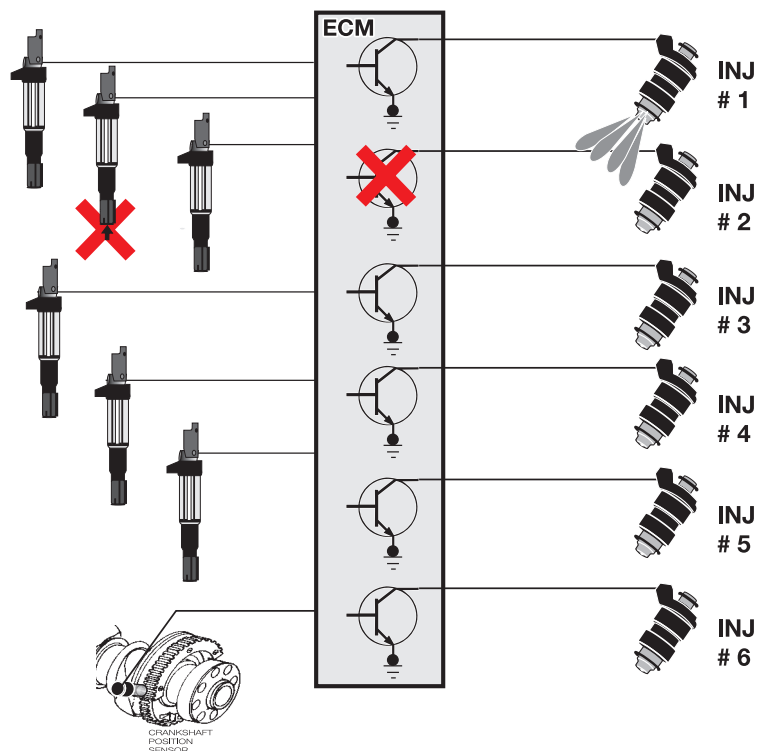
- Within an interval of 1000 crankshaft revolutions, the ECM adds the detected misfire events for each cylinder. If the sum of all cylinder misfire incidents exceeds the predetermined value, a fault code will be stored and the “Malfunction Indicator Light” will be illuminated.
- If more than one cylinder is misfiring, all misfiring cylinders will be specified and the individual fault codes for each misfiring cylinder, or multiple cylinders will be stored. The “Malfunction Indicator Light” will be illuminated.

Catalyst Damage:

- Within an interval of 200 crankshaft revolutions the detected number of misfiring events is calculated for each cylinder. The ECM monitors this based on load/rpm. If the sum of cylinder misfire incidents exceeds a predetermined value, a “Catalyst Damaging” fault code is stored and the “Malfunction Indicator Light” will be illuminated.

If the cylinder misfire count exceeds the predetermined threshold the ECM will take the following measures:

- The oxygen sensor control will be switched to open loop.
- The cylinder selective fault code is stored.
- If more than one cylinder is misfiring the fault code for all individual cylinders and for multiple cylinders will be stored.
- The fuel injector to the respective cylinder(s) is deactivated.



Electrically Heated Thermostat

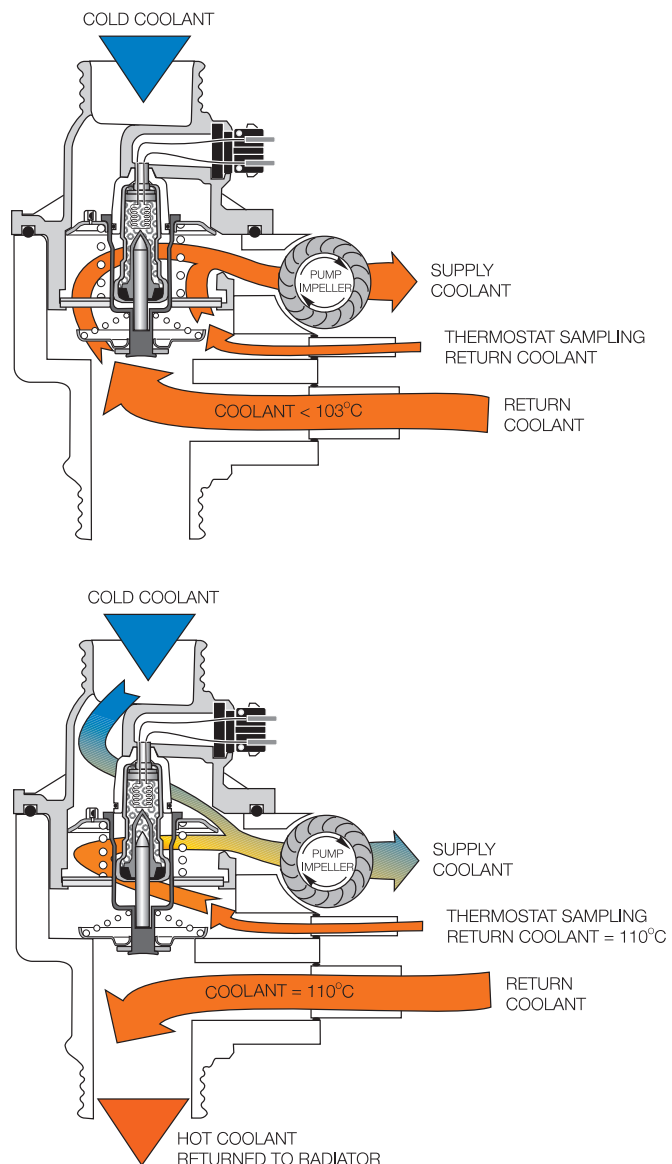
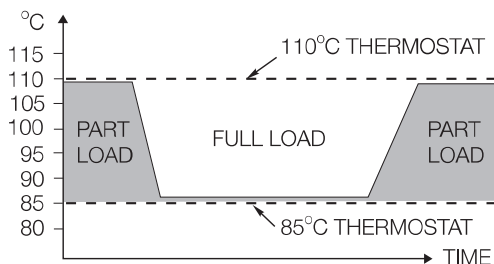
Model specific variants of the electrically heated thermostat are equipped on all LEV/ULEV compliant engines. This thermostat allows the engine to run more efficiently than conventional thermostats improving fuel economy.

The ECM also electrically activates the thermostat to lower the engine coolant temperatures based on monitored conditions. It is both a conventionally functioning and ECM controlled thermostat (two stage operation). ECM control adds heat to the wax core causing the thermostat to open earlier than it's mechanical temperature rating providing increased coolant flow.

Conventional Function: The thermostat begins to open at 103°C. This is at the inlet side of the water pump and represents the temperature of the coolant entering the engine. Before the 103°C temperature is realized, the coolant is circulated through the engine block by the water pump.

After the temperature reaches 103°C it is maintained as the inlet temperature by the thermostat. The coolant temperature at the water pump engine outlet is approximately 110°C. The additional 7°C is achieved after the coolant has circulated through the block.

The operating temperature of the engine will remain within this range as long as the engine is running at part load conditions and the engine coolant temperature does not exceed 113°C.



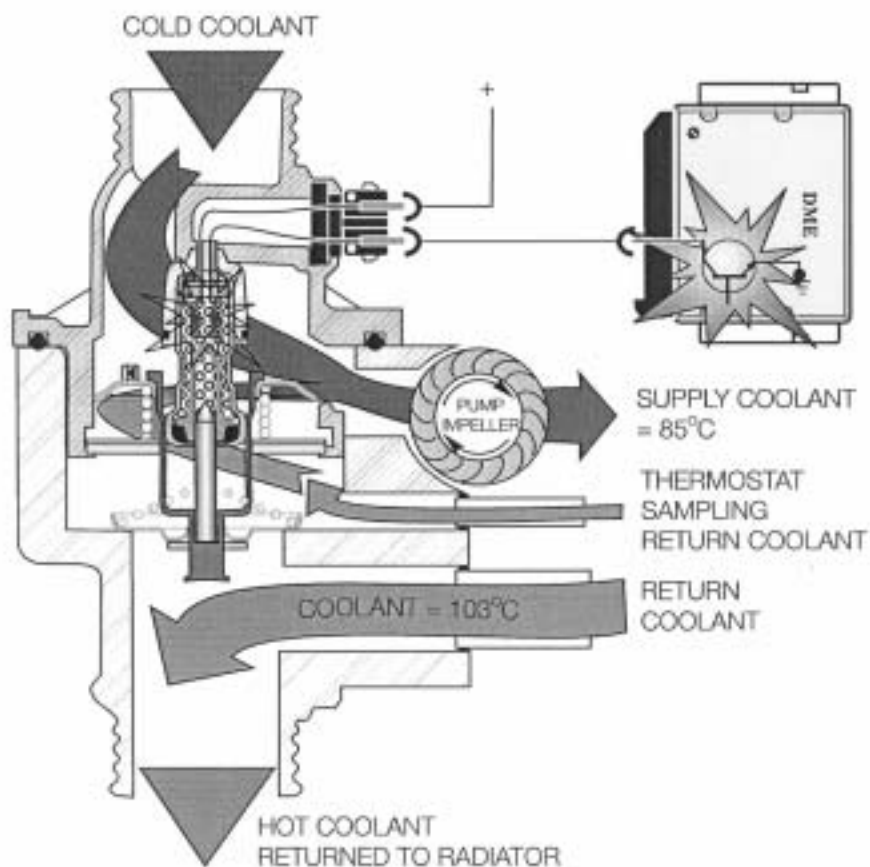
ECM Control

Electric thermostat activation is based on the following parameters:

- Engine temperature > 113°C
- Radiator Coolant Outlet Temperature
- Load signal "ti" > 5.8 ms
- Intake air temp > 52°C
- Vehicle speed > 110 MPH

When one or more of these monitored conditions is determined, the ECM activates (switched ground) the thermostat circuit. The activated heating element causes the wax core in the thermostat to heat up and open the thermostat increasing coolant circulation through the radiator which brings the engine temperature down.

The temperature of the coolant at the inlet side of the water pump will drop to approximately 85°C and the temperature at the outlet side will drop to approximately 103°C when activated.



The “**Malfunction Indicator Light**” (MIL) will be illuminated under the following conditions:

- Upon the completion of the **next consecutive driving cycle** where the previously faulted system is monitored again and the emissions relevant fault is again present.
- Immediately if a “Catalyst Damaging” fault occurs (see Misfire Detection).

The illumination of the light is performed in accordance with the Federal Test Procedure (FTP) which requires the lamp to be illuminated when:



- A malfunction of a component that can affect the emission performance of the vehicle occurs and causes emissions to exceed 1.5 times the standards required by the (FTP).
- Manufacturer-defined specifications are exceeded.
- An implausible input signal is generated.
- Catalyst deterioration causes HC-emissions to exceed a limit equivalent to 1.5 times the standard (FTP).
- Misfire faults occur.
- A leak is detected in the evaporative system, or “purging” is defective.
- ECM fails to enter closed-loop oxygen sensor control operation within a specified time interval.
- Engine control or automatic transmission control enters a "limp home" operating mode.
- Ignition is on (KL15) position before cranking = **Bulb Check Function**.

Within the BMW system the illumination of the Malfunction Indicator Light is performed in accordance with the regulations set forth in CARB mail-out 1968.1 and as demonstrated via the Federal Test Procedure (FTP). The following page provides several examples of when and how the Malfunction Indicator Light is illuminated based on the "customer drive cycle".

| TEXT NO. | DRIVE CYCLE # 1 | | | DRIVE CYCLE # 2 | | | DRIVE CYCLE # 3 | | | DRIVE CYCLE # 4 | | | DRIVE CYCLE # 5 | | | * DRIVE CYCLE # 43 | | |
|----------|------------------|----------------|----------------------------|------------------|----------------|----------------------------|------------------|----------------|----------------------------|------------------|----------------|----------------------------|------------------|----------------|----------------------------|--------------------|-------------------|----------------------------|
| | FUNCTION CHECKED | FAULT CODE SET | MIL STATUS CHECK ENGINE | FUNCTION CHECKED | FAULT CODE SET | MIL STATUS CHECK ENGINE | FUNCTION CHECKED | FAULT CODE SET | MIL STATUS CHECK ENGINE | FUNCTION CHECKED | FAULT CODE SET | MIL STATUS CHECK ENGINE | FUNCTION CHECKED | FAULT CODE SET | MIL STATUS CHECK ENGINE | FUNCTION CHECKED | FAULT CODE ERASED | MIL STATUS CHECK ENGINE |
| 1. | YES | YES | OFF | | | | | | | | | | | | | | | |
| 2. | YES | YES | OFF | YES | YES | ON | | | | | | | | | | | | |
| 3. | YES | YES | OFF | NO | NO | OFF | YES | YES | ON | | | | | | | | | |
| 4. | YES | YES | OFF | YES | NO | OFF | YES | NO | OFF | YES | YES | OFF | YES | YES | ON | | | |
| 5. | YES | YES | OFF | YES | YES | ON | YES | NO | ON | YES | NO | ON | YES | NO | OFF | | | |
| 6. | YES | YES | OFF | YES | YES | ON | YES | NO | ON | YES | NO | ON | YES | NO | OFF | YES | FAULT CODE ERASED | OFF |

1. A fault code is stored within the ECM upon the first occurrence of a fault in the system being checked.
2. The "Malfunction Indicator Light" will not be illuminated until the completion of the second consecutive "customer driving cycle" where the previously faulted system is again monitored and a fault is still present or a catalyst damaging fault has occurred.
3. If the second drive cycle was not complete and the specific function was not checked as shown in the example, the ECM counts the third drive cycle as the "next consecutive" drive cycle. The "Malfunction Indicator Light" is illuminated if the function is checked and the fault is still present.
4. If there is an intermittent fault present and does not cause a fault to be set through multiple drive cycles, two complete consecutive drive cycles with the fault present are required for the "Malfunction Indicator Light" to be illuminated.
5. Once the "Malfunction Indicator Light" is illuminated it will remain illuminated unless the specific function has been checked without fault through three complete consecutive drive cycles.
6. The fault code will also be cleared from memory automatically if the specific function is checked through 40 consecutive drive cycles without the fault being detected or with the use of either the DISplus, GT1 or Scan tool.

NOTE: In order to clear a catalyst damaging fault (see Misfire Detection) from memory, the condition must be evaluated for 80 consecutive cycles without the fault reoccurring.

Before any service work is performed on any fuel system related component, always adhere to the following:

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The diagram illustrates the K-BUS system architecture. The central K-BUS line connects various components. On the left, components are organized into four columns: IHKA, IHKS, IHS; GM5, RLS, SZM, SM; EWS III, PDC, CVM, LSZ; and RADIO, CDC, HIFI, TEL. On the right, components are organized into a single column: LWS, EPS, DSC, DME, EGS, SMG. Above the right side of the K-BUS, components include SIM, SBSL, SBSR, and a 'byteflight' label. Below the right side of the K-BUS, components include E OBD/OBD II, KWP 2000*, and DS2. A speedometer and tachometer are shown at the top right, connected to the K-BUS.

Misfire Detection

Refer to Service Information Bulletin **S.I. #12 02 97** for details about Misfire Fault Codes.

Testing the Oxygen Sensor should be performed using the DISplus Oscilloscope from the “Preset Measurement” List. The scope pattern should appear as below for a normal operating sensor.

If the signal remains high (rich condition) the following should be checked:

- Fuel Injectors
- Fuel Pressure
- Ignition System
- Input Sensors that influence air/fuel mixture
- Engine Mechanical

If the signal remains low (lean condition) the following should be checked:

- Air/Vacuum leak
- Fuel Pressure
- Input Sensor that influence air/fuel mixture
- Engine Mechanical

NOTE: A MIXTURE RELATED FAULT CODE SHOULD BE INVESTIGATED FIRST AND DOES NOT ALWAYS INDICATE A DEFECTIVE OXYGEN SENSOR!